Safety Analysis on Land Transportation of Cobalt-60 Radioactive Waste Using Fault Tree Analysis (FTA)

Juandi Antonius, Ester Wijayanti, Susetyo Hario Putero

Department of Nuclear Engineering and Engineering Physics, Universitas Gadjah Mada
Jl. Grafika 2, Yogyakarta 55281, Indonesia
juandiantonius@mail.ugm.ac.id

1. Background and Goal of the present work

The disused Cobalt-60 source of teletherapy machine must be transported from the hospital to nuclear waste repository within the country or can also be re-exported to the country of origin. The existing transport container of this source is limited and very expensive, so a new, cheaper container design is needed. One aspect that needs to be considered in a radioactive source container is the safety aspect. This study analysed the failure probability for transporting radioactive waste by land transportation. The main accident to be analysed is defined first as the top event, then the probability of the top event was calculated based on the probability of each primary event.

2. System Description

2.1. Cobalt-60 characteristics

Cobalt-60 has the following characteristics:

- Energy: 1.17 MeV and 1.33 MeV.
- Half-life 5,27 years.
- Based on BAPETEN's Chairman Regulation number 6 of 2015, the waste is included in the category 1 radioactive source.

2.2. Type B container requirements

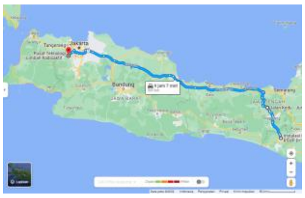
The transport container that is suit to the category 1 is type B container.

Type B container

2.3. Truck spesification

Based on RSUP Dr. Sardjito's safety and security assessment on the waste of radioactive sources, the transport vehicle used is a box truck having a transport capacity of 6 tons.

vehicles used in transportation



transport route

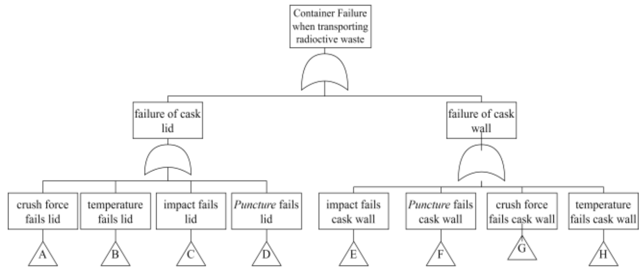
3. Basic Event Probabilities

Basic event probabilities are obtained from the road traffic accident rates in Indonesia, An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck, Severities of Transportation Accidents Involving Large Packages. The probabilities are:

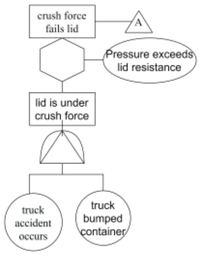
Events	Probability
Truck accident occurs	$8.0844 \cdot 10^{-3}$
Truck bumped container	$5 \cdot 10^{-2}$
Pressure exceeds lid resistance	$3 \cdot 10^{-8}$
Fire occurs	$4.7 \cdot 10^{-2}$
Temperature exceeds lid's melting point	$9.5 \cdot 10^{-1}$
Impact occurs	$9.52 \cdot 10^{-1}$
Impact fails defective lid	$2.81 \cdot 10^{-6}$
Impact fails normal lid	$4.75 \cdot 10^{-4}$
Impact fails lid with closure error	$1.2 \cdot 10^{-6}$
Puncture occurs	$2.5 \cdot 10^{-2}$
Puncture fails defective lid	$6 \cdot 10^{-11}$
Puncture fails normal lid	$4.36 \cdot 10^{-8}$
Puncture fails lid with closure error	$6 \cdot 10^{-11}$
Impact fails defective cask wall	$3.423 \cdot 10^{-4}$
Impact fails normal cask wall	$1.24 \cdot 10^{-3}$
Puncture fails defective cask wall	$8.4 \cdot 10^{-7}$
Puncture fails normal cask wall	$1.4 \cdot 10^{-4}$
Pressure exceeds cask wall resistance	$3 \cdot 10^{-8}$
Temperature exceeds cask wall's melting point	$9.5 \cdot 10^{-1}$

4. Fault Tree Analysis

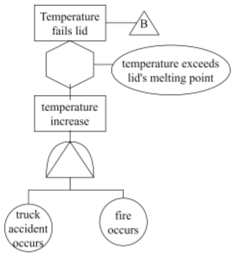
The analysis was carried out on the top event, namely the failure of the radioactive waste container during the transportation process. Failure of radioactive waste containers can occur due to two things: failure of the container lid and failure of the of the container wall.



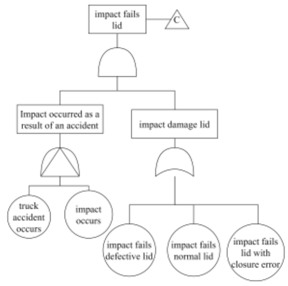
Fault tree for failure of radioactive waste containers during processing transport



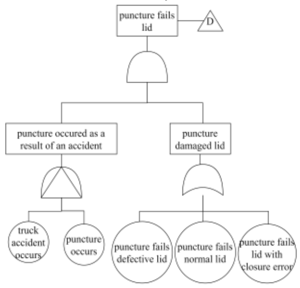
Fault tree for crush force fails lid



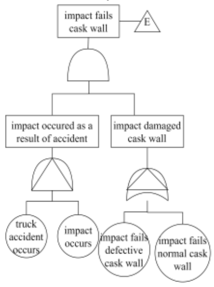
Fault tree for temperature fails lid



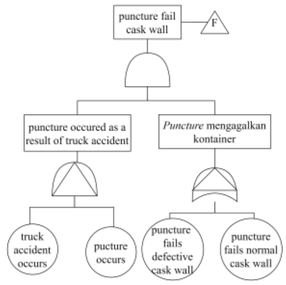
Fault tree for impact fails lid



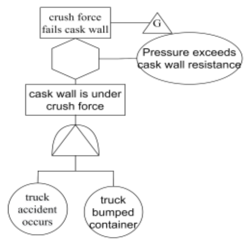
Fault tree for puncture fails lid



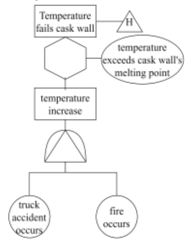
Fault tree for impact fails cask wall



Fault tree for puncture fails cask wall



Fault tree for crush force fails cask wall



Fault tree for temperature fails cask wall

Failure of the container lid can occur due to: Pressure that exceeds the resistance of the container lid, the temperature is too high which causes the container lid to melt, there is an impact on the container lid to damage the container lid, Puncture that punctures the container lid.

The container wall can fail if there is a strong enough impact in the transportation process, there is a puncture that can damage the container wall, there is strong pressure that can damage the container, there is an increase in temperature which causes the container wall to melt. The analysis shows that the probability of container failure in transporting radioactive waste is $3.6870 \ 10^{-4}$.

5. Conclusions and Acknowledgements

- The probability of a radioactive waste container failure during transportation is $3.6870 \ 10^{-4}$. The safety probability of the Cobalt-60 radioactive waste transport container by land is 0.9996.
- Factors to consider in container design are temperature, crush force, puncture and impact.