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S.S. EL FARO

Document No. 101CS01704

Report on Review of Cargo Securing Manual and Cargo Stowage and Securing

4 August 2016

<u>Requested by</u>: National Transportation Safety Board
490 L'Enfant Plaza, SW
Washington
DC 20594

This is to certify that the undermentioned personnel of National Cargo Bureau, Inc. did, at the request of the above, conduct a review of the subject vessel's Cargo Securing Manual and the cargo stowage plan provided for the vessel's departure from Jacksonville, FL on/about 1 October 2015, and have the following to report:

Geoffrey J. Davies	Chief Surveyor
Philip I. Anderson	Chief, Technical Department
Edward F. Walker Jr.	Asst. Deputy Chief, Technical

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CONTENTS PAGE

1.0 INTRODUCTION

The S.S. EL FARO was lost at sea on 1 October Oct 2015 while en route from Jacksonville, FL to San Juan, Puerto Rico. As part of its investigation, National Transportation Safety Board (NTSB) requested that National Cargo Bureau (NCB) conduct a review of the vessel's Cargo Securing Manual and further review the cargo stowage and securing for the vessel upon departure from the Port of Jacksonville.

2.0 SCOPE

We were asked to:

- Review the vessel's Cargo Securing Manual
- Review the sufficiency of securing arrangements for the Main Deck (containers) and 2nd Deck (RORO Cargo)
- Review of the sufficiency of securing arrangement for any "suspect loads" such as (but not limited to) high, heavy, or athwartship stows
- Calculation of the breaking or failing points for the above two items

3.0 EXECUTIVE SUMMARY

The Cargo Securing Manual contained a number of errors and inconsistencies with respect to information provided and the manner in which it was presented. These were assessed and deemed insignificant in that they should not have contributed towards the incident.

As much as 60% of the second deck cargo (RO-RO) was not secured in accordance with the Cargo Securing Manual. This was deemed significant and it was considered likely that lashing failure would result in the event of significant vessel movement, i.e. rolling and pitching. In the event of any lashing failure in the presence of continued significant vessel movement, primarily rolling, progressive lashing failure with potentially catastrophic shift of cargo could be expected.

Several stacks of containers on deck were not stowed and secured in accordance with the Cargo Securing Manual and/or the CargoMax program incorporated into the Manual. Maximum weights were exceeded for some stacks and several stacks that should have been lashed were not. This would increase the potential for stack collapse in the event that heavy rolling was experienced. Any loss of containers would be likely to increase the vessel's GM which would have the effect of increasing transverse accelerations, thus increasing the transverse forces on the cargo lashings and increasing the likelihood of failure of lashings on RO-RO cargo.

Precise breaking or failure points for the lashings could not be determined.

Details are contained below.

4.0 REVIEW OF CARGO SECURING MANUAL

4.1 Approval

The Cargo Securing Manual (CSM) was prepared by Herbert Engineering Corp. and approved by American Bureau of Shipping (ABS) on behalf of the U.S. Administration on 20 January 2006.

4.2 Governing guidelines

The International Maritime Organization (IMO) issued Guidelines for the preparation of the Cargo Securing Manual in MSC/Circ. 745 dated 13 June 1996. This circular has subsequently been superceded by MSC.1/Circ.1353, but was in effect at the time that the CSM was approved and is included in its entirety in the 2003 Edition of the IMO Code of Safe Practice for Cargo Stowage and Securing (CSS Code).

The CSS Code was initially adopted on 6 November 1991 (resolution A.714(17)) and amended in 1994 (MSC/Circ. 664), 1995 (MSC/Circ. 691), 1996 (MSC/Circ. 740) and 2002 (MSC/Circ. 1026). These amendments were incorporated into the 2003 edition of the CSS Code and it is this edition that should have been complied with in respect to the CSM on EL FARO. Consequently, when reviewing the CSM, it is the 2003 Edition of the CSS Code that was used to determine adequacy of the vessel's CSM. This edition of the CSS Code also contains, as Appendix 4, "Guidelines for the securing arrangements for the transport of road vehicles on ro-ro ships", incorporating Resolution A.581(14) as amended by MSC/Circ. 812.

4.3 Guidelines Chapter 1

Chapter 1 contains a number of definitions of terms in part 1.1 and then lists, in part 1.2, a number of general statements that should appear in the CSM. Some of these statements appeared exactly as written, others did not. However, text was included in the CSM that would meet the intent of these non-verbatim statements and so the CSM was considered satisfactory in that respect.

4.4 Guidelines Chapter 2

Chapter 2 includes specifications for fixed cargo-securing devices (part 2.1), portable cargo-securing devices (part 2.2) and inspection and maintenance schemes (part 2.3). Several issues were identified with respect to the information and the manner in which it was presented.

- Values were given as Safe Working Load (SWL) alongside Breaking Strength (BS). SWL is typically used for running gear and Maximum Securing Load (MSL) should be used for lashing gear. We could not see any correlation between the SWL values and BS values shown and it is not clear where these came from. Both SWL and MSL are obtained as percentages of BS, but the factors are different. SWL generally utilizes a lower percentage of BS than MSL would, hence incorporates a greater safety factor.

Assuming then, that the SWL values shown are correct, these could legitimately be used as MSL values in determining lashing strength.

- No means of obtaining correct tension on underdeck lashings was specified.
- No certification of lashing materials or documentation of inspections/maintenance was present. This, however, was to be expected as we were working with a copy of the CSM as the original was lost with the vessel. It is possible that the original contained these certificates and inspection/maintenance logs. In any event, minor discrepancies in the documentation would not be significant and we have seen nothing to suggest that any major discrepancies may have been present.

The CSM was considered to be generally in compliance with Chapter 2 of the Guidelines.

4.5 Guidelines Chapter 3

Chapter 3 is entitled "Stowage and securing of non-standardized and semi-standardized cargo".

Parts 3.1 (Handling and safety instructions), 3.2 (Evaluation of forces acting on cargo units) and 3.3 (Application of portable securing devices on various cargo units, vehicles and stowage blocks) were seen to have been generally complied with in the CSM. In particular, it should be noted that the CSM referenced Annex 13 of the CSS Code to be used to determine the adequacy of securing non-standardized and semi-standardized cargo and incorporated that into Annex 17 of the CSM.

Part 3.4 is entitled, "Supplementary requirements for ro-ro ships". 3.4.1 states in part, "The Manual should contain sketches showing the layout of the fixed securing devices with identification of strength (MSL) as well as longitudinal and transverse distances between securing points". Sketches, as described, were not seen in the CSM. It was also noted that, in Appendix 5 of the CSM (Locations of Fixed Securing Devices in Hold), Figure 1. Typical Trailer Stowage, appeared to contradict other requirements with respect to positioning of D-Rings to be used for securing of trailers. The use of D-Rings in the positions shown would be unlikely to allow for lashings with angles not less than 45° or minimum 4 feet lead as contained in CSM requirements outlined in "Other standardized cargo" below. The CSM was considered to generally comply with Chapter 3 of the Guidelines but was confusing in this respect as reliance could not be placed solely upon Appendix 5 and the user would, therefore, need to be familiar with the written instructions elsewhere in the CSM in order to determine whether lashings were satisfactorily positioned.

4.6 Guidelines Chapter 4

Chapter 4 is entitled, "Stowage and securing of containers and other standardized cargo" and is separated into parts 4.1 (Handling and safety instructions), 4.2 (Stowage and securing instructions), 4.3 (Other allowable stowage patterns) and 4.4 (Forces acting on cargo units). Part 4.1 is equally applicable to containers and other standardized cargo and the CSM was considered satisfactory in that respect. Requirements of the other parts have been addressed separately for “other standardized cargo” and “containers” below.

4.6.1 Other standardized cargo

Although generally considered semi-standardized cargo, vehicles and trailers have been included in this category as 40 feet long trailers and automobiles/vans would essentially be considered standardized cargo for this vessel and are treated as such in the CSM where, in particular, E-03-725, makes reference to two systems being used to secure standard wheeled vehicles, a standard wire lashing system in conjunction with a roloc box for trailers and a second, lighter, lashing system for automobiles and vans. This is not technically correct as the lashing system used for trailers utilized chains, not wires, in conjunction with roloc boxes. This was, however, considered insignificant as details of the chain lashings were included in the CSM.

The standard system specified that a roloc box must be used. This would be secured in place using the buttons located on the RO-RO decks. The normal configuration (fore/aft stowage with roloc box aligned with trailer) called for additional securing in the form of two lashings with rearward lead with respect to the trailer. If the rearward lead could not be achieved or roloc box could not be aligned with the trailer, then additional options calling for increased lashings were shown. Configurations were also shown that took athwartships stowage and stowage on ramps into account. In all cases, roloc boxes were to be secured using the buttons and lashings were to have minimum 4 feet lead (or angle not exceeding 45^o to the horizontal) in the athwartship direction. In addition, MSL of the securing point on the trailer/chassis should be not less than the MSL of the lashing itself and examples of appropriate points were given, along with a statement that, “You will find that some points that appear convenient are not adequately welded or otherwise fastened to the main framework”. For situations regarding the securing of RO-RO cargo not specifically detailed in the CSM, it was stated that “In these instances, the instructions for non-standardized cargo given in Procedure E-03-600 and Appendix 17 shall be followed”.

From this, it was clear that any configuration of stowage/securing not specifically referenced would require a calculation in accordance with Annex 13 methodology in order to determine adequacy. The CSM was, therefore, considered satisfactory in this respect.

4.6.2 Containers

The principles of container stowage and securing were shown, along with guidance relating to acceptable configurations of containers with lengths of 20, 40, 45, 48 and 53 feet.

The CSM stated, on page 1 of E-03-535, that planning of container stowage is done ashore. Maximum stack weights were provided in Appendix 9 and typical stack weight diagrams provided in Appendix 13 to “familiarize shipboard personnel with acceptable stack configurations” and “provide a basis for determining lashing requirements if the actual container weights or container types do not agree with the stowage plans produced by the shoreside computer system”. Appendix 13 details container weight configurations for GMs of 4 feet and 9 feet and varying stack heights for “no lash” and “single lash” systems. In the “no lash” system, containers are secured with twist locks only; in the “single lash” system, containers are secured with twist locks and lashing bars. It was considered doubtful that the diagrams shown would allow a ship's officer to comfortably determine whether weight distribution was satisfactory and/or whether container stacks needed to be lashed. This was, however, considered insignificant in this instance as shoreside computer programs (Spinnaker and CargoMax) had reportedly been used to plan the stow and determine lashing requirements.

5.0 REVIEW OF SUFFICIENCY OF SECURING ARRANGEMENTS FOR THE MAIN DECK CARGO (CONTAINERS)

In addition to a copy of the vessel's CSM, we were provided with a copy of the CargoMax Trim and Stability program and the stowage plan for the departure Jacksonville condition. Several load cases, including intermediate load cases, accompanied the CargoMax program. During our review, we noted that only one case showed the full departure condition of the vessel and that the information contained in that differed from the stowage plan provided.

Noting that the departure condition titled "full.dep.lc" did not include a container build-out and only utilized the container summary page, we created a new load case utilizing the CargoMax program and entered each container individually to determine whether any stowage or securing discrepancies existed. Lashing information provided to us indicated that generally the outer two (2) stacks on each side of each bay were secured by twist locks and lashing bars (single lash system) and the remainder were secured using twist locks only (no lash system). Several stack weight and lashing discrepancies were identified as noted below:

Overweight stacks:

- Bay 03 – Stack 07
- Bay 03 – Stack 08
- Bay 10 – Stack 06
- Bay 12 – Stack 05
- Bay 13 – Stack 10
- Bay 15 – Stack 05
- Bay 16 – Stack 02
- Bay 17 – Stack 06

See Appendix 1 - Excerpts from CSM and Appendix 2 - Printouts from CargoMax program.

Stacks secured with twist locks only when single lashing was also required:

- Bay 12 – Stack 02*
- Bay 14 – Stack 00
- Bay 14 – Stack 03*
- Bay 16 – Stack 01*
- Bay 16 – Stack 02*
- Bay 17 – Stack 08
- Bay 19 – Stack 01
- Bay 19 – Stack 02

See Appendix 2

We also located two (2) additional load cases in separate files that were not directly accessible through the CargoMax program. One of these, titled "ef185jx2.lc", included a container build-out to assist in showing stack weight and lashing requirements. This appeared to be essentially accurate and in accordance with the provided stowage plan except for containers in Bay 19 Stack 02, where the stack weight shown in the CargoMax file was approximately eight (8) long tons less than that shown in the stowage plan. The overweight stacks noted above were also noted as discrepancies in this file. However, only four (4) of the lashing discrepancies noted above (those marked with an asterisk) were shown as discrepancies in this file.

The following were shown as being lashed (single lash) and did not appear as discrepancies:

- Bay 14 – Stack 00
- Bay 17 – Stack 08
- Bay 19 – Stack 01

Information provided to us, however, indicated that these stacks were secured using twist locks only (no lash) and single lash system was not used.

Bay 19 Stack 02 was shown in this file as satisfactory when secured with twist locks only but, as referenced above, the stack weight shown was eight (8) long tons less than shown on the stowage plan. Once this was adjusted to match the stowage plan, the CargoMax program indicated that lashing was necessary.

6.0 REVIEW OF SUFFICIENCY OF SECURING ARRANGEMENTS FOR THE 2ND DECK (RO-RO) CARGO

We reviewed the securing of RO-RO cargo on the 2nd Deck, concentrating on locations in which the greatest forces would be experienced and using maximum weights that could be secured in those locations in accordance with the CSM, in order to evaluate whether the cargo was adequately secured.

The majority of the securing calculations conducted during our review of the RO-RO cargo utilized the Annex 13 Advanced Calculation method detailed in the CSS Code and incorporated into the vessel's CSM (see Appendix 3 – Annex 13 calculations). To further verify our methodology, we used an engineering mechanics calculation for rigid bodies to determine whether the cargo was correctly secured (see Appendix 4 – Engineering calculation). This method was only used for RO-RO cargo loaded in the worse position in Hold 2A.

The following assumptions were used in our calculations:

- Each calculation was done for half the assumed gross weight of the chassis/container. This was done due to the difference in friction coefficients between the front and rear of the chassis/container. We only conducted the calculation for the assumed worst end.
- An assumed GM of 4.28 feet (1.31 m) was used in all calculations.
- Angles of lashing chains were based on diagrams and information provided in the CSM.

The subject vessel's CSM states that RO-RO cargo is to be secured utilizing a roloc box attached to the 5th wheel pinion on the container chassis and a securing button on the deck of the vessel. In the standard stowage position the CSM states that two chains (one on each side) shall be used on the rear of container/chassis to effect proper securing. In certain situations, it recommends using an additional set of chains if the trailer is stowed on a ramp or is more than 30° off axis.

We calculated based on a weight of 81,560 pounds (Maximum Gross Weight (MGW) for a reefer container plus chassis weight) and noted that, in the worst position of Hold 2A, a container/chassis properly set on the roloc box and button and secured with one chain on each side of the rear of the container/chassis should be adequately secured under normal circumstances provided the lashing angles did not exceed 45° to the horizontal. If the lashing angles were increased to 75°, we found that the maximum weight which could be secured was approximately 76,500 pounds (see Appendix 3).

We carried out similar calculations for the worst positions of Holds 2B and 2C for the MGW of a reefer container/chassis (81,560 lbs) secured with a roloc box and 2 chains on the rear and found them to be adequately secured under normal circumstances for lashing angles up to 75° (see Appendix 3).

During our review of the actual departure stowage plan we noted that RO-RO cargo in Hold 2A/2F was secured utilizing four (4) lashing chains instead of two (2). This practice was also followed in the outboard rows for the other holds on Deck 2. The stowage plan for the RO-RO decks also indicated that containers/chassis that were off-button were secured with six (6) lashing chains. It was reported that, in these situations, four (4) chains would be positioned at the forward end of the unit to compensate for the roloc being off-button and the other two (2) chains would be positioned at the rear.

We note that this lashing arrangement is not in accordance with the standard method for securing RO-RO cargo contained in the vessel's CSM and an Annex 13 calculation should, therefore, have been carried out for each individual piece stowed and secured in this manner. The stowage plan does not indicate which items were stowed and secured in this manner, but it was reported that up to 60% of Deck 2 cargo was stowed off-button.

We carried out Annex 13 calculations for RO-RO cargo secured off-button to determine the maximum weight that could be secured with six (6) chains, as outlined above, in each of the holds on Deck 2. Using optimal lashing angles (not more than 60^{o}), the following maximum weights were found:

- HOLD 2A/2F – 35,400 lbs
- HOLD 2B/2E – 40,300 lbs
- HOLD 2C/2D – 42,300 lbs

See Appendix 3.

It should, however, be noted that photographic evidence detailing standard practice on a sister vessel (EL YUNQUE) indicates that the lashing angles used above are likely to have been frequently exceeded. Photographs of securing accompanying the Tote Lashing Manual also suggest that appropriate securing points on the cargo pieces were not always used. In these photographs, there are examples of lashings being hooked onto flanges and/or trailer floor members that would not provide strength equivalent to that of the lashings. Excessive lashing angles and/or use of inadequate securing points on cargo would reduce the effectiveness of the securing system. However, as we had no specific evidence that any excessive lashing angles or inadequate securing points had been used in this case, in determining the amounts above, it was assumed that all lashings were properly attached to appropriate points on the cargo pieces, such that the MSLs of the securing points were no less than the MSLs of the lashings and lashing angles were not greater than 60^{o}.

6.1 Adequacy of securing points on trailers

IMO Resolution A.581(14), contained within the CSS Code contains further guidelines for securing arrangements for the transport of road vehicles on ro-ro ships. The term “road vehicle” includes “Semi-trailer, which means a trailer which is designed to be coupled to a semi-trailer towing vehicle and to impose a substantial part of its mass on the towing vehicle”. The RO-RO cargo on EL FARO would fall under this definition.

Part 5 of Resolution A.581(14) is entitled, “Securing points on road vehicles” and contains guidelines on number, design and marking of securing points on the road vehicles (trailers). Minimum number of securing points and minimum strength requirements for each securing point are specified. From review of photographs of securing aboard the EL YUNQUE, it is apparent that these guidelines were generally not followed. However, as stated in 6.0 above, we had no specific evidence that any inadequate securing points had been used in this case.

6.1.1 Adequacy of lashing strength

The Guidelines referenced in 6.1 above also contain a recommendation that the MSL of lashings be not less than 100 kN. The lashings on EL FARO did not comply with this, indicating MSL of

41 kN, based upon SWL of the tensioners. This, however, should not affect adequacy of securing provided sufficient lashings were properly applied.

7.0 REVIEW OF THE SUFFICIENCY OF SECURING ARRANGEMENT FOR ANY “SUSPECT LOADS”

Any RO-RO cargo that exceeded the weights above and was stowed off-button and secured with six (6) chains was not secured in accordance with Annex 13 and hence was not secured in accordance with the vessel’s CSM. While we could not determine precisely which cargo was stowed on/off-button, we note that in excess of 90% of the RO-RO cargo exceeded the above maximum weights and, as up to 60% of Deck 2 cargo was stowed off-button, we consider it likely that a significant portion was not adequately secured.

In addition to the above, any of the container stacks detailed above that were overweight or should have been secured could be considered “suspect loads” as the means of securing utilized would not be considered adequate for normal conditions.

8.0 CALCULATION OF THE BREAKING OR FAILING POINTS

We were not able to determine precise points at which lashings would break or fail as this is subject to numerous variables such as cargo position, cargo securing points, lashing angles, material strength, wave properties and ship motions that we could not predict.

Normal conditions, as referenced in the previous section, would, however, generally be accepted as the parameters under which the standard lashing calculations are based and included in the CSM. When cargo is properly secured, in accordance with the CSM, it is expected that the lashings would provide satisfactory restraint for roll amplitudes up to 25^o coupled with pitch amplitudes up to 6^o. There are safety factors included, but significantly exceeding any of these values or exceeding them by even a small amount for a prolonged period would increase the risk of lashing failure. It is for this reason that the CSS Code contains guidance on actions to be taken in heavy weather and the CSM, in E-03-600 states, “In the case of marked roll resonance with amplitudes above 25^o, the figures of transverse acceleration may be exceeded. Effective measures to avoid this condition shall be taken. In the case of slamming induced by heading into heavy seas at high speed, the figures of longitudinal and vertical accelerations may be exceeded. Effective measures to avoid this condition shall be taken”.

9.0 CONCLUSIONS

1. The Cargo Securing Manual contained minor errors and omissions with respect to specifications for portable cargo securing devices. These should not have contributed towards the incident.

2. The Cargo Securing Manual was lacking with respect to information showing the layout of fixed securing devices. This should not have contributed towards the incident.

3. The Cargo Securing Manual was lacking with respect to provision of information to allow vessel's personnel to determine adequacy of container securing on deck. This should not have contributed towards the incident.

4. As much as 60% of Deck 2 (RO-RO) cargo was not stowed and secured in accordance with the Cargo Securing Manual. Lashings would be expected to fail in the event of significant vessel movement (rolling and pitching) and this is more likely than not to have contributed towards the incident as, in the event of any lashing failure in the presence of continued vessel movement, progressive lashing failure with potentially catastrophic shift of cargo could be expected.

5. Containers on deck were not stowed and secured in accordance with the Cargo Securing Manual and/or CargoMax program. Some stack weights were exceeded and container stacks that should have been lashed were not. This would increase the potential for stack collapse in the event that heavy rolling was experienced. This may have contributed towards the incident as any loss of containers would be likely to increase the vessel's GM which would have the effect of increasing transverse accelerations, thus increasing the transverse forces on the cargo lashings. As indicated above, in the event of any lashing failure in the presence of continued vessel movement, progressive lashing failure with potentially catastrophic shift of cargo could be expected.

6. Although we had no specific evidence that any excessive lashing angles or inadequate securing points on cargo had been used, photographic evidence detailing standard practice on a sister vessel (EL YUNQUE) suggests that this is likely. This may have contributed towards the incident as it could result in a reduction of lashing strength, thus increasing the potential for lashing failure with consequences as indicated in 4 and 5 above.

7. Lashing failure points could not be determined.

10.0 REMARKS

This report is issued without prejudice and is for the benefit of whom it may concern.

NATIONAL CARGO BUREAU, INC.

[redacted]

P. I. Anderson
Chief, Technical Department

Appendix 9:

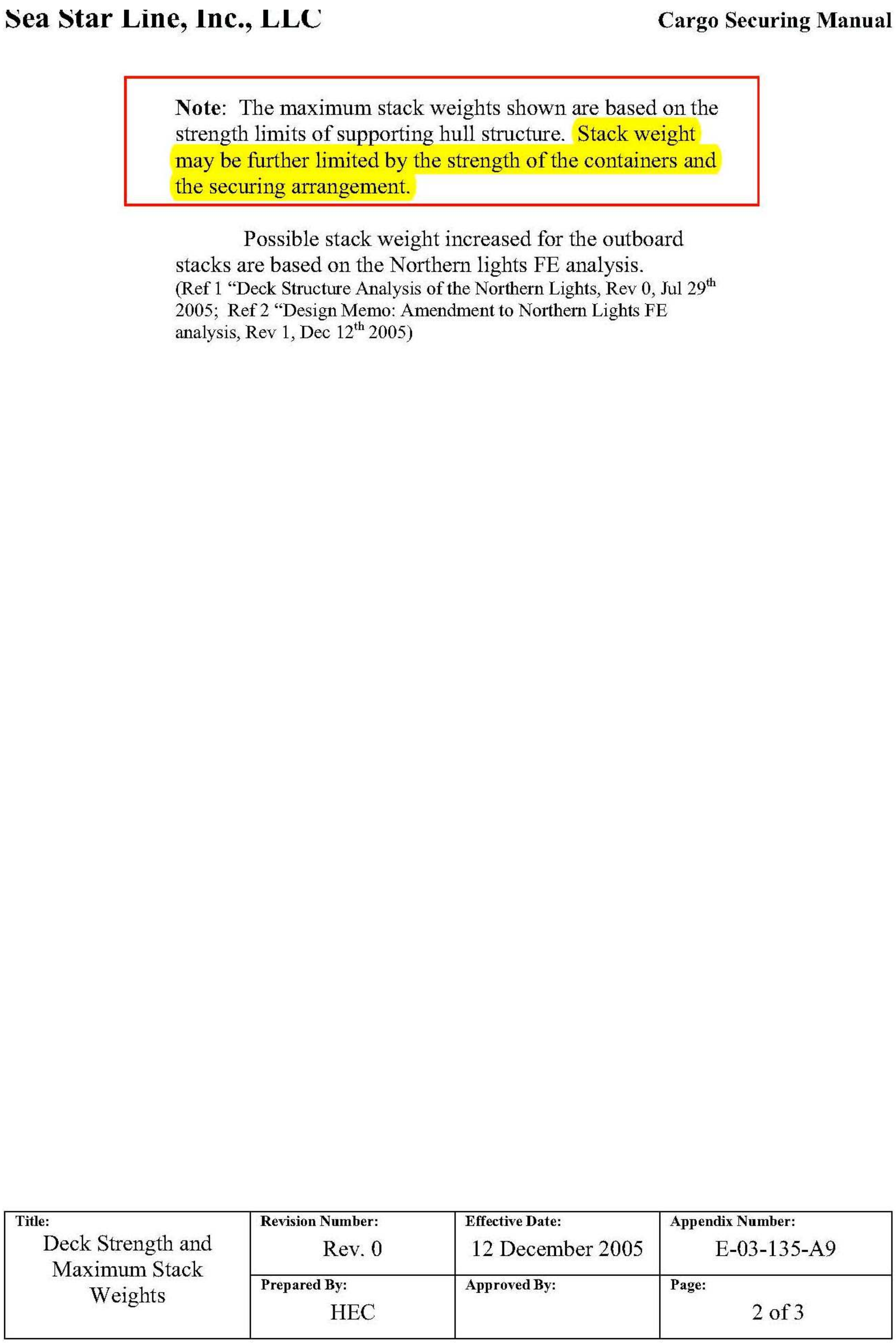
Deck Strength and Maximum Stack Weights

Scope: This appendix is applicable to *SS EL FARO*.

Table 1. Stack Weight Limits On Deck

Bay	stack	20s	40s	45s	48s	53s
1		40.2	53.6	53.6		
2	stacks 07 & 08	53.6				
	others	40.2				
3		40.2	53.6	53.6		
4		40.2				
6	stacks 09 & 10		62.5	62.5	62.5	62.5
	others		53.6	53.6	53.6	53.6
7	stacks 11 & 12	53.6				
	others	40.2				
8			53.6	53.6	53.6	53.6
10			53.6	53.6		
12	40/45's stacks 07-12		71.4	71.4		
	48/53's stacks 05-10				71.4	71.4
	others		53.6	53.6	53.6	53.6
13			53.6	53.6		
14			53.6	53.6	53.6	53.6
15			53.6	53.6		
16	40/45's stacks 08, 10 & 12		71.4	71.4		
	48's stack 06, 08 & 10				71.4	
	40/45's stack 11		62.5	62.5		
	48's stack 09				62.5	
	others		53.6	53.6	53.6	
17	stacks 11 & 12		62.5			
	others		53.6			
18	stacks 11 & 12		62.5	62.5		
	others		53.6	53.6		
19	40/45's stacks 11 & 12		62.5	62.5		
	48/53's stacks 09 & 10				62.5	62.5
	others	40.2	53.6	53.6	53.6	53.6
20		40.2				

Title:	**Revision Number:**	**Effective Date:**	**Appendix Number:**
Deck Strength and Maximum Stack Weights	Rev. 0	12 December 2005	E-03-135-A9
	Prepared By:	**Approved By:**	**Page:**
	HEC		1 of 3



Note: The maximum stack weights shown are based on the strength limits of supporting hull structure. Stack weight may be further limited by the strength of the containers and the securing arrangement.

Possible stack weight increased for the outboard stacks are based on the Northern lights FE analysis.
(Ref 1 "Deck Structure Analysis of the Northern Lights, Rev 0, Jul 29th 2005; Ref 2 "Design Memo: Amendment to Northern Lights FE analysis, Rev 1, Dec 12th 2005)

Title: Deck Strength and Maximum Stack Weights	**Revision Number:** Rev. 0	**Effective Date:** 12 December 2005	**Appendix Number:** E-03-135-A9
	Prepared By: HEC	**Approved By:**	**Page:** 2 of 3

Appendix 1 **Excerpts from Cargo Securing Manual**

Sea Star Line, Inc., LLC **Cargo Securing Manual**

Title:	Revision Number:	Effective Date:	Procedure Number:
Stowage and Securing of Containers	Rev. 0	12 December 05	E-03-535
	Prepared By:	Approved By:	Page:
	HEC		2 of 8

5.2 Maximum Stack Weight

Stack weight is limited by the design of the supporting hull structure. The Main Deck structure and stanchions are designed to safely support the maximum stack weights shown in Appendix 9. These maximum stack weights are upper limits and shall not be exceeded.

5.3 Deck Stowage and Securing

On deck securing arrangements, strength limitations and instructions are provided in Appendix 11.

Container stacks shall not exceed the strength limitations of the lashing components, the Main Deck support structure, or the containers.

5.3.1 Handling and Safety Instructions

The following procedures and directions shall be adhered to:

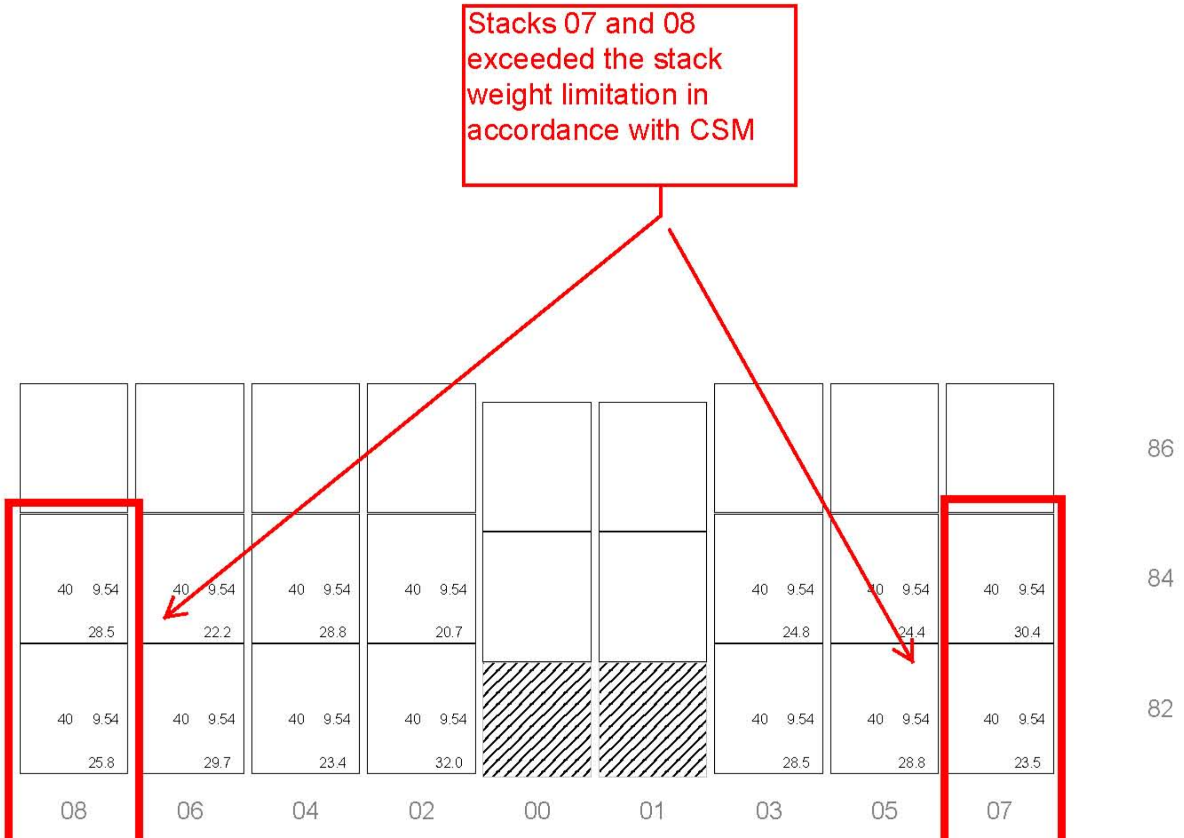
Handling of Securing Devices (DO's)

1. DO install lashings in accordance with the instructions and drawings.
2. DO check the condition of the equipment prior to installation.
3. DO remove any defective equipment from service.
4. DO install the same lashing arrangement on both sides of the stack.
5. DO use the hook and link extension fitting for upper rod lashings and the link on the lower rod lashing to extend the lash for hi-cube containers.
6. DO lock the tensioner tightly with the lock nuts.
7. DO check and tighten lashings at least daily during the voyage and make a deck logbook entry.
8. DO lubricate tensioners when dry or difficult to operate.
9. DO stow loose gear in the bins and racks provided.
10. DO remember that safety is the paramount concern of all personnel involved in the rod lashing operation.

Handling of Securing Devices (DONT's)

1. DO NOT substitute other equipment unless specifically approved by Sea Star Line's Fleet Operations Department.

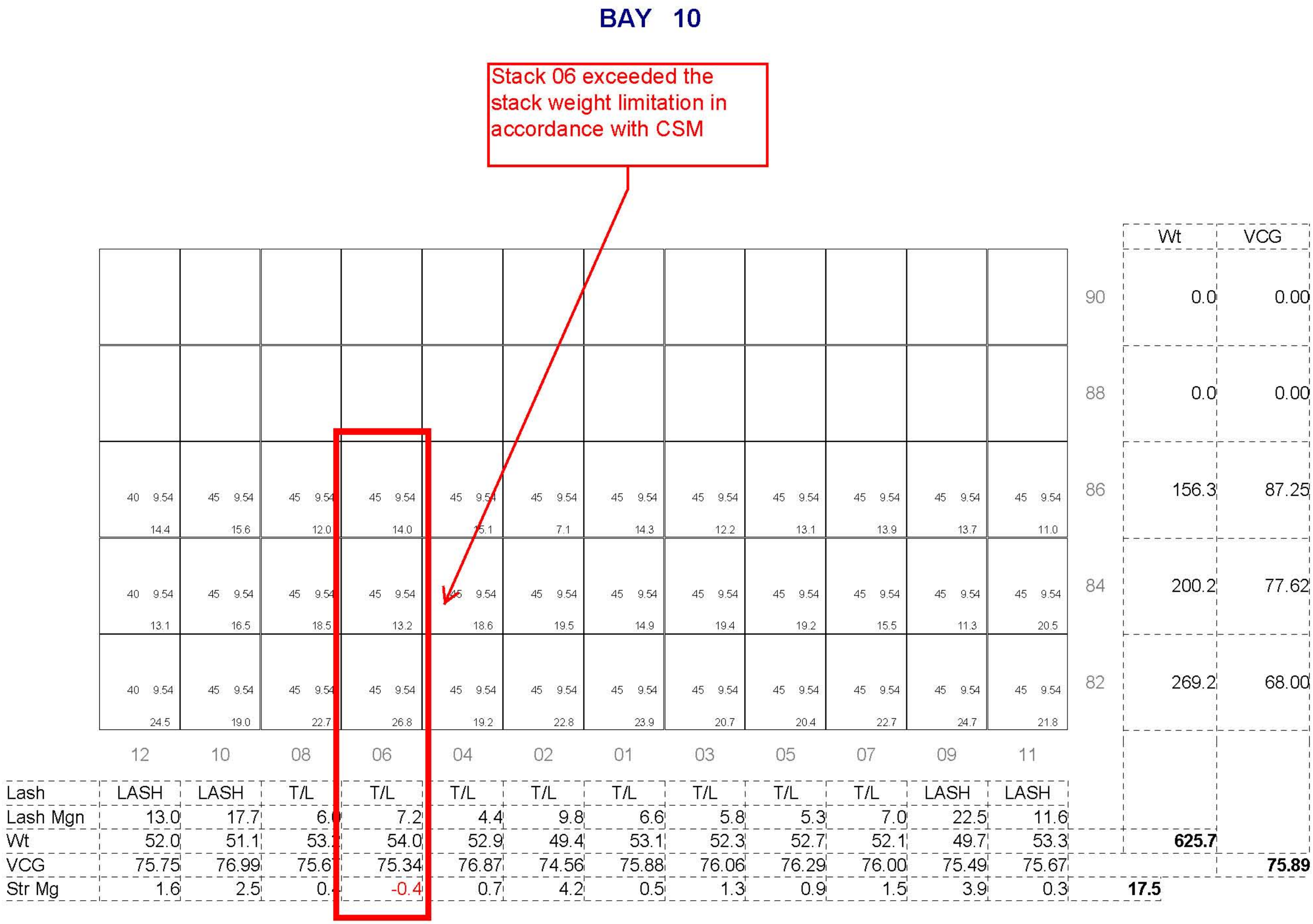
BAY 03A



Stacks 07 and 08 exceeded the stack weight limitation in accordance with CSM

	Wt	VCG
86	0.0	0.00
84	179.8	83.00
82	191.6	73.38

	08	06	04	02	00	01	03	05	07		Wt	VCG
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	LASH	LASH			
Lash Mgn	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
Wt	54.3	51.8	52.2	52.7	0.0	0.0	53.3	53.2	54.0		**371.4**	
VCG	78.43	77.50	78.69	77.16	0.00	0.00	77.86	77.79	78.81			**78.04**
Str Mg	-0.7	1.8	1.4	0.9	33.6	37.4	0.3	0.4	-0.4	**74.8**		



BAY 10

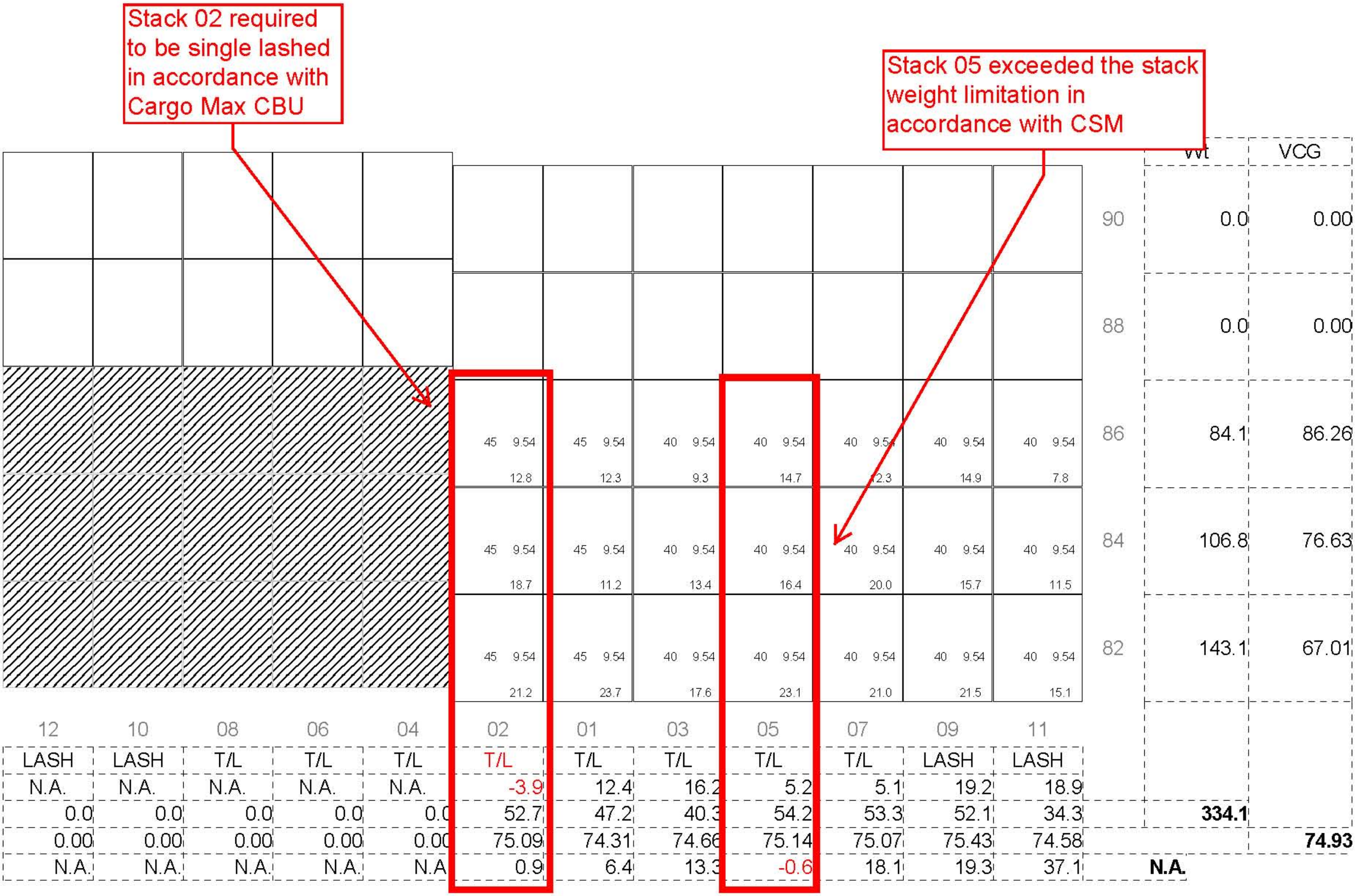
Stack 06 exceeded the stack weight limitation in accordance with CSM

													Wt	VCG
90													0.0	0.00
88													0.0	0.00
86	40 9.54 14.4	45 9.54 15.6	45 9.54 12.0	45 9.54 14.0	45 9.54 15.1	45 9.54 7.1	45 9.54 14.3	45 9.54 12.2	45 9.54 13.1	45 9.54 13.9	45 9.54 13.7	45 9.54 11.0	156.3	87.25
84	40 9.54 13.1	45 9.54 16.5	45 9.54 18.5	45 9.54 13.2	45 9.54 18.6	45 9.54 19.5	45 9.54 14.9	45 9.54 19.4	45 9.54 19.2	45 9.54 15.5	45 9.54 11.3	45 9.54 20.5	200.2	77.62
82	40 9.54 24.5	45 9.54 19.0	45 9.54 22.7	45 9.54 26.8	45 9.54 19.2	45 9.54 22.8	45 9.54 23.9	45 9.54 20.7	45 9.54 20.4	45 9.54 22.7	45 9.54 24.7	45 9.54 21.8	269.2	68.00
	12	10	08	06	04	02	01	03	05	07	09	11		
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH		
Lash Mgn	13.0	17.7	6.0	7.2	4.4	9.8	6.6	5.8	5.3	7.0	22.5	11.6		
Wt	52.0	51.1	53.	54.0	52.9	49.4	53.1	52.3	52.7	52.1	49.7	53.3	**625.7**	
VCG	75.75	76.99	75.6	75.34	76.87	74.56	75.88	76.06	76.29	76.00	75.49	75.67		**75.89**
Str Mg	1.6	2.5	0.	-0.4	0.7	4.2	0.5	1.3	0.9	1.5	3.9	0.3	**17.5**	

SS El Faro
Sea Star Line (by: ew)

CargoMax V1.21
09-May-16 at 11:47

BAY 12A

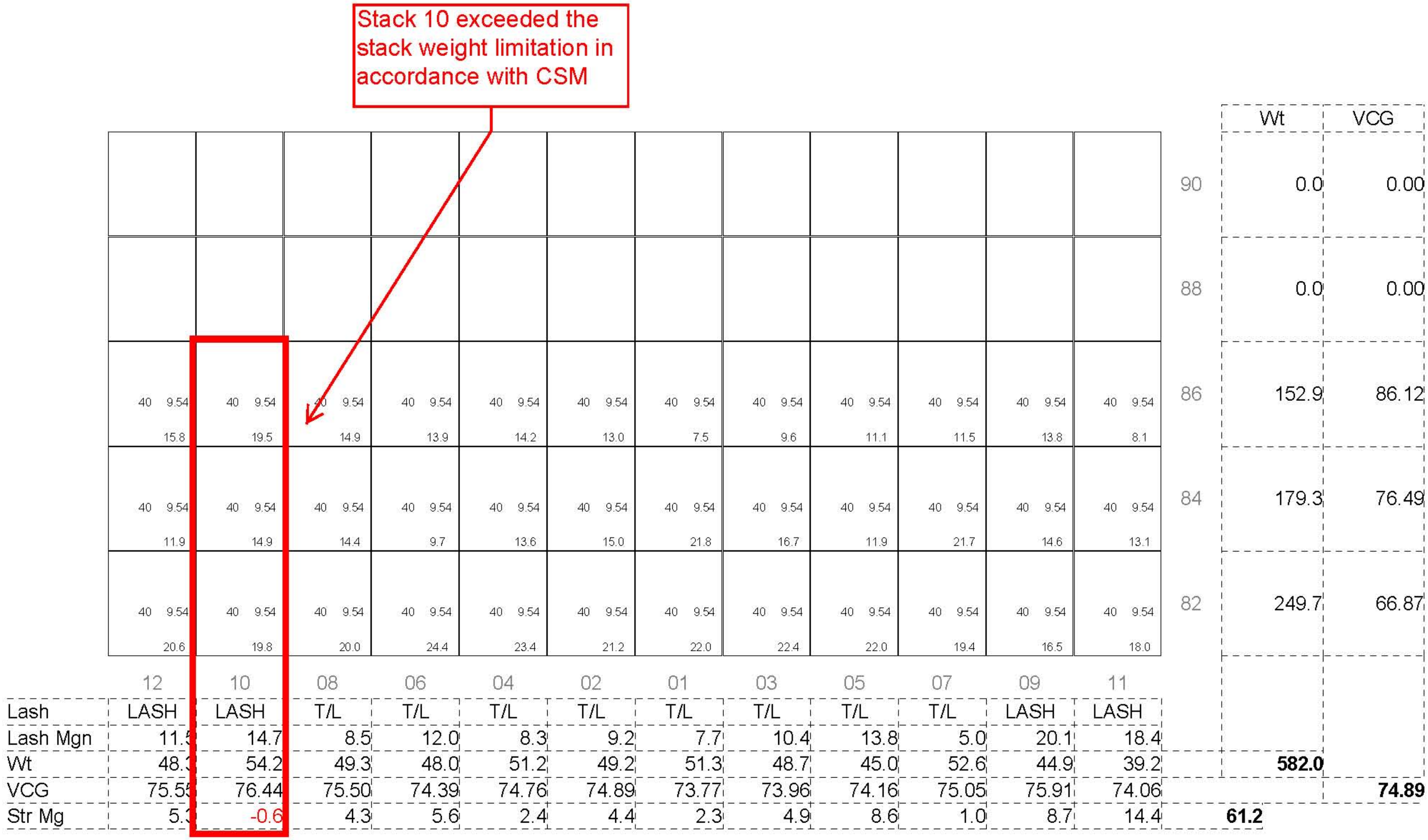


Stack 02 required to be single lashed in accordance with Cargo Max CBU

Stack 05 exceeded the stack weight limitation in accordance with CSM

														Wt	VCG
													90	0.0	0.00
													88	0.0	0.00
	▨	▨	▨	▨	▨	45 9.54 12.8	45 9.54 12.3	40 9.54 9.3	40 9.54 14.7	40 9.54 12.3	40 9.54 14.9	40 9.54 7.8	86	84.1	86.26
	▨	▨	▨	▨	▨	45 9.54 18.7	45 9.54 11.2	40 9.54 13.4	40 9.54 16.4	40 9.54 20.0	40 9.54 15.7	40 9.54 11.5	84	106.8	76.63
	▨	▨	▨	▨	▨	45 9.54 21.2	45 9.54 23.7	40 9.54 17.6	40 9.54 23.1	40 9.54 21.0	40 9.54 21.5	40 9.54 15.1	82	143.1	67.01
	12	10	08	06	04	02	01	03	05	07	09	11			
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH			
Lash Mgn	N.A.	N.A.	N.A.	N.A.	N.A.	-3.9	12.4	16.2	5.2	5.1	19.2	18.9			
Wt	0.0	0.0	0.0	0.0	0.0	52.7	47.2	40.3	54.2	53.3	52.1	34.3		**334.1**	
VCG	0.00	0.00	0.00	0.00	0.00	75.09	74.31	74.66	75.14	75.07	75.43	74.58			**74.93**
Str Mg	N.A.	N.A.	N.A.	N.A.	N.A	0.9	6.4	13.3	-0.6	18.1	19.3	37.1	**N.A.**		

BAY 13

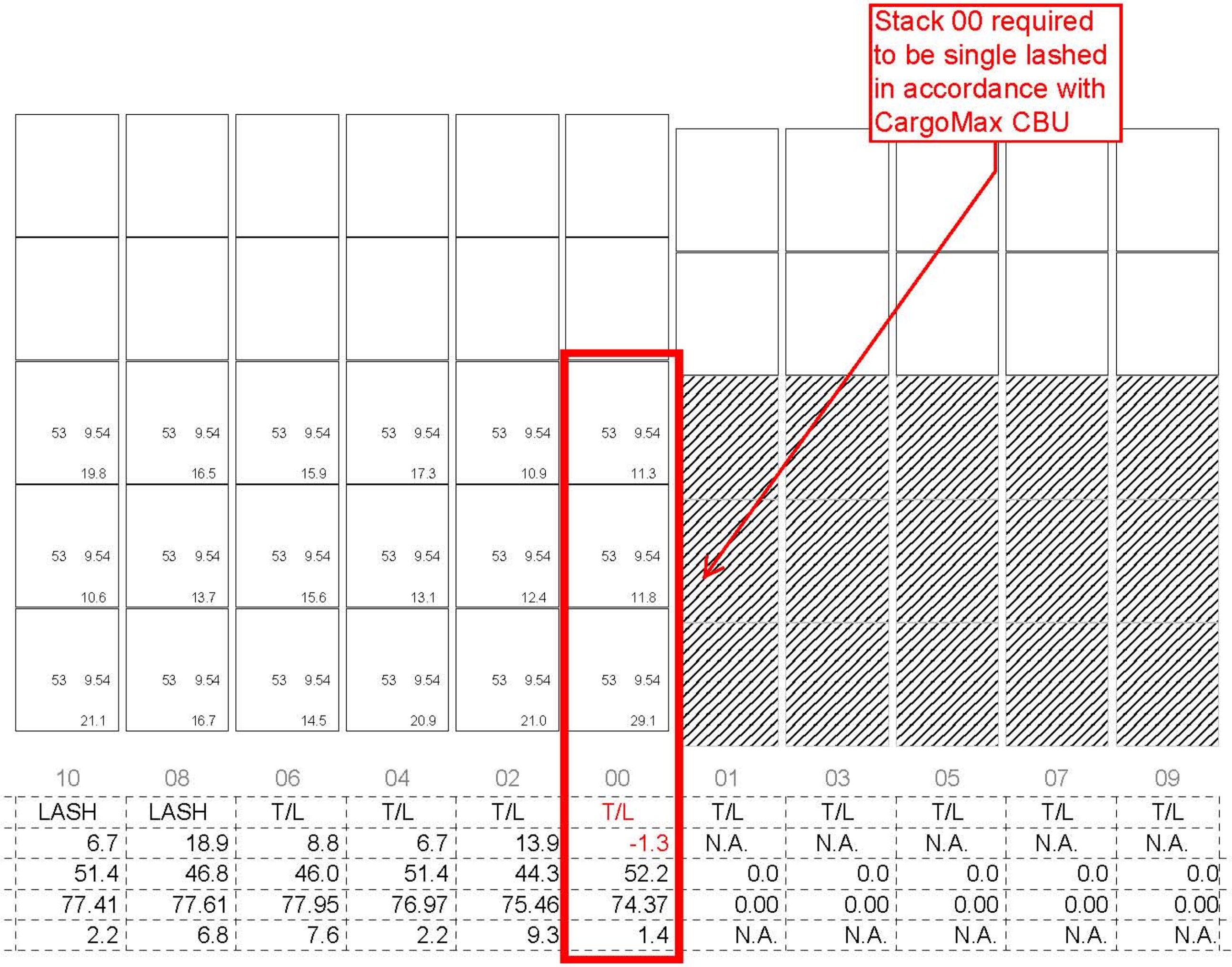


Stack 10 exceeded the stack weight limitation in accordance with CSM

12	10	08	06	04	02	01	03	05	07	09	11		Wt	VCG
												90	0.0	0.00
												88	0.0	0.00
40 9.54 15.8	40 9.54 19.5	40 9.54 14.9	40 9.54 13.9	40 9.54 14.2	40 9.54 13.0	40 9.54 7.5	40 9.54 9.6	40 9.54 11.1	40 9.54 11.5	40 9.54 13.8	40 9.54 8.1	86	152.9	86.12
40 9.54 11.9	40 9.54 14.9	40 9.54 14.4	40 9.54 9.7	40 9.54 13.6	40 9.54 15.0	40 9.54 21.8	40 9.54 16.7	40 9.54 11.9	40 9.54 21.7	40 9.54 14.6	40 9.54 13.1	84	179.3	76.49
40 9.54 20.6	40 9.54 19.8	40 9.54 20.0	40 9.54 24.4	40 9.54 23.4	40 9.54 21.2	40 9.54 22.0	40 9.54 22.4	40 9.54 22.0	40 9.54 19.4	40 9.54 16.5	40 9.54 18.0	82	249.7	66.87

	12	10	08	06	04	02	01	03	05	07	09	11			
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH			
Lash Mgn	11.5	14.7	8.5	12.0	8.3	9.2	7.7	10.4	13.8	5.0	20.1	18.4			
Wt	48.3	54.2	49.3	48.0	51.2	49.2	51.3	48.7	45.0	52.6	44.9	39.2		**582.0**	
VCG	75.55	76.44	75.50	74.39	74.76	74.89	73.77	73.96	74.16	75.05	75.91	74.06			**74.89**
Str Mg	5.3	-0.6	4.3	5.6	2.4	4.4	2.3	4.9	8.6	1.0	8.7	14.4	**61.2**		

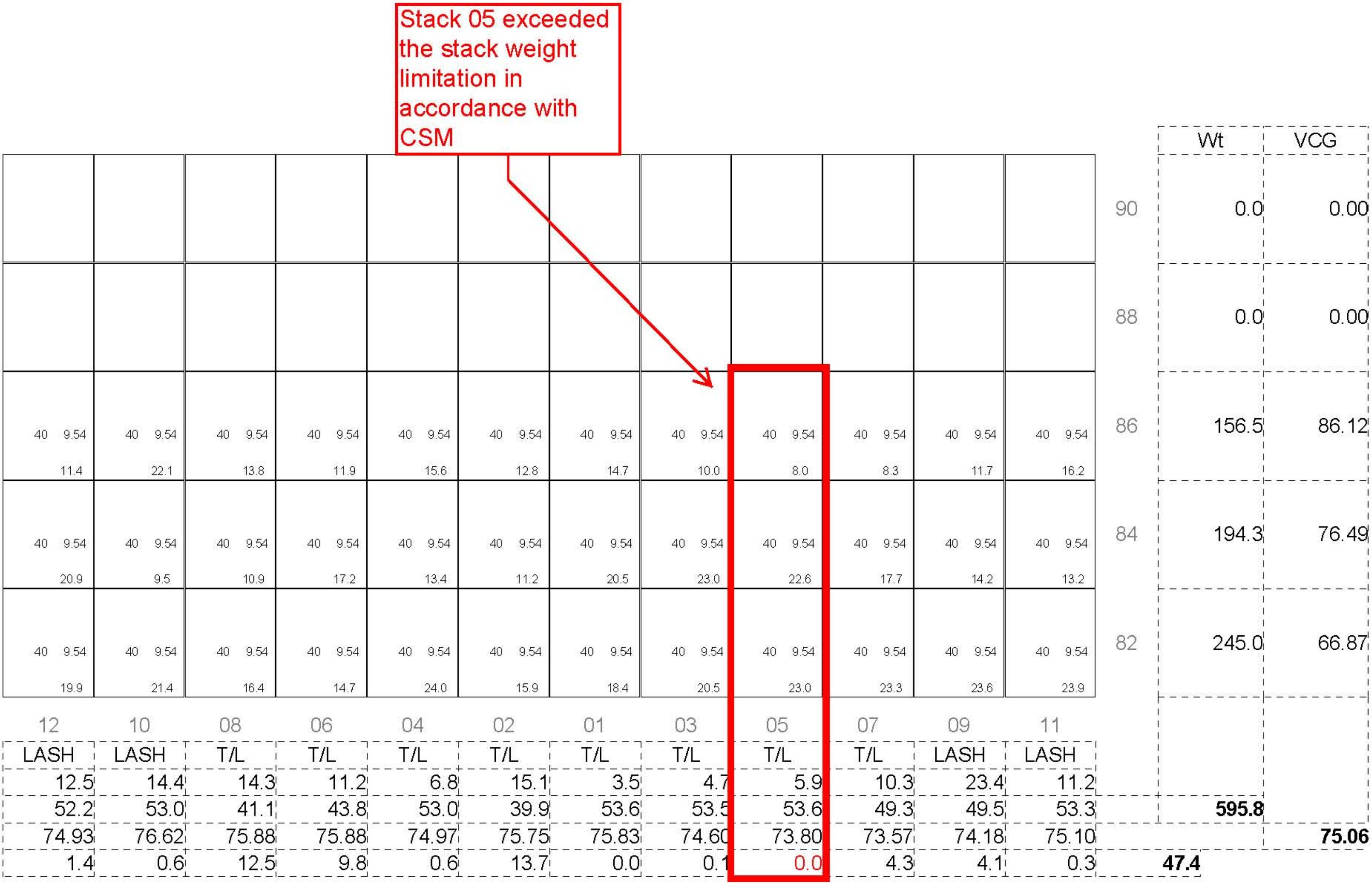
BAY   14B



Stack 00 required to be single lashed in accordance with CargoMax CBU

	10	08	06	04	02	00	01	03	05	07	09		Wt	VCG
90													0.0	0.00
88													0.0	0.00
86	53 9.54 19.8	53 9.54 16.5	53 9.54 15.9	53 9.54 17.3	53 9.54 10.9	53 9.54 11.3	▨	▨	▨	▨	▨		91.6	87.28
84	53 9.54 10.6	53 9.54 13.7	53 9.54 15.6	53 9.54 13.1	53 9.54 12.4	53 9.54 11.8	▨	▨	▨	▨	▨		77.2	77.65
82	53 9.54 21.1	53 9.54 16.7	53 9.54 14.5	53 9.54 20.9	53 9.54 21.0	53 9.54 29.1	▨	▨	▨	▨	▨		123.3	68.03
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L			
Lash Mgn	6.7	18.9	8.8	6.7	13.9	-1.3	N.A.	N.A.	N.A.	N.A.	N.A.			
Wt	51.4	46.8	46.0	51.4	44.3	52.2	0.0	0.0	0.0	0.0	0.0		**292.1**	
VCG	77.41	77.61	77.95	76.97	75.46	74.37	0.00	0.00	0.00	0.00	0.00			**76.61**
Str Mg	2.2	6.8	7.6	2.2	9.3	1.4	N.A.	N.A.	N.A.	N.A.	N.A.	**N.A.**		

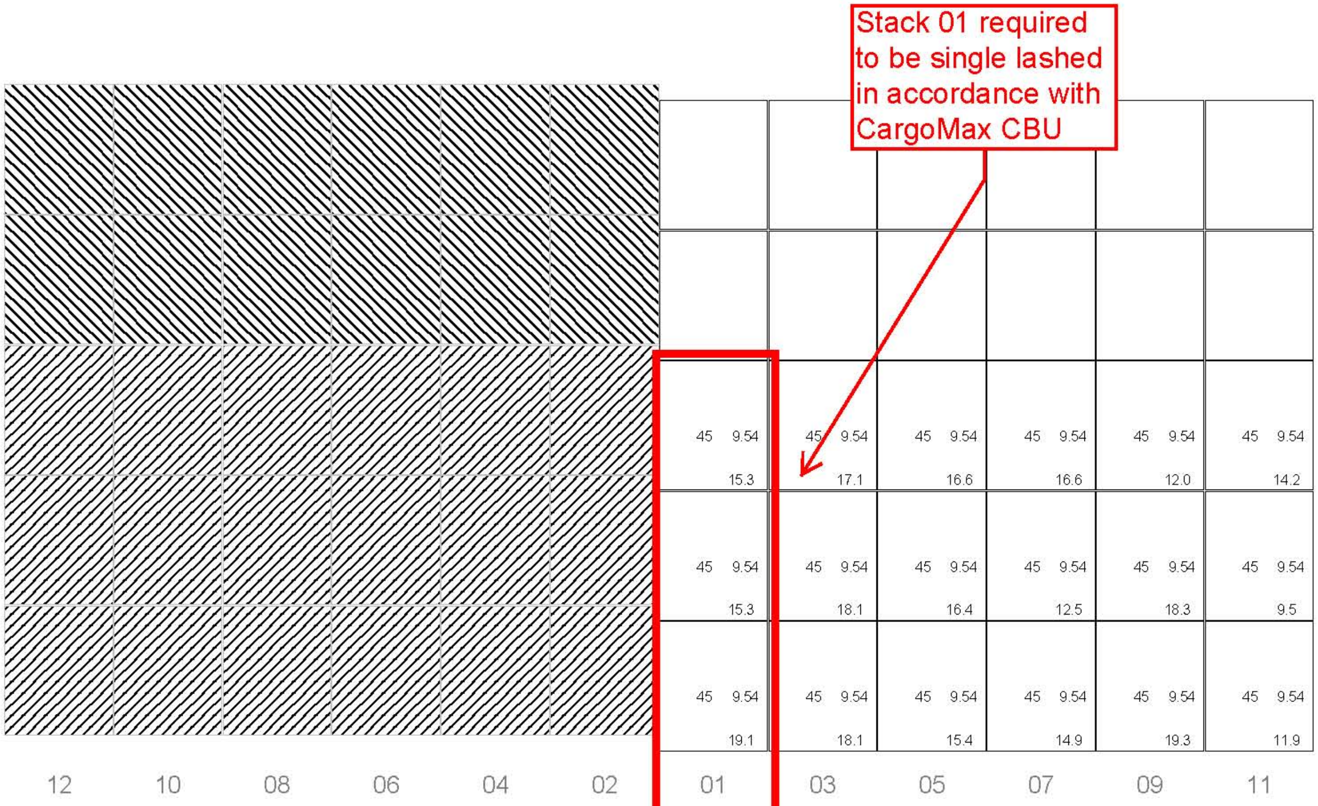
BAY 15



Stack 05 exceeded the stack weight limitation in accordance with CSM

	12	10	08	06	04	02	01	03	05	07	09	11		Wt	VCG
													90	0.0	0.00
													88	0.0	0.00
	40 9.54 11.4	40 9.54 22.1	40 9.54 13.8	40 9.54 11.9	40 9.54 15.6	40 9.54 12.8	40 9.54 14.7	40 9.54 10.0	40 9.54 8.0	40 9.54 8.3	40 9.54 11.7	40 9.54 16.2	86	156.5	86.12
	40 9.54 20.9	40 9.54 9.5	40 9.54 10.9	40 9.54 17.2	40 9.54 13.4	40 9.54 11.2	40 9.54 20.5	40 9.54 23.0	40 9.54 22.6	40 9.54 17.7	40 9.54 14.2	40 9.54 13.2	84	194.3	76.49
	40 9.54 19.9	40 9.54 21.4	40 9.54 16.4	40 9.54 14.7	40 9.54 24.0	40 9.54 15.9	40 9.54 18.4	40 9.54 20.5	40 9.54 23.0	40 9.54 23.3	40 9.54 23.6	40 9.54 23.9	82	245.0	66.87
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH			
Lash Mgn	12.5	14.4	14.3	11.2	6.8	15.1	3.5	4.7	5.9	10.3	23.4	11.2			
Wt	52.2	53.0	41.1	43.8	53.0	39.9	53.6	53.5	53.6	49.3	49.5	53.3		**595.8**	
VCG	74.93	76.62	75.88	75.88	74.97	75.75	75.83	74.60	73.80	73.57	74.18	75.10			**75.06**
Str Mg	1.4	0.6	12.5	9.8	0.6	13.7	0.0	0.1	0.0	4.3	4.1	0.3	**47.4**		

BAY 16A

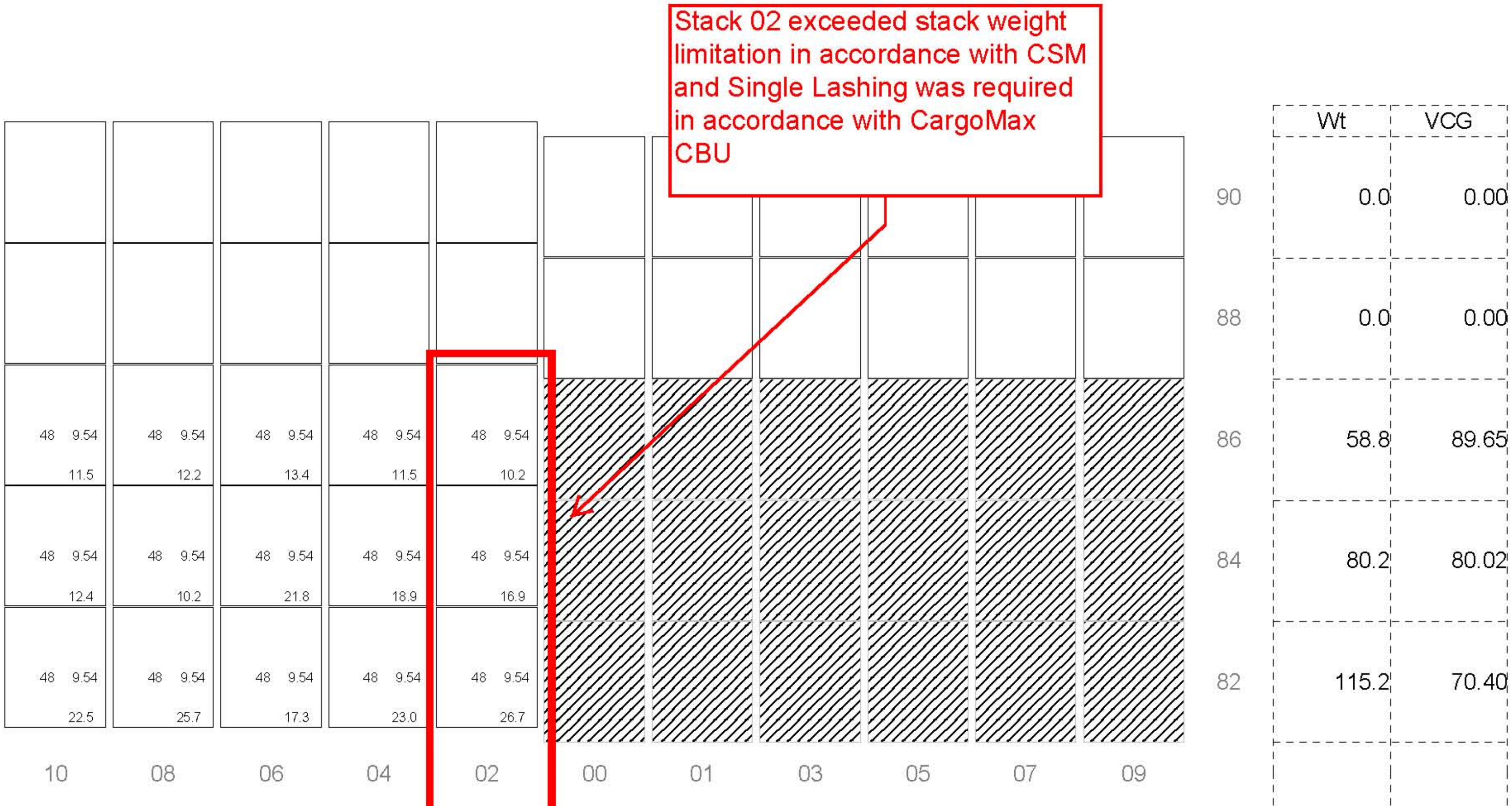


Stack 01 required to be single lashed in accordance with CargoMax CBU

	12	10	08	06	04	02	01	03	05	07	09	11	Wt	VCG
90													0.0	0.00
88													0.0	0.00
86							45 9.54 15.3	45 9.54 17.1	45 9.54 16.6	45 9.54 16.6	45 9.54 12.0	45 9.54 14.2	91.8	88.49
84							45 9.54 15.3	45 9.54 18.1	45 9.54 16.4	45 9.54 12.5	45 9.54 18.3	45 9.54 9.5	90.1	78.86
82							45 9.54 19.1	45 9.54 18.1	45 9.54 15.4	45 9.54 14.9	45 9.54 19.3	45 9.54 11.9	98.7	69.24

	12	10	08	06	04	02	01	03	05	07	09	11	Wt	VCG
Lash	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH		
Lash Mgn	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-2.3	3.3	6.8	10.4	20.6	11.5		
Wt	0.0	0.0	0.0	0.0	0.0	0.0	49.7	53.3	48.4	44.0	49.6	35.6	**280.6**	
VCG	0.00	0.00	0.00	0.00	0.00	0.00	78.13	78.68	79.10	79.24	77.45	79.49		**78.63**
Str Mg	N.A.	N.A.	N.A.	N.A.	N.A.	N.A	3.9	0.3	5.2	9.6	4.0	26.9	**N.A.**	

BAY 16B



Stack 02 exceeded stack weight limitation in accordance with CSM and Single Lashing was required in accordance with CargoMax CBU

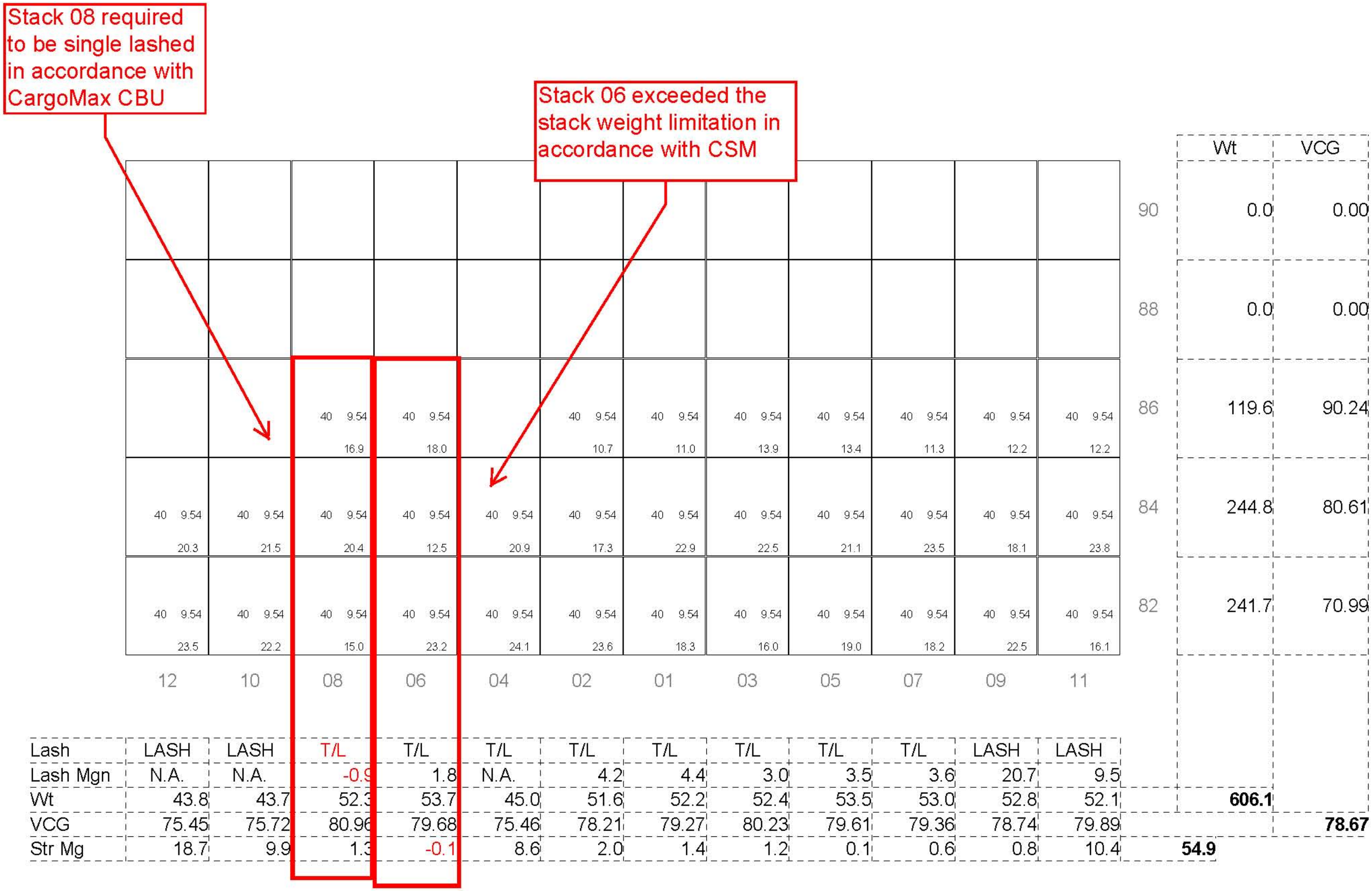
	10	08	06	04	02	00	01	03	05	07	09	Wt	VCG
90												0.0	0.00
88												0.0	0.00
86	48 9.54 11.5	48 9.54 12.2	48 9.54 13.4	48 9.54 11.5	48 9.54 10.2	▨	▨	▨	▨	▨	▨	58.8	89.65
84	48 9.54 12.4	48 9.54 10.2	48 9.54 21.8	48 9.54 18.9	48 9.54 16.9	▨	▨	▨	▨	▨	▨	80.2	80.02
82	48 9.54 22.5	48 9.54 25.7	48 9.54 17.3	48 9.54 23.0	48 9.54 26.7	▨	▨	▨	▨	▨	▨	115.2	70.40

	10	08	06	04	02	00	01	03	05	07	09		Wt	VCG
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L			
Lash Mgn	5.1	15.4	3.4	5.7	-3.2	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
Wt	46.4	48.1	52.5	53.4	53.8	0.0	0.0	0.0	0.0	0.0	0.0		**254.2**	
VCG	77.74	77.32	79.31	77.95	77.07	0.00	0.00	0.00	0.00	0.00	0.00			**77.89**
Str Mg	25.0	23.3	18.9	0.2	-0.2	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	**N.A.**		

SS El Faro
Sea Star Line (by: ew)

CargoMax V1.21
09-May-16 at 11:47

BAY 17

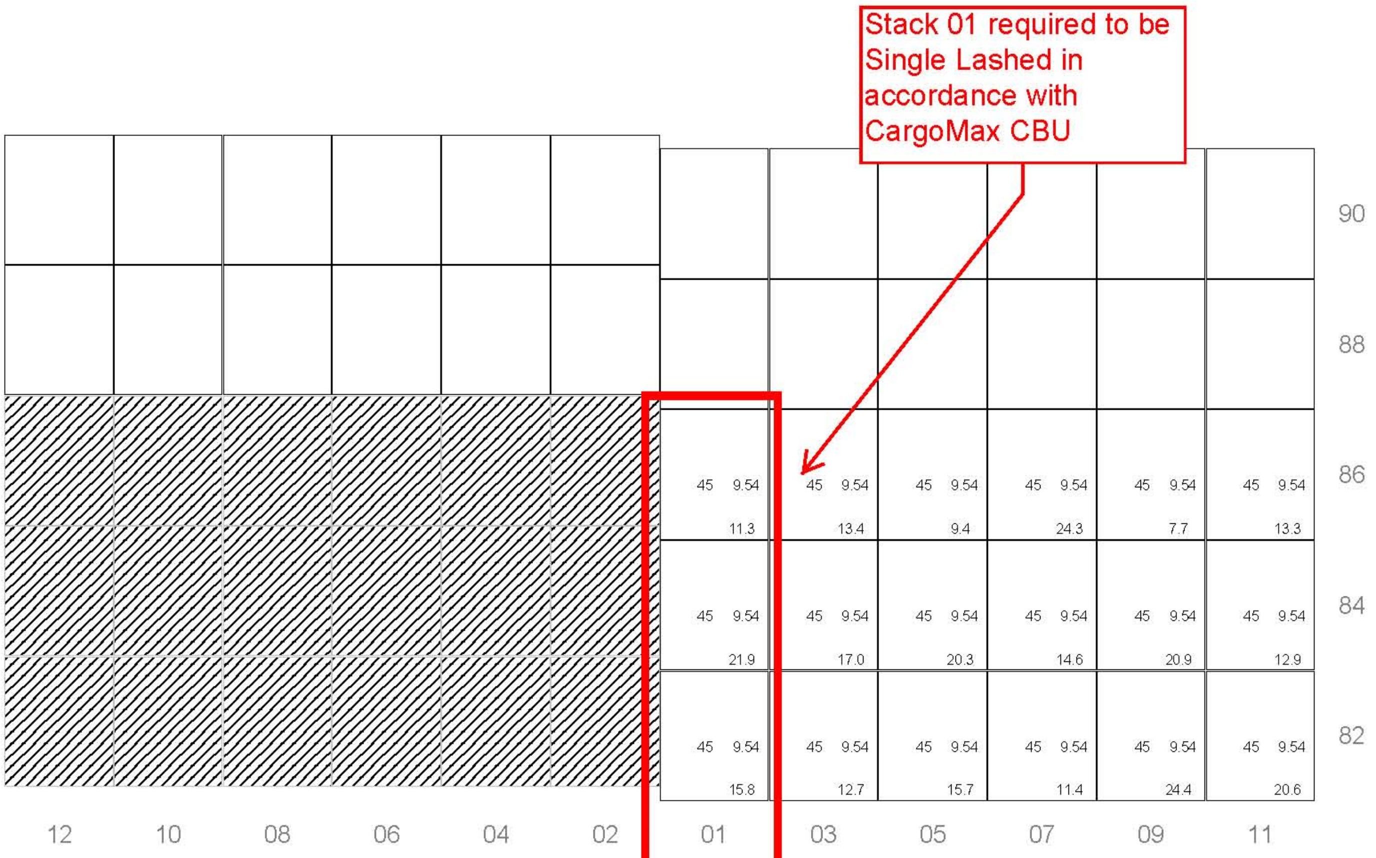


Stack 08 required to be single lashed in accordance with CargoMax CBU

Stack 06 exceeded the stack weight limitation in accordance with CSM

														Wt	VCG
													90	0.0	0.00
													88	0.0	0.00
			40 9.54 16.9	40 9.54 18.0		40 9.54 10.7	40 9.54 11.0	40 9.54 13.9	40 9.54 13.4	40 9.54 11.3	40 9.54 12.2	40 9.54 12.2	86	119.6	90.24
	40 9.54 20.3	40 9.54 21.5	40 9.54 20.4	40 9.54 12.5	40 9.54 20.9	40 9.54 17.3	40 9.54 22.9	40 9.54 22.5	40 9.54 21.1	40 9.54 23.5	40 9.54 18.1	40 9.54 23.8	84	244.8	80.61
	40 9.54 23.5	40 9.54 22.2	40 9.54 15.0	40 9.54 23.2	40 9.54 24.1	40 9.54 23.6	40 9.54 18.3	40 9.54 16.0	40 9.54 19.0	40 9.54 18.2	40 9.54 22.5	40 9.54 16.1	82	241.7	70.99
	12	10	08	06	04	02	01	03	05	07	09	11			
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH			
Lash Mgn	N.A.	N.A.	-0.9	1.8	N.A.	4.2	4.4	3.0	3.5	3.6	20.7	9.5			
Wt	43.8	43.7	52.3	53.7	45.0	51.6	52.2	52.4	53.5	53.0	52.8	52.1		**606.1**	
VCG	75.45	75.72	80.96	79.68	75.46	78.21	79.27	80.23	79.61	79.36	78.74	79.89			**78.67**
Str Mg	18.7	9.9	1.3	-0.1	8.6	2.0	1.4	1.2	0.1	0.6	0.8	10.4	**54.9**		

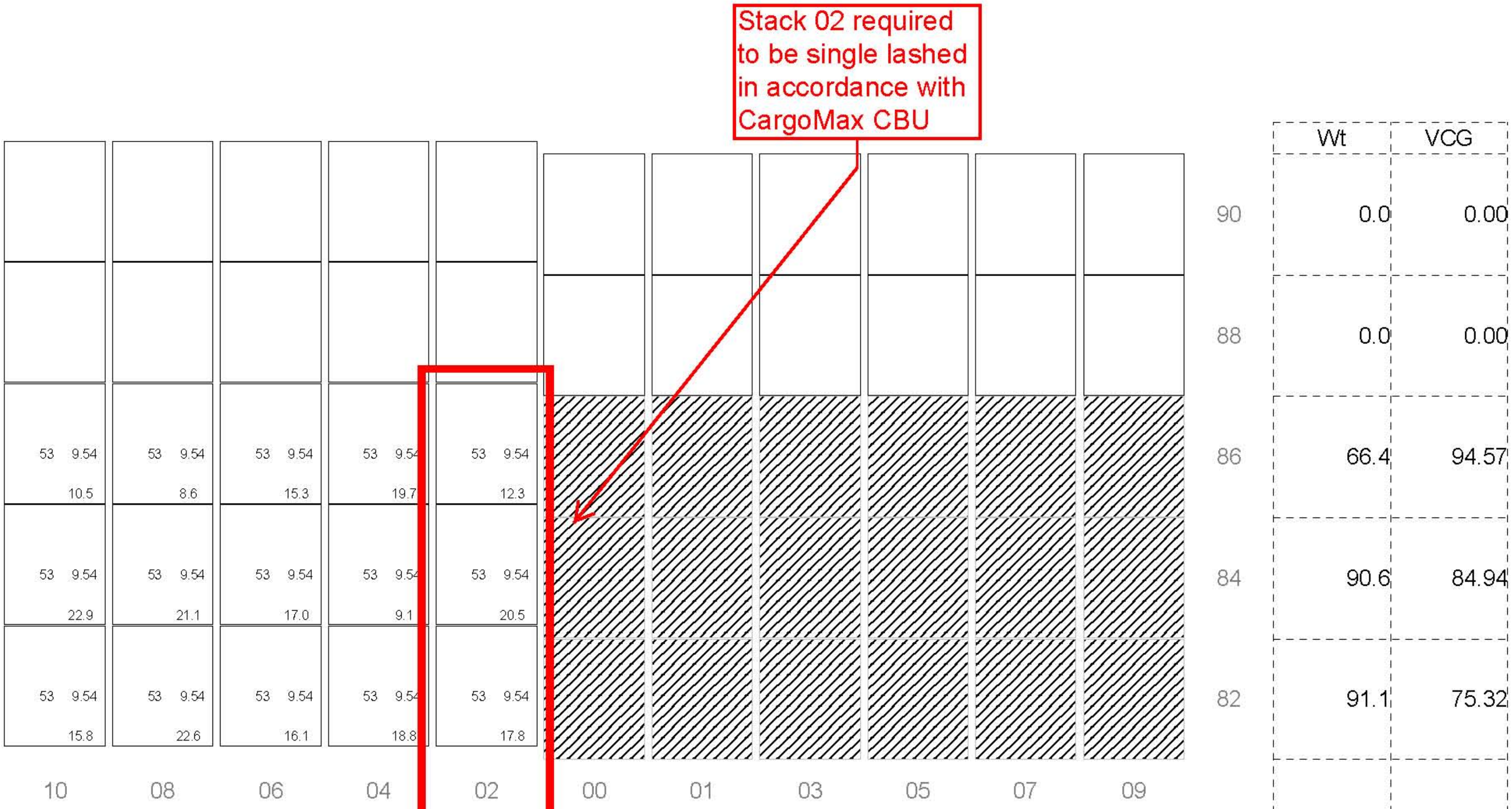
BAY 19A


Stack 01 required to be Single Lashed in accordance with CargoMax CBU

	Wt	VCG
90	0.0	0.00
88	0.0	0.00
86	79.3	93.53
84	107.6	83.90
82	100.6	74.28

	12	10	08	06	04	02	01	03	05	07	09	11		
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH		
Lash Mgn	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-3.6	10.1	9.5	0.9	22.2	11.8		
Wt	0.0	0.0	0.0	0.0	0.0	0.0	49.0	43.1	45.4	50.3	52.9	46.8	287.5	
VCG	0.00	0.00	0.00	0.00	0.00	0.00	83.02	84.06	82.57	86.37	80.86	82.40		83.19
Str Mg	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	4.6	10.5	8.2	3.3	0.7	15.7	N.A.	

BAY 19B



Stack 02 required to be single lashed in accordance with CargoMax CBU

												Wt	VCG
											90	0.0	0.00
											88	0.0	0.00
53 9.54 10.5	53 9.54 8.6	53 9.54 15.3	53 9.54 19.7	53 9.54 12.3	▨	▨	▨	▨	▨	▨	86	66.4	94.57
53 9.54 22.9	53 9.54 21.1	53 9.54 17.0	53 9.54 9.1	53 9.54 20.5	▨	▨	▨	▨	▨	▨	84	90.6	84.94
53 9.54 15.8	53 9.54 22.6	53 9.54 16.1	53 9.54 18.8	53 9.54 17.8	▨	▨	▨	▨	▨	▨	82	91.1	75.32
10	08	06	04	02	00	01	03	05	07	09			

Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH			
Lash Mgn	9.9	24.0	6.5	7.9	-6.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
Wt	49.2	52.3	48.4	47.6	50.6	0.0	0.0	0.0	0.0	0.0	0.0		**248.1**	
VCG	83.91	82.37	84.78	85.13	83.90	0.00	0.00	0.00	0.00	0.00	0.00			**83.99**
Str Mg	13.3	1.3	5.2	6.0	3.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	**N.A.**		

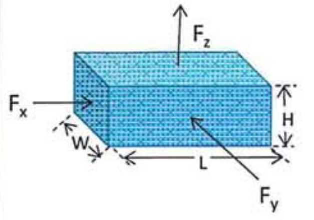
ANNEX 13 CALCULATION WORKSHEET

Surveyor: **EFW**

Caution	Before making Annex 13 calculations, mass must be in tonnes (t), forces in kilonewtons (kN), and dimensions in metric units

SHIP DATA	Ship **EF Hold 2A on but 2 chains**	Voyage No. **185**	Port **JAX**		
	Speed **24.0** knots	Length **223.7**	Beam **28.0**	GM **1.31**	B/GM **21.40**

CARGO DATA	Mass **18.50** t	Location 0. **9** L	☐ On Deck Low	☐ On Deck High	☒ Tween Deck	☐ Lower Hold



DIM.		WIND	On Deck		SEA	On Deck	Accl Corr (f)
L = **12.19**	Fx	*W x H x 1kN/m* **2.43** x **0.00** = **0.00** kN		Fx	*W x 2 x 1kN/m* **2.43** x **0.00** = **0.00** kN		F1 **0.554**
W = **2.43**							F2 **0.241**
H = **3.81**	Fy	*L x H x 1kN/m* **12.19** x **0.00** = **0.00** kN		Fy	*L x 2 x 1kN/m* **12.19** x **0.00** = **0.00** kN		f **0.795**

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
Vertical Az	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Table 3: LENGTH/SPEED Corr. Alternate Method (apply to Table 2 above only)

This correction is required only if the acceleration table in the approved Cargo Securing Manual is NOT based on the length/speed of the ship. If it is, the correction factor (f) is one. If not, use nomogram or formula, f = F1 + F2

$$F1 = \frac{0.345 \times V}{\sqrt{L}} \qquad F2 = \frac{(58.62 \times L) - 1034.483}{L^2}$$

Table 4: Correction Factors for BEAM/GM ratio

B/GM	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13 or above
On Deck High	1.56	1.48	1.40	1.33	1.27	1.23	1.19	1.15	1.11	1.08	1.05	1.03	1.00
On Deck Low	1.42	1.36	1.30	1.26	1.21	1.18	1.14	1.12	1.09	1.07	1.04	1.02	1.00
Tween Deck	1.26	1.23	1.19	1.17	1.14	1.12	1.09	1.08	1.06	1.05	1.03	1.02	1.00
Lowe Hold	1.15	1.14	1.12	1.11	1.09	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.00

CALCULATION OF EXTERNAL FORCES

Direction		Mass t	Tab.2 acc'l	f Corr.	B/GM Corr.	Wind	Sea	Total Force
Longitudinal	Fx	**18.50**	**2.0**	**0.80**	☒	**0.00**	**0.00**	**29** kN
Transverse	Fy	**18.50**	**6.2**	**0.80**	**1.00**	**0.00**	**0.00**	**91** kN
Vertical	Fz	**18.50**	**9.2**	**0.80**	☒	☒	☒	**135** kN

Appendix 3 **Annex 13 calculations**

Table 1 - MSL from breaking strength		Sketch
Material	**MSL (SWL)**	
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of BS	This calculation was done for Container on Chassis with a weight of 81,560 lb in worse position of Hold 2A. This is for ROLOC attached to button and with 2 chains attached at the rear of the trailer(max 45 degrees). Note: Calculation was done for half the weight using assumption that half weight was over ROLOC and half over rear of container. This is satisfactory.
Fiber rope	33% of BS	
Web lashing	50% of BS	
Wire rope (single use)	80% of BS	
Wire rope (re-usable)	30% of BS	
Steel band (single use)	70% of BS	
Chains	50% of BS	
Timber	0.3 kN per cm^2 normal	

SECURING MATERIALS

Item	BS kg	MSL kN	CS kN
Securing Assembly 1	**(Transverse)**		
Chain 1/2"	14606	72	**27**
Tensioner	14968	41	
Securing Assembly 2			
ROLOC	54431	533	**355**
Securing Assembly 3	**(Longitudinal)**		
			0
For EACH lashing assembly: CS = Least MSL / 1.5			

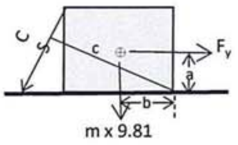
SECURING ARRANGEMENTS (TRANSVERSE)

Side	Lashing	CS	α°	f	CS x f
Port	Chain 1	27	45	0.99	26.73
Starboard	Chain 1	27	45	0.99	26.73
Coefficient of friction (μ) =				**0.4**	

Table 6 - f values as a function of α and μ

μ	0°	10°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	80°	90°
0.4	1.00	1.05	1.08	1.08	1.07	1.05	1.02	0.99	0.95	0.90	0.85	0.79	0.72	0.57	0.40
0.3	1.00	1.04	1.04	1.03	1.02	0.99	0.96	0.92	0.87	0.82	0.76	0.69	0.62	0.47	0.30
0.2	1.00	1.02	1.01	0.99	0.97	0.93	0.89	0.85	0.80	0.74	0.67	0.60	0.53	0.37	0.20
0.1	1.00	1.00	0.97	0.95	0.92	0.88	0.83	0.78	0.72	0.66	0.59	0.51	0.44	0.27	0.10
0.0	1.00	0.98	0.94	0.91	0.87	0.82	0.77	0.71	0.64	0.57	0.50	0.42	0.34	0.17	0.00

BALANCE OF FORCES AND MOMENTS

Transverse Sliding (PORT)	$F_y \le (\mu\ x\ m\ x\ 9.81) + (CS_1\ x\ f_1 + CS_2\ x\ f_2 ...$ 72.594 + 27 + 0 **91 < 99**		**OK**
Transverse Sliding (STBD)	$F_y \le (\mu\ x\ m\ x\ 9.81) + (CS_1\ x\ f_1 + CS_2\ x\ f_2 ...$ 72.594 + 27 + 0 **91 < 99**		**OK**
Longitudinal Sliding	$F_x \le \mu\ (m\ x\ 9.81 - F_z) + 0.5\ (CS_1\ x\ f_1 + CS_2\ x\ f_2 ...)$ 18.47 + 0 + 248 **29 < 266**		**OK**
Transverse Tipping	$F_y\ x\ a \le (m\ x\ 9.81\ x\ b) + CS_1\ x\ c_1 + CS_2\ x\ c_2 ...$ **174 < 286**	 a **1.91** b **1.22** c **2.43**	**OK**

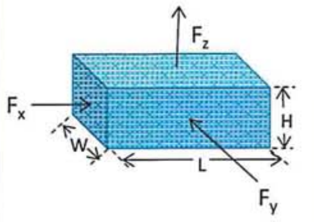
ANNEX 13 CALCULATION WORKSHEET

Surveyor: **EFW**

Caution Before making Annex 13 calculations, mass must be in tonnes (t), forces in kilonewtons (kN), and dimensions in metric units

SHIP DATA	Ship **EF Hold 2B on but 2 chains**	Voyage No. **185**	Port **JAX**		
	Speed **24.0** knots	Length **223.7**	Beam **28.0**	GM **1.31**	B/GM **21.40**

CARGO DATA	Mass **18.50** t	Location 0. **7** L	☐ On Deck Low	☐ On Deck High	☒ Tween Deck	☐ Lower Hold



DIM.	WIND		On Deck	SEA		On Deck	Accl Corr (f)
L = **12.19**	Fx	W x H x 1kN/m **2.43** x **0.00** = **0.00** kN		Fx	W x 2 x 1kN/m **2.43** x **0.00** = **0.00** kN		F1 **0.554** F2 **0.241**
W = **2.43**							f **0.795**
H = **3.81**	Fy	L x H x 1kN/m **12.19** x **0.00** = **0.00** kN		Fy	L x 2 x 1kN/m **12.19** x **0.00** = **0.00** kN		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Table 3: LENGTH/SPEED Corr. Alternate Method (apply to Table 2 above only)

This correction is required only if the acceleration table in the approved Cargo Securing Manual is NOT based on the length/speed of the ship. If it is, the correction factor (f) is one. If not, use nomogram or formula, f = F1 + F2

$F1 = \frac{0.345 \times V}{\sqrt{L}}$ $F2 = \frac{(58.62 \times L) - 1034.483}{L^2}$

Table 4: Correction Factors for BEAM/GM ratio

B/GM	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13 or above
On Deck High	1.56	1.48	1.40	1.33	1.27	1.23	1.19	1.15	1.11	1.08	1.05	1.03	1.00
On Deck Low	1.42	1.36	1.30	1.26	1.21	1.18	1.14	1.12	1.09	1.07	1.04	1.02	1.00
Tween Deck	1.26	1.23	1.19	1.17	1.14	1.12	1.09	1.08	1.06	1.05	1.03	1.02	1.00
Lowe Hold	1.15	1.14	1.12	1.11	1.09	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.00

CALCULATION OF EXTERNAL FORCES

Direction		Mass t	Tab.2 acc'l	f Corr.	B/GM Corr.	Wind	Sea	Total Force	
Longitudinal	Fx	**18.50**	**2.0**	**0.80**		**0.00**	**0.00**	**29**	kN
Transverse	Fy	**18.50**	**5.6**	**0.80**	**1.00**	**0.00**	**0.00**	**82**	kN
Vertical	Fz	**18.50**	**6.2**	**0.80**				**91**	kN

Appendix 3 **Annex 13 calculations**

Table 1 - MSL from breaking strength		Sketch
Material	**MSL (SWL)**	This calculation was done for Container on Chassis with a weight of 81,560 lb in worse position of Hold 2B. This is for ROLOC attached to button and with 2 chains attached at the rear of the trailer. Note: Calculation was done for half the weight using assumption that half weight was over ROLOC and half over rear of container. This is satisfactory provided chains were 75 degrees or less from the horizontal and were within 30 degrees of the transverse direction.
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of BS	
Fiber rope	33% of BS	
Web lashing	50% of BS	
Wire rope (single use)	80% of BS	
Wire rope (re-usable)	30% of BS	
Steel band (single use)	70% of BS	
Chains	50% of BS	
Timber	0.3 kN per cm^2 normal	

SECURING MATERIALS

Item	BS kg	MSL kN	CS kN
Securing Assembly 1	**(Transverse)**		
Chain 1/2"	14606	72	**27**
Tensioner	14968	41	
Securing Assembly 2			
ROLOC	54431	533	**355**
Securing Assembly 3	**(Longitudinal)**		
			0
For EACH lashing assembly: CS = Least MSL / 1.5			

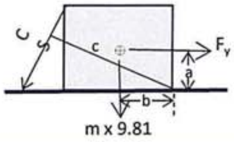
SECURING ARRANGEMENTS (TRANSVERSE)

Side	Lashing	CS	α°	f	CS x f
Port	Chain 1	27	75	0.65	17.42
Starboard	Chain 1	27	75	0.65	17.42
Coefficient of friction (μ) =				**0.4**	

Table 6 - f values as a function of α and μ

μ	0°	10°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	80°	90°
0.4	1.00	1.05	1.08	1.08	1.07	1.05	1.02	0.99	0.95	0.90	0.85	0.79	0.72	0.57	0.40
0.3	1.00	1.04	1.04	1.03	1.02	0.99	0.96	0.92	0.87	0.82	0.76	0.69	0.62	0.47	0.30
0.2	1.00	1.02	1.01	0.99	0.97	0.93	0.89	0.85	0.80	0.74	0.67	0.60	0.53	0.37	0.20
0.1	1.00	1.00	0.97	0.95	0.92	0.88	0.83	0.78	0.72	0.66	0.59	0.51	0.44	0.27	0.10
0.0	1.00	0.98	0.94	0.91	0.87	0.82	0.77	0.71	0.64	0.57	0.50	0.42	0.34	0.17	0.00

BALANCE OF FORCES AND MOMENTS

Transverse Sliding (PORT)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 ...$ 72.594 + 17 + 0 **82 < 90**	**OK**
Transverse Sliding (STBD)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 ...$ 72.594 + 17 + 0 **82 < 90**	**OK**
Longitudinal Sliding	$F_x \le \mu (m \times 9.81 - F_z) + 0.5 (CS_1 \times f_1 + CS_2 \times f_2 ...)$ 36.119 + 0 + 248 **29 < 284**	**OK**
Transverse Tipping	$F_y \times a \le (m \times 9.81 \times b) + CS_1 \times c_1 + CS_2 \times c_2 ...$ **157 < 286**  a 1.91 b 1.22 c 2.43	**OK**

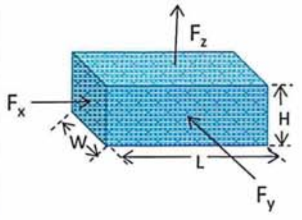
ANNEX 13 CALCULATION WORKSHEET

Surveyor: EFW

Caution	Before making Annex 13 calculations, mass must be in tonnes (t), forces in kilonewtons (kN), and dimensions in metric units

SHIP DATA	Ship **EF Hold 2C on but 2 chains**		Voyage No. **185**		Port **JAX**		
	Speed **24.0** knots	Length **223.7**		Beam **28.0**		GM **1.31**	B/GM **21.40**

CARGO DATA	Mass **18.50** t	Location 0. **5** L	☐ On Deck Low	☐ On Deck High	☒ Tween Deck	☐ Lower Hold



DIM.	WIND		On Deck	SEA		On Deck	Accl Corr (f)
L = **12.19**	Fx	W x H x 1kN/m **2.43** x **0.00** = **0.00** kN		Fx	W x 2 x 1kN/m **2.43** x **0.00** = **0.00** kN		F1 **0.554**
W = **2.43**							F2 **0.241**
H = **3.81**	Fy	L x H x 1kN/m **12.19** x **0.00** = **0.00** kN		Fy	L x 2 x 1kN/m **12.19** x **0.00** = **0.00** kN		f **0.795**

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Table 3: LENGTH/SPEED Corr. Alternate Method (apply to Table 2 above only)

This correction is required only if the acceleration table in the approved Cargo Securing Manual is NOT based on the length/speed of the ship. If it is, the correction factor (f) is one. If not, use nomogram or formula, f = F1 + F2

$$F1 = \frac{0.345 \times V}{\sqrt{L}} \qquad F2 = \frac{(58.62 \times L) - 1034.483}{L^2}$$

Table 4: Correction Factors for BEAM/GM ratio

B/GM	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13 or above
On Deck High	1.56	1.48	1.40	1.33	1.27	1.23	1.19	1.15	1.11	1.08	1.05	1.03	1.00
On Deck Low	1.42	1.36	1.30	1.26	1.21	1.18	1.14	1.12	1.09	1.07	1.04	1.02	1.00
Tween Deck	1.26	1.23	1.19	1.17	1.14	1.12	1.09	1.08	1.06	1.05	1.03	1.02	1.00
Lowe Hold	1.15	1.14	1.12	1.11	1.09	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.00

CALCULATION OF EXTERNAL FORCES

Direction		Mass t	Tab.2 acc'l	f Corr.	B/GM Corr.	Wind	Sea	Total Force
Longitudinal	Fx	**18.50**	**2.0**	**0.80**		**0.00**	**0.00**	**29** kN
Transverse	Fy	**18.50**	**5.4**	**0.80**	**1.00**	**0.00**	**0.00**	**79** kN
Vertical	Fz	**18.50**	**4.3**	**0.80**				**63** kN

Appendix 3 **Annex 13 calculations**

Table 1 - MSL from breaking strength		Sketch
Material	**MSL (SWL)**	
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of BS	This calculation was done for Container on Chassis with a weight of 81,560 lb in worse position of Hold 2C. This is for ROLOC attached to button and with 2 chains attached at the rear of the trailer. Note: Calculation was done for half the weight using assumption that half weight was over ROLOC and half over rear of container. This is satisfactory provided chains were 75 degrees or less from the horizontal and were within 30 degrees of the transverse direction.
Fiber rope	33% of BS	
Web lashing	50% of BS	
Wire rope (single use)	80% of BS	
Wire rope (re-usable)	30% of BS	
Steel band (single use)	70% of BS	
Chains	50% of BS	
Timber	0.3 kN per cm^2 normal	

SECURING MATERIALS

Item	BS kg	MSL kN	CS kN
Securing Assembly 1	(Transverse)		
Chain 1/2"	14606	72	27
Tensioner	14968	41	
Securing Assembly 2			
ROLOC	54431	533	355
Securing Assembly 3	(Longitudinal)		
			0
For EACH lashing assembly: CS = Least MSL / 1.5			

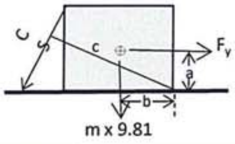
SECURING ARRANGEMENTS (TRANSVERSE)

Side	Lashing	CS	α°	f	CS x f
Port	Chain 1	27	75	0.65	17.42
Starboard	Chain 1	27	75	0.65	17.42
Coefficient of friction (μ) =				0.4	

Table 6 - f values as a function of α and μ

μ	0°	10°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	80°	90°
0.4	1.00	1.05	1.08	1.08	1.07	1.05	1.02	0.99	0.95	0.90	0.85	0.79	0.72	0.57	0.40
0.3	1.00	1.04	1.04	1.03	1.02	0.99	0.96	0.92	0.87	0.82	0.76	0.69	0.62	0.47	0.30
0.2	1.00	1.02	1.01	0.99	0.97	0.93	0.89	0.85	0.80	0.74	0.67	0.60	0.53	0.37	0.20
0.1	1.00	1.00	0.97	0.95	0.92	0.88	0.83	0.78	0.72	0.66	0.59	0.51	0.44	0.27	0.10
0.0	1.00	0.98	0.94	0.91	0.87	0.82	0.77	0.71	0.64	0.57	0.50	0.42	0.34	0.17	0.00

BALANCE OF FORCES AND MOMENTS

Transverse Sliding (PORT)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 ...$ **79** < **90**	72.594 + 17 + 0	OK
Transverse Sliding (STBD)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 ...$ **79** < **90**	72.594 + 17 + 0	OK
Longitudinal Sliding	$F_x \le \mu (m \times 9.81 - F_z) + 0.5 (CS_1 \times f_1 + CS_2 \times f_2 ...)$ **29** < **295**	47.297 + 0 + 248	OK
Transverse Tipping	$F_y \times a \le (m \times 9.81 \times b) + CS_1 \times c_1 + CS_2 \times c_2 ...$ **151** < **286**		OK

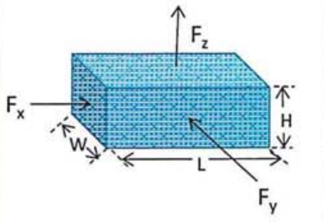
a	1.91
b	1.22
c	2.43

ANNEX 13 CALCULATION WORKSHEET

Surveyor: **EFW**

Caution	Before making Annex 13 calculations, mass must be in tonnes (t), forces in kilonewtons (kN), and dimensions in metric units

SHIP DATA	Ship **EF Hold 2A off button with 6 c**		Voyage No. **185**	Port **JAX**			
	Speed **24.0** knots	Length **223.7**	Beam **28.0**		GM **1.31**	B/GM **21.40**	
CARGO DATA	Mass **8.03** t	Location 0. **9** L	☐ On Deck Low	☐ On Deck High	☒ Tween Deck	☐ Lower Hold	



DIM.		WIND On Deck		SEA On Deck	Accl Corr (f)
L = **12.19**	Fx	*W x H x 1kN/m* **2.43** x **0.00** = **0.00** kN	Fx	*W x 2 x 1kN/m* **2.43** x **0.00** = **0.00** kN	F1 **0.554** F2 **0.241**
W = **2.43**					f **0.795**
H = **3.81**	Fy	*L x H x 1kN/m* **12.19** x **0.00** = **0.00** kN	Fy	*L x 2 x 1kN/m* **12.19** x **0.00** = **0.00** kN	

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Table 3: LENGTH/SPEED Corr. Alternate Method (apply to Table 2 above only)

This correction is required only if the acceleration table in the approved Cargo Securing Manual is NOT based on the length/speed of the ship. If it is, the correction factor (f) is one. If not, use nomogram or formula, f = F1 + F2

$$F1 = \frac{0.345 \times V}{\sqrt{L}} \qquad F2 = \frac{(58.62 \times L) - 1034.483}{L^2}$$

Table 4: Correction Factors for BEAM/GM ratio

B/GM	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13 or above
On Deck High	1.56	1.48	1.40	1.33	1.27	1.23	1.19	1.15	1.11	1.08	1.05	1.03	1.00
On Deck Low	1.42	1.36	1.30	1.26	1.21	1.18	1.14	1.12	1.09	1.07	1.04	1.02	1.00
Tween Deck	1.26	1.23	1.19	1.17	1.14	1.12	1.09	1.08	1.06	1.05	1.03	1.02	1.00
Lowe Hold	1.15	1.14	1.12	1.11	1.09	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.00

CALCULATION OF EXTERNAL FORCES

Direction		Mass t	Tab.2 acc'l	f Corr.	B/GM Corr.	Wind	Sea	Total Force
Longitudinal	Fx	**8.03**	**2.0**	**0.80**		**0.00**	**0.00**	**13** kN
Transverse	Fy	**8.03**	**6.2**	**0.80**	**1.00**	**0.00**	**0.00**	**40** kN
Vertical	Fz	**8.03**	**9.2**	**0.80**				**59** kN

Table 1 - MSL from breaking strength	
Material	**MSL (SWL)**
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of BS
Fiber rope	33% of BS
Web lashing	50% of BS
Wire rope (single use)	80% of BS
Wire rope (re-usable)	30% of BS
Steel band (single use)	70% of BS
Chains	50% of BS
Timber	0.3 kN per cm^2 normal

Sketch

This calculation was done for Container on Chassis with a weight of 35400 lb in worse position of Hold 2A. This is for ROLOC not attached to button with 4 Chains attached to the front of the container and with 2 chains attached at the rear of the trailer. Note: Calculation was done for half the weight using assumption that half weight was over ROLOC and half over rear of container. This is for the front of the container with 4 chains attached. Any container/chassis in excess of this weight and secured in this manner will not be effectively secured in this hold.

SECURING MATERIALS

Item	**BS** kg	**MSL** kN	**CS** kN
Securing Assembly 1	**(Transverse)**		
Chain 1/2"	14606	72	**27**
Tensioner	14968	41	
Securing Assembly 2			
ROLOC	54431	533	**355**
Securing Assembly 3	**(Longitudinal)**		
			0
For EACH lashing assembly: CS = Least MSL / 1.5			

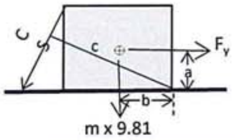
SECURING ARRANGEMENTS (TRANSVERSE)

Side	**Lashing**	**CS**	**α°**	**f**	**CS x f**
Port	Chain 1	27	60	0.59	15.84
	Chain 2	27	60	0.59	15.84
Starboard	Chain 1	27	60	0.59	15.84
	Chain 2	27	60	0.59	15.84
Coefficient of friction (μ) =				**0.1**	

Table 6 - f values as a function of α and μ

μ	0°	10°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	80°	90°
0.4	1.00	1.05	1.08	1.08	1.07	1.05	1.02	0.99	0.95	0.90	0.85	0.79	0.72	0.57	0.40
0.3	1.00	1.04	1.04	1.03	1.02	0.99	0.96	0.92	0.87	0.82	0.76	0.69	0.62	0.47	0.30
0.2	1.00	1.02	1.01	0.99	0.97	0.93	0.89	0.85	0.80	0.74	0.67	0.60	0.53	0.37	0.20
0.1	1.00	1.00	0.97	0.95	0.92	0.88	0.83	0.78	0.72	0.66	0.59	0.51	0.44	0.27	0.10
0.0	1.00	0.98	0.94	0.91	0.87	0.82	0.77	0.71	0.64	0.57	0.50	0.42	0.34	0.17	0.00

BALANCE OF FORCES AND MOMENTS

Transverse Sliding (PORT)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 \ldots$ 7.8774 + 32 + 0 **40 < 40**		**NOT OK**
Transverse Sliding (STBD)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 \ldots$ 7.8774 + 32 + 0 **40 < 40**		**NOT OK**
Longitudinal Sliding	$F_x \le \mu (m \times 9.81 - F_z) + 0.5 (CS_1 \times f_1 + CS_2 \times f_2 \ldots)$ 17.843 + 16 + 248 **13 < 266**		**OK**
Transverse Tipping	$F_y \times a \le (m \times 9.81 \times b) + CS_1 \times c_1 + CS_2 \times c_2 \ldots$ **75 < 227**	 a **1.91** b **1.22** c **2.43**	**OK**

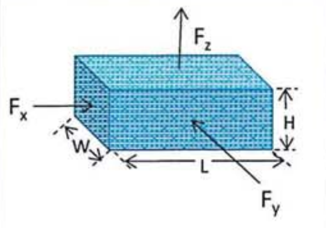
ANNEX 13 CALCULATION WORKSHEET

Surveyor: EFW

Caution	Before making Annex 13 calculations, mass must be in tonnes (t), forces in kilonewtons (kN), and dimensions in metric units

SHIP DATA	Ship **EF Hold 2B off button with 6 c**	Voyage No. **185**		Port **JAX**		
	Speed **24.0** knots	Length **223.7**	Beam **28.0**	GM **1.31**	B/GM **21.40**	

CARGO DATA	Mass **9.14** t	Location 0. **7** L	☐ On Deck Low	☐ On Deck High	☒ Tween Deck	☐ Lower Hold



DIM.		WIND	On Deck		SEA	On Deck	Accl Corr (f)	
L = **12.19**	Fx	*W x H x 1kN/m* **2.43** x **0.00** = **0.00** kN		Fx	*W x 2 x 1kN/m* **2.43** x **0.00** = **0.00** kN		F1	**0.554**
W = **2.43**							F2	**0.241**
H = **3.81**	Fy	*L x H x 1kN/m* **12.19** x **0.00** = **0.00** kN		Fy	*L x 2 x 1kN/m* **12.19** x **0.00** = **0.00** kN		f	**0.795**

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

		Transverse Ay									Longitudinal Ax
On Deck High		7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low		6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck		5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold		5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
		Vertical Az									
		7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Table 3: LENGTH/SPEED Corr. Alternate Method (apply to Table 2 above only)

This correction is required only if the acceleration table in the approved Cargo Securing Manual is NOT based on the length/speed of the ship. If it is, the correction factor (f) is one. If not, use nomogram or formula, f = F1 + F2

$$F1 = \frac{0.345 \times V}{\sqrt{L}} \qquad F2 = \frac{(58.62 \times L) - 1034.483}{L^2}$$

Table 4: Correction Factors for BEAM/GM ratio

B/GM	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13 or above
On Deck High	1.56	1.48	1.40	1.33	1.27	1.23	1.19	1.15	1.11	1.08	1.05	1.03	1.00
On Deck Low	1.42	1.36	1.30	1.26	1.21	1.18	1.14	1.12	1.09	1.07	1.04	1.02	1.00
Tween Deck	1.26	1.23	1.19	1.17	1.14	1.12	1.09	1.08	1.06	1.05	1.03	1.02	1.00
Lowe Hold	1.15	1.14	1.12	1.11	1.09	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.00

CALCULATION OF EXTERNAL FORCES

Direction		Mass t	Tab.2 acc'l	f Corr.	B/GM Corr.	Wind	Sea	Total Force	
Longitudinal	Fx	**9.14**	**2.0**	**0.80**		**0.00**	**0.00**	**15**	kN
Transverse	Fy	**9.14**	**5.6**	**0.80**	**1.00**	**0.00**	**0.00**	**41**	kN
Vertical	Fz	**9.14**	**6.2**	**0.80**				**45**	kN

Appendix 3 **Annex 13 calculations**

Table 1 - MSL from breaking strength	
Material	**MSL (SWL)**
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of BS
Fiber rope	33% of BS
Web lashing	50% of BS
Wire rope (single use)	80% of BS
Wire rope (re-usable)	30% of BS
Steel band (single use)	70% of BS
Chains	50% of BS
Timber	0.3 kN per cm^2 normal

Sketch

This calculation was done for Container on Chassis with a weight of 40,300 lb in worse position of Hold 2B. This is for ROLOC not attached to button with 4 Chains attached to the front of the container and with 2 chains attached at the rear of the trailer. Note: Calculation was done for half the weight using assumption that half weight was over ROLOC and half over rear of container. This is for the front of the container with 4 chains attached. Any container/chassis in excess of this weight and secured in this manner will not be effectively secured in this hold.

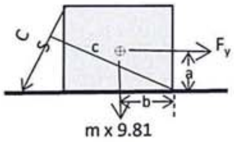
SECURING MATERIALS			
Item	**BS** kg	**MSL** kN	**CS** kN
Securing Assembly 1	**(Transverse)**		
Chain 1/2"	14606	72	**27**
Tensioner	14968	41	
Securing Assembly 2			
ROLOC	54431	533	**355**
Securing Assembly 3	**(Longitudinal)**		
			0
For EACH lashing assembly: CS = Least MSL / 1.5			

SECURING ARRANGEMENTS (TRANSVERSE)					
Side	**Lashing**	**CS**	**α°**	**f**	**CS x f**
Port	Chain 1	27	60	0.59	15.84
	Chain 2	27	60	0.59	15.84
Starboard	Chain 1	27	60	0.59	15.84
	Chain 2	27	60	0.59	15.84
Coefficient of friction (μ) =				**0.1**	

Table 6 - f values as a function of α and μ

μ	0°	10°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	80°	90°
0.4	1.00	1.05	1.08	1.08	1.07	1.05	1.02	0.99	0.95	0.90	0.85	0.79	0.72	0.57	0.40
0.3	1.00	1.04	1.04	1.03	1.02	0.99	0.96	0.92	0.87	0.82	0.76	0.69	0.62	0.47	0.30
0.2	1.00	1.02	1.01	0.99	0.97	0.93	0.89	0.85	0.80	0.74	0.67	0.60	0.53	0.37	0.20
0.1	1.00	1.00	0.97	0.95	0.92	0.88	0.83	0.78	0.72	0.66	0.59	0.51	0.44	0.27	0.10
0.0	1.00	0.98	0.94	0.91	0.87	0.82	0.77	0.71	0.64	0.57	0.50	0.42	0.34	0.17	0.00

BALANCE OF FORCES AND MOMENTS

Transverse Sliding (PORT)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 \ldots$ 8.9663 + 32 + 0 **41 < 41**	**NOT OK**
Transverse Sliding (STBD)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 \ldots$ 8.9663 + 32 + 0 **41 < 41**	**NOT OK**
Longitudinal Sliding	$F_x \le \mu (m \times 9.81 - F_z) + 0.5 (CS_1 \times f_1 + CS_2 \times f_2 \ldots)$ 20.3 + 16 + 248 **15 < 268**	**OK**
Transverse Tipping	$F_y \times a \le (m \times 9.81 \times b) + CS_1 \times c_1 + CS_2 \times c_2 \ldots$ **78 < 240**  a: **1.91** b: **1.22** c: **2.43**	**OK**

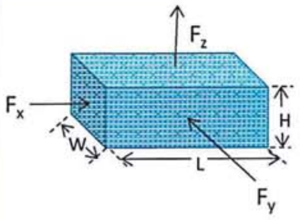
ANNEX 13 CALCULATION WORKSHEET

Surveyor: **EFW**

Caution	Before making Annex 13 calculations, mass must be in tonnes (t), forces in kilonewtons (kN), and dimensions in metric units

SHIP DATA	Ship	**EF Hold 2C off button with 6 c**	Voyage No.	**185**	Port	**JAX**		
	Speed	**24.0** knots	Length	**223.7**	Beam	**28.0**	GM **1.31**	B/GM **21.40**

CARGO DATA	Mass **9.60** t	Location 0. **5** L	☐ On Deck Low	☐ On Deck High	☒ Tween Deck	☐ Lower Hold



DIM.	WIND		On Deck	SEA		On Deck	Accl Corr (f)
L = **12.19**	Fx	*W x H x 1kN/m* **2.43** x **0.00** = **0.00** kN		Fx	*W x 2 x 1kN/m* **2.43** x **0.00** = **0.00** kN		F1 **0.554** F2 **0.241**
W = **2.43**							
H = **3.81**	Fy	*L x H x 1kN/m* **12.19** x **0.00** = **0.00** kN		Fy	*L x 2 x 1kN/m* **12.19** x **0.00** = **0.00** kN		f **0.795**

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
Vertical Az	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Table 3: LENGTH/SPEED Corr. Alternate Method (apply to Table 2 above only)

This correction is required only if the acceleration table in the approved Cargo Securing Manual is NOT based on the length/speed of the ship. If it is, the correction factor (f) is one. If not, use nomogram or formula, f = F1 + F2

$$F1 = \frac{0.345 \times V}{\sqrt{L}} \qquad F2 = \frac{(58.62 \times L) - 1034.483}{L^2}$$

Table 4: Correction Factors for BEAM/GM ratio

B/GM	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13 or above
On Deck High	1.56	1.48	1.40	1.33	1.27	1.23	1.19	1.15	1.11	1.08	1.05	1.03	1.00
On Deck Low	1.42	1.36	1.30	1.26	1.21	1.18	1.14	1.12	1.09	1.07	1.04	1.02	1.00
Tween Deck	1.26	1.23	1.19	1.17	1.14	1.12	1.09	1.08	1.06	1.05	1.03	1.02	1.00
Lowe Hold	1.15	1.14	1.12	1.11	1.09	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.00

CALCULATION OF EXTERNAL FORCES

Direction		Mass t	Tab.2 acc'l	f Corr.	B/GM Corr.	Wind	Sea	Total Force	
Longitudinal	Fx	**9.60**	**2.0**	**0.80**		**0.00**	**0.00**	**15**	kN
Transverse	Fy	**9.60**	**5.4**	**0.80**	**1.00**	**0.00**	**0.00**	**41**	kN
Vertical	Fz	**9.60**	**4.3**	**0.80**				**33**	kN

Table 1 - MSL from breaking strength	
Material	**MSL (SWL)**
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of BS
Fiber rope	33% of BS
Web lashing	50% of BS
Wire rope (single use)	80% of BS
Wire rope (re-usable)	30% of BS
Steel band (single use)	70% of BS
Chains	50% of BS
Timber	0.3 kN per cm^2 normal

Sketch

This calculation was done for Container on Chassis with a weight of 42,300 lb in worse position of Hold 2C. This is for ROLOC not attached to button with 4 Chains attached to the front of the container and with 2 chains attached at the rear of the trailer. Note: Calculation was done for half the weight using assumption that half weight was over ROLOC and half over rear of container. This is for the front of the container with 4 chains attached. Any container/chassis in excess of this weight and secured in this manner will not be effectively secured in this hold.

SECURING MATERIALS

Item	BS kg	MSL kN	CS kN
Securing Assembly 1	**(Transverse)**		
Chain 1/2"	14606	72	**27**
Tensioner	14968	41	
Securing Assembly 2			
ROLOC	54431	533	**355**
Securing Assembly 3	**(Longitudinal)**		
			0
For EACH lashing assembly: CS = Least MSL / 1.5			

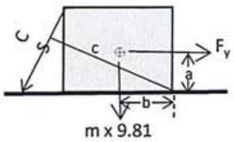
SECURING ARRANGEMENTS (TRANSVERSE)

Side	Lashing	CS	α°	f	CS x f
Port	Chain 1	27	60	0.59	15.84
	Chain 2	27	60	0.59	15.84
Starboard	Chain 1	27	60	0.59	15.84
	Chain 2	27	60	0.59	15.84
Coefficient of friction (μ) =				**0.1**	

Table 6 - f values as a function of α and μ

μ	0°	10°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	80°	90°
0.4	1.00	1.05	1.08	1.08	1.07	1.05	1.02	0.99	0.95	0.90	0.85	0.79	0.72	0.57	0.40
0.3	1.00	1.04	1.04	1.03	1.02	0.99	0.96	0.92	0.87	0.82	0.76	0.69	0.62	0.47	0.30
0.2	1.00	1.02	1.01	0.99	0.97	0.93	0.89	0.85	0.80	0.74	0.67	0.60	0.53	0.37	0.20
0.1	1.00	1.00	0.97	0.95	0.92	0.88	0.83	0.78	0.72	0.66	0.59	0.51	0.44	0.27	0.10
0.0	1.00	0.98	0.94	0.91	0.87	0.82	0.77	0.71	0.64	0.57	0.50	0.42	0.34	0.17	0.00

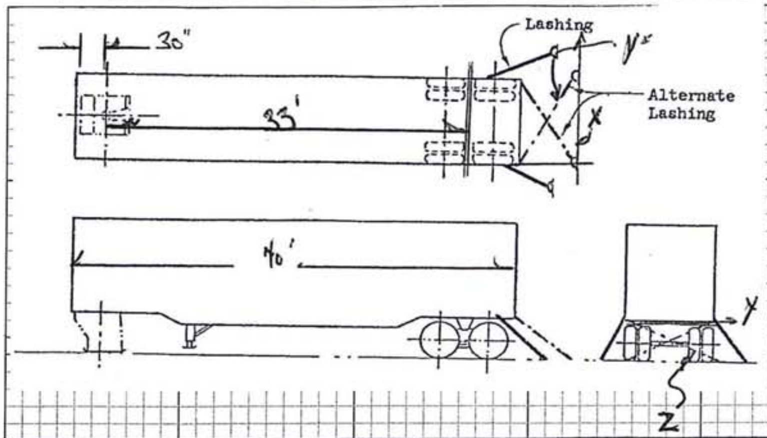
BALANCE OF FORCES AND MOMENTS

Transverse Sliding (PORT)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 \ldots$ **41 < 41**	9.4176 + 32 + 0	**NOT OK**
Transverse Sliding (STBD)	$F_y \le (\mu \times m \times 9.81) + (CS_1 \times f_1 + CS_2 \times f_2 \ldots$ **41 < 41**	9.4176 + 32 + 0	**NOT OK**
Longitudinal Sliding	$F_x \le \mu (m \times 9.81 - F_z) + 0.5 (CS_1 \times f_1 + CS_2 \times f_2 \ldots)$ **15 < 270**	21.974 + 16 + 248	**OK**
Transverse Tipping	$F_y \times a \le (m \times 9.81 \times b) + CS_1 \times c_1 + CS_2 \times c_2 \ldots$ **79 < 246**		**OK**

a	**1.91**
b	**1.22**
c	**2.43**

Appendix 4 **Engineering calculation**

SS El Faro Hold 2A | Semi-Standard on ROLOC | By EF Walker



ASSUMPTIONS

WEIGHT: 81,560 LBF

TRANSVERSE ACCELERATION: (6.2m/s)(0.80) = 4.96

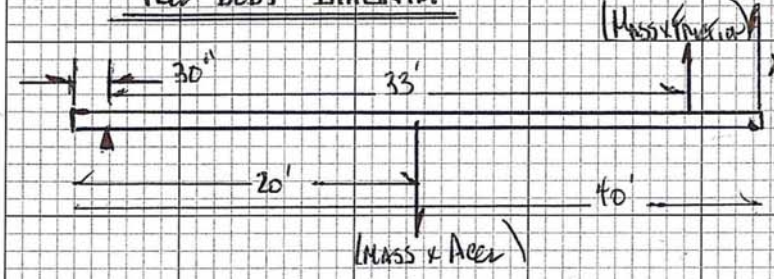
LOCATION: HOLD 2A/FORWARD (HIGHEST ACCEL)

SECURED TO ROLOC BOX AND BUTTON MAKING KING PIN PIVOT POINT

FRICTION COEFFICIENT OF TIRES = 0.4

ASSUME HALF WEIGHT OVER TIRES AND HALF OVER ROLOC BOX.

FREE BODY DIAGRAM



X = LASHING CHAIN

$\Sigma_{TORQUE} = 0$

MASS = 81,560/2204.6 = 37.00 MT

FORCE = (6.2m/s)(0.80) = (4.96 m/s)(37.00 MT) = 183.52 kN

MOMENT = (183.52kN)(20' − 30")/(3.28084 ft/m) = 978.90 kN·m

$MASS_{OT}$ = 18.50 MT

F(FRICTION) = (18.50 MT)(0.4)(9.81m/s) = 72.6 kN

$MOMENT_{(FRIC)}$ = (72.6 kN)(33'/3.28084 ft/m) = 730.2kN·m

978.9 kN·m − 730.2kN·m = X·(37.5/3.28084)

X = 248.7kN·m/(37.5/3.28084)

X = 21.75 kN

SIDEBAR:

CS = 27.1kN MSL = 41kN

Z = 27.1kN

SIN 30° = X_D/Z

X_D = (SIN30)(Z)

X_D = 13.5 kN

Added Friction = (13.5kN)(0.4)
= 5.4kN

Total Friction = 72.6+5.4 kN
$\boxed{= 78kN}$

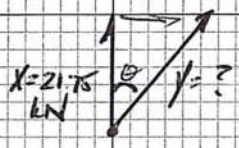
New Moment = 784.5 kN·m

978.9kN − 784.5kN = X · 37.5'

X = 17.0kN

Y = 22.19 kN

$\boxed{Z = 25.6kN}$



θ = 40°

Cos 40° = 21.75/Y

Y = 28.2 kN

β = 30° Y = 28.2kN

Cos 30° = Y/Z = 28.2kN/Z

Z = 32 kN

MSL TENSIONER = 41kN > 32kN OK

CS TENSIONER = 27.1kN ≯ 32kN BAD

NEW CS TENSION = 27.1 > 25.6kN OK

NOTE: DOWNWARD FORCE DUE TO CHAIN TENSION NOT INCLUDED. SEE SIDEBAR ABOVE