

Report on the investigation
of shift of cargo containers,
involving dangerous goods on

Dutch Navigator

25 - 26 April 2001

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The Merchant Shipping
(Accident Reporting and Investigation)
Regulations 1999

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the cause with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

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GLOSSARY OF ABBREVIATIONS

ACC	-	Acceptable container condition manual
ACEP	-	Approved continuous examination programme
ASME	-	American Society of Mechanical Engineers
BPC	-	Bristol Port Company
BS	-	British standards
CSC	-	International Convention for Safe Containers
DTLR	-	Department of Transport Local Government and Regions
EEC	-	Economic Commission for Europe
ECU	-	Emergency containment unit
ft	-	feet
GM	-	Metacentric height
gt	-	Gross tons
HSE	-	Health and Safety Executive
IMDG	-	International Maritime Dangerous Goods
IMO	-	International Maritime Organization
ins	-	inches
ISM	-	International safety management
ISO	-	International standards organisation
ITCO	-	International container organisation
kg	-	kilogramme
kN	-	kilonewton
kW	-	kilowatt
lbs	-	pounds
m	-	metre

m ²	-	square metre
MCA	-	Maritime and Coastguard Agency
mm	-	millimetre
MSC	-	Maritime safety committee
PCPSO	-	Principal Counter Pollution and Salvage Officer (of MCA)
SCBA	-	Self-contained breathing apparatus
SMM	-	Safety management manual
SMS	-	Safety management system
SOLAS	-	Safety of life at sea convention
SOSREP	-	Secretary of State's Representative for Salvage and Intervention
t	-	tonne
TCA	-	Tank container association
TEU	-	Twenty-foot equivalent unit
TTH	-	The Test House
TWI	-	The Welding Institute
UN	-	United Nations
UTC	-	Universal co-ordinated time

SYNOPSIS

While on passage from Bilbao, Spain, to Avonmouth, UK, between 25 and 26 April 2001 the 2999gt Netherlands-registered vessel *Dutch Navigator* encountered poor weather conditions. This resulted in a shift of nine of her cargo container units in the foremost bay of her hold, Bay 1. Two of the units were tank containers, each holding 20 to 22 tonnes of incompatible dangerous goods. The incident was reported to the MAIB, via the DTLR's Duty Officer, by the Secretary of State's Representative for Salvage and Intervention (SOSREP) at 0350 on 28 April. An investigation began at 0430 that day.

The vessel arrived in Avonmouth at 2025 on 26 April 2001 with a slight starboard list. Avonmouth Docks are managed by The Bristol Port Company (BPC). Discharging her cargo began the following morning. During these operations, port staff became concerned about the safety of the two tank containers. BPC declared a Major Incident, activated its Emergency Plan and requested assistance from the Maritime and Coastguard Agency and other emergency agencies.

The tank container at the bottom of a stack of three units was significantly damaged. It was, therefore, removed from the vessel at 1821 on 28 April. About 3 hours later it began to leak slightly. This tank was finally pumped out and filled with a neutralising agent 24 hours later.

The investigation found that the masses of each of the three stacks of containers in Bay 1 of *Dutch Navigator* exceeded the limits set out in the vessel's cargo securing manual. This resulted in the lower containers being subjected to racking loads, greater than their design value, while the vessel was on passage. The damaged tank was one of these. Further, both of the tank containers were overstowed, which is not in compliance with the International Maritime Goods Code and UK Regulations.

Other issues identified were; the lack of a reception facility for damaged containers at Avonmouth docks; unsatisfactory repairs to containers; weakness of the International Convention for Safe Containers; absence of a reporting requirement for vessels entering Avonmouth with a shift of cargo involving dangerous goods.

Recommendations are made to the owners of *Dutch Navigator* to ensure the masters of their vessels are aware of relevant requirements of The International Maritime Dangerous Goods (IMDG) Code, UK Regulations and the vessels' own cargo securing manuals.

Recommendations are made to BPC to consider introducing a mandatory reporting requirement for vessels which have suffered a shift of cargo involving dangerous goods, and to remind regular shippers to its ports of the IMDG Code and UK requirement that tank containers should not be overstowed on vessels which are not cellular container ships.

The owner of the damaged tank container, Tank Speed Ltd, is recommended to note some of the poor quality repairs which have been performed on his behalf, and be conscious of these when specifying future repairs, selecting contractors and monitoring standards.

Photograph courtesy of FotoFlite

2



Dutch Navigator

Figure 1

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF VESSEL AND INCIDENT

Name	:	<i>Dutch Navigator</i>
Port of registry	:	Rotterdam
IMO Number	:	9173290
Type	:	General cargo
Gross tonnage	:	2999
Length	:	99.09m
Built	:	1998
Builder	:	Slovenske Lodenice a.s. Komarno Slovak Republic
Classification Society	:	Germanischer Lloyd
Owners	:	Rederij Wessels BV Sluisjesdijk 141 3087 AG Rotterdam Netherlands
Incident	:	Shifting and damage of cargo containers
Place and date	:	On passage Bilbao, Spain, to Avonmouth, UK 25 and 26 April 2001
Damage	:	Severe damage to several containers. Minor damage to forward part of vessel's hold
Injuries	:	None

1.2 NARRATIVE

1.2.1 Loading at Bilbao

At 0805 on 24 April 2001, *Dutch Navigator* began discharging a cargo of containers in the Spanish port of Bilbao. This was completed at 1100 and loading began.

A total of 110 containers were loaded, 67 were 40ft the remainder 20ft. These containers were destined for Avonmouth, UK, or Dublin, Eire. Two of the 40ft containers, which were stowed on deck, held Class 3 dangerous goods, and two others, stowed in the hold, held Class 4 goods.

Two of the 20ft containers were of the tank type and held liquids classified as dangerous goods. These were stowed in Bay 1, at the foremost part of the hold, and were the two lower containers in a stack of three at the port side. All containers in Bay 1 were secured by twistlocks.

Once loading was completed the vessel left Bilbao, dropping the pilot at 1850.

1.2.2 The passage

Conditions recorded by the vessel's watchkeeping officers during her passage to Avonmouth, UK, were:

24 April

2000: Wind SW force 3, moderate sea.

25 April

0000: Wind SW force 7, showers, very rough seas. Sailing with reduced speed. Vessel rolling and pitching moderately.

0400: Wind W force 7 to 8. Very rough. Sailing with reduced speed. Vessel rolling and pitching. Water over deck and hatches.

0800: Wind WNW force 7 to 8. Sailing with reduced speed to avoid damage.

A report of the presence of a number of hazardous substances on board *Dutch Navigator* was received by Avonmouth signal station at 1006.

1200: Wind WNW force 7 to 8. Sailing with reduced speed.

1600: Wind WNW force 7 to 8. Sailing with reduced speed.

2000: Wind WNW force 7. Rolling/pitching. Water over fo'castle and decks. Sailing at reduced speed to avoid damage.

26 April

0000: Wind SW force 7. Sailing at reduced speed.

0400: Wind WSW force 3 to 4. Speed increased to full speed, approximately 13 knots.

At 1600, the vessel contacted the container terminal at Avonmouth Docks and reported that some cargo damage had occurred. No report was made of damage to container tanks holding the dangerous goods.

The master had transferred some ballast to partly correct a starboard list.

During the periods of running at reduced speed the vessel was making about 9 knots.

1.2.3 Arrival Avonmouth

The pilot boarded *Dutch Navigator* at 2025 on 26 April and reported to the port, by VHF, that there were no defects likely to affect her navigational safety.

The vessel berthed at the container terminal in Royal Edward Dock, starboard side alongside at berth 2/3 (**see Figure 2**). She had a slight list to starboard.

1.2.4 Discharging Avonmouth

27 April

Work began during the morning of 27 April to discharge cargo.

All the containers in the foremost underdeck bay, Bay 1 just forward of a portable bulkhead, were found to have shifted to starboard and/or to have been damaged to some degree (**see Figure 3**). Discharging continued, allowing a closer examination of the affected containers. By 1530, Bristol Port Company (BPC) had become concerned about the safety implications of the shifted stow. Advisers on the properties of the dangerous goods in the two tank containers were on scene at 1545. Following a meeting with their technical advisers, BPC declared a "Port Emergency" at 1710.

Following a meeting of BPC's incident team, a "Major Incident" was declared and the Port Emergency Plan was activated at 1800.

BPC requested advice and assistance on the situation from emergency services and the Maritime and Coastguard Agency (MCA). In turn, the MCA called on the UK chemical strike team to provide technical expertise.

BPC gathered further safety information on the contents of the two tank containers. *Dutch Navigator's* master was advised to trim his vessel by the head and leave the hatchcovers open.

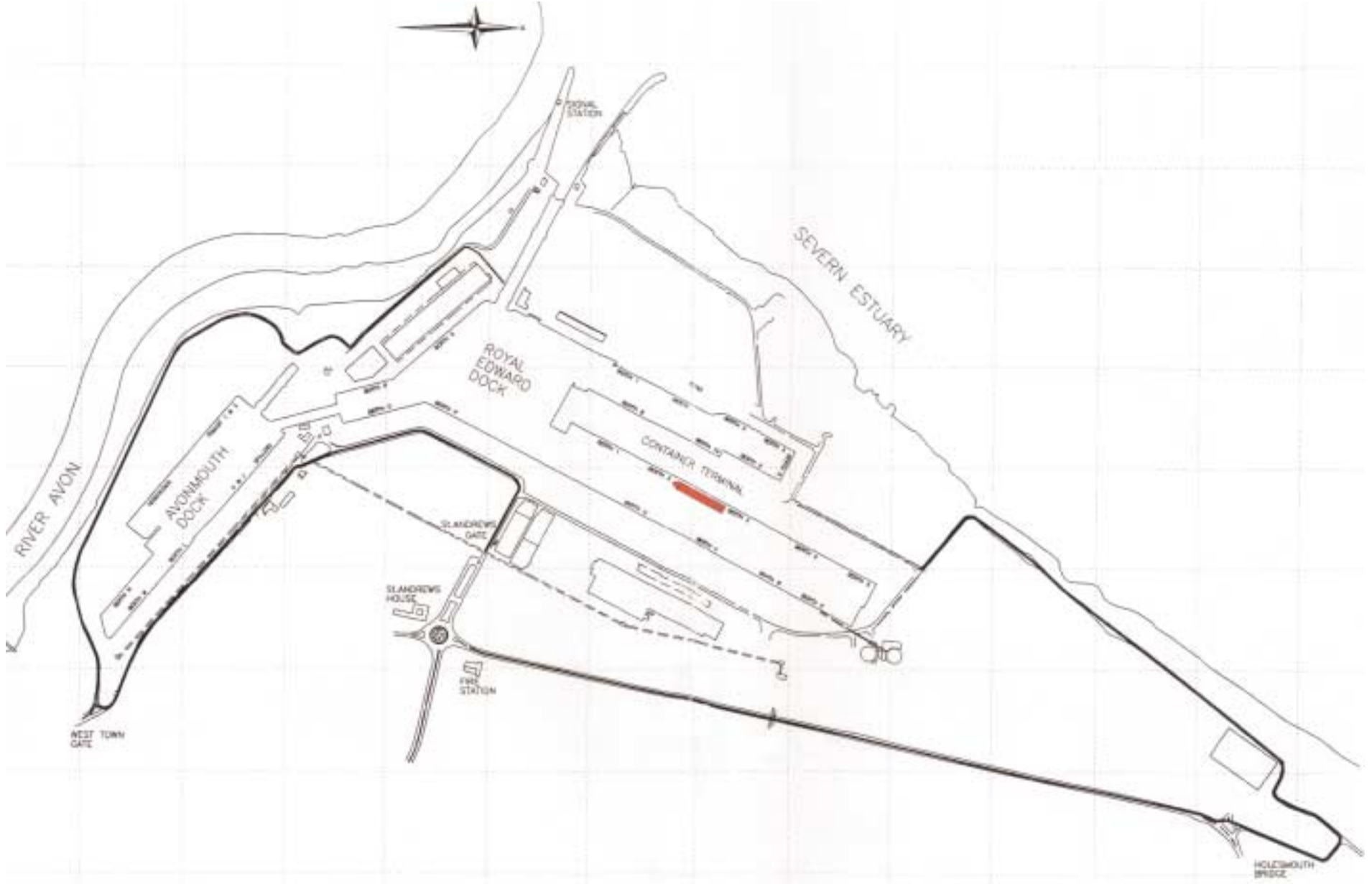


Figure 2

The fire brigade arrived on site at 1845 and at 1850 a restriction was placed on personnel working in the area of the vessel. BPC was advised that 27t of calcium hydroxide would be required to neutralise hydrofluorosilicic acid contained in the lower damaged tank container.

The MCA's regional Principal Counter Pollution and Salvage Officer (PCPSO) arrived at 2140 and was followed by the Secretary of State's Representative for Salvage and Intervention (SOSREP) at 2320.

Figure 3



View of stow in Bay 1 looking forward

28 April

The chemical strike team arrived at 0230 and, following a briefing, inspected the damaged stow. SOSREP left at 0300, without formally intervening, and the incident remained under the control of BPC.

Bagged calcium hydroxide (27 tonnes), a neutralising agent for hydrofluorosilicic acid, was placed in *Dutch Navigator's* hold, just aft of the portable bulkhead.

At 0830, a briefing/planning meeting was held in BPC offices. It involved: the MCA, the chemical strike team, health, fire, police, paramedic, vessel owners/insurers and BPC staff. Significant concern was expressed about the likely health hazards to residents in the area surrounding the port, if the two substances held by the two tank containers mixed. It was agreed that the chemical strike team would undertake a risk assessment of the tasks involved with the removing of the remaining containers from *Dutch Navigator*.

Following a second inspection of the vessel, the chemical strike team presented its risk assessment at another meeting held at 1115. This called for stevedoring staff, who would be performing the unloading tasks, to undertake some training in the use of self contained breathing apparatus (SCBA). Health Authority staff, who had earlier expressed concerns about the hazards associated with mixing the two substances involved, were persuaded to accept a programme for the safe removal of the damaged containers.

The three container stacks in Bay 1 were shored to ensure stability of shifted stow. A safety boat cover was provided, and the police moved shoreside contractors from the locality.

Dutch Navigator's master and chief engineer remained on board for the purposes of trimming the vessel. She was first trimmed on to an even keel to ease removal of the portable bulkhead just aft of Bay 1, then re-trimmed by the head to contain possible spillage. The wind speed was about 10 knots from SSW.

At 1545, wearing SCBA, a stevedore team started lifting the tank containing sodium chlorite. This tank was put ashore at 1549 and was found to be not damaged significantly.

Once this container had been removed from the vessel, the hazard was considered to be much reduced and, at 1600, the fire service stood down.

Four other containers were then removed to gain access to the damaged tank container at the bottom of the port stack.

At 1655, the fire service was requested to stand by on board the vessel while this damaged tank, containing hydrofluorosilicic acid, was lifted ashore.

Two fire pumps from the fire service were on the quay at 1716. Suited fire crews were standing by on the vessel while the tank was lifted ashore at 1821. This was then transported to an open, isolated site in the harbour area. Emergency operations were then considered complete and most emergency personnel were stood down.

BPC staff monitored the tank and, at 2115, they reported that it was showing signs of leaking. The fire brigade returned to the scene and confirmed the tank was leaking. Local health authorities and the tank's owners were advised of the development.

29 April

The fire brigade stood down at 0015 and, following discussions with the tank's owner, arrangements were made for its contents to be transferred to another container.

With the tank's owner, fire appliance, ambulance, technical advisers and salvage staff in attendance, at 1325 all equipment was in position for the transfer.

All connections were made by 1455 and pumping began. Transfer was completed at 1815 and the damaged tank was filled with water and alkali. All agencies and authorities were advised the operation was completed and personnel stood down.

1.3 WEATHER FORECASTS

Dutch Navigator received a weather bulletin at 2052 on 24 April, timed shortly after Bilbao departure, covering the period to 0000 UTC on 26 April. This was supplied by Meteo-France, Toulouse, and gave a forecast of:

For North Biscay and north of South Biscay, winds SW force 5 or 6, increasing 6 or 7 at times, gusts, rough but very rough in south.

For south of South Biscay, winds SW 4 or 5, increasing 6 or 7 soon, gusts, rough or very rough.

This bulletin also mentioned the threat of a cyclonic gale in the Bay of Biscay.

A second bulletin was received from Meteo-France at 0852 the following day, covering the period to 1200 UTC 26 April:

For North Biscay, north of South Biscay, winds W or SW 5 to 7 decreasing 4 or 5 at end of night, gusts, moderate or rough, locally very rough at first.

For south of South Biscay, W 4 to 6, occasionally 7 at first, decreasing 3 to 5 soon.

This bulletin also mentioned a threat of a cyclonic gale or near gale in the Bay of Biscay.

Area forecasts, issued by The Meteorological Office, Bracknell, were received at 0929 on 26 April, covering the period to 0800 on 27 April. These included a forecast for East Sole:

Cyclonic force 5 to 7 becoming NW'ly 4 or 5.

1.4 GENERAL ARRANGEMENT OF VESSEL (Figures 1 & 4)

Dutch Navigator is a single-hold, 2997 gross ton, general cargo vessel. She has two hatches but carries no cargo-handling gear. She is equipped to carry 297 TEU containers, 129 in the hold and 168 on deck. She is also equipped to carry grain, some refrigerated containers and dangerous goods.

Her main engine is a Deutz TBD 645 L6 of 2550kW which gives a service speed of 13.5 knots on about 11 tonnes/day of gasoil.

Her owners also operate three sister vessels of this design.

Figure 4



Dutch Navigator in Avonmouth Dock

1.5 CREW

Dutch Navigator was crewed by:

Position	Nationality	Certificate
Master	Dutch	Master of vessels less than 3000gt
Mate	Russian	Chief mate all ships
Second Mate	Russian	Officer in charge of watch all ships
Chief Engineer	Dutch	Chief engineer under 3000kW
Three Ratings	Ukranian	Certificates for navigational watch

This is in compliance with her Safe Manning Certificate, and all crew members held an appropriate certificate of competency issued by the Netherlands administration.

1.6 OWNER'S STANDING ORDERS

Dutch Navigator has an International Safety Management (ISM) Certificate, issued on 3 May 2000, following an audit by the classification society Germanischer Lloyd.

Part of her Safety Management Manual (SMM) covers the owner's guidance to the master should poor weather conditions be encountered. This states: *the master is to reduce speed in the event of heavy weather which is likely to cause damage.*

The owners also required the master to satisfy all statutory requirements.

Dutch Navigator carried a copy of the IMDG Code. However, she carried no Merchant Shipping Notice (M Notice) issued by the UK Administration, covering the carriage and stowage of dangerous goods.

1.7 DAMAGE TO STOW IN BAY 1

All nine containers in Bay 1 suffered damage to some extent. Some of the box containers, and one tank container in particular, suffered significant damage (**Figures 3, 5 & 6**).

The general direction of shift of the three stacks was towards the starboard side of the vessel. However, markings on the plating at the forward end of the hold indicates there had also been some movement forward and down.

All three lower containers showed signs of damage because of racking and, to varying degrees, crushing.

Figure 5



Box containers from Bay 1

Figure 6



The seven box containers, although damaged sufficiently to cause concern to their shippers, were seen as of limited significance to this incident, and the primary task was to make safe the two tanks containing dangerous goods. As none of the box containers held dangerous goods, this is an understandable approach and one that is generally adopted throughout this report.

The tank container in the middle tier of the port stack was relatively undamaged. However, the lowest tank in this stack suffered serious failures to its frame and some squeezing damage to its shell. The damage to this container and its frame is described in greater detail in Section 1.21.

1.8 CARGO SECURING MANUAL

The 1994 Amendments to the Safety of Life at Sea Convention (SOLAS) 1974 adopted by the Maritime Safety Committee by Resolution MSC.42(64) (as amended) requires an approved cargo securing manual to be carried on board many vessels; *Dutch Navigator* is one of those. The corresponding requirement in the UK regulations is contained in The Merchant Shipping (Carriage of Cargoes) Regulations 1999, which came into force on 15 March 1999.

Dutch Navigator carries a cargo securing manual, approved by the Netherlands Shipping Inspectorate on 15 April 1999. The manual includes a section covering the stowage and securing of containers.

Within a section covering *Forces acting on cargo units*, the manual states that its calculation methods and procedures are valid when the vessel's metacentric height (GM) is equal to, or less than, 0.96m. On departure Bilbao, the vessel's GM was 0.67m.

The section entitled *Stowage and Securing Principle* sets out the approved lashing arrangements for containers in the hold and on deck. These are:

In hold

- | | |
|--------------------------|--|
| <i>Bay 1 (foremost)</i> | <i>Independent stacks with:</i> <ul style="list-style-type: none">- <i>twistlocks at bottom</i>- <i>twistlocks between layers</i> |
| <i>Other Bays</i> | <i>Interconnected stacks with:</i> <ul style="list-style-type: none">- <i>single bottom stackers</i>- <i>double intermediate transversal stackers</i>- <i>pressure side supports</i> |
| <i>On deck (3 tiers)</i> | <i>Stowage with:</i> <ul style="list-style-type: none">- <i>dovetail foundations</i>- <i>bottom twistlocks</i>- <i>twistlocks between tiers</i> |

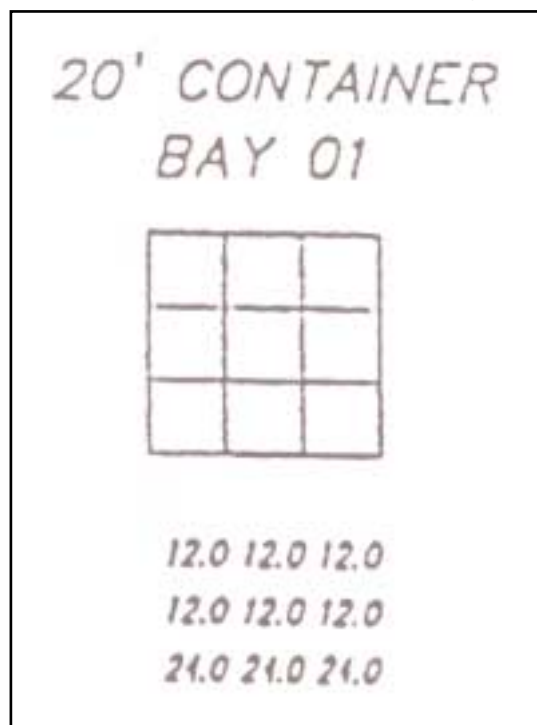
General warnings are also included setting out the dangers of exceeding the specified stack masses and/or having a mass distribution in a stack which is outside recommended limits. These warnings cite overstressed containers and securing arrangements as the likely consequences of stowing containers outside the specified limits.

To illustrate these warnings, examples are given for the percentage increase in loads on containers of having a mass distribution outside the specified range.

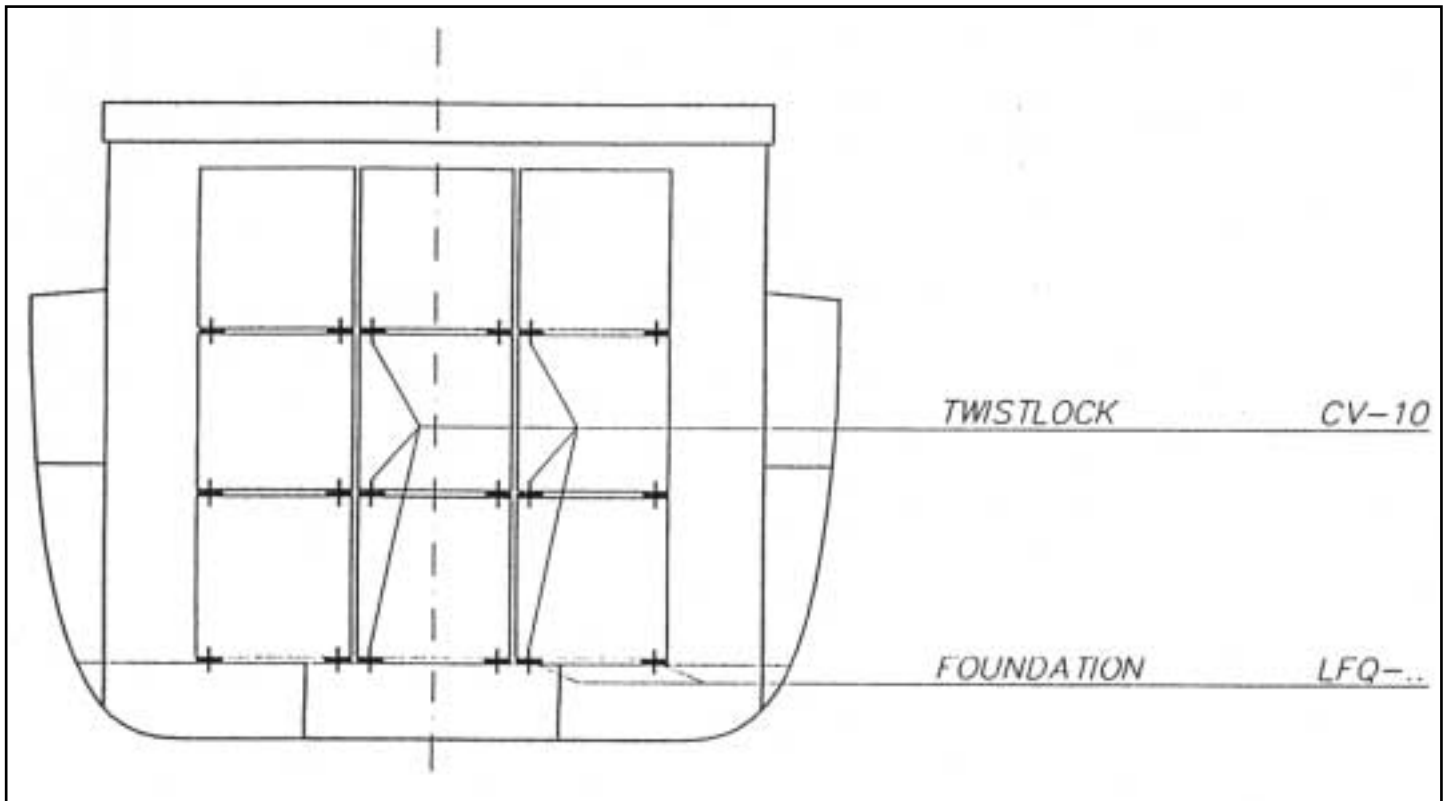
The limiting container weight distributions within stacks and bays and securing arrangements are also presented in graphic form. For Bay 1, the foremost, containers in the bottom tier are limited to 24t, all others in the bay to 12t (**Figures 7 & 8**).

The manual specifies no similar limitations on the stowage of 20ft containers in any other bays in the hold, except to place an upper limit on individual container mass of 24t, and advice to place containers of lesser mass than this towards the top of stacks.

Figure 7



Extract from cargo securing manual -
stack masses in Bay 1



Extract from cargo securing manual - container securing arrangements, Bay 1

1.9 CONTAINER STACK MASSES

During her stay in Bilbao, *Dutch Navigator* was loaded with containers for Avonmouth and Dublin. Containers in the hold were generally stacked three high, those on deck were in a single tier (**Figure 9**).

Of the 43 20ft containers loaded, 18 had a gross mass exceeding 24t. Only one was 12t or less.

The three stacks of three high 20ft containers in the foremost bay in the hold, Bay 1, were secured to the vessel's tanktops by twistlocks at the corner of each container. Twistlocks were also fitted at each corner between the tiers.

The vessel's cargo securing manual sets out the limiting stack masses for a given stowage position and container length. In general, 20' containers stowed in the hold have a limiting stack mass of 72t, each tier being 24t. However, Bay 1 is alone in having a limiting stack mass of 48t; the lower tier 24t and the two others 12t each.

For the containers loaded in Bilbao, the corresponding stack masses in Bay 1 were, from port to starboard, 78t, 58t and 68t. These were 162%, 120% and 141% of values recommended in the cargo securing manual.

Other stacks in the hold were generally and approximately within the mass limits set out in the cargo securing manual. However, three stacks were 110% to 115% of prescribed values.

Figure 9

M/V DUTCH NAVIGATOR										DATE: 24-04-01	
20		14			10		06				
21	19	17	15	13	11	09	07	05	03	01	
Deck	(14)	(22)	(23)	(26)	(20)	(8)					
	(13)	(24)	(27)	(27)	(21)	(8)					
	(14)	(22)	(25)	(27)	(8)	(22)					
	(23)	(22)	(24)	(25)	(19)	(10)					
	(22)	(20)	(26)	(25)	(28)						
Hold	(23)	(26)	(26)	(26)	(28)				(26)		
	(26)	(23)	(25)	(26)	(28)				(11)		
	(27)	(22)	(25)	(26)	(28)				(22)		
	(27)	(26)	(26)	(25)	(27.6)						
	(26)	(26)	(26)	(27.5)	(28)	(25)			Second Tier		
	(25)	(24)	(27)	(27)	(28)	(25)			(27)		
	(24)	(23)	(27)	(26)	(21.5)	(25)			(23)		
	(24)	(25)	(28)	(26)	(28)	(25)			(24)		
	(26)	(22)	(26)	(27)	(28)	(24)			First Tier		
	(24)	(24)	(26)	(24)	(28)	(25)			(25)		
	(26)	(27)	(24)	(26)	(28)	(25)			(24)		
	(27)	(26)	(27)	(28)	(29.5)	(25)			(22)		
Lower hold											

Key

(26) 40ft container + its mass (t)

(26) 20ft container + its mass (t)

Stowage plan

1.10 CONTAINER RACKING LOADS

The cargo securing manual sets out a method for calculating the likely racking loads on containers. It is emphasised that this method is applicable for vessel metacentric height (GM) less than, or equal to, 0.96m.

The calculation differentiates between stowage on deck or under deck and longitudinal position.

Applying this method to a stack of three containers in Bay 1, complying with the recommendation to limit the respective gross masses to 24t, 12t and 12t for each tier, with the lowest container being 24t, the resultant racking force on the lowest container is 153kN.

Repeating the process for the single stack to the port side of Bay 1, which held the two tank containers, having gross masses of 25t, 27t and 26t gives a resultant racking force on the lowest container of 278kN.

For the other two stacks in Bay 1, the calculated racking load for the centre stack was 195.5kN and for the starboard stack 242kN.

1.11 DANGEROUS GOODS

A total of 114 containers were loaded on *Dutch Navigator* in Bilbao. Of these, six contained dangerous goods defined by a classification in the IMDG Code.

Two of these were the tank containers stowed in the port stack in Bay 1 of the vessel.

Hydrofluorosilicic Acid

The lower port container, 25 tonnes gross, held hydrofluorosilicic acid, UN 1778. Its IMDG Code entry in the list of dangerous goods states:

Colourless liquid
Highly corrosive to most metals
Stowage category A
May cause severe burns to skin, eyes and mucous membranes if containing free hydrofluoric acid

Stowage category A allows the substance to be stowed either on deck or under deck on either cargo ships or passenger ships.

The corresponding Emergency Schedule for the substance is 8.06. This specifies that emergency equipment carried should be:

Protective clothing (gloves, boots, coveralls, headgear)
Self-contained breathing apparatus

*Inert absorbant material (e.g. diatomaceous earth)
Spray nozzles.*

Additional action specified is to *Turn ship off-wind.*

Sodium Chlorite

Stowed on the above container was a second tank, of 27 tonnes gross, containing sodium chlorite, UN1908. Its entry in the IMDG Code list of dangerous goods states:

Colourless liquid

In contact with acid, evolves very irritating and corrosive gases.

Oxidising solution.

May cause fire in contact with organic materials such as wood, cotton or straw.

Mildly corrosive to most metals

Causes burns to skin, eyes and mucous membranes

Stowage category B, 'Away from' acids

Can also be a marine pollutant or severe marine pollutant.

The Emergency Schedule for the substance is 8.06. The same emergency equipment is required as for hydrofluorosilicic acid but the schedule excludes advice to turn ship off-wind.

Information supplied to BPC by its advisers during the early stages of this incident indicated that mixing of hydrofluorosilicic acid and sodium chlorite could result in an explosion.

Stowage category B allows the substance to be stowed on deck or under deck on ships that carry no more than 25 passengers, or one passenger per 3 metre of overall length, whichever is the greater number. Where this number of passengers is exceeded, stowage under deck is not permissible. *Dutch Navigator* carried no passengers.

Of the remaining four containers carrying dangerous goods, two contained Class 3.2 substances and were stowed on deck. The last two held substances of Class 4.1 and were stowed in the hold. None of these four was a tank container.

Stowage of all containers on board was in accordance with a stowage plan compiled by the chief officer and approved by the master.

1.12 DEFINITION OF 'AWAY FROM'

The table of segregation of freight containers on board container ships, in the IMDG Code, sets out the segregation to comply with the requirement that the substances in the two tank containers, UN 1908 and UN 1778 are stowed 'away from' each other. The requirements are dependent on whether open or closed containers are used, as shown in **Figure 10**.

Figure 10

SEGREGATION REQUIREMENT	VERTICAL			HORIZONTAL						
	CLOSED VERSUS CLOSED	CLOSED VERSUS OPEN	OPEN VERSUS OPEN		CLOSED VERSUS CLOSED		CLOSED VERSUS OPEN		OPEN VERSUS OPEN	
					ON DECK	UNDER DECK	ON DECK	UNDER DECK	ON DECK	UNDER DECK
"AWAY FROM"	ONE ON TOP OF THE OTHER PERMITTED	OPEN ON TOP OF CLOSED PERMITTED	NOT IN THE SAME VERTICAL LINE UNLESS SEGREGATED BY A DECK	FORE AND AFT	NO RESTRICTION	NO RESTRICTION	NO RESTRICTION	NO RESTRICTION	ONE CONTAINER SPACE	ONE CONTAINER SPACE OR ONE BULKHEAD
		OTHERWISE AS FOR OPEN VERSUS OPEN		ATHWART-SHIPS	NO RESTRICTION	NO RESTRICTION	NO RESTRICTION	NO RESTRICTION	ONE CONTAINER SPACE	ONE CONTAINER SPACE

Extract from segregation table of IMDG code

1.13 FURTHER REQUIREMENTS

Paragraph 7.1.1.16 of Part 7 of The IMDG Code states:

Portable tanks should not be overstowed by other cargo transport units unless they are designed for that purpose and transported in specially designed ships, or they are specially protected to the satisfaction of the competent authority.

The Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997 are applicable to United Kingdom ships wherever they may be, and to other ships while they are in United Kingdom waters. The Merchant Shipping Notice MSN1705(M) is an integral part of these Regulations and this notice states, at paragraph 5.1.1:

Portable tanks should not be overstowed below deck, unless secured by proper stowage within the guides of a cellular container ship.

1.14 TANK CONTAINER TSTU3000002

This was the lower of the two tank containers stowed in the port stack of Bay 1 and, of the two tanks, is the one that suffered the most damage. It was purchased by Tank Speed Ltd. Newport, South Wales, in 1997, from Bell Lines Ltd, which ceased trading at that time.

General description

The tank is cylindrical, of 2.159 metres external diameter, with convex dished ends and overall length of 5.944 metres. It is of all-welded construction, with all internal welds dressed flush at time of manufacture.

It is fitted within a rectangular open framework of standard 20ft (6.1m) container dimensions, 8ft6ins (2.6m) high by 8ft (2.45m) wide (**see Figure 11**).

The shell is 8mm thick, with ends of 7.5mm. Internally it is lined with 5mm silica-free butyl rubber, intended for use with hydrofluorosilicic acid. Three reinforcing rings and doublers are welded around the outside of the shell.

On each of the convex dished ends, or headers, are 3mm thick doubling plates. To each of these is welded a 457mm diameter trunnion of 5mm thick plate. The trunnions have a centreline about 110mm above the longitudinal centreline of the tank. The end face of each trunnion protrudes about 45mm from the header.

There are no openings in the lower part of the tank. Filling and emptying is by an 80mm diameter diptube extending down from a flanged manhole fitting, of 520mm opening diameter, in the top of the tank. The lower end of the diptube extends into a domed sump set into the shell. At the time of the tank's manufacture, the lower end of the diptube was located by a welded and rubber coated support ring.

Also on this manhole fitting are a vent, air release and a small inspection cover.

The major elements of the frame's ends are vertical corner posts and horizontal top and bottom members, of 100mm x 100mm x 5mm square section, connected by steel corner castings. Diagonal members of 80mm x 40mm x 3mm rectangular hollow sections run from each corner casting, across the face of the trunnion on the tank's header, to the opposite corner casting. Eight other hollow rectangular longitudinal members connect the corner castings and posts of the two end frames.



Photograph of similar unit

History and markings

At the time of manufacture, July 1988, the tank and frame were subjected to various inspections and tests. The following are relevant to the tank's behaviour during this incident:

Testing of the butyl rubber lining to locate defects. None found.

Thickness and hardness checks of rubber lining were satisfactory.

Rigidity of the frame's design was assessed for type approval purposes. Records state that these tests were performed in accordance with ISO 1496/3.

The tank's original owner, Bell Lines, ceased trading in 1997 and details of the tank's maintenance and operational history before then is unobtainable. However, from personnel associated with the tank's operation since manufacture, it is understood that the only substance carried in the tank has been hydrofluorosilicic acid (UN1778).

This source also recalls that, before this incident, the tank had previously been carried at sea only in cellular container vessels.

The tank's most recent documented inspection was performed on 19 June 2000 by a surveyor from Bureau Veritas in Avonmouth. This examination included a full hydraulic pressure test of the barrel to 4.5 bar. The report of the survey shows that the examination was completed without remark.

Records of the tank's repair history since 1997 show that, in February 1998, a significant amount of repair and test work was performed in Rotterdam. This included:

*Front: bottom rail dent/bent & 2 x holed; to renew complete
Diagonal bar dent; partly to renew*

Right hand side: top rail dent; to straighten

Inside: butyl rubber patch 500 x 500 to fit incl 2 x flanges to provide with rubber lining

Further repairs to front and rear cross-members were made during August 1999 in the UK.

On an unknown date, an area of the shell around the sump was cut out and a repair insert welded in. The rubber liner was fitted with a corresponding patch. The guide for the dip tube was probably removed at this time.

The Safety Approval Plate attached to the frame, which is required by the International Convention for Safe Containers, 1972, (CSC) has the following markings:

M1 Engineering, Bradford, England
Date of manufacture 22/7/88
Tank Design Codes ASME SEC8 Div1 RID ADR IMO
CSC UK.DOT & TIR
Serial No IS/1675/88
Design/Max WP 3bar 43.5 psig
Test Pressure 4.5bar 65psig
Hyd Test Date 1-7-88
Metallurgic Design Temp 212°F 100°C Temp Ref Area 3
Tank Material BS1501-151-43A Carbon Steel
Tank Thickness Barrel 8mm
Heads 7.5mm
Corrosion allowance Nil
Tank Lining Silica Free Butyl Rubber
Total capacity 20288 litres 4463 Imp Galls
Tare Weight Max Payload Gross Weight
4985 25495 30480 kgs
4.91 25.09 30 Tons
2½ yearly test date 6/00 [most recent date]

CSC SAFETY APPROVAL

RID/ADR Approval No GL/BEI/304 Date 22-7-88
IMO Type Approval GB/IMO/BEI/304
Allowable Stacking Weight for 1.8G 152400kg 336000lbs
Racking Test Load 15000kg 33067lbs
Next Examination Date 11/97 [*most recent date*]
ACEP-GB-145

1.15 THE INTERNATIONAL CONVENTION FOR SAFE CONTAINERS (CSC)

In the 1960s, there was a rapid increase in the use of freight containers for the consignment of goods by sea and a corresponding development of specialised container ships. In 1967, the International Maritime Organization (IMO) undertook to study the safety of containerisation in marine transport. The container itself emerged as the most important aspect to be considered.

IMO, in co-operation with the Economic Commission for Europe (EEC), developed a draft convention and, in 1972, the finalised Convention was adopted at a conference jointly convened by the United Nations (UN) and IMO. This is the International Convention for Safe Containers, 1972 (CSC) and it has two goals.

One is to maintain a high level of safety of human life in the transport and handling of containers by providing generally acceptable test procedures and strength requirements.

The other is to facilitate the international transport of containers by providing uniform international safety regulations, equally applicable to all modes of surface transport. In this way, proliferation of divergent national safety regulations can be avoided.

The requirements of the Convention apply to the great majority of freight containers used internationally, except those designed for carriage by air. As it was not intended that all containers or reusable boxes should be affected, the scope of the Convention is limited to containers of a prescribed minimum size having corner fittings – devices which permit handling, securing or stacking.

The approval of a container, as evidenced by the safety approval plate granted by one contracting state, should be recognised by other contracting states. This principle of reciprocal acceptance of safety-approved containers is the cornerstone of the Convention; once approved and plated it is expected that containers will move in international transport with the minimum of safety control formalities.

The Convention places a responsibility for maintaining a container in a safe condition on its owner, who is required to examine the container, or have it examined, at specified intervals. The first examination shall be no more than 5 years from date of manufacture, and thereafter to be re-examined at intervals of no more than 30 months. All examinations shall determine whether the container has any defects which could place any person in danger.

Alternatively, the Convention allows owners the option of having containers examined under a continuous examination programme approved by the Administration concerned. All examinations performed under such a programme shall be performed in connection with a major repair, refurbishment, or on-hire/off-hire interchange, and in no case less than once every 30 months. Again, the purpose of the examinations is to determine whether a container has any defects which could place any person in danger.

A tank container subjected to a continuous examination programme is required to be marked, on its safety plate, with the initials ACEP, initials for the country of approval and the number of the programme. When marked in this way, the date of the next inspection is no longer placed on the safety plate.

1.16 EXAMINATION OF CONTAINERS

In the UK, the Freight Containers (Safety Convention) Regulations 1984 require examinations of containers to be in accordance with a scheme or programme approved by the Health and Safety Executive (HSE).

The HSE publishes conditions for approval of examination schemes or programmes. These conditions set out the standards of competence required by those carrying out the examinations, factors to be considered during examination, marking of safety plate and record keeping.

The owners of the tank container TSTU300000, Tank Speed Ltd, made an application to HSE in May 1996 for approval under the CSC to adopt a continuous examination programme. This application was accepted and approval given in February 1997.

Standard conditions applied to this approval were that the safety plate be marked with the legend ACEP-GB-145 and that examinations be in accordance with HSE's 'Conditions for Approval of Examination Schemes and Programmes'. These conditions, however, set out no detailed requirements for container condition.

1.17 STANDARDS FOR CONTAINER CONDITION

The international business of transport by tank container has produced several sets of condition standards for tank containers internationally. These standards have become generally accepted, and form the basis for the inspection and repair regimes operated by owners and inspection bodies. However, they are not mandatory in the UK.

Two significant sets of standards are:

The Acceptable Container Condition Manual (ACC) published by the International Tank Container Organisation (ITCO); and

Tank Container Repair Guidelines and Definitions published by the Tank Container Association (TCA).

The ACC manual includes as unacceptable conditions, improper repairs to bottom rails and bracing. The TCA guidelines set out the conditions which require rectification in these members, such as holes, cracks, broken welds, distortion etc.

Neither guide offers any standards on the quality of repairs to framework. However, tank inspection bodies, typically, have a requirement that all welders are approved to an accepted code, such as the American Society of Mechanical Engineers (ASME) or British Standards (BS), and that the work is performed to a good standard of workmanship.

1.18 STANDARDS FOR CONTAINER REPAIRS

While no statutory standards exist for frame repairs, the manufacturers of the frame and tank of TSTU3000002 adopt a standard technique for repairing the end frames' box section cross-bracing. This technique is designed to restore the strength to the structure, and to enable the necessary welding operations to be performed in such way as to aid the production of good quality welds.

In particular, the replacement of cross-braces calls for the damaged member to be cropped at the circumference of the tank's trunnion. The replacement length of bracing is then butt-welded to this cut surface on three sides. The weld on the fourth side, that facing the tank, is made to join the two parts of the bracing, and the circumference of the tank's trunnion. This allows the welding rod to be at a shallow angle to the bracing, and overcomes the need for perpendicular access to the rear face of the box section. The weld on two sides of the cross-brace are then dressed, and reinforcing doubling plates are welded over.

Access to other members of the end frames, to perform welded repairs, is not restricted by the proximity of any part of the tank. Their replacement is thus possible using welding procedures similar to those employed at the manufacturing stage.

An alternative method, proposed by an inspection body, is to employ a scarfed welded joint so that the joint is not square to the section. This increases the length of weld material and reduces the effects of generating a locally weakend area.

These techniques are relevant, as the cross-bracing on container TSTU3000002, which failed during this incident, had previously been repaired.

1.19 ISO 1496/3 TESTS

According to the International Convention for Safe Containers (CSC), containers tested in accordance with the methods described in ISO Standard 1496 are deemed to have been fully and sufficiently tested for the purposes of that convention.

Manufacturer's records state the frame's design underwent tests, which followed the requirements of ISO 1496/3, during type approval of the frame's design.

For the purpose of assessing the transverse rigidity of a design (resistance to racking loads) the following is required by this ISO standard:

The (empty) tank container shall be placed on four level supports, one under each corner fitting, and shall be restrained against lateral and vertical movement by means of anchor devices acting through the bottom apertures of the bottom corner fittings. Lateral restraint shall be provided only at a bottom corner fitting diagonally opposite to and in the same end frame as a top corner fitting to which force is applied.

Forces of 150kN shall be applied either separately or simultaneously to each of the top corner fittings on one side of the tank container in lines parallel both to the base and to the planes of the ends of the tank container. The forces shall be applied first towards and then away from the top corner fittings.

The allowable deflection under full test loading is:

The sideways deflection of the top of the tank container with respect to the bottom of the tank container at the same time it is under full transverse rigidity test conditions shall not cause the sum of the changes in length of the two diagonals to exceed 60mm.

There is no specific requirement for permanent deformations to be measured and recorded.

1.20 RESULTS OF RACKING TESTS ON END FRAME OF TSTU3000002

Results of the ISO1496/3 tests on the end frame design of this container, performed in 1979, showed that the maximum change of length of a diagonal was 3mm with the frame under 150kN load. The maximum sum of the changes in length of two diagonals was 6mm. It was further recorded that, 5 minutes after the loads were removed, the end frames showed no permanent set or deflection.

1.21 DAMAGE TO TANK CONTAINER TSTU3000002

The frame had suffered deformation and fracturing damage, which was severe in the end frames. As a consequence of the collapse of the frame, the tank barrel had come into contact with the tank top of *Dutch Navigator*, causing deformation damage to the barrel (see Figures 12, 13, 14 & 15).

This deflection of the barrel was sufficient to cause the sump dome to make contact with the end of the dip tube. This effectively sealed the dip tube, making it impossible to empty the tank by normal means. This was why a separate pump was used to remove the acid after the container was landed ashore.

The diagonal members, or cross-bracing, of both end frames had failed. Those on the front frame both showed signs of failure because of compressive loading resulting in buckling. One diagonal member had fractured at the site of a butt-welded repair. The lower horizontal cross-member had separated from the front corner castings, at welded joints, and both corner posts had buckled.

On the rear frame, the diagonal members each showed signs of failure by different types of loading; one due to compression, the other tension. One had fractured, again at a butt-welded repair. A corner post was badly bent as was the lower cross-member.

Longitudinal frame elements, having attachments to the end frames, were also damaged. Several areas of the shell were identified as being sites where acid had leaked before the container was emptied.

Figure 12



Damaged front end frame

Figure 13



Damaged rear end frame

Figure 14



Damage to bottom of barrel

Figure 15



1.22 METALLURGICAL EXAMINATION OF CONTAINER SHELL

After the tank's contents were removed, neutralised and drained, the shell was examined and tested to establish the cause(s) of leakage(s). The work was contracted by the MAIB to The Test House (Cambridge) Ltd. (TTH) a wholly owned subsidiary of The Welding Institute (TWI).

Two samples of the shell plating were selected to include the sites showing symptoms of leakage. These samples, each having an area of approximately 1m², were cut from the shell using a slitting wheel, and were transported to TTH for examination. TTH carried out laboratory examination of the samples and interpreted the results.

The first leak site investigated was adjacent to the sump dome (**see Figures 16 & 17**).

This leak site was located close to a 'T' joint in the liner, where a longitudinal seam intersected a rectangular insert or patch around the drain sump (**see Figure 18**). A sharp cut in the liner coincided with this leak site. This cut was 21mm long and extended from the patch's edge in the tank's longitudinal direction (**see Figure 19**).

The liner was stripped from this part of the shell to examine the liner/shell interfaces. The shell showed some corrosion (**Figure 20**). Sections taken through this damage show the leak site (**Figure 21**) and areas where corrosion extended over 50% through shell thickness (**see Figure 22**).

Once the liner had been removed from this area it showed two sharp cuts on its under face (**Figure 23**). One measured 46mm in length and the second was 61mm long. Neither cut was in the liner's patch material, and each appeared to have its origin at the cut edge of the liner, over which was fitted the patch. The patch overlapped both of these cuts except for a length of 21mm of one cut which was visible from the cargo, or liquid, side of the liner. It was through this part of the cut that acid had been able to contact the steel shell of the tank.

The second leak site was located in the bottom of the rear dished header, on the radius (**Figure 24**). Another suspected leakage was close by, and was identified by signs of external corrosion damage. Both of these sites were investigated, but the site showing signs of external corrosion was proved to have been caused only by external corrosion. There was no sign of under-liner corrosion in this area.

However, the second leakage site coincided with another "T" joint in the liner (**Figure 25**). Removal of the liner in this area confirmed local corrosion damage (**Figures 26, 27 & 28**). A corresponding defect in the liner joint was found using a dye penetrant technique (**Figure 29**). It was through this defect that acid had been able to come into contact with the shell plating.

Figure 16



Site of leakage, shown arrowed

Figure 17



Site of leakage and associated rust staining

Figure 18



'T' joint in liner

Figure 19



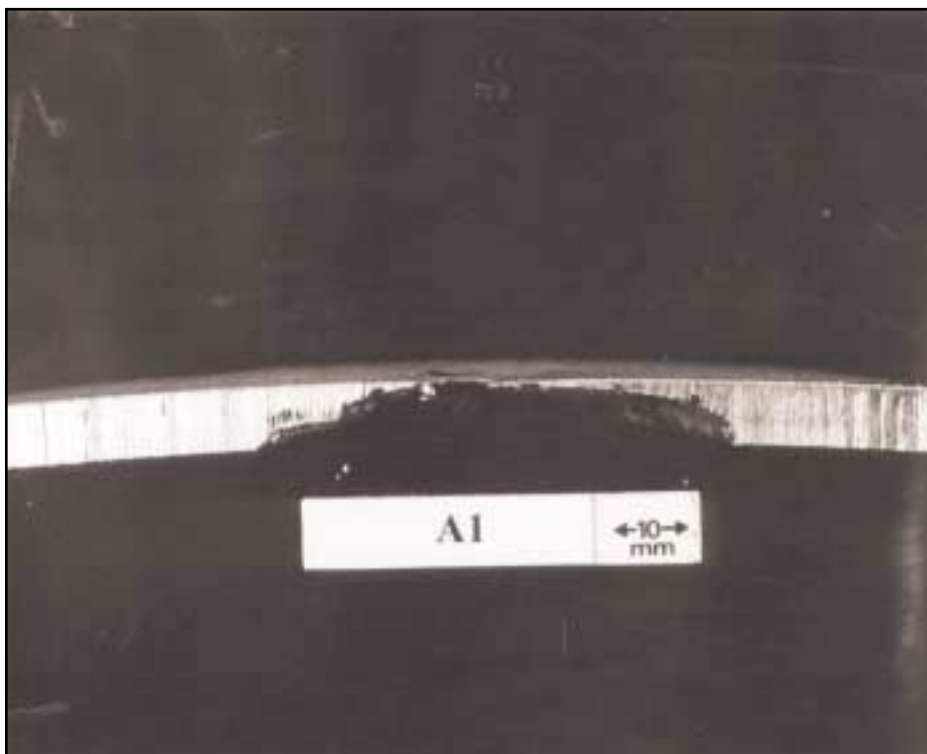
Cut in butyl liner
(lower centre of figure)

Figure 20



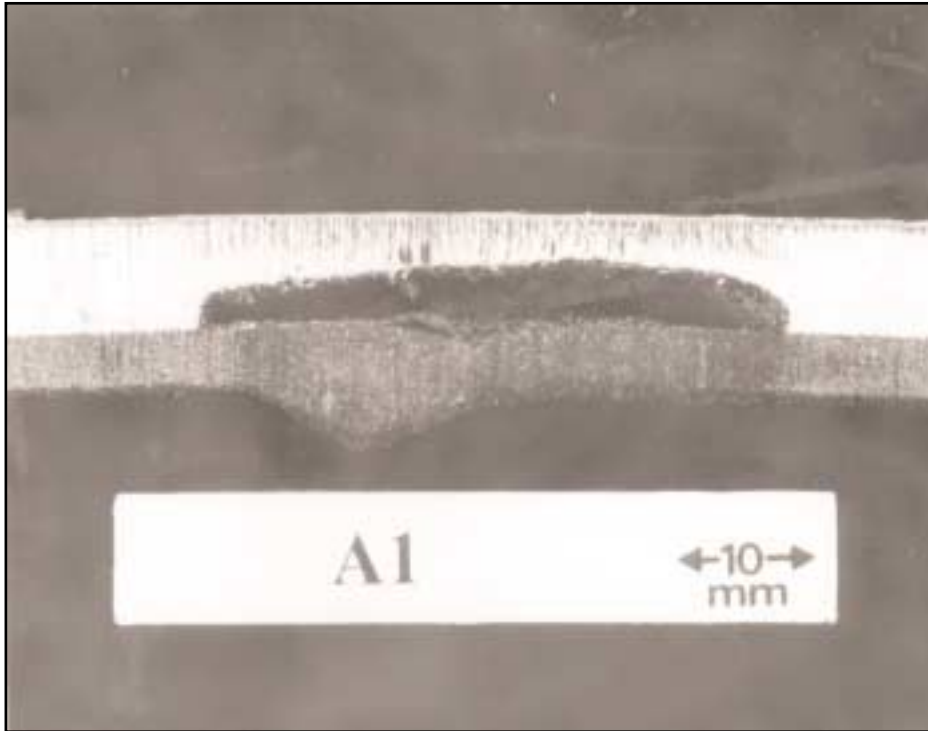
Shell corrosion in region of liner's 'T' joint

Figure 21



Section through corroded part of shell under liner's 'T' joint showing leak site

Figure 22



Under-liner corrosion damage

Figure 23



Cuts in underside of butyl liner

Figure 24



Suspected second leak site and corrosion damage - both arrowed

Figure 25



Second leak site

Figure 26



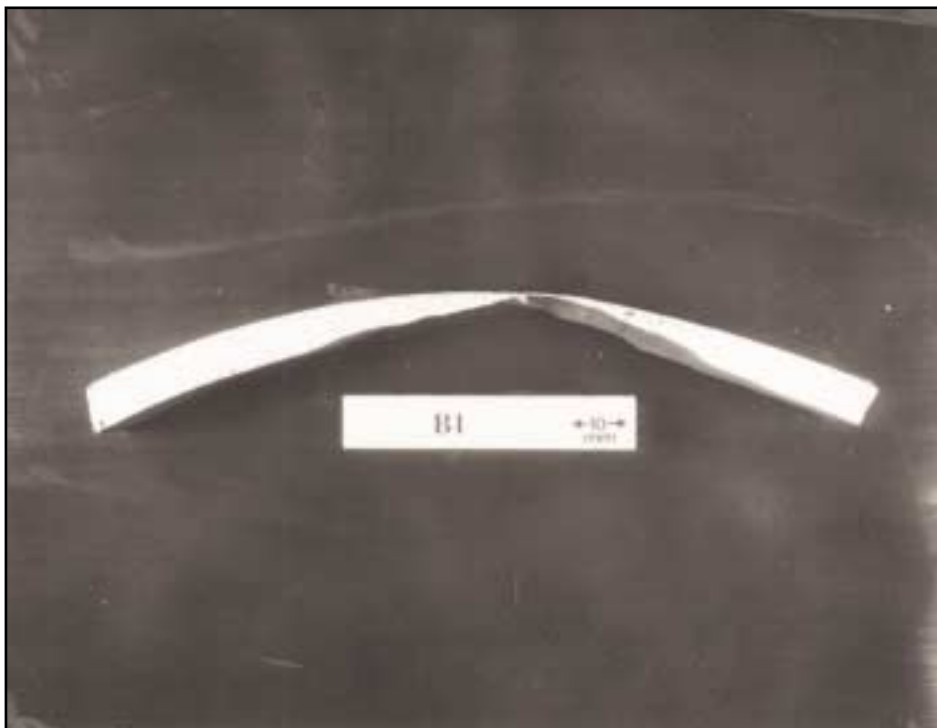
Second leak site - view on inner surface

Figure 27



Second leak site - view on outer surface

Figure 28



Section through second leak site



Site of liner perforation identified by dye penetrant test

Another feature of the liner was noted during these examinations. Efforts had been made to perform surface repairs to the liner in this region. These consisted of over-painting the liner with a hard brittle resin which showed extensive post-application cracking (**Figure 30**). However, the examination showed no evidence of liner debonding, or defects in the liner's jointing in these regions of resin application. Samples of this resin were examined, and it showed the characteristics of an epoxy resin of the type commonly marketed under the name 'Araldite' (**Figure 31**).

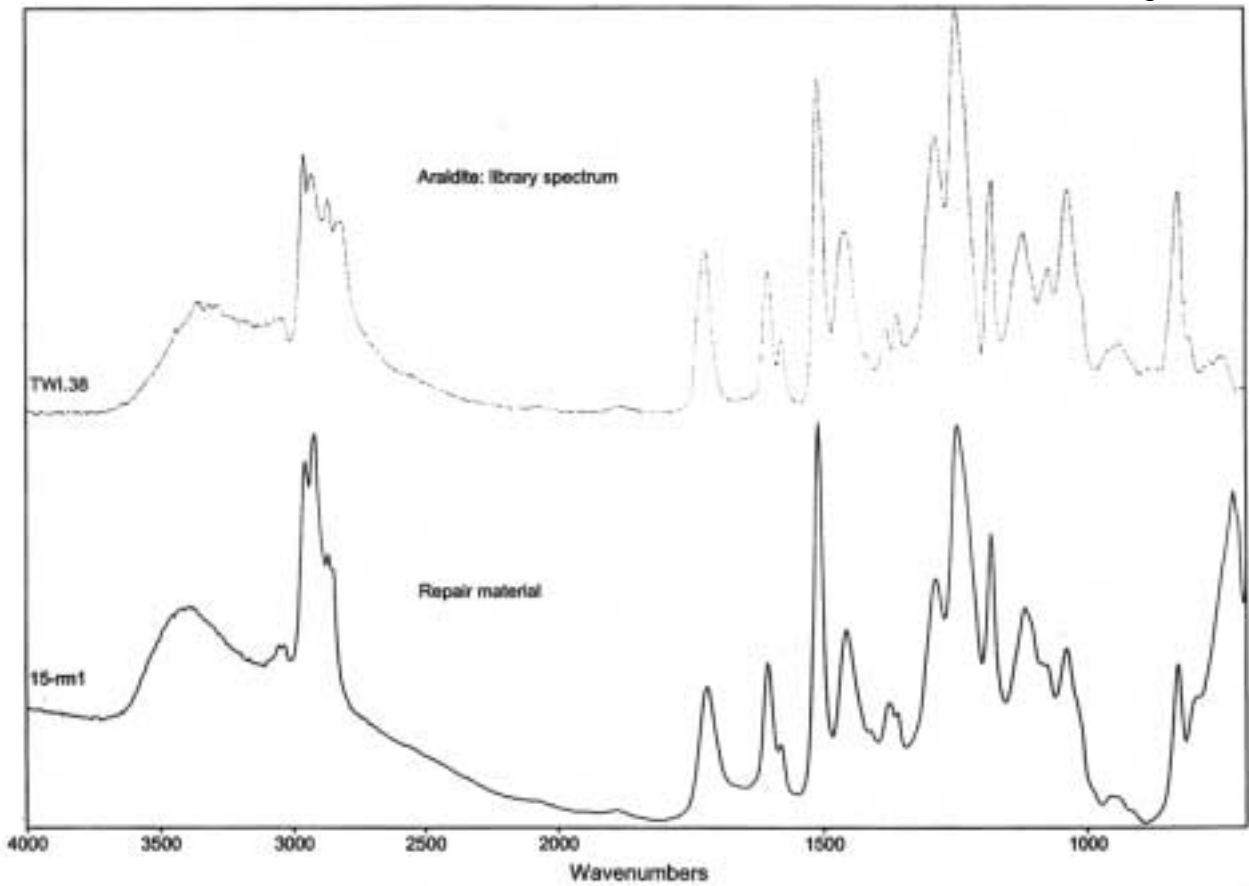
Further data supplied by TTH showed that carbon steel has a corrosion rate greater than 1.27mm per year in hydrofluorosilicic acid; the highest figure normally quoted in published literature.

Figure 30



Cracking in resin material used for repairs

Figure 31



Comparison of repair material and epoxy resin

1.23 METALLURGICAL EXAMINATION OF CONTAINER FRAME

A metallurgical examination of damaged parts of the container's frame was also performed. With the MAIB's agreement, this work was undertaken by a consultant on behalf of the owners of *Dutch Navigator* and their P&I insurers. He, in turn, supervised laboratory examinations of samples, also performed at The Test House (Cambridge), and interpreted the results.

The samples selected for examination were:

- i) bottom left-hand corner casting from front end
- ii) bottom right-hand casting from front end
- iii) both sides of fractured lower diagonal member from front end
- iv) fractured upper diagonal member from rear end

The examination identified that the lower horizontal member at the front end had been renewed, and the diagonal members from the end frames had been part renewed. The welds associated with these repairs contained major defects, including absence of weld metal and lack of weld penetration.

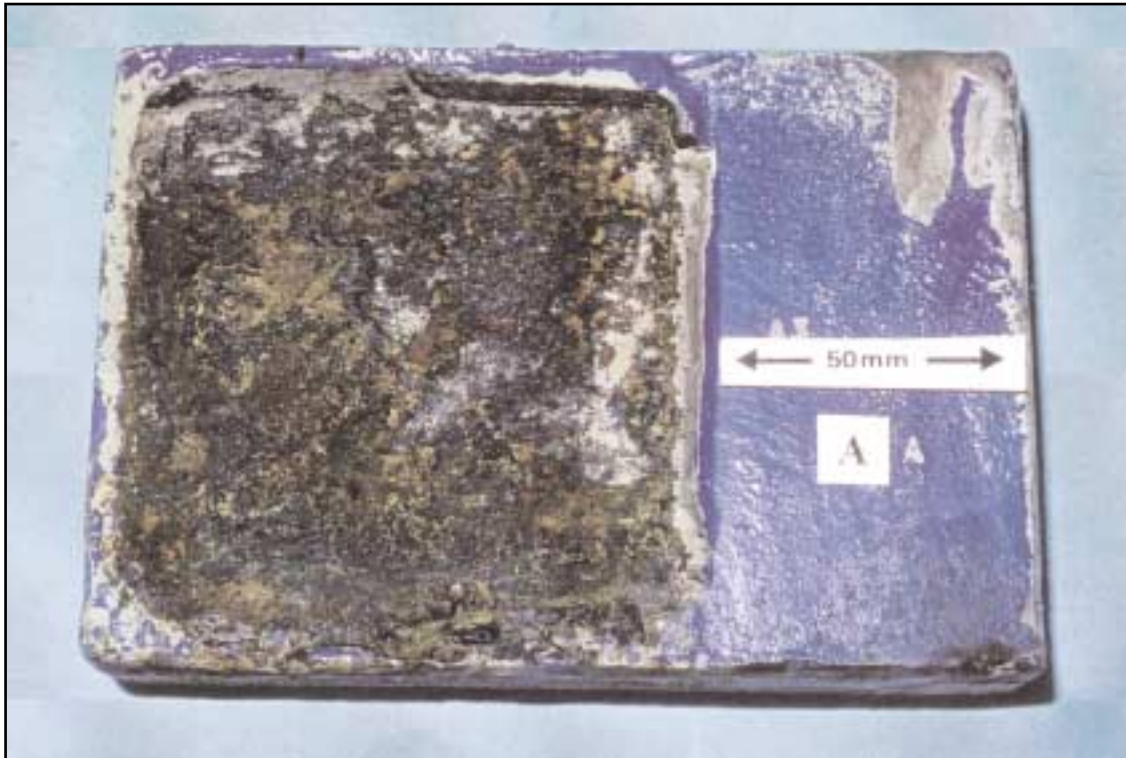
Figure 32 shows one of the lower corner posts from the front frame. The rectangle surrounding the area of corrosion is the remains of the welded attachment to the lower horizontal member. Two sides of the rectangle show signs of welds which have failed because of overload. One other side shows no sign of weld material, and the remainder shows only small weld deposits. Thus, effective fillet welds had been provided on only two of the four sides.

Figure 33 shows the other lower corner post from the front frame. Again, the rectangle surrounding the area of corrosion is the remains of its welded attachment to the horizontal member. Three sides had effective fillet welds applied. However, the fourth, the lower face, had only a short section of weld applied.

Figure 34 shows one fracture surface of the failure which occurred at the welded repair on the diagonal of the front frame. **Figure 35** shows the other fracture surface. Both surfaces show, at several positions, blue paint which had been applied to the outside surfaces of the diagonal and frame. This clearly shows the absence of welds in these areas. Other parts of the welded connection lacked weld material, had incomplete penetration, or slag inclusions and porosity.

Shown in **Figure 36** is one fracture surface from the diagonal of the rear frame. The welds forming the repair were found to have poor penetration, and had suffered from corrosive attack. Some features also suggested that cracks had been present in parts of these welds before the failure which occurred on *Dutch Navigator*.

Figure 32



Front left corner post

Figure 33



Front right corner post

Figure 34



Failed weld repair on front diagonal

Figure 35



Mating surface to failure shown in Figure 33



Failed weld repair on rear diagonal

1.24 THE PORT MARINE SAFETY CODE

Following a review of the Pilotage Act 1987, and with a wide variety of contributions from those associated with the ports industry, the Port Marine Safety Code was published by The Department of the Environment Transport and the Regions (DETR) in November 2000. The target date for its implementation was the end of 2001. However, even at the time of publication, many harbour authorities reported they had already made significant progress with its implementation.

Associated with the Code is *A Guide to Good Practice on Port Marine Operations*. This was published, also by DTLR, in September 2001 and is intended to support the Code and offer advice on its implementation.

This Code is intended to introduce a national standard for every aspect of port marine safety. Without creating new legal duties for harbour authorities, it aims to improve safety for those who use or work in ports, their ships, passengers and cargoes, and the environment. It establishes a measure by which harbour authorities can be accountable for the legal powers and duties which they have to run their harbours safely.

The Code is intended to apply to all harbour authorities, to the extent that they have duties and powers relating to marine safety. It applies, to port marine operations, the well-established principles of risk assessment and safety management systems. Harbour authorities must apply these principles if they are to discharge their duties and powers to the national standard established by the Code.

An obligation is placed on harbour authorities with respect to dangerous substances. A harbourmaster has powers to prohibit the entry into a harbour of any vessel carrying dangerous goods, if the condition of those goods, or their packaging, or the vessel carrying them is such as to create a risk to health and safety, and to control similarly the entry on to dock estates of dangerous substances brought from inland.

The harbourmaster also has powers to regulate the movement of vessels carrying dangerous goods. Prior notice must be given to bring dangerous substances into the harbour area from sea or inland. The period of notice is normally 24 hours, although the harbourmaster has some powers of discretion on both the period, and form of, the notice.

Harbour authorities have a duty to prepare emergency plans for dealing with dangerous substances.

1.25 BRISTOL PORT COMPANY'S EMERGENCY PLAN

The Emergency Plan of the Port identifies the level of response according to the perceived severity of an incident. Responses are according to the rising scale of gravity Minor, Port Emergency and Major Incident. Port Emergencies are further sub-divided into the classifications of Minor and Major.

To integrate the Plan with the emergency services and other agencies, three levels of command structure are defined. These are Bronze, Silver and Gold, designations which are in common use among emergency agencies in the UK.

Minor Incidents cover road traffic accidents, industrial accidents, minor pollution, minor fires, disruption to normal operations, warning from external agencies of major incident not expected to affect Port.

The Plan defines an incident as a "Port Emergency" as one which meets one or more of the following criteria:

- (a) a real or perceived threat to life;
- (b) serious damage or the potential for serious damage to the environment, vessels, installations, plant or equipment;

- (c) the requirement to mobilise external and internal services and resources outside the normal day to day requirements;
- (d) the closure of a navigational channel, or other such threat to the safety of navigation as a result of a marine or land-based incident.

A “Major Incident” is one which includes some, or all of the following:

- (a) the rescue and transportation of a large number of casualties;
- (b) the involvement either directly or indirectly of large numbers of people;
- (c) the handling of a large number of enquiries likely to be generated both from the public and the news media;
- (d) the large scale combined resources of the police, Avon Fire Brigade and Avon Ambulance Service;
- (e) the mobilisation and organisation of the emergency services and supporting services, for example, local authority to cater for the threat of death, serious injury, or homelessness to a large number of people.

The incident on board *Dutch Navigator* was declared a “Major Incident” under the Port’s Emergency Plan at 1800 on 27 April 2001.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents in the future.

2.2 THE SHIFT OF STOW

Although the collapse of any of the three stacks might have contributed to the subsequent collapse of the other two, the precise order of stack failure is not known. Largely because the racking load on the lowest container in the port stack was higher than the other two, it is considered likely that this stack failed first. Extra racking loads were then applied to the centre, and then the starboard stacks, as the stow progressively failed.

Because of this presumed order of failure, and the dangerous nature of the contents of the two tank containers in the port stack, this report and analysis concentrates mainly on the lower port container and the failure of its frame.

2.3 THE PASSAGE

During *Dutch Navigator's* passage across the Bay of Biscay, weather conditions were sufficiently poor for the master to reduce her speed. This was in accordance with guidance he received from the owner.

However, the weather conditions were not particularly severe, with winds no more than force 7 to 8. A vessel of *Dutch Navigator's* size, with properly secured cargo, should not be troubled by such conditions.

Apart from the containers stowed in Bay 1, no other containers on board shifted because of the weather or movement of the ship.

The poor weather was an important factor in the shift of the stow, to the degree that the shift is most unlikely to have occurred had the sea been substantially calmer. But, because poor weather is a normal and expected hazard, it is not considered to have been the fundamental cause of the shift.

Once the stow had shifted, the crew's possible action was limited. Ballast was moved to correct the resultant list, and the vessel's heading was changed to limit roll.

However, more direct action was difficult. Access to Bay 1 was limited without removing the forward hatchcover, which the master would have been ill advised to do in the prevailing weather conditions. Without access from above, with

hatches removed, the crew had no practical way of shoring the containers. Crew access, via fixed ladders in the hold, would also have placed them dangerously close to the unstable stow of containers.

In the event, the master's judgment, that the shift of stow would not further deteriorate before Avonmouth arrival, proved correct.

2.4 SEGREGATION OF DANGEROUS GOODS

While planning the removal of the damaged containers, BPC quite correctly placed great weight on the expertise of their chemical advisers. Their advice suggested that mixing of the dangerous goods, contained in the two lower tank containers in the port stack, could result in a spontaneous explosion. This raised concerns about the separation requirements for these substances during transport.

The two substances contained in the tanks involved in this incident, UN1778 and UN 1908, are required to be stowed *away from* each other to comply with the requirements of the IMDG Code. However, the definition of *away from* allows two closed containers to be stowed one on top of the other. This was how the two tank containers in Bay 1 were stowed.

Thus, the segregation requirements of the IMDG Code, allowing overstowage of the two tank containers in Bay 1, were satisfied.

However, following its own investigation of the incident, BPC concluded that shippers should be advised, or required, not to stow these two substances adjacent to each other. While this might help to prevent the catastrophic mixing of these substances in any future event, it is a requirement in excess of those contained in the IMDG Code and UK Regulations. Further consideration should be given before BPC introduces this requirement because, as is argued in the remainder of this report, the proper application of existing requirements would have prevented this incident.

2.5 OTHER REQUIREMENTS OF IMDG CODE

Part 7 of The IMDG Code requires that portable tanks should not be overstowed by other cargo transport units, unless designed for the purpose and transported in specially designed ships. This requirement is under the heading *Provisions concerning transport operations* and somewhat displaced in the IMDG publication from the section covering segregation.

Any concern about the compatibility of dangerous goods in any stow is usually satisfied by consulting separate entries for each substance in the IMDG Code. Having satisfied concerns on compatibility and separation requirements, a master needs to have good reason to consult other areas of the Code, particularly if he is pressed for time, as is often the case.

Vessels which do not carry containers exclusively, such as non-cellular feeder vessels like *Dutch Navigator*, are those whose masters need to be made aware of the requirement not to overstore tank containers holding dangerous goods.

As the owners of *Dutch Navigator* operate several sister vessels, they should highlight this requirement of the IMDG Code to the masters of their vessels which carry dangerous goods in tank containers. Also, to ensure safety of operations in their port, BPC should also remind regular shippers of this Code requirement.

2.6 OVERSTOWAGE OF TANK CONTAINERS

Although segregation requirements of the IMDG Code were satisfied, both the IMDG Code and the associated UK Merchant Shipping Regulations prohibit the overstowing of tanks containing dangerous goods, unless carried in specially designed ships.

Although *Dutch Navigator* is equipped to carry containers, she is not a specially designed ship. Although the IMDG Code does not define the term 'specially designed ship', this may be interpreted as one fitted with vertical container guides beneath deck, or equivalent, such that each container is positively located as in a cellular container ship. The UK administration has interpreted the Code in this way, and made regulations that clearly state that overstore should only be allowed on cellular container ships.

In particular, the three stacks in Bay 1 of *Dutch Navigator* cannot be located as effectively as in a cellular container vessel, and the cargo securing manual allows the stacks to be independent. However, the other bays do have some form of lateral support, and the cargo securing manual requires that these stacks are interconnected.

The absence of lateral support or interconnection of the stacks in Bay 1 would, for any given stack mass, result in greater racking loads being generated in the lower tiers of containers. Thus, compliance with the IMDG Code requirements on overstore would also have resulted in a reduction in the racking forces on the lower containers.

The relevant UK Regulations, which also cover a general duty to comply with the provisions of the IMDG Code, were not on board *Dutch Navigator* and were not known to the owners.

The vessel's owners should take steps to ensure that IMDG Code and statutory requirements are satisfied.

2.7 CONTAINER STACK MASSES

Excluding the stacks in Bay 1, the masses of container stacks in the hold did not exceed recommended values by more than 15%; generally they were below, or very close to, recommended limits. However, the three stacks in Bay 1 had masses 162 %, 120% and 141% of recommended values. Although well within the international standard for stacking loads on containers (150t), these loads are, with respect to the limitations in the vessel's cargo securing manual, substantially in excess of recommendations, particularly for the two wing stacks.

Although there was a limited range of container masses on board, modifications to the stowage plan, to reduce the stack loads in Bay 1, might have been possible. The stowage plan, shows that after loading there were four vacant 20ft bays in the hold and three on deck.

Thus, alterations to the stowage plan, which would have reduced the stack masses, and even eliminated overstowage of the tank containers completely, could have been made. The important stack mass limitations for Bay 1, as contained in the cargo securing manual, and the prohibition on overstowing tank containers, were overlooked. Therefore, no apparent consideration was given to modifying the stowage plan so that the two tank containers were not overstowed.

However, without being aware of possible limitations on stack masses, the mate and master had no reason to consider this modification. Also, they had no reason to consult the cargo securing manual unless they had doubts about allowable stack weights. Without a need to consult the cargo securing manual, they assumed allowable stack masses in Bay 1 were similar to all other bays in the hold. A natural assumption, but one which the owners are recommended to take steps to ensure is not repeated.

2.8 SHIP MANAGEMENT

Dutch Navigator came under the certification regime of the ISM Code, which requires a Safety Management System (SMS) to be in place. Part of the documentation forming part of the vessel's SMS was an instruction from the owners to the master that he should '*satisfy all statutory requirements*'.

This is an objective of the ISM Code and thus the effective application of the Code should bring about that result.

The failure to satisfy the requirements of the IMDG Code, the vessel's cargo securing manual and the UK administration, shows that the SMS of *Dutch Navigator* was not effective in achieving this objective. The owners need to amend their management system to correct these shortcomings.

2.9 CONTAINER RACKING LOADS

The container securing arrangements had consequences for racking loads on the containers in Bay 1. All other underdeck bays able to take 20ft containers are arranged so that stacks may be located by pressure side supports. Bay 1 is the only bay where stacks have no transverse support.

This is partly a consequence of the forward part of the hold narrowing, because of the hull's fineness and flare towards the bows, making the use of side supports awkward, if not difficult. As result, stack masses in Bay 1 should be limited so that container racking forces are maintained within the nominal 150kN limit.

Clearly, if stack masses are excessive, racking forces on lower containers may also be excessive when the vessel is in poor weather. Calculations, using the techniques set out in the vessel's cargo securing manual, show this is so.

The masses of all three stacks in Bay 1 were above recommendations, and could have resulted in racking loads on the three lowest containers substantially in excess of 150kN. During *Dutch Navigator's* passage across the Bay of Biscay, rolling may thus have initiated the collapse of any of the three stacks. In the event, all three collapsed.

Racking loads calculated for the lowest container in the port stack in Bay 1 were 185% of the nominal 150kN limit. This was the tank container whose frame failed, allowing the tank shell to be damaged. It is this excessive racking load which is considered to be a major factor in the failure of the stow.

2.10 SAFETY PLATE OF TSTU 3000002

An important requirement of the CSC is the fitting of a safety plate to each container. On this plate is set out an important summary of the significant features and history of the container with respect to safety.

The safety plate on the tank container TSTU 3000002 contained all the required information. In particular it showed, by the marking of dates for 'the next inspection', a history of having been inspected under the periodic inspection regime allowed by the CSC. The marking of the next examination date, 11/97, being in the past and the label ACEP-GB-145, shows that it transferred to an approved continuous examination programme before that date. This date is consistent with the tank's owners gaining approval for this programme in February 1997.

2.11 FRAMEWORK OF TANK CONTAINER TSTU3000002

All available records show that the frame design used for this container was tested in accordance with the requirements of ISO1496. It therefore satisfied the requirements of the International Convention for Safe Containers 1972, (CSC). Indeed, as part of the tests for the frame's resistance to racking loads, the deflection of the end frame was recorded 5 minutes after the racking test loads were removed. The recording of this measurement is in excess of the requirements of ISO1496 and the CSC.

Metallurgical examination of failed parts of the tank's framework identified defects, largely because of unsatisfactory repairs. Clearly, these repairs had a detrimental effect on the framework's resistance to racking forces. However, it is not possible to place a value on this reduction. A sound frame might also have failed under similar conditions of loading but most probably at a later stage of the incident. The contribution made by these poor repairs was present but is not quantifiable.

Neither is it possible to say that the frame, even in the state of repair as found, was unable to withstand the 150kN racking test load applied at the time of approval of the frame's design.

However, likely racking loads during the voyage on *Dutch Navigator*, calculated using the technique contained in the vessel's cargo securing manual, significantly exceeded the nominal limit of 150kN specified in the manual. This is a clear indication that the stack masses and securing arrangements produced a situation where the lower container, the tank container, was subjected to racking forces that it was not designed to withstand in service. Thus, whatever effects the poor repairs might have had on the frame structure, this indication of overload is considered a more significant factor in the incident.

The calculated degree of racking overload is such as to cast doubt on the ability of even a sound frame structure to resist failure in the conditions of cyclic loading caused by the vessel's motion during the voyage.

Largely because the calculated overload suggests that failure might have occurred with a structurally sound frame, the vessel's owners need to ensure that cargoes are not accepted unless stack masses can comply with the requirements of the cargo securing manual. They are recommended to take these measures.

The likely excessive racking loads on the tank's frame, most probably could have been prevented had its stowage been in compliance with the IMDG Code or UK Regulations or the vessel's cargo securing manual. Compliance with any one of these documents would, at the very least, have ensured that stack masses were limited and, at best, ensured no overstowage of the tank containers. In either case, excessive racking loads would not have been generated, and failure of the stow might not have occurred.

2.12 FAILURE OF TANK SHELL

Two areas of the tank shell, which were subjected to close examination, showed serious internal localised corrosion. These sites corresponded with loss of integrity of the tank's butyl rubber lining.

Corrosion data for the rate at which hydrofluorosilicic acid can affect mild steel, indicates that the rate is very high; the highest quoted in published data for corrosion rates. Assuming the shell corrosion rate at each of the two leakage sites was similar, and there is no reason to suppose otherwise, the time over which corrosion had taken place must also have been similar.

It follows that the liner failed at both positions of leakage at about the same time. Owing to the aggressive nature of hydrofluorosilicic acid on steel, this time must have been shortly after the lining failed. Only one known recent event could have affected both sites similarly and almost simultaneously; the squeezing and crushing of the tank during the shift on board *Dutch Navigator*.

It is therefore concluded that the tank failed as a result of the liner's failure which, in turn, coincided with the tank being subjected to crushing and squeezing during *Dutch Navigator's* passage from Bilbao to Avonmouth.

Each of these leakage sites was also closely associated with a seam in the tank's liner. The appearance and form of the relevant seam on the tank's end, or header, points to a repair. It was at this repair that leakage occurred. Leakage in the tank's bottom, near to the sump, was also close to a seam which had been made when the shell was repaired in this area. However, the seam had not failed, but the liner material had failed at a position where the liner had been cut on its under-face. This suggests that the liner had been partly pierced during the repair process, or during manufacture. Records do not allow a more certain interpretation to be made.

Although not associated with one of these corroded areas, one area of the liner showed signs of having been repaired, or at least a repair had been attempted, using a substance similar to 'Araldite'. While excellent material for many applications, Araldite sets much stiffer than butyl rubber, thus the tendency is for the Araldite to crack as the more resilient rubber deflects under loading. The cracks destroy the liquid-containing ability of the repair. Although the area where Araldite had been used did not leak, its selection for a repair to the tank's liner points to inexperienced staff becoming involved with the tank's repairs. Again, records do not offer any details of when this attempted repair was made.

There is value in recalling that the Araldited area of the liner was not identified until the sample had been cut from the tank shell, and the liner had been thoroughly cleaned dried and examined under good lighting. At no time while the area was still wet from the alkaline wash, and viewed from within the intact tank, could this area be separated visually from the surrounding black butyl rubber

surface. As all previous examinations of the liner would have been made with the examiner standing inside the intact tank, probably also with the surface slightly wet, it would have been impossible for him/her to identify the Araldite repair by visual examination alone.

The failures of the liner at the points of shell leakage were probably initiated by the shift of stow on the vessel, but eventual failure, because of the poor repairs, was probably inevitable. Locating these defects during an inspection is difficult and, particularly for the defect near the sump, almost impossible.

However, the use of an unsuitable epoxy type material, in an apparent effort to effect a repair, suggests a lack of knowledge on the part of whomever performed the work. Once executed, this poor repair proved to be difficult to identify during an inspection. This shows that tank repairs must be undertaken by reliable and knowledgeable personnel, under proper supervision.

2.13 TANK CONTAINER REPAIRS

Although excessive racking loads have been identified as the cause of the frame's failure, and thus also the subsequent squeezing and leakage of the tank, the quality of some of the unit's repairs has been identified as an area of concern.

The requirements of the Convention, and associated regulations on the matter of container examination and repair, are not very specific. Whichever examination regime, periodic or continuous, is selected by the owner, the criteria against which the examination of any container is made is '*whether it has any defect which could place any person in danger.*'

In the absence of further guidance to the examiner, and notwithstanding the guidance offered by TCA and ITCO, an examination made against this measure could be very subjective.

This incident identified some problems with one unit belonging to one owner. These problems alone do not justify any changes in the Convention. This view is supported by data available to the MAIB, which indicates that failure of tank containers while carried on seagoing vessels is not a common occurrence.

Notwithstanding this conclusion, the owners of the tank TSTU 300000 are recommended to take account of some of the poor quality repairs that have been made to this unit. They should also be conscious of these when specifying future repairs, selecting contractors for the work, and monitoring standards.

2.14 ARRIVAL OF VESSEL IN AVONMOUTH

Although BPC was told that *Dutch Navigator* was carrying dangerous goods, and that she had suffered a shift of cargo, it was not aware that dangerous goods were involved in the shift of cargo. However, BPC has a clear authority to require details of the dangerous goods and their packaging before a vessel enters the port. This authority covered the tank containers stowed in Bay 1 of the vessel, and involved in the shift of stow.

Without knowing that the dangerous goods were included in the cargo shift, port workers began to discharge the vessel. Not until many of the containers were ashore, did they become concerned. At that stage suitable expertise was called, about 18 hours after the pilot had boarded the vessel on arrival at Avonmouth.

Notification of the shift of dangerous goods when the pilot boarded would, at the very least, have allowed BPC to make an earlier assessment of the stow. This might have reduced the considerable delay in removing and making safe the damaged tank container.

In the event, the damaged tank began to leak less than 3 hours after it was removed from the ship, showing how important even a few hours delay can be in dealing with dangerous goods.

This information should be supplied to the port as soon as is possible, and no later than the time a pilot boards a vessel; or equivalent for vessels having pilotage exemptions. Forewarning of this nature would allow BPC to activate the initial stages of its emergency system to deal with such events.

BPC presently impresses upon all parties, such as agents, pilotage exemption holders and masters, the need to notify the port of any untoward incident so early action can be taken. However, the importance of this information is so great that BPC should introduce a requirement for vessels entering the port to report any shift of cargo where dangerous goods might be involved.

In support of this requirement, BPC should introduce an automatic interrogation of any ship arriving at the port that has reported a cargo shift, to establish whether dangerous goods are on board. The absence of a categorical response that dangerous goods are not involved with the cargo shift, should alert BPC to arrange its own assessment as soon as is practicable.

2.15 LANDING OF THE DAMAGED CONTAINERS

When BPC assessed the risks associated with the removal of the damaged stow, it concluded that personnel closely involved with the operation should be equipped with sets of breathing apparatus. To this end, a short training session was held for port workers involved to ensure they were proficient in the use of these sets. Others, such as members of the Chemical Strike Team, were already competent in their use.

During this unloading operation, all these personnel were either on board *Dutch Navigator*, in the vicinity of the forward end of the hold, or driving the dockside crane to lift the containers clear.

However, some personnel on the vessel at this time were not equipped with breathing apparatus. While it is not suggested that they had no function to serve on board, they were at risk from any spillage, and particularly from liberated gas. This was a potential hazard which was compounded by the wind direction from bow to stern and also across the accommodation and gangway area; the single 'dry' escape route from the vessel.

Having assessed the risk was sufficient to warrant equipping some personnel with breathing apparatus, all in the immediate area should have been similarly equipped. Alternatively, nobody, other than those essential to the operation, should have been allowed on the vessel during that time.

This points to a need for improvement in the control of access to hazardous areas. Ideally, clarification on the identification of persons allowed access to the vessel should have been given at the planning meetings. This information, if passed to the access controlling body - in this case the port police - would have assisted them in enforcing more rigorous control.

This is an issue which BPC has identified during its own investigation and, therefore, the MAIB makes no recommendation on the matter.

2.16 TREATMENT OF DAMAGED TANK ASHORE

During the period of about 30 hours, between the damaged tank container being removed from the vessel, and its contents being transferred to another tank, any leakage and spillage was allowed to fall to the ground of the open storage site. There, it was allowed to randomly drain away, soak into the ground or evaporate.

Similarly, while filling or storing the tank, any leakage or overflow of neutralising water and chemicals, was allowed to fall to the ground.

It is recognised that the quantity of substance which escaped in this fashion was very small. However, metallurgical examination of the failed tank showed that the leakage of acid from the tank had the potential to rapidly develop into a substantial leak which, presumably, would also have been allowed to fall to the ground.

Stowage of the container in a purpose-built facility would have been preferable. Such a facility should have hazardous liquid containing capability, with drainage and liquid collection arrangements, as a minimum. Other features might need to be incorporated once a full risk assessment has been made for the use of the facility, including the provision of suitably trained staff. As a consequence of this

incident, BPC now recognises the need for a facility of this type for the safe and pollution-free handling of defective containers holding dangerous goods. Because of BPC's stated plans for a facility of this type, the MAIB makes no recommendation on the matter.

BPC should be commended for identifying this need as a result of the lessons they have learned from this incident. However, a thorough risk assessment of the handling of dangerous goods within the port area would have identified the need for the facility before this incident occurred.

BPC's current Emergency Response Procedures include the use of an Emergency Containment Unit (ECU) as a key element in the system for safe handling of damaged containers holding dangerous goods. A risk assessment shows that without an ECU, the risks posed by dangerous goods breaching their containers are unacceptable. This conclusion makes the early introduction of the ECU essential.

2.17 MANAGEMENT OF THE INCIDENT

The Secretary of State's Representative (SOSREP), who has the authority to direct and control this type of operation by formally intervening, attended the incident at 2320 on 27 April and left at 0300 on 28 April without using his powers of intervention.

This meant that BPC remained in control of the incident throughout, calling on chemical expertise, MCA, fire, police, local and health authorities to assist and advise where necessary.

This retention of control allowed BPC to better identify several lessons from the incident. These include: the need for prompt access to expertise in responding to incidents involving dangerous goods; the availability of port personnel trained in the use of breathing apparatus; the need for a reception facility for damaged containers carrying dangerous goods; the control of access to hazardous areas.

It is commendable that these important lessons have been learned and action taken. However, a thorough risk assessment of handling dangerous goods in the port might have anticipated some of these issues, in particular the need for a reception facility for damaged containers.

Had this facility already been in place, the management of the incident might have been less arduous. Its duration would certainly have been shorter, as it would have ended when the damaged container was secure in the reception facility. In the event, the incident lasted a further 30 hours, during which time there was uncertainty as to the safety of the container.

A requirement that ships' masters report any shift of dangerous cargoes, before a vessel's arrival at the port, might also have reduced the duration of the incident by allowing an earlier assessment of the situation. Again, the need for this reporting requirement might have been identified by a thorough risk assessment of handling of dangerous goods through the port.

Although some limitations in BPC's risk assessments have been identified, in the event, these shortcomings did not detrimentally affect the outcome of the operation. There was, however, an element of good fortune in this outcome, particularly as the leakage from the damaged tank was only slight and did not start until after the tank's removal from the vessel.

Conversely, a significant level of skill in crisis management was demonstrated by the harbourmaster; his management of the incident allowed proper weight to be given to issues that could not reasonably have been anticipated before the event. In this respect, he was faced with conflicting opinions on the possible health hazards associated with mixing of the substances held by the two tank containers involved. He was able to resolve this issue with diplomacy, pragmatism and common sense.

However, the safety of some operations undertaken during the incident would have been improved by considering and assessing the major risks before the event. This is one of the aims of the Port Marine Safety Code.

SECTION 3 - CONCLUSIONS

3.1 CONTRIBUTING FACTORS

1. The master and owners of *Dutch Navigator* were not aware of the UK Regulations covering the transport of dangerous goods at sea. [2.6]
2. Overstowage of the tank containers in Bay 1 of *Dutch Navigator*'s hold was not in compliance with requirements the IMDG Code and UK Regulations. [2.6]
3. Container stack masses in Bay 1 of the hold were substantially in excess of the recommendations of the vessel's cargo securing manual. [2.7]
4. Calculated racking loads on the container frames in the lower tier of Bay 1 were substantially in excess of design limits. [2.9]
5. Excessive racking load is considered to be a major factor in the failure of the stow. [2.9]
6. BPC had no requirement for *Dutch Navigator*'s master to report the involvement of dangerous goods in the shift on cargo on his vessel. [2.14]
7. Shell and frame of damaged tank container had been the subject of poorly executed and monitored repairs. [2.11, 2.12]
8. The shock and distress suffered by the tank while on board *Dutch Navigator* probably lead to the liner's failure by aggravating poor repairs. [2.12]

3.2 OTHER FINDINGS

1. Damaged tank container leaked due to accelerated corrosion of shell by contents. [2.12]
2. The tank container's shell was exposed to contents due to failure of the tank's lining. [2.12]
3. The tank's frame and its liner had been the subject of poorly executed and monitored repairs. [2.11, 2.12]
4. BPC's response was delayed by the absence of a report from the master that dangerous goods were involved with the cargo shift. [2.14]
5. BPC's risk assessment did not identify the need for a reporting requirement for vessels suffering cargo shifts involving dangerous goods. [2.17]

6. Unauthorised personnel in vicinity during landing of damaged containers. [2.15]
7. Criteria for whom should be allowed in vicinity of vessel not clearly set out. [2.15]
8. Requirement of the international Convention for Safe Containers is not specific with regard to the standards for inspection and repair of containers. [2.13]
9. Once landed, the leaking tank container had potential for causing pollution. [2.16]
10. BPC had no reception facility for dealing with damaged containers holding dangerous goods. [2.16]
11. The need for a reception facility for damaged containers had not been identified by BPC. [2.16]

SECTION 4 - RECOMMENDATIONS

The owners of *Dutch Navigator*, Rederij Wessels BV are recommended to:

1. Make masters and mates of *Dutch Navigator* fully aware of
 - a) The stack mass limitations on containers stowed in Bay 1 of the hold.
 - b) The IMDG Code restrictions on the overstowage of tank containers carried on non-cellular ships.
 - c) The restrictions on the overstowage of tank containers imposed by UK Regulations.
2. Make masters and mates of vessels similar to *Dutch Navigator*, operated by themselves, aware of the points in a), b) and c) above.

The **Bristol Port Company** is recommended to:

3. Consider introducing a mandatory reporting requirement for any vessel wishing to enter the port, which has suffered from any shift of cargo involving dangerous goods.
4. Remind regular shippers of the IMDG Code and the UK requirement that tank containers should not be overstowed on vessels which are not cellular containers ships.

Tank Speed Ltd is recommended to:

5. Take note of some of the poor quality repairs that have been performed to the TSTU3000002 unit, and be conscious of these when specifying future repairs, selecting contractors for the work, and monitoring standards of work.

Marine Accident Investigation Branch
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