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(Bern, 7-11 March 2005)

TANKS

Chapter 3.2/6.8.4 - 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 UN1017 chlorine and UN1079 sulphur dioxide.
Action to be taken:	Create a new special provision TExx to allow tank filling and discharge systems below the liquid level; to apply the new special provision TExx to UN1017 and UN1079 by adding TExx to column 13 of Table A in 3.2.
Related documents:	TRANS/WP.15/AC.1/94/Add.8, paragraph 9 TRANS/WP.15/AC.1/2003/65 (United Kingdom) TRANS/WP.15/AC.1/86, paragraph 72 TRANS/WP.15/AC.1/2001/46 (United Kingdom).

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* / Circulated by the Central Office for International Carriage by Rail (OCTI) under the symbol OCTI/RID/GT-III/2005/19.

Background

The United Kingdom submitted TRANS/WP.15/AC.1/2001/46 to the September 2001 Joint Meeting, proposing that tanks containing chlorine (UN1017) or sulphur dioxide (UN1079) could be fitted with recessed valve chests below the liquid level. Following discussion at that meeting, the United Kingdom submitted a more detailed proposal, TRANS/WP.15/AC.1/2003/65 (which included a comprehensive briefing document, duplicated as the annex to this paper) to the Joint Meeting session in September/October 2003.

After substantial discussion (detailed in TRANS/WP.15/AC.1/94/Add.8, para. 9), the tank working group accepted that the proposal for filling and discharge openings below the surface level of the liquid but within a recessed chest, did not present a decrease in safety compared with current practice. The Joint Meeting recommended that the United Kingdom should submit to a future meeting a new proposal challenging the philosophy of top opening tank valves, for discussion in the plenary of the Joint Meeting.

Justification

The United Kingdom proposal for a discharge system in a recessed chest below the liquid level does challenge the ADR approach of only allowing openings above the liquid level. However, as detailed in TRANS/WP.15/AC.1/2003/65, the United Kingdom believes that carriage in accordance with this proposal offers, for these two chemicals only, increased safety, compared with other tank valve systems, a view which was supported by the tank working group at the September/October 2003 Joint Meeting.

The advantages of having a recessed valve chest system below the level of the liquid include:

- In a serious accident where the tank vehicle does not remain upright, the top mounted external valves can become positioned below the liquid surface and highly exposed to impact; an end mounted valve chest system is never exposed to this sort of risk;

- If it is necessary to remove contents following a roll-over accident, there is a significant probability that top-mounted valves would be inaccessible, whereas the proposed valves in a recessed valve chest are more likely to be accessible and remain in good working order;

- A valve mounted inside a valve chest has more protection against other kinds of impact (eg impact at the rear) than top valves mounted on top of the tank;

- Access to a recessed valve chest is at a lower level, compared to top-mounted valves, ensuring a safer working environment for connecting and testing hoses;

- Proper sealing is easily achieved for both UN1017 and UN1079 using valves situated below the liquid level;

- Valve seals and gaskets can more readily deteriorate in the vapour space of these gases and so there is a clear advantage to having such seals and gaskets in the liquid space during transport;

- With a top opening arrangement, piping inside the tank does still present liquid to the discharge valve at the top of the tank and failure of the discharge valve would allow the release of liquid;

- There is an exemplary safety record in several countries which already use such a valve chest arrangement;

- The proposal is highly specific about the design that may be used and would continue to prohibit non-recessed bottom outlets.

Given that these valves in recessed shells with valve chests represent increased safety for the carriage of UN1017 (chlorine) and UN1079 (sulphur dioxide), it is appropriate to change ADR to reflect the possibility of using such valves.

Proposal

1. Add "**TExx**" in column 13 of Table A in 3.2 against the entries for UN1017 Chlorine and UN1079 Sulphur Dioxide.

2. Add a new Special Provision TExx to 6.8.4(b) for ADR only:

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.	

Safety implications

Increased safety through having a recessed valve chest which is less likely to be damaged in the event of an accident. The proposal is highly specific about the design that may be used and would continue to prohibit non-recessed bottom outlets.

Feasibility

No problems are foreseen.

Enforceability

No problems are foreseen.

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 minimized 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, although 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 rollover 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 gases. 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 to be 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 United Kingdom chlorine distribution is by road tankers. This tanker design has been used for carrying bulk chlorine and sulphur dioxide in the United Kingdom for over thirty-five years. There have been occasional road traffic accidents but the integrity of the containment of the 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 United Kingdom 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 United Kingdom 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 a 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 United Kingdom 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.

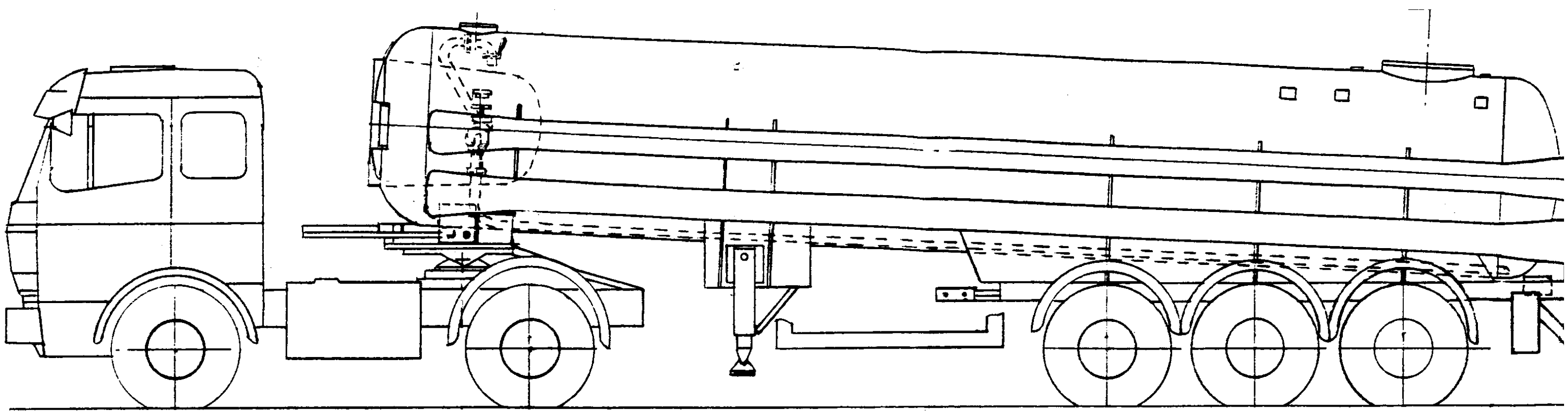
6. Chlorine and Sulphur Dioxide are not difficult to seal. Extensive experience of performance in both transport and static applications show that proper sealing is easily achievable. There is no case for prohibition of joints below the liquid level on these grounds.

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 United Kingdom 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 United Kingdom 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.

APPENDIX 1

CHLORINE TANKER DESIGN



APPENDIX 2

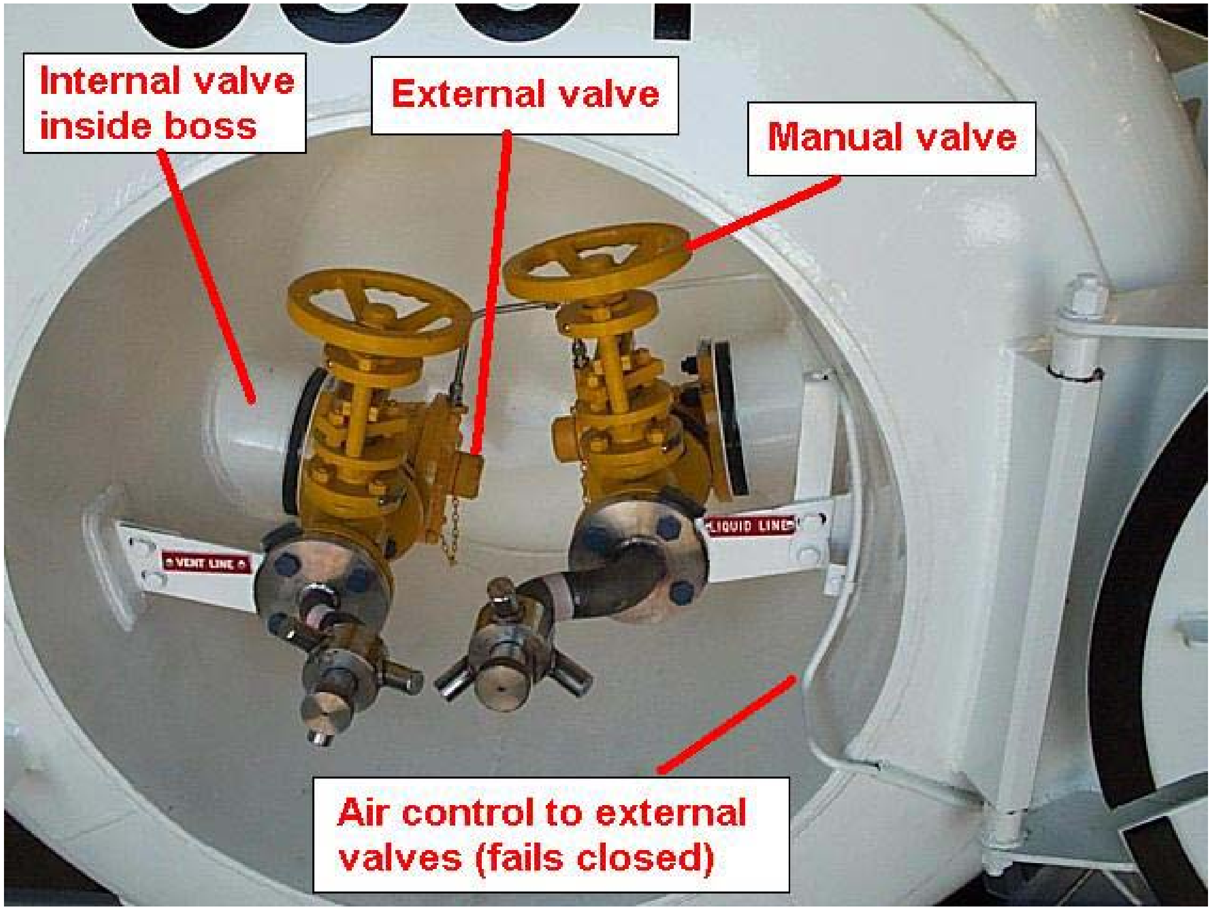
Chlorine Tanker Photograph

APPENDIX 3

Valve Chest Doors on Tanker

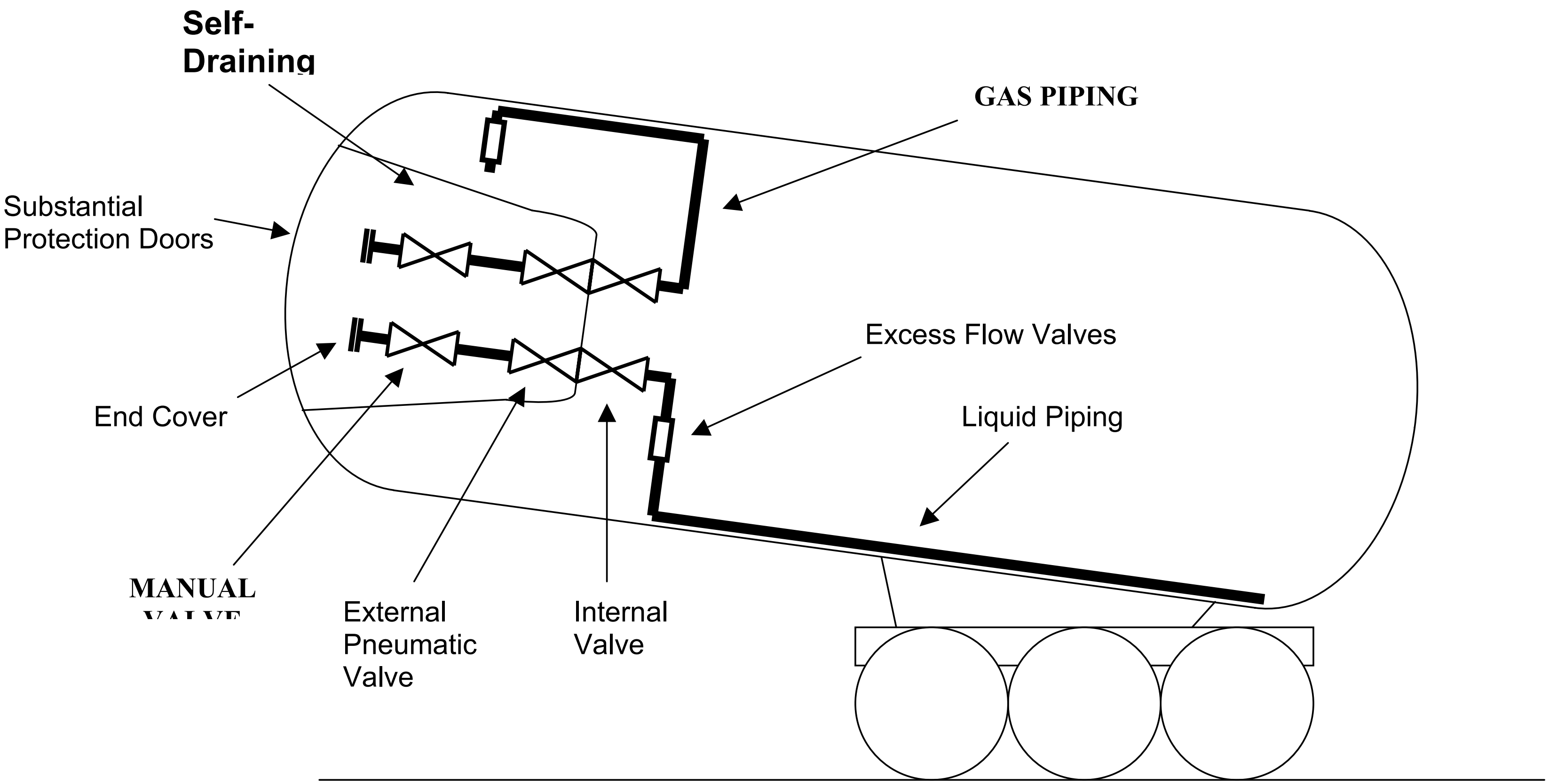
APPENDIX 4

Valves inside Valve Chest



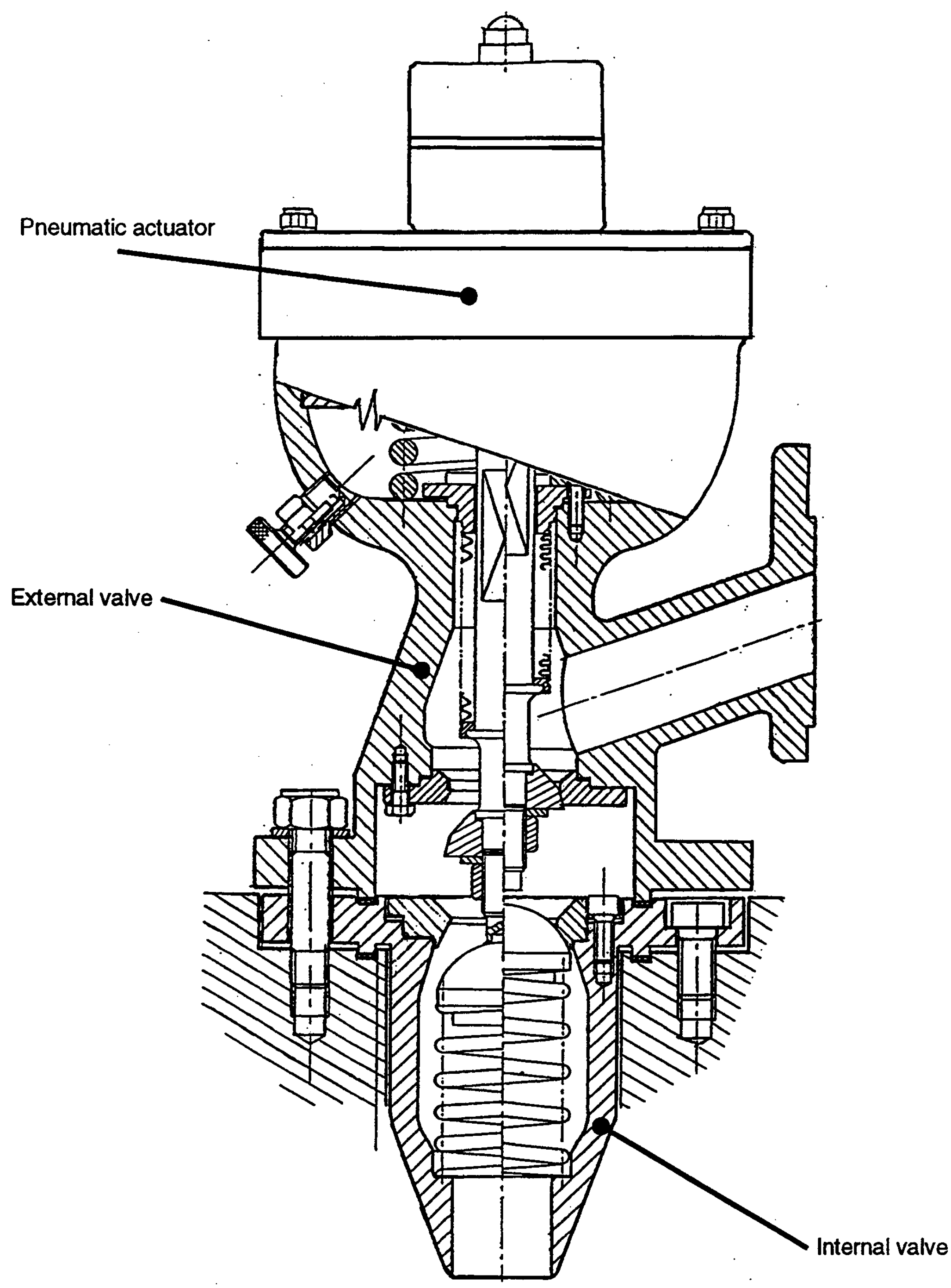
APPENDIX 5

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



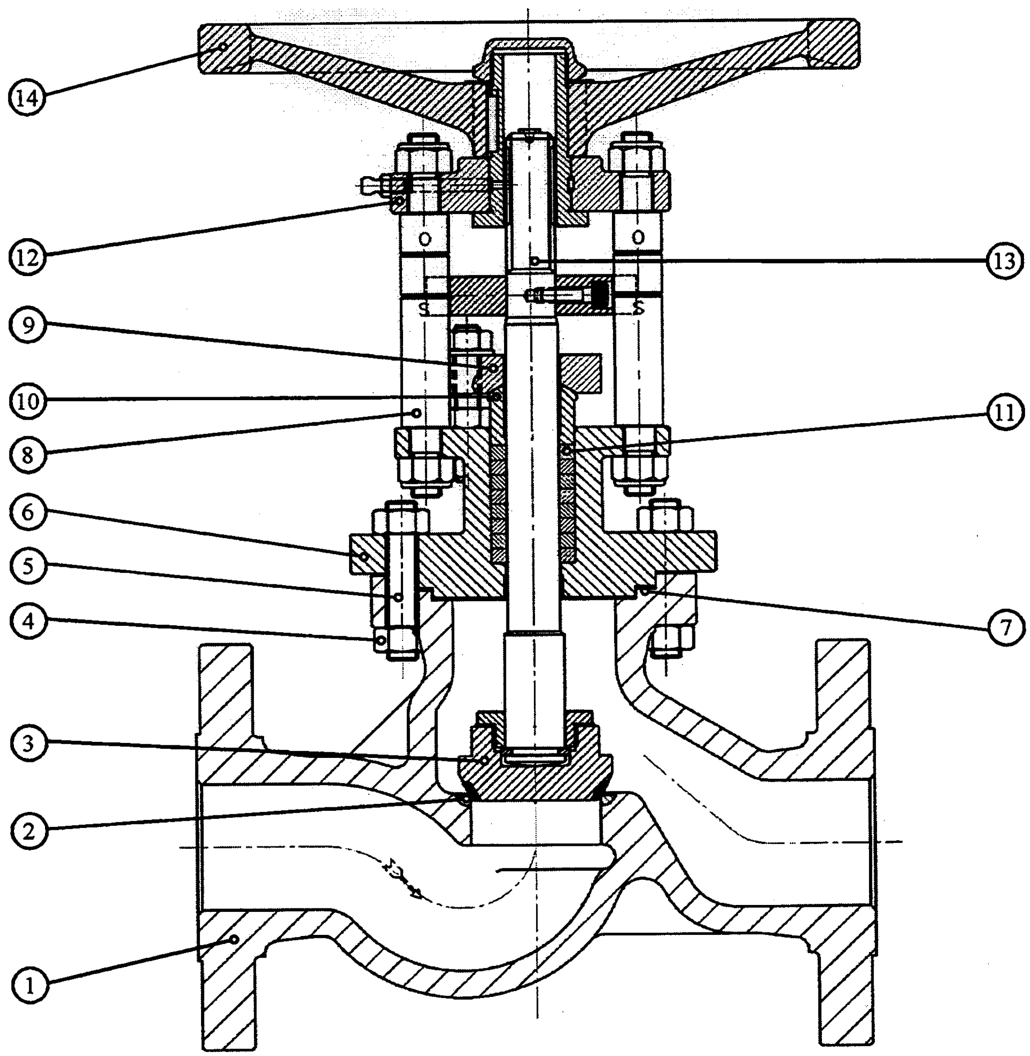
APPENDIX 6

Internal and External Valve Assembly

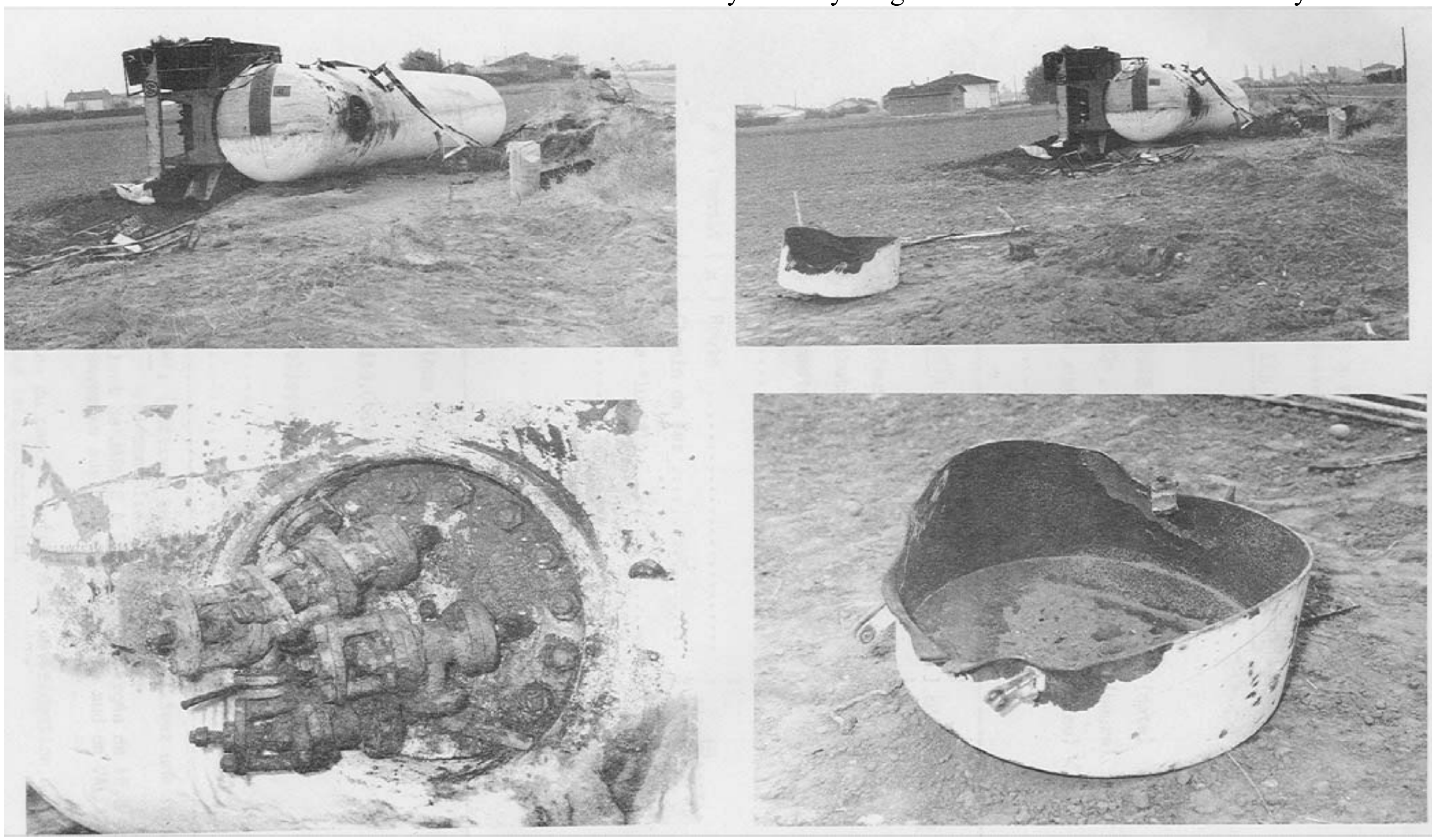


APPENDIX 7

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.