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ANY OTHER BUSINESS

Chemical tankers receiving nitrogen at high flow rates from shore

Submitted by the International Chamber of Shipping (ICS)

SUMMARY	
Executive summary:	The document draws attention to the use by some chemical cargo handling terminals of gaseous nitrogen at high flow rates to control the environment in ships' cargo tanks. There is a need for shore awareness of the risk of overpressurisation, and to ensure procedures for conducting the operation are agreed on each occasion
Action to be taken:	Paragraph 9
Related documents:	None

1 The ICS Tanker Safety Guide (Chemicals) was published in 1971 to establish the best industry practices in the operation of chemical tankers. The guide has become widely accepted as the basis for chemical tanker operators' instructions and a third edition was published in February 2002, after complete revision to reflect modern practice in the shipment of chemicals by sea.

2 There have been many significant changes in the international chemical handling industry in the past three decades. Perhaps the most important have the been the heightened awareness of the need for environmental protection and the development, through MARPOL Annex II and the IBC Code, of mandatory regulations for the design, certification and operation of all ships carrying noxious liquid substances in bulk. Technological capability has also allowed liquid handling processes to be improved and new or adapted procedures have evolved to accommodate them. The new edition of the ICS Chemical Guide necessarily reflects these changes.

3 However, there is one technique which has gradually developed that should, ICS believes, be brought to the attention of all administrations responsible for chemical cargo terminals, because it requires co-ordination between ship and shore to avoid potentially harmful consequences. The practice is that of terminals supplying ships with gaseous nitrogen at very high flow rates to control the atmosphere in cargo tanks.

4 The use of specially dried gas to reduce the dew point of the atmosphere in a tank and its associated piping system, or the use of an inert gas to reduce the level of oxygen, or the use of a pad of a specified gas to avoid contamination of a highly refined cargo, have all improved in

performance and increased in frequency in the last decade. Indeed, for some trades and some major chemical refinery terminals they are now normal practice.

5 In each case, the gas predominantly used is pure nitrogen through a permanent supply system with an outlet at the jetty and maintained at a consistent pressure, often above 5 bar. The problem presented to the ship is not that the gas is supplied at a high pressure, but that the size of the pipelines and hoses used means that it can be supplied at a high volumetric flow rate into ship systems designed only for liquid flow rates. Traditionally, a tank being charged with nitrogen could have its existing atmosphere exhausted through an open tank lid, but today's restrictions on venting now often require vapour return to shore. Overpressure can rapidly develop within a tank if the inlet rates exceed the outlet capacity.

6 A second use of pressurised nitrogen that has developed is to press a liquid chemical out of shore tanks such as railway wagons, instead of pumping it. If miscalculation allows all the liquid to pass into the ship, there is an abrupt and dramatic increase in the tank filling rate from liquid at a few hundred cubic metres per hour to gas at several thousand cubic metres per hour. Nitrogen at 3.5 bar in a 100 mm diameter pipeline will inject 250 m^3 of nitrogen into the tank in one minute; that is equivalent to 15,000 m^3 per hour, an unthinkable filling rate for liquid. Over pressurisation of a closed tank can occur in seconds, especially when the distance from the manifold is small or if the tank is nearly full and the vapour space limited.

7 Ships' crews have accepted the imposed improvement in cargo handling processes in good faith, but are often unaware of the scale of the change. In view of several significant incidents that have recently occurred, some causing physical damage to ships, the ICS Chemical Guide, in addition to the advice given in the text about cargo operations, lays stress on the need to encourage mutual recognition of the problem during the liaison meeting between ship and terminal personnel that precedes every cargo transfer. To prompt those involved, an additional question has been added to the relevant ship/shore safety checklist.

8 The annex to this paper contains the advice in the ICS Tanker Safety Guide (Chemicals), adapted for clarity in the context of this submission, together with the corresponding extract from the ship/shore safety checklist. While ICS has itself brought the matter to the attention of chemical tanker operators, administrations can also assist by raising the awareness of terminal staff to the potential hazard.

Action requested of the Sub-Committee

9 The Sub-Committee is invited to note this information.

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ANNEX

GUIDANCE FOR THOSE INVOLVED WITH CHEMICAL TANKERS RECEIVING GASEOUS NITROGEN FROM SHORE

1 It is a frequent practice at chemical loading terminals to control the atmosphere in cargo tanks with nitrogen supplied from shore. The nitrogen can be for the purpose of drying a tank and its associated piping system, purging a tank before loading the cargo, or padding cargo in a tank. Compressed nitrogen may also be used to propel a line scraper for clearing shore lines into the ship after loading, or for pressing small parcels of cargo out of their shore containers (often railway wagons) and into the ship. During both of these operations there is a possibility of an abrupt increase in loading rate from liquid at a few hundred cubic metres per hour to gas at several thousand cubic metres per hour. Agreement on the procedure for handling the nitrogen is paramount, and should be part of the pre-loading checklist between ship and shore, with emphasis on a clear understanding of the transfer rate and pressure.

2 Although the operation is an important stage in cargo handling, it is also potentially hazardous because high pressure gas is being introduced into a tank that is not designed to withstand internal pressure, and whose structure may fail at less than 0.5 bar overpressure. The associated risks of the operation should be thoroughly understood. Procedures should be in place to ensure safety during the operation, and all personnel involved should be made conversant with those procedures.

3 It is possible to overpressurise and even rupture a cargo tank if the nitrogen supply from shore is at too high a flow rate or too great a pressure. There have been incidents where structural damage has occurred.

4 When a liquid is being loaded through the cargo manifold and pipeline system on a chemical carrier, the existing atmosphere in the tank can escape through a vent system that is notably smaller than the liquid filling line, because friction and turbulence are far greater impediments to liquid flow than to gas flow. Ships are designed with this in mind. However, when a gas is being introduced through the liquid filling line, especially a gas under pressure that will expand within the tank, the same condition does not apply, and the disparate sizes between inlet and outlet can allow an overpressure to develop. To avoid such an eventuality the outlet for the existing atmosphere in the tank should be as big as or bigger than the pipeline supplying the gas. This is usually achieved by having the cargo tank lid or a tank washing hatch open.

5 But when vapour control and emission regulations require a closed operation (with the existing tank atmosphere forced to exhaust to shore), the incoming flow of nitrogen must be restricted to a rate equal to or less than the maximum flow of vapour possible through the venting system. If the capacity of the vapour return system is exceeded by the flow of nitrogen into a closed cargo tank, then the only other outlet is through the relief valve which will prevent overpressurisation (though contravening the vapour control regulations). However, if the capacity of both outlets is exceeded, then overpressure will occur and damage to the tank structure may follow.

6 The pressure or the flow rate of the incoming nitrogen must therefore be controlled. Use of a small hose or a reducer prior to the manifold will limit the flow rate, but pressure must be controlled by the shore. It is not appropriate to attempt control of gas flow by throttling it using

the ship's manifold valve because that is designed to control liquid flow. However, the manifold valve can and should be used as a rapid safety stop in an emergency; pressure surge in a gas is not as violent as in a liquid.

Drying or purging an empty tank that has been cleaned and gas freed

7 During the pre-transfer planning conference, the volume of nitrogen required should always be calculated and agreed (tank volume multiplied by number of volumes to reach the desired level of dryness or oxygen exclusion), and the flow rate agreed. Table 1 shows the volume of nitrogen that can be received in one minute through a known size of pipe at a known pressure. (The second figure in brackets indicates the associated hourly rate which should be mentally compared to a liquid loading rate. Note that these tables are intended to be indicative only, and any discrepancies are due to rounding of figures.)

	200mm (8")	**150mm (6")**	**100mm (4")**	**50mm (2")**	**25mm**
5.2 bar (75 psi)	1771 (106000)	914 (55000)	343 (20600)	67 (4000)	12 (740)
3.4 bar (50 psi)	1286 (77000)	662 (39700)	243 (14600)	48 (2900)	9 (530)
2.1 bar (30 psi)	886 (53000)	457 (27400)	171 (10300)	33 (2000)	6 (360)
0.7 bar (10 psi)	471 (28300)	214 (12900)	80 (4800)	16 (1000)	3 (170)

Table 1: Cubic metres of gas at various gauge pressures received in 1 minute (and 1 hour) through hoses of various sizes.

8 Table 2 illustrates the time taken to receive gas into a tank at different pressures and different hose sizes, the example used assuming a cargo tank of 1250 cubic metres requiring four atmosphere changes to flow through (i.e. 5000 cubic metres of nitrogen). It will be seen how varying the size of the delivery hose or delivery pressure will provide control of the operation.

	200mm	**150mm**	**100mm**	**50mm**	**25mm**
5.2 bar	3 min.	5½ min.	15 min.	1¼ hrs.	7 hrs.
3.4 bar	4 min.	7 ½ min.	21 min.	1¾ hrs.	10½ hrs.
2.1 bar	5½ min.	11 min.	29 min.	2½ hrs.	
0.7 bar	11 min.	24 min.	63 min.	5¼ hrs.	

Table 2: Time to receive 5,000 cubic metres of gas with various gauge pressures and hose sizes.

Padding cargo in a tank

9 A substantial reduction of risk of overpressurisation can be achieved by avoiding padding with nitrogen as a separate procedure on completion of closed loading. It is better to pre-purge the entire tank before loading. After such purging is completed, loading the tank in a closed condition will create the needed pad within the tank.

10 But if padding has to be performed after loading, planning and good communication are essential. The supply rate must not exceed the vent capacity of the cargo tank. The vapour space in a loaded tank is usually small, so over pressurisation can occur very suddenly, especially if cargo is forced into the vent lines which then become restricted or blocked and add to the rapid increase in tank pressure.

11 A safe practice is to introduce the nitrogen directly into the ullage space via a small diameter connection at the top of the tank or into the ship's cargo line, preferably using ship's equipment and gas supply at a low pressure, but if necessary from shore through a small diameter connection to restrict the flow. Introducing it from shore through the manifold valve and the tank filling line after clearing the shore loading line presents a higher risk and gives very little time to react correctly.

12 Pressure gauges and sensors should be closely monitored during the operation, and the ship's officer should be in direct supervision throughout. The operation should be stopped when a slight overpressure exists in the ullage space, but before reaching the tank pressure relief valve setting.

Using nitrogen to press a product out of shore tanks into the ship, or for clearing a shore line into the ship after loading

13 These operations may also be undertaken using other compressed gas, usually air, but the process and the inherent risk of overpressurisation are the same. The gas pressure used for these operations varies, but can range between 2.5 and 5 bar. During a line clearing operation it is important that terminal staff react promptly when the scraper is caught in its trap, in order to avoid all the compressed propelling gas entering a loaded cargo tank. The point of greatest concern is when the supply into the ship's tank changes from liquid to compressed gas, and the tank filling rate increases dramatically. It will be seen from Table 1 that a significant volume of gas will be received in a few seconds through the large liquid filling line. Over pressurisation of a closed tank can occur in seconds, especially when the distance from the manifold to the tank is small or the vapour space in the tank is limited.

Discharge of cargo

14 When discharging cargoes that have to be carried under a blanket of nitrogen it may be necessary to ensure that no air is drawn into the tank. Therefore an overpressure of nitrogen should be maintained as the liquid level falls, using stored compressed gas or from a nitrogen generator on board, and be introduced into the tank ullage space.

15 If it is necessary to obtain nitrogen from the shore, it is essential that the pre-transfer discussion includes agreement on the nitrogen flow rate and pressure to be used. Although the overpressure required is no more than about 0.2 bar, it is usual for the shore nitrogen supply system to be well above this figure, perhaps as high as 7 bar. Particularly in the early stages when the ullage space is still small, it is possible for the flow rate to exceed the tank venting capacity, and for an overpressure to develop. A safe procedure is to use a pressure reducing device on the nitrogen supply pipeline, and to have a calibrated gauge showing the pressure in the pipeline. There should be constant communication with the terminal, and the ship should monitor cargo tank ullage space pressure throughout.

Additional question in Part B. of the Ship / Shore Safety Checklist

Question B.10. "Where appropriate, have procedures been agreed for receiving nitrogen supplied from shore, either for inerting or purging ship's tanks or for line clearing into the ship ?"

Guideline B10. "Ship and shore should agree in writing on the inert gas supply, specifying the volume required and the flow rate in cubic metres per minute. The sequence of operating valves before beginning the operation and after completion should be agreed, so that the ship remains in control of the flow. Attention should be given to the adequacy of open vents on a tank to avoid the possibility of overpressurisation. The tank pressure should be closely monitored throughout the operation.

"The ship's agreement should be sought when the terminal wishes to use compressed nitrogen or air as a propellant, either for a line scraper to clear shore pipelines into the ship or to press cargo out of shore containment. The ship should be informed of the pressure to be used and the possibility of receiving gas into the cargo tank."