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Working Party on the Transport of Dangerous Goods
(Geneva, 13-17 October 2003)

CARRIAGE OF LIQUEFIED GASES IN TANKS WITH RECESSED VALVE CHEST

Transmitted by the Government of the United Kingdom */

SUMMARY

Executive Summary: The intention of this proposal is to permit the use of tanks with connections below the liquid level recessed into the shell and protected by a valve chest for the carriage of UN 1017 chlorine and UN 1079 sulphur dioxide.

Action to be taken: Add a new TE special provision to 6.8.4(b) and against UN 1017 chlorine and UN 1079 sulphur dioxide in Table A in 3.2.

Related Documents: TRANS/WP.15/AC.1/2001/46 (United Kingdom)
TRANS/WP.15/AC.1/86, paragraph 72.

Introduction

At the September 2001 session of the Joint Meeting, the Tanks Working Group considered a proposal from the United Kingdom in TRANS/WP.15/AC.1/2001/46.

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This proposal intended to permit the use of tanks with connections below the level of the liquid for the carriage of UN 1017 chlorine and UN 1079 sulphur dioxide. The Working Group agreed that there were considerable safety advantages for this proposal but overall there were questions over some of the details of the arrangement. These included the types of valves to be used, the internal piping arrangements and the methods of sealing. Therefore, although the group supported the principle, it was unable to recommend adoption of the paper. The United Kingdom withdrew its proposal with a view to submitting a revised version to a later session.

This document expands on the original proposal to provide the meeting with significantly more detail as was requested by the Tanks Working Group.

Background

Tank Code "D" in the third part of the tank code for gases in 4.3.3.1.1 of RID/ADR specifies that tanks used for the carriage of UN 1017 chlorine and UN 1079 sulphur dioxide must have all connections above the liquid level. This proposal requests that the text be modified to allow the carriage of these substances in tanks with connections which are always below the liquid level and are mounted inside a valve chest.

In certain countries both these products have been carried in considerable quantities in road tankers which have an enclosed valve chest located inside the dished end of the tank. The filling and discharge connections are located inside the valve chest and are protected during transit by steel doors. The valves are mounted so that they do not project outside the contour of the shell and they are therefore highly protected from impact.

Such road tankers have been used in the United Kingdom for over thirty-five years without any incidents occurring. Tankers of a similar design have also been used in South Africa and Australia for a long period of time, again with a good safety record. Although the RID and ADR Framework Directives allow tanks that meet national regulations to continue to be used for domestic transport, the construction of new tanks of such a design will be prohibited under the present terms of RID and ADR. This would be regrettable as they have a proven safety record and it is believed that their continued use is safe and appropriate.

The normal alternative to "top filling" is "bottom filling", where there is an outlet from the bottom of the tank, usually with a pipe which runs to a convenient discharge point at the back. This is *not* proposed, as it would be most inappropriate for such substances as chlorine and sulphur dioxide.

The Eurochlor publication *Protection of road tankers for the carriage of chlorine* (1) recommends two alternatives for the protection of chlorine filling/discharge valves from damage during carriage, one of which is as follows:

"Valve protection is provided by a valve chest whereby the valves are recessed inside the tanker barrel. This is ideally located at the front, behind the cab unit. The valve chest should be covered by a suitable substantial access door, which can be secured closed during transport."

Proposal

Add a new Special Provision TExx to 6.8.4(b) and in column 13 of Table A in 3.2 against the entries for 1017 Chlorine and 1079 Sulphur Dioxide, as follows:

"TExx Shells of tanks may have filling or discharge openings below the surface level of the liquid, provided the valves are recessed inside the contours of the shell protected by a valve chest. This valve chest shall be protected by doors affording protection against external damage at least equivalent to that afforded by the shell. The doors shall be capable of being securely closed during carriage."

Justification

Tank vehicles

The advantages of such a change are as follows:

1. Tank vehicles involved in serious accidents often do not remain upright. This results in any top-mounted valves being below the liquid surface and highly exposed to impact. The tank vehicle may roll upside down, in which case the top-mounted valves and dome could be subject to the full weight, impact and sliding loads. An end-mounted valve chest system is never exposed in this way.
2. Following a serious accident in which a vehicle rolls over, it may be desirable to empty the contents safely before it is moved. There is a significant probability that top-mounted valves would be inaccessible whereas those in the proposed valve chest are more likely to be accessible.
3. A valve mounted inside a valve chest that is welded inside the dished end has far more protection from impact than a valve mounted on top of the tank, outside the tank shell surface and in an external dome. The position - recessed within the bounds of the shell - and external protection provide protection against rear impact.
4. Access is at a lower level and allows a safer working environment for connection and testing of hoses.
5. Neither of the substances in question are difficult to seal. Extensive experience of performance in both carriage and static operations show that proper sealing is easily achievable. There is no case for the prohibition of joints below the liquid level on those grounds.
6. The proposal is highly specific about the design that may be used and continues to prohibit bottom outlets, thus avoiding the risks associated with these.
7. There is an exemplary safety record in several countries regarding the use of such a valve chest arrangement. The design of the shell to accommodate the valve recess is taken into account within national and international pressure vessel design codes.

Further details together with diagrams and photographs are provided in the attached briefing document (see annex to this document).

Tank wagons and tank-containers

When this proposal was initially submitted to WP.15 for road tankers, several delegates considered it was an issue more appropriate for consideration by the Joint Meeting.

Similar arguments would apply in the case of tank wagons and tank-containers and the principles are the same.

Although it would not be appropriate to locate the valve chest arrangement in the dished ends for tank wagons, the text proposed for TExx would allow valve chests in the sides as well as the ends of a tank.

Indeed a valve chest arrangement has been used on tank wagons carrying liquefied petroleum gases in Great Britain, and on tank-containers (with both types of design of the valve chest in the end and the side) generally carrying non-toxic gases for many years with very good safety records.

Reference

1. Eurochlor, *Protection of road tankers for the carriage of chlorine*, GEST 96/221, 1st edition, May 1998.
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Annex

CARRIAGE OF LIQUEFIED GASES IN TANKS WITH RECESSED VALVE CHEST

BRIEFING DOCUMENT

Tanker Design

The design of these liquefied gas road tankers is extremely robust, in line with Euro Chlor Recommendations. See drawing in Appendix 1 and photograph in Appendix 2. They have been designed with substantial external protection. During the design development, assessment was also made of the best way to protect the valves.

The most significant risk associated with a valve can be considered as two parts:

(a) Leakage through the valve

It was recognized that a valve can only leak the fluid present on the containment side of the valve. The fluid present at the containment side is entirely dependent on what is in the pipe connected to that valve and consequently where the other end of the pipe feeds from. This is totally independent of the location of the valves. In every tanker, the gas connection must always be routed to a high point in the tanker and the liquid connection must be routed to the lowest point (see Appendix 5). There can be no difference between any possible tanker design in this respect and this is therefore common to all tankers. Hence the consequence of leakage through the valve is exactly the same for all tanker designs. The risk is minimised by use of multiple valves and additional sealing caps during transport. See Appendix 4.

(b) External damage to the valves

External damage could (and has, see Appendix 8) resulted in significant uncontrollable loss of the contents of the tanker. It was therefore seen as critical that the valves were given the maximum protection possible. To do this, the valves needed to be protected by positioning them within the envelope of the barrel, which in turn necessitates housing them in a valve chest. This would prevent them being damaged in any accident. The valve chest cannot be mounted in the top of the barrel as it would then collect water leading to corrosion and consequently loss of containment. However, positioning the valve chest inside the end of the tanker (front or back) enables the valve chest to be self-draining. This places the valve connections under the surface of the liquid, however sealing a liquid chlorine or sulphur dioxide joint is not difficult and very well known to the industry. The valves are located inside a valve chest inside the end of the tanker. See Appendix 4. This concept has been used for over 35 years with no failures or consequent problems of any kind.

The design is recognized as acceptable by Euro Chlor, the European industry body for chlorine, as an acceptable design. See Appendix 9 for the relevant extract from GEST 96/221 'Protection of Road Tankers for the Carriage of Chlorine', Section 3.6 Valve Protection, Subsection (a).

Valve Types and Connections

Filling and emptying road tankers requires two hoses or pipes to be connected to the tanker. This is the same for any tank.

- **Liquid connection** – used for the transfer of the liquid product into and out of the barrel. This is connected to an internal pipe that is routed to the lowest point at the rear of the tanker.
- **Gas connection** - used to allow gas to be removed / displaced during filling of the tank and used to apply pressurized gas (typically dry air) to drive out the liquid product during discharge of the tank. These internal pipes are shown in Appendix 1 as dashed (hidden detail) and in Appendix 5 diagrammatically. Each internal pipe also has an excess flow valve so that in the most unlikely event of a complete failure of all valves and end covers, the release would be stemmed to extremely low levels.

The connections are mounted inside a recess (the valve chest) inside the dished end of the road tanker. See Appendix 4. The valve chest has substantial external doors that are closed when not filling or emptying the tanker. Hence the valves are protected from external impact both intrinsically by their position within the shell and by substantial protective covers. See Appendix 3.

Tankers using this principle of protecting the valve have been in use for at least 35 years and there has never been any release of chlorine from a tanker. Conversely during this time there have been incidents involving tankers with top connections that have, following roll over of the tanker, exposed the valves to severe danger, including one chlorine road tanker incident that resulted in significant release of liquid chlorine. See Appendix 8.

When filled, there is very little gas space (ullage) in the barrel and consequently the valve chests are under the level of the surface of the carried liquid.

There are six valves on each tanker, three on each connecting line. See Appendix 4. Each connection has:

- An air opened, spring closed, valve assembly comprising the internal and external valves. See Appendix 6. They are the first isolation against product leaks to atmosphere. Each internal and external valve assembly comprises two separate valves. These combination valves are manufactured by Ermeto or Phoenix in accordance with the Euro Chlor design for tanker valves. It can be seen in the diagram in Appendix 6 that the valve is connected to the vessel using a trapped joint, which is a well-proven design for sealing liquefied gasses. Each internal and external valve assembly comprises:

- A conventional air operated globe angle-valve, which is mounted on top of...
- An internal safety valve, which can only be opened by opening the external valve, and consequently would seal even if the outer valve were broken off.

- A second manually operated valve. See Appendix 7. It is mounted directly to the outlet flange of the external valve. The manual valves are manufactured by Shaw and are also a standard Euro Chlor approved design.

The free end of each connecting pipe is further fully closed during transport by a substantial cover, which provides a fourth seal on each line.

Hence, each connecting port is sealed by 3 valve seats and 1 sealing cover. The potential for leakage past the three valves and the final closing cover is believed negligible. Actual experience of performance agrees with this. Furthermore this design, by inclusion of the additional manual valve, which is not present in the design typically adopted for valves mounted on top of a tanker, presents a lower risk of loss of containment.

Safety Implications

All UK chlorine distribution is by road tankers. This tanker design has been used for carrying bulk chlorine and sulphur dioxide in the UK for over thirty-five years. There have been occasional road traffic accidents but the integrity of the containment of product has never been threatened. Ineos Chlor is the largest carrier of bulk liquid chlorine by road in Europe and one of the largest (if not the largest) in the World.

The most likely incident that would give rise to escape of product is believed to be one which results in a tanker rolling over. Incidents where the tanker remains upright are unlikely to result in failure of the containment system. Positioning the valves above the liquid surface forces the valves to be mounted on top of the tanker, where they are exposed to external impact. This exposure is recognized and the valves are surrounded by a steel skirt and lid. Furthermore unless a tanker remains upright, any valves originally above the liquid surface will be below the liquid surface. See Appendix 8 where it can be seen by the frosting on the shell that the contents have leaked to the half depth of the tanker.

There have been several incidents in the UK where vehicles have attempted to pass under bridges that are too low. Whilst the publicised cases have been of double-decker buses in which the top deck has been severed, the possibility of a similar fate affecting a chlorine tanker diverted from its normal route exists. Where the valves are contained inside a valve chest, there is no possibility of them being severed in such an incident.

If the valves and end cap fail to seal, their location is irrelevant. The vapour pressure would force the product through the dip pipe to atmosphere. Failure of the valves and cap to seal would result in a chemical leak no matter where the valve is located.

Flange connections have been used on chlorine and sulphur dioxide manufacturing plants for over a century. Creating a proper seal on such flanges is straightforward, common practice and extremely reliable. Plant flanges are used on a wide range of temperatures, pressures, cycling duties and vibrating duties. Providing a reliable seal on a tanker is, therefore, not seen as difficult. Far more taxing duties have been successfully sealed for decades. Hence this should not be a reason to ban flanges below the liquid surface. Furthermore, the tanker would not remain upright in a significant incident and therefore the top mounted flange would also be below the liquid surface at the exact time that the valves are most at risk.

This UK design was chosen because the assessment was (and remains) that this is the safest arrangement for road tankers. It is believed that the chief risk to the containment integrity of the tanker valves was impact damage to them in an incident where the tanker rolls over. This was therefore the chief design consideration in their location and consequently the valves were positioned inside a valve chest. The valve chest is sunk into the barrel and thereby removes the valves from exposure to impact should the tanker roll over.

If a tanker is damaged in a serious incident, it may be prudent to empty the tanker before moving it. Transfer of product from a tanker requires access to its valves to connect to and to operate them. It is far more likely that there will be suitable access to the valves if they are mounted in a valve chest at the end of the tanker barrel. There have been instances (with different products) where it has been necessary to roll a tanker from an inverted position onto its side before the valves could be accessed; this involves a risk that can be avoided if the valves are located in the end of the tanker.

It is most important to recognize that the valve position and arrangement used by this design is completely different to bottom outlet arrangements. It is fully accepted that normal bottom outlet tankers are not appropriate for chlorine or sulphur dioxide because of the vulnerability to external impact and the potential for nitrogen trichloride concentration. It is often considered that any valve connection that is not above the liquid surface of a tanker must therefore be at the bottom. This is not the case for these tankers, in which the valves are located in the end and not at the bottom or the top of the tanker.

Cost Implications

When the ADR is incorporated into UK law, any new tankers would have to be designed to the new standard. It would not be desirable to operate with a fleet with differing connection points and consequently there would have to be major investment to change the fleet.

As well as converting the tankers, the loading bays would have to be converted so that they could fill the new tanker design. During the transition the loading bays would have to fill both types of tanker.

All customer off-loading installations would have to be converted in the same way.

There would be clear cost implications in the changeover. There would be no increase in safety as a result of this change. Conversely, there would be a reduction in safety as a result of the change and investment.

Justification

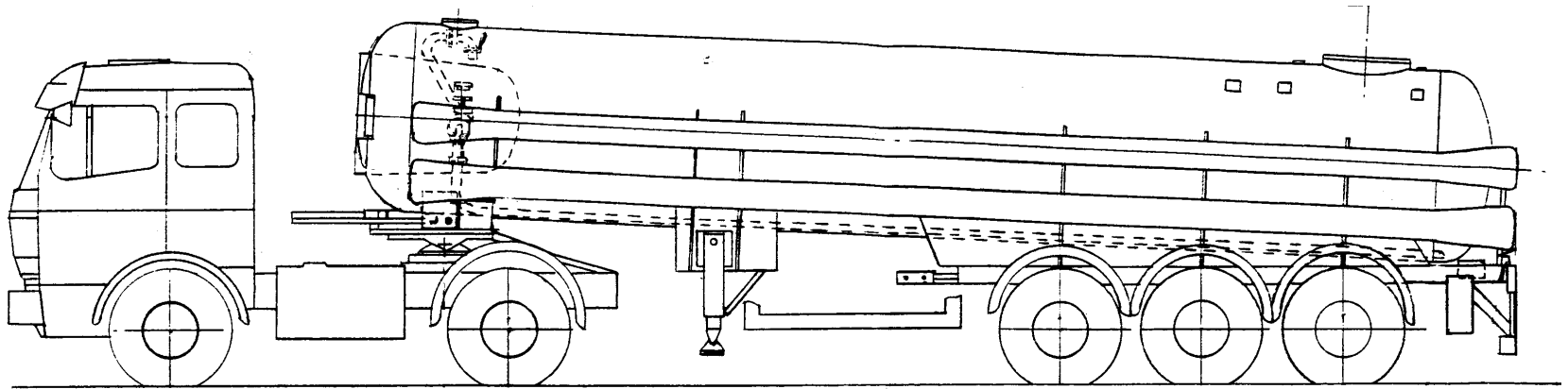
The advantages would be as follows

1. A valve mounted inside a valve chest that is welded inside the dished end has far more protection from impact than a valve mounted on top of the tank, outside the tank shell surface and in an external dome. In a serious accident where the tanker is sliding along the ground, any projection outside the torpedo shape of the tanker barrel is at risk of hitting external fixed solid objects and being damaged or broken off. See Appendix 8. External fixed solid objects cannot similarly swipe off items that are located inside the bounds of the torpedo shaped tanker barrel.
2. If a tanker with the valves located on top of the barrel is upside down during or after an incident, the dome / valve arrangement would be subjected to substantial weight and inertial forces. For this design of tanker with a valve chest, the valves would be fully protected.
3. Road tank-vehicles involved in serious accidents do not usually remain upright and this results in any top mounted valves being below the liquid surface. Hence, when the valve system is most exposed to damage risk, top mounted valves are no longer above the surface of the liquid. In this respect, following a significant incident there is absolutely no difference between the two arrangements; in both cases the valves are both below the liquid surface. See Appendix. 8
4. Following a serious incident in which a tanker rolls onto its side or upside down, it is likely to be desirable to empty the tanker before it is moved or rolled back upright. This is done by transferring the contents to another tanker or absorption system. If the tanker has valve connections on the top of the barrel (underneath a dome), there is a significant likelihood that the valves will be inaccessible. Valves mounted in a valve chest at the end of the tanker will be immediately accessible and undamaged (hence operable).
5. Access is at a lower level and allows a safer working environment for connection and testing of hoses. Slips and falls are a significant cause of injury to personnel involved with the delivery and transfer of product. Where the connections are located at the top of a tanker, any fall generally results in a serious injury. Where the access is at a lower level, any fall generally results in a minor injury. Whilst endeavours are made to minimize the risk of falls from any tanker, they do occur and it is therefore appropriate to do all that is possible to minimize the injury from any fall.
6. Chlorine and Sulphur Dioxide are not difficult to seal. Extensive experience of performance in both transport and static applications show that proper sealing is easily achievable. There is no case for prohibition of joints below the liquid level on these grounds.

7. Historically tankers have been regarded as either having discharge points at the top or the bottom. Any tanker not fitted with connections at the top has been considered as having the connections at the bottom. The design used in the UK is different to both of these arrangements and when all aspects are taken into consideration, it is believed to be the safest arrangement for chlorine and sulphur dioxide.
 8. The valve chest arrangement has been used for decades and has an exemplary safety record. The volume of chlorine transported by road in the UK is a very high proportion of all European chlorine road transport; consequently the good experience is statistically valid. Conversely top mounted valves do not have this exemplary safety record.
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APPENDIX 1

Chlorine Tanker Design



APPENDIX 2

Chlorine Tanker Photograph



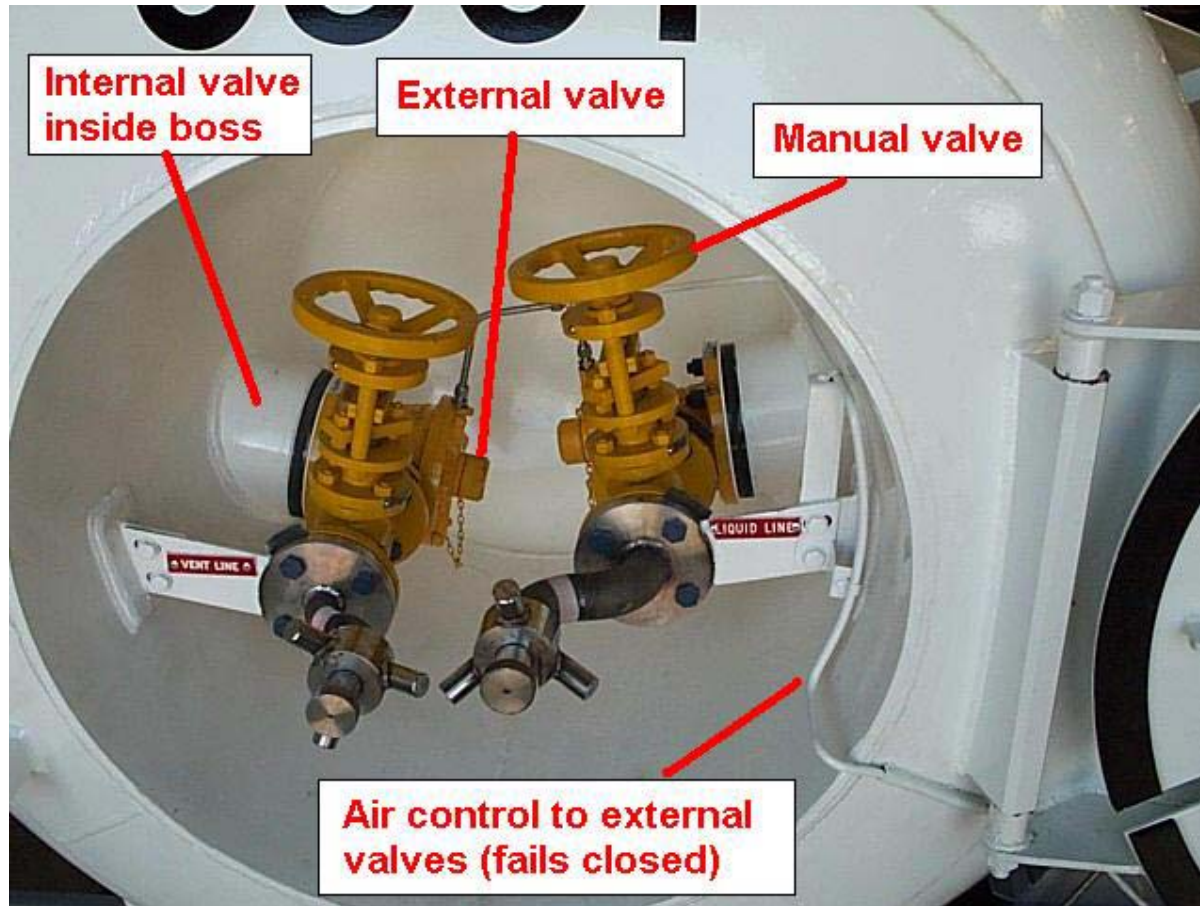
APPENDIX 3

Valve Chest Doors on Tanker



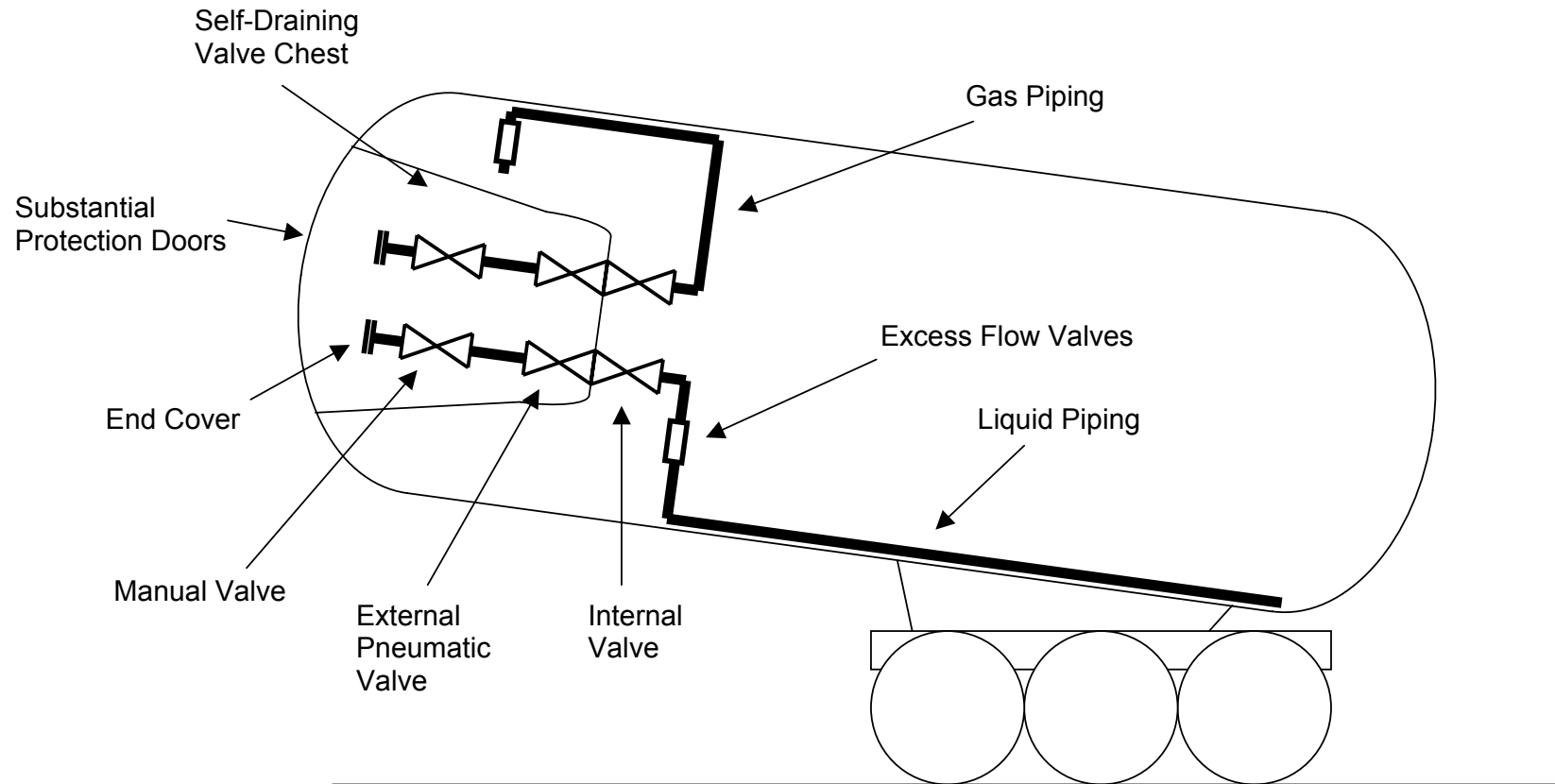
APPENDIX 4

Valves inside Valve Chest



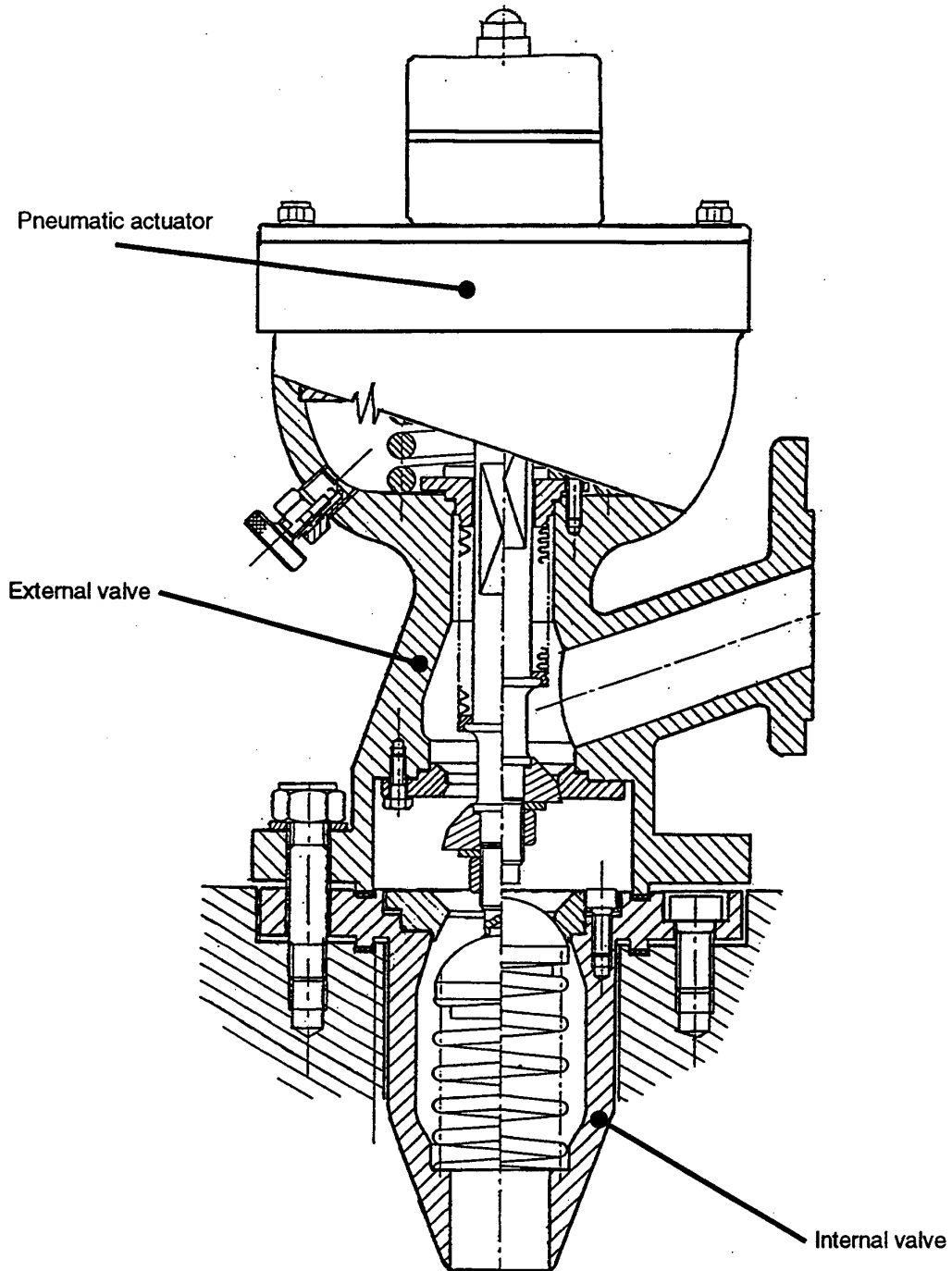
APPENDIX 5

Diagram of Tanker Barrel Valves and Internal Piping – this is not to scale and diagrammatic only



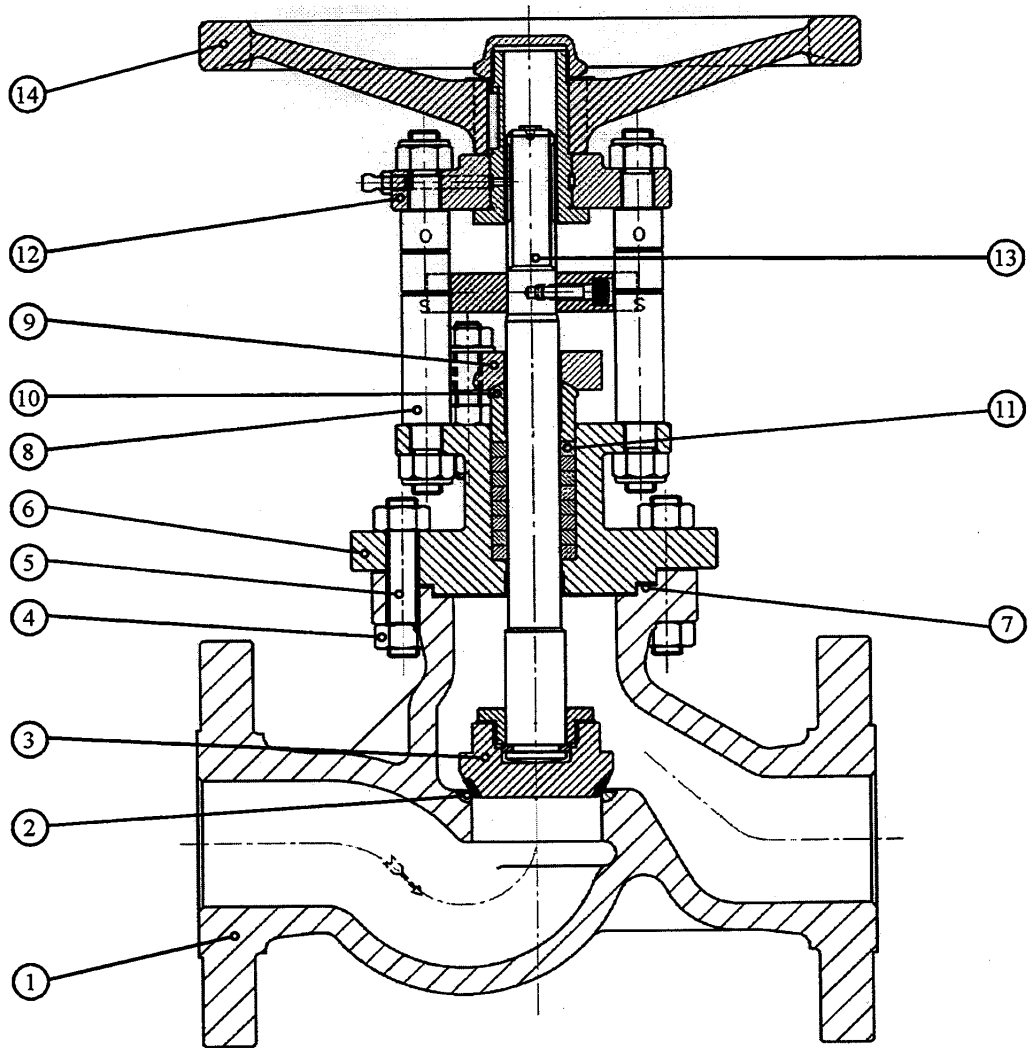
APPENDIX 6

Internal and External Valve Assembly

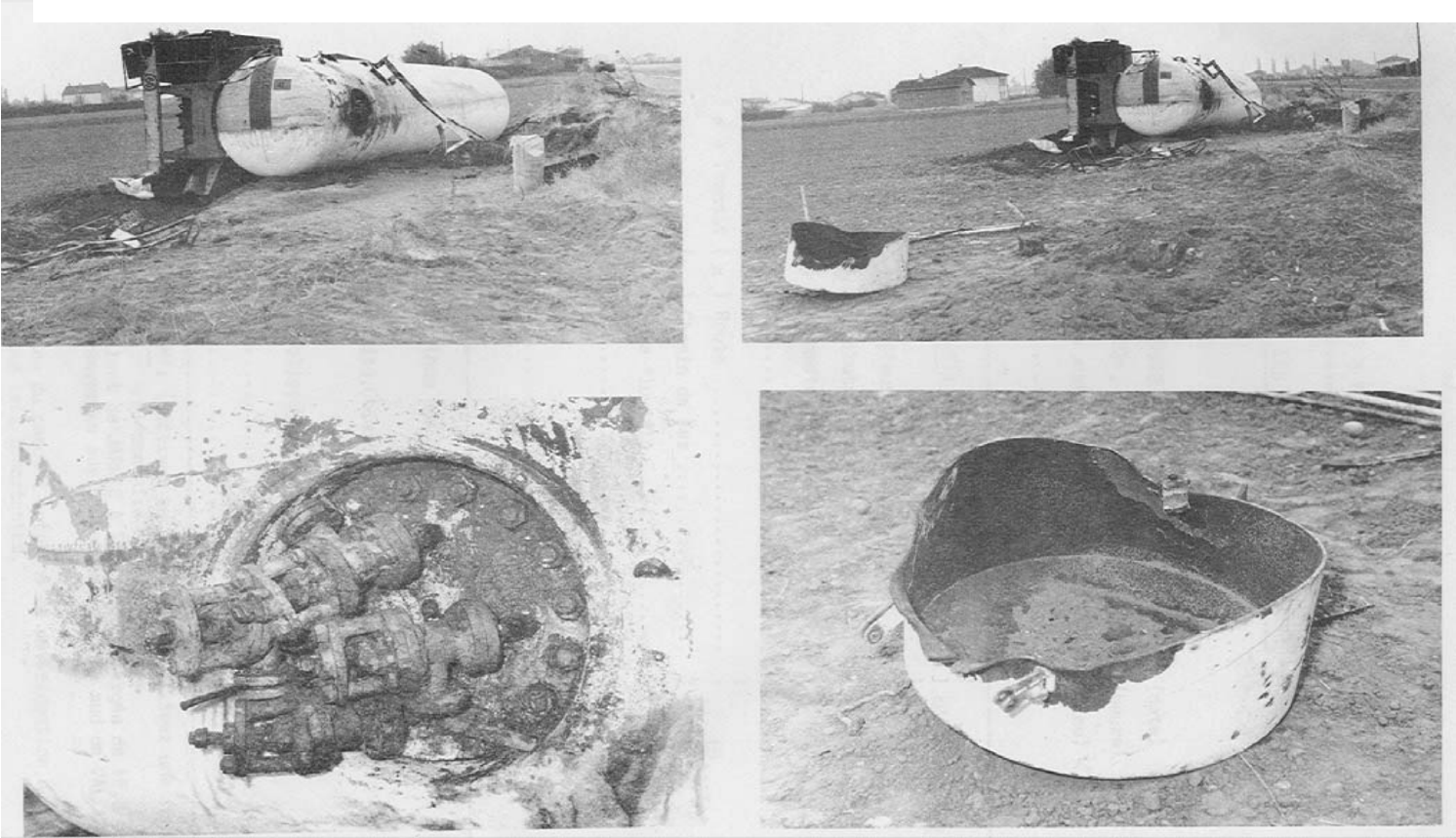


APPENDIX 7

Manual Valve



APPENDIX 8 – Chlorine Tanker Roll Over – The vulnerability of everything external to the shell can be clearly seen.



APPENDIX 9

Extract from Euro Chlor document GEST 96/221 – Protection of Road Tankers for the Carriage of Chlorine

3.6 VALVE PROTECTION

The tanker chlorine filling/discharge valves should be protected from damage during road incidents by one of two methods.

(a) Valve protection is provided by a valve chest whereby the valves are recessed inside the tanker barrel. This is ideally located at the front, behind the cab unit. The valve chest should be covered by a suitable substantial access door, which can be secured closed during transport.

(b) The valves are mounted external to the barrel shell and are protected by a substantial cover dome, which can be secured closed during transportation. The attachment of the cover to the tanker should be sufficiently secure to ensure that it will not open or detach during any accident. This is particularly important in designs where the valves are mounted externally to the barrel, and could be broken off if the dome were to open or detach.

The cover system should be designed in such a way that it will not damage the barrel when subjected to the forces generated in an accident.
