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SRNL
SAVANNAH RIVER NATIONAL LABORATORY
TM

# Crush Testing of 9977 GPFP Packagings

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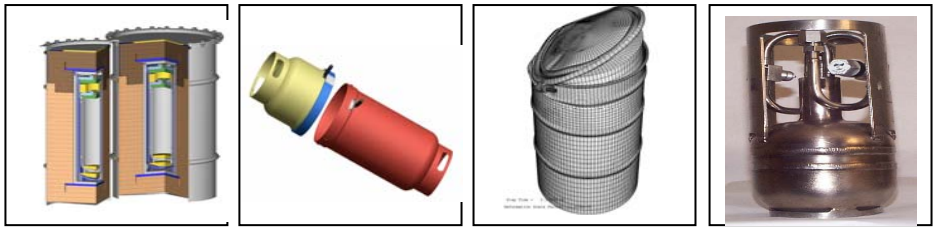
**Savannah River Packaging Technology**

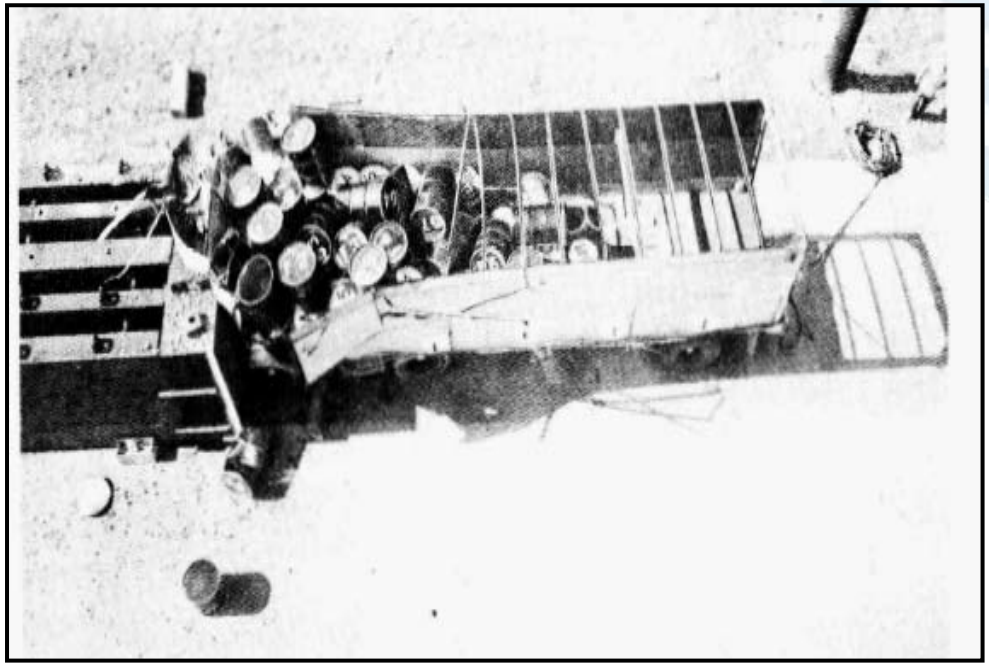


Environmental Management
safety ❖ performance ❖ cleanup ❖ closure
DOE Packaging Certification Program

# Crush Test Origins

- **Early testing showed that packages in an array were subjected to a variety of loads in accident events.**
- **Mechanical challenges to RAM Packages can be grouped into three categories.**
  - **Impact**
  - **Crush**
  - **Penetration**

# Early Tests of RAM Packaging



Aberdeen Proving Ground Test, 1966

Illustrations from “Early Accident-simulating Testing of Radioactive Material Packages in Road Vehicles”, R. B. Pope, L. B. Shappert, C. Taylor and R. A. Vaughan, Proceedings of the 15th International Symposium on Packaging and Transportation of Radioactive Material. PATRAM 2007, October 2007.

# Aberdeen Test

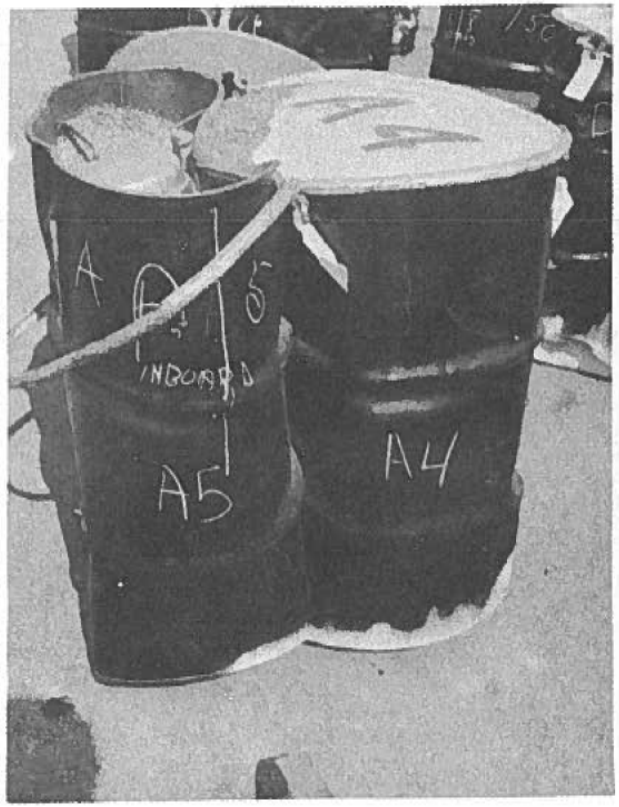
**Los Alamos BE 1763 in the damaged array prior to removal. Note loss of vermiculite, drum covers and failure of locking ring.**

# Aberdeen Test

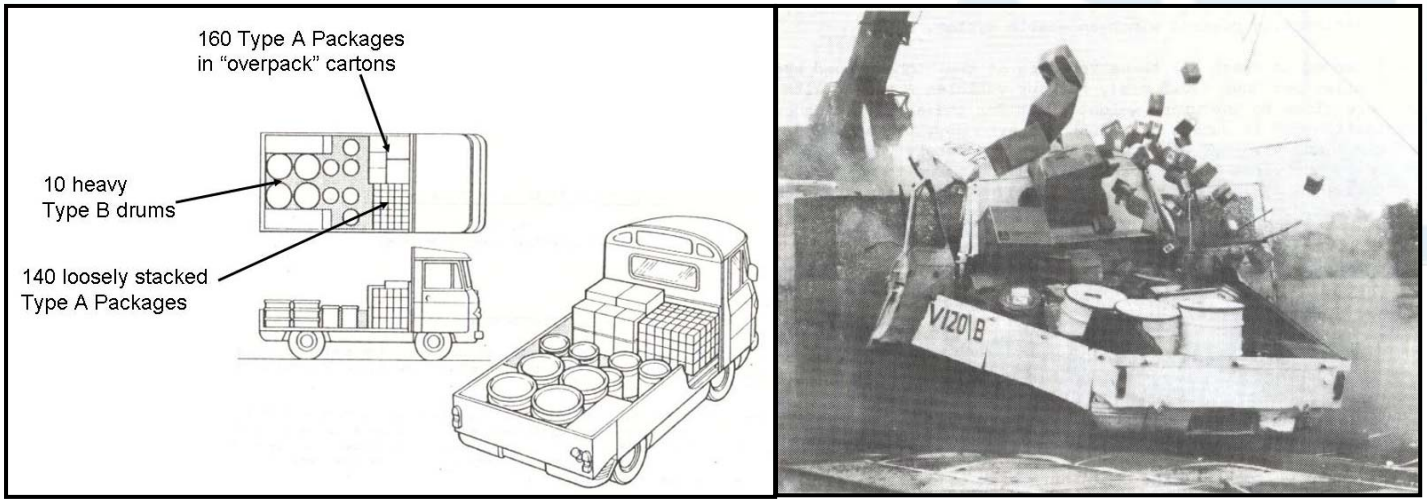
**Oak Ridge 20” Birdcage and Dow KKD-1 in the damaged array prior to removal. Five Dow KKD-1’s are shown compacted in the damaged array.**

# Aberdeen Test

**Los Alamos BE 1736 Containers A-4 and A-5 locked together.**

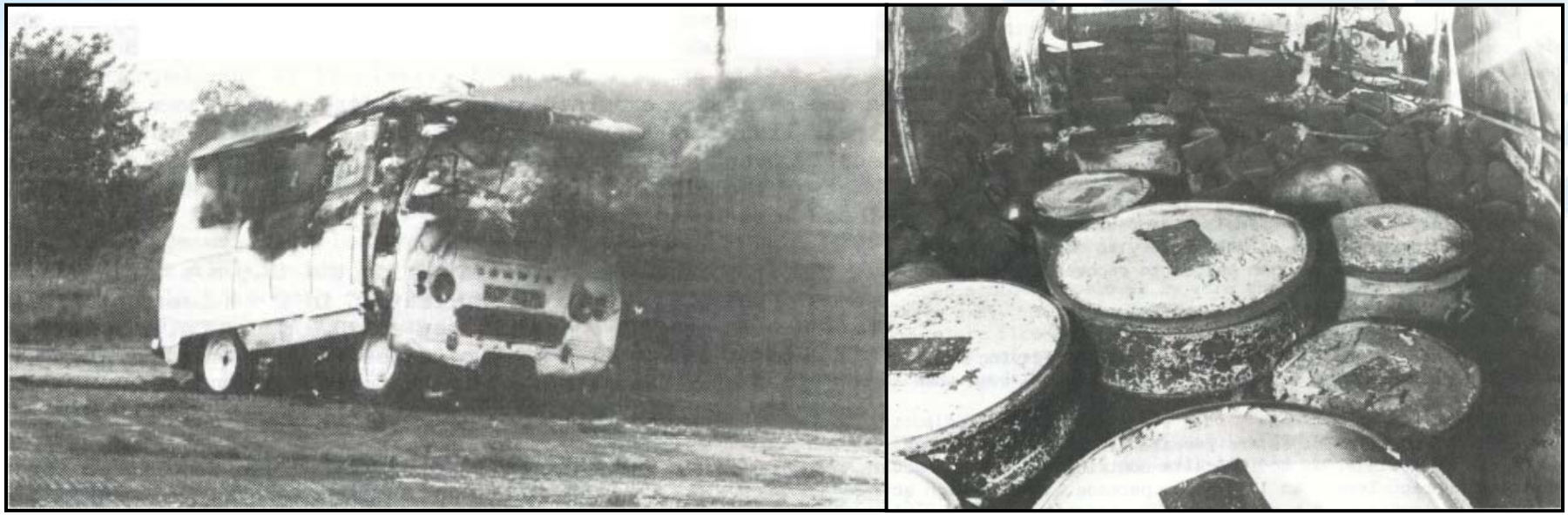


# Early Tests of RAM Packaging




Testing at MIRA facility in UK (Vehicle A)

# Early Tests of RAM Packaging



Testing at MIRA facility in UK (Vehicle B)

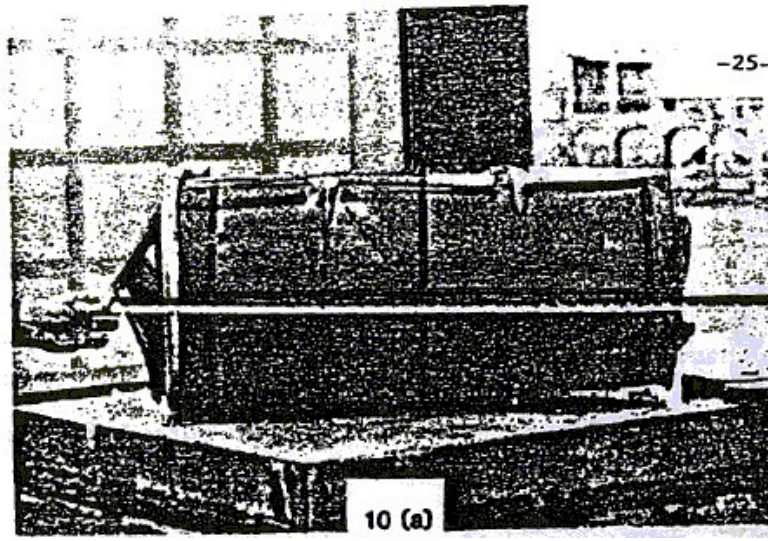
# Crush Test Origins

- **Light, low density packages are susceptible to crush loads. But are, relatively, not so vulnerable to impact loads.**
- **IAEA advisory material for TS-R-1 indicates that accident analyses show the probability for dynamic crush loads is greater than for impact. Also, handling and stowage mishaps can lead to undue static or dynamic crush loads.**
- **The end result of this was the inclusion of the crush test in the 1985 Edition of the Regulations. (Advisory Material Paragraph 727(c) Drop III)**
- **The Crush Test is required for packages having a mass not greater than 500 kg and an overall density not greater than 1000 kg/m3 based on the external dimensions, and a radioactive contents greater that 1000 A2, not as special form ram.**

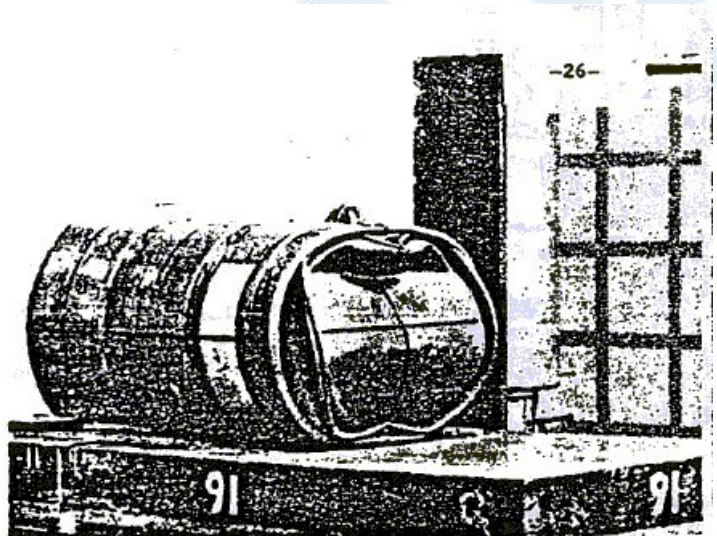
# SANDIA Crush Test Program

- **In response to the IAEA rule making, SANDIA conducted a test program to evaluate the sensitivity of small, light-weight Type B packagings to the crush environment.**
- **The test addressed a variety of contemporary packagings.**
- **The tests showed that the crush test is a severe challenge to small, light-weight packagings.**

# Results of Sandia Tests

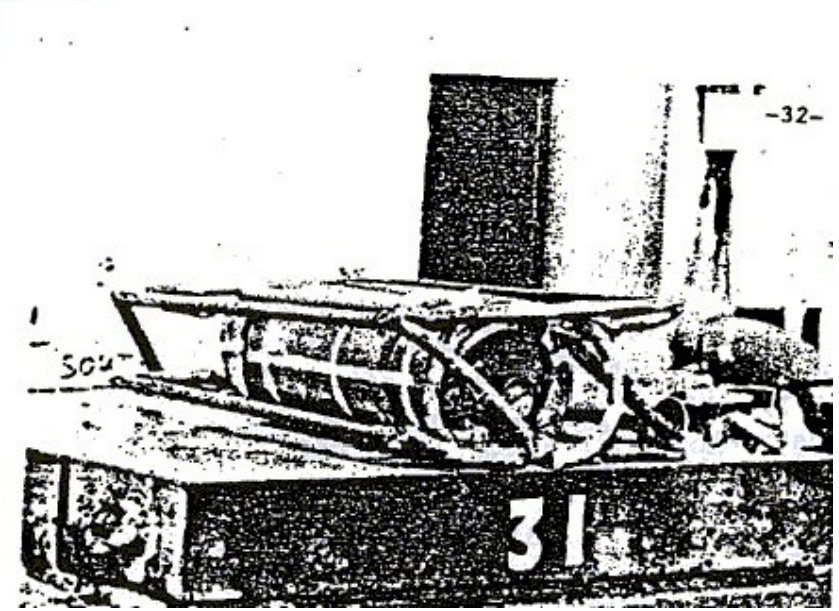



30 gal Generic Package (6M)

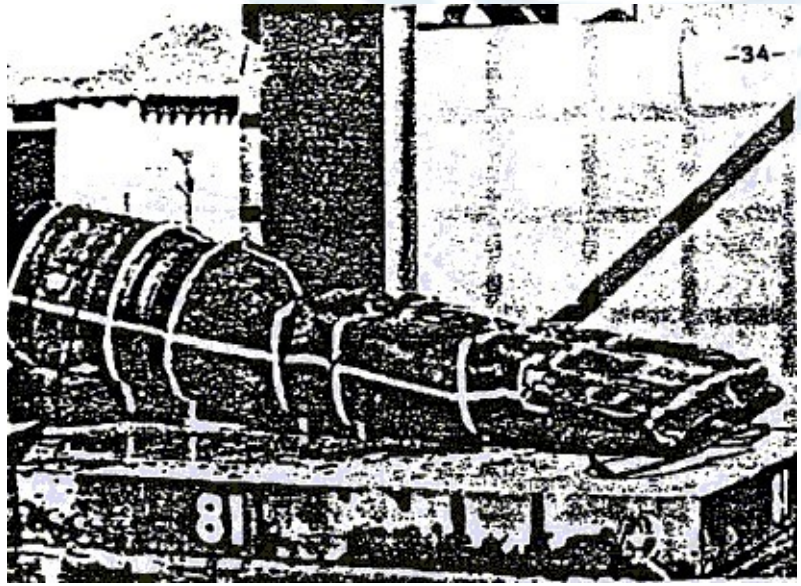



55 gal Generic Package (6M)

# Results of Sandia Tests




Rocky Flats Birdcage




Y-12 Model 9B

# Implementation of Crush Test in 10 CFR 71

- **NRC implemented the Crush Test requirement (10 CFR 71.73(c)(2)) in the 1995 revision to the regulation.**
- **In the commentary on the rule change, the NRC said:**
  - NRC believes that the crush test and the free drop test impart different types of loadings onto the package. Having sufficient crush resistance for the crush test does not insure adequacy of the package under the inertial loadings that occur during the 30-foot drop tests. NRC believes that it is important for packages to have resistance to impact and that the crush test should not be a substitute for the impact test. (this is supported by the Sandia report)
- **So, the NRC requires both drop and crush tests, for packages requiring crush.**
  - NRC requires the crush test for packages having a mass not greater than 500 kg and an overall density not greater than 1000 kg/m$^3$ based on the external dimensions, and a radioactive contents greater that 1000 $A_2$ not as special form RAM (same as IAEA).
- **The NRC has made it clear (71.41) that appropriate analyses may be used to demonstrate the ability of the package to meet crush test conditions.**

# US DOE Practice

- **DOE practice requires that all packagings be able to withstand the crush test, regardless of whether they fall within the size and mass limits of the regulations.**
- **Test programs of general purpose fissile packagings, such as the 9977 and ES-3100 have consequently included crush testing.**

# Crush Tests of the 9977 GPFP

# Crush Testing


# Crush Test Results


# Typical Crush Test Videos

# Lessons Learned

- **Crush Test is a severe challenge for light weight drum type packagings.**
- **Packaging must be designed to withstand the crush event.**
- **Response is function of package design.**
  - **Response of crush plate and package is energetic.**
  - **Accordingly, barricades are required.**
  - **Required use of out door drop pad.**
- **Appropriate design and specification of proper overpack material can result in crush resistant packagings.**