Containers Analysis Code of Zero Order (CACO0)—A Basic Design System for Type B Packages

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INTRODUCTION

Very frequently, the principal issues that have to be assesed in the design of a type B(U) package are radiation shielding and evaluation of mechanical and thermal test effects. Thermal behaviour during normal transport conditions has also to be considered when the material must dissipate high thermal power. If the transported material is fissile it should be assured that it remains subcritical during transport.The containment of radioactive material must always be assured. In some cases this requires considerable effort.

Usually these different design issues are very closely coupled. This coupling does not permit independent consideration. Also, some issues are competitive and generate conflicting design criteria. Given the goal of meeting pertinent transport regulations at a reasonable cost, all design-relevant issues must be balanced in order to obtain a good design.

For each design-relevant issue there exists a number of methods of varying efficiency and cost, which can be used to define the key parameters of that particular issues.

The overall design methodology must take into account interactions between parameters of different issues.

CACO0 is a system that integrates all design relevant issues and their interactions.

The system consists of different modules, each one oriented to a different design issue. The modules are related by a control structure that enables sequentation or iteration during design in a fast and simple manner. Modules can easily be replaced or added, so the system can be updated or adapted to new design problems.

The system was designed for use in factibility analysis, cost estimation, conceptual design and initial stages of basic design of type B(U) packages. To accomplish those ends, simple, fast and conservative methods are used.

CACOO SYSTEM DESCRIPTION

CACOO system comprises the following modules:

Shielding Module
Criticality Module
Thermal Module
Structural Module

The first three modules are divided into submodules that enable design in normal transport conditions and in accidental conditions.

The system does not include features for quantitative estimation of radioactive material releases, given that these releases are highly dependent of especific characteristics of each design.

Iteration Control Structure.

The input to the system consists of the characteristics of the material to be transported and the specification of the global design requirements. The system's iteration control structure enables the use of each module to define key parameters, as dimensions and materials, and to iterate when necessary.

The step from one module to the next is performed when the design requirements on that module have been satisfied.

The global design requierements are :

Admisible dose rate in normal conditions.
Admisible dose rate in accidental conditions.
Maximum effective criticatility coefficient (Keff).
Admisible external temperature in normal conditions.
Admisible temperatures in normal conditions.
Admisible temperatures in accidental conditions.

A simplified diagram of the iteration control structure is shown in figure 1.

Modules

Shielding Module

This module covers gamma radiation shielding. Alfa and beta radiation are not taken into acount as they generally do not influence design. Neutron shielding is to be implemented.

The methods used are those described by Foderaro (1978). Basically they consist of integral formulas for direct dose estimation and buildup factors for evaluation of dose due to scattered flux.

The external dose rate can be calculated for different source geometries together with shielding of different materials and shapes.

Due to fast calculation for different geometries, it is possible to generate aproximations to complex geometries by combination of simple ones.

Criticality Module

The methods used in this module permit a conservative calculation of Keff for a fissile material package, as a function of the dimensions, material density and moderation ratio. It is also possible to calculate Keff for a set of packages.

The methods used are of semi-empirical nature, and are described in the " Normas basicas de seguridad radiogica y nuclear " (1966).

Thermal Module

This module uses a finite difference scheme to simulate package thermal behaviour in stationary and dynamic situations. All heat transfer mechanisms present in normal transport and accidental conditions are taken into consideration in the thermal analysis. It also includes phase change simulation.

Structural Module

Empirical methods are used in this module to evaluate package damage in nine meter free fall test and in puncture test.

The nine meter free fall damage is evaluated with the dynamic yield pressure method described by Shappert (1970) and extended by Lee (1971). In the case of structures which suffer buckling a semiempirical method for rough damage evaluation is used.

This module permits the inclusion of impact-limiters in the design.

The damages that arise from puncture test are evaluated through the results given by Sakamoto et al (1974) and by Shieh (1978 and 1981).

CACOO system applications

Three cases of CACOO application are presented below:

Cost estimation of Co60 package.

A package for transport of 10000 Ci of Co60 was designed and its cost evaluated. The preliminary design which resulted is very similar to that of some packages presently in use for the same purpose. Its cost appeared to be very competitive.

Conceptual design of GURI 01

CACOO system was used for the conceptual design of GURI 01 package, which can transport up to 350000 Ci of Co60. Its approval as a type B(U) package is presently under consideration of the competent authority of Argentina.

The key design parameters defined by CACOO were confirmed by subsequent analysis and testing which were carried out in the licency process. Mechanical test were performed successfully on a package model whose structural parameters were those obtained from CACOO. Thermal parameters were validated through elaborate finite difference analysis. Shielding parameters were also ratified after analysis with a general montecarlo simulation.

A diagram of GURI 01 package is shown in figure 2.

Conceptual design of GURI 100

CACOO system was applied in the conceptual design of GURI 100 package. This is a fissile class II type B(U) package that can transport up to six fresh MTR fuel elements or three control elements. A maximum of six GURI 100 packages per expedition is allowed.

GURI 100 packages has obtained approval by the competent authority of Argentina and is being presently used.

Also in this case,the results obtained from CACOO were verified with further analysis and testing . There was successfull verification of all key parameters defined by CACOO.

Figure 3 shows a diagram of GURI 100 package.

CONCLUSIONS

CACOO system can be used to perform cost estimations, conceptual design and initial stages of basic design of type B(U) packages in a fast and economic way.

Its modular structure makes it adaptable to new design situations.

The system can be used in an interactive fashion, enabling the user to decide the flow of calculations or to arbitrarily set of design parameters values.

Experience obtained with CACOO aplications shows that this system provides good design results at a low cost.

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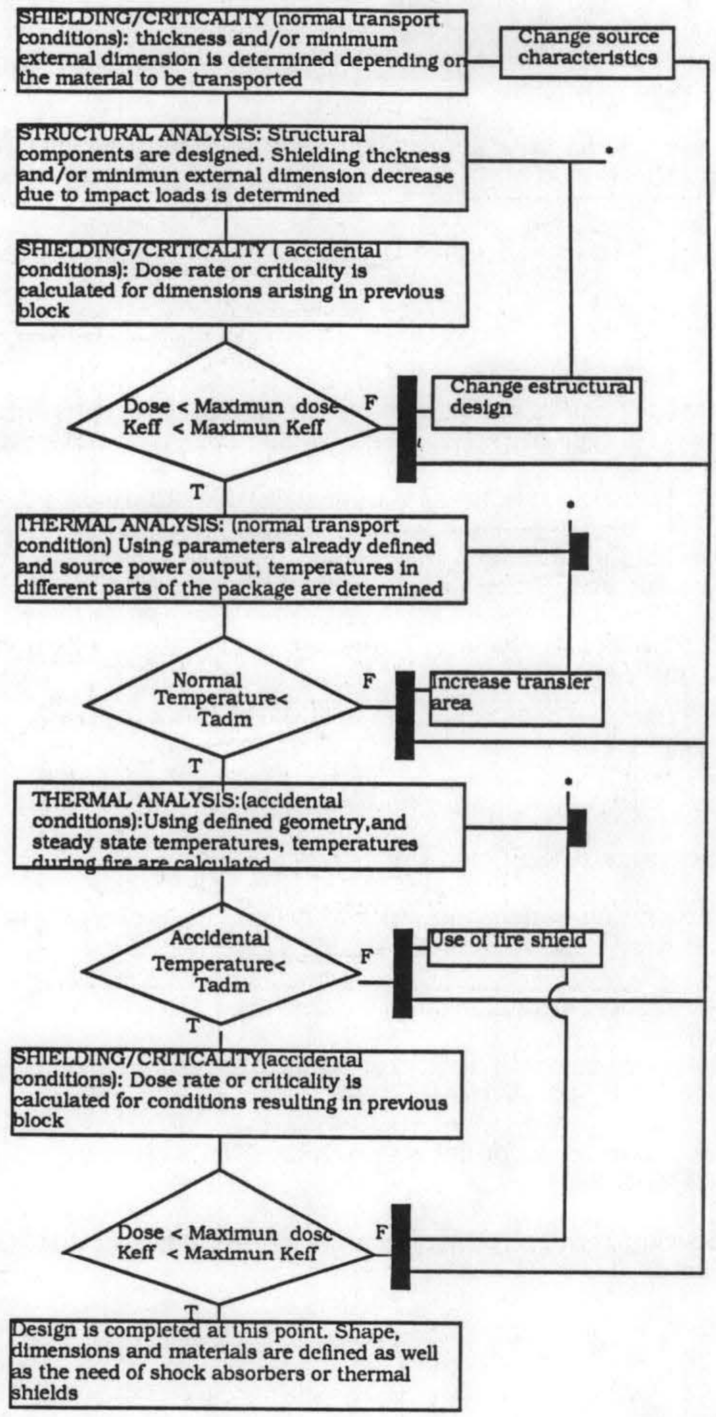
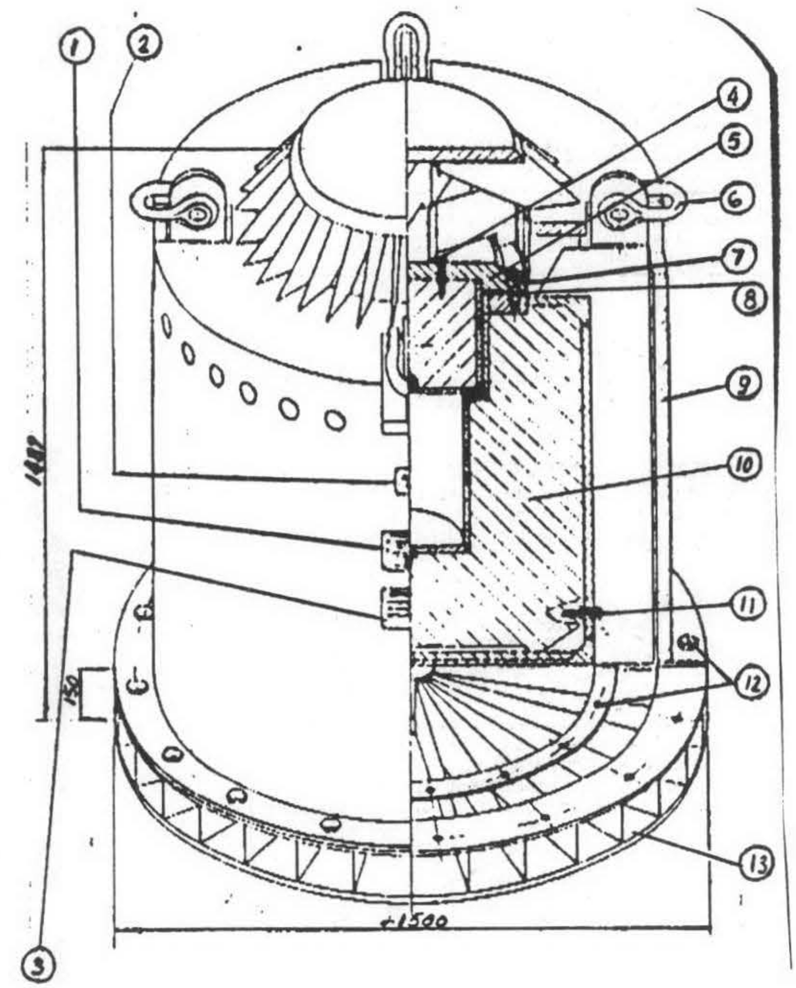


fig1: Module and Control Diagram

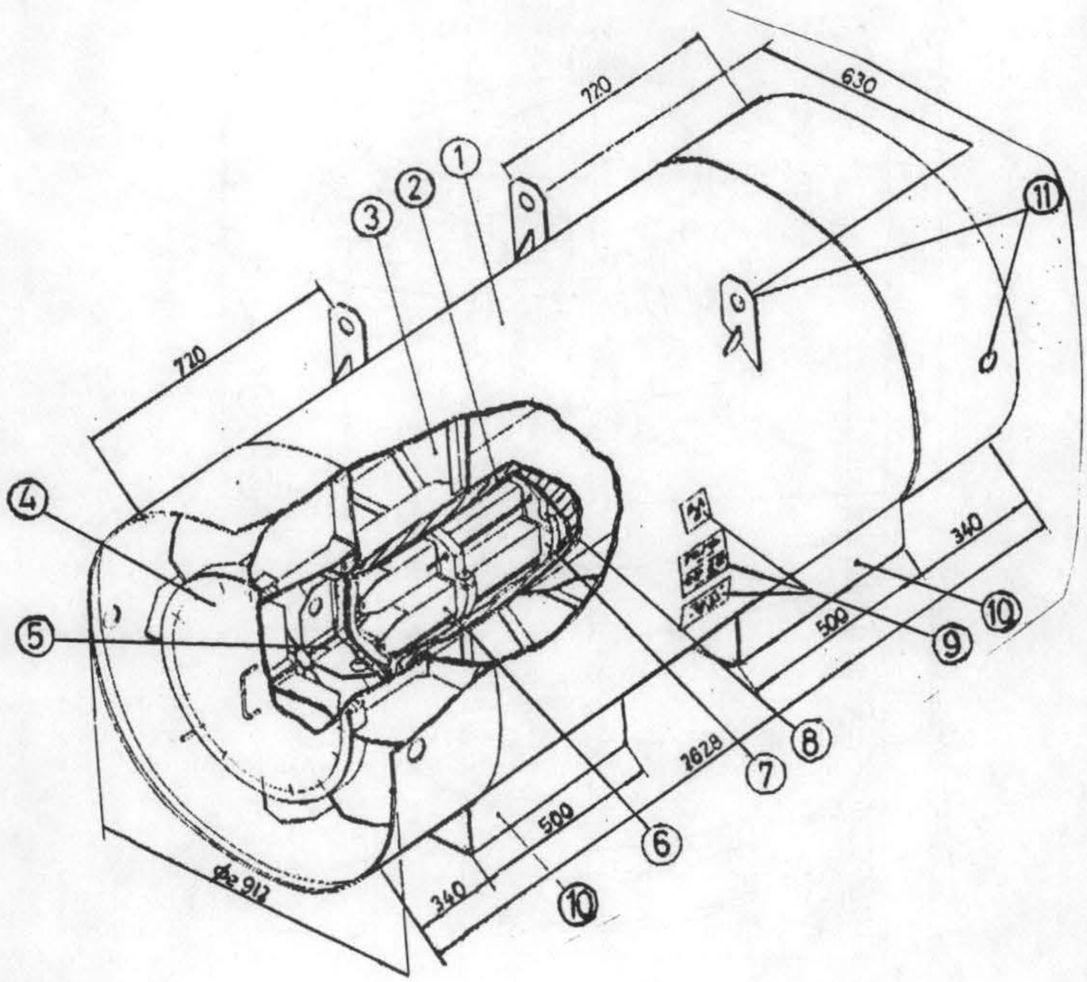
Note: * means iteration

█ means user decision



1_ Identification plate
2_ Precaution plate
3_ Storage plate
4_ Lid drain
5_ Lid
6_ Lifting attatchments
7_ Lid bolts
8_ Gasket
9_ Fire shield
10_ Shield
11_ Shield drain
12_ Support base bolts
13_ Support base

fig 2: GURI 01 container for Co^{60} (up to 350000Ci)



1_ Container body
2_ Thermal insulation
3_ Reinforcement (plates and longitudinal tubes)
4_ Outer cover
5_ Inner cover
6_ Fuel or control elements
7_ Fastening devices
8_ Primary container
9_ Identification, precaution and fabrication plates
10_ Support base
11_ lifting attatchments

fig 3: GURI 100 Container for MTR fresh fuel elements