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# PERFORMANCE OF BLC-200 CASK UNDER 9m DROP TEST

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## Abstract

BLC-200 cask is designed to carry 200 kCi Co$^{60}$ sealed sources. The cask is made of stainless steel, lead and tungsten. Lead is used as primary shielding material, whereas tungsten is used in the inner periphery to make the cask compact and light. One of the main design features of BLC-200 is its inclined fins which not only act as a shock absorber during impact but also helps in dissipating heat during normal conditions of transport. The cask is designed as a Type B (U) package as per International Atomic Energy Agency (IAEA) & Atomic Energy Regulatory Board (AERB) regulations, according to which the cask should maintain its structural integrity when dropped onto an unyielding target from a height of 9 m.Numerical simulation with Explicit Finite Element Technique is used to study the performance of the cask under 9 m drop test. The paper brings out the methodology of analysis and performance of cask under 9 m drop test. Numerical simulations of the cask under various drop orientations are presented. Results such as deformation, g-loading, lead slump and bolt stresses induced are discussed.

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*Keywords:* cask, structural integrity, inclined fins.

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## 1. Introduction

BLC-200 is an improved version of earlier version of BLC-125 Cask to carry higher amount of radioactivity BLC-125 can carry maximum radioactivity of 125 kCi of Co$^{60}$ which and is used to carry Co$^{60}$ to sealed source pencils to industrial irradiators which are designed for 1 to 2 MCi of Co$^{60}$. Every year such irradiators require 100 kCi to 200 kCi of Co$^{60}$ is to compensate the decay in activity. Therefore, two numbers of BLC-125 are needed to meet this requirement. This increases the number of consignments and the cost of transportation. Hence, it was prudent to upgrade the BLC-125 to BLC-200.

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A sectional view of BLC-200 can be seen in Fig 1. Lead and Tungsten are used as shielding material. Stainless Steel grade 304L is used as structural material and houses lead and tungsten. Tungsten is placed near to the inner shell so that the overall weight of the cask is less. Eight numbers of 20 mm thick and sixteen numbers of 10 mm fins have been provided on outer shell of the cask to protect it from the damaging effect under 9 m drop test. The fins are inclined at an angle of $10^0$ to the outer shell axis so that they get bent on impact and do not penetrate and puncture the outer shell. The cask has been designed as a Type B (U) package which needs to qualify normal conditions as well as accidental condition of transport as per national and international standard [1][2][3]. As per these regulations, the cask has to maintain its structural integrity when dropped on an unyielding target under 9m drop. Various orientations such as end drop, side drop and inverted corner drop are considered for the analysis.

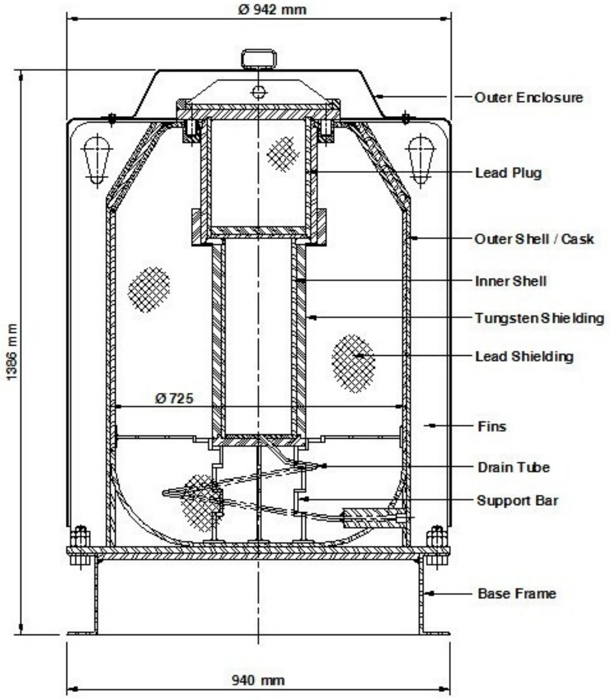

Fig. 1. Sectional view of BLC-200 Cask

Numerical simulations using finite element method has been used to study the integrity of the cask. 9m drop test is an impact problem which is governed by dynamic conditions. Dynamic analysis is carried out using explicit finite element solver PAM Crash [3]. Governing equation of motion in matrices form of a discretized body using finite element technique is

$$[M]\{\ddot{x}\} + [K]\{x\} = F_{ext} \tag{1}$$

Where **[M]** is mass matrix, **[K]** is stiffness matrix, $\mathbf{F_{ext}}$ is external nodal force and $\{\ddot{x}\}$, $\{x\}$, are the nodal vector of acceleration and displacement respectively. Problems of impact analysis are nonlinear in nature and time are dependent. Explicit analysis is mostly used for capturing the nonlinear behaviour of materials. In explicit analysis field variables are calculated at nodal points using central difference time integration techniques. Time step in explicit analysis is the critical parameter and the convergence of solution depends upon time step. An initial time step of order $10^{-6}$ has been taken for the analysis. The upper limit of critical time is given by

$$\Delta t \leq \frac{h_{min}}{c} \quad where \ c = \sqrt{\frac{E}{\rho}}$$

Where $h_{min}$ is the length of smallest element, c is the velocity of stress wave which depends upon material properties, Elastic modulus (E) and density (ρ).