

Evaluating the Possible Extension of the Propane Cargo Tank Inspection Interval

Final Report – Phase 0

January 4, 2005

Currently, the U.S. Department of Transportation requires that propane cargo tanks (“bobtails”) of MC330 and MC331 specifications be pressure-tested every five years [49CFR180.407] as part of the requalification process to continue in service. The pressure test is performed at 1.5 times the maximum allowable working pressure and is typically a hydrostatic test, with water as the test medium. To pass the test, the container must hold the pressure for 10 minutes without exhibiting leaks, distortion, or excessive permanent expansion.

The required hydrostatic testing of bobtails is a burden to the propane industry for several reasons. Bobtails must be taken out of service for a period of up to a week. Water is introduced into the container, which is detrimental to the container. Before being put back into use, the container must be completely free of any water. In addition to the cost of the test itself, the removal of bobtails from propane service can hamper a company’s operations.

Battelle performed a feasibility study for the National Propane Gas Association (NPGA) to determine if the DOT was open to discussing a change to the inspection period. The study also reviewed international standards that addressed cargo tank inspection periods. The objective of this phase of the project, Phase 0, was to determine if further engineering analyses were justified. This Phase 0 was comprised of two tasks:

- Task 1 – Meet and discuss an inspection period extension with cognizant DOT staff
- Task 2 – Review international standards of cargo tank inspections

Each of these tasks is discussed below.

Task 1 – Discussions with DOT of cargo tank inspection period extension

Battelle and NPGA staff met with staff from the Research and Special Programs Administration (RSPA) of DOT, on September 27, 2004. The full notes of this meeting, including a list of persons in attendance, are included in Appendix A. In this introductory meeting, the Battelle and NPGA staff presented the concept of extending the inspection period of cargo tanks with the following limitations:

- constructed to specification MC 330 or MC 331
- constructed with non-quenched and tempered steel
- with a capacity of less than 3500 gallons
- in dedicated propane service

During the meeting, there was a consensus that no one present knew of the origin of the current five year requalification period. It was acknowledged that even though the origin is unknown, any analyses must address the relative safety of any change to that five year period.

DOT staff raised some concerns and comments about a requalification extension and the analyses used for justifying that extension. Those concerns are listed below, including any responses of NPGA or Battelle.

- What effect will moisture in propane have on the corrosion of the tank?
 - Response → The moisture content of propane is extremely small, and previous internal inspections have not revealed corrosion in tanks.
- Do not use confidential analyses. Engineering analyses must use accepted and documented methods.
 - Response → Battelle's analyses will use methods that have been published in refereed journals.
- Is the population of under-3500 gallon tanks dwindling?
 - Battelle queried a number of cargo tank vendors after this meeting. The replies were that the vast majority of tanks, either in place or new, are in the 2600 to 3499 gallon range, with the highest population in the 3200 gallon size. Therefore, there is significant interest in extending the requalification period with the under-3500-gallon limitation.
- The pressure test is a concrete test with concrete results. Because of complex geometries, it may be difficult for visual-only tests to verify tank integrity as well as pressure checks do.
- The five year period appears to have worked well for the propane cargo tanks, because of the excellent safety record.
 - Response → Any suggested changes to the period extension must exhibit the "equivalent safety".

Battelle presented the two-phase approach to the analyses. First, an engineering model of the cargo tank and the thermodynamic loading exposed to the tank will be developed. With that model, Battelle will first determine the maximum crack size that would be undetected in the standard pressure test, and then determine the likely growth of this flaw for the assumed loading. Using this crack growth rate, Battelle will estimate the projected life of the tank based on a through-the-wall crack. If the order-of-magnitude of this projected life is significantly longer than the current five year requalification period, then there may be merit in continuing the study to address the vehicle dynamic loading. The second phase will use the engineering model developed in the first phase to consider the tank stresses induced from the dynamics of lading-tank-truck-road interactions. Similar to the first phase, Battelle will determine the maximum crack size, the projected life, and resultant safety factor on the inspection period. Battelle will review with the appropriate DOT staff the aspects of the analyses throughout both phases of work. The reviews will include model development, tank properties (geometry and construction materials and methods), loading histories, and other assumptions used in the analyses.

The DOT-RSPA staff agreed with the overall approach presented above and were agreeable to reviewing these analyses as they become available. DOT’s Charles Hochman agreed to be the RSPA point of contact for NPGA and Battelle.

It should be noted here that Congress has passed legislation to split RSPA into two administrations: the Research and Innovative Technologies Administration and the Pipeline and Hazardous Materials Safety Administration. We are uncertain how these organizational changes will affect DOT’s reception of proposed regulatory changes, and there may also be a change in the point of contact at DOT. Battelle will continue to monitor these changes in preparation for the next phases of this project.

Task 2 – Review international standards of cargo tank inspections

The ADEPT Group performed a review of international standards through a literature search and direct communications with LP gas contacts in selected countries. ADEPT contacted 42 countries and received data from 15 countries. Table 1 lists these countries.

Table 1: Countries Contacted for Cargo Tank Inspection Regulations

#	Country	Data Gathered	#	Country	Data Gathered
1	Argentina	No	22	Korea	No
2	Australia	Yes	23	¹ Latvia	No
3	¹ Austria	No	24	¹ Lithuania	No
4	¹ Belgium	Yes	25	¹ Luxembourg	Yes
5	Canada	Yes	26	Mexico	No
6	Chile	No	27	Morocco	No
7	Croatia	No	28	¹ Netherlands	Yes
8	¹ Czech Republic	No	29	New Zealand	No
9	¹ Denmark	Yes	30	Norway	No
10	¹ Estonia	No	31	¹ Poland	Yes
11	¹ Finland	No	32	¹ Portugal	No
12	¹ France	Yes	33	Romania	No
13	¹ Germany	Yes	34	Russia	No
14	¹ Greece	No	35	¹ Slovakia	No
15	¹ Hungary	No	36	¹ Slovenia	No
16	India	No	37	South Africa	Yes
17	¹ Ireland	Yes	38	¹ Sweden	Yes
18	Israel	No	39	Switzerland	No
19	¹ Italy	Yes	40	Turkey	No
20	Japan	Yes	41	¹ United Kingdom	Yes
21	Kazakhstan	No		¹ Included in European Union	

A summary of the key data collected is listed below.

Australia

- No pressure test required once put in service
- After one year in service, non-destructive tests are conducted on all welds and heat affected areas
- Every three years thereafter, all welds and heat affected areas are tested via non-destructive tests
- External visual inspection by an accredited boiler inspector is conducted every year
- At each internal inspection, internal valves are tested; vessel is then refitted with new or retested and/or re-fitted units

Canada

- Hydrostatic or pneumatic pressure test once every five years
- Raise pressure to 1.5 times design pressure (similar to U.S. maximum allowable working pressure [MAWP])
- When isolated from pressure supply, test pressure must be held for at least ten minutes, and
- Visual examination of all external surfaces must reveal no defects, leakage, or deformation

European Union (EU)

- (EU includes Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, Sweden, The Netherlands, United Kingdom, and others)
- Pressure test may be hydrostatic (most common) or pneumatic
- Pressure test tank every six years
- Raise pressure to 1.5 MAWP of tank
- No mandatory minimum duration for pressure test. (General practice is understood to be 10 to 20 minutes)

India

- (Regulations were verbally communicated)
- Must be hydrostatically tested every five years

Japan

- If a tank has been in service for less than 20 years, pressure tested every five years
- If a tank has been in service for more than 20 years, it must be pressure tested every two years
- Pressure test must be hydrostatic (pneumatic is not permitted)
- Pressure is held for 30 seconds at tank design pressure
- Tank's internal valves must be tested at the same time as the tank is pressure tested

- NOTE – This pressurization protocol is less demanding than equivalent U.S. protocol: Test time (30 seconds versus 10 minutes) and pressure (design pressure versus 1.5 design pressure) are significantly lower than U.S. protocol

Mexico

- No pressure test required (eliminated approximately 10 years ago)

South Africa

- Pressure test typically hydrostatic (though alternative test methods are gaining acceptance)
- Pressure test tank every ten years
- Raise pressure to 1.25 MAWP of tank.
- Test duration is at least five minutes

United Kingdom / Ireland

- Prior to joining E.U.
 - pressure test was hydrostatic
 - Test every six years
 - Raise pressure to 1.25 MAWP of tank for 30 minutes
- Currently:
 - Same as E.U. protocol

In summary:

- There is considerable variation in tank structural integrity testing procedures.
- The most common protocol is hydrostatic testing.
- There is a general consensus that introducing water inside vessels that store LP Gas is undesirable.
- Australia and Mexico have successfully eliminated hydrostatic testing other than at conclusion of manufacturing (allowed, but not mandatory). Current protocols in these countries are under further investigation.
- Of the countries where hydrostatic testing is allowed, U.S. and Canada mandate the most vessel stressful protocols.

It has been noted by several members of the NPGA Technology & Standards Committee that no other country has a propane delivery infrastructure similar to the United States. In other countries, the use of large storage tanks serving one customer is unusual. Many countries have heavy use of cylinders, and the overall use of propane is much less than in the U.S. Hence, the number of cargo tanks in service in international countries is small compared to the U.S. regulations. Therefore, where more stringent inspections exist internationally, especially in countries where the bobtail truck population may be small, these inspection requirements are not necessarily applicable to the U.S.

Conclusions

Battelle's objectives for this phase of the overall requalification project were to determine the openness of DOT staff to an inspection period extension and to determine if there were more substantial (more stringent and documented) international requirements. Initial discussions with DOT-RSPA staff indicated that they are open to further discussions and were also generally agreeable to the Battelle approach of two-phase engineering analyses.

The international standards review revealed that the U.S. standard is comparable to the international standards. Some minor differences exist – for example, Japan tests at the design pressure rather than the U.S.'s 1.5 times design pressure and for only 30 seconds rather than the U.S. period of 10 minutes. However, with the relatively small number of bobtail-type tank trucks internationally, this lessens the significance of a more restrictive inspection protocol.

We have found no evidence of the origin of the U.S.'s existing five year inspection period, from either a technical basis or an industry-regulatory consensus. However, as the five year period is currently the law in the U.S., all analyses must show an equivalent level of safety with any extended inspection period.

We therefore recommend proceeding to the next phase of this project, where Battelle would develop an analytical model of the cargo tank and exercise the model with simplified thermodynamic loading. Battelle will prepare a proposal to the NPGA for this next phase of work.

APPENDIX A

**Notes from the DOT RSPA / NPGA / Battelle
Meeting**

**Washington, DC
September 27, 2004**

Meeting notes – Discussions of Cargo Tank Requalification Period Extension
 US DOT RSPA offices, Washington, DC, 27-September-2004

Name	Organization / Title
Ed Mazzullo	US DOT RSPA, Director, Office of Hazardous Materials Standards
Hatti Mitchell	US DOT RSPA, Chief Regulatory Review, Office of Hazardous Materials Standards
Sandra Webb	US DOT RSPA, Transportation Regulations Specialist, Office of Hazardous Materials Standards
Charley Hochman	US DOT RSPA, Director, Office of Hazardous Materials Technology
Stan Staniszewski,	US DOT RSPA, Chief Engineer, Office of Hazardous Materials Technology
Mike Caldarera	National Propane Gas Association, Director, Regulatory and Technical Services
Rod Osborne	Battelle, Project Manager
Brian Leis	Battelle, Senior Research Leader Structures/Materials/Failures Engineer

The National Propane Gas Association is approaching the US Department of Transportation, Research and Special Programs Administration with a request to consider extending the requalification period of propane cargo tanks. This period is currently specified in 49CFR180.407 as five years. Specifically, NPGA’s request addresses only cargo tanks (“bobtails”) of less than 3500 gallons, of non-quenched and tempered (NQT) materials, in dedicated propane service. Battelle is performing engineering analyses that will address NPGA’s request.

There was a consensus that no one present knew of the origin of the current five year requalification period. It was acknowledged that even though the origin is unknown, any analyses must address the relative safety of any change to that five year period.

DOT staff expressed some concerns and comments about a requalification extension and the analyses used for justifying that extension. Those concerns are listed below, including any responses of NPGA or Battelle.

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- The pressure test is a concrete test with concrete results. Because of complex geometries, it may be difficult for visual-only tests to verify tank integrity as well as pressure checks do.
- The five year period appears to have worked well for the propane cargo tanks, because of the excellent safety record.
 - Response → Any suggested changes to the period extension must exhibit the “equivalent safety”.

Battelle presented their approach to the analyses. These analyses will use well-accepted practices in considering the loads applied to a tank and the loads’ effects on crack growth. Battelle’s approach is a two phase approach, where Phase 1 develops the engineering model of the cargo tank and the thermodynamic loading exposed to the tank. The thermodynamic loads, that is, the pressure history of a tank caused by the temperature changes of the propane lading, are considered simpler to determine than the more severe dynamic road loads. Using the tank model, Battelle will first determine the maximum crack size that would go undetected in the standard pressure test, and then determine growth of this flaw for the assumed loading. Using this crack growth, Battelle will estimate the projected life of the tank, based on a through-the-wall crack. If the order-of-magnitude of this projected life is significantly longer than the current five year requalification period, then there may be merit in continuing the study to address the vehicle dynamic loading. Phase 2 will use the engineering model developed in Phase 1 to consider the tank stresses induced from the dynamics of lading–tank–truck–road interactions. Similar to Phase 1, Battelle will determine the maximum crack size, the projected life, and resultant safety factor on the inspection period. Battelle will review with the appropriate DOT staff the aspects of the analyses throughout both phases of work. The reviews will include model development, tank properties (geometry and construction materials and methods), loading histories, and other assumptions used in the analyses.

NPGA and Battelle expect that these analyses will commence May 2005. Charley Hochman agreed to be the RSPA point of contact for NPGA and Battelle.

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