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COSYMA :
Dosismodelle und Schutz- und Gegenmaßnahmen für externe Exposition und Inhalation

Kurzfassung

Als eines der wesentlichen Ziele des von der Kommission der Europäischen Gemeinschaften initiierten Projekts MARIA ("Methods for Assessing the Radiological Impact of Accidents") wurde das Programmsystem COSYMA ("COde SYstem from MARIA") zur Abschätzung der radiologischen und ökonomischen Folgen unfallbedingter luftgetragener Radionuklidfreisetzungen gemeinsam vom Kernforschungszentrum Karlsruhe (KfK), BRD, und dem National Radiological Protection Board (NRPB), GB, entwickelt.

COSYMA enthält Modelle und Datensätze zur Abschätzung eines breiten Spektrums von Unfallfolgen, die in einzelnen Programmodulen implementiert sind. In diesem Bericht werden diejenigen Module beschrieben, die Modelle und Daten zur Abschätzung individueller und kollektiver Organdosen durch externe und interne Expositionspfade enthalten, in denen Schutz- und Gegenmaßnahmen simuliert und in ihrer räumlichen und zeitlichen Ausdehnung quantifiziert werden, und die es erlauben, deren dosisvermindernden Effekt zu bestimmen. Durch die flexible Modellierung von Schutz- und Gegenmaßnahmen kann eine Vielzahl von Maßnahmenkombinationen und Eingreifkriterien spezifiziert werden, sodaß die meisten der in den europäischen Ländern gültigen Empfehlungen berücksichtigt werden können.

Abstract

As one of the main objectives of the MARIA project ("Methods for Assessing the Radiological Impact of Accidents") initiated by the Commission of the European Communities the program package COSYMA ("COde SYstem from MARIA") for assessing the radiological and economic off-site consequences of accidental releases of radioactive material to the atmosphere has been jointly developed by the Kernforschungszentrum Karlsruhe (KfK), FRG, and the National Radiological Protection Board (NRPB), UK.

COSYMA includes models and data for assessing a broad spectrum of accident consequences, and they are implemented in independent modules. The subject of this report are those modules, which incorporate models and data for assessing individual and collective organ doses via external and internal exposure pathways and for quantifying the extent and duration of countermeasures including their dose mitigating effect. The flexible countermeasure modelling offers considerable freedom in specifying a wide range of emergency actions and criteria, what allows for consideration of most of the national regulations in the different European countries.

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List of abbreviations

Exposure pathways :

CL	cloudshine
GR	groundshine
IH	inhalation
IHR	inhalation after resuspension
IG	ingestion
SK	contamination of skin and clothes

Organs :

BM	bone marrow
BR	breast
BS	bone surface
CO	colon
EN	effective dose, weighting factors according to ICRP-60
EO	effective dose equivalent, weighting factors according to ICRP-26
GO	gonads
LI	large intestine
LU	lung
LV	liver
OV	ovaries
PA	pancreas
RE	remainder
SK	skin
TH	thyroid
UT	uterus

Others :

ACA	Accident Consequence Assessment
CCFD	Complementary Cumulative Frequency Distribution
CEC	Commission of the European Communities
COSYMA	Code System from MARIA
FL	Subsystem "Far Late" of COSYMA
GSF	GSF-Forschungszentrum für Umwelt und Gesundheit, Neuherberg, Germany
KfK	Kernforschungszentrum Karlsruhe GmbH, Karlsruhe, Germany
MARIA	Methods for Assessing the Radiological Impact of Accidents
NE	Subsystem "Near Early" of COSYMA
NL	Subsystem "Near Late" of COSYMA
NRPB	National Radiological Protection Board, Chilton, Didcot, UK

1. Introduction

In 1982, the Commission of the European Communities (CEC) initiated the **MARIA** (**M**ethods for **A**ssessing the **R**adiological **I**mpact of **A**ccidents) programme with the aim to review and build on the nuclear accident consequence assessment methods in use within the European Community. One of the main objectives of the MARIA programme has been to develop a computer code for assessing the off-site consequences of accidental releases of radioactive material to the atmosphere. The new program system, called **COSYMA** (**CO**de **SY**stem from **MA**RIA) [1], was developed jointly by the Kernforschungszentrum Karlsruhe (KfK), FRG, and the National Radiological Protection Board (NRPB), UK.

COSYMA incorporates in its modular structure models and data for assessing and evaluating all types of accident consequences under due consideration of countermeasure actions. Two important modules are the subject of this report: The **dose module** comprises for each pathway a dosimetric model to convert the distribution of activity in the atmosphere and on the ground to distributions of dose in man. The **countermeasure module** allows for implementing a variety of actions aimed at mitigating the impact of an accident on the public. The descriptions refer to version 93/1 of COSYMA, which was released in 1993. A basic knowledge about the structure of COSYMA is presumed; however, Chapter 2 gives a brief overview of it.

Following an accidental release of radionuclides to atmosphere the major exposure pathways are: external irradiation from material in the cloud, from material deposited on the ground and due to contamination of skin and clothes and internal exposure following inhalation of material in the cloud and from the ingestion of foodstuffs contaminated. In addition, material resuspended from the ground can be inhaled and lead to internal exposure. In Chapter 3 of this report the way is described in which these exposure pathways are modelled in COSYMA, except for the ingestion pathway, which is documented in a separate report [2].

For calculating doses for each of the routes of exposure described here a library with radiological data is included in the COSYMA package. They have been provided either by NRPB or by the GSF-Forschungszentrum für Umwelt und Gesundheit (GSF) and are briefly outlined in Chapter 4.

Countermeasures are implemented with the aim of reducing either acute exposure during and shortly after the accident or continuing and long-term exposure due to deposited or incorporated radionuclides. Different countermeasures may be necessary in different areas or even in the same area. Therefore not only single types of protective actions but different combinations thereof are modelled in COSYMA. This offers a high degree of flexibility, thus allowing the user considerable freedom in specifying a wide range of both emergency actions and criteria, which decide on the initiation or withdrawal of these actions. This allows for consideration in COSYMA calculations of most of the emergency management strategies and intervention criteria adopted in different countries within and outside the European Community.

After some introductory remarks on the requirements to and general features of the modelling of countermeasures in the program package COSYMA, in section 2 of Chapter 5 short-term countermeasures as they are implemented in subsystem NE are discussed. The third section deals with the modelling of long-term countermeasures included in subsystems NL and FL (except foodbans which are described in a separate report [2]). The first part of these sections describes the criteria for initiating the corresponding countermeasures and the way they are implemented in the code. In the second part the way of calculating individual organ doses including the mitigating effects of countermeasures is explained.

In Chapter 6 the paper printout of the dose and countermeasure modules is described together with an example from a run of these modules.

2. General structure of COSYMA

A detailed description of the structure of COSYMA is given in the Main Report [1] and in the User Guide [3]. The reader is referred to these publications and to the collection of papers about COSYMA in [4] for more details on the program package as a whole. However, some key features of the structure of COSYMA are summarized below.

Accident consequence assessments (ACAs) require a series of calculations to give the doses received by people, the associated emergency actions and the resulting health effects and economic costs. The calculations are based on a polar coordinate grid system with the centre point at the location of the nuclear facility; they are carried out for each of a number of areas ("grid elements"), defined in COSYMA in terms of angular segments and distance bands as shown in Figure 1. Throughout each area a uniform level of activity concentration, and hence individual doses, associated emergency actions and individual risks, are assumed. The consequences in each of these areas are calculated at a single point, the "grid point" representative for the whole "grid element".

The program package COSYMA is subdivided into three principal subsystems, each of which is an ACA program with a specific area of application. The ranges of application for each subsystem are illustrated in Figure 2.

The three ACA programs, designated the NE, NL and FL subsystem of COSYMA (where the first letter refers to **N**ear or **F**ar distance and the second to **E**arly or **L**ate health effects and the appropriate countermeasures) are written in a modular form to allow the maximum possible flexibility in their use. The modular structure of the systems and the data flow between modules is illustrated in Figure 3. Each of the modules is concerned with one part of the overall analysis. The function of the modules treated in this report are summarised below. All these modules require as input data the results of the previous module CONCEN (i.e. nuclide specific activity concentrations and arrival time of the plume; for details see [5]).

The module **POTDOS** calculates individual organ doses at each grid point, assuming that there are no protective actions. It calculates doses to people outdoors (default in subsystem NE) or doses for people with average behaviour ("normal activity", default in the NL and FL subsystems). In the three subsystems, each module POTDOS considers different times over which the doses are integrated, different routes of exposure, and different health effects as indicated in Table 1 and described in Chapter 3.

The exposure pathways considered in the NE subsystem are external irradiation from the cloud and from material deposited on the ground and on the skin, and inhalation of material from the cloud and from resuspension. The NL and FL subsystems also contain models for calculating doses from the ingestion of contaminated food [2]. The dose conversion factors for the different exposure pathways are taken from precalculated data libraries (see Chapter 4).

Different types of individual doses can be calculated in POTDOS. The "doses as an endpoint" are integrated over a user-specified time period; in subsystems NL and FL they are used for calculating collective doses in module COLLEC. Additionally or alternatively subsystem NE calculates "weighted protracted doses" used as input for the health effects model for deterministic effects which is implemented in a separate module POTRSK [6]. The model for stochastic effects (module POTRSK of subsystems NL an FL) does not use individual doses. In all subsystems, however, POTDOS does not calculate the intervention doses to decide about countermeasures.

The **PROTEC** module is designed to quantify the extent and duration of the protective actions and countermeasures. Different action types are considered in the different subsystems, because of the different distance ranges and endpoints considered. Table 1 lists the actions modelled in each of the three subsystems. The areas on which the various countermeasures are to be assumed can be defined geometrically in terms of angles and distances or by isodose lines derived from criteria specified by the user. The coding of COSYMA allows the user a great deal of flexibility in specifying the criteria at which emergency actions are assumed to be initiated or withdrawn. The options available and the effect of the action on the doses to exposed individuals are described in Chapter 5.

The **AMOUNT** module combines the information from PROTEC on the actions taken at each grid point with the distribution of population or agricultural production around the site to determine the numbers of people, the amounts of agricultural produce and the areas affected by countermeasures and their time integrals (see Chapter 5).

The module **LATDOS** of the NL and FL subsystems calculates the individual organ doses at each grid point taking into account the effects of countermeasures. It uses the results of the PROTEC module to identify the actions and their duration to be taken at each of the grid points. The doses calculated are integrated over a user specified time-period; they are used to determine collective doses considering countermeasures (module COLLEC). They are not needed for the risks of stochastic health effects which are calculated in a separate module LATRSK.

The module **COLLEC** of the subsystems NL and FL calculates the collective doses by multiplying the individual doses determined in POTDOS or LATDOS with the corresponding population and summing up the results for all grid elements.

The module **EARLY** in the NE subsystem is equivalent to LATDOS and LATRSK in the late subsystems (i.e. it contains both, the individual dose and risk calculation). It includes a detailed modelling of the effects of early emergency actions in reducing the potential doses. It uses the results of the PROTEC module to identify which actions are to be taken at each of the grid points. The module considers different groups of people who, after an initial delay, are sheltering in different types of buildings, or evacuating spontaneously or remaining outdoors for some reason. After the sheltering period, all people still in the evacuation area are assumed to leave. The module allows for the time taken to travel out of the evacuation area, with the travelling time being related to the density of the population. The model is described further in Section 5.2. The effects of stable iodine tablets in reducing thyroid

health risks are also considered in this module. The flexibility and complexity of the countermeasures model prevented a division into separate dose and risk modules because of the amount of data storage which would be required to pass the information between two such modules. This report only focusses on the dose part of EARLY; the health effects model is described in a separate document [6].

The results of the modules described above are stored on files for subsequent modules or as an endpoint for the corresponding evaluation program.

3. Principles of the dose models in COSYMA

Following an accidental release to atmosphere, people can be irradiated by radioactive material both in the atmosphere and after its deposition on the ground. The exposure pathways considered in COSYMA are:[1]

1.	external irradiation from material in the cloud	(CL - 1)
2.	inhalation of material in the cloud	(IH - 3)
3.	external β irradiation from material deposited on skin or clothing	(SK - 5/6)
4.	external irradiation from material deposited on the ground	(GR - 2)
5.	inhalation of resuspended material	(IHR - 4/5)
6.	ingestion of foodstuffs contaminated by deposited material	(IG - -/4)

This report is concerned with the major pathways for exposure due to external irradiation and due to internal irradiation from inhalation; internal irradiation from ingestion is considered in a separate report [2]. External irradiation occurs from material in the cloud and from that deposited on the ground, together with that due to contamination of skin and clothes. Internal irradiation from inhalation results from breathing in material in the cloud and material resuspended from the ground.

Not all routes of exposure are considered for each organ dose and health effect, or included in each of the subsystems as indicated in Table 1. The first three routes of exposure only affect those people who are exposed to the plume as it passes overhead. External irradiation from the cloud only occurs while the person is in or close to the contaminated plume. Radioactive material is inhaled only while standing in the plume; it can be retained in the body for long times after inhalation so that the exposure can persist over long periods of the person's lifetime. The third route also affects only those people standing under the plume during its passage and irradiation stops once the material is removed from the skin. The other routes can lead to irradiation over a considerable period of time and can even affect those people who are living outside the initially contaminated area or who were not yet born at the time of the accident.

Early health effects are only observed in those population groups exposed to high doses and dose rates for short periods of time. Ingestion doses over short time periods, and their contribution to early health effects, are not considered in COSYMA because bans on the consumption of food would be imposed if doses from this route might be high. In the current version of COSYMA the skin-pathway contributes to skin dose only. Each of the pathways

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[1] In brackets, the abbreviation for the pathways is given; the numbers refer to the index of the pathway in pathway-indexed arrays; if there are two numbers, the first is valid for NE, the second for NL and FL

can be excluded by the user setting the corresponding position in the NAMELIST array IEXPO to zero.

3.1 Basic features for all exposure pathways

The basic features of the calculation of individual doses in COSYMA are independent of the consideration of protective actions as the modelling of the exposure pathways is the same in both cases. The application of countermeasures only reduces the duration of exposure (interrupt or earlier end of exposure) and increases the shielding. In this section the principles of the dose calculations are described for each of the exposure pathways considered in COSYMA without taking into account the mitigating effects of countermeasures. The methods of allowing for protective actions in calculating doses (and health effects) are described in Sections 5.2.2 and 5.3.2.

Individual doses are calculated in COSYMA either for presentation as an endpoint of the assessment (all subsystems) or for use in further calculations of health effects (NE) or collective doses (NL and FL). Both, individual and collective doses can be evaluated.

The doses are calculated for an average adult member of the population (i.e. a person aged 20 years). However, age-dependent doses and doses to members of critical groups can be calculated using other data libraries which contain the required dose conversion factors (see Chapter 4). The individual doses calculated are valid for the individual affected (e.g. breast doses refer to women) and not averaged over the population which is done for the collective doses only. The calculated doses summed up over all pathways can be evaluated and presented with or without the effects of countermeasures.

The doses from all exposure pathways calculated with the dose conversion factors contained in the libraries are valid for people who are outdoors. Reduction factors SF allowing for average shielding by buildings during normal activity or for different radionuclide concentrations in air inside and outside buildings can be applied (see Sections 3.3 and 3.4).

Doses may be calculated for a number of organs (see Table 2) and any integration time specifying the time period over which the organ doses accumulate. For cloudshine doses the integration time is irrelevant as the dose accumulation is linked to the passage of the plume and thus determined by the release duration. For groundshine doses and doses due to skin contamination the integration time is the same as the duration of exposure. For inhalation doses the duration of exposure or intake is linked to the passage of the plume and thus the release duration; the integration time is here the time point after intake up to which the committed dose is considered. This definition of integration time is also valid for inhalation of resuspended material.

The organs considered in the dose parts of subsystem NE of COSYMA are those required for use with the dose-response relationships adopted for the calculation of the different det-

erministic health effects; they are shown in Table 2. Therefore the thyroid doses are calculated separately for external and internal irradiation. Lethal and non-lethal effects are included in the health effects part. As lung is considered for both types of effects, the program structure requires that organ doses to lung are assessed twice, marked with "morbidity" and "mortality". This labelling has no meaning for the dose results; it only indicates for which type of effect the organ doses are used. As there exists no health effects model for effective dose equivalent, effective doses are not calculated as endpoints.[2]

The dose integration time considered for individual doses as endpoints of subsystem NE can be set by the user with the maximum time allowed being one year (NAMELIST parameter IDTIME > 0); the default integration time is 7 days. Additionally the user can select deterministic health effects risks (individual and collective) to be calculated in the same run (NAMELIST parameters NORISK and NOPOTR). In this case doses are also calculated using the integration times prescribed by the health effects model; the default times are those used in the dose-response relationships described in a separate report [6]. The resulting doses are the weighted protracted doses relevant for deterministic health effects, considering the different time periods of the health effects model. The types of short-term doses calculated is described in more detail in Section 3.4.

In COSYMA-NL and -FL individual doses need not be calculated when estimating health effects because "activity risk coefficients" are used (see [6]). Individual doses can be calculated for the single organs[3] listed in Table 2 for a user chosen integration time period (NAMELIST parameter IZINT) between 1 year and 70 years which is the default value (see Section 3.4). For assessing the doses due to contamination of skin and clothes a different integration time is used (NAMELIST parameter TSKIN) with a default value of 3 days assuming that all material has been removed from the skin after this time period.

As default the program calculates the effective dose equivalent with the tissue weighting factors according to ICRP-26 [7]. In the meantime ICRP has recommended new tissue weighting factors for calculating the effective dose equivalent now called "effective dose" (ICRP-60 [8]). The program offers the user the possibility to calculate this effective dose instead of the effective dose equivalent according to ICRP-26 (NAMELIST parameter NEWEDE). Both sets of weighting factors are given in Table 3. It should be noticed that in most countries a revision of the legislation and recommendations did not yet occur and thus the old weighting factors have still to be applied. The effective dose should therefore be used only after checking its applicability. In this report the term "effective dose" refers to the quantity actually chosen for the run.

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2 However, effective doses are calculated in subsystem NE to decide about short-term countermeasures; see Sections 5.2.1.2 and 5.2.1.3

3 The genetically significant dose causing hereditary effects is not considered in the dose modules, but in the risk modules.

For each exposure pathway up to NUCMAX (default: 60) different nuclides can be considered in each subsystem. Only those nuclides can be taken into account in COSYMA which are included in the basic nuclide list shown in Table 4. It contains NUCALL nuclides with a current number of 145. The selection can be made pathway-specifically via the preprogram SOURCE (see User Guide, Part V [3]) or directly by the user.

The calculations in all modules are based on the same loop structure as shown in Figure 4. Thus, individual doses are assessed for each weather sequence L, each grid point defined by radius I and azimuthal sector J (representative for the corresponding grid element as shown in Figure 1) and each release phase NP. To save computing and storage time the calculations are only performed for those grid elements affected by the plume; this is controlled by the index array JUSED which is stored together with the results on a file. In the following sections all formulas describing the dose calculation refer to one release phase NP and one grid point (I,J); for clarity the corresponding indices are always omitted in the formulas.

3.2 External exposure pathways

3.2.1 Cloudshine

External exposure from material in the **cloud (CL)** is considered within each of the subsystems of COSYMA. The organ doses are calculated by multiplying for each nuclide the time-integrated air concentrations [Bq × s/m³] by a precalculated dose rate conversion factor [9] and a "plume correction factor" [10], both provided by GSF, and obtained from a data library. The nuclide- and organ-specific dose rate conversion factors are the dose per second and unit air concentration [(Sv × m³)/(Bq × s)]. They are calculated assuming that the plume is semi-infinite and of uniform concentration. Correction factors for plume geometry and distance from the plume centre-line are included in the dispersion models MUSEMET, RIMPUFF and COSGAP [5]. The COSGAP dispersion model contains a further method for calculating cloudshine doses for use when the plume is very narrow in the vertical direction and the centre-line is well above the ground. The dispersing material is then approximated by a horizontal line source at the plume centre line height, and the dose is obtained by integrating along the line source [11].

The multiplication of the time-integrated air concentrations by the correction factors is not done in the dose modules, but in the preceding modules (CONCEN or COSGAP which comprises the calculations of the CONCEN module). They provide so-called "effective cloud concentrations"; their multiplication by the dose conversion factors results in the organ dose due to cloudshine.

Thus, the individual dose for organ o due to cloudshine CL is calculated at each grid point (I,J) according to

$$DCL(o) = SF(CL) \cdot \sum_{k} (AC(k) \cdot DRCFCL(o,k)) \qquad [3.1]$$

where

SF(CL)	=	average shielding factor for cloudshine (normal activity or outdoors)
k	=	index of radionuclide
AC(k)	=	time-integrated "effective cloud concentration" [Bq × s/m³] AC(k) = AA(k) • PCF , already calculated in CONCEN / COSGAP where AA(k) = time-integrated activity concentration in the air near ground [Bq × s/m³]
PCF	=	plume correction factor at grid point (I,J)
DRCFCL(o,k)	=	dose rate conversion factor for cloudshine [(Sv × m³)/(Bq × s)]

3.2.2 Groundshine

External exposure from material deposited to the **ground (GR)** is calculated within each of the subsystems of COSYMA. The organ doses are calculated by multiplying for each nuclide the initially deposited activity [Bq/m²] by a precalculated dose conversion factor obtained from a data library. This organ- and nuclide-specific factor is the dose per unit deposit integrated up to the selected time period [Sv/(Bq/m²)].

Thus, the individual dose for organ o due to groundshine GR, integrated over time period IT is calculated at each grid point (I,J) according to

$$DGR(o, IT) = SF(GR) \cdot \sum_{k} (AG(k) \cdot DCFGR(o, k, IT)) \qquad [3.2]$$

where

SF(GR)	=	average shielding factor for groundshine (normal activity or outdoors)
k	=	index of radionuclide
AG(k)	=	concentration of activity initially deposited on the ground [Bq/m²]
DCFGR(o,k,IT)	=	dose conversion factor for groundshine [Sv/(Bq/m²)] integrated over time period IT

The dose conversion factors for groundshine in the data library currently included in COSYMA were taken from the NRPB data base. They give the dose per unit deposit at a

series of times for each of a large number of nuclides, including the contribution from daughter products formed after the original material is deposited. They are appropriate for people staying outdoors, allow for the non-uniform pattern of irradiation of the body and were derived by NRPB using two models (see Section 4.1.2).

The values for the nuclides which make the most important contributions to deposited γ dose from typical accidental releases (Ru-103, Ru-106, I-131, Te-132, Cs-134, Cs-137 and Ba-140) were calculated using the NRPB model EXPURT [12]. This considers the amounts of material deposited on different surfaces in residential areas, the movement of material between these surfaces and into the soil column, and the dose from material deposited on the different surfaces. It is obvious that deposits on surfaces which are common in urban environments are retained and removed by weathering in a very different way than deposits to soil. The EXPURT values are for an average environment (actually a type of urban environment calculated by weighting a range of urban environments based on population density in the UK) and average UK weather conditions.

The doses for all other nuclides were calculated using a simpler model [13] which assumes that the dose in the area where people live can be represented by that over an open field, i.e. over a large undisturbed soil surface. They allow for shielding by surface roughness and for material to move into deeper layers of soil.

3.2.3 Contamination of skin and clothes

Skin doses from material deposited on **skin and clothes (SK)** are also considered in COSY-MA. They are calculated using information on the biological half-life T_B of the material on skin and a data library provided by GSF [14], which contains values for dose rates in the affected parts of the skin averaged over a skin depth between 50 and 100 μm resulting from a unit activity deposit per unit area on bare skin [(Sv/s)/(Bq/m^2)]. Included in the dose concersion factors are contributions from β-emissions and electrons (Auger, conversion) and from γ-radiation, if this contributes more than 10% of the β- and electron component.

For the initial skin contamination, no distinction is made between a deposition on skin (and hair) and clothes. The amount ASK of material per unit area initially deposited on skin or clothes is taken to be a multiple of that to the ground by dry deposition at the same location. The user can specify this multiple for each nuclide type with different dry deposition velocity (NAMELIST parameter CONFAK).

$$ASK(k) = AA(k) \cdot SF(SK) \cdot v_d \cdot CONFAK(nk) \qquad [3.3]$$

where

k	=	index of radionuclide
ASK(k)	=	initial contamination of skin or clothes [Bq/m^2]
SF(SK)	=	average shielding factor with respect to the air concentration (normal activity or outdoors)
AA(k)	=	time-integrated air concentration [Bq $\times$ s/m^3]

v_d = dry deposition velocity [m/s] according to the nuclide type; for iodine this value is averaged over its different chemical forms according to the fractions released (this is necessary because AA is no longer available separately for each iodine form)

nk = index of nuclide type to which nuclide k belongs

The dose in the irradiated skin is calculated from the initial contamination ASK of skin or clothes and the time integral of the dose rate conversion factors DRCF over a time T_{skin}, whereby account is taken of radioactive decay and the biological residence time of the radioactive material on bare skin:

$$DSK(T_{skin}) = \sum_k (ASK(k) \cdot DRCFSK(k) \cdot U(k)) \qquad [3.4]$$

where

k = index of radionuclide

ASK(k) = initial contamination of skin and clothes [Bq/m²]

DRCFSK(k) = dose rate conversion factor for skin contamination [(Sv/s)/(Bq/m²)]

U(k) = time integral according to Eq. [3.5]

$$U(k) = \frac{T_{eff}}{\ln 2} \cdot (1 - e^{-\frac{\ln 2}{T_{eff}} \cdot T_{skin}}) \qquad [3.5]$$

with

T_{skin} = time of skin decontamination [s] after passage of the plume

T_{eff} = effective half-life [s] considering the natural peeling processes and half-life of the radionuclide

$$= \frac{T_P \cdot T_B}{T_P + T_B}, \quad \text{with} \quad \begin{array}{l} T_P = \text{physical half-life [s] of nuclide k} \\ T_B = \text{biological half-life on skin [s]} \end{array}$$

The biological half-life T_B of material on skin determined by peeling processes can be defined by the user (NAMELIST parameter TBIO). Since the dose rate conversion factors do not contain the build-up of daughter products from radioactive decay chains, a correction for this is done in COSYMA (see below).

In subsystem NE of COSYMA, the *dose in the irradiated skin* given by Eq. [3.4] is the one relevant for deterministic health effects and the integration time T_{skin} for potential calculations is defined either by the health effects model (if health effects are required as an endpoint) or by the NAMELIST parameter IDTIME (if doses are required as an endpoint).

In the NL and FL subsystems, the dose quantity relevant for the calculation of stochastic effects is the *average skin dose*. This dose is calculated from the dose in the irradiated skin by multiplication by a factor defining the fraction of the body which is irradiated:

$$\overline{DSK(T_{skin})} = PSKIN \cdot DSK(T_{skin})$$

If the β-radiation component is dominant, PSKIN can be considered to represent the fraction of bare skin relative to the total skin area (typical value: 17000 cm^2 for adults [15]), because it can be assumed that the clothes provide a 100% shielding for the β-radiation [14]. TSKIN can be changed by NAMELIST input; the current default value is is 0.1, which represents the area of head, neck and hands [15]. The integration time T_{skin} is defined by NAMELIST parameter TSKIN with a default value of 3 days; i.e. after 3 days the skin dose rate is assumed to be zero because people have been decontaminated.

The dose rate conversion factors in the data library do not contain the build-up of daughter products. Therefore the program must correct for them. For each daughter nuclide d the activity concentration is corrected by the contribution of the parent nuclide p with yield value VY according to

$$A_{d+p}^{\int} = A_d^{\int} + A_p^{\int} \cdot VY \qquad [3.6]$$

where

- the activity concentration from nuclide d with initial contamination A_d^0 and decay constant $\lambda_d = \frac{\ln 2}{T_{1/2}^d}$ is given by

$$A_d^{\int} = A_d^0 \cdot \frac{1}{\lambda_d} \cdot (1 - e^{-\lambda_d T_{skin}}) \qquad [3.7]$$

- the activity concentration from parent nuclide p with initial contamination A_p^0, decay constant $\lambda_p = \frac{\ln 2}{T_{1/2}^p}$ and yield value VY is given by

$$A_p^{\int} = A_p^0 \cdot \frac{\lambda_d}{\lambda_p - \lambda_d} \cdot \left(\frac{1 - e^{-\lambda_d T_{skin}}}{\lambda_d} - \frac{1 - e^{-\lambda_p T_{skin}}}{\lambda_p}\right) \qquad [3.8]$$

For nuclides d which are noble gases: $A_{d+p}^{\int} = 0$

3.3 Internal exposure pathways from inhalation

Radioactive material can be inhaled either directly from the cloud as it passes overhead or following the resuspension of material that has been deposited on the ground. The direct inhalation pathway is only relevant during the passage of the plume. Thus the duration of incorporation is linked to the duration of the release. Inhalation after resuspension can lead to intakes over prolonged periods of time. In both cases the exposure due to inhalation can continue over a prolonged period after intake as some radionuclides can remain in the body

for considerable periods after inhalation. The integration time of the doses defines the time point up to which the committed dose is considered.

For determining the amount of material incorporated a breathing rate has to be defined. It depends on the age and size of the individuals and if they are engaged in physical activity or resting. Generally a breathing rate typical for adults is used in accident consequence assessment codes. The default values in COSYMA are 3.333×10^{-4} m³/s for acute doses (NE) and 2.667×10^{-4} m³/s for long-term doses (NL and FL). However, they need not be identical for the two pathways (NAMELIST parameters ARATIH and ARATIR). The breathing rate has been found to be a parameter whose uncertainty can be a source of significant uncertainties in the predictions of ACA codes [4], [16].

3.3.1 Inhalation from the cloud

In COSYMA the direct **inhalation (IH)** dose is obtained as the product of the breathing rate [m³/s], the time integrated air concentration [Bq × s/m³] and a precalculated dose per unit activity inhaled [Sv/Bq].

The time-integrated air concentration is calculated in the various atmospheric dispersion modules, as discussed elsewhere [5]. Values of dose per unit activity inhaled are contained in a separate data library derived by NRPB [17], [18], [19] (see also [20]) using models of radionuclide metabolism. The models include a description of the ways in which radioactive material moves through the body after intake and allow for calculating the doses received by a large number of organs from material in the organ itself as well as from material in other body organs.

Thus, the individual dose for organ o due to inhalation IH, integrated over time period IT (i.e. incorporation during passage of the plume, dose committed up to time point IT) is calculated at each grid point (I,J) according to

$$DIH(o,IT) = ARATIH \cdot SF(IH) \cdot \sum_{k} (AA(k) \cdot DCFIH(o, k, IT)) \qquad [3.9]$$

where

ARATIH	=	breathing rate [m³/s] for inhalation
SF(IH)	=	average shielding factor for inhalation (normal activity or outdoors)
k	=	index of radionuclide
AA(k)	=	time-integrated activity concentration in the air near ground [Bq × s/m³]
DCFIH(o,k,IT)	=	dose conversion factor for inhalation [Sv/Bq] integrated over time period IT

3.3.2 Inhalation after resuspension

Resuspension in air of radioactive material already deposited can be caused by the wind or by human activities (e.g. traffic, digging or ploughing). It can occur, and hence lead to intake by inhalation (IHR), over long periods of time after the initial depositing event. It can also lead to the movement of radioactivity from one area to another. Resuspension will depend on a number of mechanisms including the degree of fixation of the material onto soil, climatic conditions and the amount and type of human activity in the area. Much of the experimental work and the measurement of resuspension has been carried out in arid or semi-arid regions with only limited data available for conditions typically found in much of Europe [21].

As there are no detailed reliable models and experimental data for resuspension in humid climates, a relatively simple approach to model resuspension has been adopted in COSYMA making use of empirical factors.

The time-dependent behaviour of the activity concentrations on the ground is influenced by the leaching of the deposited activity into deeper layers of the soil and the radioactive decay. Both processes are modelled by the time function f(k,t) as follows; the values of the coefficients are shown in Table 5.

$$AG(k,t) = AG_0(k) \cdot f(k,t) \qquad [3.10]$$

with

$$f(k,t) = e^{-\lambda_k t} \cdot (0.63 \cdot e^{-\lambda_1 t} + 0.37 \cdot e^{-\lambda_2 t}) \qquad [3.11]$$

where

k	=	index of radionuclide
t	=	time after deposition [s]
AG(k,t)	=	activity concentration on ground [Bq/m^2]
$AG_0(k)$	=	initial activity concentration on ground [Bq/m^2]
λ_k	=	radioactive decay constant in [s^{-1}]
λ_1, λ_2	=	weathering constants in [s^{-1}]

The relationship between the amount of material deposited on ground and the air concentration after resuspension is described in COSYMA using a time-dependent resuspension factor r(t). The activity resuspended into the air at time t after deposition is calculated according to

$$ARA(k,t) = AG(k,t) \cdot r(t) \qquad [3.12]$$

where

k	=	index of radionuclide
ARA(k,t)	=	activity resuspended into the air at time t [Bq/m^3]
AG(k,t)	=	activity concentration on ground at time t [Bq/m^2]
r(t)	=	resuspension factor [m^{-1}]

To describe the time dependence of resuspension processes after deposition the resuspension factor r(t) is assumed to be an exponential term varying with time together with a constant and has the following form [22]:

$$r(t) = r_0 \cdot e^{-\lambda_r t} + r_e \qquad [3.13]$$

where

r(t)	=	resuspension factor [m^{-1}]
r_0 , r_e	=	coefficients in [m^{-1}]
λ_r	=	resuspension constant in [s^{-1}]
t	=	time after deposition [s]

The user can choose the values of each of the parameters given. The current default values are shown in Table 5.

Using Eq. [3.10] and Eq. [3.12] the relation between the initial activity deposited on ground and the material resuspended into the air at time t after deposition is given by

$$ARA(k,t) = AG_0(k) \cdot f(k,t) \cdot r(t) \qquad [3.14]$$

where

k	=	index of radionuclide
ARA(k,t)	=	activity resuspended into the air at time t [Bq/m^3]
$AG_0(k)$	=	initial activity concentration on ground [Bq/m^2]
r(t)	=	resuspension factor [m^{-1}]
f(k,t)	=	soil migration function according to Eq. [3.11]

Thus, the individual dose for organ o due to resuspension IHR, integrated over time period IT is calculated at each grid point (I,J) according to

$$DIHR(o,IT) = \sum_k \left(AG_0(k) \cdot ARATIR \int_0^{IT} f(k,t) \cdot r(t) \int_0^{IT-t} DDCFIH(o,k,t_e)\, dt_e\, dt\right) \qquad [3.15]$$

where

k	=	index of radionuclide
t	=	time of resuspension (= time of incorporation)
$AG_0(k)$	=	initial activity concentration on ground [Bq/m^2]
ARATIR	=	breathing rate [m^3/s] for inhalation of resuspended activity
f(k,t)	=	soil migration function according to Eq. [3.11]
r(t)	=	resuspension factor [m^{-1}] according to Eq. [3.13]
t_e	=	time of subsequent radiation exposure
DDCFIH	=	differential dose conversion factor for inhalation [(Sv/Bq)/s]

As even without considering radioactive decay the contribution of the first year to the time integral of the resuspended activity is about 98%, for simplification it can be assumed that the incorporation of the material resuspended occurs at time t = 0. By this simplification the second integral of Eq. [3.15] vanishes and the following approximative formula is obtained:

$$DIHR(o,IT) = \sum_k (AG_0(k) \cdot ARATIR \cdot DCFIH(o,k,IT) \int_0^{IT} f(k,t) \cdot r(t)\, dt) \qquad [3.16]$$

In the code the resuspension factor r(t) and the soil migration function f(k,t) are implemented in the FUNCTION RESUS in the following analytic form:

$$RESUS(k,IT) = \int_0^{IT} f(k,t) \cdot r(t)\, dt \qquad [3.17]$$

$$= 0.63 \cdot \frac{r_0}{\lambda_1 + \lambda_r + \lambda_k} \cdot (1 - e^{-IT \cdot (\lambda_1 + \lambda_r + \lambda_k)}) + 0.63 \cdot \frac{r_e}{\lambda_1 + \lambda_k} \cdot (1 - e^{-IT \cdot (\lambda_1 + \lambda_k)})$$
$$+ 0.37 \cdot \frac{r_0}{\lambda_2 + \lambda_r + \lambda_k} \cdot (1 - e^{-IT \cdot (\lambda_2 + \lambda_r + \lambda_k)}) + 0.37 \cdot \frac{r_e}{\lambda_2 + \lambda_k} \cdot (1 - e^{-IT \cdot (\lambda_2 + \lambda_k)})$$

where λ_k = radioactive decay constant in [s^{-1}] for nuclide k

Thus, the total individual dose for organ o due to pathway IHR, integrated over time period IT is calculated according to

$$DIHR(o,IT) = ARATIR \cdot SF(IHR) \cdot \sum_k (AG_0(k) \cdot DCFIH(o,k,IT) \cdot RESUS(k,IT)) \qquad [3.18]$$

where

ARATIR	=	breathing rate [m^3/s] for inhalation of resuspended activity
SF(IHR)	=	average shielding factor for resuspension (normal activity or outdoors)
k	=	index of radionuclide
AG_0	=	initial concentration of activity deposited on the ground [Bq/m^2]
DCFIH(o,k,IT)	=	dose conversion factor for inhalation [Sv/Bq] integrated over time period IT
RESUS(k,IT)	=	resuspension function according to Eq. [3.17]

3.4 *Implementation in the dose modules*

The calculation of individual doses in the absence of countermeasures is performed in all subsystems in module POTDOS. Additionally, in NL and FL potential collective doses are calculated in module COLLEC (COLDOS submodule) by multiplying the individual doses of each grid element with the corresponding number of persons and summing up the results over the whole grid area under consideration. The principles of the implementation of the dose calculation described in this section is also valid for the modules EARLY and LATDOS taking protective actions into account.

With the NAMELIST parameter IEXPO the user can select the exposure pathways to be taken into account. The doses can be calculated for people staying outdoors all the time or considering an average shielding factor due to buildings during normal activity. The user specifies these factors for each pathway separately assuming only one group of people[4] with the same habits averaged over time (NAMELIST parameter SFPOT in subsystem NE and SFLATE in subsystems NL and FL). As the NE subsystem calculates doses integrated over a relatively short time period, it is assumed that people are staying outdoors for that time. Therefore the default values for SFPOT are set to 1.0 for all exposure pathways.

In the NL and FL subsystems of COSYMA the default shielding factors for normal activity SFLATE are 0.3 for CL and 0.2 for GR. For the other exposure pathways no reduction factors are applied (i.e. SFLATE = 1.0).

As already mentioned in Section 3.1, in subsystem NE two types of acute doses can be calculated depending on the endpoints selected by the user:

- individual doses integrated over a user specified time period (NAMELIST parameter IDTIME) of maximal one year;
- weighted protracted individual doses for deterministic health effects.

It is also possible to obtain both dose types within the same run. In this case the dose module is run twice, first calculating the weighted protracted doses and the risks for deterministic health effects and then the short-time integrated organ doses.

For calculating each of both dose types module POTDOS has to be called, i.e. NOPOTD = 1. The different dose types are chosen by the user as follows:

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[4] However, in its module EARLY taking emergency actions into account, the NE subsystem allows the user considerable flexibility in describing the location of the population and the shielding effects of buildings for those people assumed to be indoors. The way in which this is done, and the options for describing the fractions of the population in different types of housing with different shielding factors, are described in Section 5.2.2.

- If the user wants to calculate individual acute organ doses only, the NAMELIST parameter NOPOTR has to be set to zero: the calculation of individual or collective risks is excluded. Additionally, the dose integration time has to be defined with NAMELIST parameter IDTIME having a positive value. The user can choose any integration time up to 365 days which is used for all organs. The doses for which the breakdown by exposure pathways and nuclides is calculated and which are stored on NUNITS(23) and evaluated in EVADOS are the doses integrated over IDTIME.

  If the user sets IDTIME to a non-positive value, the program will calculate the weighted protracted doses, even if NOPOTR is not activated. It is assumed, that these results will be used in a later run to assess the corresponding risks. Although the program checks whether the dose type is the correct one, it is recommended to calculate risks as an endpoint together with the weighted protracted doses in the same run.

- If the user wants to calculate individual or collective risks of deterministic health effects (NOPOTR = 1) and no individual doses as an endpoint (IDTIME $\leq$ 0), the integration time periods are given by the health effects model (NAMELIST parameters IZP1, IZP2, KONST1 and KONST2). The resulting weighted protracted doses are calculated by summing up over the doses delivered in each of the different time periods, with each dose contribution normalized to the corresponding D_{50} (for details see [6]). The doses for which the breakdown by exposure pathways and nuclides is calculated and which are stored on NUNITS(23) and evaluated in the evaluation program EVADOS are in this case the weighted protracted doses for deterministic health effects.

- By setting NOPOTR to 1 and assigning a value > 0 to IDTIME, both types of individual doses are calculated, i.e. module POTDOS is run twice. The user should be aware that in this case the computing times are significantly higher. The doses stored for the evaluation program EVADOS on NUNITS(23) are the acute doses integrated over the time period IDTIME; the weighted protracted doses are only intermediate results; they are not evaluated. The breakdown by exposure pathways and nuclides is calculated for both dose types.

In COSYMA-NL and -FL the situation is much less complex. Individual doses need not be calculated when estimating health effects because "activity risk coefficients" are used (see [6]). Therefore doses are always calculated as an endpoint for a user chosen integration time period (NAMELIST parameter IZINT) between 1 year and 70 years which is the default value. In the case of resuspension IZINT defines the integration time of the dose conversion factor as well as the time point up to which inhalation is taken into account.[5] For assessing the doses due to contamination of skin and clothes a different integration time is used (NAMELIST parameter TSKIN) with a default value of 3 days assuming that all material has been removed from the skin after this time period.

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5 For calculating individual doses due to ingestion IZINT only defines the time up to which the intake is considered; the dose conversion factors are integrated over 50 years.

For these individual doses the breakdown by exposure pathways and nuclides is calculated. They are stored on NUNITS(23) for the evaluation program EVADOS which offers the possibility to combine the doses of the organs liver, pancreas, colon and stomach to a total dose for GI-tract (NAMELIST parameter IORGGI).

These doses integrated over IZINT are also used for calculating the collective doses in module COLLEC by multiplying the individual dose for each grid element with the corresponding population (when calculating collective doses for organ breast only 50% of the population are considered). The user should be aware, that by setting IZINT to another lower value the collective dose is only considered up to that time and not integrated over all time periods.

The collective doses are summed up over the whole grid area under consideration. However, the program offers the option to skip the inner (FL) or the outer (NL) distance bands: in subsystem FL the integration starts with radius index IRMIN, in subsystem NL it ends with radius index IRMAX. The reason for this is the possibility to combine results from NL and FL to get a total result integrated over the near and the far distance range. Therefore, IRMIN of FL and IRMAX of NL should refer to the same distance band defining the lower and upper limit for the applicability of the different atmospheric dispersion models for the far and near range, respectively (about 50 km). The integrated results of each subsystem are stored on NUNITS(46) for further processing in the evaluation program EVACOL. The combining of the NL and FL-results has to be done by the user.

If the ingestion pathway is activated in the calculations, individual results from ingestion are only assessed if NAMELIST parameter CIGCOL is set to 'L-P&C' (local production and consumption method). The integration time for individual doses from ingestion pathway is defined independently from IZINT to be 50 years; IZINT specifies the time point up to which intake of food is considered (see [2]). For CIGCOL='APROD' (agricultural production method) no individual results from ingestion can be obtained. In this case, the submodule for calculating collective ingestion doses is called by POTDOS and the results are stored on NUNITS(68) for use in COLLEC, where they are added to the collective dose from the other exposure pathways.

3.5 NAMELIST parameters

Name	Input group	NAMELIST	Subsystem	Description
Steering parameters				
ICOLDS	RESULTS	OPTION	NL,FL	calls COLDOS-part of COLLEC
IDSART	RESULTS	OPTION	NE,NL,FL	excludes countermeasures
IEVCOL	RESULTS	OPTION	NL,FL	calls evaluation program EVACOL
IEVDOS	RESULTS	OPTION	NE,NL,FL	calls evaluation program EVADOS
NOCOLL	RESULTS	OPTION	NL,FL	calls module COLLEC
NOPOTD	RESULTS	OPTION	NE,NL,FL	calls module POTDOS

NOPOTR	RESULTS	OPTION	NE	excludes calculation of risks for det. health effects

Printout parameters

IACT	PRINTOUT	OUTPAR	NE,NL,FL	selects distances for printout of results
ICCFD	PRINTOUT	OUTPAR	NE,NL,FL	prints CCFDs in the evaluation program
IDFOUT	PRINTOUT	OUTPAR	NE,NL,FL	prints dose conversion factors
LKZ	PRINTOUT	OUTPAR	NE,NL,FL	selects weather sequences for printout of results
NOODOS	PRINTOUT	OUTPAR	NE,NL,FL	prints detailed individual results
NOOPOP	PRINTOUT	OUTPAR	NL,FL	prints detailed collective results
NOOSIT	PRINTOUT	OUTPAR	NL,FL	prints detailed collective results

Model parameters

ARATIH	DOSRISK	DORPAR	NE,NL,FL	breathing rate, inhalation
ARATIR	DOSRISK	DORPAR	NE,NL,FL	breathing rate, resuspenion
CONFAK	DOSRISK	DORPAR	NE,NL,FL	factor for activity deposited on skin
IDTIME	DOSRISK	DORPAR	NE	integration time for organ doses
IEXPO	DOSRISK	DORPAR	NE,NL,FL	pathways to be considered for dose calculation
IMOR	DOSRISK	DORPAR	NE	doses to organs considered for lethal effects only
IZINT	DOSRISK	DORPAR	NL,FL	integration time for organ doses
IZP1 *	DOSRISK	DORPAR	NE	number of time points in health eff. model (morb.)
IZP2 *	DOSRISK	DORPAR	NE	number of time points in health eff. model (mort.)
KONST1 *	DOSRISK	DORPAR	NE	time points in the health effects model (morbidity)
KONST2 *	DOSRISK	DORPAR	NE	time points in the health effects model (mortality)
NEWEDE	DOSRISK	DORPAR	NE,NL,FL	choice between eff. dose equivalent and eff. dose
PSKIN	DOSRISK	DORPAR	NL,FL	fraction of the skin which is contaminated
RESE	DOSRISK	DORPAR	NE,NL,FL	parameter of resuspension model
RES0	DOSRISK	DORPAR	NE,NL,FL	parameter of resuspension model
SFLATE	DOSRISK	DORPAR	NL,FL	shielding factors for normal activity
SFPOT	DOSRISK	DORPAR	NE	shielding factors for normal activity
TBIO	DOSRISK	DORPAR	NE,NL,FL	biological half-life of skin
TSKIN	DOSRISK	DORPAR	NL,FL	time defining decontamination of people
WLAMR	DOSRISK	DORPAR	NE,NL,FL	parameter of resuspension model

Parameters marked with * are only needed, if deterministic health effects risks are selected and thus weighted protracted doses are calculated.

Evaluation program

DOYFS1	EVALUATE	EVAPAR	NE	upper value of special dose interval evaluated
DOYFS2	EVALUATE	EVAPAR	NE	upper value of special dose interval evaluated
DOYSS	EVALUATE	EVAPAR	NL,FL	upper value of special dose interval evaluated
DUYFS1	EVALUATE	EVAPAR	NE	lower value of special dose interval evaluated
DUYFS2	EVALUATE	EVAPAR	NE	lower value of special dose interval evaluated
DUYSS	EVALUATE	EVAPAR	NL,FL	lower value of special dose interval evaluated
IORGGI	EVALUATE	EVAPAR	NL,FL	combines organs to GI-tract
IORGNR	DOSRISK	DORPAR	NE,NL,FL	index of organs evaluated
MAXI	EVALUATE	EVAPAR	NE,NL,FL	index of outer radius for evaluation
NCDMIN	EVALUATE	EVAPAR	NL,FL	lower limit for evaluation interval, collective doses, the number of decades evaluated is 9
NDSMIN	EVALUATE	EVAPAR	NE,NL,FL	lower limit for evaluation interval, individual doses, the number of decades evaluated is 9
PERC	EVALUATE	EVAPAR	NE,NL,FL	percentiles to be calculated

4. Data libraries for dose calculation

The COSYMA package includes a number of data libraries which contain either the results of models which are not included in the accident consequence programs or other information required when running the programs. This section identifies the libraries in the package needed for dose calculations from each route of exposure except ingestion which is contained in a separate report [2] and summarises the sources of the information in them.

The libraries were derived from data bases provided by either GSF (cloudshine and skin contamination) or NRPB (groundshine, inhalation, ingestion). The original data bases needed some modifications before use in COSYMA. The reasons are differences between the file structures as well as the fact that some data are not needed while others are missing. The changes made to the original data are also described in this section. All descriptions refer to the current version 93/1.

4.1 Original data base and models

4.1.1 Cloudshine

The calculation of **cloudshine dose** in the dose modules of all COSYMA subsystems uses a library giving the cloud dose per second and unit air concentration. The data were prepared by GSF for adults for 826 nuclides and 22 organs assuming that the plume is semi-infinite and of uniform concentration [9]. Correction factors for plume geometry and distance from the plume-centreline, also provided by GSF [10], are included in the atmospheric dispersion / concentration module of COSYMA (subsystems NE and NL) which calculates time-integrated "effective cloud concentrations" [Bq*s/m^3] as described in [5]. In the dose modules these concentrations are multiplied by the dose rate conversion factors in the library producing the individual dose from cloudshine.

To generate a library for another age group, age-correction factors for external irradiation provided by GSF are given in Table 6.

Apart from the reorganization of the file structure, the following changes have been made to the original data:

- Data for nuclides and organs not used in COSYMA were removed.
- The original data base did not contain data for large intestine (colon), gonads, effective dose equivalent, effective dose and the type of remainder required for the calculations in COSYMA. The missing information was derived in the following way:

- **Large intestine (LI):** From the values for lower large intestine (L.L.I.) and upper large intestine (U.L.I.) the maximum was taken.
- **Gonads (GO):** The value was calculated as the arithmetic mean of the values for ovaries and testes.
- **Effective dose equivalent (EO) and effective dose (EN):** The value for EO was derived from the available data with the weighting factors due to ICRP-26 [7]; as there is not much difference in the cloudshine factors for the different organs, for the effective dose (EN) due to ICRP-60 [8] the same value was taken. The 10%-cut introduced by ICRP-30 [23] was not applied. Both the new and the old weighting factors are given in Table 3.
- **Remainder (RE):** The value was calculated as arithmetic mean over the five most significant doses from the organs adrenals, bladder, brain, kidneys, skin, spleen, small intestine, thymus and uterus (i.e. those organs not explicitely considered as single organs in the NL and FL dose module of COSYMA).

4.1.2 Groundshine

For material **deposited on the ground** the doses are calculated in COSYMA by multiplying the deposit by a precalculated dose per unit deposit integrated to appropriate time periods. The precalculated dose factors currently included in COSYMA are those derived from the NRPB data base [13]. This data base contains for adults (a person aged 20 years) the effective dose equivalent (ICRP-26) in Sv per unit deposit for 28 integration times (including $t = 100a$ and $t = 200a$, other times as mentioned in Sec 4.2) and for all nuclides considered in COSYMA. It was produced using two different models.

The values for the nuclides which make the most important contributions to deposited γ dose from typical accidental releases (Ru-103, Ru-106, I-131, Te-132, Cs-134, Cs-137 and Ba-140) were calculated using the NRPB model EXPURT [12]. This considers the amounts of material deposited on different surfaces in residential areas, the movement of material between these surfaces and into the soil column, and the dose from material deposited on the different surfaces. It is obvious that deposits on surfaces which are common in urban environments are retained and removed by weathering in a very different way than deposits to soil. The EXPURT values are for an average environment (actually a type of urban environment calculated by weighting a range of urban environments based on population density in the UK) and average UK weather conditions.

The doses for all other nuclides were calculated using a simpler model [13] which assumes that the dose in the area where people live can be represented by that over an open field, i.e. over a large undisturbed soil surface. The model evaluates the gamma flux from the top 30 cm of soil which is undisturbed but through which activity penetrates by natural processes into deeper layers of soil. The flux is converted to effective dose equivalent using ICRP-51 [24] fluence to dose conversion factors for rotational geometry. The contributions from daughter products formed after the original material is deposited are taken into account.

The dose from activity deposited on soil surfaces is calculated assuming that the material is immediately mixed within the top 1 mm of soil. This represents the "ground roughness shielding" for which a factor of 0.7 is often used.

From these data bases some nuclides not considered in COSYMA were removed. The noble gases were added with zero dose as they are assumed not to deposit. Doses in other organs are also included in the data base; they are calculated using the ratio of organ dose to effective dose equivalent according to ICRP-26, based on ICRP-51 for rotational geometry and for an energy of 500 keV, given in Table 7. The values for those organs not considered in ICRP-51 were taken from GSF [25]. For the effective dose according to ICRP-60 a ratio of 0.989 was derived from [26]. With these ratios for each of the 20 single organs including the remainder, dose conversion factors were determined for the 26 integration times required in COSYMA.

To generate a library for another age group, age-correction factors for external irradiation provided by GSF are given in Table 6.

4.1.3 Contamination of skin and clothes

Doses to the skin from a contamination of **skin and clothes** are calculated using data derived from a library provided by GSF [14]. The COSYMA data base contains values for 612 nuclides, which represent the dose rates in the affected parts of the skin averaged over a skin depth between 50 and 100 μm resulting from a unit activity deposit per unit area on bare skin [(Sv/s)/(Bq/m^2)]. Accounted for are contributions from β-emissions and electrons (Auger, conversion), and from γ-radiation, if this contributes more than 10% of the β- and electron component. Corrections for the build-up of daughter products from radioactive decay chains are made within COSYMA (see Section 3.2.3).

4.1.4 Inhalation

The COSYMA package contains libraries of values for the dose per unit intake by **inhalation** (and ingestion) which are obtained from metabolic models derived by NRPB [17]. The model includes a description of the ways in which radioactive material moves through the body after intake and the doses received by organs from material in that organ as well as material in other body organs. Other models are available for calculating the required values in these libraries [27].

The NRPB inhalation data base contains for almost all COSYMA nuclides values for 24 organs, each for 6 age groups (adults, infants aged 3 months, children aged 1 / 5 / 10 / 15 years), for each lung class (d, w, y), for 10 integration times (see Section 4.2; the last value gives the dose from the time of intake to age 70 years, and so the integration period in this

case depends on the age group considered). Dose equivalent from α-irradiation was calculated using a quality factor of 20.

Apart from the reorganization of the file structure, the following changes have been made to the original data:

- Reduction to only one lung class (the values referring to oxides are taken) and one age group (values for adults).
- The missing values integrated over 40 years were added by linear interpolation between 30 and 50 years.
- Data for the organs "others" and "remainder" and nuclides not used in COSYMA were removed.
- Data for four missing nuclides (Y-90m, Nb-95m, Sb-126, Eu-156) were taken from the GSF data base [27].
- The original data base did not contain data for large intestine (colon), gonads, effective dose equivalent and the type of remainder required for the calculations in COSYMA. The missing information was derived in the following way:
  - **Large intestine (LI):** From the values for lower large intestine (L.L.I.) and upper large intestine (U.L.I.) the maximum was taken.
  - **Gonads (GO):** The value was calculated as the arithmetic mean of the values for ovaries and testes.
  - **Effective dose equivalent (EO) and effective dose (EN):** The value for effective dose in the NRPB data base was calculated according to ICRP-60. Therefore the value for EO was derived from the available data with the weighting factors due to ICRP-26 [7]. The 10%-cut introduced by ICRP-30 [23] was not applied. Both the new and the old weighting factors are given in Table 3. For the four nuclides from the GSF data base, for both effective doses the same value was taken.
  - **Remainder (RE):** The value was calculated as arithmetic mean over the five most significant doses from the organs adrenals, bladder, brain, kidneys, skin, spleen, small intestine, thymus and uterus (i.e. those organs not explicitely considered as single organs in the NL and FL dose module of COSYMA).

4.2 Structure of the libraries

The calculation of doses from the exposure pathways considered in this report requires information about the dose per unit activity in air or on ground for a series of nuclides, organs and partly also integration times. The three libraries used for the CL-, GR- and IH/IHR-pathways included in the COSYMA package contain this information for 145 nuclides, 22 organs and up to 26 integration times. In COSYMA, however, only a subset

of these 22 organs is used for the assessment of individual doses and risks; the others are needed for the calculation of the effective dose, the remainder etc. by other programs. In the SK-library skin is the only organ considered; the values given are dose rates. The four libraries are identical for each subsystem.

The physical SI-units of the values are:

CL:	$Sv/(Bq*s)/m^3$
GR:	$Sv/(Bq/m^2)$
IH:	Sv/Bq
SK:	$(Sv/s)/(Bq/m^2)$

The structure of the CL-, GR- and IH/IHR-libraries is identical. Each is a direct access file with a record length of 104 bytes. One record contains the values for one nuclide, one organ and all integration times. To get the same record length the array of integration times is filled up with zeros, if necessary. The structure of the files in FORTRAN notation is as follows:

```
      PARAMETER(NUCALL=145)
      DIMENSION DOSIS(26)
      ISNR=0
      OPEN(UNIT=4#,ACCESS='DIRECT',RECL=104)
C     # = 1 (CL), 2 (GR) or 3 (IH/IHR)
      DO 10 K=1,NUCALL
      DO 10 IO=1,22
         ISNR=ISNR+1
         READ(4#,REC=ISNR) (DOSIS(IZ),IZ=1,26)
   10 CONTINUE
```

The record number ISNR for nuclide k and organ io is calculated according to ISNR(k,io) = (k-1) * 22 + io. The order of the nuclides is identical for the three files and given in Table 4. The order of the integration times and organs is as follows:

Integration times:

```
CL:     no integration times; only one value;
        array filled up with 25 dummy values
GR:     2h, 4h, 6h, 8h, 10h, 12h, 18h,
        1d, 2d, 3d, 5d,  7d, 14d, 30d, 90d, 182d,
        1a, 2a, 5a,10a, 20a, 30a, 40a, 50a,  70a, ∞
IH/IHR: 1d, 7d, 30d,
        1a, 5a, 10a, 20a, 30a, 40a, 50a, 70a
        (and filled up with 15 dummy values)
```

Organs:

1	breast	12	stomach
2	gonads [1]	13	small intestine
3	bone surface	14	kidney
4	lung	15	liver
5	red bone marrow	16	pancreas
6	thyroid	17	spleen
7	large intestine (colon)	18	thymus
8	skin	19	ovaries (ext) - uterus (int) [2]
9	adrenals	20	remainder
10	blad wall	21	effective dose equ. (ICRP-26) [3]
11	brain	22	effective dose (ICRP-60) [3]

[1] used for hereditary effects (subsystem NL/FL)
[2] used for deterministic effects (subsystems NE)
[3] with NAMELIST parameter NEWEDE one of both can be chosen for the calculations; default: ICRP-26; see also Section 3.1

The file with the dose rate conversion factors for skin doses due to contamination of skin and clothes has a record length of 4. The order of the nuclides is the same as in the other three files and given in Table 4. The structure is as follows:

```
      OPEN(UNIT=44,ACCESS='DIRECT',RECL=4)
      DO 30 K=1,NUCALL
         READ(44,REC=K) DOSRAT
   30 CONTINUE
```

5. The modelling of countermeasures in COSYMA

5.1 Introduction

The modelling of countermeasures in the program package COSYMA is characterized by a high degree of flexibility, which offers the user considerable freedom in specifying a wide range of both emergency actions and criteria at which these actions are imposed or withdrawn. This allows COSYMA to represent most of the emergency management strategies and intervention criteria adopted in different countries inside and outside the European Community.

Countermeasures are implemented with the aim of reducing either acute exposure during and shortly after the accident or continuing and long-term exposure due to deposited or incorporated radionuclides. Several single types of countermeasures are modelled in COSYMA, and the actions can be combined to a variable strategy. Strategy means: consecutive actions in the same area such as sheltering followed by evacuation and decontamination of persons, and interrelated actions in different areas. In addition, the efficiency of the warning system and unintended response of the population can be taken into account.

The countermeasures modelled in COSYMA against short-term exposure, incorporation or contamination during the plume passage and chronic exposure are:

- distribution of stable iodine tablets
- sheltering and evacuation
- relocation, foodbans and forced land decontamination
- forced decontamination of persons; skin decontamination is assumed to take place at a user selected time within one day

The countermeasures are not modelled in every subsystem of COSYMA as indicated in Table 1. Different combinations of the measures can be simulated in the NE and NL/FL subsystems regarding the following rules:

- "Sheltering only" modelled in subsystem NL in a geometrically defined area against late effects can be combined neither with evacuation nor with relocation.
- Land decontamination can only be applied together with relocation; however, relocation with decontamination is possible.
- Distribution of stable iodine tablets can be combined with every other action.

Both evacuation and relocation lead to the movement of people from their homes in order to avoid or reduce exposure. The main difference between these two countermeasures in COSYMA is the criterion used for their initiation. Evacuation is assumed to be implemented within one day as a measure for reducing risks of deterministic effects or/and high risks of stochastic effects. Relocation is assumed to be implemented within a few days or weeks, and

so only reduces the risks of stochastic health effects. The same criterion is used for return from both evacuation and relocation.

Each of the protective actions has a variety of features characterized by parameters with user-definable values. Thus the nature of an action - prophylactic, during the plume passage, in response to a release - and important aspects, such as initial delay, duration and efficiency, can be modelled, and sensitivity checks or uncertainty analyses can be performed. For all input parameters default values are provided. Uncertainty analyses have shown that the user is enabled to model all important features of countermeasures with an accuracy more than sufficient for the purposes of probabilistic risk assessment [28].

Some of the countermeasures can be assumed to be initiated automatically in a certain area and at a certain time. Area and time can be determined by the user independently of all features of the release and subsequent dispersion except the wind direction. Other countermeasures are defined on the basis of dose criteria.

Sheltering, automatic evacuation and evacuation based on organ doses are alternative countermeasures, which are modelled in great detail and offer the user a broad spectrum of variations. They are discussed in Section 5.2; the first part deals with the definition of the areas affected, while the second part gives a detailed description of the methods used to calculate acute doses (and deterministic health effects) allowing for the countermeasures adopted.

The actions for reducing stochastic health effects risks caused by both acute and chronic exposure included in COSYMA are sheltering (without evacuation), relocation and foodbans. Forced land decontamination is considered in COSYMA only as an action allowing for earlier resettlement of relocated areas. The logic of modelling the implementation and withdrawal of these long-term countermeasures in COSYMA is described in the first part of Section 5.3 (except foodbans which are considered in a separate report [2]). The effects of these actions on the doses received by the affected population are the subject of the second part.

5.2 *Short-term countermeasures in subsystem NE*

Evacuation is considered in COSYMA to be an action aimed at reducing short-term exposure, and is therefore considered in the NE subsystem of COSYMA only. Thus, the distance range covered by the near range subsystems has to be chosen by the user in such a manner, that fast emergency actions and deterministic health effects are not calculated outside this area. As an alternative, parallel or subsequent measure, evacuation can be initiated automatically in a geometrically defined area and/or on the basis of a dose criterion, and can be preceded by a period of sheltering. The area of automatic evacuation is denoted "area A", while the area defined by a dose criterion is denoted "area B".

Outside the evacuation areas an area with "sheltering without subsequent evacuation" can be modelled based on a dose criterion with a different intervention level; this area is denoted "area S".

The definition of areas A, B and S is such that a grid element can belong to only one of these areas or to the remaining area without any early actions, i.e. they are mutually exclusive.

The reduction of the thyroid dose caused by inhaled radioactive iodine by the intake of stable iodine tablets is also taken into account in subsystem NE. The area "IO" considered for the distribution of iodine tablets can be geometrically defined and/or based on a dose criterion; it can overlap with each of the areas A, B and S.

For the dose calculations, evacuation is assumed to be completed within one day. Afterwards no further external irradiation or intake of activity is considered in the areas A and B estimated in the subsystem NE. If the user input leads to a longer duration for evacuation, the run is terminated and a corresponding message is printed. The decision about return of evacuated people is made in subsystem NL; the same criterion is applied as for people relocated. If people are not allowed to return, the evacuated people remain relocated; otherwise people return after the shortest time period considered for relocation (default: 30 days). The modelling of return is described in detail in Section 5.3.1.4.

Figure 5 and Table 8 summarize the different areas with emergency actions giving their definitions and the actions invoked. In the following each of these areas is discussed in more detail. In Section 5.2.1 the definition of the areas, options and criteria applied and implemented in module PROTEC are described. Timing of evacuation (automatic, spontaneous, in response to a release) and sheltering as well as shielding factors implemented in module EARLY are discussed in Section 5.2.2 in the context of dose calculations including emergency actions. Section 5.2.3 summarizes those results which can be passed on to subsystem NL for further use. The principles of dose calculations already described in Chapter 3 are also valid for module EARLY including countermeasures.

5.2.1 Decision about countermeasures

5.2.1.1 Evacuation of a geometrically defined area (area A)

The area in which evacuation is implemented automatically is defined in terms of a circle and a sector, as illustrated in Figure 6. The keyhole shaped area is defined by 2 radii (inner radius r, outer radius R) and an angle α giving the width of the sector. It can be determined by the user: the NAMELIST parameters IEVA1 and IEVA2 define the index of radii r and R. WGRNZA defines the sector angle; it must be greater or equal to the width of one grid element. The program is sufficiently flexible to cope with special cases without changing the code by choosing the input data accordingly:

- limiting the area to a circle by making the radii of the circle and sector equal (r = R)
- limiting the area to a sector by setting the radius of the circle to zero (r = 0)
- no consideration of evacuation in a geometrically defined are by setting both radii to zero (r = R = 0)

The direction of the centre line of the sector is defined in relation to the wind direction at the start of the first release phase (this is the wind direction at the starting time of the weather sequences used) and is not changed during the whole release, even if the wind direction changes. Additionally, this angle can be shifted with NAMELIST parameter WSHIFT off the wind direction of the first release phase (WSHIFT > 0.0 means clockwise rotation). This option is appropriate for releases with more than one phase, when the largest part of the release is not in the first phase, or when it is known that the wind direction will change after the start of the release. As in both cases the wind directions must be explicitely known by the user, this option can only be used for deterministic calculations. The purpose of this shift in probabilistic assessments is only for uncertainty and sensitivity studies.

5.2.1.2 Evacuation based on dose criteria (area B)

The dose criteria for area B consist of two components:

- the definition of the intervention doses, and
- the dose intervention levels, which will be compared with the intervention doses.

The exposure pathways taken into account for calculating the intervention doses can be preselected for each organ (NAMELIST parameter NOEXPO). The model allows the choice of any combination of cloudshine, groundshine and inhalation doses. The periods over which the doses have to be integrated must also be specified by the user for each organ and pathway (NAMELIST parameters IZIH for inhalation giving the time up to which the committed dose is integrated and IZEB for groundshine). The doses considered as default are those to people out of doors during the whole plume passage and integration time; but by assigning a value < 1.0 to the NAMELIST parameter SFPROT, the user can specify pathway

specific shielding factors. COSYMA allows the user to define a criterion for up to four organs (any combination of red bone marrow, lung, gastrointestinal tract, thyroid) and / or effective dose, with different dose intervention levels, different pathways and different integration times. The default values are shown in Table 9. Evacuation in a grid element is assumed to take place if the dose in one of the organs exceeds the intervention level specified. All these grid elements are assigned to area B, if not already assigned to A.

COSYMA gives the user the option of increasing the dose intervention level beyond a specified down-wind distance or of limiting the evacuation area to a certain distance from the site. Following an accident, it may be unrealistic or considered undesirable to evacuate large areas, and particularly major cities, at some farther distances from the release unless the doses there are higher than the intervention level applied nearby. This enables the user to model the consequences of evacuating people outside a certain distance at higher dose intervention levels or not at all. The NAMELIST parameter IMAXB1 defines the index of the last distance band for which the lower intervention level (NAMELIST parameter DILB1) applies; beyond this radius, the intervention level specified by NAMELIST parameter DILB2 is taken. There are two possible ways to exclude this option: the user can set DILB1 = DILB2 or IMAXB1 = IMAX.

If the user does not want to model area B, the intervention levels DILB1 (and DILB2) have to be set to very high values (e.g. 1.E30). Another way of excluding area B is to set the array NOEXPO to zero; but as a consequence this leads also to an exclusion of area S. If both areas have to be excluded, this procedure should be chosen because it saves computing time.

5.2.1.3 Sheltering based on dose criteria without evacuation (area S)

The dose in the criteria for area S is defined by the same parameters as used for area B; i.e. the same intervention dose decides about area B and S. Only the dose intervention level is different (NAMELIST parameter DILSH); it cannot be set to different values at different distances.

If the user does not want to model area S, the intervention levels DILSH have to be set to very high values (e.g.1.E30). Another way of excluding area S is to set the array NOEXPO to zero; but as a consequence this leads also to an exclusion of area B. If both areas have to be excluded, this procedure should be taken because it saves computing time.

5.2.1.4 Stable iodine tablets (area IO)

Stable iodine tablets are assumed to be distributed automatically within an area defined by two different options.

- a circle with a user-specified radius (NAMELIST parameter IMAXIO)

- a criterion for the thyroid dose due to inhalation; the NAMELIST parameter IZTH defines the time up to which the committed dose is integrated; the dose intervention level is specified by NAMELIST parameter DILIOD

The distribution of stable iodine tablets is modelled to be an action in parallel to sheltering and evacuation; but it can also be implemented outside these areas.

5.2.1.5 Implementation in module PROTEC

The module PROTEC determines the extent of fast emergency actions. For each weather sequence it decides for each grid element whether it belongs either to the evacuation area A or B or to the sheltering area S or neither. This information is stored on NUNITS(26) as a flag KENNAB marking the type of countermeasures at each grid point. The flags for the different areas are as follows:

area A:	1
area B:	2
area S:	3
outside A, B, S:	0

The decision about area A is made in subroutine GEOEVA. All grid elements inside the radius r with index IEVA1 belong to area A. More complicated is the situation concerning the sector. This sector with an angle of WGRNZA is assumed to lie symmetrically to the wind direction of the first release phase (direction towards which the wind blows).[6] Thus, the azimuthal borderline of the sector does not necessarily coincidence with the calculation grid as illustrated in Figure 6. The marginal grid elements on both sides of the sector of area A lie only partly in area A. The fractions belonging to area A together with the indices of the associated grid elements are stored on NUNITS(26) for use by module AMOUNT where the number of persons and areas are determined.

For calculating individual doses the marginal grid elements must be assigned either to area A or not to area A. To that purpose, the fractions FLANT1/2 of the outermost grid elements with index JEAV1/2 belonging to area A are calculated. If 50% of their area or more belong to the evacuation area A, the whole grid element gets the corresponding flag. In the other case, it must be checked whether the grid element belongs to area B, S or lies outside the early countermeasure area.

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6 The wind direction is stored in CONCEN as variable WDIR on data file NUNITS(22). If the parameter WSHIFT is used to shift the sector of area A off the initial wind direction, the symmetric axis of the sector is defined by WDIR + WSHIFT

- FLANT1/2 $\geq$ 0.5: KENNAB(JEVA1) = 1; KENNAB(JEVA2) = 1
- FLANT1/2 < 0.5: KENNAB(JEVA1) $\neq$ 1; KENNAB(JEVA2) $\neq$ 1
  KENNAB(JEVA1) = 0/2/3; KENNAB(JEVA2) = 0/2/3

For those grid elements outside area A, the intervention dose is calculated and summed up over all release phases. If the intervention level for area B is exceeded, the corresponding flag is set to 2. If not, the dose is compared with the intervention level for area S. If it is higher KENNAB is set to 3; if not, KENNAB = 0 (no action).

In each of the three areas A, B, S a fixed sequence of actions is simulated in the early dose and risk assessments. Thus the flags control the further procedure in the module EARLY as explained in Section 5.2.2; outside these areas, doses (and risks) are calculated for groups of people at different residence places during normal activity. On request, the pattern of flags can be printed for each or for selected weather sequences (NAMELIST parameter NOOPRO).

The areas where iodine tablets are taken into account are also identified by a flag for each grid element (KENNIO = 1) and stored on the same data file.

The only task of the module PROTEC is to generate these flags as steering information for the following modules. The intervention doses needed for comparison with the intervention level are only used for the definition of areas B, S and IO; they are internal results and not endpoints, and thus not stored.

The information about early countermeasures can be transferred to subsystem NL for further use (see Sections 5.2.3 and 5.3).

5.2.1.6 Areas and number of persons affected: module AMOUNT

With the help of the flags generated in PROTEC, module AMOUNT calculates the areas and the number of persons affected in each of the areas A, B and S separately; additionally the results are given for evacuation in total ("A + B").

To get the number of people living in one of the areas A, B, S, A+B, the flag-matrix is linked to the population distribution Pers(J,I) which gives for each grid element the number of inhabitants. It is either produced by the preprogram GRIDS and read in by module INDAT, or set up in the input file, or assumed to be homogeneous with an average population density defined by the user. The number of people $Pers_X$ within area X (where X stands for area A, B, S or A+B) with flag IX (where IX stands for 1, 2, 3, 1 or 2) is calculated according to:

$$Pers_X = \sum_{I=1}^{IMAX} \sum_{\substack{J=1 \\ KENNAB(J,I)=IX}}^{JMAX} Pers(J,I) \qquad [5.1]$$

The areas affected by countermeasures are calculated in the same way by summing up the areas of all grid elements affected. When considering a site near to the coast, it may be desirable to take into account only those grid elements belonging to land (and not to the sea); this option can be chosen by setting the NAMELIST parameter ILDSEA to 1. To that purpose the user has to generate with the preprogram GRIDS (see COSYMA User Guide [3], Part VI, Preprogram GRIDS) and the land-sea-matrix included in the package a data file giving the land-sea distribution around the site under consideration in r-ϕ-coordinates. Additionally it is highly recommended that the user prepares a land-sea-matrix for the vicinity of the site up to 25 km which is also an input to GRIDS. The land-sea-matrix included in the COSYMA package gives the land-sea-distribution for almost the whole of Europe in a 5 km x 5 km resolution; using this does not give acceptable results near the site.

As the areas and number of people affected are available from module AMOUNT, the population densities in the evacuation areas for each weather sequence and each site considered can easily be obtained. They are required for assigning the corresponding driving time category in module EARLY (see Sections 5.2.2.5 and 5.2.2.10). Therefore this information is stored on NUNITS(37) for later use, together with the index of the outer radius of area B. Thus, module AMOUNT has to be run before module EARLY, even if the areas and persons affected are not of interest.

Both the results of PROTEC and AMOUNT can be used as input to the economics module ECONOM to assess the costs of early countermeasures (for details see [29]). If the user is only interested in the areas and the number of persons affected by evacuation and/or sheltering, all required results are obtained from the two modules PROTEC and AMOUNT and the corresponding evaluation program EVAAMT; there is no need to run any further module. The communication between these modules is shown in Figure 7.

As standard printout module AMOUNT gives the distance-dependent probabilities P_X for areas X:

$$P_X(I) = \sum_{L=1}^{LMAX} \sum_{\substack{J=1 \\ G_{J,I} \in X}}^{JMAX} \frac{PWET(L)}{JMAX} \qquad [5.2]$$

where

X	stands for area A, B, A+B or S
I	index of the distance, I = 1, IMAX
L	index of the weather sequence, L = 1, LMAX
J	index of the azimuthal sector, J = 1, JMAX
$G_{J,I}$	grid element with sector J and radius I
PWET(L)	probability for weather sequence L

From the table printout the outer distance up to which the areas are calculated can easily be seen. When area A is defined as a keyhole with an angle of 60°, then

$$P_A(I) = \begin{cases} 1.00 & \text{for} \quad I \leq IEVA1 \\ 0.1\overline{6} & \text{for} \quad IEVA1 < I \leq IEVA2 \\ 0.00 & \text{for} \quad IEVA2 < I \end{cases} \qquad [5.3]$$

The corresponding evaluation program EVAAMT calculates the frequency distributions of the areas A, B, A+B and S and derived quantities, such as zero probabilities, mean and median values and percentiles.

5.2.1.7 NAMELIST parameters

Name	Input group	NAMELIST	Description
Steering parameters			
IDSART	RESULTS	OPTION	selects countermeasures
IEVAMT	RESULTS	OPTION	calls evaluation program EVAAMT
NOAMNT	RESULTS	OPTION	calls module AMOUNT
NOPROT	RESULTS	OPTION	calls module PROTEC
Output parameters			
ICCFD	PRINTOUT	OUTPAR	prints CCFDs in the evaluation program
IDFOUT	PRINTOUT	OUTPAR	prints dose conversion factors
LKZ	PRINTOUT	OUTPAR	selects weather sequences for detailed results printout
NOOPRO	PRINTOUT	OUTPAR	prints detailed results
Model parameters			
ARATIH	DOSRISK	DORPAR	breathing rate, inhalation
DIGRZ *	PROTECT	PRTPAR	population density to define driving time groups
DILB1	PROTECT	PRTPAR	dose intervention level 1 for area B (lower level)
DILB2	PROTECT	PRTPAR	dose intervention level 2 for area B (upper level)
DILIOD	PROTECT	PRTPAR	dose intervention level for area IO
DILSH	PROTECT	PRTPAR	dose intervention level for area S
IDRIV *	PROTECT	PRTPAR	index of radius to choose between sets of driving time
IEVA1	PROTECT	PRTPAR	index of radius of full circle of area A
IEVA2	PROTECT	PRTPAR	index of outer radius of sector of area A
IMAXB1	PROTECT	PRTPAR	index of outer distance of area B for lower criteria
IMAXIO	PROTECT	PRTPAR	index of outer radius for area IO
IZEB	PROTECT	PRTPAR	integration time for intervention dose, GR
IZIH	PROTECT	PRTPAR	integration time for intervention dose, IH
IZTH	PROTECT	PRTPAR	integration time for intervention dose, area IO
NEWEDE	DOSRISK	DORPAR	choice between effective dose equivalent and effective dose
NFG *	PROTECT	PRTPAR	number of population density groups
NOEXPO	PROTECT	PRTPAR	organs and pathways to be considered for intervention dose
SFPROT	PROTECT	PRTPAR	shielding factors for intervention dose
WGRNZA	PROTECT	PRTPAR	angle of sector of area A
WSHIFT	PROTECT	PRTPAR	shift of sector of area A off the wind direction

Parameters marked with * are needed in module AMOUNT to determine the actual population density group(s) for assigning the corresponding set of driving times for all sites under consideration.

Evaluation program

NABMIA	EVALUATE	EVAPAR	lower limit for evaluation interval, areas; the number of decades evaluated is 6
NABMIP	EVALUATE	EVAPAR	lower limit for evaluation interval, persons; the number of decades evaluated is 6
PERC	EVALUATE	EVAPAR	percentiles to be calculated

5.2.2 Short-term doses including countermeasures

In the following the models and algorithms used in COSYMA for calculating early doses and early health risks including the effects of countermeasures are described starting with the simple model of stable iodine. The detailed modelling of countermeasures contained in subsystem NE considering sheltering, automatic evacuation and unintended reactions of the population (e.g. spontaneous evacuation, disregard or misinterpretation of alarm signals and requests of the authorities, existence of people who could not be found and warned) is explained in Sections 5.2.2.2 to 5.2.2.9. The implementation of the model in module EARLY is described in Section 5.2.2.10.

5.2.2.1 Distribution of stable iodine

The efficiency of stable iodine tablets depends on the time delay between the intake of stable iodine and the inhalation of the radioactive iodine. Both this time difference and the inhalation process itself are in general distribution functions in space and time. A simple approach is assumed to be adequate for COSYMA. The user is required to put in an average dose reduction factor which is used for all locations equally, irrespective of the assumed times of the accident (warning time etc), of the plume arrival and of any individual condition. Iodine tablets are assumed to be distributed automatically within area IO as defined in Section 5.2.1.4. leading to the specified reduction (NAMELIST parameter REDIOD) of everybody's thyroid dose due to inhalation of iodine. The dose from ingestion of radioactive iodine is assumed not to be reduced by taking iodine tablets.

The distribution of stable iodine tablets is modelled as an action parallel to sheltering and evacuation. If the user selects this measure, in all grid elements affected (i.e. KENNIO = 1 as defined in PROTEC) the contributions of iodine-isotopes to the thyroid dose due to inhalation from the plume are reduced by the user-specified factor without considering any time-dependencies. All assumptions about the behaviour of the population and timings are summarized in this reduction factor; a value of 1.0 describes the total failure of this measure and results in no dose reduction.

5.2.2.2 Sequence of events

The modelling adopted in COSYMA to allow for the effects of sheltering and evacuation when calculating the doses received is complex and allows the user a great deal of flexibility in modelling the likely actions. The sequence of events assumed is illustrated in Figure 8; it consists of three parts with different actions, different timing, and different behaviour of the population:

Areas A, B:	initial delay - sheltering - evacuation
Area S:	initial delay - sheltering - normal activity

In general, the actions are assumed to start in area A. After an initial delay (NAMELIST parameter TINA) which simulates the time period needed by the authorities to initiate the actions, people are assumed to take shelter or to evacuate spontaneously. Evacuation of sheltered people is assumed to begin after the end of the sheltering period which is TINA + TSHA hours after the accident (NAMELIST parameter TSHA defines the duration of the sheltering period). Spontaneous evacuation for the whole or only a part of the population can be modelled by setting the NAMELIST parameter NSPONT to 1; for this population group TSHA has no meaning. The dose received during the time required for evacuation is determined from the driving time for leaving the area (NAMELIST parameters TDR6 and TDR10; see Section 5.2.2.5) and the dose rate at the starting point. Evacuation of area B (see Figure 8) is generally assumed to begin after the evacuation in area A has been terminated; but by assigning a negative value to the "delay" time TDELB, an earlier start of evacuation can be modelled as well. Therefore the user can set whatever value is needed to model the timing of the emergency actions adequately. The general sequence of events in area B is assumed to be the same as that in area A; they are described in more detail in Section 5.2.2.7.

The risk of an early health effect does not increase linearly with the dose. Consequently it is not adequate to utilize an average dose for the whole group of people living in the same grid element but behaving in a different manner and thus being exposed to different doses. The approach adopted for each grid element in the NE subsystem considers a number of groups of people with different doses and thus different risks. The individual risk is calculated for each group separately. It is then averaged to yield an individual risk applying to that grid element.

COSYMA can model up to five population groups (l) with different behaviour in the sheltering period. Considering for each of these groups a set (m) of different behaviour during initial delay and another set (n) of different driving times would lead to a large amount of single values (l*m*n), what would require unacceptable disk and memory storage and computing time. Therefore not all combinations of groups can be modelled. Thus, during the first two time periods TINA/B and TSHA/B up to five groups (NAMELIST parameters NAGA/B; the fractions of these groups is defined by NAMELIST parameters PAUFA/B) can be considered with a fixed sequence of behaviour. For each of these NAGA/B groups up to three different driving times (NAMELIST parameter NFZV; the fractions of these classes are given by NAMELIST parameter PFD) can be chosen for leaving the evacuation area. If NSPONT is set to 1, the last of the NAGA/B groups is assumed to be the one which evacuates spontaneously.

This detailed modelling of fast protective actions requires the calculation of a large number of single dose values. This prevented the subdivision of EARLY into two separate modules for acute organ dose and early health risk estimation, because of the amount of storage which would have been required for passing the information between the two modules.

All shielding factors can be chosen pathway-specifically. Also the number of population groups and of driving time classes to be considered as well as the driving times can be changed by the user via NAMELIST parameters. The following descriptions all refer to the

actions in area A and the default values applied there. In Section 5.2.2.7 the differences for area B are outlined.

5.2.2.3 Initial delay period

The initial delay (NAMELIST parameter TINA) simulates the time period after the start of the accident needed by the authorities to come to a decision, to initiate countermeasures and finally to implement them. During that period people are assumed to behave according to normal living conditions and thus identical average shielding factors (NAMELIST parameter SFTINA) are applied for the population groups 2 to 5 (default value for NAMELIST parameter NAGA defining the number of different population groups considered in area A is 5).[7]

The factors used for cloud- and groundshine are derived from the distribution of values shown in Table 10 by averaging over the different population groups with corresponding probabilities and shielding factors. Those people who are outside during the subsequent sheltering period (default: population group no. 1) are assumed to be outdoors already in this initial delay period and a shielding factor SFTINA of 1.0 is assigned to them for these two external exposure pathways. As default no shielding is assumed for all groups during the initial delay period for inhalation directly from the plume and of resuspended material and for contamination of skin and clothes.

5.2.2.4 Sheltering period and shielding factors

During the sheltering period the population is assumed to be in shelters or well-shielded rooms of buildings; this period ends when evacuation starts. Five groups (NAMELIST parameter NAGA) of people with different behaviour are considered within area A. One group of people (the first group in the default case) is assumed to remain out of doors during the sheltering period because they could not be found, misunderstood alarm signals, were reluctant to shelter or whatever reason. Some people follow the instructions issued by the authorities and shelter as ordered. Sheltered persons may stay in various parts of houses differing in size, shape, design, construction material, ventilation rate etc. Thus a broad spectrum of shielding factors and a complex correlation between these shielding factors and the corresponding fraction of the population exists in reality. The method adopted in COSYMA for calculating doses during the sheltering period includes the effects of different shielding factors in different types of house. Three groups of the population (groups no. 2 to 4) are considered to shelter in different locations with different shielding factors and different fractions. The program also allows for some people to "self-evacuate" rather than to

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7 The two-dimensional array SFTINA defines the shielding factors applied during the initial delay time in area A for NAGA different population groups NA and five exposure pathways IEX

shelter (always population group no. NAGA). They are assumed to evacuate spontaneously as soon as they are told to shelter (that means they start to leave the evacuation area after the initial delay; the duration of their sheltering period equals zero). The modelling of this type of evacuation is described in the next section. If the user wants to model it, the NAMELIST parameter NSPONT must be set to 1.

The shielding factors SFTINA applied are valid for a population group during the whole sheltering period. It is not possible to model a time-dependent behaviour for this period, e.g. assuming a population group spending only 90% of the time indoors benefitting of dose reduction.

Shielding factors have to be defined for irradiation from the plume (cloudshine) and from deposited material (groundshine), for inhalation directly from the plume and of resuspended material and for contamination of skin and clothes. Since shielding factors are defined as the ratio of indoor doses to doses received outdoors in a rural area, the shielding factors for persons staying on the reference area are 1.0 by definition. Shielding due to ground roughness is taken into account implicitly in the dose factors [13]. The user can specify the fraction of the population in each shielding group (NAMELIST parameters PAUFA) and the shielding factors (NAMELIST parameters SFTSHA) for each group and exposure pathway. A classification scheme and the default values for cloudshine and groundshine exposure provided by COSYMA are given in Table 11. They are derived from detailed investigations documented in [30] and [31]. For the other exposure pathways all shielding factors are set to 1.0 as default.

This detailed treatment of the behaviour of people during the sheltering period offers the user the possibility of modelling special emergency actions simply by setting input parameters to the appropriate value. As during the run of EARLY the single values for all NAGA population groups are calculated and stored, the evaluation can be done for different countermeasure scenarios. For example, just by assigning appropriate percentages (probabilities) to certain population groups, automatic evacuation, all people sheltering or all people staying outdoors can be modelled with different runs of the evaluation program EVADOS. It is also possible to assume no actions. All parameters can be defined separately for area A and B. The complexity and flexibility of the model adopted allows the user to easily perform detailed parameter studies (e.g. see [32], [33]).

5.2.2.5 Driving time period

The end of the sheltering/outdoor period is given by the NAMELIST parameter TSHA defining the duration of this period. All persons still in the evacuation area (including those staying out of doors) are then assumed to start to evacuate together at the same time (TINA + TSHA hours after the time of accident). Exposure during evacuation is approximately taken into account in the dose calculations by assuming that the concentrations at the starting point apply during the whole driving time period. During the driving time to leave

the area an average shielding factor (NAMELIST parameter SFDRIV) for cars can be specified by the user.

The spectrum of individual driving times TDRA for leaving area A is approximated by four 3-step distribution functions; each distribution function applies for a certain range of the population density of area A. The program calculates for each weather situation and each site considered the population density of area A and then assigns the corresponding set of driving times; this set consists of three different values, each for a certain fraction of the population. The driving times, the population fractions and the density groups are determined from information specified by the user. The driving times can be chosen separately for two distance bands; up to a user chosen radius index (NAMELIST parameter IDRIV; its default value 10 refers to 5.6 km) the set TDR6 is used; beyond this the driving times are given by TDR10. The choice between the two sets of data is based on the size of the area to be evacuated. Dependent on the outermost radius of area A the corresponding set is used.

When spontaneous evacuation is modelled (NSPONT = 1), not all people within area A leave the evacuation area at the same time. Therefore, if the probability for the group evacuating spontaneously is assumed to be < 0.5, the driving times applied to this group are those of the next lower population density group.

The default values of the driving times TDR6 and TDR10 for leaving 6 and 10 km circles have been derived using an evacuation simulation model applied to the conditions on traffic networks of selected evacuation sectors at various sites in Germany [34]. The simulations showed that the driving times mainly depend on the population density; other aspects are of minor influence. Therefore in COSYMA only the population density is parameterized. Up to four (NAMELIST parameter NFG) different population density groups can be modelled; the classification scheme is defined by the NAMELIST parameter DIGRZ. The default values for the driving times and their classification is given in Table 12.

The model adopted allows a detailed description of the time needed by the population to leave the evacuation area. Sensitivity studies [16] have shown that they may only have a small impact on the overall results, and that simplified evacuation times are probably adequate for many purposes. The number of population density groups (NAMELIST parameter NFG) as well as the distribution within one group (NAMELIST parameters NFZV and PFD) can be reduced to one single representative time.

5.2.2.6 After end of evacuation

People who are evacuated, very probably will afterwards also be decontaminated. Therefore the integration time for determining the dose from material deposited on the skin ends after the user-specified time TSKIN after the end of the evacuation period. The value for TSKIN should be chosen in such a way that the forced decontamination of people is completed within a few hours after evacuation (default value for TSKIN is 6 hours). Decontamination of people cannot be excluded.

It is assumed that the evacuation is finished within one day. The exposure to external radiation contributing to early health effects risks ends when people have left the evacuation areas; no return is considered. The inhalation dose is integrated over organ-dependent periods according to the health effects model or the user-defined integration time IDTIME (dose committed up to IDTIME only).

5.2.2.7 Dose calculation in area B

Evacuation of area B is modelled in a way very similar to that of area A, but the values of the parameters may be substantially different. After an initial delay (TINB) assuming normal activity and one group staying outdoors (shielding factors SFTINB) fractions (PAUFB) of the population are sheltering, remaining outdoors or evacuating spontaneously (the number of the population groups NAGB need not be the same as in A; SFTSHB defines the shielding factors applied for these groups). The starting time of evacuation of area B is related to the end of the evacuation of area A. Thus, the duration of the sheltering period TSHB in area B is determined by the slowest driving time TDR_{max} applied in area A. Evacuation in area B starts after the evacuation in area A is completed plus an additional delay time TDELB. But by assigning a negative value to the NAMELIST parameter TDELB an earlier start of evacuation in B can be modelled. Thus, the duration of the sheltering period TSHB in area B is calculated according to

$$TSHB = TINA + TSHA + TDR_{max} + TDELB - TINB$$

If no area A is modelled (r = R = 0), TDELB defines directly the duration of the sheltering period, i.e. TSHB = TDELB.

As in area A, evacuation is characterized in area B by up to four (NFG) triplets of driving times TDR6/10, dependent on the population density of area B and the outer radius of area B. The classification scheme for the population density groups, the sets of driving times and the distance for switching between them are the same as used for leaving area A.

5.2.2.8 Dose calculation in areas with no early actions

Outside the evacuation area, further groups of the population at different locations and therefore having different shielding factors are considered in module EARLY. This detailed modelling of up to five groups (NAMELIST parameter NAGSC) is necessary in case early health effects occur beyond the evacuation or sheltering area, since the user is free in his choice of intervention criteria. Therefore, an average dose does not give an adequate description of the overall risk, and the dose in each group of people must be considered separately. The shielding factors (NAMELIST parameter SFNORM) and the fraction (NAMELIST parameter PAUFSC) of the total population in each of the groups of people considered can be set by the user; the default values are given in Table 10. By setting all

shielding factors to 1.0, the results obtained are identical with those from POTDOS using SFPOT = 1.0. As dose integration times the organ-dependent periods according to the health effects model are taken if deterministic health effects are required as an endpoint. Otherwise or additionally the user specifies the dose integration time with the NAMELIST parameter IDTIME, which can be any time between 1 day and 365 days (inhalation doses then are only committed up to time IDTIME).

5.2.2.9 Dose calculation in area S

The dose calculation in the sheltering area is a combination of the modelling in the evacuation area and the area with no early measures. The sequence of events also starts with an initial delay time TINS which is modelled as in A and B (shielding factors given by NAMELIST parameter SFTINS). The subsequent sheltering period, during which the shielding factors SFTSHS are applied, lasts at least until the plume has totally passed a grid element (end of passage of the last release phase), however not longer than one day. That means the user defined duration TSHS will be increased automatically by the code up to one day for those grid elements, for which the plume passage time is larger than TSHS. Afterwards the population is treated as in the area with no early actions. Therefore, the number of population groups and their fractions are taken to be identical in area S and in the area with no early actions; they are defined by the NAMELIST parameters NAGSC and PAUFSC.

5.2.2.10 Implementation in module EARLY

In module EARLY, both individual doses and risks including emergency actions are assessed with the help of the special subroutines ORGAN# (# = A/B/S/C), each of them belonging to one of the early countermeasure areas described above (C stands for the area with no countermeasures). Steered by the flag KENNAB calculated and stored in PROTEC, the corresponding subroutine ORGAN# is called. Figure 9 illustrates this general structure of EARLY. In the following the inner logic of the subroutines ORGAN# as shown in Figure 10 is explained.

Early emergency actions reduce the duration and the intensity of external exposure and inhalation. These reductions are different for each release phase NP, each population group NA and, in the area with evacuation, each population density group NF and driving time class NFZ. They are described by reduction factors, which are calculated in the subroutine ZONABS of ORGANA/B/S only for the density group(s) NF needed for the site(s) under consideration. The following descriptions refer to areas A and B, where the exposure is assumed to end within one day, i.e. after people are evacuated.

For each release phase, the duration of the time of exposure NTE in area A and B is determined by the arrival time TANK of the plume at the grid point (result of module CONCEN) and the end of evacuation:

$$NTE = TIN\# + TSH\# + TDR\# - TANK \qquad [5.4]$$

where # stands for A or B.[8]

Depending on the arrival time of the plume, NTE can consist of up to three different time intervals with corresponding behaviour of the population as shown in Table 13 to Table 15.[9] For groundshine and resuspension the reduction factor SF1 in the exposure time NTE is calculated according to

$$SF1(NP,NA,NFZ,NF) = \frac{1}{NTE} \sum_{t=1}^{3} T_{exp}(t) \cdot SF(t) \qquad [5.5]$$

with $T_{exp}(t)$ = duration of exposure during time interval t, t = 1,2,3.

If because of user input NTE lasts more than about one day (90000 sec), a message will be given and the program will stop.

In the case of cloudshine the duration of exposure, for inhalation the time of incorporation and for skin contamination the time of deposition are limited to one hour (duration of each release phase). That means, the reduction factors SF2 refer to a time period of one hour (instead of NTE) and the sum of the time periods T_{exp} must not exceed one hour (3600 seconds as all times are given in seconds):

$$SF2(NP,NA,NFZ,NF) = \frac{1}{3600} \sum_{t=1}^{3} T_{exp}(t) \cdot SF(t) \qquad [5.6]$$

with $\sum_{t=1}^{3} T_{exp}(t) \leq 3600$

The reduction factors calculated in ZONABS describe the effect of the early countermeasures and thus have to be transferred to the COSYMA subsystem NL. To that purpose a special set of pathway specific reduction factors averaged over the population groups and driving time classes is generated. Additionally, these data are related to one day and then stored for each release phase, each grid element of area A and B and each weather sequence on NUNITS(18).

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8 for the group evacuating spontaneously TSH# = 0

9 For example, if the plume arrives during the sheltering period (= case 2), the exposure period consists of the remaining part of the sheltering period (TIN + TSH - TANK) and the whole driving time TDR, with both time intervals having their specific shielding factors.

The calculation of acute individual doses is performed in ORGANA/B with the reduction factors SF1 and SF2. The integration time for doses to groundshine in the evacuation area ends when people have left the area. If the library does not contain the dose conversion factors integrated over NTE, the factors are obtained by linear interpolation between the neighbouring integration times. For skin contamination the integration time is defined by the exposure time NTE+TSKIN. For short lived nuclides, the corresponding dose conversion factor is derived by exponential interpolation from the 1-day dose; for long lived nuclides linear interpolation is applied. The integration time for doses from inhalation and resuspension is not influenced by evacuation; only the time and intensity of intake can be reduced. Thus these doses are calculated for all time periods prescribed by the health effects model (if NORISK = 1) and / or committed up to the time specified by IDTIME.

In area S the dose calculation until the end of the protective action is similar to that described for the evacuation area. In Eq. [5.4] TDR# is set to 0. In Eq. [5.5] and Eq. [5.6] the dependencies on the population density groups NF and on the driving time classes NFZ are removed. Additionally it is assumed that the sheltering period does not end before the passage of the plume, but it lasts not longer than one day. This means that the user input for TSHS can be changed automatically by the program up to one day to meet these assumptions.

In area S people remain after the sheltering period at their homes. Therefore the dose calculations continue after the sheltering period by assuming up to five population groups with different shielding factors for various normal activities up to the time period defined by the user (IDTIME) or by the health effects model. The procedure is the same as that implemented in the area with no action. A detailed description of the doses which are input to the dose-rate dependent health effects model implemented in COSYMA (subroutines RISKAB and RISKSC of module EARLY) is given in [6].

The individual doses are calculated in the innermost loop for each population group NA, the needed population density group(s) for the site(s) under consideration and each driving time class NFZ only for assessing the corresponding individual risk (if required). The doses for input into the dose risk relationship are single dose values referring to one population group, one density group and one driving time class. However, the individual organ doses stored on NUNITS(23) are averaged over the density groups and driving time classes, but still depend on the population group. They are the weighted protracted doses for deterministic health effects or the doses integrated over a certain time period IDTIME; they are not input to the health effects model. Statistical quantities of the individual organ dose distribution can be obtained with the evaluation program EVADOS.

5.2.2.11 NAMELIST parameters

Name	Input group	NAMELIST	Description
Steering parameters			
IDSART	RESULTS	OPTION	selects countermeasures
IEVDOS	RESULTS	OPTION	calls evaluation program EVADOS
NOAKUT	RESULTS	OPTION	calls module EARLY
NORISK	RESULTS	OPTION	excludes calculation of risks for deteministic health effects
Output parameters			
IACT	PRINTOUT	OUTPAR	selects distances for printout of results
ICCFD	PRINTOUT	OUTPAR	prints CCFDs in the evaluation program
IDFOUT	PRINTOUT	OUTPAR	prints dose conversion factors
LKZ	PRINTOUT	OUTPAR	selects weather sequences for printout of results
NOODOS	PRINTOUT	OUTPAR	prints detailed results
Model parameters			
ARATIH	DOSRISK	DORPAR	breathing rate, inhalation
ARATIR	DOSRISK	DORPAR	breathing rate, resuspension
CONFAK	DOSRISK	DORPAR	factor for activity deposited on skin
DIGRZ	PROTECT	PRTPAR	population density to define driving time groups
IDRIV	PROTECT	PRTPAR	index of radius to choose between sets of driving time
IDTIME	DOSRISK	DORPAR	integration time for individual organ doses
IEXPO	DOSRISK	DORPAR	pathways to be considered for dose calculations
IMOR	DOSRISK	DORPAR	doses to organs considered for lethal effects only
IZP1 *	DOSRISK	DORPAR	number of time points in the health effects model (morbidity)
IZP2 *	DOSRISK	DORPAR	number of time points in the health effects model (mortality)
KONST1*	DOSRISK	DORPAR	time points in the health effects model (morbidity)
KONST2*	DOSRISK	DORPAR	time points in the health effects model (mortality)
NAGA	PROTECT	PRTPAR	number of population groups in area A
NAGB	PROTECT	PRTPAR	number of population groups in area B
NAGSC	PROTECT	PRTPAR	number of population groups outside area A and B
NEWEDE	DOSRISK	DORPAR	choice between effective dose equivalent and effective dose
NFG	PROTECT	PRTPAR	number of population density groups
NFZV	PROTECT	PRTPAR	number of driving time classes within each density group
NSPONT	PROTECT	PRTPAR	spontaneous evacuation
PAUFA	PROTECT	PRTPAR	probability of population groups in area A
PAUFB	PROTECT	PRTPAR	probability of population groups in area B
PAUFSC	PROTECT	PRTPAR	probability of population groups outside areas A and B
PFD	PROTECT	PRTPAR	probabilty for driving time classes and density groups
RESE	DOSRISK	DORPAR	parameter of resuspension model
RES0	DOSRISK	DORPAR	parameter of resuspension model
SFDRIV	PROTECT	PRTPAR	shielding factors for cars
SFNORM	PROTECT	PRTPAR	shielding factors for normal activity outside areas A and B
SFTINA	PROTECT	PRTPAR	shielding factors for initial delay period in area A
SFTINB	PROTECT	PRTPAR	shielding factors for initial delay period in area B
SFTINS	PROTECT	PRTPAR	shielding factors for initial delay period in area S

SFTSHA	PROTECT	PRTPAR	shielding factors for sheltering period in area A
SFTSHB	PROTECT	PRTPAR	shielding factors for sheltering period in area B
SFTSHS	PROTECT	PRTPAR	shielding factors for sheltering period in area S
TABIOD	PROTECT	PRTPAR	dose reduction factor of stable iodine tablets
TBIO	DOSRISK	DORPAR	biological half-life of skin
TDELB	PROTECT	PRTPAR	delay time of evacuation in area B
TDR6	PROTECT	PRTPAR	set of driving times up to radius with index IDRIV
TDR10	PROTECT	PRTPAR	set of driving times outside radius with index IDRIV
TINA	PROTECT	PRTPAR	initial delay time in area A
TINB	PROTECT	PRTPAR	initial delay time in area B
TINS	PROTECT	PRTPAR	initial delay time in area S
TSHA	PROTECT	PRTPAR	duration of sheltering period in area A
TSHS	PROTECT	PRTPAR	duration of sheltering period in area S
TSKIN	PROTECT	PRTPAR	time defining decontamination of people
WLAMR	DOSRISK	DORPAR	parameter of resuspension model

Parameters marked with * are only needed, if deterministic health effects risks are selected and thus weighted protracted doses are calculated.

Evaluation program

DOYFS1	EVALUATE	EVAPAR	upper value of special dose interval evaluated
DOYFS2	EVALUATE	EVAPAR	upper value of special dose interval evaluated
DUYFS1	EVALUATE	EVAPAR	lower value of special dose interval evaluated
DUYFS2	EVALUATE	EVAPAR	lower value of special dose interval evaluated
IORGNR	DOSRISK	DORPAR	index of organs evaluated
MAXI	EVALUATE	EVAPAR	index of outer radius for evaluation
NDSMIN	EVALUATE	EVAPAR	lower limit for evaluation interval; the number of decades evaluated is 9
PERC	EVALUATE	EVAPAR	percentiles to be calculated

5.3 *Transfer of NE-results into NL*

As subsystem NL for the near range decides only about long-term countermeasures and calculates doses accumulated over time periods longer than one year, it requires information about the early phase shortly after the accident assessed in subsystem NE. The information needed concerns the extent of the evacuation area and the distribution of stable iodine tablets. Additionally, an appropriate quantity describing the dose reducing effect of evacuation has to be available. However, if the source term does not give rise to early countermeasures or deterministic health effects, the transfer of results from NE into NL can be omitted by setting NAMELIST parameter IFAST to 0. In the following the data and the files passed on to NL for dose calculation are described.[10]

- Information from NE-PROTEC: data file NUNITS(26)

  As the same criterion is applied for return from evacuation and relocation, the data file containing the flags for early countermeasures has to be transferred to NL-PROTEC. All grid elements affected by evacuation and thus marked with a flag KENNAB = 1 or 2 are considered for the return criterion, even if they are not affected by relocation. Further, the areas affected by distribution of stable iodine tablets as a result of the dose criterion applied in NE can be used in NL.
  The information about area S is not used in NL.

  Also module LATDOS needs the information about grid elements affected by evacuation to calculate the early contribution to the total long-term integrated dose. These calculations are done using a quantity determined in EARLY and described in the next item.

- Information from NE-EARLY: data file NUNITS(18)

  For each grid element of area A or B this data file contains pathway-specific effective dose reduction factors for each release phase. They refer to one day and take into account the end of external exposure after evacuation and the mitigating effect of the shielding factors applied during the sheltering period. As there are no threshold effects in NL, these factors are averaged over the shielding groups and driving time classes considered during the early phase. In Section 5.2.2.10 they are described in more detail.

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10 Additionally, for calculating risks for stochastic health effects NL needs information about the total risk for deterministic health effects (data files NUNITS(25) and NUNITS(37)) as described in [6]

5.4 Long-term countermeasures in subsystems NL and FL

Relocation, decontamination and foodbans are considered in COSYMA to be actions aimed at reducing long-term exposure and are therefore implemented in the NL and FL subsystems of COSYMA only. Decontamination can only be applied in combination with relocation. It is an action to allow for earlier return of people. Additionally, a single countermeasure "sheltering only" can be modelled in subsystem NL. An option allowing for distribution of stable iodine tablets is contained in both subsystems. The criteria for initiating these actions are summarized in Table 16; Table 17 gives the corresponding criteria for their withdrawal. In this section each of these countermeasures is discussed in more detail. In Section 5.3.1 the definition of areas, options and criteria applied and implemented in PROTEC are described. The logic of the dose calculation including countermeasures implemented in module LATDOS is explained in Section 5.3.2.

5.4.1 Decision about countermeasures

5.4.1.1 Stable iodine tablets

The distribution of stable iodine tablets is considered as a means of reducing both early and late health effects and is therefore also modelled in subsystems NL and FL. However, the tablets are here assumed to be distributed automatically only within a circle with a radius specified by the user as described in Section 5.2.1.4. Additionally, subsystem NL offers the possibility to consider stable iodine also in those grid elements which have been assigned to area IO on dose criterion by subsystem NE.

5.4.1.2 Sheltering only

Automatic sheltering as the only countermeasure (i.e. without subsequent evacuation or relocation) is intended for a small release of long duration or for a noble gas release; it cannot be combined with any other countermeasure (except foodbans and stable iodine tablets) as already mentioned in Section 5.1. It can only be initiated automatically in a circle with a radius defined by the user (NAMELIST parameter IMAXSH) and is considered in the NL subsystem of COSYMA only. Sheltering may reduce the external doses from both deposited material and the cloud and internal doses from inhalation of material directly from the plume and following resuspension. It may also reduce the amount of material deposited on skin and clothes. The sets of reduction factors can be specified by the user, with a maximum value of 1.0 corresponding to no reduction in doses during sheltering. The duration of sheltering is also a free parameter.

5.4.1.3 Implementation of relocation

Relocation is considered in COSYMA to be an action aimed at reducing long-term exposure, and is therefore considered in the NL and FL subsystems, but not in the NE subsystem. It is initiated only on a criterion based on the effective dose. Relocation cannot be combined with an earlier period of sheltering in COSYMA. The area affected by relocation is denoted "area C".

The doses considered in the criterion are any combination of the external dose from the cloud or from deposited material, and the internal dose from inhalation of material in the cloud or of resuspended material (NAMELIST parameter NOEXPO). The user can specify the period (NAMELIST parameter INTREL) over which the doses and the intakes from resuspension are integrated. This period can be any time up to 1 year, and could be sufficiently short that the criterion becomes effectively one of dose rate. In the case of inhalation the doses are not the committed doses, but the doses which accumulate within this time period. If the periods specified are not ones for which doses are contained in the data file, then the doses are obtained by interpolation.

As the user can choose any intervention levels, the criterion for relocation may be stronger than those for foodbans leading to the situation that an area is interdicted for people but not for agricultural production. To avoid this unrealistic combination the ban module of the ingestion model checks the different flags against each other and guarantees that in relocated areas foodbans are implemented with at least the same duration.

For calculating the intervention dose, the initial concentrations are used; that means the integration time of one year does not begin at the time of accident but starts with the arrival time of the plume. Thus, it is not possible to model an intervention dose defined as dose saved in the first 365 days after relocation (i.e. dose in the time period ITUMS days to 365 + ITUMS days, where ITUMS defines the time point after accident at which people are relocated).

The present default value of the dose intervention level for relocation in COSYMA (NAMELIST parameter DILREL) is oriented at the recommendations of ICRP-40 [35]: As dose intervention level the lower reference level of 50 mSv effective dose equivalent in the first year after the accident is taken; as contributing exposure pathway only groundshine is considered without applying a shielding factor.

COSYMA gives the user the option of increasing the dose intervention level considered in the criterion at two selected down-wind distances. Following an accident, it may however be unrealistic to relocate large areas, and particularly major cities, at some distance from the site unless the doses there are larger than those considered in relocating smaller areas. This enables the user to model this type of decision, similar to that done for evacuation. The NAMELIST parameters IMAXC1 and IMAXC2 define the index of the distances for switching to another intervention level (DILREL(2) and DILREL(3)). There are two possible ways to exclude this option: the user can set DILREL(1) = DILREL(2) = DILREL(3) or IMAXC1 = IMAXC2 = IMAX.

If the user does not want to model area C, the array NOEXPO should be set to zero (except index 4 referring to foodbans); then the dose to be compared with the relocation criterion is always zero.

5.4.1.4 Return from evacuation or relocation and decontamination

The same criterion is used for returning from evacuation and relocation (resettlement). Therefore the information about evacuation from NE-PROTEC has to be transferred to the near late subsystem NL (as there is no evacuation in the far range, this is not required for FL). A distinction between areas A/B and C is no longer made. The results for "areas and persons affected by relocation" will always include those grid elements which have been evacuated. By setting the NAMELIST parameter IFAST to 0, this effect will be excluded; that means area C consists only of those grid elements defined by the relocation criterion. But as a consequence of this option, in the late dose and risk calculation the reduction effects in the early phase due to evacuation will not be taken into account (for details see Section 5.3.2)

Return from evacuation or relocation and decontamination are considered together in COSYMA. Decontamination is always assumed to be completed before people return unimportant when it exactly occurs and how long it lasts. It is considered as a measure to allow for earlier return to relocated areas rather than avoiding movement of people. The areas affected by decontamination are denoted "area D". By definition: area D $\subseteq$ area C. Setting the decontamination factor to 1.0 will exclude this measure.

Return is assumed once the effective dose in any subsequent year falls below a level which is specified by the user (NAMELIST parameter DILRES). The dose considered in this criterion can be any combination of the external dose from deposited material and the internal dose from inhalation of the cloud and of resuspended material. The inhalation dose is not the committed dose but the differential dose value within the corresponding year.

Return is only considered at a discrete series of times (up to 15 time points with a maximum of 70 years after the accident) selected by the user (NAMELIST parameter NNT defining the number of time periods considered and NAMELIST array NT giving the time periods), with the possibility of returning in each time period checked in order of increasing time. The program first checks whether people could return at the end of a period because natural processes have reduced the doses to below the level specified in the criterion for resettlement (NAMELIST parameter DILRES). If this has occurred then return is assumed and decontamination is not considered. If return is not possible at the end of a period, then the effects of decontamination are considered. The program checks whether decontamination with a time-specific maximal factor (NAMELIST array DFMAX) can reduce the doses to values below the intervention level for resettlement. If that is the case, it is assumed that decontamination is performed and completed at the end of the time period and thus, allowing return of people afterwards. Thus, not all areas from which people have been evacuated or relocated will be decontaminated. Decontamination is assumed to be carried out if it allows

people to return during a time period when they would not be able to do so without the decontamination occurring. It is always assumed that the area is decontaminated with the factor DFMAX, even if a lower value would be sufficient to get a dose below DILRES. The user can specify decontamination factors which may be different for each time period considered. A factor of 1.0 for all time periods results in an area D of zero.

For the individual dose (and risk) calculation it is assumed that people return to the same location where they lived before. If after the last time period considered (given by NT(NNT), default 70 years) no resettlement is possible, these areas are assumed to be banned forever.

The default values currently used are given in Table 18: for relocation-periods within the first year after the accident no decontamination is assumed to take place before resettlement (DFMAX = 1.0); for all other time periods a maximal decontamination factor of 3.0 is assumed; the dose intervention level for resettlement is taken to be 25 mSv.

Even if the user has assumed to exclude area C by setting NOEXPO to zero, for those grid elements belonging to the evacuation areas A or B (provided that IFAST $\neq$ 0), the resettlement dose D_{res} is calculated; as it is zero, all evacuated grid elements will be resettled after NT(1) days.

5.4.1.5 Implementation in module PROTEC

The module PROTEC determines the extent and duration of long-term countermeasures by assigning four flags to each grid element as follows:

sheltering only (NL):	KENNSH	(1 = yes, 0 = no)
stable iodine tablets:	KENNIO	(1 = yes, 0 = no)
relocation:	KENNC	(0 = no, $\neq$0 = yes)
decontamination:	KENND	(0 = no, $\neq$0 = yes)

All flags are stored for each weather sequence on the same data file, together with the flags KENNNIG characterizing foodbans (NUNITS(19)).

If the user selects "sheltering only" all grid elements up to radius IMAXSH are marked with KENNSH = 1; this forces KENNC and KENND to be 0. KENNIO can be chosen in addition to each other action.

In the following it is assumed that KENNSH = 0 for all grid elements and thus relocation and decontamination can be implemented. PROTEC decides for each weather sequence and for each grid element, whether it belongs to the relocation area C or not. This information is stored as a flag KENNC marking the duration of relocation (= number of years after which people are assumed to return) as a time index. If resettlement was preceded by decontamination, the flag KENND denotes the year (as an index) in which decontamination measures are completed. Both flags control the procedure of dose calculation in LATDOS (and of risk assessments in LATRSK) as explained in Section 5.3.2.

The logic of relocation and resettlement as modelled in PROTEC is shown in Figure 11; all time periods have to be specified in days. The following procedure is executed for each weather sequence and each grid element:

1. At first the decision about implementing relocation must be made. For this purpose the effective dose D_{rel} integrated over INTREL days considering the pathways specified by NOEXPO and the shielding factors SFPROT is calculated. If $D_{rel} <$ DILREL, two different cases have to be considered:

   - If the grid element was not affected by evacuation (i.e. KENNAB = 0 or KENNAB = 3), then no decision about resettlement has to be made and KENNC = 0 = KENND. The calculations continue at item 1. with the next grid element.
   - But if people have already left the area due to evacuation, the procedure of resettlement must be applied for this grid element; the calculations continue with item 2.

2. Beginning with the first time period NT(1) the yearly effective dose D_{res} received in the time period NT(1) + 365 is calculated applying shielding factors SFPROT. If D_{res} is below DILRES, people will return after NT(1) days; the corresponding flags are KENNC = 1 and KENND = 0.

3. If $D_{res} \geq$ DILRES, the dose with preceding decontamination $D_{dec} = D_{res}/DFMAX(1)$ is compared with DILRES. If $D_{dec} \leq$ DILRES, people will return after NT(1) days and after decontamination was performed (because this is unrealistic for time periods NT < 365 days, the decontamination factor DFMAX should be set to 1.0 for these periods); the flags are set to KENNC = 1 and KENND = 1.

4. If even $D_{dec} \geq$ DILRES, the next time-period NT(2) is checked in a similar way. For those time periods n with NT(n) $\geq$ 365, the yearly dose D_{res} is the dose received during the year NT(n)-365. This explains, why there are often no areas which will be resettled after one year (in this case the relocation dose is identical with the resettlement dose; the decontamination factor is too low to reduce the dose significantly).

5. This loop terminates once the yearly dose D_{res} or D_{dec} falls below DILRES; the flags are KENNC = n and KENND = 0 (or n).

6. If for each time period the yearly doses D_{res} and D_{dec} are above DILRES no resettlement takes place; KENNC = NNT and KENND = 0.

Thus, the value of KENND can only be 0 or identical with KENNC; a combination of KENNC = NNT (= index of the last relocation time considered) and KENND = 0 refers to a grid element which is not resettled.

Each combination of flags KENNAB (only valid for NL), KENNC and KENND is connected to a fixed sequence of events to be considered in late dose and risk assessments. Thus the flags control the further procedure in the modules LATDOS and LATRSK as explained

in Section 5.3.2; outside these areas doses (and risks) are calculated assuming normal activity. On request, the pattern of flags can be printed for each or selected weather sequences (NAMELIST parameter NOOPRO).

The standard printout of module PROTEC (for printout see also Chapter 6) gives some distance-dependent statistics about the flags KENNC and KENND. During one run, for each radius JMAX grid elements are considered for LMAX weather sequences which results in a total of JMAX * LMAX cases for each distance. Each case is associated with a specific value for KENNC and KENND. In the table printed the frequency for each possible value is listed. Further, the mean (averaged over sectors and weather sequences) and maximum value of the intervention dose are given for each radius, together with a breakdown by the pathways considered in the criteria.

5.4.1.6 Areas and number of persons affected: Module AMOUNT

With the help of the flags generated in PROTEC, module AMOUNT calculates the areas and number of persons affected by relocation and decontamination, for each time period separately and in total.

To get the number of people living in area X integrated over all grid elements, the flag-matrix is connected with the population distribution giving for each grid element the number of inhabitants. It is either derived by the preprogram GRIDS and read in by module INDAT via NUNITS(31) or set up in the input file or assumed to be homogeneous.

Number of people relocated for exactly NT(n) days:

$$\mathrm{Pers}_X(n) = \sum_{I=1}^{IMAX} \sum_{\substack{J=1 \\ KENNX(J,I)=n}}^{JMAX} \mathrm{Pers}(J,I) \qquad [5.7]$$

Number of people initially relocated independent of the duration:

$$\mathrm{Pers}_X = \sum_{n=1}^{NNT} \mathrm{Pers}_X(n) \qquad [5.8]$$

where

X	stands for "area C" or "area D"
n	index of the relocation period, n = 1, NNT; after NT(n) days the area will be resettled
I	index of the distance, I = 1, IMAX
J	index of the azimuthal sector, J = 1, JMAX

The areas affected are calculated in the same way. When considering a site near to the coast, it may be desirable to take into account only those grid elements belonging to land (and not

to the sea). This option can be chosen by the NAMELIST parameter ILDSEA (see Section 5.2.1.6 and COSYMA User Guide [3], Part VI, Preprogram GRIDS).

Module AMOUNT produces two different kinds of standard printout (see also Chapter 6). The first one contains the distance-dependent probabilities for areas C and D (additionally for the areas affected by foodstuff-specific bans, which are determined in the same way); these results are presented as a function of time (differential values). In addition, the integral value over all time periods (initial probability) is printed in the first column. These probabilities are calculated according to:

$$P_X(I,n) = \sum_{L=1}^{LMAX} \sum_{\substack{J=1 \\ KENNX(J,I)=n}}^{JMAX} \frac{PWET(L)}{JMAX} \qquad [5.9]$$

where

X	stands for "area C" or "area D"
I	index of the distance, I = 1, IMAX
n	index of the relocation period, n = 1, NNT; after NT(n) days the area will be resettled
L	index of the weather sequence, L = 1, LMAX
J	index of the azimuthal sector, J = 1, JMAX
$P_X(I,n)$	probability for area X in distance I
PWET(L)	probability for weather sequence L

From this printout it can easily be seen up to which distance the different areas extend. The second printout gives some mean values averaged over all weather sequences.

Both, the results of PROTEC and AMOUNT can be specified as input to the economics module ECONOM. The user obtains all results about the extent and duration of long-term countermeasures by only running module PROTEC. If these endpoints are the subject of his investigations, he can stop the calculations at this early stage. The communication between these modules is shown in Figure 7.

5.4.1.7 NAMELIST parameters

Name	Input group	NAMELIST	Description
Steering parameters			
IDSART	RESULTS	OPTION	selects countermeasures
IEVAMT	RESULTS	OPTION	calls evaluation program EVAAMT
NOAMNT	RESULTS	OPTION	calls module AMOUNT
NOPROT	RESULTS	OPTION	calls module PROTEC
Output parameters			
ICCFD	PRINTOUT	OUTPAR	prints CCFDs in the evaluation program
IDFOUT	PRINTOUT	OUTPAR	prints dose conversion factors
LKZ	PRINTOUT	OUTPAR	selects weather sequences for detailed results printout
NOOPRO	PRINTOUT	OUTPAR	prints detailed results
Model parameters			
ARATIH	DOSRISK	DORPAR	breathing rate, inhalation
ARATIR	DOSRISK	DORPAR	breathing rate, resuspenion
DFMAX	PROTECT	PRTPAR	decontamination factors
DILREL	PROTECT	PRTPAR	dose intervention level, relocation
DILRES	PROTECT	PRTPAR	dose intervention level, resettlement
IFAST	PROTECT	PRTPAR	consideration of evacuation (NL only)
IMAXC1	PROTECT	PRTPAR	index of radius to define 2nd criteria for relocation
IMAXC2	PROTECT	PRTPAR	index of radius to define 3rd criteria for relocation
IMAXIO	PROTECT	PRTPAR	index of outer radius for area IO
IMAXSH	PROTECT	PRTPAR	index of outer radius for sheltering only (NL only)
INTREL	PROTECT	PRTPAR	integration time for intervention dose for relocation
NEWEDE	DOSRISK	DORPAR	choice between effective dose equivalent and effective dose
NNT	PROTECT	PRTPAR	number of time points considered for resettlement
NOEXPO	PROTECT	PRTPAR	pathways to be considered for intervention dose
NT	PROTECT	PRTPAR	time points considered for resettlement
SFPROT	PROTECT	PRTPAR	shielding factors for intervention dose
Evaluation program			
NABMIA	EVALUATE	EVAPAR	lower limit for evaluation interval, areas (areas C and D); the number of decades evaluated is 9
NABMIG	EVALUATE	EVAPAR	lower limit for evaluation interval, foodban areas; the number of decades evaluated is 7
NABMIP	EVALUATE	EVAPAR	lower limit for evaluation interval, persons (area C and D); the number of decades evaluated is 9
NABMIQ	EVALUATE	EVAPAR	lower limit for evaluation interval, amount of production; the number of decades evaluated is 10
PERC	EVALUATE	EVAPAR	percentiles to be calculated

5.4.2 Lifetime doses including countermeasures

For each grid element the flags determined in PROTEC define the countermeasure scenario adopted with its corresponding timings. The possible countermeasure combinations which have to be considered are shown in Table 19 and Figure 12. The following sections describe the logic of dose calculations in the different time periods of relocation and decontamination.

The modelling of the distribution of stable iodine tablets and their dose mitigating effects in the subsystems NL and FL is identical to that of subsystem NE; the reader is therefore referred to Section 5.2.2.1.

5.4.2.1 Allowance for sheltering only

All grid elements belonging to the area with sheltering as the only countermeasure are identified in PROTEC and are marked with a flag KENNSH = 1. If this action is implemented (only possible in subsystem NL), the countermeasures evacuation, relocation and decontamination are excluded. The area considered here is not related to the "area S" as defined in subsystem NE; it is defined independently in NL-PROTEC as a full circle with outer radius IMAXSH. Inside this area COSYMA allows for reduction factors (NAMELIST parameter SFSH) for doses received during the sheltering period when people are indoors. Different factors are used for the external doses from the cloud or from deposited material. Reduction factors are also included for calculating the doses from inhalation of material directly from the plume or of resuspended material. In the calculation of the amount of material deposited on the skin it is also considered whether people are indoors or outdoors at the time of the deposition.

The duration of the sheltering period is defined by the NAMELIST parameter ITSH as a multiple of one day. It is assumed that for each grid element the sheltering period begins with the arrival time of the plume. Thus people are indoors during the whole passage of the plume. The doses due to cloudshine, the intake of material and the deposition on skin are reduced by the shielding factors; the integration time for inhalation doses is IZINT years, for skin dose TSKIN days (both are NAMELIST parameters). For groundshine and resuspension there is a reduction of dose during the first ITSH days; afterwards doses are calculated up to IZINT years assuming normal activity (average shielding factors are defined by NAMELIST parameter SFLATE).

5.4.2.2 Dose received before relocation

COSYMA does not consider relocation in combination with sheltering. Therefore the doses received before relocation are calculated assuming normal activity, with people spending parts of their time indoors and parts outdoors; average shielding factors are used for all exposure pathways (NAMELIST parameter SFLATE).

COSYMA assumes that all people to be relocated will leave the area at the same time. There are two possible ways of specifying this time. The first option is simply to specify the time directly by user input (NAMELIST parameter ITUMS, a multiple of one day). The second is to use a time derived from the area to be located C_{area} and a user-specified relocation rate (NAMELIST parameter AUMS) expressed in area relocated per day; in this case the time ITUMS needed to relocate the whole area C is calculated according to

$$\text{ITUMS} = \frac{C_{area}}{\text{AUMS}}$$

The time period ITUMS starts after the passage of the plume and not with the time of accident. Therefore, whatever value is assigned to ITUMS, people are assumed to be still at their home during the passage of the plume. Thus, doses due to cloudshine and inhalation can neither be avoided nor reduced by relocation. The inhalation doses are integrated over IZINT years. Also the period with deposition on skin lasts over the whole plume passage; TSKIN days after the accident people are assumed to be decontaminated and the dose accumulation ends. The doses due to groundshine are calculated using the initial ground concentrations and the dose conversion factors integrated over ITUMS. After ITUMS days all people are assumed to have left area C; the exposure is interrupted up to the time of return or completely interrupted (no return allowed).

The NL-subsystem offers the possibility of including the dose reducing effects of evacuation (steered by NAMELIST parameter IFAST) in assessing lifetime doses and late health effects. If the user selects this option (IFAST = 1), average reduction factors related to one day and determined in the NE-module EARLY are transferred for use in NL via NUNITS(18). As evacuation is assumed to be finished within one day, the dose received during the first day after the accident is calculated using these factors. In this case it is assumed that people evacuated will not return but remain away from their home and are then treated as relocatees. It is assumed that people do not receive any further dose during the period while they are relocated.

5.4.2.3 Dose received after return from evacuation or relocation

The method of determining when people can return from evacuation and/or relocation was described in Sections 5.3.1.4 and 5.3.1.5. The information about the time point of resettlement and the carrying out of decontamination measures is given by flags KENNC and KENND created in PROTEC. The doses and risks received after return are calculated assuming normal activity with average shielding factors specified by the user for all exposure pathways (NAMELIST parameter SFLATE). When decontamination is assumed to be carried out in a grid element, all doses/risks from deposited activity are calculated dividing the dose/risk which would be received in the absence of decontamination by the maximum decontamination factor appropriate for the time period during which the decontamination was assumed to be completed (even if a lower decontamination factor would have been sufficient to allow people to return).

In the dose and risk calculation, it is assumed, that people forced to move out of a certain grid element return after resettlement to their original living places. This approach may not be valid in the case of a real emergency, because for various reasons people may not wish to return to their homes after a lengthy period of relocation and/or other population groups resettle the interdicted areas.

After resettlement the process of exposure continues; the dose contributions are only caused by the groundshine and resuspension pathways. The ingestion pathway is considered separately; if the "individual dose approach" (L-P&C) is used, ingestion doses will be added after the withdrawal of foodbans to get the overall individual dose. The groundshine doses and intake by resuspension are considered up to IZINT years; the resuspension doses are integrated over IZINT years.

5.4.2.4 Implementation in module LATDOS

In the dose and risk calculation (see Figure 13) generally six exposure pathways are taken into account. If relocation or evacuation takes place, it is assumed that before leaving the area and during the interdiction period people do not consume foodstuffs produced there. In the dose calculations two time periods of exposure have to be considered: the early phase before leaving the area and the late phase after resettlement.

The early exposure by groundshine and resuspension is assumed to be terminated when people are out of the interdicted area (time points TEVA in the case of evacuation and ITUMS for relocation, respectively). In the case of evacuation people may leave the area before or during the passage of the plume. In this case, which can only occur in the near range and thus is only modelled in subsystem NL, the actual duration of inhalation and external exposure is taken into account by using effective reduction factors determined in NE. According to the corresponding flags module LATDOS (and LATRSK) calculates the dose due to this early exposure, which ends after TEVA ($\leq$ 1) or ITUMS days. This dose includes the total dose received by cloudshine and by inhalation (integrated over IZINT years). The dose conversion factors used for groundshine are integrated over 1 and ITUMS days, respectively; if the exact values are not contained in the library, they are linearly interpolated. The shielding factors used for calculating this early dose are results of NE (unit 18) and mean factors SFLATE for normal activity, respectively; they are all specified for each pathway. After TSKIN days people are assumed to be decontaminated; this stops the dose accumulation due to skin contamination.

No dose calculation is carried out, if resettlement is not possible before the time IZINT years; this case is identified by NT(KENNC) = IZINT*365. In all other cases the second period of exposure must be considered with dose contributions from groundshine and

resuspension only.[11] In the case of relocation it is assumed that people return to their original living places and radiation exposure continues according to the activity concentration at the corresponding grid point. If resettlement is preceded by decontamination, the ground contamination is assumed to be reduced by the maximum decontamination factor DFMAX. The material resuspended until time point IZINT is determined with the function RESUS (see Section 3.3.2); the integration time is IZINT years.

The dose due to deposited material after resettlement (i.e. from time point given by flag KENNC up to IZINT) is calculated according to

$$D_{KENNC}^{IZINT} = (D_0^{IZINT} - D_0^{KENNC}) \cdot \frac{1}{DFM}$$

where DFM denotes the decontamination factor (= DFMAX $\geq$ 1.0).

In the case of "sheltering only" the early period is defined up to the end of the sheltering period (time point ITSH) with an average shielding factor SFSH. Afterwards the exposure continues without interrruption. Dose contributions only result from groundshine and resuspension with an average shielding factor SFLATE for normal activity up to time point IZINT.

In grid elements with no action a potential dose is determined assuming normal behaviour (SFLATE) which is identical to the dose calculated in POTDOS.

Individual doses are assessed for adults only; they are integrated over a user-specified period (NAMELIST parameter IZINT) up to 70 years with due consideration of the countermeasures described above. However, when estimating individual risks of stochastic health effects the age distribution of the affected population is taken into account (modules POTRSK and LATRSK) [6].

5.4.2.5 NAMELIST parameters

Name	Input group	NAMELIST	Description
Steering parameters			
ICOLDS	RESULTS	OPTION	calls COLDOS-part of COLLEC
IDSART	RESULTS	OPTION	selects countermeasures
IEVCOL	RESULTS	OPTION	calls evaluation program EVACOL
IEVDOS	RESULTS	OPTION	calls evaluation program EVADOS
NOCOLL	RESULTS	OPTION	calls module COLLEC
NOLATD	RESULTS	OPTION	calls module LATDOS

[11] In the resettled area foodbans are withdrawn if the corresponding criteria are fulfilled; the integration time for the IG dose conversion factors is 50 years and cannot be changed; for details see [2].

Output parameters

IACT	PRINTOUT	OUTPAR	selects distances for printout of results
ICCFD	PRINTOUT	OUTPAR	prints CCFDs in the evaluation program
IDFOUT	PRINTOUT	OUTPAR	prints dose conversion factors
LKZ	PRINTOUT	OUTPAR	selects weather sequences for printout of results
NOODOS	PRINTOUT	OUTPAR	prints detailed individual results
NOOPOP	PRINTOUT	OUTPAR	prints detailed collective results
NOOSIT	PRINTOUT	OUTPAR	prints detailed collective results

Model parameters

ARATIH	DOSRISK	DORPAR	breathing rate, inhalation
ARATIR	DOSRISK	DORPAR	breathing rate, resuspenion
AUMS	PROTECT	PRTPAR	relocation rate (area relocated per day)
CONFAK	DOSRISK	DORPAR	factor for activity deposited on skin
DFMAX	PROTECT	PRTPAR	decontamination factors
IEXPO	DOSRISK	DORPAR	pathways to be considered for dose calculation
IFAST	PROTECT	PRTPAR	consideration of evacuation (NL only)
ITSH	PROTECT	PRTPAR	duration of sheltering only period (NL only)
ITUMS	PROTECT	PRTPAR	time needed to relocate all people affected
IZINT	DOSRISK	DORPAR	integration time for organ doses (all pathways except IG)
NEWEDE	DOSRISK	DORPAR	choice between effective dose equivalent and effective dose
NNT	PROTECT	PRTPAR	number of time points considered for resettlement
NT	PROTECT	PRTPAR	time points considered for resettlement
PSKIN	DOSRISK	DORPAR	fraction of the skin which is contaminated
RESE	DOSRISK	DORPAR	parameter of resuspension model
RES0	DOSRISK	DORPAR	parameter of resuspension model
SFLATE	DOSRISK	DORPAR	shielding factors for normal activity
SFSH	PROTECT	PRTPAR	shielding factors for sheltering only (NL only)
TABIOD	PROTECT	PRTPAR	dose reduction factor of stable iodine tablets
TBIO	DOSRISK	DORPAR	biological half-life of skin
TSKIN	DOSRISK	DORPAR	time defining decontamination of people
WLAMR	DOSRISK	DORPAR	parameter of resuspension model

Evaluation program

DOYSS	EVALUATE	EVAPAR	upper value of special dose interval evaluated
DUYSS	EVALUATE	EVAPAR	lower value of special dose interval evaluated
IORGGI	EVALUATE	EVAPAR	combines organs to GI-tract
IORGNR	DOSRISK	DORPAR	index of organs evaluated
MAXI	EVALUATE	EVAPAR	index of outer radius for evaluation
NCDMIN	EVALUATE	EVAPAR	lower limit for evaluation interval, collective doses the number of decades evaluated is 9
NDSMIN	EVALUATE	EVAPAR	lower limit for evaluation interval, individual doses the number of decades evaluated is 9
PERC	EVALUATE	EVAPAR	percentiles to be calculated

6. Output description

6.1 Dose part

This section describes all printout available from the dose modules (POTDOS and EARLY of subsystem NE; POTDOS, LATDOS and COLLEC-COLDOS of subsystems NL and FL) and the corresponding evaluation programs. Examples of the printout are contained in Chapter 9. Some of the tables are self-explanatory and need no further discussion here.

6.1.1 Subsystem NE

Table 22 and **Table 23:** Modules POTDOS / EARLY: Printout of dose conversion factors
This printout is obtained only if IDFOUT $\neq$ 0. It gives for each nuclide and each organ/effect considered (i.e. IORGNR $\neq$ 0) the dose conversion factors for the exposure pathways taken into account (i.e. IEXPO $\neq$ 0). For groundshine (GR) and inhalation (IH) the integration time is defined by IDTIME if individual doses are assessed as an endpoint (upper part of the tables). If individual health effects risks are calculated the dose conversion factors are differential values (i.e. not integrated from 0) and refer to the time periods of the health effects model (lower part of the tables; when countermeasures are considered only the values for the first time period are printed for GR). For contamination of skin and clothes 'SK-P' contains the contribution coming from the parent of the nuclide.

When counteremeasures are taken into account additional printout is given for groundshine and integration times up to one day; the values are integrated starting from 0 (middle part of Table 23).

Table 24: Modules POTDOS and EARLY: Printout of results of point values
This printout is obtained only if NOODOS $\neq$ 0. A value of 1 gives the information for all weather sequences calculated, a value of 2 only for those up to 20 weather sequences specified by LKZ. The distances are selected by IACT. Starting with azimuthal sector J = 1 (sector due North) the point results for all JMAX sectors are given (the sectors count clockwise). The individual doses printed here are either integrated over IDTIME or they are the weighted protracted doses for deterministic health effects. If countermeasures are taken into account this information is printed only for the first shielding group (NA = 1). Another shielding group can be selected by changing the value of NAGOUT in the DATA-statement.

Table 25 and **Table 26:** Modules POTDOS and EARLY: Breakdown of mean individual doses by exposure pathways and for each pathway by nuclides
This information is printed for all distances selected by IACT. The necessary calculations are done in subroutine TABWT. The individual doses are averaged over all weather sequences and all azimuthal sectors. Additionally, when considering countermeasures the

results are also averaged over the shielding groups NA and the driving time classes NFZ and - if more than one site is considered - also over the population density groups NF of driving times. The individual doses are either integrated over IDTIME or they are a quantity related to the doses for deterministic health effects risks. Nuclides with a contribution of < 0.005% for all organs are skipped.

Table 27 and **Table 28:** Modules POTDOS and EARLY: Distance-dependent mean individual doses

This information cannot be suppressed. It gives for each distance the mean individual dose for all organs/effects. The results are averaged over all weather sequences and azimuthal sectors. When taking countermeasures into account, they are additionally averaged over the driving time classes NFZ and - if more than one site is considered - also over the population density groups NF of driving times and they are valid for the shielding group NA = 1. Another shielding group can be selected by changing the value of NAGOUT in the DATA-statement.

Table 29 and **Table 30:** Evaluation program EVADOS

After some information about the input parameters the radius-dependent statistical evaluation is printed for all organs specified by IORGNR. The first line gives the index of the weather sequence (not the starting time) leading to the maximal dose value printed in the second line. Maximal means the maximum individual dose of all weather sequences and azimuthal sectors (and shielding groups when countermeasures are taken into account; the maximum values are, however, averaged over the driving time classes NFZ and - if more than one site is considered - also over the population density groups NF of driving times). The mean value is identical to that described for Table 25.

SUM P (JUSED): Gives the fraction of each distance band affected by the plume (i.e. with a normalized air concentration > CHIMAX); this fraction is averaged over the weather sequences. By subtracting this probability from 1, the zero-probability (i.e. the probability for a dose value of 0.0) can be obtained in the potential case. If countermeasures are considered the zero-probability can be even lower (e.g. if evacuation is ended before the plume arrives).

SUM P < DOSMIN: Gives the fraction of grid elements under the plume having a dose value below DOSMIN = 10^{NDSMIN}; NDSMIN is a NAMELIST parameter. If DOSMIN is chosen in such a way that all non-zero dose values calculated are higher, this probability is 0 in the potential case. If countermeasures are considered, subtracting this value from P(JUSED) gives the zero-probability.

SU P DU = ... DO = ... : Gives the probability that the individual dose values lie in a given dose interval; this interval is specified by the NAMELIST parameters DUYFS1/2 and DOYFS1/2. Setting the interval boundaries to a very low and very high value (e.g. 1.E-30 and 1.E30) gives the non-zero-probability. Setting the lower boundary to a specific value

and the upper boundary to a very high value, the probability for doses above the specific value can be obtained.

FRACTILE ... : Gives the fractile values for the percentiles specified by NAMELIST parameter PERC. They are derived from the CCFD which is printed only on request (see Table 31). A value of -0.10E+01 indicates that the corresponding percentile cannot be found in the CCFD. There can be two reasons: either the starting value NDSMIN for the evaluation interval has not been chosen appropriately or the probability for results equal 0.0 (zero-probability) is above the specified PERC-value.

Table 31: Evaluation program EVADOS: CCFDs for individual organ doses
If the NAMELIST parameter ICCFD is set to 1, a printout of the CCFD (Complementary Cumulative Frequency Distribution) will be given for the organ doses evaluated by IORGNR and the distances specified with IACT. For calculating the CCFD the dose range from the lower limit 10^{NDSMIN} to the upper limit $10^{NDSMIN+NDEKAD}$ is taken into account with the number of decades NDEKAD being 9. Each of these decades is subdivided into 100 logarithmically equidistant dose intervals. Each single dose value belongs to one of these intervals. The probability for this interval is increased by the probability of the single dose value. The CCFD starts with the dose value 10^{NDSMIN} and ends with $10^{NDSMIN+NDEKAD}$. In the printout of the CCFD every 5th value is shown. If the probability value for $10^{NDSMIN+NDEKAD}$ is not 0, a higher value for NDSMIN should be chosen, because the maximum dose result would not be contained in the evaluation decades.

6.1.2 Subsystems NL and FL

In the modules POTDOS and LATDOS calculating **individual** doses, ingestion as exposure pathway is only contained in the results, if CIGCOL is set to 'L-P&C' (local production and consumption method). For CIGCOL='APROD' (agricultural production method) no individual results from ingestion can be obtained (see [2]).

In submodule COLDOS of module COLLEC calculating **collective** results the grid point and distance dependent printouts contain the doses from ingestion pathway only for CIGCOL='L-P&C'. Using the APROD-method the collective contribution from ingestion is added to the results integrated over the whole grid area.

Table 32: Module LATDOS: Title page with information about parameter values
The values of some of the NAMELIST parameters needed for the calculation of individual doses are printed after the title page. A similar printout is obtained from module POTDOS.

Table 33: Modules POTDOS and LATDOS: Printout of dose conversion factors
This printout is obtained only if IDFOUT $\neq$ 0. It gives for each nuclide considered and each organ the dose conversion factors for the exposure pathways taken into account (i.e. IEXPO $\neq$ 0). For groundshine (GR) and inhalation (IH) the integration time is defined by IZINT.

In subsystem NL also shorter integration times are needed for groundshine when considering countermeasures. GR1D is integrated over 1 day, GRSHD over ITSH days (can be ignored if "sheltering only" is not considered).

For contamination of skin and clothes the integration times are 1 day (only when considering countermeasures) and TSKIN days in subsystem NL. In FL values integrated over 1 day are not needed. 'SK-P' contains the contribution coming from the parent of the nuclide.

Table 34: Module LATDOS: Printout of dose conversion factors
This printout is obtained only when countermeasures are taken into account and IDFOUT $\neq 0$. It gives for each nuclide considered and each organ the dose conversion factors for groundshine integrated from 0 to the time periods considered for resettlement and specified by NAMELIST parameter NT.

Table 35: Modules POTDOS and LATDOS: Printout of results of point values
This printout is obtained only if NOODOS $\neq 0$. A value of 1 gives the information for all weather sequences calculated, a value of 2 only for those up to 20 weather sequences specified by LKZ. The distances are selected by IACT. Starting with azimuthal sector J = 1 (sector due North) the point results for all JMAX sectors are given (the sectors count clockwise). The individual doses printed here are integrated over IZINT.

Table 36 and **Table 37:** Modules POTDOS and LATDOS: Breakdown of mean individual doses by exposure pathways and for each pathway by nuclides
This information is printed for all distances selected by IACT. The necessary calculations are done in subroutine TABWT. The individual doses are averaged over all weather sequences and all azimuthal sectors and integrated over IZINT. Nuclides with a contribution of < 0.005 % for all organs are skipped. Ingestion pathway is included in these results only for CIGCOL = 'L-P&C'.

Table 38: Modules POTDOS and LATDOS: Distance-dependent mean individual doses
This information cannot be suppressed. It gives for each distance the mean individual dose for all organs. The results are averaged over all weather sequences and azimuthal sectors. Ingestion pathway is included in these results only for CIGCOL = 'L-P&C'.

Table 39: Module COLLEC-COLDOS: Title page with information about parameter values
After the title page the integration time of the individual doses used for the calculation of collective doses and the index of the distance up to which (subsystem NL) or beyond which (subsystem FL) the collective doses are integrated are printed.

Table 40: Module COLLEC-COLDOS: Printout of results of point values
This printout is obtained for each site only if NOOPOP $\neq 0$. A value of 1 gives the information for all weather sequences calculated, a value of 2 only for those up to 20 weather sequences specified by LKZ. The distances are selected by IACT. Starting with azimuthal sector J = 1 (sector due North) the point results for all JMAX sectors are given (the sectors count clockwise). The collective doses printed are integrated up to IZINT years. Ingestion pathway is included in these results only for CIGCOL = 'L-P&C'.

Table 41: Module COLLEC-COLDOS: Distance-dependent mean collective doses
This information cannot be suppressed. It gives for each distance the mean collective dose for all organs. The results are averaged over all weather sequences, azimuthal sectors and sites. Ingestion pathway is included in these results only for CIGCOL = 'L-P&C'.

Table 42: Module COLLEC-COLDOS: Printout of results integrated over the whole grid area for each site
This printout is obtained for each site only if NOOSIT $\neq$ 0. A value of 1 gives the information for all weather sequences calculated, a value of 2 only for those up to 20 weather sequences specified by LKZ. The collective doses printed are integrated over IZINT years and summed up over the grid area up to IRMAX (subsystem NL) and starting with IRMIN (subsystem FL), respectively. Ingestion pathway is included in these results whenever it is considered.

Table 43: Module COLLEC-COLDOS: Breakdown of mean collective doses by exposure pathways
This information cannot be suppressed. It gives for each organ the mean collective dose integrated over the grid area up to IRMAX (subsystem NL) and starting with IRMIN (subsystem FL), respectively, and the breakdown by exposure pathways of this dose. The collective doses are averaged over all weather sequences, azimuthal sectors and sites. Ingestion pathway is included in these results whenever it is considered.

Table 44 and **Table 45:** Evaluation program EVADOS
After some information about the input parameters the radius-dependent statistical evaluation is printed for all organs specified by IORGNR. The first line gives the index of the weather sequence (not the starting time) leading the the maximal dose value printed in the second line. Maximal means the maximum individual dose of all weather sequences and azimuthal sectors. The mean value is identical with that described for Table 36. Ingestion pathway is included in these results only for CIGCOL = 'L-P&C'.

SUM P (JUSED): Gives the fraction of each distance band affected by the plume (i.e. with a normalized air concentration > CHIMAX); this fraction is averaged over the weather sequences.

SUM P < DOSMIN: Gives the fraction of grid elements under the plume having a dose value below DOSMIN = 10^{NDSMIN}; NDSMIN is a NAMELIST parameter.

SU P DU = ... DO = ... : Gives the probability that the individual dose value lies in a dose interval; this interval is specified by the NAMELIST parameters DUYSS and DOYSS.

FRACTILE ... : Gives the fractile values for the percentiles specified by NAMELIST parameter PERC; they are derived from the CCFD which is printed only on request (see explanations for Table 30).

If ICCFD is set to 1, the CCFD will be printed for the organ doses evaluated and the distances specified with IACT. The algorithm for calculating the CCFDs has already been described for Table 31.

Table 46 and **Table 47:** Evaluation program EVACOL
After some information about the input parameters the statistical evaluation is printed for all organs. The first line gives the maximal collective dose value of all weather sequences and sites. The mean value is identical with that described for Table 43. Ingestion pathway is included in these results whenever it is considered.

SUM P < COLMIN: Gives the probability that the collective dose summed up over the whole grid area is below COLMIN = 10^{NCDMIN}; NCDMIN is a NAMELIST parameter.

FRACTILE ... : Gives the fractile values for the percentiles specified by NAMELIST parameter PERC; they are derived from the CCFD which is printed only on request (see explanations for Table 30).

If ICCFD is set to 1, the CCFD will be printed for all organ doses. The algorithm for calculating the CCFDs has already been described for Table 31. Also for collective doses 9 decades are considered but starting with NCDMIN.

6.2 *Countermeasure part*

This section describes all printout available from the countermeasure modules PROTEC and AMOUNT and the corresponding evaluation programs. Examples of the printout are contained in Chapter 10. Some of the tables are self-explanatory and need no further discussion here.

6.2.1 Subsystem NE

Table 48 to **Table 52:** Module INDAT: Control output
These tables are printed from subroutine EVAKUR; they belong to the control printout of module INDAT and inform about the values of the parameters in NAMELIST PROTECT and partly DOSRISK chosen by the user for the calculations.

Table 54: Module PROTEC: Printout of dose conversion factors
This printout is obtained only if IDFOUT $\neq$ 0. It gives for each nuclide and each organ considered in the dose criteria for areas B and/or S the dose conversion factors for the exposure pathways taken into account (i.e. NOEXPO $\neq$ 0). For groundshine (GR) and inhalation (IH) the integration times are defined by IZEB and IZIH. For inhalation the dose calculated is committed up to time point IZIH.

Table 55: Module PROTEC: Intervention dose, point values
This printout is obtained only for a deterministic run (i.e. only one weather sequence is calculated, LMAX = 1); NOOPRO has to be set $\neq$ 0. It gives for each organ considered in the criterion for area B and S the intervention dose for all grid elements (starting with azimuthal sector J = 1 and continuing clockwise). For those grid elements lying inside area A no intervention dose is calculated and therefore -0.9999 + E09 is printed.

Table 56: Module PROTEC: Countermeasure implemented at each grid element
This printout is obtained only if NOOPRO $\neq$ 0. A value of 1 gives the information for all weather sequences calculated, a value of 2 only for those up to 20 weather sequences specified by LKZ. For each grid element identified by its index of distance and azimuthal sector the flag KENNAB is printed indicating the early countermeasure implemented.

Table 57: Module PROTEC: Intervention doses
This printout cannot be suppressed. It gives for each organ considered in the criterion for area B and S the mean and maximum intervention dose together with a breakdown by exposure pathways of the mean value. The values are averaged over all weather sequences and azimuthal sectors. For distance bands completely or partly belonging to area A the values are only averaged over the sectors outside area A.

Table 59: Module AMOUNT: Distance-dependent probabilities for implementation of early countermeasures

This printout cannot be suppressed. It gives for each countermeasure area considered the probability that the action is assumed to be implemented in that distance. From this table it can easily be seen up to which distance a countermeasure is assumed to be taken. The values are averaged over all weather sequences and azimuthal sectors.

Table 60: Evaluation program EVAAMT
After some information about the input parameters the statistical evaluation of number of people and areas [km^2] affected is printed for all protective actions. The first line gives the maximal value of all weather sequences (and sites, for the number of people). The mean value is averaged over all weather sequences (and sites).

SUM P < PERMIN: Gives the probability that the number of people affected within the whole grid area is below PERMIN = 10^{NABMIP}; NABMIP is a NAMELIST parameter.

SUM P < AREMIN: Gives the probability that the size of the areas affected within the whole grid area is below AREMIN = 10^{NABMIA}; NABMIA is a NAMELIST parameter.

FRACTILE ... : Gives the fractile values for the percentiles specified by NAMELIST parameter PERC; they are derived from the CCFD which is printed only on request (see explanations for Table 30).

If ICCFD is set to 1, the CCFD will be printed for areas and persons affected by all countermeasures implemented. The algorithm for calculating the CCFDs has already been described in the dose part for Table 31. The number of decades considered is 9 starting with 10^{NABMIA} for areas and 10^{NABMIP} for persons.

6.2.2 Subsystems NL and FL

Table 61 to **Table 63:** Module INDAT: Control output
These tables are printed from subroutine UMSIED; they belong to the control printout of module INDAT and inform about the values of the parameters in NAMELIST PROTECT and partly DOSRISK chosen by the user for the calculations.

Table 65: Module PROTEC: Printout of dose conversion factors
This printout is obtained only if IDFOUT $\neq 0$. It gives for the effective dose (equivalent) the dose conversion factors for the exposure pathways taken into account in the relocation criterion (i.e. NOEXPO $\neq 0$). For groundshine (GR) and inhalation (IH) the integration times are defined by INTREL (upper part of the table) and the resettlement time points NT (lower part). The integration over INTREL starts from 0; for inhalation it is the dose committed up to time point INTREL. All dose conversion factors in the lower part of the table are differential factors for a period of one year (INTRES) at the different time points for resettlement (i.e. time NT after the accident).

Table 66: Module PROTEC: Intervention dose, point values
This printout is obtained only for a deterministic run (i.e. only one weather sequence is calculated, LMAX = 1); NOOPRO has to be set $\neq 0$. It gives for the effective dose considered in the criterion for relocation the intervention dose for all grid elements (starting with azimuthal sector J = 1 and continuing clockwise).

Table 67: Module PROTEC: Countermeasure implemented at each grid element
This printout is obtained only if NOOPRO $\neq 0$. A value of 1 gives the information for all weather sequences calculated, a value of 2 only for those up to 20 weather sequences specified by LKZ. For each grid element identified by its index of distance and azimuthal sector the flag KENNC is printed indicating the duration of relocation. The flags refer to the index in array NT giving the resettlement time points (A = 10, B = 11, C = 12, ...).
When considering foodbans, a similar printout will be given for all foodstuffs considered.

Table 68: Module PROTEC: Frequency distributions for the duration of relocation
This printout cannot be suppressed. For all distances a frequency distribution is given for the duration of relocation which is identical to the time point of resettlement. These statistics are derived from all grid points (JMAX) and all weather sequences (LMAX) calculated resulting in JMAX * LMAX cases to be classified. The duration of relocation is given by its index in the array of resettlement time points NT and is shown in the upper part of the table. As mostly resettlement will occur only after the area has been decontaminated, the frequency distributions for area C and D are very similar. The difference in the values for the last time point considered (NNT) indicates the cases where no return is allowed. These statistics only count the cases for each time point and does not take into account the different probabilities of the weather sequences.

Table 69: Module PROTEC: Intervention doses
This printout cannot be suppressed. It gives for the effective dose considered in the criterion for relocation the mean and maximum intervention doses together with a breakdown by exposure pathways of the mean value. The values are averaged over all weather sequences and azimuthal sectors.

Table 71: Module AMOUNT: Distance-dependent probabilities for resettlement
This printout cannot be suppressed. It gives for relocation the probability that the action is assumed to be implemented in the corresponding distance. From this table it can easily be seen up to which distance the relocation criterion is exceeded and the countermeasure is assumed to be implemented. The values are averaged over all weather sequences and azimuthal sectors. The column TOTAL gives the initial probability, that means independent of the time point of withdrawal. The following columns give the differential probabilities that resettlement will occur at the specific time point. It has to be noticed that the values are not cumulative. For example, 3650 days means that people are assumed to be relocated for exactly 3650 days (not shorter and not longer; they are assumed to return after 3650 days). Thus, those people are not contained in the probability for 1825 days and all earlier time points. A similar table shows the results for decontamination.

When the distribution of land and sea is not considered in the calculations (ILDSEA = 0), all grid elements are assumed to belong to the land area and are taken into account to derive these probabilities.

When considering foodbans, a similar printout will be given for all foodstuffs considered. It shows the probability that the criterion is exceeded, independent whether the corresponding foodstuff is produced there or not.

Table 72: Module AMOUNT: Averaged results
This printout cannot be suppressed. The upper part of the table gives the mean number of people and the mean areas [km^2] affected by relocation and decontamination as a function of the time point of resettlement. The values are averaged over all weather sequences and sites and integrated over the whole grid area considered. When interpreting the time points as duration of relocation it has to be noticed that the values are differential and not cumulative. For example, 3650 days means that people are assumed to be relocated for exactly 3650 days (not shorter and not longer; they are assumed to return after 3650 days). Thus, those people are not contained in the value for 1825 days and all earlier time points.

The lower part of the table sums up the results for all time periods and shows the mean total number of people and the mean total areas affected by relocation and the corresponding time integrals (multiplication of number of people / areas with duration).

When the distribution of land and sea is not considered in the calculations (ILDSEA = 0), all grid elements are assumed to belong to the land area and are taken into account to derive these results.

Table 73 and **Table 74:** Evaluation program EVAAMT (subroutine AREPER)
After some information about the input parameters the statistical evaluation of the number of people affected by relocation and decontamination is printed for all time points. The table printed for the areas affected is similar and is not shown here. The first line gives the maximal value of all weather sequences and sites. The mean value is averaged over all weather sequences and sites. The upper part of the table gives the evaluation for the total number of people (areas) affected by relocation and decontamination, independent of its duration. The lower part contains the time integral, i.e. the multiplication of the number of people affected with the duration of being relocated. The evaluation of the different resettlement time points NT is contained in the middle part. The time point NT means that people are assumed to return to their original home after time NT.

When the distribution of land and sea is not considered in the calculations (ILDSEA = 0), all grid elements are assumed to belong to the land area and are taken into account to derive these results.

When considering foodbans, similar printouts will be given for all foodstuffs considered. They are produced in three different subroutines (see [2]):

- AREAIG: It shows the evaluation of potential areas; these are those areas in which the criterion for a foodban is exceeded, independent whether the corresponding foodstuff is produced there or not.
- QUANIG: It shows the evaluation of the amount of agricultural production. Gridded data containing the yearly agricultural production of the foodstuffs considered have to be available (CIGRL3 = 'Y').
- ECONIG: It shows the evaluation of the amount of agricultural production which is used for economic consequences. Gridded data containing the yearly information have to be available (CIGRL4 = 'Y').

SUM P < PERMIN: Gives the probability that the number of people affected within the whole grid area is below PERMIN = 10^{NABMIP}; NABMIP is a NAMELIST parameter.

SUM P < AREMIN: Gives the probability that the size of the areas affected within the whole grid area is below AREMIN = 10^{NABMIA}; NABMIA is a NAMELIST parameter.

SUM P < MIN.AREA: Gives the probability that the size of the areas affected by foodbans within the whole grid area is below AREMIN = 10^{NABMIG} (only in AREAIG); NABMIG is a NAMELIST parameter.

SUM P < MIN.PROD.: Gives the probability that the amount of agricultural producted affected by foodbans within the whole grid area is below PRODMIN = 10^{NABMIQ} (only in QUANIG and ECONIG); NABMIQ is a NAMELIST parameter.

FRACTILE ... : Gives the fractile values for the percentiles specified by NAMELIST parameter PERC; they are derived from the CCFD which is printed only on request (see explanations for Table 30).

If ICCFD is set to 1, the CCFD will be printed for areas and persons initially affected by relocation and decontamination and their time integrals. The algorithm for calculating the CCFDs has already been described in the dose part for Table 31. The number of decades considered is 9 starting with 10^{NABMIA} for areas and 10^{NABMIP} for persons.

For the foodban results 7 decades are considered for potential areas and 10 for the amount of agricultural production. The CCFDs are only printed for the initially affected quantity and the time integral, however calculated for each food category.

7. Figures

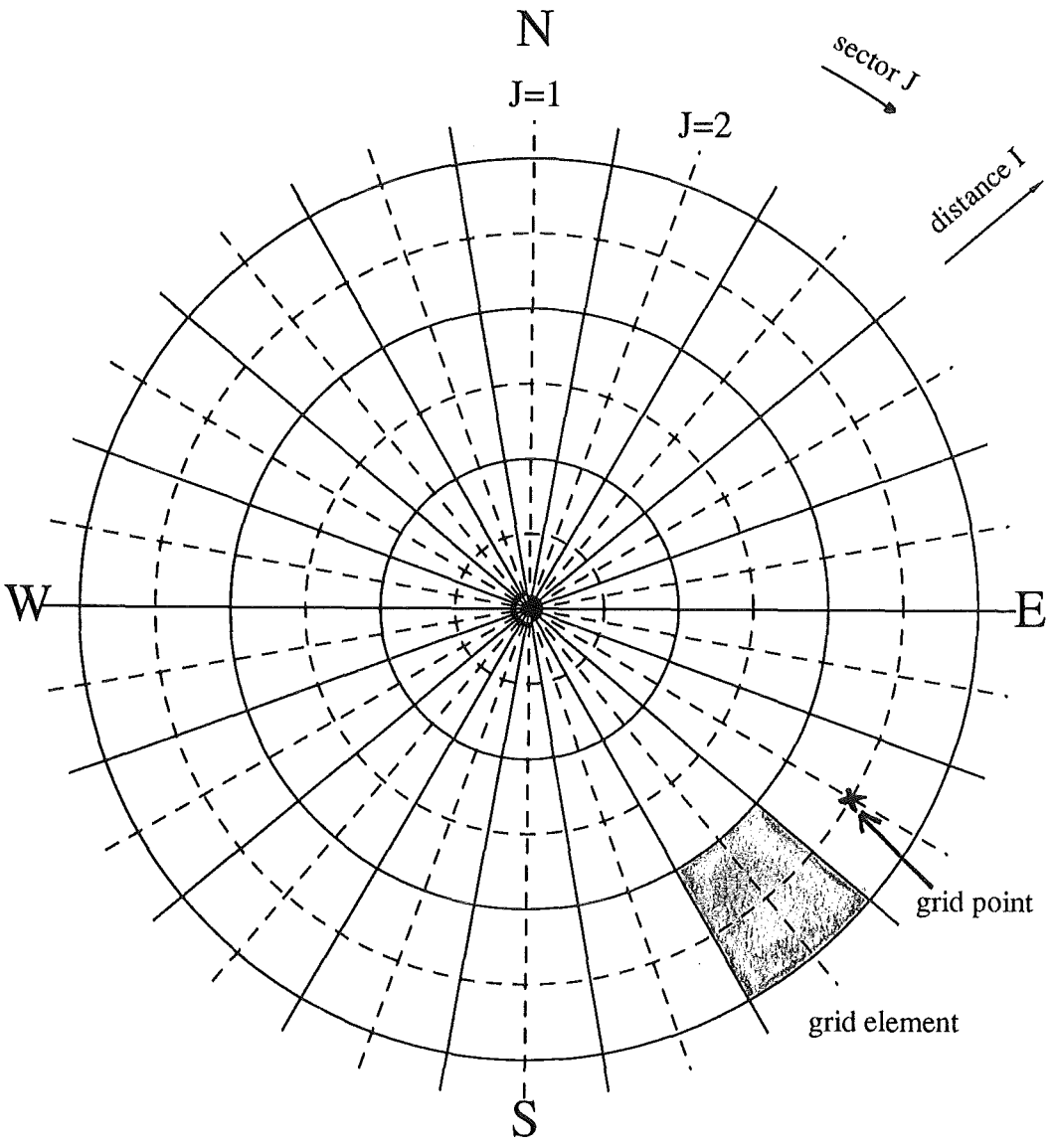

Figure 1. The polar coordinate system in COSYMA

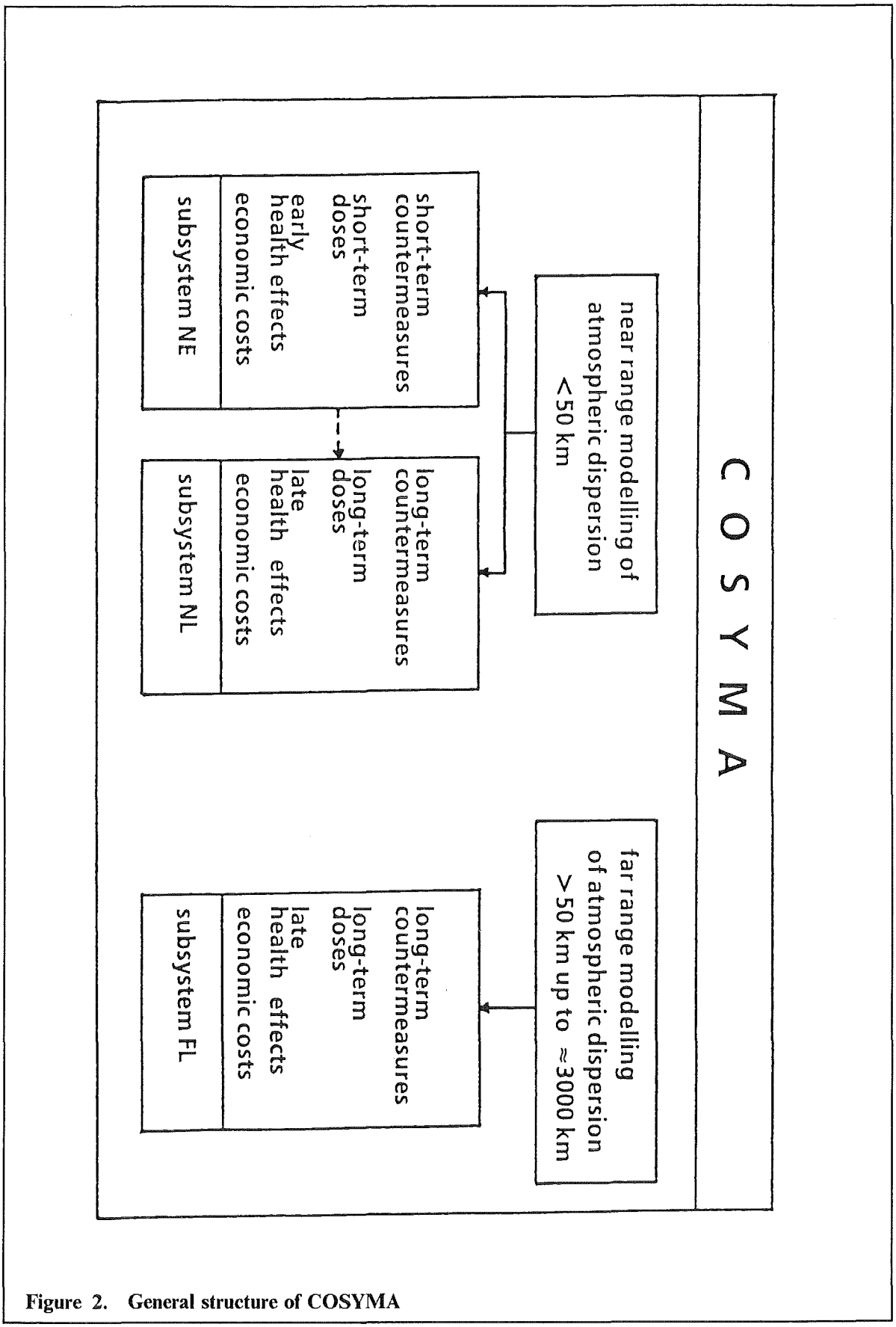

Figure 2. General structure of COSYMA

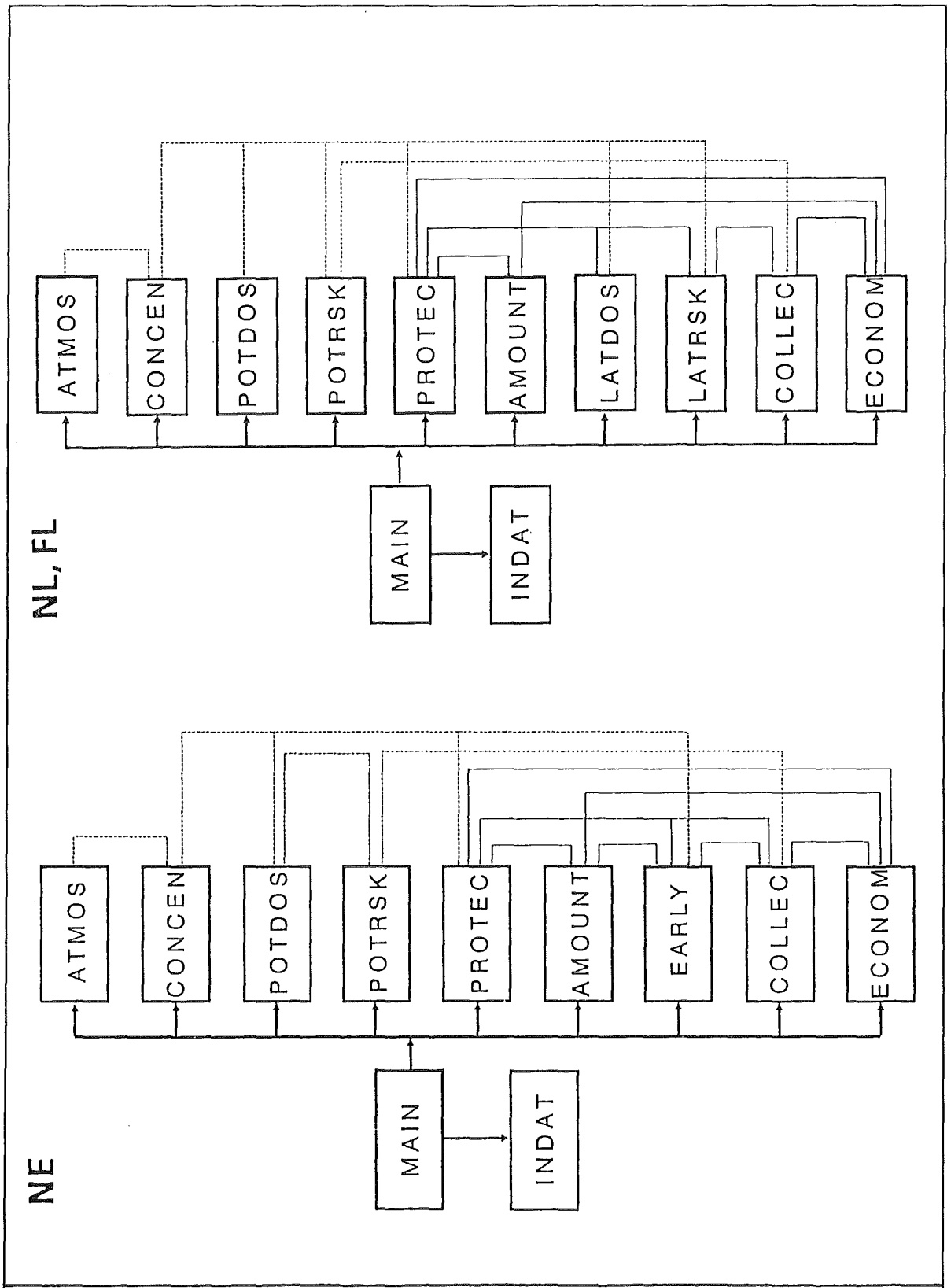

Figure 3. General structure and data flow of each subsystem of COSYMA

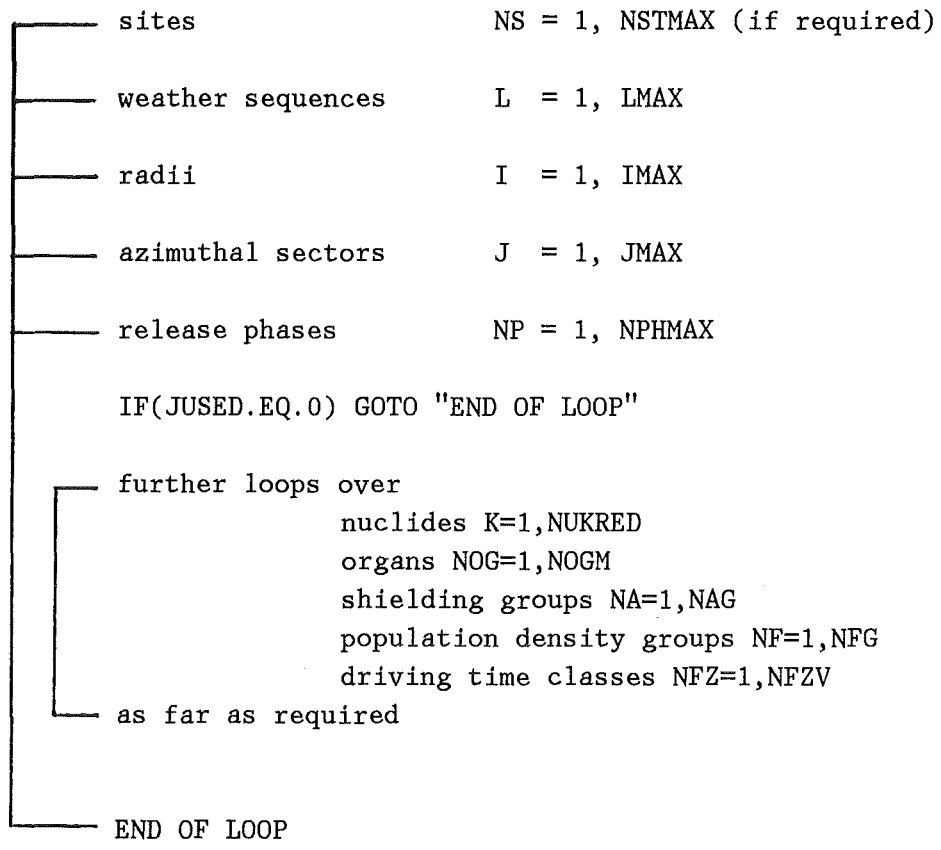

Figure 4. General loop structure of the modules in COSYMA

area A

definition: keyhole shaped area with inner radius r, outer radius R and sector angle α (e.g. r = 2.4 km, R = 5.6 km, α = 60°)

actions: sheltering followed by evacuation and / or spontaneous evacuation

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area B

definition: dose to lung, bone marrow, GI-tract, thyroid and / or effective dose above organ specific thresholds

actions: sheltering followed by evacuation and / or spontaneous evacuation

---

area S

definition: dose to lung, bone marrow, GI-tract, thyroid and / or effective dose above organ specific thresholds

actions: sheltering without evacuation

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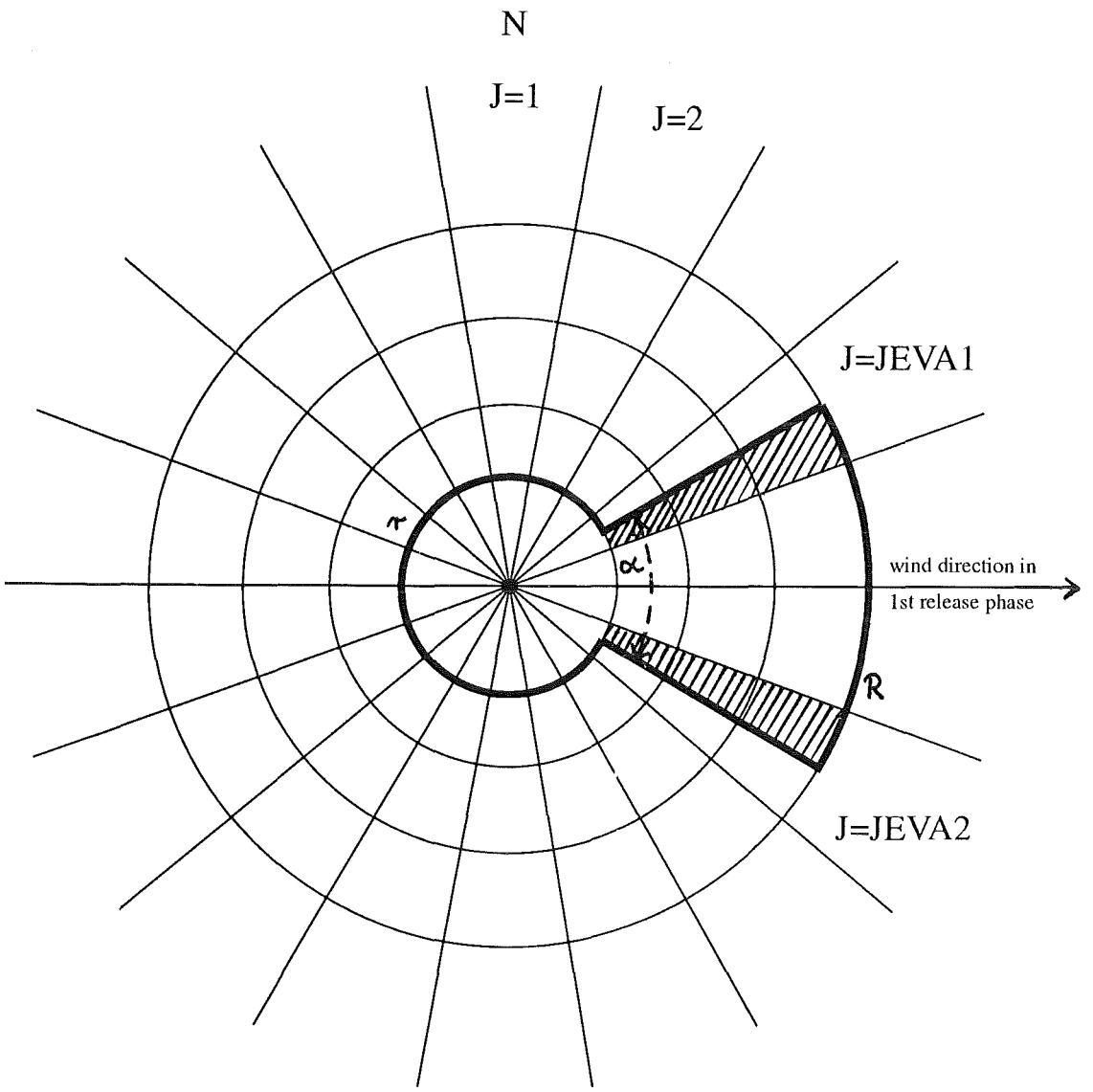
area IO

definition: full circle with radius ri and / or dose to thyroid above threshold

actions: distribution of stable iodine tablets

Figure 5. Modelling of protective actions in the early phase



Example:

With a value of JMAX of 18 sectors (i.e. azimuthal grid resolution of 20°; first sector J=1 - which is always centred on the North direction - lies between 350° and 10.0°; the numbers of J count clockwise) and WGRNZA=60.0 and an assumed wind direction towards East, only half of the marginal grid elements J=JEVA1 (50° to 70°) and J=JEVA2 (110° to 130°) lie in area A. The hatched fractions belonging to area A on both sides of the sector are in this example FLANT1 = FLANT2 = 0.5; the indices of the associated grid elements are JEVA1=4 and JEVA2=7.

Figure 6. Location of area A within the calculation grid

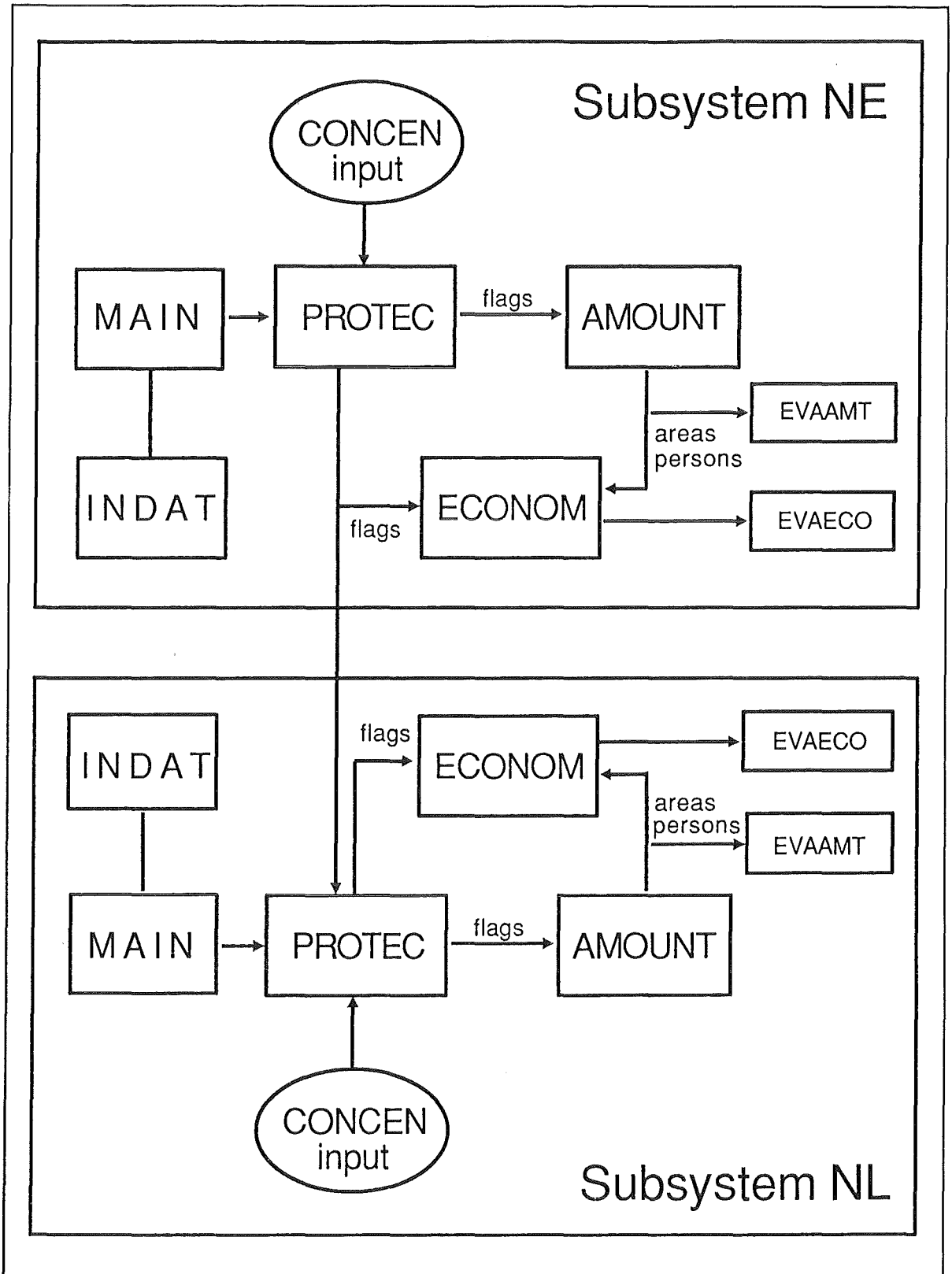
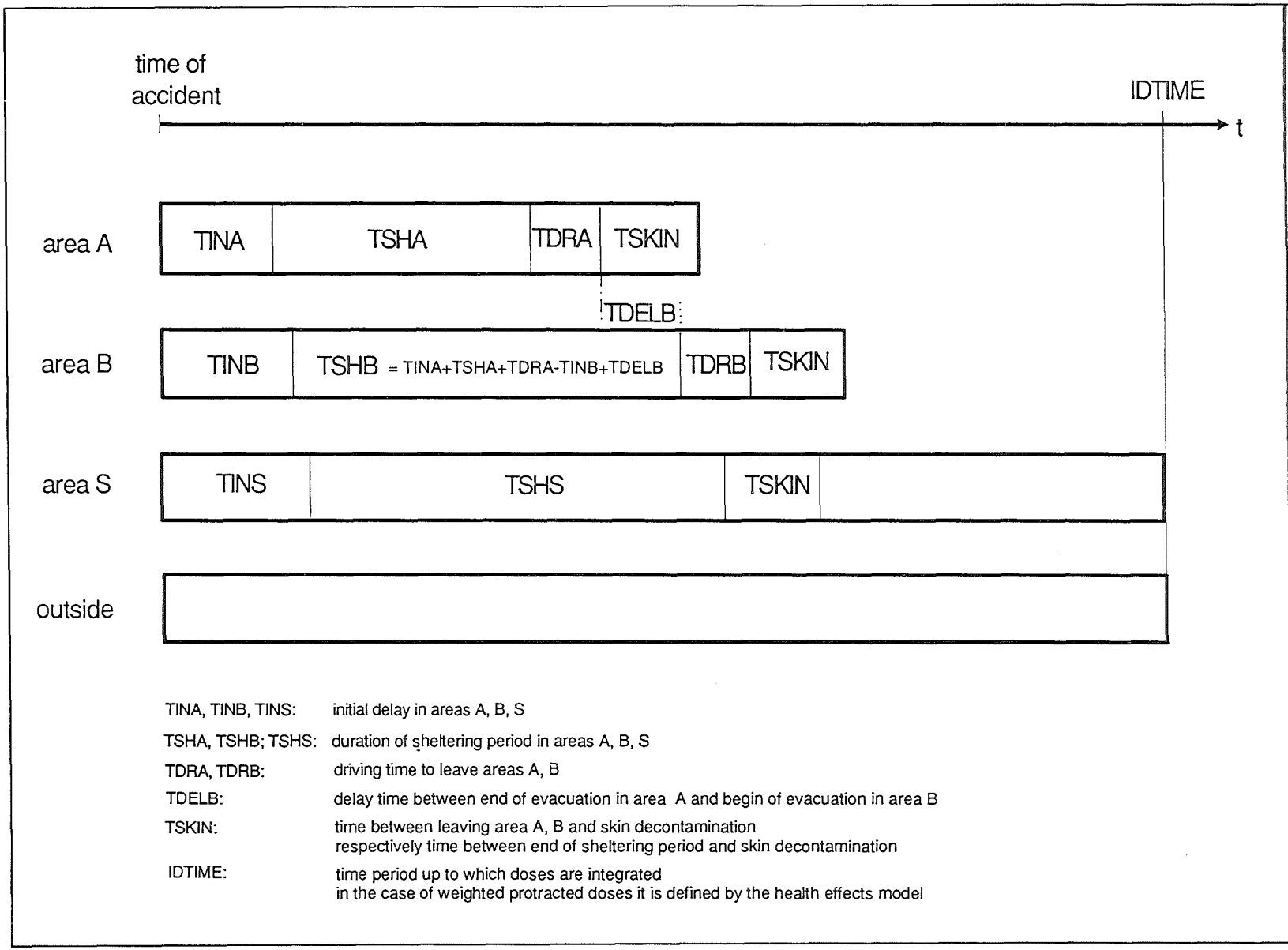


Figure 7. Communication between modules PROTEC, AMOUNT and ECONOM



TINA, TINB, TINS:	initial delay in areas A, B, S
TSHA, TSHB; TSHS:	duration of sheltering period in areas A, B, S
TDRA, TDRB:	driving time to leave areas A, B
TDELB:	delay time between end of evacuation in area A and begin of evacuation in area B
TSKIN:	time between leaving area A, B and skin decontamination respectively time between end of sheltering period and skin decontamination
IDTIME:	time period up to which doses are integrated in the case of weighted protracted doses it is defined by the health effects model

Figure 8. Timing of early protective actions

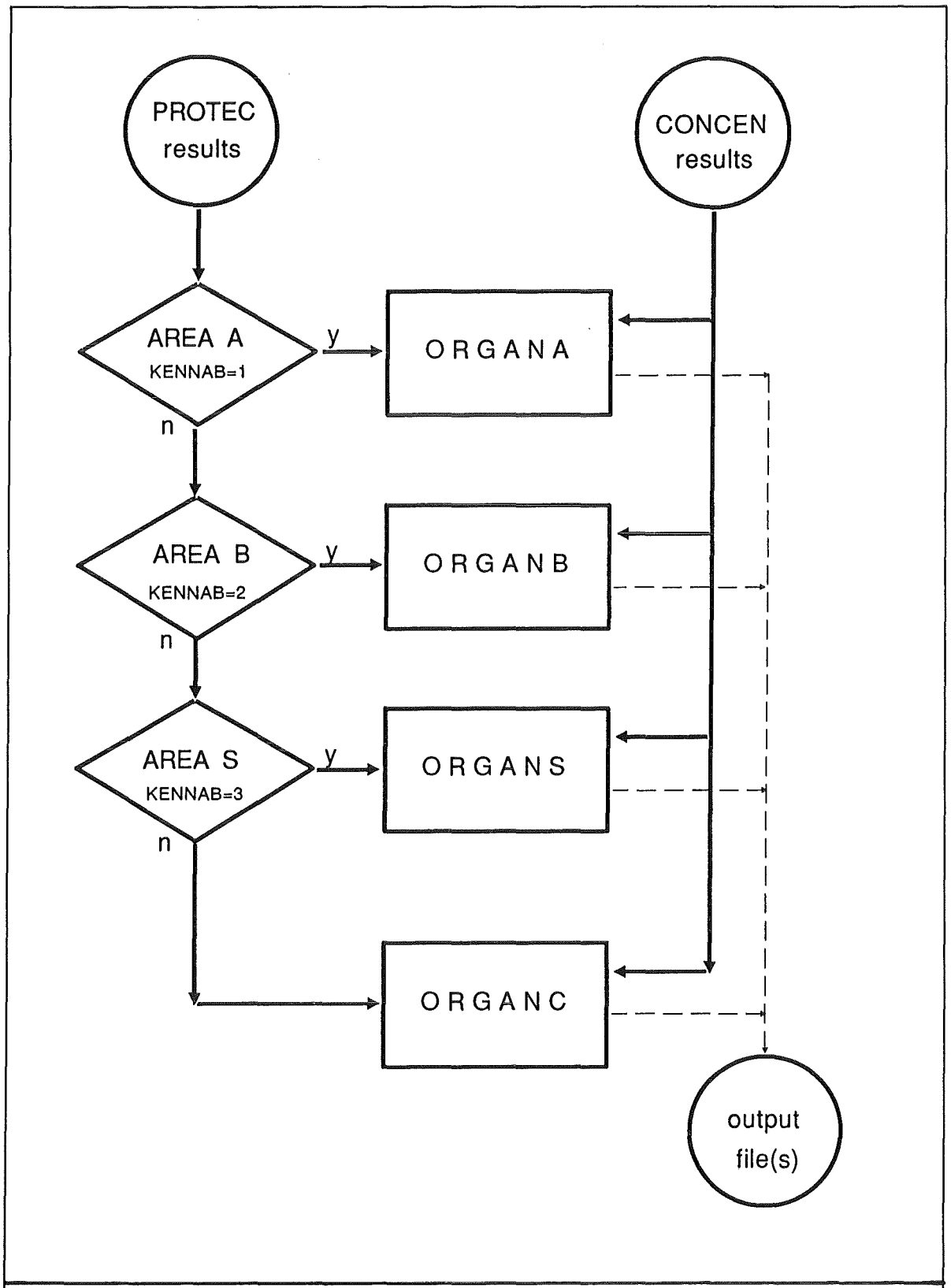


Figure 9. General logic of module EARLY

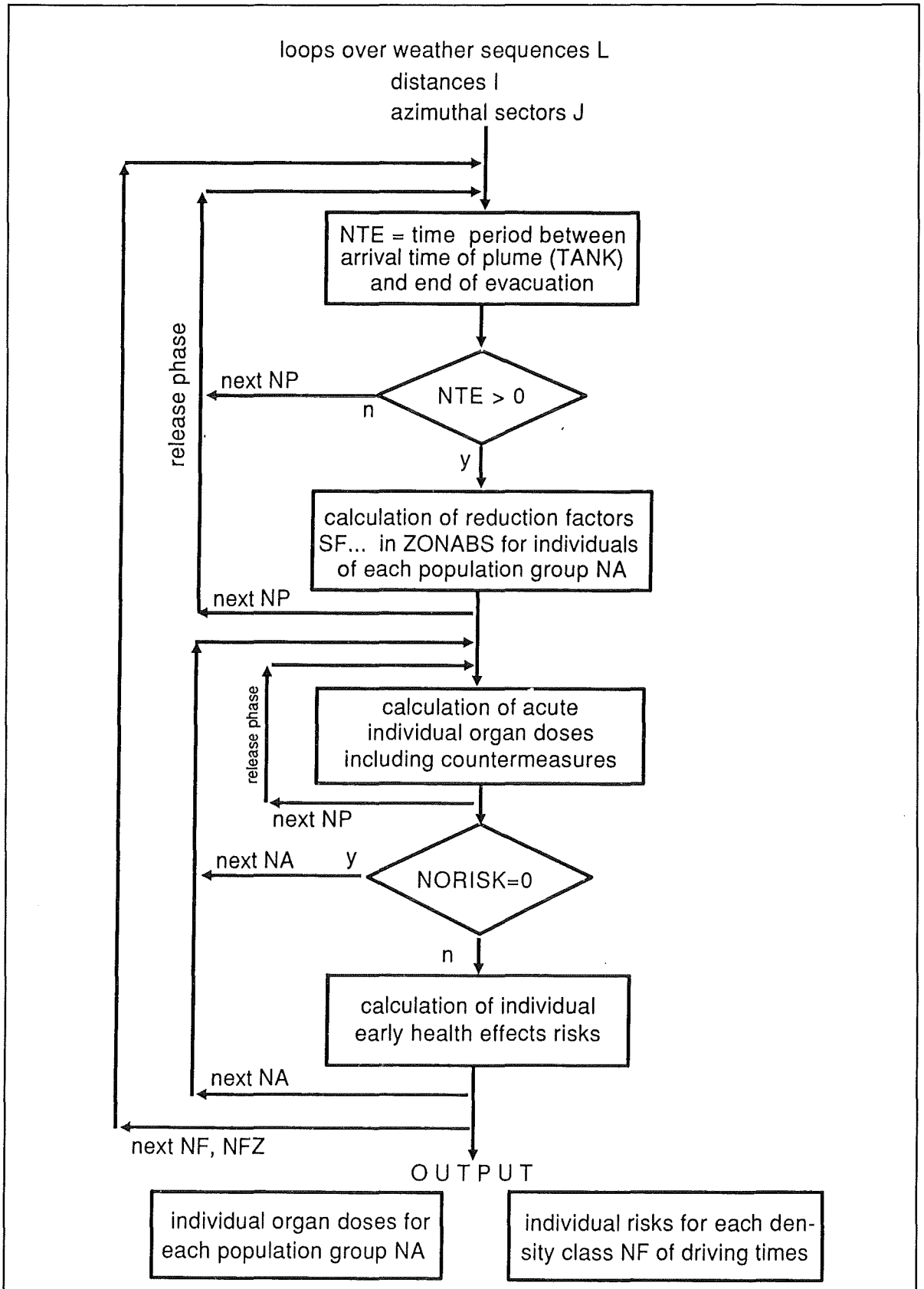


Figure 10. General logic of the subroutines ORGAN# of module EARLY

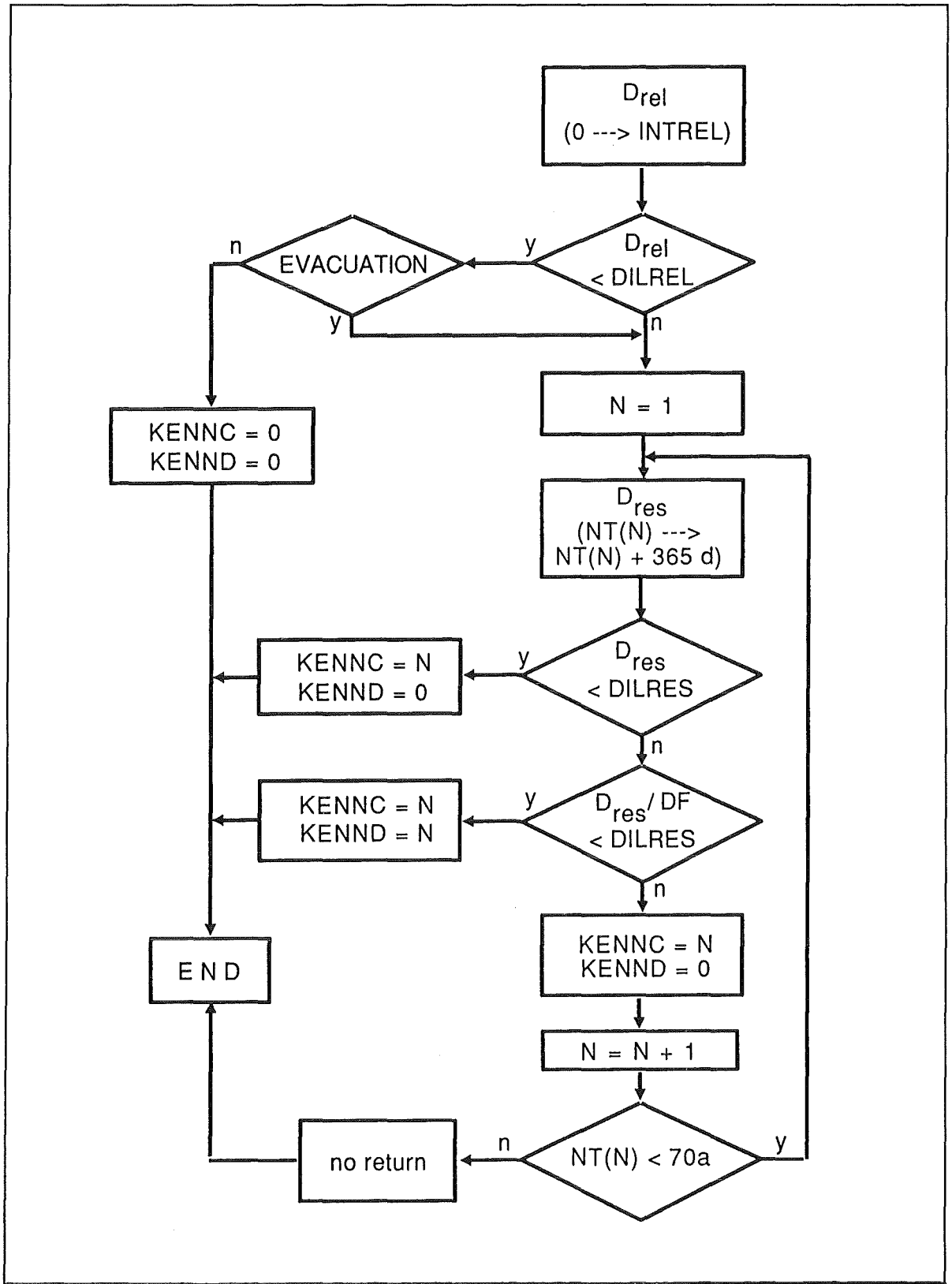


Figure 11. Logic of countermeasures, subsystem NL

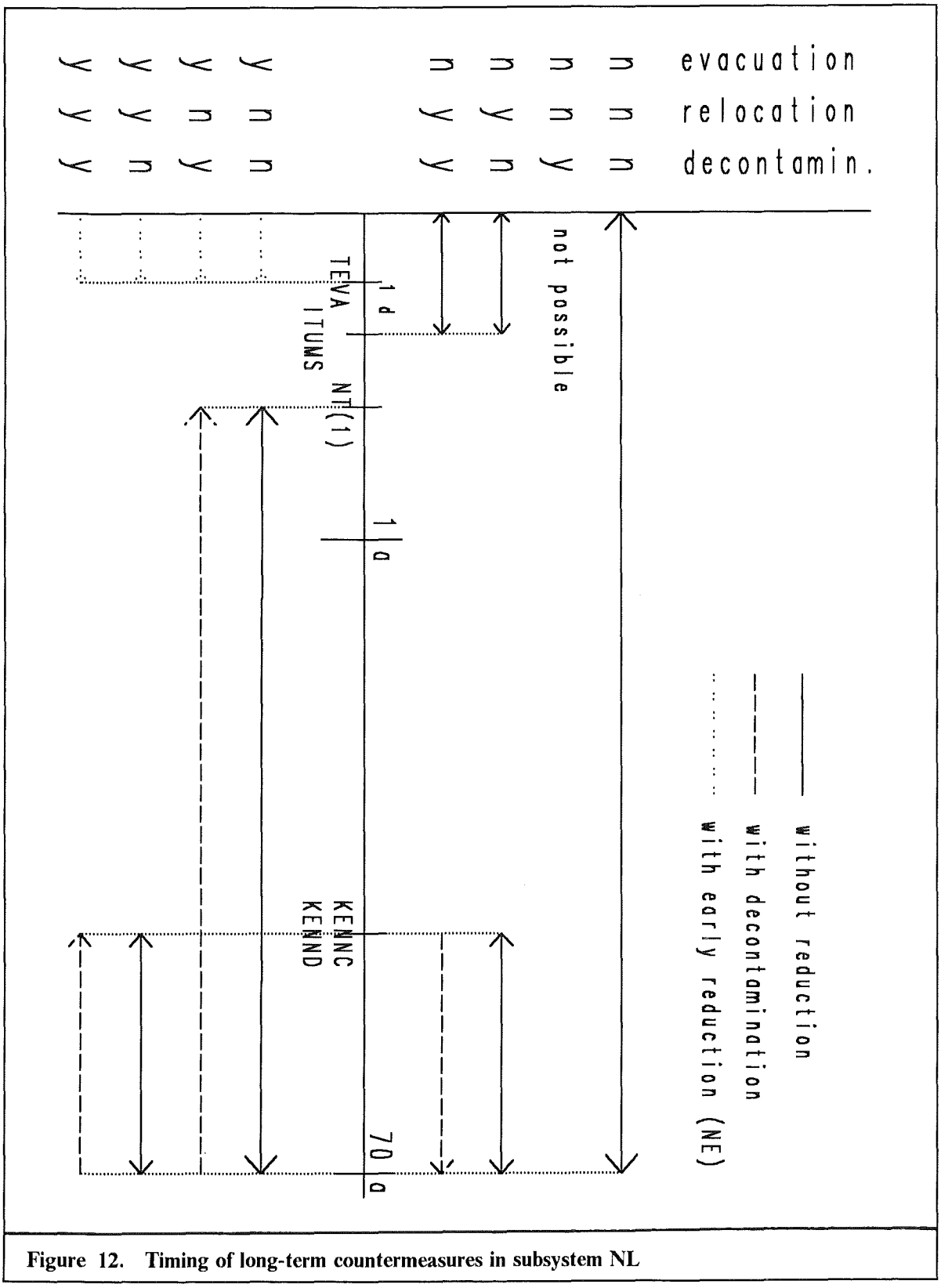


Figure 12. Timing of long-term countermeasures in subsystem NL

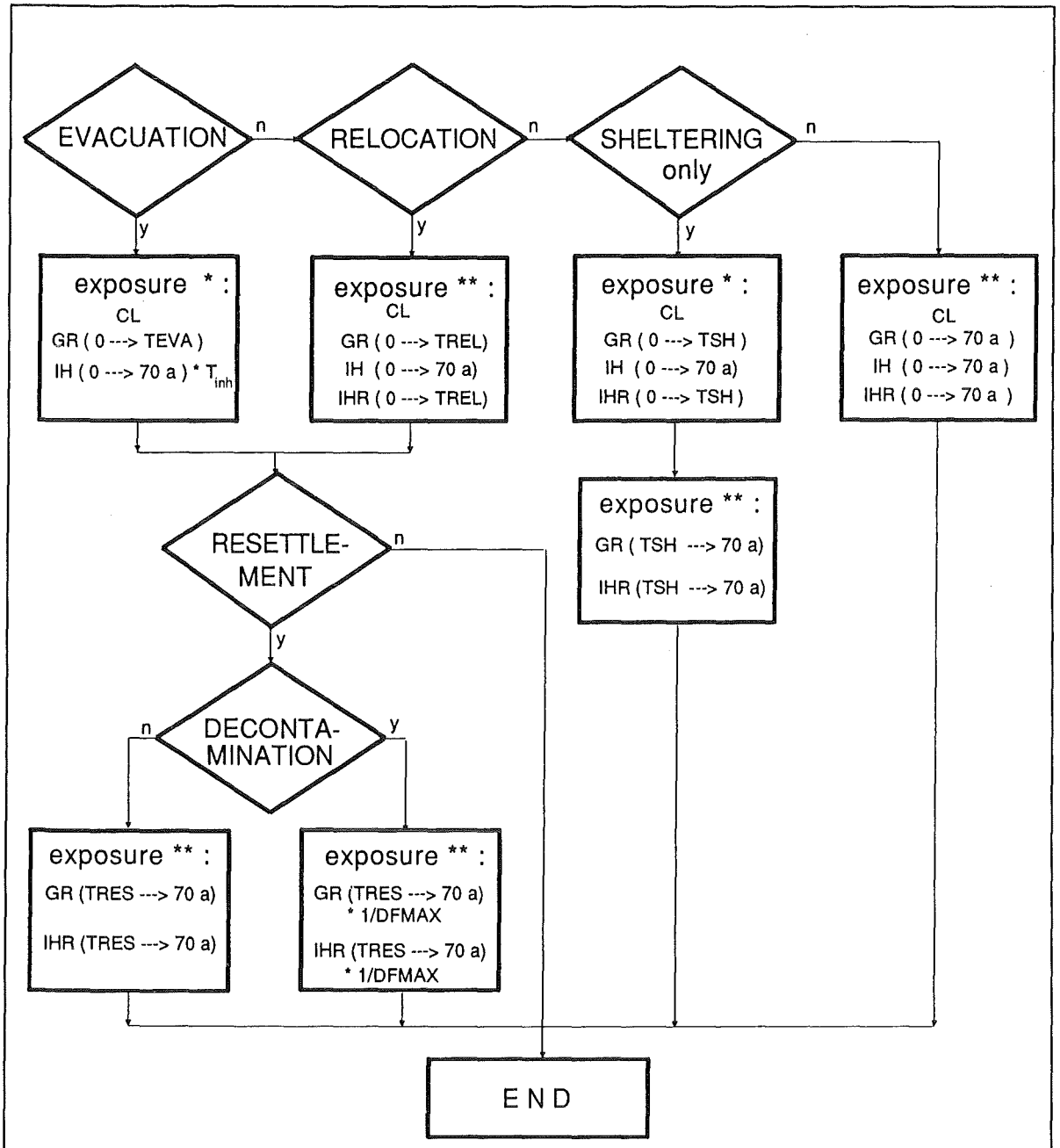


Figure 13. Logic of dose calculation, subsystem NL

8. Tables

EFFECT	COSYMA-Subsystem		
	NE	NL	FL
Exposure Pathways			
External irradiation from the cloud	*	*	*
External irradiation from deposit on the ground	*	*	*
Inhalation from the cloud	*	*	*
Inhalation of resuspended material	*	*	*
External irradiation from deposit on skin and clothes	*	*	*
Ingestion of contaminated food		*	*
Organ doses			
Acute doses (integration times $\geq$ 1 d, $\leq$ 1 a)	*		
Lifetime doses (integration times $\geq$ 1 a, $\leq$ 70 a)		*	*
Countermeasures			
Sheltering	*	*	
Evacuation	*		
Relocation		*	*
Forced land decontamination		*	*
Stable iodine tablets	*	*	*
Food restrictions		*	*

Table 1. Contents of the different subsystems of COSYMA

SUBSYSTEM NE: short-time integrated doses

organs	exposure pathways, corresponding target organ					integration time (d)
	CL	GR	IH	IHR	SK	
lung	LU	LU	LU	LU	--	any time period ≥ 1 d up to 365 d
red bone marrow	BM	BM	BM	BM	--	
GI-tract	LI	LI	--	--	--	
thyroid (external)	TH	TH	--	--	--	
thyroid (internal)	--	--	TH	TH	--	
skin (eye lens)	SK	SK	SK	SK	--	
ovaries/uterus	OV	OV	UT	UT	--	
skin (SK only)	--	--	--	--	SK	

SUBSYSTEMS NL & FL: long-time integrated doses

single organs [1]			integration time (a)
red bone marrow	* stomach [2]	thyroid	any time period (full years) ≥ 1 a up to 70 a
bone surface	* colon [2]	gonads [3]	
breast	* liver [2]	remainder	
lung	* pancreas [2]	skin	
effective dose equivalent (or effective dose) [4]			

NOTE:

[1] Pathways considered:
for all organs except skin: CL, GR, IH, IHR, IG
for skin: SK only

[2] Setting NAMELIST parameter IORGGI combines the organs marked with * to GI-tract (in the evaluation program only)

[3] ≠ genetically significant dose assessed in the risk modules

[4] One of both can be selected with NAMELIST parameter NEWEDE

Table 2. The organs considered for dose calculation, pathways, target organs and integration times

Organ / Tissue	ICRP-26	ICRP-60
bladder	---	0.05
bone marrow	0.12	0.12
bone surface	0.03	0.01
breast	0.15	0.05
colon	---	0.12
liver	---	0.05
lung	0.12	0.12
thymus	---	0.05
skin	---	0.01
stomach	---	0.12
thyroid	0.03	0.05
remainder	0.30	0.05
gonads (hereditary effects)	0.25	0.20

Table 3. Target organs and ICRP weighting factors

1	Na - 24	51	Tc - 99m	101	Ba - 140
2	Ar - 41	52	Tc - 99	102	La - 140
3	Cr - 51	53	Tc - 101	103	La - 141
4	Mn - 53	54	Ru - 103	104	La - 142
5	Mn - 54	55	Ru - 105	105	Ce - 141
6	Mn - 56	56	Ru - 106	106	Ce - 143
7	Fe - 55	57	Rh - 103M	107	Ce - 144
8	Fe - 59	58	Rh - 105	108	Pr - 143
9	Co - 56	59	Ag - 110m	109	Pr - 145
10	Co - 57	60	Ag - 111	110	Nd - 147
11	Co - 58m	61	Sb - 124	111	Pm - 147
12	Co - 58	62	Sb - 125	112	Pm - 148m
13	Co - 60m	63	Sb - 126	113	Pm - 148
14	Co - 60	64	Sb - 127	114	Pm - 149
15	Co - 61	65	Sb - 128L (9 h)	115	Pm - 151
16	Ni - 59	66	Sb - 129	116	Eu - 152m
17	Ni - 63	67	Sb - 130L (40 min)	117	Eu - 152
18	Ni - 65	68	Sb - 131	118	Eu - 154
19	Zn - 65	69	Te - 125m	119	Eu - 155
20	Zn - 69m	70	Te - 127m	120	Eu - 156
21	Kr - 83m	71	Te - 127	121	W - 181
22	Kr - 85m	72	Te - 129m	122	Ra - 226
23	Kr - 85	73	Te - 129	123	U - 234
24	Kr - 87	74	Te - 131m	124	U - 235
25	Kr - 88	75	Te - 131	125	U - 238
26	Se - 75	76	Te - 132	126	Np - 237
27	Rb - 86	77	Te - 133m	127	Np - 238
28	Rb - 88	78	Te - 133	128	Np - 239
29	Rb - 89	79	Te - 134	129	Pu - 236
30	Sr - 89	80	I - 125	130	Pu - 238
31	Sr - 90	81	I - 129	131	Pu - 239
32	Sr - 91	82	I - 130	132	Pu - 240
33	Sr - 92	83	I - 131	133	Pu - 241
34	Sr - 93	84	I - 132	134	Pu - 242
35	Y - 90m	85	I - 133	135	Am - 241
36	Y - 90	86	I - 134	136	Am - 242m
37	Y - 91m	87	I - 135	137	Am - 242
38	Y - 91	88	Xe - 131m	138	Am - 243
39	Y - 92	89	Xe - 133m	139	Cm - 242
40	Y - 93	90	Xe - 133	140	Cm - 243
41	Zr - 93	91	Xe - 135m	141	Cm - 244
42	Zr - 95	92	Xe - 135	142	Cm - 245
43	Zr - 97	93	Xe - 138	143	Cm - 246
44	Nb - 93m	94	Cs - 134m	144	Cm - 247
45	Nb - 95m	95	Cs - 134	145	Cm - 248
46	Nb - 95	96	Cs - 135		
47	Nb - 97	97	Cs - 136		
48	Mo - 93	98	Cs - 137		
49	Mo - 99	99	Cs - 138		
50	Mo - 101	100	Ba - 139		

Table 4. Identification numbers of the nuclides included in COSYMA

coefficient	parameter	default value
r_0	RES0	$10^{-5}[m^{-1}]$
r_e	RESE	$10^{-9}[m^{-1}]$
λ_r	WLAMR	$1.62 \cdot 10^{-7}[s^{-1}]$
λ_1	WLAM1	$1.5 \cdot 10^{-8}[s^{-1}]$
λ_2	WLAM2	$2.38 \cdot 10^{-10}[s^{-1}]$

Table 5. Parameters for calculating the resuspension function RESUS

age [a]	cloudshine	groundshine
0	1.5	1.8
1	1.5	1.8
5	1.4	1.5
10	1.3	1.4
15	1.15	1.15
20	1.0	1.0

Table 6. Age-correction factors for external irradiation

Organ	organ dose / effective dose equivalent
breast	0.990
gonads	0.948
bone surface	1.031
lung	1.033
bone marrow	0.977
thyroid	1.148
large intestine (colon)	0.886
skin	1.097
adrenals	0.886
blad wall	0.913
brain	0.958
stomach	0.919
small intestine	0.867
kidney	0.927
liver	0.919
pancreas	0.846
spleen	0.919
thymus	0.952
ovaries	0.923
remainder	1.018
effective dose (EN)	0.989

Table 7. Ratio of organ dose to effective dose equivalent (ICRP-26) for groundshine

area	definition	actions invoked
A	geometric	sheltering followed by evacuation and / or evacuation without sheltering
B	based on dose criteria	sheltering followed by evacuation and / or evacuation without sheltering
S	based on dose criteria	sheltering without evacuation
IO	geometric and / or based on dose criteria	stable iodine tablets

Table 8. Short-term countermeasures in subsystem NE

organs	lung	red bone marrow	gastrointesti-nal tract	thyroid	effective dose
pathways	integration time				
cloudshine	----	----	----	----	----
groundshine	7 d	7 d	7 d	----	----
inhalation[1]	----	----	----	----	----
areas	intervention level (mSv)				
area B	500	500	500	----	----
area S	50	50	50	----	----

NOTE:
[1] The integration time for inhalation defines the time point up to which the committed dose is considered

Table 9. Dose criteria for areas B and S and current default values

percentage of population	residence	shielding factor	
		cloudshine	groundshine [1]
8 %	outside, rural area	1.00	1.00
8 %	outside, urban area	0.30	0.50
9 %	in buildings with low shielding	1.00	0.50
35 %	in buildings with medium shielding	0.30	0.10
40 %	in buildings with high shielding	0.01	0.01
[1]normalized to external radiation from ground surface with shielding factor of about 0.7			

Table 10. Probabilistic treatment of population behaviour in areas with no action and corresponding shielding factors

percentage of population	residence	shielding factor	
		cloudshine	groundshine [1]
10 %	outside, rural area	1.00	1.00
30 %	in cellars	0.05	0.03
15 %	in buildings with low shielding	0.30	0.10
15 %	in buildings with high shielding	0.01	0.01
30 %	in cars (spontaneous evacuation)	1.00	0.70
[1]normalized to external radiation from ground surface with shielding factor of about 0.7			

Table 11. Probabilistic treatment of population behaviour in areas A and B during sheltering period and corresponding shielding factors

population density PD (1/km^2)	percentage of population	driving time [min] for	
		R = 6 km	R = 10 km
PD $\leq$ 100	10	13	14
	40	11	12
	50	6	6
100 < PD $\leq$ 500	10	25	50
	40	18	35
	50	8	12
500 < PD $\leq$ 1000	10	70	125
	40	50	85
	50	15	15
1000 < PD	10	160	500
	40	110	290
	50	25	60

Table 12. Parameterization of driving time

ARRIVAL TIME OF THE PLUME		
(1) during initial delay	(2) during sheltering period	(3) during driving period
TIN#	TSH#	TDR#
shielding factors for population group NA, NA = 1, NAG#		
SFTIN#	SFTSH#	SFDRIV

Table 13. Assignment of shielding factors to different time periods in EARLY

exposure period NTE = TIN# + TSH# + TDR# - TANK

case 1: the plume arrives during initial delay time period

T = TIN# - TANK > 0

case 2: the plume arrives during sheltering period

T = TIN# + TSH# - TANK > 0

case 3: the plume arrives during driving period

T = TIN# + TSH# + TDR# - TANK > 0

Table 14. Calculation of reduction factors for assessing early doses and risks in areas A, B, S

Table 15. Calculation of reduction factors

exposure period NTE NTE = TIN# + TSH# + TDR# - TANK	exposure period NTE NTE = TIN# + TSH# + TDR# - TANK	exposure period NTE NTE = TIN# + TSH# + TDR# - TANK
Case 1 : TIN# - TANK > 0 T1 = TIN - TANK T2 = min(3600,T1) TI = min(3600-T2,TSH) TO = min(3600-T2-TI,TDR)	Case 2 : TIN# +TSH# - TANK > 0 T1 = TIN + TSH - TANK T2 = min(3600,T1) TO = min(3600-T2,TDR)	Case 3 : TIN# + TSH# + TDR# - TANK > 0 T1 = TIN + TSH + TDR - TANK T2 = min(3600,T1)
a) INITIAL DELAY: TAF1 = T1 * SFTIN#(IE1,NA) TAF2 = T2 * SFTIN#(IE2,NA) b) SHELTERING PERIOD: TAK1 = TSH# * SFTSH#(IE1,NA) TAK2 = TI * SFTSH#(IE2,NA) c) DRIVING PERIOD: TAR1 = TDR# * SFDRIV(IE1) TAR2 = TO * SFDRIV(IE2)	a) INITIAL DELAY: --- --- b) SHELTERING PERIOD: TAK1 = T1 * SFTSH#(IE1,NA) TAK2 = T2 * SFTSH#(IE2,NA) c) DRIVING PERIOD: TAR1 = TDR# * SFDRIV(IE1) TAR2 = TO * SFDRIV(IE2)	a) INITIAL DELAY: --- --- b) SHELTERING PERIOD: --- --- c) DRIVING PERIOD: TAR1 = T1 * SFDRIV(IE1) TAR2 = T2 * SFDRIV(IE2)
reduction factors SF: SF1 = (TAF1 + TAK1 + TAR1) / NTE SF2 = (TAF2 + TAK2 + TAR2) / 3600	reduction factors SF: SF1 = (TAK1 + TAR1) / NTE SF2 = (TAK2 + TAR2) / 3600	reduction factors SF: SF1 = TAR1 / NTE SF2 = TAR2 / 3600

	definition of area	intervention criteria, default values	model assumptions
C	isodose line DILREL	ED(GR-1a) ≥ DILREL (DILREL = 50 mSv)	normal activity; relocation assumed to occur at a fixed time point
Sh[1]	geometrically	circle with radius IMAXSH (not applied)	sheltering of all people; no other protective actions; different shielding factors for all exposure pathways possible
IO	geometrically isodose line DILIOD [2] defined in NE	circle with radius IMAXIO TH(IH-IZTH days) ≥ DILIOD (not applied)	all people take iodine tablets; user-defined reduction factor for thyroid dose from radioactive iodine

Note:
[1] countermeasure only implemented in subsystem NL
[2] dose criterion defined in subsystem NE; it can be only transferred to subsystem NL

Table 16. Implementation of long-term countermeasures, subsystems NL and FL

	definition of area	withdrawal criteria, default values	model assumptions
C_n	isodose line DILRES (DILRES ≤ DILREL)	ED(GR-nth year) ≤ DILREL (DILREL = 25 mSv)	same criterion for returning from evacuation and relocation; reduction of doses below DILRES by natural processes
D_n	isodose line DILRES*DFMAX	ED(GR-nth year) ≤ DILRES*DFMAX (25 mSv * 3)	only in evacuated and relocated areas; decontamination before resettlement; ground concentrations are reduced by DFMAX
Sh	geometrically	user-defined time-point ITSH (not applied)	

Table 17. Withdrawal of long-term countermeasures, subsystems NL and FL

		action invoked	
		relocation	resettlement
pathways and integration times	cloud gamma deposited gamma inhalation inhalation of resuspended activity	--- 0 - 365 d --- ---	--- 365 d --- ---
intervention level (mSv)		50	25

resettlement times with maximum decontamination factors											
days			years								
30	90	180	1	2	5	10	20	30	40	50	70
1.0	1.0	1.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

Table 18. Default values for long-term countermeasures model

case	scenario	description	time period	shielding factor
1	sheltering only:	- sheltering period - normal activity	- TANK to TANK + ITSH - TANK + ITSH to TANK + ITSH + IZINT	- SFSH - SFLATE
6,5	evacuation / return with (no) decontamination:	- evacuation period - no exposure - normal activity after return	- 0 to TEVA (≤ 1 day) - TEVA to KENNC(n) - KENNC(n) to IZINT	- SF... (unit 18) - 0.0 - SFLATE
8,7	evacuation / relocation / return with (no) decontamination:	- evacuation period - no exposure - normal activity after return	- 0 to TEVA (≤ 1 day) - TEVA to KENNC(n) - KENNC(n) to IZINT	- SF... (unit 18) - 0.0 - SFLATE
8,7	evacuation / relocation / no return:	- evacuation period - no exposure	- 0 to TEVA (≤ 1 day) - TEVA to ∞	- SF... (unit 18) - 0.0
4,3	relocation / return with (no) decontamination:	- normal activity until relocated - no exposure - normal activity after return	- 0 to ITUMS (≤ NT(1)) - ITUMS to KENNC - KENNC to IZINT	- SFLATE - 0.0 - SFLATE
4,3	relocation / no return:	- normal activity until relocated - no exposure	- 0 to ITUMS (≤ NT(1)) - ITUMS to ∞	- SFLATE - 0.0

Table 19. Sequence of events for calculating lifetime doses

9. Output of dose modules

9.1 Subsystem NE

```
PPPPPPPPPP      OOOOOOOOOO    TTTTTTTTTTTT  DDDDDDDDD      OOOOOOOOOO      SSSSSSSSS
PPPPPPPPPPP    OOOOOOOOOOOO   TTTTTTTTTTTT  DDDDDDDDDD    OOOOOOOOOOOO    SSSSSSSSSSS
PP         PP  OO          OO      TT      DD         DD  OO          OO  SSS        SSS
PP         PP  OO          OO      TT      DD         DD  OO          OO  SSS         SS
PP         PP  OO          OO      TT      DD         DD  OO          OO    SSS
PPPPPPPPPPP    OO          OO      TT      DD         DD  OO          OO      SSS
PPPPPPPPPP     OO          OO      TT      DD         DD  OO          OO        SSS
PP             OO          OO      TT      DD         DD  OO          OO          SSS
PP             OO          OO      TT      DD         DD  OO          OO  SS        SSS
PP             OO          OO      TT      DD         DD  OO          OO  SSS       SSS
PP             OOOOOOOOOOOO       TT      DDDDDDDDDD    OOOOOOOOOOOO    SSSSSSSSSS
PP              OOOOOOOOOO        TT      DDDDDDDDD      OOOOOOOOOO      SSSSSSSSS


 POTDOS READS THE RESULTS OBTAINED IN CONCEN
 AND CALCULATES SHORT-TIME INTEGRATED INDIVIDUAL
 ORGAN DOSES UNDER THE CONDITION OF ABSENT ACTIONS
```

Table 20. POTDOS: Title page.

```
EEEEEEEEEEE   AAAAAAAAAA   RRRRRRRRR    LL            YY          YY
EEEEEEEEEEE  AAAAAAAAAAAA  RRRRRRRRRR   LL             YY        YY
EE           AA          AA RR       RR LL              YY      YY
EE           AA          AA RR       RR LL               YY    YY
EE           AA          AA RR       RR LL                YY  YY
EEEEEEEEE    AAAAAAAAAAAA  RRRRRRRRRR   LL                 YYYY
EEEEEEEEE    AAAAAAAAAAAA  RRRRRRRRR    LL                  YY
EE           AA          AA RR    RR     LL                  YY
EE           AA          AA RR     RR    LL                  YY
EE           AA          AA RR      RR   LL                  YY
EEEEEEEEEEE  AA          AA RR       RR  LLLLLLLLLLL         YY
EEEEEEEEEEE  AA          AA RR        RR LLLLLLLLLLL         YY


          EARLY READS THE RESULTS OBTAINED IN CONCEN
 AND CALCULATES SHORT-TIME INTEGRATED ORGAN DOSES AND INDIVIDUAL
 RISKS OF NONSTOCHASTIC HEALTH EFFECTS,  TAKING INTO ACCOUNT THE
    PATTERNS OF DOSE MITIGATING ACTIONS, DETERMINED IN PROTEC
```

Table 21. EARLY: Title page.

Table 22. POTDOS: Printout of dose conversion factors.

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS FOR THE ORGAN LU
CL: SV/(BQ*S/M**3) GR: SV/(BQ/M**2) IH: SV/BQ

NUCLIDE NO.	NUCLIDE NAME	CL	GR	IH
			- 7 D	- 7 D -
25	KR- 88	0.1046E-12	0.0000E+00	0.0000E+00
28	RB- 88	0.3170E-13	0.5714E-12	0.1470E-09
83	I -131	0.1839E-13	0.1694E-09	0.6260E-09
95	CS-134	0.7608E-13	0.8169E-09	0.1250E-08
98	CS-137	0.2759E-13	0.3016E-09	0.1170E-08

.....

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS (SV/(BQ/M**2) FOR THE ORGAN SK

NUCLIDE NO.	NUCLIDE NAME	SK	SK-P
		0 D - 7 D	0 D - 7 D
28	RB- 88	0.4612E-10	0.4406E-09
83	I -131	0.1690E-07	0.0000E+00
95	CS-134	0.1670E-07	0.0000E+00
98	CS-137	0.2233E-07	0.0000E+00

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS FOR THE ORGAN BM
CL: SV/(BQ*S/M**3) GR: SV/(BQ/M**2) IH: SV/BQ

NUCLIDE NO.	NUCLIDE NAME	CL	GR	GR	GR	IH	IH	IH
			- 1 D	- 14 D	- 30 D	- 1 D	- 14 D	- 30 D
25	KR- 88	0.9510E-13	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.3075E-13	0.5404E-12	0.0000E+00	0.0000E+00	0.1450E-11	0.0000E+00	0.0000E+00
83	I -131	0.1680E-13	0.2940E-10	0.2170E-09	0.7641E-10	0.1650E-10	0.2383E-10	0.1377E-10
95	CS-134	0.7291E-13	0.1116E-09	0.1417E-08	0.1672E-08	0.8250E-10	0.1026E-08	0.1182E-08
98	CS-137	0.2519E-13	0.4109E-10	0.5248E-09	0.6275E-09	0.4770E-10	0.6431E-09	0.7492E-09

.....

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS (SV/(BQ/M**2) FOR THE ORGAN SK

NUCLIDE NO.	NUCLIDE NAME	SK	SK-P	SK	SK-P
		0 D - 1 D	0 D - 1 D	1 D - 7 D	1 D - 7 D
28	RB- 88	0.4612E-10	0.4392E-09	0.0000E+00	0.1371E-11
83	I -131	0.3274E-08	0.0000E+00	0.1363E-07	0.0000E+00
95	CS-134	0.2561E-08	0.0000E+00	0.1414E-07	0.0000E+00
98	CS-137	0.3416E-08	0.0000E+00	0.1892E-07	0.0000E+00

Table 23. EARLY: Printout of dose conversion factors.

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS FOR THE ORGAN LU

NUCLIDE NO.	NUCLIDE NAME	SV/(BQ*S/M**3) CL	SV/(BQ/M**2) GR 0D- 7D	IH: SV/BQ IH 0D- 7D
25	KR- 88	0.1046E-12	0.0000E+00	0.0000E+00
28	RB- 88	0.3170E-13	0.5714E-12	0.1470E-09
83	I -131	0.1839E-13	0.1694E-09	0.6260E-09
95	CS-134	0.7608E-13	0.8169E-09	0.1250E-08
98	CS-137	0.2759E-13	0.3016E-09	0.1170E-08

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS (SV/(BQ/M**2) FOR THE ORGAN SK

NUCLIDE NO.	NUCLIDE NAME	SK 0 D - 7 D	SK-P 0 D - 7 D
28	RB- 88	0.4612E-10	0.4406E-09
83	I -131	0.1690E-07	0.0000E+00
95	CS-134	0.1670E-07	0.0000E+00
98	CS-137	0.2233E-07	0.0000E+00

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS, GR (SV/(BQ/M**2)) FOR THE ORGAN LU

NUCL.NAME	2 HOURS	4 HOURS	6 HOURS	8 HOURS	10 HOURS	12 HOURS	18 HOURS	24 HOURS
KR- 88	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
RB- 88	0.5660E-12	0.5713E-12	0.5714E-12	0.5714E-12	0.5714E-12	0.5714E-12	0.5714E-12	0.5714E-12
I -131	0.2701E-11	0.5375E-11	0.8031E-11	0.1067E-10	0.1328E-10	0.1588E-10	0.2355E-10	0.3108E-10
CS-134	0.9862E-11	0.1970E-10	0.2953E-10	0.3936E-10	0.4920E-10	0.5901E-10	0.8845E-10	0.1180E-09
CS-137	0.3630E-11	0.7250E-11	0.1087E-10	0.1449E-10	0.1811E-10	0.2172E-10	0.3256E-10	0.4344E-10

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS FOR THE ORGAN LU

NUCLIDE NO.	NUCLIDE NAME	SV/(BQ*S/M**3) CL	SV/(BQ/M**2) GR 0D- 1D	IH: SV/BQ IH 0D- 1D	IH 1D- 14D	IH 14D-200D	IH 200D-365D
25	KR- 88	0.1046E-12	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.3170E-13	0.5714E-12	0.1470E-09	0.0000E+00	0.0000E+00	0.0000E+00
83	I -131	0.1839E-13	0.3108E-10	0.4410E-09	0.1920E-09	0.1752E-10	0.1477E-11
95	CS-134	0.7608E-13	0.1180E-09	0.5630E-09	0.1168E-08	0.5144E-08	0.3926E-08
98	CS-137	0.2759E-13	0.4344E-10	0.6200E-09	0.8635E-09	0.3634E-08	0.2832E-08

*** SHORT-TIME-INTEGRATED DOSE CONVERSION FACTORS (SV/(BQ/M**2) FOR THE ORGAN SK

NUCLIDE NO.	NUCLIDE NAME	SK 0 D - 1 D	SK-P 0 D - 1 D	SK 1 D - 7 D	SK-P 1 D - 7 D
28	RB- 88	0.4612E-10	0.4392E-09	0.0000E+00	0.1371E-11
83	I -131	0.3274E-08	0.0000E+00	0.1363E-07	0.0000E+00
95	CS-134	0.2561E-08	0.0000E+00	0.1414E-07	0.0000E+00
98	CS-137	0.3416E-08	0.0000E+00	0.1892E-07	0.0000E+00

Table 24. EARLY: Printout of individual doses, point values

```
SHORT-TIME-INTEGRATED ORGAN DOSES  ( MORBIDITY )  FOR THE WEATHER SEQUENCE NO.   1 IN SV  (SHIELDING GROUP NA = 1)
DOSES ARE INTEGRATED OVER IDTIME DAYS

RADIUS  R( 4) =     875.00 M

ORGAN NO. 1  (LU)

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.18105E-02 0.34934E-02
0.70242E-02 0.29089E-01 0.10632E+00 0.35340E+00 0.79692E+00 0.12996E+01 0.15402E+01 0.12996E+01 0.79692E+00 0.35339E+00
0.10632E+00 0.29089E-01 0.70242E-02 0.34934E-02 0.18105E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00

 ORGAN NO. 2  (TH)

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.20324E-02 0.38711E-02
0.68418E-02 0.22257E-01 0.60170E-01 0.18526E+00 0.38948E+00 0.61953E+00 0.73725E+00 0.61953E+00 0.38948E+00 0.18526E+00
0.60170E-01 0.22257E-01 0.68417E-02 0.38711E-02 0.20324E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00

  ............

ORGAN NO. 5  (TH)

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.12756E-03 0.63018E-02
0.12582E+00 0.12508E+01 0.71134E+01 0.25412E+02 0.60693E+02 0.10084E+03 0.11915E+03 0.10084E+03 0.60693E+02 0.25411E+02
0.71133E+01 0.12508E+01 0.12582E+00 0.63018E-02 0.12755E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00

ORGAN NO. 6  (SK)

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.23875E-03 0.11792E-01
0.23537E+00 0.23392E+01 0.13301E+02 0.47509E+02 0.11346E+03 0.18849E+03 0.22272E+03 0.18849E+03 0.11346E+03 0.47508E+02
0.13301E+02 0.23392E+01 0.23536E+00 0.11792E-01 0.23874E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
```

Table 25. POTDOS/EARLY: Breakdown of mean individual doses by exposure pathways

CONTRIBUTIONS (IN %) OF EXPOSURE PATHWAYS AND NUCLIDES TO MEAN INDIVIDUAL 7-DAYS ORGAN DOSES

RADIUS R(4) : 875.0 M

MORBIDITY	CLOUD-SHINE	GROUND-SHINE	INHALATION	RESUS-PENSION	CONTAM. SKIN/CL.	MEAN TOTAL DOSE (SIEVERT)
LUNG FUNCT. IMPAIRM.	4.659	10.364	84.741	0.237	0.000	0.448E-01
HYPOTHYROIDISM (EXT)	31.239	68.761	0.000	0.000	0.000	0.750E-02
CATARACTS	31.470	68.530	0.000	0.000	0.000	0.719E-02
MENTAL RETARDATION	14.208	34.485	51.187	0.120	0.000	0.120E-01
HYPOTHYROIDISM (INT)	0.000	0.000	99.700	0.300	0.000	0.516E+01
EFFECTS ON SKIN	0.000	0.000	0.000	0.000	100.000	0.950E+01

EXPOSURE PATHWAY: CLOUDSHINE

NO.	NUCLIDE	LU	TH	SK	UT	TH	SK
25	KR- 88	54.48	52.92	53.27	54.43	0.00	0.00
28	RB- 88	17.62	18.83	17.87	18.94	0.00	0.00
83	I -131	17.83	17.79	18.42	16.90	0.00	0.00
95	CS-134	10.07	10.46	10.44	9.74	0.00	0.00

EXPOSURE PATHWAY: GROUNDSHINE

NO.	NUCLIDE	LU	TH	SK	UT	TH	SK
83	I -131	70.18	70.18	70.18	70.18	0.00	0.00
95	CS-134	25.10	25.10	25.10	25.10	0.00	0.00
98	CS-137	4.72	4.72	4.72	4.72	0.00	0.00

EXPOSURE PATHWAY: INHALATION

NO.	NUCLIDE	LU	TH	SK	UT	TH	SK
83	I -131	71.28	0.00	0.00	12.29	99.91	0.00
95	CS-134	19.43	0.00	0.00	68.04	0.06	0.00
98	CS-137	9.29	0.00	0.00	19.68	0.02	0.00

EXPOSURE PATHWAY: RESUSPENSION

NO.	NUCLIDE	LU	TH	SK	UT	TH	SK
83	I -131	76.90	0.00	0.00	15.81	99.94	0.00
95	CS-134	15.63	0.00	0.00	65.30	0.05	0.00
98	CS-137	7.48	0.00	0.00	18.89	0.02	0.00

EXPOSURE PATHWAY: CON.SKIN/CLOTHES

NO.	NUCLIDE	LU	TH	SK	UT	TH	SK
28	RB- 88	0.00	0.00	0.00	0.00	0.00	0.04
83	I -131	0.00	0.00	0.00	0.00	0.00	97.78
95	CS-134	0.00	0.00	0.00	0.00	0.00	1.30
98	CS-137	0.00	0.00	0.00	0.00	0.00	0.89

Table 26. POTDOS/EARLY: Breakdown of mean individual doses by nuclides for each exposure pathway

MEAN ORGAN DOSES (SV) FOR EACH RADIUS (MORBIDITY)
DOSES ARE INTEGRATED OVER IDTIME DAYS

I	R(I), M	LU	TH	SK	UT	TH	SK
1	250.00	0.5966E+01	0.6080E+01	0.5810E+01	0.4963E+01	0.6797E+02	0.2757E+03
2	400.00	0.3150E+01	0.3246E+01	0.3102E+01	0.2644E+01	0.3133E+02	0.1263E+03
3	625.00	0.1710E+01	0.1784E+01	0.1705E+01	0.1450E+01	0.1426E+02	0.5688E+02
4	875.00	0.1088E+01	0.1146E+01	0.1095E+01	0.9293E+00	0.7726E+01	0.3047E+02
5	1150.00	0.7589E+00	0.8053E+00	0.7696E+00	0.6524E+00	0.4663E+01	0.1817E+02
6	1550.00	0.5164E+00	0.5519E+00	0.5275E+00	0.4466E+00	0.2675E+01	0.1025E+02
7	2100.00	0.3516E+00	0.3782E+00	0.3614E+00	0.3057E+00	0.1515E+01	0.5679E+01
8	2700.00	0.2566E+00	0.2773E+00	0.2650E+00	0.2240E+00	0.9455E+00	0.3462E+01
9	3700.00	0.1730E+00	0.1880E+00	0.1796E+00	0.1517E+00	0.5224E+00	0.1845E+01
10	4900.00	0.1214E+00	0.1324E+00	0.1265E+00	0.1068E+00	0.3071E+00	0.1042E+01
11	6550.00	0.8474E-01	0.9252E-01	0.8842E-01	0.7461E-01	0.1964E+00	0.6506E+00
12	8750.00	0.5892E-01	0.6433E-01	0.6148E-01	0.5188E-01	0.1370E+00	0.4539E+00
13	11500.00	0.4088E-01	0.4463E-01	0.4265E-01	0.3599E-01	0.9545E-01	0.3163E+00
14	15500.00	0.2857E-01	0.3119E-01	0.2980E-01	0.2515E-01	0.6672E-01	0.2211E+00
15	21000.00	0.1853E-01	0.2023E-01	0.1933E-01	0.1631E-01	0.4333E-01	0.1436E+00
16	27000.00	0.1191E-01	0.1300E-01	0.1242E-01	0.1048E-01	0.2812E-01	0.9327E-01
17	37000.00	0.7212E-02	0.7873E-02	0.7524E-02	0.6348E-02	0.1708E-01	0.5670E-01
18	49000.00	0.3645E-02	0.3978E-02	0.3802E-02	0.3207E-02	0.8833E-02	0.2938E-01
19	65500.00	0.1800E-02	0.1964E-02	0.1877E-02	0.1583E-02	0.4452E-02	0.1486E-01
20	87500.00	0.5525E-03	0.6027E-03	0.5760E-03	0.4857E-03	0.1416E-02	0.4759E-02

Table 27. POTDOS: Distance-dependent mean individual doses

MEAN ORGAN DOSES (SV) FOR EACH RADIUS AND THE SHIELDING GROUP NA = 1 (MORBIDITY)
DOSES ARE INTEGRATED OVER IDTIME DAYS

I	R(I), M	LU	TH	SK	UT	TH	SK
1	250.00	0.6889E+00	0.2432E+00	0.2330E+00	0.2669E+00	0.6406E+02	0.1202E+03
2	400.00	0.3344E+00	0.1322E+00	0.1267E+00	0.1385E+00	0.2934E+02	0.5501E+02
3	625.00	0.1626E+00	0.7275E-01	0.6972E-01	0.7277E-01	0.1322E+02	0.2475E+02
4	875.00	0.9355E-01	0.4606E-01	0.4414E-01	0.4458E-01	0.7084E+01	0.1324E+02
5	1150.00	0.5966E-01	0.3173E-01	0.3041E-01	0.2996E-01	0.4226E+01	0.7885E+01
6	1550.00	0.3654E-01	0.2110E-01	0.2021E-01	0.1944E-01	0.2385E+01	0.4438E+01
7	2100.00	0.2232E-01	0.1397E-01	0.1339E-01	0.1259E-01	0.1322E+01	0.2452E+01
8	2700.00	0.1484E-01	0.9882E-02	0.9464E-02	0.8767E-02	0.8069E+00	0.1490E+01
9	3700.00	0.8930E-02	0.6396E-02	0.6124E-02	0.5576E-02	0.4306E+00	0.7898E+00
10	4900.00	0.5678E-02	0.4316E-02	0.4131E-02	0.3712E-02	0.2434E+00	0.4430E+00
11	6550.00	0.1704E-01	0.1763E-01	0.1685E-01	0.1433E-01	0.1595E+00	0.3241E+00
12	8750.00	0.1033E-01	0.1058E-01	0.1011E-01	0.8614E-02	0.1104E+00	0.2223E+00
13	11500.00	0.6240E-02	0.6309E-02	0.6032E-02	0.5147E-02	0.7644E-01	0.1522E+00
14	15500.00	0.1675E-01	0.1811E-01	0.1731E-01	0.1462E-01	0.6023E-01	0.1047E+00
15	21000.00	0.1030E-01	0.1113E-01	0.1064E-01	0.8988E-02	0.3881E-01	0.7148E-01
16	27000.00	0.1191E-01	0.1300E-01	0.1242E-01	0.1048E-01	0.2812E-01	0.4419E-01
17	37000.00	0.7212E-02	0.7873E-02	0.7524E-02	0.6348E-02	0.1708E-01	0.2521E-01
18	49000.00	0.3645E-02	0.3978E-02	0.3802E-02	0.3207E-02	0.8833E-02	0.1205E-01
19	65500.00	0.1800E-02	0.1964E-02	0.1877E-02	0.1583E-02	0.4452E-02	0.9438E-02
20	87500.00	0.5525E-03	0.6027E-03	0.5760E-03	0.4857E-03	0.1416E-02	0.4759E-02

Table 28. EARLY: Distance-dependent mean individual doses

Table 29. EARLY/POTDOS-EVADOS: Information about input parameter values

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                RESULTS OF THE EVALUATION PROGRAM FOR THE INDIVIDUAL ORGAN DOSES

                   CALCULATED IN THE MODULES POTDOS AND EARLY, RESPECTIVELY

                                   SUBROUTINE EVADOS


                          THE DOSES EVALUATED ARE INTEGRATED OVER   7 DAYS


*****  PRINTOUT OF THE INPUT  *****

       NDSMIN:  -6
       NDEKAD:   9
       MAXI:    20

       IORGNR(IOR):            1           0           0           0           0           0
       IORGNR(IOR):            1           0           0           0           0

       DUYFS1(IOR):   0.2500E+01  0.2000E+01  0.1000E+01  0.1000E+00  0.1000E+02  0.2300E+02
       DOYFS1(IOR):   0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31

       DUYFS2(IOR):   0.5000E+01  0.2300E+01  0.1000E+02  0.1000E+00  0.2300E+02
       DOYFS2(IOR):   0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31


       EVALUATION INTERVALS:

       LOWER LIMIT FOR DOSES:    0.1000E-05 SV
       UPPER LIMIT FOR DOSES:    0.1000E+04 SV


       A PRINTOUT OF CCFDS IS GIVEN FOR THE RADII DEFINED BY IACT:
                    ICCFD =  1
                    IACT  =  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0


LEGEND FOR THE PRINTOUT OF THE EVALUATION PROGRAM
-------------------------------------------------

VALUE = DOSES      :   INDIVIDUAL ORGAN DOSES

MAX. VALUE :           MAXIMAL VALUE DETERMINED IN THE CALCULATIONS
MEAN VALUE :           MEAN VALUE, AVERAGED OVER WEATHER SEQUENCES, AZIMUTHAL SECTORS, POPULATION
                       GROUPS AND DRIVING TIME CLASSES
SUM P (JUSED) :        PROBABILITY FOR GRID ELEMENTS AFFECTED BY THE PLUME
SUM P < ...MIN :       PROBABILITY FOR VALUES < ...MIN AT GRID ELEMENTS AFFECTED BY THE PLUME
SU P DU=    DO= :      PROBABILITY FOR VALUES IN THE INTERVAL FROM DU TO DO
FRACTILE 99.0 :        99.0%-FRACTILE VALUE
```

Table 30. POTDOS/EARLY-EVADOS: Statistical quantities of individual doses

********** MORBIDITY **********

EVALUATION OF THE DISTRIBUTION OF ACUTE INDIVIDUAL DOSES FOR LUNG FUNCT. IMP.

RADIUS (M)	250.0	400.0	625.0	875.0	1150.0	1550.0
WEATHER S.(MAX DOSE)	1	1	1	1	1	1
MAX. DOSES	0.8582E+01	0.4619E+01	0.2492E+01	0.1540E+01	0.1050E+01	0.6865E+00
MEAN DOSES	0.3840E+00	0.1786E+00	0.8212E-01	0.4480E-01	0.2717E-01	0.1563E-01
SUM P (JUSED)	0.2917E+00	0.2639E+00	0.2361E+00	0.2361E+00	0.2083E+00	0.2083E+00
SUM P < DOSMIN	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SU P DU=.3E+01 DO=.1E+31	0.6806E-01	0.3194E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
FRACTILE 99.9	0.8582E+01	0.4619E+01	0.2492E+01	0.1540E+01	0.1050E+01	0.6865E+00
FRACTILE 99.0	0.6166E+01	0.3162E+01	0.1585E+01	0.9332E+00	0.5888E+00	0.3631E+00
FRACTILE 95.0	0.3715E+01	0.1660E+01	0.7079E+00	0.3548E+00	0.2042E+00	0.1047E+00
FRACTILE 90.0	0.7943E+00	0.2818E+00	0.1202E+00	0.5623E-01	0.2512E-01	0.9550E-02
FRACTILE 50.0	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01

RADIUS (M)	2100.0	2700.0	3700.0	4900.0	6550.0	8750.0
WEATHER S.(MAX DOSE)	1	1	1	1	1	1
MAX. DOSES	0.4502E+00	0.3167E+00	0.2041E+00	0.1386E+00	0.4206E+00	0.2491E+00
MEAN DOSES	0.8895E-02	0.5572E-02	0.3099E-02	0.1846E-02	0.3969E-02	0.2442E-02
SUM P (JUSED)	0.1806E+00	0.1806E+00	0.1806E+00	0.1528E+00	0.1528E+00	0.1250E+00
SUM P < DOSMIN	0.0000E+00	0.0000E+00	0.2083E-01	0.4583E-01	0.2361E-01	0.1250E-01
SU P DU=.3E+01 DO=.1E+31	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
FRACTILE 99.9	0.4502E+00	0.3167E+00	0.2041E+00	0.1386E+00	0.4206E+00	0.2491E+00
FRACTILE 99.0	0.2188E+00	0.1413E+00	0.8318E-01	0.5129E-01	0.8128E-01	0.5623E-01
FRACTILE 95.0	0.5370E-01	0.2951E-01	0.1349E-01	0.6457E-02	0.2344E-01	0.1175E-01
FRACTILE 90.0	0.3388E-02	0.1380E-02	0.9772E-04	0.4365E-05	0.2570E-03	0.7586E-04
FRACTILE 50.0	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01

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RADIUS (M)	65500.0	87500.0
WEATHER S.(MAX DOSE)	1	1
MAX. DOSES	0.7687E-01	0.2498E-01
MEAN DOSES	0.3920E-03	0.1216E-03
SUM P (JUSED)	0.9722E-01	0.6944E-01
SUM P < DOSMIN	0.2083E-01	0.0000E+00
SU P DU=.3E+01 DO=.1E+31	0.0000E+00	0.0000E+00
FRACTILE 99.9	0.7687E-01	0.2498E-01
FRACTILE 99.0	0.1318E-01	0.3715E-02
FRACTILE 95.0	0.1047E-03	0.1995E-04
FRACTILE 90.0	-0.1000E+01	-0.1000E+01
FRACTILE 50.0	-0.1000E+01	-0.1000E+01

Table 31. POTDOS/EARLY-EVADOS: CCFDs for the organ doses evaluated

CCFDS OF INDIVIDUAL ORGAN DOSES FOR THE RADIUS 875.00 M (MORBIDITY)

INTERVAL	LUNG FUNCT. IMP.	HYPOTHYROID.,EXT	CATARACTS	MENTAL RETARDAT.	HYPOTHYROID.,INT	EFFECTS ON SKIN
>= 0.1000E-05	0.2361	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1122E-05	0.2361	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1259E-05	0.2361	0.0000	0.0000	0.0000	0.0000	0.0000
.....						
>= 0.1259E-04	0.2361	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1413E-04	0.2361	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1585E-04	0.2361	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1778E-04	0.2361	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1995E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.2239E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.2512E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.2818E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.3162E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.3548E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.3981E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.4467E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.5012E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.5623E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.6310E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.7079E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.7943E-04	0.2319	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.8912E-04	0.2278	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1000E-03	0.2194	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1122E-03	0.2194	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1259E-03	0.2194	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1413E-03	0.2194	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1585E-03	0.2194	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1778E-03	0.2194	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.1995E-03	0.2111	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.2239E-03	0.2028	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.2512E-03	0.2028	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.2818E-03	0.2028	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.3162E-03	0.2028	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.3548E-03	0.2028	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.3981E-03	0.1944	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.4467E-03	0.1944	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.5012E-03	0.1944	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.5623E-03	0.1903	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.6310E-03	0.1903	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.7079E-03	0.1819	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.7943E-03	0.1819	0.0000	0.0000	0.0000	0.0000	0.0000
.....						
>= 0.7943E+03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>= 0.8912E+03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

```
LL              AAAAAAAAAA   TTTTTTTTTTTT  DDDDDDDDD     0000000000     SSSSSSSSS
LL             AAAAAAAAAAAA  TTTTTTTTTTTT  DDDDDDDDDD   000000000000   SSSSSSSSSS
LL             AA        AA      TT        DD       DD  00        00  SSS       SSS
LL             AA        AA      TT        DD       DD  00        00  SSS        SS
LL             AA        AA      TT        DD       DD  00        00   SSS
LL             AAAAAAAAAAAA      TT        DD       DD  00        00     SSS
LL             AAAAAAAAAAAA      TT        DD       DD  00        00       SSS
LL             AA        AA      TT        DD       DD  00        00         SSS
LL             AA        AA      TT        DD       DD  00        00  SS       SSS
LL             AA        AA      TT        DD       DD  00        00  SSS      SSS
LLLLLLLLLLLL   AA        AA      TT        DDDDDDDDDD   000000000000   SSSSSSSSSS
LLLLLLLLLLLL   AA        AA      TT        DDDDDDDDD     0000000000     SSSSSSSSS

   LATDOS READS THE RESULTS OBTAINED IN CONCEN
   AND CALCULATES INDIVIDUAL LIFETIME ORGAN DOSES TAKING
   INTO ACCOUNT THE PATTERNS OF DOSE MITIGATING ACTIONS
   DETERMINED IN PROTEC

THE FOLLOWING MEAN SHIELDING FACTORS ARE CONSIDERED:

                FOR CLOUDSHINE   (CL):        0.300   (= SFLATE(1))
                FOR GROUNDSHINE  (GR):        0.200   (= SFLATE(2))
                FOR INHALATION   (IH):        1.000   (= SFLATE(3))
                FOR RESUSPENSION (IHR):       1.000   (= SFLATE(5))
                FOR SKIN CONTAM. (SK):        1.000   (= SFLATE(6))

BREATHING RATE, INHALATION (ARATIH) :    0.2667E-03 M**3/S

BREATHING RATE, RESUSPENSION (ARATIR) :  0.2667E-03 M**3/S

FOR INGESTION LOCAL PRODUCTION AND CONSUMPTION METHOD IS ASSUMED (CIGCOL) : L-P&C

BIOLOGICAL HALFLIFE FOR SKIN CONTAMINATION (TBIO) :  30.00 DAYS
INTEGRATION TIME FOR SKIN DOSES (TSKIN) :             3.00 DAYS
PART OF THE SKIN CONTAMINATED   (PSKIN) :             0.10

INTEGRATION TIME FOR DOSES (IZINT) = 70 A
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Table 32. LATDOS: Title page with information about input parameter values

Table 33. LATDOS: Printout of dose conversion factors (integration time IZINT)

********** 70-A DOSE CONVERSION FACTORS FOR THE ORGAN BM

NUCLIDE NO.	NUCLIDE NAME	CL SV/(BQ*S/M**3)	GR SV/(BQ/M**2)	IH SV/BQ	GR1D SV/(BQ/M**2)	GRSHD SV/(BQ/M**2)
25	KR- 88	0.9510E-13	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.3075E-13	0.5404E-12	0.1450E-11	0.5404E-12	0.5404E-12
83	I -131	0.1680E-13	0.3476E-09	0.5730E-10	0.2940E-10	0.2940E-10
95	CS-134	0.7291E-13	0.5371E-07	0.1170E-07	0.1116E-09	0.1116E-09
98	CS-137	0.2519E-13	0.6931E-07	0.8230E-08	0.4109E-10	0.4109E-10

********** 70-A DOSE CONVERSION FACTORS FOR THE ORGAN BS

NUCLIDE NO.	NUCLIDE NAME	CL SV/(BQ*S/M**3)	GR SV/(BQ/M**2)	IH SV/BQ	GR1D SV/(BQ/M**2)	GRSHD SV/(BQ/M**2)
25	KR- 88	0.1014E-12	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.3170E-13	0.5703E-12	0.1470E-11	0.5703E-12	0.5703E-12
83	I -131	0.2282E-13	0.3668E-09	0.5240E-10	0.3102E-10	0.3102E-10
95	CS-134	0.8559E-13	0.5668E-07	0.1080E-07	0.1177E-09	0.1177E-09
98	CS-137	0.2999E-13	0.7314E-07	0.7880E-08	0.4336E-10	0.4336E-10

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********** 70-A DOSE CONVERSION FACTORS FOR THE ORGAN EO

NUCLIDE NO.	NUCLIDE NAME	CL SV/(BQ*S/M**3)	GR SV/(BQ/M**2)	IH SV/BQ	GR1D SV/(BQ/M**2)	GRSHD SV/(BQ/M**2)
25	KR- 88	0.1008E-12	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.3217E-13	0.5531E-12	0.2259E-10	0.5531E-12	0.5531E-12
83	I -131	0.1800E-13	0.3558E-09	0.8139E-08	0.3009E-10	0.3009E-10
95	CS-134	0.7570E-13	0.5497E-07	0.1221E-07	0.1142E-09	0.1142E-09
98	CS-137	0.2687E-13	0.7094E-07	0.8483E-08	0.4205E-10	0.4205E-10

********** DOSE CONVERSION FACTORS (SV/(BQ/M**2)) FOR CONTAMINATION OF SKIN AND CLOTHES
INTEGRATED OVER 1 DAY AND 3.00 (=TSKIN) DAYS

NUCLIDE NO.	NUCLIDE NAME	SK	SK-P	SK	SK-P
28	RB- 88	0.4612E-10	0.4392E-09	0.4612E-10	0.4406E-09
83	I -131	0.3274E-08	0.0000E+00	0.8838E-08	0.0000E+00
95	CS-134	0.2561E-08	0.0000E+00	0.7502E-08	0.0000E+00
98	CS-137	0.3416E-08	0.0000E+00	0.1002E-07	0.0000E+00

Table 34. LATDOS: Printout of dose conversion factors (integration times NT days)

******* TIME-INTEGRATED DOSE CONVERSION FACTORS (GR, SV/(BQ/M**2)) FOR THE ORGAN BM

NUCNO.	NUCNAM	30 D	90 D	180 D	365 D	730 D	1825 D	3650 D
25	KR- 88	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.5404E-12	0.5404E-12	0.5404E-12	0.5404E-12	0.5404E-12	0.5404E-12	0.5404E-12
83	I -131	0.3228E-09	0.3475E-09	0.3476E-09	0.3476E-09	0.3476E-09	0.3476E-09	0.3476E-09
95	CS-134	0.3201E-08	0.8888E-08	0.1594E-07	0.2647E-07	0.3816E-07	0.4972E-07	0.5316E-07
98	CS-137	0.1193E-08	0.3397E-08	0.6308E-08	0.1118E-07	0.1795E-07	0.2960E-07	0.4084E-07

******* TIME-INTEGRATED DOSE CONVERSION FACTORS (GR, SV/(BQ/M**2)) FOR THE ORGAN BM

NUCNO.	NUCNAM	7300 D	10950 D	14600 D	18250 D	25550 D
25	KR- 88	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.5404E-12	0.5404E-12	0.5404E-12	0.5404E-12	0.5404E-12
83	I -131	0.3476E-09	0.3476E-09	0.3476E-09	0.3476E-09	0.3476E-09
95	CS-134	0.5369E-07	0.5371E-07	0.5371E-07	0.5371E-07	0.5371E-07
98	CS-137	0.5340E-07	0.6019E-07	0.6418E-07	0.6665E-07	0.6931E-07

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******* TIME-INTEGRATED DOSE CONVERSION FACTORS (GR, SV/(BQ/M**2)) FOR THE ORGAN EO

NUCNO.	NUCNAM	30 D	90 D	180 D	365 D	730 D	1825 D	3650 D
25	KR- 88	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.5531E-12	0.5531E-12	0.5531E-12	0.5531E-12	0.5531E-12	0.5531E-12	0.5531E-12
83	I -131	0.3304E-09	0.3557E-09	0.3558E-09	0.3558E-09	0.3558E-09	0.3558E-09	0.3558E-09
95	CS-134	0.3276E-08	0.9098E-08	0.1631E-07	0.2709E-07	0.3906E-07	0.5089E-07	0.5441E-07
98	CS-137	0.1221E-08	0.3477E-08	0.6457E-08	0.1144E-07	0.1838E-07	0.3030E-07	0.4180E-07

******* TIME-INTEGRATED DOSE CONVERSION FACTORS (GR, SV/(BQ/M**2)) FOR THE ORGAN EO

NUCNO.	NUCNAM	7300 D	10950 D	14600 D	18250 D	25550 D
25	KR- 88	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.5531E-12	0.5531E-12	0.5531E-12	0.5531E-12	0.5531E-12
83	I -131	0.3558E-09	0.3558E-09	0.3558E-09	0.3558E-09	0.3558E-09
95	CS-134	0.5496E-07	0.5497E-07	0.5497E-07	0.5497E-07	0.5497E-07
98	CS-137	0.5466E-07	0.6161E-07	0.6569E-07	0.6822E-07	0.7094E-07

Table 35. POTDOS/LATDOS: Printout of individual doses, point values

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INDIVIDUAL  70-A ORGAN DOSES FOR THE WEATHER SEQUENCE NO.   1 IN SV


RADIUS  R( 1) =     0.250 KM

EFFECT NO. 1  (BM)

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.13872E-01 0.26344E-01 0.64527E-01 0.29043E+00
0.74368E+00 0.22624E+01 0.58879E+01 0.11929E+02 0.19368E+02 0.25686E+02 0.28213E+02 0.25686E+02 0.19368E+02 0.11929E+02
0.58878E+01 0.22624E+01 0.74367E+00 0.29043E+00 0.64526E-01 0.26344E-01 0.13872E-01 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00

EFFECT NO. 2  (BS)

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.14244E-01 0.27766E-01 0.65445E-01 0.28965E+00
0.74490E+00 0.22652E+01 0.58909E+01 0.11934E+02 0.19376E+02 0.25696E+02 0.28227E+02 0.25696E+02 0.19376E+02 0.11934E+02
0.58908E+01 0.22652E+01 0.74489E+00 0.28965E+00 0.65443E-01 0.27766E-01 0.14244E-01 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00

 ...............

EFFECT NO.12  (EO)

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.14708E-01 0.29096E-01 0.91430E-01 0.50662E+00
0.18402E+01 0.61314E+01 0.15984E+02 0.32354E+02 0.52462E+02 0.69550E+02 0.76336E+02 0.69550E+02 0.52462E+02 0.32353E+02
0.15984E+02 0.61314E+01 0.18401E+01 0.50662E+00 0.91428E-01 0.29096E-01 0.14708E-01 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00

EFFECT NO.13  (SK)

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.15983E-03 0.61324E-02 0.96847E-01 0.80599E+00
0.41460E+01 0.14654E+02 0.38232E+02 0.77316E+02 0.12524E+03 0.16598E+03 0.18208E+03 0.16598E+03 0.12524E+03 0.77315E+02
0.38231E+02 0.14654E+02 0.41459E+01 0.80599E+00 0.96844E-01 0.61324E-02 0.15983E-03 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
```

Table 36. POTDOS/LATDOS: Breakdown of mean individual doses by exposure pathways

CONTRIBUTIONS (IN %) OF EXPOSURE PATHWAYS AND NUCLIDES TO MEAN 70 A-ORGAN DOSES

RADIUS R(1) : 0.250 KM

	CLOUD-SHINE	GROUND-SHINE	INHALATION	INGESTION	RESUS-PENSION	MEAN TOTAL DOSE (SV)
BONE MARROW	0.640	54.625	42.358	0.260	2.117	0.223E+01
BONE SURFACE	0.719	57.617	39.447	0.247	1.971	0.223E+01
BREAST	0.746	56.424	40.545	0.250	2.036	0.219E+01
LUNG	0.597	49.845	46.765	0.214	2.580	0.259E+01
STOMACH	0.639	51.821	45.008	0.276	2.256	0.221E+01
COLON	0.601	49.145	47.611	0.282	2.360	0.225E+01
LIVER	0.640	51.753	45.093	0.272	2.242	0.222E+01
PANCREAS	0.646	50.730	46.050	0.283	2.291	0.208E+01
THYROID	0.014	1.141	91.993	0.005	6.847	0.126E+03
GONADS	0.620	53.927	43.052	0.266	2.135	0.219E+01
REMAINDER	0.640	52.116	44.743	0.260	2.241	0.244E+01
EFFECT. DOSE	0.250	20.698	73.846	0.098	5.109	0.603E+01

Table 37. POTDOS/LATDOS: Breakdown of mean individual doses by nuclides for each exposure pathway

EXPOSURE PATHWAY: CLOUDSHINE

NO.	NUCLIDE	BM	BS	BR	LU	ST	LI	LV	PA	TH	GO	RE	EO
25	KR- 88	52.96	50.28	52.51	53.93	53.49	54.07	53.38	54.38	52.37	53.77	52.99	53.09
28	RB- 88	18.66	17.12	18.51	17.81	18.65	18.70	18.81	18.60	19.03	18.79	18.49	18.47
83	I -131	17.90	21.65	18.62	18.14	17.74	17.13	17.71	16.87	18.10	17.39	18.18	18.14
95	CS-134	10.48	10.95	10.36	10.12	10.12	10.10	10.10	10.16	10.51	10.05	10.34	10.29

EXPOSURE PATHWAY: GROUNDSHINE

NO.	NUCLIDE	BM	BS	BR	LU	ST	LI	LV	PA	TH	GO	RE	EO
83	I -131	71.34	71.34	71.34	71.34	71.34	71.34	71.34	71.34	71.34	71.34	71.34	71.34
95	CS-134	23.93	23.93	23.93	23.93	23.93	23.93	23.93	23.93	23.93	23.93	23.93	23.93
98	CS-137	4.73	4.73	4.73	4.73	4.73	4.73	4.73	4.73	4.73	4.73	4.73	4.73

EXPOSURE PATHWAY: INHALATION

NO.	NUCLIDE	BM	BS	BR	LU	ST	LI	LV	PA	TH	GO	RE	EO
83	I -131	2.60	2.55	3.54	23.14	3.18	1.04	1.60	1.70	99.23	1.06	3.07	78.48
95	CS-134	71.65	70.99	70.44	55.53	71.50	74.05	73.01	72.50	0.56	72.95	72.52	15.88
98	CS-137	25.75	26.46	26.02	21.32	25.33	24.90	25.39	25.80	0.20	25.99	24.42	5.63

EXPOSURE PATHWAY: INGESTION

NO.	NUCLIDE	BM	BS	BR	LU	ST	LI	LV	PA	TH	GO	RE	EO
83	I -131	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.86	0.00	0.00	0.15
95	CS-134	4.49	4.38	4.39	4.38	4.56	4.81	4.67	4.57	4.25	4.55	4.82	4.59
98	CS-137	95.50	95.61	95.61	95.61	95.43	95.19	95.33	95.43	90.89	95.45	95.18	95.27

EXPOSURE PATHWAY: RESUSPENSION

NO.	NUCLIDE	BM	BS	BR	LU	ST	LI	LV	PA	TH	GO	RE	EO
83	I -131	3.89	3.81	5.27	31.30	4.73	1.57	2.40	2.55	99.49	1.59	4.57	84.66
95	CS-134	70.64	70.00	69.11	49.58	70.28	73.59	72.34	71.80	0.37	72.49	71.32	11.31
98	CS-137	25.48	26.19	25.62	19.11	24.99	24.84	25.26	25.65	0.14	25.92	24.11	4.03

Table 38. POTDOS/LATDOS: Distance-dependent mean individual doses

MEAN INDIVIDUAL ORGAN DOSES (SV) FOR EACH RADIUS

I	R(I), KM	BM	BS	BR	LU	ST	LI	LV
1	0.250	0.2233E+01	0.2234E+01	0.2190E+01	0.2587E+01	0.2214E+01	0.2251E+01	0.2217E+01
2	0.400	0.1134E+01	0.1139E+01	0.1115E+01	0.1302E+01	0.1120E+01	0.1134E+01	0.1121E+01
3	0.625	0.5841E+00	0.5899E+00	0.5763E+00	0.6647E+00	0.5743E+00	0.5790E+00	0.5749E+00
4	0.875	0.3588E+00	0.3639E+00	0.3550E+00	0.4047E+00	0.3515E+00	0.3530E+00	0.3519E+00
5	1.150	0.2447E+00	0.2490E+00	0.2425E+00	0.2738E+00	0.2390E+00	0.2393E+00	0.2392E+00
6	1.550	0.1660E+00	0.1693E+00	0.1647E+00	0.1836E+00	0.1617E+00	0.1614E+00	0.1618E+00
7	2.100	0.1082E+00	0.1108E+00	0.1077E+00	0.1190E+00	0.1050E+00	0.1044E+00	0.1050E+00
8	2.700	0.7972E-01	0.8179E-01	0.7938E-01	0.8698E-01	0.7725E-01	0.7667E-01	0.7727E-01
9	3.700	0.5721E-01	0.5864E-01	0.5690E-01	0.6155E-01	0.5556E-01	0.5512E-01	0.5551E-01
10	4.900	0.3899E-01	0.4011E-01	0.3887E-01	0.4185E-01	0.3772E-01	0.3731E-01	0.3770E-01
11	6.550	0.3010E-01	0.3086E-01	0.2993E-01	0.3199E-01	0.2925E-01	0.2899E-01	0.2920E-01
12	8.750	0.2306E-01	0.2357E-01	0.2288E-01	0.2436E-01	0.2248E-01	0.2232E-01	0.2243E-01
13	11.500	0.2042E-01	0.2074E-01	0.2017E-01	0.2129E-01	0.2006E-01	0.2001E-01	0.1999E-01
14	15.500	0.1722E-01	0.1734E-01	0.1691E-01	0.1773E-01	0.1710E-01	0.1715E-01	0.1701E-01
15	21.000	0.1157E-01	0.1171E-01	0.1140E-01	0.1197E-01	0.1142E-01	0.1140E-01	0.1136E-01
16	27.000	0.1169E-01	0.1168E-01	0.1141E-01	0.1184E-01	0.1171E-01	0.1180E-01	0.1163E-01
17	37.000	0.8722E-02	0.8789E-02	0.8566E-02	0.8894E-02	0.8659E-02	0.8680E-02	0.8611E-02
18	49.000	0.5794E-02	0.5787E-02	0.5656E-02	0.5841E-02	0.5810E-02	0.5859E-02	0.5769E-02
19	65.500	0.3595E-02	0.3584E-02	0.3505E-02	0.3611E-02	0.3613E-02	0.3650E-02	0.3587E-02
20	87.500	0.5509E-02	0.5689E-02	0.5499E-02	0.5711E-02	0.5317E-02	0.5236E-02	0.5309E-02

I	R(I), KM	PA	TH	GO	RE	EO	SK
1	0.250	0.2082E+01	0.1256E+03	0.2195E+01	0.2438E+01	0.6031E+01	0.1438E+02
2	0.400	0.1052E+01	0.5809E+02	0.1113E+01	0.1234E+01	0.2889E+01	0.6583E+01
3	0.625	0.5384E+00	0.2656E+02	0.5729E+00	0.6329E+00	0.1386E+01	0.2965E+01
4	0.875	0.3291E+00	0.1446E+02	0.3517E+00	0.3874E+00	0.7952E+00	0.1588E+01
5	1.150	0.2235E+00	0.8779E+01	0.2397E+00	0.2634E+00	0.5093E+00	0.9472E+00
6	1.550	0.1511E+00	0.5078E+01	0.1625E+00	0.1780E+00	0.3187E+00	0.5343E+00
7	2.100	0.9790E-01	0.2903E+01	0.1058E+00	0.1157E+00	0.1954E+00	0.2960E+00
8	2.700	0.7203E-01	0.1831E+01	0.7797E-01	0.8505E-01	0.1346E+00	0.1805E+00
9	3.700	0.5185E-01	0.1031E+01	0.5602E-01	0.6093E-01	0.8794E-01	0.9619E-01
10	4.900	0.3515E-01	0.6158E+00	0.3814E-01	0.4143E-01	0.5729E-01	0.5430E-01
11	6.550	0.2730E-01	0.4006E+00	0.2949E-01	0.3201E-01	0.4195E-01	0.3392E-01
12	8.750	0.2102E-01	0.2815E+00	0.2262E-01	0.2452E-01	0.3136E-01	0.2366E-01
13	11.500	0.1882E-01	0.2009E+00	0.2008E-01	0.2176E-01	0.2629E-01	0.1649E-01
14	15.500	0.1610E-01	0.1432E+00	0.1700E-01	0.1842E-01	0.2137E-01	0.1153E-01
15	21.000	0.1072E-01	0.9355E-01	0.1140E-01	0.1234E-01	0.1428E-01	0.7489E-02
16	27.000	0.1107E-01	0.6516E-01	0.1157E-01	0.1252E-01	0.1353E-01	0.4863E-02
17	37.000	0.8153E-02	0.4165E-01	0.8613E-02	0.9320E-02	0.9888E-02	0.2956E-02
18	49.000	0.5493E-02	0.2276E-01	0.5741E-02	0.6212E-02	0.6417E-02	0.1532E-02
19	65.500	0.3419E-02	0.1217E-01	0.3565E-02	0.3860E-02	0.3923E-02	0.7751E-03
20	87.500	0.4947E-02	0.9639E-02	0.5393E-02	0.5824E-02	0.5742E-02	0.2483E-03

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 CCCCCCCCCCC   OOOOOOOOOO   LL            LL            EEEEEEEEEEE   CCCCCCCCCCC
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CC            OO        OO  LL            LL            EE           CC
CC            OO        OO  LL            LL            EEEEEEEEE    CC
CC            OO        OO  LL            LL            EEEEEEEEE    CC
CC            OO        OO  LL            LL            EE           CC
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 COLLEC READS THE RESULTS OBTAINED IN POTDOS AND LATDOS, RESPECTIVELY
 AND DETERMINES THE COLLECTIVE ORGAN DOSES

             SUBROUTINE COLDOS


      RRRRR   EEEEEE   SSSS    U     U  L      TTTTTTT   SSSS
      R    R  E       S    S   U     U  L         T     S    S
      R    R  E       S        U     U  L         T     S
      RRRRR   EEEEE    SSSS    U     U  L         T      SSSS
      R RR    E            S   U     U  L         T          S
      R  RR   E       S    S   U     U  L         T     S    S
      R   RR  EEEEEE   SSSS    UUUUUUU  LLLLLL    T      SSSS


                O F   M O D U L E   C O L L E C

          INTEGRATION TIME FOR DOSES (IZINT) = 70 A

          DISTANCES CONSIDERED UP TO IRMAX   = 18
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Table 39. COLLEC-COLDOS: Title page with information about input parameter values

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COLLECTIVE DOSE FOR THE RADIUS  R( 1) =     0.250 KM FOR WEATHER SEQUENCE NO.   1 AND SITE NO.   1

ORGAN NO.  1  (BM)     TOTAL COLLECTIVE DOSE FOR THE RADIUS =  0.00000E+00

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
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ORGAN NO.  2  (BS)     TOTAL COLLECTIVE DOSE FOR THE RADIUS =  0.00000E+00

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ORGAN NO. 12  (EO)     TOTAL COLLECTIVE DOSE FOR THE RADIUS =  0.00000E+00

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
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ORGAN NO. 13  (SK)     TOTAL COLLECTIVE DOSE FOR THE RADIUS =  0.00000E+00

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Table 40. COLLEC-COLDOS: Printout of collective doses, point values

Table 41. COLLEC-COLDOS: Distance-dependent mean collective doses

MEAN COLLECTIVE DOSE FOR EACH RADIUS

NO.	RADIUS (KM)	BONE MARROW	BONE SURFACE	BREAST	LUNG	STOMACH	COLON
1	0.25000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
2	0.40000E+00	0.10880E+03	0.10931E+03	0.53506E+02	0.12500E+03	0.10749E+03	0.10887E+03
3	0.62500E+00	0.12616E+03	0.12741E+03	0.62243E+02	0.14358E+03	0.12404E+03	0.12507E+03
4	0.87500E+00	0.11195E+03	0.11352E+03	0.55368E+02	0.12625E+03	0.10966E+03	0.11014E+03
5	0.11500E+01	0.11746E+03	0.11950E+03	0.58205E+02	0.13140E+03	0.11471E+03	0.11484E+03
6	0.15500E+01	0.17922E+03	0.18282E+03	0.88935E+02	0.19831E+03	0.17464E+03	0.17433E+03
7	0.21000E+01	0.18433E+03	0.18884E+03	0.91713E+02	0.20284E+03	0.17884E+03	0.17783E+03
8	0.27000E+01	0.24296E+03	0.24928E+03	0.12097E+03	0.26509E+03	0.23545E+03	0.23367E+03
9	0.37000E+01	0.28968E+03	0.29691E+03	0.14407E+03	0.31167E+03	0.28132E+03	0.27912E+03
10	0.49000E+01	0.36493E+03	0.37536E+03	0.18190E+03	0.39169E+03	0.35302E+03	0.34920E+03
11	0.65500E+01	0.50999E+03	0.52282E+03	0.25357E+03	0.54194E+03	0.49553E+03	0.49121E+03
12	0.87500E+01	0.68664E+03	0.70195E+03	0.34073E+03	0.72541E+03	0.66954E+03	0.66474E+03
13	0.11500E+02	0.95881E+03	0.97404E+03	0.47365E+03	0.99992E+03	0.94224E+03	0.93957E+03
14	0.15500E+02	0.18170E+04	0.18297E+04	0.89214E+03	0.18704E+04	0.18042E+04	0.18099E+04
15	0.21000E+02	0.19841E+04	0.20091E+04	0.97791E+03	0.20524E+04	0.19579E+04	0.19557E+04
16	0.27000E+02	0.35639E+04	0.35614E+04	0.17404E+04	0.36116E+04	0.35715E+04	0.35990E+04
17	0.37000E+02	0.43931E+04	0.44267E+04	0.21571E+04	0.44797E+04	0.43612E+04	0.43720E+04
18	0.49000E+02	0.54102E+04	0.54038E+04	0.26406E+04	0.54542E+04	0.54255E+04	0.54709E+04
19	0.65500E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
20	0.87500E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

NO.	RADIUS (KM)	LIVER	PANCREAS	THYROID	GONADS	REMAINDER	EFFECT. DOSE	SKIN
1	0.25000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
2	0.40000E+00	0.10762E+03	0.10094E+03	0.55749E+04	0.10685E+03	0.11841E+03	0.27729E+03	0.63177E+03
3	0.62500E+00	0.12419E+03	0.11628E+03	0.57374E+04	0.12376E+03	0.13671E+03	0.29941E+03	0.64053E+03
4	0.87500E+00	0.10977E+03	0.10266E+03	0.45125E+04	0.10973E+03	0.12087E+03	0.24807E+03	0.49557E+03
5	0.11500E+01	0.11480E+03	0.10726E+03	0.42135E+04	0.11505E+03	0.12642E+03	0.24442E+03	0.45463E+03
6	0.15500E+01	0.17471E+03	0.16317E+03	0.54836E+04	0.17550E+03	0.19226E+03	0.34414E+03	0.57696E+03
7	0.21000E+01	0.17894E+03	0.16681E+03	0.49466E+04	0.18030E+03	0.19709E+03	0.33285E+03	0.50441E+03
8	0.27000E+01	0.23549E+03	0.21952E+03	0.55804E+04	0.23764E+03	0.25920E+03	0.41010E+03	0.55012E+03
9	0.37000E+01	0.28107E+03	0.26255E+03	0.52212E+04	0.28365E+03	0.30854E+03	0.44531E+03	0.48706E+03
10	0.49000E+01	0.35281E+03	0.32894E+03	0.57631E+04	0.35696E+03	0.38778E+03	0.53622E+03	0.50824E+03
11	0.65500E+01	0.49477E+03	0.46257E+03	0.67866E+04	0.49969E+03	0.54228E+03	0.71075E+03	0.57468E+03
12	0.87500E+01	0.66794E+03	0.62595E+03	0.83831E+04	0.67356E+03	0.73040E+03	0.93382E+03	0.70478E+03
13	0.11500E+02	0.93874E+03	0.88366E+03	0.94370E+04	0.94318E+03	0.10222E+04	0.12348E+04	0.77436E+03
14	0.15500E+02	0.17945E+04	0.16993E+04	0.15111E+05	0.17937E+04	0.19432E+04	0.22553E+04	0.12164E+04
15	0.21000E+02	0.19487E+04	0.18394E+04	0.16045E+05	0.19546E+04	0.21159E+04	0.24488E+04	0.12845E+04
16	0.27000E+02	0.35459E+04	0.33761E+04	0.19871E+05	0.35297E+04	0.38190E+04	0.41251E+04	0.14829E+04
17	0.37000E+02	0.43369E+04	0.41066E+04	0.20978E+05	0.43383E+04	0.46942E+04	0.49801E+04	0.14890E+04
18	0.49000E+02	0.53869E+04	0.51296E+04	0.21255E+05	0.53609E+04	0.58007E+04	0.59926E+04	0.14308E+04
19	0.65500E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
20	0.87500E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

COLLECTIVE DOSE FOR EACH SITE AND THE WEATHER SEQUENCE L

L = 1	T-SITE-1	T-SITE-2
BONE MARROW	0.19422E+05	0.24308E+05
BONE SURFACE	0.19555E+05	0.24473E+05
BREAST	0.95345E+04	0.11933E+05
LUNG	0.19958E+05	0.24982E+05
STOMACH	0.19291E+05	0.24143E+05
COLON	0.19355E+05	0.24223E+05
LIVER	0.19187E+05	0.24013E+05
PANCREAS	0.18169E+05	0.22740E+05
THYROID	0.15169E+06	0.19137E+06
GONADS	0.19177E+05	0.24000E+05
REMAINDER	0.20775E+05	0.26001E+05
EFFECT. DOSE	0.23809E+05	0.29845E+05
SKIN	0.12683E+05	0.16056E+05

Table 42. COLLEC-COLDOS: Printout of results integrated over the whole grid for each site

BREAKDOWN BY EXPOSURE PATHWAYS OF COLLECTIVE DOSES

	CL	GR	IH	IG	IHR	MEAN
BONE MARROW	0.227	53.474	4.298	40.103	1.898	0.21048E+05
BONE SURFACE	0.251	56.048	3.977	37.967	1.757	0.21192E+05
BREAST	0.264	55.190	4.111	38.626	1.809	0.10333E+05
LUNG	0.239	55.018	5.355	37.196	2.192	0.21631E+05
STOMACH	0.227	50.642	4.559	42.563	2.009	0.20906E+05
COLON	0.217	48.662	4.886	44.066	2.169	0.20975E+05
LIVER	0.229	50.918	4.598	42.218	2.037	0.20793E+05
PANCREAS	0.230	49.497	4.657	43.554	2.063	0.19691E+05
THYROID	0.035	8.021	67.301	5.107	19.537	0.16489E+06
GONADS	0.220	52.551	4.348	40.950	1.931	0.20782E+05
REMAINDER	0.232	52.090	4.636	40.999	2.043	0.22514E+05
EFFECT. DOSE	0.196	44.621	16.554	33.288	5.341	0.25818E+05

Table 43. COLLEC-COLDOS: Breakdown of collective doses by exposure pathways

Table 44. POTDOS/LATDOS-EVADOS: Information about input parameter values

```
                RESULTS OF THE EVALUATION PROGRAM FOR THE INDIVIDUAL ORGAN DOSES

                   CALCULATED IN THE MODULES POTDOS AND LATDOS, RESPECTIVELY

                                   SUBROUTINE EVADOS

***  IF CIGCOL=APROD HAS BEEN SPECIFIED, THE INDIVIDUAL DOSES DO NOT CONTAIN THE INGESTION PATHWAY  ***


*****  PRINTOUT OF THE INPUT  *****

       NDSMIN:  -7
       NDEKAD:   9
       MAXI:    20

       IORGNR(IOR):      0      0      0      1      0      0      0      0      0      0      0      0

       DUYSS(IOR):   0.5000E-01  0.3000E+00  0.1500E+00  0.1500E+00  0.1500E+00  0.1500E+00  0.1500E+00
                     0.1500E+00  0.3000E+00  0.5000E-01  0.1500E+00  0.5000E-01  0.5000E+00
       DOYSS(IOR):   0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31
                     0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31  0.1000E+31

       EVALUATION INTERVALS:

       LOWER LIMIT FOR DOSES:    0.1000E-06 SV
       UPPER LIMIT FOR DOSES:    0.1000E+03 SV

       NO PRINTOUT OF CCFDS IS GIVEN:  ICCFD = 0

LEGEND FOR THE PRINTOUT OF THE EVALUATION PROGRAM
-------------------------------------------------

VALUE = DOSES       :   INDIVIDUAL ORGAN DOSES

MAX. VALUE :            MAXIMAL VALUE DETERMINED IN THE CALCULATIONS
MEAN VALUE :            MEAN VALUE, AVERAGED OVER WEATHER SEQUENCES AND AZIMUTHAL SECTORS
SUM P (JUSED) :         PROBABILITY FOR GRID ELEMENTS AFFECTED BY THE PLUME
SUM P < ...MIN :        PROBABILITY FOR VALUES < ...MIN AT GRID ELEMENTS AFFECTED BY THE PLUME
SU P DU=    DO= :       PROBABILITY FOR VALUES IN THE INTERVAL FROM DU TO DO
FRACTILE 99.0 :         99.0%-FRACTILE VALUE
```

Table 45. POTDOS/LATDOS-EVADOS: Statistical quantities of individual doses

EVALUATION OF THE DISTRIBUTION OF INDIVIDUAL LIFETIME DOSES FOR LUNG

RADIUS (KM)	0.250	0.400	0.625	0.875	1.150	1.550
WEATHER S.(MAX DOSE)	1	1	1	1	1	1
MAX. DOSES	0.3270E+02	0.1827E+02	0.1031E+02	0.6709E+01	0.4769E+01	0.3314E+01
MEAN DOSES	0.2587E+01	0.1302E+01	0.6647E+00	0.4047E+00	0.2738E+00	0.1836E+00
SUM P (JUSED)	0.2917E+00	0.2639E+00	0.2361E+00	0.2361E+00	0.2083E+00	0.2083E+00
SUM P < DOSMIN	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SU P DU=.1E+00 DO=.1E+31	0.2083E+00	0.1806E+00	0.1528E+00	0.1528E+00	0.1250E+00	0.1250E+00
FRACTILE 99.9	0.3270E+02	0.1827E+02	0.1031E+02	0.6709E+01	0.4769E+01	0.3314E+01
FRACTILE 99.0	0.3270E+02	0.1827E+02	0.1031E+02	0.6709E+01	0.4769E+01	0.3314E+01
FRACTILE 95.0	0.2291E+02	0.1148E+02	0.5888E+01	0.3467E+01	0.2239E+01	0.1380E+01
FRACTILE 90.0	0.6918E+01	0.2570E+01	0.9120E+00	0.4898E+00	0.3631E+00	0.2754E+00
FRACTILE 50.0	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01

.....
.....

RADIUS (KM)	11.500	15.500	21.000	27.000	37.000	49.000
WEATHER S.(MAX DOSE)	1	1	1	1	1	1
MAX. DOSES	0.4811E+00	0.3580E+00	0.2743E+00	0.2847E+00	0.1858E+00	0.1693E+00
MEAN DOSES	0.2129E-01	0.1773E-01	0.1197E-01	0.1184E-01	0.8894E-02	0.5841E-02
SUM P (JUSED)	0.1250E+00	0.1250E+00	0.9722E-01	0.9722E-01	0.9722E-01	0.9722E-01
SUM P < DOSMIN	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SU P DU=.1E+00 DO=.1E+31	0.6944E-01	0.4167E-01	0.4167E-01	0.4167E-01	0.1389E-01	0.1389E-01
FRACTILE 99.9	0.4811E+00	0.3580E+00	0.2743E+00	0.2847E+00	0.1858E+00	0.1693E+00
FRACTILE 99.0	0.4811E+00	0.3580E+00	0.2743E+00	0.2847E+00	0.1858E+00	0.1693E+00
FRACTILE 95.0	0.1738E+00	0.1380E+00	0.6607E-01	0.4467E-01	0.8710E-01	0.3162E-01
FRACTILE 90.0	0.7762E-02	0.4571E-02	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01
FRACTILE 50.0	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01

RADIUS (KM)	65.500	87.500
WEATHER S.(MAX DOSE)	1	1
MAX. DOSES	0.1239E+00	0.2457E+00
MEAN DOSES	0.3611E-02	0.5711E-02
SUM P (JUSED)	0.9722E-01	0.6944E-01
SUM P < DOSMIN	0.0000E+00	0.0000E+00
SU P DU=.1E+00 DO=.1E+31	0.0000E+00	0.1389E-01
FRACTILE 99.9	0.1239E+00	0.2457E+00
FRACTILE 99.0	0.1239E+00	0.2457E+00
FRACTILE 95.0	0.1148E-01	0.7586E-02
FRACTILE 90.0	-0.1000E+01	-0.1000E+01
FRACTILE 50.0	-0.1000E+01	-0.1000E+01

Table 46. COLLEC-COLDOS-EVACOL: Information about input parameter values

```
                    RESULTS OF THE EVALUATION PROGRAM FOR THE COLLECTIVE ORGAN DOSES

                                CALCULATED IN THE MODULE COLLEC-COLDOS

                                      SUBROUTINE EVACOL


*****  PRINTOUT OF THE INPUT  *****

       NCDMIN:   0
       NDEKCD:   9


       EVALUATION INTERVALS:

       LOWER LIMIT FOR COLLECTIVE DOSE:    0.1000E+01
       UPPER LIMIT FOR COLLECTIVE DOSE:    0.1000E+10


       INTEGRATION ENDS WITH RADIUS :  18


       NO PRINTOUT OF CCFDS IS GIVEN:  ICCFD = 0


LEGEND FOR THE PRINTOUT OF THE EVALUATION PROGRAM
-------------------------------------------------

VALUE = COLDOS      :   COLLECTIVE ORGAN DOSES

MAX. VALUE :            MAXIMAL VALUE DETERMINED IN THE CALCULATIONS
MEAN VALUE :            MEAN VALUE, AVERAGED OVER WEATHER SEQUENCES
SUM P < ...MIN :        PROBABILITY FOR VALUES  < ...MIN (VALUE = SUM OVER THE GRID ELEMENTS)
FRACTILE 99.0 :         99.0%-FRACTILE VALUE
```

Table 47. COLLEC-COLDOS-EVACOL: Statistical quantities of collective doses

ORGAN	BONE MARROW	BONE SURFACE	BREAST	LUNG	STOMACH	COLON
MAX. COLDOS	0.2431E+05	0.2447E+05	0.1193E+05	0.2498E+05	0.2414E+05	0.2422E+05
MEAN COLDOS	0.2105E+05	0.2119E+05	0.1033E+05	0.2163E+05	0.2091E+05	0.2098E+05
SUM P < COLMIN	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
FRACTILE 99.9	0.2431E+05	0.2447E+05	0.1193E+05	0.2498E+05	0.2414E+05	0.2422E+05
FRACTILE 99.0	0.2431E+05	0.2447E+05	0.1193E+05	0.2498E+05	0.2414E+05	0.2422E+05
FRACTILE 95.0	0.2431E+05	0.2447E+05	0.1193E+05	0.2498E+05	0.2414E+05	0.2422E+05
FRACTILE 90.0	0.2431E+05	0.2447E+05	0.1193E+05	0.2498E+05	0.2414E+05	0.2422E+05
FRACTILE 50.0	0.1950E+05	0.1995E+05	0.9550E+04	0.2042E+05	0.1950E+05	0.1950E+05

ORGAN	LIVER	PANCREAS	THYROID	GONADS	REMAINDER	EFFECT. DOSE	SKIN
MAX. COLDOS	0.2401E+05	0.2274E+05	0.1914E+06	0.2400E+05	0.2600E+05	0.2984E+05	0.1606E+05
MEAN COLDOS	0.2079E+05	0.1969E+05	0.1649E+06	0.2078E+05	0.2252E+05	0.2582E+05	0.1381E+05
SUM P < COLMIN	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
FRACTILE 99.9	0.2401E+05	0.2274E+05	0.1914E+06	0.2400E+05	0.2600E+05	0.2984E+05	0.1606E+05
FRACTILE 99.0	0.2401E+05	0.2274E+05	0.1914E+06	0.2400E+05	0.2600E+05	0.2984E+05	0.1606E+05
FRACTILE 95.0	0.2401E+05	0.2274E+05	0.1914E+06	0.2400E+05	0.2600E+05	0.2984E+05	0.1606E+05
FRACTILE 90.0	0.2401E+05	0.2274E+05	0.1914E+06	0.2400E+05	0.2600E+05	0.2984E+05	0.1606E+05
FRACTILE 50.0	0.1950E+05	0.1820E+05	0.1549E+06	0.1950E+05	0.2089E+05	0.2399E+05	0.1288E+05

Table 48. Information about input parameter values for area A

AREA A
======

INNER RADIUS	(KM)	2.4	(IEVA1 = 7)
OUTER RADIUS	(KM)	5.6	(IEVA2 = 10)
SECTOR ANGLE	(DEGREE)	60.0	(= WGRNZA)
AZIMUTHAL SHIFT OF THE SECTOR AGAINST THE WIND DIRECTION OF THE 1ST PHASE	(DEGREE)	0.0	(= WSHIFT, > 0.0 = CLOCKWISE)
INITIAL DELAY	(H)	2.0	(= TINA)
DURATION OF THE SHELTERING PERIOD	(H)	4.0	(= TSHA)
DELAY BETWEEN END OF EVACUATION AND SKIN DECONTAMINATION	(H)	6.0	(= TSKIN)
HALFLIFE OF NATURAL SKIN DECONTAMINATION	(D)	30.0	(= TBIO)
BREATHING RATE INHALATION	(M**3/S)	3.33E-04	(= ARATIH)
BREATHING RATE RESUSPENSION	(M**3/S)	3.33E-04	(= ARATIR)

PROBABILISTIC TREATMENT OF POPULATION BEHAVIOUR IN AREA A AND CORRESPONDING SHIELDING FACTORS DURING

	I N I T I A L D E L A Y					AND S H E L T E R I N G P E R I O D				
FRACTION	S H I E L D I N G F A C T O R S					S H I E L D I N G F A C T O R S				
	CL	GR	IH	IHR	SK	CL	GR	IH	IHR	SK
0.100E+00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.150E+00	0.30	0.20	1.00	1.00	1.00	0.30	0.10	1.00	1.00	1.00
0.300E+00	0.30	0.20	1.00	1.00	1.00	0.05	0.03	1.00	1.00	1.00
0.150E+00	0.30	0.20	1.00	1.00	1.00	0.01	0.01	1.00	1.00	1.00
0.300E+00	0.30	0.20	1.00	1.00	1.00	1.00	0.70	1.00	1.00	1.00

Table 49. Information about input parameter values for area B

AREA B
======

INITIAL DELAY	(H)	2.0	(= TINB)
DELAY BETWEEN END OF EVACUATION AND SKIN DECONTAMINATION	(H)	6.0	(= TSKIN)
HALFLIFE OF NATURAL SKIN DECONTAMINATION	(D)	30.0	(= TBIO)
BREATHING RATE INHALATION	(M**3/S)	3.33E-04	(= ARATIH)
BREATHING RATE RESUSPENSION	(M**3/S)	3.33E-04	(= ARATIR)

INTERVENTION DOSE TO DEFINE AREA B:

ORGAN	INTERVENTION LEVEL (SV)	EXPOSURE PATHWAYS	INTEGRATION TIME (DAYS)
LU	0.500E+00	GR	7
BM	0.500E+00	GR	7
LI	0.500E+00	GR	7

SHIELDING FACTORS APPLIED IN INTERVENTION DOSE CALCULATION	CLOUD :	1.00	(= SFPROT(1))
	GROUND :	1.00	(= SFPROT(2))
	INHALATION :	1.00	(= SFPROT(3))

DURATION OF THE SHELTERING PERIOD, IN DEPENDENCE OF THE DRIVING TIME IN A:

- IF THE OUTER RADIUS OF AREA B <= 5600.0 M
  5.22 H (= TSHB6(1)) 5.42 H (= TSHB6(2)) 6.17 H (= TSHB6(3)) 7.67 H (= TSHB6(4))
- IF THE OUTER RADIUS OF AREA B > 5600.0 M
  5.23 H (= TSHB10(1)) 5.83 H (= TSHB10(2)) 7.08 H (= TSHB10(3)) 13.33 H (= TSHB10(4))

PROBABILISTIC TREATMENT OF POPULATION BEHAVIOUR IN AREA B AND CORRESPONDING SHIELDING FACTORS DURING

FRACTION	INITIAL DELAY SHIELDING FACTORS					AND SHELTERING PERIOD SHIELDING FACTORS				
	CL	GR	IH	IHR	SK	CL	GR	IH	IHR	SK
0.100E+00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.150E+00	0.30	0.20	1.00	1.00	1.00	0.30	0.10	1.00	1.00	1.00
0.300E+00	0.30	0.20	1.00	1.00	1.00	0.05	0.03	1.00	1.00	1.00
0.150E+00	0.30	0.20	1.00	1.00	1.00	0.01	0.01	1.00	1.00	1.00
0.300E+00	0.30	0.20	1.00	1.00	1.00	1.00	0.70	1.00	1.00	1.00

Table 50. Information about input parameter values for driving times

PARAMETERIZATION OF DRIVING TIME TO LEAVE AREA A AND B IN THE CASE OF EVACUATION

- OUTER RADIUS <= 5600.0 M (RA(IDRIV); TDR6):

	POPULATION DENSITY <= 0.100E+03 P/KM**2		POPULATION DENSITY <= 0.500E+03 P/KM**2		POPULATION DENSITY <= 0.100E+04 P/KM**2		POPULATION DENSITY <= 0.100E+07 P/KM**2	
GROUP	FRACTION	DRIV.TIME	FRACTION	DRIV.TIME	FRACTION	DRIV.TIME	FRACTION	DRIV.TIME
1	0.10	13.0 MIN	0.10	25.0 MIN	0.10	70.0 MIN	0.10	160.0 MIN
2	0.40	11.0 MIN	0.40	18.0 MIN	0.40	50.0 MIN	0.40	110.0 MIN
3	0.50	6.0 MIN	0.50	8.0 MIN	0.50	15.0 MIN	0.50	25.0 MIN

- OUTER RADIUS > 5600.0 M (RA(IDRIV); TDR10):

	POPULATION DENSITY <= 0.100E+03 P/KM**2		POPULATION DENSITY <= 0.500E+03 P/KM**2		POPULATION DENSITY <= 0.100E+04 P/KM**2		POPULATION DENSITY <= 0.100E+07 P/KM**2	
GROUP	FRACTION	DRIV.TIME	FRACTION	DRIV.TIME	FRACTION	DRIV.TIME	FRACTION	DRIV.TIME
1	0.10	14.0 MIN	0.10	50.0 MIN	0.10	125.0 MIN	0.10	500.0 MIN
2	0.40	12.0 MIN	0.40	35.0 MIN	0.40	85.0 MIN	0.40	290.0 MIN
3	0.50	6.0 MIN	0.50	12.0 MIN	0.50	15.0 MIN	0.50	60.0 MIN

Table 51. Information about input parameter values for area S

AREA S
======

INITIAL DELAY	(H)	2.0	(= TINS)
DURATION OF SHELTERING PERIOD	(H)	6.0	(= TSHS)
DELAY BETWEEN END OF SHELTERING AND SKIN DECONTAMINATION	(H)	6.0	(= TSKIN)
HALFLIFE OF NATURAL SKIN DECONTAMINATION	(D)	30.0	(= TBIO)
BREATHING RATE INHALATION	(M**3/S)	3.33E-04	(= ARATIH)
BREATHING RATE RESUSPENSION	(M**3/S)	3.33E-04	(= ARATIR)

INTERVENTION DOSE TO DEFINE AREA S:

ORGAN	INTERVENTION LEVEL (SV)	EXPOSURE PATHWAYS	INTEGRATION TIME (DAYS)
LU	0.500E-01	GR	7
BM	0.500E-01	GR	7
LI	0.500E-01	GR	7

PROBABILISTIC TREATMENT OF POPULATION BEHAVIOUR IN AREA S AND CORRESPONDING SHIELDING FACTORS DURING

	I N I T I A L D E L A Y					AND S H E L T E R I N G PERIOD				
FRACTION	S H I E L D I N G F A C T O R S					S H I E L D I N G F A C T O R S				
	CL	GR	IH	IHR	SK	CL	GR	IH	IHR	SK
0.800E-01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.800E-01	0.30	0.20	1.00	1.00	1.00	0.30	0.50	1.00	1.00	1.00
0.900E-01	0.30	0.20	1.00	1.00	1.00	0.30	0.10	1.00	1.00	1.00
0.350E+00	0.30	0.20	1.00	1.00	1.00	0.05	0.03	1.00	1.00	1.00
0.400E+00	0.30	0.20	1.00	1.00	1.00	0.01	0.01	1.00	1.00	1.00

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OUTSIDE AREAS A, B AND S
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PROBABILISTIC TREATMENT OF POPULATION BEHAVIOUR AND
CORRESPONDING SHIELDING FACTORS, NORMAL ACTIVITY

 FRACTION              S H I E L D I N G    F A C T O R S

                      CL        GR        IH        IHR       SK

 0.800E-01          1.00      1.00      1.00      1.00      1.00
 0.800E-01          0.30      0.50      1.00      1.00      1.00
 0.900E-01          1.00      0.50      1.00      1.00      1.00
 0.350E+00          0.30      0.10      1.00      1.00      1.00
 0.400E+00          0.01      0.01      1.00      1.00      1.00



CONSIDERATION OF STABLE IODINE TABLETS
======================================

DISTRIBUTION OF IODINE TABLETS IS NOT TAKEN INTO  ACCOUNT  (IMAXIO =  0  IZTH =  0)
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Table 52. Information about input parameter values for area IO and area with no action

```
 PPPPPPPPPP     RRRRRRRRR      OOOOOOOOO    TTTTTTTTTTT  EEEEEEEEEEE   CCCCCCCCCC
 PPPPPPPPPPP    RRRRRRRRRR    OOOOOOOOOOO   TTTTTTTTTTT  EEEEEEEEEEE  CCCCCCCCCCC
 PP         PP  RR        RR  OO       OO       TT       EE           CC
 PP         PP  RR        RR  OO       OO       TT       EE           CC
 PP         PP  RR        RR  OO       OO       TT       EE           CC
 PPPPPPPPPPP    RRRRRRRRRR    OO       OO       TT       EEEEEEEEE    CC
 PPPPPPPPPP     RRRRRRRRR     OO       OO       TT       EEEEEEEEE    CC
 PP             RR    RR      OO       OO       TT       EE           CC
 PP             RR     RR     OO       OO       TT       EE           CC
 PP             RR      RR    OO       OO       TT       EE           CC
 PP             RR       RR   OOOOOOOOOOO       TT       EEEEEEEEEEE  CCCCCCCCCCC
 PP             RR        RR   OOOOOOOOO        TT       EEEEEEEEEEE   CCCCCCCCCC


                PROTEC READS THE RESULTS OBTAINED IN CONCEN
          AND DETERMINES THE EXTENT AND DURATION OF PROTECTIVE MEASURES.
    THE RESULTS ARE STORED AS FLAGS AND CAN BE READ IN BY SUBSEQUENT PROGRAM UNITS
```

Table 53. PROTEC: Title page.

*** DOSE CONVERSION FACTORS FOR THE ORGAN LU USED TO CALCULATE INTERVENTION DOSES

NUCLIDE NO.	NUCLIDE NAME	CL SV/(BQ*S/M**3)	GR SV/(BQ/M**2)	IH SV/BQ
			7D	0D
25	KR- 88	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.0000E+00	0.5714E-12	0.0000E+00
83	I -131	0.0000E+00	0.1694E-09	0.0000E+00
95	CS-134	0.0000E+00	0.8169E-09	0.0000E+00
98	CS-137	0.0000E+00	0.3016E-09	0.0000E+00

*** DOSE CONVERSION FACTORS FOR THE ORGAN BM USED TO CALCULATE INTERVENTION DOSES

NUCLIDE NO.	NUCLIDE NAME	CL SV/(BQ*S/M**3)	GR SV/(BQ/M**2)	IH SV/BQ
			7D	0D
25	KR- 88	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.0000E+00	0.5404E-12	0.0000E+00
83	I -131	0.0000E+00	0.1602E-09	0.0000E+00
95	CS-134	0.0000E+00	0.7726E-09	0.0000E+00
98	CS-137	0.0000E+00	0.2852E-09	0.0000E+00

*** DOSE CONVERSION FACTORS FOR THE ORGAN LI USED TO CALCULATE INTERVENTION DOSES

NUCLIDE NO.	NUCLIDE NAME	CL SV/(BQ*S/M**3)	GR SV/(BQ/M**2)	IH SV/BQ
			7D	0D
25	KR- 88	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.0000E+00	0.4901E-12	0.0000E+00
83	I -131	0.0000E+00	0.1453E-09	0.0000E+00
95	CS-134	0.0000E+00	0.7006E-09	0.0000E+00
98	CS-137	0.0000E+00	0.2587E-09	0.0000E+00

Table 54. PROTEC: Printout of dose conversion factors.

Table 55. PROTEC: Intervention dose, point values

INTERVENTION DOSE (SV) FOR AREAS B AND S FOR EACH GRID ELEMENT; DISTANCE (KM) = 6.550

(NEGATIVE VALUES INDICATE GRID ELEMENTS OF AREA A, WHERE NO INTERVENTION DOSES WERE CALCULATED)

FOR ORGAN LU

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.2892E-04	0.2090E-02	0.4814E-01	0.4115E+00	0.1439E+01	0.2171E+01	0.1439E+01	0.4115E+00	0.4814E-01
0.2090E-02	0.2892E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00								

FOR ORGAN BM

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.2735E-04	0.1977E-02	0.4553E-01	0.3892E+00	0.1361E+01	0.2053E+01	0.1361E+01	0.3892E+00	0.4553E-01
0.1977E-02	0.2735E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00								

FOR ORGAN LI

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.2480E-04	0.1793E-02	0.4129E-01	0.3530E+00	0.1234E+01	0.1862E+01	0.1234E+01	0.3530E+00	0.4129E-01
0.1793E-02	0.2480E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00								

```
==========================================================================
WEATHER SEQUENCE NR.   1   *****    WEATHER SEQUENCE NR.   1   *****
==========================================================================

INDICES INDICATING THE AREAS FOR EVACUATION
-------------------------------------------
(1=AREA A, 2=AREA B, 3=AREA S, 0=NOT A/B/S)
```

SECTOR INDEX	INDEX OF DISTANCE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
....																				
25	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
26	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
27	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
28	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
29	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
30	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
31	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
32	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
33	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
34	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
35	1	1	1	1	1	1	1	1	1	1	3	3	3	3	0	0	0	0	0	0
36	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	0	0
37	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	0
38	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	0	0
39	1	1	1	1	1	1	1	1	1	1	3	3	3	3	0	0	0	0	0	0
40	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
41	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
42	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
43	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
44	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
45	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
46	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
47	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
48	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
49	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
50	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
.....																				
66	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
67	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
68	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
69	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
70	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
71	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
72	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 56. PROTEC: Printout for each grid element of the countermeasure implemented

PERCENTAGE CONTRIBUTIONS OF EXPOSURE PATHWAYS TO INTERVENTION DOSE, ORGAN LU

(DOSE-VALUES ONLY REFER TO GRID ELEMENTS OUTSIDE AREA A)

I	R(I), KM	CL	GR	IH	MEAN DOSE	MAX. DOSE (SV)
1	0.250	0.000	0.000	0.000	0.00000E+00	0.00000E+00
2	0.400	0.000	0.000	0.000	0.00000E+00	0.00000E+00
3	0.625	0.000	0.000	0.000	0.00000E+00	0.00000E+00
4	0.875	0.000	0.000	0.000	0.00000E+00	0.00000E+00
5	1.150	0.000	0.000	0.000	0.00000E+00	0.00000E+00
6	1.550	0.000	0.000	0.000	0.00000E+00	0.00000E+00
7	2.100	0.000	0.000	0.000	0.00000E+00	0.00000E+00
8	2.700	0.000	0.000	0.000	0.00000E+00	0.00000E+00
9	3.700	0.000	0.000	0.000	0.00000E+00	0.00000E+00
10	4.900	0.000	0.000	0.000	0.00000E+00	0.00000E+00
11	6.550	0.000	100.000	0.000	0.82939E-01	0.21708E+01
12	8.750	0.000	100.000	0.000	0.57656E-01	0.16058E+01
13	11.500	0.000	100.000	0.000	0.39987E-01	0.11809E+01
14	15.500	0.000	100.000	0.000	0.27940E-01	0.87840E+00
15	21.000	0.000	100.000	0.000	0.18120E-01	0.61060E+00
16	27.000	0.000	100.000	0.000	0.11639E-01	0.41269E+00
17	37.000	0.000	100.000	0.000	0.70486E-02	0.26919E+00
18	49.000	0.000	100.000	0.000	0.35580E-02	0.14274E+00
19	65.500	0.000	100.000	0.000	0.17530E-02	0.74871E-01
20	87.500	0.000	100.000	0.000	0.53705E-03	0.24263E-01

Table 57. PROTEC: Printout of intervention doses

```
 AAAAAAAAAA   MM         MM   OOOOOOOOOO   UU         UU  NN         NN  TTTTTTTTTTTT
AAAAAAAAAAAA  MMM       MMM  OOOOOOOOOOOO  UU         UU  NNN        NN  TTTTTTTTTTTT
AA        AA  MMMM     MMMM  OO        OO  UU         UU  NNNN       NN      TT
AA        AA  MM MM   MM MM  OO        OO  UU         UU  NN NN      NN      TT
AA        AA  MM  MMMM  MM  OO        OO  UU         UU  NN  NN     NN      TT
AAAAAAAAAAAA  MM   MM   MM  OO        OO  UU         UU  NN   NN    NN      TT
AAAAAAAAAAAA  MM        MM  OO        OO  UU         UU  NN    NN   NN      TT
AA        AA  MM        MM  OO        OO  UU         UU  NN     NN  NN      TT
AA        AA  MM        MM  OO        OO  UU         UU  NN      NNNN      TT
AA        AA  MM        MM  OO        OO  UU         UU  NN       NNN      TT
AA        AA  MM        MM  OOOOOOOOOOOO  UUUUUUUUUUUU  NN        NN      TT
AA        AA  MM        MM   OOOOOOOOOO    UUUUUUUU    NN         N      TT


              AMOUNT TAKES THE FLAGS GENERATED IN PROTEC
                AND CALCULATES LAND AREAS AND NUMBER OF
              PEOPLE AFFECTED BY DIFFERENT COUNTERMEASURES
```

Table 58. AMOUNT: Title page.

Table 59. AMOUNT: Distance-dependent probabilities for implementation of countermeasures

RADIUS-DEPENDENT PROBABILITY FOR EVACUATION AREAS A AND B, SHELTERING AREA S AND STABLE IODINE AREA IO

(WITHOUT CONSIDERING LAND-SEA-DISTRIBUTION)

I	R(I), KM	AREA A	AREA B	A + B	AREA S	AREA IO
1	0.250	0.10000E+01	0.00000E+00	0.10000E+01	0.00000E+00	0.00000E+00
2	0.400	0.10000E+01	0.00000E+00	0.10000E+01	0.00000E+00	0.00000E+00
3	0.625	0.10000E+01	0.00000E+00	0.10000E+01	0.00000E+00	0.00000E+00
4	0.875	0.10000E+01	0.00000E+00	0.10000E+01	0.00000E+00	0.00000E+00
5	1.150	0.10000E+01	0.00000E+00	0.10000E+01	0.00000E+00	0.00000E+00
6	1.550	0.10000E+01	0.00000E+00	0.10000E+01	0.00000E+00	0.00000E+00
7	2.100	0.10000E+01	0.00000E+00	0.10000E+01	0.00000E+00	0.00000E+00
8	2.700	0.16667E+00	0.00000E+00	0.16667E+00	0.00000E+00	0.00000E+00
9	3.700	0.16667E+00	0.00000E+00	0.16667E+00	0.00000E+00	0.00000E+00
10	4.900	0.16667E+00	0.00000E+00	0.16667E+00	0.00000E+00	0.00000E+00
11	6.550	0.00000E+00	0.41667E-01	0.41667E-01	0.27778E-01	0.00000E+00
12	8.750	0.00000E+00	0.41667E-01	0.41667E-01	0.27778E-01	0.00000E+00
13	11.500	0.00000E+00	0.41667E-01	0.41667E-01	0.27778E-01	0.00000E+00
14	15.500	0.00000E+00	0.13889E-01	0.13889E-01	0.55556E-01	0.00000E+00
15	21.000	0.00000E+00	0.13889E-01	0.13889E-01	0.27778E-01	0.00000E+00
16	27.000	0.00000E+00	0.00000E+00	0.00000E+00	0.41667E-01	0.00000E+00
17	37.000	0.00000E+00	0.00000E+00	0.00000E+00	0.41667E-01	0.00000E+00
18	49.000	0.00000E+00	0.00000E+00	0.00000E+00	0.41667E-01	0.00000E+00
19	65.500	0.00000E+00	0.00000E+00	0.00000E+00	0.13889E-01	0.00000E+00
20	87.500	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESULTS OF THE EVALUATION PROGRAM FOR THE AREAS AND PERSONS

AFFECTED BY COUNTERMEASURES

CALCULATED IN THE MODULE AMOUNT

SUBROUTINE EVAAMT

***** PERSONS AFFECTED BY EVACUATION OR SHELTERING *****

***** PRINTOUT OF THE INPUT *****
NABMIN: 0
NDEKPF: 6

EVALUATION INTERVALS:

LOWER LIMIT: 0.1000E+01
UPPER LIMIT: 0.1000E+07

LEGEND FOR THE PRINTOUT OF THE EVALUATION PROGRAM

VALUE = NUMBER : NUMBER OF PERSONS AFFECTED

MAX. VALUE : MAXIMAL VALUE DETERMINED IN THE CALCULATIONS
MEAN VALUE : MEAN VALUE, AVERAGED OVER WEATHER SEQUENCES, POPULATION GROUPS AND DRIVING TIME CLASSES
SUM P < ...MIN : PROBABILITY FOR VALUES < ...MIN (VALUE = SUM OVER THE GRID ELEMENTS)
FRACTILE 99.0 : 99.0%-FRACTILE VALUE

NO PRINTOUT OF CCFDS IS GIVEN: ICCFD = 0

	PERSON A	PERSON B	PERS A+B	PERSON S	PERSN IO
MAX. NUMBER	0.7824E+04	0.8946E+04	0.1677E+05	0.1262E+06	0.0000E+00
MEAN NUMBER	0.6799E+04	0.7751E+04	0.1455E+05	0.1094E+06	0.0000E+00
SUM P < PERMIN	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.1000E+01
FRACTILE 99.9	0.7824E+04	0.8946E+04	0.1677E+05	0.1262E+06	-0.1000E+01
FRACTILE 99.0	0.7824E+04	0.8946E+04	0.1677E+05	0.1262E+06	-0.1000E+01
FRACTILE 95.0	0.7824E+04	0.8946E+04	0.1677E+05	0.1262E+06	-0.1000E+01
FRACTILE 90.0	0.7824E+04	0.8946E+04	0.1677E+05	0.1262E+06	-0.1000E+01
FRACTILE 50.0	0.6310E+04	0.7244E+04	0.1349E+05	0.1023E+06	-0.1000E+01

	AREA A	AREA B	AREA A+B	AREA S	AREA IO
MAX. SIZE	0.3150E+02	0.3578E+02	0.6727E+02	0.5048E+03	0.0000E+00
MEAN SIZE	0.3150E+02	0.3578E+02	0.6727E+02	0.5048E+03	0.0000E+00
SUM P < AREAMIN	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.1000E+01
FRACTILE 99.9	0.3150E+02	0.3578E+02	0.6727E+02	0.5048E+03	-0.1000E+01
FRACTILE 99.0	0.3150E+02	0.3578E+02	0.6727E+02	0.5048E+03	-0.1000E+01
FRACTILE 95.0	0.3150E+02	0.3578E+02	0.6727E+02	0.5048E+03	-0.1000E+01
FRACTILE 90.0	0.3150E+02	0.3578E+02	0.6727E+02	0.5048E+03	-0.1000E+01
FRACTILE 50.0	0.3150E+02	0.3578E+02	0.6727E+02	0.5048E+03	-0.1000E+01

Table 60. AMOUNT-EVAAMT: Information about input parameter values and statistical quantities of number of person and areas affected by countermeasures

```
AREA C (RELOCATION)
===================

PATHWAYS CONSIDERED IN INTER-          CLOUD :      0       (= NOEXPO(1))
VENTION DOSE CALCULATION              GROUND :      1       (= NOEXPO(2))
                                  INHALATION :      0       (= NOEXPO(3))
                                RESUSPENSION :      0       (= NOEXPO(5))

SHIELDING FACTORS APPLIED IN           CLOUD :    1.000     (= SFPROT(1))
INTERVENTION DOSE CALCULATION         GROUND :    1.000     (= SFPROT(2))
                                  INHALATION :    1.000     (= SFPROT(3))
                                RESUSPENSION :    1.000     (= SFPROT(5))

INTERVENTION LEVEL FOR RELOCATION (EFFECTIVE DOSE EQUIVALENT)
  UP TO      18.000 KM  (= R(IMAXC1))    (SV)  0.500E-01   (= DILREL(1))
  UP TO      75.000 KM  (= R(IMAXC2))    (SV)  0.200E+00   (= DILREL(2))
  OUTSIDE    75.000 KM  (= R(IMAXC2))    (SV)  0.500E+00   (= DILREL(3))

INTEGRATION TIMES (DAYS) FOR           GROUND :      365     (= INTREL(2))
INTERVENTION DOSE CALCULATION     INHALATION :      365     (= INTREL(3))
                                RESUSPENSION :      365     (= INTREL(5))

RELOCATION RATE                    (KM**2/D)   100.000     (= AUMS)
DIRECTLY SPECIFIED RELOCATION TIME    (DAYS)         0     (= ITUMS)
INTERVENTION LEVEL FOR RESETTLEMENT     (SV)  0.250E-01     (= DILRES)

INTEGRATION TIMES (DAYS) FOR           GROUND :      365     (= INTRES(2))
RESETTLEMENT DOSE CALCULATION     INHALATION :      365     (= INTRES(3))
                                RESUSPENSION :      365     (= INTRES(5))

BREATHING RATE INHALATION             (M**3/S)  2.67E-04     (= ARATIH)
BREATHING RATE RESUSPENSION           (M**3/S)  2.67E-04     (= ARATIR)
```

Table 61. Information about input parameter values for relocation

```
AREA D (LAND DECONTAMINATION)
=============================

MAXIMUM DECONTAMINATION FACTORS (=DFMAX(N)) FOR NNT=12 RESETTLEMENT TIME POINTS (=NT(N))

                N       DFMAX(N)      NT(N)


                1          1.00         30
                2          1.00         90
                3          1.00        180
                4          3.00        365
                5          3.00        730
                6          3.00       1825
                7          3.00       3650
                8          3.00       7300
                9          3.00      10950
               10          3.00      14600
               11          3.00      18250
               12          3.00      25550
```

Table 62. Information about input parameter values for decontamination

```
CONSIDERATION OF STABLE IODINE TABLETS
======================================

DISTRIBUTION OF IODINE TABLETS IS NOT TAKEN INTO  ACCOUNT   (IMAXIO =   0)


CONSIDERATION OF SHELTERING WITHOUT EVACUATION:
===============================================

SHELTERING WITHOUT EVACUATION AND RELOCATION IS NOT TAKEN INTO ACCOUNT (IMAXSH=0)


THE FOLLOWING MEAN SHIELDING FACTORS ARE CONSIDERED IN DOSE/RISK CALCULATION :

                  FOR CLOUDSHINE   (CL):        0.300   (= SFLATE(1))
                  FOR GROUNDSHINE  (GR):        0.200   (= SFLATE(2))
                  FOR INHALATION   (IH):        1.000   (= SFLATE(3))
                  FOR RESUSPENSION (IHR):       1.000   (= SFLATE(5))
                  FOR SKIN CONTAM. (SK):        1.000   (= SFLATE(6))
```

Table 63. Information about input parameter values for other countermeasures

```
 PPPPPPPPP     RRRRRRRRR      OOOOOOOOO    TTTTTTTTTTT  EEEEEEEEEEE   CCCCCCCCCC
 PPPPPPPPPP    RRRRRRRRRR    OOOOOOOOOOO   TTTTTTTTTTT  EEEEEEEEEEE  CCCCCCCCCCC
 PP         PP RR         RR OO         OO      TT       EE           CC
 PP         PP RR         RR OO         OO      TT       EE           CC
 PP         PP RR         RR OO         OO      TT       EE           CC
 PPPPPPPPPP    RRRRRRRRRR    OO         OO      TT       EEEEEEEEE    CC
 PPPPPPPPP     RRRRRRRRR     OO         OO      TT       EEEEEEEEE    CC
 PP            RR    RR      OO         OO      TT       EE           CC
 PP            RR     RR     OO         OO      TT       EE           CC
 PP            RR      RR    OO         OO      TT       EE           CC
 PP            RR       RR   OOOOOOOOOOO       TT       EEEEEEEEEEE  CCCCCCCCCC
 PP            RR        RR   OOOOOOOOO        TT       EEEEEEEEEEE   CCCCCCCCC


  PROTEC READS THE RESULTS OBTAINED IN CONCEN
  AND DETERMINES THE EXTENT AND DURATION OF PROTECTIVE MEASURES.
  THE RESULTS ARE STORED AS FLAGS AND CAN BE READ IN BY SUBSEQUENT PROGRAM UNITS

MEAN SHIELDING FACTOR (SFPROT) FOR PATHWAY NO 2   1.000

FOODBANS ARE BASED ON DOSE LEVELS: CFBANS = DOSE
```

Table 64. PROTEC: Title page and information about run conditions

********** EFFECTIVE DOSE CONVERSION FACTORS, INTEGRATED OVER INTREL DAYS
(FOR COMPARISON WITH RELOCATION INTERVENTION LEVEL)

NUCLIDE NO.	NUCLIDE NAME	CL SV/(BQ*S/M**3)	GR SV/(BQ/M**2)	IH SV/BQ
25	KR- 88	0.0000E+00	0.0000E+00	0.0000E+00
28	RB- 88	0.0000E+00	0.5531E-12	0.0000E+00
83	I -131	0.0000E+00	0.3558E-09	0.0000E+00
95	CS-134	0.0000E+00	0.2709E-07	0.0000E+00
98	CS-137	0.0000E+00	0.1144E-07	0.0000E+00

********** EFFECTIVE DOSE CONVERSION FACTORS FOR TIME PERIOD INTRES AT TIME
30 DAYS AFTER THE ACCIDENT

NUCLIDE NO.	NUCLIDE NAME	GR SV/(BQ/M**2)	IH SV/BQ
25	KR- 88	0.0000E+00	0.0000E+00
28	RB- 88	0.0000E+00	0.0000E+00
83	I -131	0.2534E-10	0.0000E+00
95	CS-134	0.2480E-07	0.0000E+00
98	CS-137	0.1079E-07	0.0000E+00

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********** EFFECTIVE DOSE CONVERSION FACTORS FOR TIME PERIOD INTRES AT TIME
18250 DAYS AFTER THE ACCIDENT

NUCLIDE NO.	NUCLIDE NAME	GR SV/(BQ/M**2)	IH SV/BQ
25	KR- 88	0.0000E+00	0.0000E+00
28	RB- 88	0.0000E+00	0.0000E+00
83	I -131	0.0000E+00	0.0000E+00
95	CS-134	0.0000E+00	0.0000E+00
98	CS-137	0.2527E-09	0.0000E+00

********** EFFECTIVE DOSE CONVERSION FACTORS FOR TIME PERIOD INTRES AT TIME
25550 DAYS AFTER THE ACCIDENT

NUCLIDE NO.	NUCLIDE NAME	GR SV/(BQ/M**2)	IH SV/BQ
25	KR- 88	0.0000E+00	0.0000E+00
28	RB- 88	0.0000E+00	0.0000E+00
83	I -131	0.0000E+00	0.0000E+00
95	CS-134	0.0000E+00	0.0000E+00
98	CS-137	0.1361E-09	0.0000E+00

Table 65. PROTEC: Printout of dose conversion factors for calculating relocation and resettlement intervention doses

Table 66. PROTEC: Intervention dose, point values

INTERVENTION DOSE (SV) FOR RELOCATION FOR EACH GRID ELEMENT

FOR DISTANCE (KM) = 0.250

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.5421E-03	0.2143E-01	0.3477E+00	0.2966E+01
0.1559E+02	0.5613E+02	0.1487E+03	0.3042E+03	0.4970E+03	0.6621E+03	0.7276E+03	0.6621E+03	0.4970E+03	0.3042E+03
0.1487E+03	0.5613E+02	0.1559E+02	0.2966E+01	0.3477E+00	0.2143E-01	0.5420E-03	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00								

FOR DISTANCE (KM) = 0.400

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.5421E-03	0.8285E-03	0.2954E-01	0.4540E+00
0.3729E+01	0.1885E+02	0.6443E+02	0.1588E+03	0.2944E+03	0.4222E+03	0.4753E+03	0.4222E+03	0.2944E+03	0.1588E+03
0.6443E+02	0.1885E+02	0.3729E+01	0.4540E+00	0.2954E-01	0.8285E-03	0.5420E-03	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00								

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FOR DISTANCE (KM) = 65.500

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.5421E-03	0.8285E-03	0.2056E-03	0.3492E-03
0.1218E-03	0.4821E-03	0.6367E-03	0.4341E-04	0.1375E-01	0.3961E+00	0.1195E+01	0.3961E+00	0.1375E-01	0.4340E-04
0.6367E-03	0.4821E-03	0.1218E-03	0.3492E-03	0.2056E-03	0.8285E-03	0.5420E-03	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00								

FOR DISTANCE (KM) = 87.500

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.5421E-03	0.8285E-03	0.2056E-03	0.3492E-03
0.1218E-03	0.4821E-03	0.6367E-03	0.4341E-04	0.2552E-02	0.1111E+00	0.3824E+00	0.1111E+00	0.2552E-02	0.4340E-04
0.6367E-03	0.4821E-03	0.1218E-03	0.3492E-03	0.2056E-03	0.8285E-03	0.5420E-03	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00								

```
================================================================================
WEATHER SEQUENCE NR.    1 ** WEATHER SEQUENCE NR.    1 ** WEATHER SEQUENCE NR.    1 *
================================================================================


INDICES INDICATING THE TIME SPAN FOR RELOCATION
-----------------------------------------------

DISTNCE    SECTOR INDEX
 INDEX              1         2         3         4         5         6         7
          123456789012345678901234567890123456789012345678901234567890123456789012

      1    ............................68BCCCCCCCCCCB86.............................
      2    ............................68BCCCCCCCCCB86..............................
      3    ............................479CCCCCCCCC974..............................
      4    ..............................68BCCCCCCB86..............................
      5    ............................479CCCCCCC974................................
      6    ..............................68BCCCCCB86................................
      7    ..............................58ACCCCCA85................................
      8    ................................79CCCCC97...............................
      9    ................................68BCCCB86...............................
     10    ................................58ACCCA85...............................
     11    ..................................79CCC97...............................
     12    ..................................69BCB96...............................
     13    ..................................58ABA85...............................
     14    ..................................47ABA74...............................
     15    ....................................79A97...............................
     16    ....................................68986...............................
     17    ......................................898...............................
     18    ......................................787...............................
     19    ......................................676...............................
     20    ..................................................................
```

Table 67. PROTEC: Printout for each grid element of the duration of relocation

Table 68. PROTEC: Frequency distribution for the duration of relocation

EXTENT AND DURATION OF THE PROTECTIVE MEASURES RELOCATION (AREA C) AND DECONTAMINATION (AREA D)

AREA C: THE FLAG KENNC GIVES THE INDEX FOR THE DURATION OF THE MEASURE
AREA D: THE FLAG KENND GIVES THE INDEX FOR THE TIME POINT OF THE MEASURE

ASSIGNMENT OF INDEX AND TIME (IN DAYS):

FLAG:	1	2	3	4	5	6	7	8	9	10	11	12
TIME:	30	90	180	365	730	1825	3650	7300	10950	14600	18250	25550

RADIUS DEPENDENT STATISTICS OF COUNTERMEASURE DURATION DERIVED FROM ALL GRID POINTS
AND WEATHER SEQUENCES (JMAX*LMAX = 72)

RADIUS R(1) = 0.250 KM

FLAG:	1	2	3	4	5	6	7	8	9	10	11	12
AREA C:	0	0	0	0	0	2	0	2	0	0	2	11
AREA D:	0	0	0	0	0	2	0	2	0	0	2	0

RADIUS R(2) = 0.400 KM

FLAG:	1	2	3	4	5	6	7	8	9	10	11	12
AREA C:	0	0	0	0	0	2	0	2	0	0	2	9
AREA D:	0	0	0	0	0	2	0	2	0	0	2	0

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.....

RADIUS R(19) = 65.500 KM

FLAG:	1	2	3	4	5	6	7	8	9	10	11	12
AREA C:	0	0	0	0	0	2	1	0	0	0	0	0
AREA D:	0	0	0	0	0	2	1	0	0	0	0	0

RADIUS R(20) = 87.500 KM

FLAG:	1	2	3	4	5	6	7	8	9	10	11	12
AREA C:	0	0	0	0	0	0	0	0	0	0	0	0
AREA D:	0	0	0	0	0	0	0	0	0	0	0	0

PERCENTAGE CONTRIBUTIONS OF EXPOSURE PATHWAYS TO THE EFFECTIVE DOSE FOR RELOCATION

I	R(I), KM	CL	GR	IH	IG	IHR	MEAN DOSE	MAX.DOSE(SV)
1	0.250	0.000	100.000	0.000	0.000	0.000	0.56969E+02	0.72756E+03
2	0.400	0.000	100.000	0.000	0.000	0.000	0.33350E+02	0.47533E+03
3	0.625	0.000	100.000	0.000	0.000	0.000	0.20105E+02	0.31667E+03
4	0.875	0.000	100.000	0.000	0.000	0.000	0.13782E+02	0.23372E+03
5	1.150	0.000	100.000	0.000	0.000	0.000	0.10163E+02	0.18291E+03
6	1.550	0.000	100.000	0.000	0.000	0.000	0.72932E+01	0.14001E+03
7	2.100	0.000	100.000	0.000	0.000	0.000	0.51981E+01	0.10654E+03
8	2.700	0.000	100.000	0.000	0.000	0.000	0.39176E+01	0.84760E+02
9	3.700	0.000	100.000	0.000	0.000	0.000	0.27315E+01	0.63237E+02
10	4.900	0.000	100.000	0.000	0.000	0.000	0.19629E+01	0.48269E+02
11	6.550	0.000	100.000	0.000	0.000	0.000	0.13816E+01	0.36162E+02
12	8.750	0.000	100.000	0.000	0.000	0.000	0.95760E+00	0.26669E+02
13	11.500	0.000	100.000	0.000	0.000	0.000	0.66165E+00	0.19538E+02
14	15.500	0.000	100.000	0.000	0.000	0.000	0.46254E+00	0.14543E+02
15	21.000	0.000	100.000	0.000	0.000	0.000	0.29989E+00	0.10105E+02
16	27.000	0.000	100.000	0.000	0.000	0.000	0.19108E+00	0.67746E+01
17	37.000	0.000	100.000	0.000	0.000	0.000	0.11573E+00	0.44195E+01
18	49.000	0.000	100.000	0.000	0.000	0.000	0.57439E-01	0.23041E+01
19	65.500	0.000	100.000	0.000	0.000	0.000	0.27984E-01	0.11950E+01
20	87.500	0.000	100.000	0.000	0.000	0.000	0.84697E-02	0.38244E+00

Table 69. PROTEC: Breakdown of intervention doses by exposure pathways

```
 AAAAAAAAAA    MM         MM   OOOOOOOOOO    UU         UU  NN         NN  TTTTTTTTTTTT
AAAAAAAAAAAA   MMM       MMM  OOOOOOOOOOOO   UU         UU  NNN        NN  TTTTTTTTTTTT
AA         AA  MMMM     MMMM  OO        OO   UU         UU  NNNN       NN      TT
AA         AA  MM MM   MM MM  OO        OO   UU         UU  NN NN      NN      TT
AA         AA  MM  MMMM  MM   OO        OO   UU         UU  NN  NN     NN      TT
AAAAAAAAAAAA   MM   MM   MM   OO        OO   UU         UU  NN   NN    NN      TT
AAAAAAAAAAAA   MM        MM   OO        OO   UU         UU  NN    NN   NN      TT
AA         AA  MM        MM   OO        OO   UU         UU  NN     NN  NN      TT
AA         AA  MM        MM   OO        OO   UU         UU  NN      NNNN      TT
AA         AA  MM        MM   OO        OO   UU         UU  NN       NNN      TT
AA         AA  MM        MM   OOOOOOOOOOOO   UUUUUUUUUUUU  NN         NN      TT
AA         AA  MM        MM    OOOOOOOOOO     UUUUUUUU    NN         N       TT


          AMOUNT  TAKES THE FLAGS GENERATED IN PROTEC
          AND CALCULATES LAND AREAS, NUMBER OF PEOPLE
             AND AMOUNT OF AGRICULTURAL RPODUCTION
             AFFECTED BY DIFFERENT COUNTERMEASURES
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Table 70. AMOUNT: Title page

Table 71. AMOUNT: Distance-dependent probabilities for implementation of relocation and resettlement

PROBABILITIES FOR AREAS WITH RELOCATION
WITHOUT CONSIDERING LAND-SEA-DISTRIBUTION

R(I), KM	TOTAL	30 D	90 D	180 D	365 D	730 D	1825 D	3650 D
0.250	0.2361E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00
0.400	0.2083E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00
0.625	0.2083E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00	0.2778E-01
0.875	0.1806E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00
1.150	0.1806E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00	0.2778E-01
1.550	0.1528E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00
2.100	0.1528E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00
2.700	0.1250E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01
3.700	0.1250E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00
4.900	0.1250E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00
6.550	0.9722E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01
8.750	0.9722E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00
11.500	0.9722E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00
15.500	0.9722E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00	0.2778E-01
21.000	0.6944E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01
27.000	0.6944E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.0000E+00
37.000	0.4167E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
49.000	0.4167E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01
65.500	0.4167E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2778E-01	0.1389E-01
87.500	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

PROBABILITIES FOR AREAS WITH RELOCATION
WITHOUT CONSIDERING LAND-SEA-DISTRIBUTION

R(I), KM	7300 D	10950 D	14600 D	18250 D	25550 D
0.250	0.2778E-01	0.0000E+00	0.0000E+00	0.2778E-01	0.1528E+00
0.400	0.2778E-01	0.0000E+00	0.0000E+00	0.2778E-01	0.1250E+00
0.625	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00	0.1250E+00
0.875	0.2778E-01	0.0000E+00	0.0000E+00	0.2778E-01	0.9722E-01
1.150	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00	0.9722E-01
1.550	0.2778E-01	0.0000E+00	0.0000E+00	0.2778E-01	0.6944E-01
2.100	0.2778E-01	0.0000E+00	0.2778E-01	0.0000E+00	0.6944E-01
2.700	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00	0.6944E-01
3.700	0.2778E-01	0.0000E+00	0.0000E+00	0.2778E-01	0.4167E-01
4.900	0.2778E-01	0.0000E+00	0.2778E-01	0.0000E+00	0.4167E-01
6.550	0.0000E+00	0.2778E-01	0.0000E+00	0.0000E+00	0.4167E-01
8.750	0.0000E+00	0.2778E-01	0.0000E+00	0.2778E-01	0.1389E-01
11.500	0.2778E-01	0.0000E+00	0.2778E-01	0.1389E-01	0.0000E+00
15.500	0.0000E+00	0.0000E+00	0.2778E-01	0.1389E-01	0.0000E+00
21.000	0.0000E+00	0.2778E-01	0.1389E-01	0.0000E+00	0.0000E+00
27.000	0.2778E-01	0.1389E-01	0.0000E+00	0.0000E+00	0.0000E+00
37.000	0.2778E-01	0.1389E-01	0.0000E+00	0.0000E+00	0.0000E+00
49.000	0.1389E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
65.500	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
87.500	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

PERSONS AND AREAS AFFECTED BY COUNTERMEASURES
AVERAGE OVER ALL SITES AND ALL WEATHER SEQUENCES

DAYS	PC	PD	AC	AD
30	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
90	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
180	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
365	0.29504E+04	0.29504E+04	0.13614E+02	0.13614E+02
730	0.16119E+04	0.16119E+04	0.74386E+01	0.74386E+01
1825	0.56538E+05	0.56538E+05	0.26096E+03	0.26096E+03
3650	0.57739E+05	0.57739E+05	0.26650E+03	0.26650E+03
7300	0.37225E+05	0.37225E+05	0.17182E+03	0.17182E+03
10950	0.17397E+05	0.17397E+05	0.80296E+02	0.80296E+02
14600	0.69251E+04	0.69251E+04	0.31960E+02	0.31960E+02
18250	0.31271E+04	0.31271E+04	0.14433E+02	0.14433E+02
25550	0.22415E+04	0.14836E+04	0.10370E+02	0.68428E+01

SUM OVER ALL TIME PERIODS (MEAN RESULTS):

PERSONS AFFECTED BY RELOCATION : 0.18575E+06
AREAS AFFECTED BY RELOCATION : 0.85739E+03

PERSONS AFFECTED BY DECONTAMINATION : 0.18500E+06
AREAS AFFECTED BY DECONTAMINATION : 0.85386E+03

TOTAL TIME INTEGRALS (MEAN VALUES) :

NUMBER OF PEOPLE AFFECTED BY RELOCATION : 0.27229E+07 PERSON-Y
AREAS AFFECTED BY RELOCATION : 0.12569E+05 KM**2 -Y

Table 72. AMOUNT: Averaged results for relocation and decontamination

```
                E V A L U A T I O N   P R O G R A M

          EEEEE   V   V   AAAAA   AAAAA   M   M   TTTTT
          E       V   V   A   A   A   A   MM MM     T
          EEEEE    V V    AAAAA   AAAAA   M M M     T
          E        V V    A   A   A   A   M   M     T
          EEEEE     V     A   A   A   A   M   M     T


TIME PERIODS FOR RESETTLEMENT :
     NUMBER  (=NNT)     :  12
     DAYS    (=NT)      :         30       90      180      365      730
                                 1825     3650     7300    10950    14600
                               18250    25550
```

```
            RESULTS OF THE EVALUATION PROGRAM FOR AREAS AND PERSONS

                          AFFECTED BY COUNTERMEASURES

                        (RELOCATION AND DECONTAMINATION)

                        CALCULATED IN THE MODULE  AMOUNT

                              (SUBROUTINE AREPER)

   ******  PERSONS AFFECTED BY RELOCATION /  DECONTAMINATION ******

       NO PRINTOUT OF CCFDS IS GIVEN:  ICCFD = 0
```

```
*****  PRINTOUT OF THE INPUT  *****

       NABMIC:   0
       NDEKPF:   9

       EVALUATION INTERVALS:

       LOWER LIMIT:      0.1000E+01
       UPPER LIMIT:      0.1000E+10



LEGEND FOR THE PRINTOUT OF THE EVALUATION PROGRAM
-------------------------------------------------

VALUE = NUMBER:  NUMBER OF PERSONS AFFECTED

MAX. VALUE :     MAXIMAL VALUE DETERMINED IN THE CALCULATIONS
MEAN VALUE :     MEAN VALUE, AVERAGED OVER WEATHER SEQUENCES
SUM P < ...MIN:  PROBABILITY FOR VALUES < ...MIN (VALUE = SUM OVER THE GRID ELEMENTS)
FRACTILE 99.0:   99.0%-FRACTILE VALUE
```

Table 73. AMOUNT-EVAAMT: Information about input parameter values

TOTAL NUMBER OF PERSONS AFFECTED	PERSON C	PERSON D
MAX. NUMBER	0.21435E+06	0.21347E+06
MEAN NUMBER	0.18576E+06	0.18500E+06
SUM P < PERMIN	0.00000E+00	0.00000E+00
FRACTILE 99.9	0.21435E+06	0.21347E+06
FRACTILE 99.0	0.21435E+06	0.21347E+06
FRACTILE 95.0	0.21435E+06	0.21347E+06
FRACTILE 90.0	0.21435E+06	0.21347E+06
FRACTILE 50.0	0.17378E+06	0.17378E+06

PERSONS AFFECTED	PERSON C 30 DAYS	PERSON D 30 DAYS
MAX. NUMBER	0.00000E+00	0.00000E+00
MEAN NUMBER	0.00000E+00	0.00000E+00
SUM P < PERMIN	0.10000E+01	0.10000E+01
FRACTILE 99.9	-0.10000E+01	-0.10000E+01
FRACTILE 99.0	-0.10000E+01	-0.10000E+01
FRACTILE 95.0	-0.10000E+01	-0.10000E+01
FRACTILE 90.0	-0.10000E+01	-0.10000E+01
FRACTILE 50.0	-0.10000E+01	-0.10000E+01

.....
.....

PERSONS AFFECTED	PERSON C 25550 DAYS	PERSON D 25550 DAYS
MAX. NUMBER	0.25870E+04	0.17130E+04
MEAN NUMBER	0.22415E+04	0.14836E+04
SUM P < PERMIN	0.00000E+00	0.00000E+00
FRACTILE 99.9	0.25870E+04	0.17130E+04
FRACTILE 99.0	0.25870E+04	0.17130E+04
FRACTILE 95.0	0.25870E+04	0.17130E+04
FRACTILE 90.0	0.25870E+04	0.17130E+04
FRACTILE 50.0	0.20893E+04	0.13804E+04

TOTAL TIME INTEGRAL (PERSON-YRS)	PERSON C	PERSON D
MAX. NUMBER	0.31421E+07	0.30809E+07
MEAN NUMBER	0.27229E+07	0.26699E+07
SUM P < PERMIN	0.00000E+00	0.00000E+00
FRACTILE 99.9	0.31421E+07	0.30809E+07
FRACTILE 99.0	0.31421E+07	0.30809E+07
FRACTILE 95.0	0.31421E+07	0.30809E+07
FRACTILE 90.0	0.31421E+07	0.30809E+07
FRACTILE 50.0	0.25704E+07	0.25119E+07

Table 74. AMOUNT-EVAAMT: Statistical quantities of number of persons affected by relocation and decontamination

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