

**Government of India
Atomic Energy Regulatory Board
Radiological Safety Division**

**Niyamak Bhavan, Anushaktinagar
Mumbai – 400 094**

**STANDARD FORMAT OF SAFETY ANALYSIS REPORT (SAR) FOR PACKAGE
DESIGN APPROVAL FOR TRANSPORT OF RADIOACTIVE MATERIAL**

1. General Information

- 1.1. Name, address and telephone number of the Applicant
- 1.2. Type of approval required
- 1.3. Packaging model name
- 1.4. Whether approved earlier
- 1.5. Competent authority identification mark if previously allocated
- 1.6. Date of expiry of the certificate issued by the competent authority, if applicable

2. Codes and Standards followed for Design and Analysis

- 2.1. Mandatory documents:
- 2.2. Guideline documents
- 2.3. Any other supporting documents

3. Detailed description of packaging

- 3.1. A detailed description of the packaging including complete engineering drawings and specification of all the materials used in package components

4. Radioactive contents of package

- 4.1. A detailed description of the proposed radioactive contents with reference to their physical and chemical states and nature of radiation emitted

- 4.2. Activity
 - 4.2.1. Total quantity
 - 4.2.2. Evaluation of A_1/A_2 values
 - 4.2.3. Quantification of activity in terms of A_1/A_2 values

5. Shielding requirements compliance

- 5.1. Description of shielding
- 5.2. Method employed for analysis
- 5.3. Radiation level measured/estimated
 - 5.3.1. On the external surface of the package
 - 5.3.2. At 1m Distance from the external surface of the package

6. Demonstration of regulatory compliance of general requirements

- 6.1. Amenability for decontamination
- 6.2. Protruding features
- 6.3. Water collection/retention

- 6.4 Any other component added to package during transport
- 6.5 Effects of acceleration/ vibrations during transport on closing devices
- 6.6 Compatibility of packaging material with each other and radioactive contents; and their behavior under irradiation
- 6.7 Provision of valves and protection of their operation against unauthorised operation
- 6.8 Design compatibility of package materials and radioactive materials to ambient temperature & pressure during routine transport conditions
- 6.9 Provision of thermal protection for satisfying the requirements of thermal test
- 6.10 Effectiveness of thermal protection if the package is subjected to the tests to demonstrate its ability to withstand the normal conditions of transport and the mechanical test to demonstrate its ability to withstand accident conditions of transport
- 6.11 Tamper proof seal
- 6.12 Tie-down
 - 6.12.1 Design criteria
 - 6.12.2 Analytical calculation
- 6.13 Detailed description of containment system
- 6.14 If liquid contents are expected to be present or formed in the package, additional design features of package
- 6.15 If gaseous contents are expected to be present or formed in the package, additional design features of package
- 6.16 Does the design of the package take into account temperatures ranging from - 40° C to 70° C for the components of the package?
- 6.17 Is the package designed for an ambient temperature range from from - 40° C to + 38° C
- 6.18 If the answer to the above is no, mention the ambient temperature range for which the package is designed
- 6.19 Package accessible surface temperature for ambient conditions of transport without insolation
- 6.20 Package maximum normal operating pressure for ambient conditions of transport with/without insolation (include measurement/design/analysis calculations)
- 6.21 Does the package include a pressure relief system?
- 6.22 If the answer to the above is yes, does the pressure relief system allow the release of radioactive material to the environment under the conditions of the tests to demonstrate the ability of the package to withstand normal and accident conditions of transport?
- 6.23 If yes, activity released in each venting and frequency of venting

7. Demonstration of ability to withstand normal conditions of transport

- 7.1. Water spray test
- 7.2 Free drop test
- 7.3 Stacking test
- 7.4 Penetration test
- 7.5 Performance of package after above tests with respect to loss of radioactive content per hour

8. Demonstration of ability to withstand accident conditions of transport

- 8.1 Structural Integrity Demonstration under Mechanical Tests

- 8.1.1 Design features for structural requirements under impact
 - 8.1.2 Material properties of structural components under dynamic conditions of impact under the ambient conditions
 - 8.1.3 Method employed for demonstration of compliance
 - 8.1.4 If demonstration by scale model testing, then design criteria / selection of model size , deviations, reduction and scaling factors for equivalent damage
 - 8.1.5 Determination of the order of mechanical tests which causes maximum damage in the thermal test which follows
 - 8.1.6 Drop I or Drop III
 - 8.1.6.1 Different possible drop attitudes
 - 8.1.6.2 Determination of worst attitude
 - 8.1.6.3 Stresses / deformations in worst attitude
 - 8.1.6.4 Comparison of results with acceptance criteria for stresses/ deformation
 - 8.1.7 Drop II
 - 8.1.7.1 Different possible drop attitudes
 - 8.1.7.2 Determination of worst attitude
 - 8.1.7.3 Stresses / deformations in worst attitude
 - 8.1.7.4 Comparison of results with acceptance criteria for stresses/ deformation
 - 8.1.8 Justification of design at -40°C
- 8.2 Structural integrity demonstration under thermal tests
 - 8.2.1 Thermal design features
 - 8.2.2 Thermal properties of materials used to withstand thermal test
 - 8.2.3 Thermal evaluation for accident conditions of transport
 - 8.2.3.1 Method employed and its validation
 - 8.2.3.2 Worst orientation for thermal test / analysis considering the damaged condition of package after mechanical tests
 - 8.2.3.3 Temperature profile in the package at the end of thermal test / analysis
 - 8.2.3.4 Maximum internal pressure inside containment at the end of thermal test / analysis
 - 8.2.3.5 Maximum pressure in space between inner & outer shells at the end of thermal test / analysis
 - 8.2.3.6 Maximum thermal stresses & deformation on the structural components of package at highest temperature / molten condition of lead
 - 8.2.3.7 Contraction stresses on structural components during cooling, if any
 - 8.2.3.8 Extrapolation of results to damaged package, if analysis / tests done on undamaged package
 - 8.3 containment integrity demonstration after water immersion test or enhanced water immersion test for packages designed for radioactive contents with activity $> 10^5 \text{ A}_2$
 - 8.4 Cumulative effects of tests to demonstrate ability to withstand accident conditions of transport
 - 8.4.1 Maximum radiation level at 1 m from the external surface of the package with the maximum radioactive contents which the package is designed to contain
 - 8.4.2 Accumulated loss of radioactive contents in one week

9. For packages to be transported by air

- 9.1 Surface temp
- 9.2 Proof that if it is exposed to ambient temperatures ranging from -40°C to $+55^{\circ}\text{C}$, the integrity of containment will not be impaired

- 9.3 Proof that it is capable of withstanding, without leakage, an internal pressure of not less than maximum normal operating pressure plus 95 kPa

10. For packages designed to contain 0.1 kg or more of uranium hexafluoride, demonstration of regulatory compliance after

- 10.1 Structural test
- 10.2 Free drop test
- 10.3 Thermal test

11. For packages designed to contain fissile materials

11.1 Criticality design

- 11.1.1 Description of confinement design
- 11.1.2 Design features
- 11.1.3 Material properties
- 11.1.4 Fissile material contents
- 11.1.5 General considerations
- 11.1.6 Single package evaluation
- 11.1.7 Evaluation of package arrays under normal conditions of transport
- 11.1.8 Model configuration for the most unsafe condition
- 11.1.9 Evaluation of damaged package arrays under hypothetical accident conditions
- 11.1.10 Model configuration for the most unsafe condition
- 11.1.11 Summary table of criticality evaluation
- 11.1.12 Criticality safety index
- 11.2.1 Demonstration that the package maintains sub-criticality during normal and accident conditions of transport; in particular, considering (i) water leaking into or out of packages; (ii) loss of efficiency of built-in neutron absorbers or moderators; (iii) rearrangement of the contents either within the package or as a result of loss from the package; (iv) reduction of spaces within or between packages; (v) packages becoming immersed in water or buried in snow; and (vi) temperature changes
- 11.2.2 Does the package, after being subjected to the tests to demonstrate its ability to withstand normal conditions of transport prevent the entry of a 10 cm cube?
- 11.2.3 Does the package include multiple high standard water barriers, each of which would remain watertight if the package were subject to the tests to demonstrate its ability to withstand normal and accident conditions of transport?

12. Operating procedures

- 12.1 Procedures for loading the package
- 12.2 Procedures for unloading the package
- 12.3 Lifting arrangements
- 12.4 Proposed mode of transport
- 12.5 Tie-down arrangements and normally occupied position
- 12.6 Whether to be transported under exclusive use

13. Quality assurance programme as per ASME Sec-3, Div-3

- 13.1 References to quality assurance procedures followed for design and manufacture of package
- 13.2 Material Testing
- 13.3 Weld Inspection
- 13.4 Pressure Test
- 13.5 Leak Test

- 13.6 Shielding Integrity Test
- 13.7 Thermal Acceptance Test

14. Maintenance programme

- 14.1 Periodic maintenance schedule
- 14.2 Replacements if Seal, Valves, etc. on containment
- 14.3 Leak Testing

15. Miscellaneous

- 15.1 Details of earlier approvals, if any
- 15.2 Details of experience of transportation of package of same / similar design

- 15.3 Marking, Labelling

16. Appendices of the various design / analysis

- Appendix- A** Specification of All the Materials used in Package Components
- Appendix- B** Estimation of Weights of Package and Other Components
- Appendix- C** Shielding Report for Estimation of Radioactive Material Source Term, Activity Limits, Dose Levels and Releasable Activity
- Appendix- D** Tie-Down Design /Analysis Report
- Appendix- E** Structural Design /Analysis Report against Mechanical Tests
- Appendix- F** Thermal Performance Design / Analysis Report of Package
- Appendix- G** Design / Analysis Report of Criticality
 - G.1** Benchmark evaluations
 - G.2** Applicability of benchmark experiments
 - G.3** Computer codes and cross-section libraries
 - G.4.** Demonstration of maximum reactivity
 - G.5** Confirmatory analyses
 - G.6** Bias determination

- Appendix- H** Quality Assurance Plan

- Appendix-I** Any other additional analysis conducted by the applicant