U.S. Department of Transportation
Federal Railroad Administration

Response to National Transportation Safety Board (NTSB) Recommendations Arising out of the Graniteville, South Carolina, Collision of January 6, 2005

Safety Recommendation R-05-14:

> *"Require that, along main lines in non-signaled territory, railroads install an automatic activated device, independent of the switch banner, that will, visually or electronically, compellingly capture the attention of employees involved with switch operations and clearly convey the status of the switch both in daylight and darkness."*

The evident purpose of this recommendation is to help prevent crews from leaving main line switches in other than the normal position and thereby prevent train accidents involving misrouting of trains with consequent derailments or collisions. On October 24, 2005, FRA published Emergency Order No. 24, which is designed to address this need through improved crew briefings, more effective communication procedures and documentation of actions taken. FRA has more recently prepared a Notice of Proposed Rulemaking (scheduled for publication in September) that would address this issue and certain other significant human factors issues, including management of programs of operational tests. We believe that these actions will contribute to a reduced incidence of misaligned main line switches.

We certainly agree that additional actions need to be taken to protect the safety of trains in dark territory. Over time, Positive Train Control (PTC) will serve this function by monitoring switches and alerting trains when they need to slow or stop approaching reversed switches. However, given the considerable period that will be required to implement PTC, we are working toward technology that will be forward-compatible with PTC and that will address this need at an earlier date.

The FRA initiated a joint project with BNSF in 2005 to integrate a system using existing technologies and components to monitor, detect and report switch point gapping for switches on the main track located within dark territories that could lead to unsafe train movement. The Switch Position Monitoring System (SPMS) is a one million dollar project with 50/50 cost sharing between BNSF and FRA. Instead of relying on verbal communication to determine if switches are left lined properly, this system will detect an improper switch point alignment and convey the information automatically to the dispatching system at Fort Worth, Texas. The dispatcher can cross-check this information against the communication with personnel that have thrown or reported switch position, and ensure that a track warrant would not be provided that could potentially send the train to the incorrect track. The main subsystems in this technology are a US&S U-5 vital switch circuit controller and the

Meteorcomm wireless network operated at 45.90 MHz, interfaced with the computer-aided dispatching system at the railroad's operations center.

The BNSF has used the communications network with great success in their Hy-rail Compliance Program, a system to warn hy-rail vehicles when they are out of their authority limits. They also adopted this network for their Electronic Train Management System.

The SPMS project was initiated in September 2005 and completed by early November 2005 to equip 49 switches on 174 miles of Avard Subdivision, which runs between Avard and Tulsa, Okalahoma. As of this date, the system has been found functioning as intended and providing dispatchers with notices of exceptions to proper switch position. On several occasions, the system has given warnings for misalignment or mal-adjustment promptly.

The BNSF is currently in talks with FRA about the possibility of conducting another joint pilot project to provide the ability to remotely control power switches from the train dispatch system without the cost burden of a signal system. This would allow the dispatchers to have even better control, but the cost per switch is approximately $120,000, which is six times more expensive than SPMS.

The Norfolk Southern (NS) has also advised FRA that they intend to begin development of their Optimized Train Control Project with a demonstration of a switch point detection technology on a non-signalized line in South Carolina.

The FRA will aggressively encourage these and other railroads to deploy forward-compatible technology on non-signalized lines where train speeds warrant, beginning with lines carrying heavy volumes of hazardous materials or where there are other special risk factors. FRA, in concert with the Pipeline and Hazardous Materials Safety Administration and the Transportation Security Administration, has also prepared a proposed rulemaking that would require risk analysis related to hazardous materials routes (including route selection) and consideration of mitigations such as switch point detection systems.

With respect to the NTSB's specific suggestion, FRA is concerned that any attempt to make a reversed switch more visible to employees working at the location would face substantial obstacles. To be effective, a visual device would need a source of power and would need to be so conspicuous as to capture the employee's attention through peripheral vision. Any such visual signal could be lost against the background of other signals in a situation of visual clutter; by contrast, the presence of such a signal in a less cluttered location (e.g., near a residential area) could face considerable objections from persons in the neighborhood during prolonged switching operations. During hours of darkness the device would need to be conspicuous, yet not so bright as to affect the ground employee's night vision. There is some possibility that calling attention to the switch could create an "attractive nuisance" drawing unauthorized persons onto railroad property.

A wireless electronic device would apparently need a source of power, a transmitter, and a receiver for each employee (or a least for the senior ground employee, or on each locomotive). Communication regarding switch status would need to be limited to one or more switches in the immediate proximity without imposing a significant number of false alarms (which could cause the system to be disregarded). At first blush, at least, this seems not to be a trivial problem.

Any system that requires power at the location will involve significant costs, simply because of the number of switches involved. Solar panels can be used for this purpose, but both initial installation and maintenance are costly. There are on the order of 23,000 main line switches in dark territory in the United States, and a significant portion of those would need to be equipped to address the NTSB's concern. Although FRA can make staff available to further explore these concepts with the NTSB's staff, at this time our judgment is that the alternate strategies described above are more likely to provide reliable solutions.

It is important to add that remote switch position monitoring has the potential to identify instances of misalignment committed by persons engaged in criminal acts, while the approaches suggested by this recommendation would at best have limited value in that scenario (i.e., only where a train approaching the location might have sufficient sight distance to the target to slow and mitigate the consequences).

The FRA respectfully requests that the NTSB classify Safety Recommendation R-05-14 as "Open—Acceptable Alternative Action."

Safety Recommendation R-05-15:

> *"Require railroads, in non-signaled territory and in the absence of switch position indicator lights or other automated systems that provide train crews with advance notice of switch positions, to operate those trains at speeds that will allow them to be safely stopped in advance of misaligned switches."*

While FRA can appreciate the NTSB's rationale for this recommendation, FRA believes the recommendation is not feasible for operational and economic reasons and may also increase the risk of train derailments. An analysis of FRA accident/incident data from 2002 to October 2005 indicates that there were approximately 473 human-factor related main track derailments. Of these, 214 were attributed to train handling/train makeup causes. In fact, excessive buff/slack action (H503 cause code) is the leading cause of main track derailments.

Of the 214 derailments, 65 or 30 percent involved excessive buff/slack action causes. By requiring crews to brake trains when approaching all facing point switches, the risk of train handling incidents may be increased. Switches are not always located in ideal places for slowing trains. Depending on terrain and train make-up, train braking can prove difficult, generating excessive in-train forces that could cause a derailment. It is obviously routine for crews to slow approaching turnouts, slow orders, and other locations. However, the larger the number of such events, the more likely it is that an error of judgment will occur. Given the fact that there are a relatively small number of train accidents caused by misaligned main track switches (fewer than ten each year), a relative few additional accidents related to train handling could potentially result in a net disbenefit. Additional train delays would result from broken train events, as well. (For further information on train make-up and management of draft and buff forces, please see discussion under Recommendation R-05-16, below).

In this post-9-11 era, railroad security is another important factor to consider. This recommendation would require many trains to come to a stop or proceed at a very low rate of speed in a geographically predictable manner. Switches are often found in more heavily populated areas were industries exist. This situation could subject the train to vandalism or possible terrorist activities. Individuals could board under these circumstances to vandalize lading or to target hazardous material cars for sabotage.

From an economic standpoint, the recommendation would severely impede the movement of trains. On those railroad divisions where many main track switches exist, the delays could be significant. Running times would be significantly increased and, in many cases, would result in the train being re-crewed before it reached its destination. Additionally, continually slowing and then accelerating trains would consume large amounts of fuel (releasing additional pollutants from the diesel prime mover).

Some dark territory lines are capacity constrained or are approaching that point, and slowing trains in the manner proposed would reduce capacity.[1] Slower trains would also occupy highway-rail crossings for a longer period of time, potentially affecting emergency services and certainly causing delay to motorists and pedestrians in communities along the railroad.

Making rail transportation less efficient and more costly would result, long term, in transfer of traffic to the highways (by diverting existing traffic or slowing the growth of rail traffic). Highway freight transportation is less safe than rail freight transportation, so it is highly unlikely that the trade-offs for intermodal safety would be favorable.[2]

In short, the direct safety benefits associated with this recommendation would not justify the costs, given the occurrence frequency of these types of accidents; and it is very likely that the safety of the American public would be adversely affected when all consequences are considered.

We hasten to add that there are undoubtedly certain situations where requiring trains to approach switches prepared to stop would be practical and an appropriate safety response. Railroads should consider this option as they conduct risk assessments of their hazardous materials routes. However, we are not aware of any means to describe, *a priori*, how this strategy could be applied in a safe and cost-effective manner.

---

[1] Installation of a signal system increases capacity, but for a line that is not yet over capacity the only rationale for requiring a signal system is safety. FRA's calculations to date indicate that accident avoidance cannot support the cost of installing and maintaining conventional signal systems. What cannot be mandated directly should not be mandated indirectly.

[2] See Appendix B, *Benefits and Costs of Positive Train Control* (FRA Report to the Committees on Appropriations; August 2004).

The FRA appreciates and shares the frustration that underlies this recommendation. However, it is imperative that the NTSB proceed in a suitably analytical way when crafting its recommendations. The quality of this recommendation does not approach the typical standards to which the NTSB normally adheres, and we believe it should be promptly withdrawn.

The FRA respectfully requests that the NTSB classify Safety Recommendation R-05-15 as "Closed—Reconsidered."

Safety Recommendation R-05-16:

> *Require railroads to implement operation measures, such as positioning tank cars toward the rear of trains and reducing speeds through populated areas, to minimize impact forces from accidents and reduce the vulnerability of tank cars transporting chlorine, anhydrous ammonia, and other liquefied gases designated as poisonous by inhalation."*

The FRA appreciates that it is important to find ways to reduce the likelihood that toxic hazardous materials will be released in the event of a train accident. As the NTSB is aware, FRA is currently conducting additional research directed at preserving the integrity of tank cars involved in derailments and collisions. The railroad industry works to reduce risk through their "key train" program and other means, and the key train program does include a 50 mile per hour maximum train speed.

However, FRA believes that the actions called for by this recommendation would be contrary to railroad safety and would result in significant costs to the railroad industry that could not be justified under any circumstances. In the following discussion, we explain why placing toxic inhalation hazard (TIH) cars at the rear of the train will do little to protect them from damage, why it is inappropriate from a train make-up perspective to concentrate loaded hazardous materials cars at the rear of the train, and why the safety impacts of doing so would likely overwhelm any benefit that might accrue. Further, we again explain the negative effects of slowing trains on a location-by-location basis.

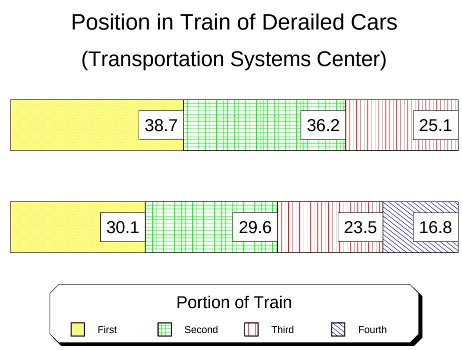
Train Placement:

Would placing TIH cars at the end of the train reduce loss of product?

Studies cited by the NTSB, and other work, suggest that some advantage might be achieved by placing hazardous materials cars in the last quarter of the train. However, when the possibility of both collisions and derailments are considered and data specific to the products in question are analyzed, it is by no means clear that the "obvious" conclusion is the correct one.

The Transportation Systems Center (now, the Volpe National Transportation Systems Center) published a study in March of 1979 exploring the idea that most derailments involve cars placed towards the front of a train.[3] TSC's analysis grew from a determination of the in-train location of all derailed units in reportable accidents for the years 1975, 1976, and 1977. After eliminating what it called "bad data," for instance, reports where the number of cars derailed equaled a greater number than the length of the train, TSC was left with over 22,000 derailments over the three-year period.

Dividing the train into thirds, TSC found that 38.7 percent of the cars derailed were in the first third of the train, 36.2 percent were in the middle third, and 25.1 percent were in the last third. Splitting the train into quarters showed 30.1 percent of the cars derailed were in the first quarter, 29.6 in the second, 23.5 in the third, and 16.8 in the last quarter of the train. The data also appear here as a bar graph. The study concluded that the risk of derailment is higher in the forward section of the train than in the rear third or rear quarter of the train.



Please note that this analysis did not consider the speed of the train at time of derailment; as a result, these results are undoubtedly influenced by the fact that derailments at gapping switch points, broken out rail, significant obstructions and other gross conditions will normally involve the first locomotive and often a few cars at the very front of the train. This is not to say that, in a high energy event, the results will necessarily follow the same distribution.

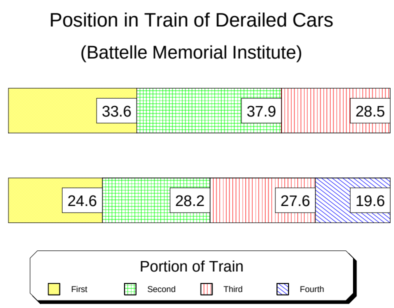
Under contract with FRA, Battelle completed a more recent study.[4] Because Battelle concentrated on identifying opportunities for reducing the number and severity of hazardous materials car derailments, it selected only derailments on "main track" involving "freight trains" and "mixed trains," and it eliminated any derailment associated with a "short train," that is, a train with 10 or fewer cars and locomotives. As with TSC, Battelle weeded out

---

[3] Fang, Paul Ching-I and Reed, H. David, "Strategic Positioning Of Railroad Cars To Reduce Their Risk Of Derailment," Internal Staff Study, Transportation Systems Center (DOT/TSC), March 1979.

[4] Thompson, R.E., Zamejc, E.R., and Ahlbeck, D.R., *Hazardous Materials Car Placement In A Train Consist*, Final Report, Technical Task No. 6, Contract No. DTFR53-86-C-00006, 1989. The study is in two volumes: Volume I, Review and Analysis, and Volume II, Appendices.

"bad data" and developed a final total of 5,451 derailments in 1982 through 1985.[5] The three- and four-section analysis of derailments in this study is similar to the earlier TSC project, and appears in the accompanying bar graph. Both studies show that the risk of derailment is significantly less in the rear of the train. The Battelle study also shows that the next safest section of the train is the front and the four section analysis indicates that, except for the rear of the train, "...there is little difference in the relative safety of the first three quarters."[6]



It should be noted that the advantage cited in the Battelle report is relatively small when compared with the earlier, less refined analysis. To gain the advantage, loaded tank cars would have to be placed in the last quarter of the train.

While the NTSB's Recommendation R-05-16 cites the Battelle report in support of the notion that hazardous materials cars should be at the rear of the train, the NTSB fails to also site a key conclusion/recommendation from the report:

> Hazmat car placement and separation requirements will negatively impact normal railroad operating practices and efficiencies. Hazmat car placement, instead of the normal practice of building train consists in station-order blocks, will require additional switching moves in classification yards and en route in pick-up and set-out of cars whenever hazmat cars are involved. Additional switching moves may actually expose hazmat cars to additional potential danger. Costs/benefits of hazmat car placement and separation are difficult to assess: the costs will be real, but the benefits may be elusive.[7]

Another study of mainline derailments and the effects of car placement within a train, cited by the NTSB, also comes to incomplete conclusions about the total impact of car

---

[5] An analysis by Battelle, within its report, demonstrates that mainline, long-train derailments constitute approximately the same percentage of incidents during the years included in the TSC study as in the years examined by Battelle. The more recent study simply focuses on a subset of the overall statistics.

[6] Battelle study, Vol. I, p. 11. Battelle attributes the relatively minor statistical differences between its study and the TSC work to the examination by TSC of derailments on all types of track, rather than on mainline track only. Battelle also excluded "short" trains and this may well have given a clearer picture of the relationship between each of the thirds or quarters of the train. (The average length in Battelle's study was 81 cars and locomotives, in the VNTSC work, it was 65.)

[7] *Ibid*., p. 146.

position/train handling/switching hazards.[8] The authors conclude that, for derailments caused by axle and journal defects, the best marshaling strategy is to place hazardous materials cars at the front of the train, presumably because axle and journal defects tend to happen randomly and, the fewer cars in front of the hazardous materials loads, the less chance that an axle or journal failure will happen in front of the hazmat. Conversely, for derailments caused by roadbed defects, rear of the train marshaling is advantageous, again, presumably because the track structure is more likely to fail towards the front of the train. The obvious point is that, unless a railroad can predict in advance what kind of derailment will occur, marshaling as a single strategy for improved safety has an extremely limited value.[9] The author's conclusion is that:

> (T)he distribution of causes of derailments is affected by the rail corridor considered. For example, a new or properly maintained track is expected to have more car- and equipment-related derailments than track-related derailments. Effective marshaling policies for SDC[10] cars in a train consist must reflect rail corridor conditions that influence both the cause of derailments and position of derailed cars along a train. Therefore, it is recommended that any analysis of marshaling regulations be performed for a specific rail corridor.[11]

Because the Graniteville derailment was caused by neither a failed track structure, nor a failed freight car, the Transportation Research Board analysis is of limited value in evaluating Graniteville or preventing its reoccurrence.

The Association of American Railroads Tank Car Committee is currently involved in an extensive review of the safety of chlorine transport by rail. A primary focus of that study is the tank car itself, but risk analyses of the environment in which the car operates are vital to achieve an overall reduction in transportation risk. The Director of the Railroad Tank Car Safety Research and Test Project prepared a report[12] that included an analysis of the position in train of chlorine cars losing lading in derailments from 1965 through 2003. This examination has admitted limitations because it includes data over a long period, the older of which often lacked the detail of more recent data and because the review "reflects only lading loss cases, and not the opportunities for loss, neither in the sense of derailed cars that did not release, nor in the sense of cars that were in a derailed train but were not themselves

---

[8] Saccomano, F.F. and El-Hage, S. of the Department of Civil Engineering, University of Waterloo, Ontario N2l 3G1, Canada, "Minimizing Derailments of Railcars Carrying Dangerous Commodities Through Effective Marshaling Strategies," *Transportation Research Record* 1245, Transportation Research Board, National Research Council, Washington, DC, 1989.

[9] Of course, if a railroad could predict what kind of a derailment it was about to have, it could take steps to avoid it altogether.

[10] In Canada, extremely high hazard commodities are known as Special Dangerous Commodities (SDC). Special extra hazard communication requirements apply to cars carrying these commodities. A similar concept appears at 49 CFR 172.504, where hazardous materials are divided into Table 1 and Table 2 for hazard communications requirements.

[11] Saccomanno and El-Hage, p. 47.

[12] Railway Supply Institute / Association of American Railroads Railroad Tank Car Safety Research and Test Project; T.T. Treichel, Director, "Supplemental Information on the Accident History of Chlorine Tank Cars, 500 psi Tank Cars and 600 psi Tank Cars Through 2003," Report RA 06-02, Leesburg, VA, February, 2006, pp. 15-16.

derailed."[13] The trains under study were broken into quintiles, with the relative location of the leaking tank car determining its placement into one of the quintiles. The results do not establish any statistically significant relationship between the location of the car and the potential that it will lose lading in a derailment, with the possible exception of probability of head puncture in the last quintile. (The data were not normalized for numbers of cars transported in each quintile; and for reasons given elsewhere in this report good train make-up practices very often will not allow such placement).

Finally, there is considerable question about whether or not the rear of the train is truly the safest portion, absent any other considerations. Analysis of derailment events only may result in insufficient focus on the potential for releases associated with collisions.

As the tables below illustrate, recent experience supports the hypothesis that, although minor product releases will always be more numerous in derailment events, given the larger number of derailments, that does not necessarily mean that a marshalling strategy should focus wholly on derailments. Products such as anhydrous ammonia and chlorine are required to be packaged in more robust tank cars, with re-closeable safety relief devices that survive most derailments. When releases of substantial quantities of product occur, it is because very high forces have been brought to bear or special circumstances obtained. However, collisions involving higher closing speeds generate the kinds of forces that can more readily damage even a chlorine car (overall, the most robust type of car in the fleet).

In considering collisions, it should be noted that, on main track—

- Rear end collisions are more numerous than head-on collisions;
- Because of directional running on paired rail lines and the construction of multiple main tracks to handle high volumes of trains in traffic control territory, rear end collisions appear to be growing in number; and
- Side collisions are also quite prominent (see NTSB's files on Macdona, Texas), but nothing can be done to anticipate where in the side of a train the other train will strike it.

The point here is that, while it might make some sense to consider placing hazardous materials cars near the rear of trains to prevent derailment, very little would be accomplished in reducing derailment-related releases; and even less would be accomplished in preventing derailment-related releases of TIH materials. Further, whatever benefits might accrue would likely be offset by an increased risk of TIH release in rear-end collisions.

(Please see tables to follow.)

[13] *Ibid*., p. 15.

SUMMARY OF TRAIN ACCIDENTS REPORTED ON FORM 54, EXCLUDING CROSSING INCIDENTS, WHERE THERE WAS A RELEASE OF HAZMAT, 1996-2005

CASUALTIES ARE ALL THAT OCCURED IN EVENT AND MAY NOT BE DUE TO EXPOSURE TO HAZMAT

Type track and accident		Hazmat Releases				
		Number	Cars Releasing	Cars Carrying	Deaths	Injuries
MAIN	Derailments	180	364	3,108	7	1,473
	Head on collision	1	2	13	4	0
	Rear end collision	3	3	48	2	6
	Side collision	5	9	42	3	8
	Raking collision	2	2	7	0	0
	Obstruction impact	1	3	10	0	0
	Other impacts	3	4	5	0	1
	Other events	2	2	2	0	0
	Total	197	389	3,235	16	1,488
YARD						
	Derailments	71	98	723	0	0
	Side collision	4	4	7	0	0
	Raking collision	2	3	8	0	0
	Broken train collision	1	1	1	0	0
	Explosion/detonation	1	1	2	0	0
	Fire/violent rupture	1	1	1	0	0
	Other impacts	12	13	89	0	3
	Other events	3	3	15	0	0
	Total	95	124	846	0	3
SIDING						
	Derailments	16	19	221	0	1
	Head on collision	1	1	61	1	4
	Other impacts	2	3	13	0	2
	Total	19	23	295	1	7
INDUSTRY						
	Derailments	20	27	240	0	1
	Rear end collision	1	1	7	0	2
	Obstruction impact	1	1	26	0	0
	Other impacts	1	1	2	0	0
	Other events	3	4	26	9	300
	Total	26	34	301	9	303
TYPE						
Derailments		287	508	4,292	7	1,475
Head on collision		2	3	74	5	4
Rear end collision		4	4	55	2	8
Side collision		9	13	49	3	8
Raking collision		4	5	15	0	0
Broken train collision		1	1	1	0	0
Obstruction impact		2	4	36	0	0
Explosion/detonation		1	1	2	0	0
Fire/violent rupture		1	1	1	0	0
Other impacts		18	21	109	0	6
Other events		8	9	43	9	300
YEAR4						
1996		34	69	394	5	10
1997		31	38	418	1	6
1998		41	66	450	0	7
1999		41	75	547	1	4
2000		35	75	677	0	12
2001		32	57	380	0	5
2002		31	56	525	1	1,443
2003		27	38	415	0	2
2004		29	47	400	3	8
2005		36	49	471	15	304

SUMMARY OF TRAIN ACCIDENTS REPORTED ON FORM 54, EXCLUDING CROSSING INCIDENTS, 1996-2005

Type track and accident		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
		Accidents	Accidents	Accidents	Accidents	Accidents	Accidents	Accidents	Accidents	Accidents	Accidents
Other/missing	Derailments	2	16	17	30	18	25	14	17	14	17
	Rear end collision	.	1	1	.	.	.	.	.	.	.
	Side collision	.	.	3	1	1	.	2	2	2	1
	Obstruction impact	.	.	.	1	1	.	.	.	1	.
	Fire/violent rupture	.	.	.	1	.	.	.	.	.	.
	Other impacts	1	2	.	.	1	1	1	.	3	2
	Other events	.	.	3	.	1	1	.	1	1	.
	Total	3	19	24	33	22	27	17	20	21	20
MAIN											
	Derailments	752	686	733	656	733	757	667	714	760	729
	Head on collision	9	7	3	7	5	6	8	6	5	5
	Rear end collision	11	17	16	18	13	23	14	13	11	25
	Side collision	20	8	15	14	16	15	9	11	23	19
	Raking collision	10	12	13	12	21	9	6	6	9	17
	Broken train collision	3	3	.	1	4	5	2	3	5	.
	RR crossing collision	.	4	2	1	1	.	.	.	.	.
	Obstruction impact	51	39	43	40	46	51	42	49	52	48
	Explosion/detonation	.	.	.	.	.	1	1	.	.	1
	Fire/violent rupture	17	9	11	14	17	27	22	23	15	18
	Other impacts	68	34	22	23	35	33	40	32	36	34
	Other events	.	48	76	72	85	98	75	106	100	96
	Total	941	867	934	858	976	1,025	886	963	1,016	992
YARD											
	Derailments	858	800	785	988	1,070	1,123	1,021	1,093	1,278	1,151
	Head on collision	3	4	4	2	2	1	5	7	2	2
	Rear end collision	2	3	2	3	5	8	4	5	3	2
	Side collision	106	99	74	103	115	97	94	92	123	130
	Raking collision	22	28	18	29	35	26	36	41	33	38
	Broken train collision	2	3	.	1	3	10	1	2	4	2
	RR crossing collision	.	1	.	1	.	.	.	.	.	.
	Obstruction impact	14	16	10	10	13	16	10	15	13	12
	Explosion/detonation	1	.	.	.	2	1	1	.	1	.
	Fire/violent rupture	1	5	4	7	3	4	1	9	3	6
	Other impacts	240	199	187	308	317	250	272	353	397	331
	Other events	.	65	222	79	54	33	33	38	46	42
	Total	1,249	1,223	1,306	1,531	1,619	1,569	1,478	1,655	1,903	1,716
SIDING											
	Derailments	75	90	72	93	98	94	61	79	100	97
	Head on collision	.	3	1	1	1	.	.	.	1	3
	Rear end collision	1	.	1	1	.	1	1	1	2	1
	Side collision	2	1	5	.	1	1	1	.	2	2
	Raking collision	.	.	1	1	3	3	.	1	.	.
	Obstruction impact	1	2	2	.	1	1	.	2	.	3
	Fire/violent rupture	.	1	1	2	.	1	1	1	1	.
	Other impacts	5	9	7	3	13	7	11	10	4	5
	Other events	.	.	11	5	3	3	4	1	3	4
	Total	84	106	101	106	120	111	79	95	113	115
INDUSTRY											
	Derailments	129	149	150	194	193	235	226	217	264	247
	Head on collision	3	.	.	1	1	2	.	.	2	.
	Rear end collision	.	.	.	1	.	2	1	1	1	.
	Side collision	9	7	5	6	8	4	3	4	5	8
	Raking collision	2	1	4	1	3	7	4	3	4	5
	Broken train collision	.	.	.	.	.	.	1	.	.	.
	Obstruction impact	4	4	3	5	8	6	8	9	3	3
	Fire/violent rupture	.	.	.	.	.	.	.	2	.	.
	Other impacts	19	15	22	21	24	29	25	31	18	23
	Other events	.	6	26	11	9	6	10	4	8	7
	Total	166	182	210	240	246	291	278	271	305	293

Again, it is worthy of note that, of the three fatal train accidents involving release of products toxic by inhalation since the year 2001 (Minot, Macdona, and Graniteville), two began as collisions. Whether or not the almost 4:1 ratio of rear-end collisions to head-on collisions will continue into the future is the subject of speculation; but, as railroads exploit the multiple routes now open to a single railroad because of mergers with former competitors, the practice of directing traffic one-way on a given route has increased, and the use of double track is also growing to address capacity needs, increasing the likelihood that future collisions will involve the rear of the train, at least until suitable Positive Train Control systems are extensively deployed.

From a train make-up perspective, should loaded tank cars be required to be placed at the rear of the train?

What would be the other consequences of forcing TIH cars to the rear of the train?

The FRA believes it would be imprudent to further complicate the marshaling of trains, which must consider train make-up guidelines, train placement regulatory requirements, and the need to limit switching for both safety and efficiency reasons, by mandating that loaded TIH tank cars be placed in the near quarter of the train.

Another FRA study,[14] concluded that the preferred location for loaded cars is towards the front of the train because, under braking, heavy cars decelerate more slowly than empty cars and, if placed towards the rear, would "push" the more rapidly decelerating empty cars in front of them and generate high buff forces. Another danger of placing extended strings of light cars ahead of loads is the "stringline" effect.[15] Analysis of the July 14, 1991, accident at Dunsmuir, California,[16] shows that the pulling force of the engines combined with the drag of heavy loads may cause a group of light cars (especially long, light cars) to be pulled off the tracks and towards the inside of a curve. The tighter the curve, the more pronounced the possible effect.

The FRA has considered both the in-train placement of hazardous materials cars and the make-up of trains in such a manner as to prevent derailments caused by in-train forces. In 2005, a report was prepared and submitted to the Congress.[17] While the NTSB's Recommendation R-05-16 deals only with the position in train of hazardous materials tank cars, FRA found that consideration of both factors was necessary for safety. A copy of the report accompanies this enclosure for ready reference.

---

[14] Nayak, P.R. and Palmer, D.W., "Issues and Dimensions of Freight Car Size: A Compendium," Report No. FRA/ORD-79/56, January 1980.

[15] "Stringlining" was discussed earlier in this report.

[16] An earlier example is the November 9, 1977, accident at Pensacola, Florida where a derailment, at least partly attributable to the "stringline" effect, lead the puncture of a tank car of anhydrous ammonia and the resulting gas cloud caused 2 deaths, many injuries, and the evacuation of 1,000 people.

[17] *Safe Placement of Train Cars: A Report.* Report to Senate Committee on Commerce, Science and Transportation and the House Committee on Transportation and Infrastructure. U.S. DOT, Federal Railroad Administration, June 2005.

Train make-up refers to the distribution within the train of railroad cars that are empty or loaded, short or long, or that have other characteristics affecting their ability to negotiate railroad track while subject to "draft" (stretching) forces and "buff" (compressive) forces within the train. Improperly assembled trains are more susceptible to derailment, depending upon grade, curvature, train handling (use of the throttle, independent brake, dynamic brake and automatic braking system), and other factors.

Excessive in-train forces can break equipment, cause a rail to turn over, or cause a car to climb a rail. Steady state forces are those that are applied for a relatively long period of time such as the pull up a grade or the compressive forces of descending a grade under dynamic braking.[18] High steady state forces can cause four types of problems: train separation, stringlining, buckling and jackknifing.

Transient forces, by definition of short duration, also play a role in optimizing train make-up.[19] They are primarily the result of train operations over changing grades or during acceleration or deceleration. The most certain way to avoid excess transient forces in terrain with a changing contour is to evenly distribute tonnage throughout the train; failing that, tonnage should be concentrated at the head end. The worst case scenario places concentrated tonnage to the rear of empty or lightly loaded cars.

Good train make-up must also take into consideration certain “difficult cars,” including multiple platform cars and cars with end-of-car cushioning, and combinations of long and short cars.

Beginning in the 1970’s the Association of American Railroads (AAR) and the FRA conducted extensive research into track-train dynamics. The AAR, through the Transportation Technology Center, Inc. (TTCI), has also continued to develop a computer-based model used to analyze and predict in-train forces, known currently as the Train Operations and Energy Simulator (TOES). Although it has offered to conduct analyses for the FRA, AAR has declined to license the TOES model to FRA. AAR explains that control of the model is maintained “to ensure the model is run properly.”[20]

With encouragement from staffs of the NTSB and Transport Canada, in Fiscal Year 2003 FRA initiated development of a new computer-based model called Analysis of Train/Track Interaction Forces (ATTIF) to accomplish this work. It is currently under development through a joint collaboration with the University of Illinois at Chicago. The new model is being designed as a public-domain code and will be available to the NTSB and Transport Canada and will be used immediately in support of ongoing FRA research.

At the request of the Office of Safety, FRA’s Office of Research and Development is conducting a study of train make-up considerations. The goals of the study are—

---

[18] *Train Make-up Manual*, p. 10.

[19] *Train Make-up Manual*, p. 11.

[20] Letter of November 1, 2002, from AAR President Edward R. Hamberger to FRA Administrator Rutter.

- to assess train make-up guidance describing “good practice” as it is available in the open literature,
- to review individual railroads’ operating rules relating to train make-up,
- to review railroads’ train make-up practices in the field, and
- to review records of accidents attributed to improper train make-up.

In order to better understand the operating rules and field practices, the study has begun with a review and analysis of train accidents attributed to train make-up and train handling. From here, it will move to a review of the written policy, as expressed in the operating rules, and the field practices. Finally, the research will “run” actual railroad consists on a train operations simulator to determine whether the particular trains could traverse varied terrain safely.

For the future, FRA, the NTSB, and the railroads continue to identify train accidents attributed to train make-up. In any given year railroads now report approximately 40 derailments using a train make-up “cause code,” down from as many as 80 in the early 1990's. These totals include code H599, “other causes relating to train handling or train make-up.” It should be noted that the rate of these events has declined more steeply than their absolute numbers, given the growth in train miles over the period.

However, additional accidents attributed to improper use of power brakes, improper train handling, and other causes may also be related in part to train make-up where the combination of grade and curvature together with less-than-ideal train make-up creates an excessive challenge for the locomotive engineer. On an annual basis over 100 derailments are reported under these cause codes, accounting for roughly $10 million per year in harm to persons and railroad property. It is not known how many of these events might have been prevented with better train make-up.

Better train make-up practices may lead to further reductions in the train accident rate. However, in evaluating options for improved train make-up, it will be important to consider the costs—and especially the safety costs—associated with more extensive switching of cars. The most common cause of fatalities to railroad employees is being crushed or run over in switching operations. According to the Switching Operations Fatality Analysis (SOFA) Working Group, there were 146 such fatalities in the period 1992-2005. Although every effort is being made to reduce these numbers, and some success is being achieved, increasing the exposure of train and yard crews to these hazards should be carefully weighed.

Further reductions in adverse train make-up and train handling events are possible under existing rules and practices. More extensive use of empty/load brake valves (evening out the rate of deceleration of cars in the train when brakes are applied) and, where employed, distributed power (with additional locomotives in the middle of the train under radio control from the lead engine) should make it somewhat easier for locomotive engineers to control in-train forces. Running counter to this influence, however, are the more extensive use of pre-blocking of cars to destination, the trend toward heavier-tonnage trains, and virtually exclusive reliance on extended-range dynamic braking to reduce fuel consumption and prevent undesired emergency brake applications.

Finally, in determining where to place hazardous materials in train, attention must be paid both to compliance with Department of Transportation (DOT) train placement restrictions for hazardous materials cars (explained in detail in the enclosed report) and to the possibility for introducing heightened risk of unfavorable interactions among regulated commodities (discussed in detail by the Battelle report cited by the NTSB and discussed in other particulars above).

Analysis of Train Placement Issues

Releases of TIH materials in train accidents are extremely rare, because of the care taken in their transportation and the robustness of the packaging (tank car characteristics). Although FRA shares the NTSB's concern that every reasonable effort be made to further reduce the risk of such an occurrence, it is critical that the full implications of proposed safety measures be considered.

The option suggested by the NTSB would require that TIH cars, typically loaded to capacity, be placed in the rear quarter of the train. In addition to exposing the cars to the consequences of a rear-end collision, such a strategy as applied to trains of any significant length could violate train make-up guidelines and lead to an increase in derailments. This is particularly the case since hazardous materials cars are often shipped in blocks that remain intact from origin to destination—or at least to the final point where they will be stored in transit awaiting final placement at the consignee's location. As discussed above, sub-optimum train make-up is already contributing to derailments. FRA is not willing to take action that would likely lead to the consequences the NTB seeks to avoid.

Even if FRA were persuaded that risk of derailment and consequent release of TIH materials could be reduced by placing heavy cars at the rear of a train, other considerations would need to be taken into account. Switching railroad cars involves the risk of accidents and employee injury. Switching involves the risk of overspeed impact, and–historically–some of the most catastrophic rail accidents involving hazardous materials have been in classification yards, with effects into the adjacent or nearby neighborhoods. Accordingly, a tradeoff of more highly refined train placement requirements could be more numerous switching incidents involving release of hazardous materials and derailment of cars resulting in precautionary evacuations.

In the period 1992-2005, a total of 16 persons died as a result of exposure to all hazardous materials following train accidents (9 of which resulted from the Graniteville collision, which was the worst such event since the Waverly, Tennessee, derailment of February 22, 1978). Yet in the same period 146 employees died during switching operations (applying the SOFA criteria), and many others suffered serious injuries. Each year, approximately 100,000 shipments of TIH are offered for transportation. Even given questionable train make-up practices affecting a minority of trains, most of these cars will currently be found in the first two-thirds of the train. If, in addition to the normal switching required to move this product to destination it became necessary to place these cars in the rear of the train, a significant number of additional switching moves would be required (at the initial point that the train was made up and/or at the point the cars are placed in other trains).

In-train placement regulations do consider both reducing the likelihood of a tank puncture—by prohibiting a hazardous materials tank car next to a load of telephone poles, for instance—and reducing the lethal effects of the post accident scene by requiring, for instance, that poison gas and explosives cars not be coupled to each other. To the extent that placement of TIH cars in the last quarter of the train might require relocation of other cars in order to comply with Department of Transportation train placement restrictions, additional switching could be required.

In summary, when all factors are taken into consideration, placement of loaded TIH cars in the rear portion of the train is unlikely to accomplish its intended purpose. Very likely, it would result in additional derailments presenting further opportunities for loss of product. It is likely that additional risk to employees making up and breaking up trains would also be incurred.

Train Speed Considerations:

In addition to recommending that FRA require the railroads to implement operating rules that would put hazardous materials laden cars towards the rear of the train, the NTSB also recommended that FRA require operating rules reducing the speed of trains through populated areas. Speed reduction might seem an intuitively good idea for reducing the severity of train accidents; but, in common with any large, complicated system or machine, what is intuitive may not always stand the light of rigorous study.

First, it must be noted that America's communities were initially built along railroads that served their transportation needs. Accordingly, in many parts of the Nation very substantial portions of the routes are peppered, and often blanketed, with small towns and urban areas. History teaches that catastrophic releases of hazardous materials that result from train accidents do not tend to occur in major urban areas but in the smaller communities (e.g., Goldonna, Waverly, Ridgefield, Youngstown, Minot, Macdona). For the recommendation to be effective, trains would need to be slowed along many of the track segments where achieving track speed is currently possible. Because of this fact, and because, as explained in response to Recommendation R-05-15, it is imprudent to introduce additional train handling challenges by slowing trains unnecessarily, any speed restriction contemplated would need as a practical matter to apply to all trains carrying TIH commodities on all non-signalized lines.

Second, it is necessary to consider the impact of such a measure on the efficiency and capacity of the rail network. American's transportation system is presently capacity-constrained. Although it is true that many lines in dark territory are not capacity constrained, others are. Slowing a single train on a line may result in higher crew costs and longer trip time (which is a cost to the shipper). Slowing a single train on a capacity-constrained line may have the effect of slowing rail traffic as a whole, with cascading effects elsewhere.

Third, it must be recognized that slowing a train containing TIH will not in every case protect it from a high-energy accident scenario, because energy may be introduced by another train operating at track speed, or by topography and gravity (e.g., derailment on approach to a bridge).

Finally, slowing operations could have a negative effect on the many small communities located along such track. The increased time a train would be blocking a crossing could further affect mobility in towns without grade separations and could (in admittedly rare cases) adversely effect the ability of emergency response vehicles to reach their dispatched emergency sites.

Accordingly, FRA is skeptical that the suggestion to lower the speed of trains containing TIH is feasible or wise. However, we are presently examining that issue in light of historical evidence and current industry conditions. We expect to complete that review by the end of October 2006.

Accordingly, FRA respectfully requests that the NTSB classify this Safety Recommendation R-05-16 as "Open—Acceptable Action."

Safety Recommendation R-05-17:

> *"Determine the most effective methods of providing emergency escape breathing apparatus for all crewmembers on freight trains carrying hazardous materials that would pose an inhalation hazard in the event of unintentional release, and then require railroads to provide these breathing apparatus to their crewmembers along with appropriate training."*

The provision of emergency escape breathing apparatus to crewmembers on freight trains carrying hazardous materials, that are toxic by inhalation, is a complex matter. The type of substance involved, the circumstances of release, the weather conditions and the location in the train are only a few of the factors to be considered. The fact that the devices must provide protection against substances with widely different chemical, physical and toxicological properties only adds to the complexity. That said, the FRA is undertaking a series of actions to explore the issues involved.

The FRA is reviewing accident data and related employee casualty data in order to do a quantitative risk assessment of harm to train crews due to incidents involving hazardous materials exposures. FRA is exploring data that defines the efficacy of commercially available emergency escape breathing devices in protecting crewmembers from exposure to the chemically different substances that comprise the major TIH materials shipped by rail. In addition FRA is investigating the economic issues involved in the provision of these devices to all crew members including initial purchases, life cycle cost for inspection, maintenance and replacement, initial and refresher training, and administrative costs for recordkeeping for maintenance and training activities.

During FY 2006, the FRA's Office of Research and development will initiate a study of potential emergency escape breathing apparatus for use by crewmembers of freight trains carrying hazardous materials that are toxic by inhalation. The study will include the types of emergency escape breathing apparatus; how they are to be used, what training is required, and their cost. Recommendations will be provided on where to locate such devices; if they are shown to be cost effective and easy to use.

Accordingly, FRA respectfully requests that the NTSB classify Safety Recommendation R-05-17 as "Open—Acceptable Action," pending completion of the subject research.

#