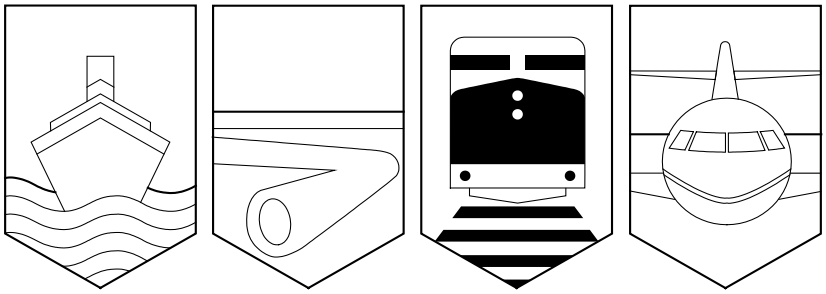
Transportation Safety Board
of Canada



RAILWAY OCCURRENCE REPORT

OXYGEN LEAK

CANADIAN NATIONAL
TANK CAR UTLX 80012
MILE 146.2, SAINT-LAURENT SUBDIVISION
MONTREAL, QUEBEC
15 JULY 1995

REPORT NUMBER R95D0114

Canada

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Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

Railway Occurrence Report

Oxygen Leak

Canadian National

Tank Car UTLX 80012

Mile 146.2, Saint-Laurent Subdivision

Montreal, Quebec

15 July 1995

Report Number R95D0114

Synopsis

At approximately 0800 eastern daylight time (EDT), on 15 July 1995, a Canadian National (CN) carman discovered that tank car UTLX 80012, containing a load of liquid oxygen, was leaking product on track MR-15 in Taschereau Yard, Montreal, Quebec. CN's Emergency Response Personnel (ERP) lowered the pressure in the tank car from 15 pounds per square inch gauge (psig) to 10 psig and then used water to thaw the ice outside and inside the valve to permit valve closure. The tank car was then released for transportation to its final destination.

The Board determined that a road valve was frozen in the open position causing a continuous venting of the product. The road valve was neither designed nor approved for cryogenic railway tank car service.

Ce rapport est également disponible en français.

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5.0 Appendices

1.0 Factual Information

1.1 Background Information

At approximately 0800, on 15 July 1995, a Canadian National (CN) carman discovered that tank car UTLX 80012, containing a load of liquid oxygen, was leaking product on track MR-15 in Taschereau Yard, Montreal, Quebec.

CN's Emergency Response Personnel (ERP) found that a pressure regulating valve was frozen with ice in the open position. This caused continuous venting of the product. ERP lowered the pressure in the tank car from 15 pounds per square inch gauge (psig) to 10 psig by opening the vapour valve and then used water to thaw the ice outside and inside the valve to permit valve closure. The tank car was then released for transportation to its final destination.

This was not the first reported occurrence involving tank car UTLX 80012 leaking product. Between 1993 and 1995, tank car UTLX 80012 was involved in six occurrences. It was found leaking from one of the pressure regulating valves, usually called a road valve, on 02 March 1993, 28 May 1994, 15 March 1995, 18 April 1995 and 09 June 1995. It was also found leaking from an oxygen trycock 1/2-inch outage valve on 09 March 1993. This small valve is located in the main control box and serves to establish proper outage.

Subsequent to the 15 July 1995 occurrence in Taschereau Yard, tank car UTLX 80012 was again found leaking from the road valve on 29 July 1995, shortly after which the valve was replaced.

On 26 September 1995, CN reported that tank car UTLX 80012 was leaking again from the road valves in Taschereau Yard in Montreal. Close examination of the car revealed that the car had recently vented from both road valves and from the pressure relief valve. All three valves had not reseated properly after opening. At that time, the pressure in the tank was only 12 psig and all three valves with settings of 15 psig, 17 psig and 35 psig, respectively, continued to release a stream of oxygen vapours. A check of the vacuum between the tank shells with the use of two different probes and two different measuring instruments determined that the vacuum had been lost.

[1] All times are eastern daylight time (Coordinated Universal Time (UTC) minus four hours) unless otherwise stated.

As a result of this finding, Transport Canada issued a directive to immediately return the tank car to the shipper for off-loading and then to send it to the owner for repairs. CN's ERP marked the car in accordance with regulations and arranged for swift movement back to the shipper for off-loading.

1.2 Equipment Damage

There was no equipment damage as a result of the valve freezing and the oxygen leaking.

1.3 Tank Car Information

Tank car UTLX 80012 was built by the Union Tank Car Co., Chicago, Illinois, U.S.A., in June 1961. The car was designed in accordance with the Association of American Railroads (AAR) specification AAR-204W. A design was approved by the AAR on 08 March 1962. A certificate of construction was issued on 28 March 1962, under application No. 15179. This car and four sister cars were built for use in liquid oxygen or liquid nitrogen service. Piping arrangement drawing No. 59870 from the Union Tank Car Co. shows that there is no liquid trap nor protective baffles in the upper part of the tank where the pipe leading to safety relief devices is located and connected to the vapour space of the tank. This can cause liquid product to enter the vapour line, if the tank is subject to impact, which can create an upsurge of liquid oxygen.

In 1985, Procor Limited, from Oakville, Ontario, which is the Canadian subsidiary of the Union Tank Car Co., submitted application C-858805-A to the AAR to modify the car by changing valving and piping in accordance with drawing No. SKD4899. This drawing was superseded on 20 November 1986 by drawing No. SKE4899. After modification, the car was used in captive service for liquid oxygen transport.

Both liquid oxygen and liquid nitrogen are commodities that only exist as liquids at very low temperatures (normally referred to as "cryogenic liquids"). These commodities must, therefore, be transported or contained in highly efficient, thermally insulated containers. In this respect, any tank car of the AAR-204W specification has an inner shell made of high alloy steel and an outer shell made of carbon steel. The space between the inner and outer shell is filled with pearlite or polymeric insulant. The function of this

insulant is to minimize the radiant heat transfer between the inner and outer shell. Further, the space between the inner and outer shell is evacuated to prevent conductive heat transfer to the lading. The certificate of construction for tank car UTLX 80012 does not contain any data on the thermal efficiency of the design. Thermal efficiency data are used to calculate the minimum flow rating of the safety relief valves.

1.4 AAR-204W Specification - Safety Relief Device Information

1.4.1 General

Specification AAR-204W is a part of the *Manual of Standards and Recommended Practices* published by the AAR. The Tank Car Committee of the AAR is the principal body for tank car specification development and maintenance. The Tank Car Committee consists of representatives of railways, shippers, and tank car builders. The U.S. Department of Transportation and Transport Canada have observer status on the Tank Car Committee. Until 1992, one seat at the Tank Car Committee was reserved for a representative of the Compressed Gas Association (CGA). At present, there is no CGA representation on the Tank Car Committee.

The CGA is an international industrial association dedicated to developing and promoting safety standards and safe practices in the industrial gas field. The former Cryogenic and Low Temperature Committee and Tank Car Committee of the CGA were recently combined into the Bulk Distribution and Equipment Standard Committee (BDESC). The members of this committee represent the best collective knowledge and industrial expertise in the cryogenic field in North America.

A tank car built to AAR-204W specification must be equipped with a number of prescribed safety relief devices. There must be a safety vent with a frangible disc assembly which would prevent the rupture of the tank because of over-pressurization. Specification AAR-204W requires that the minimum bursting pressure of the inner tank be 240 psig. The flow rating of the safety vent must be such that the pressure in the tank could not exceed 60 psig during all operating conditions. The most severe abnormal condition described in specification AAR-204W is when there is a loss of vacuum between the inner and outer shell combined with the tank being subjected to fire.

The tank must also be equipped with large flow capacity safety relief valving. The AAR-204W specification provides a choice, in this respect, of two different arrangements. In the first arrangement (the one-valve arrangement), one large flow capacity safety relief valve is prescribed. In the second arrangement (the two-valve arrangement), two large capacity safety relief valves are prescribed.

1.4.2 One-valve Arrangement

If the one-valve arrangement is selected, the large flow capacity safety relief valve is referred to as a safety relief valve. It must be designed and set in such a way that it will start a discharge when the internal tank pressure reaches 25 psig ± 3 psi. The flow rating of the safety relief valve (volume of gas per unit of the time) must be such that the pressure inside

the tank car would not exceed 35 psig in a situation where the vacuum insulation is lost and the outer shell of the tank car is at a temperature of 130 degrees Fahrenheit (projected maximum shipping condition).

This specification permits an additional valve, attached in parallel, usually of a small flow capacity and a lower-set discharge pressure. This second valve is usually called a road valve. The purpose of the road valve is to control the pressure in the tank in such a way that the main safety relief valve would not operate under normal conditions of transport. The start to discharge pressure of the road valve is usually set at 15 psig.

The operating principle of the road valve is as follows:

> Cryogenic liquids are loaded into tank cars at temperatures which are very close to the boiling point at atmospheric pressure. For oxygen and nitrogen, the boiling point at atmospheric pressure is respectively minus 182.96 degrees Celsius and minus 195.81 degrees Celsius. Immediately after loading, the pressure of the product in the tank car is slightly above 0 psig, provided the car was first flushed with a sufficient amount of product to cool the inside of the tank shell to a temperature close to the product's boiling point. After the car is loaded, the vapour pressure commences to increase because of the heat transfer from outside the tank car. After a certain time, the length of which depends on the quality of the insulation and the ambient temperature, the vapour pressure of the cryogenic liquid may reach the pressure setting of the road valve (e.g. 15 psig). At that pressure, the road valve opens and releases the vapours of the product. This creates a drop in the tank pressure which in turn causes the product inside the tank car to boil. As the product is boiling, the liquid portion of the product is cooled by supplying part of its heat content to provide for latent heat of evaporation -- the amount of heat needed to change a unit of liquid at boiling temperature into a unit of vapour at the same temperature. The cooler the liquid becomes, the lower the pressure inside the tank. When the tank pressure drops to 13 to 14 psig, the road valve

closes. The pressure inside the tank car then begins to rise again and the whole process is repeated.

1.4.3 The Two-valve Arrangement

The AAR-204W specification for the second safety valve arrangement contains a provision for two large flow capacity safety valves. One valve is described as a transport safety relief valve. The other is called a pressure relief valve. Both valves are located in a box on the low mid-right side of the tank. A safety interlock is installed between those two valves. The transport safety relief valve is identical in its performance to the safety relief valve described in the one-valve arrangement.

The other valve of the second arrangement is described as a pressure relief valve. This valve must be set to start to discharge at a pressure no higher than 35 psig ± 3 psi. The discharge capacity of this valve must be sufficient to limit the pressure within the inner shell to a maximum of 45 psig in a situation where the vacuum insulation is lost and the temperature of the outer shell is at 130 degrees Fahrenheit.

The pressure relief valve is intended to shorten the time of loading or off-loading the car by allowing higher pressure in the tank. When the lading of the tank is being transferred, the safety interlock could be set in a position where the transport safety relief valve (25 psig) is rendered inoperative by eliminating the flow path from the tank. However, the design of the interlock must be such that the flow path from the tank to the transport safety relief valve must be unrestricted at all times when the tank car is being transported.

The two-valve arrangement prescribed by the specification does not provide for the addition of a road valve.

1.4.4 Valving Arrangement on Tank Car UTLX 80012

At the time of the last recorded modification (1985) to tank car UTLX 80012, it contained the following safety relief devices:

- a Crosby 40A pressure relief valve - set at 35 psig;
- a Lunkenheimer 1227 transport safety relief valve - set at 25 psig;
- a Lunkenheimer 1227 road valve - set at 15 psig; and
- a two-inch safety vent with BS&B rupture disc assembly with aluminum disc - set to rupture at 45 psig.

When tank car UTLX 80012 was checked on 25 July 1995, it was found to contain the following safety devices:

- a Crosby 41A pressure relief valve - set at 35 psig;

- a Crosby 40A two-inch by two and one-half inch transport safety relief valve - set at 25 psig;

- a Consolidated 1975S one-inch road valve - set at 15 psig; and

- the safety vent and rupture disc assembly was not identified as the metal tab with prescribed data was missing.

On 17 August 1995, the valving on tank car UTLX 80012 was verified again. It was found that the road valve had been removed and replaced by two CASH-ACME FRM-2 valves of one-half-inch size, serial Nos. 10673TK and 10673RF. One valve was set to discharge at 15 psig, the other, at 17 psig. The valves appeared to be identical. One of them bore the mark "for cryogenic service."

The leaking valve had a relief capacity of 33 standard cubic feet/minute. It had last been inspected and tested on 01 November 1994 and the valve had been cleared for oxygen service by a company approved by the car owner. An identification tag had been attached and sealed.

1.4.5 Current Specifications for Tank Cars in Cryogenic Service

At present, there are no tank car specifications, similar to AAR-204W, in the Canadian General Standards Board standard CAN/CGSB-43.147-94 or in the previous standard 43-GP-147. It is, however, industrial practice in North America to follow the requirements of *Specifications for Tank Cars - Specification M-1002* of the AAR which contains the AAR-204W specification. Appendix A of that standard prescribes the requirements for tank car valves and fittings. The scope, approvals and service trials are prescribed in detail and are attached as Appendix A.

As mentioned above, the application, service trials, and final test and inspection reports are prescribed by standard, and all pertinent data must be presented on AAR forms 4-3, 4-4 and 4-6.

1.5 The Leaking Road Valve on car UTLX 80012

The Consolidated 1975S road valve is no longer produced. A review of the drawing of the valve shows that, when it is in the open

position, the flow of the gas is limited by the size of the openings in the cylindrical guide attached to the body of the valve nozzle. The catalogue describing the valve does not mention any approval or recommendation for use in cryogenic service.

The shipper and the consignee were unable to provide any proof of AAR certification of the Consolidated 1975S road valve for cryogenic service. The owner of the car was not aware that the valve was installed on his car. The regulatory bodies, Transport Canada and the U.S. Department of Transportation, do not keep an index or registry of valves approved for tank cars. The AAR keeps copies of the approvals of the valves issued after 1980; however, none of the valves on tank car UTLX 80012 seem to be registered as "approved" by the AAR because they were made before 1980.

Discussions with two technical experts in the field of pressure relief valves revealed that they would not recommend the Consolidated 1975S model of valve for cryogenic service in railway tank car service because of the possibility of valve freezing. The manufacturer of the valve indicated that, although the material of the valve would withstand the cryogenic service temperature, the small flow capacity may cause freezing. The manufacturer further indicated that they do not have the AAR approval for cryogenic tank car service nor did they apply for one as the valve was not intended to be used on rail tank cars.

1.6 Cryogenic Commodities

1.6.1 Cryogenic Liquids other than Oxygen

With the exception of oxygen, cryogenic liquids made of atmospheric gases are considered high hazard materials. Isolation of the leak area is considered mandatory in the case of small leaks. In instances of large spills, or situations where the transportation vehicle is on fire, an evacuation (500 metres in all directions) is recommended.

1.6.2 Liquid Oxygen

In addition to the dangers typical for other cryogenic liquids, oxygen presents a danger of reactivity. It may ignite combustible materials and/or cause an explosion on contact with common materials such as asphalt, coal, wood, or paper. For that reason, the recommended distances for isolation and evacuation are larger than for other atmospheric cryogenic liquids.

1.7 Miscellaneous Information

After the tank car of liquid oxygen is loaded at the shipper's plant, it may take up to four days before the rail carrier picks it up. In this particular occurrence, however, UTLX 80012 was delivered for loading, loaded and accepted for transportation all in one day. The tank car was found leaking from a frozen road valve the next day.

After the 18 April 1995 occurrence, the shipper and consignee discovered that the vacuum on the tank car was less than desirable. Shortly after, the space between the inner and outer shell was evacuated again, to what was considered an adequate level.

The *Rail Road Tank Car Pre Trip Inspection Report* form which is filled by employees of the shipper does not contain an entry on pressure or temperature in the tank car after loading. For that reason, it was not possible to estimate the thermal efficiency of the tank car insulation.

The owner of the tank car was not aware of the previous occurrences involving tank car UTLX 80012, nor was he aware that the original road valve had been replaced by a different model.

2.0 Analysis

2.1 Introduction

The leakage of oxygen - at face value - would appear to be a release of a harmless, life-giving gas into the atmosphere. In reality, it creates a serious problem for the rail carrier as a leaking tank car must be isolated and handled by specially trained personnel. The analysis will explore the reasons for the leak of product and discuss issues relative to the regulatory process and industrial input into standards.

2.2 The Leak

The leak of the product from tank car UTLX 80012 was caused by the road valve being frozen in the open position. The valve did not have sufficient flow capacity to vent the continuously releasing oxygen gas without freezing.

Tank car UTLX 80012 does not have a liquid trap or protective baffles in the upper vapour portion of the tank. This may cause liquid oxygen to enter piping which leads to the safety relief devices. Impact at the time of coupling of the car would cause a wave of liquid oxygen to move through the tank. Any such liquid entering the vapour line may cause damage to the valves or may freeze the valve in the open position. The design of the tank may have therefore caused or contributed to freezing the valve in the open position.

2.3 Regulation and Oversight

At the time of the occurrences, the tank car did not comply with the requirements of specification AAR-204W for safety relief devices. Had the car been in compliance with such requirements, i.e., without a road valve, the leak of oxygen would not have occurred.

However, if the same car had been equipped with a pressure relief valve, the road valve would have been permissible and the leak could have happened despite the fact that the car would have had safety relief devices installed in full compliance with specification AAR-204W.

This seemingly incongruous statement points out the current inconsistency in specification AAR-204W. At present, the specification permits the road valve under arrangements in subsection 200-20(b) but does not authorize the road valve under arrangements in subsection 200-20(c).

The concept of a road valve with a relief setting lower than the other safety relief devices is a matter for contemplation. Considering the characteristics of cryogenic products, it seems reasonable to permit occasional venting of any atmospheric gases transported, provided that it starts well after loading and each venting cycle is of a limited duration.

Specification AAR-204W is in the hands of the Tank Car Committee of the AAR. The Tank Car Committee representation does not include specialists in the transportation of cryogenic liquids. However, members of the CGA (particularly members of the CGA BDESC) possess the best collective North American knowledge and experience in the transportation of cryogenic liquids. It would therefore stand to reason that permanent liaison between the AAR and the CGA would lead to increased transportation safety in this area.

Periodic upgrading of the specifications, the exchange of information on safety issues, and the introduction of new developments in industrial practices were provided in the past by the CGA representative on the AAR Tank Car Committee. Although the CGA does not now have such representation, it would be reasonable to suggest that the CGA propose changes in the AAR-204W specification to the Tank Car Committee. It also would seem reasonable to suggest that close cooperation between the two prominent, safety-oriented associations would have long-term benefits.

The valve which froze in the open position, thus causing this occurrence, was of a type approved by the American Society of Mechanical Engineers. However, the valve was not intended for rail tank car service. For that reason, the manufacturer never applied for AAR approval.

The current procedure for approval by the AAR for safety relief devices is rather impressive. Considering the detailed technical information which has to be submitted, the service trial which must be successfully performed, and the identification requirements for each valve, it appears that the procedure and system are close to being fool-proof. However, in this case, the system failed.

At one point in time, someone decided that the road valve needed to be changed. The change was made and the fact that the valve

was not of any approved type went unnoticed. When the first problems with the substituted valve occurred, the owner of the tank car was not notified and was therefore unaware that the valve on the tank car was changed. Even if the owner had been notified, it would not have been easy for him to find the approval status of the replaced valve because there is no central registry of approved valves for tank cars pre-dating 1980.

Considering that most manufacturers of the valves keep the approvals received for their products indefinitely, and that most of the valve manufacturers are members of the CGA, it would seem reasonable to suggest that, through cooperation between the AAR and the CGA, the AAR-approved valves registry could be extended to the indefinite past. The experience of the valve users, most of them also CGA members, would be of an additional benefit in enlarging the current AAR registry and knowledge of performance of different valves.

The facts of the last incident (26 September 1995) involving tank car UTLX 80012 revealed that the car, as a result of lost vacuum, vented not only from the road valves but also from the main pressure relief valve which is set at 35 psig. At the same time, the transport safety relief valve, with pressure setting of 25 psig, remained closed. This then leads to the conclusion that the pressure relief valve blew open while the car was still at the shipper's plant. At that point, the safety interlock would have been in such a position that the transport safety relief valve (with 25 psig setting) would have been rendered inoperative. After the initial venting, the pressure relief valve did not reseat properly and the car was released for transport while leaking.

3.0 Conclusions

3.1 Findings

1. Tank car UTLX 80012 leaked oxygen on 15 July 1995 when a road valve froze in the open position.

2. The road valve was not designed or approved for use on railway tank cars in cryogenic service.

3. The use of a road valve was not permissible on a tank car with a two-valve arrangement installed on UTLX 80012 although the use of a road valve is approved for the one-valve arrangement.

4. The car owner was unaware that the valves on the car had been changed since the car was modified and put into captive oxygen service in 1985.

5. The continuing problems with the leaking valve were not reported to the owner of the car.

6. Occasional pressure venting of oxygen into the atmosphere is not considered a safety hazard.

7. Increased cooperation between industrial partners and industrial associations would improve the overall level of safety in the transportation of cryogenic liquids.

3.2 Cause

A road valve was frozen in the open position causing a continuous venting of the product. The road valve was neither designed nor approved for cryogenic railway tank car service.

4.0 Safety Action

4.1 Action Taken

4.1.1 Regulatory Matters

Transport Canada (TC) has proposed amendments to the Canadian General Standards Board standard CAN/CGSB-43.147-94 to clarify the standard and its link to both the Transportation of Dangerous Goods Regulations and the Association of American Railroads' (AAR) Specifications for Tank Cars, Specification M-1002. TC has also developed a facility to test the performance characteristics of pressure relief valves.

In addition, work is in progress to upgrade the AAR Manual with respect to the formula used to perform flow calculations for relief valves.

4.1.2 Air Liquide Canada Ltée

As a result of this occurrence, Air Liquide Canada Ltée (ALC) identified deficiencies in the implementation of its inspection and preventative maintenance procedures for tank cars transporting cryogenic liquids. ALC will take the appropriate measures to correct these deficiencies.

Furthermore, ALC believes that a representative of the Compressed Gas Association (CGA) on the AAR Tank Car Committee might improve the safety of the transportation of cryogenic liquids. ALC intends to raise this issue at the CGA transport committee.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, Benoît Bouchard, and members Maurice Harquail and W.A. Tadros, authorized the release of this report on 14 August 1996.

Appendix A - AAR Requirements for Tank Car Valves and Fittings

From Appendix A of the AAR *Manual of Standards and Recommended Practices*

A1.01 SCOPE

Appendix A describes AAR requirements for design, testing, materials and marking of tank car valves and fittings:

1. Safety relief devices, including the determination of relieving capacity requirements.

2. Liquid and vapor valves, including bottom loading and unloading valves.

3. Vacuum relief valves.

4. Liquid level control and gaging devices.

5. Temperature sensing equipment and thermowells.

6. Bottom washouts.

7. Accessories and special appurtenances related to handling the lading.

A1.02 APPROVALS

Tank car valves and fittings must be approved by the Tank Car Committee.

(a) For safety relief device approval procedures, see 1.4.1.9 and 1.4.3.2 requiring submittal of Form AAR 4-3, Application For Approval of Safety Relief Device.

(b) For other valves and fittings approval procedures, see 1.4.1.10 and 1.4.3.5 requiring submittal of Form AAR 4-5, Application For Approval of Valves and Fittings.

(c) Devices that may not require submission to the Tank Car Committee are:

(1) External changes to previously approved devices.

(2) Changes in materials that do not affect the operation of the devices.

(3) Changes in materials that are compatible with the intended commodity service.

(4) Designs previously approved but of smaller sizes or lower pressure ratings.

A1.03 SERVICE TRIALS

a) All new devices within the scope of this Appendix are subject to service trials before they are given Committee approval, except as provided in A1.02(c). Service trials, when authorized by the Tank Car Committee, must be reported semiannually in accord with the procedure outlined in 1.4.3.3 on Form AAR 4-4.

b) The guidelines for acceptance of valves and fittings by the Tank Car Committee as a result of service trials are:

(1) For non-regulated commodities, each carset of the device must be subjected to a trial of one year minimum duration covering an average of 5000 loaded miles or an average of ten loaded trips or load/unload cycles.

For regulated commodities, each carset of the device must be subjected to a trial of two years minimum duration covering an average of 10000 loaded miles or an average of twenty loaded trips or load/unload cycles. Completion of one year, 5000 loaded miles and ten load cycles in regulated commodity service may be used to qualify the device for non-regulated service.

(2) Difficulties experienced during the service trial, i.e. leakage, breakage or performance, must be reported on Form AAR 4-4 together with a statement of design revisions to improve operation or to correct the defect, for review by the Tank Car Committee.

(3) The service trial must also include a Final Product Testing and Inspection Report Form AAR 4-6 to be submitted to the Tank Car Committee at the conclusion of the specified service trial.

(4) The Tank Car Committee may request additional tests to supplement manufacturer's tests or service trials prior to acceptance of device.

(5) Approval of a device for a commodity or commodity type does not provide for blanket approval of the device. Additional data must be submitted to confirm that the device is compatible with other commodities, including consideration of corrosion or stress corrosion cracking where appropriate. Commodity types are:

Compressed gases

Corrosives

Solids requiring heat to liquefy

Free flowing liquids (general service)

Products with special temperature requirements

(6) Sample size and number of units to be subject to post-trial teardown are as follows:

Device	Minimum Sample Size	Minimu to F Te
Safety valve or bottom outlet valve	25	
Top valve or excess flow valve	15	
Sample line valve, gaging device or vacuum relief device	10	
Thermometer well or auxiliary fitting	5	