ICHCA International Limited

**INTERNATIONAL SAFETY PANEL**

**SAFETY BRIEFING PAMPHLET #38**

# Safe Handling of Flexitanks in General Purpose Freight Containers

**by**

**Bill Brassington**

**ICHCA INTERNATIONAL PREMIUM MEMBERS:**

TT CLUB STRANG HPH

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Bill Brassington is an engineer who has worked within the freight container industry for over fifteen years, firstly working as the Global Maintenance Manager for P&O Containers. Following his years with a Shipping Line, Bill joined Sea Containers as their Technical Services Manager. After the merger with Genstar to form GE SeaCo he was promoted to lead the Engineering and Technical Services Department responsible for all elements of container design, build and maintenance for all container types as well as providing Health, Safety, Security and Environmental advice to the company.

Bill now provides independent consulting services under the name of ETS Consulting to the freight container and logistics industries specialising in cargo packing and security and container safety and design. He works closely with UN agencies such as the IMO, ILO and UN ECE and other international bodies on freight safety, security and design issues. He is chairman of the TC 104, subcommittee 2 “Freight Containers - Specialist Containers” and is a designated Expert to the ISO Technical Committee 104 and its other subcommittees.

Bill was a founder member of the Container Owners Association (COA) and remains closely associated with them.

Bill has been a member of the International Safety Panel for some years.

ICHCA International Safety Panel Briefing Pamphlet #38 Safe Handling of Flexitanks in General Purpose Freight Containers

**Contents** **Page**




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# SAFE HANDLING OF FLEXITANKS IN GENERAL PURPOSE FREIGHT CONTAINERS

## 1. Introduction

1.1 What is a flexitank? A flexitank is a bladder that is designed to fit inside a 20ft general freight container and which converts that freight container into a non-hazardous bulk liquid transportation unit. It is not an approved form of packaging for the carriage by sea of dangerous goods classified under the International Maritime Dangerous Goods (IMDG) Code.

1.2 Flexitanks have been used for the carriage of bulk liquids for over twenty years. However, there has been unprecedented expansion since the year 2000 with the emergence of single-trip flexitanks. Prior to that, shipments amounted to around 5,000 container loads per annum. Since then there has been a steady increase and in 2006 the total global market had reached 120,000 flexitank movements with a continued forecasted annual growth of between 15% and 20%.

1.3 Of the present trade, it is estimated that between 15% and 20% of global loads emanate from South America, with the movement of wine and fruit juices being particularly prominent.

1.4 This Briefing Pamphlet provides best practice guides for flexitank types, features, flexitank / container combination (FCC) safety and handling, stowage recommendations and cleaning and disposal.

1.5 For more details on flexitank testing and container selection see the Container Owners Association's Recommended Code of Practice for Flexitanks.

## 2. Flexitank types

2.1 Single Layer Flexitanks (SLFs)

2.1.1 In general single layer flexitanks are manufactured from a single sheet of co-extruded polyethylene – approximately 40mil or 1000mu (micron) in thickness.

2.1.1 SLFs use materials such as ethylene vinyl alcohol (EVOH) and aluminium as barriers. These barriers are added to single layer flexitanks as external sleeves.

2.2 Multilayer Flexitanks (MLFs)

2.2.1 Multilayer flexitanks are built up of a number of layers (3,4,5 layers) which are dependent of the cargo that the flexitank will carry (e.g. products that require a taint/barrier layer would have at least 4 inner plies of material, one of which would be the barrier layer). Generally the thickness of material ranges from 100mu through to 500mu per layer. An external layer of material is usually present on MLFs. Each manufacturer will have their own preference or design – most commonly used is a cross woven layer of polypropylene (PE). An example of a MLF is shown in Picture 1.

**Picture 1**

2.2.1 Multilayer (barrier options)

The same barrier options are used on the MLF as the SLF, however the multilayer offers protection against damage and humidity to the barrier as it can become an integral part of the construction by being “sandwiched” between plies of PE.

Picture 2 shows an example of damage to an external EVOH.

***Picture 2***

2.3 Other Materials

There are other designs and materials used in the manufacture of flexitanks. However this pamphlet recognises their existence but does not provide further information or data.

## 3 Flexitank Features

3.1 Valves

3.1.1 Flexitanks should be fitted with valve collars that are secured to the flexitank material using mechanical fixings which are capable of withstanding the pressures associated with the approval testing (Picture 3).

3.1.2 The tank may be fitted with a top valve, with a bottom valve or with both. Either construction may allow the tank to empty completely, depending on exterior conditions, e.g. ground slope and pumps.

***Picture 3***

***Picture 4***

***Picture 5***

***Picture 6***

3.1.3 Pictures 4 to 6 show examples of common valves used.

3.1.3.1 Valves are generally ball (Picture 6) or butterfly designs (Picture 4 and 5)

3.1.3.2 Valve diameters used are 2” and 3” although larger diameters are also available.

3.2 Tank barriers

3.2.1 Due to heavy contamination pressure from some containers and in some environments, and due to PE type materials’ ability to absorb and release odours, flexitanks used for certain cargoes, such as wine, should include an efficient barrier material against exterior contamination. For transport through hot and humid areas (e.g. the equatorial line or other tropical regions or warm and humid seasons anywhere), the barrier material must perform well under difficult conditions.

3.2.2 Alternatively, the flexitank material should be of such a thickness that contaminants cannot penetrate it within a reasonable time (for example some manufacturers specify that flexitanks have a storage life of 3 months at 40 ºC)

3.2.3 PE materials will, after a certain amount of time, allow penetration, but thick material will form a longer lasting barrier than thin material. The speed of degradation will depend on the cargo

carried; therefore it is essential that the shipper is aware of the time the cargo is to be held in the flexitank.

3.3 Contaminant and oxygen barriers

3.3.1 Most multilayer tanks have a barrier layer, consisting of either EVOH or a metallised (aluminiumised) barrier or an aluminium foil.

3.3.2 Aluminium will dissolve when in contact with the wine; therefore multilayer constructions which include an aluminium barrier must be strong and all welds and seals truly tight. The aluminium must either be part of an outer layer or laminated thoroughly with protecting layers.

3.3.3 The barrier should be able to prevent or absolutely minimise the contact between wine and oxygen as well as chemical contaminants from the environment.

3.3.4 There appears to be a correlation between oxygen barrier properties and barrier properties to other compounds. However, this has not been thoroughly investigated.

3.4 Other fittings

3.4.1 Some flexitanks may be fitted with an overpressure valve. This will allow $CO_2$ to escape if:

3.4.1.1 $CO_2$ is released from the wine as a consequence of raising temperatures, turbulence during transport or a slightly elevated $CO_2$- content in the wine;

3.4.1.2 Post fermentation occurs due to residual sugars in the wine and insufficient filtration and hygiene measures are taken at the time of loading.

3.4.2 A sample valve is rare, consequently it is often hard to take samples from a flexitank. This problem is more easily solved on a bottom valve tank than on a top valve tank: On the bottom valve, a cap with a sample valve may be fitted, which will allow the drawing of samples. However, this will in most cases mean that a seal must be broken.

3.4.2.1 Certain manufacturers are able to offer sample caps for both top and bottom discharge designs

3.4.2.2 It is not known whether sterile samples can be drawn from standard flexitanks.

3.5 Bulkheads

3.5.1 There are various designs of bulkhead provided by the flexitank manufacturers. Pictures 7 and 8 show two examples. Picture 7 shows an example of a bulkhead where the material is designed to completely fill the door aperture. The fitting instructions state that tapes should be attached to the rear most lashing points, not as shown to the left of the container.

***Picture 7***

***Picture 8***

3.5.2 Materials used for bulkheads include steel frame, wood and polypropylene (with steel bars)

3.5.3 The various designs of bulkhead have a number of materials used as backing, i.e. to provide additional strength to material bulkheads. The backing material include plywood, cardboard, corrugated plastic, EPS polystyrene etc.

3.5.4 Bulkhead designs change slightly for the flexitanks with bottom discharge. Bottom discharge flexitanks requires a port through which the loading / discharge valve is fitted.

3.5.5 Bulkheads, once in place, should be strong enough to support an operator climbing into the container if access is required during the fitting or unloading process.

3.5.6 Bulkheads need to be sufficiently strong so as to prevent the flexitank applying any pressure onto either door.

**4 Flexitank / Container Combination Safety**

4.1 At all times, the correct personal protection equipment/clothing (including gloves, hats overalls, boots masks etc) should be worn.

4.2 The flexitanks are generally laid within the freight container without any major means of retention apart from a bulkhead placed across the rear (door) end of the container. The filled flexitank expands into the freight container and relies on the pressure of the liquid to hold it in position.

4.3 While it is the intention of the shipper to ensure that the flexitank is filled correctly the nature of the flexitank film materials is such that they are liable to stretch which may increase the risk of instability of the container due to free surface effect.

4.3.1 The free surface effect is one of several mechanisms where a vessel or vehicle, including a container on a rail wagon or chassis / trailer, can become unstable and roll-over. It refers to the tendency of liquids to move in response to changes in the attitude of cargo holds, decks, chassis, wagons or liquid tanks in reaction to operator-induced motions.

4.3.2 The free surface effect can become a problem in a vessel or container with large partially-full cargo compartments, fuel or water tanks, especially if they are located spanning its fore to aft centreline. If a compartment or tank is either empty or full, there is no change in the loading of the mass, or the vessel's centre of mass as it rolls from side to side (in strong winds, heavy seas, or on sharp motions or turns). If the tank is only half-full, however, the liquid in the tank will respond to the vessel's heave, pitch, roll, surge, sway or yaw. For example, as the vessel rolls to the left (port), a liquid will move so that much of it is now on the left (port) side of a tank, and this will move the vessel's centre of mass and centre of moment towards the left (port). This has the effect of slowing the vessel's return to vertical.

4.3.3 The free surface effect becomes worse if the vessel then rolls through the vertical towards the right (starboard). It takes time for the liquid in the tank to respond and move towards the right (starboard) side of the tank. After the vessel rolls through the vertical towards the right (starboard), most of the liquid moving in the vessel's tank then slams into the right (starboard) side of the tank, often with the effect of causing the vessel to heel further over, as the liquid mass hits the bulkheads of the tank. In turbulent winds, heavy sea states, or on rough roads, this can become a positive feedback loop, causing each roll to become more and more extreme, until the vessel or vehicle rolls-over.

4.4 The nature of the dry freight container means that there are no outward signs that the container is carrying a flexitank with a bulk liquid.

4.5 The liquid cargo should only be non regulated goods which means that cargoes are not classified as Dangerous under the IMDG Code or other international dangerous goods rules.

4.6 Opening Containers fitted with flexitanks

4.6.1 If the container is mounted on a chassis / trailer during the discharge process and the operator is on the ground, i.e. not level with the chassis / trailer bed, then it should be remembered that the operator may need to reach up to open the container doors. In such

circumstances, the risk of injury is increased due to abnormal handling positions and greater fall heights. Wherever available a loading bay or a suitably adjusted loading ramp, or platform should be used.

4.6.2 Before opening a container carrying a loaded flexitank, the doors and side panels should be "rung". A dull sound indicates that there is pressure from the flexitank, whereas a "ringing" sound indicates that the panel is not under internal pressure. The right hand door should not be opened if the door panel does not "ring".

4.6.3 If the side panels and / or end panels are substantially bowed outwards, a dull sound to all panels when "rung", and the flexitank is carrying wine, there is a risk that the wine has fermented during the voyage. This container should not be opened as the flexitank may burst at any time. Small holes may be drilled through the container and flexitank through the roof of the container by means of a hand drill to release the pressure.

4.6.4 Most designs of flexitank will have some form of bulkhead arrangement which should be capable of retaining the flexitank within the container. It is the pressure of the inflated / filled tank against the side walls that prevents greater movement within the container. However this does not eliminate all movement and there is a risk that the full flexitank may migrate towards the front or rear of the container during transport.

4.6.5 Flexitank designs sometimes use the left hand door as part of the retaining mechanism which should prevent any force being applied to the right hand door. However improperly fitted flexitanks and those subjected to extraordinary longitudinal forces during transportation may have moved towards the rear of the container and some force may be applied to the right hand door.

**Care should be taken when opening the doors for the first time.**

4.6.6 Always apply a retaining strap between the inner lock rods on both doors or a chain fixed diagonally across the doors (see picture 9) before opening to ensure that the right hand door does not "burst open".

***Picture 9***

4.6.7 It is recommended that when opening the right hand door for the first time the lock rod handles are firstly removed from their retainers and allowed to hang free without rotating them. The operator should stand clear to the left of the container. If there is any excessive force applied to the door then it may open on its own.

4.6.8 If the door does not open it does not mean that there is no force being applied to the right hand door. The lock rods should be rotated whilst pressure is applied to the door to prevent it from "flying" open. The operator should again stand clear once the lock rods cams are totally disengaged.

4.6.9 The operator should open the right hand door with care.

4.6.10 **The left hand door should not be opened**.

4.6.11 The interior of the container should be illuminated during interior inspection so that any deficiencies can be readily seen.

4.6.12 The operator should ensure that the bulkhead bars are correctly secured before climbing into the container.

4.6.13 If there is a need to work within the container then the operator should be aware of any liquid that has leaked out and walk with care over the flexitank as there remains a trip and slip hazard.

4.6.14 If the flexitank bulkhead is not a solid design, then the components should be correctly fitted within their retaining features and secured in place before the flexitank is loaded or

the operator attempts to enter the container space by climbing over the bulkhead. Failure to correctly locate and secure the bulkhead could result in the bulkhead collapsing as the operator climbs over it or as the flexitank is loaded.

4.6.15 No operator should enter the container space unless a second operator is in attendance and should only do so if absolutely necessary. Care should be taken when climbing over the bulkhead to ensure that the footholds are clear from obstruction and trip hazards.

**5 Marking the container**

5.1 The left hand door should be closed and marked with an appropriate warning indicating that there is a flexitank installed and a “Do Not Open” sign.

5.2 If there are customs’ holes in the left hand door retainer / handle then a plastic seal can be used to attach the sign to the door handle thus preventing the left hand door from being opened without removing the seal and label. If there is no customs seal hole in the handle then the label can be attached to the lock rod or stuck to the door.

5.3 The warning sign should be attached to the bulkhead bars near to the centre so that it is visible to the operator when the right hand door is opened.

5.4 See also part 3 of the Container Owners Association’s Recommended Code of Practice for Flexitanks.

**6 Transporting Flexitank / Container Combinations (FCCs)**

6.1 Handling empty containers

6.1.1 Handling empty freight containers is covered elsewhere in detail; however it is important that the container is safe for the carriage of cargo:

6.1.1.1 The container has a safety approval plate with a next examination date in the future or an ACEP reference.

6.1.1.2 The container does not suffer from severe structural deficiencies as defined by the International Maritime Organisation (IMO) circular CSC.1 / Circ. 138

6.1.1.3 The container is considered as cargo worthy as defined by internationally accepted interchange and inspections standards such as the Container Owners Association‘s Container Interchange Criteria (CIC).

6.1.2 Furthermore it is important that the container is transported safely:

6.1.2.1 The container doors should be closed and the lock rod handles secured in their retainers.

6.1.2.2 The container is secured onto the chassis / trailer or wagon by engaging the twistlock or retaining pins at all four corners.

6.2 Fork lift trucks

6.2.1 Many 20 ft containers are fitted with fork pockets which would allow the loaded container to be lifted with a suitable fork lift truck. When the container is loaded with a flexitank containing bulk liquids the container is subject to dynamic forces associated with liquids and similar to those experienced by tank containers.

**Therefore lifting loaded FCCs with a fork lift truck should not be permitted.**

6.3 Lifting and lowering

6.3.1 The container doors should be closed and the lock rod handles secured in their retainers.

6.3.2 When lifting and lowering it is important to recognise that the liquid within the freight container will continue to move even though the container has stopped.

6.3.3 Lifting and lowering speeds should be restricted so that the static / accelerated liquid can make a smooth transition without damaging the container or the lifting equipment.

6.3.4 When swinging or moving a FCC transversely care should be taken when attempting to position the unit within a slot or on a chassis / trailer.

6.4 Road transport

6.4.1 The container is secured onto the chassis / trailer by engaging the twistlock or retaining pins at all four corners.

6.4.2 The driver should be made aware that the container is carrying a loaded flexitank as the handling characteristics for the container may be different, especially if the flexitank is not correctly filled. Where possible, only use experienced drivers accustomed to handling bulk liquids in tank containers or within containers.

6.4.3 The driver should inspect the container for signs of leakage prior to starting and periodically during the journey to the destination. If there are signs of leakage, then the driver should park the container in a position that will not cause a blockage / disruption and notify the shipper / consignee and park away from any drains, rivers or waterways.

6.4.4 If the route should take the container over / through a bridge / tunnel where leaked material may cause a major disruption to transport, then the driver should check the container for leakage before crossing / entering.

6.4.5 The container should not be opened.

6.4.6 Care should be taken when approaching and negotiating roundabouts, sharp corners, sudden changes in carriageway or uneven surfaces which may cause the liquid within the flexitank to swill from side to side causing the container and chassis / trailer to overturn.

6.4.7 When braking, the driver may experience a sudden forward force as the liquid within the flexitank moves within the container. This can be disconcerting when experienced for the first time.

6.4.8 Uneven surfaces and twisting roads can cause the cargo to move within the flexitank. Abrupt movements could cause an internal wave that could result in the end, or side walls being damaged (see picture 10). If the driver notices such damage it should be reported when the load is dropped at its destination.

***Picture 10***

6.5 Rail Transport

6.5.1 The container is secured onto the wagon by engaging the twistlock at all four corners.

6.5.2 The container should be inspected for signs of leakage prior to starting and periodically during the journey to the destination. If there are signs of leakage, then the shipper / consignee should be notified.

6.5.3 Shunting wagons with containers carrying loaded flexitanks should be only carried out with caution.

6.5.4 If the route should take the container over / through a bridge / tunnel where leaked material may cause a major disruption to transport, then the train crew should check the container for leakage before crossing / entering.

6.5.5 The container should not be opened.

## 7. Stowage on board

7.1 Containers carrying flexitanks can be categorised as follows:

7.1.1 Generally 20 ft dry freight containers although flexitanks could be carried in 40 ft containers and reefer containers.

7.1.2 Generally will have a payload that is greater than 20,000 kg.

7.1.3 Ship planners normally place containers with a heavy gross mass as low as possible, however when positioning these containers the planner should consider that:

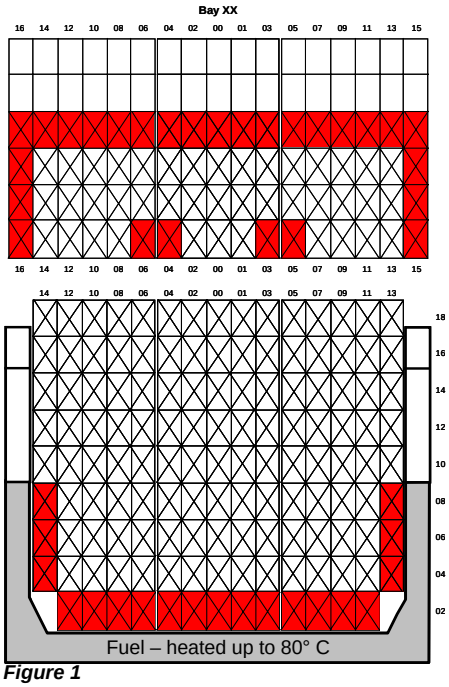

*Figure 1*

7.1.4 Temperature sensitive cargoes should not be placed on or near heated bunker tanks, the elevated temperature required to keep the fuel viscosity low may heat or otherwise damage the cargo (red slots below deck in Figure 1). Note the height up the side will depend on the ship's design and may be higher or lower than shown in the figure. Containers carrying flexitanks should not be stowed adjacent to the engine room bulkhead.

7.1.5 Above deck, containers with flexitanks should not be stowed in the outer and upper most slots as or at the edges of deck covers (red slots above deck in Figure 1) as.

7.1.5.1 Containers in the top slot can be subjected to high temperatures from the sun's radiation.

7.1.5.2 Containers in the outer slots can be subjected to high acceleration loads and there is anecdotal evidence that flexitanks may burst through the side wall.

7.1.5.3 Containers placed at the edge of the deck covers may have slightly wider separation and there is an increase in the risk of the side walls being bowed outwards.

***Picture 11***

7.1.6 Picture 11 shows an example of a modern container vessel capable of carrying 8750 teu. Because of the layout of the lashing bridges, the majority of the slots above deck are allocated to 40 ft containers with very limited slots for 20 ft units. . Additionally the forward bay and those astern of the superstructure are generally unsuitable for stowing containers with loaded flexitanks due to the dynamic forces that the containers in these bays are subjected to.

7.1.7 Containers carrying products that are viscous or that solidify or which become more viscous when released from the containment of the flexitank should not be stowed below deck where

a failure of the flexitank container combination may result in the product clogging the bilge pumps.

7.1.8 Water polluting and oily products on the other hand should be stowed below decks where any leakage can be captured within the ship's bilge.

## 8 Incident Management

8.1 See also part 4 of the Container Owners Association's Recommended Code of Practice for Flexitanks.

8.2 Containers known to be carrying bulk liquids should be inspected at every interchange to ensure that there are no signs of leakage.

8.3 Dry freight containers are the work horse of the freight container industry and as such are handled robustly using normal handling procedures. The nature of the handling process and the required need for high productivity during handling means that accidents can and will happen. Therefore flexitanks carried within dry freight containers are likely to be subjected to forces and impacts that may also damage or puncture it.

8.4 Flexitanks carried within dry freight containers are hard to identify by the terminal and freight handlers and so there is a risk of failure to the flexitank that could result in a bulk discharge of the cargo.

8.5 Flexitanks, by their very nature, will discharge all of their cargo if the flexitank is punctured. In the event of a failure urgent action is required to contain the spill.

8.5.4 If any freight container is seen with any liquid escaping from the door gasket area or through the flooring, the container should be moved to an isolation area as quickly as possible. An example is shown in picture 12.

*Picture 12*

8.5.4.1 While the cargo within the flexitank is unlikely to be hazardous as defined by the IMDG Code, some cargoes can cause severe disruption to operations should large volumes leak from the flexitank

8.5.4.2 The materials safety data sheet (MSDS) should be consulted immediately to ensure that precautions are taken to reduce the risk of injury or harm to the operators.

8.5.4.3 The isolation area should not have any drains where the cargo can contaminate surface water drainage.

8.5.5 If there is no nearby isolation area, the container should be moved to an area away from the main trucking and handling routes which can be used as a temporary isolation area.

*Picture 13*

8.5.5.1 **All operators should vacate the isolation area and should not return until the nature of the cargo is confirmed and it is safe to do so**.

8.5.5.2 Some facilities will have bund trailers or mafis, (see picture 13) which are designed to carry leaking containers and retains the cargo within its bund area.

**Note: Water running off the roof or from containers placed above the container containing the flexitank should not be confused with cargo leaking from the flexitank.**

8.5.6 Containment barriers should be positioned around the container

8.5.6.1 The area enclosed by the barrier should be sufficiently large so as to contain the majority of the flexitank's volume.

8.5.6.2 Should the entire contents of the flexitank leak out, then it is unlikely that a containment barrier will be high enough to hold the liquid. Therefore it may be necessary to use a pump to transfer the liquid from the containment area into a suitable container.

8.5.6.3 A suitable absorption agent should be sourced and made available once compatibility with the cargo has been confirmed.

8.5.7 On discovery that a flexitank is leaking, the shipper should be notified immediately and required to provide instructions for any special containment or disposal of the cargo. The shipper and / or the cargo insurer may appoint a surveyor to oversee the incident. It is important that this surveyor is experienced in flexitanks and their operation, so that proper decisions can be made.

8.5.8 Once all relevant permissions have been obtained, a physical inspection of the flexitank may be required to determine actions required. Preferably this should be performed by flexitank operators, their agents or representatives as, given their flexitank experience, they are most likely to be able to determine the root cause.

8.5.9 The local customs office should be alerted so that entry can be made into the container once the nature of the cargo is confirmed and, when it is safe to do so, the rear doors may be opened.

8.5.9.1 Once the rear doors are open and if suitable pipe work and pumping equipment is available, it may be possible to transfer the remaining cargo into another container with a flexitank or a tank container, whichever is available.

8.5.9.2 The flexitank manufacturer may be able to assist in the transfer of cargo from the punctured flexitank into another dry freight container or the use of a tank container instead.

8.5.10 Once the liquid has been collected and the area cleaned, the container and the damaged flexitank should be returned to a depot nominated by the flexitank manufacturer.

**Note: If any container is seen travelling along the road and cargo seen to be leaking from the container, then the driver should be alerted straight away. The driver should remove the container to a place where the leaking cargo will not cause disruption to traffic or increase the risk of accidents.**