ACCIDENT REPORT

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

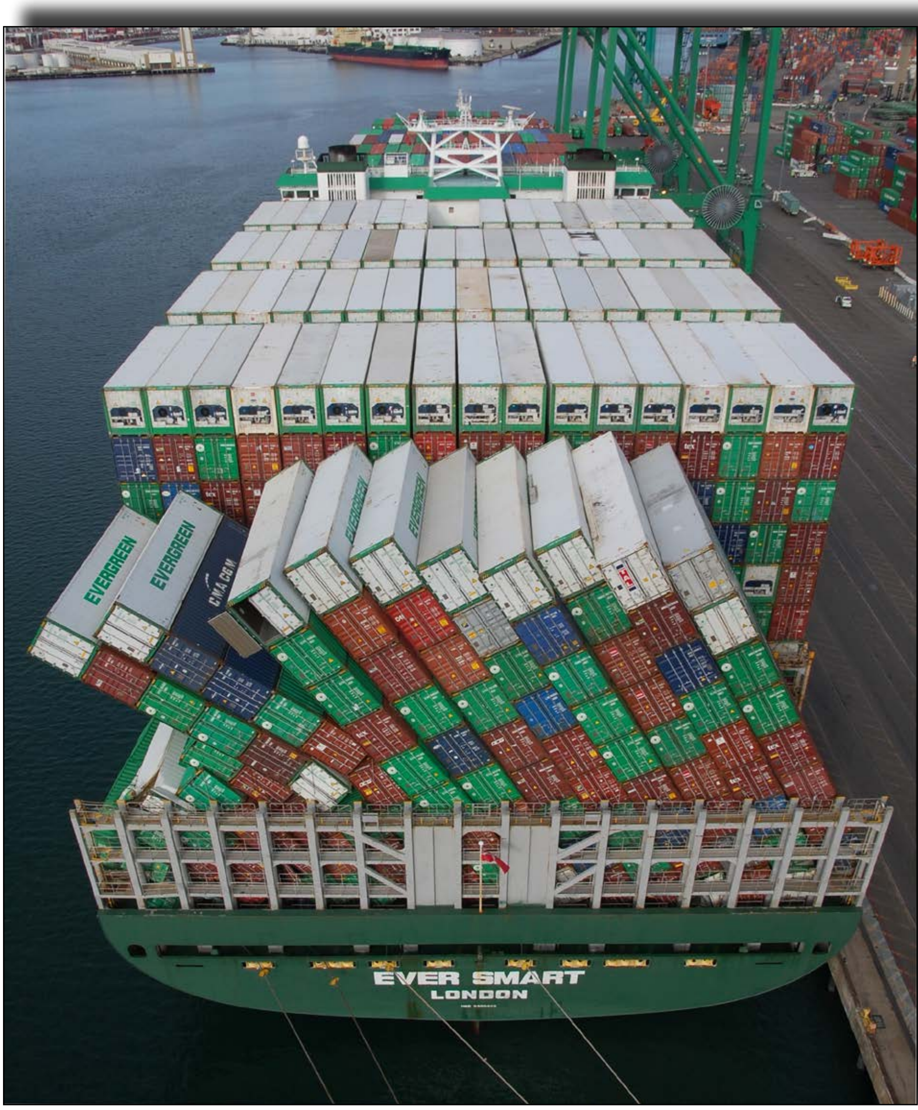
Report on the investigation of the loss of

42 containers from the container ship

Ever Smart

700 miles east of Japan, North Pacific Ocean

30 October 2017



LESS SERIOUS MARINE CASUALTY REPORT NO 14/2020 JULY 2020

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ACEP	-	Approved Continuous Examination Programme
ATSB	-	Australian Transport Safety Bureau
C/O	-	Chief Officer
CSC	-	International Convention for Safe Containers, 1972
CSC plate	-	Container safety approval plate
CSM	-	Cargo securing manual
CSS Code	-	Code of Safe Practice for Cargo Stowage and Securing
CTU	-	Cargo Transport Unit
CTU Code	-	Code of Practice for the Packing of Cargo Transport Units
ft	-	feet
GM	-	Metacentric height
IMO	-	International Maritime Organization
in	-	inch
ISO	-	International Organization for Standardization
ISO 1496	-	ISO 1496-1:2013 Series 1 freight containers - Specifications and testing – Part 1: General cargo containers for general purposes
kg	-	kilogram
kN	-	kilonewton
kts	-	knots
LR	-	Lloyd’s Register
m	-	metre
MARIN	-	Maritime Research Institute Netherlands
MCA	-	Maritime and Coastguard Agency
mm	-	millimetre
NCB	-	National Cargo Bureau
OOW	-	Officer of the Watch
rpm	-	revolutions per minute
SEMM	-	Safety and Environmental Management Manual
SOLAS	-	International Convention for the Safety of Life at Sea 1974, as amended
t	-	tonne

TEU	-	Twenty-foot equivalent unit
UTC	-	Universal Coordinated Time
VGM	-	Verified Gross Mass
WNI	-	Weathernews Inc.
WSC	-	World Shipping Council

Container ship terminology

Bay	-	Transverse deck areas available for container stowage, numbered sequentially from forward to aft.
Hi-cube	-	The standard height of a container is 8ft 6in; a high-cube container has a height of 9ft 6in.
Outer stack	-	The stack of containers within a bay nearest the ship's side.
Row	-	Horizontal coordinate used to define the position of a container across a bay. A row is given a numerical designation from the centre line (00), with even rows to port (02, 04, 06 etc) and odd rows to starboard (03, 05, 07 etc).
Stack	-	Number of containers stowed vertically within a given row.
TEU	-	The TEU is a unit of cargo capacity used to describe the capacity of container ships and container terminals. It is based on the standard 20ft long container.
Tier	-	A vertical coordinate used to define the height of a container in a given row. A tier is given numerical designation commencing from the deck or hatch level (82). Each tier level increases incrementally by 2.

TIMES: All times used in this report are ship's and port local time unless otherwise stated. Local times in Taipei, Taiwan were UTC+8 and Los Angeles, USA were UTC-8.

Image courtesy of Hannes van Rijn (www.shipspotting.com)

Ever Smart

SYNOPSIS

On 29 October 2017, the UK registered container ship *Ever Smart* suffered a container stow collapse while on passage between Taipei, Taiwan and Los Angeles, USA. The master had changed the ship's passage plan to avoid severe weather caused by a developing depression east of Japan. The ship continued in heavy seas; rolling 10º to 12º and pitching heavily with frequent bow flare slamming.

Following the company's heavy weather procedure, the crew were confined to the accommodation block. The following afternoon, once the weather had abated, the crew discovered that the container stacks on the aft most bay had collapsed and toppled to port. Of the 151 containers in the stow, 42 were lost overboard and 34 were damaged. Superficial damage was caused to the ship.

The MAIB investigation concluded that:

- The loss of the containers most likely occurred during a period of heavy pitching and hull vibration in the early morning of 30 October.
- A combination of factors resulted in a loss of integrity for the whole deck cargo bay; in particular, the containers were not stowed or secured in accordance with the cargo securing manual.
- The container lashings might not have been secured correctly.

Following the accident, Evergreen Marine Corp. (Taiwan) Ltd. issued a fleet circular reiterating the need for ships' masters to manage heavy weather encounters effectively.

Recommendations have been made to Evergreen Marine Corp. (Taiwan) Ltd to improve standards of stowage plans produced ashore, knowledge of the dangers of bow flare slamming and lashing gear maintenance management.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *EVER SMART* AND ACCIDENT

SHIP PARTICULARS	
Ship's name	*Ever Smart*
Flag	UK
Classification society	Lloyd's Register
IMO number	9300403
Type	Container ship
Registered owner	A&L CF March (5) Ltd.
Manager(s)	Evergreen Marine Corp. (Taiwan) Ltd.
Construction	Steel
Year of build	2005
Length overall	299.99m
Gross tonnage	75246
Deadweight	78716
Capacity	7024 TEU
Minimum safe manning	16
Authorised cargo	General cargo in containers

VOYAGE PARTICULARS	
Port of departure	Taipei, Taiwan
Port of arrival	Los Angeles, USA
Type of voyage	International
Cargo information	54285t (gross) in containers
Manning	19

MARINE CASUALTY INFORMATION	
Date and time	30 October 2018. Time unknown
Type of marine casualty or incident	Less Serious Marine Casualty
Location of incident	Approximately 700 miles east of Japan, North Pacific Ocean
Place on board	Cargo deck
Injuries/fatalities	None
Damage/environmental impact	42 containers lost, 34 damaged. Superficial damage to ship
Ship operation	On passage
Voyage segment	Mid-water
External & internal environment	Wind southerly force 7 or 8. Very rough sea. 6m wave height. Darkness. Ship pitching heavily, and rolling to 12º
Persons on board	19

1.2 NARRATIVE

At 0342 on 26 October 2017, the UK registered container ship *Ever Smart* completed cargo operations in Taipei, Taiwan. The crew had checked the ship's stability status and cargo lashing arrangements and the ship's pre-departure checklist had been completed. At 0412, *Ever Smart* departed the berth and proceeded on passage to Los Angeles, USA.

Once clear of the harbour, the pilot disembarked and the ship was secured for the sea passage; some of the crew took up sea watches and others retired to their cabins. The wind was north-north-easterly, Beaufort force 5 to 6 and, with its engine set to 81 revolutions per minute (rpm), *Ever Smart*'s speed over the ground was about 18.2kts.

During the morning the master used the ship's satellite linked weather routeing computer to check the weather forecast. Between about 0830 and 1000, the bosun and four of his deck crew conducted a routine daily inspection of the deck cargo lashing arrangements. During the afternoon, the main engine speed was reduced from 81rpm to 78rpm to achieve the required passage speed.

The following morning (27 October), *Ever Smart*'s master checked the ship's weather routeing computer again. Concerned about two developing depressions to the north, he sent an email to the company's service provider, Weathernews Inc. (WNI), and requested a routeing assessment. WNI advised the master that a more southerly course should be steered to avoid the worst of the weather to the north **(Figure 1)**. The master accepted WNI's advice and instructed the officer of the watch (OOW) to amend the passage plan. At 1445, *Ever Smart*'s course was altered from 069º to 077º to follow the revised route.

At 0800 on 29 October, the bosun and his deck crew began their daily lashings' inspection. By 1000, the strength of the prevailing south-easterly wind had increased to force 8 (34-40kts) and *Ever Smart* was pitching and rolling more heavily. In accordance with the ship's heavy weather procedure, the master ordered all weathertight and watertight doors to be closed and loose items to be secured. The crew were confined to the accommodation block and not permitted to go on deck.

Throughout the day, *Ever Smart* continued to pitch heavily and roll to about 10º to 12º. It also shuddered with vibration every 10 to 15 minutes. The ship's course was maintained, and engine speed was kept at 78rpm.

In the early hours of the following morning, the frequency and intensity of *Ever Smart*'s pitching and shuddering increased, prompting the master to go to the bridge. At around the same time, a crew member who was awake in his cabin heard an unusual crashing and banging noise coming from the aft end of the ship. The noise was noticeable but not overly loud, so he did not report it. The master observed that the southerly force 7 to 8 wind had veered onto the starboard beam, and at 0240 he reduced the engine speed to 74rpm to alleviate the pitching and shuddering. The ship's speed reduced to about 16kts.

Ever Smart's movement improved over the course of the day as the strength of the wind dropped and its direction changed. Shortly after midday, the master increased the engine speed to 78rpm. At 1545, the chief officer (C/O) went to the bridge to relieve the OOW. The master discussed the weather improvement with the C/O and lifted the heavy weather restrictions. The C/O then instructed the deck crew to conduct a cargo lashings inspection.

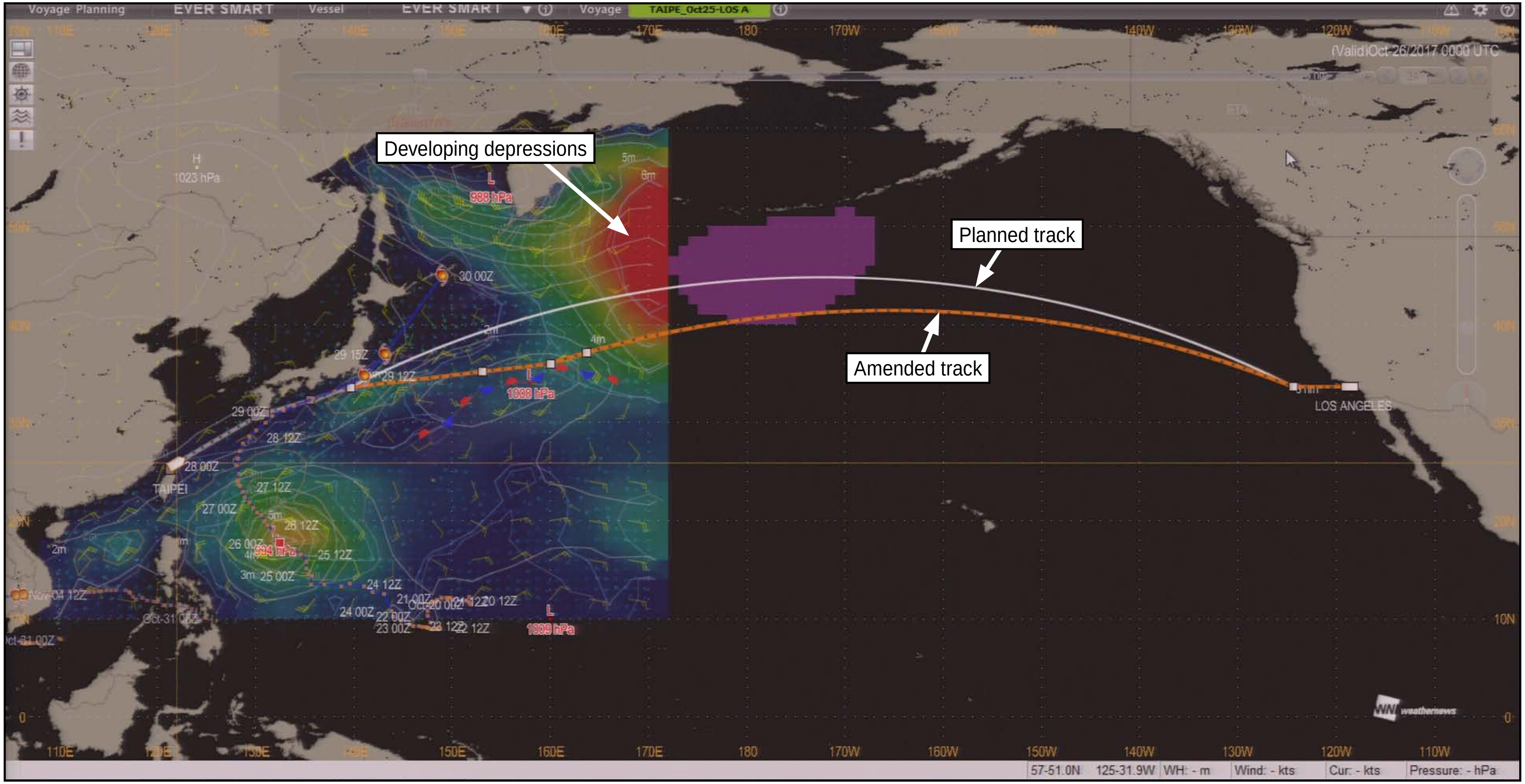


Figure 1: Snapshot of *Ever Smart*'s weather routing computer display screen showing developing depressions with original and amended tracks

At 1648, one of the deck crew discovered that the container stacks in the ship's aftermost bay, bay 70 **(Figure 2)**, had collapsed, and reported this to the C/O using a hand-held radio. The C/O called the master to the bridge and, once relieved, went aft to investigate.

When the C/O arrived on the aft deck he discovered that all 17 of the container stacks stowed in bay 70 had toppled over to port **(Figure 3)**. The two bottom tiers on the port side were crushed, three containers were hanging over the side of the ship and some were missing. The deck containers forward of bay 70 were checked and none were found to be missing or damaged.

With darkness approaching, the master and C/O agreed to make a further assessment in the morning. The master then informed all relevant parties ashore, including the ship's managers, of the collapse and explained that no hazardous cargo had been lost or damaged.

The master changed the ship's course to 090° and increased the engine speed to 80rpm to alleviate rolling and pitching with the quarterly sea. The wind was south-westerly force 7.

The next morning (31 October), *Ever Smart*'s C/O inspected bay 70 and counted 42 containers missing **(Figure 4)**; two of the containers that were previously hanging over the ship's side had disappeared overnight. The ship's aft structure was inspected, and no significant damage was found. The ship continued on passage and arrived in Los Angeles on 8 November and went to anchor for an initial damage assessment.

1.3 *EVER SMART*

1.3.1 Ship details

Ever Smart was a fully cellular container ship with a cargo carrying capacity of 7,024 twenty-foot equivalent units (TEU). It was designed to carry a variety of container sizes in under-deck holds and on deck. The deck arrangement utilised lashing bridges to enable lashing of the fourth and fifth tiers of containers and facilitate stack heights up to nine containers. *Ever Smart* was managed and operated by Evergreen Marine Corp. (Taiwan) Ltd and classed by Lloyd's Register (LR).

Ever Smart's accommodation block was located about 70% of the ship's length from the bow **(Figure 5)**. Bay 70 was not visible from the ship's fully enclosed navigating bridge when the adjacent bay (bay 66) was loaded eight containers high. A closed-circuit television camera was fitted on the mainmast to improve rearward visibility. The bridge wing extremities did not afford a view of the ship's side unless the side windows were open.

1.3.2 Service route

Ever Smart was one of eight container ships operated by the Evergreen Group[1] (Evergreen) on its Transpacific Southwest Service between ports in China, Hong Kong, Taiwan, and the west coast of the USA. Evergreen operated over 150 ships and was the fourth largest container ship company in the world.

[1] The Evergreen Group operated under its brand name, Evergreen Line.

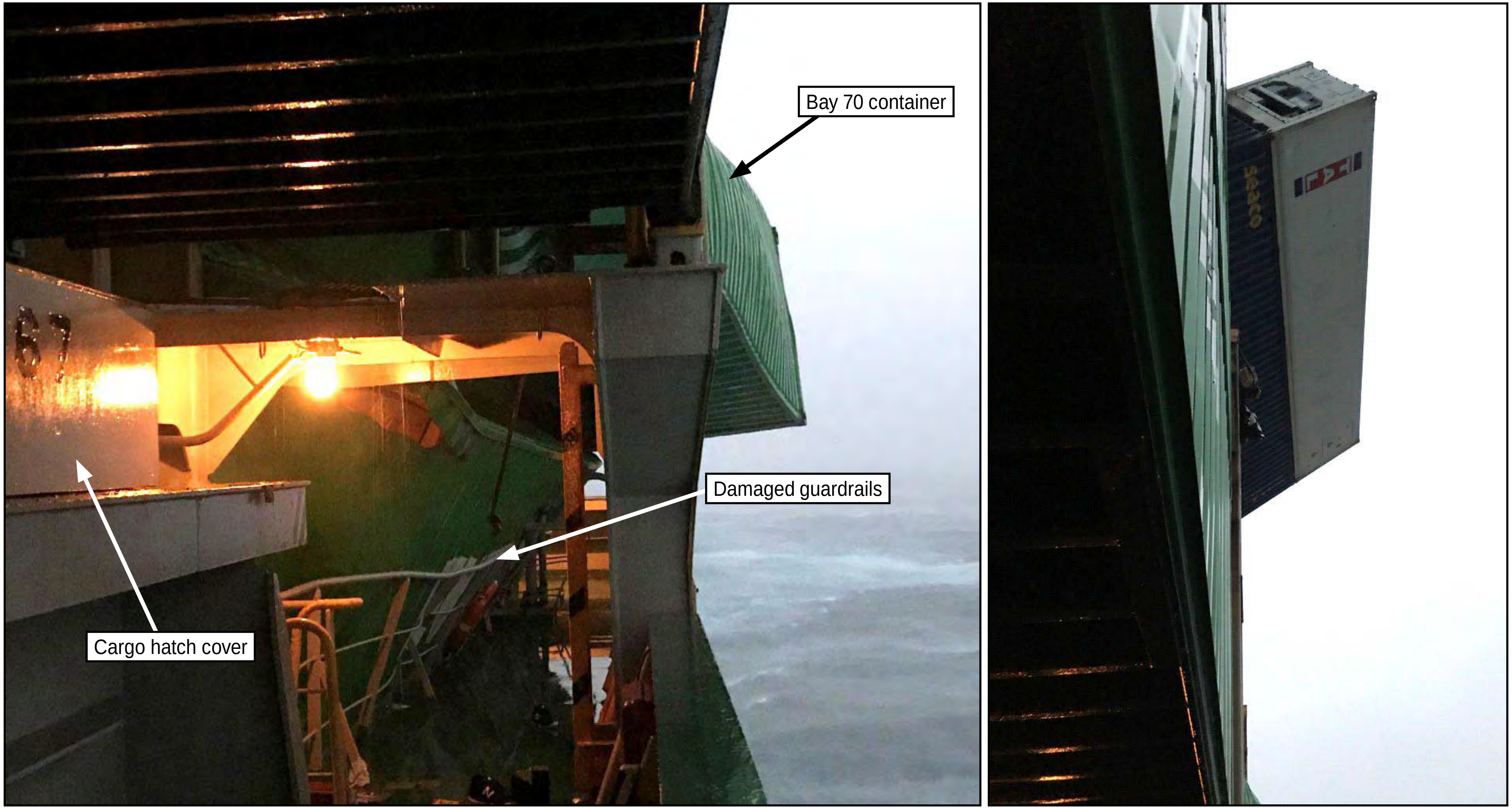


Figure 2: Collapsed containers discovered in the afternoon of 30 October

Figure 3: Bay 70 container stow collapse to port

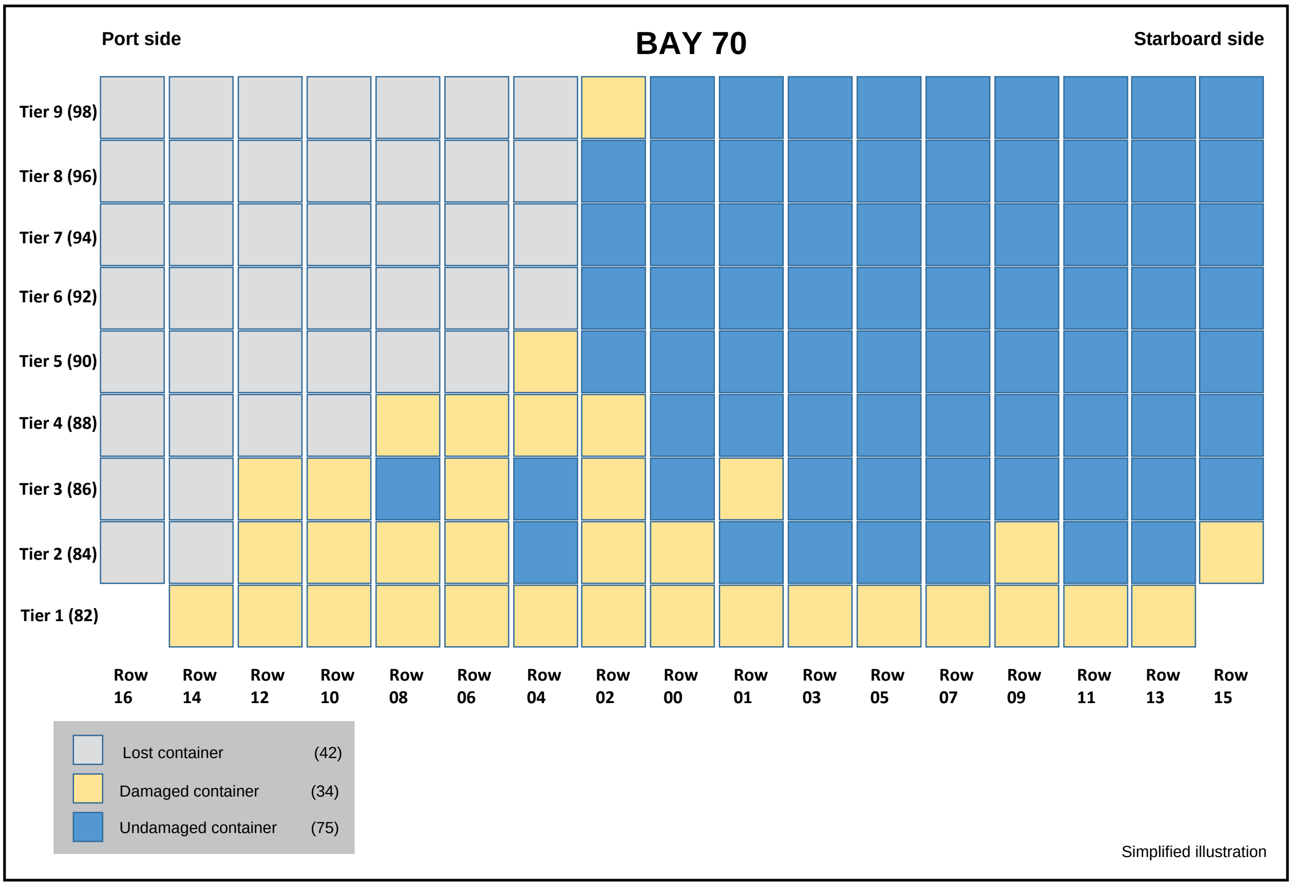


Figure 4: Aft end of bay 70 showing the original positions of the missing and damaged containers

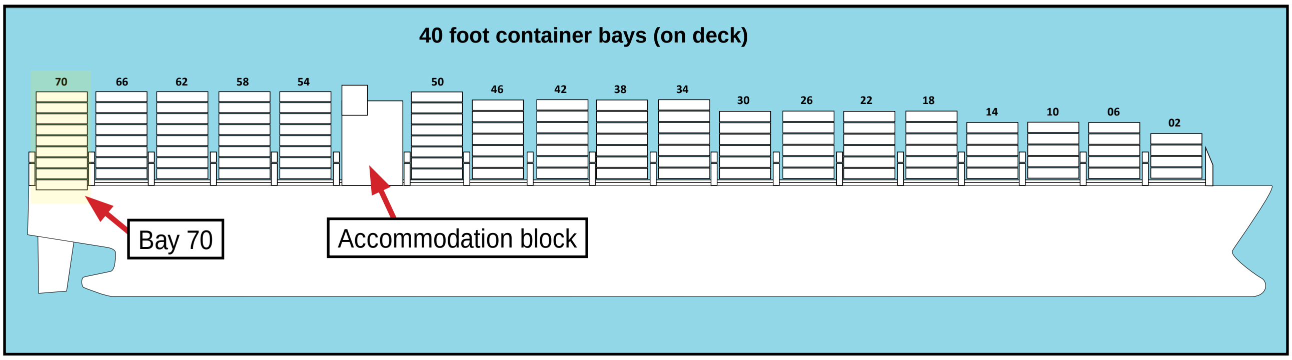


Figure 5: Simplified illustration of 40ft container bay locations on deck

Ever Smart's voyage plan included a great circle[2] ocean leg between the south of Japan to 300 nautical miles from the west coast of the USA. The total passage distance was 6,056 nautical miles. The ship was required to achieve an average speed of 18.2kts for its planned arrival at Los Angeles at 0400 on 8 November.

1.3.3 Crew

Ever Smart had a crew of 19, the majority of whom were Taiwanese or Filipino nationals. One of the ship's engineers was Chinese and its two deck cadets were Italian and British. The deck crew were all Filipino nationals and comprised a bosun and five able seafarers. All crew were appropriately qualified for their ranks and roles.

The master was a Taiwanese national. He had served on Evergreen ships for 30 years and had 10 years' experience as master. He joined *Ever Smart* on a 9-month contract 3 months before the accident. He had experienced a similar loss of containers from a deck stow collapse during severe rolling in heavy weather 4 years earlier.

The C/O was a Taiwanese national. He had served on Evergreen ships for 7 years and had previously sailed on ships of the same class as *Ever Smart*. He joined the ship on a 9-month contract 6 months before the accident.

1.3.4 Loaded condition

Ever Smart was loaded with 54,285t of cargo in 3,533 loaded containers (720 x 20ft, 2,735 x 40ft and 78 x 45ft). Additionally, 85 empty 40ft containers were on board. The number of containers carried equated to 6,524 TEU, which was almost 93% of the ship's container-carrying capacity. Bay 70 was loaded to its maximum TEU capacity of 151 x 40ft containers. Empty refrigerated containers occupied the top tier and the two outermost positions in the tier below **(Figure 6)**. The remaining containers were packed with a variety of dry commodities. All the containers stowed on deck in bay 70 and the other bays aft of the accommodation block (bays 66, 62, 58 and 54) were hi-cube containers (9ft 6in high).

Ever Smart's initial cargo stowage plan, which allocated slots for ports of loading and discharge, was produced by a central planner in Taipei. The central planner's cargo plans were passed to the terminal planners, who allocated individual

[2] A great circle is the shortest distance between two points on a sphere, and appears as an arc on a ship's chart.

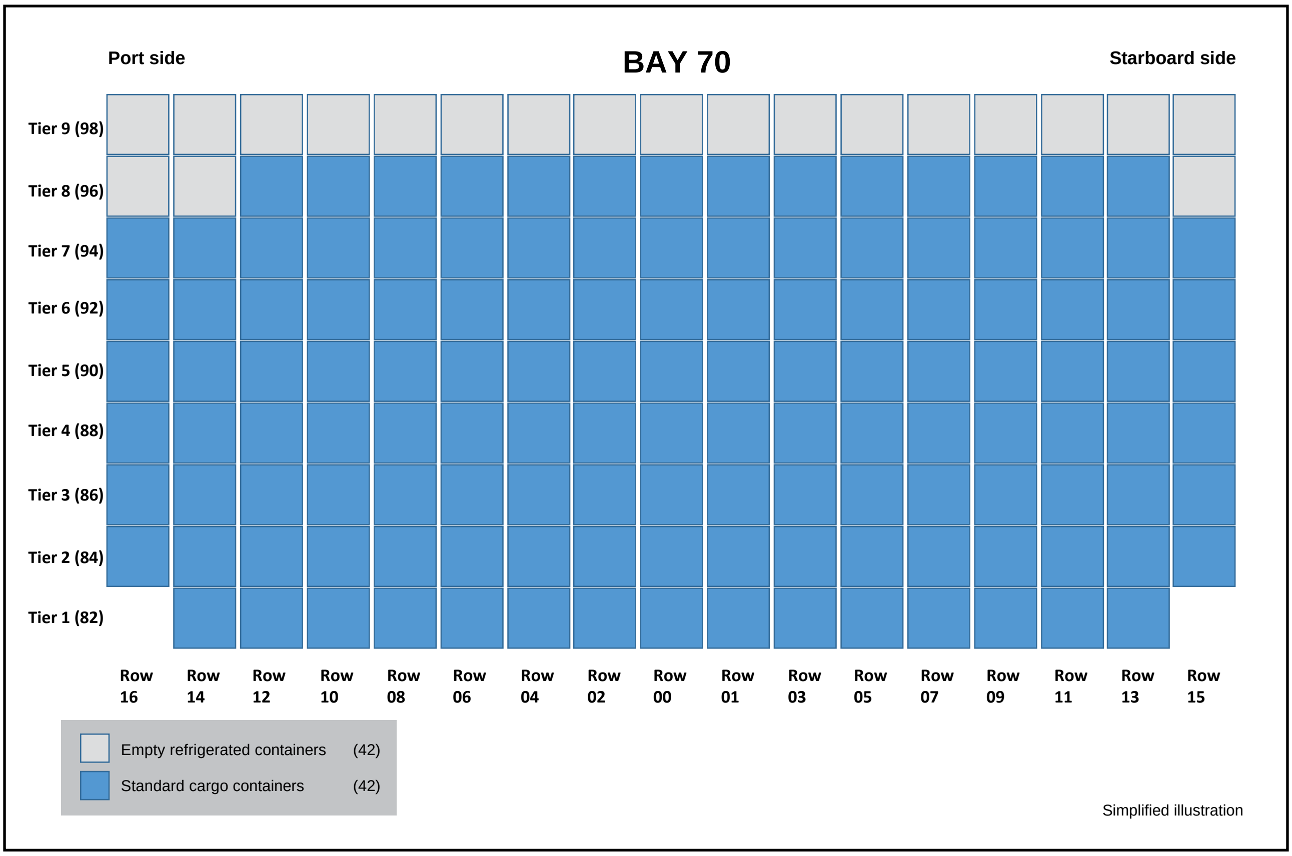


Figure 6: Simplified illustration showing the locations of the empty refrigeration containers in bay 70

containers to specific positions on the ship. The terminal planners then passed their cargo loading plans to the ship's master, by satellite communication, before arrival in port.

The C/O reviewed the cargo plans prior to arrival and developed container discharge and loading plans. He also checked the container weights and disposition, and calculated ballast requirements. Once alongside, the terminal planner passed the latest version of the cargo stowage plan to the C/O, who then reviewed it.

1.3.5 Safety and Environmental Management Manual

Ever Smart's Safety and Environmental Management Manual (SEMM) contained generic instructions and guidance for shipboard operations. The cargo-handling section of the SEMM explained that:

> *The master is responsible for ensuring the seaworthiness of the ship at sea for carriage of human lives and cargo thereon,* and
>
> *The CO is responsible for handling and taking care of cargoes under the instruction and supervision of the Master.*

The guidance required the C/O to refer to the ship's cargo securing manual (CSM) and ensure that the maximum number of tiers and maximum weights of containers loaded on board remain within the allowable limits for the ship. The SEMM also advised the C/O to give proper instructions to workers, including sketches, if necessary, and task the duty officer to supervise and ensure a proper lashing. To aid the process, the SEMM contained a pre-departure *Cargo Operation Record* **(Annex A)**, which had to be verified by the C/O and duty officer/rating at each stage during cargo operation.

The SEMM also required the stowage plan to be reviewed, and stated that:

> *Before cargo operation, a loading stowage plan should be prepared by the in-charge Port Captain of the operation department. The loading stowage plan must be carefully reviewed by the Master and/or the C/O pursuant to the conditions of corresponding draft, stability, trimming, danger cargo segregation, lashing, bunkers, fresh water, water depth of the berth as well as water depth at passage channel, so as to ensure safe navigation and environmental protection.* [sic]

If the master identified or was made aware of any difficulty complying with the intended stowage plan, he was required to consult with the Port Captain or the company's representative before making any amendment. The C/O found no problems with bay 70's cargo stowage plan and the master raised no concerns.

The guidance contained in the SEMM for cargo monitoring during sea passage stated that:

> *The condition of containers securing/lashing shall be checked at least once daily and tightened containers lashing condition from time to time to prevent lashing gears loosing. In case of heavy weather, more frequent lashing checks to be carried out and additional lashing taken as necessary, at Master's discretion.* [sic]

1.3.6 Cargo securing manual

The general principles for the safe stowage of containers on board *Ever Smart* were set out in the ship's CSM. The CSM was produced by the ship builder, Mitsubishi Heavy Industries Ltd, and was approved[3] by LR. The CSM complied with the requirements set out in the International Maritime Organization's (IMO) *Code of Safe Practice for Cargo Stowage and Securing* (CSS Code). It was updated and approved on 29 August 2016 following the introduction of new requirements in IMO document *MSC.1/Circ.1353/Rev.1 Revised Guidelines for the Preparation of the Cargo Securing Manual*.

The CSM contained specified stack arrangements and lashing plans for each bay. Stack weight tables and typical container stowage and lashing patterns were provided for metacentric heights (GM)[4] of 0.7, 0.8, 1.5 and 2.0m **(Figure 7)**. The typical full load GM range for departure and arrival given in the 'main particulars of the ship' section of the CSM was 0.73 and 0.62m respectively (draughts 14.2 and 13.84m). The SEMM stated that the arrival GM for Evergreen's S-type ships should not be less than 1m.

[3] LR approved the general content of the CSM in accordance with IMO requirements. Its approval process did not consider the container stowage and securing arrangement calculations; and any included in the submitted documentation were regarded as advisory or indicative.

[4] The metacentric height of the ship, referred to as GM, indicates the degree of initial stability.

When the containers in the outer most rows (outer stacks) of bays 70, 66, 62, 58, 54 and 50 are loaded eight high (i.e. fully loaded), stack weight tables and lashing patterns were only provided for a GM of 0.7m **(Figure 7)**. In addition, the CSM advised that:

> *In case of 8 tiers on the side most row, only 8ft 6in container can be stowed* **(Figure 8)**.

1.3.7 Ship's loading computer

Ever Smart's cargo loading computer used Techmarine S/W Co. Ltd's *Ship Manager-88* stress and stability program, which had been approved[5] by LR. The loading computer calculated loading stresses and ship stability from data files provided by the terminal planners, and fuel and ballast inputs from the ship's C/O. The output gave a visual indication of the ship's condition of loading. The computer outputs for the departure from Taipei **(Figure 9)** indicated that all stability and stress results were within company and classification society limits.

The C/O used the loading computer's verifications functions to assess the departure conditions for Kaohsiung and Taipei. The draught, hull stresses, GM, total stack weights and hatch loading values were all found to be within the ship's departure limits. The calculated mean departure draught and GM for Taipei were 13.57m and 0.949m respectively **(Figure 10)**. The observed departure draught was 13.90m. The discrepancy between calculated and actual draughts was not uncommon, and was not resolved by the C/O. Post-departure, the GM was not checked by timing the ship's actual roll period[6] and comparing it to the loading computer's calculated roll period of 27.8 seconds.

The loading computer also had a lashing calculation function that allowed the C/O to check the predicted forces acting on the containers and the lashing gear. The predicted forces for a given lashing pattern were displayed for each stack as a percentage of the prescribed limit[7]. When a force limit was exceeded, its value would turn grey. The loading computer allowed the user to adjust the lashing pattern for each bay and re-calculate the forces. The C/O used the generic lashing patterns recommended in the CSM for the bays aft of the accommodation block when the outer stacks were stacked seven containers high **(Figure 11)**. The lashing calculation warned that three of the force limits could be exceeded during the passage in each of bay 70's outer stacks; one of the predicted lashing force values was 2.5 times (250%) its limit **(Figure 12)**.

1.3.8 Container lashing system

Ever Smart's container lashing system was designed and manufactured by Minato Seiki Iron Works Co. Ltd and marketed under the brand name Taiyo. The deck cargo was secured using two types of duel function semi-automatic twistlocks and a variety of lashing rods and turnbuckles.

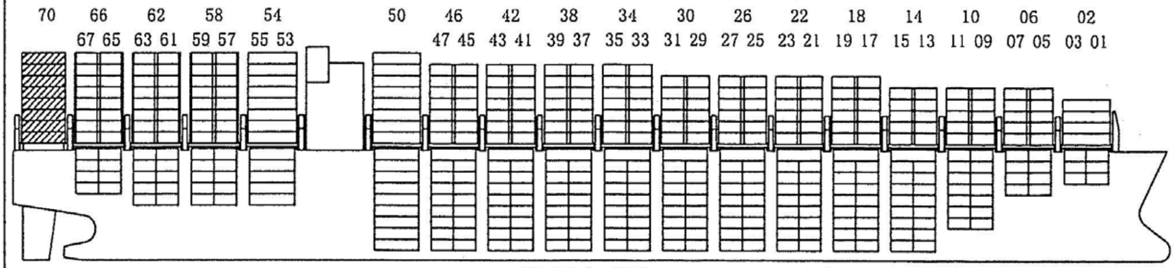
[5] LR approved the loading computer software for strength and stability against specific loading conditions. The software approval did not cover container securing arrangements, and the calculations would not have been checked (LR offers this service, but it was not a requirement and was not requested by Evergreen).

[6] Roll period is the time measured between the ship rolling fully from one side and back again. Roll period is dependent on the beam of the ship and its GM.

[7] The limits were calculated based on worst anticipated conditions.

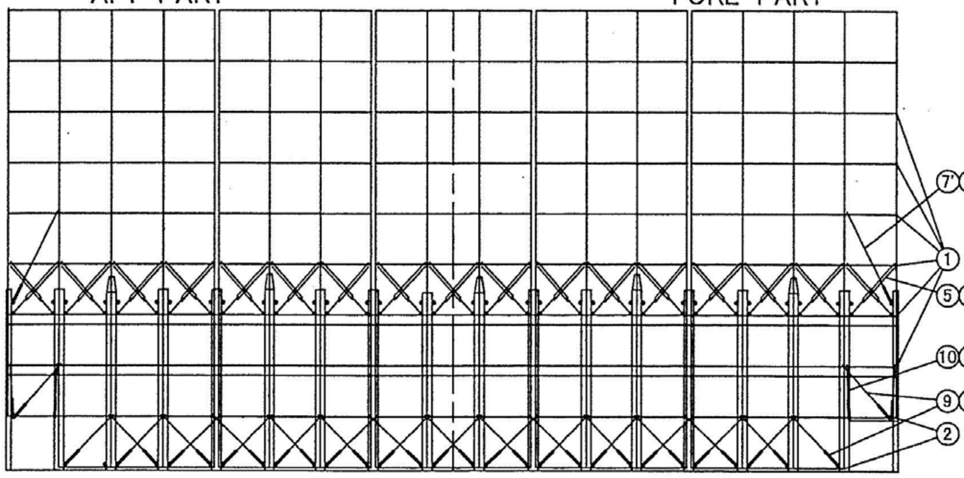
CONTAINER LASHING SYSTEM

40' CONTAINER (ON DECK)



BAY 70 (9 TIER)

(LASHING PATTERN)

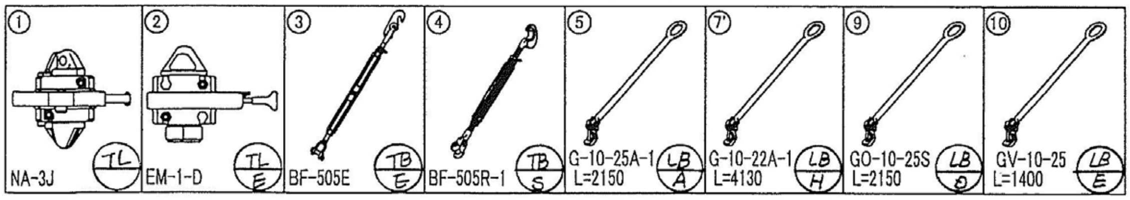


G.M=0.7m

(STACK WEIGHT TABLE)

(UNIT:MT)

9Tier	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8Tier	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
7Tier	4	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	4
6Tier	4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	4
5Tier	4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	4
4Tier	21	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	21
3Tier	30.5	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	30.5
2Tier	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
1Tier		30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	
TOTAL	102	136	136	136	136	136	136	136	136	136	136	136	136	136	136	136	136	102



TAIYO

Figure 7: Container lashing sytem manufacturer's container lashing pattern and stack weight table for bay 70 when loaded with 151 containers for GM 0.7m

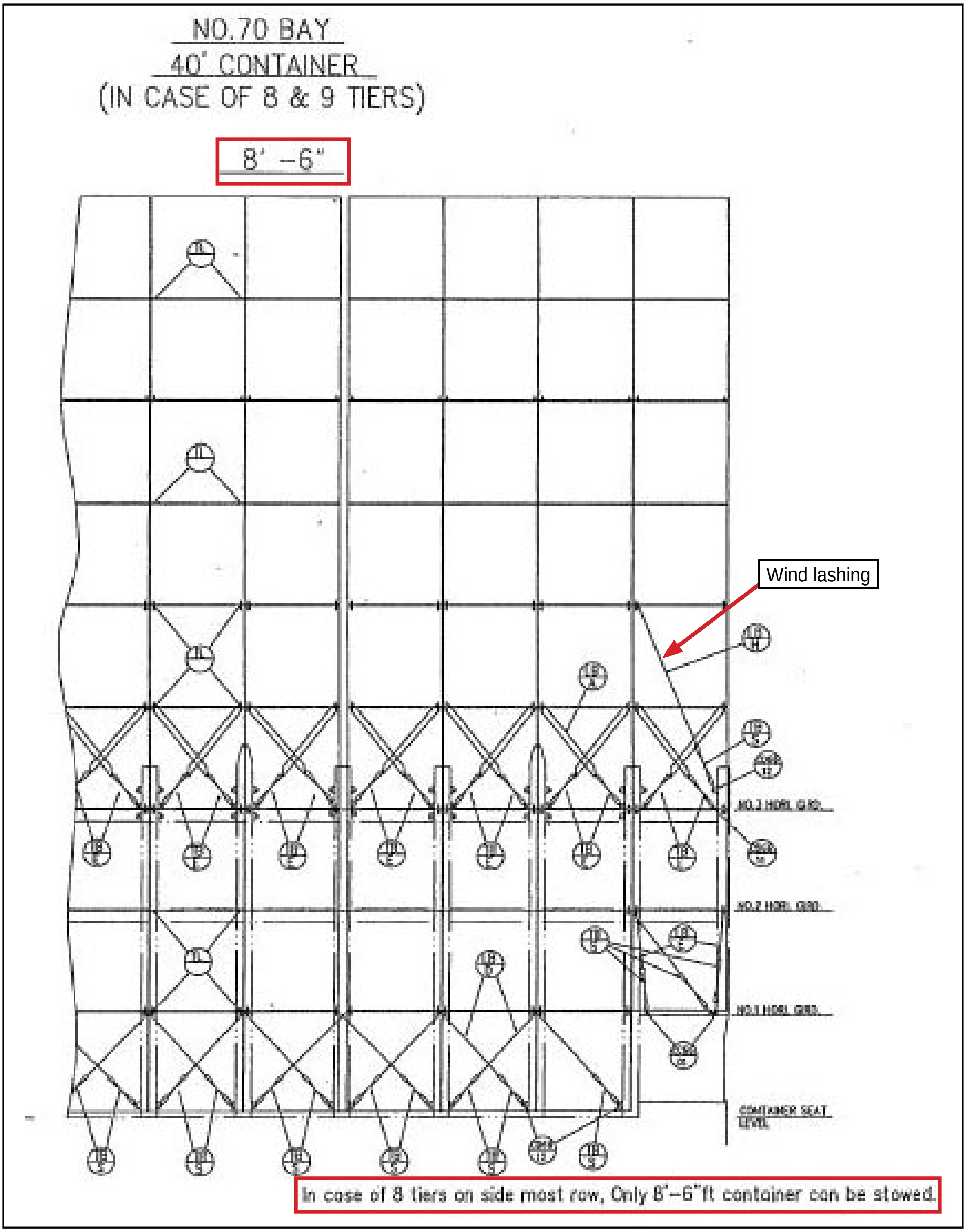


Figure 8: Cargo securing manual location of fixed securing devices drawing for bay 70 when outer stack is loaded eight containers high (to tier 9)

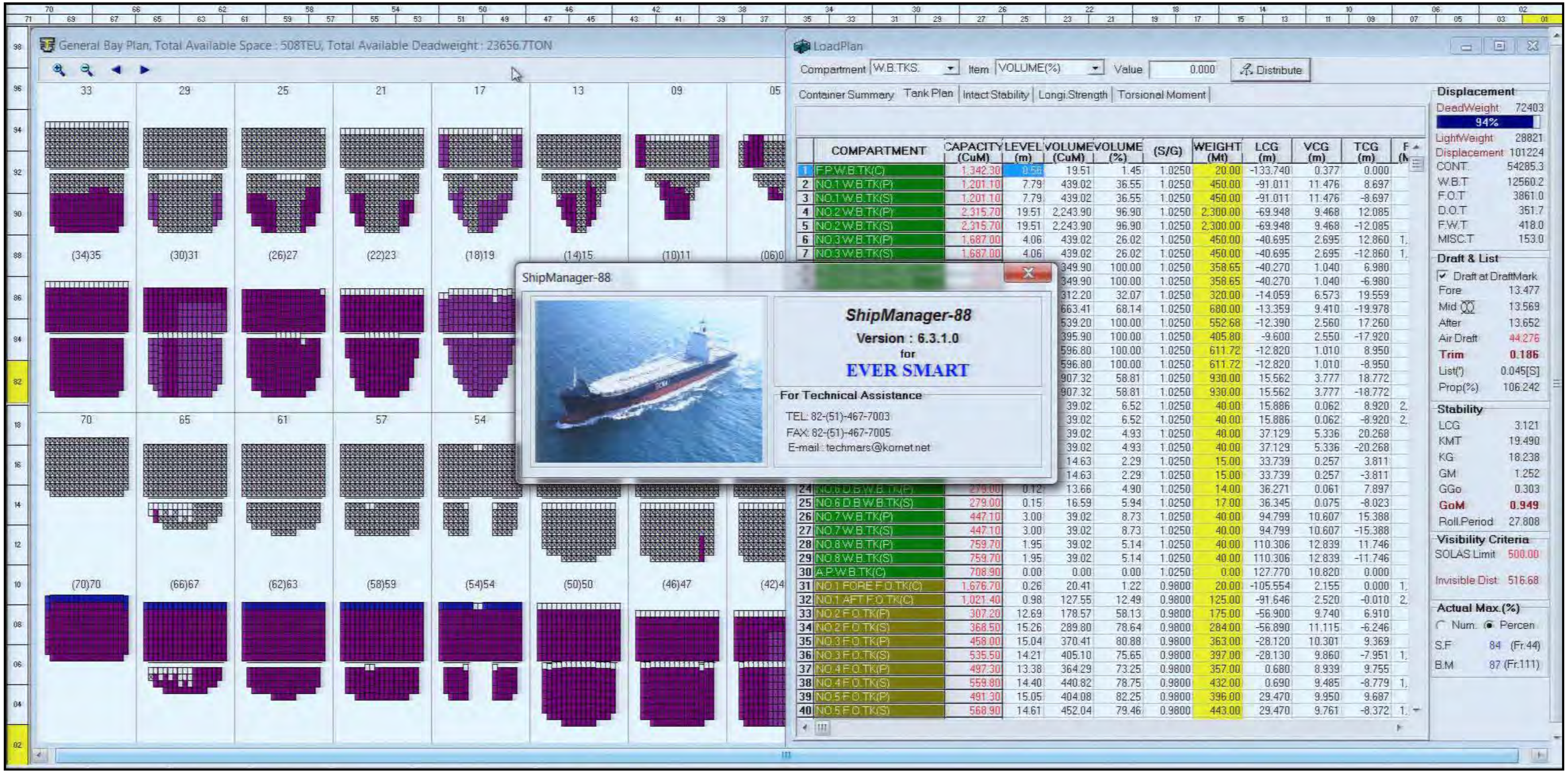


Figure 9: *Ever Smart*'s stability computer – condition for departure Taipei

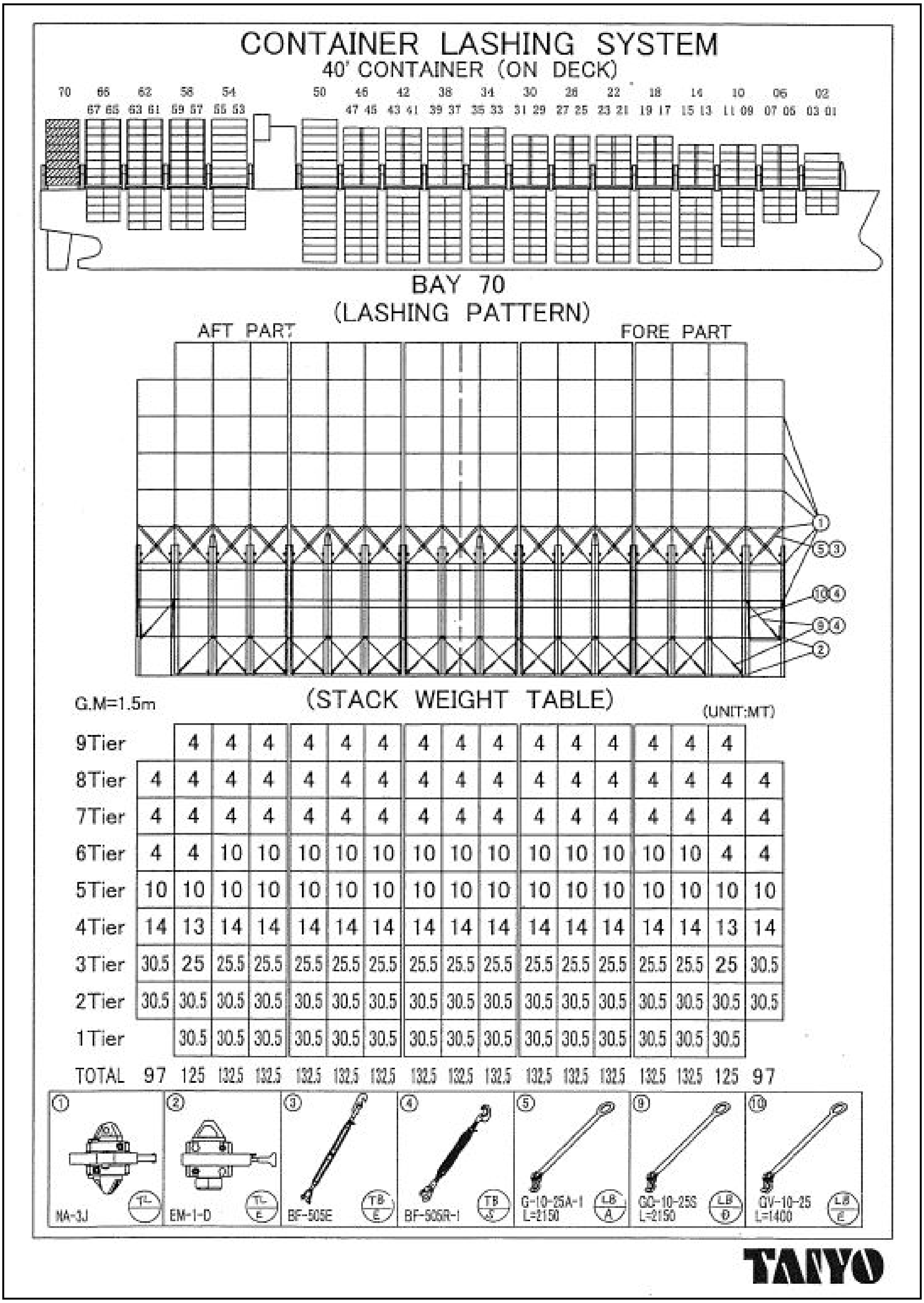
PORT DRAFT — S-TYPE — VOY NO: 0891-085 — TPS

RPM | FUEL CONSUME/Hr | SPD. | SLIP

HARBOUR DEEP | 舵柱比船艉水尺多20CM | Df | Da

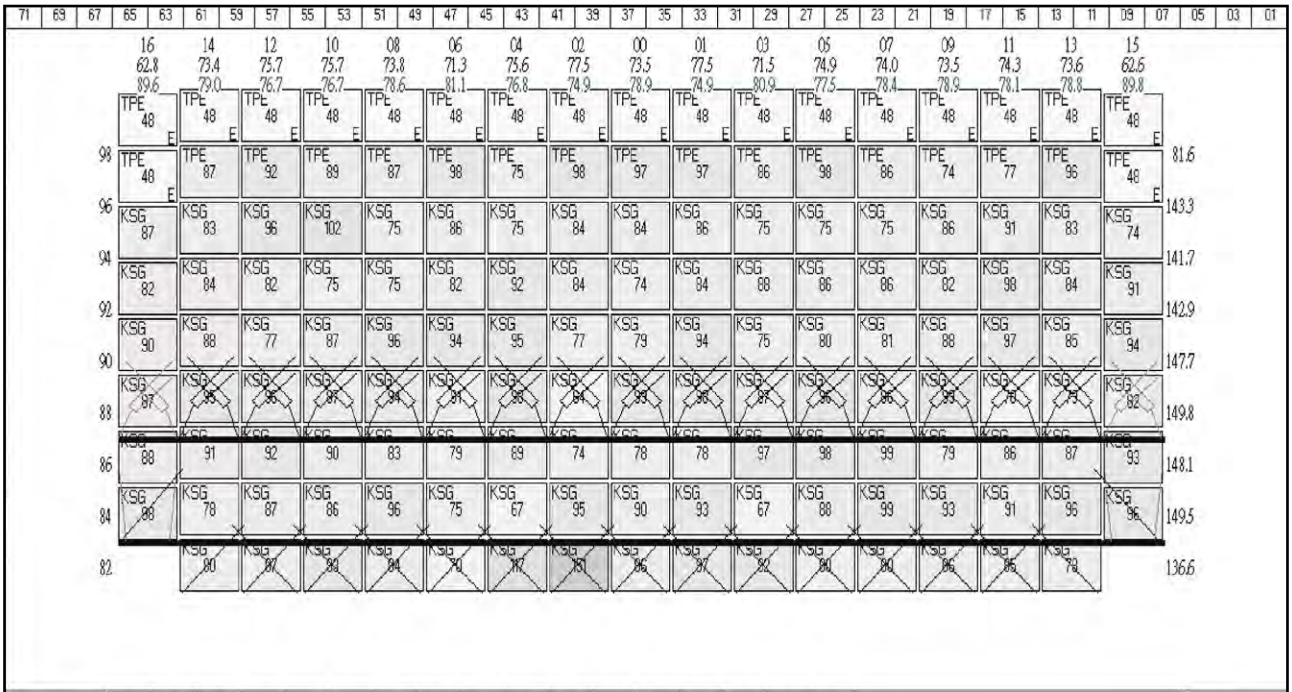
PORT			CASP F	CORR. (cm)	CASP M	CORR. (cm)	CASP A	CORR. (cm)	SM-88 F	CORR. (cm)	SM-88 M	CORR. (cm)	SM-88 A	CORR. (cm)	GAUGE F	CORR. (cm)	GAUGE M	CORR. (cm)	GAUGE A	CORR. (cm)	ACTUAL F	ACTUAL M	(F+A)/2	ACTUAL A	DENSITY	DRAFT CORR. (cm)
01		arr	9.11	0.34		0.00	9.36	0.34	9.06	0.39		0.00	9.39	0.31	9.43	0.02		0.00	9.80	(0.10)	9.45		9.58	9.70		
	YYT	dep	8.86	0.39		0.00	9.12	0.18	8.80	0.45		0.00	9.16	0.14	9.25	0.00		0.00	9.35	(0.05)	9.25		9.28	9.30		
02		arr	8.87	0.38		0.00	9.11	0.19	8.80	0.45		0.00	9.15	0.15	9.22	0.03		0.00	9.36	(0.06)	9.25		9.28	9.30		
	HKG	dep	9.36	0.29		0.00	9.84	0.31	9.32	0.33		0.00	9.85	0.30	9.62	0.03		0.00	10.15	0.00	9.65		9.90	10.15		
03		arr	9.31	0.34		0.00	9.86	0.29	9.27	0.38		0.00	9.87	0.28	9.62	0.03		0.00	10.15	0.00	9.65		9.90	10.15		
	KSG	dep	12.39	0.36		0.00	12.59	0.26	12.36	0.39		0.00	12.61	0.24	12.74	0.01		0.00	12.85	0.00	12.75		12.80	12.85		
04		arr	12.37	0.38		0.00	12.59	0.26	12.33	0.42		0.00	12.61	0.24	12.71	0.04		0.00	12.85	0.00	12.75		12.80	12.85		
	TPE	dep	13.53	0.37		0.00	13.62	0.28	13.48	0.42		0.00	13.65	0.25	13.91	(0.01)		0.00	13.80	0.10	13.90		13.90	13.90		
05		arr	13.31	0.34		0.00	13.50	0.20	13.26	0.39		0.00	13.52	0.18	13.74	(0.09)		0.00	13.67	0.03	13.65		13.68	13.70		
	LAX	dep		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
06		arr		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
	OKL	dep		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
07		arr		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
	TCM	dep		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
08		arr		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
	KSG	dep		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
09		arr		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
		dep		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
10		arr		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
		dep		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
11		arr		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
		dep		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
12		arr		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
		dep		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			
13		arr		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00			0.00			

Figure 10: Draught discrepancy record for departure Taipei



9Tier		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
8Tier	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
7Tier	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6Tier	4	4	10	10	10	10	10	10	10	10	10	10	10	10	10	4	4
5Tier	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
4Tier	14	13	14	14	14	14	14	14	14	14	14	14	14	14	14	13	14
3Tier	30.5	25	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25	30.5
2Tier	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
1Tier		30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	
TOTAL	97	125	132.5	132.5	132.5	132.5	132.5	132.5	132.5	132.5	132.5	132.5	132.5	132.5	132.5	125	97

Figure 11: Container lashing sytem manufacturer's container lashing pattern and stack weight table for bay 70 for GM 1.50m



Unit	16	14	12	10	08	06	04	02	00	01	03	05	07	09	11	13	15
Stack Weight	41.2	48.2	49.7	49.7	48.4	46.8	49.6	50.8	48.2	50.8	46.9	49.2	48.6	48.2	48.8	48.3	41.1
Rack Force	44.0	50.1	51.7	51.8	48.2	52.3	48.9	51.1	49.7	52.5	48.5	50.3	48.6	48.4	52.5	51.2	43.7
Btm. Tension	250.6	41.7	36.3	36.1	29.6	42.4	26.2	31.5	35.6	35.0	32.9	34.2	29.5	28.6	34.2	44.7	248.0
Top Tension	106.8	54.3	44.6	45.2	35.9	51.6	35.9	45.5	44.0	44.1	41.8	41.2	35.0	35.1	42.0	57.2	104.6
Post Comp.	31.5	65.5	67.6	67.2	64.1	66.5	63.0	64.5	65.3	67.9	62.8	66.4	64.3	63.5	65.9	66.5	31.4
Bottom Comp.	109.7	61.8	63.8	63.7	60.6	62.3	60.6	63.0	61.8	64.4	59.7	62.6	60.8	60.2	62.3	62.6	108.8
Rod Tension	29.3	38.3	39.0	38.8	37.6	38.2	38.0	36.5	37.7	39.7	36.7	38.6	37.5	37.5	38.3	38.0	29.1
	58.8	51.8	50.3	50.3	51.6	53.2	50.4	49.2	51.8	49.2	53.1	50.8	51.4	51.8	51.3	51.7	58.9

Unit
Stack Weight
Rack Force
Btm. Tension
Top Tension
Post Comp.
Bottom Comp.
Rod Tension

Figure 12: Ship's loading computer cargo lashing pattern for bay 70 and calculated lashing forces

The twistlocks locked automatically when the containers were landed on the ship's deck or on the top of another container. Taiyo's EM-1-D semi-automatic twistlocks **(Figure 13)** were used to lock the bottom tier of containers to the deck or hatch covers. The NA-3J semi-automatic twistlocks **(Figure 14)** were used to secure the stacked containers, and stevedores on the quayside fitted them to the containers' bottom corner castings before they were craned on board. The ship's crew were required to visually check that twistlock operating handles were in the fully engaged position. Twistlocks that had not engaged properly had to be locked manually by the stevedores.

The lashing rod turnbuckles were attached to anchor points on the deck and the top level of the lashing bridges at the forward and aft end of each bay. The lashing rod hooks were attached to the corner castings of the containers and then to the turnbuckles. The lashing rods were tightened using a 400mm long L-shaped bar to rotate the turnbuckles. Once tight, the turnbuckles should have been locked in position by tightening their locking nut **(Figure 15)**.

Ever Smart's C/O provided the stevedore supervisor with a copy of the lashing plan once the stow had been confirmed. The C/O also gave a copy of the plan to the duty officer and deck crew. When the loading of a cargo bay had been completed, the crew checked the lashings against the plan and reported back to the C/O. The C/O and/or ship's crew raised any discrepancies between the required and actual lashings with the shore supervisor so that these could be rectified.

The guidance contained in the CSM required Bay 70's lashing rod securing hooks to be attached to the bottom corner castings of the containers in tiers two, three and five, and the top corner castings of the containers in tier four **(Figures 7** and **8)** when loaded eight or nine tiers high. When the containers in bay 70 were loaded eight high in the outer stacks, the CSM lashing plan required an extra lashing to be secured to the inner casting of the tier six containers. (this was also the case for bays 66, 62, 58, 54 and 50). These additional lashings are often referred to as wind lashings. Wind lashings were not fitted to any of the outer stack containers in the bays aft of the accommodation block.

1.3.9 Lashing equipment maintenance

When not in use, the lashing rods and turnbuckles were either stowed in racks on the sides of the hatch coaming or kept attached to their anchor points for future easy deployment. The unused twistlocks were stowed in six open-top half-height storage containers that were landed ashore on arrival in port. The storage containers were loaded back on board before departure.

Ever Smart's inventory of lashing equipment was maintained on board, and the planned maintenance system required visual checks and greasing according to the manufacturer's instructions. Damaged and corroded items, when discovered, were replaced from stock held on board. Unserviceable items were landed ashore at an appropriate port. The cargo securing equipment was reported to be in a serviceable condition.

1.4 DAMAGE ASSESSMENT

MAIB inspectors boarded *Ever Smart* shortly after it berthed alongside in Los Angeles and inspected the accident site prior to, and during, the operation to remove the containers from bay 70. Access restrictions to bay 70, due to safety concerns over the stability of the collapsed container stacks, made it difficult to closely assess the extent of the damage with all the containers in situ.

A total of 34 containers were damaged to varying degrees, and some of their doors had sprung open. The forward inboard corner post of the bottom container in bay 70's starboard outer stack (row 15, tier 2) was buckled and had collapsed **(Figure 16)**. The container's aft outer corner casting had been torn away but was still attached to the deck by its twistlock **(Figure 17)**. The forward outboard twistlock that had secured the container to the deck fitting, had failed. The adjacent container (row 13, tier 2) was undamaged, but the twistlocks between it and the tier 1 container below had failed and it had toppled over.

Several broken twistlocks and bent lashing rods and turnbuckles **(Figure 18)** were found close to the damaged containers. In most cases the original location of the lashing equipment could not be determined. Nevertheless, it was evident that the damage had been caused during the container stow collapse.

Several of the twistlocks from bay 70 were found to be corroded **(Figure 19)**, but their main shafts appeared visually to be in sound condition. The ship's crew advised that twistlocks with that level of corrosion should be considered for disposal when seen.

NAME

EM LOCK

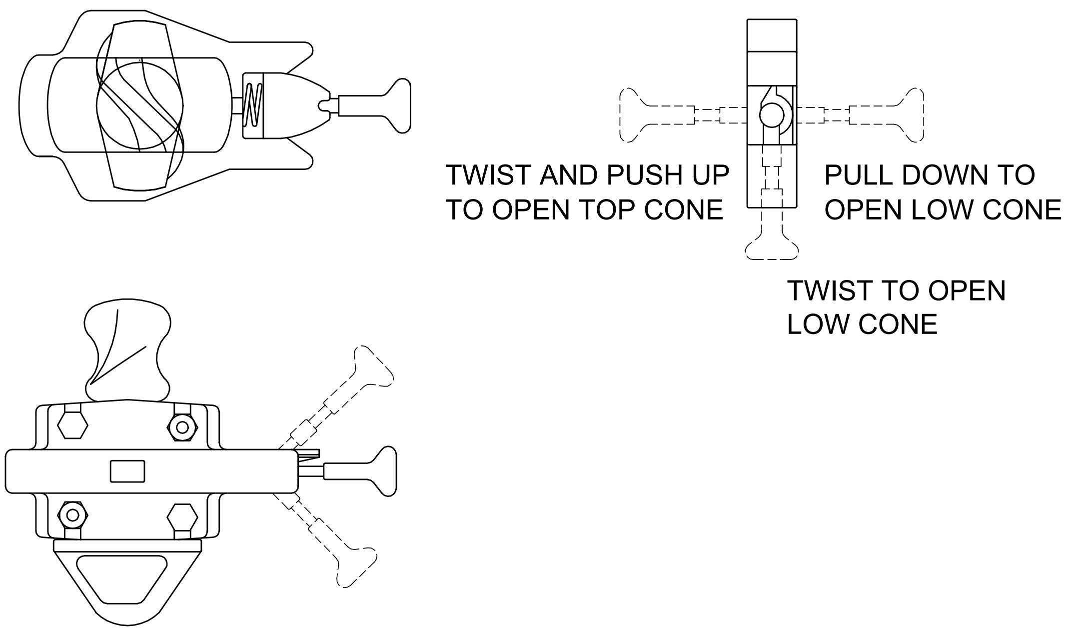
MODEL NO.

EM-1 , EM-1-D

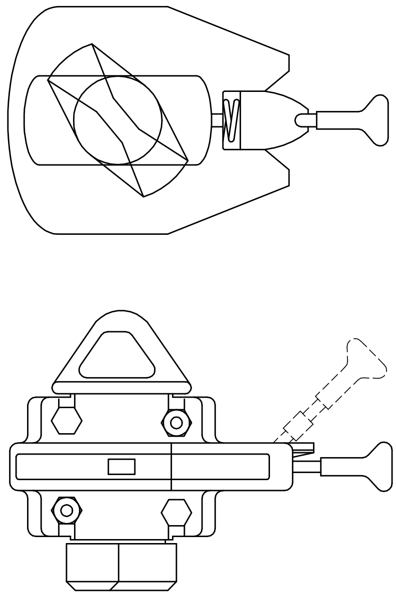
MODEL	B.L.	WEIGHT	FINISH
EM-1	50ton (490.3kN)	7.2kg	Galv.
EM-1-D		7.9kg	

B.L. : Tension load

EM-1

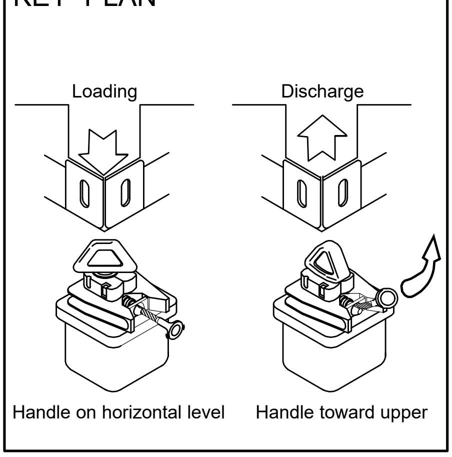


EM-1-D



HEAVY DUTY PURPOSE
(LARGE FLANGE)

KEY PLAN



TAIYO

TAIYO SEIKI RION WORKS CO., LTD.

Figure 13: Taiyo EM-1-D semi-automatic twistlock

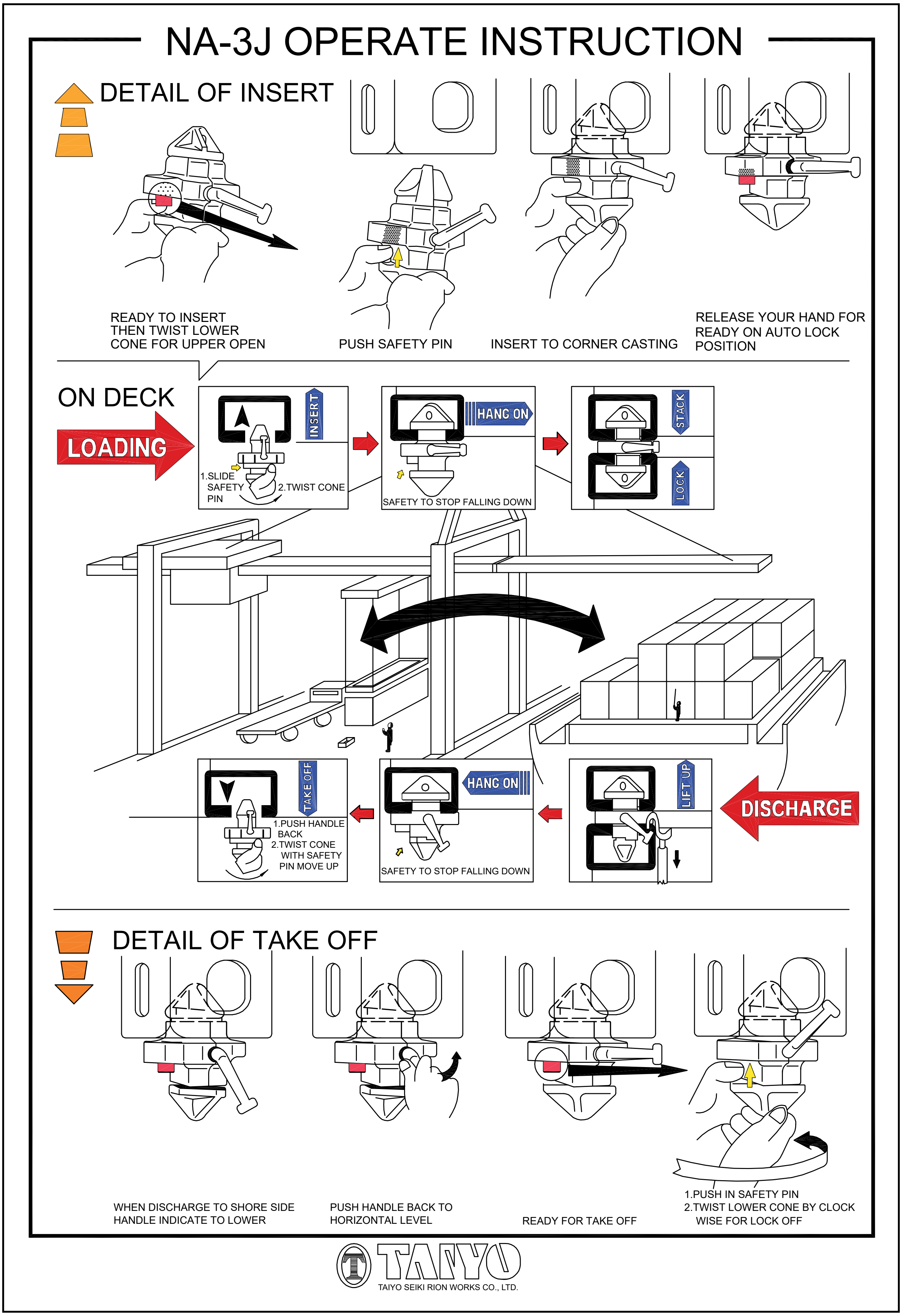
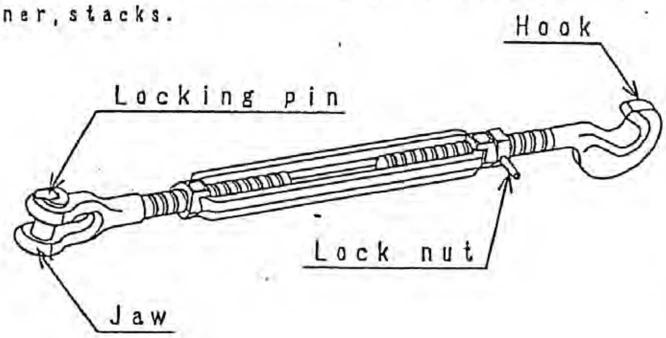


Figure 14: Taiyo NA-3J semi-automatic twistlock

LASHING TURNBUCKLE

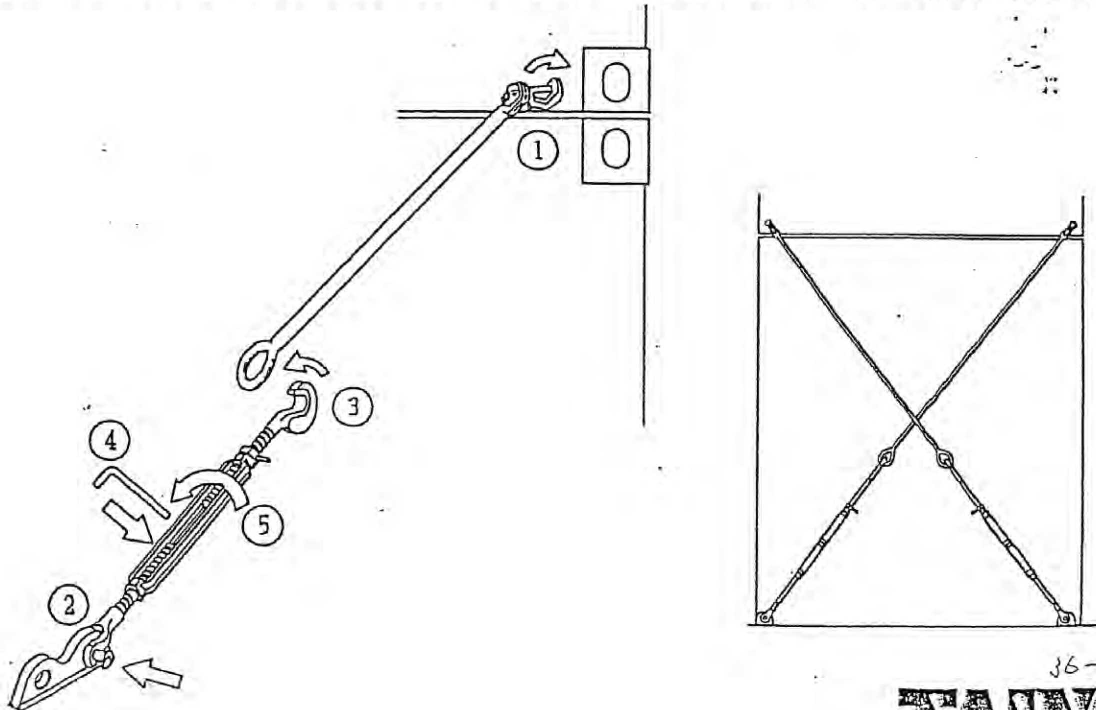
MODEL: BF-505R-1

BF-505R-1 is used for combination with Lashing Rod G-10 or G-1 to lash container, stacks.



OPERATION

1. Take off locking pin of Jaw and insert Jaw opening into eye plate or Portable D ring on deck or hatch cover and lock with the locking pin.
2. Wait till container to be stacked at settled place fixing Lashing Turnbuckle with eye plate or D ring. After container is stacked hang Lashing Rod G-10 or G-1 on lower corner casting or Upper Securing Hook K-19.
3. Connect hook of Lashing Turnbuckle with eye of Lashing Rod.
4. Turn the body of Lashing Turnbuckle using L type handle until to be tight .Then lock with lock nut at side of hook to do not loose the screw



36-9

TAIYO

Figure 15: Cargo securing manual instructions for attachment and tightening of turnbuckle and lashing rods

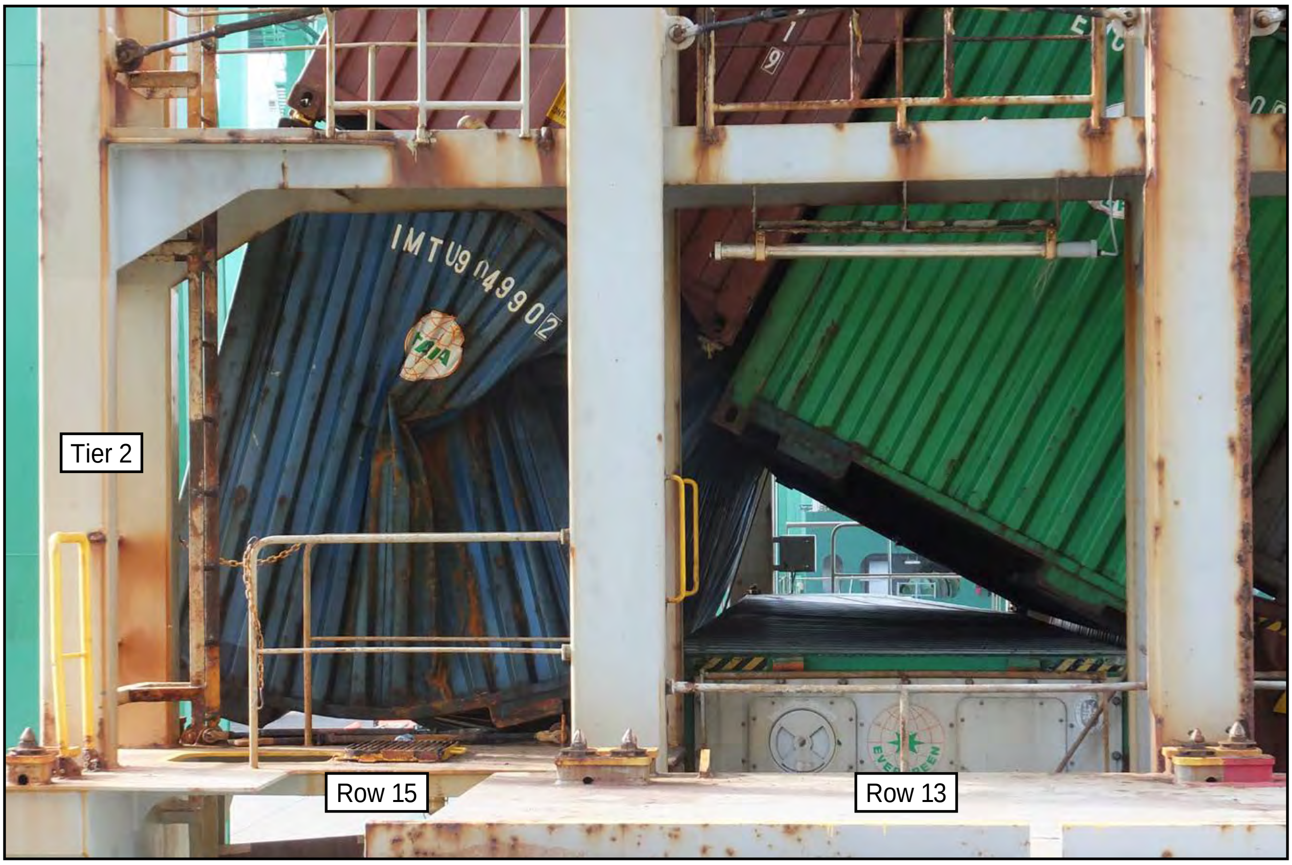


Figure 16: Bay 70: rows 15 and 13 tier 2 containers

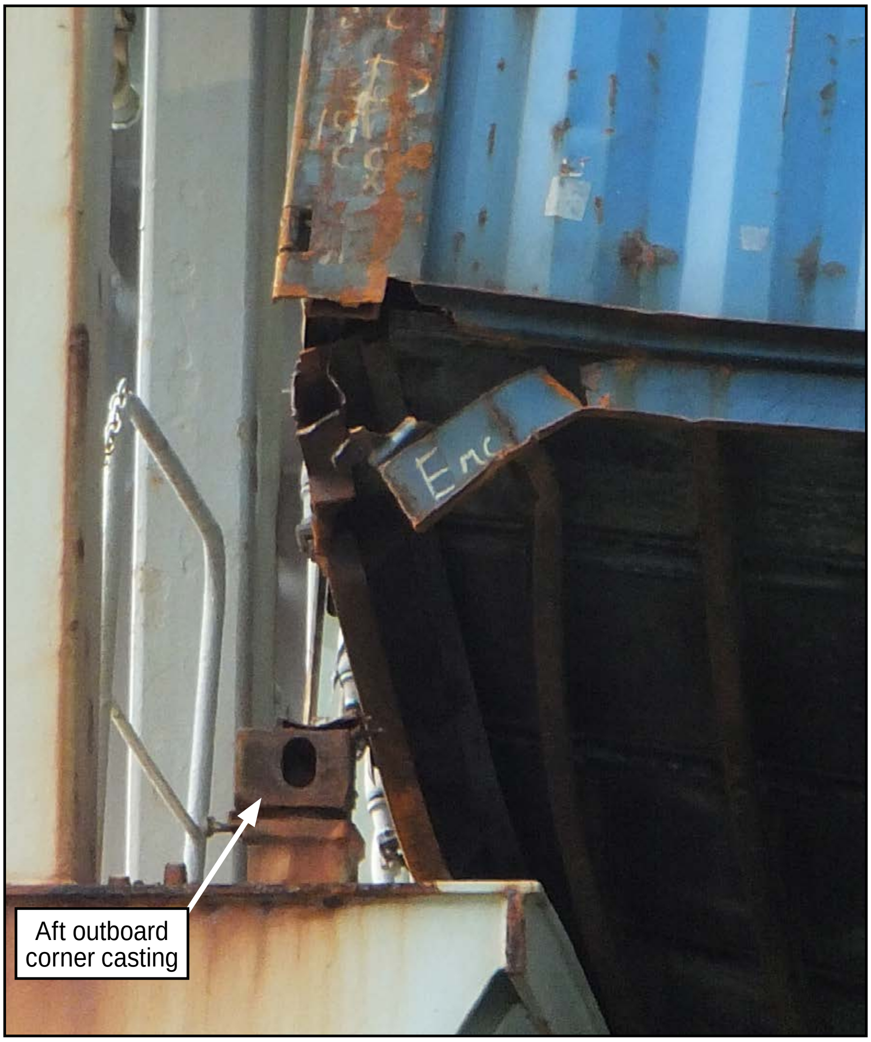


Figure 17: Aft outboard corner casting torn away from bay 70's row 15 tier 2 container

Figure 18: Bent and damaged turnbuckles, lashing rods and twistlocks

Figure 19: Corroded twistlocks

As the containers were being craned ashore, MAIB inspectors checked the lashing arrangements in bays that were not being discharged in Los Angeles. Several of the lashing rods inspected were found to be slack. It was also noted that many of the turnbuckle lock nuts had not been tightened and were loose **(Figure 20)**.

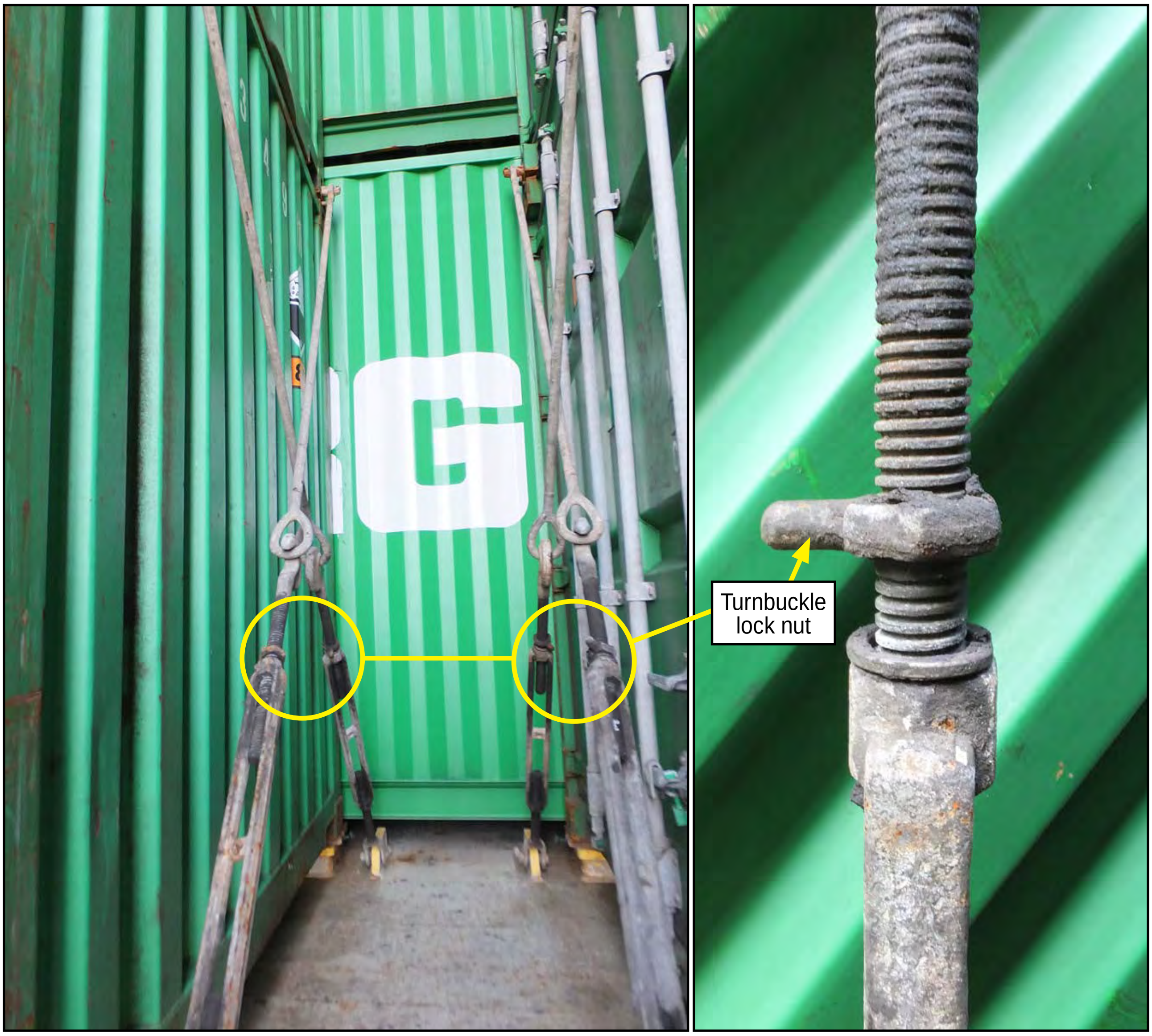


Figure 20: Loose turnbuckle lock nuts

The containers were weighed when they were landed ashore (two were too damaged to be weighed). When bay 70's containers were inspected ashore it was noted that:

- Most of those stowed in the bottom two tiers had suffered varying degrees of buckling damage to the port forward corner posts **(Figure 21)**.
- Some container side walls suffered creasing damage, mainly in line with the corner posts' buckles.

- Several corner castings had been torn from their corner posts.
- Patches of corrosion were visually apparent on the external walls of the container recovered from the bottom of the starboard outer stack **(Figure 22)**.

An LR surveyor inspected the ship's structure once bay 70 was clear of containers and debris. He found that the ship had suffered only superficial damage and its hull integrity had not been compromised. *Ever Smart* departed Los Angeles on 12 November.

Figure 21: Damage to port forward corner posts of the containers stowed in Bay 70, tiers 1 and 2

Figure 22: Visually apparent level of corrosion to the container stowed at the bottom of Bay 70's starboard outer stack

1.5 FORCES ACTING ON CONTAINERS AND CONTAINER LASHING EQUIPMENT AT SEA

A ship in a seaway can experience three forms of rotational motion: roll, pitch and yaw. It can also experience three forms of linear motion: sway, surge and heave **(Figure 23)**. These motions impose forces **(Figure 24)** on the containers as follows:

Corner post load. The vertical compression forces within a stack (container masses and motion induced acceleration forces) act on the container corner posts.

Racking force. When a ship rolls, the lower containers in the stack are subjected to horizontal sideways forces. This movement is resisted by the container rod and turnbuckle lashings.

Lifting force. As a container stack is subjected to a transverse force, the outside corners of the containers within the stack will be subjected to a tensile loading. If the lifting force is excessive, it can break or pull securing devices out of corner castings or separate corner castings from the containers themselves. The safe working load of *Ever Smart*'s twistlocks was 250kN.

Containers stowed on deck are also subjected to **lashing load** and **wind load**. Lashing load is the diagonal compressive force imposed on the containers by the lashing rods and turnbuckles. The maximum permissible load from a lashing rod onto a container is between 230kN and 245kN. Wind forces act on the exposed container stacks. In general terms this means that the stack heights and container weights are typically reduced within the outer stacks of deck container bays. *Ever Smart*'s CSM stated that the wind forces to be applied to exposed 8ft 6in x 40ft containers should be 2t (19.6kN). Some classification societies apply wind loads of 60kN for the first and 30kN for the second and subsequent tiers when conducting lashing arrangement calculations.

The magnitude of the transverse accelerations experienced by containers stowed on deck at sea differs depending on their location within a bay and their fore and aft position within the ship. The greatest transverse accelerations are typically experienced by those stowed in the upper tiers of the outer stacks. Higher transverse accelerations are also experienced by those containers stowed at the bow or stern of the ship and the lowest are experienced by those in the bays amidships.

Whipping or springing accelerations due to deck deformation in severe head seas and interaction between container rows can significantly increase the forces acting on containers and their lashing systems.

1.5.1 Hull deformation and interactions between container rows in a seaway

In 2006, an international consortium comprising nine shipping owners/operators, three government bodies, five classification societies, three lashing system manufacturers and four technology providers came together to conduct the Lashing@Sea research project. The project was commissioned following a marked increase in the number of incidents involving cargo damages and losses, and industry recognition that the regulatory framework had allowed the development of

Image courtesy of International Chamber of Shipping and the World Shipping Council

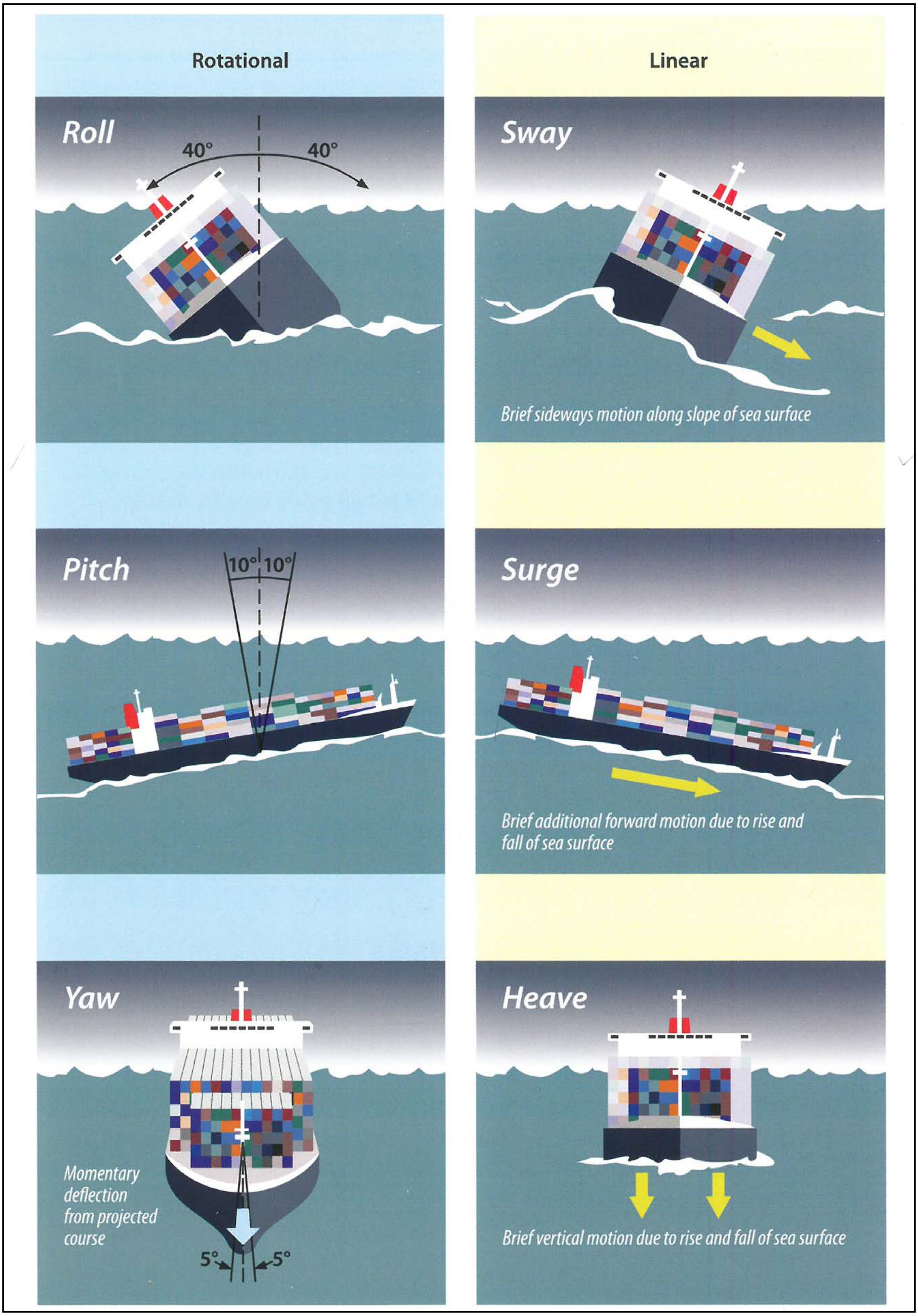


Figure 23: Ship motion in a seaway

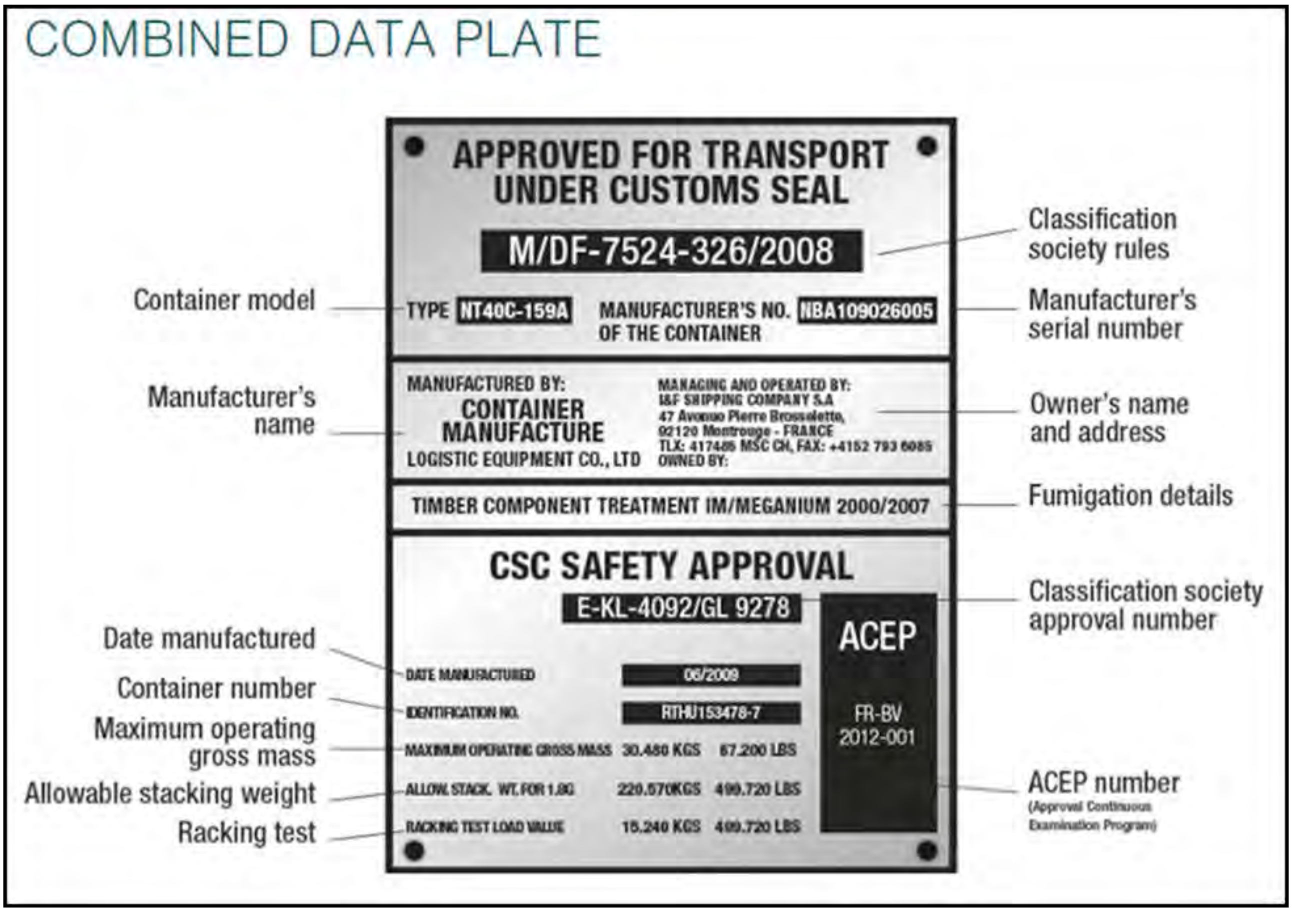


Figure 24: Example of a container CSC plate

a non-level playing field. The aim of the joint industry project was to evaluate the effectiveness of the cargo securing standards and equipment and to improve the safety and efficiency of cargo securing.

The Lashing@Sea project was coordinated by the Maritime Research Institute Netherlands (MARIN). It lasted 3 years and considered three types of marine transport: deep sea container shipping, heavy lift transport and RoRo shipping.

During the project, the researchers reviewed lashing procedures, rules and gear; conducted interviews, issued questionnaires to ships' crews (158 respondents); recorded 3-years' worth of acceleration, vibration, weather and lashing load data on five ships; and conducted container stow motion experiments using a scale model test rig on shore.

The Lashing@Sea report, published in 2009, noted that:

> *Several aspects of in-service conditions were found to be not explicitly included in the principles of the existing rules and standards. The most important ones are:*
>
> - *Increased accelerations due to flexible hull deformations (whipping/springing). These are observed to be occurring regularly in severe head seas.*
>
> - *Multiplication of the expected forces in cargo stacks due to interactions between adjacent rows. This effect occurs if gaps can open up between adjacent stacks allowing impacts when stacks sway sideways. This mechanism concentrates inertia loads on the most rigid row.*

Among the report's conclusions it was stated that:

> *Unexpected high loads in the securing system and container stacks were found to occur due to stack interactions when there are one or more stacks within the bay which are overloaded or not lashed correctly. This mechanism is identified as the most likely responsible for progressive collapse of entire bays resulting in tens of containers lost to sea in single incidents. Safety improvements with regards to the "unexplained losses" of recent past should be aimed to control this mechanism.*

The conclusions highlighted the need for masters to be able to choose suitable heading and speed, in relation to the environment, but that evaluation of dynamic loads was not always possible without movement feedback sensor equipment. Over 50% of the questionnaire respondents said it was not always possible to get a good impression from the bridge of developing loads acting on the cargo and take timely action to reduce them.

The report recommended that ships should have sensors for motion/acceleration; this would enable the crew to identify when high stresses were developing and alter the ship's speed and heading to reduce any excessive forces.

Ever Smart had an inclinometer on the bridge to indicate roll angle **(Figure 25)**. There were no other instruments or sensors to help the bridge team to gauge ship movement or assess the acceleration forces acting on the cargo.

MARIN was expected to continue its research into cargo losses, but funding was not available after the downturn of the global economy in 2009.

1.6 REGULATION AND GUIDANCE FOR CONTAINER SHIP CARGO

1.6.1 Container construction

The structure of a general cargo container is composed of a steel framework with corrugated steel walls and four corner posts. The corner posts support the container's weight and that of containers loaded above them. The corner posts are provided with corner castings at their upper and lower ends, which are also used to attach container securing devices (twistlocks and lashing bars).

Containers for carriage on board ships are approved by national governments through classification societies to the standard set out in the *International Convention for Safe Containers 1972, as amended* (CSC). The construction and testing requirements for totally enclosed general purpose shipping containers is specified by the International Organization for Standardization (ISO) in its international standard ISO 1496-1:2013 *Series 1 freight containers - Specifications and testing – Part 1: General cargo containers for general purposes* (ISO 1496).

There are five approved nominal lengths for freight containers (10ft, 20ft, 30ft, 40ft and 45ft), and these were defined in ISO 668:2013 – *Series 1 freight containers – Classification, dimensions and ratings*. All series 1 ISO containers have a uniform width of 8ft.

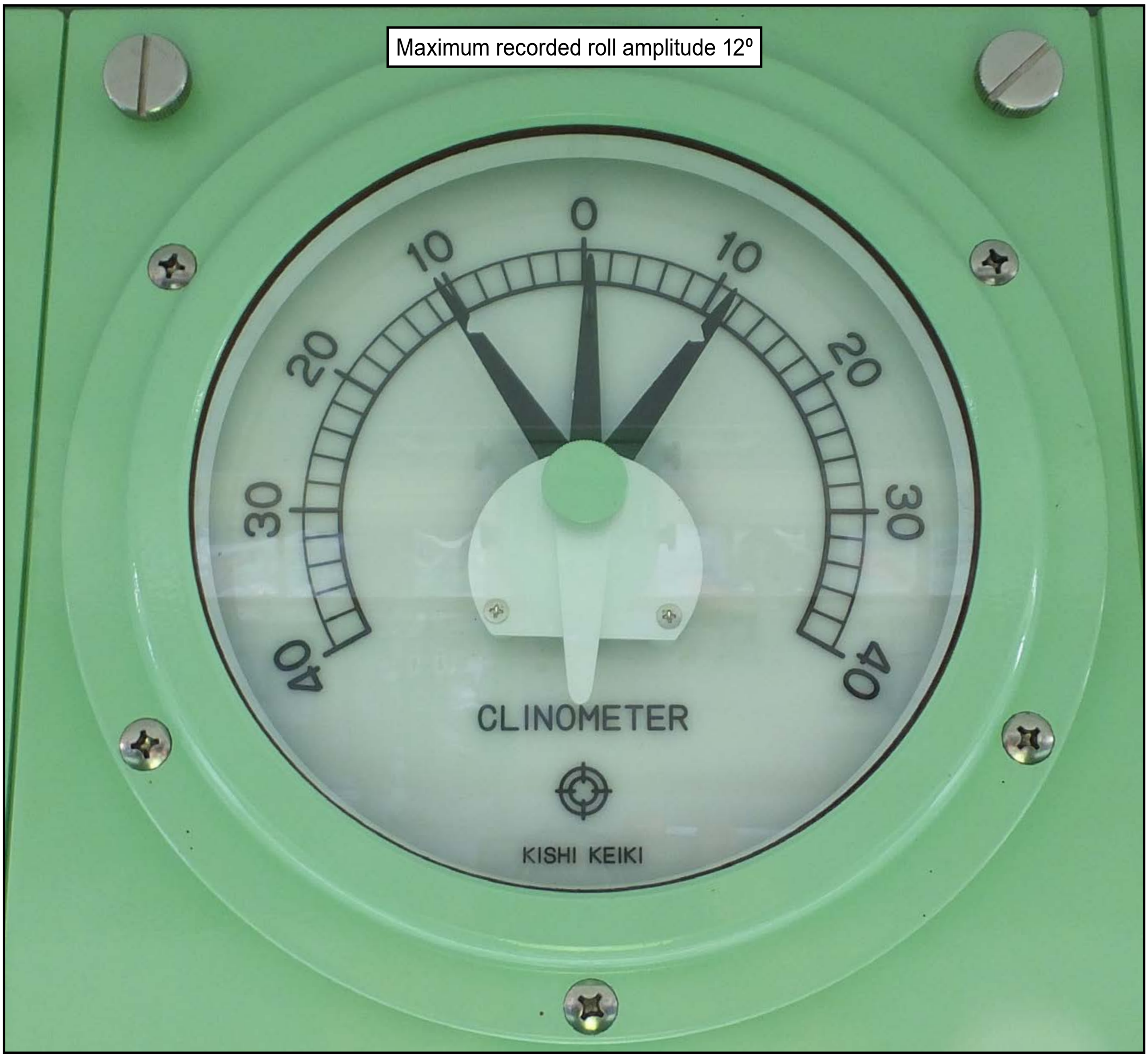


Figure 25: Bridge inclinometer

Containers constructed and tested in accordance with ISO 1496 are considered to have met the requirements of the CSC and are fitted with a safety approval plate (CSC plate) that includes load limits[8] **(Figure 26)**.

The maximum allowable stack weight stated in the CSC for containers was 192,000kg; the stacking strength stipulated in ISO 1496 was 213,360kg. This discrepancy dated back to 2005, when the stacking strength requirement was increased in the ISO standard. While most containers are now constructed to comply with ISO 1496, a small number are still being produced with the lower rating required by the CSC. Nearly all the containers stowed in bay 70, including the bottom container in the starboard outer stack, were constructed in accordance with the latest ISO standard.

Containers built to the ISO 1496 standard have their corner posts tested to a static load of 86,400kg. This is the load applied to the posts of the bottom container in an 8-on-1 stack of 24,000kg (gross weight) containers with a regulation 1.8 safety factor to allow for the ship's dynamic forces.

[8] Approximately 1 in 50 newly manufactured containers is subjected to racking force load tests.

BUREAU VERITAS

(R.O.C. N°. 159907-P)

CERTIFICAT DE CONTROLE / CERTIFICATE OF INSPECTION

BVCT N° 0780863/S

Nom et addresse du Demandeur / *Name and address of Applicant* : **EVERGREEN HEAVY INDUSTRIAL CORP. (M) BERHAD LOT 139, JLN. CECAIR, PHASE 2, F.T.Z. JOHOR PORT AUTHORITY, 81700 PASIR GUDANG, JOHOR, MALAYSIA.**

Nom et adresse du Titulaire / *Name and address of Owner* : **ITALIA MARITTIMA S.p.A. PASSEGGIO S.ANDREA 4-34123, TRIESTE, ITALY.**

CONTENEURS - CONTAINERS

Type / *Type* : **40' x 8' x 9'6"** Modèlè / *Model* : **E45G1IM- 03**

Numèros de sèrie de construction / *Serial number of manufacture* : **M-0214156** Au / *to* **M-0214905**

N° d'immatriculation / *Registration numbers* : De / *from* **IMTU 903851** Au / *to* **IMTU 904600**

Dates de livraison / *Dates of delivery* : Du / *from* **APRIL 2007** Au / *to* **APRIL 2007**

Dèclaration du constructeur / Manufacturer's statement - Le soussignè certifie que les conteneurs mentionnès ci-dessus ontètè construits en conformite avec le type de rèfèrence / *The undersigned certifies that the here above containers have been manufactured in conformity with the reference type.*

Cachet et signature du constructeur / *Stemp and signature of the manufacturer* : [redacted] **DEPUTY MANAGER Q. C. SECTION TECHNICAL DEPT.** [redacted]

Type de construction de rèfèrence / *Reference design type* : BVCT 0581719/S2

- N° BVCT de classification / *BVCT n° for classification*	: BVCT 0581719/S2			
- Masse brute maximale / *Maximum gross weight*	: 30,480	kg	67,200	lbs
- Charge Utile / *Payload*	: 26,680	kg	58,820	lbs
- Tare / *Tare*	: 3,800	kg	8,380	lbs

Conditions d'essais / *Testing conditions*

- Charge admissible de gerbage / *Allowable stacking weight*	: 213,360	kg	470,370	lbs
- Rèsistance du plancher / *Floor strenght test*	: 7,260	kg	16,000	lbs
- Rigiditè transversale / *Transverse racking test load*	: 15,240	kg	33,600	lbs

Les conteneurs ci-dessus ont ètè contrôlès selon les prescriptions des règlements applicables et les marquages suivants ont ètè apposès / *The here above mentioned containers have been inspected with regard to the applicable rules and have been marked as follows:*

C.S.C. (numèro / *number*)	: F/BV/9096/05
U.I.C. (marque / *mark*)	: IC/87
T.I.R. (numèro / *number*)	: GB/C 7073 BV/2007
Marque BV / *BV mark*	: TT
Code ISO / ISO code	: 45 G1
Austres / *Others*	: WOOD TREATMENT - IM/MEGANIUM 2000/07

Etabli à / *Issued at* : **PASIR GUDANG, MALAYSIA**
Le / *On* : **01/05/2007**

L'Expert / *The surveyor* : [redacted]
(Signature et cachet / *Signature and stamp*)

/AdME 5641a

Figure 26: CSC plate and Classification Society approval certificate for the container stowed at the bottom of Bay 70's starboard outer stack

Containers are also designed to withstand transverse and longitudinal racking forces resulting from ship movement. ISO 1496 requires the container to withstand a transverse racking force of 150kN. The test load figures are stated on the CSC plate.

1.6.2 Container maintenance and inspection

The CSC requires containers to be thoroughly inspected either periodically every 30 months, or through an approved continuous examination programme (ACEP). Both procedures are intended to ensure that the containers are maintained to the required level of safety, and both should be considered equal. Owners and renters of large quantities of containers use the ACEP.

The standards and requirements for inspection were set out in IMO document *CSC.1/Circ.138 - Revised recommendations on harmonized interpretation and implementation of the International Convention for Safe Containers, 1972, as amended*. The document stated that:

> *…each examination should include a detailed visual inspection for defects or other safety-related deficiencies or damage which will render the container unsafe and include examination of all structurally significant components of the container, particularly the corner fittings.,* and
>
> *It is accepted that a visual examination of the exterior of the container will normally be sufficient.*

All the containers recovered from *Ever Smart*'s bay 70 had CSC plates and documentation showing compliance with the ACEP. The bottom container in the starboard outer stack was last inspected on 20 August 2016 **(Figure 27)**. It had suffered corrosion and structural damage during its working life and had weld repairs.

1.6.3 Container packing

International guidance for packing (or stuffing) freight containers is provided in the *Code of Practice for the Packing of Cargo Transport Units* (CTU Code). The aim of the CTU Code is to give advice on the safe packing of cargo transport units, which includes containers, to those responsible for the packing and securing of the cargo and by those whose task it is to train people to pack such units.

Poorly packed containers and mis-declared cargoes and gross masses present well recognised hazards to ships and their crews. The CTU Code warned that:

> *Improperly packed and secured cargo, the use of unsuitable CTUs* [cargo transport units] *and the overloading of CTUs may endanger persons during handling and transport operations. Improper declaration of the cargo may also cause dangerous situations. The misdeclaration of the CTU's gross mass may result in the overloading of a road vehicle or a rail wagon or in the allocation of an unsuitable stowage position on board a ship thus compromising the safety of the ship.*

CNTR No.	SEQ	Damage Date	Depot	SEQ	Repair	Components	Description	QTY	Condition
IMTU9049902	1	2016/8/20	THBKKI	1	SEAL	DOOR GASKET		1	CUT
				2	STRAIGHTEN AND WELD	DOOR HEADER		1	BROKEN
IMTU9049902	2	2016/3/27	CNXHKM	1	SECTION	DOOR GASKET		1	BROKEN
				2	WELD	PANEL ASSEMBLY		1	CORROSION
IMTU9049902	3	2016/1/4	CNNBOV	1	SECTION	DOOR GASKET		1	BROKEN
IMTU9049902	4	2011/6/24	IDDKTM	1	WASHING BY WATER	FLOOR BOARD, T-FLOOR		1	DIRTY
IMTU9049902	5	2011/2/22	CAVCRC	1	SECTION	BOTTOM RAIL	FRONT BOTTOM RAIL BENT & BUCKLED - SECTION TUBE & ANGLE 30CM TWICE	2	BENT
				2	REMOVE,GREASE AND REFITTING	BOTTOM RAIL	FRONT CUT OUT AT ABOVE BROKEN - REPLACE	1	BRO
				3	STRAIGHTEN	CORNER POST	R/BOTTOM REAR CASTING BENT - REALIGN	1	BENT
				4	INSERT	REAR SILL (Door Sill)	DOOR SILL BUCKLED -INSERT 30CM	1	BENT
				5	REMOVE,GREASE AND REFITTING	REAR SILL (Door Sill)	AT ABOVE CUT OUT BENT - REPLACE	1	BENT
				6	STRAIGHTEN	REAR SILL (Door Sill)	AT ABOVE STRN & WELD CUT OUT BOX & REALIGN CASTING 15CM	1	MISC
IMTU9049902	6	2010/12/30	IDDKTM	1	WASHING BY WATER	FLOOR BOARD, T-FLOOR		1	DIRTY

Figure 27: ACEP inspection and maintenance history for the container stowed at the bottom of Bay 70's starboard outer stack

In 2019, following a surge in major fires on board large container ships, the USA-based National Cargo Bureau (NCB)[9] inspected a random sample of 500 containers being transported to and from the USA by four major shipping companies. A mixture of containers carrying dangerous goods and general cargo was examined.

Of the 500 containers inspected, 55% failed with one or more deficiencies: 69% of the import and 38% of export containers containing dangerous goods failed. Of the import containers with dangerous goods:

- 44% had problems with the way cargo was secured
- 39% had improper placarding, and
- 8% had misdeclared cargo.

Of the export containers with dangerous goods:

- 25% had securing issues
- 15% were improperly placarded, and
- 5% were misdeclared.

The failures found among containers containing general cargo involved improperly secured cargo. Many of the targeted import containers with problems originated in the Far East.

The NCB explained that not all misdeclarations identified had safety implications, and recognised that the inspection project had uncovered a much bigger problem than NCB finds in the normal course of its business. In 2018, only 7.4% of the approximately 31,000 export containers containing dangerous goods that NCB inspected resulted in failed inspections.

1.6.4 Verified gross mass

The International Convention for the Safety of Life at Sea 1974, as amended (SOLAS) *Chapter VI, Part A, Regulation 2 – Cargo information*, requires the gross mass of a packed container to be verified by a shipper before it is permitted to be loaded on a ship. The regulation, which became effective from July 2016, was adopted by the IMO to improve maritime safety and reduce the dangers to ships, cargo, and personnel throughout the container supply chain.

The gross mass of a packed container can be verified using one of the following two methods:

- *weighing the packed container using calibrated and certified equipment; or*

[9] The NCB is a non-profit surveying organization that does inspections of both bulk and container ships. It inspects over 30,000 dangerous goods containers leaving ports in the USA annually for container carriers to help ensure the cargo being loaded on their ships is safe. The NCB does not normally inspect containers arriving at ports in the USA.

- *weighing all packages and cargo items, including the mass of pallets, dunnage and other securing material to be packed in the container and adding the tare mass of the container to the sum of the single masses, using a certified method approved by the competent authority of the State in which packing of the container was completed.*

The verified gross mass (VGM) must be stated in the container's shipping document. This is required to be submitted to the ship's master or his representative and to the terminal representative sufficiently in advance to allow it to be used in the preparation of the ship's stowage plan. It is not the terminal's responsibility to check or verify the declared gross mass of a container. However, many do, and shippers often request terminals to weigh their packed containers and issue VGM declarations. The shipper had declared the VGM for all the packed containers at bay 70 and they were entered in the ship's cargo loading computer.

The total weight of the 107 containers from bay 70 weighed in Los Angeles was 890.14t. The sum of the declared VGMs for the same containers was 888.62t. The variance[10] between the declared VGM and the actual weights for 63.6% (68) of the individual containers was less than 5% **(Table 1)**. Of the remaining containers, the variance for 21.5% (23) was between 5 and 10%. The variance for four containers exceeded 20% and one of them exceeded 50%.

Variance between declared VGM and actual weight	Number of containers	Percentage of containers weighed
<5%	68	63.6%
5 to 10%	23	21.5%
>10 to 20%	12	11.2%
>20 to 30%	1	0.9%
>30 to 40%	2	1.9%
>40 to 50%	0	0
>50%	1	0.9%

Table 1: Variances between the containers' declared verified gross mass and their actual weight

The container that had a variance greater than 50% was 4.6t heavier than the declared VGM, and was located at row 02 tier 4. The locations of the other mis-declared VGMs with variances greater than 5% are shown in **Figure 28**.

1.6.5 Container lashing systems

SOLAS regulation requires that cargoes on ships be secured in accordance with an approved CSM. SOLAS Chapter VI: Regulation 5, Stowage and Securing states:

> *Cargo, cargo units and cargo transport units carried on or under deck shall be so loaded, stowed and secured as to prevent as far as is practicable, throughout the voyage, damage or hazard to the ship and the persons on board, and loss of cargo overboard.*

10 Variance may be positive or negative.

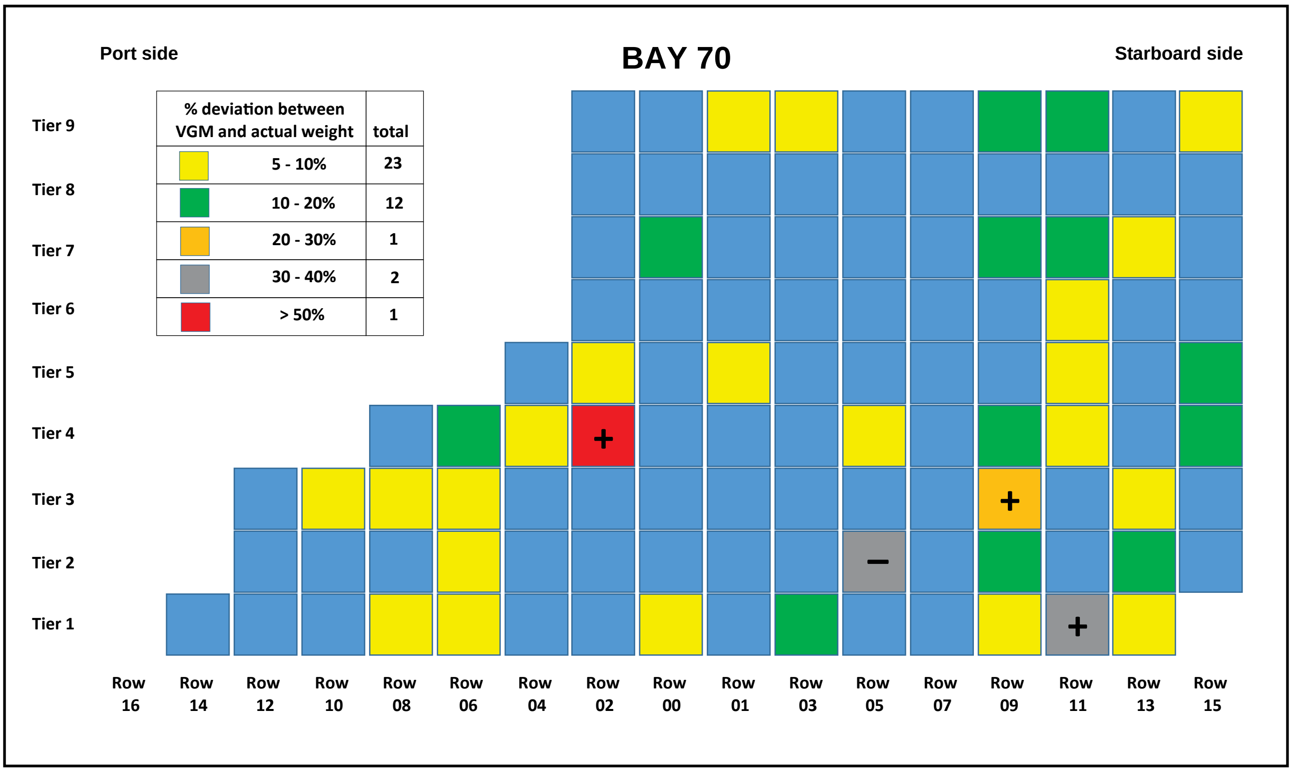


Figure 28: Locations of containers with declared and actual weight deviations greater than 5%

It further states that:

> *Freight containers shall not be loaded to more than the maximum gross weight indicated on the Safety Approval Plate under the International Convention for Safe Containers (CSC), as amended. "All cargoes, other than solid and liquid bulk cargoes, cargo units and cargo transport units, shall be loaded, stowed and secured throughout the voyage in accordance with the Cargo Securing Manual approved by the Administration. (...) The Cargo Securing Manual shall be drawn up to a standard at least equivalent to relevant guidelines developed by the Organization.*

The purpose of the CSS Code is to provide an international standard to promote the safe stowage and securing of cargoes by:

- Drawing the attention of shipowners and ship operators to the need to ensure that the ship is suitable for its intended purpose.
- Providing advice to ensure that the ship is equipped with proper cargo securing means.
- Providing general advice concerning the proper stowage and securing of cargoes to minimise the risks to the ship and personnel.
- Providing specific advice on those cargoes that are known to create difficulties and hazards with regard to their stowage and securing.
- Advising on actions that may be taken in heavy sea conditions.
- Advising on actions that may be taken to remedy the effects of cargo shifting.

The arrangements and cargo securing devices for securing containers during adverse weather and sea conditions were specified within *Ever Smart*'s CSM, which stated that:

> *It is the Masters responsibility to ensure that cargo and cargo units (as defined in MSC.1/Circ.1353) are at all times stowed and secured in an efficient manner, taking into account the prevailing conditions and the general principles of safe stowage set out in this Manual, and that the securing equipment and timber used are adequate for the loadings calculated in accordance with this Manual.*

The CSM also contained the following guidance regarding action that may be taken in heavy weather:

> *General*
>
> *The purpose of this section is not to usurp the responsibilities of the master, but rather to offer some advice on how stresses induced by excessive accelerations caused by bad weather conditions could be avoided.*
>
> *Excessive accelerations*
>
> *Measures to avoid excessive accelerations are:*
>
> 1. *alteration of course or speed, or a combination of both;*
> 2. *heaving to;*
> 3. *early avoidance of areas of adverse weather and sea conditions; and*
> 4. *timely ballasting or de-ballasting to improve the behaviour of the ship, taking into account the actual stability conditions.*

The CSM also listed the quantity and type of lashing gear supplied. The inventory included over 13,600 twistlocks and nearly 4,000 lashing rods and turnbuckles.

1.7 SIMILAR ACCIDENTS

1.7.1 *P&O Nedlloyd Genoa* – MAIB report 20/2006

On 27 January 2006, while on passage from Le Havre, France to Newark, USA, the UK registered container ship *P&O Nedlloyd Genoa* encountered heavy weather. The ship suffered a container collapse in Bay 34, directly in front of the bridge, which resulted in 27 containers lost overboard and 28 containers collapsed on deck. Nine containers were undamaged and remained secured in position.

The investigation report[11] found that the requirements set out in the cargo loading manual were not followed, such that the weight distribution in Bay 34 was out of tolerance. The lashings on the affected containers were destroyed, and it was

[11] MAIB report 20/2006: Report on the investigation of the loss of cargo containers overboard from *P&O Nedlloyd Genoa*, North Atlantic Ocean on 27 January 2006: https://www.gov.uk/maib-reports/loss-of-cargo-containers-overboard-from-container-vessel-p-o-nedlloyd-genoa-during-heavy-weather-in-the-north-atlantic-ocean.

considered probable that the stow was sufficiently out of tolerance for the excessive heavy rolling to cause a refrigerated container in one of the lower rows to buckle and collapse, resulting in a progressive collapse of the stacks to port.

The investigation highlighted that the container inspection requirements did not include the assessment of structural strength and rigidity. The Maritime and Coastguard Agency (MCA) was recommended to:

- *In consultation with MARIN, review the contents of container vessel CSMs and, if appropriate, issue further guidance on their minimum required content.*
- *Use the data from an MCA study into container damage, to review:*
  - *container structural strength and rigidity standards, and*
  - *the need to improve container inspection regimes.*

Following work, which included addressing the issues above, by several organisations, including the MCA, the IMO amended its regulations and guidelines for CSMs and CSC.

1.7.2 *Annabella* – MAIB report 21/2007

On 25 February 2007, while on passage in the Baltic Sea, *Annabella* encountered heavy seas, which caused the ship to roll and pitch heavily. The master reduced speed and adjusted course to reduce the motion, and by the following day the ship had resumed its normal passage. Later it was discovered that a row of seven 30ft cargo containers in bay 12, number 3 hold, had collapsed against the forward part of the hold.

The collapse of cargo containers occurred because of the magnitude of the downward compression and racking forces acting on the containers at the bottom of the stack. The MAIB investigation report[12] identified that the maximum allowable stack weight had been exceeded and no lashing bars had been applied to the containers.

The report concluded that there was a compelling need for the introduction of a Code of Practice for the container shipping industry.

1.7.3 *MSC Napoli* – MAIB report 9/2008[13]

During the morning of 18 January 2007, when on passage in the English Channel, the 4419 TEU container ship *MSC Napoli* encountered heavy seas, causing the ship to pitch heavily. At about 1105, the ship suffered a catastrophic failure of her hull in way of her engine room. The master quickly assessed the seriousness of the situation and decided to abandon ship. Following the broadcast of a distress call at 1125, the 26 crew abandoned the ship in an enclosed lifeboat.

[12] MAIB report 21/2007: Report on the investigation of the collapse of cargo containers on Annabella, Baltic Sea on 26 February 2007: https://www.gov.uk/maib-reports/collapse-of-cargo-containers-during-heavy-weather-on-container-vessel-annabella-in-the-baltic-sea-near-gotland-island-sweden

[13] MAIB report 9/2008: Report on the investigation of the structural failure of MSC Napoli English Channel on 18 January 2007: https://www.gov.uk/maib-reports/structural-failure-of-container-vessel-msc-napoli-in-the-english-channel-resulting-in-beaching-at-branscombe-bay-england

MSC Napoli was subsequently taken under tow. As it approached the UK coast there was a risk that the ship might break up or sink, so it was intentionally beached. Several containers were lost overboard when the ship listed heavily after beaching.

Factors identified during the investigation included:

- The load on the hull was likely to have been increased by whipping effect.
- The ship's speed was not reduced sufficiently in the heavy seas.

A recommendation was made to the International Association of Classification Societies to consolidate research into [ships' hull] whipping effect, and to initiate research into the development and use of technological aids for measuring hull stresses on container ships. This research has continued as ship size increases.

1.7.4 *Maersk Shanghai*

On 3 March 2018, *Maersk Shanghai*'s master informed the US Coast Guard that 76 containers had been lost overboard in heavy weather, 17 miles from the coast of the USA. It was later reported that at least one of the containers was carrying hazardous cargo; sulphuric acid.

1.7.5 *CMA CGM G.Washington* – MAIB report 2/2020[14]

At 0127 on 20 January 2018, the UK flagged container ship *CMA CGM G. Washington* unexpectedly rolled 20° to starboard, paused for several seconds then rolled 20° to port. The ship was experiencing heavy seas in the North Pacific Ocean while on passage from Xiamen, China to Los Angeles, USA. As the sun rose later that morning, it was discovered that container bays 18, 54 and 58 had collapsed; 137 containers were lost overboard and a further 85 were damaged.

The collapses were not witnessed but all three bays probably collapsed during the unexpected 20° rolls. The amplitude of the rolls exceeded the ship's estimated roll limits, and were almost certainly the consequence of parametric rolling, which had been recorded by the ship's motion monitoring decision support tool.

The investigation identified several factors that would have adversely affected the safety of the container stows on deck. These included: reduced structural strength of non-standard 53ft containers, inaccurate container weight declarations, mis-stowed containers and loose lashings.

Action was taken by CMA Ships, in conjunction the manufacturer of the motion monitoring and weather routeing decision support tool, to improve its presentation of ship-handling advice to masters during bad weather. In addition, Bureau Veritas, *CMA CGM G. Washington*'s classification society, amended its rules for the carriage of non-standard containers.

Recommendations were made to CMA Ships, the MCA and Bureau Veritas aimed at improving the accuracy of declared container weights, material state of containers, and stowage and securing standards on board ships.

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[14] MAIB report 2/2020: Report on the investigation into the loss of 137 containers from the container ship CMA CGM G. Washington in the North Pacifc Ocean on 20 January 2018: https://www.gov.uk/maib-reports/loss-of-cargo-containers-overboard-from-container-ship-cma-cgm-g-washington

1.7.6 *YM Efficiency* – ATSB Transport Safety Report 344-MO-2018-008[15]

At about 0035 on 1 June 2018, *YM Efficiency* was on passage to Sydney, steaming slowly into strong gale force winds and very rough seas when it suddenly rolled heavily. As a result, 81 containers were lost overboard and a further 62 were damaged. The ship also sustained structural damage to its lashing bridges, superstructure and accommodation ladder. Some containers and substantial debris were washed ashore on New South Wales beaches.

The Australian Transport Safety Bureau (ATSB) determined that the loss of containers overboard occurred because forces generated during the sudden, heavy rolling placed excessive stresses on containers stowed aft of the ship's accommodation. This resulted in the structural failure of containers and components of the lashing system, leading to the loss of containers.

The ATSB found that:

- The weights and distribution of containers in the affected bays were such that calculated forces exceeded allowable force limits as defined in the ship's CSM. Of note:
    - *The loading of hi-cube containers exceeded the tier height limit.*
    - *Some stack weight limits were exceeded.*
    - *The weight of many containers exceeded the weights specified in the CSM (stack weight tables) for their allocated slots.*
    - *There were many instances of heavy containers being stacked above lighter ones.*
- The stowage arrangement was not checked for compliance with the CSM's calculated lashing force limitations during the cargo planning process ashore.
- The sole responsibility for stowage arrangement compliance was left with the ship's officers, who had limited options to resolve deficiencies at a late stage in the process without unduly impacting operations.
- The ship's officers did not use the ship's loading computer system and its lashing calculation program to check if the stowage arrangement complied as they probably did not have an adequate understanding of the system.

Actions have been taken by the ship managers, Yang Ming, to ensure predicted lashing forces are checked during the initial cargo stowage planning stage ashore. A review of loading computer systems in use across the Yang Ming fleet resulted in the adoption of class-specified, route-specific container stowage standards for part of the fleet. YM Efficiency, and the other ships of the same size and type, have been equipped with class-approved container stowage planning software systems, with the same software replicated ashore. In addition, periodic training in the use of the ship's loading computer system will be delivered to the responsible ship's officers. Cargo procedures were also reviewed to ensure that the requirement for lashing forces checks to be conducted, both ashore and on board, was captured.

[15] https://www.atsb.gov.au/publications/investigation_reports/2018/mair/344-mo-2018-008/

1.7.7 World scale container losses

The World Shipping Council (WSC) conducts periodic surveys to determine and monitor the extent of container losses at sea. Its 2017 *Containers Lost at Sea Report* **(Annex B)** analysed the survey information gathered for the period 2014 to 2016. All WSC members participated in the survey and the results of the report represented 80% of the industry's global container capacity.

The WSC 2017 report stated that, excluding catastrophic losses[16], 612 containers were lost at sea each year. The annual movement of loaded containers was about 130 million. Consequently, the annual losses represented about 0.0005% of total loaded movement.

[16] The report defines catastrophic as "*for the purposes of this analysis* [catastrophic loss] *is defined as a loss overboard of 50 or more containers in a single incident*". These events have tended to occur because of groundings and hull failure.

SECTION 2 - ANALYSIS

2.1 AIM

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

2.2 OVERVIEW

Ever Smart was a purpose-built container ship that had been operated by Evergreen for 12 years, and was employed on a regular route between China and the USA. It was loaded to 93% of its cargo carrying capacity and the deck stowage plans had been approved by the master and C/O, and the lashing arrangements inspected daily by the ship's crew. Despite this, the containers stacked on deck in bay 70 toppled to port during a routine passage across the North Pacific Ocean and 42 containers were lost overboard; a further 34 suffered structural damage.

Container stow collapses of this type are rarely attributed to a single cause and are usually the consequence of several complex factors, such as:

- **The quality of the stowage plan:** The safe stowage of containers on deck; specifically, stack weights, weight distribution and container securing arrangements within each bay are governed by the guidance provided in the ship's CSM, and the calculations carried out by the ship's crew or its loading computer.

- **Container securing arrangements:** The design and condition of the twistlocks and container lashings, their arrangement and application.

- **Ship's motion:** Ship's motion introduces dynamic loading on container stacks and is affected by the sea and wind conditions, and the ship's course and speed, hull design and GM.

- **Containers:** The structural strength, material condition and the way containers are packed can all affect the stability of a stow.

The investigation into the causes and circumstances of *Ever Smart*'s container stow collapse identified several factors that would have significantly increased the loads acting on the containers and reduced the effectiveness of the ship's lashing system. This section of the report will examine the contributory factors and establish the most likely causes of the container bay collapse.

2.3 INITIATION OF THE CONTAINER STOW COLLAPSE

The ship's crew discovered the container collapse in bay 70 at 1648 on 30 October during a cargo lashings deck inspection. The crew had been confined to the accommodation block for over 24 hours due to heavy weather and did not witness the collapse. However, the collapse most likely occurred shortly before 0240 that morning, when the master reduced the ship's speed to alleviate increased levels of pitching and shuddering, and when a crew member heard unusual noises from the aft end of the ship.

Most container stow collapses of this kind occur following the structural failure of an individual container within the stow or the failure of the lashing arrangements. In either case, the containers in the stack directly above the deformed or unsecured container will topple sideways into the adjacent row. This leads to a domino effect as one stack hits another, causing structural or lashing system failure in each adjacent row. This sequence of failure will continue until the outer stack is reached and containers are lost overboard.

It was apparent that the collapse was initiated in bay 70's starboard outer stack (row 15) and propagated to port due to the forces created as the containers struck each other **(Figure 29)**. The container at the bottom of the starboard outer stack was the only one that suffered significant structural damage. Its forward inboard corner post had buckled and its bottom aft outboard corner casting had torn free. The forward outboard twistlock had been pulled from its deck mounting. The containers in the adjacent row (row 13) suffered very little structural damage and toppled to port at tier 2 level. The port side corner posts at the forward ends of the tier 1 containers in the other stacks had all buckled and collapsed.

The evidence might suggest that the collapse was initiated by the structural failure of the bottom container in the starboard outer stack. However, rather than being the cause, the buckling of the container's corner post and the failure of its corner casting might have been the consequence of a lashing system or lashing equipment failure **(Figure 29)**.

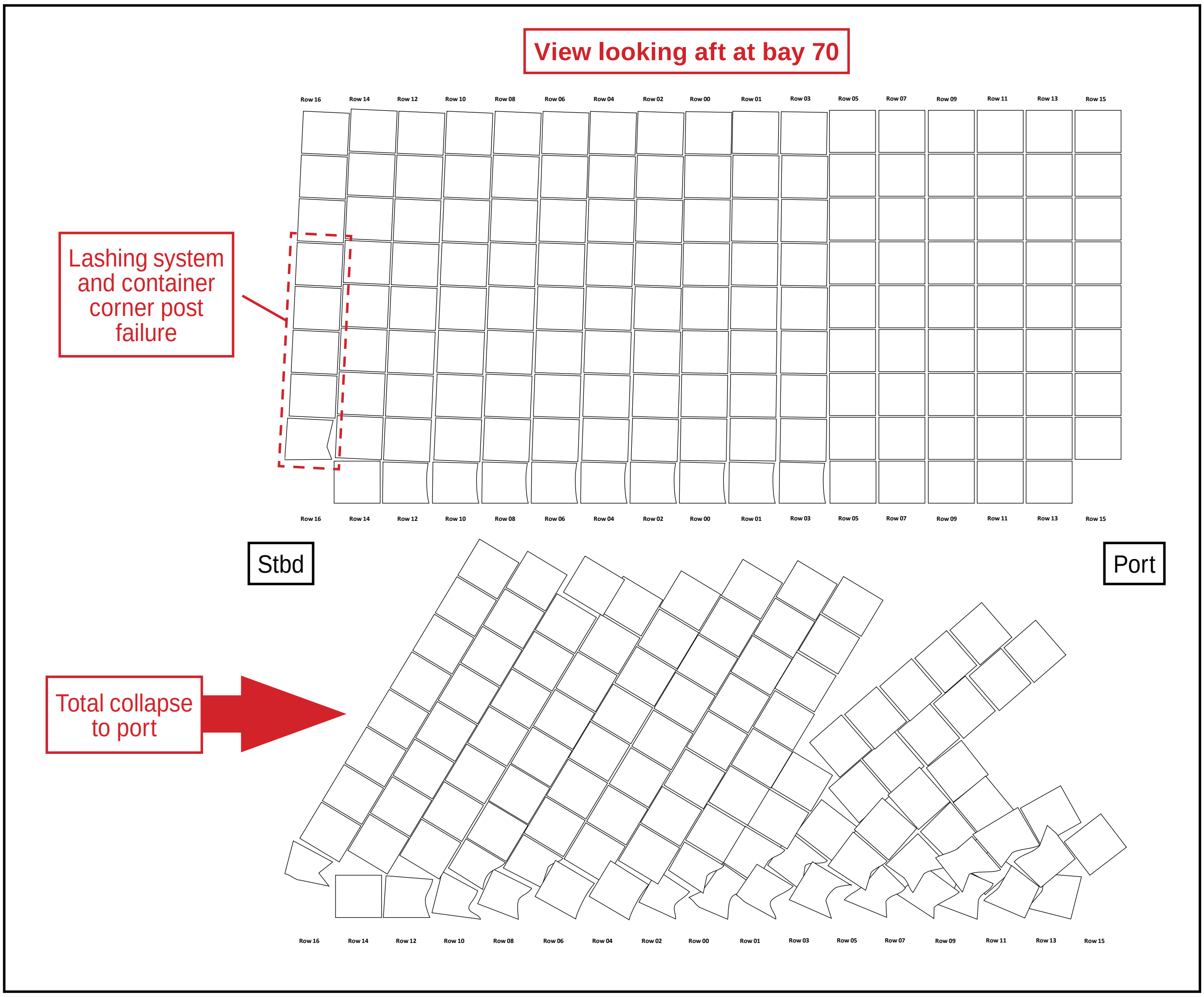

Figure 29: Likely sequence of the stowage collapse

2.4 CONTAINER STOWAGE PLAN

2.4.1 General

Bay 70 was fully loaded nine tiers high with 151 x 40ft hi-cube containers. The total stack weights of the containers in all 17 rows of the stow were below the calculated limits; the weight in the starboard outer stack was just below 63t, which was 62% of the maximum permissible weight given in the CSM's stack weight tables for a GM of 0.7m. Nevertheless, anomalies were identified between the bay plan produced by the shore planners and approved by the ship's master, and the requirements set out in the CSM. Of note:

- The container weights in the upper tiers of the stow exceeded the recommended limits given in the CSM's stack weight table.
- Hi-cube containers were loaded eight high in the stow's outer stacks.
- The ship's GM was above the indicative GMs provided for a fully loaded ship and that used to calculate the lashing requirements and stack weight limits for bay 70 when loaded nine tiers high with 151 containers.

Therefore, the stowage plan did not comply with the requirements set out in the ship's CSM and almost certainly contributed to the stow collapse.

2.4.2 Container weight distribution

According to the stack weight tables contained in *Ever Smart*'s CSM, when bay 70 is fully loaded with 151 containers **(Figure 7)** the gross mass of each container in tiers 8 and 9, and 5, 6 and 7 in the outer stacks should not exceed 4t. This was not the case; the tare weight of the empty refrigeration containers in tier 9 of the stow and tier 8 of the outer stacks was between 4.6 and 4.8t **(Figure 30)**. The rest of the containers in tier 8 weighed between 7.4 and 9.8t. The weights of the containers in tiers 5, 6, and 7 of the starboard outer stack were 9.6, 8.6 and 7.6t respectively. The weights of the containers in tiers 2, 3 and 4 were 9.6, 9.3t and 8.2t respectively, and were all well below the weights given in the stack weight table.

The forces imparted on the containers stowed on deck, and their lashing arrangements by the ship's rolling and pitching are greatest outboard and higher up in the stow. For this reason, restrictions are set out in the CSM for the gross weight of the containers located in the outer stacks and upper tiers in each stow. If the individual weight of any container in a stack exceeds the limit given in the CSM, there is a risk that the lashing devices will become overloaded and will fail. Similarly, the risk of containers suffering compression or racking damage lower down in the stowage will also be increased.

Many P&I clubs have made this point; Gard warned in its book *Gard guidance on freight containers* that:

> *…the lashing system chosen **determines how high containers can be stacked and how heavy the containers in each tier of the stack can be**.*

G.M=0.7m (STACK WEIGHT TABLE) (UNIT:MT)

9Tier	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8Tier	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
7Tier	4	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	4
6Tier	4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	4
5Tier	4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	4
4Tier	21	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	21
3Tier	30.5	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	30.5
2Tier	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
1Tier		30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	
TOTAL	102	136	136	136	136	136	136	136	136	136	136	136	136	136	136	136	102

Row 16	Row 14	Row 12	Row 10	Row 08	Row 06	Row 04	Row 02	Row 00	Row 01	Row 03	Row 05	Row 07	Row 09	Row 11	Row 13	Row 15
4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
4.8	8.7	9.2	8.9	8.7	9.8	7.5	9.8	9.7	9.7	8.6	9.8	8.6	7.4	7.7	9.6	4.8
8.7	8.3	9.6	10.2	7.5	8.6	7.5	8.4	8.4	8.6	7.5	7.5	7.5	8.6	9.1	8.3	7.4
8.2	8.4	8.2	7.5	7.5	8.2	9.2	8.4	7.4	8.4	8.8	8.6	8.6	8.2	9.8	8.4	9.1
9.0	8.8	7.7	8.7	9.6	9.4	9.5	7.7	7.9	9.4	7.5	8.0	8.1	8.8	9.7	8.5	9.4
8.7	9.5	9.6	8.7	9.4	8.1	9.8	6.4	9.9	9.8	8.7	9.6	8.6	9.9	7.0	7.9	8.2
8.8	9.1	9.2	9.0	8.3	7.9	8.9	7.4	7.8	7.8	9.7	9.8	9.9	7.9	8.6	8.7	9.3
8.8	7.8	8.7	8.6	9.6	7.5	6.7	9.5	9.0	9.3	6.7	8.8	9.9	9.3	9.1	9.6	9.6
	8.0	8.7	9.3	8.4	7.0	11.7	15.1	8.6	9.7	9.2	8.0	8.0	8.6	8.5	7.8	

Containers heavier than values/limits set out in the stack weight tables

Figure 30: Comparison between the cargo stowage plan and cargo securing manual weight distributions for containers stowed in bay 70

Reducing the weight of the containers in the lower tiers of a stack can also increase the load on the lashing system even if the total stack weight limit is not exceeded. This is because the centre of gravity of the stack may move upwards. One of the examples Gard used in its book to explain the potential consequences of ignoring indicative tier weight limits was:

> *The same CSM shows that in a certain bay on deck the containers can be stacked six tiers high, and that the tier weight from the base to the top is: 30 t, 20 t, 20 t, 15 t, 10 t, 7 t. The maximum stack weight is then 102 tonnes. However, containers are never loaded exactly as prescribed by the CSM. If, for example, the container in the bottom tier weighs 21 tonnes instead of 30 tonnes, the first instinctive reaction may be that the forces will be less than the example given in the CSM, and the stowage would therefore be safe. However, the opposite is the case as less weight in the bottom tier will create higher forces as the centre of gravity of the stack moves upwards.*

The North of England P&I Association's 2012 loss prevention briefing explained that:

> *When containers are stowed on deck they must be stowed in accordance with the stack and tier weight limits set out in the Cargo Securing Manual.*

The document went on to warn that:

> *If the weights of any containers in a tier or stack exceed the limit given in the Cargo Securing Manual, there is a risk that the securing devices will become overloaded when the ship rolls and pitches heavily in the seaway…*

It is therefore essential that tier weight restrictions are followed and are not ignored, even if the overall stack weight limits are not exceeded. That was clearly not the case for bay 70; the weights of the containers allocated to the upper tier slots exceeded the indicative limits provided in CSM stack weight tables, and the weights of those in the lower tier slots were well below the limits.

2.4.3 Stowage of hi-cube containers eight tiers high in the outer stacks

The CSM clearly stated that only 8ft 6in containers could be stowed in the outer stacks of bays 50, 54, 58, 62, 66 and 70 when they were stacked 8 containers high. However, all the containers stowed in bay 70, and the other bays aft of the accommodation block, were 9ft 6in hi-cube containers. As a result, the total height of the containers in bay 70's outer stacks was almost equivalent to nine standard height containers.

The loading of hi-cube containers in bay 70's outer stacks meant that the acceleration forces acting on the highest containers, the centre of gravity of the stack, and the wind forces acting on them, were all higher than those allowed for in the CSM and the lashing system manufacturer's stack weight tables. Furthermore, the increased height of the containers might have altered the angles of the lashing rods to a point where they differed from those used in the initial calculations. All these factors would have increased the likelihood of a lashing system failure and stack collapse.

2.4.4 Metacentric height

The CSM contained stack weight tables for GMs of 0.8, 1.5 and 2.0m for a wide variety of loaded conditions, but contained only one stack weight table for bay 70 when its outer stacks were loaded 8 containers high. This was based on a GM of 0.7m, and was also the case for bays 50, 54, 58, 62 and 66. The calculated GM on departure was 0.949m, but the C/O did not verify this once under way.

The transverse acceleration forces acting on the deck cargo in a seaway will increase as the GM increases. This means the total stack and individual tier weight limits will be reduced for higher GMs. The typical departure and arrival GM range given in the ship's CSM for its fully loaded condition was 0.62 and 0.73m respectively. However, *Ever Smart*'s SEMM stated that the arrival GM should not be less than 1m. Although bay 70 was fully loaded regarding its container carrying capacity, *Ever Smart* was not fully loaded.

The discrepancies between the CSM, SEMM and actual GM values might seem to be inconsequential given the additional assurances provided by modern ship loading computers. Nevertheless, the information relating to GM contained in the CSM provides further indication that the ship designers and lashing system manufacturers did not envisage that bay 70 would be loaded as it was on departure Taipei.

2.5 LASHING SYSTEM FAILURE

The stevedores in Taiwan rigged *Ever Smart*'s cargo lashings in accordance with the C/O's instructions, and this was checked as satisfactory by the crew. The ship's maintenance records indicated that the lashing gear was in a serviceable condition. However, weakness in the lashing arrangements was evident when the ship arrived in Los Angeles. Of note:

- The wind lashings in the outer stacks of bays 50, 54, 58, 62, 66 and 70 had not been applied **(Figure 31)**.
- Several lashing rods were found to be loose.
- The lock nuts had not been applied to many of the lashing rod turnbuckles.
- Some twistlocks appeared to be heavily corroded.

It is probable that the wind lashings had not been applied in the outer stacks of the stows aft of the accommodation block because the lashing rods were designed for standard 8'6" high containers and therefore were not long enough for a stack of hi-cube containers. This oversight would have reduced the effectiveness of the lashing system, particularly during strong winds.

Several lashing rods and many turnbuckle lock nuts were found to be loose in unaffected bays during the MAIB's post-accident inspections. It was apparent that the turnbuckle lock nuts had not been applied, rather than vibrated loose, because most were two or three threads clear of their mating surfaces **(Figure 20)**. It was therefore likely that the lock nuts had either not been tightened prior to sailing or had not been reapplied after the crew had re-tensioned the lashings during the passage. The former should have been identified and corrected during the crew's daily inspections of the lashings. Releasing and then reapplying the turnbuckle lock

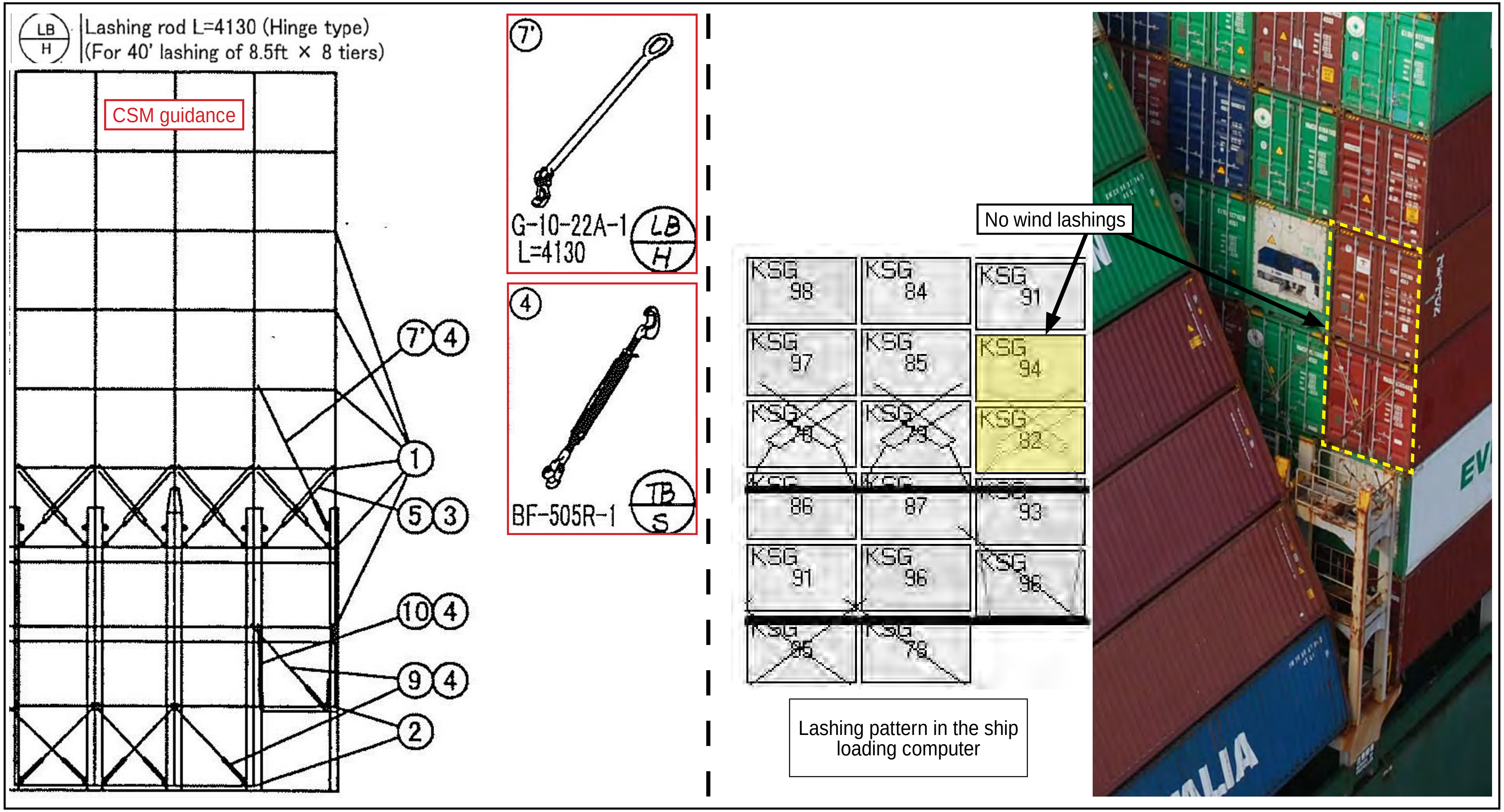

Figure 31: Missing wind lashings at bay 70 and other bays aft of the accommodation block

nut each time a lashing rod has to be re-tensioned can be time consuming, however failure to apply the lock nuts increases the likelihood of lashings becoming loose. Loose lashings will increase the risk of contact between container stacks, and allow increased racking forces to act on the containers at the bottom of the stacks.

The MARIN report discussed the potential consequences of interactions between containers in adjacent stacks. Contact between containers at the top of adjacent stacks can introduce dynamic loads that exceed the compressive load-bearing capacity of the container corner posts and the effectiveness of the lashing system. If one or some of the lashings in Bay 70 were slack, the likelihood of contact between containers would have been significantly increased, particularly given the height of the stacks.

The main bodies of some of the twistlocks inspected after the accident were found to be heavily corroded **(Figure 19)**. This might not have affected their breaking load, however, according to the manufacturer's maintenance instructions, corroded twistlocks should have been retired after inspection.

The maintenance of twistlocks by the ship's crew was problematic as they were in constant use. It was only when the ship had little deck cargo, or when *Ever Smart* was in dry dock, that the crew had the time necessary to carry out effective inspections. The maintenance of lashing equipment is critical to the secure stowage of containers on deck, and every effort should be made to ensure the equipment manufacturer's guidance is followed.

The container lashing system is an integral part of a ship's overall design as it determines how high containers can be stacked and the maximum permitted weight of the containers in each tier. Ignoring the guidance for, and exceeding the limitations placed on the lashing system by the lashing system manufacturer will significantly increase the risk of cargo losses, and will endanger the ship, its crew and the environment. In this case, the lashing arrangements for bay 70 did not comply with the lashing system manufacturer's instructions and the guidance contained in the CSM.

2.6 USE OF THE SHIP'S CARGO LOADING COMPUTER

Ever Smart's C/O used the ship's loading computer to calculate the ship's stability, the forces acting on the hull, and to check the cargo stowage and lashing plans. The central planners ashore used the same version of software. The ship's loading computer identified that the lashing pattern selected by bay 70's stowage plan was insufficient. Some load limits were exceeded by 150% in both outer stacks. The CSM was not referred to.

The ship's loading computer offered several advantages over the CSM. It was able to quickly produce results and highlight to the C/O any areas where the forces acting on the ship and the cargo lashing system were out of tolerance. Moreover, it also allowed greater flexibility in container planning. However, it was apparent that the known discrepancies regarding draught and GM were accepted, and the alarms/warnings for overloaded lashings were ignored.

Non-compliant and out of tolerance stows on the scale evident on board *Ever Smart* are not uncommon, as highlighted by the ATSB in its *YM Efficiency* report (Section 1.7.6). Given the nature of the modern container shipping industry, and the ever-increasing size of container ships, it is extremely difficult, if not impossible, to meet or match the stowage plan and weight distribution examples provided in CSMs. This is particularly the case during the months leading up to Christmas when demand is greatest and many containers will be stuffed full of high-volume low-density cargoes.

Regardless of the logistical and commercial challenges faced by the container shipping industry, the guidance provided in a ship's CSM and the warnings given by its loading computer should not be ignored. Ships' masters and C/Os might be able to identify and rectify isolated cargo stowage plan issues, but it is impractical to expect them to address large scale problems such as those identified in this report due to the potential commercial impact such interventions would have. The onus should be on the shore planners to deliver compliant and safe stowage plans.

2.7 HEAVY WEATHER AND MOTION-INDUCED FORCES

2.7.1 Weather routeing

Following advice provided by Evergreen's weather routeing service, *Ever Smart*'s master altered the passage plan to pass south of a predicted storm. At the likely time of the container collapse the prevailing force 7 to 8 southerly wind was on *Ever Smart*'s starboard beam, and the ship was rolling and pitching heavily in rough seas. These conditions, as had been forecast, built up steadily over an 18-hour period and had been closely monitored by the master.

During heavy weather conditions, masters need to exercise good seamanship by choosing suitable routes, headings and speeds to minimise ship's motion and control the risk of inducing excessive linear and dynamic loads on its cargo securing system. The initial action to avoid the worst of the weather was effective in that the ship did not roll beyond 12º, and the pitching was not considered to be excessive. Nevertheless, bay 70 was located at the stern of the ship, and therefore its containers would have been exposed to higher vertical and transverse acceleration forces than those at the midships section of the ship. In addition, *Ever Smart* was experiencing high levels of vibration, and shuddered regularly as its bow slammed into the head seas.

2.7.2 Bow slamming

Overnight on 29/30 October, the wind had veered to the south but the swell waves remained on the bow. This changed the wave pattern and ship motion, and induced increased levels of slamming, hull vibration and stern shaking. It is likely that the increased shaking of the ship at the stern was induced by whipping forces generated by bow flare slamming. It is also likely that the container collapse occurred when the hull vibrations and frequency of stern shaking were at their worst.

Whipping of a ship is the rapid flexing of the hull girder as a consequence of wave impacts on the hull. High whipping responses are usually driven by bow flare impacts due to large bow flare angles and high speed, or by bottom slamming[17]. Stern counter slamming can occasionally lead to high whipping responses. *Ever Smart*'s bow flare, particularly, would have caused slamming as it drove into the waves, and this would have created large impulse loadings. The transient

[17] Bottom slamming is the impact of the bottom structure of a ship onto the sea surface. It is mainly observed while sailing in waves, when the bow raises from the water and subsequently impacts on it.

impulse forces would transmit through the hull from forward to aft and create a whipping motion at the stern. This would result in severe vibration at the stern and consequential high loading on the cargo containers.

The Marin report (Section 1.5.1) described circumstances in which the accelerations on a ship's hull could be amplified and the loads on container stack systems increased. Specifically, it said that:

> *IMO guidelines do not consider contributions by "non linear" loads such as parametric roll, broaching, dynamic loss of stability and **slamming** to be a part of the design envelope. These are to be avoided by the crew. Various incidents however suggest that these effects do occur and as such contribute to actual service loads.* [sic]

Increased accelerations due to whipping or springing can contribute to extreme loading on containers and their lashing systems. In this case, the master reduced the levels of bow flare slamming by reducing the ship's speed. This action was probably taken after the container stow collapse had occurred, and it is likely that the non-linear forces generated by bow flare slamming contributed to this casualty event.

2.7.3 Wind forces

The near gale to gale force winds were acting directly on the starboard outer stacks of *Ever Smart*'s deck stows. Although the prevailing winds were below the strength assumed during the lashing system strength calculations, the effect of the wind would have been increased due to the height of the outer stacks and the lack of wind lashings. In particular, the increased windage and missing lashings would have resulted in higher racking stresses on the containers at the bottom of the stack and the load acting on the other lashings.

2.8 CONTAINER STRUCTURAL FAILURE

The bottom container in Bay 70's starboard outer stack was of particular interest during the investigation as the collapse was almost certainly initiated in that row, and it was the stack's only container that suffered significant damage. Like most of the containers in tier one of the adjacent rows, it suffered buckling damage to its forward inboard (port) corner post. Its outboard aft bottom corner casting was also torn away from the frame of the container. Corner post buckling is caused by compressive forces and can be the direct result of excessive stack weights, high acceleration forces due to rolling and pitching, and dynamic shock loads introduced by hull deformations or contact between containers. Buckling can also occur at or below design loads if the corner post strength has deteriorated due to corrosion or impact damage.

The total weight of the containers in bay 70's starboard outer stack was well below the maximum for the ship's loaded condition, even given the anomalies already discussed. Therefore, if the corner post failure of the stack's bottom container triggered the stow collapse, its strength must have been much reduced due to corrosion or previous damage.

The stack's bottom container was owned by Evergreen and was 10 years old. On visual inspection it appeared to be badly corroded in several places **(Figure 22)** and had been repaired several times during its working life, but it was fully ISO compliant and had recently been inspected under the ACEP.

It is highly unlikely that the structural failure of a container due to static overload or linear ship motion was the direct cause of this accident. It is also unlikely that material condition of the bottom container in the starboard outer stack had reduced its structural strength to the extent needed to trigger the collapse. It is more likely that the container's structural failure was the consequence of shock loads caused by contact between container stacks following a lashing system failure or bow flare slamming.

2.9 CONTAINER PACKING STANDARDS AND DECLARED WEIGHTS

Container packing or stuffing standards and the declaration of their content and gross mass has been, and continues to be, of considerable concern within the container ship industry. The contents of poorly stuffed containers can raise the centre of gravity of the container and/or move around in a seaway; both will reduce the stability of a container stack. Similarly, mis-declared weights, high or low, will affect both the forces acting on the containers in a stack and the effectiveness of the lashing system.

The investigation did not identify any issues relating to the packing of the containers, but it did find some discrepancies with the declared weights. Of the 107 containers weighed from bay 70, 39 (36.4%) were outside the generally accepted VGM error limit of 5%. The incorrect VGM was from both ports of loading, and there was no commonality of shipper or position on the ship.

Ever Smart's draughts on departure from Taipei had a difference of 33cm between calculated (13.37m) and actual (13.90m). Given that 95.2t was required to immerse the ship 1cm, this equated to an error of 3142t between calculated and actual weights. If the quantities of ballast, fuel and stores were broadly accurate then it would indicate a cargo weight error of 5.8%.

Ever Smart's crew accepted that large errors were inherent in the computed and actual draughts, but did not resolve them. Their priority was to ensure that the ship was at an acceptable draught for the port and intended voyage. Consequently, the error continued to be accepted without being checked. Furthermore, that the difference in draught might be due to cargo weight was not confirmed. The containers' weight should have been accurate (in accordance with VGM requirements), and any cargo weight error would have given an indication that the verification system was not operating as required.

There is no global standard error margin for VGM. Many government administrations allow ± 5%, with several also applying a tonnage limit. For instance, one administration declared that:

> *The discrepancies between the verified container gross mass declared by the shipper and the verified gross mass obtained by marine management agencies, vessels, carriers or terminal operators must be within +/-5% or 1 ton (the smaller value applies) and does not exceed the maximum payload of the container.*

While another stated that:

> *Tolerance of VGM deviation:*
>
> > *VGM ≤ 10 MT, acceptable tolerance: +/- 0.5 MT*
> >
> > *VGM > 10 MT, acceptable tolerance: +/- 5%*

In the UK, the MCA advised, in its Marine Guidance Note 534 (M+F), *Cargo Safety – Guidance on the implementation of SOLAS VI Regulation 2 amendment requiring the verification of the gross mass of packed containers*, that:

> *It is anticipated that Regulators and other authorised cargo inspectors will use an enforcement threshold ±5% of the verified gross mass of the container. However, this will be used on a case by case basis.*

The post-accident weighing check in Los Angeles indicated a mean weight variance of 5.6%. However, many of the discrepancies were negative; the VGM declaration was greater than the physical measurement.

Of concern is that the VGM system was introduced to improve safety by assuring ships' masters that the weights of containers loaded were accurate. The ship was carrying 3533 containers; if the weight survey of the bay 70 containers is extrapolated to the whole cargo of 3533 containers, 1286 of them would have been outside of the 5% variance limit.

In this case, mis-declared container weights of *Ever Smart*'s bay 70 cargo inspection, the comparison between VGM declarations and actual weights, does not promote confidence in the process envisaged by the IMO.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. The container stow collapse on board *Ever Smart* was caused by a combination of factors; in particular, container weight distribution, container lashing arrangements and the ship's motion. [2.2]

2. The collapse was discovered during a deck lashings' inspection at 1648 on 30 October, but it most likely occurred shortly before 0240 that morning. [2.3]

3. The stow collapse to port was probably initiated by a lashing system or structural container failure in bay 70's starboard outer stack. [2.3]

4. The container stowage plan developed by the shore planners did not comply with the instructions and guidance contained in the ship's cargo securing manual. Of note: the container weight distribution was not in accordance with the stack weight tables; hi-cube containers were loaded eight high in the outer stacks of the stow; and the ship's GM exceeded the recommended full load GM. [2.4.1]

5. The weights of the containers' allocated slots in bay 70 did not match or resemble the weight distribution patterns provided in the CSM; the weights in the upper tiers exceeded the values given in the stack weight tables and those in the lower tiers were much reduced. This would have caused the stacks' centre of gravity to move upwards, and the acceleration forces acting on the lashings and containers at the bottom of the stack to increase. [2.4.2]

6. The stowing of hi-cube containers eight high in the outer stacks raised the height of the stacks and therefore further increased the acceleration forces acting on the containers and their lashings. It also increased the windage area of the outer stacks. [2.4.3]

7. *Ever Smart*'s GM exceeded that used in the CSM to calculate stack weight limits, weight distribution and lashing patterns for the bays aft of the accommodation block when loaded to their maximum container carrying capacity. [2.4.4]

8. Bay 70 was not lashed in accordance with the instructions and guidance provided in the CSM and by the lashing system manufacturer. [2.5]

9. Many lashing rod turnbuckle lock nuts had not been applied and, as a result, there was a high likelihood that some of bay 70's lashings would loosen. [2.5]

10. The ship's loading computer was not fully utilised, and warnings that the permissible load limits could be exceeded were not acknowledged or were ignored. [2.6]

11. The master's course and speed alterations during the voyage to avoid the worst of the weather and reduce hull vibrations were effective. The roll amplitude remained well below the calculated maximum and the frequency of stern shaking was reduced. [2.7.1]

12. It is likely that the accident occurred at the time the hull vibrations and frequency of stern shaking were at their worst. The vibration was probably the result of whipping forces transferred through the hull as the ship's bow slammed into the sea. [2.7.2]

13. The gale force wind was acting directly on the starboard outer stack, and its effect would have been significantly amplified due to the increased height and lack of the additional wind lashings prescribed in the CSM. [2.7.3]

3.2 SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. The maintenance of twistlocks by the ship's crew was problematic as they were in constant use. Some twistlocks used to secure the containers in bay 70 were corroded and should have been discarded. [2.5]

2. The potential commercial impact of addressing all the cargo stowage non-conformities contained in the plans produced ashore would have been high, and it is unreasonable to expect ships' masters and C/Os to intervene. [2.6]

3. It is unlikely that the structural failure of a single container was the direct cause of this accident. If it was, the most likely container to have failed would have been the one stowed at the bottom of the starboard outer stack. It was the only container in the stack to suffer buckling damage and it was corroded. [2.8]

4. The verified gross mass declarations for the containers at bay 70 exceeded the general industry error margin of 5% for 39 of the 107 containers loaded (36%). In this case, the differences between the declared and actual weights were unlikely to have been a major factor in the collapse. [2.9]

SECTION 4 - ACTIONS TAKEN BY OTHER ORGANISATIONS

Evergreen Marine Corp. (Taiwan) Ltd has:

- Issued a fleet circular reiterating the need for its ships' masters to manage heavy weather encounters effectively **(Annex C)**.

SECTION 5 - RECOMMENDATIONS

Evergreen Marine Corp. (Taiwan) Ltd is recommended to:

2020/125 Highlight to its ships' masters the increased risk of cargo damage when ships experience hull slamming and stern shuddering during heavy weather.

2020/126 Introduce a programme for lashing equipment inspections when the ship is not in service.

2020/127 Take action to ensure its shore planners are fully trained in the use of its ship loading computers and that they understand the importance of checking the permissible load limits for containers and lashing systems.

Safety recommendations shall in no case create a presumption of blame or liability

Cargo Operation Record template

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Revision: 0
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Date: 01. JAN. 2017

CARGO OPERATION RECORD

PORT: DATE:

	ITEM	P.I.C.	Check
1.	**Before cargo operation**		
	• Cleats of hatch cover are opened and are ready for cargo operation.	C/O	
	• Ballast system is normal, bilge wells are clean and bilge alarm system is normal.	C/O	
	• The intended stowage plan, bay plan and cargo data (or disk) have been carefully reviewed by computed program or by hand.	C/O	
	• Establish safety requirements with terminal staff.	C/O	
	• Sufficient quantities of lashing gears are properly provided.	C/O	
	• Cargo securing manual has been properly instructed to stevedore, special lashing and securing requirements be observed.	C/O	
	• Max. tiers & weight of containers are within allowable limit.	C/O	
	• Stability (GM), oil & water tanks, draught, trim, ship's strength and visibility criteria are well considered.	C/O	
	• Ensure D.G. cargo stowage in compliance with special restriction requirements of ship's DOC (for Ships Carrying Dangerous Goods)	C/O	
	• Ensure the visibility from bridge in compliance with requirements of SOLAS.	C/O	
2.	**During cargo operation**		
	• Strict cargo watch is maintained, duty officers fully understand the procedures of ballast operation and cargo calculation, cargo unloading/loading is in accordance with the agreed stowage plan and the ship is ensured in upright position and has enough GM all the time.	Duty officer	
	• Keep the tension condition of mooring ropes fore and after under close watch and ease over-tension whenever necessary.	C/O	
	• Prepare stevedore damage reports whenever cargo is damaged as a result of improper operation by stevedore.	C/O	
	• Confirm D.G.manifest and IMDG labels for loading D.G. cargoes and the setting temperature normal for loading Reefer cargoes.	C/O	
3.	**On completion cargo operation**		
	• All containers are in good lashing condition, and the lashing gears are stowed back to the ship.	BSN or DK AB	
	• Adjusted ship's trim and GM as per master order.	C/O	
	• Watertight doors are closed, hatch cover cleats are locked, and cargo holds are free from structural damage.	C/O	
	• The final plan, D.G. manifest, reefer manifest are received.	C/O	
	• The range of blind area from bridge to bow visibility :______________m.	C/O	

Remark:

MASTER:________________________ C/O:______________________________

Annex B

World Shipping Council "Containers Lost at Sea" paper

Containers Lost At Sea – 2017 Update

In 2016, the international liner shipping industry transported approximately 130 million containers packed with cargo, with an estimated value of more than $4 trillion. Proper packing, stowage and securing of containers and reporting of correct weight is very important to the safety of a container ship, its crew and its cargo, to shore-based workers and equipment, and to the environment. However, even with proper packing of the cargo into the container, correct container weight declaration, and proper stowage and securing aboard ship, a number of factors ranging from severe weather and rough seas to more catastrophic and rare events like ship groundings, structural failures, and collisions can result in containers being lost at sea.

In the past, obtaining an accurate assessment of how many containers actually are lost at sea was a highly speculative process. For many years, there were widely circulated, but unsupported and grossly inaccurate claims that the industry might lose as many as 10,000 containers a year at sea.

Ocean carriers operating the containerships, which the World Shipping Council (WSC) represents, remain the best sources for accurate information on this subject. [1] Therefore, in an effort to provide greater clarity and a more accurate assessment of the number of containers lost at sea on an annual basis, WSC undertook the first survey of its member companies in 2011, with updates in 2014 and 2017, and has published the results to make the information readily available to all interested parties.

[1] The WSC's member companies operate 80 percent of the global containership capacity; thus, a survey of their losses should provide a valid estimate of the number of containers lost at sea. More information about WSC and the liner shipping industry can be obtained at: www.worldshipping.org

Methodology of the Surveys

In each of the surveys conducted in 2011, 2014 and 2017, the WSC member companies were asked to report the number of containers lost overboard for the preceding three years. For the 2017 report, all WSC member companies responded and together, they represent 80% of the total global vessel container capacity. WSC assumes for the purpose of its analysis that the container losses for the 20% of the industry's capacity that is operated by carriers that did not participate in the survey would be roughly the same as those of the 80% of the industry that responded.

The total annual figure reported by WSC members is adjusted upward to provide an estimated loss figure for all carriers, both WSC members and non-members, and arrive at a total industry figure. As expected, some carriers lost no containers during the period, while others noted a catastrophic loss, which for the purposes of this analysis is defined as a loss overboard of 50 or more containers in a single incident. Catastrophic losses are rare, but the total number of containers lost in such events represents more than half of all containers lost.

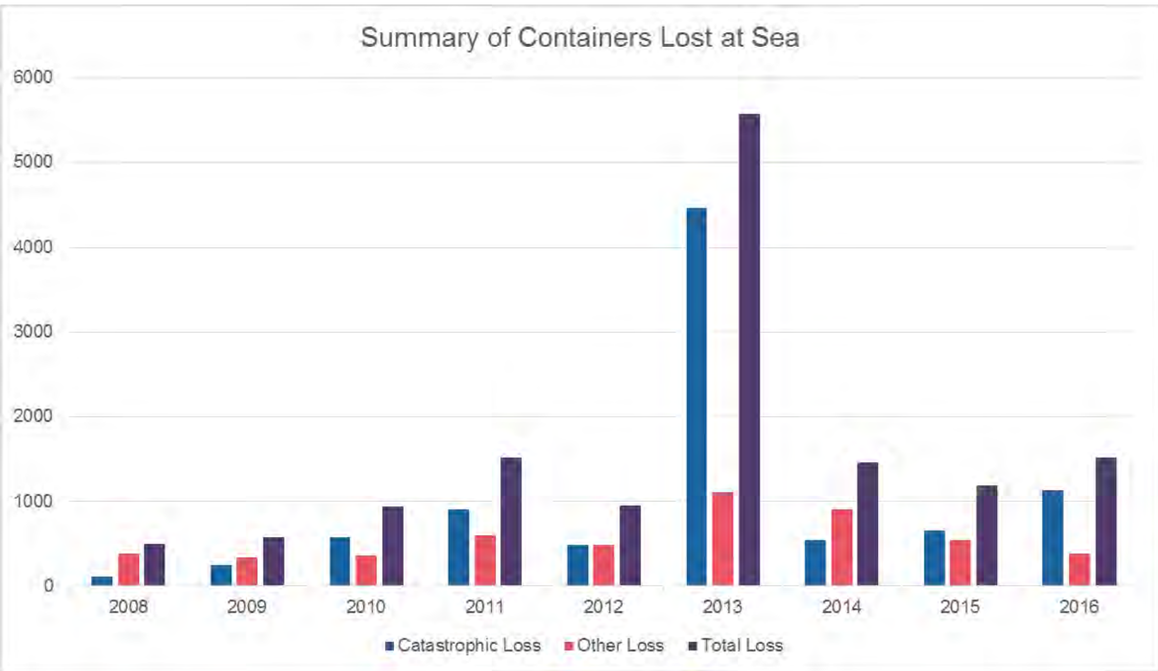
Based on the 2011 survey results, the World Shipping Council estimated that on average there were approximately 350 containers lost at sea each year during the 2008-2010 time frame, not counting catastrophic events. When one counted the catastrophic losses, an average annual total loss per year of approximately 675 containers was estimated for this three year period.

In the 2014 survey, WSC received reports from carriers on losses during 2011, 2012 and 2013. From those results, WSC estimated that there were approximately 733 containers lost at sea on average for each of these three years, not counting catastrophic events. When one includes catastrophic losses (as defined above) during these years, the average annual loss for the period was approximately 2,683 containers.

This larger number in 2014 is due primarily to two factors: the complete loss in 2013 of the *MOL Comfort* in the Indian Ocean and all of the 4,293 containers on board – which remains the worst containership loss in history; and, in 2011, the grounding and loss of the *M/V Rena* off New Zealand, which resulted in a loss overboard of roughly 900 containers. Both of these incidents involved complete and total vessel losses.

The most recent 2017 survey gathered input for 2014, 2015 and 2016. All WSC member companies responded, and additional information was made available on certain non-member catastrophic events. For each of the three years surveyed, the average number of containers lost at sea excluding catastrophic events was 612, which is about 16% less than the average of 733 units lost each year for the previous three year period. When catastrophic losses are included, the total containers lost at sea averaged 1,390 with 56% of those lost being attributed to catastrophic events. This is a 48% reduction from the average annual total losses of 2,683 estimated in 2014.

Analysis of the Nine Year Trends



Upon review of the results of the nine year period (2008-2016) surveyed, the WSC estimates that there were on average 568 containers lost at sea each year, not counting catastrophic events, and on average a total of 1,582 containers lost at sea each year including catastrophic events. On average, 64% of containers lost during the last decade were attributed to a catastrophic event.

The data consistently demonstrates that container losses in any particular year can vary quite substantially based on differences in weather and other unusual events. The data also consistently shows that the majority of containers lost at sea result from catastrophic events. For example, in 2013, there was a total loss of 5,578 containers – 77% of which occurred with the sinking of the *MOL Comfort* in the Indian Ocean. The tragic total loss of vessel *El Faro* occurred two years later in 2015. All containers on the *El Faro* were lost and this event alone accounted for almost 43% of the total containers lost into the sea in 2015.

Active Safety Improvement Initiatives

While containers lost overboard represent about one thousandth of 1% of the roughly 130 million container loads shipped each year, the industry has been actively supporting a number of efforts to enhance container safety that should help reduce the number of containers lost at sea, including:

- **Amendments to the Safety of Life at Sea (SOLAS) Convention:** In November 2014, the International Maritime Organization (IMO) adopted changes to the Safety of Life at Sea (SOLAS) convention requiring verification of container weights before packed containers may be loaded aboard ships. This is an effort WSC advocated in support of for many years. The requirement making container weight verification a condition for vessel loading became legally binding internationally on July 1, 2016. Misdeclared container weights have contributed to the loss of containers at sea, as well as to other safety and operational problems. For more information about this issue, visit: http://www.worldshipping.org/industry-issues/safety/cargo-weight

- **Code of Practice for Packing of Cargo Transport Units (CTU):** The IMO, the International Labour Organization (ILO), and the United Nations Economic Commission for Europe (UNECE), with industry support, have produced a code of practice for the packing of CTU, including containers, outlining specific procedures and techniques to improve safety, such as how to ensure correct distribution of the weight inside the container, proper positioning, blocking and bracing according to the type of cargo, and other safety considerations. The code was approved in 2014. For more information about this and other initiatives related to the improved safety of handling containers, visit: http://www.worldshipping.org/industry-issues/safety/containers

- **Revised ISO standards for container lashing equipment and corner castings:** In support of the IMO's efforts to enhance container safety, the International Organization for Standardization (ISO), with the industry's active participation, has revised its standards regarding lashing equipment and corner castings. For more information about this issue visit: http://www.worldshipping.org/industry-issues/safety/containers

At any point in time, there are about 6,000 containerships active on the world's seas and waterways linking continents and communities through trade. The container shipping industry's goal remains to keep the loss of containers carried on those ships as close to zero as possible. Carriers will continue to explore and implement preventative and realistic measures to achieve that goal.

Evergreen Marine Corp. (Taiwan) Ltd. Fleet circular

MARINE CIRCULAR

TO: Fleet vessels

DATE: NOV / 7 / 2017
REF. NO. : 2017-034

SUBJECT: MAT reiterate that winter is approaching, Fleet vessels need to enhance environmental awareness keep safe navigation in all circumstance
重申冬季將至，請務必提高警覺，小心航行、注意安全。

MESSAGE:

1. For the reason of persistent global warming, weather patterns have been changed and differed from previous years. It seems unavoidable that vessel may encounter regional rough weather in any of the voyage.
地球持續暖化，天氣型態與往年已有所差異，船舶在航程中都有可能遭遇局部的惡劣海況。

2. Masters please refer to the route recommended by WNI service and local weather forecast, closely monitor the prevailing weather and take countermeasure in advance. To avoid damage to the ship or cargo, in addition to the enhancement of cargo lashing before sailing, countermeasure against heavy weather such as altering course or speed reduction or both during sea passage must be considered. Besides, if found any shortage of cargo lashing accessories, please directly apply for a complement from supply department.
船長請參照氣象導航的航路建議及船舶所在地區當地所發佈的天氣預測。密切注意當前天氣並預作防範。除加強開航前所有貨物固縛工作外，在航行中遭遇惡劣天候，必要時改變航向或減速，以防止或減少惡劣海況對船貨可能造成的傷害。此外，貨物固縛裝備如有短缺，請向補給單位提出申請補足。

3. After the recommendation from WNI service, Masters should assess the feasibility of the route through Captain's DOSCA/BRIDGE and his own professional knowledge. If there is any safety concern or doubt about the route, e-mails and satellite phone calls should be utilized to coordinate with WNI service and MAT in order to conclude a unanimous voyage plan and avoid misunderstandings between ship and shore.
在氣象導航提供相關航路建議後，船長應利用Captain's DOSCA／BRIDGE軟體配合自身專業知識判斷航路建議之可行性。對於航路建議有安全疑慮時，應利用郵件或電話與氣象導航公司及海技部進行三方協調，以取得航路計畫的一致性，避免船岸兩端出現誤解。

4. In order to prevent crew from injury in the severe weather, and eliminate all possible risks prior to work assignment, the Check−List CK−0704−02 need to be confirmed and an applicable Risk Assessment also need to be carefully assessed. In addition, work assignment for crew whilst carrying routine cargo lashing checking and enhancing, shall proceeding in two−men group for a better chance to take care each other.
防止船員在惡劣海況中工作受傷；船上在進行各項作業前，必須遵照公司SE手冊中的檢查表CK−0704−02先行檢查確認；並在作業前先行風險評估，確認並排除各種可能發生的風險。此外，提醒航行中如

進行甲板常規固縛檢查或加強作業時，務須以二人一組進行，相互照應。

5. We would like to extend our sincere gratitude to Captain, Chief Engineer and crewmembers of all vessels for your endeavored efforts to uphold the safety in the boisterous weather.
公司對各輪船長、輪機長、船員們在惡劣海況時仍戮力維護安全，謹致深厚謝忱！

Bon Voyage.
順頌　航安！

Marine Accident Report

INVESTORS IN PEOPLE