An Assessment of Corrugated HDPE Pipe Performance Under Railroads

Michael Pluimer
Director of Engineering
Plastics Pipe Institute

When what's inside has to stay inside, it's polyethylene pipe. Count on it.
Corrugated Polyethylene Pipe Testing under 315,000-Pound Cars at FAST

Letter Report No. P-09-052
Prepared for Plastic Pipe Institute
by Joseph A. LoPresti
Transportation Technology Center, Inc.

...a subsidiary of the Association of American Railroads
P. O. Box 11130, Pueblo, Colorado 81001 USA,
December 28, 2009
Revised January 14, 2010
Railroad Network of the UNITED STATES 2008

Map shows rail line ownership based on 2008 National Transportation Atlas Database published by the U.S. DOT's Bureau of Transportation Statistics.

- Currently 7 major railroads (Class I) and hundreds of Class II and III railroads comprising 140,000 miles of track in U.S.

- Revenues in the freight rail industry were $63B in 2009

- 1.4 million freight cars operating in 2009 (450,000 Class I)

- Freight Rail Infrastructure Expansion Act of 2009 proposes increased funding and tax incentives for freight rail

- FRA recently announced $25M funding for high speed rail
ENVIRONMENTAL ADVANTAGES OF RAIL

• Railroad fuel efficiency is up 94% since 1980

• A freight train moves a ton of freight an average of 480 miles on a gallon of fuel (0.6 liters of fuel per 100 km)

• According to Federal Railroad Administration, railroads are 2 – 5 times more fuel-efficient than trucks

• A single freight train can take the load of 280 trucks

• If 10% of current long distance highway freight switched to rail, national fuel savings would exceed 1B gallons/year (3.8 B Liters/year)
Storm Water Culvert Repair
Stands Up To Weight
Of Railroad Trains And Contaminated Soil

A 20-foot section of SanTite® HP pipe being nudged into the culvert. It took the crew just hours to slipline the entire 200 feet of the culvert.
This required the repair to be able to seal out any contamination from above, not inhibit the creek’s water flow rate and still be able to withstand the weight of 17 feet of earth and the multi-ton Amtrak passenger and freight railcars frequently passing overhead every day.

Contractor easily assembles the field joint together with ratchet straps.

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
The final headwall and the 60-inch diameter pipe blends in with the surrounding area.

When what’s inside has to stay inside, it’s polyethylene pipe. **Count on it.**
- TTCI – Transportation Technology Center, Inc., Pueblo, CO
- FAST – Facility for Accelerated Service Testing

- Typical train consist = 80 315,000 lb (156 ton) cars and 4 GP-40 locomotives
- Static Wheel Loads
  - (Wheel Load)(# of wheels) = Gross Weight of Car

<table>
<thead>
<tr>
<th>Axle Load (tons)</th>
<th>Gross Weight of Cars (lbs)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>80,000</td>
<td>Light rail transit</td>
</tr>
<tr>
<td>15</td>
<td>120,000</td>
<td>Heavy rail transit</td>
</tr>
<tr>
<td>25</td>
<td>200,000</td>
<td>Passenger Cars</td>
</tr>
<tr>
<td>27.5</td>
<td>220,000</td>
<td>Common European freight limit</td>
</tr>
<tr>
<td>33</td>
<td>263,000</td>
<td>U.K. and Select European limit</td>
</tr>
<tr>
<td>36</td>
<td>286,000</td>
<td>North American free interchange limit</td>
</tr>
<tr>
<td>39</td>
<td>315,000</td>
<td>Current Heavy Axle load weight for North American Class 1</td>
</tr>
</tbody>
</table>

We Used 39 Ton Axle Load Cars (315,000 lb) for the test; TTCI started using these loads in 1988.

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
**Live Load Transferred to Pipe**

<table>
<thead>
<tr>
<th>Cover, ft. (m)</th>
<th>AASHTO H-25 or HS-25</th>
<th>Cooper E-80</th>
<th>AASHTO H-25 or HS-25</th>
<th>Cooper E-80</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Live Load Transferred to Pipe, $P_L$, psi (N/mm²)</td>
<td>Live Load Distribution Width, $L_W$ in (mm)</td>
<td>Live Load Transferred to Pipe, $P_L$, psi (N/mm²)</td>
<td>Cover, ft. (m)</td>
</tr>
<tr>
<td>1 (0.3)</td>
<td>15.63 (0.108)</td>
<td>31 (787)</td>
<td>N/R</td>
<td>14 (4.3)</td>
</tr>
<tr>
<td>2 (0.6)</td>
<td>6.95 (0.048)</td>
<td>52 (1321)</td>
<td>26.39 (0.1824)</td>
<td>16 (4.9)</td>
</tr>
<tr>
<td>3 (0.9)</td>
<td>5.21 (0.036)</td>
<td>73 (1854)</td>
<td>23.61 (0.1632)</td>
<td>18 (5.5)</td>
</tr>
<tr>
<td>4 (1.2)</td>
<td>3.48 (0.024)</td>
<td>94 (2388)</td>
<td>18.40 (0.1272)</td>
<td>20 (6.1)</td>
</tr>
<tr>
<td>5 (1.5)</td>
<td>2.18 (0.015)</td>
<td>115 (2921)</td>
<td>16.67 (0.1152)</td>
<td>22 (6.7)</td>
</tr>
<tr>
<td>6 (1.8)</td>
<td>1.74 (0.012)</td>
<td>136 (3454)</td>
<td>15.63 (0.1080)</td>
<td>24 (7.3)</td>
</tr>
<tr>
<td>7 (2.1)</td>
<td>1.53 (0.011)</td>
<td>157 (3988)</td>
<td>12.15 (0.0840)</td>
<td>26 (7.9)</td>
</tr>
<tr>
<td>8 (2.4)</td>
<td>0.86 (0.006)</td>
<td>178 (4521)</td>
<td>11.11 (0.0768)</td>
<td>28 (8.5)</td>
</tr>
<tr>
<td>10 (3.0)</td>
<td>negligible</td>
<td>N/A</td>
<td>7.64 (0.0528)</td>
<td>30 (9.1)</td>
</tr>
<tr>
<td>12 (3.7)</td>
<td>negligible</td>
<td>N/A</td>
<td>5.56 (0.0384)</td>
<td>35 (10.7)</td>
</tr>
</tbody>
</table>

**Cooper E-80 Load**

When what’s inside has to stay inside, it’s polyethylene pipe. **Count on it.**
TTCI

- Headquartered in Pueblo, CO at the U.S. Federal Railroad Administration’s Transportation Technology Center

- Includes 50 miles of test track for specialized full scale rail tests

- TTCI capable of accumulating 1 million gross ton-miles / day on high tonnage loop

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
When what's inside has to stay inside, it's polyethylene pipe. **Count on it.**
When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
- Instrumented 2 58” pipes (1 for each backfill type)

- 16 strain gages, 10 string pots on each pipe

- One end of pipe had an inline bell WT coupler; the other end a fabric wrapped split coupler

- Track loads directly over joints

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
EXCAVATION FOR THE PIPES

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
Excavating trench for the pipe
Installing the instrumented pipe sections
Bell and spigot WT joint

Split coupler Joint
Placing crushed stone backfill around pipe
SITE 1 – Crushed stone #57 Backfill, vibrated with jumping jack

SITE 2 – Native soil backfill (ASTM Class III), vibrated with jumping jack

When what's inside has to stay inside, it's polyethylene pipe. Count on it.
Pipe #2
Soil Backfill

First foot over pipe - Compacted to 94% SPD with small vibratory roller.

Second foot over pipe – Compacted to 98% SPD with loader and large vibratory larger roller.

Pipe #1
Stone Backfill
Initial compaction of the native cover soil

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
Final Compaction

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
When what’s inside has to stay inside, it’s polyethylene pipe. **Count on it.**
When what’s inside has to stay inside, it’s polyethylene pipe. **Count on it.**
Strains and Deflections were Measured:

• Statically, when backfill and track construction was complete

• Statically, after accumulating 1 MGT of Heavy Axle Load (HAL) traffic

• Dynamically, during 10 laps of train operations after completing 1 MGT of HAL traffic

• Statically, prior to train operations after accumulating 96 MGT of HAL traffic

• Dynamically, during 10 laps of train operations after completing 96 MGT of HAL traffic
Data Collection
(See Video)
When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
When what’s inside has to stay inside, it’s polyethylene pipe. **Count on it.**
When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
Pipe Wall Strains from Construction and Backfill

When what’s inside has to stay inside, it’s polyethylene pipe. **Count on it.**
Pipe Deflections from Construction and Backfill

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
Maximum dynamic wall strains from 40 mph train after 1 MGT
Maximum peak-peak dynamic wall strains from 40 mph train after 1 MGT
Maximum deflections from 40 mph train

When what's inside has to stay inside, it's polyethylene pipe. Count on it.
Maximum peak-peak changes in deflection due to dynamic load from 40 mph train
Measured vs. Allowable Deflections

- Maximum Allowable Deflection per Standard
- Maximum Measured Deflection From Construction
- Maximum Measured Deflection from Dynamic Loading
- Maximum Measured Total Deflection

When what’s inside has to stay inside, it’s polyethylene pipe. *Count on it.*
Sample dynamic strain and deflection data for train pass

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.
Dynamic distribution of wheel loads over track

When what's inside has to stay inside, it's polyethylene pipe. Count on it.
Data was collected after 96 MGT as well:

- Strains were slightly higher than after 1 MGT test (max strain increased by 600 microstrain, or 0.06%)

- Deflections were slightly higher than after 1 MGT (max deflection increased by 0.2”, or 0.4%)

- Maximum circumferential shortening increased from 0.5” to 0.8”
After 6 Weeks Static Load:

- One set of wheels parked over each pipe continuously for 6 weeks

- Negligible track deflection at the end of 6 weeks; rebounded completely when train was removed

- No track geometry maintenance needed after the test due to soil settlement or pipe deflection
- Maximum strain due to construction loads was \(-7300\) microstrain (0.73\%) compressive

- Tensile strains were negligible

- Maximum peak-peak strain due to dynamic loads was \(1173\) microstrain (0.12\%) compressive

- Maximum deflection due to construction loads was 1.46\%

- Maximum deflection due to dynamic loads was 0.12\%
- Pipes performed acceptably through 96 MGT

- No track geometry maintenance was required at test site due to pipe deflection or fill settlement

- Ride quality over the pipes was satisfactory

- The maximum deflection caused by dynamic loads was 0.06” (0.12%)
CONCLUSION

• Large diameter corrugated HDPE pipe is recommended for railroad applications, including shallow fills, when properly installed.

• Large Diameter corrugated HDPE pipe was included in the 2012 AREMA Specifications as a result of this study.
QUESTIONS?

When what’s inside has to stay inside, it’s polyethylene pipe. Count on it.