



Rail Event Tree


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RAIL EVENT TREE FROM VOLPE REPORT: SPENT NUCLEAR FUEL TRANSPORTATION RISK


2


F-11

ASSUMPTIONS

Volpe assumptions and data

- Consequences only on derailment
- No "fire only" scenario
- Used Railroad Accident/Incident Reporting System rather than Bureau of Transportation Statistics for conditional probabilities
- Initial events are accident types: derailment, head-on collision, etc.

SNL assumptions

- Adopted Volpe data
- Consequences only on derailment
- Assumed an accident
- Sought consistency with NUREG/CR-6672 approach
- Reorganized initial events: impact speeds and fire
- Separated "fire" and "no fire"
- Maximum number of severity fractions = 40; could be collapsed to 10.
- 2006 state by state accident data for accident probabilities

Table 2. Reported Train Accidents 1988-2001

RAIRS Accidents 1988-2001	Total and Yard		Only		Yard Only	
	Accident Count	Probability	Accident Count	Probability	Accident Count	Probability
Derailment	23,219	0.6634	10,672	0.6681	12,547	0.6594
Head-on Collision	246	0.007	149	0.0093	97	0.0051
Rear-end Collision	312	0.0089	237	0.0148	75	0.0039
Side Collision	1,889	0.054	219	0.0137	1,670	0.0878
Raking Collision	510	0.0146	163	0.0102	347	0.0182
Broken Train Collision	84	0.0024	45	0.0028	39	0.0021
Highway-Rail Crossing*	2,393	0.0684	2,365	0.1481	28	0.0015
Rail-Rail Crossing	16	0.0005	14	0.0009	2	0.0001
Obstruction	763	0.0218	605	0.0379	158	0.0083
Explosive	9	0.0003	2	0.0001	7	0.0004
Fire/Violent Explosion	337	0.0096	245	0.0153	92	0.0048
Other Impacts**	4,388	0.1254	830	0.0531	3,508	0.1844
Other in Narrative	814	0.0238	377	0.0236	457	0.0244
Total	35,000		15,973		19,027	

* RAIRS data contains only a portion of highway-rail crossing accidents.

** Other: Acts of God, or other events involving the operation of on-track equipment (standing or moving) that results in reportable casualty/damages (e.g., humping accidents, switch damage)

Source: Railroad Accident/Incident Reporting System (RAIRS)

Table 21. Accident Scenarios and Equivalent Velocities for the NRC Compliance Test

Scenario	Speed of Concern	Equivalent Velocity
Derailment	>30 MPH	For train derailments where the cask car does not derail (assigned an 80 percent probability), it is assumed that the cask may impact other rail equipment. The resulting damage from such an impact is assumed not to exceed the regulatory limit of 30 mph (48.2 km/hr). For train derailments where the cask car does derail (assigned a 20 percent probability) it is assumed that the cask impacts a hard object in the surrounding environment. Any train speed in excess of 30 mph (48.2 km/hr) will result in damage to the cask that exceeds regulatory limits.
Head-on Collision	>70 MPH	For head-on train-to-train collisions, the worst-case assumptions applied are: the cask train speed is 50 mph (80.4 km/hr), the cask breaks free of its car, the cask collides head-on with the second train's locomotive. For speeds of the second locomotive above 70 mph (112.6 km/hr), it is assumed that the cask impacts a hard object in the environment and damage that exceeds regulatory limits occurs.
Rear-end Collision	>50 MPH	The worst-case rear-end scenario assumed is that a stationary cask is struck by the second train's locomotive and derails. After impact, both the cask and locomotive continue to move at a residual velocity. For striking locomotive speeds under 50 mph (80.5 km/hr) the residual velocities do not exceed 30 mph (48.2 km/hr). For striking locomotive speeds greater than 50 mph (80.5 km/hr), the cask impacts a hard object in the environment and damage that exceeds regulatory limits occurs.
Side Collision	>50 MPH	The side-collision scenario assumes the cask is hit broadside by a train and derails. After impact, both the cask and locomotive continue to move at a residual velocity. For striking locomotive speeds under 50 mph (80.5 km/hr) the residual velocities do not exceed 30 mph (48.2 km/hr). For striking locomotive speeds greater than 50 mph (80.5 km/hr), the cask impacts a hard object in the environment and damage that exceeds regulatory limits occurs.
Raking Collision	>70 MPH	For raking collisions, it is assumed that the cask is struck on the corner by another piece of rail equipment and derails. For speeds of the second locomotive below 70 mph (112.6 km/hr) LOS events can occur. For speeds of the second locomotive above 70 mph (112.6 km/hr), it is assumed that the cask impacts a hard object in the environment and damage that exceeds regulatory limits occurs which corresponds to a release event.
Broken Train Collision	>70 MPH	In the broken train collision scenario, a section of a train rolls into the path of a moving train, or rolls into another stopped train. The speeds of concern are assumed the same as in the raking collision. The broken train must be traveling at a speed below 70 mph (112.6 km/hr) for a LOS event to occur. The broken train must be traveling at a speed above 70 mph (112.6 km/hr), for a release event to occur.
Highway-Rail Crossing	>30 MPH	For a highway-rail crossing scenario, the worst case occurs when the train derails. The derailment logic is then applied.
Rail-Rail Crossing	>50 MPH	For the rail-rail crossing scenario, the cask is impacted broadside by a locomotive and derails. After impact, both the cask and locomotive continue to move at a residual velocity. For striking locomotive speeds under 50 mph (80.5 km/hr) the residual velocities do not exceed 30 mph (48.2 km/hr). For striking locomotive speeds greater than 50 mph (80.5 km/hr), the cask impacts a hard object in the environment and damage that exceeds regulatory limits occurs, which corresponds to a release event.
Obstruction	>30 MPH	These collisions are assumed to be similar to highway-rail crossing accidents discussed above. These events are evaluated independently in terms of potential fire hazard.
Explosion / Fire	>30 MPH	




Table 22. Summary of Accident / Fire Probabilities

Scenario	Probability
Fall off bridge - 30 feet onto hard bedrock surface	1.40 ⁻¹³
Major Derailment with impact into slope of hard bedrock	8.03E-10
Major Derailment with fall off embankment into hard bedrock	3.21E-10
Major Derailment with impact into structure	7.73E-10
Major Derailment with impact into tunnel	8.05E-10
Pool Fire Temp Duration - Seal Leak	
steel-lead-steel	1.389 ⁻²⁰
monolithic steel	1.250 ⁻²⁰
Pool Fire Temp Duration - Seal Leak / Rod Bust	
steel-lead-steel	8.3383E-21
monolithic steel	1.250 ⁻²⁰

