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Integrated Waste Management
Office of Spent Fuel and Waste Disposition
Nuclear Energy

Development of Rail Accident Rates for Spent Nuclear Fuel Rail Shipments

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Background

- DOE has been engaged in planning for an integrated system to manage spent nuclear fuel (SNF).
- This would require transporting SNF from existing sites to eventual storage and disposal locations.
- Much of the transportation activity is anticipated to utilize the rail mode.
- To support this effort, development is underway to design and build new railcars capable of moving heavy, rail-sized SNF casks.

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Study Objective

- **Develop rail accident rates appropriate for evaluating the safety of an SNF train configuration.**
- **Key differences in SNF rail transport from regular freight:**
  - Typical size of a regular freight train is comprised of many more cars than an SNF configuration.
  - SNF shipments are not generally expected to go through yards, and be subject to decoupling and reassembling.
  - Speed restrictions (i.e., maximum of 50 mph) would be imposed on an SNF train in accordance with the Association of American Railroads' (AAR) recommended railroad operating practices for transportation of hazardous materials.
  - Train would preferentially operate on tracks with positive train control, where available.
  - SNF shipments would be accompanied by armed security personnel.

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Data Sources

- **<u>Accidents</u> - Rail Equipment Accident/Incident Report database maintained by the Federal Railroad Administration (FRA): 2011-2016**
  - Railroad class
  - Accident type
  - Location
  - Track type
  - Accident cause

- **<u>Exposure</u> – Bureau of Transportation Statistics (BTS); prior railroad research studies**
  - Car-miles; train-miles (averaged over a 12-year period)
  - % of car-miles and train-miles by track class (Class I railroads)

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Accident Analysis

- **Accident Cause**
  - FRA defines several hundred eligible cause codes.
  - These can be classified and grouped into being either car-mile or train-mile related.
- **Accident Location**
  - Occurrence on mainline, in yard, at siding or on industrial lead.
- **Track Class**
  - X/1, 2, 3, 4, 5 & higher
- **Accident Type**
  - Derailment
  - Collision
  - Other

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Accident Cause Groups & Categories

Group	CM/TM	Cause Description	Group	CM/TM	Cause Description
01E	CM	air hose defect (car)	06H	TM	radio communications error
02E	CM	brake rigging defect (car)	07H	TM	switching rules
03E	CM	handbrake defects (car)	08H	TM	mainline rules
04E	CM	UDE (car or loco)	09H	CM	train handling (excl. brakes)
05E	CM	other brake defect (car)	10H	TM	train speed
06E	CM	centerplate/carbody defects (car)	11H	TM	use of switches
07E	CM	coupler defects (car)	12H	TM	misc. track and structure defects
08E	CM	truck structure defects (car)	01M	TM	obstructions
09E	CM	sidebearing, suspension defects (car)	02M	TM	grade crossing collisions
10E	CM	bearing failure (car)	03M	CM	lading problems
11E	CM	other axle/journal defects (car)	04M	CM	track-train interaction
12E	CM	broken wheels (car)	05M	TM	other miscellaneous
13E	CM	other wheel defects (car)	01S	CM	signal failures
14E	CM	TOFC/COFC defects	01T	TM	roadbed defects
15E	CM	loco trucks/bearings/wheels	02T	TM	nontraffic, weather causes
16E	TM	loco electrical and fires	03T	TM	wide gauge
17E	TM	all other locomotive defects	04T	TM	track geometry (excl. wide gauge)
18E	TM	all other car defects	05T	CM	buckled track
19E	TM	stiff truck (car)	06T	CM	rail defects at bolted joint
20E	CM	track/train interactions - hunting (car)	07T	CM	joint bar defects
21E	CM	current collection equpment (loco)	08T	CM	broken rails or welds
01H	CM	brake operation (main line)	09T	CM	othe rail and joint defects
02H	TM	handbrake oeprations	10T	CM	turnout defects - switches
03H	TM	brake operations (other)	11T	CM	turnout defects - frogs
04H	TM	employee physical condition	12T	TM	misc. track and structure defects
05H	TM	failure to obey/display signals			

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Exposure Analysis

- **Annual car-miles and train-miles averaged over a multi-year period (2000-2012).**
- **Percentage of car-miles and train-miles by track class based on prior studies.**

FRA Track Class	X/1	2	3	4	5&6
Annual Car-Miles (billions)	0.11	1.15	4.18	22.72	7.88
Annual Train-Miles (millions)	1.53	16.86	61.83	315.8	115.49

Annual Number of Car and Train-Miles by Track Class

- **Exposure by track class not available for non-Class I railroad activity, but prior study found that non-Class I railroad activity amounts to 5.2% of Class 1 railroad traffic.**

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Analysis Results

Track Class	Derailment	Collision	Other	All
X/1	117.37	0	0	117.37
2	18.33	0.30	0.61	19.24
3	7.02	0	0.46	7.48
4	2.92	0.05	0.34	3.31
5 & higher	1.92	0.04	0.25	2.21

Class I Railroad Car-Mile Accident Rates (per billion car-miles)

Track Class	Derailment	Collision	Other	All
X/1	7.5	0.92	1.72	10.14
2	0.79	0.13	0.34	1.26
3	0.20	0.07	0.48	0.75
4	0.08	0.03	0.26	0.37
5 & higher	0.09	0.02	0.24	0.35

Class I Railroad Train-Mile Accident Rates (per million train-miles)

Mileage Category	Derailment	Collision	Other	All
CM (per billion car-miles)	33.27	0.28	1.03	34.58
TM (per million train-miles)	1.43	0.13	0.78	2.34

Non-Class I Railroad Accident Rates

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Key Findings

- **Accident rates, regardless of railroad type or cause, decrease with higher track classes. For Class I railroads, there is a sizeable drop in accident rate when going from track class X/1 to higher rated track.**
  - Use of rail segments with higher track class ratings is preferred.
  - Rail segments with X/1 track class ratings should be avoided whenever possible.
- **Derailment rates generally exceed rates for other accident types.**
  - Needs to be the primary focus of rail safety improvement programs.
  - Risk mitigation strategies embodied in SNF railcar design and AAR's recommended railroad operating practices for hazmat transportation designed to reduce number of derailments as well as other accident types.

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Utilizing Analysis Results in Rail Risk Assessments

Hypothetical SNF rail shipment
Total trip distance: 290 miles
- Non-Class I railroad (short line): 20 miles
- Class I railroad – track class 2: 30 miles; 4: 180 miles; 5: 60 miles

No. of Casks Shipped	No. of Cars in Train	Total Train-Miles	Total Car-Miles	Overall Accident Likelihood
1	6	290	1,740	0.000185
3	10	290	2,900	0.000194
5	14	290	4,060	0.000202

Accident Likelihood for Hypothetical Cask Shipments

- Results suggest that shipping multiple casks as part of same train (rather than the same number of casks shipped in multiple trains) will provide safety benefit in terms of the overall accident likelihood of the SNF shipping campaign.
- Ability to do so may be constrained in terms of the location and timing of casks that can be loaded where the SNF currently resides.

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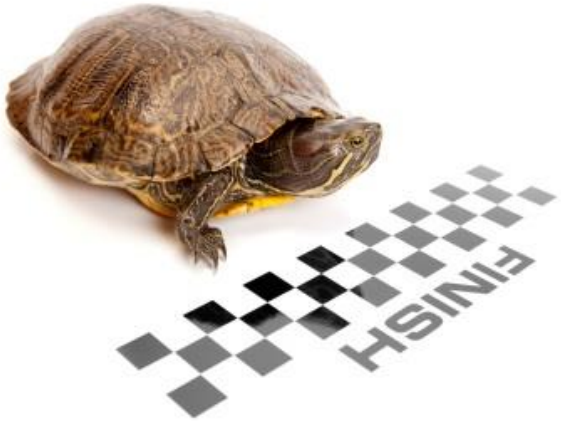
Contact Information



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