Two fully loaded (80,000 pounds nominal weight) tractor semi-trailer trucks were impacted into an instrumented wall at 55 miles per hour and an oblique angle of 15 degrees to the wall. This effort was conducted under two separate contracts, one under FHWA and the other NHTSA. The objective of the FHWA contract was to determine lateral impact forces in heavy vehicle collisions with an instrumented wall. The objectives of the NHTSA contract were to study heavy truck occupant kinematics and trauma outcomes. The report covers results mostly from the NHTSA contract. The FHWA contract is still ongoing and the results will be presented in a separate report.

Peak 0.050-second average forces imparted on the instrumented wall ranged from 66,000 to 408,000 pounds; vehicle acceleration ranged from 2.1 g (longitudinal) to 12.3 g (lateral); driver dummy had HIC indices of 243 and 417 and maximum 0.003-second chest acceleration of 13 g and 20 g, which are well within the ranges deemed survivable. The fuel tanks were damaged extensively in both tests. The right front wheel assembly was pushed back into the fuel tank as the lug nuts on the wheel dug into the surface of the instrumented wall.
TABLE OF CONTENTS

I. INTRODUCTION ................................................. 1

II. CRASH TEST SETUP AND PROCEDURES ........................ 2

   INSTRUMENTED WALL ........................................... 2
   VEHICLE INSTRUMENTATION ..................................... 4
   CRASH TEST PROCEDURES ....................................... 5
   DATA ANALYSIS PROCEDURES .................................... 6

III. CRASH TEST RESULTS ........................................ 8

   TEST NUMBER 1 .................................................. 8
      Test Description and General Test Results .................. 8
      Results From Instrumented Wall and Vehicle
      Accelerometers ................................................ 17
      Results From Instrumented Dummy ............................ 17
      Results From Instrumented Fuel Tank ....................... 26
   TEST NUMBER 2 .................................................. 37
      Test Description and General Test Results .................. 37
      Results From Instrumented Wall and Vehicle
      Accelerometers ................................................ 49
      Results From Instrumented Dummy ............................ 49
      Results From Instrumented Fuel Tank ....................... 58

IV. SUMMARY OF FINDINGS AND CONCLUSIONS ..................... 80

APPENDICES

A Detailed Documentation of Fuel Tank (Test 1) ............... 82
B Detailed Documentation of Fuel Tanks (Test 2) ............... 87
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Construction details of instrumented wall</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>Test vehicle before Test 1</td>
<td>9</td>
</tr>
<tr>
<td>3.</td>
<td>Test vehicle properties for Test 1</td>
<td>10</td>
</tr>
<tr>
<td>4.</td>
<td>Sequential photographs for Test 1</td>
<td>11</td>
</tr>
<tr>
<td>5.</td>
<td>Wall after Test 1</td>
<td>14</td>
</tr>
<tr>
<td>6.</td>
<td>Final resting position of vehicle after Test 1</td>
<td>15</td>
</tr>
<tr>
<td>7.</td>
<td>Tractor after Test 1</td>
<td>16</td>
</tr>
<tr>
<td>8.</td>
<td>Summary of results for Test 1</td>
<td>18</td>
</tr>
<tr>
<td>9.</td>
<td>Vehicle angular displacements for Test 1 (measured on rear tandem of tractor)</td>
<td>19</td>
</tr>
<tr>
<td>10.</td>
<td>Vehicle longitudinal accelerometer trace for Test 1 (measured on rear tandem of tractor)</td>
<td>20</td>
</tr>
<tr>
<td>11.</td>
<td>Vehicle lateral accelerometer trace for Test 1 (measured on rear tandem of tractor)</td>
<td>21</td>
</tr>
<tr>
<td>12.</td>
<td>Vehicle vertical accelerometer trace for Test 1 (measured on rear tandem of tractor)</td>
<td>22</td>
</tr>
<tr>
<td>13.</td>
<td>Resultant forces from 80,080-lb Tractor Van-Trailer</td>
<td>23</td>
</tr>
<tr>
<td>14.</td>
<td>Dummy accelerometer traces for Test 1</td>
<td>24</td>
</tr>
<tr>
<td>15.</td>
<td>Sequential photographs of dummy positions for Test 1</td>
<td>27</td>
</tr>
<tr>
<td>16.</td>
<td>Anthropomorphic dummy before Test 1</td>
<td>29</td>
</tr>
<tr>
<td>17.</td>
<td>Fuel tank prior to Test 1</td>
<td>30</td>
</tr>
<tr>
<td>18.</td>
<td>Fuel tank after Test 1</td>
<td>32</td>
</tr>
<tr>
<td>19.</td>
<td>Damage to front end of fuel tank</td>
<td>33</td>
</tr>
<tr>
<td>20.</td>
<td>View of rear of fuel tank</td>
<td>33</td>
</tr>
<tr>
<td>21.</td>
<td>View of top of fuel tank</td>
<td>34</td>
</tr>
<tr>
<td>22.</td>
<td>View of rear of fuel tank</td>
<td>34</td>
</tr>
<tr>
<td>23.</td>
<td>Pressure transducer trace for fuel tank (Test 1)</td>
<td>35</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES (CONTINUED)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.</td>
<td>Fuel tank cap and opening of fuel tank</td>
<td>36</td>
</tr>
<tr>
<td>25.</td>
<td>Longitudinal accelerations on the gas tank for Test 1</td>
<td>38</td>
</tr>
<tr>
<td>26.</td>
<td>Lateral accelerations on the gas tank for Test 1</td>
<td>39</td>
</tr>
<tr>
<td>27.</td>
<td>Resultant accelerations on the gas tank for Test 1</td>
<td>40</td>
</tr>
<tr>
<td>28.</td>
<td>Vehicle before Test 2</td>
<td>41</td>
</tr>
<tr>
<td>29.</td>
<td>Test vehicle properties for Test 2</td>
<td>43</td>
</tr>
<tr>
<td>30.</td>
<td>Sequential photographs of Test 2</td>
<td>44</td>
</tr>
<tr>
<td>31.</td>
<td>Instrumented wall after Test 2</td>
<td>47</td>
</tr>
<tr>
<td>32.</td>
<td>Vehicle after Test 2</td>
<td>48</td>
</tr>
<tr>
<td>33.</td>
<td>Summary of results for Test 2</td>
<td>50</td>
</tr>
<tr>
<td>34.</td>
<td>Vehicle angular displacements for Test 2</td>
<td>51</td>
</tr>
<tr>
<td>35.</td>
<td>Longitudinal accelerometer trace for Test 2</td>
<td>52</td>
</tr>
<tr>
<td>36.</td>
<td>Lateral accelerometer trace for Test 2</td>
<td>53</td>
</tr>
<tr>
<td>37.</td>
<td>Resultant forces for 80,000 lb Tank Truck</td>
<td>54</td>
</tr>
<tr>
<td>38.</td>
<td>Dummy head accelerometer traces for Test 2</td>
<td>55</td>
</tr>
<tr>
<td>39.</td>
<td>Dummy chest accelerometer traces for Test 2</td>
<td>56</td>
</tr>
<tr>
<td>40.</td>
<td>Instrumented dummy before and after Test 2</td>
<td>59</td>
</tr>
<tr>
<td>41.</td>
<td>Load exerted on lap belt during Test 2</td>
<td>60</td>
</tr>
<tr>
<td>42.</td>
<td>Load exerted on the tether strap during Test 2</td>
<td>60</td>
</tr>
<tr>
<td>43.</td>
<td>Sequential photographs of dummy positions for Test 2</td>
<td>61</td>
</tr>
<tr>
<td>44.</td>
<td>Right side fuel tanks before Test 2</td>
<td>63</td>
</tr>
<tr>
<td>45.</td>
<td>Right side of tractor after Test 2</td>
<td>64</td>
</tr>
<tr>
<td>46.</td>
<td>Location of fuel tanks after Test 2</td>
<td>65</td>
</tr>
<tr>
<td>47.</td>
<td>Side views of right front fuel tank after Test 2</td>
<td>66</td>
</tr>
<tr>
<td>48.</td>
<td>End views of right front fuel tank after Test 2</td>
<td>67</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>49</td>
<td>Side views of right rear fuel tank after Test 2</td>
<td>68</td>
</tr>
<tr>
<td>50</td>
<td>End views of right rear fuel tank after Test 2</td>
<td>69</td>
</tr>
<tr>
<td>51</td>
<td>Side views of left fuel tank after Test 2</td>
<td>70</td>
</tr>
<tr>
<td>52</td>
<td>End views of left fuel tank after Test 2</td>
<td>71</td>
</tr>
<tr>
<td>53</td>
<td>Fuel tank cap from right front tank after Test 2</td>
<td>72</td>
</tr>
<tr>
<td>54</td>
<td>Opening to right front fuel tank after Test 2</td>
<td>73</td>
</tr>
<tr>
<td>55</td>
<td>Pressure transducer trace for right front fuel tank (Test 2)</td>
<td>74</td>
</tr>
<tr>
<td>56</td>
<td>Longitudinal accelerations on right front fuel tank (Test 2)</td>
<td>76</td>
</tr>
<tr>
<td>57</td>
<td>Lateral accelerations on right front fuel tank (Test 2)</td>
<td>77</td>
</tr>
<tr>
<td>58</td>
<td>Resultant accelerations on right front fuel tank (Test 2)</td>
<td>78</td>
</tr>
</tbody>
</table>
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Injury Indices for Test 1</td>
<td>25</td>
</tr>
<tr>
<td>2. Injury Indices for Test 2</td>
<td>57</td>
</tr>
</tbody>
</table>
I. INTRODUCTION

The work reported herein covers efforts conducted under two separate contracts. The first contract, No. DTFH61-85-C-00101, was sponsored by the Federal Highway Administration (FHWA), U.S. Department of Transportation, entitled "Measurement of Heavy Vehicle Impact Forces and Inertia Properties". The objectives of this study are to measure lateral impact forces in heavy vehicle collisions with an instrumented wall and to obtain inertial, geometric and suspension properties of heavy vehicles needed for use in analysis of collision performance.

Under this study, an instrumented wall was designed and constructed. A number of vehicles, ranging from a 4,500-pound automobile to an 80,000-pound tractor trailer, were impacted into the instrumented wall to measure the lateral impact forces associated with the various vehicle types.

The National Highway Traffic Safety Administration (NHTSA), U. S. Department of Transportation, was interested in additional data collection and analysis in two of the crash tests, one involving an 80,000-pound tractor van-trailer and the other an 80,000-pound tractor tank-trailer. A second contract, No. DTNH22-85-D-37259, Task Order No. 2, entitled "Heavy Truck Restraint System Performance in an Accident Avoidance Maneuver and Subsequent Crash", was sponsored by NHTSA for this additional effort.

The objectives of this second contract are to study heavy truck occupant kinematics and trauma likelihoods and crashworthiness performance of heavy trucks, with emphasis on occupant restraints and occupant compartment and fuel system integrity. Specifically, data were collected and analyzed from instrumentation of the following items: an anthropomorphic dummy in the driver position, seat belt for the dummy, and the right front fuel tank.

It should be noted that this report covers only results from these two specific crash tests. The results of other crash tests conducted under the FHWA contract are to be presented in a separate final report.

A general description of the research methodology and test procedures is provided in Section II. The results of the two crash tests are presented in Section III. A summary of findings and conclusions is presented in Section IV. Information too bulky for incorporation into the main body of the report is included as Appendices.
II. CRASH TEST SETUP AND PROCEDURES

Brief descriptions of the test setup and procedures for these two tractor trailer crash tests are presented in this chapter, including:

1. Instrumented wall design and instrumentation,
2. Vehicle instrumentation,
3. Crash test procedure,
4. Data analysis procedure.

INSTRUMENTED WALL

The instrumented wall consisted of four independent reinforced concrete wall segments. Each of the wall segments was supported vertically and isolated from each other with low-friction teflon pads. In addition, the wall segments were supported laterally by four specially fabricated strain gage load cells. Figure 1 shows complete details of the construction of the instrumented wall.

Three of the wall segments were instrumented with three accelerometers arranged in a triangular pattern on the back face of the wall segment. The fourth wall segment, the one furthest upstream, was instrumented with only a single accelerometer positioned at the center of gravity of the wall segment. This arrangement was necessary because the number of channels of data that can be recorded simultaneously was limited. However, the fourth wall segment with the single accelerometer is unlikely to experience a significant impact force, being furthest upstream from the point of impact. Furthermore, the error introduced by having a single accelerometer was found to be small in calibration tests.

The electronic signals from the accelerometers and load cells were transmitted through cables to a mobile station located on-site for recording on magnetic tape. Provision was made for transmission of calibration signals before and after the test, and an accurate time reference signal was simultaneously recorded with the data.

The combined outputs of the load cells and the accelerometers allowed calculation of the magnitude and location of the resultant of the impact force using kinetic equations of rigid body dynamics. A computer program incorporating the necessary algorithms to accomplish this calculation was
Figure 1. Construction Details of Instrumented Wall.
developed and verified first from a mathematical standpoint and then validated experimentally with static and dynamic tests.

The calibration of the instrumented wall involved three separate steps. First, each of the strain gage load cells was individually calibrated in a load test machine and the accelerometers were calibrated in a centrifuge. Then, each instrumented wall segment was statically calibrated by applying known loads with hydraulic jacks. Finally, each instrumented wall segment was dynamically calibrated by impacting it with a 5,000-pound rolling cart at speeds up to 20 miles per hour. The results of the calibration tests verified that the instrumentation for the wall segments and the computer program to calculate impact forces are functioning properly as designed.

VEHICLE INSTRUMENTATION

Each test vehicle was equipped with four accelerometer groups: one triaxial accelerometer block mounted on the rear tandem of the tractor; one biaxial accelerometer block mounted toward the front of the tractor in front of the fuel tanks; and two biaxial accelerometer blocks placed on the trailer. The exact locations of these accelerometer groups varied slightly between the two tests, depending on the configuration of the test vehicle and the availability of suitable mounting spaces. In addition, three rate transducers were mounted near the vehicle center of gravity to measure the yaw, pitch and roll rates of the tractor.

One 50 percent male anthropomorphic dummy (Alderson Hybrid II) was placed in the driver position of the tractor for each test. The dummy was equipped with triaxial accelerometers mounted in the head and chest for determination of injury severity indices. Femur loads on the dummy were not recorded due to limitation in the number of data channels. The dummy was restrained with standard equipment lap belt. The belt was instrumented with a strain gage load cell to measure forces exerted by the dummy’s movement during the test. The tether belt from the driver’s seat to the floor of the cab was also instrumented with a strain gage load cell in the second test involving the tractor tank-trailer.

The right (impact side) fuel tank of the tractor was instrumented with a pressure transducer to measure the interior pressure of the tank during the test. The fuel tank was filled to the rated capacity with water (which is about 95 percent of total tank volume). The location of the transducer
varied between the two tests to make use of existing connector on the fuel tank.

The electronic signals from the various accelerometers, transducers and load cells were telemetered to a base station for recording on magnetic tape and for display on a real-time strip chart. Again, provision was made for transmission of calibration signals before and after the test, and accurate time reference signal was simultaneously recorded with the data. Contact switches on the bumper were actuated just prior to impact by wooden dowels to indicate the elapsed time over a known distance to provide a measurement of impact velocity. The initial contact also produced an "event" mark on the data record to establish the exact instant of impact.

CRASH TEST PROCEDURES

A push vehicle (another tractor) was used to set the test vehicle into motion and to accelerate the test vehicle to a predetermined speed. When that predetermined speed was reached, the clutch and gas pedal of the test vehicle were then engaged remotely and the test vehicle would continue to accelerate to the desired test speed under its own power. The push vehicle stayed with the test vehicle for a short additional time to make sure that the test vehicle was accelerating properly under its own power before separating from the test vehicle. Control of the test vehicle, including steering and engagement and disengagement of clutch and gas pedal, was handled remotely from a chase vehicle via a radio-controlled guidance system, similar to that used for model airplanes.

The clutch and gas pedal were disengaged remotely just before impact so that the test vehicle was free-wheeling and unrestrained during impact with the instrumented wall. Shortly after the test vehicle separated from the instrumented wall, braking on the test vehicle was actuated remotely to bring the test vehicle to a safe stop.

Still photography, real-time 16-mm movie, and video were used to record conditions of the test vehicle and instrumented wall before and after the test. Video and real-time and high-speed 16-mm movie were used to record the test from just prior to impact to final rest of the test vehicle. A total of five high-speed cameras were used: one overhead camera directly over the wall at the point of impact to have a field of view perpendicular to the ground; one ground level camera at the downstream end and another one at the upstream end of the wall with a field of view parallel to and aligned
with the wall; one ground level camera at a 10 degree angle to the path of
the test vehicle; and one camera inside the cab of the tractor to record the
motions of the dummy during the test. The films from these high-speed
cameras were used to observe phenomena occurring during collision and to
obtain time-event, displacement and angular data.

DATA ANALYSIS PROCEDURES

The analog data from the various accelerometers, transducers and load
cells were digitized, using a microcomputer, for analysis and evaluation of
performance. The digitized data were then analyzed using a number of
computer programs: CRASHE, VEHICLE, PLOTANGLE, CRASH TEST, INJURY. Brief
descriptions on each these computer programs are provided as follows.

The CRASHE program uses digitized data from vehicle-mounted linear
accelerometers to compute occupant/compartment impact velocities, time of
occupant/compartment impact after vehicle impact, final occupant
displacement, highest 0.010-second average. The CRASHE program also
calculates a vehicle impact velocity and the change in vehicle velocity at
the end of a given impulse period.

The VEHICLE program also uses digitized data from vehicle-mounted
linear accelerometers to compute vehicle accelerations, areas enclosed by
acceleration-time curves, changes in velocity, changes in momentum,
instantaneous forces, average forces, and maximum average accelerations over
0.050-second intervals in each of three directions. The VEHICLE program
also plots acceleration versus time curves for the longitudinal, lateral,
and vertical directions.

The PLOTANGLE program uses the digitized data from the yaw, pitch, and
roll rate charts to compute angular displacement in degrees at 0.001-second
intervals and then instructs a plotter to draw a reproducible plot: yaw,
pitch, and roll versus time. It should be noted that these angular
displacements are sequence dependent with the sequence being yaw-pitch-roll
for the data presented in this report. These displacements are in reference
to the vehicle-fixed coordinate system with the initial position and
orientation of the vehicle-fixed coordinate system being that which existed
at initial impact.

The CRASH TEST program computes accelerations at 0.002-second
intervals using digitized data from dummy head or chest X, Y, and Z charts
and provides these three accelerations at each interval in printout form.
The program computes accelerations for each chart independently and combines accelerations at corresponding times to obtain resultant acceleration of the dummy head or chest.

The INJURY program uses the accelerations assembled in the CRASH TEST program to compute the HIC injury severity index. Head injury criteria (HIC) approximates the time-dependent effects of acceleration by integrating resultant head accelerations over varying time intervals to determine a maximum value of HIC.

As mentioned previously, in the section on "Instrumented Wall", a computer program was developed that can combine outputs of the load cells and the accelerometers from the four individual wall segments to determine the magnitude and location of the resultant of the impact force using kinetic equations of rigid body dynamics. Another computer program was developed to calculate the lateral and longitudinal components of the accelerations experienced by each vehicle unit (i.e., the tractor and the trailer) using rigid body assumptions and linear interpolation.

The forces acting between the test vehicle and the instrumented wall are calculated by multiplying the mass of the vehicle units by the corresponding accelerations. This approximates the magnitudes of the impact force associated with each vehicle unit. Once the impact forces and the angular data between the test vehicle and the instrumented wall are known, the resultant force normal to the face of the wall are then calculated.
III. CRASH TEST RESULTS

TEST NUMBER 1

Test Description and General Test Results

The first test (No. 7046-3) involved a 1973 White Freightliner tractor with a 1966 Fruehauf van-trailer, as shown in Figure 2. Total weight of the vehicle, including telemetry equipment, instrumented dummy and sand bags (used for ballast) was 80,080 pounds. Detailed dimensions and information on the test vehicle are given in Figure 3. The speed of the vehicle at impact was 55 miles per hour and the angle of impact was 15.3 degrees. Impact occurred at the joint between the second and third wall segments.

Significant events during the impact sequence were noted from high-speed film and are described as follows. Shortly after impact, the front right quarter of the vehicle began to deform. The right front wheel was pushed back as the lug nuts of the wheel dug into the concrete wall. At 0.052 second after impact, the right front tire contacted the front end of the fuel tank and, at 0.065 second, the fuel tank came into contact with the wall. The tractor began to redirect and then the right front corner of the trailer impacted the wall at approximately 0.119 second. The tractor was moving parallel with the wall at 0.192 second.

The fuel tank lost contact with the wall at approximately 0.282 second. By 0.292 second, the tractor also lost contact with the wall and was exiting at a 10-degree angle, although the trailer was still in contact with the barrier at this time. The rear end of the trailer slapped against the wall at 0.534 second and then lost contact with the wall at about 0.706 second after impact. Sequential photographs of the test period are shown in Figure 4. As the vehicle left the barrier, it pulled to the right due to damages to the right front suspension system and wheel assembly. The vehicle continued forward and traversed over a bridge deck under construction and rolled over onto its left side.

The instrumented wall received cosmetic damages, mostly to the third and fourth block, as shown in Figure 5. There was some gouging in the third block where the right front wheel dug into the wall. The scrapes on the top of the second block occurred when the rear of the trailer impacted the wall.

Damage to the vehicle was extensive, as shown in Figures 6 and 7. The entire right side of the vehicle was dented and scraped and the windshield
Figure 2. Test vehicle before Test 1.
1973 White Tractor
Model WFT 8654T
VIN CA213HP077608

1966 Fruehauf Trailer
Serial No. FWG647909

Center of gravity = 297" from front axle

Figure 3. Test vehicle properties for Test 1.
Figure 4. Sequential photographs for Test 1.
Figure 4. Sequential photographs for Test 1.
(Continued)
Figure 4. Sequential photographs for Test 1.
(Continued)
Figure 5. Wall after Test 1.
Figure 6. Final resting position of vehicle after Test 1.
popped out. Maximum crush of 10.0 inches occurred at the right front corner at bumper height and there was some deformation and intrusion into the occupant compartment. There were damages to the frame, suspension and wheel assembly of the vehicle.

A summary of the results and other information pertinent to this test are given in Figure 8. The maximum 0.050-second average acceleration on the rear tandem axle of the tractor was 3.2 g in the longitudinal direction and 9.7 g in the lateral direction. Vehicle angular displacements measured on the tractor are plotted in Figure 9 and vehicle accelerometer traces are displayed in Figures 10 through 12.

Results From Instrumented Wall and Vehicle Accelerometers

Results of analysis on the instrumented wall data show that the load imparted to the instrumented wall was resisted primarily by the last three wall segments, with wall segment 2 being exposed to the most severe loading. This observation is consistent with an analysis of the overhead high-speed movie, which indicates that wall segment 2 received the maximum impact.

Figure 13 presents the magnitudes and locations of the 0.050 second average forces acting on the instrumented wall. It can be seen that the 0.050-second average force has three peaks. The first peak load was approximately 66,000 pounds and was associated with the initial impact of the tractor. The second peak load was approximately 176,000 pounds and was associated with the impact of the rear tandem axles of the tractor and the front of the van trailer. The third peak load was approximately 220,000 pounds and was associated with the final impact of the van-trailer into the wall. The vertical location graph shows that the heights of the first, second and third peak loads were 31 inches, 44 inches, and 70 inches, respectively. The horizontal location graph shows that the resultants of all three of the peak loads acted on wall segment 2. These observations are consistent with results from the high-speed movies.

Results From Instrumented Dummy

Acceleration traces of the dummy head and chest triaxial accelerometers are shown in Figure 14. Data from the accelerometers were digitized and analyzed and the results are summarized in Table 1. The highest HIC index recorded is 243 from 0.002 to 0.996 second after impact.
Test No. ............... 7046-3
Date ............... 4/07/87
Test Installation. .... Instrumented Wall
Four blocks
@ 10 ft x 7.5 ft x
1.5 ft
Length of Installation .... 75 ft (23 m)
Vehicle ............. 1973 White Tractor
Vehicle Weight .......... 80,080 lb (36,356 kg)
Impact Speed .......... 55.0 mi/h (88.5 km/h)
Impact Angle ........... 15.3 degrees
Exit Speed ............. 49.1 mi/h (79.0 km/h)
Exit Angle of Tractor .... 10.6 degrees

Vehicle Acceleration (Tractor rear tandems)
(Maximum 0.050-sec Average)
Longitudinal ........... -3.2 g
Lateral ................ 9.7 g
Driver Dummy
HIC .................. 243
Chest Acceleration
(Maximum 0.003-sec Average) .... 13 g
Fuel Tank
Maximum Internal Pressure .... 26.5 psi (0.183 Pa)
Maximum Load ............. 6,336 lb (28,183 N)

Figure 8. Summary of results for Test 1.
Axes are vehicle fixed.
Sequence for determining orientation is:
1. Yaw
2. Pitch
3. Roll

Figure 9. Vehicle angular displacements for Test 1. (measured on rear tandem of tractor)
Figure 10. Vehicle longitudinal accelerometer trace for Test 1. (measured on rear tandem of tractor)
Figure 11. Vehicle lateral accelerometer trace for Test 1. (measured on rear tandem of tractor)
Figure 12. Vehicle vertical accelerometer trace for Test 1.
(measured on rear tandem of tractor)
Figure 13. Resultant forces from 80,080-lb Tractor Van-Trailer.
Figure 14. Dummy accelerometer traces for Test 1.
Table 1. Injury Indices for Test 1.

<table>
<thead>
<tr>
<th>DRIVER HEAD</th>
<th></th>
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</thead>
<tbody>
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<td>HIC:</td>
<td>243</td>
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<tr>
<td></td>
<td>between 0.002 and 0.996 s</td>
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<tr>
<td>Highest 0.003-s sustained acceleration exceeds:</td>
<td></td>
</tr>
<tr>
<td>18 g</td>
<td>from 0.089 to 0.092 s</td>
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</tr>
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<tbody>
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<tr>
<td>13 g</td>
<td>from 0.056 to 0.059 s</td>
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</tbody>
</table>
This HIC value is considerably less than the value of 1,000, above which fatal and serious injuries are considered likely. The highest 0.003-second chest acceleration recorded is 13 g between 0.056 and 0.059 second. Again, this chest acceleration level is considerably less than the 60 g level, above which fatal and serious injuries are considered likely.

The dummy was restrained with the standard lap belt. The seat belt was instrumented with a strain gage load cell to measure forces exerted by the dummy’s movement during the test. Shortly after impact, the load cell was damaged and seat belt force data were thus not available.

The motions of the dummy during the impact was recorded by the high-speed camera mounted inside the cab of the tractor. Sequential photographs of the dummy positions during the impact sequence are shown in Figure 15. As can be seen in the photograph at 0.000 second, the dummy had already leaned over to the right before impact. This was due to the rough ride during approach to the instrumented wall. The dummy’s original position is shown in Figure 16.

At approximately 0.140 second after impact, the dummy’s head impacted the center console to its right. The dummy then moved to the left and hit the left door at 0.790 second. Judging by the movement of the steering wheel, the front wheels of the tractor began to go off the bridge deck at about 1.726 second. The dummy moved to the right and hit its head on the center console again at 1.961 second. The vehicle began to roll to the left at about 2.091 second and the dummy also moved to the left and hit the left door again at 2.301 second. As the vehicle continued to roll, the dummy leaned over the steering wheel until it was jarred to the left into the left door at about 3.602 second. The dummy assumed its final position at 4.502 second.

Results From Instrumented Fuel Tank

The right side (impact side) of the fuel tank was dented and scraped from contact with the wall. The front end of the tank was dented from contact with the right front tire with a maximum deformation of 3.5 inches. A small hole was found at the bottom of the front end of the fuel tank, probably punctured by some object from the engine compartment or the right front wheel assembly. There was also a small dent in the top of the fuel tank made by the cab mounting bracket. The tank was pushed back 1-1/8 inches and was resting against the battery box. Figure 17 shows
Figure 15. Sequential photographs of dummy positions for Test 1.
Figure 15. Sequential photographs of dummy positions for test 1. (Continued)
Figure 16. Anthropomorphic dummy before Test 1.
Figure 17. Fuel tank prior to Test 1.
photographs of the fuel tank prior to the test. Photographs illustrating the damages sustained by the fuel tank are shown in Figures 18 to 22. More detailed documentation of the damages are provided in Appendix A.

The cap on the fuel tank popped off at approximately 0.083 second after impact with the wall and landed on the ground at 2.486 second and was found roughly 115 feet from the point where it departed from the fuel tank. The vertical component of the velocity at which the cap departed from the fuel tank is calculated to be 37.35 feet per second and the horizontal component of the velocity is estimated to be 48 feet per second. The maximum internal tank pressure recorded prior to the cap popping off is 19.1 pounds per square inch (psi) at 0.072 second. The transducer was located on the front end of the fuel tank, about 6.5 inches from the top and 5.5 inches from the right (inboard) of the tank.

The pressure transducer trace is shown in Figure 23. Note that the pressure recorded by the transducer continued to rise to a maximum of 26.5 psi after the cap popped off. Under static conditions, one may expect the internal tank pressure to drop after the cap popped off. However, under dynamic conditions, the water in the tank is expected to be accelerated toward the front of the fuel tank upon impact which may account for the pressure readings after the cap popped off.

The detachment of the cap from the fuel tank could potentially be an area of concern from a fuel system integrity and fire hazard standpoint. However, it should be pointed out that the threads on the cap and the fuel tank were well worn, as shown in Figure 24. Considerably higher pressure may be required to pop off the cap for a newer tank. Also, the tank is filled to the rated capacity. Such a condition would occur only right after the fuel tanks are topped off.

An attempt was made to estimate the forces acting on the fuel tank during impact using available load cell data on the wall and accelerometer data on the tractor. It should be emphasized that these force estimates are very approximate in nature and have not been validated. Also, these estimates do not take into account the forces imparted on the fuel tank when the right front tire of the tractor was pushed back into the fuel tank. There simply is not sufficient data to even attempt such an estimate.

During the period the fuel tank was in contact with the wall (i.e., from 0.065 to 0.282 second), there were two peak loads (0.050 second
Figure 18. Fuel tank after Test 1.
Figure 19. Damage to front end of fuel tank.

Figure 20. View of rear of fuel tank.
Figure 21. View of top of fuel tank.

Figure 22. View of rear of fuel tank.
Figure 23. Pressure transducer trace for fuel tank (Test 1).
Figure 24. Fuel tank cap and opening of fuel tank.
average forces) acting on the wall. The first peak load was approximately 66,000 pounds at time 0.70 second and it was associated with the initial impact of the tractor. The second peak load was approximately 176,000 pounds at time 0.192 second and it was associated with the impact of the rear tandem axles of the tractor and the front of the van-trailer.

One approach to estimate the forces acting on the fuel tank is to assume that the force acting on the fuel tank is proportional to the area of contact. During the first peak load period, it is estimated that the area of contact for the fuel tank was roughly 7.5 percent of the total surface area in contact with the wall and the force acting on the fuel tank was roughly 4,950 pounds. For the second peak, the area of contact for the fuel tank is estimated to be roughly 4 percent of the total surface area in contact with the wall and the force acting on the fuel tank was therefore roughly 7,040 pounds.

A better and more accurate approach to estimate the forces acting on the fuel tank is to determine the acceleration levels experienced by the tractor at the fuel tank location during the crash sequence. The forces acting on the fuel tank are then determined by multiplying the acceleration with the weight of the tank and water, which is estimated to be roughly 800 pounds. The accelerations experienced by the tractor at the fuel tank location in the longitudinal \((A_x)\) and lateral \((A_y)\) directions as well as the resultant accelerations are shown in Figures 25, 26 and 27, respectively.

The highest resultant acceleration experienced by the tractor at the fuel tank location during the first peak load was 5.32 \(g\) (0.72 \(g\) longitudinal and 5.27 \(g\) lateral) at time 0.084 second, which corresponds to a force of 4,256 pounds. For the second peak load, the highest resultant acceleration experienced was 7.98 \(g\) (0.95 \(g\) longitudinal and 7.92 \(g\) lateral) at time 0.148 second, which corresponds to a force of 6,336 pounds. Note that the times for peak loads on the fuel tank and the wall are quite different, as may be expected.

**TEST NUMBER 2**

**Test Description and General Test Results**

The second test (No. 7046-4) involved a 1971 Peterbilt tractor with a 1968 Fruehauf tank-trailer, as shown in Figure 28. Total weight of the vehicle, including telemetry equipment, instrumented dummy and water (used
Figure 25. Longitudinal accelerations on the gas tank for Test 1.
Figure 26. Lateral accelerations on the gas tank for Test 1.
Figure 27. Resultant accelerations on the gas tank for Test 1.
Figure 28. Vehicle before Test 2.
to simulate the load) was 79,900 pounds. Detailed dimensions and information on the test vehicle are given in Figure 29. The speed of the vehicle at impact was 54.8 miles per hour and the angle of impact was 16.0 degrees. Impact occurred at the joint between the second and third wall segments.

Significant events during the impact sequence were noted from high-speed film and are described as follows. Shortly after impact, the entire front of the tractor came loose from the frame and began to shift to the left. The right front wheel was pushed back as the lug nuts of the wheel dug into the concrete wall and the right front wheel assembly contacted the front end of the right front fuel tank. At approximately 0.093 second, the fuel tank came into contact with the wall. The tractor began to redirect and then the rear tandem of the tractor impacted the wall at approximately 0.225 second. As the tractor moved parallel with the wall, the rear of the tank-trailer began to slide towards the wall.

The fuel tank lost contact with the wall at approximately 0.362 second. As the tractor exited from the wall, it was noted that the front mounting strap of the right front fuel tank had broken loose. At approximately 0.423 second, the rear mounting strap also broke loose and the right front fuel tank separated from the tractor. The right rear fuel tank separated from the tractor shortly thereafter. The left side fuel tank also separated from the tractor, but rode along with the vehicle until it stopped.

The top of the tank-trailer slapped against the wall at approximately 0.618 second and the rear wheels of the trailer impacted the wall at about 0.638 second. The vehicle continued to move parallel with the wall until it lost contact with the wall at about 0.854 second after impact. Sequential photographs of the test period are shown in Figure 30.

The instrumented wall received some marring and spalling on the second and third blocks, as shown in Figure 31. There was also some cosmetic damage to the first and last blocks.

Damage to the vehicle was extensive, as shown in Figure 32. The front axle of the tractor and both fuel tanks on the right side were torn away. There was damage to the frame of the tractor as well. The entire right side of the tank-trailer was dented and scraped. There was also some deformation and intrusion into the occupant compartment.
TRACTOR: 1971 Peterbilt
TRAILER: 1968 Fruehauf
8,500 gallon capacity

### TRACTOR-TRAILER

<table>
<thead>
<tr>
<th>Empty Weights</th>
<th>Left</th>
<th>Right</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight on front axle</td>
<td>4,380</td>
<td>4,030</td>
<td>8,410</td>
</tr>
<tr>
<td>Weight on center axles</td>
<td>2,830</td>
<td>2,750</td>
<td>11,100</td>
</tr>
<tr>
<td>Weight on rear axles</td>
<td>2,430</td>
<td>2,030</td>
<td>7,300</td>
</tr>
<tr>
<td>Total Empty Weight</td>
<td>8,640</td>
<td>8,800</td>
<td>17,440</td>
</tr>
</tbody>
</table>

### Loaded Weights

| Weight on front axle | 5,850 | 5,990 | 11,840 |
| Center axles | 8,460 | 8,500 | 16,960 |
| Rear axles | 8,740 | 8,070 | 16,810 |
| Total Loaded Weight | 23,050 | 22,560 | 45,610 |

Figure 29. Test vehicle properties for Test 2.
Figure 30. Sequential photographs for Test 2.
Figure 30. Sequential photographs for Test 2. (Continued)
Figure 30. Sequential photographs for Test 2.
(Continued)
Figure 31. Instrumented wall after Test 2.
Figure 32. Vehicle after Test 2.
A summary of the results and other information pertinent to this test are given in Figure 33. The maximum 0.050-second average acceleration on the rear tandem axle of the tractor was 2.1 g in the longitudinal direction and 12.3 g in the lateral direction. Vehicle angular displacements measured on the rear tandems of the tractor are plotted in Figure 34 and vehicle accelerometer traces at the rear tractor tandems are displayed in Figures 35 and 36.

Results From Instrumented Wall and Vehicle Accelerometers

Results of analysis on the instrumented wall data show that the load imparted to the instrumented wall was resisted by all of the wall segments, with wall segment 3 being exposed to the most severe loading. This observation is consistent with an analysis of the overhead high-speed movie, which indicates that wall segment 3 received the maximum impact.

Figure 37 presents the magnitudes and locations of the 0.050 second average forces acting on the instrumented wall. It can be seen that the 0.050-second average force has three peaks. The first peak load was approximately 91,000 pounds and was associated with the initial impact of the tractor. The second peak load was approximately 212,000 pounds and was associated with the impact of the rear tandem axles of the tractor and the front of the tank trailer. The third peak load was approximately 408,000 pounds and was associated with the final impact of the tank-trailer into the wall. The vertical location graph shows that the heights of the first, second and third peak loads were 36 inches, 40.5 inches, and 56 inches, respectively. The horizontal location graph shows that the resultants of all three of the peak loads acted on wall segments 2 and 3. These observations are consistent with results from the high-speed movies.

Results From Instrumented Dummy

Acceleration traces of the dummy head and chest triaxial accelerometers are shown in Figures 38 and 39, respectively. Data from the accelerometers were digitized and analyzed and the results are summarized in Table 2. There was considerable activity in these traces between 0.245 and 0.320 second with some sharp peaks in the dummy head accelerometer data. These spikes were attributed to the dummy's impact with some of the sharp objects in the instrumentation package on the floor of the tractor. The highest HIC index recorded is 417 from 0.244 to 0.250 second after impact. This HIC
Test No. .......... 7046-4
Date ............ 5/08/87
Test Installation. Instrumented Wall
Four blocks
10 ft x 7.5 ft x 1.5 ft
Length of Installation ... 75 ft (23 m)
Vehicle .......... 1971 Peterbilt Tractor
Vehicle Weight ...... 79,900 lb (36,275 kg)
Impact Speed .... 54.8 mi/h (88.2 km/h)
Impact Angle .... 16.0 degrees
Exit Speed .... 53.0 mi/h (85.3 km/h)
Exit Angle of Tractor .. 3.8 degrees

Vehicle Acceleration (Tractor rear tandems)
(Maximum 0.050-sec Average)
Longitudinal .......... -2.1 g
Lateral ................ 12.3 g

Driver Dummy
HIC ................... 417
Chest Acceleration
(Maximum 0.003-sec Average) .... 20 g

Maximum Lap Belt Load ..... 892 lb (3,968 N)
Fuel Tank
Maximum Internal Pressure ... 20.7 psi (0.143 Pa)
Maximum Load .......... 5,336 lb (23,735 N)

Figure 33. Summary of results for Test 2.
Axes are vehicle fixed. 
Sequence for determining orientation is:
1. Yaw
2. Pitch
3. Roll

Figure 34. Vehicle angular displacements for Test 2.
Figure 35. Longitudinal accelerometer trace for Test 2.
Figure 36. Lateral accelerometer trace for Test 2.
Figure 37. Resultant forces for 80,000 lb tank truck.
Figure 38. Dummy head accelerometer traces for Test 2.
Figure 39. Dummy chest accelerometer traces for Test 2.
Table 2. Injury Indices for Test 2.

<table>
<thead>
<tr>
<th>DRIVER</th>
<th>HEAD</th>
<th>HIC: 417 between 0.244 and 0.250 s</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Highest 0.003-s sustained acceleration exceeds:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>76 g from 0.246 to 0.249 s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DRIVER</th>
<th>CHEST</th>
<th>Highest 0.003-s sustained acceleration exceeds:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20 g from 0.268 to 0.271 s</td>
</tr>
</tbody>
</table>
value is considerably less than the value of 1,000, above which fatal and serious injuries are considered likely. The highest 0.003-second chest acceleration recorded is 20 g between 0.268 and 0.271 second. Again, this chest acceleration level is considerably less than the 60 g level, above which fatal and serious injuries are considered likely.

The dummy was restrained with the standard lap belt, as shown in Figure 40. The lap belt, which was bolted to each side of the frame of the seat, was instrumented with a strain gage load cell to measure forces exerted by the dummy’s movement during the test. A second load cell was placed on the tether strap on the left side of the driver seat which ran from the lap belt anchor to the floor. Traces from these two load cells are shown in Figures 41 and 42. The maximum load exerted on the lap belt was 892 pounds at 0.240 second and the maximum load exerted on the tether strap was 279 pounds at 0.223 second. The seat shifted to the right approximately 4 to 6 inches. The frame of the seat was bent where it connects to the floor mount.

A high-speed camera was mounted inside the tractor sleeper compartment to record the motions of the dummy during the impact. Sequential photographs of the dummy positions during the impact sequence are shown in Figure 43. The mount holding the camera broke during the impact sequence, allowing the camera to move slightly. As a result of this movement, the view of the camera was partially blocked by the wall of the sleeper compartment.

At approximately 0.115 second after impact, the seat and dummy began to shift to the right. At about 0.170 second, the camera mount broke and the view was obstructed until about 0.400 second. At this time, the dummy was lying across the instrumentation and battery box which was mounted to the floor of the tractor. The dummy then started moving to the left and reached an almost upright position at 0.700 second and began to move to the right. By 0.975 second, the dummy was again lying across the instrumentation on the floor. The dummy was jarred around in this position until the vehicle came to rest.

Results From Instrumented Fuel Tank

As mentioned previously, both fuel tanks on the right side of the tractor broke loose during the impact sequence and were separated from the tractor before the vehicle came to rest. The right front fuel tank came to rest approximately 175 feet from the point of impact and the right rear fuel
Figure 40. Instrumented dummy before and after Test 2.
Figure 41. Load exerted on lap belt during Test 2.

Figure 42. Load exerted on the tether strap during Test 2.
Figure 43. Sequential photographs of dummy positions for Test 2.
tank came to rest roughly 300 feet from the point of impact. The fuel tank on the left side also separated from the tractor, but rode along with the vehicle until it stopped. Figure 44 shows the right side of the tractor and the fuel tank before the test and Figure 45 shows the same after the test. The locations of the two right side fuel tanks in relation to the final rest position of the tractor are shown in Figure 46.

The front end of the right front fuel tank was severely dented with weld separation and a rip on the outside (impact side) from contact with the right front wheel assembly. The rear end of the tank was damaged from contact with the ground. There is a small puncture near the opening on top of the tank. The outside of the tank was also dented by the front of the aluminum ladder assembly as it impacted the wall. (Note that an aluminum step ladder was attached to the right front fuel tank, as shown in Figure 44. Also, the fuel tanks are located inward of the front and rear tandem wheel assemblies which partially protected them from direct contact with the wall during impact). Damages to the right rear and left fuel tanks were mainly from contact with the ground after separation from the wall. Damages to the right front, right rear, and left fuel tanks are shown in Figures 47 to 48, 49 to 50, and 51 to 52, respectively. More detailed documentation of the damages to the fuel tanks are provided in Appendix B.

The cap on the fuel tank popped off at approximately 0.313 second after impact with the wall and was found roughly 110 feet from the impact point. It is not apparent from the film analysis as to the trajectory of the cap after it popped off from the fuel tank due to the presence of other debris from the impact. Photographs of the cap and the opening to the right front fuel tank are shown in Figures 53 and 54, respectively.

Traces from the pressure transducer attached to the right front fuel tank is shown in Figure 55. The transducer was connected to the fuel tank via a connecting line attached to the existing crossover line fitting on the bottom of the fuel tank. The maximum internal tank pressure recorded prior to the cap popping off was 20.7 pounds per square inch (psi) at 0.278, 0.286, and 0.310 second. Note that the cap on the fuel tank popped off at 0.313 second, right after the maximum pressure was attained. This is different from previous test 1 (No. 7046-3), in which the cap on the fuel tank popped off shortly after impact with the wall and long before the maximum pressure was attained. A possible explanation for this difference
Figure 44. Right side fuel tanks before Test 2.
Figure 45. Right side of tractor after Test 2.
Figure 46. Location of fuel tanks after Test 2.
Figure 47. Side views of right front fuel tank after Test 2.
Figure 48. End views of right front fuel tank after Test 2.
Figure 49. Side views of right rear fuel tank after Test 2.
Figure 50. End views of right rear fuel tank after Test 2.
Figure 51. Side views of left fuel tank after Test 2.
Figure 52. End views of left fuel tank after Test 2.
Inside

Outside

Figure 53. Fuel tank cap from right front tank after Test 2.
Figure 54. Opening to right front fuel tank after Test 2.
Figure 55. Pressure transducer trace for right front fuel tank Test 2.
is that the fuel tank in this test did not come into direct contact with the wall.

The fact that the caps on the fuel tanks popped off in both tests suggests that this could potentially be an area of concern from a fuel system integrity and fire hazard standpoint. However, it should be borne in mind that these two test trucks are both very old and are probably not representative of the current truck population. The cap attachment mechanism in this test, as shown in Figure 53, is a very old design and no longer used for the newer truck. The threads on the cap and the opening on the fuel tank in the previous test were well worn and considerably higher pressure may be required to pop off the cap for a newer tank. Also, the tank is filled to the rated capacity. Such a condition would occur only right after the fuel tanks are topped off.

An attempt was made to estimate the forces acting on the fuel tank during impact using available accelerometer data on the tractor. No attempt was made to estimate the forces using the load cell data from the wall since the fuel tank did not actually come into direct contact with the wall. Again, it should be emphasized that these force estimates are very approximate in nature and have not been validated. Also, these estimates do not take into account the forces imparted on the fuel tank when the right front tire of the tractor was pushed back into the fuel tank. There simply is not sufficient data to even attempt such an estimate.

To estimate the forces acting on the fuel tank, acceleration levels experienced by the tractor at the right front fuel tank location during the crash sequence were determined. The forces acting on the fuel tank are then determined by multiplying the acceleration with the weight of the tank and water, which is estimated to be approximately 800 pounds. The accelerations experienced by the tractor at the fuel tank location in the longitudinal ($A_X$) and lateral ($A_Y$) directions as well as the resultant accelerations are shown in Figures 56, 57, and 58, respectively.

The right front fuel tank experienced two peak load periods, as shown in the acceleration traces. The highest resultant acceleration experienced by the tractor at the right front fuel tank location during the first peak load was $6.17 \, g$ ($0.60 \, g$ longitudinal and $6.14 \, g$ lateral) at time $0.130$ second, which corresponds to a force of 4,936 pounds. For the second peak load, the highest resultant acceleration experienced was $6.67 \, g$ ($1.10 \, g$
Figure 56. Longitudinal accelerations on right front fuel tank (Test 2).
Figure 57. Lateral accelerations on right front fuel tank (Test 2).
Figure 58. Resultant accelerations on right front fuel tank (Test 2).
longitudinal and 6.58 g lateral) at time 0.199 second, which corresponds to a force of 5,336 pounds. Note that the times for peak loads on the fuel tank and the wall are quite different, as may be expected.
IV. SUMMARY OF FINDINGS AND CONCLUSIONS

The findings and conclusions discussed herein pertain only to the portion of the work sponsored by the National Highway Traffic Safety Administration. The work sponsored by the Federal Highway Administration is still ongoing and the findings and conclusions from that study will be presented in a separate final report.

- The injury indices sustained by the driver dummy restrained by a standard lap belt were considerably less than the levels where fatal and serious injuries are considered likely. The highest HIC index recorded was 243 from 0.002 to 0.996 second in Test 1 and 417 from 0.244 to 0.250 second in Test 2. The highest 0.003-second chest acceleration recorded is 13 g between 0.056 and 0.059 second in Test 1 and 20 g between 0.268 and 0.271 second in Test 2.

- The maximum force exerted by the dummy on the lap belt in Test 2 was 892 pounds at 0.240 second after impact. The maximum load exerted on the left tether strap between the lap belt anchor and the floor was 279 pounds at 0.223 second after impact.

- Even though the dummy was restrained by a lap belt, it is evident from the high-speed photography that the dummy came into contact with various parts of the cab interior, including the steering wheel, dash board, center console, the left door, and the passenger seat or the passenger, if present.

- The right (impact side) front fuel tanks sustained extensive damages in both tests, including impact from the right front wheel assembly as the lug nuts on the wheel dug into the surface of the instrumented wall. Also, All three fuel tanks broke loose from the tractor during the impact sequence in Test 2. This illustrates the vulnerability of the fuel tanks to damages from impacts and the subsequent loss of fuel system integrity and fire hazards.

- The fact that the caps on the right front fuel tanks popped off in both tests suggests that this could potentially be another area of concern from a fuel system integrity and fire hazard standpoint. However, it should be emphasized that the cap attachment mechanism was severely worn in Test 1 and of an outdated design in Test 2 such that considerably higher pressure and force may be required to pop off the
cap for a newer tank. Also, the tanks were filled to the rated capacity. Such a condition would occur only right after the fuel tanks were topped off.

- The maximum internal tank pressure recorded prior to the cap popping off was 19.1 pounds per square inch (psi) at 0.072 second for Test 1 and 20.7 psi at 0.278, 0.286, and 0.310 second for Test 2. The pressure levels are surprisingly low for the caps to pop off. Again, the results are likely affected by the condition and outdated design of the cap attachment mechanism and may not reflect the situation with newer fuel tanks.

- The acceleration and force levels experienced by the fuel tank during impact are estimated based on acceleration levels experienced by the tractor at the fuel tank location. There were two peak loads in both tests. The highest resultant acceleration during the first peak load was 5.32 g at time 0.084 second for Test 1 and 6.17 g at time 0.130 second for Test 2, corresponding to forces of 4,256 and 4,936 pounds, respectively. For the second peak load, the highest resultant acceleration experienced was 7.98 g at time 0.148 second for Test 1 and 6.67 g at time 0.199 second for Test 2, with corresponding forces of 6,336 and 5,336 pounds, respectively.
Appendix A

Detailed Documentation of Fuel Tank (Test 1)
CASE NUMBER 7046-3 (crash test)

FUEL TANKS    Right side tank ONLY

1. Tank Material Aluminum

2. Number of Tanks Left Side

3. Number of Tanks Right Side 1

<table>
<thead>
<tr>
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<th>FUEL TANK</th>
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<th>Other</th>
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<tr>
<td>L</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7/8 in</td>
</tr>
</tbody>
</table>

4. Fuel Levels

5. Fuel Tank Caps
   I. D. Temco M0878
   Position Top near center
   Condition Blew off during test

6. Fuel Pick-up NOT ON

7. Fuel Return THIS TANK

8. Cross-over Detached

9. Attachment
   Condition Good
   Movement 1-1/8 in rearward

10. Valves
    Position Open
    (open or closed) Handle broken
    Condition Line detached

11. Drain Plugs Okay

FUEL LINES

12. Cross-over Lines
    Describe Material and Condition Detached at both ends (wear, leaks, etc.)

4/87
12. Cross-over Lines cont.
Describe Routing 1 in angle iron -- broken and (hangers, covers, etc.) bent in impact sequence

Measure Mid-point Sag N/A

Evidence of Fuel Saturation N/A

End-point connections Detached

Evidence of Modification ?

Evidence of Damage Detached

13. Fuel Lines
Describe Material and Condition Detached at tank end (wear, leaks, etc.) Detached at fuel filter

Describe Routing Nothing unusual (hangers, covers, etc.)

Evidence of Fuel Saturation Leaking at detachment

End-point connections Detached

Evidence of Modification None Noted

Evidence of Damage Detached at both ends

14. Fuel Filters
How many filters are present 2

Describe Condition One is missing -- Other is (wear, leaks, etc.) damaged -- Lines detached

Describe Mounting Screw mount

Manufacturer

End-point connections ?

Evidence of Modification None Noted

Evidence of Damage Front one destroyed

4/87
<table>
<thead>
<tr>
<th>Case Number</th>
<th>7046-3</th>
</tr>
</thead>
</table>

### OTHER

15. **Fuel Injection Pump, Injector Lines and Injectors**

Describe condition and any damage

- Completely separated from engine

---

16. **Cold Start Ether Injector**

Mechanical

Electric

Describe condition and any damage

---

17. **Fuel System Heater**

Water

Electric

Describe Type, manufacturer and location

Describe condition and any damage

---

18. **Document any other fuel system components as needed**

---

4/87
FUEL TANK SKETCH FORM

TANK IDENTIFICATION  LF  LR  (CIRCLE)
COPY AND PHOTOGRAPH MANUFACTURER ID PLATE.

Capacity: 90 gallons
Tank I.D. No. 03-10237 (from bottom of tank)

---

TOP
Dent from cab mounting bracket

BOTTOM
Small hole at 6:00

OUTSIDE
Dent from cab mounting bracket

INSIDE
Drain plug

REAR
FRONT

48"

27"

20"

9"

23"

11.5"

7"

7.5"

12.5"

8"

11"

8"

15"

12"

Maximum Deformation = 3.5"

SKETCH ALL VALVES, LINES, FITTINGS AND CAPS. SHOW ALL DIMENSIONS.
ANNOTATE AND SKETCH ALL DAMAGE TO TANK OR HARDWARE.
4/87
Appendix B

Detailed Documentation of Fuel Tanks (Test 2)
**TTI/MVMA/WHI HEAVY TRUCK FUEL SYSTEM INTEGRITY STUDY**

**FUEL SYSTEM FORM**

**CASE NUMBER** Crash Test 7046-4

**FUEL TANKS**

1. Tank Material Aluminum

2. Number of Tanks Left Side  1

3. Number of Tanks Right Side  2

<table>
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<th>L</th>
<th>R</th>
<th>F</th>
<th>R</th>
<th>R</th>
<th>Other</th>
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</thead>
<tbody>
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<td>4. Fuel Levels</td>
<td>1-1/4&quot;</td>
<td>N/A</td>
<td>None</td>
<td>1/2&quot;</td>
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<tr>
<td>5. Fuel Tank Caps</td>
<td>Temco 3918606</td>
<td>off</td>
<td>None</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Position</td>
<td>Top: 12:00</td>
<td>Top: 11:00</td>
<td>Top: 11:00</td>
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<tr>
<td>Condition</td>
<td>Okay</td>
<td>gone</td>
<td>dented</td>
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<tr>
<td>6. Fuel Pick-up</td>
<td>plugged</td>
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<td>7. Fuel Return</td>
<td>plugged</td>
<td>plugged</td>
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<td></td>
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<tr>
<td>8. Cross-over</td>
<td>sheared</td>
<td>altered</td>
<td>plugged</td>
<td></td>
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<td>9. Attachment Condition</td>
<td>off</td>
<td>off</td>
<td>rear mount broken</td>
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<td>Movement</td>
<td>off</td>
<td>off</td>
<td>rear:fwd 3&quot; inside</td>
<td></td>
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<tr>
<td>10. Valves Position (open or closed)</td>
<td>none</td>
<td>none</td>
<td>none</td>
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<tr>
<td>Condition</td>
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<td>N/A</td>
<td>N/A</td>
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<td></td>
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<tr>
<td>11. Drain Plugs</td>
<td>Okay</td>
<td>Okay</td>
<td>Okay</td>
<td></td>
<td></td>
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**FUEL LINES**

12. Cross-over Lines

Describe Material and Condition       
(wear, leaks, etc.)       

4/87
<table>
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<tr>
<th>Section</th>
<th>Description</th>
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| 12. Cross-over Lines cont. | Describe Routing (hangers, covers, etc.)
| | Measure Mid-point Sag
| | Evidence of Fuel Saturation
| | End-point connections
| | Evidence of Modification
| | Evidence of Damage

| 13. Fuel Lines | Describe Material and Condition (wear, leaks, etc.)
| | Describe Routing (hangers, covers, etc.)
| | Evidence of Fuel Saturation
| | End-point connections
| | Evidence of Modification
| | Evidence of Damage

| 14. Fuel Filters | How many filters are present
| | Describe Condition (wear, leaks, etc.)
| | Describe Mounting
| | Manufacturer
| | End-point connections
| | Evidence of Modification
| | Evidence of Damage

4/87
15. Fuel Injection Pump, Injector Lines and Injectors
   Describe condition and any damage

16. Cold Start Ether Injector
   Mechanical
   Electric
   Describe condition and any damage

17. Fuel System Heater
   Water
   Electric
   Describe Type, manufacturer and location
   Describe condition and any damage

18. Document any other fuel system components as needed
FUEL TANK SKETCH FORM

TANK IDENTIFICATION LF LR RF RR OTHER (Circle)
COPY AND PHOTOGRAPH MANUFACTURER ID PLATE.
A11 1058 46"x23"

TOP

45" 45" 16"

REAR FRONT

BOTTOM

Drain Plug

17"

REAR FRONT

CROSSOVER LINE FITTING
ID No. 11-368

OUTSIDE

Dent 12"Hx2"Wx1/2"D

REAR FRONT

Dent 13"Hx12"Wx1 1/2"D

INSIDE

Dent 16"Hx15 1/2"W x6 1/2"D

REAR FRONT

FRONT

REAR

Dent @ 5 o'clock
5"Hx13"Wx5 1/2"D
(from ground)

REAR

FRONT

Dent 7-9 o'clock
18"Hx7"Wx8"D

SKETCH ALL VALVES, LINES, FITTINGS AND CAPS. SHOW ALL DIMENSIONS.
ANNOTATE AND SKETCH ALL DAMAGE TO TANK OR HARDWARE.
4/87
FUEL TANK SKETCH FORM

CASE NUMBER 7046-4

TANK IDENTIFICATION LF LR RF RR OTHER (Circle)
COPY AND PHOTOGRAPH MANUFACTURER ID PLATE.
No identification 50"x23"

SKETCH ALL VALVES, LINES, FITTINGS AND CAPS. SHOW ALL DIMENSIONS.
ANNOTATE AND SKETCH ALL DAMAGE TO TANK OR HARDWARE.
4/87
FUEL TANK SKETCH FORM

TANK IDENTIFICATION (Circle)

COPY AND PHOTOGRAPH MANUFACTURER ID PLATE.
Temco 3918606

1 - Meltdown plug

29" 30"

23"

46"Wx17"Hx4"D

30"Wx12"Hx7"D

6"Dx21"Wx19"H

17"Hx13"W x7"D

SKETCH ALL VALVES, LINES, FITTINGS AND CAPS. SHOW ALL DIMENSIONS.
ANNOTATE AND SKETCH ALL DAMAGE TO TANK OR HARDWARE.

4/87