

ENTERED
Office of Proceedings
March 15, 2012
Part of
Public Record

BEFORE THE
SURFACE TRANSPORTATION BOARD

Finance Docket No. 35517

CF INDUSTRIES, INC. v. INDIANA & OHIO RAILWAY, POINT COMFORT
AND NORTHERN RAILWAY, AND THE MICHIGAN SHORE RAILROAD—
PETITION FOR DECLARATORY ORDER

MOTION FOR LEAVE TO CORRECT THE RECORD

In their Reply Evidence filed February 27, 2012, Complainants submitted the testimony of Dipen Shah Ph.D. as an Exhibit to their filing. It has now become clear that through an administrative oversight the Verification page of Dr. Shah's testimony was omitted. Complainants hereby request leave to resubmit the testimony that has been properly filed and served but without the Verification page with the Verification page. Since the testimony remains unchanged no party can claim prejudice from this omission. A copy of the testimony including the Verification page is attached hereto.

Respectfully submitted,

/s/ Paul M. Donovan
Paul M. Donovan
LaRoe, Winn, Moerman & Donovan
1250 Connecticut Ave, N.W. Suite 200
Washington, DC 20036
(202) 298-8100

 GRANTED Office of Proceedings	DECISION ID NO.: <u>42327</u>
	DECIDED DATE: <u>4/5/12</u>
	SERVICE DATE: <u>4/6/12</u>
	APPROVED: <u>Richard Armstrong</u> Acting Director
	☐

Counsel for Complainants

/s/ Jeffery O. Moreno

Jeffery O. Moreno

Thompson Hine LLP

1920 N Street, N.W. Suite 800

Washington, DC 20036

(202) 331-8800

Counsel for The Fertilizer Institute

March 15, 2012

IN CHARGE		
DATE		
DATE		
APPROVED		
Director	☐	Office of Investigation

Certificate of Service

The undersigned hereby certifies that I have this 15th day of March, 2012, filed a copy of this Motion for Leave to Correct the Record on all parties of record in this proceeding by electronic mail.

/s/ Paul M. Donovan

HLA Job Number: 12305

**LIMITING TRAIN SPEEDS TO PREVENT
PUNCTURE CONDITIONS FOR
TIH/PIH TANK CARS**

Prepared For: Mr. Frank Reiner
President
The Chlorine Institute

Prepared By: Dipen Shah, Ph.D.
Chief Engineer
HLA Engineers, Inc.

Approved By: Ricky Cribbs, P.E., S.E.
Vice President
HLA Engineers, Inc.

January 27, 2012



HLA ENGINEERS, INC.
7267 Envoy Court
Dallas, Texas 75247
(214) 267-0930 (214) 267-0970 Fax

TABLE OF CONTENTS

1.0 SUMMARY OF FINDINGS 1

 1.1 Part A: Accident Histories 1

 1.2 Part B: Collision Dynamics Modeling 3

 1.3 Part C: Puncture Velocities 4

 1.4 Conclusions 6

2.0 REFERENCES: 7

APPENDIX A : 49 CFR - TRANSPORTATION 8

APPENDIX B : 49 USC 11101 - SEC. 11101 11

APPENDIX C : CV OF DIPEN SHAH, PH.D. 12

TABLE OF FIGURES

Figure 1.	Number of Accidents per Year with at least One Car Releasing Hazmat from FRA RAIRS Database [6]	1
Figure 2.	TIH Tanks Cars Releasing Lading in Accidents by Year, 1965-2005 [6]	2
Figure 3.	Accident-Caused Releases in TIH Tank Cars, 1965-2005 [6]	2
Figure 4.	30-car model with 70 car equivalent lumped mass – initial contact.	3
Figure 5.	30-car model with 70 car equivalent lumped mass – initial closing velocities.	4
Figure 6.	Tank-shell Puncture Velocity in Analytical Studies	5
Figure 7.	Tank-head Puncture Velocity in Analytical Studies.....	5

Upon your request, I have conducted a study of the relevant engineering rationale in the transport of TIH/PIH tank cars in limiting train speeds to prevent accident and derailment conditions. This work was performed in reference to STB Finance Docket (FD) 35517 CF Industries vs. Indiana & Ohio Railway, Point Comfort & Northern Railway, and The Michigan Shore Railroad -Petition for Declaratory Order.

1.0 SUMMARY OF FINDINGS

Based upon my review and understanding of the documents provided and researched, I summarize the findings of my studies as follows:

1.1 Part A: Accident Histories

1. Accident data collected by the Railroad Tank Car Safety Research and Test Project (sponsored by the Railway Supply Institute (RSI) and the Association of American Railroads (AAR)), and FRA's Railroad Accident/Incident Reporting System (RAIRS) [1], indicate that the two types of accidents namely, derailments and train collisions, account for a vast majority (more than 90 percent) of all hazmat-related accidents [2].
2. Data from FRA's Railroad Accident/Incident Reporting System (RAIRS) indicates that the number of accidents per year with at least one car releasing hazmat has decreased significantly since the late 1970s (Figure 1)[6].

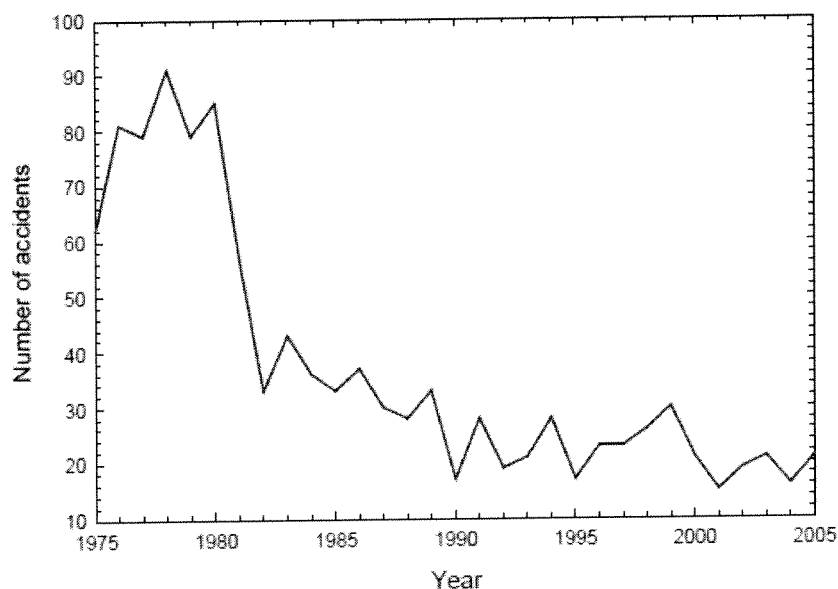


Figure 1. Number of Accidents per Year with at least One Car Releasing Hazmat from FRA RAIRS Databse [6]

3. Derived from data on damage to tank cars involved in accidents, Figure 2 shows a similar trend in the number of accident-caused releases from tank cars carrying specific lading called toxic inhalation hazardous (TIH) materials [6]. Between 1965 and 2005, a total of 252 tank cars released TIH in 176 accidents.

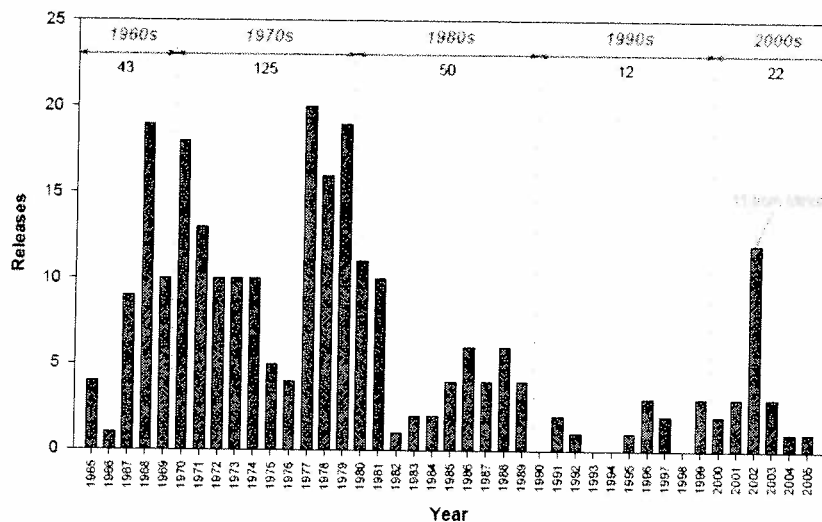


Figure 2. TIH Tanks Cars Releasing Lading in Accidents by Year, 1965-2005 [6]

4. Figure 3 shows the causes of lading loss and the number of gallons lost associated with these releases. For example, roughly less than half of the releases are caused by failures in the head and the shell of the tank car, but head and shell failures resulted in over 85 percent of the gallons lost. Failures to valves and fittings account for about one-third of the number of accident-caused releases, but less than 5 percent of the total gallons of lost lading.

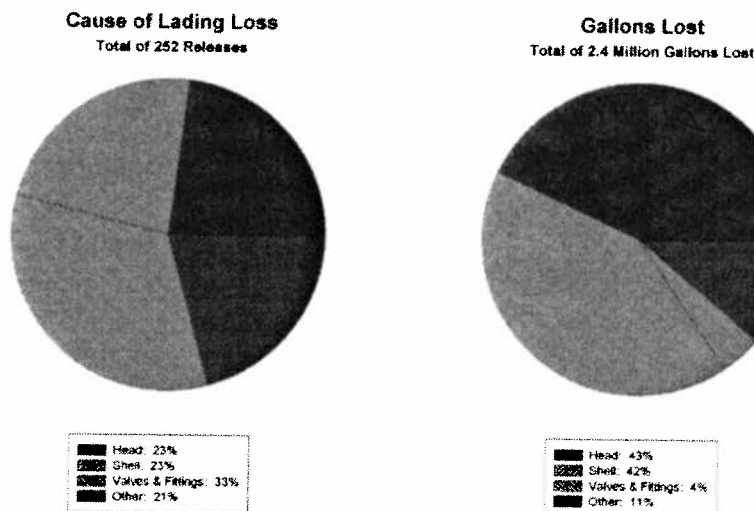


Figure 3. Accident-Caused Releases in TIH Tank Cars, 1965-2005 [6]

5. While the frequency of tank-head and tank-shell failures is slightly less than all other causes combined, their consequence in terms of gallons of lost commodity is much greater.

1.2 Part B: Collision Dynamics Modeling

6. Collision dynamics modeling performed by the Volpe Center [4,5] suggests that the gross motions of rail cars in derailments and collisions produce initial and secondary car-to-car impacts that are similar to those observed in actual accidents when cars come off the rails. Modeling of derailments and collisions as well as field experience suggests that the car-to-car impact scenarios of concern are Tank-head and tank-shell impacts. These studies describe a planar or two-dimensional model to examine the gross motions of rail cars in a generalized train derailment. Results from the purpose-built model are also compared to those from a model for derailment dynamics developed using commercial software for rigid-body dynamics called Automatic Dynamic Analysis of Mechanical Systems (ADAMS). Moreover, the purpose-built and the ADAMS models produce nearly identical results, which suggest that the dynamics are being calculated correctly in both models.
7. The analytical model performed for an initial train speed of 40 mph also shows a typical derailment pattern for the model when coupler break is included. The evolution of the derailment shows how a pile-up configuration develops in Figure 4.

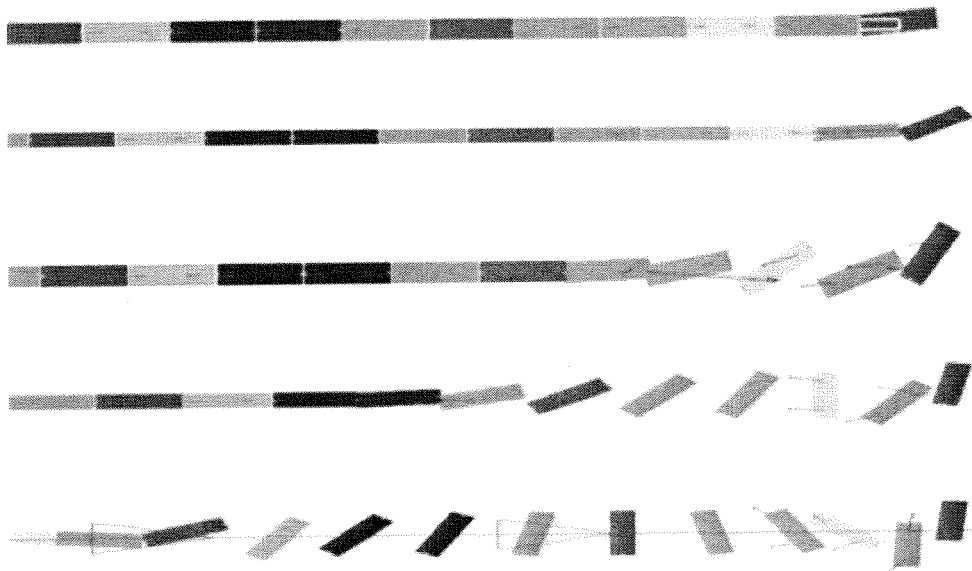


Figure 4. 30-car model with 70 car equivalent lumped mass – initial contact.

8. The corresponding closing velocities of the initial impacts are shown in Figure 5.

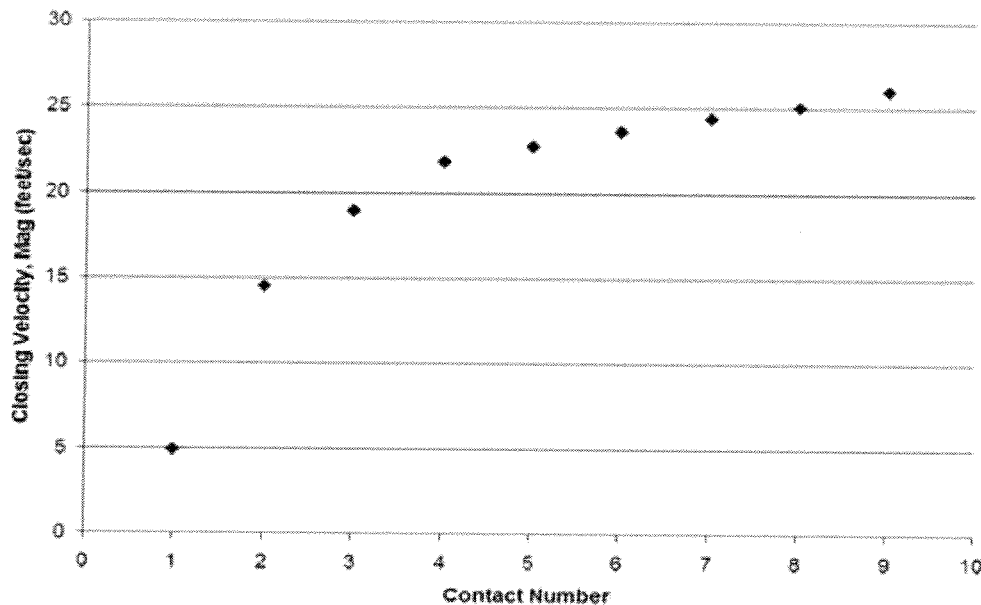


Figure 5. 30-car model with 70 car equivalent lumped mass – initial closing velocities.

9. Based on initial contact in the referenced study, the maximum closing speed tends to become fairly constant after the first 6 cars. It was also found that the maximum initial closing velocity (the speed that is defined as puncture velocity) is approximately half the train initial speed. Thus, as an example, a Train Speed of 50 mph would give a closing speed or puncture velocity of approx. 25 mph.

1.3 Part C: Puncture Velocities

10. Analytical studies have also been performed to compute the safe tank-head and tank-shell puncture velocities (also termed as closing speeds). Analytical studies performed by the Volpe Center [7] show that several factors affect the puncture velocities of tank cars. Baseline tank-shell puncture analysis was predicted to be 20 mph, and that for Tank-head puncture were estimated to be 13 mph. However, the puncture velocities for tank-shell puncture range from 10 to over 30 mph depending on internal pressure and impactor sizes (Figure 6). Similarly for tank-head puncture the puncture velocities range from 9 mph to 18 mph as shown in Figure 7.

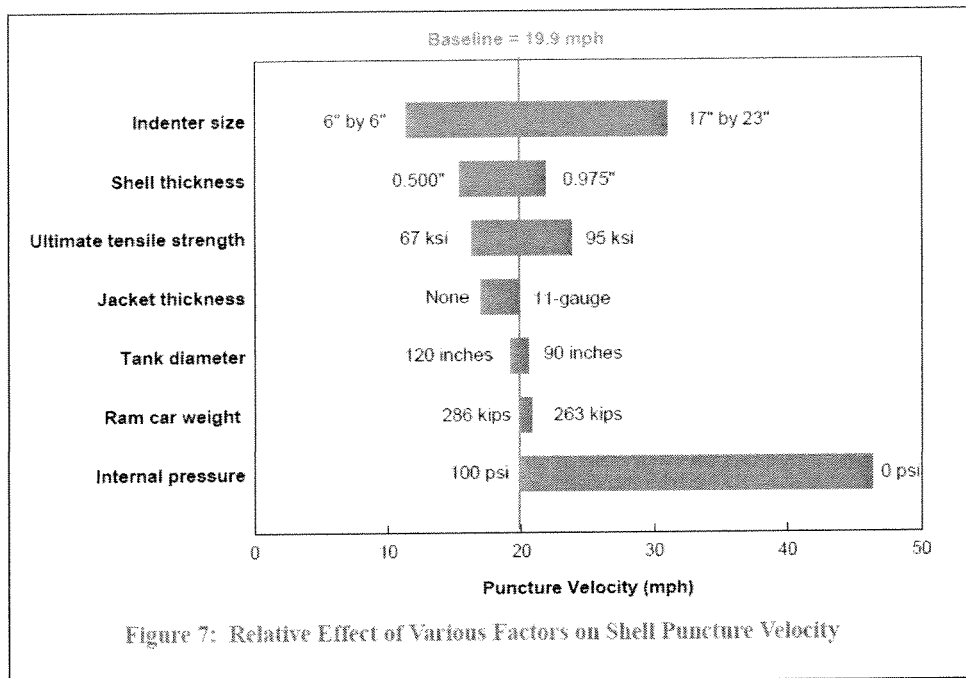


Figure 6. Tank-shell Puncture Velocity in Analytical Studies

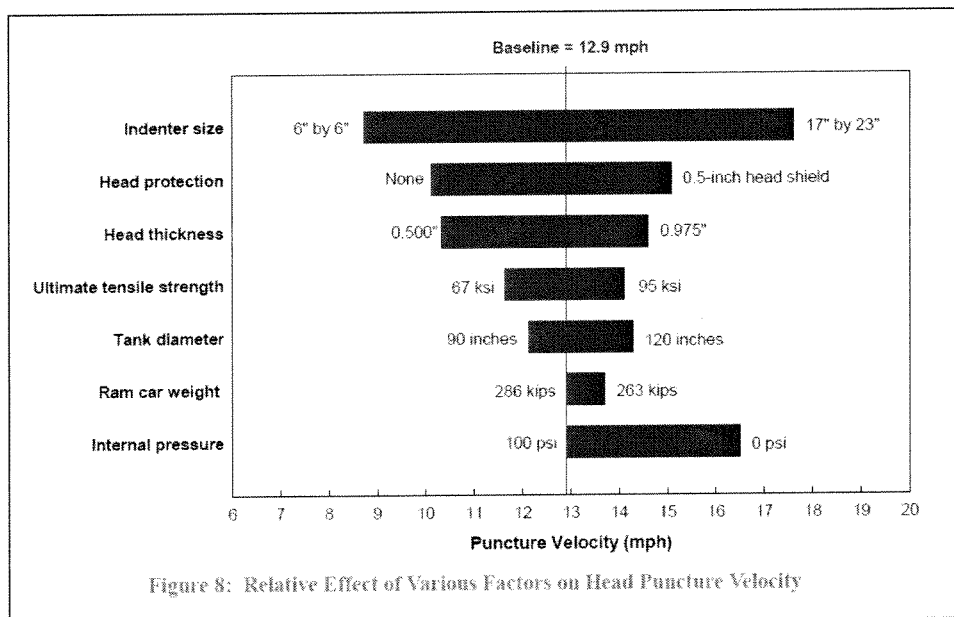


Figure 7. Tank-head Puncture Velocity in Analytical Studies

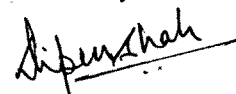
11. Based on CFR 49 Section 179.16 (Appendix A), these puncture velocities are estimated at 18 mph for Tank-head puncture. Again equivalent pre-collision train speeds would be twice the values given. Thus it can be inferred that the safe operating train speed before collision, would be in the range of 36 mph for tank-head impact and higher for tank-shell impact.

12. Puncture tests conducted in 1992 [8] showed that the DOT 105A500W (chlorine) car tested had a puncture resistance near the 18 mph threshold required by 49 CFR 179.105-5 for tank cars in LPG (propane) and other specifically identified flammable gas Lading.

1.4 Conclusions

13. Based on the available Accident Histories, it appears that the tank-head and tank-shell puncture of tank cars are the two most critical conditions for lading loss in derailments and collisions.
14. Analytical collision dynamics modeling shows that placing the PIH/TIH cars in the middle of the consist provides for the least likelihood of puncture in train collision and that appears to be reflected in CFR 49 Part 174.85.
15. The 3 car limit is solely arbitrary by RailAmerica "SOP". The risk associated with more than 3 cars in a consist is not any different than a maximum of 3 cars. In fact, if 1 out of 4 cars received (as an example) is held at the interchange for a Dedicated Train, the undue risk should be considered in the context of 49 CFR part 179.14.
16. From a tank-head and tank-shell puncture safety perspective, based on a general Tank car configuration and a variety of factors, a 25 mph Train speed would preclude the likelihood of a catastrophic breach in a derailment or train collision. Specific to the DOT 105A500W (chlorine car), tests conducted have shown that the car is safe from head puncture until 18 mph, which would indicate a safe train speed up to 36 mph.
17. CFR 49: Section 174.86 b) specifies an allowable maximum speed of 50 mph for PIH/TIC tank cars. No minimum is specified. The 10 mph speed limited by the Class 1 track stands by itself and is not part of 49 CFR Section 174.86.
18. It appears that the RailAmerica "SOP" is unclear about the purpose of the 10 mph limit. The 10 mph speed limit is clearly based on track classification and should not be stated as a safety concern from a tank puncture perspective.

Sincerely,



Dipen Shah, Ph.D.
Chief Engineer
HLA Engineers, Inc.

2.0 REFERENCES:

1. Nayak, P.R., Rosenfield, D.B., Hagopian, J.H., "Event Probabilities and Impact Zones for Hazardous Materials Accidents on Railroads," Final Report, DOT/FRA/ORD- 83/20, November 1983.
2. Anderson, R.T., and Barkan, C.P.L., "Railroad Accident Rates for Use in Transportation Risk Analysis," Transportation Research Record 1863 (2004) 88-98.
3. Karl Alexy, "Tank Car Safety and Security - NextGen Project to the Present", 2010 Mechanical Association Railcar Technical Services - Annual Conference.
4. C.R. Paetsch, A.B. Perlman, D.Y. Jeong, "Dynamic Simulation of Train Derailments", Proceedings of IMECE2006 2006 ASME International Mechanical Engineering Congress and Exposition November 5-10, 2006, Chicago, Illinois, USA
5. D.Y. Jeong, M.L. Lyons, O. Orringer, A.B. Perlman, "Equations of Motion For Train Derailment Dynamics", RTDF2007-46009, Proceedings of the 2007 ASME Rail Transportation Division Fall Technical Conference, RTDF2007, September 11-12, 2007 Chicago, Illinois, USA.
6. D.Y. Jeong, Y.H. Tang, H. Yu, M.L. Lyons, J.E. Gordon, O. Orringer, and A.B. Perlman, "Engineering Studies on Structural Integrity of Railroad Tank Cars Under Accident Loading Conditions", U.S. Department of Transportation Volpe National Transportation Systems Center Research and Innovative Technology Administration Cambridge, MA, REPORT NUMBER DOT/FRA/ORD-09/18.
7. David Y. Jeong, Yim H. Tang, A. Benjamin Perlman, "Semi-Analytical Approach to Estimate Railroad Tank Car Shell Puncture", Proceedings of the ASME/ASCE/IEEE 2011 Joint Rail Conference JRC2011 March 16-18, 2011, Pueblo, Colorado, USA. JRC2011-56028.
8. Michael Coltman, Morrin E. Hazel, Jr. , Chlorine Tank Car Puncture Resistance Evaluation, U.S. Department of Transportation, Report No. DOT/FRA/ORD-92/11

APPENDIX A : 49 CFR - TRANSPORTATION

§ 179.16 Tank-head puncture-resistance systems.

(a) *Performance standard.* When the regulations in this subchapter require a tank-head puncture-resistance system, the system shall be capable of sustaining, without any loss of lading, coupler-to-tank-head impacts at relative car speeds of 29 km/hour (18 mph) when:

- (1) The weight of the impact car is at least 119,295 kg (263,000 pounds);
- (2) The impacted tank car is coupled to one or more backup cars that have a total weight of at least 217,724 kg (480,000 pounds) and the hand brake is applied on the last "backup" car; and
- (3) The impacted tank car is pressurized to at least 6.9 Bar (100 psig).

(b) *Verification by testing.* Compliance with the requirements of paragraph (a) of this section shall be verified by full-scale testing according to appendix A of this part.

(c) *Alternative compliance by other than testing.* As an alternative to requirements prescribed in paragraph (b) of this section, compliance with the requirements of paragraph (a) of this section may be met by installing full-head protection (shields) or full tank-head jackets on each end of the tank car conforming to the following:

(1) The full-head protection (shields) or full tank-head jackets must be at least 1.27 cm (0.5 inch) thick, shaped to the contour of the tank head and made from steel having a tensile strength greater than 379.21 N/mm² (55,000 psi).

(2) The design and test requirements of the full-head protection (shields) or full tank-head jackets must meet the impact test requirements in Section 5.3 of the AAR Specifications for Tank Cars (IBR, see §171.7 of this subchapter).

(3) The workmanship must meet the requirements in Section C, Part II, Chapter 5, of the AAR Specifications for Design, Fabrication, and Construction of Freight Cars (IBR, see §171.7 of this subchapter).

[Amdt. 179–50, 60 FR 49077, Sept. 21, 1995, as amended by Amdt. 179–50, 61 FR 33255, June 26, 1996; 66 FR 45390, Aug. 28, 2001; 68 FR 75759, Dec. 31, 2003]

174.14 Movements to be expedited.

(a) A carrier must forward each shipment of hazardous materials promptly and within 48 hours (Saturdays, Sundays, and holidays excluded), after acceptance at the originating point or receipt at any yard, transfer station, or interchange point, except that where biweekly or weekly service only is performed, a shipment of hazardous materials must be forwarded on the first available train.

(b) A tank car loaded with any Division 2.1 (flammable gas), Division 2.3 (poisonous gas) or Class 3 (flammable liquid) material, may not be received and held at any point, subject to forwarding orders, so as to defeat the purpose of this section or of §174.204 of this subchapter.

[Amdt. 174–26, 41 FR 16092, Apr. 15, 1976, as amended by Amdt. 174–68, 55 FR 52677, Dec. 21, 1990]

174.85 Position in train of placarded cars, transport vehicles, freight containers, and bulk packagings.

(a) Except as provided in paragraphs (b) and (c) of this section, the position in a train of each loaded placarded car, transport vehicle, freight container, and bulk packaging must conform to the provisions of this section.

(b) A car placarded "RADIOACTIVE" must comply with train positioning requirements of paragraph (d) of this section and must be separated from a locomotive, occupied caboose, or carload of undeveloped film by at least one non-placarded car.

(c) A tank car containing the residue of a hazardous material must be separated from a locomotive or occupied caboose by at least one rail car other than a placarded tank car.

(d) Position of rail cars in a train. In the following table:

Position in Train of Placarded Cars Transporting Hazardous Materials

RESTRICTIONS	Placard Group 1	Placard Group 2		Placard Group 3		Placard Group 4
	Rail Car	Tank Car	Rail Car	Tank Car	Rail Car	Rail Car
1. When train length permits, placarded car may not be nearer than the sixth car from the engine or occupied caboose	X	X		X		
2. When train length does not permit, placarded car must be placed near the middle of the train, but not nearer than the second car from an engine or occupied caboose	X	X		X		
3. A placarded car may not be placed next to an open-top car when any of the lading in the open top car protrudes beyond the car ends, or if the lading shifted, would protrude beyond the car ends.	X	X		X		
4. A placarded car may not be placed next to a loaded flat car, except closed TOFC/COFC equipment, auto carriers, and other specially equipped cars with tie-down devices for securing vehicles. Permanent bulk head flat cars are considered the same as open-top cars	X	X		X		
5. A placarded car may not be placed next to any transport vehicle or freight container having an internal combustion engine or an open-flame device in operation.	X	X		X		
6. Placarded cars may not be placed next to each other based on the following:						
Placard Group 1		X	X	X	X	X
Placard Group 2	X			X	X	X
Placard Group 3	X	X	X			X
Placard Group 4	X	X	X	X	X	

PLACARD GROUP:

Group 1—Divisions 1.1 and 1.2 (explosive) materials.

Group 2—Divisions 1.3, 1.4, 1.5 (explosive), Class 2 (compressed gas; other than Div 2.3, PG I, Zone A), Class 3 (flammable liquid), Class 4 (flammable solid), Class 5 (oxidizing), Class 6 (poisonous liquid; other than Div 6.1, PG I, Zone A), and Class 8 (corrosive) materials.

Group 3—Divisions 2.3 (Zone A; poisonous gas) and 6.1 (PG I, Zone A; poisonous liquid) materials.

Group 4—Class 7 (radioactive) materials.

(1) Where an "X" appears at the intersection of a Placard Group column and a Restriction row, the corresponding restriction applies.

(2) "Rail Car" means a car other than a tank car.

(3) For purposes of this subpart, each unit of an articulated intermodal rail car shall be considered as one car.

[Amdt. 174–68, 55 FR 52680, Dec. 21, 1990, as amended at 57 FR 45464, Oct. 1, 1992; Amdt. 174–83, 61 FR 28678, June 5, 1996; Amdt. 174–83, 61 FR 50255, Sept. 25, 1996; Amdt. 174–83, 61 FR 51339, Oct. 1, 1996; 64 FR 51919, Sept. 27, 1999; 66 FR 45383, Aug. 28, 2001]

§ 174.86 Maximum allowable operating speed.

(a) For molten metals and molten glass shipped in packagings other than those prescribed in §173.247 of this subchapter, the maximum allowable operating speed may not exceed 24 km/hour (15 mph) for shipments by rail.

(b) For trains transporting any loaded, placarded tank cars containing a material poisonous by inhalation, the maximum allowable operating speed may not exceed 80.5 km/hour (50 mph) for shipments by rail.
[74 FR 1801, Jan. 13, 2009]

§ 213.9 Classes of track: operating speed limits.

(a) Except as provided in paragraph (b) of this section and §§213.57(b), 213.59(a), 213.113(a), and 213.137(b) and (c), the following maximum allowable operating speeds apply—

[In miles per hour]

Over track that meets all of the requirements prescribed in this part for—	The maximum allowable operating speed for freight trains is—	The maximum allowable operating speed for passenger trains is—
Excepted track	10	N/A
Class 1 track	10	15
Class 2 track	25	30
Class 3 track	40	60
Class 4 track	60	80
Class 5 track	80	90

(b) If a segment of track does not meet all of the requirements for its intended class, it is reclassified to the next lowest class of track for which it does meet all of the requirements of this part. However, if the segment of track does not at least meet the requirements for Class 1 track, operations may continue at Class 1 speeds for a period of not more than 30 days without bringing the track into compliance, under the authority of a person designated under §213.7(a), who has at least one year of supervisory experience in railroad track maintenance, after that person determines that operations may safely continue and subject to any limiting conditions specified by such person.

APPENDIX B : 49 USC 11101 - Sec. 11101

49 USC 11101 - Sec. 11101. Common carrier transportation, service, and rates

(a) A rail carrier providing transportation or service subject to the jurisdiction of the Board under this part shall provide the transportation or service on reasonable request. A rail carrier shall not be found to have violated this section because it fulfills its reasonable commitments under contracts authorized under section 10709 of this title before responding to reasonable requests for service.

Commitments which deprive a carrier of its ability to respond to reasonable requests for common carrier service are not reasonable. (b) A rail carrier shall also provide to any person, on request, the carrier's rates and other service terms.

The response by a rail carrier to a request for the carrier's rates and other service terms shall be - (1) in writing and forwarded to the requesting person promptly after receipt of the request; or (2) promptly made available in electronic form. (c) A rail carrier may not increase any common carrier rates or change any common carrier service terms unless 20 days have expired after written or electronic notice is provided to any person who, within the previous 12 months - (1) has requested such rates or terms under subsection (b); or (2) has made arrangements with the carrier for a shipment that would be subject to such increased rates or changed terms. (d) With respect to transportation of agricultural products, in addition to the requirements of subsections (a), (b), and (c), a rail carrier shall publish, make available, and retain for public inspection its common carrier rates, schedules of rates, and other service terms, and any proposed and actual changes to such rates and service terms.

For purposes of this subsection, agricultural products shall include grain as defined in section 3 of the United States Grain Standards Act (7 U.S.C. 75) and all products thereof, and fertilizer. (e) A rail carrier shall provide transportation or service in accordance with the rates and service terms, and any changes thereto, as published or otherwise made available under subsection (b), (c), or (d). (f) The Board shall, by regulation, establish rules to implement this section.

The regulations shall provide for immediate disclosure and dissemination of rates and service terms, including classifications, rules, and practices, and their effective dates.

Final regulations shall be adopted by the Board not later than 180 days after January 1, 1996.

Prior Provisions

A prior section 11101, Pub. L. 95-473, Oct. 17, 1978, 92 Stat. 1419; Pub. L. 96-258, Sec. 1(10), June 3, 1980, 94 Stat. 426; Pub. L. 96-448, title II, Sec. 222, Oct. 14, 1980, 94 Stat. 1929; Pub. L. 99-521, Sec. 9(a), Oct. 22, 1986, 100 Stat. 2997; Pub. L. 103-180, Sec. 8, Dec. 3, 1993, 107 Stat. 2052, related to duties of carriers to provide transportation and service, prior to the general amendment of this subtitle by Pub. L. 104-88, Sec. 102(a). See sections 11101, 13710, 14101, and 15701 of this title.

AMENDMENTS 1996 - Subsec. (f). Pub. L. 104-287 substituted "January 1, 1996" for "the effective date of the ICC Termination Act of 1995". EFFECTIVE DATE Chapter effective Jan. 1, 1996, except as otherwise provided in Pub. L. 104-88, see section 2 of Pub. L. 104-88, set out as a note under section 701 of this title.

Section Referred To In Other Sections

APPENDIX C : CV of Dipen Shah, Ph.D.

Dipen K. Shah, Ph.D.
Chief Engineer
HLA Engineers, Inc.

Education and Training:

Ph.D. in Mechanical Engineering, University of Texas at Arlington, 1993

M.E. in Mechanical Engineering, University of Texas at Arlington, 1989

B.E. in Mechanical Engineering, Ravishankar University, India, 1987

Areas of Experience and Interest:

- 2D and 3D Finite Element Stress Analysis with ANSYS, NASTRAN and MARC.
- Fracture and Damage Mechanics, Fatigue, Durability and Damage Tolerance.
- Composite Delamination.
- Creep at Isothermal and High Temp.
- Experimental Characterization of Metals and Composites.
- Material and Geometric non-linear Analysis.
- Computer-Aided Design and Geom. Modeling.
- Mesh Generation and Optimization.
- Structural and Design Optimization.
- Isotropic and orthotropic materials.
- Thermoset, Thermoplastic and Elastomeric composites.
- Continuous and short fiber composites.
- Piezoelectric, piezopolymers and other smart materials

Years with HLA Engineers, Inc. : 17 years

Experience:

TRANSPORTATION STRUCTURES – Railcar and Intermodal Cargo Containers, Locomotive Structures, Puncture Resistance of Toxic Inhalation Hazards (TIH) Tank Cars, Static and Dynamic Stress Analysis, Crash Worthiness, Damage Tolerance, Crack Growth, Fracture Mechanics and Fatigue Life Assessment, Structural and Buckling Analyses.

DSN/ANTENNAS – Static, Dynamic, Buckling and Stress Analysis, Thermal, Pointing and Frequency Analyses of Deep Space and other commercial satellite antennas.

WIND TOWERS - Static, Dynamic, Buckling, Stress Analysis and Fatigue of Wind Tower Structures.

CRANES - Static, Dynamic, Buckling, Wind Loading and Stress Analysis and Fatigue of Cranes Structures, Tower Cranes, Pedestal Cranes, Cableways etc.

ROLL-OVER PROTECTIVE STRUCTURES (ROPS) - Large Displacement FE Analysis with Material Plasticity of Roll-over Protective Structures (ROPS).

COMPOSITES AND ELASTOMERS - Material Properties Characterization of Composites and FEA Analysis of elastomeric materials, conveyor belts and bearings.

SOFTWARE AND PROGRAMMING - Developed Computer applications and GUIs for Thermal Curing and Finite Element Analysis of Conveyor Belts. Features included Networking, TCP/IP, FTP, Open Inventor Graphics, Finite Element Analysis, 2D and 3D FEA Meshing.

FORENSIC AND LEGAL INVESTIGATIONS – Deposed and Testified in several legal cases including structural failures and collapses.

Publications:

Include several Reports, Journal Articles and Conference Presentations for U.S. Army Research Office, ASME, AIAA, Computers and Structures, Interlaminar Fracture of Composites, Journal of Smart Structures, Journal of Aerospace Engineering, and Journal of The American Physiological Society.

Depositions and Testimonies

1. FEBRUARY 10, 2006 - Deposed

THEODOROFF vs. TUCKER and GENERAL MOTORS CORPORATION, STATE OF MICHIGAN, CIRCUIT COURT FOR THE COUNTY OF WAYNE, CASE NO. 03-308716-NI

2. SEPTEMBER 29, 2008 - Deposed

THE COMMUNITY FOUNDATION FOR PALM BEACH AND MARTIN COUNTIES, INC. vs. KOLTER PROPERTIES MANAGEMENT, INC. d/b/a KOLTER PROPERTY COMPANY; MORROW EQUIPMENT COMPANY, LLC, LC; KOLTER CITY PLAZA II, INC.; KAST CONSTRUCTION COMPANY, LLC, AND BAY ERECTORS & RIGGING, INC., CIRCUIT COURT OF THE 15TH JUDICIAL CIRCUIT IN AND FOR PALM BEACH COUNTY, FLORIDA, CASE NO. 50 2006 CA 004164

3. AUGUST 14, 2009 - Deposed

OBUYASHI CORPORATION / PSM CONSTRUCTION USA JOINT VENTURE vs. AMERICAN BRIDGE, AMERICAN ARBITRATION ASSOCIATION, AAA CASE NO. 79 110 Y 00146 07 BRSH. Case related to the Hoover Dam Bypass Construction over the Colorado River, Collapse of the Cableway System.

4. OCTOBER 21, 2009 - Testified

OBAYASHI CORPORATION / PSM CONSTRUCTION USA JOINT VENTURE vs. AMERICAN BRIDGE, AMERICAN ARBITRATION ASSOCIATION, AAA CASE NO. 79 110 Y 00146 07 BRSH. Case related to the Hoover Dam Bypass Construction over the Colorado River, Collapse of the Cableway System.

Work Performed on Other Legal Cases

1. Sanchez vs. General Shelters – FEA of Trailer Tongue, 2008
2. Elliot vs. Emerson, 2007 – 2008, Case Settled
3. Jack Stands – Case Settled
4. Trucut UR 6500 Auto Ramp – Case Settled
5. Elmendorf AFB Moment Connection Weld Analysis - Trial
6. Stimpson vs. Manitowoc – Case Settled
7. Temple Inland – Case Settled
8. Lexington vs. Morrow – Case Settled
9. People vs. James Lomma, et.al. Indictment No. 852/2010 – #2 NYC Crane Collapse 91st Street - Pending.

List of Publications:

- Hsia CCW, R.L. Johnson Jr, D. Shah.**, "Red cell distribution and the recruitment of pulmonary diffusing capacity." *Journal of Applied Physiological Society*, Vol. 86:1460-1467, 1999.
- H. Keith Hunt, Ricky Cribbs, Steve Stahl and Dipen Shah**, "FEA Modeling Of Hazardous Material Cargo Tanks", Presented at the National Research Council, Transportation Research Board 77th Annual Meeting, Washington D.C., January 1997.
- R. H. Finney, D. K. Shah and R. Cribbs**, "Have we learned anything yet?" A discussion on elastomeric FEA and material modeling, Presented at the Elastomer-FEA Forum '97, University of Akron, Ohio. 1997
- H. Neelakanthan, D. K. Shah and W. S. Chan**, "Effects of stiffener around multiple loaded holes in composite shear panel", Presented at the 38th AIAA/ASME/ASCE/AHS/ASC-SDM Conference at Kissimmee, FL in April, 1997.
- D. J. Chen, D. K. Shah and W. S. Chan**, "Interfacial Stress Estimation Using Least-square Extrapolation and Local Stress Smoothing in Laminated Composites", *Computers and Structures*, Vol. 58, No. 4, pp. 765-774, 1996.
- D. J. Chen, D. K. Shah and W. S. Chan**, "Using Stress Smoothing for Interlaminar Stress Distributions in FE Analysis of Composite Laminates", *Interlaminar Fracture of Composites*, 1996.
- D. K. Shah and W. S. Chan**, "Analysis of stiffened shear panels with a loaded hole," Presented at the 7th Japan-US conference on composite materials in June 1995 at Kyoto Japan.
- D. K. Shah, S. P. Joshi and W. S. Chan**, "Delamination suppression and detection in a composite laminate using embedded piezoelectric patch", *Journal of Smart Structures and Materials*, 1994.
- D. K. Shah, S. P. Joshi and W. S. Chan**, "Stress Concentration Reduction in a Plate with a Hole using Piezoceramic Layers", *Journal of Smart Structures and Materials*, 1994.
- D. K. Shah, S. P. Joshi and W. S. Chan**, "Static Structural Response of Plates with Piezoceramic Layers", *Journal of Smart Structures and Materials*, 1993.
- D. K. Shah and W. S. Chan**, "Delamination Characteristics around a Hole in Laminates with a Softening Strip", *Journal of Aerospace Engineering*, Apr. 1993.
- D. K. Shah, W. S. Chan and S. P. Joshi**, "Finite Element Analysis of plates with piezoelectric layers", Presented at the 34th AIAA/SDM Conf. in Apr. 1993 at La Jolla, CA.
- D. K. Shah, S. P. Joshi and W. S. Chan**, "Comparison of Embedded and Surface Mounted Piezoelectric Actuators," Presented at the 1993 ASME/AIAA/AHS Winter Annual Meeting at New Orleans LA. Also in 'Adaptive Structures and Material Systems', AD-Vol. 35, Ed.: Carman and Garcia, 1993, pp. 237-245.
- Chapter on "Finite Element Analysis of Smart Plates"**, *Damage-Survivable and Damage-Tolerant Laminated Composites with Optimally placed Piezoelectric Layers*, Final Report No. 1, U.S. Army Research Office, Grant No. DAAL 03-89-G-0090. Dec. 1992.
- D. K. Shah, W. S. Chan and S. P. Joshi**, "Response of a Piezoelectric layer in composite laminates due to Electro-mechanical Loads," Presented at the 33rd AIAA/SDM Conference in Apr. 1992 at Dallas, TX.
- D. K. Shah, W. S. Chan, S. P. Joshi and S. Subramanian**, "Analysis of Laminates with Embedded Piezoelectric Layers," Recent Developments in Composite Materials Structures, Ed.: David Hui and C.T. Sun, AD-vol. 19, AMD-Vol. 113, Presented at the 1990 ASME/AIAA/AHS Winter Annual Meeting at Dallas, TX. pp. 19-24, November 25-30, 1990.

VERIFICATION

I, Dipen Shah, verify under penalty of perjury under the laws of the United States that the foregoing is true and correct. Further, I certify that I am qualified and authorized to file this Verified Statement.

Executed January 27, 2012 and reaffirmed March 14, 2012.



Dipen Shah, Ph.D.

