Consequences of Drop Test Parameter Limitations for Subsequent Package Design Safety Analysis

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Outline

- Motivation
- Parameters
- Assessment Cube
- Use the Cube
- Conclusions
Motivation

Drop Test Programs

Expectations

• Maximum benefit for subsequent safety analysis should be provided
• Additional safety demonstrations should be reduced as many as possible

Reality

• Drop test program needs time and money
• Expected scope of demonstrations is not fulfilled

Reason for unexpected additional analysis: drop test limitations
Drop Test Limitations

Examples

- Testing conditions as temperatures
- Manufacturing influences as material properties
- Scaling

Conclusions

- Main problem: number and large variety of parameters
- Drop test is only one point in a field of parameters
Field of Parameters

Parameters divided in three groups

- Safety requirements
- Testing conditions
- Design specifications
Safety Requirements

Basic requirements

- Brittle fracture safety
- Leak tightness
- Sufficient shielding
- Subcriticality

Deviated ones

- Cladding integrity
- Neutron absorber repositioning
- No flange deformation
- Shielding parts stability
- ...
Parameters

Testing Conditions

Drop test conditions

- Simplifications (e.g. content)
- Drop test sequence
- Test specimen properties
- Ambient conditions
- Design changes
- Scaling
- ...
Parameters

Design specifications

Min/max characteristics

- geometrical tolerances
- tightening torques
- temperatures: -40°C to service
- strengths

Manufacturing processes as welding/casting/forging
Assessment Cube

Three-dimensional parameter array sorted as a cube according to the ideas of Schneider (safety cube) and Zwicky (morphological box)
Use the cube

- brittle fracture
- (numerical analysis)
- validation
- scaling
- numerical analysis
- brittle fracture
- material testing

1:1 -40C
1:3 room temp.

shell integrity

temperatures -40C - operational

requirements

design specification

drop test

tasks for subsequent analysis

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Use the cube

- weak drop
- hard drop
- cask penetration
- trunnion impact

Most damaging conditions can be found by pre-calculations

Koch, Droste, Krietsch
(BAM, Berlin, Germany)

Drop Test Limitations
Use the cube

- flange deformation
- bolt bending
- bolt prestress
- seal testing

- bolt prestress tasks for subsequent analysis
Conclusions

Summary

- First parameter set: safety requirements
- Second parameter set: testing conditions
- Third parameter set: design specifications
- Parameter array can be imagined as *Assessment Cube*

Benefit

- Recognize easier limitations of drop tests
- Get the extent of subsequent analysis
- Redefine drop test conditions to minimize analysis

Recommendation

*Perform pre-calculations to define most benefit test conditions*