



# *Sustainable Upgrades of Container Securing Systems*

23 Nov. 2022

*By  
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**ELINT / HIMT**

***ANNUAL CONFERENCE OF  
MARINE TECHNOLOGY***

**Evgenides Foundation  
Athens Nov 2022**



# Container Stowage & Securing

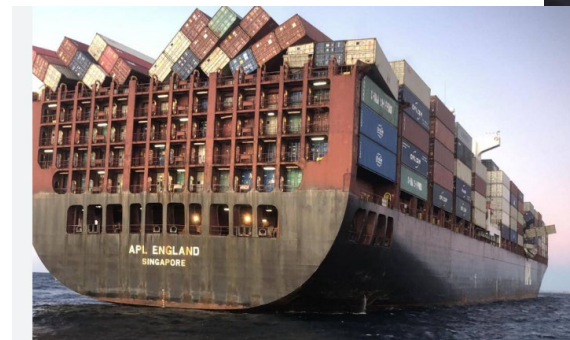
- ❑ **Current Operational & Safety Challenges**
- ❑ **New Class Rules 2020 at a Glance**
  - Differences vs 2013
  - Effect on Safety & Carrying Capacity
  - Analysis Tools & Class Approval
  - An Actual Damage Analysis
- ❑ **Typical System Upgrades**
  - Update CSM to New Class Rules
  - Twistlock Change from SAT to FAT
  - Mixed 20ft /40ft Stow
  - Change from Internal to External Lashing
  - Elevation of Lashing Bridges
  - Enhanced Lashings supporting Upgrade
  - Future Upgrades in the Pipeline
- ❑ **Return on Investment**
  - Benefits for Charterers / Owners



# Current Operational & Safety Challenges

# Current Operational & Safety Challenges

- Growth of Ships vs Ports Development
- Congestion & Turnaround at Ports
- Boxes out of Shape
- Carrying Capacity at a Limit
- Stevedores & Crew Training
- Extreme Weather - Climate Change
- Fire Initiation in Containers



***New Class Rules  
2019-20 at a Glance***

# New Class Rules 2019-20 at a Glance

## Since 2013:

- **Size of Ships & Stack Heights Exploded**
  - Currently 23,000 TEU vessels are being built (Length ~ 400m x Width ~63m)
  - 26,000 TEU vessels coming soon
- **Lashing Patterns are changing**
  - External Lashing prevailing over Internal Lashing
  - 2-Tier Lashing Bridges getting rare
  - Vertical lashings no more
  - “Mickey Mouse” extension instead of Wind Lashing

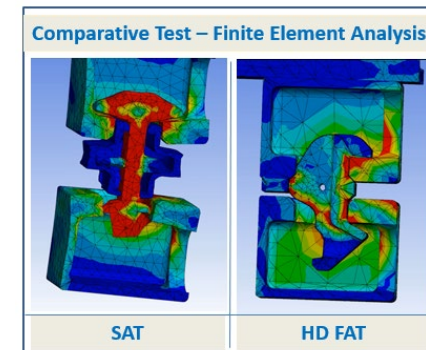
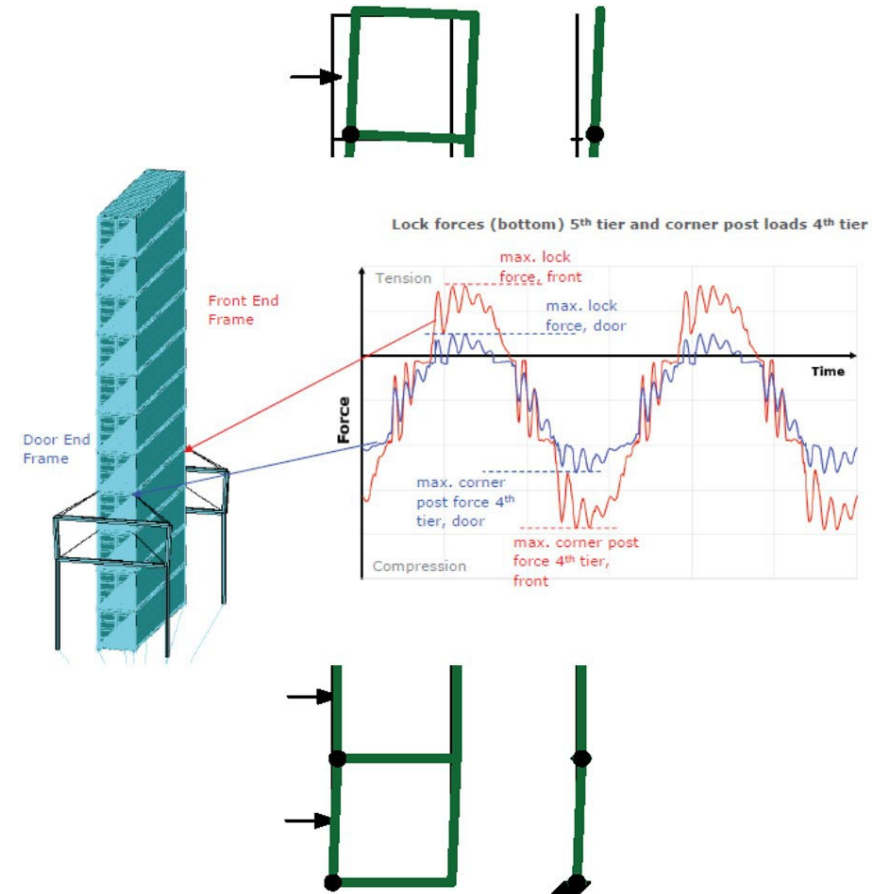
## Evolvement of Calculation Methods

- **CSS Code**
  - No deflections
  - Pure static momentum
- **Linear**
  - Racking considered, later Tipping effect
  - Horizontal deflection per end
  - No vertical deflection
- **Non-Linear**
  - Vertical Twistlock gap
  - Vertical Deflection per end
  - Effects highly complex
- **3D Non-Linear**
  - Complete non-linear FEM for whole container
  - Effects extremely complex

# New Class Rules 2019-20 at a Glance

## Calculations have become 'Non-Linear'

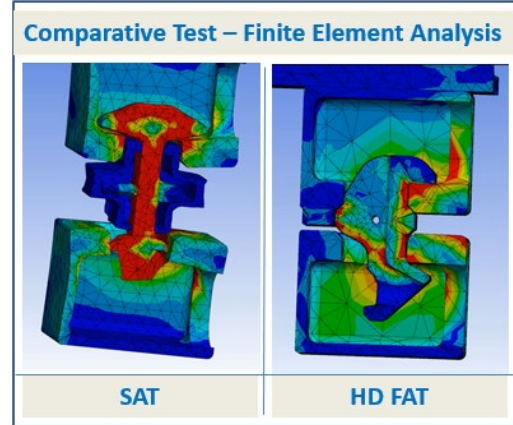
- **Vertical gap** of twistlocks is now considered
- **Complex Deflections** of Container Stacks considered
- Treatment of **Wind Exposed Containers** changed a lot
- **Accelerations revised** a lot since 2013+
- **GM not limited** by Container Arrangement
- **Season added to Route Specific** operation
- **Approved Onboard Software** typically required
- **Stiffness of Lashing Bridge** considered



# New Class Rules 2019-20 at a Glance

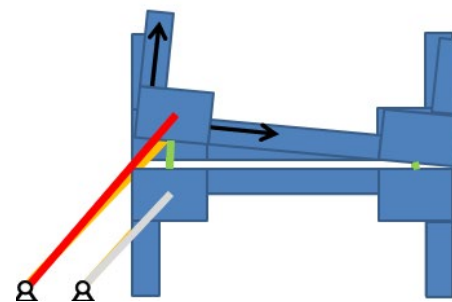
## Vertical Gap of Twistlocks

- Twistlocks have vertical tolerance (gap) for enabling connecting containers. Earlier rules assumed zero movement once containers connected.
- New rules consider the vertical gap causing movement and different acceleration of connected containers.
- Large gap increases stack acceleration. The smaller the gap the more favourable.
- Different twistlock types have different vertical gaps:
  - Typical SAT: 12-37 mm (measured / depending on maker)
  - Standard FAT: 18-20 mm (measured) / 20 mm (certified)
  - HD FAT: 10-12 mm (measured) / 12mm (certified)



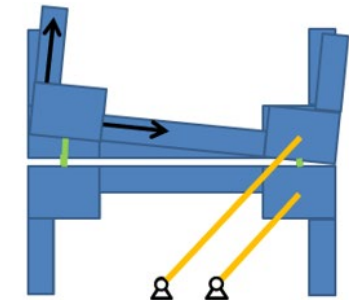
### External Lashing

Large vertical gap may allow full tensile load taken by the lashing line prior to twistlock engagement, resulting thus to premature failure of lashings.



### Internal Lashing

Large vertical gap may result in compression overload (increased racking force) of the opposite post and buckling of the stack.



# *Effects on Carrying Capacity*





## Comparison of Stack Weights Distribution under Old & New Rules taking Twistlock VG into account

Considering that carrying empty containers generates no income and heavy containers are hard to find, the market considers *'effective cargo'* the containers range between 10t ~ 24t.

	Standard FAT 20mm vertical gap			HD FAT 12mm vertical gap		
2013	Bay 42 - GL Rules 2013 w/ Standard FAT					
	Weights Distribution					
	Weight	Nr of Boxes	%			
	< 10t	94	46%			
	10t ~ 24t	4	2%			
	>24t	106	52%			
	<b>Total</b>	<b>204</b>	<b>100%</b>			
2020	Bay 42 - DNV/GL Rules 2019 w/ Standard FAT			Bay 42 - DNV/GL Rules 2019 w/ HD FAT		
	Weights Distribution			Weights Distribution		
	Weight	Nr of Boxes	%	Weight	Nr of Boxes	%
	< 10t	78	38%	< 10t	14	7%
	10t ~ 24t	42	20%	10t ~ 24t	124	60%
	>24t	86	42%	>24t	68	33%
	<b>Total</b>	<b>206</b>	<b>100%</b>	<b>Total</b>	<b>206</b>	<b>100%</b>

*Combining the use of HD FAT with the upgrade of the vessel's CS lashing / loading software to 2019 Rules increases dramatically the effective cargo range 10t~24t of loaded containers.*

# *An Actual Damage Analysis*



# An Actual Damage Analysis

## Actual Stowage from Vessel's Loading Software

The actual loading plan taken from the vessel's loading programme at the time of damage (22 containers collapsed) was analysed by SEC with the use of GL Rules 2013 and DNV/GL 2019. Route particulars, GM, twistlocks and lashing arrangement were identical in both cases.

### Calculation acc to GL Rules 2013 (Linear)

Existing Standard FAT 20mm vg

All vessel parameters in accordance with the received loading information.

	20	18	16	14	12	10	08	06	04	02	01	03	05	07	09	11	13	15	17	19
Racking	61.3	50.1	40.6	40.3	43.1	42.5	57.8	56.3	58.0	60.2	63.6	59.0	59.2	58.5	49.5	45.8	44.2	39.9	51.4	52.4
Lashing	46.4	26.7	24.3	23.5	25.7	25.9	33.8	32.8	34.5	36.2	37.7	35.6	34.4	34.6	28.2	26.5	26.2	23.5	30.2	45.6
Post	81.8	79.1	67.0	56.1	70.2	70.2	91.2	88.0	92.3	95.3	95.5	94.6	93.2	93.1	80.5	75.5	71.9	66.2	82.1	81.3
Lift	90.7	78.2	39.8	41.4	43.9	42.9	62.5	57.5	62.8	62.5	71.2	64.5	58.4	67.5	59.9	50.8	47.6	39.8	78.4	87.1
LRacking	40.4	47.1	48.6	47.6	51.2	52.1	60.9	59.6	61.7	64.3	65.7	63.1	60.9	61.0	52.6	51.5	52.4	48.2	49.5	41.2

### Calculation acc to DNV/GL Rules 2019 (Non-Linear)

Existing Standard FAT 20mm vg

	20	18	16	14	12	10	08	06	04	02	01	03	05	07	09	11	13	15	17	19
Rack	47.8	42.8	41.4	41.1	43.8	43.2	58.0	56.4	58.1	60.2	63.4	59.2	59.3	58.6	50.3	46.6	44.9	40.7	44.1	49.2
LRack	33.7	39.3	40.5	39.7	42.7	43.4	59.7	49.7	51.4	53.6	54.8	52.6	50.7	50.9	44.0	42.0	43.7	40.2	41.2	34.3
Lash	87.0	92.2	87.1	88.1	92.4	90.3	119.8	117.7	117.2	119.2	125.7	116.5	115.8	118.5	108.7	102.4	96.7	86.7	96.0	85.6
Post	86.2	88.0	86.5	86.4	89.6	89.5	112.0	109.0	114.8	117.3	122.4	114.3	117.3	116.3	103.9	94.8	91.0	86.0	90.4	85.4
Lift	56.4	50.1	40.9	44.8	48.3	46.3	63.5	58.4	55.6	60.0	69.8	60.1	61.3	69.9	79.5	64.2	56.5	41.4	54.8	55.0

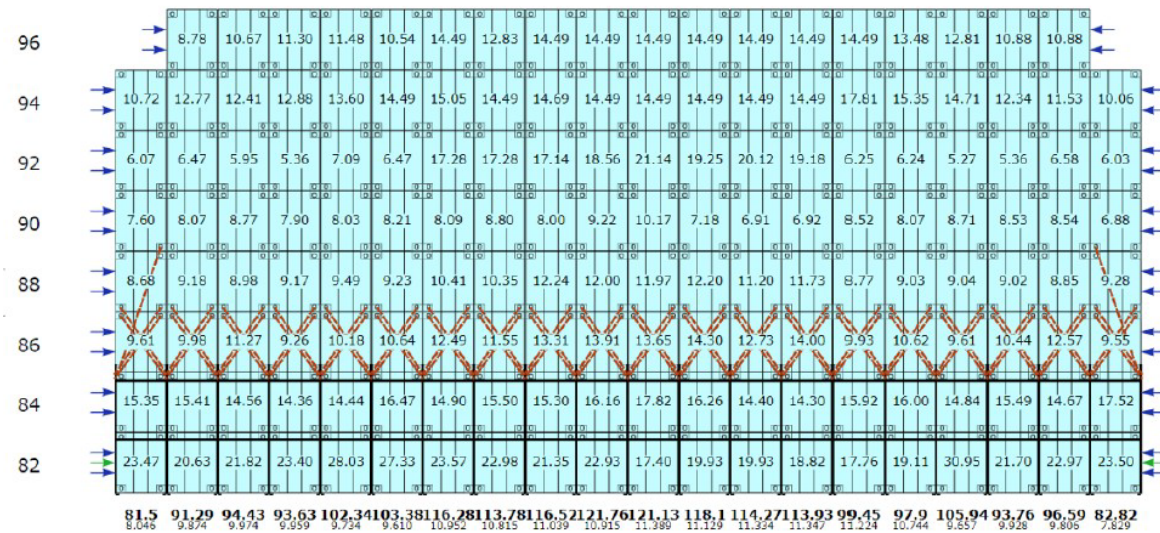


Figure 1: shows the weight distribution and resulting forces in accordance with GL Rules 2013. All forces are within permissible limits.

**Under 2013 Rules stowage appears perfectly alright!  
No warning of the accident bound to happen!**

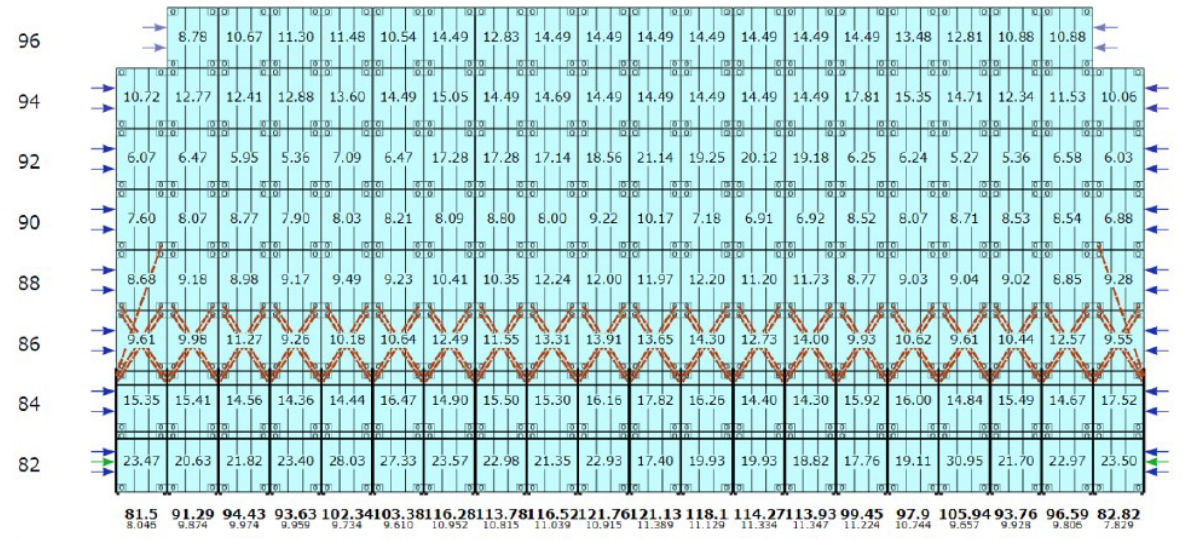


Figure 2: shows same bay calculated with DNV/GL 2019 Rules. Same stowed weights result in significant posts overload in the central stacks and lashing forces in excess of limits!

**Under 2019 Rules excessive loads are shown exactly where failure occurred, explaining the accident! Had the vessel's CS & loading software been upgraded to 2019 Rules, warning of excessive loading would have incurred, and the accident prevented with certain limitation of stowage!**

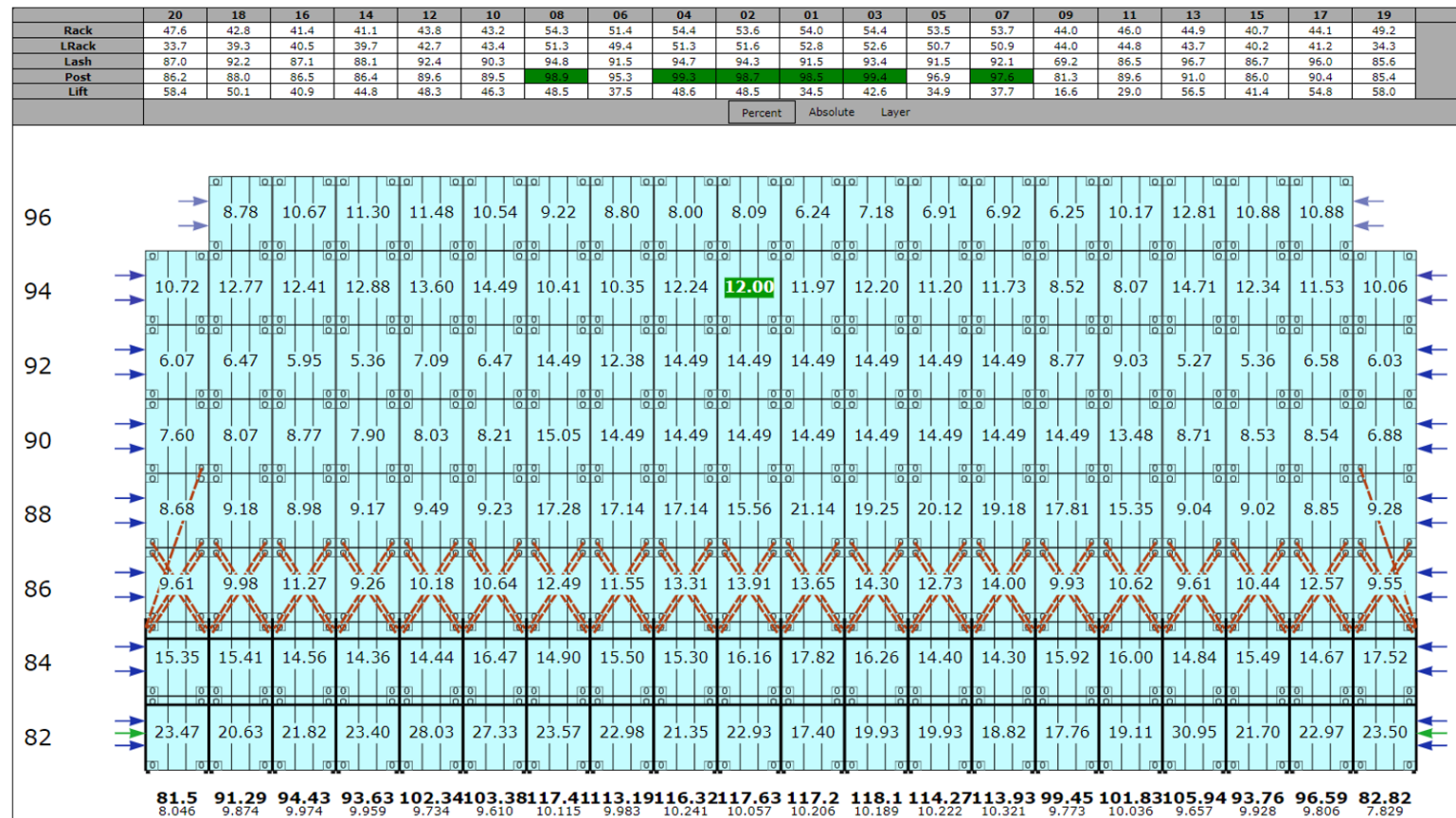
# An Actual Damage Analysis

## Actual Stowage from Vessel's Loading Software

Replacing the existing 20mm vertical gap standard FAT with the new 12mm vertical gap HD FAT excessive forces were 100% corrected by shifting only one container.

### Calculation acc to DNV/GL Rules 2019 (Non-Linear)

#### HD FAT 12mm vg



**With the use of the HD FAT (certified for max 12mm vertical gap) forces remain 100% within permissible limits, without loading limitation.**

**No accident, no reduction of stowed weights!**

## Damage Analysis Conclusion

- ❑ **Under GL Rules 2013:** All forces were found (misleadingly) within permissible limits. The cause of accident was attributed entirely to conditions beyond design parameters (deteriorated deformed boxes, loosen turnbuckles, etc.).
- ❑ **Under DNV/GL Rules 2019:** Same containers stowage was found to result in **significant posts overload in the central stacks and lashing forces in excess of permissible limits!** Meaning that even if the boxes were brand-new and the lashing turnbuckles perfectly tight, the accident would still happen! To avoid it, the loading programme would have to rearrange the stowage inducing considerable container weight reductions in that area and in any other similar areas.
- ❑ When a **HD FAT** (12mm vertical gap) was introduced in the 2019 calculations in replacement of the Standard Twistlock (20mm vertical gap) forces corrected by 92% and with the shift or one container **by 100% to be within permissible limits, without stack weights limitation.**
- ❑ **The combination of HD FAT and the upgrade of CS lashing / loading software to 2019 Rules, ensures 100% safety while achieving best stack weights distribution!**

*Typical Container  
Securing System  
Upgrades*

# Typical System Upgrades

- Update CSM to New Class Rules

**SECC**  
SECURING YOUR VISIONS

S 16094.08 0.1

## CSA

### CONTAINER SECURING ARRANGEMENT

DNV 2019

UNRESTRICTED SERVICE  
GM ≤ 0.80 m

Owner : REEDEREI CLAUS-PETER OFFEN  
Yard : DAEWOO SHIPBUILDING & MARINE ENGINEERING Co.,Ltd.

Approval :

Nb.	IMO-No.	Name
4178	9460356	MSC SAVONA
4180	9461386	MSC GENOVA
4182	9461403	MSC LA SPEZIA
4184	9461427	MSC LIVORNO
4186	9461441	MSC BARI
4196	9475258	MSC TARANTO
4198	9484431	MSC RAVENNA

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T +49 (0)421 3 98 91-0  
P.O. Box 101604 / 28015 Bremen  
www.sec-bremen.de

DNV

SEC Ship's Equipment Centre Bremen GmbH & Co. KG  
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28217 Bremen

DNV GL SE Ship Classification  
Hull Structure & Outfitting  
Speicherhof 18  
20457 Hamburg  
Germany

Date: 2022-08-08  
Our reference: M-SA-BHJOHWER/  
G114897-J-12867  
Your reference:  
Job ID: PA.0152209-1

MSC SAVONA, ID G114897  
G114897 - Approval of G114897 CSA + RSCS-Amendment  
Reference is made to your e-mail dated 2022-08-08. The following documents are stamped 2022-08-08 and given the status as shown below:

Document No	Rev	DNV No	Title	Code	Status
CSA S-16094-S08	1	11517	CSA S-16094-S08	1040	Approved
		11518	DSME_4178 CSM Amendment for scrubber conversion	1040	Approved

Document No. **CSA S-16094-S08/1**, "CSA S-16094-S08" and  
Document No. (empty), "DSME\_4178 CSM Amendment for scrubber conversion" have both been reviewed in accordance with DNV RU Ship Pt. 5 Ch. 2 Sec. 8

General comments

- All actual loading conditions have to be verified by a DNVGL-approved lashing computer.
- All fixed and loose container securing devices to be used have to be delivered with a product certificate issued by DNV GL according to our class program CP-0088 Certification of container securing devices.
- The amount of loose container securing devices to be on board does not have to comply with the number listed in the container securing arrangement plan. However there must be sufficient loose container securing devices available, to secure the actual container load in accordance with the container securing arrangement plan.

Sincerely  
DNV GL SE

Ordnung

Johannes Werner  
Contact Person

welsh 1, P.O. Box 300, 1322 Høvik, Norway. Tel: +47 67 57 99 00. www.dnv.com

DNV GL SE

## Typical System Upgrades

- Twistlock Change from SAT to FAT



Semi-Automatic Twistlock (SAT)

- Longer Turnaround in Port due to Manual Unlocking
- Increased Stevedore Fees
- Damaged easily (handles, cones)
- Requires Maintenance – Exp. Parts
- Vertical Gap 12~32mm



HD-FAT

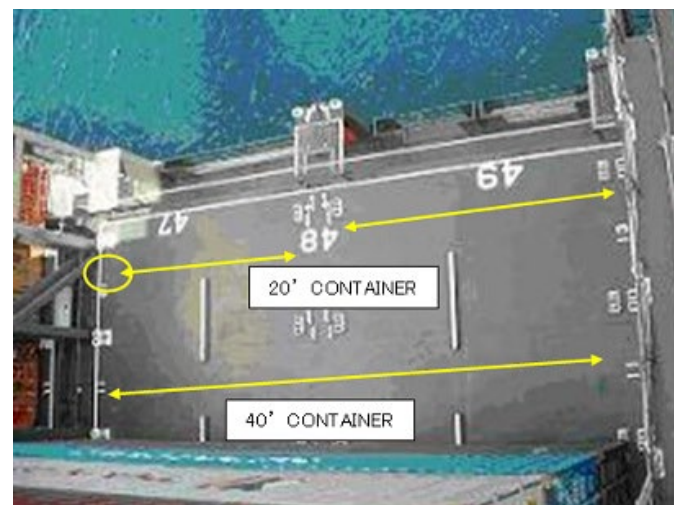
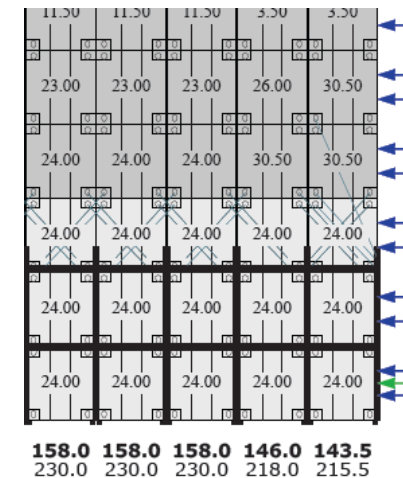
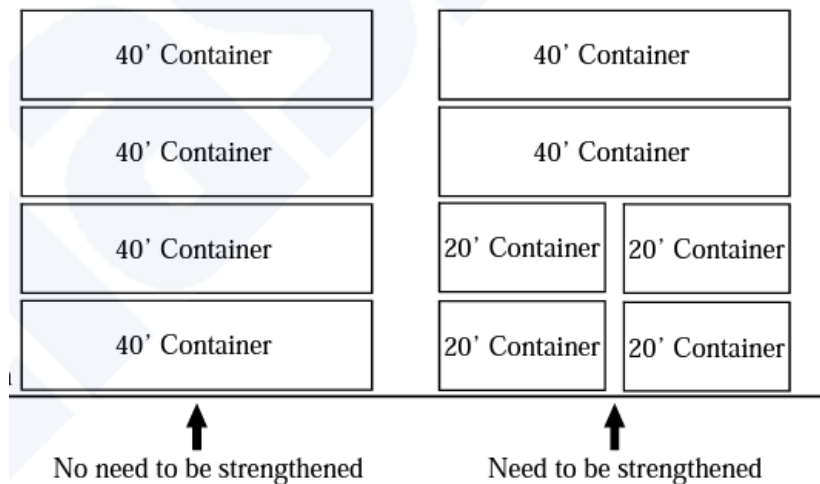
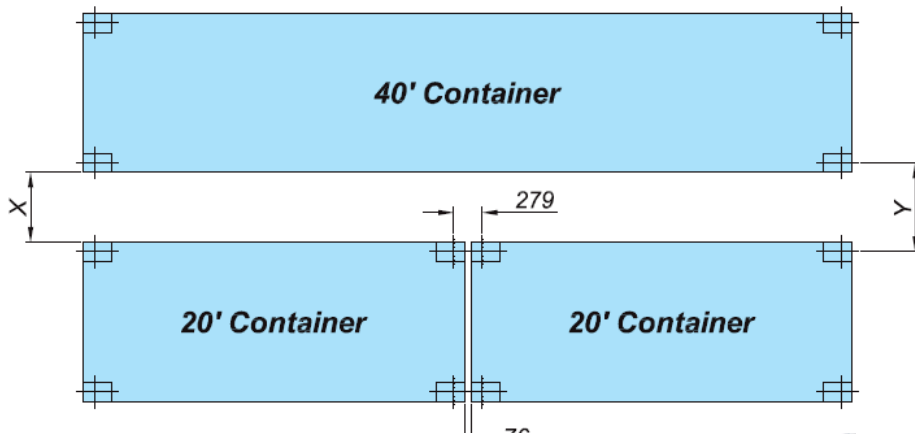
Fully Automatic Twistlock (FAT)

- Reduces Turnaround Time of Ship in Port (<20~40%)
- Reduced Stevedore Fees
- Higher Strength – Higher Performance
- Monoblock -No Maintenance
- Vertical Gap (class certified)  $\leq 12\text{mm}$

**Consideration:** Flange thickness difference to be considered

# Typical System Upgrades

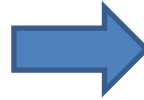
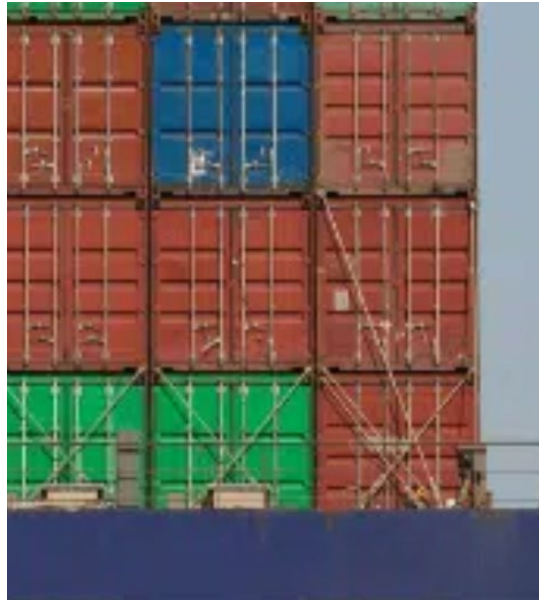
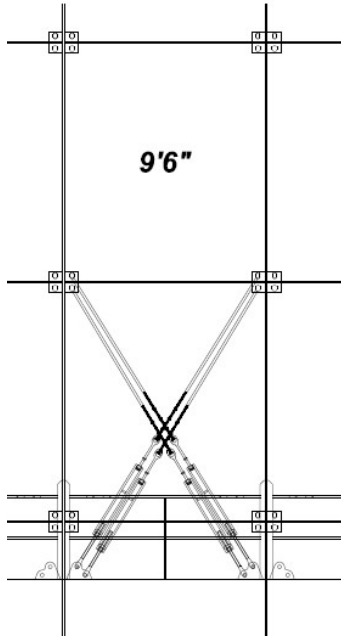
- Mixed 20ft /40ft Stow



- Increases flexibility
- Increases perm. stack weight
- Requires HC strengthening & bending control, or alt. HC Adaptor

## Typical System Upgrades

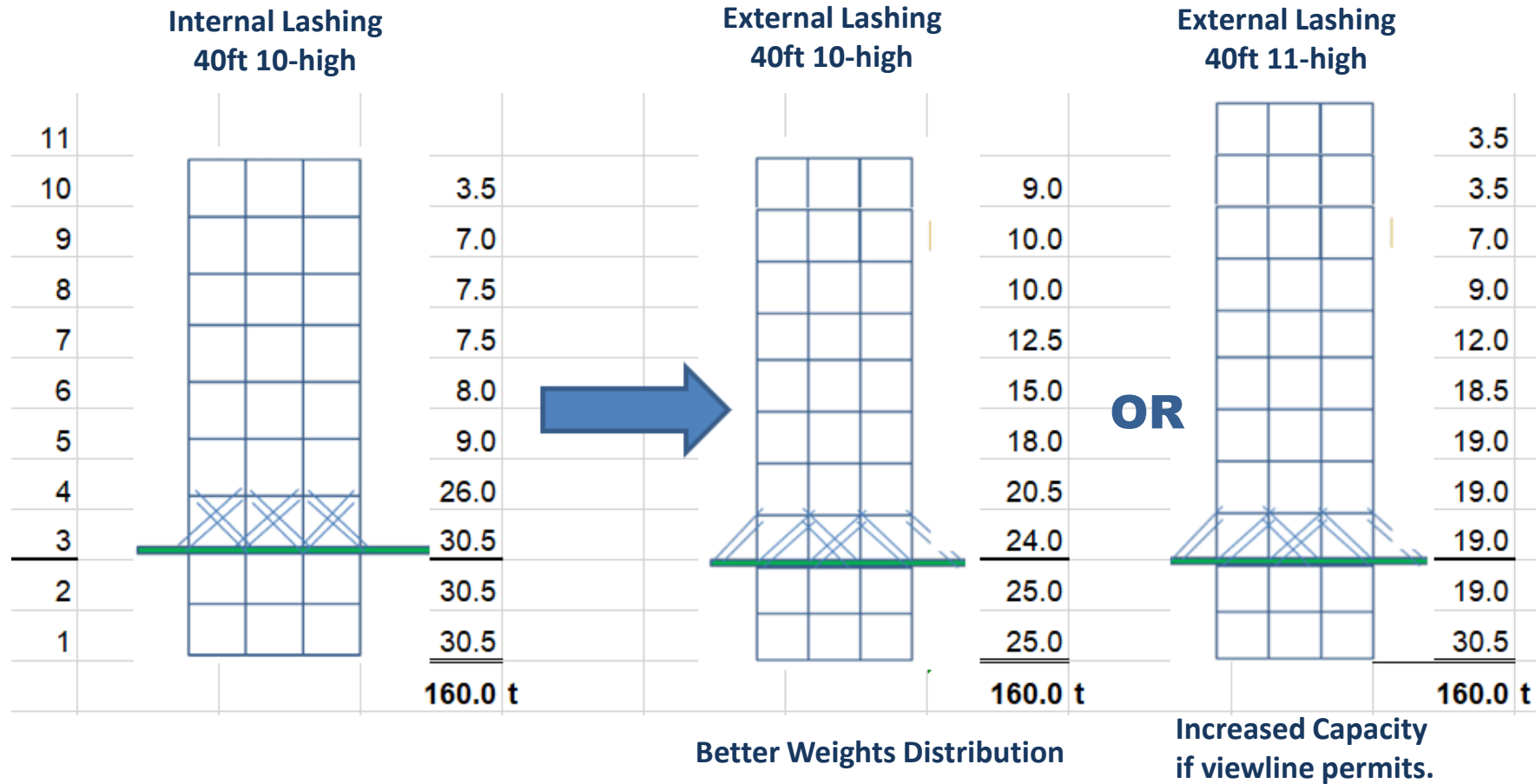
- Change from Internal to External Lashing



The **External Lashing System** secures the lifting side of the container instead of the compressed side, resulting in **higher stack loads** and **better weight distribution** compared to the conventional Internal Lashing.

# Typical System Upgrades

- Change from Internal to External Lashing



## Typical System Upgrades

- Change from Internal to External Lashing



### Important Considerations:

- Necessitates twistlocks with low vertical gap to avoid excessive loads in lashings.
- Different container heights in adjacent stacks and hatch cover movements in joints must be analyzed and compensated.
- Sequential lashing and unlashings of rods required.
- Special high tolerance rod heads necessary
- Mock Up Test to ensure free movement of all parts in every container configuration is mandatory.

## Typical System Upgrades

- Elevation of Lashing Bridges

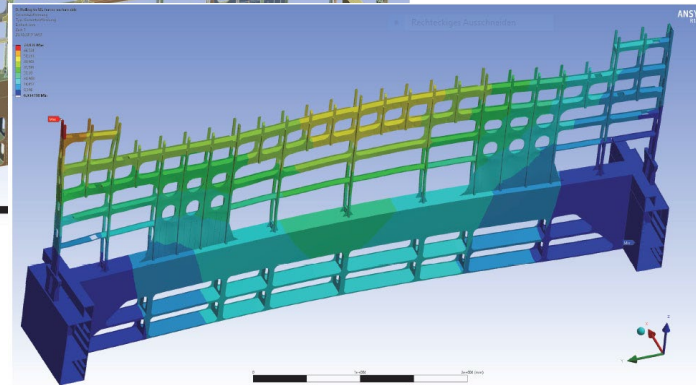
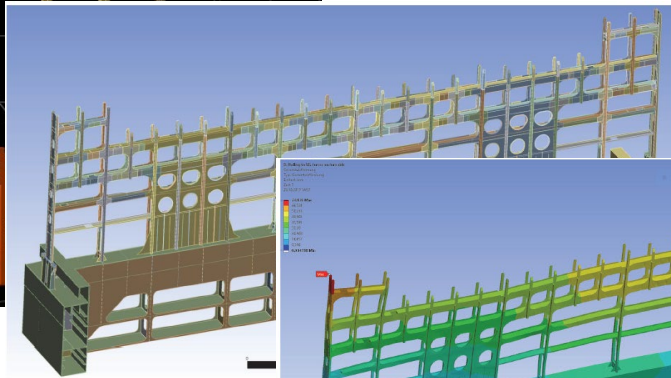
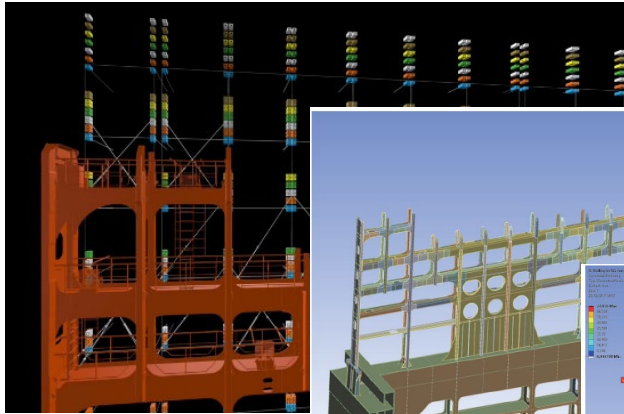


- Addition of **'Mickey Mouse extension'** on existing lashing bridges abolishes long vertical rods that are extremely hard to handle.
- **Elevation** of existing lashing bridges from 2-tier to 3- or 4-tier further enhances stack weights and increases overall capacity subject to viewline. Often combined with elevation of accommodation.



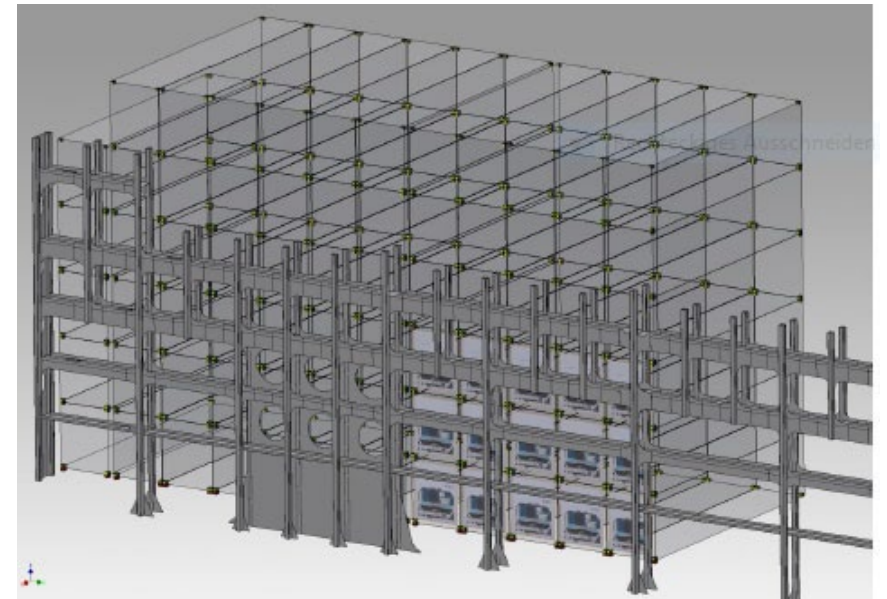
# Typical System Upgrades

- Elevation of Lashing Bridges



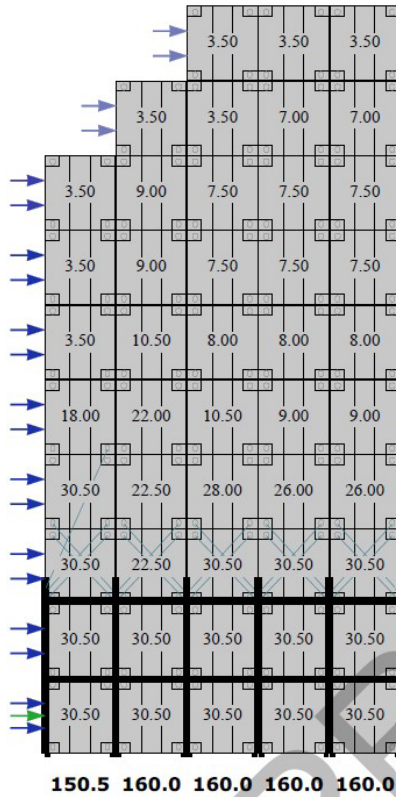
Overall deformation of the lashing bridge for the load case with lashing forces on fore side

- Design Considerations
- Lashing System Calculations
- FEM based strength analysis
- Reefer accessibility
- Mock Up Test

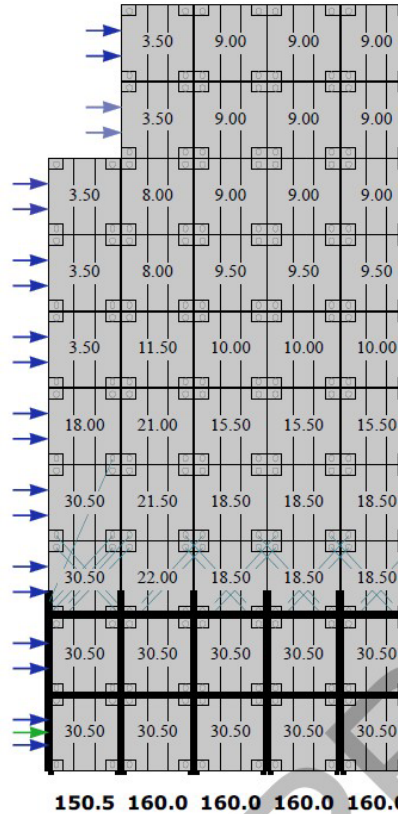


# Typical System Upgrades

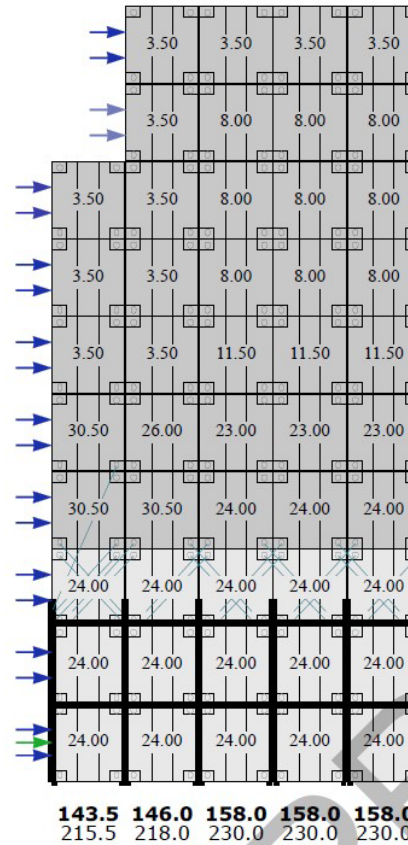
- Example of Upgrades in Carrying Capacity



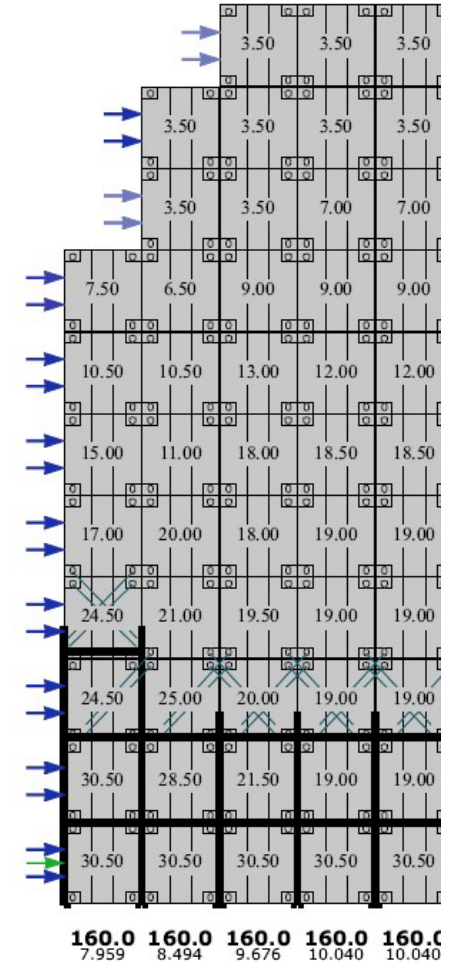
Internal Lash 40ft  
2-high Lash Bridge



External Lash 40ft  
2-high Lash Bridge



External Lash 20/40ft mixed  
2-high Lash Bridge



External Lash 40ft  
2-high LB + 'MM'

## Typical System Upgrades

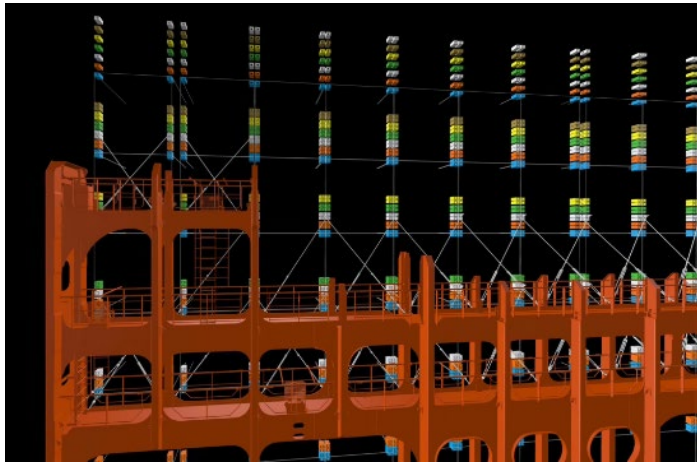
- Future Upgrades in the Pipeline
  - SEC RT Onboard Temperature Differentiation + Overload Detecting Platform



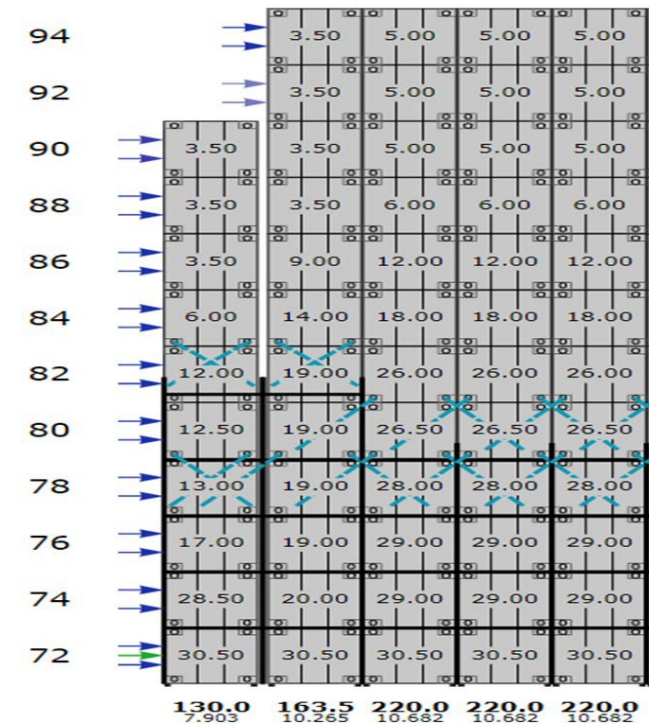
***Design Tools  
Supporting Upgrade***

# Design Tools

## SEC WebLash



	24	22	20	18	16
Rack	80.3	73.5	80.3	80.3	80.3
LRack	55.6	72.0	99.7	99.7	99.7
Lash	119.4	124.2	151.7	151.7	151.7
Post	63.9	85.2	97.4	97.4	97.4
Lift	103.8	132.6	64.3	64.3	64.3
?					



### 3D Virtual Lashing Design Calculation Software

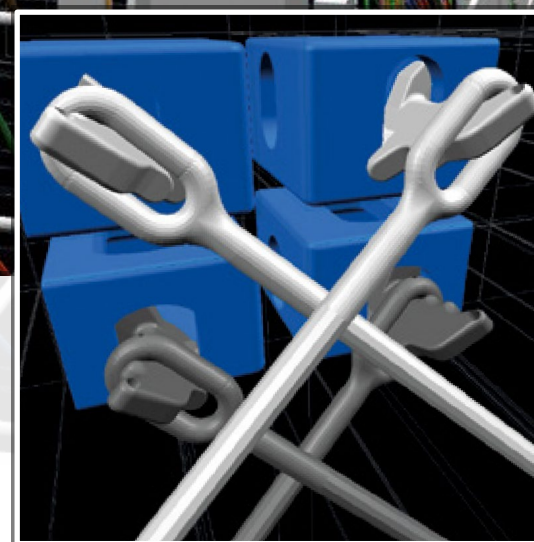
- Web based. 3D Non-Linear
- Calculating according to all mayor Classification Societies
- Dimensioning (3D) Lashing Bridges and Lashing Components
- Performing VR Tests (also remotely)
- Preparing Documentation



SECURING YOUR VISIONS

## SEC'S WEBLASH ONLINE

NEXT GENERATION MOCKUP TEST



***Enhanced Lashings  
Supporting Upgrade***



## HD FAT (Heavy Duty Fully Automatic Twistlock)

Developed in cooperation with Maersk Lines in 2020 it has now been established as the **'industry standard twistlock'**

### Sturdy body of HT steel:

- **Break Load >1000 kN**  
*vs 500 kN of all other twistlocks incl. SATs*
- **Pull Out Force (holding power) >500 kN**  
*vs 275~325 kN of other twistlocks incl. SATs*
- **Vertical Gap <12mm (class certified)**  
*vs 18~37mm of other twistlocks*

### Enhanced Design

- **100% larger seating area**  
*minimize damage of corner castings*
- **Larger safety latch – No Drop Off**  
*secures no-drop of hanging twistlocks even with corner castings worn-out beyond ISO standards*
- **Wrong Insertion impossible**  
*Solid Pin ensures HD FAT cannot go wrong*

### Functionality

- **Ease of Operation**  
*minimal human involvement*
- **Maintenance Free**  
*solid body – latch stainless steel spring*

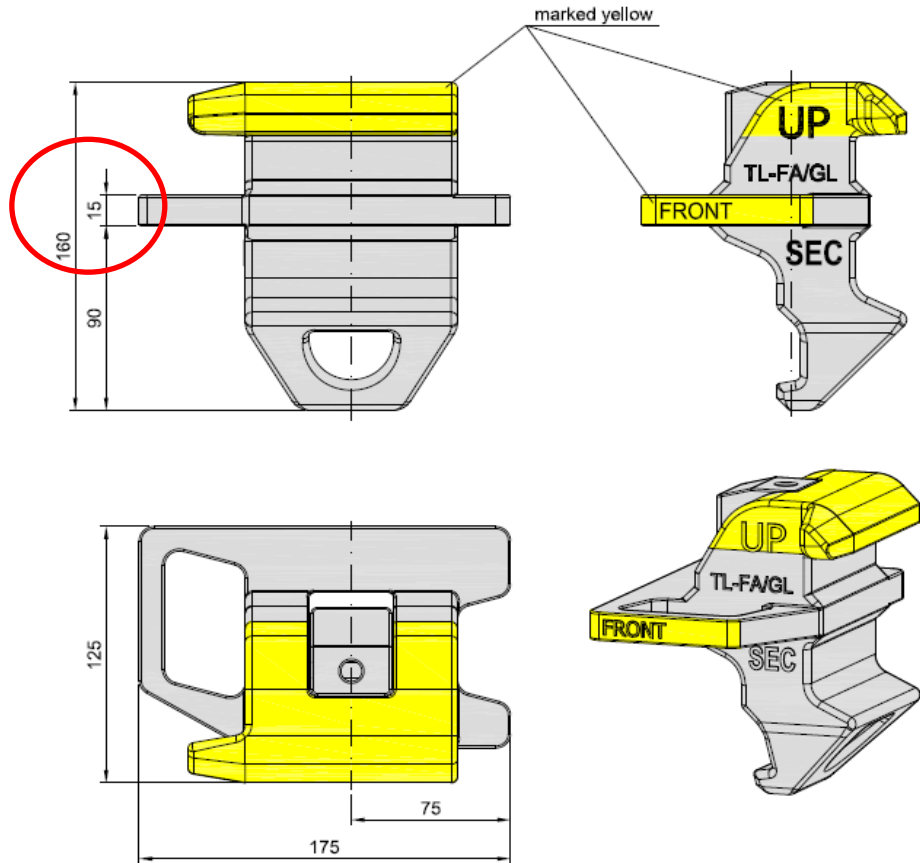
**Adopted already by the Majority of Charterers & Shipowners for their fleets since Jan 2020**



## Upgrading to HD FAT – Easy Substitution

Fully Automatic Twistlock

TL-FA/GL



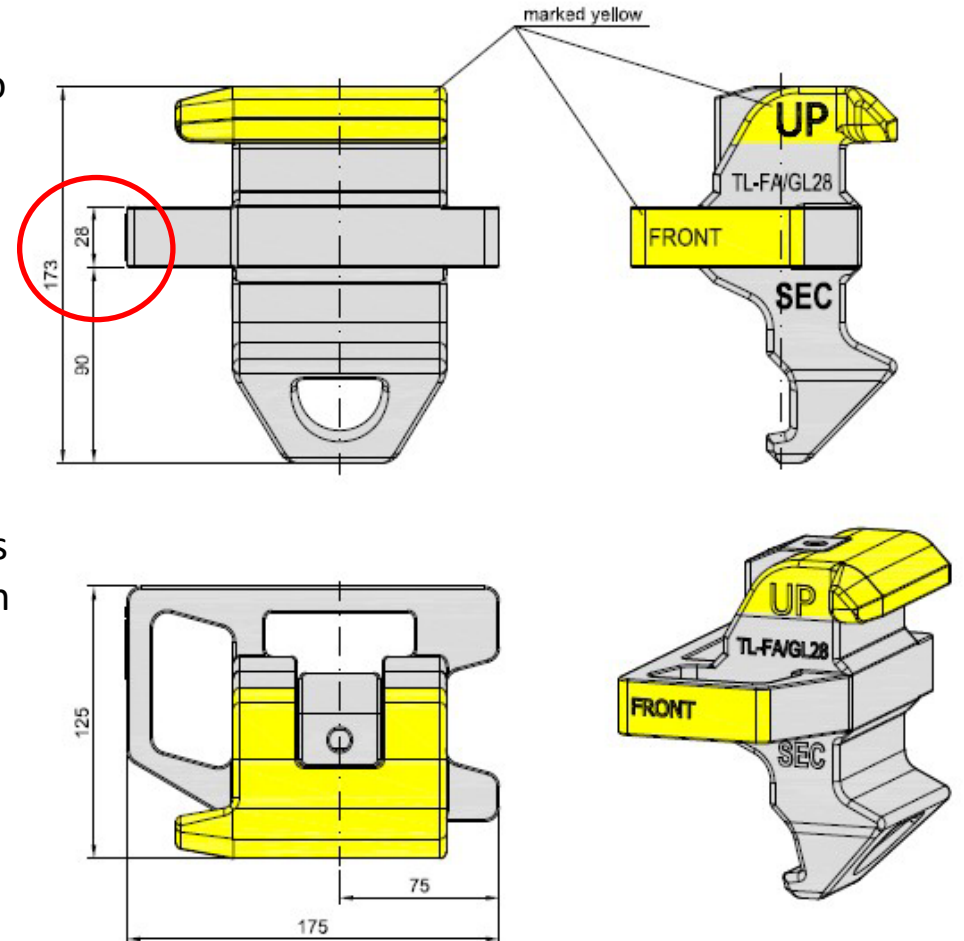
The **HD FAT** comes out in two *flange versions*:

With the default **15mm flange** as previous FATs

Or, with **28mm flange** for replacing SATs with no change in system configuration.

Fully Automatic Twistlock

TL-FA/GL28



**Upgrading your CSS to HD FAT is only a logistic issue. We make the swap easy for you. Contact SEAMARK!**

## Current SEC FAT Types

### HD-FAT Heavy Duty Model

TL-FA/GL



**Patented!**

### U-FAT Utility Model

TL-FA/L



**Patented!**

### L-FAT Light Model

TL-FA/SL



**Patented!**

**Class Approved for:**

- Break Load >1000 kN
- Holding Power >500 kN
- Vertical Gap 12mm

- **Wrong Insertion Impossible**
- **Maintenance Free**
- **Extra Large Seating Area**
- **Non-Drop beyond ISO tolerance**  
(up to 72mm corner casting width)

- **Approved by Major Charterers for their own fleets**

**Class Approved for:**

- Break Load >500 kN
- Holding Power >375 kN
- Vertical Gap 20mm

- **Wrong Insertion Impossible**
- **Maintenance Free**
- **Large Seating Area**
- **Non-Drop beyond ISO tolerance**  
(up to 69mm corner casting width)

- **Approved by Major Charterers for chartered 3<sup>rd</sup> party fleets.**

**Class Approved for:**

- Break Load >500 kN
- Holding Power >375 kN
- Vertical Gap 20mm

- **Wrong Insertion Impossible**
- **Maintenance Free**
- **Large Seating Area**
- **Non-Drop up to ISO tolerance**  
(up to 68 mm corner casting width)

- **Economy Model**

## Summary of all Twistlocks

Twistlock type	HD-FAT	L-FAT	U-FAT	SAT standard version
Features				
Min. breaking load requirement acc. class $\geq 500$ kN	$\geq 1000$ kN / $\geq 100$ tons Safety factor 4 times	$\geq 500$ kN / $\geq 50$ tons Safety factor 2 times	$\geq 500$ kN / $\geq 50$ tons Safety factor 2 times	$\geq 500$ kN / $\geq 50$ tons Safety factor 2 times
Pull out force in Functional Test Class Requirement $\geq 275 / 325$ kN under worst conditions	$\geq 500$ kN / $\geq 50$ tons	$\geq 350$ kN / $\geq 35$ tons	$\geq 350$ kN / $\geq 35$ tons	$\geq 400$ kN / $\geq 40$ tons
Pull out force in Functional Test Class Requirement $\geq 275 / 325$ kN under 2ble / 3ple worst condition	$\sim 500$ kN / $\sim 50$ tons	$\sim 250$ kN / $\sim 25$ tons	$\sim 250$ kN / $\sim 25$ tons	$\sim 300$ kN / $\sim 30$ tons
Vertical Clearance in Functional Test required by LR: $\leq 18$ mm by 250 kN SWL under worst condition	12 mm	18 mm	15 mm	20 mm
Vertical Clearance in Functional Test required by LR $\leq 18$ mm by 250 kN SWL in average condition	12 mm	18 mm	15 mm	20 mm (SEC) (competitors up to 37 mm!)
Container corner casting support	excellent	very good	medium	medium
Contact surface with corner casting	oversized	large	medium	small
Compression flange surface	oversized	large	medium	medium
Handling performance	very good	excellent	very good	good
Wrong insertion possible	No	No <i>competitor's YES</i>	No	Yes
Operation	very good	excellent	very good	good
Maintenance free	Yes	Yes	Yes	No
Spare parts needed	No	No	No	Yes
Risk of possible damage	No	small	small	big
Overall performance	excellent	very good	very good	medium

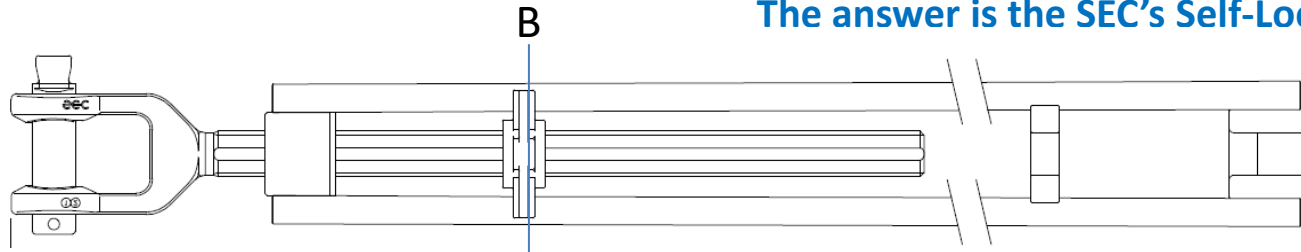
**Patented!**

# Self-Locking Turnbuckle

**No more accidents due to turnbuckles slacken due to vibrations during voyage!**

The counter-nut of conventional turnbuckles takes extra time to adjust. Stevedores in a rush tend to skip it and crew cannot patrol during harsh weather. Result: Slack turnbuckles = no (effective) lashing!

**The answer is the SEC's Self-Locking Turnbuckle**



Section B-B

Stainless Steel Spring

Stainless Steel Ball

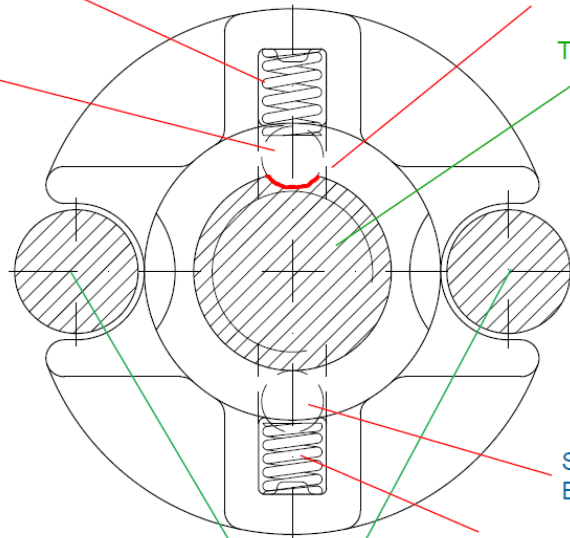
Groove in the Turnbuckle Spindle

Turnbuckle Spindle

Stainless Steel Ball

Stainless Steel Spring

Turnbuckle Body



**Function:**

The 2 springs press the 2 balls against the spindle. Every 180° turn one of the balls falls into the spindle groove and locks.





## FAB-4 Lashing Bars

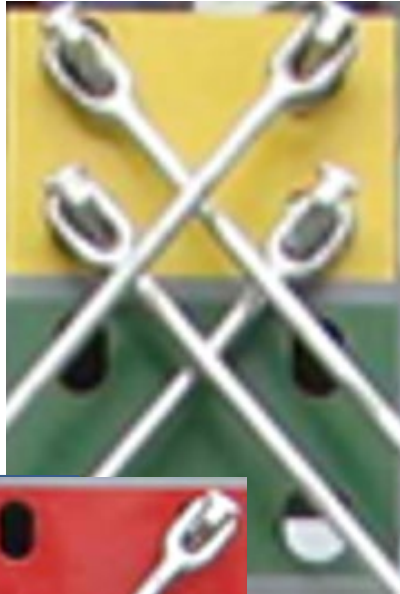
**Patented one head suitable for all 4 corner castings – internal or external lashing!**

Enable SEC to resolve the most complex external lashing configurations on lashing bridges

*minimizing the number of different lashing bars for the entire ship*

*(very often to only one or two!)*

**No more lashing bars confusion!**





## Twist Stacker Allround Chamfered

### Did the crane operator miss the hole?

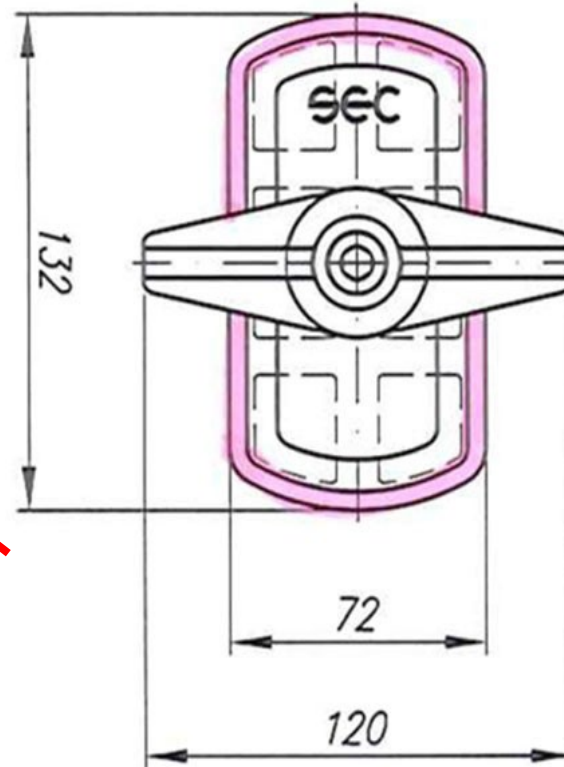
The new flangeless SEC twist stacker is shaped to seat all around the corner casting hole.

It will withstand a 680 kN pressure before giving in! Almost twice any of competitors.

Most importantly, even if hammered in, it can be retrieved without damaging the corner casting!



**No more punched-in stackers!**



**No more punched-in stackers!  
No more expensive delays to flame-cut the boxes apart!**

# ***Return on Investment***

***Benefits for  
Charterers & Owners***

# Return on Investment

- Assessment of Benefits vs Costs

For each perspective project:

We provide owners with preliminary assessment of *incremental benefits vs cost* for each upgrade step, so they can conclude with charterers the *sustainable upgrade extent*.



# Thank you very much for your attention!

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