Conversion from a Single-Hull to a Double-Hull Oil Barge, Keeping the Load Capacity

Conversión de una barcaza petrolera de monocasco a doble casco, conservando la capacidad de carga

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Abstract

This document consists of a description of the project for converting a bunker oil barge from single-hull to double-hull, for this to meet the regulations of the maritime authority of Peru and the rules of the RINA Classification Society. It is exposed to the Owner, technical and economic options, in order to bring to him the best solution in time and budget. Also, is brought into discussion, the benefit to the owner that it would be of converting the outer hull. So as well, is presented, the challenges faced during the production process and the solutions adopted by the engineering team and shipyard production.

Key words: Conversion, single-hull, double-hull, bunker oil barge.

Resumen

Este documento consiste en una descripción de un proyecto para convertir una barcaza petrolera de monocasco a doble casco, para esto convergen las regulaciones de la autoridad marítima de Perú y las reglas de la sociedad clasificadora de RINA. Es expuesto al propietario, opciones técnicas y económicas, para otorgarle la mejor solución en tiempo y presupuesto. También, se trajo a discusión el beneficio para el propietario que sería convertir el caso exterior. Así mismo, se presentan los diferentes retos asumidos durante el proceso de producción y las soluciones adoptadas por el equipo de ingenieros y de producción de buque.

Palabras claves: Conversión, monocasco, doble caso, barcaza petrolera

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Introduction

The purpose of this document is to expose the activities developed during the work of converting a bunker oil barge capacity of 16,000 barrels, with RINA class, from single hull to double hull, to meet the regulations of the national maritime authority to transport of liquid fuels in Peru.

The work begins with the meeting between the shipyard and ship-owner, in order to determine the scope of the modernizing jobs. There were two critical points of the project, the first one, the effect of conversion of the barge with its capable of maintaining the load capacity , and the second one, meet the need of the owner, proposing to it, a short-term project delivery. Additionally, the Owner required having the latest date for entry of the barge to the dock and a date as close to their departure. It was vital propose to him, the shortest possible time for standstill of the barge in the yard, so they can continue to meet its trade commitments with their customers.

The Design Office of the shipyard Construcciones A. Maggiolo S.A. (CAMSA), in conjunction with staff of the yard, developed a constructive strategy so that they were able carry out the conversion of the barge attending to the needs of the ship-owner. Conversion single hull to double hull it was planned through the change in width and depth of the Barge. Will be fabricated Modules at both sides and new double bottom, which constitute the new side shell of the hull. Building blocks and erection sequence, allowed us to define a schedule of activities in conjunction with the ship-owner. Project milestones are set according to the schedule provided, which were subsequently considered in the contract signed between the shipyard and ship-owner.

At the beginning of the work, the shipyard planned the preparation of the pieces and parts, sub-assemblies and assemblies of the new modules. With these structures, the different panels and modules of the port and starboard sides and double bottom were made. All work was carried out by performing traceability and under quality assurance standards. The conceptual design and construction works were inspected by the classification society RINA (Italian Register of Ships) member of IACS (International Association of Classification Societies).

Brief history of Maggiolo Shipyard

Construcciones A. Maggiolo SA (CAMSA) was founded in 1942 by Don Augusto Maggiolo Cavenecia, At Chucuito City area in the port of Callao, department of Lima in Peru. In the beginning, small boats for artisanal fisheries were built. By the mid-50s with the development of industrial fisheries in Peru, the company expands its operations, and starts a period of shipbuilding industrial fishing of anchovy (purse seiners) intended for fish meal.

Fig. 1. View of Shipyard CAMSA - Chucuito in the port of Callao.

The Peru became the world's largest producer of fishmeal, in those years CAMSA had up to 40 vessels under construction at a time. In the late

50s, the shipyard delivered a series of patrol boats to the Peruvian Navy. During the 60s, they came to convert more than 300 industrial fishing vessels. During the 70, 80, and 90 shipyard focuses on maintenance the Peruvian industrial fishing fleet. In the late 90s, investments increased the capacity of Dry-docking, for vessels up to 55 meters in length and 1,000 tons of displacement.

In the early 2000, begin construction of fishing vessels including cooling systems in warehouses (RSW) with a length of up to 55 meters; at the same time, in order to correct the conditions of stability and freeboard Peruvian fishing boats, CAMSA begins to proceed with the modification of these vessels (extensions). In late 200, CAMSA acquires a new field of 55 hectares, which began operations in 2010. This new shipyard has the capacity to serve ships up to 105 meters in length and 2,500 tons of displacement.

Fig. 2. Vista Shipyard CAMSA- Barlovento Oquendo near the port of Callao.

Fig. 2. View of Ferry project Shuttle maneuver.

In 2011, CAMSA builds a Ferry to 82.4 meters with capacity for 850 passengers and 160 cars. In 2012, a Platform of Petroleum Exploration is constructed with 100 meters high and 1,800 tons.

Project Background

Through Regulating R. D. 018-2011 (DICAPI, et al., 2011) which requires all ships and barges greater deadweight 150DWT, transporting, storing or producing oil in bulk, and operating within the maritime domain of Peru and inland water, must have double hulls. This comes as additional reach the requirement of international MARPOL convention which entails taking double hull vessels or barges with greater deadweight 5000DWT.

Within the scope of the standard, Peru maritime authority has issued certificates for extension of time, setting as peremptory date until 31 December 2014 for vessels that have not yet reached 25 years of service. Whereupon it was established that as of that date, ships or barges that do not have double hull and double bottom as required by MARPOL and DICAPI not will be allowed to operate.

With this background, the ship-owner and shipyard started talks to propose the best alternative for carrying out the project of conversion to double hull and double bottom in the Barge ANTU, the same that has the following characteristics:

Table 1. Project Data Sheet (Compilation).

Owner / Ship Name:	PETROTANKERS S.A. / Barcaza “ANTU”
Length :	64.200m
Width:	10.584m
Depth:	4.400m
Deadweight:	2336 DWT (Aprox.)
Place of operation:	Bahía del Callao
Classification (RINA):	C • barge-oil product (pi>60 C); sheltered waters

Analysis of Alternative Solutions

To initiate the technical and economic evaluation of the project as well as develop basic engineering, and due to the barge did not have reliable information as to the physical condition of structures, complete inspection of the barge was necessary, Noting the level of detail required for this stage, we proceeded to inspect the barge at anchor in the port of Callao. During project appraisal, CAMSA present two work alternatives, which could be met by existing shipyard facilities, which were:

- External Modification
  To pursue this alternative would involve modifying the width and depth of the barge. It would require the development of detailed engineering for the construction of new compartments double bottom and double hull side.
- Internal Modification
  Which would involve the need for Dry-docking during the time required to modify the internal structures of the barge, without altering the dimensions of the width and depth, but reduced load capacity.

The advantages and disadvantages of the alternatives listed below:

According to this preliminary assessment, the ship-owner requested to carry out the proposed modification of the outer hull, since in this way the impact on future operations would not be affected by the loss of capacity of 27% compared to the original conditions. Maintaining the capacity at 100% allowed the customer clearly finance the project and also shows the additional benefits of starting work without having the barge aground in the shipyard.

Development of the Project

Once the contractual conditions is been defined, CAMSA requested to the ship-owner the Dry-docking of the barge in the shipyard for a period of 48 hours, in order to carry out a technical inspection and collect detailed information for the development of project plans which they were unable to be evaluated during the first inspection. This activity allowed to the engineering office team; determine existing distortions and misalignments in the original barge. Module planes are shown in the figures shown below:

Table 2. Validation of Alternatives Project (Compilation).

Description	External Modification	DRDB
Advantage	- Ease of module construction of the hull and double bottom - Longer commercial use, late entry into the shipyard for doing work. - Relatively short duration work and stay in shipyard - Availability of space in the yard (No use of docks) - Conservation capacity of the ship (DWT)	- Low steel consumption, utilization of internal structures. - The new structures will accommodate existing, being avoided problems of misalignment. - Lowest price project
Disadvantage	- Increased consumption of Steel - Increased cost of the Project - Possible misalignments relative to the old hull structures	- Loss of carrying capacity of the barge (DWT) - Greater downtime of the barge
Relative amount of steel to be processed in% (C)	165%	100%
Relative cost per Kg. steel processing (c)	1	1.5
Relative cost of the project[1]	165/150 = 1.1	150/150 = 1
Variation DWT	0%	-27%

[1] Value obtained from the ratio of the External Project Cost divided on the Internal Cost Project.

Fig. 4. Breakdown of module DFZ1ER.

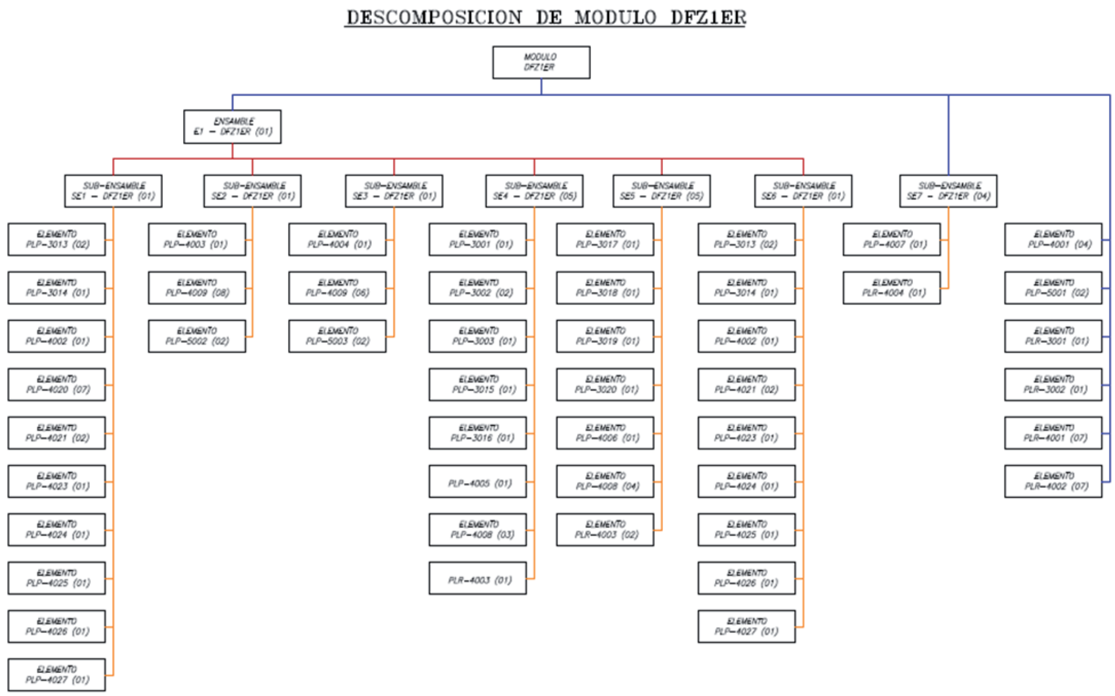


Fig. 5. Isometric View of DFZ1ER module.

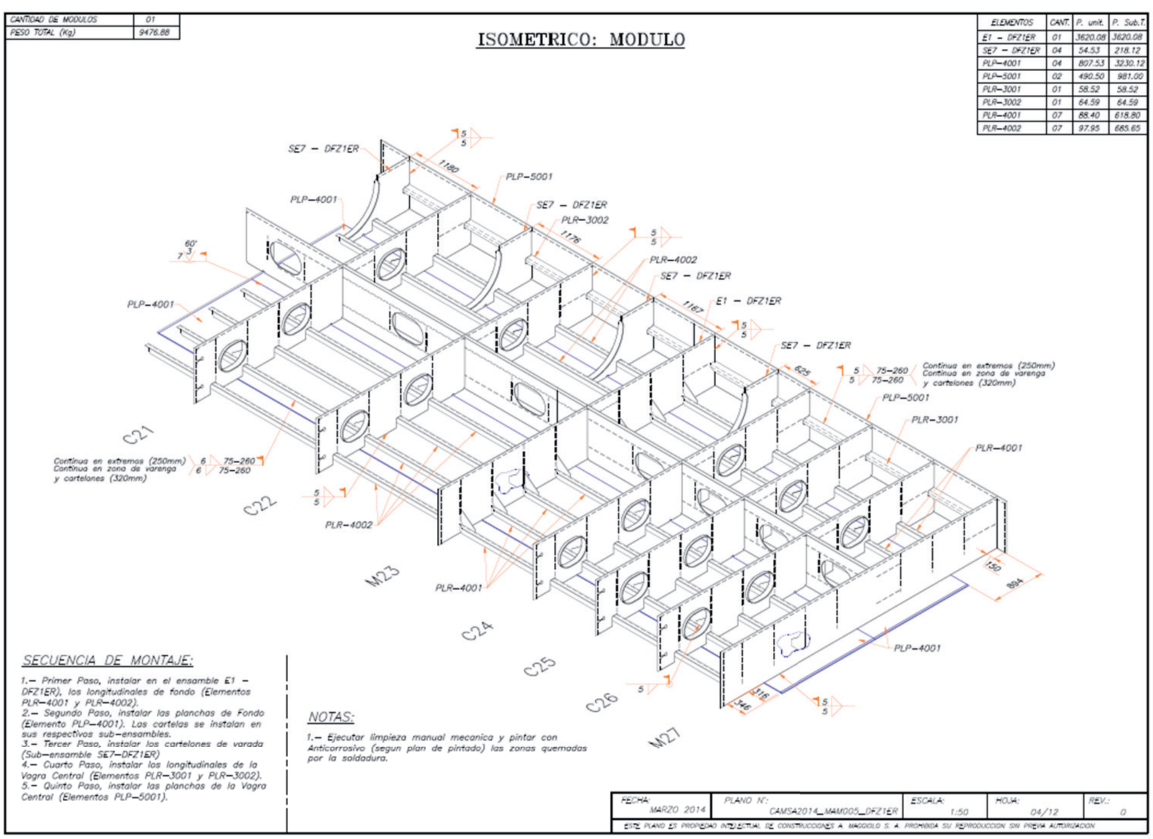
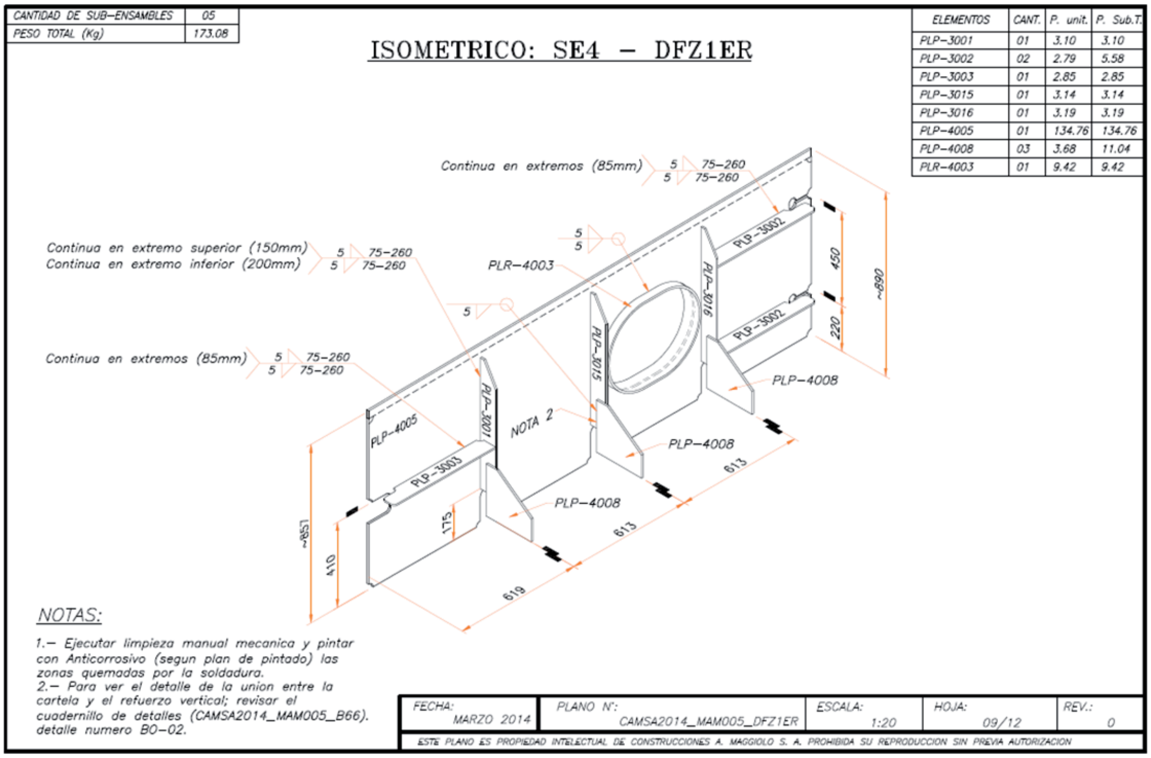


Fig. 6. Isometric View SE4 - DFZ1ER module.



The engineering office prepared the detailed engineering information for the area of production, a way that allows the cutting of 100% of the parts, subassembly and assembly of panels and modules side hull and double bottom. The deliverables were classified according to:

- Development of Detail Engineering.
- Fabrication of parts (Nesting[2]).
- Installing Modules and modification of the bow and stern.

Fig. 7. Steels Parts - Fabrication Phase.

Fig. 8. View of panels – Sub Assembly.

[2] Nesting: placing process in a steel plate as information necessary for cutting pieces executed automatically by a numerically controlled flame cutting machine, avoiding wastage.

Fig. 9. Panels of bottom and side hull.

Fig. 10. RINA inspection in the yard.

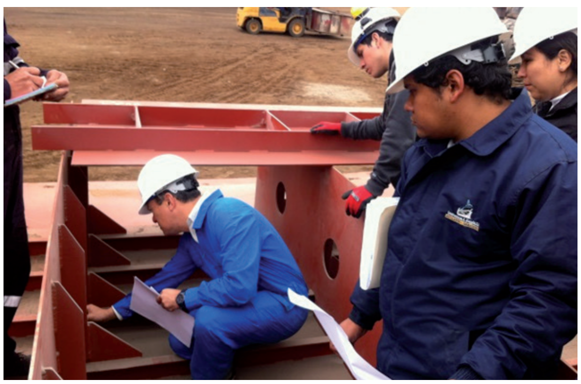


Fig. 11. View of Double Bottom.

Fig. 12. View of Side Hull.

Fig. 13. View of the bow.

Fig. 14. View of the stern.

Modular Manufacturing Challenges

During the initial inspections on the barge, it was found existing deformations in the bottom and on the sides of the barge, produced throughout their services. Reason why all modules have worked with machining allowances strategically placed to absorb these deformations without the need to reduce the regulatory distances double hull and double bottom. The machining allowances were trimmed with existing hull shape.

Another challenge, a little more complicated of coping, was the misalignment of existing structures, presumed to be due to the age of the barge and all repairs that he received throughout his life. Ultimately this misalignment was impossible to make new structures are aligned to existing structures. Neither was feasible to build structures misaligned since it would require a lot of work and the concept of modularity and standardization that were exposed advantage to adopt the outer hull conversion would be lost.

Misalignment sections structures were observed up to 40mm. To determine how these structures are affected by misalignments indicated, the following analysis was performed.

Calculation of hydrostatic pressure on the double bottom plate

For this calculation the following data were obtained:

- Height of liquid cargo tanks to the top of the vent pipe (h) = 7.75m
- Approximate density of load (d) = 1,000kg / m3
- Acceleration of gravity (g) = 9.81m / s2

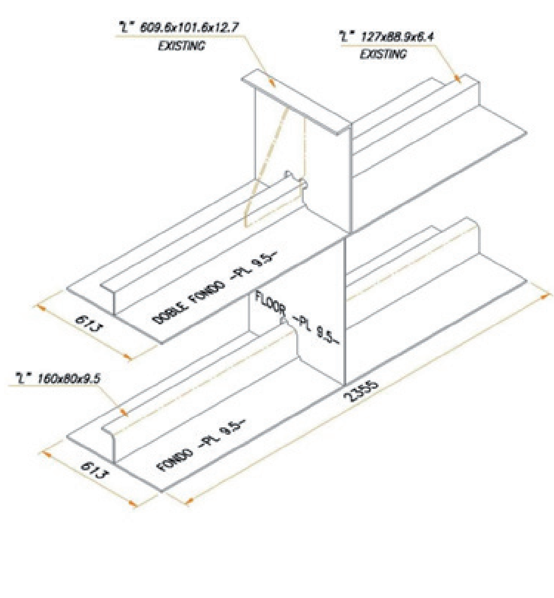
With these data it was found that the value of the hydrostatic pressure that occurs on the bottom plate is 76,000N / m2.

Determination of the typical analysis section.

Typical section, Is a representative section to help simplify the calculations, the same as shown below:

- The width of the typical section of 613mm (spacing between longitudinal)
- The length of the typical section of 2355mm (separation between bottom transverses)

Fig. 15. Typical Section.



Considerations for stress transfer

Another approach which simplifies the calculations without lead to significant errors knows how their stress between the structures of the barge is transmitted. In general, the forces are transmitted via the adjacent structures which have increased resistance to deformation; i.e. the stress that have greater moment of inertia.

Our analysis is simplified to apply the concepts of bottom floors; in this case, the deformation is directly proportional to the load applied divided by the moment of inertia.

$$Deformation = Cte \times \frac{load\ applied}{Moment\ of\ inertia\ (I)} \tag{1}$$

In this regard, if two bottom floors subjected to the same deformation, the load applied is distributed in proportion to the moments of inertia, as follows:

$$\frac{Load\ applied\ in\ Floor\ 1}{Moment\ of\ inertia\ in\ Floor\ 1\ (I_1)} = \frac{Load\ applied\ in\ Floor\ 2}{Moment\ of\ inertia\ in\ Floor\ 2\ (I_2)} \tag{2}$$

Thus, it showed the sequence of force transfer from the inner bottom plate to the reinforcing structures of the double bottom:

- The plate supports the hydrostatic pressure of the liquid.
- Longitudinal double bottom are attached to the plate using the welding between longitudinal reinforcements and inner bottom plate.
- The bottom floors (new and existing) holding the longitudinal absorbing stress in proportion to its moment of inertia.
  - Existing misaligned floors, are tied to the longitudinal through the welded joint between the web of longitudinal reinforcement and the web of the floor, absorbing 11.8% of stress (see "Moment of inertia of bottom floor"), which is not a problem.
  - The new floors are tied to the longitudinal through a prismatic cross-section, with

rectangular horizontal section of 9.5mm x 6.4mm, absorbing the 89.2% of stress (see "Moment of inertia of bottom floor"), which is a problem.

Moment of inertia of the bottom floor

By continuing, it shown the moment of inertia of the new and existing floors, including involved plates, with respect to a longitudinal axis (xx) passing through its neutral axis.

- $Ixx_{\text{(existing floor)}}$ = 1097x106mm4 (11.8%)
- $Ixx_{\text{(new floor)}}$ = 8140x106mm4 (89.2%)

Fig. 16. Section of calculation lxx in existing bottom girders.

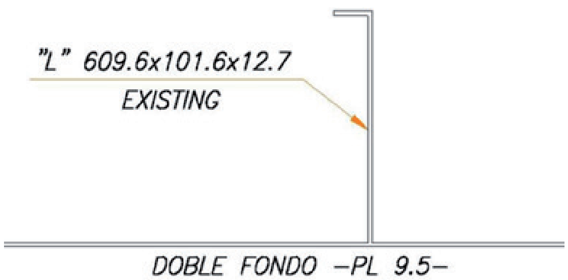
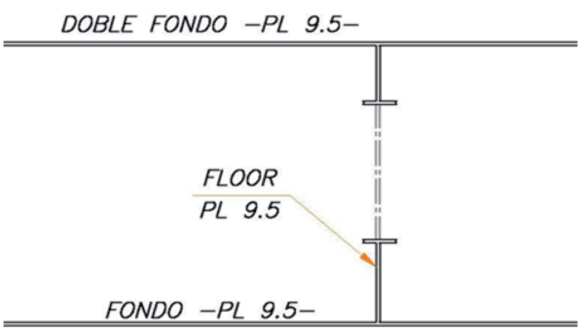


Fig. 17. Section of calculation lxx in new bottom floors.



Intersection stress in the new bottom floor and longitudinal of the double bottom

In Figs. 18, 19 and 20 it shown the critical area of study, it will serve to obtain technical and viable solution states. The calculation of stress at the point shown is applied by:

- The acting pressure on the inner bottom plate (P) = d * g * h = 76027Pa
- The acting force on the plate of typical section (Ft) = P * 0.613 * 2.355 = 109754N
- The longitudinal force transmitted to the bottom floor (F) = 0.892 * Ft = 97900N
- Transversal area for calculating normal stress = 9.5 * 6.4 = 60.8mm2
- Normal stress = 97900/60.8 = 1610.2N/mm2

In the demonstrated calculation it is observed that the stress concentration well exceeds the allowable value (235N / mm2), so it is necessary to increase the stress transmission area at least 14 times, to ensure that these results do not exceed the permissible values and maintain a safety factor equal to or greater than 2.

Fig. 18. Critical Zone of evaluation.

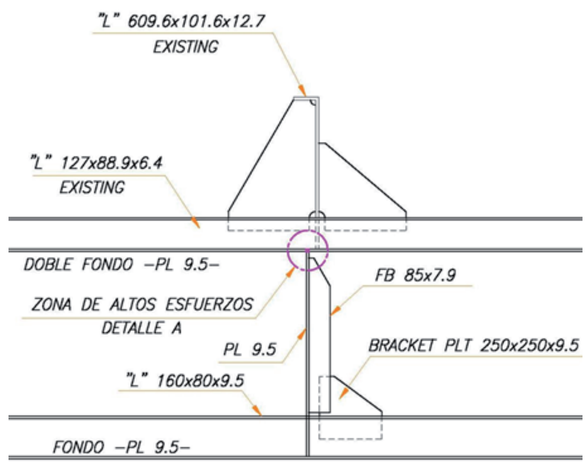


Fig. 19. Detail A.

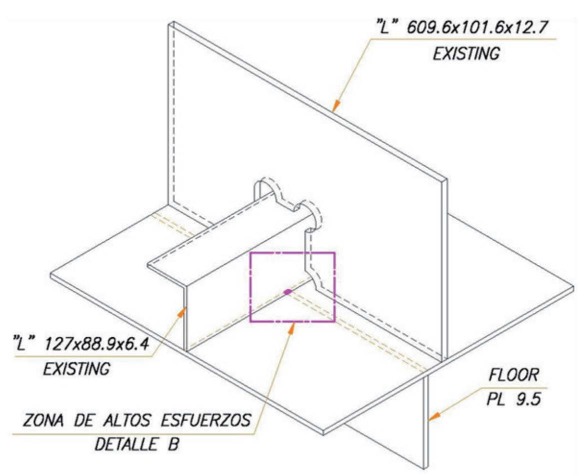
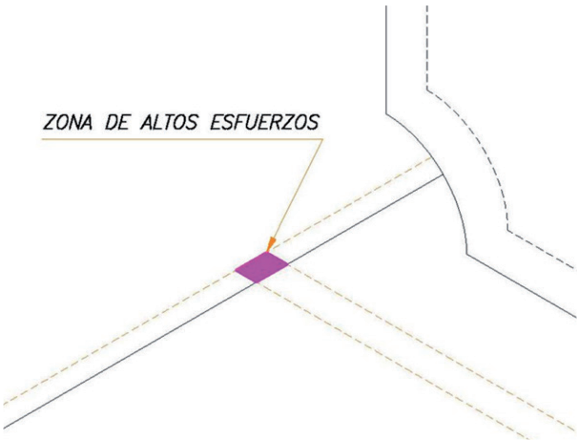


Fig. 20. Detail B.

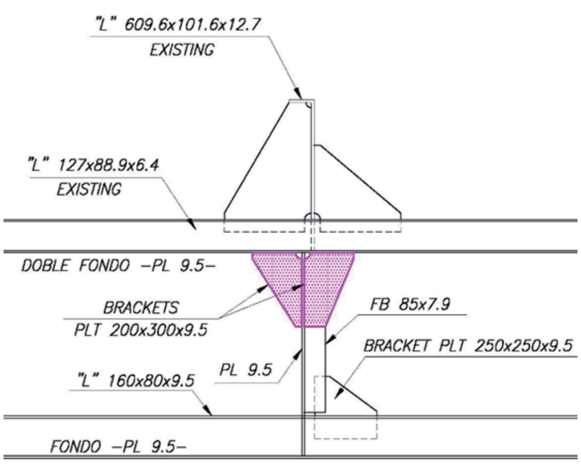


Distribution proposal of stress

Fig. 21 below shows the proposal to reduce the stress concentration generated in the misalignment of the structures.

This proposal increases the stress transmission area to 2361.6mm2, which helps reduce the normal stress from 1610.2 to 41.4N / mm2, which is considered safe (safety factor equal to 5.6)

Fig. 21. Proposal of reinforcement by two gussets 200x300x9.5.



Distribution proposal of stress

The project was developed as planned. Table 3 summarizes the project.

Conclusions

- The short time that the barge was in the yard without operating was meaningful and beneficial to the Owner.
- Performing the conversion of double hull barge using the external original hull, allows the barge keep 100% of its original charge capacity. With which, from the economic point of view, keep up future flows of freight operation, which facilitate the investment financing of the project.
- The solution proposed by the shipyard engineering office, allowed providing technical and economically viable solution to the problem of misalignment of structures. Since it would not be possible to remove the existing bottom girders because, according to what observed by RINA, these bottom girders serve to reduce the unsupported length of the longitudinal double bottom deck.
- The benefits of working over the outer hull, allowing using a modular construction strategy, achieving higher productivity and better working conditions within the shipyard.
- This project was the first work of conversion outer hull barge, performed successfully in Peru.

References

DICAPI, DG and Coastguards of Peru, Directorial Resolution 018-2011, Rules relating to the requirement of double hull vessels between 150 DWT. Less than 5000 DWT.

Table 3. Project Results (Compilation).

Project	Before	After
Length:	64.200m	64.200m
Width:	10.584m	12.123m
Depth:	4.400m	5.187m
Dead weight:	2336 DWT	2336 DWT
Class (RINA):	C • barge-oil product (pi>60 C); sheltered waters	
Project Start Date:	12 Mayo 2014	
Date of Dry-docking for inspection (48 hrs.)	22 Mayo 2014	
Dry-docking date for fabrication start	14 Julio 2014	
Time Length of block manufacture	15 Mayo al 30 Julio 2014	
End date of Project:	18 Noviembre 2014	
Project Duration time:	120 días de trabajos de construcción 25 días de pruebas a flote	

Fig. 22. View Barge "ANTU" in final stages of work.
Behind the fishing vessel "SIMON" after lengthening it.