Office for Nuclear Regulation

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| ONR GUIDE | | | |
| **RADIOLOGICAL ANALYSIS – FAULT CONDITIONS** | | | |
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## 1. INTRODUCTION

1.1 The Office for Nuclear Regulation (ONR) has established its Safety Assessment Principles (SAPs) which apply to the assessment by ONR specialist inspectors of safety cases for nuclear facilities that may be operated by potential licensees, existing licensees, or other duty-holders. The principles presented in the SAPs are supported by a suite of guides to further assist ONR's inspectors in their technical assessment work in support of making regulatory judgements and decisions. This Technical Assessment Guide (TAG) is one of these guides.

## 2. PURPOSE AND SCOPE

2.1 ONR has the responsibility for regulating the safety of nuclear installations in the United Kingdom. The Safety Assessment Principles for Nuclear Facilities (SAPs) [1] provide a framework to guide ONR's decision making in the nuclear permissioning process. The SAPs are supported by Technical Assessment Guides (TAGs) that provide guidance on the interpretation of the principles to assist assessors in the exercise of their professional regulatory judgements about the adequacy of safety submissions.

2.2 This TAG provides guidance on the radiological analysis of faults, including Targets 4 – 9 which lay down numerical criteria for fault frequencies, radiation doses and risks to employees and others. The background to these Targets and an explanation of the associated Basic Safety Levels (BSLs) and Basic Safety Objectives (BSOs) are given in the Explanatory Note on the Numerical Targets and Legal Limits [2].

## 3. THE SITE LICENCE AND OTHER RELEVANT LEGISLATION

3.1 The Nuclear Installations Act 1965 (as amended) permits ONR to attach to the site licence conditions as may appear to be necessary or desirable in the interests of safety. Licence Condition 14 (Safety documentation) requires licensees to make adequate arrangements for the production and assessment of safety case documentation to justify safety during design, construction, manufacture, commissioning, operation and decommissioning phases of the installation. Safety case documentation is also relevant to Licence Conditions 15 (Periodic review), 19 (Construction or installation of new plant), 20 (Modification to design of plant under construction), 21 (Commissioning), 22 (Modification or experiment on existing plant) and 23 (Operating rules). Radiological analysis of the consequences of faults forms an important component of these safety cases.

3.2 In the UK, the operators of nuclear installations in England, Scotland and Wales, in common with other employers, must comply with the general provisions of the Health and Safety at Work etc. Act 1974 (HSW Act) [3]. In particular it is their duty:

1) to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all their employees (Section 2 of the HSW Act); and

2) to conduct their undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in their employment who may be affected are not thereby exposed to risks to their health or safety (Section 3 of the HSW Act).

An assessment of the radiological consequences of faults is an important input into decisions on reasonably practicable measures to ensure the safety of persons on and off the licensed site.

## 4. RELATIONSHIP TO SAPS, WENRA REFERENCE LEVELS AND IAEA SAFETY STANDARDS

Part of the specification for the update of the Safety Assessment Principles was to consider the Reactor, Decommissioning and Storage Safety Reference Levels published by the Western European Nuclear Regulators' Association (WENRA), and International Atomic Energy Agency (IAEA) Standards, Guidance and Documents. The update of this TAG also considers the WENRA and IAEA publications for specific applicability.

**Relevant SAPs and numerical targets**

4.1 The Fundamental Principles 5 and 6 highlight the need for all reasonably practicable measures in order to control radiation risks so that no individual bears an unacceptable risk of harm and also to prevent and mitigate nuclear or radiation accidents. These Fundamental Principles underpin the fault analysis SAPs FA.1 – FA.16 and FA.25 and the supporting paragraphs; the radiation protection SAPs; and also Numerical Targets 4 – 9 for fault conditions, which are relevant to this guidance. They are given in paragraphs 726 – 758 and include the following numerical BSL and BSO targets:

| **Design basis fault sequences – any person** | **Target 4** |
|---|---|
| The targets for the effective dose received by any person arising from a design basis fault sequence are:<br><br>On-site<br>BSL: 20 mSv for initiating fault frequencies exceeding 1 x $10^{-3}$ pa<br>200 mSv for initiating fault frequencies between 1 x $10^{-3}$ and 1 x $10^{-4}$ pa<br>500 mSv for initiating fault frequencies less than 1 x $10^{-4}$ pa<br><br>BSO: 0.1 mSv<br><br>Off-site<br>BSL: 1 mSv for initiating fault frequencies exceeding 1 x $10^{-3}$ pa<br>10 mSv for initiating fault frequencies between 1 x $10^{-3}$ and 1 x $10^{-4}$ pa<br>100 mSv for initiating fault frequencies less than 1 x $10^{-4}$ pa.<br><br>BSO: 0.01 mSv | |

| **Individual risk of death from accidents – any person on the site** | **Target 5** |
|---|---|
| The targets for the individual risk of death to a person on the site, from accidents at the site resulting in exposure to ionising radiation, are:<br>BSL: 1 x $10^{-4}$ pa<br>BSO: 1 x $10^{-6}$ pa | |

| Frequency dose targets for any single accident – any person on the site | Target 6 |
|---|---|

The targets for the predicted frequency of any single accident in the facility, which could give doses to a person on the site, are:

| Effective dose, mSv | Predicted frequency per annum | |
|---|---|---|
| | BSL | BSO |
| 2 - 20 | $1 \times 10^{-1}$ | $1 \times 10^{-3}$ |
| 20 - 200 | $1 \times 10^{-2}$ | $1 \times 10^{-4}$ |
| 200 - 2000 | $1 \times 10^{-3}$ | $1 \times 10^{-5}$ |
| > 2000 | $1 \times 10^{-4}$ | $1 \times 10^{-6}$ |

| Individual risk to people off the site from accidents | Target 7 |
|---|---|

The targets for the individual risk of death to a person off the site, from accidents at the site resulting in exposure to ionising radiation, are:

BSL: $1 \times 10^{-4}$ pa

BSO: $1 \times 10^{-6}$ pa

| Frequency dose targets for accidents on an individual facility – any person off the site | Target 8 |
|---|---|

The targets for the total predicted frequencies of accidents on an individual facility, which could give doses to a person off the site, are:

| Effective dose, mSv | Total predicted frequency per annum | |
|---|---|---|
| | BSL | BSO |
| 0.1 - 1 | 1 | $1 \times 10^{-2}$ |
| 1 - 10 | $1 \times 10^{-1}$ | $1 \times 10^{-3}$ |
| 10 - 100 | $1 \times 10^{-2}$ | $1 \times 10^{-4}$ |
| 100 - 1000 | $1 \times 10^{-3}$ | $1 \times 10^{-5}$ |
| > 1000 | $1 \times 10^{-4}$ | $1 \times 10^{-6}$ |

| Total risk of 100 or more fatalities | Target 9 |
|---|---|

The targets for the total risk of 100 or more fatalities, either immediate or eventual, from accidents at the site resulting in exposure to ionising radiation, are:

BSL: $1 \times 10^{-5}$ pa

BSO: $1 \times 10^{-7}$ pa

### WENRA Reference Levels

4.2 The following WENRA Reference Levels [4] are relevant for this TAG:

1. "The design basis shall have as an objective the prevention or, if this fails, the mitigation of consequences resulting from anticipated operational occurrences and design basis accidents. Design provisions shall be made to ensure that potential radiation doses to the public and the site personnel do not exceed prescribed limits and are as low as reasonably achievable." (Appendix E - Design Basis Envelope for Existing Reactors, Section 1).

In the SAPs the prescribed limits for the potential radiation doses to employees on the site and persons off the site from accident conditions are expressed in terms of Basic Safety Levels, some of which are legal limits. The predicted doses for a new facility or activity should at least meet the BSLs and must be As Low As Reasonably Practicable (ALARP).

2. "Demonstration of reasonable conservatism and safety margins - The initial and boundary conditions shall be specified with conservatism." (Appendix E - Design Basis Envelope for Existing Reactors, Section 8).

3. "PSA shall be based on a realistic modelling of plant response, using data relevant for the design, and taking into account human action to the extent assumed in operating and accident procedures." (Appendix O – Probabilistic Safety Analysis, Section 1).

The SAPs and this TAG state that the radiological analysis supporting the Design Basis Analysis (DBA) should be on a conservative basis whereas the Probabilistic Safety Analysis (PSA) and Severe Accident Analysis (SAA) should be on a best estimate basis.

### IAEA Safety Standards

4.3 One of the requirements of IAEA's safety document on the design of nuclear power plants [5] is:

" To take all reasonably practicable measures to prevent accidents in nuclear installations and to mitigate their consequences should they occur; to ensure with a high level of confidence that, for all possible accidents taken into account in the design of the installation, including those of very low probability, any radiological consequences would be minor and below prescribed limits; and to ensure that the likelihood of accidents with serious radiological consequences is extremely low. "

As indicated in 3.1, the prescribed limits are expressed in terms of Basic Safety Levels and Basic Safety Objectives. Also the predicted doses for a new facility or activity should at least meet the BSLs and must be ALARP.

4.4 The IAEA document also states that a conservative approach should be adopted for design basis analysis and a best estimate approach for the PSA and the SAA. These approaches for the radiological analyses are highlighted in this TAG.

## 5. GUIDANCE FOR ASSESSORS

### General

5.1 Numerical Targets 4 – 9 and the supporting text in paragraphs 721-758 [1] are concerned with the predicted radiation doses and the associated risks to persons on and off the site during fault conditions in a facility on the licensed site. The doses in these targets are expressed in terms of mSv which is appropriate for relatively low doses received over a relatively long period of time. However, the assessor should be aware that for relatively high doses received in a relatively short time, the dose expressed in terms of mGy (or sub units) is more relevant. Guidance in this TAG is confined to the radiological analyses that support the nuclear safety analyses for the facility. Guidance on other aspects is provided in other TAGs [6,7,8].

5.2 The assessment of the predicted doses/risks aims to establish whether the actual doses/risks are likely to be within levels that should be met and also the extent to which the doses/risks have been shown to be ALARP. It is ONR's policy that a new facility should at least meet the BSLs. Assessors should use their judgement and discretion to ensure that the assessment is proportionate and targeted. The depth and scope to which this guidance is employed should be on a case by case basis.

5.3 The radiological analysis involves the predictions of doses to persons on the site and off the site from faults affecting the facility and is an input to three types of analysis, namely:

- DBA
- PSA and
- SAA

Faults lacking the potential to lead to doses > 0.1 mSv to a person on the site or > 0.01 mSv to a person off site are regarded as part of normal operation and excluded from the fault analysis (SAP para 618). The results of the radiological analyses should be judged against Numerical Targets 4 – 9.

5.4 The assessors should ensure that the licensee reduces the predicted doses to ALARP levels by applying the hierarchy of control measures, which is highlighted in Reg. 8(2) of the Ionising Radiations Regulations 1999 and in paragraph 155 of the SAPs, together with recognised good practices rather than by the inappropriate refinement of the parameters used in the radiological analyses.

5.5 Guidance is provided in the following sections on the general aspects of predicting doses to persons on and off the site and also on the different approaches normally adopted in the radiological analyses supporting the DBA, PSA and SAA.

**Radiological consequences to persons on the site**

5.6 The models for estimating doses to persons on the site, usually to the operators in the facility of interest, are generally specific to the nature of the operations being undertaken and the associated fault conditions. Simple bounding estimates for the doses should normally be sufficient particularly if the calculated doses are subject to relatively large uncertainties. Doses associated with the recovery actions following faults should be excluded. The assessor should be aware of the principles and guidance for the protection of persons on-site in the event of a radiological accident [9].

5.7 The assessor should consider the licensees' models on a case by case basis. Doses from all pathways should be considered for all faults analysed. The calculation of the dose to a person should be based on radiation levels, airborne contamination levels and exposure times. Attenuation provided by any shielding and the use of personal protective equipment may be taken into account if it is reasonable to expect it to be worn.

5.8 The assumed response by the operators should be consistent with, for example, the time taken to recognise the fault condition, the radiation levels, the extent of likely contamination and the defined roles and responsibilities of the operators. Where the assumptions appear to be optimistic, particularly for the most limiting high consequence faults, the assessor should seek evidence of the feasibility of the operator response e.g. evacuation times.

**Radiological consequences to persons off the site**

5.9 The radiological consequences to a person off the site may arise from several different exposure pathways e.g. direct shine, inhalation and ingestion from radioactivity released off the site. A person off the site may also be exposed to direct shine if there is a significant release of radioactivity within the facility or if there is a significant increase in the radiation levels in the facility e.g. as a result of a criticality accident. In the case of a release of radioactivity within the facility the estimated direct shine dose to a person off the site would include the following factors:

- The distribution of the radioactivity in the facility
- The attenuation provided by the building structure and other relevant equipment
- The distance between the person off the site and facility
- The period of time the person is exposed to the direct radiation

5.10 If there is a release of radioactivity outside the facility the determination of the associated doses from direct shine, inhalation, and ingestion and from deposited radioactivity normally requires knowledge of how the radioactivity is dispersed off the site. The important parameters can generally be broken down into the following components:

- The radioactive source term
  - Quantity of radioactivity
  - Isotopic composition
  - Chemical composition
  - Particle size distribution
- The features of the release
  - Duration of release
  - Height of release
  - Building wake effects
- Atmospheric dispersion
  - Weather category
  - Wind speed
  - Dry deposition
  - Wet deposition
- Dose estimation
  - Location
  - Duration of exposure
  - Age
  - Inhalation rate
  - Dose coefficients
  - Exposure pathways
  - Protective actions

The following paragraphs provide advice to assessors on the approach which is expected to be followed by licensees in their radiological analysis.

5.11 The source term:-

- The source term consistent with the limiting fault condition should be considered. The source term should be characterised by the amount of radioactivity released, isotopic composition, chemical composition and particle size distribution. (Note: the assessment of the source term may involve ONR assessors in different technical disciplines e.g. fault analysis and chemistry.)

5.12 The features of the release:-

- The assessor needs to be satisfied that the duration assumed for the release is appropriate to the fault being considered. A short release e.g. 30 minutes should be used unless a longer duration is justified by the nature of the fault.

- The release should be assumed to be at ground level unless a justification can be made for an elevated release e.g. a stack release.

5.13 Atmospheric dispersion:-

- The meteorological data should be appropriate to the site of interest and have been collected close to the site over a number of years. The data would typically include wind direction, wind speed, stability category, rainfall and mixing layer depth.

- Where computer codes are used to model the atmospheric dispersion of the radioactive release and to determine the dose to an individual, the assessor needs to be satisfied that the computer models and codes have been validated and that the methods and assumptions for determining the dispersion of the radioactive released are consistent with industry good practice.

- The assessor should note that the UK Atmospheric Dispersion Modelling Liaison Committee (ADMLC) is a group chaired by the Meteorological Office and includes representatives from the nuclear industry, ONR and HSE. One of its objectives is to provide guidance to, and to endorse good practice, in the dispersion modelling community, particularly in the nuclear industry. It was formed about 40 years ago and during that period has reviewed a wide range of topics associated with atmospheric dispersion.

- The assessor should be aware that the National Dose Assessment Working Group (NDAWG) is also important in the development of methods for assessing the doses to public from current and future authorised discharges. NDAWG reports are currently available on a range of topics.

- The simplest dispersion model in general use is the so-called R-91 methodology [10]. recognised by the UK ADMLC. This assumes that the plume disperses in a gaussian manner both vertically and horizontally. The effects of any buildings in close proximity to the release point should be considered in calculating the dispersion of the plume.

- The assessor needs to be aware of the limitations of the R-91 model and also of the refinements to the methodology highlighted in reports of the UK ADMLC including the following topics:-

    - dispersion at low wind speed,

    - dispersion from sources near groups of buildings, or in urban areas,

    - plume rise,

    - dispersion in coastal areas,

  - o uncertainty in dispersion model predictions from the uncertainty in deriving stability indicators from meteorological observations,
  - o the proceedings of a workshop on the reliability of dispersion models for regulatory applications,
  - o review of Royal Meteorological Society guidelines for atmospheric dispersion modelling,
  - o calculation of air concentration indoors,
  - o dispersion following explosions,
  - o review of atmospheric dispersion in complex terrain.

- The assessor should be aware of the limitations and inherent uncertainties associated with any models used for radiological analyses. This applies also to the results from computer codes which are mostly only indicative of what might be expected from a given accident.

5.14 Dose estimation:-

- The maximum dose to a person off the site should generally be determined assuming the person is directly downwind of the airborne release. The location should be chosen to be conservative for an analysis in support of a DBA, and best estimate for input to a PSA or a SAA. In estimating the societal risk (Target 9) dose to the many persons on and off the site needs to be considered.
- The dose estimates for an individual should also take account of how long the individual is exposed to the airborne release, the age group, the rates of inhalation, the dose coefficients, the exposure pathways and the implementation of any justified protective measures.
- The up to date International Commission on Radiological Protection (ICRP) recommended values should be used e.g. for dose coefficients. Where this is not the case the assessor should seek a justification for the use of alternative values, especially if their use results in optimistic dose predictions.
- Similarly, where doses to persons off the site are estimated using models other than those that reflect good practice i.e. those recognised by the UK ADMLC group, the assessor should seek justification and evidence that the models do not significantly under-estimate the radiological consequences when compared to the predictions of the UK ADMLC models.
- The models used for estimating the dose contributions from all pathways should reflect current good practice.
- Protective actions may be taken into account subject to the likelihood that they will be implemented. However, protective actions should not be treated as a means of reducing doses to meet relevant target levels.

**Risks to individuals**

5.15 For assessment against Targets 5 and 7 (i.e. the risk of death to individuals on and off the site respectively) the risk estimates should be derived from the radiological consequences in terms of dose and suitable dose/risk conversion factors. At relatively low doses the most appropriate factors are the ICRP recommendations [11], 4% per Sv for workers and 5% per Sv for members of the general population. Since the factors are subject to review from time to time, assessors should to be aware of the most up to date authoritative guidance. For high doses received in a relatively short period of time the most appropriate factors increase and at very high dose levels the risk are invariably fatal, in which case the risk of death is the frequency of the associated fault.

5.16 Where the dose/risk conversion factors used are lower than those recommended by authoritative bodies e.g. ICRP and HPA/RPD, the assessor should examine the underlying assumptions and seek an adequate justification.

**Design Basis Analysis (Target 4)**

5.17 The SAPs for design basis analysis are given in paragraphs 626 – 643 and 726-729 including Target 4. FA.7 and paragraphs 635 - 639 are particularly relevant for the radiological analysis. The analysis should demonstrate that for most DBAs, sufficient physical barriers will be maintained to reduce so far as is reasonably practicable, the doses to persons on and off the site. In the most severe design basis accident, no person on the site should receive a dose in excess of 500 mSv and no person off the site should a dose greater than 100 mSv. Generally, the larger the potential consequences of an accident, the smaller should be its frequency. This is illustrated in Target 4 which identifies the relevant BSL and BSO values for ranges of fault frequencies and radiological consequences.

5.18 Principle FA.7 states that the 'analysis of design basis fault sequences should use appropriate tools and techniques, and be performed on a conservative basis to demonstrate that consequences are ALARP'. The assessor should ensure that the radiological analysis predicts the maximum effective dose to a person on the site and to a person off the site directly downwind of the release. It should be assumed for off site releases that 'the person remains at the point of greatest dose or the maximum duration, although for extended faults a more realistic occupancy may be assumed after a suitable interval.' (SAP para 729(a)).

**On site radiological consequences**

5.19 The person most at risk on the site is likely to be an operator in the facility. The assessor should ensure that the assumptions made for the operator's response to each fault take account of the operational conditions likely to prevail in the event of the fault and are conservative but not overly pessimistic.

**Off site methodology**

5.20 The radiological analysis should be conservative and assume

- the person remains at the point of greatest dose for the duration of the release, although for extended faults a more realistic occupancy may be assumed after a suitable interval,
- the weather category and conditions have characteristics which produce the highest dose to that person,
- no off-site emergency protective actions are implemented, other than those whose implementation can be shown to be very highly likely to avert a dose via a particular pathway e.g. food bans,
- the maximum effective dose to an adult, child and infant should be considered and the most limiting value used for assessment against Target 4.

5.21 Where a methodology other than that recognised by the UK ADMLC is used, the assessor should seek to establish that the consequences are not unduly lower than those predicted by the UK ADMLC methods.

**Probabilistic Safety Analysis (Targets 5 – 8)**

5.22 The PSA predictions of the doses to persons on the site and persons off the site should be based on a best estimate approach. Alternatively, licensees may wish to use reasonably conservative assumptions. A general guide to off-site consequences and estimation of risks to the public for PSA (Level 3) can be found in IAEA Safety Series No. 50-P-12 [12].

**On site radiological consequences (Targets 5 and 6)**

5.23 The assessor should ensure that the assumptions made for the operator's response to the fault takes account of the operational conditions likely to prevail in the event of the fault and are best estimates. The operator should be assumed to be situated at the point of maximum potential exposure and realistic occupancy factors should be used to determine the exposure time.

**Off site radiological consequences (Targets 7 and 8)**

5.24 The determination of risk to individuals is based on estimations of the radiological consequence and frequency for each of the identified fault sequences. The radiological analysis will clarify the dose band to which each fault sequence should be allocated. The frequency associated with the fault sequence should be below the respective BSL and be ALARP.

5.25 The assessor should ensure that the off site radiological consequences for identified fault sequences have been determined in an appropriate manner. Co-operation is likely to be required between the fault studies specialists and the radiological protection specialists since the former assess the validity of the frequencies.

5.26 Best-estimate methods and data should preferably be used for the radiological analysis in the PSA and should

- assume the weather conditions that give a best estimate dose, usually category D weather,
- assume a hypothetical person located at the nearest habitation or location where occupancy is likely e.g. workplace or at a distance of 1 kilometre from the facility, or at the point of greatest dose if that is further away,
- assume the hypothetical person to be directly downwind of the release for the duration of the release, except for extended faults where realistic occupancy factors may be assumed after a suitable interval,
- take account of the likelihood of the different weather conditions and wind,
- directions, including wind rose data, that are most relevant for the site,
- take account of only those protective actions that are highly likely to be implemented. In the case of the most exposed individual member of the public, it will be difficult to provide justification for short term protective actions such as shelter, evacuation and administration of stable iodine.

5.27 Where the licensee's approach differs significantly from the above, the assessor should seek justification to ensure that the dose predictions are not unduly optimistic.

5.28 The objective for the Licensees in performing a PSA is to estimate the radiological consequence and frequency for each of the fault sequences they have identified. The radiological analysis will determine which of the Target 8 dose bands the fault sequence is allocated. The frequency associated with the fault sequence should be below the respective BSL and must be ALARP.

5.29 The assessor will need to form a judgement on the depth and breadth of the assessment of the licensee's case in order to be satisfied that consequences have been derived in an appropriate way. In some cases the assessor may wish to perform independent calculations e.g. using a code such as PC Cosyma (an EC code) to check the claims made by the licensee. If independent calculations are performed, it must be borne in mind that differences in the results of less than an order of magnitude may not be significant.

**Severe Accident Analysis (Target 9)**

5.30 Severe accidents are defined as those fault sequences that lead either to consequences exceeding the highest radiological doses given in the BSLs in Target 4 or to a substantial unintended relocation of radioactive material within the facility which places a demand on the remaining physical barriers (SAP para 663).

5.31 The '100 or more deaths' in Target 9 include those arising from the immediate effects of accidents and also the longer term stochastic effects. It is the total for all severe accidents and also includes on and off site fatalities, in contrast to the other targets where the on and off site consequences have their respective BSL and BSO levels.

5.32 The analysis should determine the risks from severe accidents to demonstrate no sudden escalation of consequences just beyond the design basis (i.e. no 'cliff edge' effects). Sensitivity studies, which include systematic variation of the parameters used in the radiological analysis, should be performed to identify the important parameters for the demonstration.

5.33 The assessor should consider whether the results of the analysis show the need for additional features to be incorporated in the plant design to reduce the risks so far as is reasonably practicable.

5.34 The radiological analysis should generally be carried out using best estimate assumptions, methods and data. Where this is not possible, reasonably conservative assumptions should be made to take account of the uncertainties in the understanding of the physical processes being modelled.

**On site radiological consequences**

5.35 The assessor should ensure that the calculations adopt a best estimate approach with the following constraints:-

- a conservative or bounding case approach to be adopted to avoid optimistic conclusions being drawn (SAP para 669) if uncertainties are such that a realistic analysis cannot be performed with confidence,
- inclusion of persons within the facility and others on site,
- recognition of the limitations of applying the simple atmospheric dispersion codes,
- inclusion of protective actions that are consistent with the licensee's accident management plan.

**Off site radiological consequences**

5.36 The methods and data for the radiological analysis should follow a best estimate approach with constraints similar to those used in the PSA. The earlier guidance on source terms, features of the release and atmospheric dispersion should be applied although dose determination should be subject to the following constraints:-

- methods are consistent with those used by Public Health England,
- integration of the effects over 100 years,
- consideration of the effects on the UK population only (SAP para 756),

- population data based on current demography taking account of reasonable expectations for change in the future to be considered in a sensitivity analysis and
- account of off site protective actions consistent with current UK and international advice.

5.37 Where the consequences are determined to be significantly greater than 100 deaths, the assessor should seek a demonstration of correspondingly lower frequencies of occurrence.

**Summary of guidance on assumptions made with respect to protective measures (countermeasures)**

5.38 The reader will have noted that assumptions made with respect to whether credit is taken for protective measures, also known as countermeasures, depends on the type of the analysis that is undertaken. For clarity, the guidance given above is summarised in the 5 points below.

1. In all cases it is agreed that protective actions should only be claimed when these are justified to by the licensee or Generic Design Assessment applicant in their safety case.
2. For DBA, consideration should only be given to protective actions that are highly likely to be implemented, and are justified as such.
3. Probabilistic analysis can deal with protective measures explicitly by modelling the likelihood of protective actions failing or succeeding.
4. For exposures to individuals off site, namely in relation to targets 7 and 8, only long term protective actions should be considered, such as food bans and measures to decontaminate land and buildings.
5. For exposures to society as a whole, namely in relation to target 9, both short term and long term protective actions should be considered. These need to be justified, as in all cases.

## 6. REFERENCES

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## 7. GLOSSARY AND ABBREVIATIONS

| | |
|---|---|
| ADMLC | Atmospheric Dispersion Modelling Liaison Committee |
| ALARP | As low as reasonably practicable |
| BSL | Basic Safety Level |
| BSO | Basic Safety Objective |
| DBA | Design Basis Analysis |
| HSE | Health and Safety Executive |
| HSW | The Health and Safety at Work etc. Act 1974 |
| IAEA | International Atomic Energy Agency |
| NDA | Nuclear Decommissioning Authority |
| ONR | Office for Nuclear Regulation |
| PSA | Probabilistic Safety Analysis |
| SAA | Severe Accident Assessment |
| SAP | Safety Assessment Principle(s) |
| TAG | Technical Assessment Guide(s) |
| WENRA | Western European Nuclear Regulators' Association |