Hydrostatic test on tanks during the section stage of a ship: The case study of the PSV 5000

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Galati, February 2015

To my sister.

CONTENTS

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ABSTRACT

The main topic discussed in the thesis, is the "Hydrostatic test on tanks during the section stage of a ship" and it is particularly focused on the existing project of the vessel PSV5000. The hydrostatic test is framed from the international rules (IACS S.14; Lloyd's Register; etc...) as a structural test carried out to demonstrate the tightness of the tanks and the structural adequacy of the design of the vessel. The test is required for all the types of tanks present on board in consideration of the different types of structure and location. Only after this test the Class Society assigns the usability of the tank and it is accepted by the client. So the hydrostatic test that could appear simply as secondary activity in the whole complexity of the shipbuilding construction, it is a *condicio sine qua non* for the final delivery.

In the actual organization of the ship production process at DAMEN Shipyard Galati the hydrostatic test is performed after the launching of the ship, during the commissioning, using the pump systems installed on board for the displacement of the masses of water from one tank to another one and for the discharge. The main concern about this strategy is in the event if the tank fails the test. The problem will affect the engineering department that must redesign the tank and inevitably the production chain will stop and be compromised. If a huge structural modification is required, it becomes a difficult task to solve in advanced state of construction. It must be considered also that in normal conditions this test is performed in a period very crowed of activities and few time available, with the high risk of overlapping, bottleneck issues and delays. Therefore, the thesis was oriented to identify the possibility to perform the hydrostatic test at the earlier building stage of the ship, preferably at the section stage of the fabrication process of the vessel. It could have a positive impact on all the production chain if shortening of expenditures and of delivery time are obtained. So the main goal is to find the point of construction stage where technically it is possible to carry out the test and to verify that this constitutes an advantage for the shipyard.

The tanks that must be tested are individuate on the structural test plan of the PSV 5000, this plan is already prepared at the shipyard and approved from the class society. Knowing the position and distribution of the tanks, it is analyzed the building strategy of the vessel PSV 5000 in construction in the dry dock. The analysis returns eligible stage points where the test could be performed, they are chosen on the base of the stage of completion of the structure, presence of critical equipment that must be insert as well as weights that load over the tank. At this point it is necessary to check whether the total load on each support below the ship does not exceed the limit of 50 tons. With this purpose the software CVSL_64 was used, in which the project for the vessel PSV 5000 was uploaded and where it is possible to insert the weight estimation with all the loads and their positions. The study indicates the necessity of placing 4 four additional supports below the ship to sustain the weight of the structure, foundations, piping, equipment and the mass of water added during the test. The dates of start and finish of testing for each single tank are elaborated on the base of the actual planning, taking into consideration all the activities that affect the completion of the tank.

In conclusion, it is possible to perform the hydrostatic test before the launch and to insert it in the planning of the activities, but it must be take into account that the systems on board are not operative yet. Thus must be used external pumps and special devices that they have to be available in time for the test. Moreover an economic analysis returns a total cost of 6800€ for perform all the package of activities of testing on the vessel. It is emerged that the main cost item is the man-hour. In addition with the plan proposed for the test in the earlier stage, it is possible to save money without using fresh water in the tanks that are designated to contain fuel, oil, or fresh water. This is possible because the tests are performed before the painting. The amount of saving for the fresh water is of 1200€ (included in the previous cost). In last analysis were advanced two proposals regarding investments in new equipments, that could save man-hours, reduce the total time necessary for the test execution and consequently provide more days of advantage on the final delivery day. The first investment gives the possibility to introduce inflatable plugs that could reduce the time consumption of the 50% for the preparation piping operations with a saving of 1300€ (to subtract to the total cost). To this saving it is added the cost for the special equipments unnecessary that will not be prepared. Some other savings come from the absence of welding and consequently the missing of paint/coating damaged by heat. Thus the total cost it is reduced till 5200€. In addition to this investment it is possible to buy 4 four more pumps. This allows the possibility to test till four tanks at the same time, With these solutions it is possible to finish with a total advance of four working days on the previous schedule.

1. INTRODUCTION

The main topic that is developed in this thesis, is the "**Hydrostatic test on tanks during the section stage of a ship**" and particularly focused on the existing project of the vessel **PSV5000**.

The hydrostatic test (from now it will be referred as h. t.) is framed from the international rules (IACS S.14; Lloyd's Register; etc....) as a structural test carried out to demonstrate the tightness of the tanks and the structural adequacy of the design. The test is required on all the type of tanks present on board in consideration of the different type of structure and location. Only after this test the class society assigns the usability of the tank and it is accepted by the client. So the h. t. that could appear a simply secondary activity in the whole complexity of the shipbuilding construction, it is a *condicio sine qua non* for the final delivery.

This topic has been requested by DAMEN SHIPYARDS GALATI, (from now it will be referred as D.S.G.). D.S.G. is part of the Damen Group that is an international shipyard group and it operates in a wide market range. Damen was established in 1927 in the town of Hardinxveld-Giessendam in the Netherlands by Jan and Marinus Damen.

The main vision of the Group, which has led to be a worldwide competitor, is to offer to the clients a custom-built vessel nevertheless with an efficient standardization too. This assures best quality, proven designs, short delivery time, low maintenance and excellent resale value.

In this frame my work is oriented to identify the possibility to perform the h. t. on the tanks at the earlier building stage of the ship, preferable at the section stage of the fabrication process of the vessel. The identification of the possibility to perform the h. t. at the earliest building stage of the ship could have a positive impact on all the production chain if money and delivery time are saved. So the main goal is to find the point of construction stage where technically is possible carry out the test and verify that this constitutes an advantage for the shipyard. So technical, economical and quality evaluations must be done.

2. D.S.G. ORGANIZATION

The h. t. is an activity that affects several departments and divisions and it involves the confluence of different competences. For this reason it is necessary to show briefly the shipyard organization.

The modern shipbuilding has oriented its methodology to a production system based on the modularity of different blocks. The ship now is build splitting the project in different blocks which are produced in different workshops and at different times in the shipyards and only after these block are jointed together.

This approach brings the advantage of better efficiency ,"the right tool for each job", because each block presents its own particularity that requires specialized job. So it is clear that a such complicate work can be done with an higher quality and efficiency if it is done in an environment well suited for it.

At difference of the classical approach "bottom-up", the blocks are built far from the water and only successively are transported in the dock. Consequently it is avoid disturbance between workers dedicated at different jobs, it is reduced the overlapping during the construction and it is possible a more precise planning.

With this methodology in the last 30-20 years the layout of a shipyard is deeply changed, and several types of layout are imaginable, each with a peculiar aspect.

Elements that influences the layout are:

- Size and type of ship to be built.
- Material production per year to be achieved.
- Material handling equipment to be supplied.
- Machining processes to be installed.
- Unit size and weight to be fabricated and erected.
- Amount of outfit and engine installation to be undertaken.
- Control services to be supplied.
- Administration facilities required.

A big disadvantage of having block ship production, it is the necessity of big cranes with huge capacity for move the blocks. Consequently high cost of installation are present.

D.S.G. has an organizational structure with a managing director, five division:

- Technical Division
- Projects Division

- Production Division
- Financial Division
- Human Resources Division

Production Division has three Deputed Division:

- Managing Commissioning
- Managing Hull
- Managing Outfitting

Every Division has Departments and sub-departments.
This type of organization bring to consider different levels of decision:

- Operational Decisions
- Tactical Decisions
- Strategic Divisions

Moving from the first one to the last, the time leap of the decision increases from a daily level to an breath of more than 2 years.
The concept at the base of the D.S.G. organization is the gradually splitting of big problems in small and smaller ones that are more handling. Because build a ship it is a big task and it requires a lot of efforts and resources simplification is the key word to reach an efficient production and a high quality level of the final product.

2.1. Engineering & Production Support Department

The Engineering & Production Support Department is under the Technical Division, it has a function of controller and eventually of corrector of all the detailed designs and plans necessary for the production. Related with the main topic “hydrostatic test of the tanks” this department results important because it provides the plans for the test and the required load calculations on the structure.
The department does not produce drawings from the sketch at the contrary **the Production Information Packages** are prepared from external companies: D.S. Gorinchem, DSNS Vlissingen, Amels and DSBergum.
The drawings (pipping, detailed, electricity, etc.) are prepared from Marine Engineering Galati (MEGA) and others. Even if these service providers are inside the Damen Group for D.S.G. these figure like activities in outsourcing.

Two are the systems used for the transmission of the documentation :

- IFS with a Letter Of Transmittal (LOT) by email.
  All documents from D.S. Gorinchem Engineering are transmitted via IFS Document Management and announced by email having attached a Letter of Transmittal
- All documents from Engineering Companies (as DSNS, AMELS, DSBergum) are placed on FTP servers and announced by email having attached a Letter Of Transmittal.

The letter of transmittal has inside a list of all the information inside the package and the reference numbers of the drawings.

The IFS system is common to all the group DAMEN, it is not a internal server of the D.S.G. in this way the data are accessible from every offices of the group.

In case of use of a FTP server is duty of the engineering department to receive and upload the Production Information Packages on IFS.

Before the release of the documentation in production is checked according to the SEPI, Standard Engineering Production Information.

This document was developed also with the collaboration of E.& P. S. department. It describes:

- The standard engineering production information to be delivered by engineering company to the building yard.
- Particular input from the building yard needed by the engineering company at start of the engineering.
- Formats of production information to be delivered.
- Contents of production information/documents.

It can happen that the information received are not complete, in this case the department has two possibilities of operate: it makes a remark and wait for their completion or ,because the time is short and this information are necessary to start the production, to operate on the info packages. The completion of Engineering Production Info can be:

- Part lists for steel outfitting drawings.
- Spool lists.
- Additional detail for dxf, dwg - files like missing detail , bill of materials.
- Documentation to mount pipes for compartments of the vessel, for this documentation it is done from the pipes upper 25mm, lower of this size the material lists per system is based on diagrams, for pipes and fittings without iso’s and spools.

The department prepare also the Visual Progress xls file for piping. Other competence of the Engineering & Production Support Department is to prepare NDT (Non-Destructive Tests) Plan and approving with local surveyor of Classification Societies.

2.2. Proposal, Contracting & Planning Ships Department

Proposal, Contracting & Planning Ships Department is under the Technical Division, it comes from the fusion of two previous separate departments the Proposal & Contracting Dep. and the Planning Dep. This type of organization does not affect the two main functions of the department. One is to define the building strategy and the planning, the other the department prepares some documents annex to the contract. The work of this department starts in the early stage of the ship construction and follows the progress for all the length of the different activities. Inside the competences of the department, branch proposal and contracting, fall also some economical estimations at beginning of the construction.

2.2.1. Proposal, Contracting

The principal activity is the building strategy because it has a direct impact on the planning, engineering and production department.
The building strategy is formulated on the basis of the information received:

- Inquiry.
- Technical specification.
- Drawings (General construction plan, General arrangement, Section Plan, Section weights & dimensions, Mid ship section, Tank arrangement, Welding details).

Moreover the Building Strategy Team has well clear the dimensions and weight of the ship that will be built, but this information alone is not sufficient must be related with the shipyard capabilities (cranes, building location, assembling and launching location). At the end the strategy must be take into account also other ongoing projects, naturally is duty of the planer coordinate the single activities but this is made in accordance with the strategist. So between B.S. Team and the Planning Team there is a strictly interconnection. After the B.S. is defined, it is sent to the Engineering Dept., Planning team, Production Divisions.

2.2.2. Planning Ships

Planning is the process of organizing the activities required to achieve a desired goal. It involves the creation and maintenance of a plan. In the ship industry the planning has the objectives of:

- Work organization and schedule of different activities.
- Planning of the required resources.
- Planning of the required material.
- Prediction of the date of delivery.

Due to the presence of high penalties for delivery delays (millions for each day) the last aspect in the previous list acquires a predominant role.

In the figure 1 is shown a general planning development of construction for a PSV 5000.

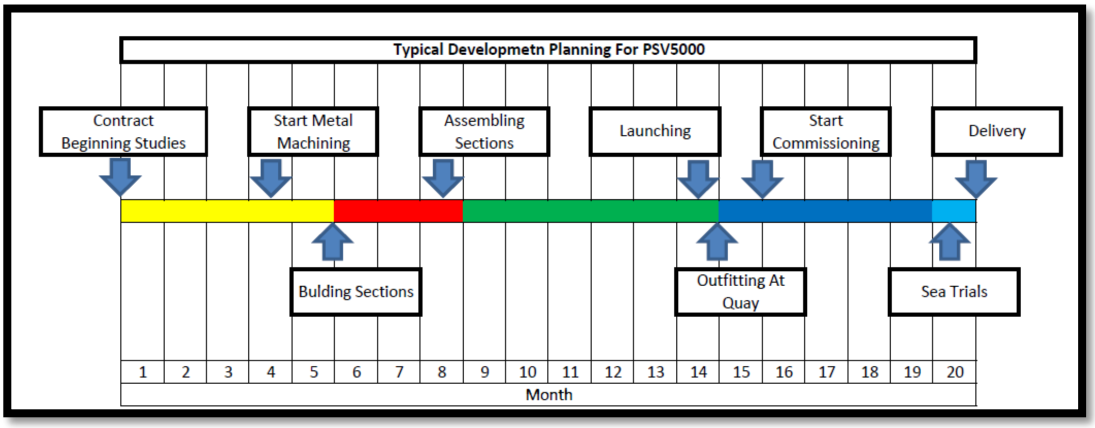


Fig. 1 - Typical planning development for PSV5000.

The planning does not consider only the “material activities of building” but it includes in the whole prediction also the activities of studies and sea trials to arrive till the final delivery date. Fundamental element for a good planning is to avoid, when is possible the bottlenecks, because a delay before the bottleneck will affect all the successive production chain. Because unexpected inconvenient always could happen is good procedure in a planning to anticipate all the possible critical operations as soon as possible and consider after them some time lags able to absorb eventually delays. These are general recommendations and a plan always is adapted with the typology and strategy of the specific shipyard and the unit in production. In the previous image are considered in the last days before the delivery a series of activities called “sea trials”, these tests are fundamental to demonstrate the compliance of the ship to the contractual requests of the client and to the requirements of the Classification Societies.

The planning of the ship is done by defining the steps in the production process, the sequence is :

1) Planning documents (planning portfolio, production capacities workload, execution schedules, plates and profiles cutting schedule, position of vessels in dock and on slipways);
2) Compiling march-out, which establishes the technological route for each product's assembly, sub-assembly and item;
3) Drawing-up the monthly/weekly detailed production programs for each product under execution;
4) Drawing-up monthly production programs for each production division, workshop and foreman formation.

The I.T. tool used for support all the planning operations is the Primavera software. It is involved in all the phase of the planning (list below) and it is continuously updated.

1) Building strategies
2) Engineering
3) Purchase
4) Work preparation
5) Production
6) Subcontractors
7) Commissioning

The planning gives the possibility of monitoring all the activities and processes, Primavera gives the possibility to see graphically the advance status and to generate reports on the status of the project. Every department is involved in the planning process and it must update the plan status according to the work done of its competence. Also the sub-contractors are included and they give the advance status of their works but they do not have direct access to primavera on IFS. In substitution they generate excel file that is implemented by the planning department on Primavera.

An hydrostatic test that must be done, is scheduled as well as the other activities and it occupy a voice in the plan list. The use of primavera can show what is the impact on all the planning chain when the hydrostatic test is moved from the latest stages to the section stage. It is not simply one movement from the bottom to the top and everything is shifted down, but activities like outfitting of pipes, painting, must be took into account and maybe anticipated. Moreover could be that others activities, before not present, must be inserted in the plan.

2.3. Mechanic Department

The Mechanic Department is under the deputed division of "Managing Outfitting" and this is under the Production Division. Several are the competences of the M.D. but it is important to underline that the principal function of this department is the handling and the installation of all the heavy equipments and systems over 50 Kg (for weight lower they are installed directly by the workers without assistance). Important element is the coordination of the activities between M.D. and the others departments for the installation of critical equipment. A system is critical when it must be installed on board before the completion of the structure otherwise it is impossible the access to the assigned space at it. Inside the organization of this department there is a workshop where every mechanical piece necessary can be product. These pieces are assembled according to the drawings edit by the engineering department. The special equipment required to perform a hydrostatic test is assembled in this workshop. For what concerns the hydrostatic test, the Mechanical Department will provide all the assistance necessary for its preparation before its carrying out. It could be necessary to install a temporary pumps for fill and discharge the fluid of the tanks, these temporary pumps, external and submersible ones, are in the disposition of the department. The pumps are installed by the M.D. but after the connection is made by the Piping department.

2.4. Piping Department

The Piping Department is under the deputed division of "Managing Outfitting" and this is under the Production Division.
The main tasks of the department are:

1) Receive/check and validate of the documentation from the Job Preparation Department.
2) Assembling the pipes that will be installed on board.
3) Mounting the piping plants onboard.

After the first step the workflow take us in the workshop, where are performed operations of :

- Cutting and bending
- Assembling
- Welding
- Galvanizing
- Painting

The pipes are bended with machines like in the Fig. 2

Fig. 2 - Bending Machine. DAMEN copyright.

And their edges are prepared with V cutting for allow the penetration welding junction between two pieces. This type of junction is used for connect the pipe with other pipes or with flanges on the terminal . Problem that could be occur in this phase is roundness of the curve, smaller slices of elbows, smaller pieces of pipe between 2 welds. So it is not possible reduce too much the size of the slice otherwise there is the overlap of two thermal affected areas of two welds.

When the pipe is ready it is sent at the galvanization process. The pipe is put in a bath with water and chemical solvents for clean all the internal and external surfaces. After the pipe is dried in a pit, and only after some hours inside, it is ready and it is put in a bath of zinc for the final galvanization.

Fig. 3 - Chemical Bath and Dry Pit. DAMEN copyright.

The last step is the painting of the pipe and after it, all the pipes are grouped for section and system .

Finished the preparation and assembling phase, it starts the piping mounting that can be structured in 3 stages:

- Section Outfitting
- Outfitting Compartments
- Technical Presentation and Tightness test of Systems

The pipe delivered to the ship section are mounted according to the:

- Documentation
- Spool list
- Combination drawings

If the pipes have a diameters less than 25 mm they are not attached with any drawings but they are correlated to pipe sketch documentation. So in this case the worker, based on his own experience, is free to choose the best solution for the installation of these small pipes.

For what concern the hydrostatic test, the piping department is in charge to prepare and mount all the pipes necessary to carry out the test. For example, it is prescribed by the class societies a water column of 2 m, for perform an h. t. . This height is reached with the mounting on the aeration opening of the tank, a pipe long enough to reach the desiderata height. Usually due to the abundance of scrap pipes in the warehouse, these temporary pipes are mounted using the scrap.

2.5. Commissioning Department

The Commissioning Department is under the deputed division of “Managing Commissioning” and this is under the Production Division. The commissioning is the process that anticipates the sea trials and makes operative the ship, ensuring that all systems and components are installed, tested and they are operating according to the operational requirements of the final client and of the class society. During the commissioning, machineries are tested for the first time onboard and many systems can be tested only after the launch of the ship, so the commissioning must be done when the vessel is floating.

When the commissioning activities start, the first operation is to load fuel in the tanks, this because it is necessary fuel for put in function systems like engines, compressors, pumps, generators. The presence of fuel in the tanks impede the internal inspection, so if it is necessary perform the hydrostatic test of that specific tank, it is necessary do it before the phase of commissioning .

In the commissioning all the pumps are tested e.g. the bilge pump or the pumps for the fresh water. When these systems are in function easily the tanks can be filled and discharged. During the commissioning all the electrical system are tested and calibrated, also the navigational equipment is ready for the inspection.

Commissioning is very important stage of the ship production, because is at this point are made all the trials on the main engine and how it interacts with the structure, it is at this time that vibrations are studied. The international rules (B.V. source) prescribes that an eventually shop test must be take place not later than the commissioning of the plant aboard ship.

During this stage the controls (local and remote) are also tested. In general, local manual controls are to be fitted to enable safe operation during commissioning and maintenance, and to allow for effective control in the event of an emergency or failure of remote control. The fitting of remote controls is not to compromise the level of safety and operability of the local controls.

Other system to be tested are propulsion shafting, steering gears, thrusters and dynamic positioning systems. Eventually leakage of oil for oil systems under pressure must be checked.

2.6. Ships Coordinating Department

The Ships Coordinating Department is under the Production Division. The ship coordinator defines the milestones of the planning and how to schedule them, this because not all the operations are compatible between them. So it is necessary establish a priority . Two or more operations are not compatible when they overlap on the same place and they go to act on the same part, system etc. of the ship. Or if two operations for safety reasons cannot be done close to each other, for example welding operation with painting. This because the paint is flammable so the ship coordinator must be assure that vapors do not take fire when there are free flames on board. Regarding the h. t. the ship coordinator decides the moment when it must performed, taking fully into consideration all the activities that are in conflict with it. It is important underline that the h. t. is not the only operation that the ship coordinator must supervise but he must have a general overview of all the ship with the main goal of the maximum operational efficiency and time saving.

3. SWOT ANALYSIS

The analysis SWOT is an instrument for support the strategy planning. It allows to summarize the points of strength and weakness and possibilities/threats of products, companies, projects, etc…The acronym SWOT stands for: Strengths Weakness Opportunities Threats.

At beginning of the SWOT analysis it is necessary to fix a target to reach, in this case it will: "Perform the Hydrostatic Test during the section stage". Direct competitor of this target it is the actual strategy used. The target must be SMART : Specific, Measurable, Achievable, Realistic, Time related.

The result of this analysis is a matrix 2x2 that summarize the elements emerged by the observation of the reality, external and internal environment and technology level. Different points of view must be taken into account , with several approach, at the end the SWOT analysis is a multidisciplinary work where a specific think tank could be formed.

	Internal Factors	External Factors
Favorable Factors	⌘ Time Saving ⌘ Prediction Planning ⌘ Efficient allocation of resources ⌘ Know how of the worker ⌘ Economic savings ⌘ Flexibility S	⌘ Possibilities of improvements by investments in equipments ⌘ New higher standards imposed by international rules O
Unfavorable Factors	⌘ Not sufficient resources for a full work load capacity ⌘ Constraints change ⌘ Complexity of the analysis W	⌘ Acceptance of the new strategy at the class society T

Table 1 – SWOT Analysis.

The reading of the SWOT matrix is easy and intuitive and it offers an helpful instrument for the guide of the subsequent development of the project.

One clarification is necessary, it is placed inside the block Opportunities the element: “Higher standards imposed by international rules”. This because a restriction of the actual rules bad crush on the actual strategy in use. But the new strategy offers more possibility of adaptation and so to receive the new rules and to provide a final product with higher quality and improved competitiveness on the market.

From this analysis it is possible to define the actions that will realize and improve the project. These action are defined for: magnify the strengths, mitigate the weakness, capitalize on the opportunities, curb the threats. The actions could influence the SWOT and generate the new points of strength and weakness.

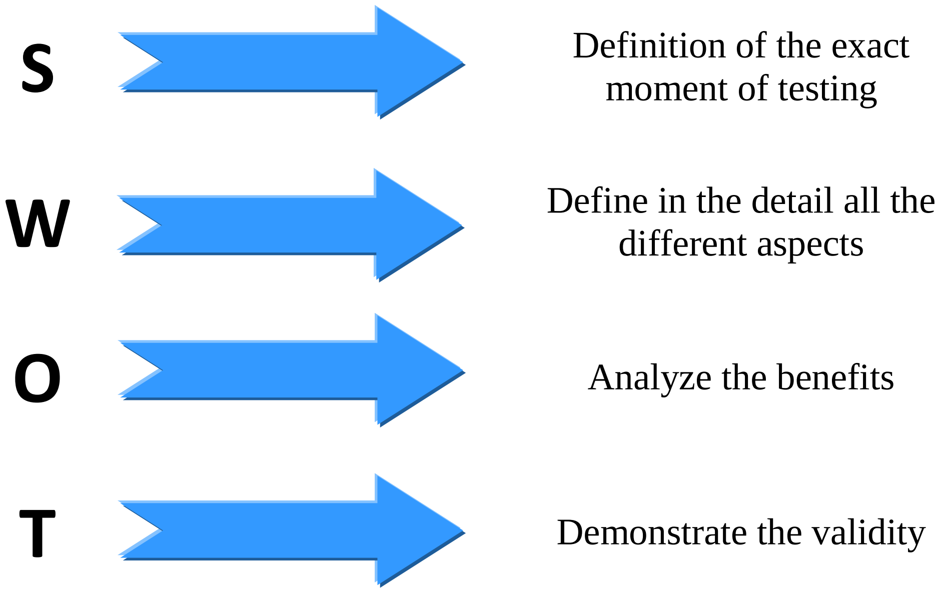


Table 2 – SWOT Actions.

If the actions are repeated for different points, these actions acquire a higher priority.

4. TYPES OF TEST ON THE TANKS.

According to the international regulations edit by IACS[1](unified rules for Class Societies) and Lloyd's Register[2] are defined different types of tests:

- Leak testing
- Hose testing
- Structural testing:
    - Hydrostatic testing
    - Hydro-pneumatic testing
- Other testing methods

It is necessary to underline that the tank can be tested with the purpose to prove different goals so different types of test are available. The definition of each type can be found in the rules with its applicability and limitations.

4.1. Leak Testing

Leak testing is an air or other medium test carried out to demonstrate the tightness of the structure. The rules prescribe:

- The pressure at which the test is performed is : 0,15 bar (0,15 kgf/cm2).
- It is recommended that the air pressure be raised to 0,2 bar (0,2 kgf/cm2) and kept at this level for about one hour to reach a stabilized state and then lowered to the test pressure prior to inspection.
- The test pressure must be verified with a pressure gauge, or alternative equivalent system.
- The test is performed prior to the application of a protective coating
- The test is carried out on:
    - All fillet welds
    - Erection welds on tank boundaries
    - All outfitting penetrations
    - Are excluded Automatic and Flux Core Arc Welding (FCAW) semi-automatic butt welds of

1 IACS. (2010). *Testing Procedures of Watertight*, S14, Req. 1996/Rev.3 2010.

2 Lloyd's Register. (July 2015). Procedures for testing tanks and tight boundaries. In *Rules and Regulations for the Classification of Ships, Part 3*. London.

the erection joints under conditions that a visual inspections shows continuous uniform weld profile shape.

4.2. Hose Testing

Hose testing has the objective to demonstrate the tightness of structural items not subjected to hydrostatic or leak testing and to other components which contribute to the watertight or watertight integrity of the hull. The rules prescribe:

- Maximum distance of 1,5 m
- A pressure not less than 2,0 bar (2,0 kgf /cm2).
- The nozzle diameter is not to be less than 12 mm.
- The jet is to be targeted directly onto the weld or seal being tested.

4.3. Structural Testing

Structural testing is a hydrostatic test carried out to demonstrate the tightness of the tanks and the structural adequacy of the design. Where practical limitations prevail and hydrostatic testing is not feasible, hydro pneumatic testing may be carried out instead.

When the structural test is performed afloat each tanks and cofferdam must be filled separately to the test head. Successively with half of the number of tanks full, the bottom and lower side shell in the empty tanks is to be examined and the remainder of the bottom and lower side shell is examined when the water is moved to the remaining tanks.

Some prescriptions for this kind of test are presented in the "**Rules and Regulations for the Classification of Ships**"[3] are:

- The attachment of fittings to oil tight surfaces is to be completed before tanks are structurally tested. Where it is intended to carry out structural tests after the protective coating has been applied, welds are generally to be leak tested prior to the coating application.
- For welds: other than manual and automatic erection welds, manual fillet welds on tank boundaries and manual penetration welds, the leak test may be waived provided that careful visual inspection is carried out, to the satisfaction of the Surveyor, before

[3] (Lloyd's Register, July 2015)

the coating is applied. The cause of any discoloration or disturbance of the coating is to be ascertained, and any deficiencies repaired.

4.3.1. Hydrostatic Testing

A hydrostatic test is a way in which tanks can be tested for ensure the safety, reliability, and leak tightness of pressure systems. A test is required for a new system under pressure before the use or an existing pressure system after repair or alteration. In a shipbuilding process a hydrostatic test is performed before sea trials. The tests must always be performed under controlled conditions, following an approved test plan, and documented in a test record. A single approved test plan may be used for several similar tests, but a separate test record is required for each.

The test involves filling the tank with a liquid, usually water and measuring permanent deformation of the tank. The presence of water inside the tank creates a hydrostatic head on the sides of the tank consequently the structure must be stiff enough to sustain this pressure.

The value of the height of the water column prescribed by the rules can be equal to the value of the overflow or increased. For increase the water column it is added on the tank top a temporary pipe to reach the height missing. The maximum value is established on base of the type of tank and its position.

Item number	Structure to be tested	Type of testing	Structural test pressure	Remarks
1	Double bottom tanks	Structural testing [1]	The greater of the following: • head of water up to the top of overflow • head of water up to the margin line	Tank boundaries tested from at least one side
2	Double side tanks	Structural testing [1]	The greater of the following: • head of water up to the top of overflow • 2.4 m head of water above highest point of tank	Tank boundaries tested from at least one side
3	Tank bulkheads, deep tanks	Structural testing [1]	The greater of the following [2]: • head of water up to the top of overflow • 2.4 m head of water above highest point of tank • setting pressure of the safety relief valves, where relevant	Tank boundaries tested from at least one side
	Fuel oil bunkers	Structural testing		
4	Ballast holds in bulk carriers	Structural testing [1]	The greater of the following: • head of water up to the top of overflow • 0.90 m head of water above top of hatch	
5	Fore peak and after peak used as tank	Structural testing	The greater of the following: • head of water up to the top of overflow • 2.4 m head of water above highest point of tank	Test of the after peak carried after the stern tube has been fitted

	Fore peak not used as tank	Refer to SOLAS Ch. II.1 Reg. 14		
	After peak not used as tank	Leak testing		
6	Cofferdams	Structural testing [3]	The greater of the following: • head of water up to the top of overflow • 2.4 m head of water above highest point of tank	
7	Watertight bulkheads	Refer to SOLAS Ch. II.1 Reg. 14 [4]		
8	Watertight doors below freeboard or bulkhead deck	Refer to SOLAS Ch. II.1 Reg. 18		
9	Double plate rudders	Leak testing		
10	Shaft tunnel clear or deep tanks	Hose testing		
11	Shell doors	Hose testing		
12	Watertight hatch covers of tanks in bulk-carriers	Hose testing		
	Watertight hatch covers of tanks in combination carriers	Structural testing [1]	The greater of the following: • 2.4 m head of water above the top of the hatch cover • setting pressure of the safety relief valves, where relevant	At least every 2nd hatch cover are to be tested
13	Weathertight hatch covers and closing appliances	Hose testing		
13	Weathertight hatch covers and closing appliances	Hose testing		
14	Chain locker (if aft of collision bulkhead)	Structural testing	Head of water up to the top	
15	Independent tanks	Structural testing	Head of water up to the top of the overflow, but not less than 0.9 m	
16	Ballast ducts	Structural testing	Ballast pump maximum pressure	

Table 3 - Specifications of the water column height on the base of the type of tank. (IACS, 2010)

Every test has its particularity and it can change on the base of the type of the tank, its position, its accesses, etc. For example in the Fig. 4 it is show a tank with a hydrostatic head of 2,4 m. This height it is composed by the height of the tank 1,8 m plus an additional pipe of 0,7 m. The resulting pressure is the pressure of the test.

Under the action of this force the external side of the tank is inspected and verified the absence of a permanent deformation. When the tank is emptied the internal also can be inspected, but according to the rules at least one side must be accessible.

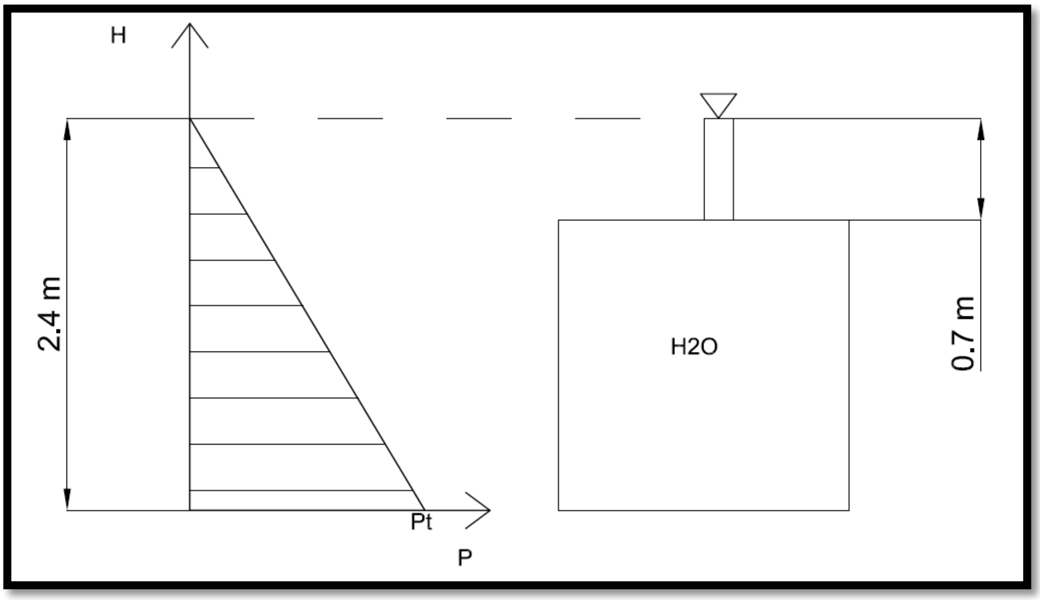


Fig. 4 - Sketch Hydrostatic Test.

4.3.2. Hydro-pneumatic Testing

This test is a combination of hydrostatic and air testing. The tanks is partial filled with liquid and is applied an additional air pressure. Where practical limitations prevail and hydrostatic testing is not feasible (for example when it is difficult, in practice, to apply the required head at the top of the tank), hydro-pneumatic testing may be carried out instead. When a hydro-pneumatic testing is performed, the conditions should simulate, as far as practicable, the actual loading of the tank. The value of the additional air pressure is at the discretion of the class society.[4]

In the Fig. 5 it is shown the total pressure on the wall, but if the tank has already liquid inside can be to effectuate an hydro-pneumatic test.

In this case part of the pressure is given by the hydrostatic load (green line) of the liquid (that does not reach the prescribed height) and the remaining by the air (blue line) with a pressure of 0,2 bar.

In this case the tank is subject to an extra-pressure, given by the superposition of the two loads. The two tests are equivalent but the hydro-pneumatic involves risks because an excessive air pressure (compressive effect) can cause damages to the structure of the tank. The hydro-pneumatic test must be done with caution.

[4] (IACS, 2010)

It was noted that for the tanks aimed to contain oil, the actual structural test plan in use for the PSV 5000 in D.S.G. contains instructions to carry out the structural test with oil and compressed air instead of fill the tanks only with water. In this case it is used an hydro-pneumatic test, with 10% of Fuel Oil plus air at pressure of 24 kN/m^2.

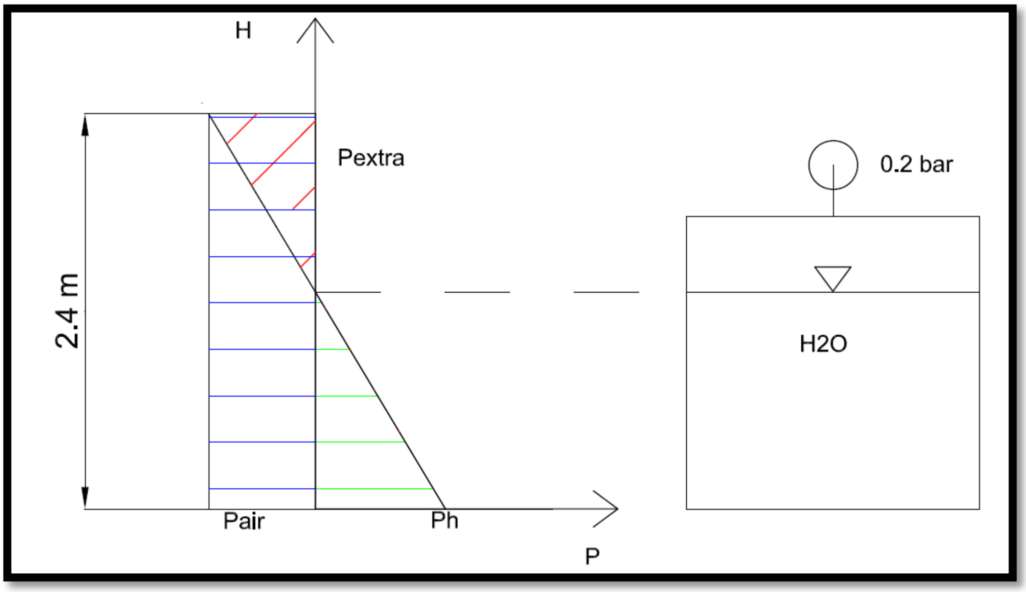


Fig. 5 - Sketch Hydro-pneumatic Test.

5. PRINCIPAL CONCERNS FROM THE CURRENT H. T.

Currently in D.S.G. the h. t. is performed after the launching of the vessel. This solution is taken in consideration of the facts that the tanks are completed and the principal systems on board, like pumps and off valves are ready to enter in function. These make the operations of testing more easy because they move big masses of liquid from one tank to the other one without external support. Moreover with the floating vessel there are not any concerns regarding the extra loads distributed on the supports caused by the masses of water.

In contrast with these advantages, the current solution has the following concerns that must be taken into account.

1) An efficient strategy handles also the worst possible scenario and not only the case that everything goes according to the plans. The execution of h. t. during the commissioning has a critical event whose consequences must be predicted. This is the case of the tank that fails the test. If the tank is not stiff enough and permanent deformations will occur, it cannot be certified by the Class Society and the ship cannot be delivered. This problem will affect the engineering department that must redesign the tank and inevitably the production chain will stop and be compromised. The commissioning phase is very close to the delivery day and there is little time to undertake for a satisfactory solution. Furthermore if a huge structural modifications are required, it becomes a difficult task to solve in late state of construction. It will require an high destruction level of the systems and of the outfitting, which are already completed and in function.

   If the non compliance is extremely serious, it can require modifications of the hull. It is possible only in case the vessel is reallocated in the dry dock. Bringing back the ship on the blocks, is time consuming and the whole refitting operations will rise dramatically the costs for the shipyard. A these, it must be added the huge contractual penalties for each day of delay.

2) Small delays usually are propagated along the production chain and the tendency is to cover them during the outfitting and commissioning operations. These are not so serious to bring a delay on the delivery day but they create a degree of uncertainly that makes difficult the prediction of the exact day of execution of the h. t.. In fact the h. t. is not scheduled with precision in the present planning document.

3) The hydrostatic test is not allowed to be performed when it is in course the alignment of the engine because the ship must be position without heel angle or difference of draft.

4) Tanks with end use to contain fresh water, after the painting are tested exclusively with fresh water (expensive).
5) Impossibility to paint a surface, because the presence of water in the tank create on the external surface condense.
6) The presence of insulation panels already installed that obstruct the inspection.
7) After the h. t. eventually could be necessary to restore the painting and coating that were damaged during the testing operations. But the painting is not compatible with the welding operations. This because the paint is flammable and it must be sure that vapors do not take fire when there are free flames on board.
8) After the launching of the vessel, there is the tendency to put the systems on board in function as soon as possible. Systems like generators, pumps, engine require fuel and oil in the tanks. Their presence prevent to fill the tanks with water. This oblige to use hydro-pneumatic test instead of the h. t. or to realize a degassing of the tank. This operation is very costly and time consuming.

6. FEASIBILITY ANALYSIS OF THE H. T. IN A EARLIER STAGE

The main goal is to find the point of construction stage where technically it is possible to carry out the h. t.. The documentation used for such study are provided by the Engineering & Production Support Department and they represent the starting point because the PSV 5000 is a project already existing, and several units are already produced. Thus the thesis is going to insert in a whole system well proven, without disturb and minimizing the interferences with other production aspects. In detail these documents are:

1) **General Arrangement**, in this document it is possible to see the main dimensions of the vessel, the subdivision of the spaces, the disposition of the rooms (engine room, cabins ,control rooms, etc.), disposition of the equipments. Inside are contained many section views of different decks.

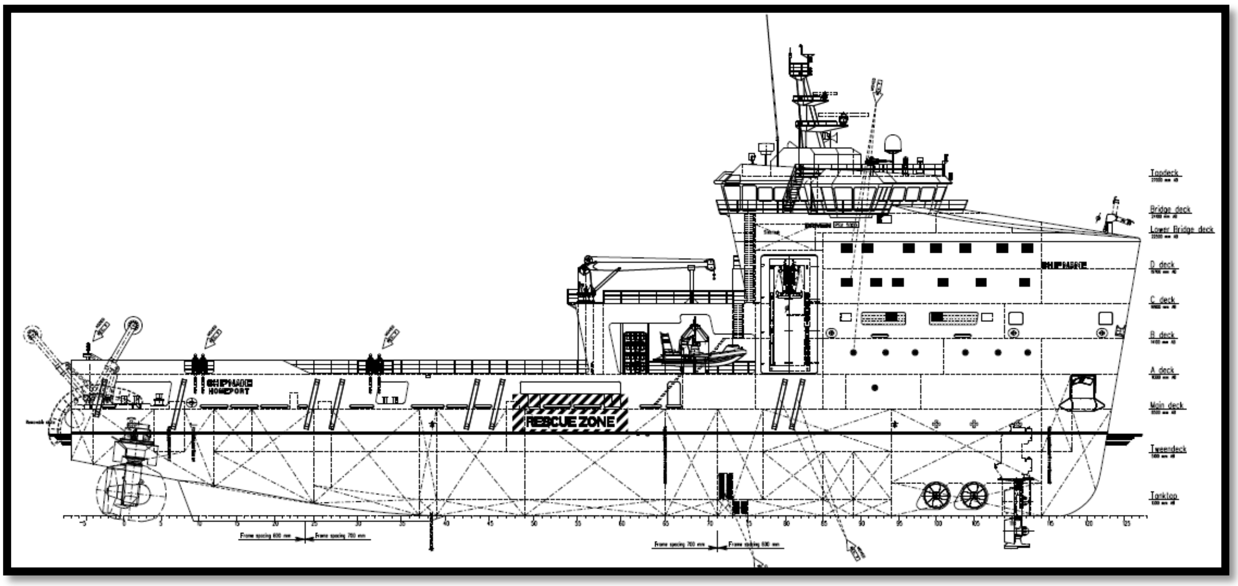


Fig. 6 - General Arrangement PSV 5000. DAMEN Copyright.

2) **Block Fabrication Plan**, it is the general division of the ship in blocks and how it is arranged for the production. It identifies each single block and adjacent blocks. The Block Fabrication Plan is strictly interconnected with the Building Strategy. It visualizes the division in modules, in batches and more in detail the division in blocks. Also in this document there are different section views to make more clear and simple the identification of the elements. The blocks are solely identified with a number e.g. 305-1 where the first number indicate the level from bottom to up, the 05 indicate the longitudinal position starting from the bow and -1 the side (-1 portside, -2 starboard, -0 central).

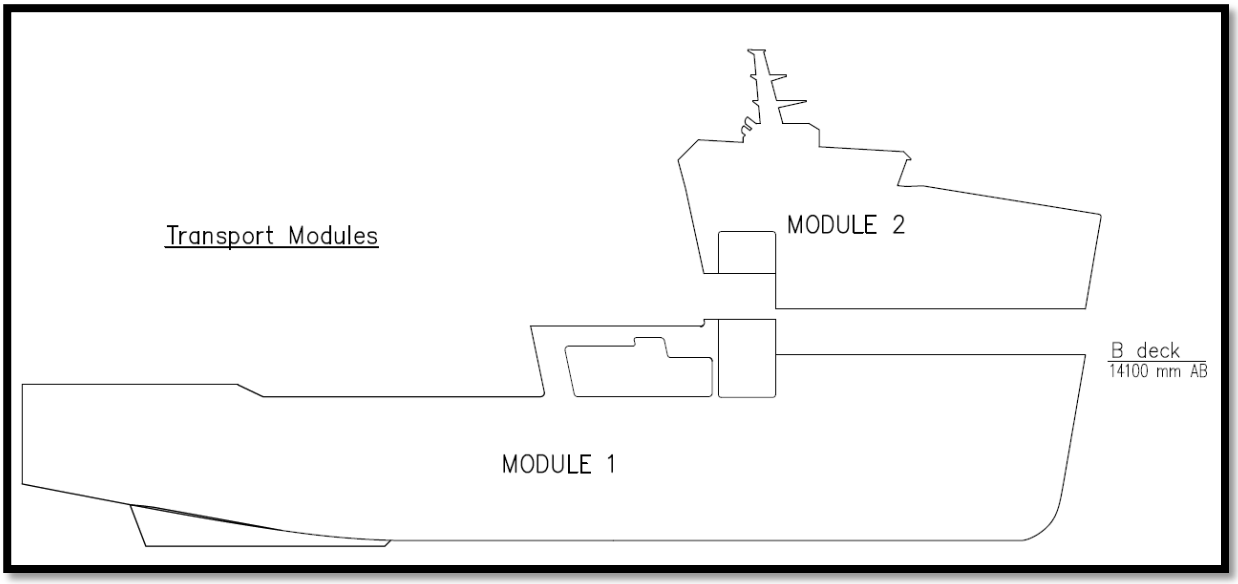


Fig. 7 - Block Fabrication Plan, module division. DAMEN copyright.

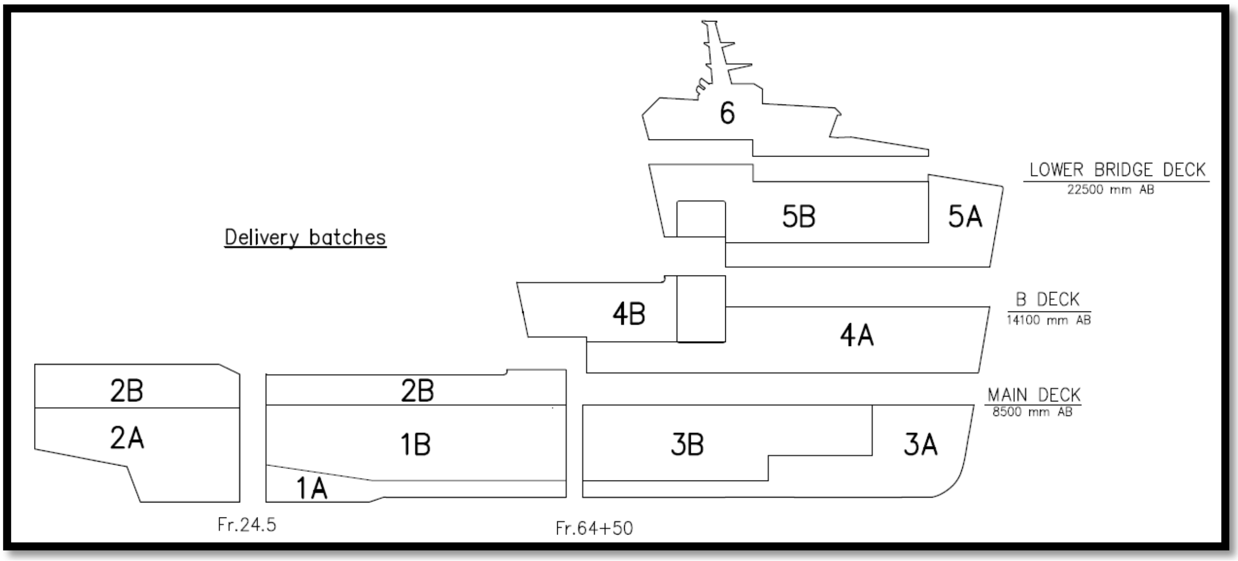


Fig. 8 -Block Fabrication Plan, batch division. DAMEN copyright.

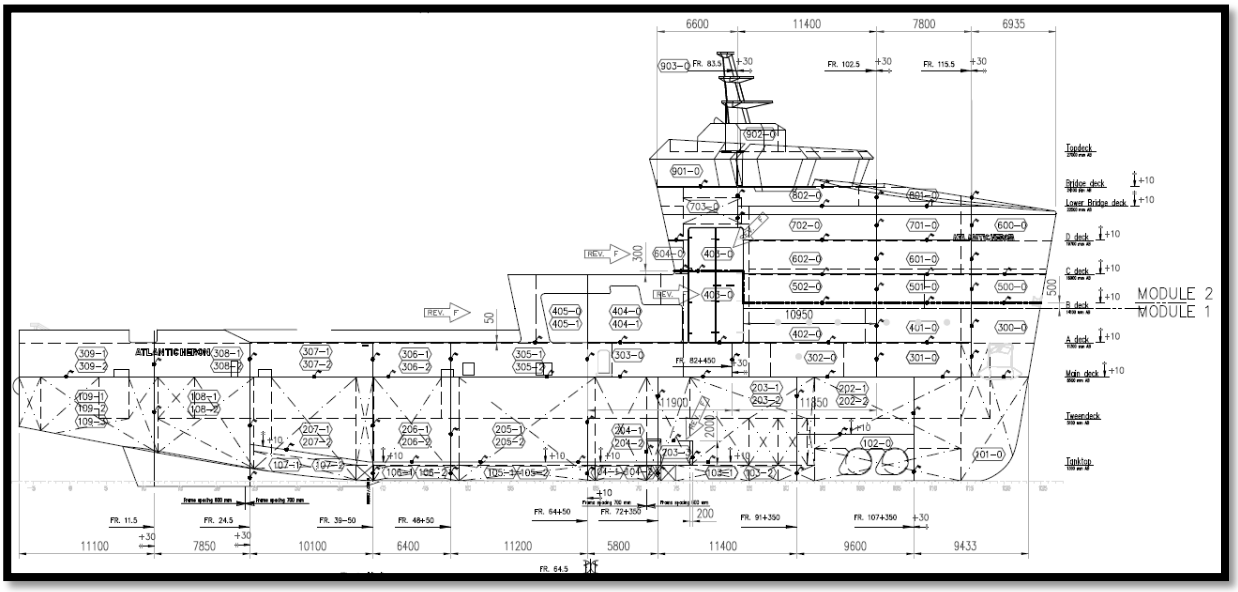


Fig. 9 - Block Fabrication Plan, block division. DAMEN copyright.

3) **Space Identification Plan**, it is the detailed plan where each single volume is defined and it is specified its destination of use. Several horizontal and transversal sections are inside the document.

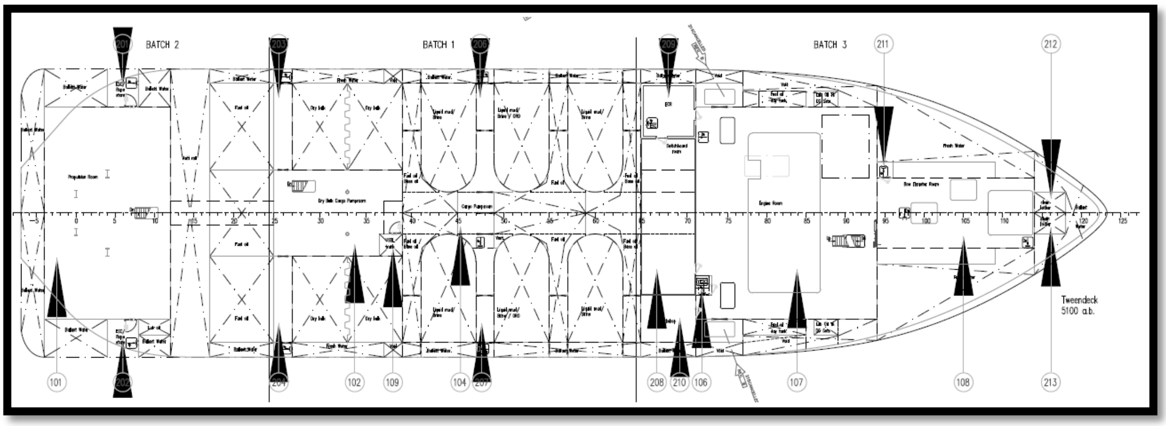


Fig. 10 - Space Identification Plan, tween deck horizontal section. DAMEN copyright

4) **Docking Plan,** in this plan are identified the relative positions between the supports and the hull. It indicates also the type of each support.

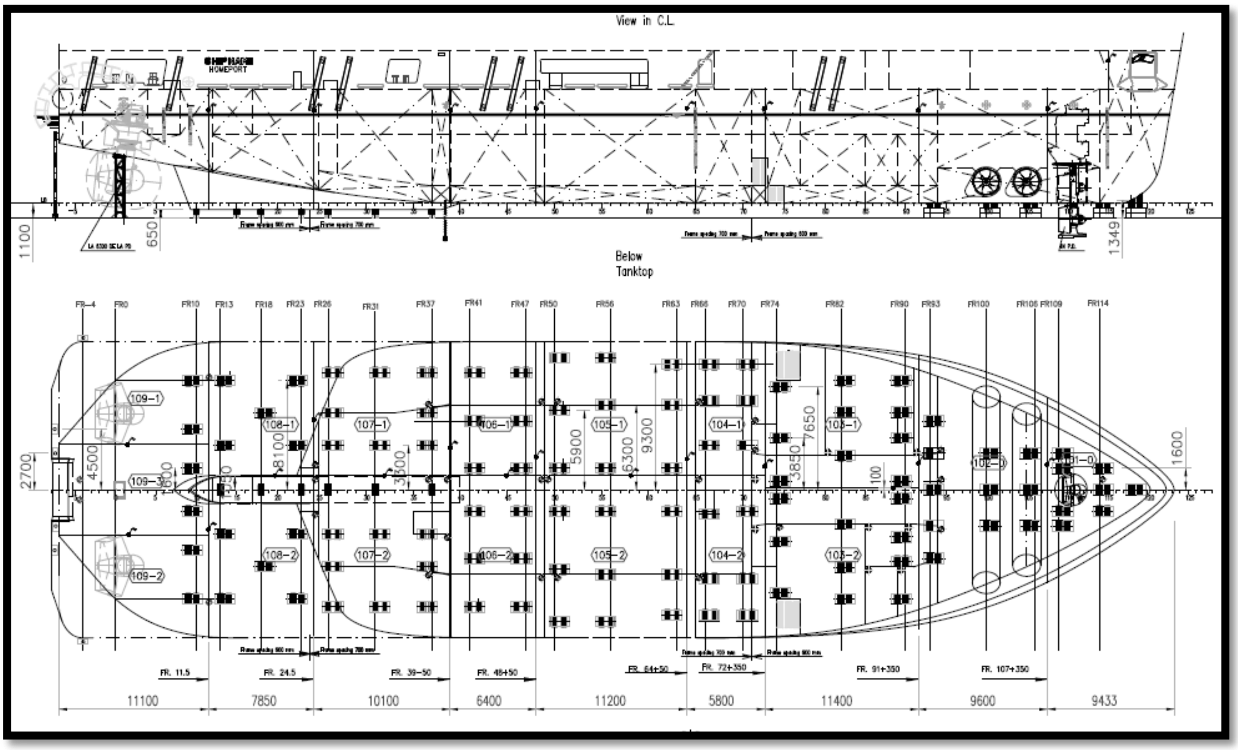


Fig. 11 - Docking Plan. DAMEN copyright.

5) **I.T. 2222 E**, it is an internal document of D.S.G.. It is a list of detailed instructions that must be observed when the technical inspections are performed on the tanks. It indicates the tools that must be used, how these tools must be used and how the

inspection must be conducted. It foresees different operational cases like under 0°c temperature conditions.

6) **Tank Capacity Plan And Table**, in this plan every tank is defined for compartment, destination of use, position, volumetric capacity and moment of inertia.
7) **Building Strategy**, it is the document where is shown in detail all the subsequent steps of the construction of the ship. Scrolling the document, it is possible identify the sequence of all the sections that are added to the assembling of the vessel. For the PSV 5000 currently in D.S.G. there are three under construction, two with equal strategy and one with different one. Each ship in construction has its own document titled Building Strategy. For this study it is used the PSV 5000 #2 located in the dry dock.

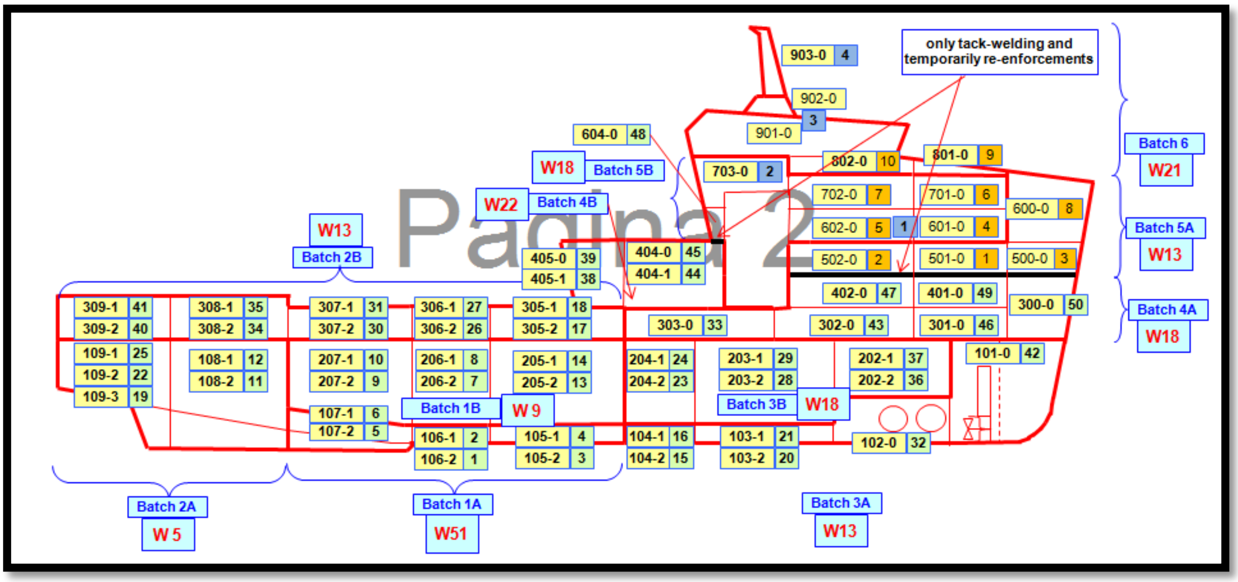
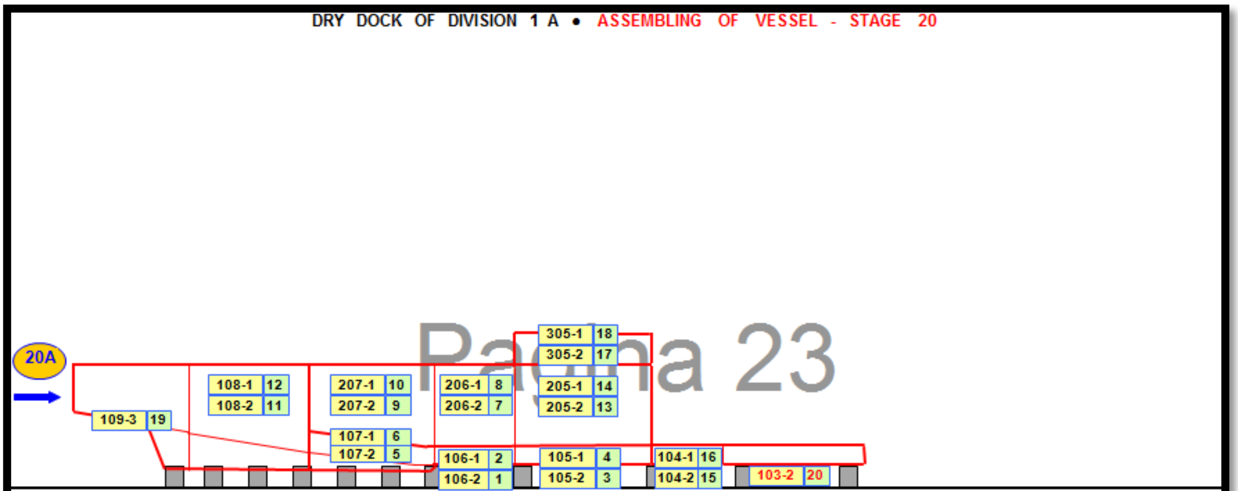


Fig. 12 - Building Strategy PSV 5000#2. DAMEN copyright.

Every block is identified with the same number of the Block Fabrication Plan plus the stage number of the assembling of the vessel. Moreover along the development of the assembling in this plan are indicated activities that must be done before of the assembling of one unit at the main construction, because some critical equipments must be installed, otherwise forward is obliged to make a cutoff in the structure for have the access at the location. For example at the stage 20 there is the activity 20A (installation of Propulsion Thrust Drivers, etc., in the propulsion room).



Building Strategy	Put in parts	Location	Deck	Space no.	Identification number	Rev.
20A	**In Propulsion Room after assembling 109-3**			101		12,01
	AC 7 (0,88t) (IFS DG00991)				372A0007	23,03
	Propulsion Thruster Drives (5,6t) (2x) (IFS BSF1601(Ps)/1602(Sb))				14E7000 Ps / 7002 Sb	23,03
	HPU Shark JAW & Towing pins (1,15t) (IFS 1296668)				550A1006	23,03
	HPU Pump starter (0,07t) (2x) (IFS DG01075(Ps) / 1074(Sb))				213E1002/1001	23,03
	HPU Azimuth Thruster (1,4t) (2x) (IFS DG01069(Ps) / 01068(Sb))				213A1003 / 1002	23,03
	HPU Towing & Hose securing (0,95t) Sb (IFS 1296604)				550A0003	23,03

Fig. 13 - Building Strategy at stage 20. DAMEN copyright.

8) **Tank Pressure Test And Structural Test Plan**, this is the detailed plan where each tank that must be tested is identified and the type of test that must be performed on that specific tank (Structural or Pressure test). In addition to the tank characteristics, also the information like "head of liquid above base line" regarding the h. t. are indicated.

The whole analysis is structured in three main steps. The **Building Strategy Analysis** that returns eligible stage points where to perform the h. t.. Subsequently these points are subjected to the **Planning Analysis** for obtain the calendar date of starting and ending. When are obtained points of the building process structurally suitable, these are inserted in the **Load Analysis** and eventually rejected if the total load on each support below the ship exceed the limit of 50 tons. Moreover for each tank must be analyzed the singular peculiarities that influence the whole process of testing.

This process is not divided in separate non-communicating blocks, but it is a continuous iterative process, where elements of different analysis could influence between themselves.

6.1. Building Strategy Analysis

Initially it is necessary to identify the tanks that are subjected to the test. From the Tank Pressure Test And Structural Test Plan it is read that the tanks number: 1, 3, 4, 10, 12, 13, 14, 29, 30, 33, 34, 37, 38, 43, 45, 48, 49, 55, 63, 66, 68, 73, 76, 77 must be structural tested. Not all the tanks on board are tested but only a sample number. Naturally these are not chosen in random way but on the base of specific criteria of: volume, position, type and destination of use. For tanks similar it is required only a test on single unit. It is for this reason that the Tank Pressure Test And Structural Plan is pre-approved by the Class Society.

Using the Tank Capacity Plan it is possible to collect all the information necessary regarding the position and the volume. A superposition of the drawings is possible because they are made for the same section views. Knowing the exact positions of the tanks respect the frames of the ship it is possible to identify the fabrication blocks at which each tank belongs. With this purpose it is used the Block Fabrication Plan that contains all the boundaries block for the whole vessel. Each block contains part of the unit in fabrication, for reasons of efficiency these are assembled in the specific workshops/assembling areas and after their completion, are transported in the dry dock (PSV 500#2 case) or in another area where the blocks are erected and joined together. An example of block is in the Fig. 12. It is possible to notice that the outfitting is partially complete and the tank on the left is not entire. So it is necessary the junction with the other block to complete the tank.

Fig. 14 - Block unit. DAMEN copyright.

During the analysis of the plan it was understood that only few tanks have the volume completed in one single block unit but the others due to their big dimensions are structurally complete only with the combination of two or more units.

N° of tank that must be structural tested	**N° of unit in the building strategy**	**Tank completed in the block unit**	**Stage at which the block is added to the main structure**
B.W.			
1	101-0	yes	42
3	102-0; 101-0	no	32;42
12	103-2	yes	20
29	204-2; 204-1	no	23;24
30	204-1	yes	24
37	105-2; 205-2	no	3;13
48	206-2; 206-1; 205-2; 205-1	no	7;8;13;14
49	206-1; 205-1	no	8;14
66	108-1; 207-1	no	12;10
76	108-2; 109-2	no	12;22
77	109-3; 109-1	no	19;25
Fresh Water			
4	202-1; 101-0	no	37;42
55	107-2; 107-1; 207-2; 207-1	no	5;6;9;10
63	107-2	yes	5
Fuel Oil			
14	203-2	yes	28
33	104-1; 204-1	no	16;24
34	104-2; 204-2	no	15;23
68	107-2; 107-1; 207-2; 207-1; 108-1;108-2	no	5;6;9;10;11;12
Fuel Oil Cargo			
38	105-1; 205-1; 104-1; 204-1	no	4;14;16;24
43	105-2; 205-2; 104-2; 204-2	no	3;13;15;23
Liquid Mud			
45	105-2; 205-2	no	3;13
Anti-Roll			
73	180-2; 108-1	no	11;12
Miscellaneous			
10	103-2	yes	20
13	103-2; 103-1; 102-0	no	20;21;32

Table 4 - Block units containing the tanks

From the Building Strategy, it is possible to know at which stage each block is added to the main structure. N. b. the stage does not identify a temporal moment but an order of activity, two or more activities not in contrast between them could be advanced in contemporary.

Only 6 six tanks are entire when the block is completed, but the test cannot be performed in this moment on these units. Because the only load that acts on the structure is the hydrostatic pressure. Weights of the upper structures and equipments are not present and the hull integrity misses. Thus the conditions of testing are far from the final state of construction and service, so the structural response cannot be the same and test does not have any effectiveness.

For the same reasons must be exclude execution of the test at stage 25 where the tanks in the aft part are structurally complete. At stage 25 the aft part is not complete, the hull is assembled only till the main deck, still remain blocks to be added upper the main deck.

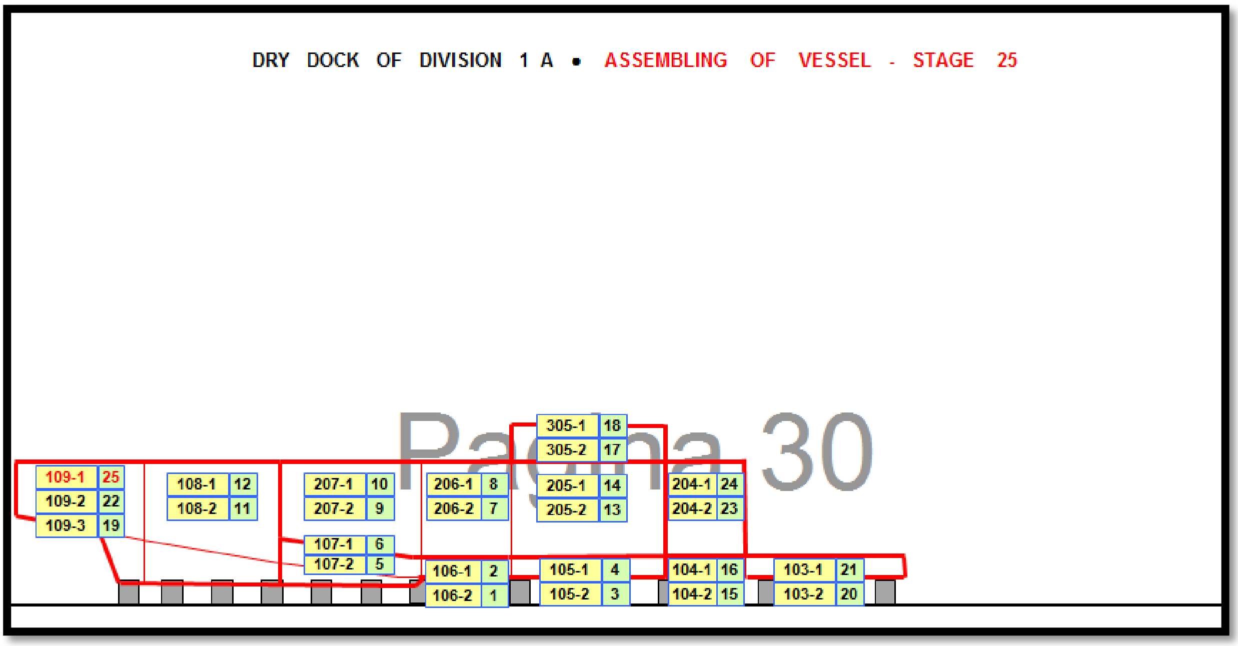


Fig. 15 - Building Strategy at stage 20. DAMEN copyright.

Same observation is made regarding the stage 42 where it is reached the completion of the tanks located in the fore part of the ship. Moreover in the stages 25 and 42 the assembling of the block units at the main structure is not complete, so for perform the test, the operations of erection are interrupted for 2-3 days. This is a disadvantage for the entire production chain. Thus the moments of testing must be moved forward in the building strategy.

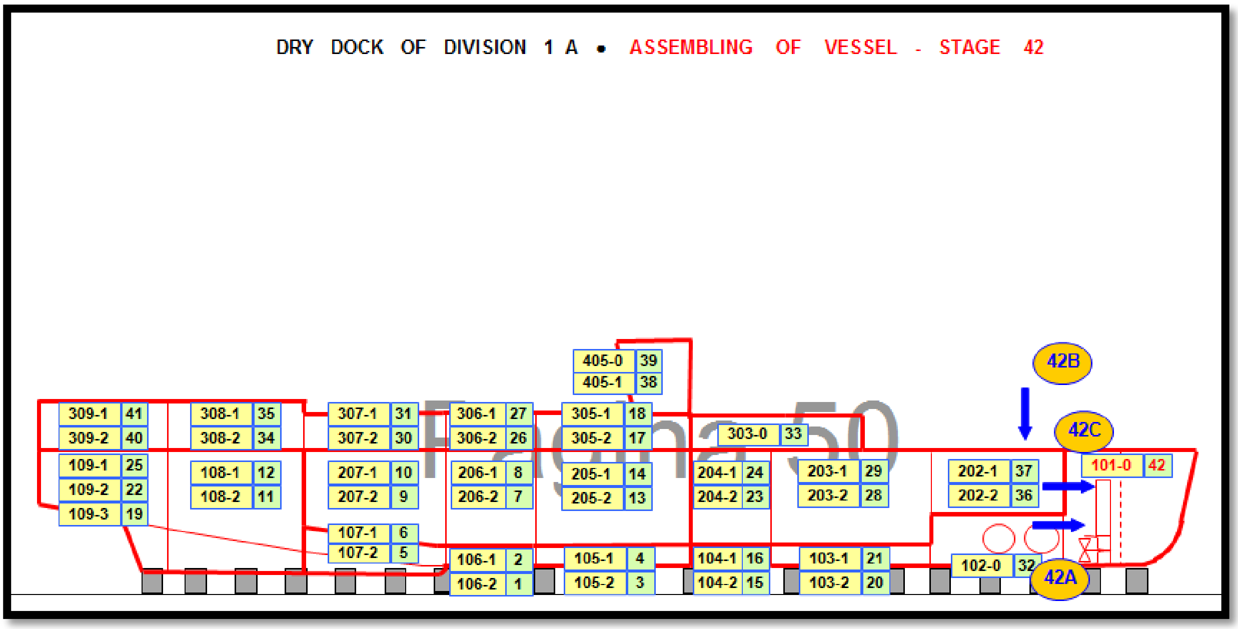


Fig. 16 - Building Strategy at stage 20. DAMEN copyright.

In contrast with the previous stages, the tests are run when an advanced completion of the structure is reached, in such way is possible to have integrity of the structure and all the loads weigh upper the tanks and have a correct distribution on the supports.

In this case are present two moments when the tanks are tested, phases that divides tanks in the fore part and tanks in the aft part. This was made in consideration of the fact that the development of the assembling starts from the center going to left till the stern and from the center to right till the bow. The tests of the tanks in the aft part of the vessel are postponed till the stage, where all the stern structure is completed, this is happen at stage 41.

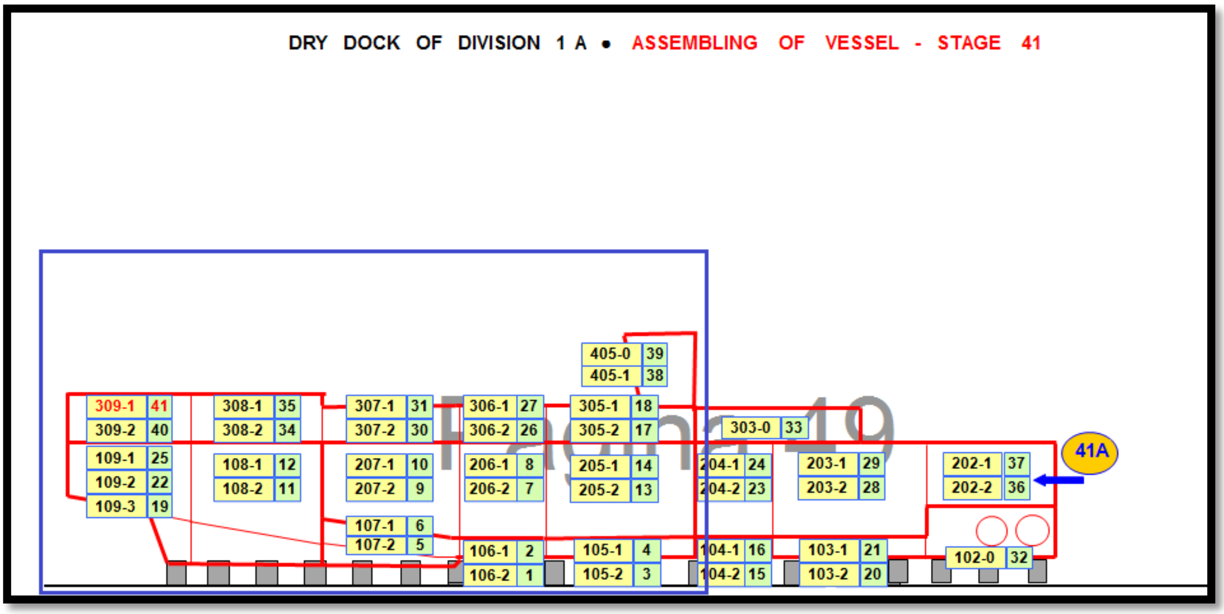


Fig. 17 - Building Strategy at stage 41. DAMEN copyright.

The structure of the aft part is complete and the main loads like engines, generators, pumps are installed on board, so the proposal is to perform in this moment the tests. Because with stage 41 (with the assembling of the block 309-1) the stern is completed, at the same time is possible to progress with the assembling of the fore part like it is planned in the building strategy meanwhile the tests are performed without stop the operations of erection.

The tanks that are suitable for the structural test at this stage, according with the Structural Test Plan document, are:

Type	**N° of tank**
B.W.	37, 48, 76, 77, 66, 49
F.W.	63, 55
Fuel Oil	68
Fuel Oil Cargo	43, 38
Liquid Mud/Brine	45
Anti-Roll	73

Table 5 - Tanks in the aft part.

These tanks are all located at left of the frame 65, locking the longitudinal section, and they are below the main deck with the upper structure completed.

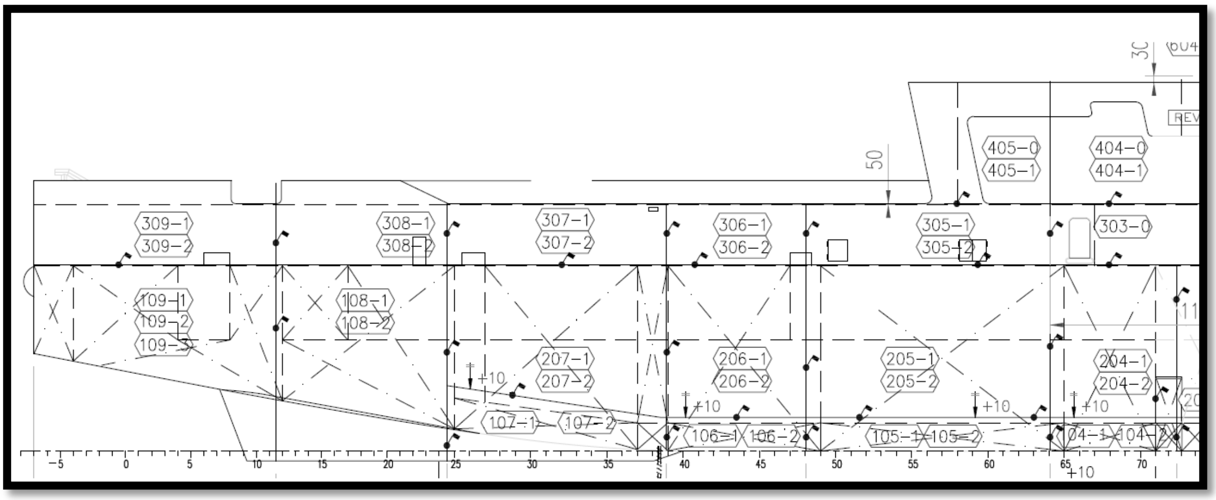


Fig. 18 - Stern part of the ship. DAMEN copyright.

The remaining tanks to be tested are located in the fore part of the vessel, at the right of the frame 65, locking the longitudinal section. These are structural completed and with the critical equipments installed (generators, anchoring and maneuvering systems,….) at the stage 50. At the main structure must be added the superstructure, built with separate sequence.

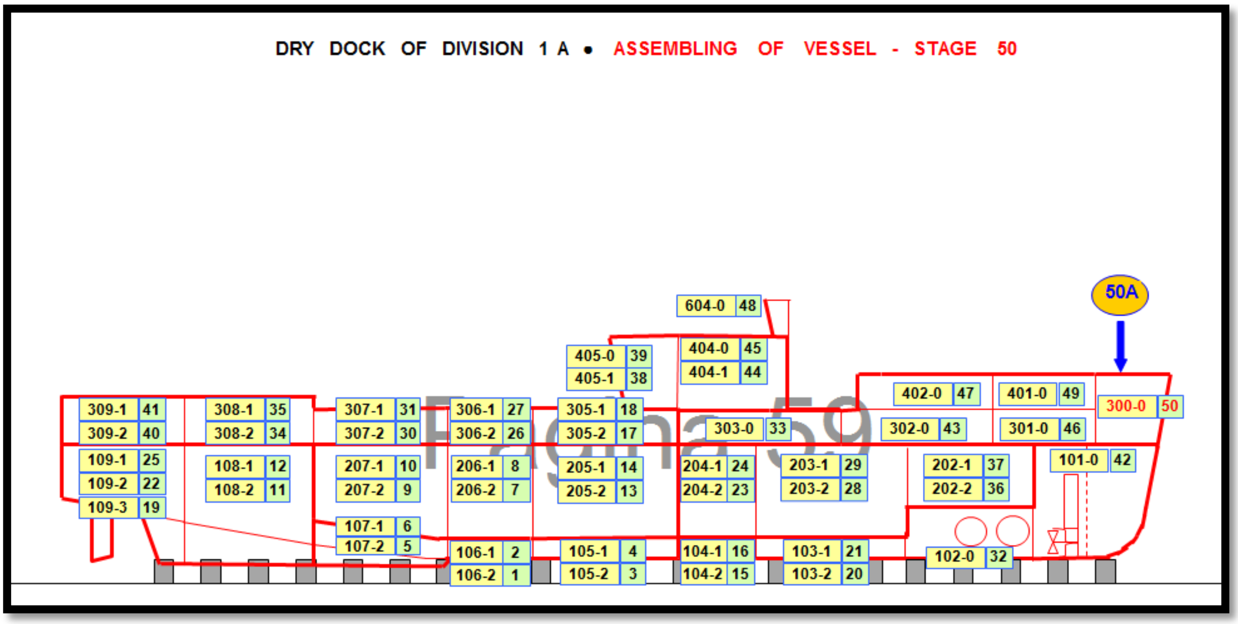


Fig. 19 - Building Strategy at stage 50. DAMEN copyright.

The remaining tanks to be structural tested are:

Type	N° of tank
B.W.	12, 3, 1, 29, 30
F.W.	4
Miscellaneous	13, 10
Fuel Oil	14,33, 34

Table 6 - Tanks in the fore part.

In the Block Fabrication Plan, they are individuate:

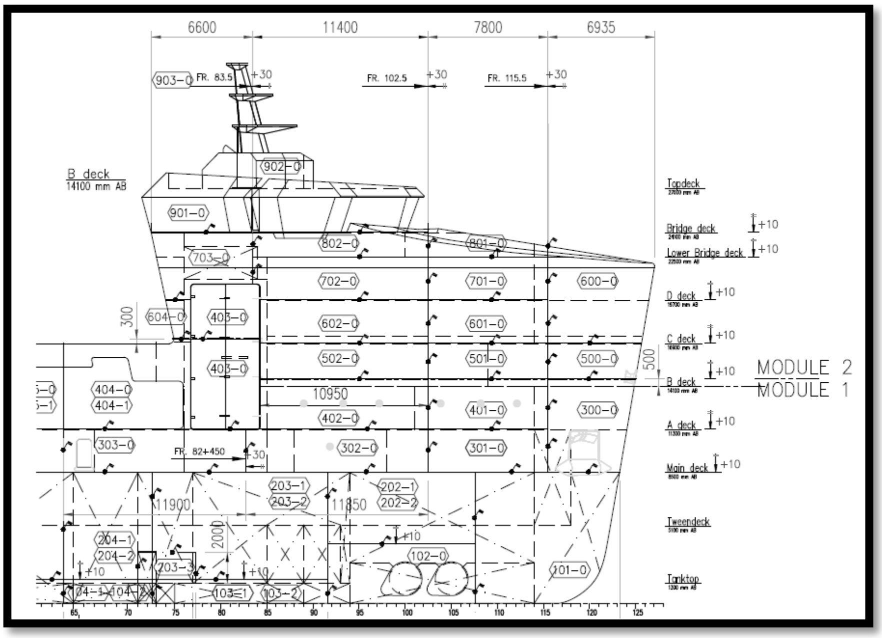


Fig. 20 - Bow part of the ship. DAMEN copyright.

The advantages obtained choosing stages 41 and 50, as points in the building strategy for perform the tests, are :

- The structure is completed when the tests are performed.
- The assembling of the blocks is not interrupted, no overlapping of the test with erection operations.
- All the main loads on board (critical equipment +weight of the structure) are present.

The second advantage in the previous list, makes more simple to insert in the actual construction planning of D.S.G. the hydrostatic test scheduling in the earlier stage. Indeed meanwhile the tests are performed in the aft part of the ship, the assembling continues in the fore part, giving continuity at the production flow.

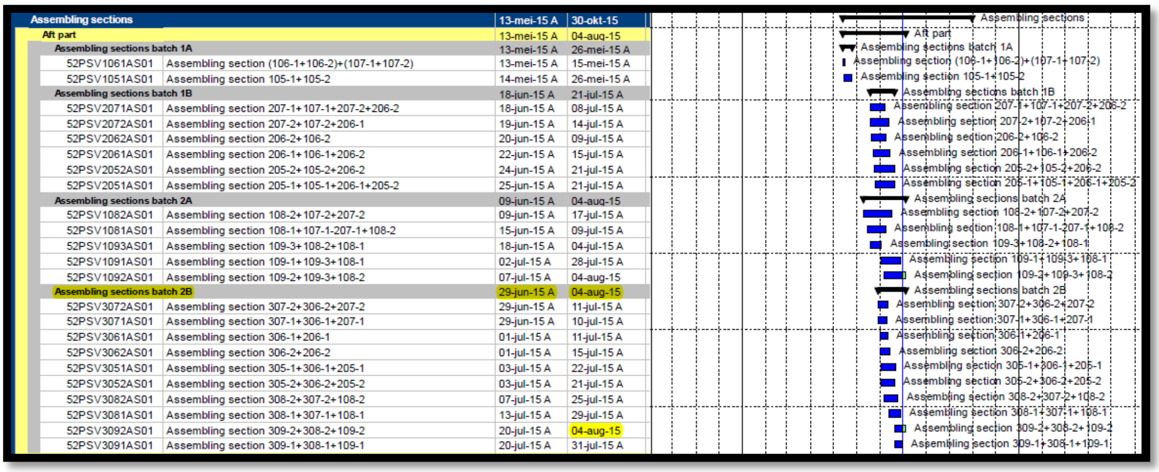
The successive step is to analyze the actual planning and to obtain which calendar dates correspond for the stages: 41 and 50.

6.2. Planning Analysis

It is analyzed the interaction of the previous proposals of h.t. in earlier stage on the actual planning for the PSV 5000#2. The two stages to identify in the planning are 41 and 50.

6.2.1. Stage 41

The stage 41 corresponds to that moment of the building process where all the stern structure is completed. The level of completion desired is reached in date 04August2015, with the assembling of the block 309-1 to the blocks 308-1 and 109-1.

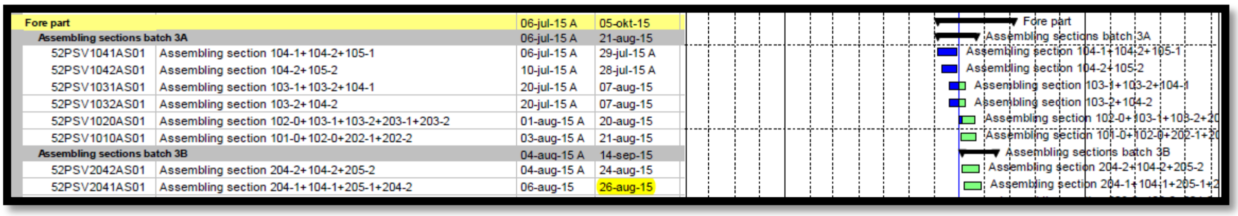


Assembling sections		13-mei-15 A	30-okt-15
Aft part		13-mei-15 A	04-aug-15
Assembling sections batch 1A		13-mei-15 A	26-mei-15 A
52PSV1061AS01	Assembling section (106-1+106-2)+(107-1+107-2)	13-mei-15 A	15-mei-15 A
52PSV1051AS01	Assembling section 105-1+105-2	14-mei-15 A	26-mei-15 A
Assembling sections batch 1B		18-jun-15 A	21-jul-15 A
52PSV2071AS01	Assembling section 207-1+107-1+207-2+206-2	18-jun-15 A	08-jul-15 A
52PSV2072AS01	Assembling section 207-2+107-2+206-1	19-jun-15 A	14-jul-15 A
52PSV2062AS01	Assembling section 206-2+106-2	20-jun-15 A	09-jul-15 A
52PSV2061AS01	Assembling section 206-1+106-1+206-2	22-jun-15 A	15-jul-15 A
52PSV2052AS01	Assembling section 205-2+105-2+206-2	24-jun-15 A	21-jul-15 A
52PSV2051AS01	Assembling section 205-1+105-1+206-1+205-2	25-jun-15 A	21-jul-15 A
Assembling sections batch 2A		09-jun-15 A	04-aug-15
52PSV1082AS01	Assembling section 108-2+107-2+207-2	09-jun-15 A	17-jul-15 A
52PSV1081AS01	Assembling section 108-1+107-1-207-1+108-2	15-jun-15 A	09-jul-15 A
52PSV1093AS01	Assembling section 109-3+108-2+108-1	18-jun-15 A	04-jul-15 A
52PSV1091AS01	Assembling section 109-1+109-3+108-1	02-jul-15 A	28-jul-15 A
52PSV1092AS01	Assembling section 109-2+109-3+108-2	07-jul-15 A	04-aug-15
Assembling sections batch 2B		29-jun-15 A	04-aug-15
52PSV3072AS01	Assembling section 307-2+306-2+207-2	29-jun-15 A	11-jul-15 A
52PSV3071AS01	Assembling section 307-1+306-1+207-1	29-jun-15 A	10-jul-15 A
52PSV3061AS01	Assembling section 306-1+206-1	01-jul-15 A	11-jul-15 A
52PSV3062AS01	Assembling section 306-2+206-2	01-jul-15 A	15-jul-15 A
52PSV3051AS01	Assembling section 305-1+306-1+205-1	03-jul-15 A	22-jul-15 A
52PSV3052AS01	Assembling section 305-2+306-2+205-2	03-jul-15 A	21-jul-15 A
52PSV3082AS01	Assembling section 308-2+307-2+108-2	07-jul-15 A	25-jul-15 A
52PSV3081AS01	Assembling section 308-1+307-1+108-1	13-jul-15 A	29-jul-15 A
52PSV3092AS01	Assembling section 309-2+308-2+109-2	20-jul-15 A	04-aug-15
52PSV3091AS01	Assembling section 309-1+308-1+109-1	20-jul-15 A	31-jul-15 A

Fig. 21 - Extract of the planning PSV#2. DAMEN copyright.

But two more date are emerged from the Planning Analysis due to the grade of completion of the whole structure: 24August2015 and 18September2015.

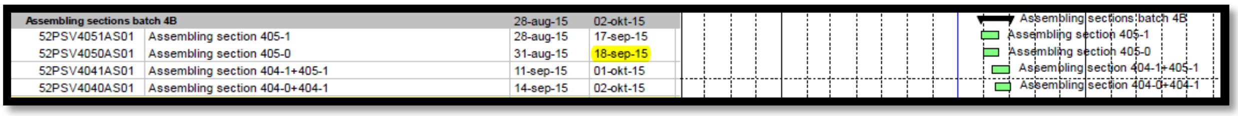
In 26August it is completed the assembling of the block 204-1 to the blocks 205-1 and 104-1.



Fore part		06-jul-15 A	05-okt-15
Assembling sections batch 3A		06-jul-15 A	21-aug-15
52PSV1041AS01	Assembling section 104-1+104-2+105-1	06-jul-15 A	29-jul-15 A
52PSV1042AS01	Assembling section 104-2+105-2	10-jul-15 A	28-jul-15 A
52PSV1031AS01	Assembling section 103-1+103-2+104-1	20-jul-15 A	07-aug-15
52PSV1032AS01	Assembling section 103-2+104-2	20-jul-15 A	07-aug-15
52PSV1020AS01	Assembling section 102-0+103-1+103-2+203-1+203-2	01-aug-15 A	20-aug-15
52PSV1010AS01	Assembling section 101-0+102-0+202-1+202-2	03-aug-15 A	21-aug-15
Assembling sections batch 3B		04-aug-15 A	14-sep-15
52PSV2042AS01	Assembling section 204-2+104-2+205-2	04-aug-15 A	24-aug-15
52PSV2041AS01	Assembling section 204-1+104-1+205-1+204-2	06-aug-15	26-aug-15

Fig. 22 - Extract of the planning PSV#2. DAMEN copyright.

In 18September it is completed the assembling of the block 405-0 to the main structure.



Assembling sections batch 4B		28-aug-15	02-okt-15
52PSV4051AS01	Assembling section 405-1	28-aug-15	17-sep-15
52PSV4050AS01	Assembling section 405-0	31-aug-15	18-sep-15
52PSV4041AS01	Assembling section 404-1+405-1	11-sep-15	01-okt-15
52PSV4040AS01	Assembling section 404-0+404-1	14-sep-15	02-okt-15

Fig. 23 - Extract of the planning PSV#2. DAMEN copyright.

But from the weight estimation according to the actual planning for the vessel PSV 5000 #2 the date 04 August is not eligible because the sections 204-2 and 204-1 are not completely assembled to the main structure since the end of the operations is estimated for the 24 August. So even if the weight of the sections load on the structure, these contain part of the tanks 35, 37, 38.

Considering the dates of start and end of the operations it is created a detailed weight estimation in relation of the above dates. The weight in reference it is that one at the stage 41 of the building strategy. But the actual planning presents some differences in the order of the execution from the building strategy, because the planning is related with the production capacities of the shipyard and the other projects at the same time carried out.

The total weight is different for the three dates

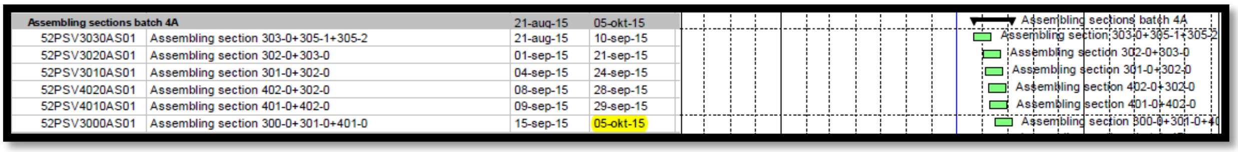
	Total weight at 41 stage	weight 04 Aug	weight 24 Aug	weight 18 Sep
Kg	23936323	1671450	2162233	2342228
%from the T. W.		69.83	90.33	97.85

Table 7 - Weights at stage 41.

How is possible to note already at 24 August it is reached more than the 90% of the total weight. The missing weight most of is due to fraction of the piping not completed in the sections. And it is possible to note that major part of it is located in the structure at the right side of the frame 65 so not vertically located on the tanks of interest.

6.2.2. Stage 50

The hull at stage 50 is complete and the tanks inside it, could be tested after the 05october2015, date of the end of the assembly of the section 300-0.



Assembling sections batch 4A		21-aug-15	05-okt-15
52PSV3030AS01	Assembling section 303-0+305-1+305-2	21-aug-15	10-sep-15
52PSV3020AS01	Assembling section 302-0+303-0	01-sep-15	21-sep-15
52PSV3010AS01	Assembling section 301-0+302-0	04-sep-15	24-sep-15
52PSV4020AS01	Assembling section 402-0+302-0	08-sep-15	28-sep-15
52PSV4010AS01	Assembling section 401-0+402-0	09-sep-15	29-sep-15
52PSV3000AS01	Assembling section 300-0+301-0+401-0	15-sep-15	05-okt-15

Fig. 24 - Extract of the planning PSV#2. DAMEN copyright.

For this date must be considered also the superstructure that will be added to the main body.
They are necessary some clarifications:

- If the dates proposed are adopted, the structural test is carried out before the tightness test and the painting with protective coating. This is allowed by the **IACS Req. 1996/Rev.3 2010,** that it puts conditions just in the case if the structural testing is carried out after the protective coating has been applied.
- The date proposed for the finish the tests is a draft, this can be shifted of one or two days in relation at the time necessary for fill, empty and clean the tanks. This necessary time will be evaluated in the forward steps and it depends by:
  - The volume of the tanks.
  - The number of pumps available.
  - The capacity of the pumps.

6.3. Load Analysis

It is necessary to do the calculations for the evaluation of the loads applied on the blocks when the ship is in the dry dock. These calculations are done in relation of the main topic of the thesis, so they are performed taking into account that the load will not be referred at the complete ship before the launching but at the earlier stage (41 and 50), ship partially completed plus the load of mass of water contained in the tanks.
In D.S.G. is used the software CVSL_64 that it allows to find the reaction force on the blocks according with their number, disposition and spacing along the vessel. The first step to do for run this software, is to give to it some input data that contain all the information about the weight of the ship. So it is necessary the creation of detailed weight estimation.

6.3.1. Weight Estimation

The weight estimation is compiled on an excel sheet, this file extension can be read by CVSL_64. Because the objective it is to be focused on the section stage, are created two excel sheets, each for two different moment of the building strategy, exactly they are referred to the stage 41 and the stage 50.

The result is a detailed list of all the loads present on board.

The loads took into account are:

- The weight of the block unit.
- The weight of the foundation (if present) in the block.
- The weight of piping.
- The weight of the critical equipment.

The criteria used in the compilation is to advance it according with the building strategy and add the weights in the same sequence as they appear in the building strategy.

For each weight the following data are inserted in columns:

- The mass in Kg.
- The CoG break up on Cartesian coordinates so Xg, Yg, Zg. In mm
- Start, the beginning of the object referred to the 0 of the ship, it can be positive if it is at right of the zero or negative if it is at left. (it is a sign convention). In mm
- End, the finish of the object also referred to the 0 with same sign convention. In mm.
- Coefficient, it allows to consider the mass fully loaded with 1 or not present with the coef = 0. Intermediate values consider only partial load.

The data necessary are token from the detailed drawings and reports. These are organized in batches and each batch are divided in block unit. For each block unit there are the sub-folders dedicated to the structure, foundation and piping.

In the weight estimation are included also the equipments and they are uniquely labeled by its own identification number. When discrepancies between the data are reveled it is possible to consult the E-browser. This tool give a 3D representation of the ship and it is possible to navigate inside it and to explore the whole structure and also to put in evidence a specific object. The E-browser allows also to extract position data associated with the coordinate system of the ship and characteristics of the objects like the dimensions.

An extract for example of the weight estimation is in the Table 8. In the Appendix I are present the full weight estimations used.

Denumire	Masa[kg]	Xg[mm]	Yg[mm]	Zg[mm]	Start[mm]	End[mm]	Coef
1093 unit	75467	771	0	5690	-4200	6900	1
1093 foundation	1642.8	2148	-155	5554	-4200	6900	1
1093 piping	3868.1	2800	200	4550	-4200	6900	1
Prop thruster PS - Frequency drive 20A 414E7000	6540	4200	-1600	6600	2203	6193	1
Prop thruster SB - Frequency drive 20A 414E7002	6540	4200	1600	6600	2203	6193	1
HPU Shark JAW & Towing pins 20A 550A1006	1150	-2030	-2760	6790	-2212	-1792	1
HPU Pump starter 20A (1) 213E1002	70	-50	-3000	7050	-200	100	1
HPU Pump starter 20A (2) 213E1001	70	-150	3000	7050	-300	0	1
HPU Azimuth Thruster 20A (1) 213A1003	1400	600	0	7000	-200	1400	1

Table 8 - Weight estimation extract.

Moreover in the weight estimation are inserted the caractheristics (mass, CoG, start, end) of the 24 tanks that must be tested.

Denumire	Masa[kg]	Xg[mm]	Yg[mm]	Zg[mm]	Start[mm]	End[mm]	Coef
TK BW 37	174202.2	37500	9471	2951	32900	43100	0
TK BW 48	128683	28408	0	726	24900	31900	0
TK BW 49	103356.5	28266	-9422	2763	24900	31900	0
TK BW 66	156902.6	11083	-6732	3757	7200	15100	0
TK BW 76	68706.98	2486	9506	6518	-2400	7200	0
TK BW 77	56845.6	-3246	-4754	6786	-4200	-2400	0
TK FW 55	141585.6	19235	-56	1257	15100	23500	0
TK FW 63	116103.6	19714	9092	3211	15100	23500	0
TK FUEL OIL 68	147875.9	12688	0	6092	10200	15100	0
TK FUEL OIL CARGO 38	106816.5	42121	-4572	5364	38900	43100	0
TK FUEL OIL CARGO 43	138376.2	36424	3775	5600	31900	38900	0
TK Liquid Mud/Brine 45	227686.7	34001	5903	5069	31900	36100	0
TK Anti-Roll 73	225911.9	8700	0	6800	7200	10200	0
TK BW 1	152963.5	75029	0	4740	73100	78656.26	0
TK BW 3	133856	66254	3260	1291	61100	73100	0
TK BW 12	66517.09	52320	6222	685	49100	55700	0
TK BW 29	73937.8	45230	-32	713	43100	47300	0
TK BW 30	62465.39	45145	-9509	3005	43100	47300	0
TK FW 4	275580.9	65969	-5451	5567	61100	73100	0
TK Miscellaneous 10	53940.58	55616	-5911	677	52700	59300	0
TK Miscellaneous 13	94345.72	54208	0	650	47300	61100	0
TK FUEL OIL 14	27985.58	53140	8860	3200	50900	55700	0
TK FUEL OIL 33	98521.98	45239	6562	3333	43100	47300	0
TK FUEL OIL 34	106496.5	45231	5681	3312	43100	47300	0

Table 9 - Weight estimation tanks.

This because on the base of the weight estimation it is possible to simulate different scenarios of loading, activating one or more tanks with the coefficient. In first place for each stage point it is verified that it is satisfied the starting condition of a correct load distribution without any concentrate loads on the supports. Only after, the tanks are activated in different configurations with the aim to find the best one.

6.3.2. CVSL_64 Software

CVSL_64 is the software in use in D.S.G. for different purposes: for the stationing of the hull during the assembling, for the moving of the vessel inside the yard or for the calculations necessary before the launching. It is based on the Beam Theory, where the load is distributed transversely and longitudinally on all the supports below the ship.

In this type of calculations the load is a **Static Load**[5], they are related to a specific load condition and they have not variation during all the application of the load.

The software take into consideration the frame spacing of the ship and it distributes the loads along the transverse supports. The loads, of which it is known the center of gravity and extension, do not act on a single frame but it is supported by multiple frames. Nevertheless for the nature of these loads, they are **Local Loads**[5]: they are loads applied to a limited portion of the ship.

The Finite Element Theory could give results more interlaced with the singles peculiarities of the local structure that it is sustained by the supports. The choice to use a software based on the beam theory instead of one FEM based, it is justified by:

1) CVSL_64 it is the software daily used in DAMEN shipyard.
2) Necessity to have results in short time. This characteristic is fundamental because in case of last moment changes during the production process, it is necessary to have immediate results.
3) The maximum limit of 50 tons allowed on each support, it is plenty below the safety limit above which a permanent deformation occurs.

When the CSVL_64 is launched the first step is to load the project, in this case the one of the PSV5000. The file with extension .pri has the information regarding the vessel in exam, it contains the dimensions (longitudinal and transverse), the frame spacing and the spline lines.

The following step is to choose the configuration, different modalities are available and each one allows a different type of calculation.

[5] Rigo, P., & Rizzuto, E. (2003). Analysis and Design of Ship Structure. In SNAME, *Ship Design and Construction*. New York: Thomas Lamb.

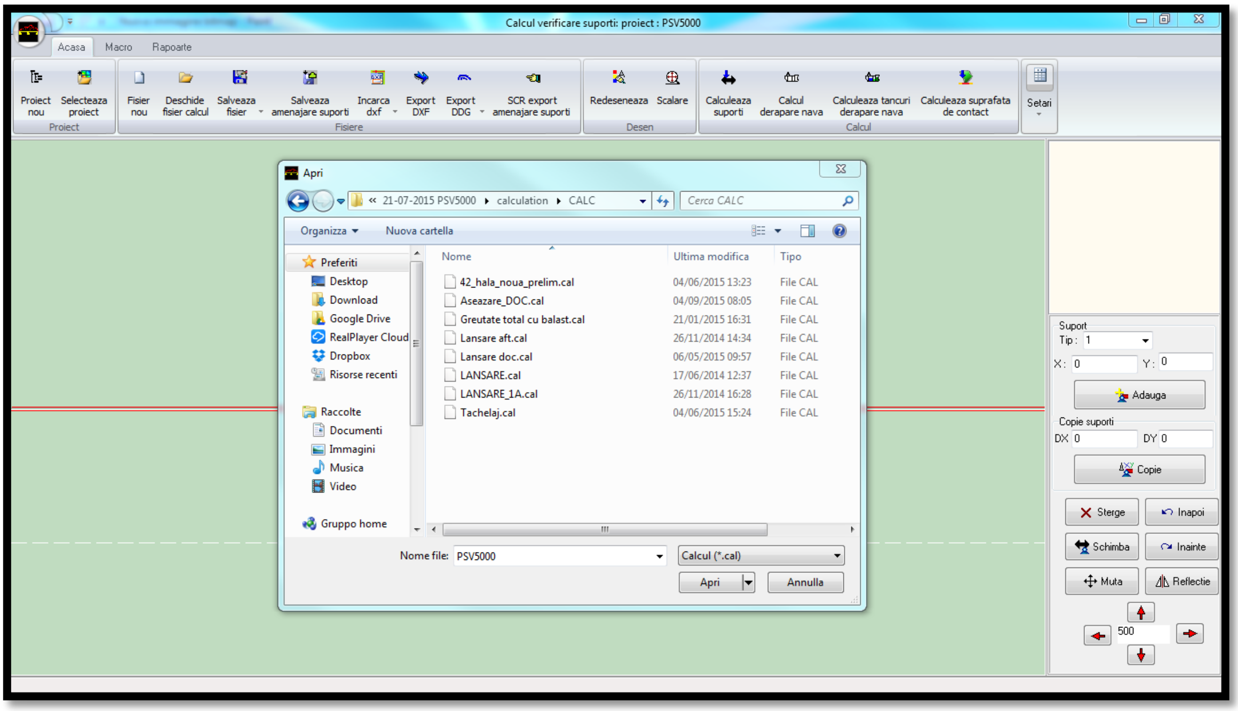


Fig. 25 - CVSL_64. DAMEN copyright.

It is chosen the asenzare that describes the situation in the dry dock, the others can simulate the configuration at the launching system or during the handling of the vessel in the shipyards from one station to another one. After it is chosen the stationary position in the dry-dock, it appears the representation of the ship and the concrete block disposition below it.

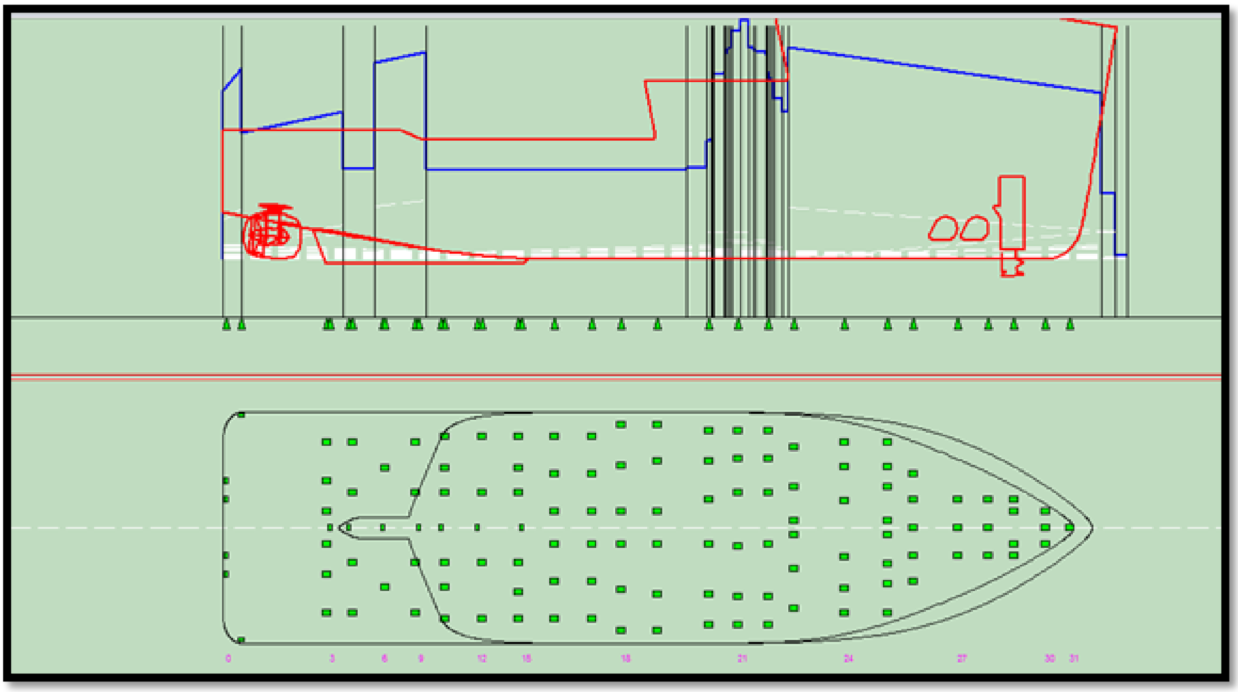


Fig. 26 - CVSL_64, dry dock configuration. DAMEN copyright.

The screen is divided in two and it shows in the upper part the longitudinal profile of the vessel with overlying the vertical loads in their cg (black lines) and the total weight distribution (blue line). In the second half of the screen it is shown the disposition of all the supports plus the horizontal profile. N.B. in the fig. 26 it is not shown the complete weight distribution. In fig. 27 it is plotted the detailed weight distribution without the masses of water[6].

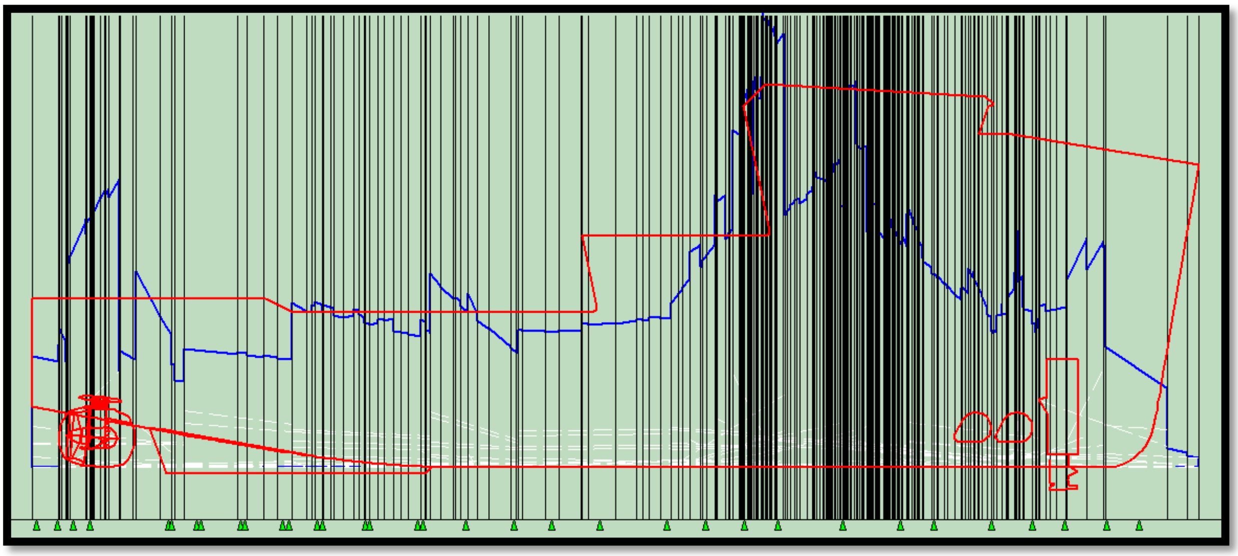


Fig. 27 - Complete weight distribution. DAMEN copyright

The weight distribution is obtained by division of the ship length into portions. For each one, the total weight and center of gravity is calculated adding the contribution of all the items included in the section. The distribution is approximated by a trapezoidal curve obtained by imposing the correspondence of area and barycenter of the trapezoid respectively to the total weight and center of gravity of the considered ship section[7].

In the two previous views are represented also the supports (green triangles). The green color means that the load exercised on them is under 50 tons, over this value it appears yellow and over the 75 tons (critical value) it appears red.

With the command setari it is possible to load the excel file (saved in .csv extension) that it contains the load configuration desired. Eventual errors, when the Xg is not between the start and the end, are reveled by the program and signed with the coefficient -1.

[6] Detailed results of all the loads on every support are presented on the Appendix II

[7] (Rigo & Rizzuto, 2003)

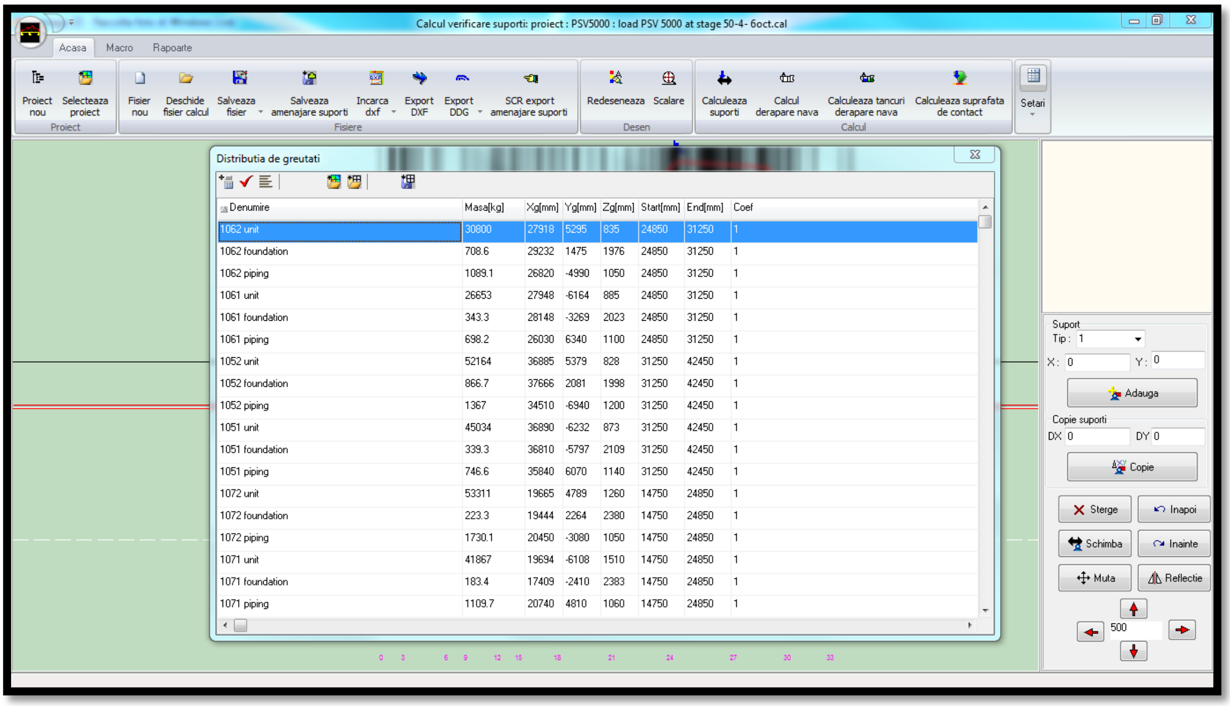


Fig. 28 - CVSL_64. DAMEN copyright.

In the setari command, it is possible to set also the type of support on which the vessel is based. They are available:

- Cart (for the movements on the rails).
- Train of cart, 2-3 or more carts placed together.
- Concrete block of height 1000 used in the dry dock.
- Concrete block of height 1400 used in the assembling hall.
- Pillars.

The concrete block has positioned on the end two sliding diaphragms to adjust in base of the variable height of the hull and to assure the perfect contact. Between the hull and the support is interposed some compressible material (usually wood). This kind of support is considered in the calculation as simple support.

The pillar is fixed with temporary brackets welded to the hull, usually upper the waterline for allow the painting of the hull. This kind of support is considered in the calculation as clamped support.

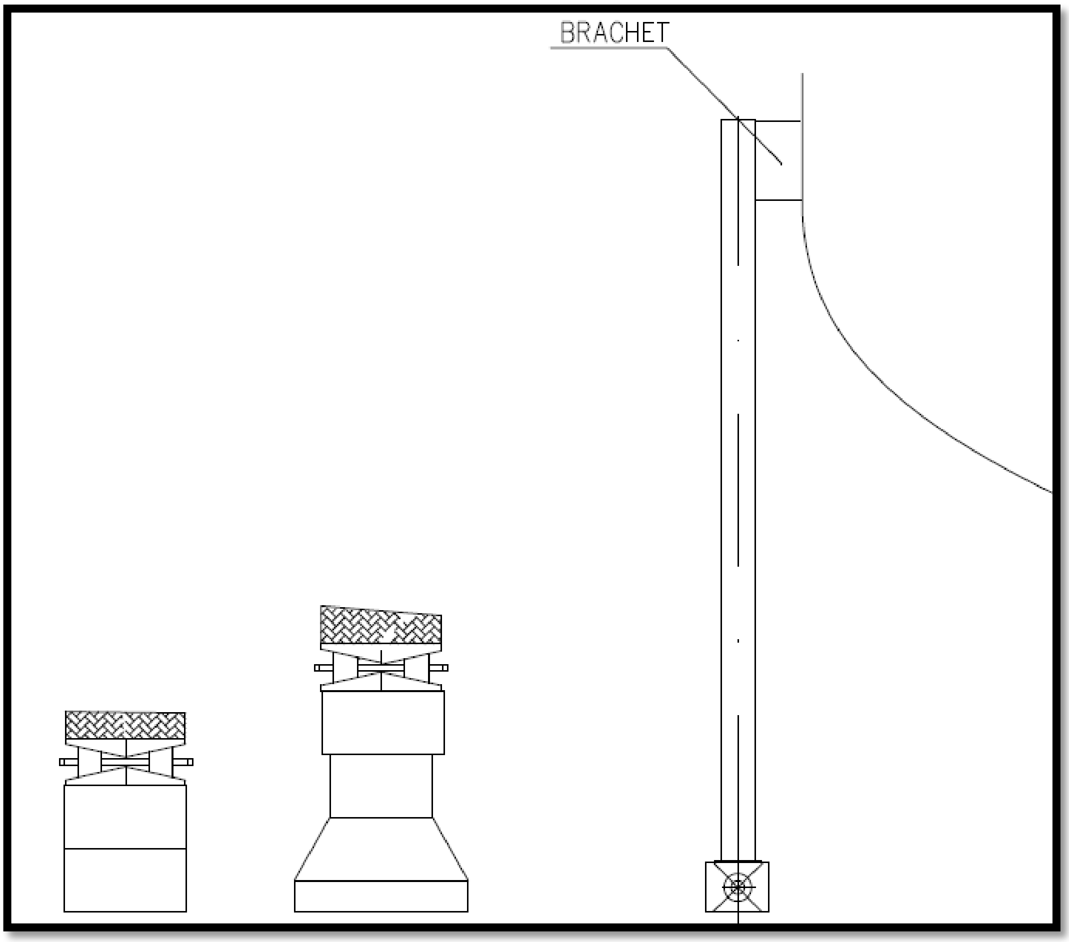


Fig. 29 - Supports. DAMEN copyright.

When are necessary information of one specific support, it is possible to click on it and it will be opened a window with coordinate and force applied.

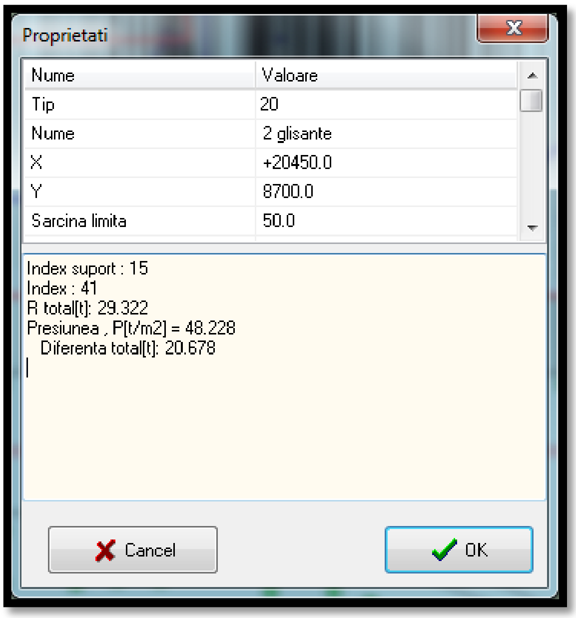


Fig. 30 - CVSL_64, support detail. DAMEN copyright.

The CSVL is able also to generate reports that could be used for the successive analysis and considerations. This report contains all the information about the supports.

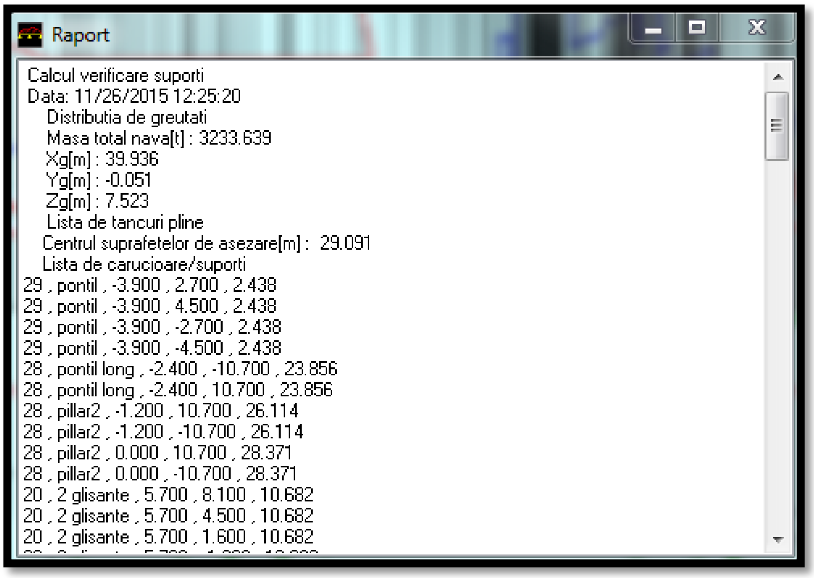


Fig. 31 - CVSL_64 report. DAMEN copyright.

Combining these data with excel and AutoCAD is created a graphic report ready for the consultation.

In the input excel file are inserted also the tanks with their barycenters and masses, and using the coefficient is possible to activate or deactivate the load. This allows to simulate different scenarios with different tanks filled. All these scenarios are developed on the base of the weight distribution given by the structure, foundations, piping and critical equipment at the stage 41 or 50.

The goal of the next step is to find a configuration with the tanks filled that it is allowed by the resultant of the forces on the blocks, without concentrate loads that exceed the permitted ones.

6.3.3. Loading configurations

In this sub-paragraph it is searched the best configuration of loads applied by the masses of water during the h.t. It is searched the maximum loads allowable with as many as possible of tanks filled at the same time. At this point it is not considered yet the capacity of the yard, the equipments necessary and the man work. In this study the strategy followed for the h. t. is to divide the number of the tanks in two big groups that contain all the tanks in the aft part of the ship (before frame 65) and all the tanks the fore part (after frame 65).

These two groups are summarize in the table8.

N° of tank located aft	N° of tank located fore
37, 48, 76, 77, 66, 49, 63, 55, 68, 43, 38, 45, 73	12, 3, 1, 29, 30, 4, 13, 10,14, 33, 34

Table 10 - Tanks groups.

From the analysis of the actual planning of the vessel PSV 5000 #2, two suitable dates are found for the test of the tanks located in the aft: 24 August and 18 September. And one date for the remaining tanks in the fore part: 6 October.

The verification of the loads and their distribution, applied on the supports when the ship is in the dry dock during these dates, is made using the software CVSL_64.

The analysis, according to the level of completion reached, has revealed that the date 24 August is not adapt to support an extra load, derived from a not ideal distribution of the weight that brings to concentrate loads on two supports. They are located respectively in x = -2.400 m , y = -10.700 m and x = -2.400 m, y = 10.700 m. These two supports are loaded with 55,586 tons against the 50 tons allowed. It is understood that this 5 tons of extra load are not critical and temporarily they can be accepted, but of course it is not possible to weight the structure with extra weight of several tons of water mass.

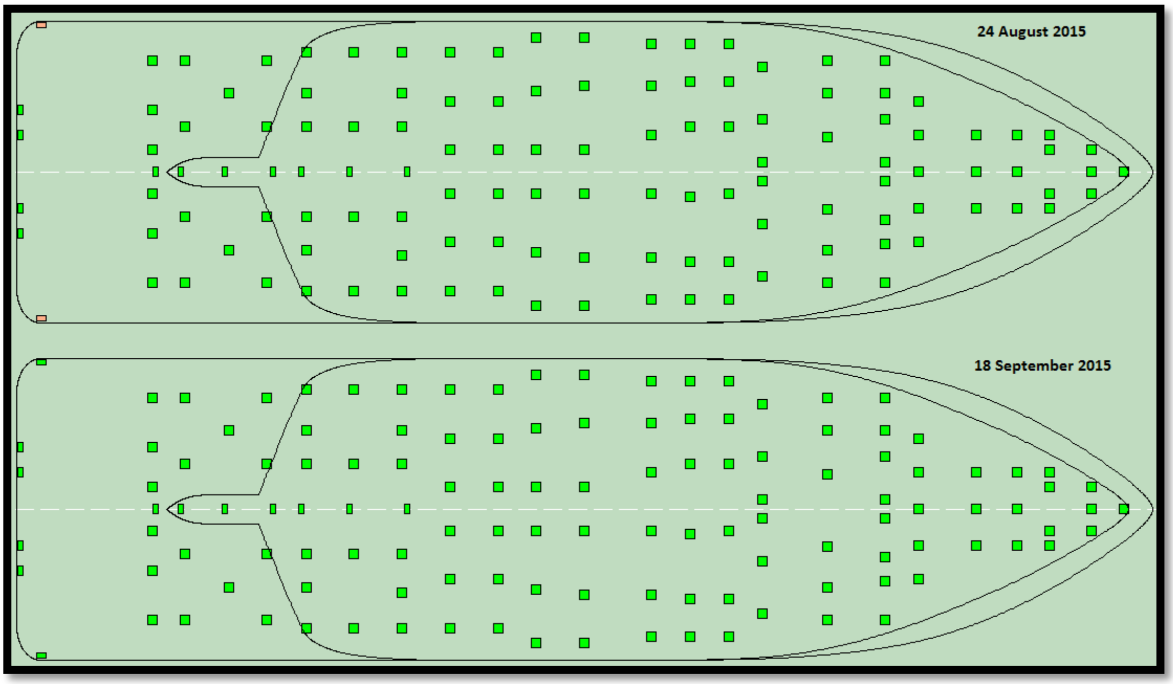


Fig. 32 - Loading comparison. DAMEN copyright.

With the load estimation of the 18 September, the two supports have a load of 47.364 tons against the 55.586 tons[8] of the 24 August. For this reason the date of 24 August is excluded. Then all the analysis of the supports loaded by the added mass of water of the tanks of the aft part are performed using the weight estimation corresponding to the one of the 18 September. For perform the h. t. four more supports are placed below the hull respect the original arrangement, as shown in the fig. 33. This because all the simulations have shown that the most solicited supports are located in the sterns on the side. But the increase of the number of supports in this area presents one principal difficulty: the area under the arch stern must be free for the pod propeller and its insertion.

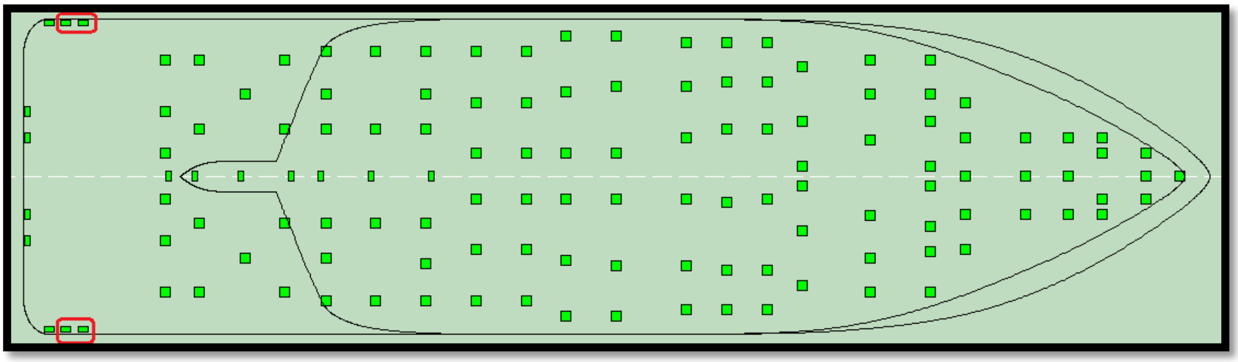


Fig. 33 - New supports arrangement. DAMEN copyright.

These supports are four pillars of dimension 760 mm x 400 mm with a capacity of 50 tons. Moreover the weight of the mass of water added for the calculation, according with the IACS and L.R. rules, is the volume of fresh water of the tank plus the water column of height specified by the abovementioned. The water column of wanted height is created by adding one pipe at the snorkel of the tank. These data are extrapolated from the structural test plant for the dimensions of the tanks and from e-browser for the dimension of the pipes that corresponds to the same diameter of the external tube of the snorkel.

N. of tank	Volume (m^3)	Mass (Kg)	Head of liquid above the base line (m)	Height of the tank (m)	Height of the pipe (m)	Diameter of the pipe (m)	Volume of the pipe (m^3)	Mass of the water inside the pie (Kg)	Total Mass (Kg)
37	169.2	173430	10.9	8.5	2.4	0.31	0.753	772	174200
48	123.88	126977	9.26	1.3	7.96	0.21	1.664	1706	128700
76	66.4	68060	10.9	8.5	2.4	0.26	0.631	647	68700
77	54.44	55801	10.9	7.025	3.875	0.26	1.019	1045	56850
66	152.1	155902.5	9.26	5.55	3.71	0.26	0.975	1000	156900
49	100.31	102817.8	10.9	8.5	2.4	0.21	0.525	539	103360
63	112.77	115589.3	10.9	8.5	2.4	0.21	0.501	514	116100

[8] Detailed results of all the loads on every support are presented on the Appendix II

55	137.79	141234.8	9.26	1.3	7.96	0.04	0.342	351	141590
68	143.89	147487.3	10.9	8.5	2.4	0.16	0.379	389	147880
43	134.37	137729.3	10.9	8.5	2.4	0.26	0.631	647	138380
38	103.58	106169.5	10.9	8.5	2.4	0.26	0.631	647	106820
45	221.38	226914.5	10.9	8.5	2.4	0.31	0.753	772	227690
73	219.9	225397.5	10.9	8.5	2.4	0.21	0.501	514	225910

Table 11 - Mass of the tanks in the aft part.

For what concerns the tanks number 68, 38 and 43 that contain fuel oil, the original structural test plan document prescribes a structural test performed with an hydro-pneumatic test. This happens because the tests are performed in an advanced stage of the building where is not easy to remove the oil contained, clean the tank from the petroleum residuals, do the hydrostatic test with water and restore the tank without any residual to be adapt to contain oil or fuel. The proposal is to perform also for these tanks an hydrostatic test, at this point of the building process. It has the advantages:

1) Big masses of fuel are not moved, handled or shifted from one tank to another tank.
2) It is possible to use the same equipment for all the tanks, no dedicated equipment is necessary.
3) The tank will be cleaned just one time and be ready for the delivery.
4) The hydrostatic test does not present any difficulty, at the contrary the hydro-pneumatic test must be done with extreme attention because an over pressure of the air could damage the tank.
5) When a hydro-pneumatic test is performed, the conditions should simulate, as far as practicable, the actual loading of the tank.

The proposal is to test all these kind of tanks with an hydrostatic test with a water column of 10.9 meters.

The tanks cannot be tested all together for two reasons:

1) Some tanks are adjacent, so they have in common one side. It must be free to be inspected and to deform (in the case if it happens). Thus is not possible to have on the same structure two opposite forces that tend to deform on the opposite side, so they cancel each other.
2) The total weight that results is excessive.

For these reasons the total amount of tanks is divided in sub groups.

The following calculations are performed using the software CVSL_64 considering the weight at the date of 18 September plus the weight of the tanks under test.

First sub-group.

The first sub-group is composed by the tanks number:

Number	Position
37	Starboard, frame 49-65
48	Central, frame 39-49
38	Portside, frame 59-65
66	Portside, frame 12-25

Table 12 - First sub-group.

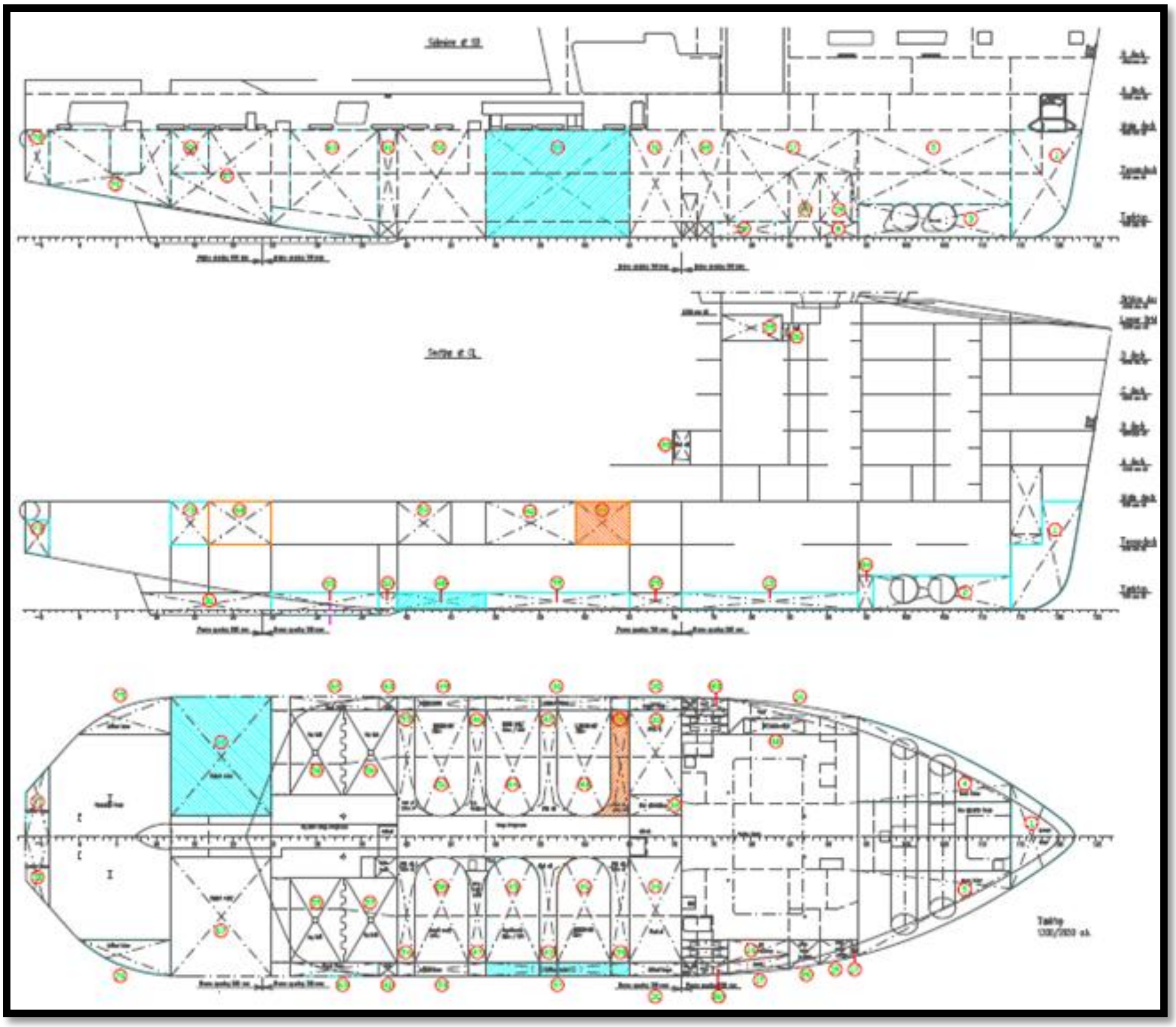


Fig. 34 - First sub-group. DAMEN copyright.

On all the supports the maximum load does not exceed the 50 tons[9].

[9] Detailed results of all the loads on every support are presented on the Appendix II, I° sub-group.

Second sub-group.

The second sub-group is composed by the tanks number:

Number	Position
76	Starboard, frame -4-12
77	Portside, frame aft - -4
55	Central, frame 27-39

Table 13 - Second sub-group.

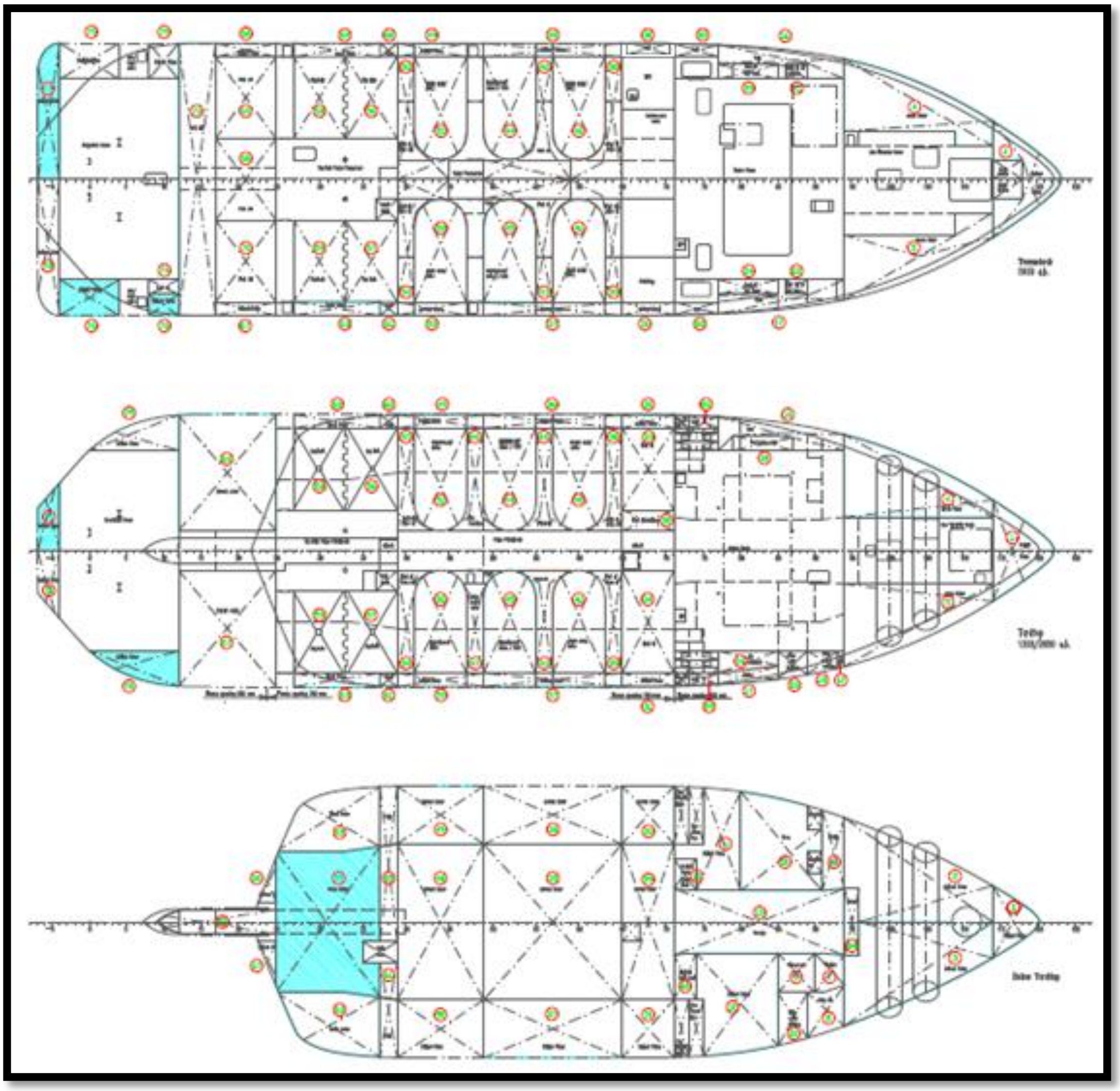


Fig. 35 - Second sub-group. DAMEN copyright.

On all the supports the maximum load does not exceed the 50 tons[10].

[10] Detailed results of all the loads on every support are presented on the Appendix II, II° sub-group.

Third sub-group.

The third sub-group is composed by the tanks number:

Number	Position
68	Central, frame 17-25
49	Portside, frame 39 - 49
63	Starboard, frame 26-37

Table 14 - Third sub-group.

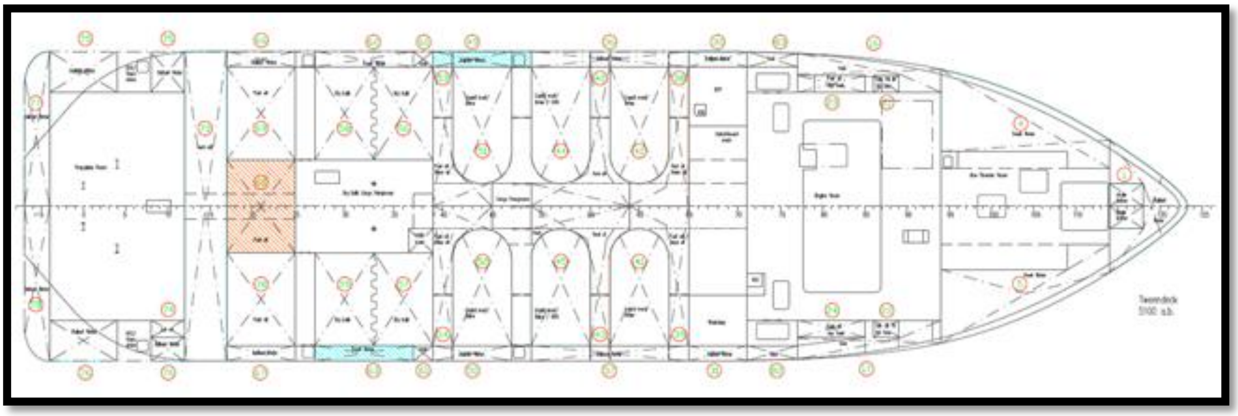


Fig. 36 - Third sub-group. DAMEN copyright.

The calculation reveals an overload on the supports in position x = 0 m, y = 10.700 m and x = 0 m, y = -10.700 m, but the quantity of the overload is only of 118 Kg so it can be accepted. In consideration of the fact that the tolerance of these supports is of some tons[11].

Fourth sub-group.

The fourth sub-group is composed by the tanks number:

Number	Position
73	Central, frame 12-17
43	Starboard, frame 49-59

Table 15 - Fourth sub-group.

[11] Detailed results of all the loads on every support are presented on the Appendix II, III° sub-group.

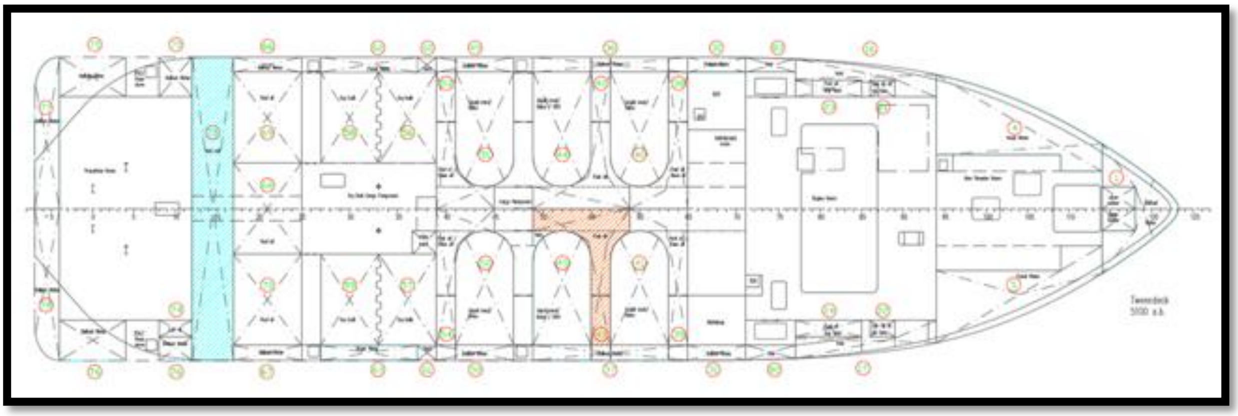


Fig. 37 - Fourth sub-group. DAMEN copyright.

The calculation reveals an overload on the supports in position x = 0 m, y = 10.700 m, and x = 0 m, y = -10.700 m, but the quantity of the overload is only of 28 Kg so it can be accepted. In consideration of the fact that the tolerance of these supports is of some tons[12].

Fifth sub-group

The fifth Sub-group is composed by the tanks number:

Number	Position
45	Starboard, frame 49-55

Table 16 - Fifth sub-group.

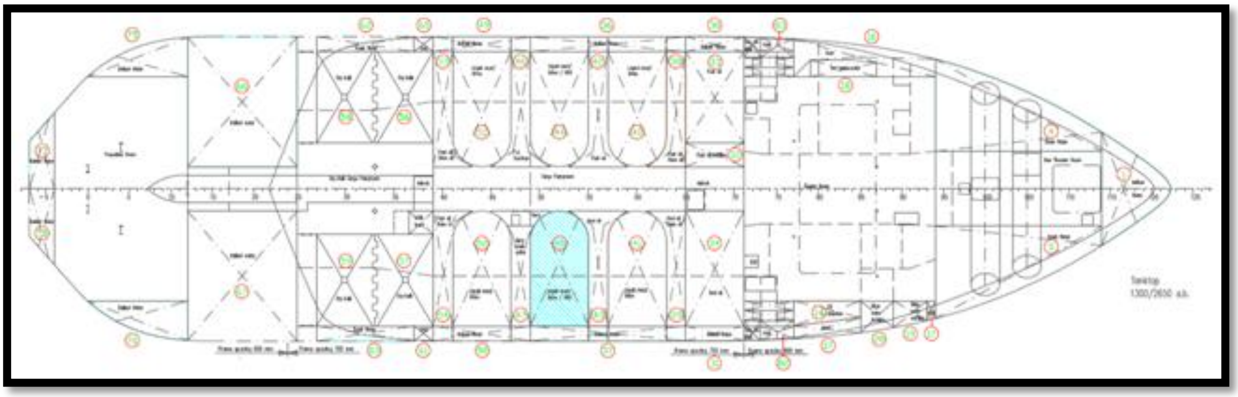


Fig. 38 - Fifth sub-group. DAMEN copyright.

On all the supports the maximum load does not exceed the 50 tons[13].

Similarly to the tanks located in the aft part, it is conducted analysis on the tanks located in the fore part. It is used the software CVSL_64, and uploaded the weight estimation with all

[12] Detailed results of all the loads on every support are presented on the Appendix II, IV° sub-group.
[13] Detailed results of all the loads on every support are presented on the Appendix II, V° sub-group.

the loads and their position correspondent to the date of 6 October. On this starting point it is added the weight of the mass of water contained in the tank under test. The arrangement of the supports used, comes from the previous set of tests, where new supports were added.

Analogously to the previous case, new data for the tanks are inserted according to the IACS rules. These data are extrapolated from the structural test plant for the dimensions of the tanks and from e-browser for the dimension of the pipes that corresponds to the same diameter of the external tube of the snorkel.

Moreover for the fuel oil tanks 14,33,34 it is proposed an hydrostatic test with a water column of 10.9 m instead of the hydro-pneumatic test

N. of tank	Volume (m^3)	Mass (Kg)	Head of liquid above the base line (m)	Height of the tank (m)	Height of the pipe (m)	Diamiter of the pipe (m)	Volume of the pipe (m^3)	Mass of the water inside the pie (Kg)	Total Mass (Kg)
1	147.56	151249	14.86	8.5	6.36	0.26	1.672	1714	152960
3	127.38	130564.5	14.86	2.65	12.21	0.26	3.211	3292	133860
12	62.02	63570.5	14.86	1.3	13.56	0.21	2.875	2947	66520
29	70.47	72231.75	9.26	1.3	7.96	0.21	1.664	1706	73940
30	60.44	61951	10.9	8.5	2.4	0.21	0.501	514	62465
4	267.49	274177.3	14.86	8.5	6.36	0.21	1.369	1404	275580
13	89.77	92014.25	28.06	1.3	26.76	0.085	2.274	2331	94350
10	51.73	53023.25	14.86	1.3	13.56	0.066	0.894	917	53940
14	26.81	27480.25	10.9	5.1	5.8	0.085	0.493	505	27990
33	95.8	98195	10.9	5.1	5.8	0.055	0.319	327	98520
34	121.94	124988.5	10.9	5.1	5.8	0.055	0.319	327	125315

Table 17 - Mass of the tanks in the fore part.

Sixth sub-group

The sixth sub-group is composed by the tanks number:

Number	Position
1	Central, frame 114-FWD
10	Portside, frame 80-91
12	Starboard, frame 74-84
29	Central, frame 65-71

Table 18 - Sixth sub-group.

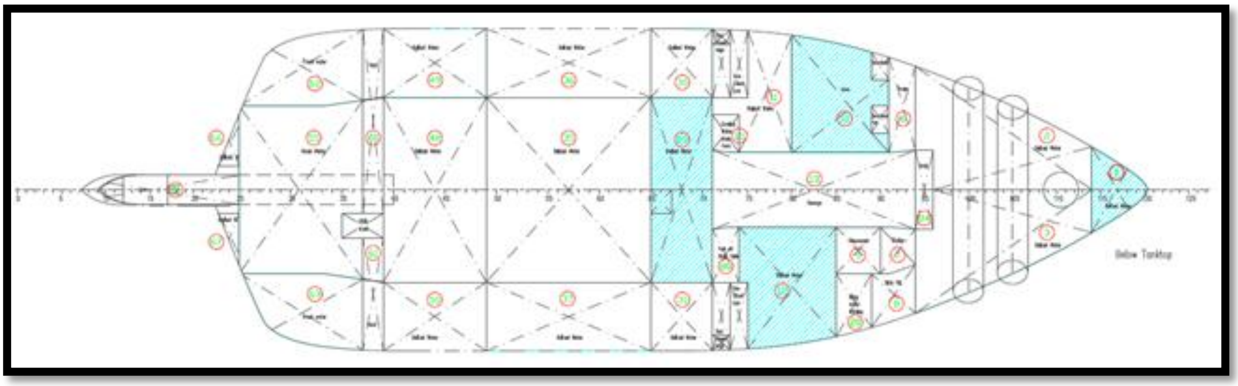


Fig. 39 - Sixth Sub -group. DAMEN copyright.

On all the supports the maximum load does not exceed the 50 tons[14].

Seventh sub-group

The seventh sub-group is composed by the tanks number:

Number	Position
3	Starboard, frame 94-114
13	Central, frame 79-94
30	Portside, frame 65-71

Table 19 - Seventh sub-group.

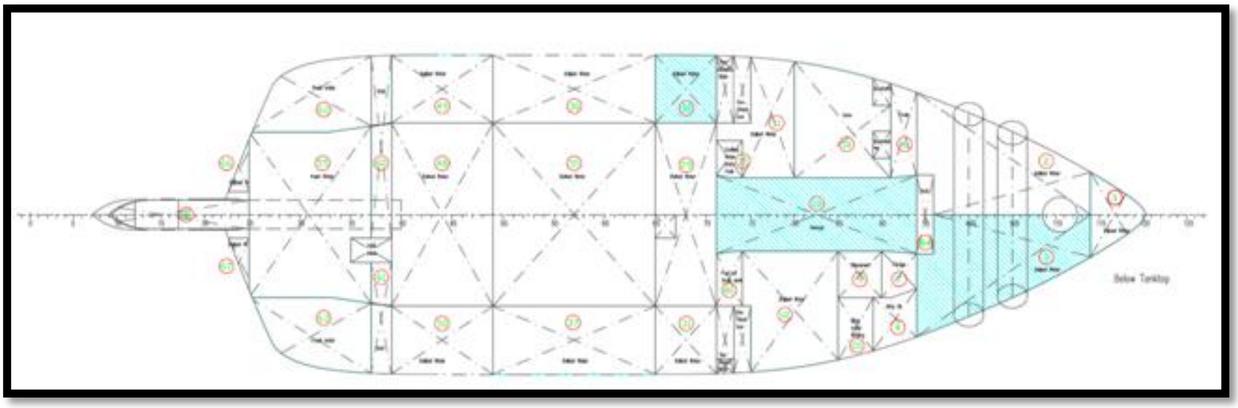


Fig. 40 - Seventh sub-group. DAMEN copyright.

On all the supports the maximum load does not exceed the 50 tons[15].

[14] Detailed results of all the loads on every support are presented on the Appendix II, VI° sub-group.
[15] Detailed results of all the loads on every support are presented on the Appendix II, VII° sub-group.

Eighth sub-group

The eighth sub-group is composed by the tanks number:

Number	Position
4	Portside, frame 94-114
14	Starboard, frame 77-85
33	Portside, frame 65-71
34	Starboard, frame 65-71

Table 20 - Eighth sub-group.

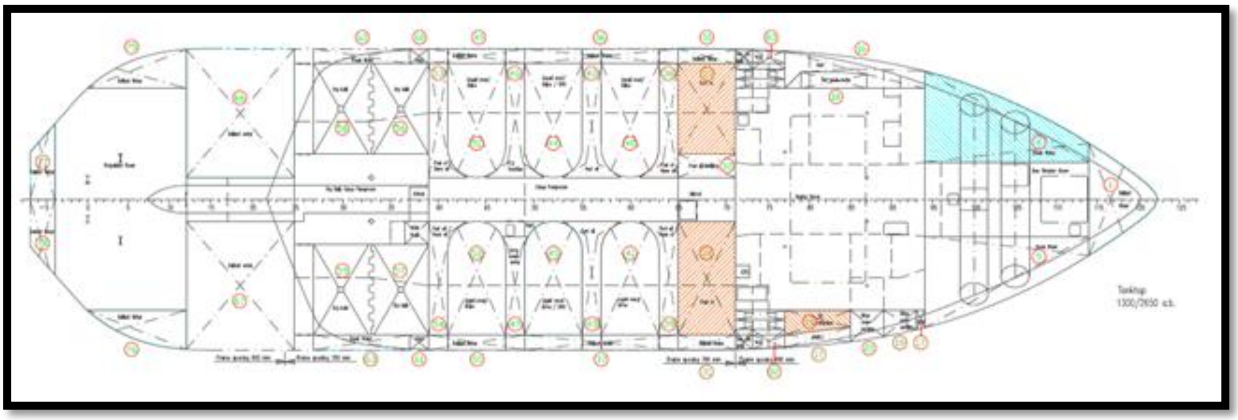


Fig. 41 - Eighth sub-group. DAMEN copyright.

On all the supports the maximum load does not exceed the 50 tons[16].

The analysis on the fore part has revealed that the several tons of extra load due to the mass of water in the tanks for the tests does not bring to an excessive stress on the supports. This to cause of the supports distribution and high number in the fore part of the vessel, in such way the load is widely distributed. It is avoided the creation of peak values as like in the aft part, where the supports are highly loaded, reaching the limit allowed.

[16] Detailed results of all the loads on every support are presented on the Appendix II, VIII° sub-group.

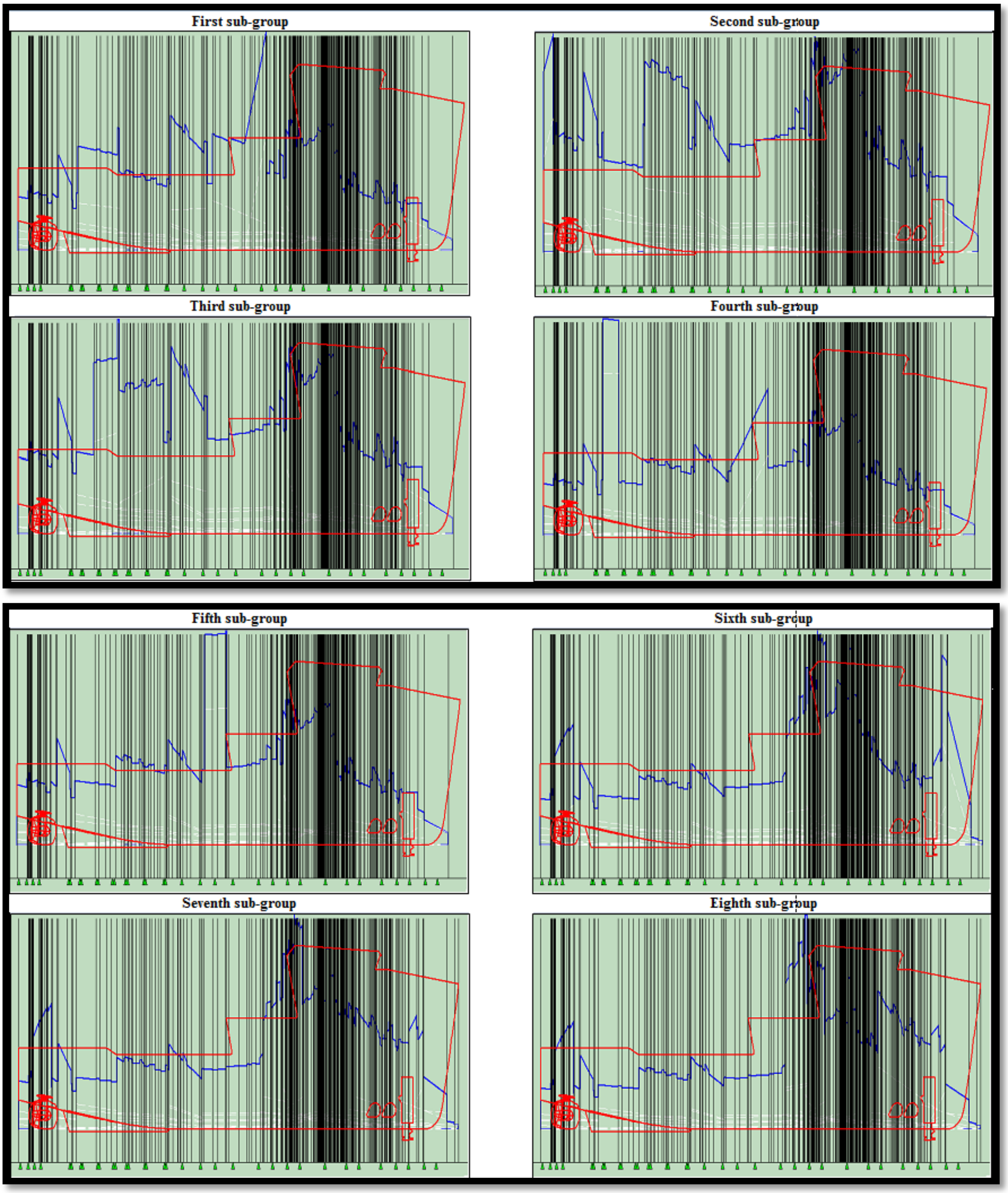


Fig. 42 – Weight distribution. DAMEN copyright.

6.4. Analysis On The Single Tanks

After it is individuated the moment in the earlier stage when to perform the test, it is necessary to analyze each single tank for individuate the different peculiarities. This because each tank has a different geometry, type and destination of use, position of the manholes, different pipes for the aeration. All these elements that must be taken into account, influence the strategy of execution of the test.

6.4.1. Ballast Water Tank n°1

The tank has the following characteristics:

Position	114-FWD
Height	8.5 m
Volume	147.56 m^3

Table 21 - Tank n°1.

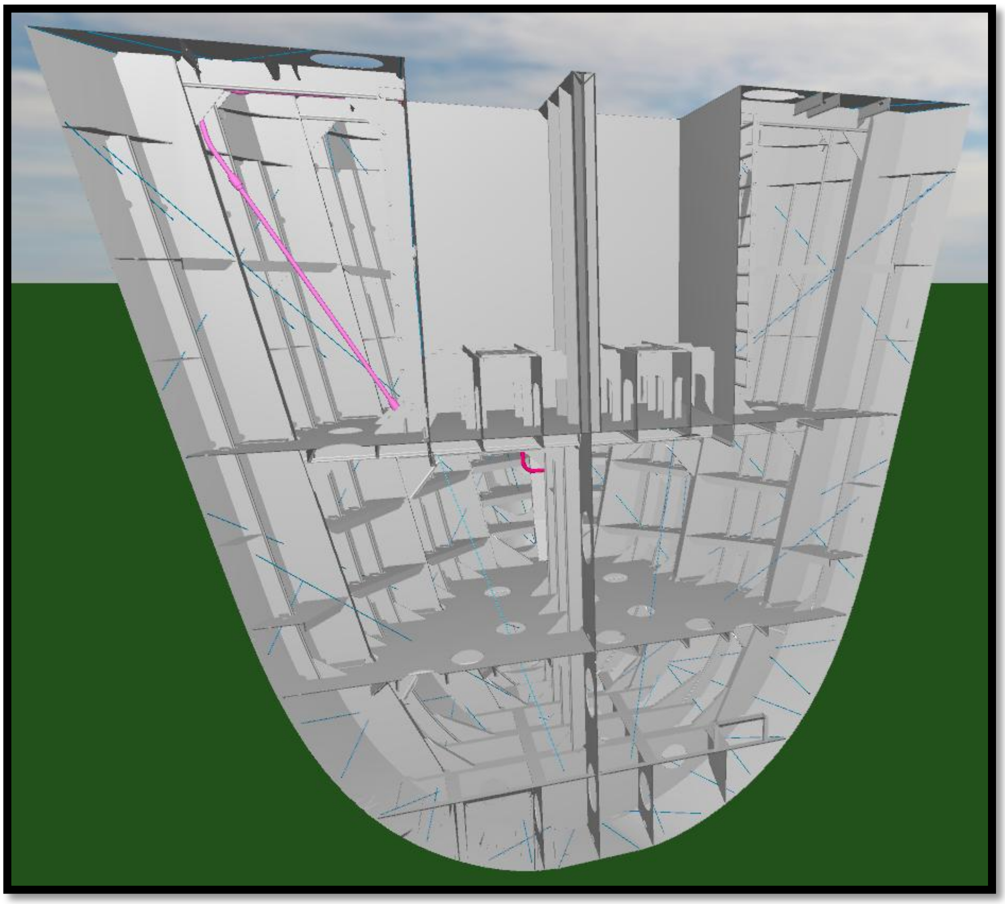


Fig. 43 - Tank n°1. DAMEN copyright.

Are present two horizontal manhole, one in position x = 74.077 m, y = 2.353 m above the main deck, and the second in x = 74.077 m, y = -2.353 m. The manhole has a dimension of one oval of 420X620 (mm). The aeration hole is located in x = 76.974 m , y = 1.453 m, the pipe from it has a diameter of 0.263 m, and it is extended till the height of 14.450 m, so it is necessary to mount on it an adjunctive pipe of 0.410 m (with the same diameter) for reach the prescribed height.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe , after the test the water is pumped out. For the discharge of the tank, it will be installed a temporary submersible pump inside the tank because the height of 8.5 m prevents the use of one type above the surface of the liquid. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean and the presence of diaphragms inside bring the maximum internal height to 3.3 m instead of 8.5m. Therefore the mud and other residuals can be easily removed.

6.4.2. Ballast Water Tank n° 3

The tank has the following characteristics:

Position	94-114starboard
Height	0.70 m(min), 2.65 m(max)
Volume	127.38 m^3

Table 22 - Tank n°3.

Are present three horizontal manhole, two oval: one in position x = 71.546 m, y = -1.820 m above the top of the tank and the second in x = 62.727 m, y = -1.825 m, the third is one circular in x = 66.185 m, y = -0.310 m. The last one is located between the first two. The oval manholes has a dimension of 420X620 (mm) and the circular one has a diameter of 0.470 m. The aeration holes are three, one is located in x = 70.886 m, y = -1.958 m with a pipe of diameter of 0.212 m, second in x = 66.025 m, y = -2.560 m with a pipe of diameter of 0.084 m and the last is in x = 62.869 m, y = -2.444 m with a pipe of 0.212 m diamiter. These three pipes are connected into a converged pipe of diameter 0.266 m and it is extended till the height of 14.272 m, so it is necessary to mount on it an adjunctive pipe of 0.588 m (with the same diameter) for reach the prescribed height.

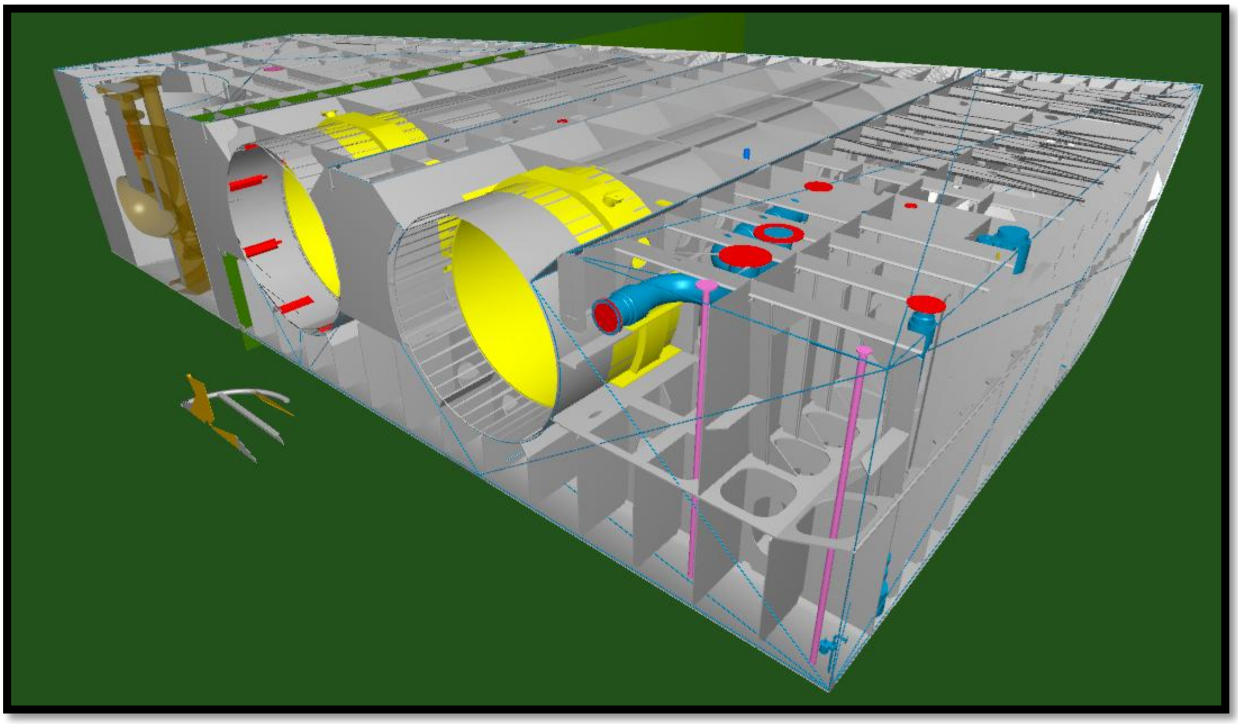


Fig. 44 - Tank n°3. DAMEN copyright.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe , after the test the water is pumped out by the pump. The height of the tank of 2.65 m give the possibility to install two different types of pumps for the discharge of the tank: external one above the tank or submersible one. It can be located in correspondence of one of the three manhole. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank is quite complex with an height that goes down till 0.700 m. This must be taken into consideration because it could affect the cleaning operation that will be done after the test. In this case could be economically more advantageous and less time consuming to use fresh water (more expensive) than normal water which contains residual and mud, into consideration of the time for cleaning will be double with the normal water.

6.4.3. Ballast Water Tank n° 12

The tank has the following characteristics:

Position	74-85starboard
Height	1.30 m
Volume	62.02 m^3

Table 23 - Tank n°12.

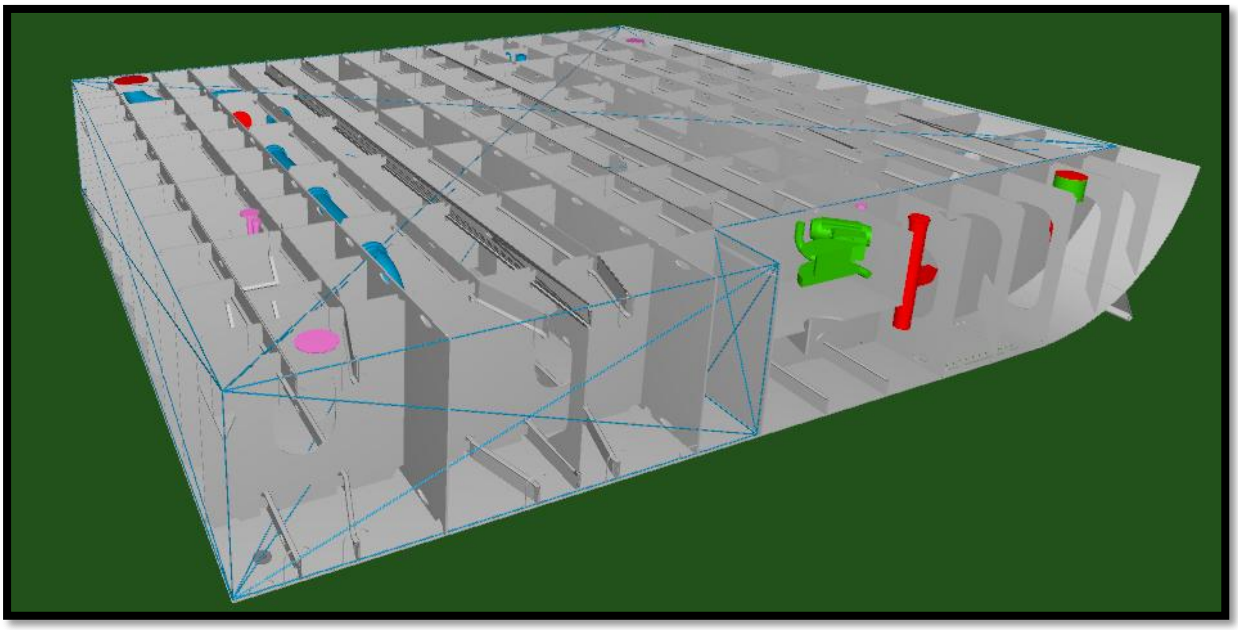


Fig. 45 - Tank n°12. DAMEN copyright.

Are present two horizontal manhole, two oval: one in position x = 54.596 m, y = -7.185 m above the tanktop deck and the second in x = 50.152 m, y = -3.311 m. The oval manholes has a dimension of 420X620 (mm). The two aeration hole are located in x = 54.869 m, y = -9.592 m with a pipe of diameter of 0.212 m and one in x = 49.375 m, y = -3.165 m with also a pipe of diameter of 0.212 m. The two pipes are connected together and the converged pipe of diameter 0.263 m arrives till the height of 9.035 m, so it is necessary to mount on it an adjunctive pipe to increase the height of 5.825 m (with the same diameter) for reach the prescribed height. This is not possible using a straight piece of pipe, because the upper space remaining is of only 2 meters, so it is necessary to find a way for the pipe to reach the prescribed height. This can be done profit temporary cut off or mounting an external pipe using the opening located in x = 55.275 m, y = -10.625 m, z = 9.268 m.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe , after the test the water is pumped out by the temporary pump. For the discharge of the tank, the height of the tank of 1.30 m gives the possibility to install two different type of pump: external type above the tank or submersible. It can be located in correspondence of one of the two manhole. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed, but the height of the tank of only 1.30 m is not the optimal work condition and this increases the time necessary.

6.4.4. *Ballast Water Tank n° 29*

The tank has the following characteristics:

Position	65-71central
Height	1.30 m(min), 1.68 m(max)
Volume	70.47 m^3

Table 24 - Tank n°29.

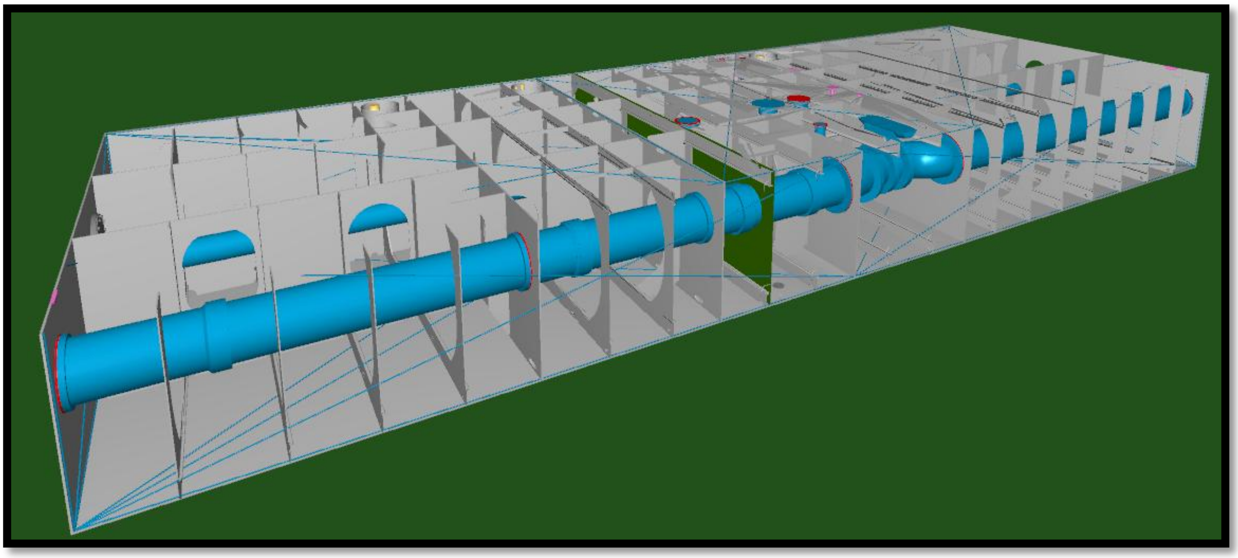


Fig. 46 - Tank n°29. DAMEN copyright.

Are present two horizontal manhole in position x = 44.190 m, y = 0.774 m and in x = 46,260 m, y = -0.774 m, both at the height of z = 1,3 m . The oval manhole has a dimension of 420X620 (mm). The two aeration hole are located in x = 43.570 m, y = 6.277 m with a pipe of diameter of 0.209 m and one in x = 43.570 m, y = -6.277 m with also a pipe of diameter of 0.209 m. The two pipes are not connected together and they reach the height of 8.893 m, because they are specular, it is possible to close one of them. It is necessary to mount on the pipe an adjunctive pipe to increase the height of 0.367 m (with the same diameter) for reach the prescribed height.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, the height of the tank gives the possibility to install two different type of pump: external type above the tank or submersible. It can be located in correspondence of one of the two manhole. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed, but the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.5. Ballast Water Tank n° 30

The tank has the following characteristics:

Position	65-71portside
Height	1.68 m(min), 8.50 m(max)
Volume	60.44 m^3

Table 25 - Tank n°30.

Is present one vertical manhole: one in position in x = 45.534 m, y = 6.240 m. And one horizontal manhole in position x = 43.452 m, y = 10.377 m on the main deck. The oval manholes have a dimension of 420X620 (mm). The two aeration hole are located in x = 43.110 m, y = 8.276 m with a pipe of diameter of 0.209 m, that reaches the height of 8.893 m and one in x = 46.835 m, y=10.330 m with also a pipe of diameter of 0.209 m and it reaches the height of 9.053 m. The two pipes are not connected together, it is possible to close one of them, preferably the one lowest. It is necessary to mount on the pipes an adjunctive pipe to increase the height of 2 m or one of 1.85 m in the second case (with the same diameter) for reach the prescribed height.

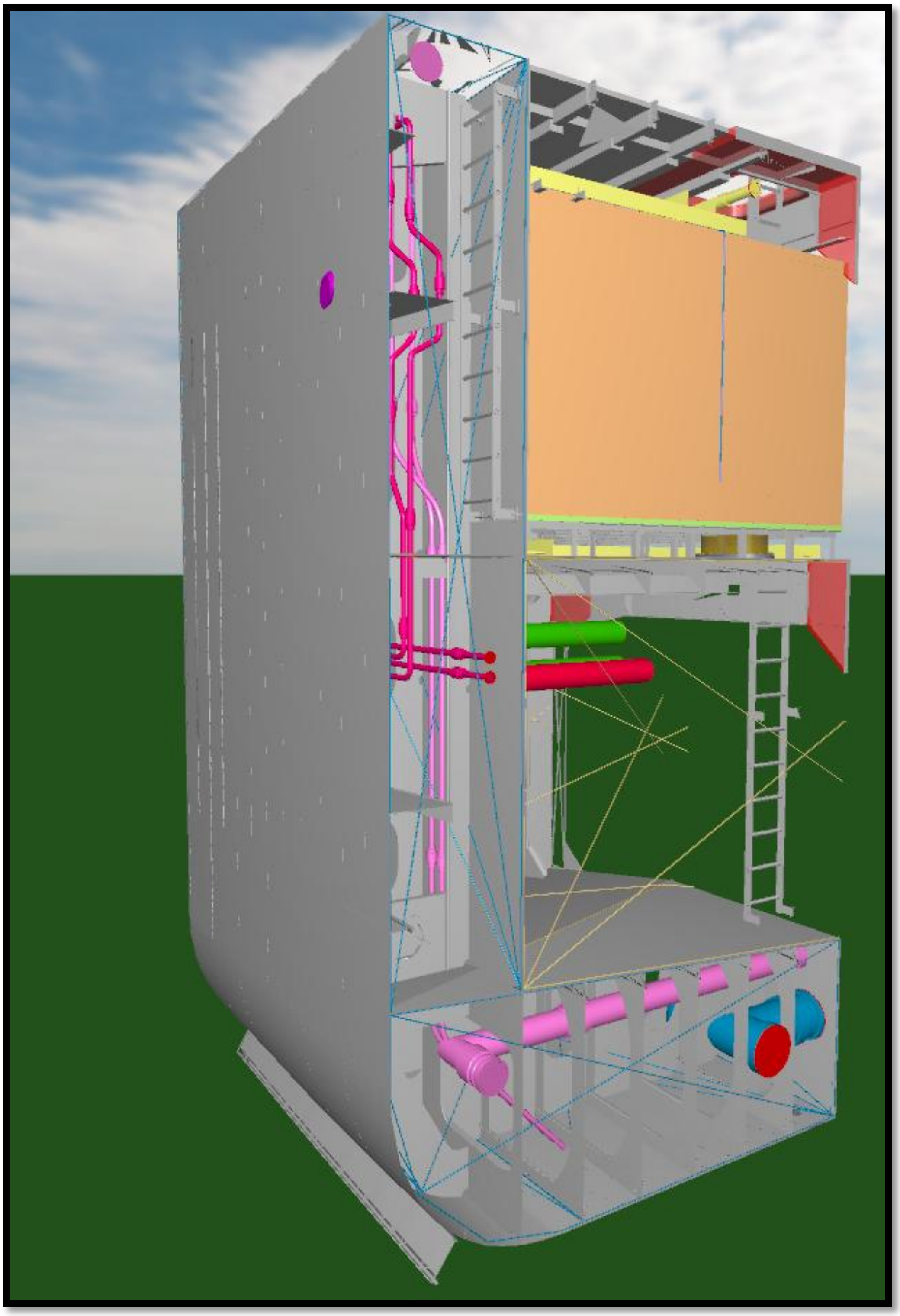


Fig. 47 - Tank n°30. DAMEN copyright.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe , after the test the water is pumped out by the temporary pump. For the discharge of the tank, if it used an external pump above the tank top, it must be located in correspondence of the vertical manhole, otherwise the height of the tank is too big, if it is preferred the horizontal manhole it must be used the submerged pump. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed, but the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.6. Ballast Water Tank n° 37

The tank has the following characteristics:

Position	49-65starboard
Height	1.68 m(min), 8.50 m(max)
Volume	169.2 m^3

Table 26 - Tank n°37.

Is present one oval vertical manhole: one in position in x = 32.941 m, y = -6.240 m. And one horizontal manhole in position x = 43.434 m, y = -10.277 m on the main deck. The oval manholes have a dimension of 420X620 (mm). The two aeration hole are located in x = 31.92 m, y = -10.3 m with a pipe of diameter of 0.209 m, that reaches the height of 9.323 m and one in x = 41.496 m, y = -10.730 m with also a pipe of diameter of 0.209 m and it reaches the height of 8.917 m. The two pipes are not connected together, it is possible to close one of them, preferably the one lowest. It is necessary to mount on the pipes an adjunctive pipe to increase the height of 1.577 m or one of 1.983 m in the second case (with the same diameter) for reach the prescribed height. Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe , after the test the water is pumped out by the temporary pump. For the discharge of the tank, if it used an external pump above the tank top, it must be located in correspondence of the vertical manhole, otherwise the height of the tank is too big, if it is preferred the horizontal manhole it must be used the submerged pump. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

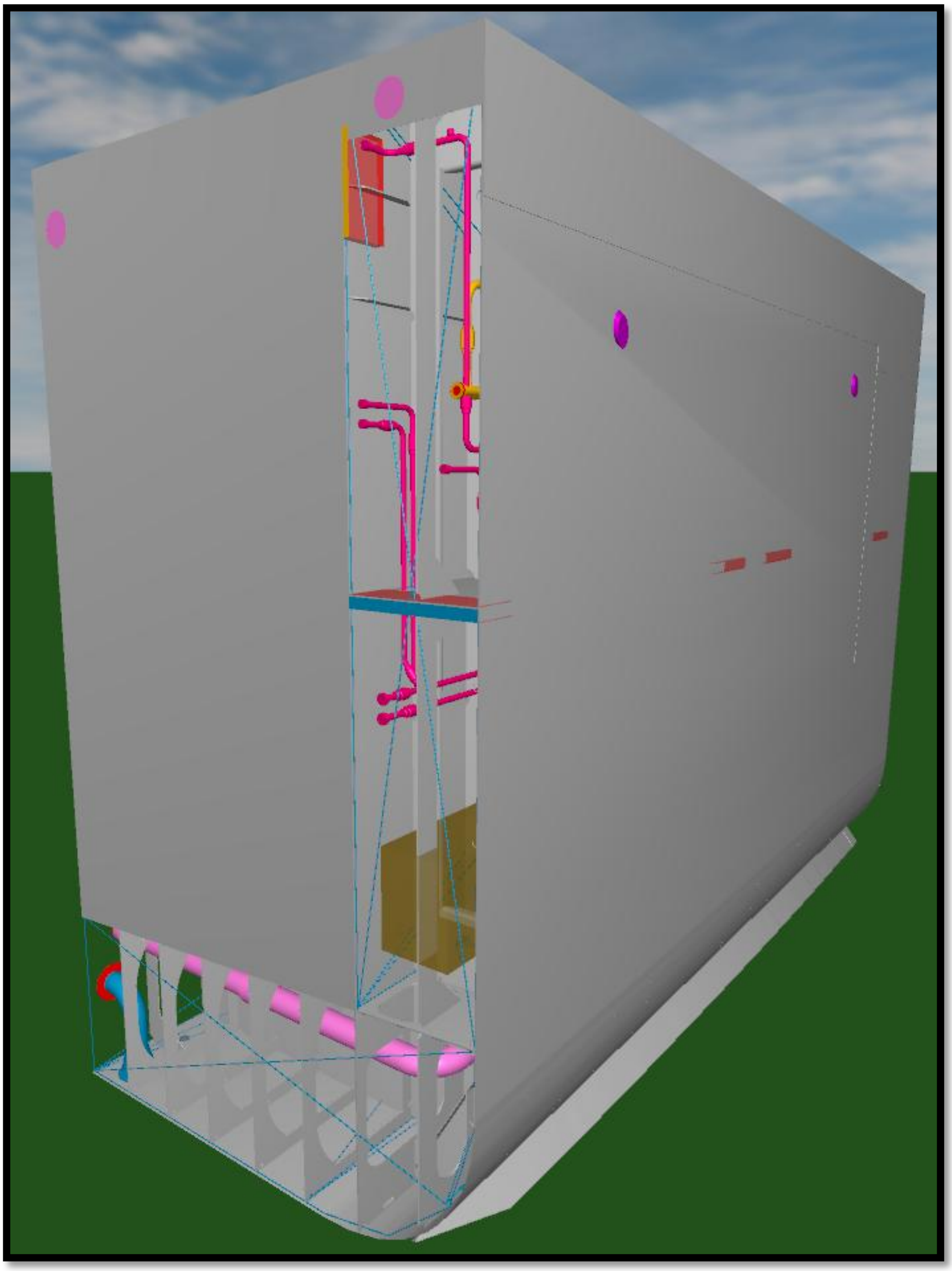


Fig. 48 - Tank n°37. DAMEN copyright.

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed, but the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.7. *Ballast Water Tank n° 48*

The tank has the following characteristics:

Position	39-49central
Height	1.30 m(min), 1.68 m(max)
Volume	123.88 m^3

Table 27 - Tank n°48.

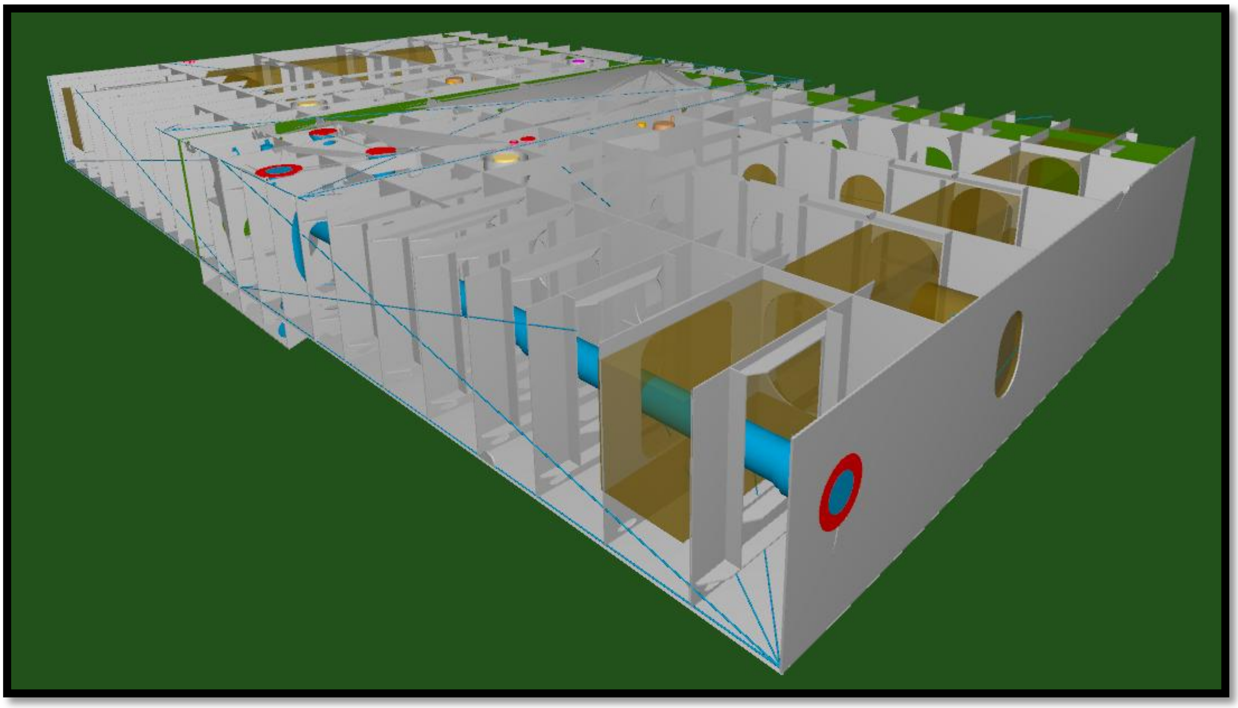


Fig. 49 - Tank n°48. DAMEN copyright.

Is present one horizontal manhole in position x = 29.955 m, y = -0.721 m above the tank. The oval manholes have a dimension of 420X620 (mm). The two aeration hole are located in x = 29.56 m, y = -6.301 m with a pipe of diameter of 0.209 m, that reaches the height of 8.903 m and one in x = 26.751 m, y = 6.277 m with also a pipe of diameter of 0.209 m and it reaches the height of 8.903 m. The two pipes are not connected together, it is possible to close one of them. It is necessary to mount on the pipes an adjunctive pipe to increase the height of 0.357 m for reach the prescribed height.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, the height of the tank gives the possibility to install two different type of pump: external type above the tank or submersible. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed, but the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.8. Ballast Water Tank n° 49

The tank has the following characteristics:

Position	39-49portside
Height	1.68 m(min), 8.50 m(max)
Volume	100.31 m^3

Table 28 - Tank n°49.

Is present one vertical manhole: one in position in x = 27.300 m, y = 6.240 m. And one horizontal manhole in position x = 28.060 m, y = 10.438 m on the main deck.. The oval manholes have a dimension of 420X620 (mm). The two aeration hole are located in x = 25.250 m, y =10.720 m with a pipe of diameter of 0.209 m, that reaches the height of 8.890 m and one in x = 29.590 m, y = 10.720 m with also a pipe of diameter of 0.209 m and it reaches the height of 8.890 m. The two pipes are not connected together, it is possible to close one of them. It is necessary to mount on the pipes an adjunctive pipe to increase the height of 2 m for reach the prescribed height.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, if it used an external pump above the tank top, it must be located in correspondence of the vertical manhole, otherwise the height of the tank is too big, if it is preferred the horizontal manhole it must be used the submerged pump. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

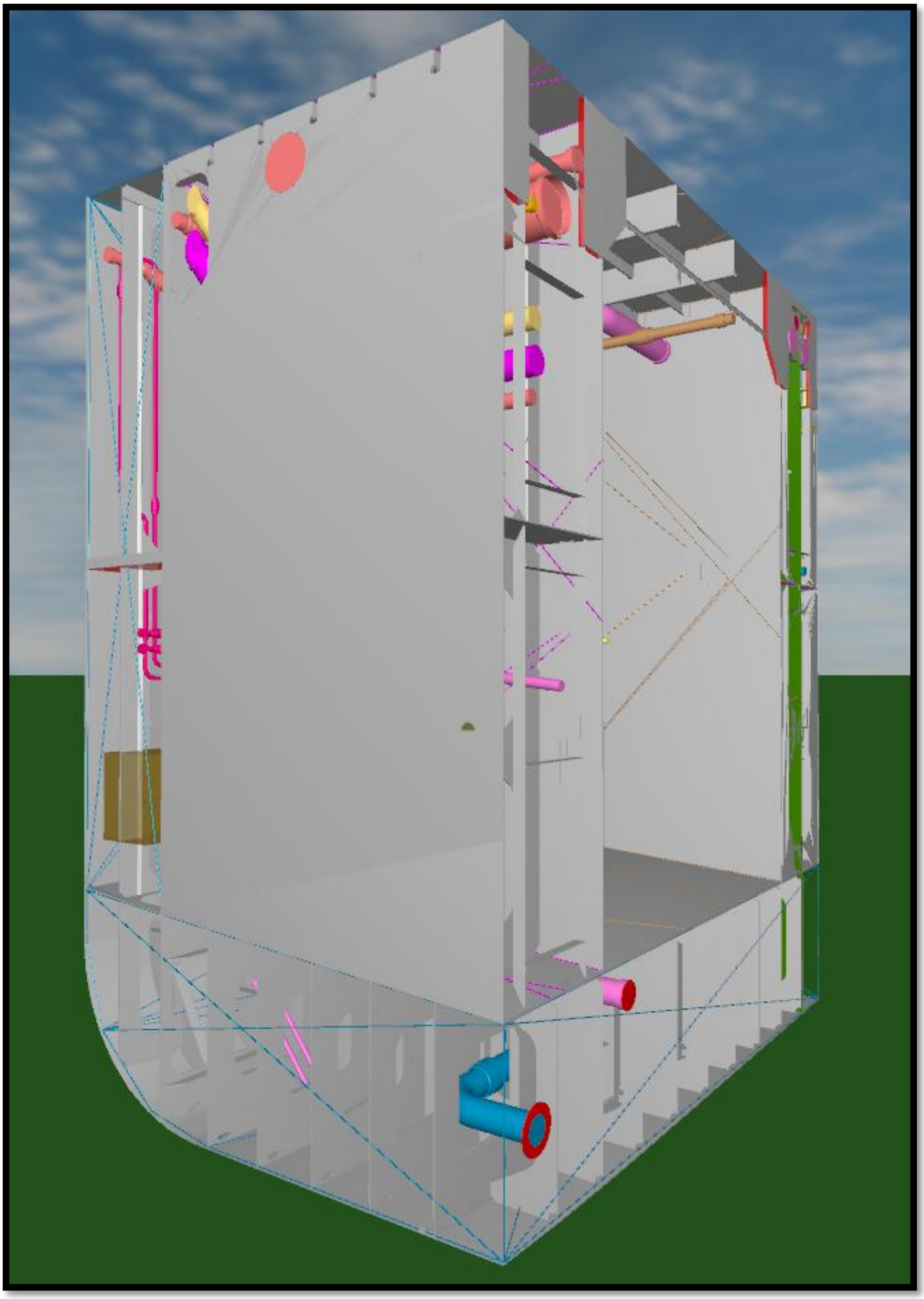


Fig. 50 - Tank n°49. DAMEN copyright.

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed, but the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.9. Ballast Water Tank n° 66

The tank has the following characteristics:

Position	12-25portside
Height	1.30 m(min), 8.50 m(max)
Volume	152.1 m^3

Table 29 - Tank n°66.

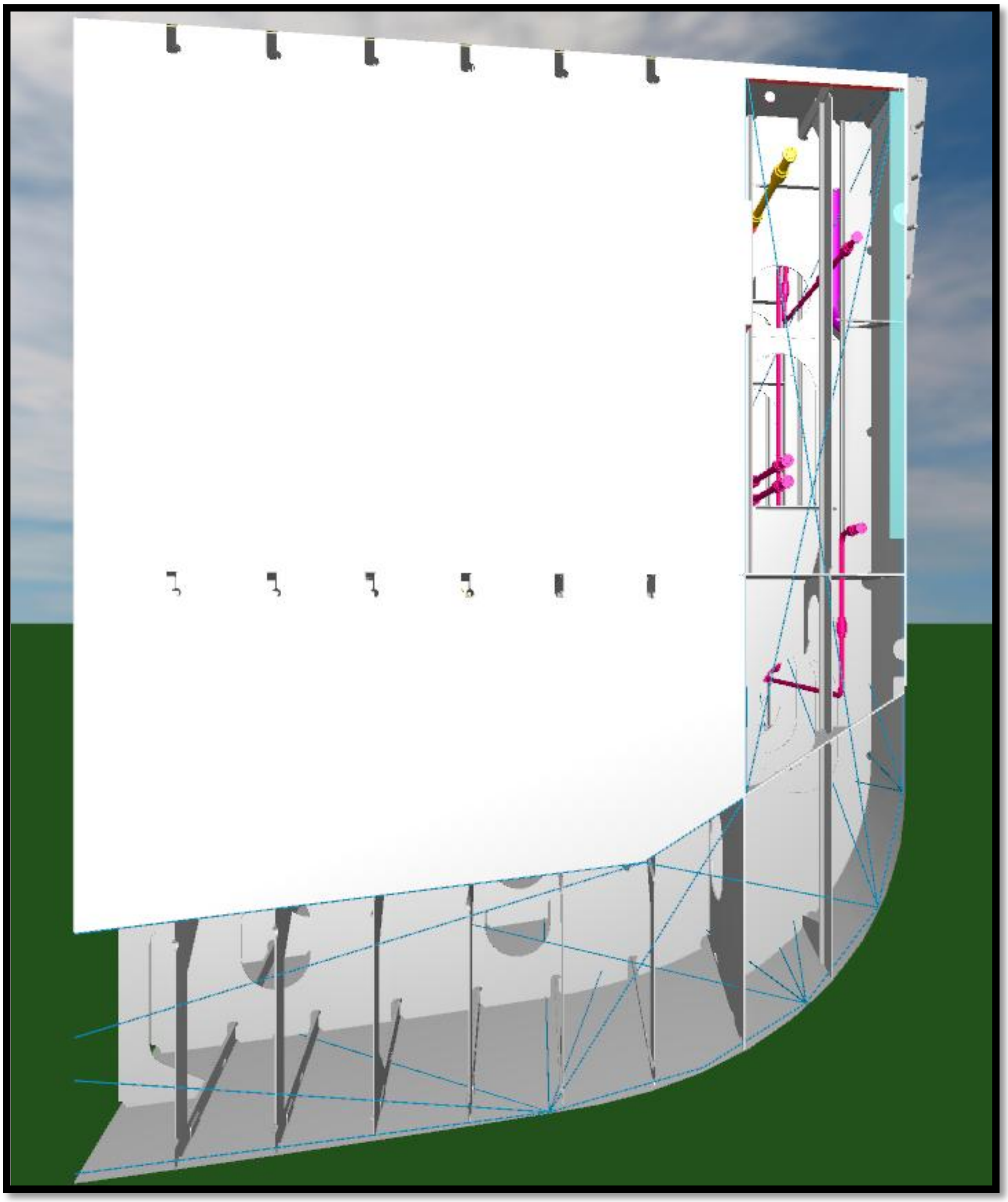


Fig. 51 - Tank n°66. DAMEN copyright.

Is present one vertical manhole: one in position in x = 12.296 m, y = 1.540 m. And one horizontal manhole in position x = 12.260 m, y = 10.510 m on the main deck.. The oval manholes have a dimension of 420X620 (mm). The two aeration hole are located in x = 10.500 m, y = 10.720 m with a pipe of diameter of 0.209 m, that reaches the height of 8.890 m and one in x = 12.950 m, y = 10.720 m with also a pipe of diameter of 0.209 m and it reaches the height of 8.890 m. The two pipes are not connected together, it is possible to close one of them. It is necessary to mount on the pipes an adjunctive pipe to increase the height of 0.370 m for reach the prescribed height

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, if it used an external pump above the tank top, it must be located in correspondence of the vertical manhole, otherwise the height of the tank is too big, if it is preferred the horizontal manhole it must be used the submerged pump. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank present some complexities of shape that could increase the time for the execution of the cleaning operations, the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.10. Ballast Water Tank n° 76

The tank has the following characteristics:

Position	-4 -12starboard
Height	1.30 m(min), 8.50 m(max)
Volume	66.4 m^3

Table 30 - Tank n°76.

Is present one vertical manhole: one in position in x = 5.702 m, y = -8.054 m. And one horizontal manhole in position x = -1.920 m, y = -9.000 m on the main deck. The oval manholes have a dimension of 420X620 (mm). The two aeration hole are located in x = -2.10 m, y = -10.700 m with a pipe of diameter of 0.209 m, that reaches the height of 9.310 m and one in x = 6.850 m y = -10.720 m with also a pipe of diameter of 0.209 m and it reaches the height of 8.890 m. The two pipes are not connected together, it is possible to close one of them. It is necessary to mount on the pipes an adjunctive pipe to increase the height of 1.590 m for the first one or of 2 m for the second case, to reach the prescribed height.

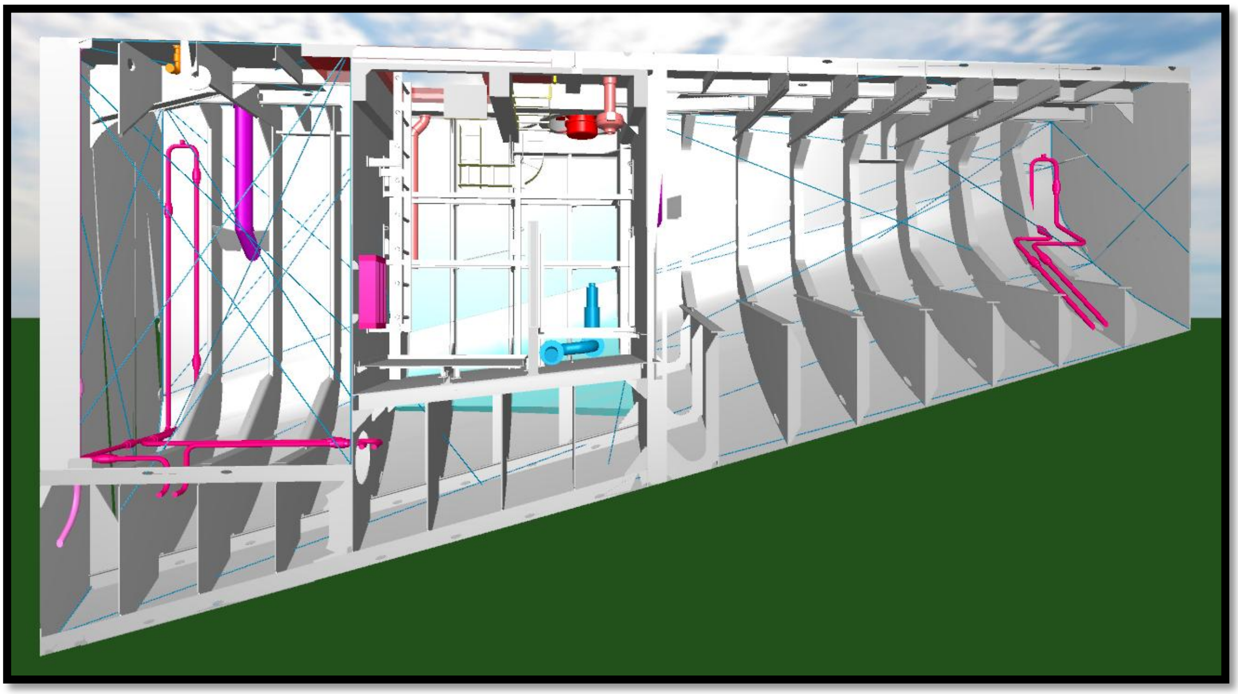


Fig. 52 - Tank n°76. DAMEN copyright.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, if it used an external pump above the tank top, it must be located in correspondence of the vertical manhole, otherwise the height of the tank is too big, if it is preferred the horizontal manhole it must be used the submerged pump. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank present some complexities of shape that could increase the time for the execution of the cleaning operations, the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.11. Ballast Water Tank n° 77

The tank has the following characteristics:

Position	AFT- -4Portside
Height	1.30 m(min), 4.00 m(max)
Volume	54.44 m^3

Table 31 - Tank n°77.

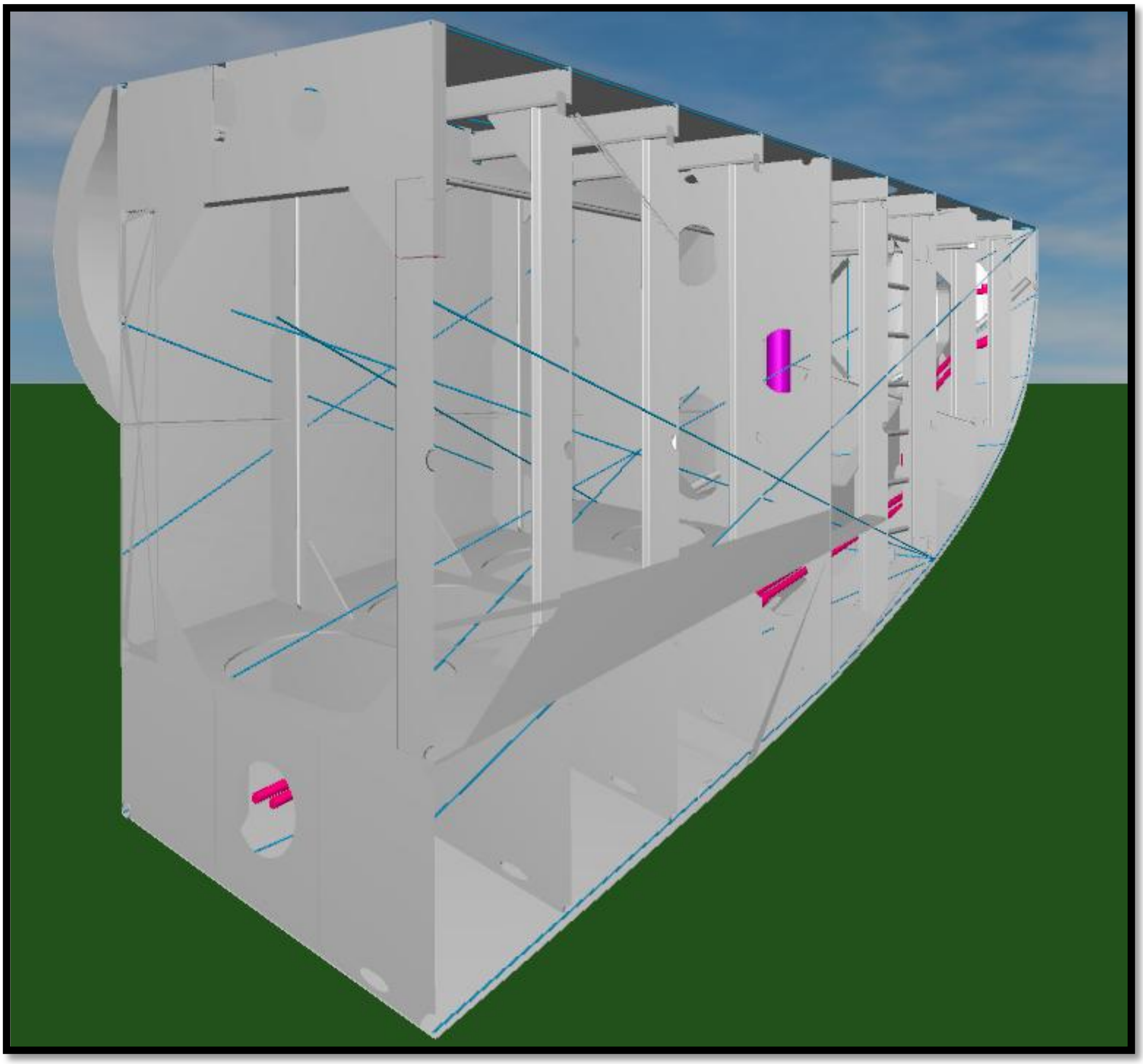


Fig. 53 - Tank n°76. DAMEN copyright.

Is present one vertical manhole: one in position in x = -2.355 m, y = 4.187 m. And one horizontal manhole in position x = -2.825 m, y = -9.000 m on the main deck.. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = -2.625 m, y = 10.700 m with a pipe of diameter of 0.263 m, that reaches the height of 9.310 m so it is necessary to mount on the pipe an adjunctive pipe to increase the height of 1.590 m to reach the prescribed height

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, the height of the tank gives the possibility to install two different type of pump: external type above the tank or submersible. It can be located in correspondence of the horizontal manhole, it is to prefer the horizontal manhole because the installation is more easy. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank present some complexities of shape that could increase the time for the execution of the cleaning operations, the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.12. Fresh water n° 4

The tank has the following characteristics:

Position	94 -114portside
Height	5.850 m
Volume	267.49 m^3

Table 32 - Tank n°4.

Is present two vertical manhole: one in position in x = 62.005 m, y = 2.691 m. And one in position x = 72.179 m, y = 2.691 m. The oval manholes have a dimension of 420X620 (mm). The three aeration hole are located in x = 72.935 m, y = 2.890 m with a pipe of diameter of 0.212 m, that reaches the height of 8.807 m and one in x = 70.510 m, y = 5.950 m with a pipe of diameter of 0.217 m and it reaches the height of 14.375 m, the third one is located in x = 61.265 m, y = 9.470 m with a pipe of diameter of 0.217 m and it reaches the height of 14.375 m. The second and the third pipes are connected together, it is suggest to close the first aeration hole because will be much more easy to reach the quota of 14.860 m mounting on the pipes an adjunctive pipe to increase the height of only 0.485 m instead of 6 meters for the first hole.

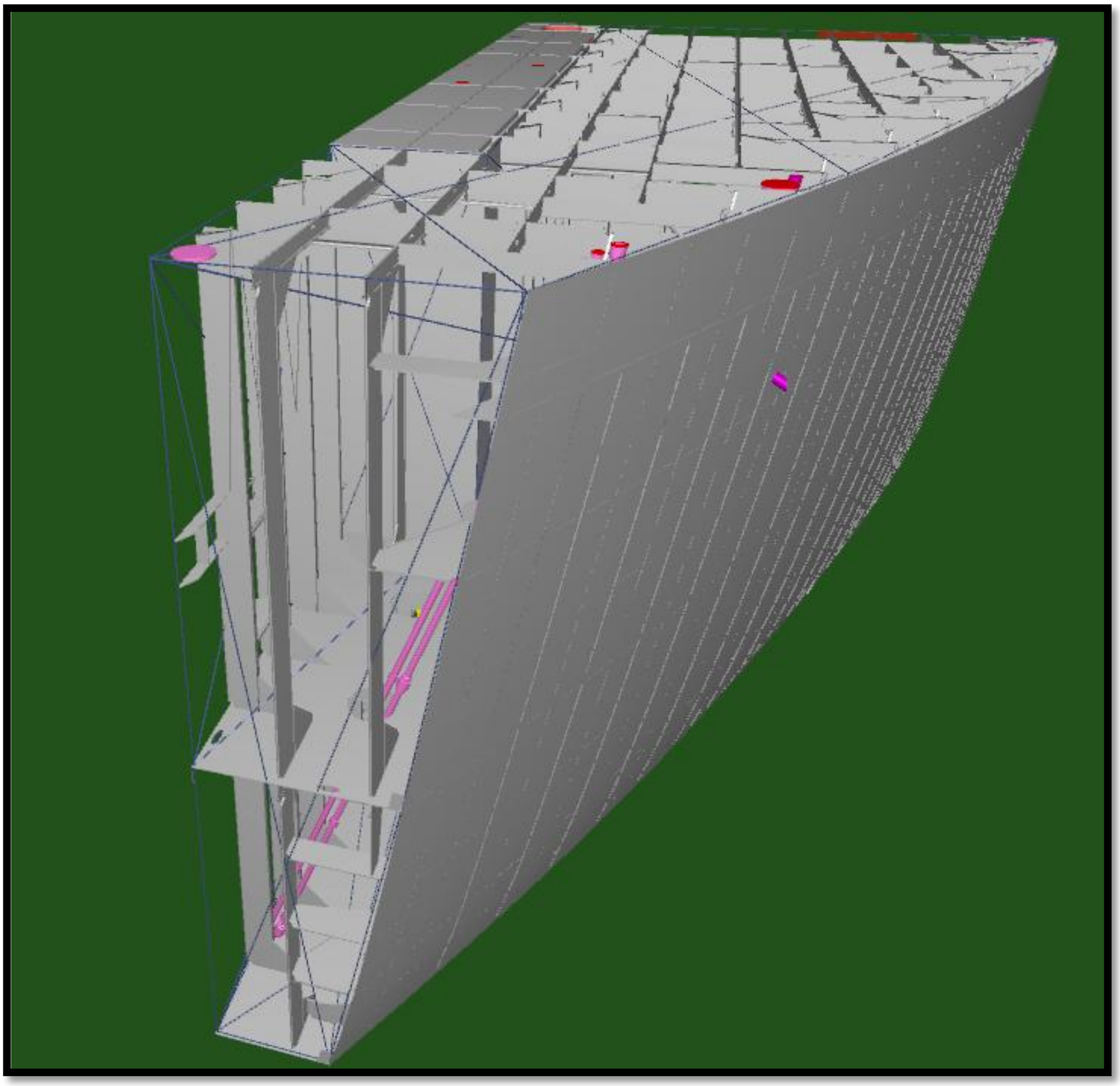


Fig. 54 - Tank n°4. DAMEN copyright.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, the height of the tank gives the possibility to install two different type of pump: external type or submersible. The pump can be located only in correspondence of one of the vertical manhole. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock.

The geometry of the tank results easy to clean and the presence of diaphragms inside bring the maximum internal height from 5.850 m to the half. Therefore the mud and other residuals can be easily removed.

6.4.13. Fresh water n° 55

The tank has the following characteristics:

Position	27 -37central
Height	0.75 m(min), 1.30 m(max)
Volume	137.79 m^3

Table 33 - Tank n°55.

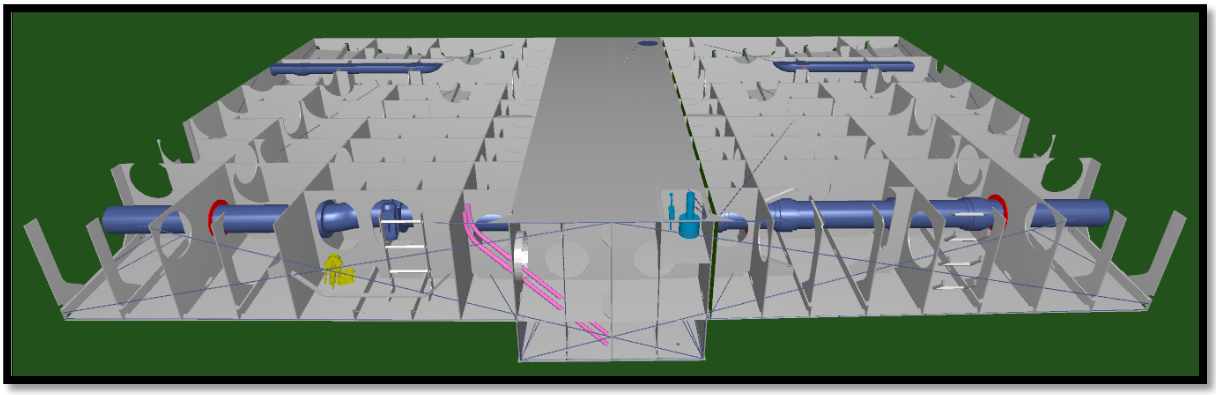


Fig. 55 - Tank n°55. DAMEN copyright.

Are present two horizontal manholes in position x = 16.128 m, y = -2.249 m and x = 20.424 m, y = -5.777 m on the tanktop. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 16.140 m, y = -5.450 m with a pipe of diameter of 0.216 m, that reaches the height of 8.90 m so it is necessary to mount on the pipe an adjunctive pipe to increase the height of 0.36 m to reach the prescribed height.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, the height of the tank gives the possibility to install two different type of pump: external type or submersible. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank is quite complex with an height that goes down till 0.750 m. This must be taken into consideration because the it could affect the cleaning operation that will be done after the test. In this case could be economically more advantageous and less time consuming to use fresh water (more expensive) than normal water which contains residual and mud into consideration of the time for cleaning will be double with the normal water.

6.4.14. Fresh water n° 63

The tank has the following characteristics:

Position	26 -37starboard
Height	1.65 m(min), 8.50 m(max)
Volume	112.77 m^3

Table 34 - Tank n°63.

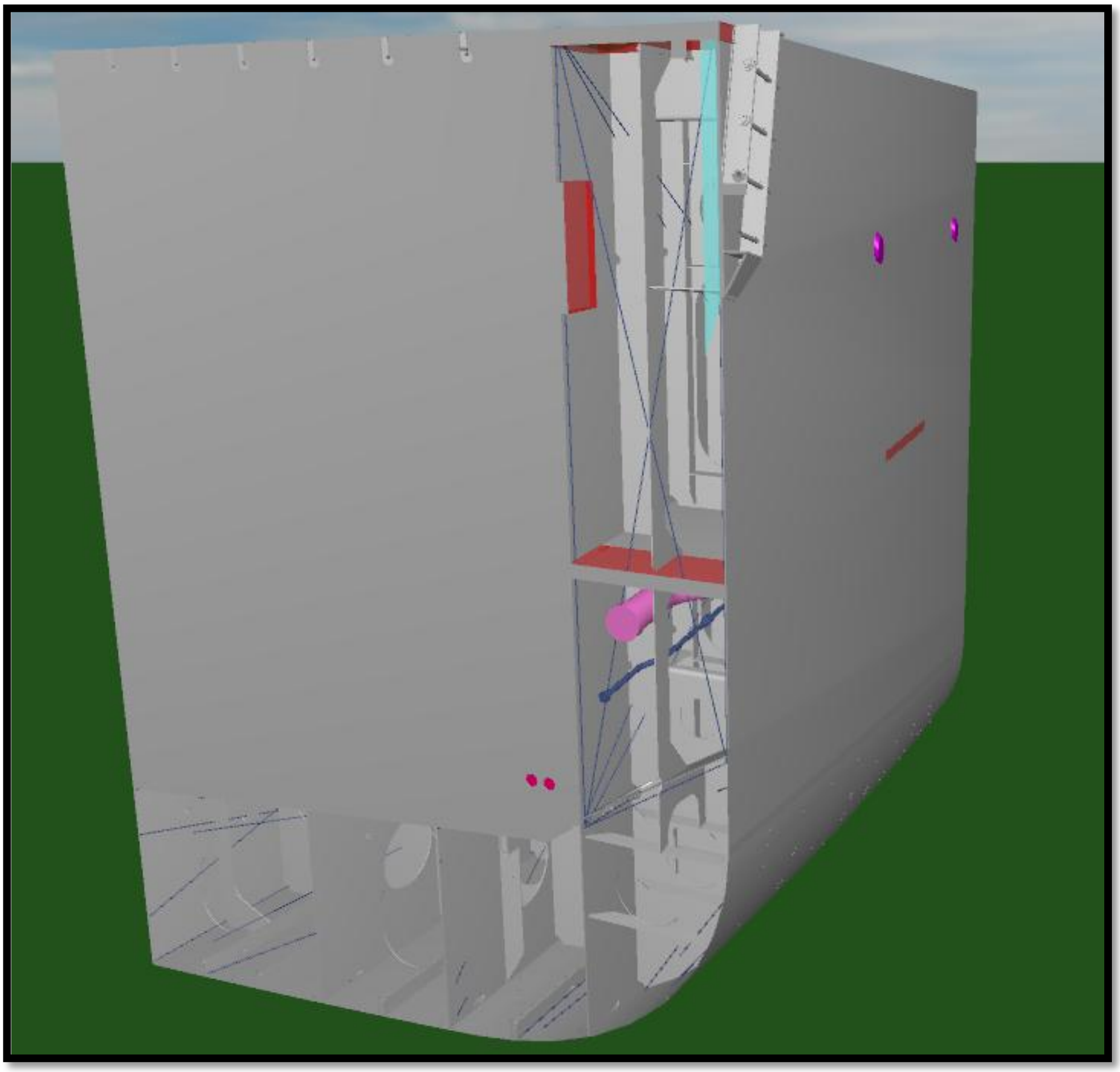


Fig. 56 - Tank n°63. DAMEN copyright.

Are present two horizontal manholes in position x = 20.428 m, y = -6.016 m on the tanktop and x = 18.942 m, y = -10.522 m on the main deck. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 23.335 m, y = -10.720 m with a pipe of diameter of 0.216 m, that reaches the height of 8.90 m so it is necessary to mount on the pipe an adjunctive pipe to increase the height of 2 m to reach the prescribed height, but because above the head of the pipe there is not sufficient height, it is necessary to curve it horizontally (for 1.5 m) and to reach outside, where it is possible to erect the pipe for 2 m vertical. One other aeration hole is located in x = 18.085 m, y = -10720 m with a pipe of diameter of 0.216 m, that reaches the height of 8.90 m, so it is necessary to mount on the pipe an adjunctive pipe to increase the height of 2 m to reach the prescribed height, but because above the head of the pipe there is not sufficient height, it is necessary to curve it horizontally (for 1.5 m) and to reach outside, where it is possible to erect the pipe for 2 m vertical. The two pipes are not connected so one of two can be closed for the test.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. For the discharge of the tank, the height of the tank gives the possibility to install two different type of pump: external type or submersible. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed, but the height of the tank is not the optimal work condition and this increases the time necessary.

6.4.15. Fuel oil n° 14

The tank has the following characteristics:

Position	77 -85 starboard
Height	3.80 m
Volume	26.81 m^3

Table 35 - Tank n°14.

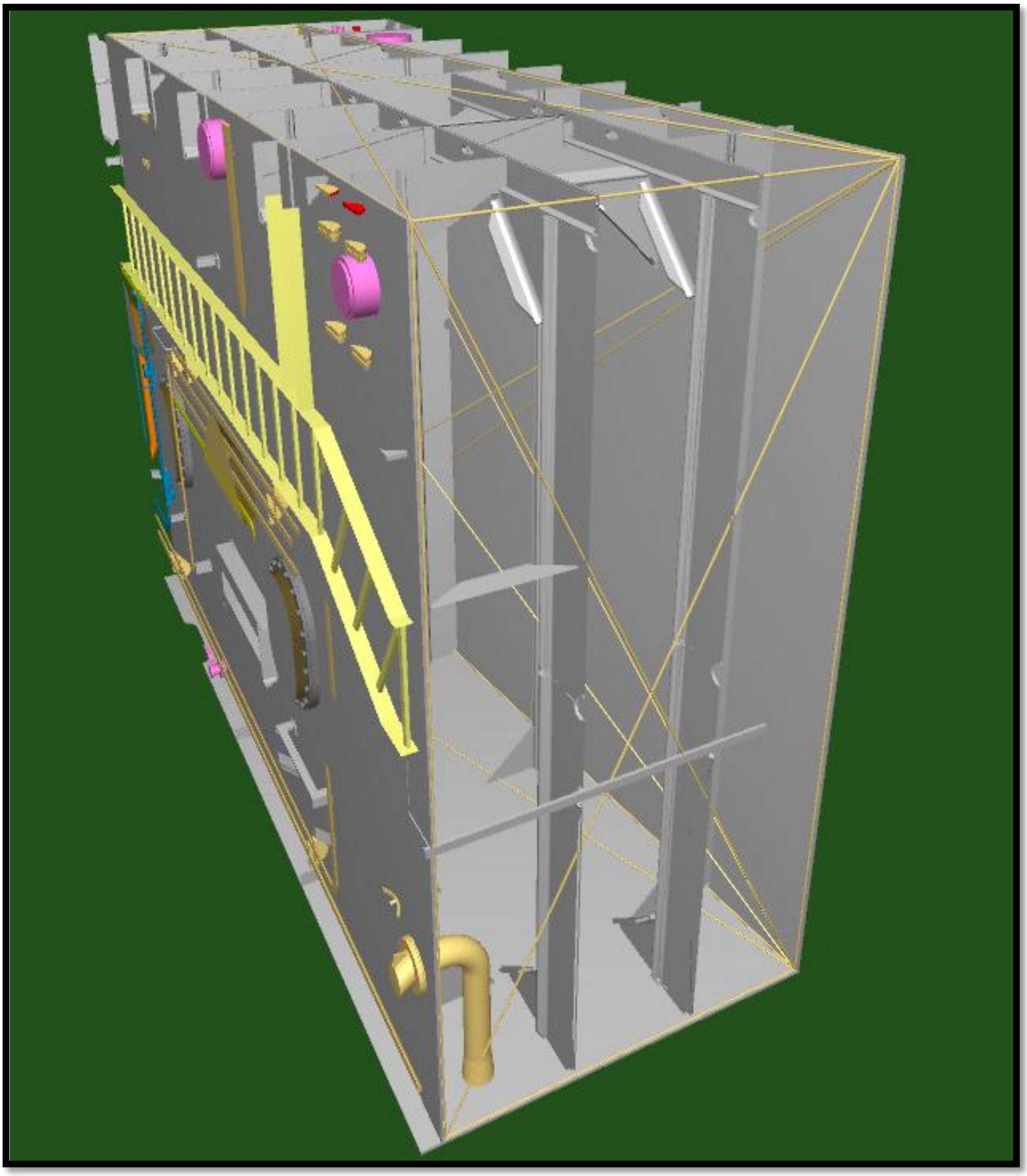


Fig. 57 - Tank n°14. DAMEN copyright.

Are present two vertical manholes in position x = 54.805 m, y = -8.053 m and x = 52.408 m, y = -8.054 m. The oval manholes have a dimension of 420X620 (mm). The aeration holes are located in x = 51.230 m, y = -8.110 m and in x = 52.910 m, y = -8.110 m In this case for the tank that contains fuel oil these aeration holes are connected by pipes to the FO alarm box, this fact impends to use these aeration pipes for the test, so the openings must be closed to avoid that the water goes to the alarm box.

For this tank must be adopted one other solution respect the previous cases, at the manhole must be mounted a top with two openings one for load the water and one connected to a pipe for let the air in the tank to flow outside. For reach the height of 10,9 m of water column it is used a sonde pipe with access hole in x = 55.477 m, y = -9.929 m, z = 5.035 m and connected with a pipe of diameter 0.043 m that reach the height of 14.50 m.

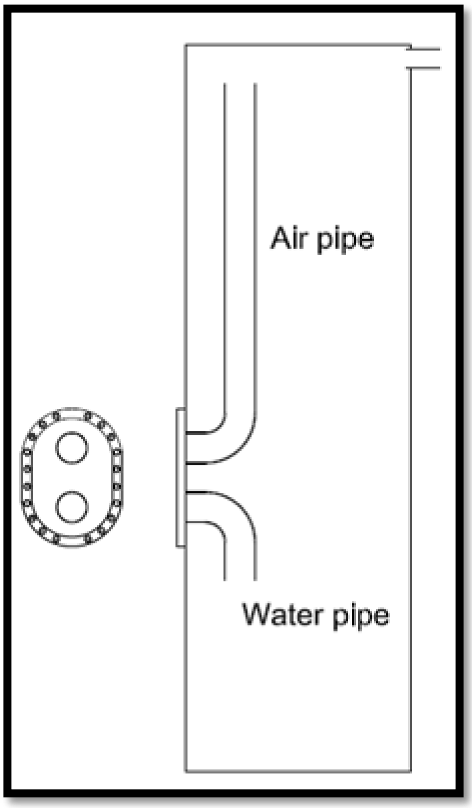


Fig. 58 - Special device for fuel oil tank.

There are some considerations and attentions to do regarding this procedure. When the water level reach the top of the aeration pipe inserted inside the tank, the velocity of the entrance flow of the water must be reduced for avoid a rise of internal pressure due to the small diameter of the hole that limits the exit of air. It is suggest to reduce this velocity to 1/3 of the starting velocity.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed. For the oil tank also the aeration holes connected with the pipe must be closed. For the discharge of the tank, the water must be extracted by the water line pipe installed through the top. When the water level, during the operation, arrives below the pipe, it is possible to open the manhole and mount the pump on the bottom of the tank and to finish the discharge of the water. Moreover can be used for speed up the procedure of discharge a faucet located in position x = 54.300 m, y = -8.058 m, z = 1.4 m. If the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed.

6.4.16. Fuel oil n° 33

The tank has the following characteristics:

Position	65 -71 Portside
Height	3.80 m
Volume	95.80 m^3

Table 36 - Tank n°33.

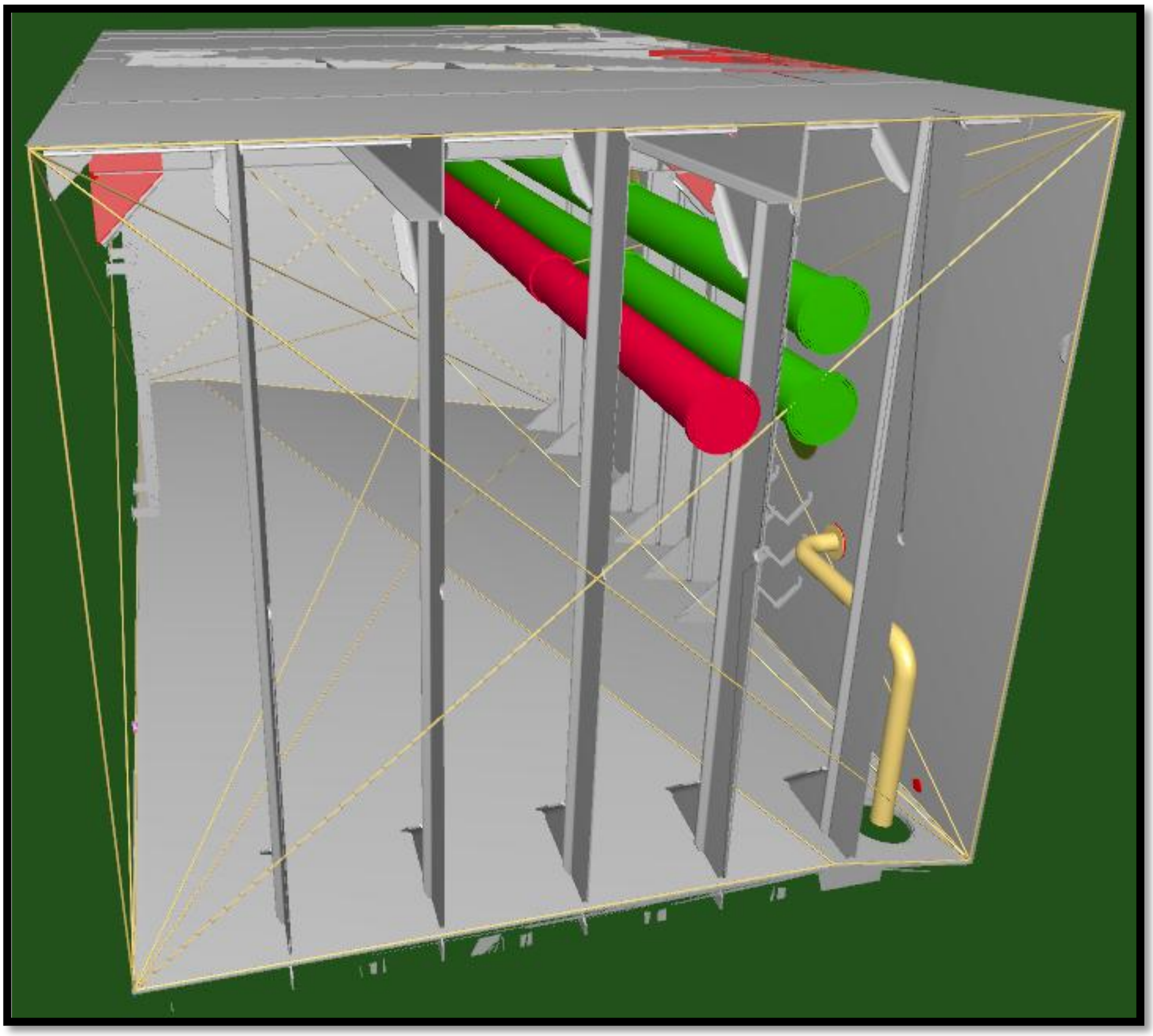


Fig. 59 - Tank n°33. DAMEN copyright.

Are present one vertical manholes in position x = 47.300 m, y = 5.390 m and one horizontal manhole in x = 43.685 m, y = 7.205 m on the tanktop. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 47.291 m, y = 4.290 m. In this case for the tank that contains fuel oil this aeration hole is connected by pipes to the FO alarm box, this fact impends to use this aeration pipe for the test, so the opening must be closed to avoid that the water goes to the alarm box.

For this tank must be adopted one other solution respect the previous cases, at the manhole must be mounted a top with two openings one for load the water and one connected to a pipe for let the air in the tank to flow outside. For reach the height of 10.9 m of water column it is used a sonde pipe with access hole in x = 43.121 m, y = 4.944 m, z = 5.020 m and connected with a pipe of diameter 0.043 m that reach the height of 8.955 m. With the scope to reach the prescribed height it is necessary to add one pipe of 1m with the same diameter on the top of the pipe.

There are some considerations and attentions to do regarding this procedure. When the water level reach the top of the aeration pipe inserted inside the tank, the velocity of the entrance flow of the water must be reduced for avoid a rise of internal pressure due to the small diameter of the hole that limits the exit of air. It is suggest to reduce this velocity to 1/3 of the starting velocity.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed. For the oil tank also the aeration holes connected with the pipe must be closed. For the discharge of the tank, the water must be extracted by the water line pipe installed through the top. When the water level, during the operation, arrives below the pipe, it is possible to open the manhole and mount the pump on the bottom of the tank and to finish the discharge of the water. Moreover can be used for speed up the procedure of discharge a faucet located in position x = 44.477 m, y = 3.790 m, z = 1.4 m. If the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed.

6.4.17. Fuel oil n° 34

The tank has the following characteristics:

Position	65 -71 Starboard
Height	3.80 m
Volume	121.94 m^3

Table 37 - Tank n°34.

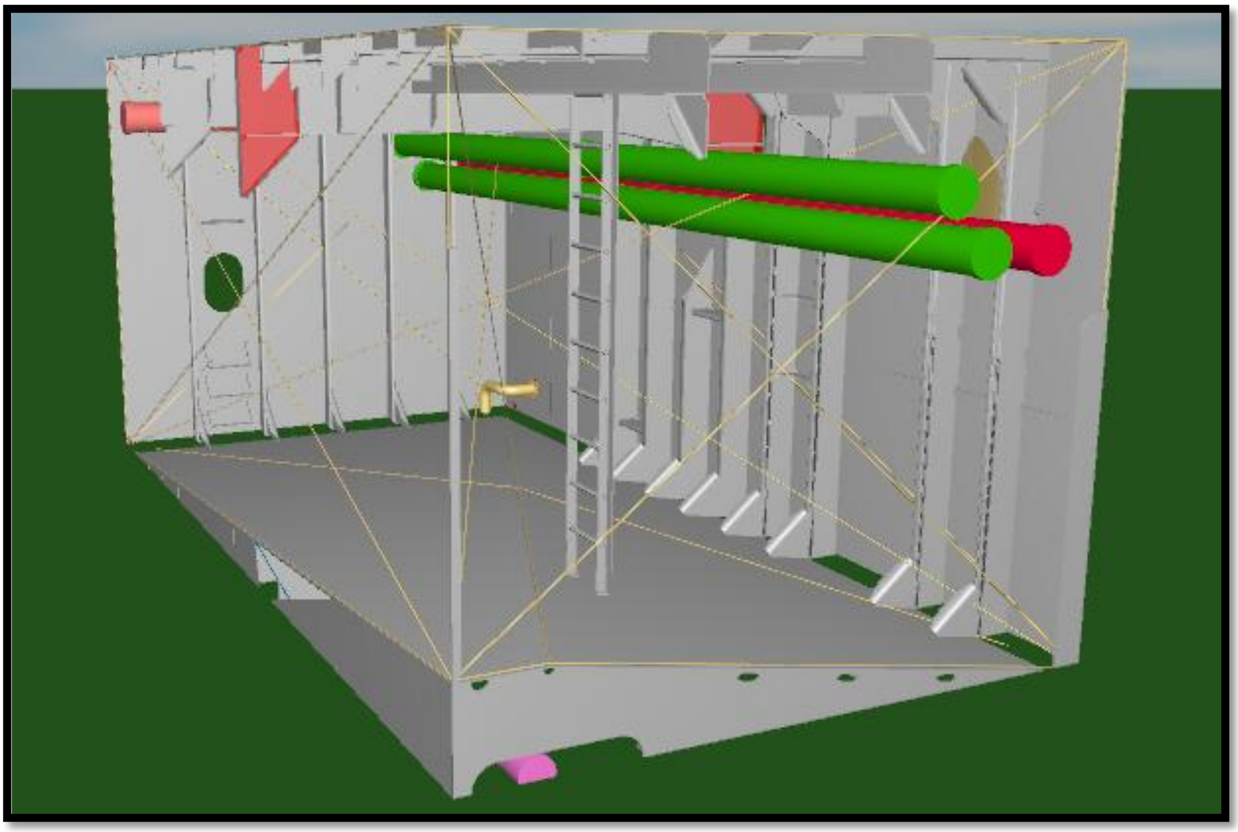


Fig. 60 - Tank n°34. DAMEN copyright.

Are present one vertical manholes in position x = 44.300 m, y = -1.590 m and one horizontal manhole in x = 44.880 m, y = -8.367 on the tanktop. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 47.291 m, y = -3.480 m. In this case for the tank that contains fuel oil this aeration hole is connected by pipes to the FO alarm box, this fact impends to use this aeration pipe for the test, so the opening must be close to avoid that the water goes to the alarm box.

For this tank must be adopted one other solution respect the previous cases, at the manhole must be mounted a top with two openings one for load the water and one connected to a pipe for let the air in the tank to flow outside. For reach the height of 10.9 m of water column it is used a sonde pipe with access hole in x = 43.121 m, y = 4.944 m, z = 5.020 m and connected with a pipe of diameter 0.043 m that reaches the height of 8.955m. With the scope to reach the prescribed height it is necessary to add one pipe of 1m with the same diameter on the top of the pipe.

There are some considerations and attentions to do regarding this procedure. When the water level reaches the top of the aeration pipe inserted inside the tank, the velocity of the entrance flow of the water must be reduced for avoid a rise of internal pressure due to the small diameter of the hole that limits the exit of air. It is suggest to reduce this velocity to 1/3 of the starting velocity.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed. For the oil tank also the aeration holes connected with the pipe must be closed. For the discharge of the tank, the water must be extracted by the water line pipe installed through the top. When the water level, during the operation, arrives below the pipe, it is possible to open the manhole and mount the pump on the bottom of the tank and to finish the discharge of the water. If the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, therefore the mud and other residuals can be easily removed.

6.4.18. Fuel oil n° 68

The tank has the following characteristics:

Position	17 -25 central
Height	5.80 m
Volume	143.89 m^3

Table 38 - Tank n°68.

Are present one vertical manholes in position x = 11.678 m, y = -1.590 m and one horizontal manhole in x = 11.000 m, y = -0.724 m on the tank top. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 14.225 m, y = -3.281 m. In this case for the tank that contains fuel oil this aeration hole is connected by pipes to the FO alarm box, this fact impends to use this aeration pipe for the test, so the opening must be close to avoid that the water goes to the alarm box.

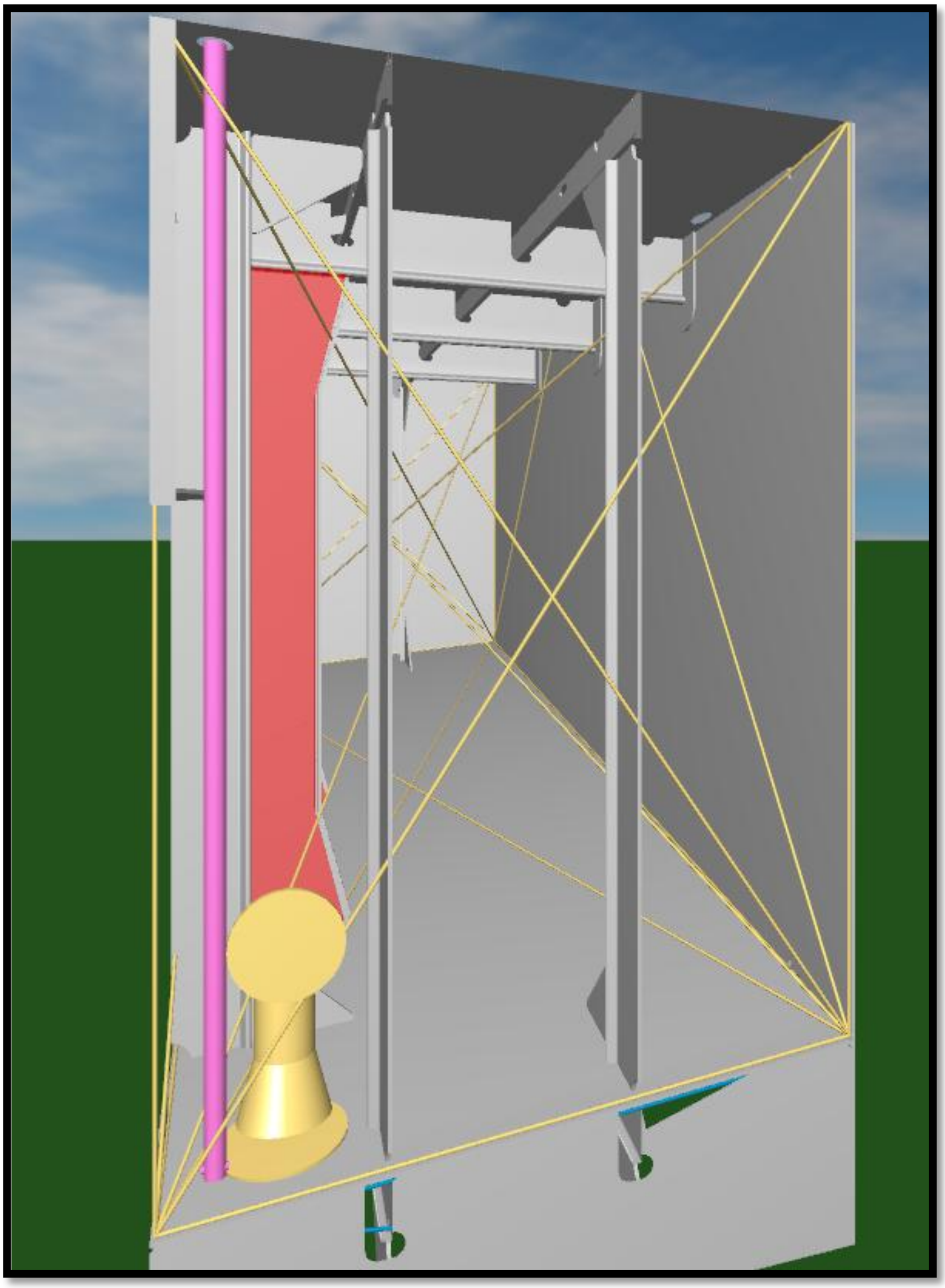


Fig. 61 - Tank n°68. DAMEN copyright.

For this tank must be adopted one other solution respect the previous cases, at the manhole must be mounted a top with two openings one for load the water and one connected to a pipe for let the air in the tank to flow outside. For reach the height of 10.9 m of water column it is used a sonde pipe with access hole in x = 15.000 m, y = 1.725 m, z = 8.500 m and connected with a pipe of diameter 0.043 m that reaches the height of 8.500m (main deck). With the scope to reach the prescribed height it is necessary to add one pipe of 1.9 m with the same diameter on the top of the pipe.

There are some considerations and attentions to do regarding this procedure. When the water level reach the top of the aeration pipe inserted inside the tank, the velocity of the entrance flow of the water must be reduced for avoid a rise of internal pressure due to the small diameter of the hole that limits the exit of air. It is suggest to reduce this velocity to 1/3 of the starting velocity.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed. For the oil tank also the aeration holes connected with the pipe must be closed. For the discharge of the tank, the water must be extracted by the water line pipe installed through the top. When the water level, during the operation, arrives below the pipe, it is possible to open the manhole and mount the pump on the bottom of the tank and to finish the discharge of the water. If the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, and the presence of diaphragms inside bring the maximum internal height to 3,4 m instead of 5.8 m. Therefore the mud and other residuals can be easily removed, therefore the mud and other residuals can be easily removed.

6.4.19. Fuel oil cargo n° 38

The tank has the following characteristics:

Position	59 -65 portside
Height	6.60 m
Volume	103.58 m^3

Table 39 - Tank n°38.

Are present one vertical manholes in position x = 42.055 m, y = 1.590 m and one horizontal manhole in x = 39.513 m, y = 0.838 m on the main deck. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 42.655 m, y = 6.623 m. In this case for the tank that contains fuel oil this aeration hole is connected by pipes to the FO alarm box, this fact impends to use this aeration pipe for the test, so the opening must be close to avoid that the water goes to the alarm box.

For this tank must be adopted one other solution respect the previous cases, at the manhole must be mounted a top with two openings one for load the water and one connected to a pipe for let the air in the tank to flow outside. For reach the height of 10,9 m of water column it is used a sonde pipe with access hole in x = 42.108 m, y=5.249 m, z = 8.500 m and connected with a pipe of diameter 0.043 m that reaches the height of 8.500 m (main deck). With the scope to reach the prescribed height it is necessary to add one pipe of 1.9 m with the same diameter on the top of the pipe.

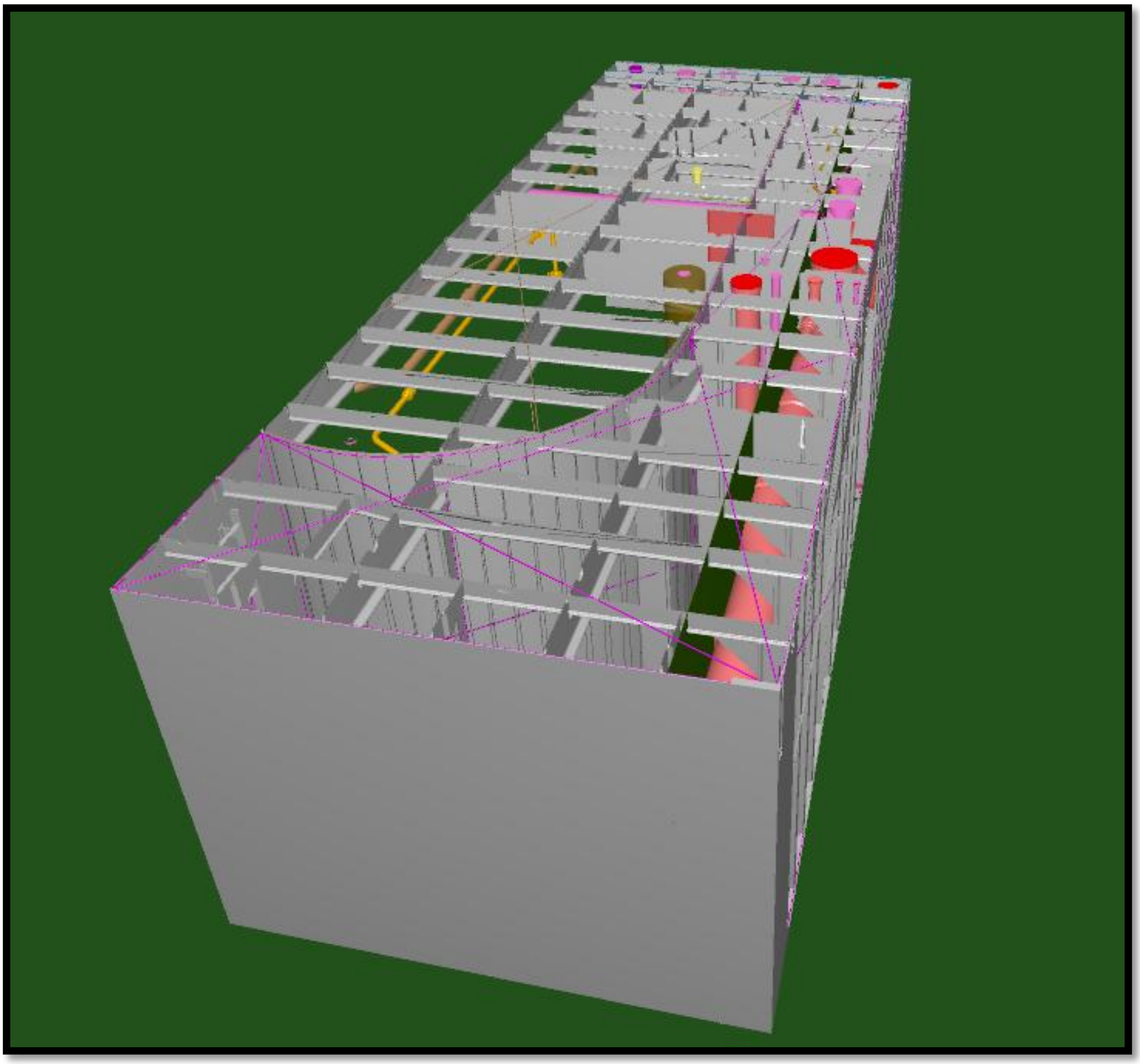


Fig. 62 - Tank n°38. DAMEN copyright.

For this tank must be adopted one other solution respect the previous cases, at the manhole must be mounted a top with two openings one for load the water and one connected to a pipe for let the air in the tank to flow outside. For reach the height of 10,9 m of water column it is used a sonde pipe with access hole in x = 42.108 m, y = 5.249 m, z = 8.500 m and connected with a pipe of diameter 0.043 m that reaches the height of 8.500 m (main deck). With the scope to reach the prescribed height it is necessary to add one pipe of 1.9m with the same diameter on the top of the pipe.

There are some considerations and attentions to do regarding this procedure. When the water level reach the top of the aeration pipe inserted inside the tank, the velocity of the entrance flow of the water must be reduced for avoid a rise of internal pressure due to the small diameter of the hole that limits the exit of air. It is suggest to reduce this velocity to 1/3 of the starting velocity.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed. For the oil tank also the aeration holes connected with the pipe must be closed. For the discharge of the tank, the water must be extracted by the water line pipe installed through the top. When the water level, during the operation, arrives below the pipe, it is possible to open the manhole and mount the pump on the bottom of the tank and to finish the discharge of the water. If the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, but some parts of the tank could be difficult to reach so the time of execution of the cleaning operations is increased.

6.4.20. Fuel oil cargo n° 43

The tank has the following characteristics:

Position	49 -59 starboard
Height	6.60 m
Volume	134.37 m^3

Table 40 - Tank n°43.

Are present one vertical manholes in position x = 36.462 m, y = -1.590 m and one horizontal manhole in x = 38.312 m, y = -0.820 m on the maindeck. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 37.490 m, y = -9.605 m. In this case for the tank that contains fuel oil this aeration hole is connected by pipes to the FO alarm box, this fact impends to use this aeration pipe for the test, so the opening must be close to avoid that the water goes to the alarm box.

For this tank must be adopted one other solution respect the previous cases, at the manhole must be mounted a top with two openings one for load the water and one connected to a pipe for let the air in the tank to flow outside. For reach the height of 10.9 m of water column it is used a sonde pipe with access hole in x = 36.085 m, y = -9.780 m, z = 7.901 m and connected with a pipe of diameter 0.043 m that reaches the height of 8.950m. With the scope to reach the prescribed height it is necessary to add one pipe of 1.9m with the same diameter on the top of the pipe.

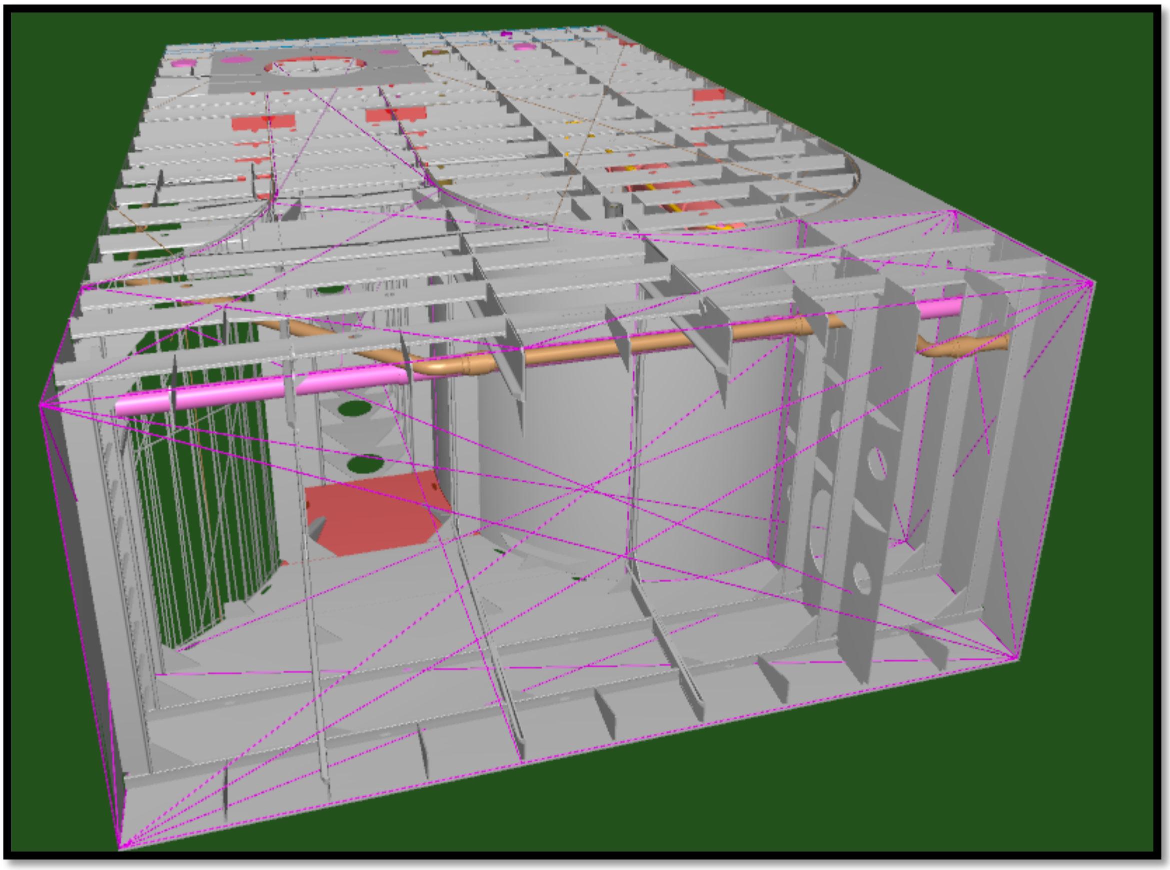


Fig. 63 - Tank n°43. DAMEN copyright.

There are some considerations and attentions to do regarding this procedure. When the water level reach the top of the aeration pipe inserted inside the tank, the velocity of the entrance flow of the water must be reduced for avoid a rise of internal pressure due to the small diameter of the hole that limits the exit of air. It is suggest to reduce this velocity to 1/3 of the starting velocity.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed. For the oil tank also the aeration holes connected with the pipe must be closed. For the discharge of the tank, the water must be extracted by the water line pipe installed through the top. When the water level, during the operation, arrives below the pipe, it is possible to open the manhole and mount the pump on the bottom of the tank and to finish the discharge of the water. If the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, but some parts of the tank could be difficult to reach so the time of execution of the cleaning operations is increased.

6.4.21. Liquid Mud n° 45

The tank has the following characteristics:

Position	49 -55 starboard
Height	7.20 m
Volume	221.38 m^3

Table 41 - Tank n°45.

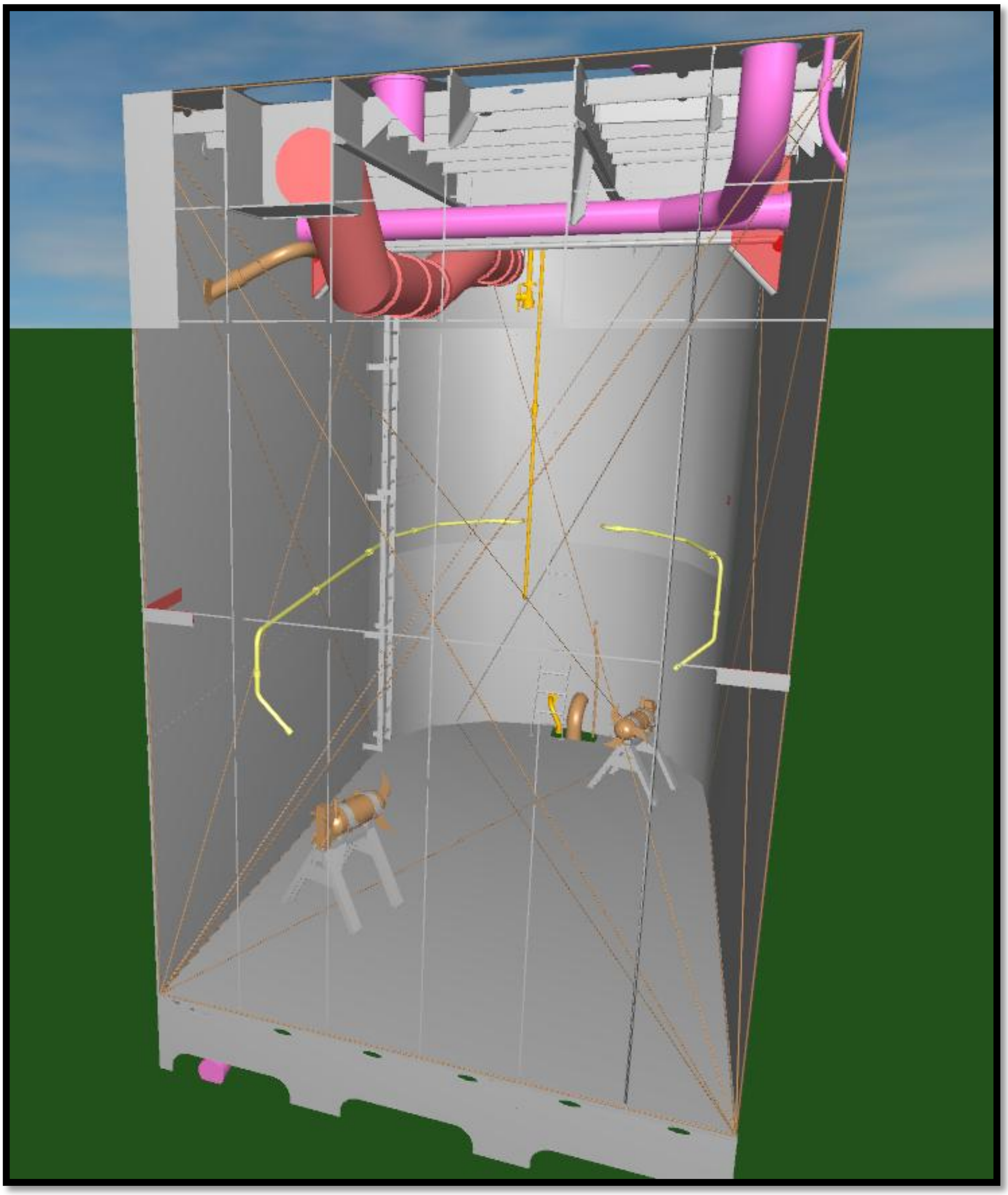


Fig. 64 - Tank n°45. DAMEN copyright.

Is present one vertical manhole: one in position in x = 34.018 m, y = -1.609 m. And one horizontal manhole in position x = 32.538 m, y = -4.172 m. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 33.665 m, y = -9.605 m with a pipe of diameter of 0.314 m that reaches the height of 11.473 m . The prescribe height necessary for perform the hydrostatic test it is of 10.9 m, so it is not necessary to add any extension pipe.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. The tank has one height of 7.20 m this obliges to mount a submersible pump on the bottom of the tank for the discharge operations. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, are not present difficult points to access and because it is not painted yet, it is possible to mount inside the tank scaffold to reach the higher structure. Therefore the mud and other residuals can be easily removed.

6.4.22. Anti Roll n° 73

The tank has the following characteristics:

Position	12 -17 Central
Height	3.40 m
Volume	219.90 m^3

Table 42 - Tank n°73.

Are present two horizontal manhole in position x = 9.703 m, y = -8.407 m and in x = 9.714 m, y = 8.388 m on the main deck. The oval manholes have a dimension of 420X620 (mm). The aeration holes are located in x = 8.720 m, y = 10.720 m and x = 7.520 m, y = -10.720 m with a pipe that reaches the height of 8.933 m . The prescribe height necessary for perform the hydrostatic test it is of 10.9 m, so it is necessary to add an extension pipe of 2 m on the top of the pipe. The two pipes are not connected and one of them could be closed before the test.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. The tank has one height of 3.40m this obliges to mount a submersible pump on the bottom of the tank for the discharge operations.

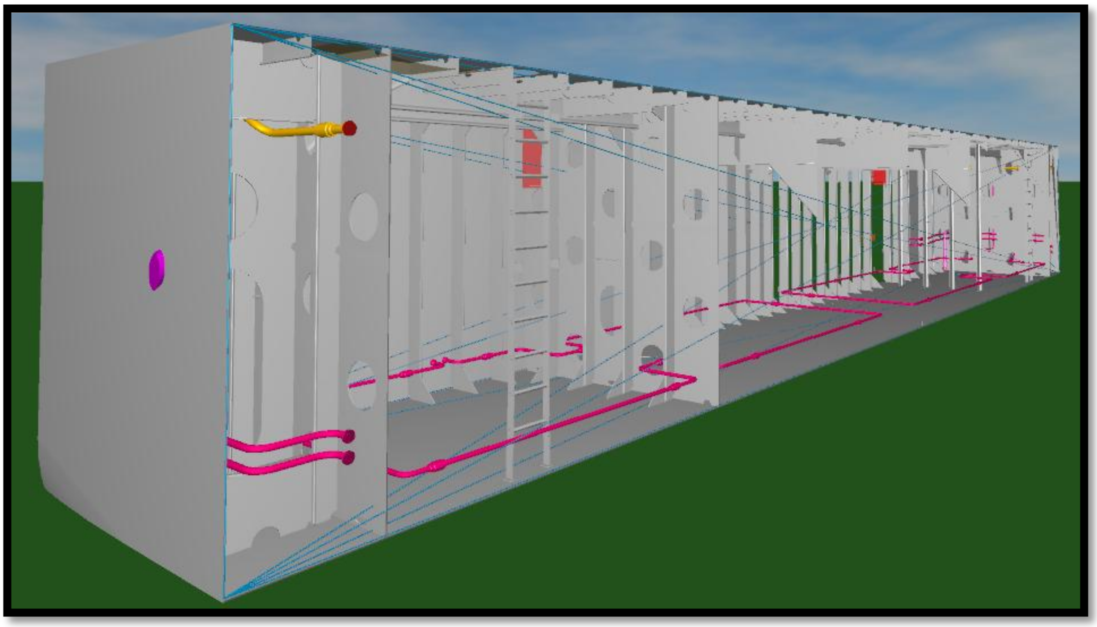


Fig. 65 - Tank n°73. DAMEN copyright.

Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank results easy to clean, are not present difficult points to access, therefore the mud and other residuals can be easily removed.

6.4.23. Miscellaneous urea n° 10

The tank has the following characteristics:

Position	80 -91 Portside
Height	0.70 m(min), 1.30 m(max)
Volume	51.73 m^3

Table 43 - Tank n°10.

Are present two horizontal manhole in position x = 53.770 m, y = 7.796 m and x = 58.770 m, y=3.184 m above the tanktop. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 59.215 m, y = 7.710 m with a pipe of diameter 0.066 m that reaches the height of 11.600 m . The prescribe height necessary for perform the hydrostatic test it is of 14.860 m, so it is necessary to add an extension pipe of 3.26 m on the top of the pipe. This height could not be reached on the vertical of the pipe, so the extension pipe must be curved and shifted of 1 m, so to reach the desired height.

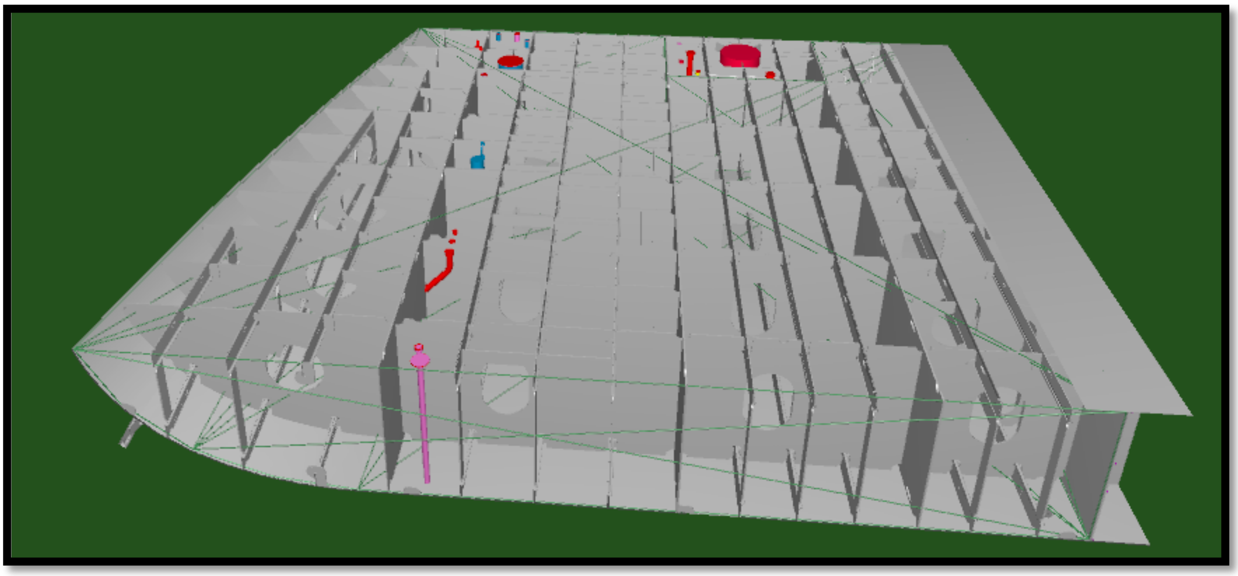


Fig. 66 - Tank n°10. DAMEN copyright.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank is quite complex with an height that goes down till 0.70 m. The average height is 1 m so it is not optimal for the worker. This must be take into consideration because the it could be affect the cleaning operation that will be done after the test. In this case could be economically more advantageous and less time consuming to use fresh water (more expensive) than normal water which contains residual and mud into consideration of the time for cleaning will be double with the normal water.

6.4.24. Miscellaneous sewage n° 13

The tank has the following characteristics:

Position	79-94 central
Height	1.30 m
Volume	89.77 m^3

Table 44 - Tank n°13.

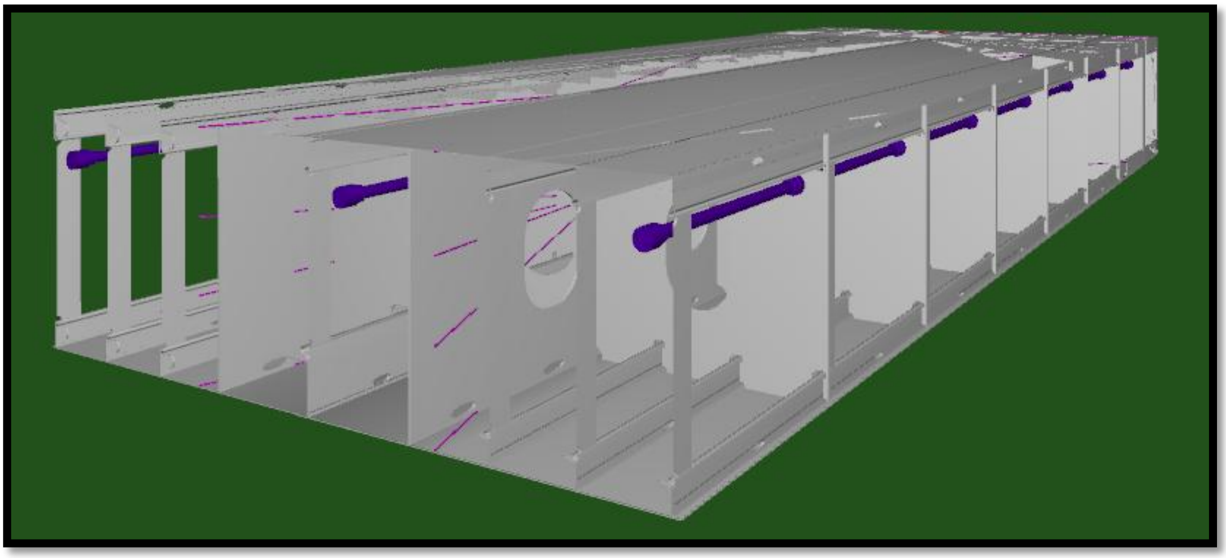


Fig. 67 - Tank n°13. DAMEN copyright.

Are present two horizontal manhole: one circular of diameter 0.470 m, in position x = 60.730 m, y = 1.350 m and one oval in x = 47.706 m, y = -0.760 m above the tanktop. The oval manholes have a dimension of 420X620 (mm). The aeration hole is located in x = 60.920 m, y = 0.360 m with a pipe of diameter 0.134 m, that reaches the height of 28.875 m. The prescribe height necessary for perform the hydrostatic test it is of 28.060 m, so it is not necessary to add any extension pipe on the top.

Before that the tank is filled all the openings (manhole, eventually cutoff, etc.) must be closed, leaving open only the aeration hole connected with the pipe. The tank could be filled till the desiderated height pumping in water by the aeration pipe, after the test the water is pumped out by the temporary pump. Because the water is not contaminated by oil or fuel, it can be discharged in the draining system of the dock .

The geometry of the tank is quite complex, with an average height of 1.3 m so it is not optimal for the worker. This must be take into consideration because the it could be affect the cleaning operation that will be done after the test. In this case could be economically more advantageous and less time consuming to use fresh water (more expensive) than normal water which contains residual and mud into consideration of the time for cleaning will be more time with the normal water.

6.5. Equipments

Now are discussed about the equipments necessary to perform the h. t.. The equipments currently used in D.S.G. and the possibility to acquire new useful tools functional to perform the operations in a more efficient way.

6.5.1. Pipe Plugs

The actual procedure in D.S.G. for close the access of the pipe inside the tank is to place a plug bolted on temporary welded supports, the presence of pressed rubber assure the tightness. The device is schematically shown in the fig. 67.

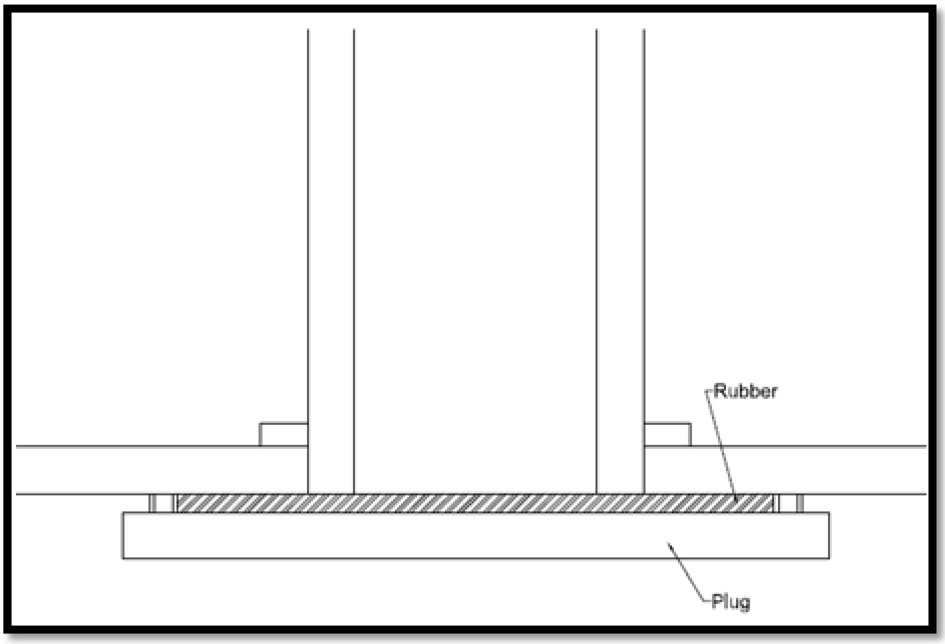


Fig. 68 - Pipe plug.

The mounting of this temporary system implies a preparation work on the surface before the welds and most complicated and time consuming the restore of the surface to the original condition. So after the test the surface must be locally grinded and if it was already painted before the test, the paint coating must be applied again.

❖ **Solution Proposed**

Instead to use the actual device it is proposed to adopt a plug of inflatable type. It is inserted in the pipe and it is inflated with air till the pressure (it works at 3 bar) will assure the adherence with the internal surface of the pipe. In this way it is reached the watertight of the pipe.

Fig. 69 - Inflatable plugs. Petersen® product.

In the example it is showed the model 114 Series Multi-Flex™ and 130-0 Series Plumber Style, it has a wide range of diameter available. The cost is variable in relation of the range of maximum diameter. It was proposed these two typology of products because they cover the range of diameter encountered in the tanks.

The advantages to use these devices respect the previous one are multiple:

- Faster installation operation.
- Light weight.
- Flexibility in the use.
- Avoid temporary supports welded on the structure.
- The device is reusable.

Three models are selected with the following characteristic:

Model Unit	Max Diameter	Min Diameter	Max Inflation	Max Head
114-010	254 mm	89 mm	2,1 bar	10,6 m
130-002-M	53 mm	32 mm	2,75 bar	12 m
130-004-M	104 mm	70 mm	2,75 bar	12 m

Table 45 - Inflatable plug characteristics.

The following quantities are necessary for perform the hydrostatic test on four tanks at the same time:

Model Unit	Number Necessary	Unitary Cost	Total Cost
114-010	8	276€	2200€
130-002-M	9	30€	270€
130-004-M	2	40€	80€
		Total	2550€

Table 46 - Cost of inflatable plug.

This investment has multiple advantages:

- It will be possible to perform multiple tests.
- The device works also for the tightness test.
- Considering only the h. t., the use of inflatable plugs will bring one reduction of 50% of the time necessary for the preparation of the tank before the structural test. This is converted in a reduction from 8 hours to 4 hours of the man-hours time used for this operation. A first economic estimation gives as result a saving of 96 man-hours for one single PSV5000 vessel, against an initial investment of 2550€.

6.5.2. Pumps Supplied

The shipyard is equipped with two type of temporary pump, external and submersible .
The models available are two:

a) Grundfos DW.50.09.3; in quantity of 2.
b) Vogel Pump LSB 65; in quantity of 2.

a) The Grundofs (Fig. 69) it is a submergible pump with vertical discharge port. The Grundfos DW pumps are capable of pumping water containing abrasive materials such as sand and clay particles. The Grundfos DW pumps incorporate an automatic level control system, which automatically controls pump operation as the water level varies.

b) The Vogel Pump (Fig.70) is a single stage end suction pump. The chart (from the technical manual for the LSB series) shows the course of the manometric prevalence H in meter of water column, in function of the flow rate Q. The model in question is the LSB 65-40-200.

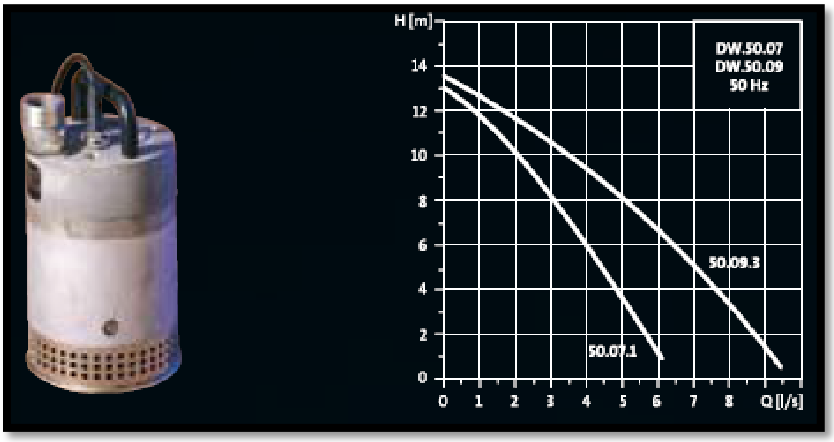


Fig. 70 - Grundfos DW.50.09.3. Grundfos Technical Manual.

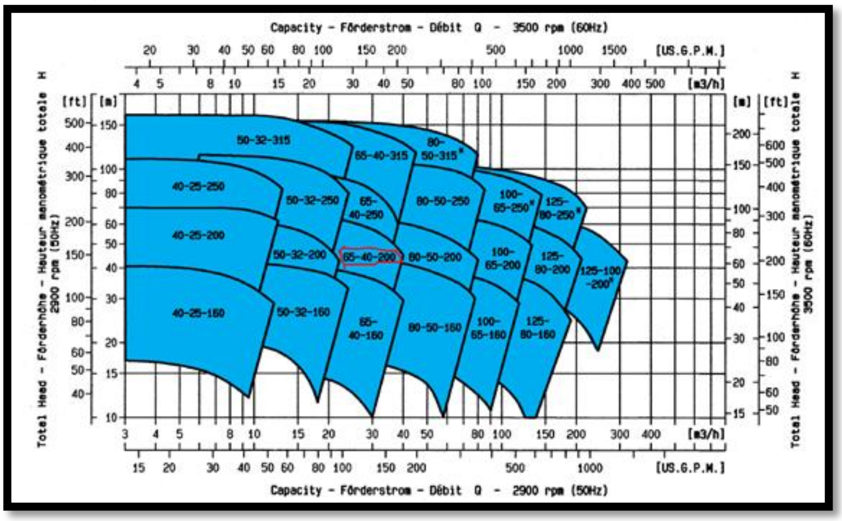


Fig. 71 - Vogel Pump LSB 65-40-200. Vogel Technical Manual.

❖ Solution Proposed

The increase of the total number of pumps available in the shipyard could be taken into consideration for future investments and improvements because it brings the advantages of:

- Possibility of running more activities in parallel.
- Possibility of halve the duration of filing or discharge of a tank, if it is necessary, using two pumps at the same time.
- Reduce the risk of bottleneck. Because the breakdown of one pump could affect a stop of the operations of testing.
- With the acquisition of other pumps of the same model there is an optimization of the maintenance and the spare parts.

The cost of the investment will be:

- 2 units of Grundfos DW.50.09.3, price for unit 2000€. Total = 4000€.
- 2 Vogel Pump LSB 65, price for unit 4200€. Total = 8400€.

Total investment in new equipment for 4 pumps is 12400€.

7. SCHEDULING ANALYSIS

Now in continuation with the previous chapters, it is inserted the hydrostatic test program in the actual planning. In this analysis is taken into consideration the previous starting dates proposed, 18 September and 6 October and also the duration of each test for the single tank. In such way are found the definitive dates for each single test.

With this goal it is advanced the proposal of modification of the actual planning in consideration of the fact that some activities could overlap each other.

Moreover are conducted two types of analysis one that takes into account the devices present actually in the shipyard. And one that takes in consideration the potential investments proposed.

7.1. Time Consumption

In this paragraph all the entries that take part to the duration of the hydrostatic test, are taken into account. They are:

- Preparation Time of the tank. It is the time necessary to prepare the tank to the test, to close all the openings, mount the extension pipe, mount the temporary pump.
- Filling Time of the tank. It is the time necessary to fill the tank with water to the desired height.
- Discharge Time of the tank. It is the time necessary to unload all the mass of water presents in the tanks.
- Cleaning Time of the tank. It is the time necessary to clean all the tank from the residuals, mud left from the water. It is given considering as basic unit of time consumption one average cleaning time of one simple box tank of 100 m^3 that needs 4 hours of work with two worker. This basic unit for the volume of the tank returns to us the time necessary for complete the cleaning operations. But not all the tanks are simple boxes so it is necessary to multiply for one complexity coefficient that will return an estimation of the total time. This coefficient is given to each tank considering three characteristic aspects of the tank:
    - Complexity of the geometry of the tank.
    - Accessibility to all the points of the tank.
    - Height of working inside the tank.

- Drying Time of the tank it is the time necessary for dry all the surfaces inside the tank. In the summer period with natural ventilation it is required one night, but in autumn with higher humidity of the air and lower temperatures it is required between half and one day with the use of dehumidifier dryer.

The total time necessary is the combination of different activities, some of these activities does not require the human work but only supervision of the operation. Like the filling of the tank, it does not require a constant human presence but the progress can be checked at regular intervals.

Tank n°	Preparation Time (h)	Filling Velocity Pump (m^3/h)	Total Volume (m^3)	Filing Time (h)	Discharge Velocity Pump (m^3/h)	Discharge Time (h)	Tank Volume (m^3)	Cleaning Time (h)	Coeff.	Total cleaning time (h)	Drying time (h)	Total Time (h)
1	8	35	149	4.3	15.12	9.9	148	5.9	1	5.9	11.8	39.8
3	8	35	131	3.7	27.72	4.7	127	5.1	2.2	11.2	10.2	37.8
12	8	35	65	1.9	30.6	2.1	62	2.5	1.6	4.0	5.0	20.9
29	8	35	72	2.1	30.6	2.4	70	2.8	1.3	3.7	5.6	21.7
30	8	35	61	1.7	15.12	4.0	60	2.4	1.3	3.1	4.8	21.7
37	8	35	170	4.9	15.12	11.2	169	6.8	1.3	8.8	13.5	46.4
48	8	35	126	3.6	30.6	4.1	124	5.0	1.6	7.9	9.9	33.5
49	8	35	101	2.9	15.12	6.7	100	4.0	1.3	5.2	8.0	30.8
66	8	35	153	4.4	15.12	10.1	152	6.1	1.6	9.7	12.2	44.4
76	8	35	67	1.9	15.12	4.4	66	2.7	1.9	5.0	5.3	24.7
77	8	35	55	1.6	25.2	2.2	54	2.2	1.3	2.8	4.4	19.0
4	8	35	269	7.7	21.6	12.4	267	10.7	1	10.7	21.4	60.2
55	8	35	138	3.9	30.6	4.5	138	5.5	2.2	12.1	11.0	39.6
63	8	35	113	3.2	15.12	7.5	113	4.5	1.3	5.9	9.0	33.6
14	8	35	27	0.9	25.2	1.1	27	1.1	1	1.1	2.1	13.2
33	8	35	96	3.3	25.2	3.8	96	3.8	1	3.8	7.7	26.6
34	8	35	122	4.2	25.2	4.9	122	4.9	1	4.9	9.8	31.7
68	8	35	144	4.9	19.8	7.3	144	5.8	1	5.8	11.5	37.5
38	8	35	104	3.6	18	5.8	104	4.1	1.3	5.4	8.3	31.0
43	8	35	135	4.6	18	7.5	134	5.4	1.3	7.0	10.7	37.9
45	8	35	222	6.3	15.12	14.7	221	8.9	1	8.9	17.7	55.6
73	8	35	220	6.3	25.2	8.7	220	8.8	1	8.8	17.6	49.4
10	8	35	53	1.5	30.6	1.7	52	2.1	2	4.1	4.1	19.5
13	8	35	92	2.6	30.6	3.0	90	3.6	1.9	6.8	7.2	27.6

Table 47 - Time Consumption detail.

It returns a total time required of just above than 800 hours.

The table 45 of the time consumption changes considering the improvements investments in equipment. Reducing the preparation time from 8 to 4 for each tank, it returns an amount of just above than 700 hours, with a save of 96 hours.

7.2. Scheduling

The limited number of devices that actually are present in the D.S.G., influences the maximum number of tanks that could be tested at the same time. If in the previous chapter is obtained the maximum number of tanks filled at the same time from a structural point of view (no overload), now that number of tanks cannot be reached for limitations in the equipment. So every group proposed is divided. The Shipyard is equipped with two pumps for loading operations and two submersible for unloading, so it is possible only to load two tanks for time. Connecting all the activities and their duration it is possible to obtain the calendar dates. The dates proposed are elaborated keeping in careful consideration the elements like total structural loading, that must not excide the limit, other activities planned and the relative position between the tanks[17]. The test is organized to optimize the resources and to have a constant and uniform work load. For the aft part of the ship:

Third Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
F.O.68	18/09/2015	21/09/2015	22/09/2015	02/12/2015	17/12/2015	After
F.W.63	18/09/2015	22/09/2015	23/09/2015	30/09/2015	15/10/2015	After
B.W.49	19/09/2015	22/09/2015	23/09/2015	25/08/2015	09/09/2015	Before

Second Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
F.W.55	19/09/2015	23/09/2015	24/09/2015	25/09/2015	12/10/2015	After
B.W.76	20/09/2015	22/09/2015	23/09/2015	01/09/2015	18/09/2015	Before
B.W.77	20/09/2015	22/09/2015	23/09/2015	07/08/2015	15/09/2015	Before

Forth Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
A.R.73	21/09/2015	25/09/2015	26/09/2015	20/10/2015	04/11/2015	After
F.O.C.43	21/09/2015	25/09/2015	26/09/2015	26/11/2015	15/12/2015	After

Fifth Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
L.M.45	22/09/2015	28/09/2015	29/09/2015	09/11/2015	24/11/2015	After

First Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
B.W.48	23/09/2015	26/09/2015	27/09/2015	17/08/2015	01/09/2015	Before
F.O.C.38	24/09/2015	28/09/2015	29/09/2015	09/12/2015	24/12/2015	After
B.W.66	25/09/2015	30/09/2015	01/10/2015	21/08/2015	03/09/2015	Before
B.W.37	30/09/2015	05/10/2015	06/10/2015	10/09/2015	29/09/2015	Before

Table 48 - Scheduling of the aft tanks, without investments.

[17] Detailed results of the loads on all the supports in the different conditions are presented in the Appendix II.

❖ **Observations**

1) In first place, it is observed that for the tank n° 37 two solutions are possible: or perform the test after the painting or anticipate the test from 30 to 25 September and consequently delaying the operation of the painting.

Tank n°	Surface preparation and painting actual planed start	Surface preparation and painting actual planed end	Surface preparation and painting proposed start	Surface preparation and painting proposed end	Painting is made
B.W.37	10/09/2015	29/09/2015	01/10/2015	20/10/2015	After

Table 49 - Alternative test date tank n°37.

2) If the test is performed after the painting of the tank, particular attention has to be made to do not damage the paint coating. In any case in some points will be necessary to adjust it.

3) The fuel oil tanks and the fresh water tanks are tested with fresh water if they are tested after the painting, but if they are tested before the painting, it is allowed the use of normal water (with residuals and mud) instead of fresh water. Because the fresh water has a cost of 1€/ m^3. It is possible to save:

Tank	Saving
F.O.68	170€
F.W.63	114€
F.W.55	138€
F.O.C.43	135€
F.O.C.38	104€
TOTAL	661€

Table 50 - Cost saving.

Similarity the same organization is adopted for the tanks located in the fore part of the ship.

Eighth Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
F.W.4	06/10/2015	12/10/2015	13/10/2015	15/10/2015	30/10/2015	After
F.O.14	06/10/2015	07/10/2015	08/10/2015	21/01/2016	27/01/2016	After
F.O.33	08/10/2015	10/10/2015	11/10/2015	11/01/2016	20/01/2016	After
F.O.34	08/10/2015	11/10/2015	12/10/2015	08/01/2016	21/01/2016	After

Seventh Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
B.W.3	07/10/2015	11/10/2015	12/10/2015	12/10/2015	27/10/2015	After
M.13	15/10/2015	18/10/2015	19/10/2015	01/10/2015	14/10/2015	Before
B.W.30	09/10/2015	11/10/2015	12/10/2015	22/09/2015	05/10/2015	Before

Sixth Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
B.W.1	16/10/2015	20/10/2015	21/10/2015	06/10/2015	15/10/2015	Before
U.10	09/10/2015	11/10/2015	12/10/2015	18/09/2015	24/09/2015	Before
B.W.12	17/10/2015	19/10/2015	20/10/2015	01/01/2016	14/01/2016	Before
B.W.29	10/10/2015	12/10/2015	13/10/2015	17/09/2015	30/09/2015	Before

Table 51 - Scheduling of the fore tanks, without investments.

❖ Observations

1) In first place, it is observed that for the tank n° 13, 1 and 12, two solutions are possible: or perform the test after the painting or anticipate the test and consequently delaying the operation of the painting.

Tank n°	Day test start	Day test finish	Day tank ready
M.13	09/10/2015	12/10/2015	13/10/2015
B.W.1	10/10/2015	14/10/2015	15/10/2015
B.W.12	07/10/2015	09/10/2015	10/10/2015

Tank n°	Surface preparation and painting actual planed start	Surface preparation and painting actual planed end	Surface preparation and painting proposed start	Surface preparation and painting proposed end	Painting is made
M.13	01/10/2015	14/10/2015	13/10/2015	17/10/2015	After
B.W.1	06/10/2015	15/10/2015	15/10/2015	24/10/2015	After
B.W.12	01/01/2016	14/01/2016	10/10/2015	24/10/2015	After

Table 52 - Alternative test dates.

2) If the test is performed after the painting of the tank, particular attention has to be made for do not damage the paint coating. In any case in some points will be necessary to restore it.

3) The fuel oil tanks and the fresh water tanks are tested with fresh water if they are tested after the painting but if they are tested before the painting, it is allowed the use of normal water (with residuals and mud) instead of fresh water. Because the fresh water has a cost of 1€/ m^3. It is possible to save:

Tank	Saving
F.W.4	269€
F.O.14	27€
F.O.33	96€
F.O.34	123€
TOTAL	515€

Table 53 - Cost saving.

An improving of the equipment available in the shipyard could improve the efficiency of the work and reduce the total amount of days necessary for perform the test on all the tanks.

With the use of inflatable plugs for close the pipes that have access to the tank, it is possible to reduce the time of preparation for predispose the tank to the structural test. Moreover the buying of four more pumps (two external for the loading operations and two submersible for the discharge) will allow the possibility to test till four tanks at the same time, always taking in the correct considerations the structural limitations to the huge quantity of water mass on board[18]. So now are presented the calendar dates in this scenario for all the tanks tested.

The test is so organized for the aft part of the ship:

First Sub-group (with delay in the painting operations for tank n° 37)

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
B.W.48	18/09/2015	20/09/2015	21/09/2015	17/08/2015	01/09/2015	Before
F.O.C.38	18/09/2015	21/09/2015	22/09/2015	09/12/2015	24/12/2015	After
B.W.66	18/09/2015	22/09/2015	23/09/2015	21/08/2015	03/09/2015	Before
B.W.37	18/09/2015	23/10/2015	24/09/2015	10/09/2015	29/09/2015	Overlapping

With the purpose to optimize the possibility of work on 4 tanks at the same time, the internal painting of the tank is delayed and rescheduled:

Tank n°	Surface preparation and painting actual planed start	Surface preparation and painting actual planed end	Surface preparation and painting proposed start	Surface preparation and painting proposed end	Painting is made
B.W.37	10/09/2015	29/09/2015	24/10/2015	13/11/2015	After

Second Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
F.W.55	20/09/2015	23/09/2015	24/09/2015	25/09/2015	12/10/2015	After
B.W.76	20/09/2015	22/09/2015	23/09/2015	01/09/2015	18/09/2015	Before
B.W.77	20/09/2015	22/09/2015	23/09/2015	07/08/2015	15/09/2015	Before

Third Sub-group

[18] Detailed results of the loads on all the supports in the different conditions are presented in the Appendix II.

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
F.O.68	21/09/2015	24/09/2015	25/09/2015	02/12/2015	17/12/2015	After
F.W.63	21/09/2015	24/09/2015	25/09/2015	30/09/2015	15/10/2015	After
B.W.49	21/09/2015	24/09/2015	23/09/2015	25/08/2015	09/09/2015	Before

Forth Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
A.R.73	23/09/2015	26/09/2015	27/09/2015	20/10/2015	04/11/2015	After
F.O.C.43	23/09/2015	26/09/2015	27/09/2015	26/11/2015	15/12/2015	After

Fifth Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
L.M.45	24/09/2015	28/09/2015	29/09/2015	09/11/2015	24/11/2015	After

Table 54 - Scheduling of the aft tanks, with investments.

The test is so organized for the fore part of the ship:

Sixth Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
B.W.1	06/10/2015	09/10/2015	10/10/2015	06/10/2015	15/10/2015	Overlapping
U.10	06/10/2015	07/10/2015	08/10/2015	18/09/2015	24/09/2015	Before
B.W.12	06/10/2015	07/10/2015	08/10/2015	01/01/2016	14/01/2016	Overlapping
B.W.29	06/10/2015	07/10/2015	08/10/2015	17/09/2015	30/09/2015	Before

With the purpose to optimize the possibility of work on 4 tanks at the same time, the internal painting of the tank is delayed and rescheduled:

Tank n°	Surface preparation and painting actual planed start	Surface preparation and painting actual planed end	Surface preparation and painting proposed start	Surface preparation and painting proposed end	Painting is made
B.W.1	06/10/2015	15/10/2015	10/10/2015	19/10/2015	After
B.W.12	01/01/2016	14/01/2016	08/10/2015	21/10/2015	After

Seventh Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
B.W.3	07/10/2015	10/10/2015	11/10/2015	12/10/2015	27/10/2015	After
M.13	07/10/2015	10/10/2015	11/10/2015	01/10/2015	14/10/2015	Overlapping
B.W.30	07/10/2015	08/10/2015	09/10/2015	22/09/2015	05/10/2015	Before

With the purpose to optimize the possibility of work on 4 tanks at the same time, the internal painting of the tank is delayed and rescheduled:

Tank n°	Surface preparation and painting actual planed start	Surface preparation and painting actual planed end	Surface preparation and painting proposed start	Surface preparation and painting proposed end	Painting is made
M.13	01/10/2015	14/10/2015	11/10/2015	25/10/2015	After

Eighth Sub-group

Tank n°	Day test start	Day test finish	Day tank ready	Surface preparation and painting start	Surface preparation and painting end	Painting is made
F.W.4	08/10/2015	12/10/2015	13/10/2015	15/10/2015	30/10/2015	After
F.O.14	08/10/2015	09/10/2015	10/10/2015	21/01/2016	27/01/2016	After
F.O.33	08/10/2015	09/10/2015	10/10/2015	11/01/2016	20/01/2016	After
F.O.34	08/10/2015	10/10/2015	11/10/2015	08/01/2016	21/01/2016	After

Table 55 - Scheduling of the fore tanks, with investments.

With this arrangement it is possible to finish all the operations of testing on 28 September instead on 30 September for the aft part of the vessel and for the fore part the day of end is the 12 October instead on 14 October respect the previous program, in this way it is possible to have a total advance of four days.

All the scheduling take into consideration that the tests will be performed in the autumn season that increases the duration of drying. If the same operations are performed in the summer, it is possible consider one day less for all the tests, because it will be necessary only one night of drying.

Making a comparison with the actual planning, the launching of the vessel PSV 5000 #2 is set for the day November/10/2015, therefore all the operation of testing are ended one month earlier. On the contrary, the h. t. with the strategy in use is scheduled in week 12/13/14/15, year 2016. So the activities of testing start March/21/2016 and finish April/17/2016. Considering that the delivery day is fixed for May/31/2016, if troubles happen (non compliance at the tests, delays, etc.) there is not enough time to study and apply an adequate solution in time and the shipyard risks huge penalties. Then the solution proposed involves less risks.

8. COST ANALYSIS

Now all the operations necessary for perform a structural test on each tank will be analyzed and decomposed with the purpose to find the final cost.

First of all it is necessary to separate the costs of equipments common to all the tanks from that expenses that instead are variable and correlate with the nature and the dimension of the tank. So we have fixed costs and variable costs. In no of the previous two categories are counted the investments proposed previously, because these represent expenses for all the shipyard that they will be amortized in the financial statements of subsequent years. These equipment once are acquired, if they have operational costs (like the pumps) these will be counted in the total cost of test.

8.1. Fixed Cost

These costs are related to the equipments that must prepared and placed before the start of tests. In this entry participate all that elements that are independents from the specific tank and its geometry, volume and destination of use.

1) Must placed 4 more supports the cost for the movement from the storage to the dry dock it is calculated in base to the cost of the crane operator. The whole operation can be estimate around 100€.
2) Must be prepared the special tops for tanks with the flanges for the filling and aeration. In base of the plane proposed are tested till a maximum number of three fuel oil tanks at the same tame. The cost for one unit it is estimate in base of the weight, so cost for kilos, plus the man-hours for the manufacturing.
   Unitary cost = 65€; Total cost = 195€.

The cost of the pipe mounted over the tank is not an expensive that must be put into the list because it is used scrap material and its cost is already counted in the total cost of the pipes fabrication. What it will be take into account will be the man-hours necessary for the preparation and installation during the tank preparation phase.

8.2. Variable Cost

These costs are named "variable" because are strictly related with the characteristic of the tanks like: dimension, geometry and accessibility. The following table show summary for the all tanks that are tested.

Tank n°	Total cost for preparation piping (€)	Total cost for preparation mechanical (€)	Total operative cost for filling the pump (€)	Total cost for the supervision of the filling operation (€)	Total operative cost for the discharge pump (€)	Total Cost for cleaning (€)	Total Cost for restoration (€)	Total Cost for paint damage (€)	Final Cost of the test (€)
1	108	54	2	19	0.7	30	54	0	267
3	108	54	2	17	0.4	56	54	0	290
12	108	54	1	8	0.1	20	54	0	245
29	108	54	1	9	0.2	18	54	20	264
30	108	54	1	8	0.3	16	54	20	260
37	108	54	2	22	0.8	44	54	0	284
48	108	54	2	16	0.3	40	54	20	293
49	108	54	1	13	0.5	26	54	20	276
66	108	54	2	20	0.7	49	54	20	307
76	108	54	1	9	0.3	25	54	20	271
77	108	54	1	7	0.2	14	54	20	258
4	108	54	4	34	0.9	53	54	0	308
55	108	54	2	18	0.3	61	54	0	296
63	108	54	2	15	0.5	29	54	0	261
14	108	54	1	4	0.1	5	54	0	225
33	108	54	2	15	0.3	19	54	0	251
34	108	54	2	19	0.4	24	54	0	261
68	108	54	2	22	0.6	29	54	0	269
38	108	54	2	16	0.4	27	54	0	260
43	108	54	2	21	0.5	35	54	0	274
45	108	54	3	28	1.0	44	54	0	292
73	108	54	3	28	0.7	44	54	0	291
10	108	54	1	7	0.1	21	54	20	264
13	108	54	1	12	0.2	34	54	0	263
								Total	6500€

Table 56 - Variable costs new strategy.

In detailed these operations are:

- **Total cost for preparation piping**: It is given by the unitary cost of man-hour of 13.46€ for 8 hours. Keeping into account that it is the average time for predispose a tank to the test and complete the operations like mounting adjunctive pipes and close pipes access to the tank.
- **Total cost for preparation mechanical:** It is given by the unitary cost of man-hour of 13.46€ for 4 hours. Keeping into account that it is the average time for predispose a tank to the test and complete the operations like to close the manhole and mount the temporary pumps.

- **Total operative cost for the filling pump:** It is given by the time that the pump is in function for the price for kwh that is 0.05817€ for kw for the power consumption of the pump that is working at one specific capacity. The technical data are referred to the pump model: LSB 65-40-200 S1NL2 and they are extracted from the curve charts and technical data present in the manual.

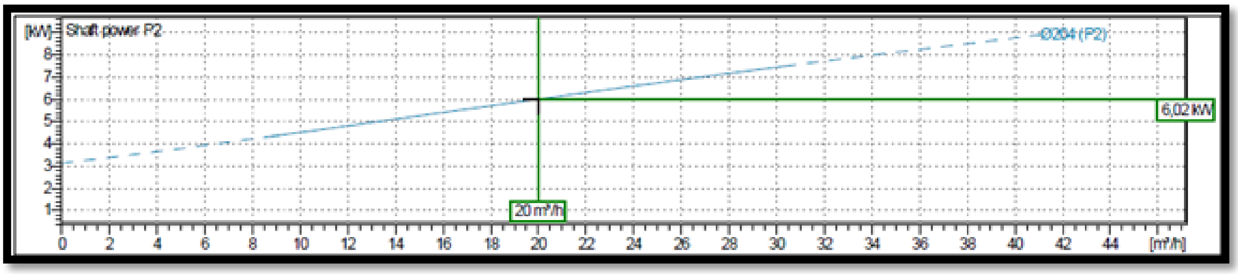


Fig. 72 - LSB 65-40-200 S1NL2 consumption curve.

- **Total cost for the supervision of the filling operation:** The filling operation does not require a constant surveillance by the operator but only a periodic control for verify that are not present anomaly like leakage, excessive pressure, etc . So it was considered a time consumption of 10 min every 30 min of loading. This time multiplied for the unitary cost of man-hour of 13.46€ returns the total cost for this entry.
- **Total operative cost for the discharge pump:** It is given by the time that the pump is in function for the price for kwh that is 0.05817€ for kw for the power consumption of the pump that is working at one specific capacity. The technical data are referred to the pump model: DW.50.09.03 and they are extracted from the curve charts and technical data present in the manual.

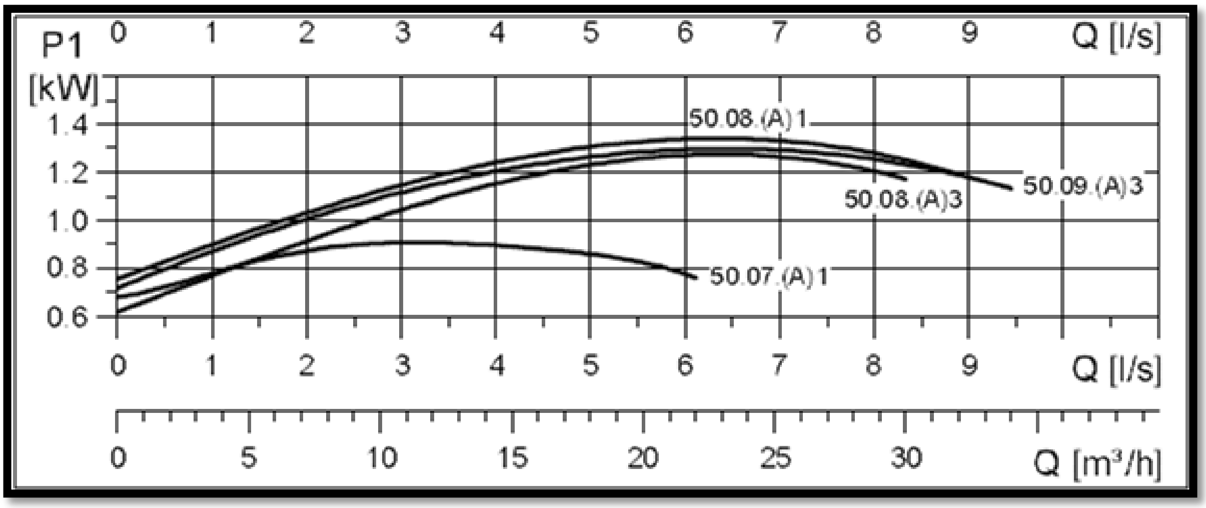


Fig. 73 - DW.50.09.03 consumption curve.

- **Total Cost for cleaning:** It is given by the unitary cost for cleaning work for man-hour that is of 2.5€ for the total time necessary for clean the tank by two men. In this cost are included the cost for all the products used during the cleaning. This because the cleaning operation is given in outsourcing and it is not made by the direct Damen worker that has a higher cost.
- **Cost for restoration.** It is the cost determinate by the time necessary for remove all the provisional installations like pipes. It is considered an average of 4 hour of work by an operator of piping, so with a cost of 13.46€/hour.
- **Cost for the paint damage.** The paint and coating if damaged must be locally replaced. It is difficult to determine this cost item before the execution because it is connected with the extension of the damage. The damage can be done by the welding of temporary supports, the deployment of the pumps on the bottom of the tanks and the cleaning operations. It is considered an average of 1.5 hour of manpower for that tanks tested after the painting. Therefore with this strategy not all the tanks are affected by this cost.

The sum of all these cost items returns the total cost for test a tank, all the tanks together give the cost of 6500€ adding the fixed cost it is obtained the final cost of 6800€ using this strategy . With the plan proposed for the test in the earlier stage it is possible to save money without using fresh water for the tanks that are designated to contain fuel, oil, or fresh water. This is possible because the tests are ran before the painting. The amount of saving for the fresh water is 1200€ (already counted in the previous).

It is possible to notice that main factor that influences the final cost is the man work. So it could be economically convenient to introduce devices able to reduce it.

Inflatable plugs could reduce the time consumption of the 50% for the preparation piping operation. Reducing from 108€ to 54€ for tank and to have a total saving of 1300€, to this saving it is added the cost for the special equipments unnecessary that will not be prepared. Some other savings come from the absence of welding and consequently the missing of paint/coating damaged by heat. Thus the total cost it is reduced till 5200€. In this way the inflatable plugs are a short time investment that it returns the initial capital only after two ships built (one year investment). Moreover the total savings for the whole yard are increased due to the flexibility of use these tools, that they could be used also for other purpose like the tightness test of pipes.

8.3. Cost With The Strategy In Use In DSG

The cost for the h. t. how it is performed now, it is not very far from what proposed previously. Because the execution procedure is similar and it implies some fundamental passages that cannot be skipped. In this case the pumps and others system are powered by the generator on board, it is assumed that the electrical cost for kwh is the same of that on the shore. Besides the date of execution is after the end of the painting of all the tanks therefore for 9 tanks (oil and fresh water) must be used fresh water during the test that it has a cost.

All the tanks are affected by the paint/coating damage in consequence for each one is present this cost item.

Tank n°	Total cost for preparation piping (€)	Total cost for preparation mechanical (€)	Total operative cost for filling pump (€)	Total cost for the supervision of the filling operation (€)	Total operative cost for the discharge pump (€)	Total Cost for cleaning (€)	Cost for restoration (€)	Cost for the paint damage (€)	Final Cost of the test (€)
1	108	54	2	19	0,7	30	54	20	287
3	108	54	2	17	0,4	56	54	20	310
12	108	54	1	8	0,1	20	54	20	265
29	108	54	1	9	0,2	18	54	20	264
30	108	54	1	8	0,3	16	54	20	260
37	108	54	2	22	0,8	44	54	20	304
48	108	54	2	16	0,3	40	54	20	293
49	108	54	1	13	0,5	26	54	20	276
66	108	54	2	20	0,7	49	54	20	306
76	108	54	1	9	0,3	25	54	20	270
77	108	54	1	7	0,2	14	54	20	258
4	108	54	4	34	0,9	53	54	20	328
55	108	54	2	18	0,3	61	54	20	316
63	108	54	2	15	0,5	29	54	20	281
14	108	54	1	4	0,1	5	54	20	245
33	108	54	2	15	0,3	19	54	20	271
34	108	54	2	19	0,4	24	54	20	281
68	108	54	2	22	0,6	29	54	20	289
38	108	54	2	16	0,4	27	54	20	280
43	108	54	2	21	0,5	35	54	20	294
45	108	54	3	28	1,0	44	54	20	312
73	108	54	3	28	0,7	44	54	20	311
10	108	54	1	7	0,1	21	54	20	264
13	108	54	1	12	0,2	34	54	20	283
								Total	6850€

Table 57 - Variable costs old strategy.

Adding the others costs.

Variable costs	6850€
Special equipment	200€
Fresh water	1200€
Final cost	8250€

9. APPLICABILITY OF H.T. ON DIFFERENT TYPES OF SHIPS

There are many ways to catalog and to differentiate the different types of ships: commercial/passenger ships; civil/war ships; etc. One of the main categories are the ships that have their own propulsion system and equipments against the constructions ,that do not possess any independent system, like barges and pontoons and for all the operations they need external support. At the light of the maritime law this last category is not properly correct to call them “ships” since they have not any capacity of maneuvering and propulsion but in the view of a industrial system like Damen Shipyard Galati, barges and pontoons are part of a wider definition of “ship”. This last definition contains all the floating structures that must be tested before the delivery to the client.

Currently in D.S.G. the hydrostatic test is performed after the launching and before/during the commissioning phase. The main advantage of this solution is that all the systems of the ship are ready to work and using the onboard pumps, it results very easy to fill and discharge one tank without the use external pumps temporarily mounted.

In the case of barges, pontoons and in general those constructions whose they have not systems responsible for such operations, there is not anymore that advantage. To carry out an hydrostatic test it is necessary to install pumps, installation that will be done in conditions of floating vessel and in general a series of operations (preparation, inspection, cleaning, etc.) are implied which they are performed in a not optimal work environment. Moreover the commissioning is the busiest and crowded part of construction process. Commissioning engineers, paint workers, welders, yard sea trial team or test engineers, supervisors, ship stores suppliers, owner superintendents, class surveyors, and ship’s crew, external cleaning operators are on board with tasks to complete before the sea trial and ship delivery. It is understood that a lot of activities are carried out at the same time so to move one of them in a earlier period it is an advantage. Because it reduces the risk of overlapping between incompatibles works, in case of delays it is more easy to re-arrange the planning to compensate them, and last but not least one activity performed on the shore will be always done in more efficient way.

The purpose of this paragraph is to introduce to the feasibility of the hydrostatic test on simpler ships. The study case of the PSV 5000 may be used as guidelines for future development, taking in considerations that a barge and pontoon present less critical elements.

An example of "simpler ship" product by the D.S.G. which is well suited for a hydrostatic test in the earlier stage, it is the Multi Purpose Pontoon 85 m long, 22 m wide.

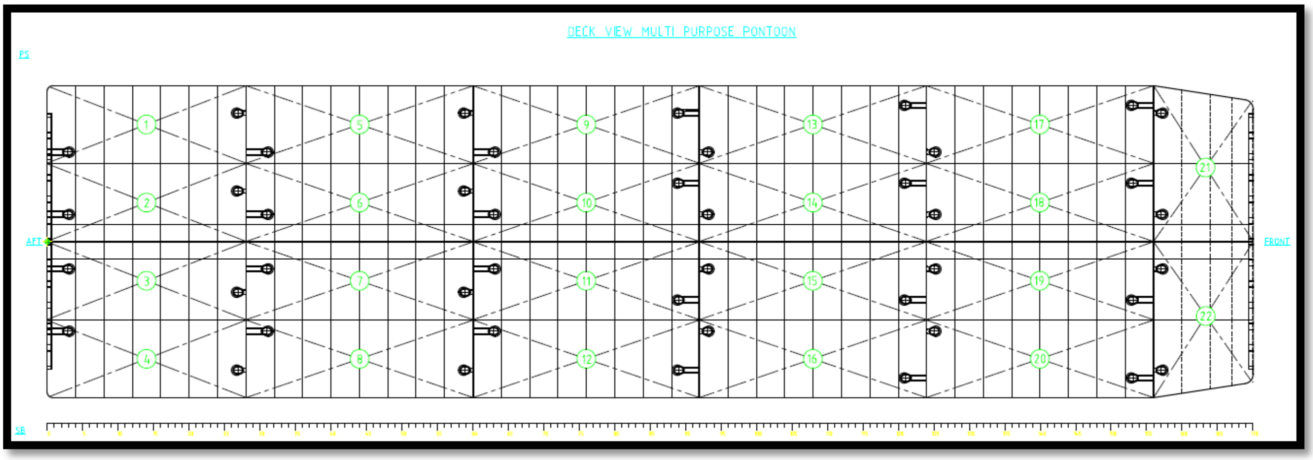


Fig. 74 - Multi Purpose Pontoon

This pontoon has 22 tanks with the following characteristic shown in the table below:

TANK	VOLUME(m^3)	LCG(mm)	TCG(mm)	VCG(mm)	FSM(ton×m)
WATER BALLAST TANK 1	353.6	7241	-8250	2643	135.7
WATER BALLAST TANK 2	353.8	7236	-2750	2643	135.7
WATER BALLAST TANK 3	353.8	7236	2750	2643	135.7
WATER BALLAST TANK 4	353.6	7.241	8250	2643	135.7
WATER BALLAST TANK 5	431.2	22000	-8250	2500	227.4
WATER BALLAST TANK 6	431.2	22000	-2750	2500	227.4
WATER BALLAST TANK 7	431.2	22000	2750	2500	227.4
WATER BALLAST TANK 8	431.2	22000	8250	2500	227.4
WATER BALLAST TANK 9	431.2	22000	-8250	2500	227.4
WATER BALLAST TANK 10	431.2	22000	-2750	2500	227.4
WATER BALLAST TANK 11	431.2	22000	2750	2500	227.4
WATER BALLAST TANK 12	431.2	22000	8250	2500	227.4
WATER BALLAST TANK 13	431.2	54000	-8250	2500	227.4
WATER BALLAST TANK 14	431.2	54000	-2750	2500	227.4
WATER BALLAST TANK 15	431.2	54000	2750	2500	227.4
WATER BALLAST TANK 16	431.2	54000	8250	2500	227.4
WATER BALLAST TANK 17	431.0	70000	-8.250	2500	227.4
WATER BALLAST TANK 18	431.2	70000	-2750	2500	227.4
WATER BALLAST TANK 19	431.2	70000	2750	2500	227.4
WATER BALLAST TANK 20	431.0	70000	8250	2500	227.4
WATER BALLAST TANK 21	244.9	80888	-5294	3168	695.3
WATER BALLAST TANK 22	244.9	80888	5294	3168	695.3

Fig. 75 - Tank arrangement Multi Purpose Pontoon

five of them must be tested in consideration of the different type of structure and location, these could be 1PS, 3STB, 10PS, 12STB, 21PS. Due to the symmetry of the whole structure other tanks of the same type could be tested instead of these five. This is mentioned because other factors could influence the opportunity of the choice.

It is necessary before the filling of the tanks a careful analysis of the load distribution, check that are not present concentrated loads and verify that the supports below the structure are in sufficient number. Moreover the absence of rudder, propeller and other appendices give the possibility to place the supports uniformly along the length of the structure, and in the correspondence of the most strong points of the structure, crossing between longitudinal and transversal stiffeners.

The preparation of the tanks to the test consists in the closing of all the opening that have an access to the tank, leaving open only the aeration pipe on the main deck. This pipe must reach the height of 14 m respect the base line to obtain the desired water column which weights on the structure.

This pontoon presents a simple modular structure, as show in below drawing.

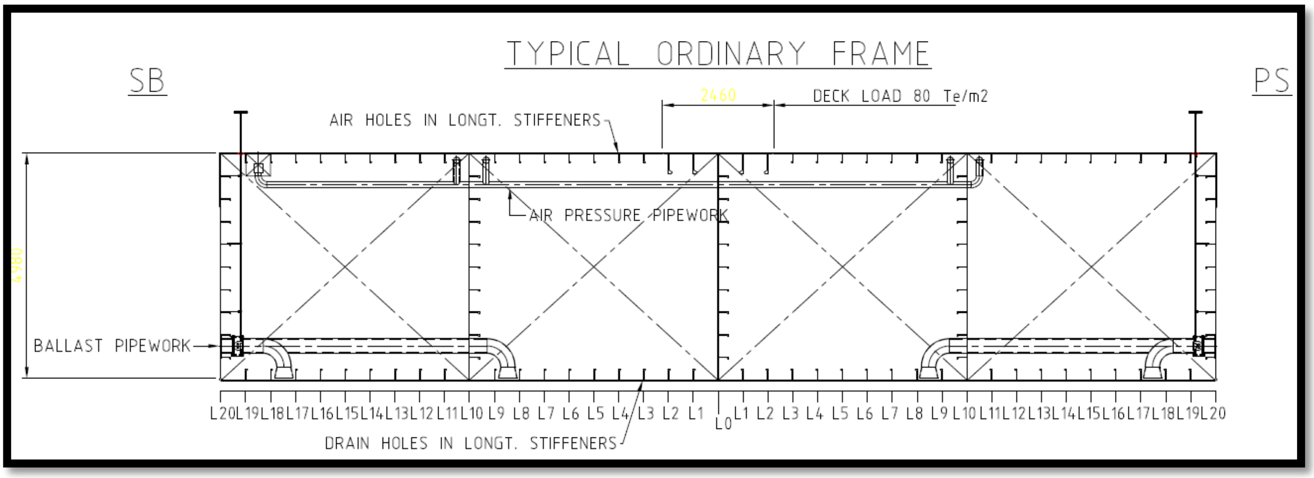


Fig. 76 - Transversal section Multi Purpose Pontoon

The tanks of this pontoon have a cubic geometry that is very suitable to an easy access and cleaning operations. These are performed fast and without big difficulties.

Moreover the presences of ballast water valves on the port side and on the starboard side, in the lower part, it is an element that facilitates all the operations of filling and discharge. These valves give a direct access to the tank from the exterior.

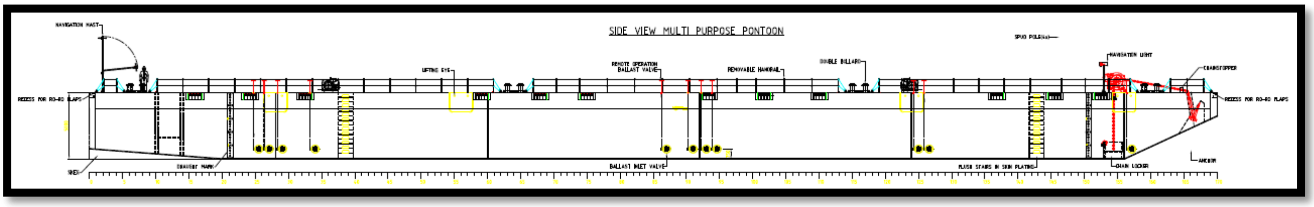


Fig. 77 - Longitudinal section Multi Purpose Pontoon

So if the hydrostatic test is performed before the launching could be used an external horizontal block pump, like the Vogel LSB pump supplied to D.S.G., that it has a flow rate higher than a submersible pump. Then reduce the whole time necessary for the test.

Last element that must be take into consideration, it is that the pontoon it is not equipped with generators. So during the test it is not possible to use the electric power of board and it is necessary to use the a derivation from the shore or from a support vessel, in the case of test performed after the launching. On the contrary, the electrical access it is easily available in the dry dock or in the new assembling hall. This is another element that could be lean to a test in the earlier stage.

In conclusion floating structures like barges, pontoon and others lacking of autonomous systems for the service, are well suited for be tested before the launching. This accelerates the velocity of execution and save money.

10. CONCLUSIONS

The necessity of improvement of the production process in order to increase the efficiency and to be more competitive on the market, has led to the idea to perform the hydrostatic test before the commissioning, during the section stage.

The hydrostatic test is carried out to demonstrate the structural adequacy of the design of the vessel. In the actual organization of the ship production process at DAMEN Shipyard Galati the hydrostatic test is performed after the launching of the ship, during the commissioning. If the tank is not stiff enough it may cause permanent deformations to occur. Thus, it cannot be certified by the Class Society and the ship cannot be delivered. In the case of test failure, the consequences on the shipyard and the production chain are huge. At the commissioning stage, the ship is almost complete and structural modifications are difficult to perform, operations of welding imply the destruction/disassembling of the systems already installed and in function. Thus the non compliance will rise dramatically the costs and the delay on the final delivery.

In normal condition this test is performed in a very crowed period of activities and few time is available, with the high risk of overlapping, bottleneck issues and delays. Therefore, the thesis is oriented to identify the possibility to perform the hydrostatic test at the earlier building stage of the ship, preferably at the section stage. Thus, the main goal was to find the point of construction stage where technically it is possible to carry out the test, without disturbing and minimizing the interferences with other production aspects.

The whole study is structured in a continuous iterative process between **Building Strategy Analysis**, the **Planning Analysis** and the **Load Analysis**. Moreover, each tank must be analyzed according its peculiarity that influence the whole process of testing. Nevertheless, the production capacities of the shipyard and possible improvements in equipments have be kept in the right consideration

It is revealed that it is possible to perform the h. t. in the earlier stage, before the launching and two moments of execution are found during the assembling. In these two stage points (41 and 50) are tested before the tanks located in the stern and later are tested those in the fore. During the tests, the erection operations of the block units to the main structure it is not interrupt, allowing the development of the building strategy as planned.

In continuation with the previous analysis, it is inserted the hydrostatic test program in the actual planning. In such way are found the definitive calendar dates for each single test. With this goal it is advanced the proposal of modification of the actual planning in consideration of the fact that some activities could overlap each other.

The limited number of devices that actually are present in the D.S.G., influences the maximum number of tanks that could be tested at the same time. The maximum number of tanks cannot be reached for limitations in the equipment. The shipyard is equipped with two pumps for loading operations and two submersible for unloading, so it is possible only to load two tanks for time. Connecting all the activities and their duration, the calendar dates can be defined and the day of ending can be predict. This solution allows to end all the activities related with the testing (filling, cleaning restoring of the tank, etc.) one month before the launching of the vessel as it is currently planned.

In conclusion an economical analysis revels that the entire testing process for the same tanks is less expensive respect the one actually in use, because there is an optimization in the operations and the fresh water is not used.

To summarize, the use of this study offers the advantages:

- Sufficiency of time to make any necessary modifications to the structure in case of the test failure. Moreover, it is more easy to make transformations on the ship located in the dry dock than the case of floating ship;
- Easier planning in accordance with others activities, no overlapping;
- Better efficiency in the single activities, organizing the testing groups in sequence;
- Economic gain;
- Possibilities of improvements with the acquisition of new equipments;
- Applicability for other types of vessel, especially for ones without systems on board like Multi Purpose Pontoon.

The implementation of this strategy inside the production chain has the final effect of improving the quality of the final product, thus increasing the competitivity of the company on the market. In this way the tightening up of the international rules (new revision of the IACS S14) about the testing of tanks, can be well acknowledged from the shipyard, magnifying the advantage on direct competitors that use a different obsolete solution.

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Denumire	Masa[kg]	Xg[mm]	Yg[mm]	Zg[mm]	Start[mm]	End[mm]	Coef
1062 unit	30800	27918	5295	835	24850	31250	1
1062 foundation	708,6	29232	1475	1976	24850	31250	1
1062 piping	1089,1	26820	-4990	1050	24850	31250	1
1061 unit	26653	27948	-6164	885	24850	31250	1
1061 foundation	343,3	28148	-3269	2023	24850	31250	1
1061 piping	698,2	26030	6340	1100	24850	31250	1
1052 unit	52164	36885	5379	828	31250	42450	1
1052 foundation	866,7	37666	2081	1998	31250	42450	1
1052 piping	1367	34510	-6940	1200	31250	42450	1
1051 unit	45034	36890	-6232	873	31250	42450	1
1051 foundation	339,3	36810	-5797	2109	31250	42450	1
1051 piping	746,6	35840	6070	1140	31250	42450	1
1072 unit	53311	19665	4789	1260	14750	24850	1
1072 foundation	223,3	19444	2264	2380	14750	24850	1
1072 piping	1730,1	20450	-3080	1050	14750	24850	1
1071 unit	41867	19694	-6108	1510	14750	24850	1
1071 foundation	183,4	17409	-2410	2383	14750	24850	1
1071 piping	1109,7	20740	4810	1060	14750	24850	1
2062 unit	57005	27688	5833	5541	24850	31250	1
2062 foundation	298,3	28130	1803	4712	24850	31250	1
2062 piping	13320,1	27750	-2960	5040	24850	31250	0,893939
2061 unit	51207	27675	-6478	5448	24850	31250	1
2061 foundation	28,6	29026	-1119	3678	24850	31250	1
2061 piping	8801,4	27330	5220	5610	24850	31250	0,883333
Water tight sliding door 8	750	15123	423	3269	14745	15808	1
Blower GM 10S (1) 8A 63	540	16885	-2140	3235	16415	17584	1
Blower GM 10S (2) 8A 63	540	19310	-2495	2942	18465	19634	1
HIPAP 501 HPU Foregate	53	23187	-760	2115	22725	23250	1
2072 unit	75718	19652	6153	5712	14750	24850	1
2072 foundation	638	19675	1802	5064	14750	24850	1
2072 piping	22826,3	19530	-2920	5630	14750	24850	0,898551
Compressor VMX 250 RD	4600	19462	2013	16280	5157	20027	1
Compressor VMX 250 RD	4600	19462	63	16280	5157	20027	1
Vacuum blower GM 35SN	1500	21480	-1948	5230	20087	22200	1
Vacuum blower GM 35SN	1500	21480	55	5230	20087	22200	1
2071 unit	69278	19605	-6656	5692	14750	24850	1
2071 foundation	1220,9	22454	-2845	3767	14750	24850	1
2071 piping	14878,8	19330	4400	5340	14750	24850	0,897059
1082 unit	84994	10646	4940	4594	6900	14750	1
1082 foundation	341,7	10845	2491	4727	6900	14750	1
1082 piping	7521,9	11230	-3360	4750	6900	14750	0,984127
1081 unit	67920	10696	-6168	5150	6900	14750	1
1081 foundation	92,1	9971	-5056	6014	6900	14750	1
1081 piping	4870,6	11000	5980	6180	6900	14750	0,984127
2052 unit	89594	36866	5997	5714	31250	42450	1
2052 foundation	566,2	37748	3606	6348	31250	42450	1
2052 piping	18252,9	36410	-3030	48600	31250	42450	0,981481
Water tight sliding door 1	920	24971	-340	2860	24543	25598	1

2051 unit	79100	36911	-6654	5608	31250	42450	1
2051 foundation	245,5	40424	-7688	8538	31250	42450	1
2051 piping	9695,5	36060	4960	5530	31250	42450	0,923077
1042 unit	27542	45450	5229	733	42450	48450	1
1042 foundation	0	0	0	0	0	0	0
1042 piping	2575,8	44250	-3980	950	42450	48450	0,553191
PCL + MODBUS Commun	210	21250	1300	2950	21050	21450	1
Centrifugal pump NIM 10	1250	16600	-2280	3780	16205	16995	1
Centrifugal pump NIM 10	1250	17450	-2280	3780	17055	17845	1
Reloader tank 15A (1) 63	50	24640	-730	6310	24434	24835	1
Reloader tank 15A (2) 63	50	24640	150	6310	24434	24835	1
1041 unit	23437	45413	-6143	773	42450	48250	1
1041 foundation	0	0	0	0	0	0	0
1041 piping	1982,5	44220	5110	970	42450	48250	0,475
3052 unit	13487	37125	9269	11174	31250	42450	1
3052 foundation	191	35464	9778	9671	31250	42450	1
3052 piping	2752,8	36640	-9800	10490	31250	42450	0,829268
3051 unit	9283	37350	-9290	10604	31250	42450	1
3051 foundation	170,2	36057	-9767	9796	31250	42450	1
3051 piping	2603,9	36300	9820	10400	31250	42450	0,847826
DB - HP03 Ps 18A (1) 430	150	13200	-650	3310	12700	13700	1
DB - HP03 Ps 18A (2) 430	150	13200	650	3310	12700	13700	1
1093 unit	75467	771	0	5690	-4200	6900	1
1093 foundation	1642,8	2148	-155	5554	-4200	6900	1
1093 piping	3868,1	2800	200	4550	-4200	6900	1
1032 unit	53130	53450	4729	766	48450	59650	1
1032 foundation	1945,1	57944	2798	1935	48450	59650	1
1032 piping	1173,4	53560	-4110	990	48450	59650	0,475
AC 7 20A 372A0007	880	760	-540	6810	180	1171	1
Prop thruster PS - Freque	6540	4200	-1600	6600	2203	6193	1
Prop thruster SB - Freque	6540	4200	1600	6600	2203	6193	1
HPU Shark JAW & Towing	1150	-2030	-2760	6790	-2212	-1792	1
HPU Pump starter 20A (1	70	-50	-3000	7050	-200	100	1
HPU Pump starter 20A (2	70	-150	3000	7050	-300	0	1
HPU Azimuth Thruster 20	1400	600	0	7000	-200	1400	1
HPU Azimuth Thruster 20	1400	600	0	7000	-200	1400	1
HPU Towing & Hose secu	950	19700	-2200	5880	19260	20423	1
Shark JAW 20A 550A100	2450	-780	0	8140	-1470	-280	1
Towing Pins 20A 550A10	1600	-2030	0	8300	-2313	-1727	1
Starter and control panel	90	600	1290	6700	200	800	1
Interface CAB PROP AZIM	50	-2200	-3590	7570	-2317	-2066	1
Interface CAB PROP AZIM	50	-2200	3590	7570	-2317	-2066	1
Accumulator Unit Shark J	190	-1790	-1250	6990	-2085	-1442	1
1031 unit	53314	53521	-4910	773	48450	59650	1
1031 foundation	2811,9	57164	-4356	1924	48450	59650	1
1031 piping	749,1	53480	5880	1110	48450	59650	0,475
1092 unit	58137	1411	7262	6192	-4200	6900	1
1092 foundation	1528,3	3779	5812	5575	-4200	6900	1
1092 piping	3109,7	2890	-7340	5820	-4200	6900	1
Flowmeter 250mc/h 22A	235	26815	-1228	3512	26500	27050	1

Flowmeter 150mc/h 22A	108	26880	1141	3448	26650	27100	1
Discharge Pump 22A 632	60	29900	1280	2220	29100	30720	1
Pump Set Edriver 211,13	860	27980	-740	3260	27632	28322	1
Pump Set Edriver 211,13	990	27680	740	3260	27632	28322	1
Pump Set E-driver SHP 14	1490	31360	-310	2440	29090	33233	1
Pump Set E-driver SHP 14	1490	36120	-310	2440	34252	38416	1
Centrifugal Pump NB 65-	145	41210	-580	2220	40840	41632	1
Centrifugal Pump NB 65-	145	41210	-170	2220	40840	41632	1
Strainer DN 150 22A (1) 3	91	40159	575	1230	39919	40399	1
Strainer DN 150 22A (2) 3	91	40159	165	1230	39919	40399	1
Strainer DN 150 22A 630I	91	31339	310	1600	31099	31579	1
Strainer DN 200 22A 630I	149	36129	310	1660	35853	36429	1
HIPAP 501 USBL Transdu	1350	24350	2380	3430	24150	24560	1
Propulsion motor 22C 21	16100	4450	-5550	6200	3389	5940	1
Centrifugal pump NIMS 8	400	11100	550	2800	10766	11441	1
CJC OFF-LINE Filter Separ	70	600	-7950	7650	320	1080	1
LO Unit Azimuth Thruster	1000	-750	0	7050	-1580	275	1
Flex Coupling Thruster Sb	300	2300	5030	6360	2170	3170	1
Water tight sliding door 2	920	47200	260	3030	46624	47645	1
2042 unit	46753	45290	6178	5637	42450	48250	1
2042 foundation	1370,9	46380	6070	7148	42450	48250	1
2042 piping	8932,3	45300	-4340	4490	42450	48250	0,203704
2041 unit	43081	45259	-6668	5506	42450	48250	1
2041 foundation	522,1	46439	-5176	5997	42450	48250	1
2041 piping	6601,4	45170	5970	5190	42450	48250	0,25
1091 unit	57165	1333	-7233	6177	-4200	6900	1
1091 foundation	1464,9	4325	-5766	5516	-4200	6900	1
1091 piping	2935,9	2860	7300	6050	-4200	6900	1
Propulsion motor 25A 21	16100	4450	5550	6200	3389	5940	1
CJC OFF-LINE Filter Separ	70	600	7950	7650	320	1080	1
LO Unit Azimuth Thruster	1000	-750	0	7050	-1580	275	1
Flex Coupling Thruster Sb	300	2300	-5030	6360	2170	3170	1
3062 unit	5624	28144	10007	10467	24850	31250	1
3062 foundation	128,6	26971	9767	10075	24850	31250	1
3062 piping	2075,7	28070	-10260	10370	24850	31250	0,829268
Lathe 26B 756A1003	420	45900	1500	2700	45000	46700	1
Elettrical test panel 26B 7	300	43900	1500	2700	43000	44700	1
3061 unit	5535	28143	-10019	10486	24850	31250	1
3061 foundation	215,2	26824	-10092	10394	24850	31250	1
3061 piping	3908,8	28160	10250	10330	24850	31250	0,844444
Main Generator Set 2 27	43500	53600	4800	2620	49000	56715	1
Main Generator Set 4 27	35000	52950	1690	2620	49140	56000	1
Main Generator Set 3 27	35000	52950	-1690	2620	49140	56000	1
Main Generator Set 1 & S	43500	53600	-4800	2620	49000	56715	1
Gearbox / Clutch 27A 65C	1900	57990	-4800	2730	57193	59094	1
Fire Pump 27A 650A100	1090	58780	-4640	2800	58245	59135	1
Flexible coupling MGS1 2	530	57146	5062	2770	56801	57453	1
Sewage treatment plant	1660	59440	130	2779	58716	60560	1
Ballast water treatment u	1560	59240	-2210	2610	58990	60258	1
Separator module 27A 3	1350	59840	4290	2720	59350	60515	1

LO Sparator module P605	600	59840	6340	2730	59350	60450	1
Preheating electric unit 2	120	54800	-3610	2580	54077	55319	1
Preheating electric unit 2	120	54010	380	2580	53292	54561	1
Preheating electric unit 2	120	54010	2820	2580	53292	54561	1
Preheating electric unit 2	120	54800	6040	2580	54077	55319	1
FO Heat Exchanger 27A (1	50	54000	520	2560	53860	54100	1
FO Heat Exchanger 27A (2	50	54720	-5890	2560	54577	54818	1
FO Heat Exchanger 27A (3	50	54350	3810	2560	54209	54450	1
FO Heat Exchanger 27A (4	50	53890	-2580	2560	53744	53981	1
LO Duplex Filter 27A (1) 3	570	57070	1480	2930	56317	57473	1
LO Duplex Filter 27A (2) 3	570	57070	-6450	2930	56317	57473	1
LO Duplex Filter 27A (3) 3	570	57751	-3900	2930	57327	58039	1
LO Duplex Filter 27A (4) 3	570	57040	-1730	2930	56462	57618	1
LO Cooler 27A (1) 361A10	360	56040	640	2830	55967	57072	1
LO Cooler 27A (2) 361A10	360	58460	-6130	2700	58225	59240	1
LO Cooler 27A (3) 361A10	360	58350	4180	2700	58115	58585	1
LO Cooler 27A (4) 361A10	360	56230	-2470	2820	55967	57030	1
Centrifugal Pump NB 2/40	100	58860	2090	2420	58575	59300	1
Centrifugal Pump NB 2/40	100	58860	2490	2420	58575	59300	1
Centrifugal Pump NISM 1	1250	60120	5124	3123	59725	60515	1
Heat Exchanger 27(1) 373	250	57220	-910	2790	57060	57380	1
Heat Exchanger 27(2) 373	250	57220	2300	2790	57060	57380	1
Heat Exchanger Tank Hea	150	60260	2530	2620	60020	60775	1
Heat Exchanger L8 Engine	290	58610	-6580	2790	58362	58957	1
Plate Heat Exchanger 27A	150	56550	-7600	2710	56188	56693	1
Centrifugal Pump NIMS 8	400	55124	6987	2582	54762	55499	1
Pump Station 27A 382A10	150	54560	-7640	3000	53900	55100	1
Centrifugal Pump NIMS 8	550	52714	-6987	2663	52352	53070	1
Strainer DN 400 27A (1) 3	550	49000	6755	2600	48500	49500	1
Strainer DN 400 27A (2) 3	550	47940	6755	2600	47440	48440	1
Strainer DN 125 27A 311I	150	51612	6987	2344	51432	51812	1
FO Heat Exchanger L8 27A	50	54719	5804	2538	54584	54818	1
Strainer DN 300 27A 312I	250	58348	7447	2393	58140	58798	1
Centrifugal Pump MA 200	980	49000	-7590	3758	48630	49370	1
Centrifugal Pump MA 200	980	47940	-7590	3758	47570	48310	1
Bilge water separator 27A	225	56030	7365	2575	55599	56437	1
Preheating HTC Water 27	115	54801	6037	2576	54452	55350	1
Screw pump ACF 27A (1)	365	52975	7691	2513	52891	53508	1
Screw pump ACF 27A (2)	365	52975	7001	2513	52892	53508	1
Heat Exchanger L8 Engine	290	58480	6170	2790	58320	58640	1
Strainer DN 400 27A (1) 3	550	49000	-6755	2700	48734	49183	1
Strainer DN 400 27A (2) 3	550	47940	-6755	2700	47672	49333	1
Centrifugal Pump MA 200	980	49000	7590	3758	48630	49370	1
Centrifugal Pump MA 200	980	47940	7590	3758	47570	48310	1
2032 unit	64321	53713	7455	5943	48450	59650	1
2032 foundation	5026,6	51298	3368	6906	48450	59650	1
2032 piping	12143,5	52140	-8050	5720	48450	59650	0
2031 unit	61394	53745	-7752	5800	48450	59650	1
2031 foundation	2737,7	52912	-6295	6214	48450	59650	1
2031 piping	13984,6	51720	7900	5950	48450	59650	0

3072 unit	8110	19740	9981	10495	14750	24850	1
3072 foundation	213	20266	10365	10515	14750	24850	1
3072 piping	5687,2	19810	-10230	10450	14750	24850	0,829268
3071 unit	8174	19737	-9971	10485	14750	24850	1
3071 foundation	139,7	22616	-10176	10190	14750	24850	1
3071 piping	5182,4	19990	10260	10520	14750	24850	0,829268
Air Handling Unit 31A 372	600	43940	5420	6530	43290	44726	1
Main Switchboard 440V 3	4100	44205	0	6700	43830	44605	1
Main Switchboard 690V 3	7700	46025	300	6765	45650	46415	1
Board NET Trafo Ps / Sb 3	860	48365	-770	6390	47990	48795	1
Board NET Trafo Ps / Sb 3	860	48365	770	6390	47990	48795	1
Main Light Trafo Ps / Sb 3	860	48265	-4060	6150	47780	48785	1
Main Light Trafo Ps / Sb 3	860	48265	2446	6150	47780	48785	1
Main DOM Trafo Ps / Sb 3	300	48440	-4910	5990	48105	48775	1
Main DOM Trafo Ps / Sb 3	300	48440	-4910	5990	48105	48775	1
Dispersant Pump Skid 31I	500	50133	157	5505	49682	50583	1
Battery Cabinet 4 battery	300	51500	6525	5707	51183	51818	1
Workhing Air Compressor	630	53700	-6640	6042	52359	55081	1
Chilled Water Plant 1 31C	1800	59350	-7150	6090	58400	60745	1
Battery Cabinet 4 battery	302	51500	-6525	5707	51183	51818	1
Compressor / Condensor	400	53180	6100	5830	52775	53575	1
Chillede water pump 31D	150	54440	6600	5600	54363	54947	1
Chillede water pump 31D	150	55760	6600	5600	55336	56032	1
Chilled Water Plant 2 31D	1800	59350	7270	6090	58053	60745	1
Start Air Compressor Skid	750	59320	4550	6182	58445	60195	1
Distribution manifold rec	300	57330	4400	6180	56985	57554	1
Oil Fired Heater 31E 373A	3100	57550	-140	6007	56850	58597	1
Distribution manifold con	330	60610	-2190	6520	60450	60893	1
Pump Unit 31E 373A0034	400	57610	-3000	5540	57061	58157	1
Expansion tank 300L 31E	55	57300	-5175	5657	57010	57555	1
Expansion tank 300L 31E	55	57300	-4430	5657	57010	57555	1
Control Unit 31E 382E10C	350	60169	-4132	6207	59769	60568	1
1020 unit	77150	64119	77	1245	59650	69250	1
1020 foundation	1280,5	66145	-188	2767	59650	69250	1
1020 piping	1646,2	62010	-400	1870	59650	69250	0,26
Bow thruster aft 32A 223	5900	64700	0	2500	63573	65815	1
Bow thruster fore 32A 22	5900	67700	0	2500	66565	68798	1
ROV HPU 32B 075A1004	1724	54102	8858	9614	52837	55215	1
Hydraulic power Pack 32I	250	51185	-8802	9458	50880	51606	1
SC TRAFO 32B 430E7841	1400	45228	6123	9554	44748	45708	1
Frequency Convertor Cab	110	47025	8000	9909	46625	47425	1
Frequency Convertor Cab	110	47896	8000	9909	47496	48296	1
Frequency Convertor Cab	410	47900	6800	9670	46956	48501	1
Frequency Convertor Cab	220	48796	10241	9638	48496	49096	1
Combined Towing-sal Wi	33500	47997	369	9638	46918	49780	0
3030 unit	54900	48185	-59	10640	42450	54350	1
3030 foundation	1715	47173	-743	11144	42450	54350	1
3030 piping	10495,7	48740	510	10600	42450	54350	0
3082 unit	7798	10929	10147	10695	6900	14750	1
3082 foundation	0	0	0	0	0	0	0

3082 piping	3376,6	11480	-10320	10460	6900	14750	0,75
3081 unit	7868	10981	-10140	10686	6900	14750	1
3081 foundation	21,2	12308	-9806	8849	6900	14750	1
3081 piping	3337,8	11210	10420	10470	6900	14750	0,75
Chilled water plant 35A 3	1800	59350	-7150	6090	58047	60745	0
Chilled water pump 35A (	150	54440	6600	5600	54362	54947	0
Chilled water pump 35A (	150	55760	6600	5600	55253	55838	0
Chilled water plant 35B 3	1800	59350	7270	6090	58051	60745	0
Retractable Azimuth Thru	4300	67939	50	3825	66967	69046	1
Flexible Coupling 35C 224	95	69005	-83	3798	68829	69298	0
Hydrophore Treatment U	400	62100	-1117	3336	61600	62600	1
2022 unit	43395	64032	5496	6104	59650	69250	0
2022 foundation	1871,1	64665	2642	6379	59650	69250	0
2022 piping	9470	62140	-2740	4520	59650	69250	0
Water Tight sliding door 3	950	60998	2025	6220	60359	61458	1
2021 unit	42358	64062	-5577	6098	59650	69250	0
2021 foundation	923,7	64009	-2614	5496	59650	69250	0
2021 piping	14206,6	61580	3980	4550	59650	69250	0
Watermist Skid 7-zones 3	190	65323	2150	2975	64800	65845	0
CJC off-line filter separato	73	62777	2394	4250	62420	63180	0
4051 unit	6896	39783	8865	14761	35938	42450	0
4051 foundation	0	0	0	0	0	0	0
4051 piping	277,9	39080	-10060	15750	35938	42450	0
4050 unit	7501	39706	-8916	14856	35938	42450	0
4050 foundation	0	0	0	0	0	0	0
4050 piping	302,7	39280	9990	15810	35938	42450	0
3092 unit	14190	-71	9372	10614	-4200	6900	1
3092 foundation	141,9	4712	10630	10959	-4200	6900	1
3092 piping	298,7	3470	-10350	10220	-4200	6900	0,740741
3091 unit	14068	-66	-9369	10625	-4200	6900	1
3091 foundation	150,4	1850	-10575	11050	-4200	6900	1
3091 piping	1255,6	4310	10140	10350	-4200	6900	0,740741
Retractable Azimuth Thru	1850	64928	-3189	3820	61900	68222	1
Bowthruster Aft VFD 41A	1600	64928	-1381	3820	62628	66618	1
Bowthruster Fore VFD 41	1600	64928	1381	3820	62628	66618	1
LO Tank Bowthruster Roo	510	66306	0	6110	66000	66600	1
Provision Cooling Plant 4	1700	67728	1100	5182	67623	67816	1
Bowthruster Aft Motor 4	4500	64700	0	4375	64160	65541	1
Bowthruster Fore Motor	4500	67700	1775	4375	66859	68138	1
Gravity Oil Tank Bowthru	130	64554	3411	6900	64502	64611	1
Gravity Oil Tank Bowthru	130	67514	3411	6900	67497	67570	1
Gravity Oil Tank Seal Bow	45	64120	3428	2900	63925	64325	1
Gravity Oil Tank Seal Bow	45	67275	3428	2900	67075	67475	1
Hydraulic Unit Bowthrust	75	64900	3416	1708	64818	64920	1
Hydraulic Unit Bowthrust	75	67900	3416	1708	67818	67920	1
1010 unit	90147	73156	13	4617	69250	78683	1
1010 foundation	554,2	70764	-393	5414	69250	78683	1
1010 piping	4606,8	71950	-20	5920	69250	78683	0,28
Retractable azimuth thru	16500	71320	0	3750	69337	72795	0
Air Handling Unit 3 42B 3	920	64400	850	9770	63700	65100	0

Air Handling Unit 4 42B 3	330	62600	3350	9080	61460	63700	0
Starter and control panel	50	45160	-7390	7710	44551	45775	0
CJC off-line filter separato	73	69723	2400	4238	69370	70130	0
CJC off-line filter separato	73	62788	2400	4238	62420	63180	0
Noise reduction Compres	490	69473	3100	5872	69084	69816	0
Noise reduction Compres	490	69473	-3100	5872	69084	69816	0
Grease trap 42C 343A10C	100	70900	-2267	5789	70550	71250	0
3020 unit	42149	59680	-14	10474	54350	66200	0
3020 foundation	622,2	57973	882	9951	54350	66200	0
3020 piping	8635,9	59660	1110	10500	54350	66200	0
3010 unit	20811,6	70160	-32	10370	66200	74000	0
3010 foundation	47,8	70495	2172	11020	66200	74000	0
3010 piping	2424,3	71410	-71	10640	66200	74000	0
EM BRD NET Trafo 43A 4:	600	49737	-807	12100	49447	50027	0
EM Light Trafo 43A 430E7	600	49737	-1070	12100	49447	50027	0
HTC-LTC Radiator 43A 41	1590	47900	1600	12100	46956	49044	0
Emergency Generator 43.	4450	47900	1600	12100	47477	48732	0
Emergency SWBD 43A 43	770	49892	1127	12620	49602	50142	0
TK BW 37	173430	37500	9471	2951	32900	43100	0
TK BW 48	126980	28408	0	726	24900	31900	0
TK BW 49	102820	28266	-9422	2763	24900	31900	0
TK BW 66	155910	11083	-6732	3757	7200	15100	0
TK BW 76	68060	2486	9506	6518	-2400	7200	0
TK BW 77	55800	-3246	-4754	6786	-4200	-2400	0
TK FW 55	137790	19235	-56	1257	15100	23500	0
TK FW 63	112770	19714	9092	3211	15100	23500	0
TK FUEL OIL 68	120860	12688	0	6092	10200	15100	0
TK FUEL OIL CARGO 38	87010	42121	-4572	5364	38900	43100	0
TK FUEL OIL CARGO 43	112870	36424	3775	5600	31900	38900	0
TK Liquid Mud/Brine 45	553440	34001	5903	5069	31900	36100	0
TK Anti-Roll 73	225400	8700	0	6800	7200	10200	0

Weight estimation stage 41 - 18 September 2015

Denumire	Masa[kg]	Xg[mm]	Yg[mm]	Zg[mm]	Start[mm]	End[mm]	Coef
1062 unit	30800	27918	5295	835	24850	31250	1
1062 foundation	708,6	29232	1475	1976	24850	31250	1
1062 piping	1089,1	26820	-4990	1050	24850	31250	1
1061 unit	26653	27948	-6164	885	24850	31250	1
1061 foundation	343,3	28148	-3269	2023	24850	31250	1
1061 piping	698,2	26030	6340	1100	24850	31250	1
1052 unit	52164	36885	5379	828	31250	42450	1
1052 foundation	866,7	37666	2081	1998	31250	42450	1
1052 piping	1367	34510	-6940	1200	31250	42450	1
1051 unit	45034	36890	-6232	873	31250	42450	1
1051 foundation	339,3	36810	-5797	2109	31250	42450	1
1051 piping	746,6	35840	6070	1140	31250	42450	1
1072 unit	53311	19665	4789	1260	14750	24850	1
1072 foundation	223,3	19444	2264	2380	14750	24850	1
1072 piping	1730,1	20450	-3080	1050	14750	24850	1
1071 unit	41867	19694	-6108	1510	14750	24850	1
1071 foundation	183,4	17409	-2410	2383	14750	24850	1
1071 piping	1109,7	20740	4810	1060	14750	24850	1
2062 unit	57005	27688	5833	5541	24850	31250	1
2062 foundation	298,3	28130	1803	4712	24850	31250	1
2062 piping	13320,1	27750	-2960	5040	24850	31250	1
2061 unit	51207	27675	-6478	5448	24850	31250	1
2061 foundation	28,6	29026	-1119	3678	24850	31250	1
2061 piping	8801,4	27330	5220	5610	24850	31250	1
Water tight sliding door 8	750	15123	423	3269	14745	15808	1
Blower GM 10S (1) 8A 63	540	16885	-2140	3235	16415	17584	1
Blower GM 10S (2) 8A 63	540	19310	-2495	2942	18465	19634	1
HIPAP 501 HPU Foregate	53	23187	-760	2115	22725	23250	1
2072 unit	75718	19652	6153	5712	14750	24850	1
2072 foundation	638	19675	1802	5064	14750	24850	1
2072 piping	22826,3	19530	-2920	5630	14750	24850	1
Compressor VMX 250 RD	4600	19462	2013	16280	5157	20027	1
Compressor VMX 250 RD	4600	19462	63	16280	5157	20027	1
Vacuum blower GM 35SM	1500	21480	-1948	5230	20087	22200	1
Vacuum blower GM 35SM	1500	21480	55	5230	20087	22200	1
2071 unit	69278	19605	-6656	5692	14750	24850	1
2071 foundation	1220,9	22454	-2845	3767	14750	24850	1
2071 piping	14878,8	19330	4400	5340	14750	24850	1
1082 unit	84994	10646	4940	4594	6900	14750	1
1082 foundation	341,7	10845	2491	4727	6900	14750	1
1082 piping	7521,9	11230	-3360	4750	6900	14750	1
1081 unit	67920	10696	-6168	5150	6900	14750	1
1081 foundation	92,1	9971	-5056	6014	6900	14750	1
1081 piping	4870,6	11000	5980	6180	6900	14750	1
2052 unit	89594	36866	5997	5714	31250	42450	1
2052 foundation	566,2	37748	3606	6348	31250	42450	1
2052 piping	18252,9	36410	-3030	48600	31250	42450	1
Water tight sliding door 1	920	24971	-340	2860	24543	25598	1

2051 unit	79100	36911	-6654	5608	31250	42450	1
2051 foundation	245,5	40424	-7688	8538	31250	42450	1
2051 piping	9695,5	36060	4960	5530	31250	42450	1
1042 unit	27542	45450	5229	733	42450	48450	1
1042 foundation	0	0	0	0	0	0	0
1042 piping	2575,8	44250	-3980	950	42450	48450	1
PCL + MODBUS Commun	210	21250	1300	2950	21050	21450	1
Centrifugal pump NIM 10	1250	16600	-2280	3780	16205	16995	1
Centrifugal pump NIM 10	1250	17450	-2280	3780	17055	17845	1
Reloader tank 15A (1) 63	50	24640	-730	6310	24434	24835	1
Reloader tank 15A (2) 63	50	24640	150	6310	24434	24835	1
1041 unit	23437	45413	-6143	773	42450	48250	1
1041 foundation	0	0	0	0	0	0	0
1041 piping	1982,5	44220	5110	970	42450	48250	1
3052 unit	13487	37125	9269	11174	31250	42450	1
3052 foundation	191	35464	9778	9671	31250	42450	1
3052 piping	2752,8	36640	-9800	10490	31250	42450	1
3051 unit	9283	37350	-9290	10604	31250	42450	1
3051 foundation	170,2	36057	-9767	9796	31250	42450	1
3051 piping	2603,9	36300	9820	10400	31250	42450	1
DB - HP03 Ps 18A (1) 430	150	13200	-650	3310	12700	13700	1
DB - HP03 Ps 18A (2) 430	150	13200	650	3310	12700	13700	1
1093 unit	75467	771	0	5690	-4200	6900	1
1093 foundation	1642,8	2148	-155	5554	-4200	6900	1
1093 piping	3868,1	2800	200	4550	-4200	6900	1
1032 unit	53130	53450	4729	766	48450	59650	1
1032 foundation	1945,1	57944	2798	1935	48450	59650	1
1032 piping	1173,4	53560	-4110	990	48450	59650	1
AC 7 20A 372A0007	880	760	-540	6810	180	1171	1
Prop thruster PS - Freque	6540	4200	-1600	6600	2203	6193	1
Prop thruster SB - Freque	6540	4200	1600	6600	2203	6193	1
HPU Shark JAW & Towing	1150	-2030	-2760	6790	-2212	-1792	1
HPU Pump starter 20A (1	70	-50	-3000	7050	-200	100	1
HPU Pump starter 20A (2	70	-150	3000	7050	-300	0	1
HPU Azimuth Thruster 20	1400	600	0	7000	-200	1400	1
HPU Azimuth Thruster 20	1400	600	0	7000	-200	1400	1
HPU Towing & Hose secu	950	19700	-2200	5880	19260	20423	1
Shark JAW 20A 550A100	2450	-780	0	8140	-1470	-280	1
Towing Pins 20A 550A10	1600	-2030	0	8300	-2313	-1727	1
Starter and control panel	90	600	1290	6700	200	800	1
Interface CAB PROP AZIM	50	-2200	-3590	7570	-2317	-2066	1
Interface CAB PROP AZIM	50	-2200	3590	7570	-2317	-2066	1
Accumulator Unit Shark J	190	-1790	-1250	6990	-2085	-1442	1
1031 unit	53314	53521	-4910	773	48450	59650	1
1031 foundation	2811,9	57164	-4356	1924	48450	59650	1
1031 piping	749,1	53480	5880	1110	48450	59650	1
1092 unit	58137	1411	7262	6192	-4200	6900	1
1092 foundation	1528,3	3779	5812	5575	-4200	6900	1
1092 piping	3109,7	2890	-7340	5820	-4200	6900	1
Flowmeter 250mc/h 22A	235	26815	-1228	3512	26500	27050	1

Flowmeter 150mc/h 22A	108	26880	1141	3448	26650	27100	1
Discharge Pump 22A 632.	60	29900	1280	2220	29100	30720	1
Pump Set Edriver 211,13!	860	27980	-740	3260	27632	28322	1
Pump Set Edriver 211,13!	990	27680	740	3260	27632	28322	1
Pump Set E-driver SHP 14	1490	31360	-310	2440	29090	33233	1
Pump Set E-driver SHP 14	1490	36120	-310	2440	34252	38416	1
Centrifugal Pump NB 65-:	145	41210	-580	2220	40840	41632	1
Centrifugal Pump NB 65-:	145	41210	-170	2220	40840	41632	1
Strainer DN 150 22A (1) 3	91	40159	575	1230	39919	40399	1
Strainer DN 150 22A (2) 3	91	40159	165	1230	39919	40399	1
Strainer DN 150 22A 630I	91	31339	310	1600	31099	31579	1
Strainer DN 200 22A 630I	149	36129	310	1660	35853	36429	1
HIPAP 501 USBL Transduc	1350	24350	2380	3430	24150	24560	1
Propulsion motor 22C 21:	16100	4450	-5550	6200	3389	5940	1
Centrifugal pump NIMS 8	400	11100	550	2800	10766	11441	1
CJC OFF-LINE Filter Separ.	70	600	-7950	7650	320	1080	1
LO Unit Azimuth Thruster	1000	-750	0	7050	-1580	275	1
Flex Coupling Thruster Sb	300	2300	5030	6360	2170	3170	1
Water tight sliding door 2	920	47200	260	3030	46624	47645	1
2042 unit	46753	45290	6178	5637	42450	48250	1
2042 foundation	1370,9	46380	6070	7148	42450	48250	1
2042 piping	8932,3	45300	-4340	4490	42450	48250	0,648148
2041 unit	43081	45259	-6668	5506	42450	48250	1
2041 foundation	522,1	46439	-5176	5997	42450	48250	1
2041 piping	6601,4	45170	5970	5190	42450	48250	0,75
1091 unit	57165	1333	-7233	6177	-4200	6900	1
1091 foundation	1464,9	4325	-5766	5516	-4200	6900	1
1091 piping	2935,9	2860	7300	6050	-4200	6900	1
Propulsion motor 25A 21	16100	4450	5550	6200	3389	5940	1
CJC OFF-LINE Filter Separ.	70	600	7950	7650	320	1080	1
LO Unit Azimuth Thruster	1000	-750	0	7050	-1580	275	1
Flex Coupling Thruster Sb	300	2300	-5030	6360	2170	3170	1
3062 unit	5624	28144	10007	10467	24850	31250	1
3062 foundation	128,6	26971	9767	10075	24850	31250	1
3062 piping	2075,7	28070	-10260	10370	24850	31250	1
Lathe 26B 756A1003	420	45900	1500	2700	45000	46700	1
Elettrical test panel 26B 7	300	43900	1500	2700	43000	44700	1
3061 unit	5535	28143	-10019	10486	24850	31250	1
3061 foundation	215,2	26824	-10092	10394	24850	31250	1
3061 piping	3908,8	28160	10250	10330	24850	31250	1
Main Generator Set 2 27/	43500	53600	4800	2620	49000	56715	1
Main Generator Set 4 27/	35000	52950	1690	2620	49140	56000	1
Main Generator Set 3 27/	35000	52950	-1690	2620	49140	56000	1
Main Generator Set 1 & S	43500	53600	-4800	2620	49000	56715	1
Gearbox / Clutch 27A 65C	1900	57990	-4800	2730	57193	59094	1
Fire Pump 27A 650A100:	1090	58780	-4640	2800	58245	59135	1
Flexible coupling MGS1 2	530	57146	5062	2770	56801	57453	1
Sewage treatment plant 4	1660	59440	130	2779	58716	60560	1
Ballast water treatment u	1560	59240	-2210	2610	58990	60258	1
Separator module 27A 3:	1350	59840	4290	2720	59350	60515	1

LO Sparator module P605	600	59840	6340	2730	59350	60450	1
Preheating electric unit 2	120	54800	-3610	2580	54077	55319	1
Preheating electric unit 2	120	54010	380	2580	53292	54561	1
Preheating electric unit 2	120	54010	2820	2580	53292	54561	1
Preheating electric unit 2	120	54800	6040	2580	54077	55319	1
FO Heat Exchanger 27A (1	50	54000	520	2560	53860	54100	1
FO Heat Exchanger 27A (2	50	54720	-5890	2560	54577	54818	1
FO Heat Exchanger 27A (3	50	54350	3810	2560	54209	54450	1
FO Heat Exchanger 27A (4	50	53890	-2580	2560	53744	53981	1
LO Duplex Filter 27A (1) 3	570	57070	1480	2930	56317	57473	1
LO Duplex Filter 27A (2) 3	570	57070	-6450	2930	56317	57473	1
LO Duplex Filter 27A (3) 3	570	57751	-3900	2930	57327	58039	1
LO Duplex Filter 27A (4) 3	570	57040	-1730	2930	56462	57618	1
LO Cooler 27A (1) 361A10	360	56040	640	2830	55967	57072	1
LO Cooler 27A (2) 361A10	360	58460	-6130	2700	58225	59240	1
LO Cooler 27A (3) 361A10	360	58350	4180	2700	58115	58585	1
LO Cooler 27A (4) 361A10	360	56230	-2470	2820	55967	57030	1
Centrifugal Pump NB 2/40	100	58860	2090	2420	58575	59300	1
Centrifugal Pump NB 2/40	100	58860	2490	2420	58575	59300	1
Centrifugal Pump NISM 1	1250	60120	5124	3123	59725	60515	1
Heat Exchanger 27(1) 373	250	57220	-910	2790	57060	57380	1
Heat Exchanger 27(2) 373	250	57220	2300	2790	57060	57380	1
Heat Exchanger Tank Hea	150	60260	2530	2620	60020	60775	1
Heat Exchanger L8 Engine	290	58610	-6580	2790	58362	58957	1
Plate Heat Exchanger 27A	150	56550	-7600	2710	56188	56693	1
Centrifugal Pump NIMS 8	400	55124	6987	2582	54762	55499	1
Pump Station 27A 382A10	150	54560	-7640	3000	53900	55100	1
Centrifugal Pump NIMS 8	550	52714	-6987	2663	52352	53070	1
Strainer DN 400 27A (1) 3	550	49000	6755	2600	48500	49500	1
Strainer DN 400 27A (2) 3	550	47940	6755	2600	47440	48440	1
Strainer DN 125 27A 311I	150	51612	6987	2344	51432	51812	1
FO Heat Exchanger L8 27A	50	54719	5804	2538	54584	54818	1
Strainer DN 300 27A 312I	250	58348	7447	2393	58140	58798	1
Centrifugal Pump MA 200	980	49000	-7590	3758	48630	49370	1
Centrifugal Pump MA 200	980	47940	-7590	3758	47570	48310	1
Bilge water separator 27A	225	56030	7365	2575	55599	56437	1
Preheating HTC Water 27	115	54801	6037	2576	54452	55350	1
Screw pump ACF 27A (1)	365	52975	7691	2513	52891	53508	1
Screw pump ACF 27A (2)	365	52975	7001	2513	52892	53508	1
Heat Exchanger L8 Engine	290	58480	6170	2790	58320	58640	1
Strainer DN 400 27A (1) 3	550	49000	-6755	2700	48734	49183	1
Strainer DN 400 27A (2) 3	550	47940	-6755	2700	47672	49333	1
Centrifugal Pump MA 200	980	49000	7590	3758	48630	49370	1
Centrifugal Pump MA 200	980	47940	7590	3758	47570	48310	1
2032 unit	64321	53713	7455	5943	48450	59650	1
2032 foundation	5026,6	51298	3368	6906	48450	59650	1
2032 piping	12143,5	52140	-8050	5720	48450	59650	0,205128
2031 unit	61394	53745	-7752	5800	48450	59650	1
2031 foundation	2737,7	52912	-6295	6214	48450	59650	1
2031 piping	13984,6	51720	7900	5950	48450	59650	0,205128

3072 unit	8110	19740	9981	10495	14750	24850	1
3072 foundation	213	20266	10365	10515	14750	24850	1
3072 piping	5687,2	19810	-10230	10450	14750	24850	1
3071 unit	8174	19737	-9971	10485	14750	24850	1
3071 foundation	139,7	22616	-10176	10190	14750	24850	1
3071 piping	5182,4	19990	10260	10520	14750	24850	1
Air Handling Unit 31A 372	600	43940	5420	6530	43290	44726	1
Main Switchboard 440V 3	4100	44205	0	6700	43830	44605	1
Main Switchboard 690V 3	7700	46025	300	6765	45650	46415	1
Board NET Trafo Ps / Sb 3	860	48365	-770	6390	47990	48795	1
Board NET Trafo Ps / Sb 3	860	48365	770	6390	47990	48795	1
Main Light Trafo Ps / Sb 3	860	48265	-4060	6150	47780	48785	1
Main Light Trafo Ps / Sb 3	860	48265	2446	6150	47780	48785	1
Main DOM Trafo Ps / Sb 3	300	48440	-4910	5990	48105	48775	1
Main DOM Trafo Ps / Sb 3	300	48440	-4910	5990	48105	48775	1
Dispersant Pump Skid 31I	500	50133	157	5505	49682	50583	1
Battery Cabinet 4 battery	300	51500	6525	5707	51183	51818	1
Workhing Air Compressor	630	53700	-6640	6042	52359	55081	1
Chilled Water Plant 1 31C	1800	59350	-7150	6090	58400	60745	1
Battery Cabinet 4 battery	302	51500	-6525	5707	51183	51818	1
Compressor / Condensor	400	53180	6100	5830	52775	53575	1
Chillede water pump 31D	150	54440	6600	5600	54363	54947	1
Chillede water pump 31D	150	55760	6600	5600	55336	56032	1
Chilled Water Plant 2 31D	1800	59350	7270	6090	58053	60745	1
Start Air Compressor Skid	750	59320	4550	6182	58445	60195	1
Distribution manifold rec	300	57330	4400	6180	56985	57554	1
Oil Fired Heater 31E 373A	3100	57550	-140	6007	56850	58597	1
Distribution manifold con	330	60610	-2190	6520	60450	60893	1
Pump Unit 31E 373A0034	400	57610	-3000	5540	57061	58157	1
Expansion tank 300L 31E	55	57300	-5175	5657	57010	57555	1
Expansion tank 300L 31E	55	57300	-4430	5657	57010	57555	1
Control Unit 31E 382E10(	350	60169	-4132	6207	59769	60568	1
1020 unit	77150	64119	77	1245	59650	69250	1
1020 foundation	1280,5	66145	-188	2767	59650	69250	1
1020 piping	1646,2	62010	-400	1870	59650	69250	0,74
Bow thruster aft 32A 223	5900	64700	0	2500	63573	65815	1
Bow thruster fore 32A 22	5900	67700	0	2500	66565	68798	1
ROV HPU 32B 075A1004	1724	54102	8858	9614	52837	55215	1
Hydraulic power Pack 32I	250	51185	-8802	9458	50880	51606	1
SC TRAFO 32B 430E7841	1400	45228	6123	9554	44748	45708	1
Frequency Convertor Cab	110	47025	8000	9909	46625	47425	1
Frequency Convertor Cab	110	47896	8000	9909	47496	48296	1
Frequency Convertor Cab	410	47900	6800	9670	46956	48501	1
Frequency Convertor Cab	220	48796	10241	9638	48496	49096	1
Combined Towing-sal Wi	33500	47997	369	9638	46918	49780	1
3030 unit	54900	48185	-59	10640	42450	54350	1
3030 foundation	1715	47173	-743	11144	42450	54350	1
3030 piping	10495,7	48740	510	10600	42450	54350	0,37037
3082 unit	7798	10929	10147	10695	6900	14750	1
3082 foundation	0	0	0	0	0	0	0

3082 piping	3376,6	11480	-10320	10460	6900	14750	1
3081 unit	7868	10981	-10140	10686	6900	14750	1
3081 foundation	21,2	12308	-9806	8849	6900	14750	1
3081 piping	3337,8	11210	10420	10470	6900	14750	1
Chilled water plant 35A 3	1800	59350	-7150	6090	58047	60745	1
Chilled water pump 35A (	150	54440	6600	5600	54362	54947	1
Chilled water pump 35A (	150	55760	6600	5600	55253	55838	1
Chilled water plant 35B 3	1800	59350	7270	6090	58051	60745	1
Retractable Azimuth Thru	4300	67939	50	3825	66967	69046	1
Flexible Coupling 35C 224	95	69005	-83	3798	68829	69298	1
Hydrophore Treatment U	400	62100	-1117	3336	61600	62600	1
2022 unit	43395	64032	5496	6104	59650	69250	1
2022 foundation	1871,1	64665	2642	6379	59650	69250	1
2022 piping	9470	62140	-2740	4520	59650	69250	0,055556
Water Tight sliding door 3	950	60998	2025	6220	60359	61458	1
2021 unit	42358	64062	-5577	6098	59650	69250	1
2021 foundation	923,7	64009	-2614	5496	59650	69250	1
2021 piping	14206,6	61580	3980	4550	59650	69250	0,323529
Watermist Skid 7-zones 3	190	65323	2150	2975	64800	65845	1
CJC off-line filter separato	73	62777	2394	4250	62420	63180	1
4051 unit	6896	39783	8865	14761	35938	42450	1
4051 foundation	0	0	0	0	0	0	0
4051 piping	277,9	39080	-10060	15750	35938	42450	0,7
4050 unit	7501	39706	-8916	14856	35938	42450	1
4050 foundation	0	0	0	0	0	0	0
4050 piping	302,7	39280	9990	15810	35938	42450	0,44
3092 unit	14190	-71	9372	10614	-4200	6900	1
3092 foundation	141,9	4712	10630	10959	-4200	6900	1
3092 piping	298,7	3470	-10350	10220	-4200	6900	1
3091 unit	14068	-66	-9369	10625	-4200	6900	1
3091 foundation	150,4	1850	-10575	11050	-4200	6900	1
3091 piping	1255,6	4310	10140	10350	-4200	6900	1
Retractable Azimuth Thru	1850	64928	-3189	3820	61900	68222	1
Bowthruster Aft VFD 41A	1600	64928	-1381	3820	62628	66618	1
Bowthruster Fore VFD 41	1600	64928	1381	3820	62628	66618	1
LO Tank Bowthruster Roo	510	66306	0	6110	66000	66600	1
Provision Cooling Plant 4:	1700	67728	1100	5182	67623	67816	1
Bowthruster Aft Motor 4:	4500	64700	0	4375	64160	65541	1
Bowthruster Fore Motor	4500	67700	1775	4375	66859	68138	1
Gravity Oil Tank Bowthru	130	64554	3411	6900	64502	64611	1
Gravity Oil Tank Bowthru	130	67514	3411	6900	67497	67570	1
Gravity Oil Tank Seal Bow	45	64120	3428	2900	63925	64325	1
Gravity Oil Tank Seal Bow	45	67275	3428	2900	67075	67475	1
Hydraulic Unit Bowthrust	75	64900	3416	1708	64818	64920	1
Hydraulic Unit Bowthrust	75	67900	3416	1708	67818	67920	1
1010 unit	90147	73156	13	4617	69250	78683	1
1010 foundation	554,2	70764	-393	5414	69250	78683	1
1010 piping	4606,8	71950	-20	5920	69250	78683	0,76
Retractable azimuth thru:	16500	71320	0	3750	69337	72795	1
Air Handling Unit 3 42B 3	920	64400	850	9770	63700	65100	1

Air Handling Unit 4 42B 3	330	62600	3350	9080	61460	63700	1
Starter and control panel	50	45160	-7390	7710	44551	45775	1
CJC off-line filter separato	73	69723	2400	4238	69370	70130	1
CJC off-line filter separato	73	62788	2400	4238	62420	63180	1
Noise reduction Compres	490	69473	3100	5872	69084	69816	1
Noise reduction Compres	490	69473	-3100	5872	69084	69816	1
Grease trap 42C 343A10C	100	70900	-2267	5789	70550	71250	1
3020 unit	42149	59680	-14	10474	54350	66200	1
3020 foundation	622,2	57973	882	9951	54350	66200	1
3020 piping	8635,9	59660	1110	10500	54350	66200	0,185185
3010 unit	20811,6	70160	-32	10370	66200	74000	1
3010 foundation	47,8	70495	2172	11020	66200	74000	1
3010 piping	2424,3	71410	-71	10640	66200	74000	0,12963
EM BRD NET Trafo 43A 43	600	49737	-807	12100	49447	50027	1
EM Light Trafo 43A 430E7	600	49737	-1070	12100	49447	50027	1
HTC-LTC Radiator 43A 41	1590	47900	1600	12100	46956	49044	1
Emergency Generator 43.	4450	47900	1600	12100	47477	48732	1
Emergency SWBD 43A 43	770	49892	1127	12620	49602	50142	1
TK BW 37	173430	37500	9471	2951	32900	43100	0
TK BW 48	126980	28408	0	726	24900	31900	0
TK BW 49	102820	28266	-9422	2763	24900	31900	0
TK BW 66	155910	11083	-6732	3757	7200	15100	0
TK BW 76	68060	2486	9506	6518	-2400	7200	0
TK BW 77	55800	-3246	-4754	6786	-4200	-2400	0
TK FW 55	137790	19235	-56	1257	15100	23500	0
TK FW 63	112770	19714	9092	3211	15100	23500	0
TK FUEL OIL 68	120860	12688	0	6092	10200	15100	0
TK FUEL OIL CARGO 38	87010	42121	-4572	5364	38900	43100	0
TK FUEL OIL CARGO 43	112870	36424	3775	5600	31900	38900	0
TK Liquid Mud/Brine 45	553440	34001	5903	5069	31900	36100	0
TK Anti-Roll 73	225400	8700	0	6800	7200	10200	0

Weight estimation stage 50 - 06 October 2015

Denumire	Masa[kg]	Xg[mm]	Yg[mm]	Zg[mm]	Start[mm]	End[mm]	Coef
1062 unit	30800	27918	5295	835	24850	31250	1
1062 foundation	708,6	29232	1475	1976	24850	31250	1
1062 piping	1089,1	26820	-4990	1050	24850	31250	1
1061 unit	26653	27948	-6164	885	24850	31250	1
1061 foundation	343,3	28148	-3269	2023	24850	31250	1
1061 piping	698,2	26030	6340	1100	24850	31250	1
1052 unit	52164	36885	5379	828	31250	42450	1
1052 foundation	866,7	37666	2081	1998	31250	42450	1
1052 piping	1367	34510	-6940	1200	31250	42450	1
1051 unit	45034	36890	-6232	873	31250	42450	1
1051 foundation	339,3	36810	-5797	2109	31250	42450	1
1051 piping	746,6	35840	6070	1140	31250	42450	1
1072 unit	53311	19665	4789	1260	14750	24850	1
1072 foundation	223,3	19444	2264	2380	14750	24850	1
1072 piping	1730,1	20450	-3080	1050	14750	24850	1
1071 unit	41867	19694	-6108	1510	14750	24850	1
1071 foundation	183,4	17409	-2410	2383	14750	24850	1
1071 piping	1109,7	20740	4810	1060	14750	24850	1
2062 unit	57005	27688	5833	5541	24850	31250	1
2062 foundation	298,3	28130	1803	4712	24850	31250	1
2062 piping	13320,1	27750	-2960	5040	24850	31250	1
2061 unit	51207	27675	-6478	5448	24850	31250	1
2061 foundation	28,6	29026	-1119	3678	24850	31250	1
2061 piping	8801,4	27330	5220	5610	24850	31250	1
Water tight sliding door 8	750	15123	423	3269	14745	15808	1
Blower GM 10S (1) 8A 63	540	16885	-2140	3235	16415	17584	1
Blower GM 10S (2) 8A 63	540	19310	-2495	2942	18465	19634	1
HIPAP 501 HPU Foregate	53	23187	-760	2115	22725	23250	1
2072 unit	75718	19652	6153	5712	14750	24850	1
2072 foundation	638	19675	1802	5064	14750	24850	1
2072 piping	22826,3	19530	-2920	5630	14750	24850	1
Compressor VMX 250 RD	4600	19462	2013	16280	5157	20027	1
Compressor VMX 250 RD	4600	19462	63	16280	5157	20027	1
Vacuum blower GM 35SM	1500	21480	-1948	5230	20087	22200	1
Vacuum blower GM 35SM	1500	21480	55	5230	20087	22200	1
2071 unit	69278	19605	-6656	5692	14750	24850	1
2071 foundation	1220,9	22454	-2845	3767	14750	24850	1
2071 piping	14878,8	19330	4400	5340	14750	24850	1
1082 unit	84994	10646	4940	4594	6900	14750	1
1082 foundation	341,7	10845	2491	4727	6900	14750	1
1082 piping	7521,9	11230	-3360	4750	6900	14750	1
1081 unit	67920	10696	-6168	5150	6900	14750	1
1081 foundation	92,1	9971	-5056	6014	6900	14750	1
1081 piping	4870,6	11000	5980	6180	6900	14750	1
2052 unit	89594	36866	5997	5714	31250	42450	1
2052 foundation	566,2	37748	3606	6348	31250	42450	1
2052 piping	18252,9	36410	-3030	48600	31250	42450	1
Water tight sliding door 1	920	24971	-340	2860	24543	25598	1

2051 unit	79100	36911	-6654	5608	31250	42450	1
2051 foundation	245,5	40424	-7688	8538	31250	42450	1
2051 piping	9695,5	36060	4960	5530	31250	42450	1
1042 unit	27542	45450	5229	733	42450	48450	1
1042 foundation	0	0	0	0	0	0	0
1042 piping	2575,8	44250	-3980	950	42450	48450	1
PCL + MODBUS Commun	210	21250	1300	2950	21050	21450	1
Centrifugal pump NIM 10	1250	16600	-2280	3780	16205	16995	1
Centrifugal pump NIM 10	1250	17450	-2280	3780	17055	17845	1
Reloader tank 15A (1) 63	50	24640	-730	6310	24434	24835	1
Reloader tank 15A (2) 63	50	24640	150	6310	24434	24835	1
1041 unit	23437	45413	-6143	773	42450	48250	1
1041 foundation	0	0	0	0	0	0	0
1041 piping	1982,5	44220	5110	970	42450	48250	1
3052 unit	13487	37125	9269	11174	31250	42450	1
3052 foundation	191	35464	9778	9671	31250	42450	1
3052 piping	2752,8	36640	-9800	10490	31250	42450	1
3051 unit	9283	37350	-9290	10604	31250	42450	1
3051 foundation	170,2	36057	-9767	9796	31250	42450	1
3051 piping	2603,9	36300	9820	10400	31250	42450	1
DB - HP03 Ps 18A (1) 430	150	13200	-650	3310	12700	13700	1
DB - HP03 Ps 18A (2) 430	150	13200	650	3310	12700	13700	1
1093 unit	75467	771	0	5690	-4200	6900	1
1093 foundation	1642,8	2148	-155	5554	-4200	6900	1
1093 piping	3868,1	2800	200	4550	-4200	6900	1
1032 unit	53130	53450	4729	766	48450	59650	1
1032 foundation	1945,1	57944	2798	1935	48450	59650	1
1032 piping	1173,4	53560	-4110	990	48450	59650	1
AC 7 20A 372A0007	880	760	-540	6810	180	1171	1
Prop thruster PS - Freque	6540	4200	-1600	6600	2203	6193	1
Prop thruster SB - Freque	6540	4200	1600	6600	2203	6193	1
HPU Shark JAW & Towing	1150	-2030	-2760	6790	-2212	-1792	1
HPU Pump starter 20A (1	70	-50	-3000	7050	-200	100	1
HPU Pump starter 20A (2	70	-150	3000	7050	-300	0	1
HPU Azimuth Thruster 20	1400	600	0	7000	-200	1400	1
HPU Azimuth Thruster 20	1400	600	0	7000	-200	1400	1
HPU Towing & Hose secu	950	19700	-2200	5880	19260	20423	1
Shark JAW 20A 550A100	2450	-780	0	8140	-1470	-280	1
Towing Pins 20A 550A10	1600	-2030	0	8300	-2313	-1727	1
Starter and control panel	90	600	1290	6700	200	800	1
Interface CAB PROP AZIM	50	-2200	-3590	7570	-2317	-2066	1
Interface CAB PROP AZIM	50	-2200	3590	7570	-2317	-2066	1
Accumulator Unit Shark J	190	-1790	-1250	6990	-2085	-1442	1
1031 unit	53314	53521	-4910	773	48450	59650	1
1031 foundation	2811,9	57164	-4356	1924	48450	59650	1
1031 piping	749,1	53480	5880	1110	48450	59650	1
1092 unit	58137	1411	7262	6192	-4200	6900	1
1092 foundation	1528,3	3779	5812	5575	-4200	6900	1
1092 piping	3109,7	2890	-7340	5820	-4200	6900	1
Flowmeter 250mc/h 22A	235	26815	-1228	3512	26500	27050	1

Flowmeter 150mc/h 22A	108	26880	1141	3448	26650	27100	1
Discharge Pump 22A 632.	60	29900	1280	2220	29100	30720	1
Pump Set Edriver 211.13!	860	27980	-740	3260	27632	28322	1
Pump Set Edriver 211.13!	990	27680	740	3260	27632	28322	1
Pump Set E-driver SHP 14	1490	31360	-310	2440	29090	33233	1
Pump Set E-driver SHP 14	1490	36120	-310	2440	34252	38416	1
Centrifugal Pump NB 65-:	145	41210	-580	2220	40840	41632	1
Centrifugal Pump NB 65-:	145	41210	-170	2220	40840	41632	1
Strainer DN 150 22A (1) 3	91	40159	575	1230	39919	40399	1
Strainer DN 150 22A (2) 3	91	40159	165	1230	39919	40399	1
Strainer DN 150 22A 630I	91	31339	310	1600	31099	31579	1
Strainer DN 200 22A 630I	149	36129	310	1660	35853	36429	1
HIPAP 501 USBL Transduc	1350	24350	2380	3430	24150	24560	1
Propulsion motor 22C 21	16100	4450	-5550	6200	3389	5940	1
Centrifugal pump NIMS 8	400	11100	550	2800	10766	11441	1
CJC OFF-LINE Filter Separ.	70	600	-7950	7650	320	1080	1
LO Unit Azimuth Thruster	1000	-750	0	7050	-1580	275	1
Flex Coupling Thruster Sb	300	2300	5030	6360	2170	3170	1
Water tight sliding door 2	920	47200	260	3030	46624	47645	1
2042 unit	46753	45290	6178	5637	42450	48250	1
2042 foundation	1370,9	46380	6070	7148	42450	48250	1
2042 piping	8932,3	45300	-4340	4490	42450	48250	0,981481
2041 unit	43081	45259	-6668	5506	42450	48250	1
2041 foundation	522,1	46439	-5176	5997	42450	48250	1
2041 piping	6601,4	45170	5970	5190	42450	48250	1
1091 unit	57165	1333	-7233	6177	-4200	6900	1
1091 foundation	1464,9	4325	-5766	5516	-4200	6900	1
1091 piping	2935,9	2860	7300	6050	-4200	6900	1
Propulsion motor 25A 21	16100	4450	5550	6200	3389	5940	1
CJC OFF-LINE Filter Separ.	70	600	7950	7650	320	1080	1
LO Unit Azimuth Thruster	1000	-750	0	7050	-1580	275	1
Flex Coupling Thruster Sb	300	2300	-5030	6360	2170	3170	1
3062 unit	5624	28144	10007	10467	24850	31250	1
3062 foundation	128,6	26971	9767	10075	24850	31250	1
3062 piping	2075,7	28070	-10260	10370	24850	31250	1
Lathe 26B 756A1003	420	45900	1500	2700	45000	46700	1
Elettrical test panel 26B 2	300	43900	1500	2700	43000	44700	1
3061 unit	5535	28143	-10019	10486	24850	31250	1
3061 foundation	215,2	26824	-10092	10394	24850	31250	1
3061 piping	3908,8	28160	10250	10330	24850	31250	1
Main Generator Set 2 27/	43500	53600	4800	2620	49000	56715	1
Main Generator Set 4 27/	35000	52950	1690	2620	49140	56000	1
Main Generator Set 3 27/	35000	52950	-1690	2620	49140	56000	1
Main Generator Set 1 & S	43500	53600	-4800	2620	49000	56715	1
Gearbox / Clutch 27A 65C	1900	57990	-4800	2730	57193	59094	1
Fire Pump 27A 650A100:	1090	58780	-4640	2800	58245	59135	1
Flexible coupling MGS1 2	530	57146	5062	2770	56801	57453	1
Sewage treatment plant 4	1660	59440	130	2779	58716	60560	1
Ballast water treatment u	1560	59240	-2210	2610	58990	60258	1
Separator module 27A 3:	1350	59840	4290	2720	59350	60515	1

LO Sparator module P605	600	59840	6340	2730	59350	60450	1
Preheating electric unit 2	120	54800	-3610	2580	54077	55319	1
Preheating electric unit 2	120	54010	380	2580	53292	54561	1
Preheating electric unit 2	120	54010	2820	2580	53292	54561	1
Preheating electric unit 2	120	54800	6040	2580	54077	55319	1
FO Heat Exchanger 27A (1	50	54000	520	2560	53860	54100	1
FO Heat Exchanger 27A (2	50	54720	-5890	2560	54577	54818	1
FO Heat Exchanger 27A (3	50	54350	3810	2560	54209	54450	1
FO Heat Exchanger 27A (4	50	53890	-2580	2560	53744	53981	1
LO Duplex Filter 27A (1) 3	570	57070	1480	2930	56317	57473	1
LO Duplex Filter 27A (2) 3	570	57070	-6450	2930	56317	57473	1
LO Duplex Filter 27A (3) 3	570	57751	-3900	2930	57327	58039	1
LO Duplex Filter 27A (4) 3	570	57040	-1730	2930	56462	57618	1
LO Cooler 27A (1) 361A10	360	56040	640	2830	55967	57072	1
LO Cooler 27A (2) 361A10	360	58460	-6130	2700	58225	59240	1
LO Cooler 27A (3) 361A10	360	58350	4180	2700	58115	58585	1
LO Cooler 27A (4) 361A10	360	56230	-2470	2820	55967	57030	1
Centrifugal Pump NB 2/40	100	58860	2090	2420	58575	59300	1
Centrifugal Pump NB 2/40	100	58860	2490	2420	58575	59300	1
Centrifugal Pump NISM 1	1250	60120	5124	3123	59725	60515	1
Heat Exchanger 27(1) 373	250	57220	-910	2790	57060	57380	1
Heat Exchanger 27(2) 373	250	57220	2300	2790	57060	57380	1
Heat Exchanger Tank Hea	150	60260	2530	2620	60020	60775	1
Heat Exchanger L8 Engine	290	58610	-6580	2790	58362	58957	1
Plate Heat Exchanger 27A	150	56550	-7600	2710	56188	56693	1
Centrifugal Pump NIMS 8	400	55124	6987	2582	54762	55499	1
Pump Station 27A 382A10	150	54560	-7640	3000	53900	55100	1
Centrifugal Pump NIMS 8	550	52714	-6987	2663	52352	53070	1
Strainer DN 400 27A (1) 3	550	49000	6755	2600	48500	49500	1
Strainer DN 400 27A (2) 3	550	47940	6755	2600	47440	48440	1
Strainer DN 125 27A 311I	150	51612	6987	2344	51432	51812	1
FO Heat Exchanger L8 27A	50	54719	5804	2538	54584	54818	1
Strainer DN 300 27A 312I	250	58348	7447	2393	58140	58798	1
Centrifugal Pump MA 200	980	49000	-7590	3758	48630	49370	1
Centrifugal Pump MA 200	980	47940	-7590	3758	47570	48310	1
Bilge water separator 27A	225	56030	7365	2575	55599	56437	1
Preheating HTC Water 27	115	54801	6037	2576	54452	55350	1
Screw pump ACF 27A (1)	365	52975	7691	2513	52891	53508	1
Screw pump ACF 27A (2)	365	52975	7001	2513	52892	53508	1
Heat Exchanger L8 Engine	290	58480	6170	2790	58320	58640	1
Strainer DN 400 27A (1) 3	550	49000	-6755	2700	48734	49183	1
Strainer DN 400 27A (2) 3	550	47940	-6755	2700	47672	49333	1
Centrifugal Pump MA 200	980	49000	7590	3758	48630	49370	1
Centrifugal Pump MA 200	980	47940	7590	3758	47570	48310	1
2032 unit	64321	53713	7455	5943	48450	59650	1
2032 foundation	5026,6	51298	3368	6906	48450	59650	1
2032 piping	12143,5	52140	-8050	5720	48450	59650	0,358974
2031 unit	61394	53745	-7752	5800	48450	59650	1
2031 foundation	2737,7	52912	-6295	6214	48450	59650	1
2031 piping	13984,6	51720	7900	5950	48450	59650	0,358974

3072 unit	8110	19740	9981	10495	14750	24850	1
3072 foundation	213	20266	10365	10515	14750	24850	1
3072 piping	5687,2	19810	-10230	10450	14750	24850	1
3071 unit	8174	19737	-9971	10485	14750	24850	1
3071 foundation	139,7	22616	-10176	10190	14750	24850	1
3071 piping	5182,4	19990	10260	10520	14750	24850	1
Air Handling Unit 31A 372	600	43940	5420	6530	43290	44726	1
Main Switchboard 440V 3	4100	44205	0	6700	43830	44605	1
Main Switchboard 690V 3	7700	46025	300	6765	45650	46415	1
Board NET Trafo Ps / Sb 3	860	48365	-770	6390	47990	48795	1
Board NET Trafo Ps / Sb 3	860	48365	770	6390	47990	48795	1
Main Light Trafo Ps / Sb 3	860	48265	-4060	6150	47780	48785	1
Main Light Trafo Ps / Sb 3	860	48265	2446	6150	47780	48785	1
Main DOM Trafo Ps / Sb 3	300	48440	-4910	5990	48105	48775	1
Main DOM Trafo Ps / Sb 3	300	48440	-4910	5990	48105	48775	1
Dispersant Pump Skid 31I	500	50133	157	5505	49682	50583	1
Battery Cabinet 4 battery	300	51500	6525	5707	51183	51818	1
Workhing Air Compressor	630	53700	-6640	6042	52359	55081	1
Chilled Water Plant 1 31C	1800	59350	-7150	6090	58400	60745	1
Battery Cabinet 4 battery	302	51500	-6525	5707	51183	51818	1
Compressor / Condensor	400	53180	6100	5830	52775	53575	1
Chillede water pump 31D	150	54440	6600	5600	54363	54947	1
Chillede water pump 31D	150	55760	6600	5600	55336	56032	1
Chilled Water Plant 2 31D	1800	59350	7270	6090	58053	60745	1
Start Air Compressor Skid	750	59320	4550	6182	58445	60195	1
Distribution manifold rec	300	57330	4400	6180	56985	57554	1
Oil Fired Heater 31E 373A	3100	57550	-140	6007	56850	58597	1
Distribution manifold con	330	60610	-2190	6520	60450	60893	1
Pump Unit 31E 373A0034	400	57610	-3000	5540	57061	58157	1
Expansion tank 300L 31E	55	57300	-5175	5657	57010	57555	1
Expansion tank 300L 31E	55	57300	-4430	5657	57010	57555	1
Control Unit 31E 382E10C	350	60169	-4132	6207	59769	60568	1
1020 unit	77150	64119	77	1245	59650	69250	1
1020 foundation	1280,5	66145	-188	2767	59650	69250	1
1020 piping	1646,2	62010	-400	1870	59650	69250	1
Bow thruster aft 32A 223	5900	64700	0	2500	63573	65815	1
Bow thruster fore 32A 22	5900	67700	0	2500	66565	68798	1
ROV HPU 32B 075A1004	1724	54102	8858	9614	52837	55215	1
Hydraulic power Pack 32B	250	51185	-8802	9458	50880	51606	1
SC TRAFO 32B 430E7841	1400	45228	6123	9554	44748	45708	1
Frequency Convertor Cab	110	47025	8000	9909	46625	47425	1
Frequency Convertor Cab	110	47896	8000	9909	47496	48296	1
Frequency Convertor Cab	410	47900	6800	9670	46956	48501	1
Frequency Convertor Cab	220	48796	10241	9638	48496	49096	1
Combined Towing-sal Wi	33500	47997	369	9638	46918	49780	1
3030 unit	54900	48185	-59	10640	42450	54350	1
3030 foundation	1715	47173	-743	11144	42450	54350	1
3030 piping	10495,7	48740	510	10600	42450	54350	0,703704
3082 unit	7798	10929	10147	10695	6900	14750	1
3082 foundation	0	0	0	0	0	0	0

3082 piping	3376,6	11480	-10320	10460	6900	14750	1
3081 unit	7868	10981	-10140	10686	6900	14750	1
3081 foundation	21,2	12308	-9806	8849	6900	14750	1
3081 piping	3337,8	11210	10420	10470	6900	14750	1
Chilled water plant 35A 3	1800	59350	-7150	6090	58047	60745	1
Chilled water pump 35A (	150	54440	6600	5600	54362	54947	1
Chilled water pump 35A (	150	55760	6600	5600	55253	55838	1
Chilled water plant 35B 3	1800	59350	7270	6090	58051	60745	1
Retractable Azimuth Thru	4300	67939	50	3825	66967	69046	1
Flexible Coupling 35C 224	95	69005	-83	3798	68829	69298	1
Hydrophore Treatment U	400	62100	-1117	3336	61600	62600	1
2022 unit	43395	64032	5496	6104	59650	69250	1
2022 foundation	1871,1	64665	2642	6379	59650	69250	1
2022 piping	9470	62140	-2740	4520	59650	69250	0,388889
Water Tight sliding door 3	950	60998	2025	6220	60359	61458	1
2021 unit	42358	64062	-5577	6098	59650	69250	1
2021 foundation	923,7	64009	-2614	5496	59650	69250	1
2021 piping	14206,6	61580	3980	4550	59650	69250	0,588235
Watermist Skid 7-zones 3	190	65323	2150	2975	64800	65845	1
CJC off-line filter separato	73	62777	2394	4250	62420	63180	1
4051 unit	6896	39783	8865	14761	35938	42450	1
4051 foundation	0	0	0	0	0	0	0
4051 piping	277,9	39080	-10060	15750	35938	42450	1
4050 unit	7501	39706	-8916	14856	35938	42450	1
4050 foundation	0	0	0	0	0	0	0
4050 piping	302,7	39280	9990	15810	35938	42450	1
3092 unit	14190	-71	9372	10614	-4200	6900	1
3092 foundation	141,9	4712	10630	10959	-4200	6900	1
3092 piping	298,7	3470	-10350	10220	-4200	6900	1
3091 unit	14068	-66	-9369	10625	-4200	6900	1
3091 foundation	150,4	1850	-10575	11050	-4200	6900	1
3091 piping	1255,6	4310	10140	10350	-4200	6900	1
Retractable Azimuth Thru	1850	64928	-3189	3820	61900	68222	1
Bowthruster Aft VFD 41A	1600	64928	-1381	3820	62628	66618	1
Bowthruster Fore VFD 41	1600	64928	1381	3820	62628	66618	1
LO Tank Bowthruster Roo	510	66306	0	6110	66000	66600	1
Provision Cooling Plant 4	1700	67728	1100	5182	67623	67816	1
Bowthruster Aft Motor 4	4500	64700	0	4375	64160	65541	1
Bowthruster Fore Motor	4500	67700	1775	4375	66859	68138	1
Gravity Oil Tank Bowthru	130	64554	3411	6900	64502	64611	1
Gravity Oil Tank Bowthru	130	67514	3411	6900	67497	67570	1
Gravity Oil Tank Seal Bow	45	64120	3428	2900	63925	64325	1
Gravity Oil Tank Seal Bow	45	67275	3428	2900	67075	67475	1
Hydraulic Unit Bowthrust	75	64900	3416	1708	64818	64920	1
Hydraulic Unit Bowthrust	75	67900	3416	1708	67818	67920	1
1010 unit	90147	73156	13	4617	69250	78683	1
1010 foundation	554,2	70764	-393	5414	69250	78683	1
1010 piping	4606,8	71950	-20	5920	69250	78683	1
Retractable azimuth thru	16500	71320	0	3750	69337	72795	1
Air Handling Unit 3 42B 3	920	64400	850	9770	63700	65100	1

Air Handling Unit 4 42B 3	330	62600	3350	9080	61460	63700	1
Starter and control panel	50	45160	-7390	7710	44551	45775	1
CJC off-line filter separato	73	69723	2400	4238	69370	70130	1
CJC off-line filter separato	73	62788	2400	4238	62420	63180	1
Noise reduction Compres	490	69473	3100	5872	69084	69816	1
Noise reduction Compres	490	69473	-3100	5872	69084	69816	1
Grease trap 42C 343A10C	100	70900	-2267	5789	70550	71250	1
3020 unit	42149	59680	-14	10474	54350	66200	1
3020 foundation	622,2	57973	882	9951	54350	66200	1
3020 piping	8635,9	59660	1110	10500	54350	66200	0,518519
Battery Cabinet 4 battery	302	49760	-2658	12120	49440	50072	1
EM BRD NET Trafo 43A 43	600	49737	-807	12100	49447	50027	1
EM Light Trafo 43A 430E7	600	49737	-1070	12100	49447	50027	1
HTC-LTC Radiator 43A 41	1590	47900	1600	12100	46956	49044	1
Emergency Generator 43.	4450	47900	1600	12100	47477	48732	1
Emergency SWBD 43A 43	770	49892	1127	12620	49602	50142	1
Azimuth Thruster SB 43B	57300	460	6300	3480	-1647	2112	1
Azimuth Thruster PS 43B	57300	460	-6300	3480	-1647	2112	1
4041 unit	15736	48037	7233	14964	42450	50740	1
4041 foundation	402,7	44862	8027	17882	42450	50740	1
4041 piping	66252,6	49330	-10000	12320	42450	50740	1
4040 unit	26308	48361	-4680	14690	42450	50740	1
4040 foundation	230	47131	-6242	14949	42450	50740	1
4040 piping	69969,8	49340	9730	12420	42450	50740	0,46875
3010 unit	20811,6	70160	-32	10370	66200	74000	1
3010 foundation	47,8	70495	2172	11020	66200	74000	1
3010 piping	2424,3	71410	-71	10640	66200	74000	0,462963
4020 unit	40260	59925	14	13433	55260	66200	1
4020 foundation	94	62019	6327	13653	55260	66200	1
4020 piping	5906,8	60030	14	13280	55260	66200	0,388889
4010 unit	27990	70549	63	13513	66200	74000	1
4010 foundation	1606	72805	519	14178	66200	74000	1
4010 piping	3504	70530	1130	13480	66200	74000	0,37037
3000 unit	40800	76299	-4	11820	74000	78683	1
3000 foundation	37,6	74510	-2664	11188	74000	78683	1
3000 piping	963,3	76570	680	12580	74000	78683	0,259259
Windlass-mooring-sal wir	40000	73018	69	15140	71320	74168	1
5010 unit	17882	70078	164	16297	66200	74000	1
5010 foundation	243,5	70801	-4	15684	66200	74000	1
5010 piping	545,6	71390	-2190	16530	66200	74000	1
5020 unit	30917	59868	112	16257	55260	66200	1
5020 foundation	769,5	58671	-4582	16688	55260	66200	1
5020 piping	2682,3	59910	1040	15920	55260	66200	1
5000 unit	5956	76716	-9	16438	74000	80092	1
5000 foundation	274,2	77860	2	15704	74000	80092	1
5000 piping	226	75590	43	16850	74000	80092	1
6010 unit	16062	70273	590	19042	66200	74000	1
6010 foundation	87,3	73504	-3282	17813	66200	74000	1
6010 piping	295,5	70450	1140	19320	66200	74000	0,94
6020 unit	28585	59870	-422	18973	55260	66200	1

6020 foundation	840,2	58547	-4796	19256	55260	66200	1
6020 piping	2517,7	59650	1460	18880	55260	66200	0,958333
7010 unit	17133	70090	39	21823	66200	74000	1
7010 foundation	87,3	73504	-3282	17813	66200	74000	1
7010 piping	746,4	70860	-1710	22120	66200	74000	0,978261
7020 unit	35301	59086	-344	21706	55260	66200	1
7020 foundation	558,4	58730	-3574	22252	55260	66200	1
7020 piping	2526,8	60120	10	21730	55260	66200	0,952381
6000 unit	17202	77219	-10	20646	74000	80926	1
6000 foundation	7878,3	75552	245	19698	74000	80926	1
6000 piping	1596,8	76610	90	21940	74000	80926	0,975
8010 unit	14810	70049	-93	23427	66200	74000	1
8010 foundation	0	0	0	0	0	0	0
8010 piping	2648,1	69350	3600	22820	66200	74000	0,90625
Air Handling Unit 9A 372/	795	59892	7474	23240	57969	61828	1
8020 unit	33656	59700	-154	23720	55260	66200	1
8020 foundation	791,3	62192	-957	23218	55260	66200	1
8020 piping	8142,2	59150	2580	23300	55260	66200	0,9
6040 unit	8519	49816	-164	18846	49100	50740	1
6040 foundation	1018,5	49636	-273	16344	49100	50740	1
6040 piping	1544,7	50480	510	18550	49100	50740	1
7030 unit	50211	51786	-196	22446	48174	54800	1
7030 foundation	419,9	52677	-829	21060	48174	54800	1
7030 piping	5120,5	51340	1550	22440	48174	54800	0
TK BW 37	174202,2	37500	9471	2951	32900	43100	0
TK BW 48	128683	28408	0	726	24900	31900	0
TK BW 49	103356,5	28266	-9422	2763	24900	31900	0
TK BW 66	156902,6	11083	-6732	3757	7200	15100	0
TK BW 76	68706,98	2486	9506	6518	-2400	7200	0
TK BW 77	56845,6	-3246	-4754	6786	-4200	-2400	0
TK FW 55	141585,6	19235	-56	1257	15100	23500	0
TK FW 63	116103,6	19714	9092	3211	15100	23500	0
TK FUEL OIL 68	147875,9	12688	0	6092	10200	15100	0
TK FUEL OIL CARGO 38	106816,5	42121	-4572	5364	38900	43100	0
TK FUEL OIL CARGO 43	138376,2	36424	3775	5600	31900	38900	0
TK Liquid Mud/Brine 45	227686,7	34001	5903	5069	31900	36100	0
TK Anti-Roll 73	225911,9	8700	0	6800	7200	10200	0
TK BW 1	152963,5	75029	0	4740	73100	78656,26	0
TK BW 3	133856	66254	3260	1291	61100	73100	0
TK BW 12	66517,09	52320	6222	685	49100	55700	0
TK BW 29	73937,8	45230	-32	713	43100	47300	0
TK BW 30	62465,39	45145	-9509	3005	43100	47300	0
TK FW 4	275580,9	65969	-5451	5567	61100	73100	0
TK Miscellaneous 10	53940,58	55616	-5911	677	52700	59300	0
TK Miscellaneous 13	94345,72	54208	0	650	47300	61100	0
TK FUEL OIL 14	27985,58	53140	8860	3200	50900	55700	0
TK FUEL OIL 33	98521,98	45239	6562	3333	43100	47300	0
TK FUEL OIL 34	106496,5	45231	5681	3312	43100	47300	0

24 August actual configuration

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	6.508
29	pontil	-3.900	4.500	6.508
29	pontil	-3.900	-2.700	6.508
29	pontil	-3.900	-4.500	6.508
28	pontil long	-2.400	-10.700	55.586
28	pontil long	-2.400	10.700	55.586
20	2 glisante	5.700	8.100	15.632
20	2 glisante	5.700	4.500	15.632
20	2 glisante	5.700	1.600	15.632
20	2 glisante	5.700	-1.600	15.632
20	2 glisante	5.700	-4.500	15.632
20	2 glisante	5.700	-8.100	15.632
21	1 glisanta	6.000	0.000	2.102
21	1 glisanta	7.800	0.000	2.116
20	2 glisante	8.100	8.100	23.652
20	2 glisante	8.100	3.300	23.652
20	2 glisante	8.100	-3.300	23.652
20	2 glisante	8.100	-8.100	23.652
21	1 glisanta	11.000	0.000	2.140
20	2 glisante	11.300	5.700	34.304
20	2 glisante	11.300	-5.700	34.304
20	2 glisante	14.100	-8.100	24.160
20	2 glisante	14.100	-3.300	24.160
20	2 glisante	14.100	3.300	24.160
20	2 glisante	14.100	8.100	24.160
21	1 glisanta	14.500	0.000	2.167
21	1 glisanta	16.600	0.000	2.183
20	2 glisante	16.950	-8.700	17.418
20	2 glisante	16.950	-5.700	17.418
20	2 glisante	16.950	-3.300	17.418
20	2 glisante	16.950	3.300	17.418
20	2 glisante	16.950	5.700	17.418
20	2 glisante	16.950	8.700	17.418
21	1 glisanta	20.100	0.000	2.209
20	2 glisante	20.450	-8.700	26.445
20	2 glisante	20.450	-3.300	26.445
20	2 glisante	20.450	3.300	26.445
20	2 glisante	20.450	8.700	26.445
20	2 glisante	23.950	-8.700	17.842
20	2 glisante	23.950	-6.100	17.842
20	2 glisante	23.950	-3.300	17.842
20	2 glisante	23.950	3.300	17.842
20	2 glisante	23.950	5.700	17.842
20	2 glisante	23.950	8.700	17.842
21	1 glisanta	24.300	0.000	2.241
20	2 glisante	27.450	-8.700	18.053
20	2 glisante	27.450	-5.100	18.053
20	2 glisante	27.450	-1.600	18.053

20	2 glisante	27.450	1.600	18.053
20	2 glisante	27.450	5.100	18.053
20	2 glisante	27.450	8.700	18.053
20	2 glisante	30.950	-8.700	18.265
20	2 glisante	30.950	-5.100	18.265
20	2 glisante	30.950	-1.600	18.265
20	2 glisante	30.950	1.600	18.265
20	2 glisante	30.950	5.100	18.265
20	2 glisante	30.950	8.700	18.265
20	2 glisante	33.750	-9.800	20.668
20	2 glisante	33.750	-5.900	20.668
20	2 glisante	33.750	-1.600	20.668
20	2 glisante	33.750	1.600	20.668
20	2 glisante	33.750	5.900	20.668
20	2 glisante	33.750	9.800	20.668
20	2 glisante	37.250	-9.800	20.905
20	2 glisante	37.250	-6.300	20.905
20	2 glisante	37.250	-1.600	20.905
20	2 glisante	37.250	1.600	20.905
20	2 glisante	37.250	6.300	20.905
20	2 glisante	37.250	9.800	20.905
20	2 glisante	42.150	-9.300	20.194
20	2 glisante	42.150	-6.300	20.194
20	2 glisante	42.150	-1.600	20.194
20	2 glisante	42.150	2.700	20.194
20	2 glisante	42.150	6.300	20.194
20	2 glisante	42.150	9.300	20.194
20	2 glisante	44.950	-9.300	20.375
20	2 glisante	44.950	-6.600	20.375
20	2 glisante	44.950	-1.800	20.375
20	2 glisante	44.950	3.300	20.375
20	2 glisante	44.950	6.600	20.375
20	2 glisante	44.950	9.300	20.375
20	2 glisante	47.750	-9.300	20.555
20	2 glisante	47.750	-6.600	20.555
20	2 glisante	47.750	-1.600	20.555
20	2 glisante	47.750	3.300	20.555
20	2 glisante	47.750	6.600	20.555
20	2 glisante	47.750	9.300	20.555
20	2 glisante	50.200	-7.650	17.182
20	2 glisante	50.200	-3.850	17.182
20	2 glisante	50.200	-0.650	17.182
20	2 glisante	50.200	7.650	17.182
20	2 glisante	50.200	3.850	17.182
20	2 glisante	50.200	0.650	17.182
20	2 glisante	55.000	-8.100	18.416
20	2 glisante	55.000	-5.750	18.416
20	2 glisante	55.000	-2.750	18.416
20	2 glisante	55.000	2.550	18.416
20	2 glisante	55.000	5.750	18.416

20	2 glisante	55.000	8.100	18.416
20	2 glisante	59.200	3.850	13.990
20	2 glisante	59.200	-8.100	13.990
20	2 glisante	59.200	-5.300	13.990
20	2 glisante	59.200	-3.500	13.990
20	2 glisante	59.200	-0.650	13.990
20	2 glisante	59.200	0.650	13.990
20	2 glisante	59.200	5.750	13.990
20	2 glisante	59.200	8.100	13.990
20	2 glisante	61.600	-5.100	14.570
20	2 glisante	61.600	-2.700	14.570
20	2 glisante	61.600	2.700	14.570
20	2 glisante	61.600	5.100	14.570
20	2 glisante	61.600	0.000	14.570
20	2 glisante	65.800	0.000	13.821
20	2 glisante	65.800	-2.700	13.821
20	2 glisante	65.800	2.700	13.821
20	2 glisante	68.800	-2.700	13.944
20	2 glisante	68.800	2.700	13.944
20	2 glisante	68.800	0.000	13.944
20	2 glisante	71.200	2.700	10.532
20	2 glisante	71.200	1.600	10.532
20	2 glisante	71.200	-1.600	10.532
20	2 glisante	71.200	-2.700	10.532
20	2 glisante	74.200	-1.600	9.106
20	2 glisante	74.200	0.000	9.106
20	2 glisante	74.200	1.600	9.106
20	2 glisante	76.600	0.000	5.280

18 September actual configuration

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	5.447
29	pontil	-3.900	4.500	5.447
29	pontil	-3.900	-2.700	5.447
29	pontil	-3.900	-4.500	5.447
28	pontil long	-2.400	-10.700	47.364
28	pontil long	-2.400	10.700	47.364
20	2 glisante	5.700	8.100	14.417
20	2 glisante	5.700	4.500	14.417
20	2 glisante	5.700	1.600	14.417
20	2 glisante	5.700	-1.600	14.417
20	2 glisante	5.700	-4.500	14.417
20	2 glisante	5.700	-8.100	14.417
21	1 glisanta	6.000	0.000	1.941
21	1 glisanta	7.800	0.000	1.985
20	2 glisante	8.100	8.100	22.286
20	2 glisante	8.100	3.300	22.286
20	2 glisante	8.100	-3.300	22.286
20	2 glisante	8.100	-8.100	22.286
21	1 glisanta	11.000	0.000	2.064
20	2 glisante	11.300	5.700	33.219
20	2 glisante	11.300	-5.700	33.219
20	2 glisante	14.100	-8.100	23.936
20	2 glisante	14.100	-3.300	23.936
20	2 glisante	14.100	3.300	23.936
20	2 glisante	14.100	8.100	23.936
21	1 glisanta	14.500	0.000	2.150
21	1 glisanta	16.600	0.000	2.202
20	2 glisante	16.950	-8.700	17.645
20	2 glisante	16.950	-5.700	17.645
20	2 glisante	16.950	-3.300	17.645
20	2 glisante	16.950	3.300	17.645
20	2 glisante	16.950	5.700	17.645
20	2 glisante	16.950	8.700	17.645
21	1 glisanta	20.100	0.000	2.288
20	2 glisante	20.450	-8.700	27.498
20	2 glisante	20.450	-3.300	27.498
20	2 glisante	20.450	3.300	27.498
20	2 glisante	20.450	8.700	27.498
20	2 glisante	23.950	-8.700	19.019
20	2 glisante	23.950	-6.100	19.019
20	2 glisante	23.950	-3.300	19.019
20	2 glisante	23.950	3.300	19.019
20	2 glisante	23.950	5.700	19.019
20	2 glisante	23.950	8.700	19.019
21	1 glisanta	24.300	0.000	2.392
20	2 glisante	27.450	-8.700	19.706
20	2 glisante	27.450	-5.100	19.706
20	2 glisante	27.450	-1.600	19.706

20	2 glisante	27.450	1.600	19.706
20	2 glisante	27.450	5.100	19.706
20	2 glisante	27.450	8.700	19.706
20	2 glisante	30.950	-8.700	20.393
20	2 glisante	30.950	-5.100	20.393
20	2 glisante	30.950	-1.600	20.393
20	2 glisante	30.950	1.600	20.393
20	2 glisante	30.950	5.100	20.393
20	2 glisante	30.950	8.700	20.393
20	2 glisante	33.750	-9.800	23.479
20	2 glisante	33.750	-5.900	23.479
20	2 glisante	33.750	-1.600	23.479
20	2 glisante	33.750	1.600	23.479
20	2 glisante	33.750	5.900	23.479
20	2 glisante	33.750	9.800	23.479
20	2 glisante	37.250	-9.800	24.249
20	2 glisante	37.250	-6.300	24.249
20	2 glisante	37.250	-1.600	24.249
20	2 glisante	37.250	1.600	24.249
20	2 glisante	37.250	6.300	24.249
20	2 glisante	37.250	9.800	24.249
20	2 glisante	42.150	-9.300	24.084
20	2 glisante	42.150	-6.300	24.084
20	2 glisante	42.150	-1.600	24.084
20	2 glisante	42.150	2.700	24.084
20	2 glisante	42.150	6.300	24.084
20	2 glisante	42.150	9.300	24.084
20	2 glisante	44.950	-9.300	24.669
20	2 glisante	44.950	-6.600	24.669
20	2 glisante	44.950	-1.800	24.669
20	2 glisante	44.950	3.300	24.669
20	2 glisante	44.950	6.600	24.669
20	2 glisante	44.950	9.300	24.669
20	2 glisante	47.750	-9.300	25.255
20	2 glisante	47.750	-6.600	25.255
20	2 glisante	47.750	-1.600	25.255
20	2 glisante	47.750	3.300	25.255
20	2 glisante	47.750	6.600	25.255
20	2 glisante	47.750	9.300	25.255
20	2 glisante	50.200	-7.650	21.375
20	2 glisante	50.200	-3.850	21.375
20	2 glisante	50.200	-0.650	21.375
20	2 glisante	50.200	7.650	21.375
20	2 glisante	50.200	3.850	21.375
20	2 glisante	50.200	0.650	21.375
20	2 glisante	55.000	-8.100	23.453
20	2 glisante	55.000	-5.750	23.453
20	2 glisante	55.000	-2.750	23.453
20	2 glisante	55.000	2.550	23.453
20	2 glisante	55.000	5.750	23.453

20	2 glisante	55.000	8.100	23.453
20	2 glisante	59.200	3.850	18.167
20	2 glisante	59.200	-8.100	18.167
20	2 glisante	59.200	-5.300	18.167
20	2 glisante	59.200	-3.500	18.167
20	2 glisante	59.200	-0.650	18.167
20	2 glisante	59.200	0.650	18.167
20	2 glisante	59.200	5.750	18.167
20	2 glisante	59.200	8.100	18.167
20	2 glisante	61.600	-5.100	19.125
20	2 glisante	61.600	-2.700	19.125
20	2 glisante	61.600	2.700	19.125
20	2 glisante	61.600	5.100	19.125
20	2 glisante	61.600	0.000	19.125
20	2 glisante	65.800	0.000	18.475
20	2 glisante	65.800	-2.700	18.475
20	2 glisante	65.800	2.700	18.475
20	2 glisante	68.800	-2.700	18.874
20	2 glisante	68.800	2.700	18.874
20	2 glisante	68.800	0.000	18.874
20	2 glisante	71.200	2.700	14.395
20	2 glisante	71.200	1.600	14.395
20	2 glisante	71.200	-1.600	14.395
20	2 glisante	71.200	-2.700	14.395
20	2 glisante	74.200	-1.600	12.595
20	2 glisante	74.200	0.000	12.595
20	2 glisante	74.200	1.600	12.595
20	2 glisante	76.600	0.000	7.370

18 September new configuration

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	3.678
29	pontil	-3.900	4.500	3.678
29	pontil	-3.900	-2.700	3.678
29	pontil	-3.900	-4.500	3.678
28	pontil long	-2.400	-10.700	32.865
28	pontil long	-2.400	10.700	32.865
28	pillar2	-1.200	10.700	34.040
28	pillar2	-1.200	-10.700	34.040
28	pillar2	0.000	10.700	35.215
28	pillar2	0.000	-10.700	35.215
20	2 glisante	5.700	8.100	11.142
20	2 glisante	5.700	4.500	11.142
20	2 glisante	5.700	1600	11.142
20	2 glisante	5.700	-1600	11.142
20	2 glisante	5.700	-4.500	11.142
20	2 glisante	5.700	-8.100	11.142
21	1 glisanta	6.000	0.000	1.501
21	1 glisanta	7.800	0.000	1.566
20	2 glisante	8.100	8100	17.675
20	2 glisante	8.100	3.300	17.675
20	2 glisante	8.100	-3.300	17.675
20	2 glisante	8.100	-8.100	17.675
21	1 glisanta	11.000	0.000	1.681
20	2 glisante	11.300	5.700	27.185
20	2 glisante	11.300	-5.700	27.185
20	2 glisante	14.100	-8100	20.081
20	2 glisante	14.100	-3300	20.081
20	2 glisante	14.100	3.300	20.081
20	2 glisante	14.100	8.100	20.081
21	1 glisanta	14.500	0.000	1.807
21	1 glisanta	16.600	0.000	1.882
20	2 glisante	16.950	-8.700	15.150
20	2 glisante	16.950	-5.700	15.150
20	2 glisante	16.950	-3300	15.150
20	2 glisante	16.950	3.300	15.150
20	2 glisante	16.950	5.700	15.150
20	2 glisante	16.950	8.700	15.150
21	1 glisanta	20.100	0.000	2.008
20	2 glisante	20.450	-8.700	24.228
20	2 glisante	20.450	-3.300	24.228
20	2 glisante	20.450	3.300	24.228
20	2 glisante	20.450	8.700	24.228
20	2 glisante	23.950	-8.700	17.153
20	2 glisante	23.950	-6.100	17.153
20	2 glisante	23.950	-3300	17.153
20	2 glisante	23.950	3.300	17.153
20	2 glisante	23.950	5.700	17.153
20	2 glisante	23.950	8.700	17.153

21	1 glisanta	24.300	0.000	2.159
20	2 glisante	27.450	-8.700	18.155
20	2 glisante	27.450	-5.100	18.155
20	2 glisante	27.450	-1.600	18.155
20	2 glisante	27.450	1.600	18.155
20	2 glisante	27.450	5.100	18.155
20	2 glisante	27.450	8.700	18.155
20	2 glisante	30.950	-8.700	19.157
20	2 glisante	30.950	-5.100	19.157
20	2 glisante	30.950	-1.600	19.157
20	2 glisante	30.950	1.600	19.157
20	2 glisante	30.950	5.100	19.157
20	2 glisante	30.950	8.700	19.157
20	2 glisante	33.750	-9.800	22.376
20	2 glisante	33.750	-5.900	22.376
20	2 glisante	33.750	-1.600	22.376
20	2 glisante	33.750	1.600	22.376
20	2 glisante	33.750	5.900	22.376
20	2 glisante	33.750	9.800	22.376
20	2 glisante	37.250	-9.800	23.499
20	2 glisante	37.250	-6.300	23.499
20	2 glisante	37.250	-1.600	23.499
20	2 glisante	37.250	1.600	23.499
20	2 glisante	37.250	6.300	23.499
20	2 glisante	37.250	9.800	23.499
20	2 glisante	42.150	-9.300	23.840
20	2 glisante	42.150	-6.300	23.840
20	2 glisante	42.150	-1.600	23.840
20	2 glisante	42.150	2.700	23.840
20	2 glisante	42.150	6.300	23.840
20	2 glisante	42.150	9.300	23.840
20	2 glisante	44.950	-9.300	24.694
20	2 glisante	44.950	-6.600	24.694
20	2 glisante	44.950	-1.800	24.694
20	2 glisante	44.950	3.300	24.694
20	2 glisante	44.950	6.600	24.694
20	2 glisante	44.950	9.300	24.694
20	2 glisante	47.750	-9.300	25.549
20	2 glisante	47.750	-6.600	25.549
20	2 glisante	47.750	-1.600	25.549
20	2 glisante	47.750	3.300	25.549
20	2 glisante	47.750	6600	25.549
20	2 glisante	47.750	9.300	25.549
20	2 glisante	50.200	-7.650	21.814
20	2 glisante	50.200	-3850	21.814
20	2 glisante	50.200	-0.650	21.814
20	2 glisante	50.200	7.650	21.814
20	2 glisante	50.200	3.850	21.814
20	2 glisante	50.200	0.650	21.814
20	2 glisante	55.000	-8.100	24.319

20	2 glisante	55.000	-5.750	24.319
20	2 glisante	55.000	-2.750	24.319
20	2 glisante	55.000	2.550	24.319
20	2 glisante	55.000	5.750	24.319
20	2 glisante	55.000	8.100	24.319
20	2 glisante	59.200	3850	19.081
20	2 glisante	59.200	-8100	19.081
20	2 glisante	59.200	-5.300	19.081
20	2 glisante	59.200	-3.500	19.081
20	2 glisante	59.200	-0.650	19.081
20	2 glisante	59.200	0.650	19.081
20	2 glisante	59.200	5.750	19.081
20	2 glisante	59.200	8.100	19.081
20	2 glisante	61.600	-5100	20.227
20	2 glisante	61.600	-2700	20.227
20	2 glisante	61.600	2.700	20.227
20	2 glisante	61.600	5.100	20.227
20	2 glisante	61.600	0.000	20.227
20	2 glisante	65.800	0.000	19.763
20	2 glisante	65.800	-2700	19.763
20	2 glisante	65.800	2.700	19.763
20	2 glisante	68.800	-2.700	20.345
20	2 glisante	68.800	2.700	20.345
20	2 glisante	68.800	0.000	20.345
20	2 glisante	71.200	2.700	15.609
20	2 glisante	71.200	1600	15.609
20	2 glisante	71.200	-1.600	15.609
20	2 glisante	71.200	-2700	15.609
20	2 glisante	74.200	-1.600	13.753
20	2 glisante	74.200	0.000	13.753
20	2 glisante	74.200	1.600	13.753
20	2 glisante	76.600	0.000	8.091

9 October new configuration

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	2.438
29	pontil	-3.900	4.500	2.438
29	pontil	-3.900	-2.700	2.438
29	pontil	-3.900	-4.500	2.438
28	pontil long	-2.400	-10.700	23.856
28	pontil long	-2.400	10.700	23.856
28	pillar2	-1.200	10.700	26.114
28	pillar2	-1.200	-10.700	26.114
28	pillar2	0.000	10.700	28.371
28	pillar2	0.000	-10.700	28.371
20	2 glisante	5.700	8.100	10.682
20	2 glisante	5.700	4.500	10.682
20	2 glisante	5.700	1600	10.682
20	2 glisante	5.700	-1600	10.682
20	2 glisante	5.700	-4.500	10.682
20	2 glisante	5.700	-8.100	10.682
21	1 glisanta	6.000	0.000	1.443
21	1 glisanta	7.800	0.000	1.567
20	2 glisante	8.100	8100	17.872
20	2 glisante	8.100	3.300	17.872
20	2 glisante	8.100	-3.300	17.872
20	2 glisante	8.100	-8.100	17.872
21	1 glisanta	11.000	0.000	1.788
20	2 glisante	11.300	5.700	29.162
20	2 glisante	11.300	-5.700	29.162
20	2 glisante	14.100	-8100	22.493
20	2 glisante	14.100	-3300	22.493
20	2 glisante	14.100	3.300	22.493
20	2 glisante	14.100	8.100	22.493
21	1 glisanta	14.500	0.000	2.030
21	1 glisanta	16.600	0.000	2.175
20	2 glisante	16.950	-8.700	17.624
20	2 glisante	16.950	-5.700	17.624
20	2 glisante	16.950	-3300	17.624
20	2 glisante	16.950	3.300	17.624
20	2 glisante	16.950	5.700	17.624
20	2 glisante	16.950	8.700	17.624
21	1 glisanta	20.100	0.000	2.416
20	2 glisante	20.450	-8.700	29.322
20	2 glisante	20.450	-3.300	29.322
20	2 glisante	20.450	3.300	29.322
20	2 glisante	20.450	8.700	29.322
20	2 glisante	23.950	-8.700	21.473
20	2 glisante	23.950	-6.100	21.473
20	2 glisante	23.950	-3300	21.473
20	2 glisante	23.950	3.300	21.473
20	2 glisante	23.950	5.700	21.473
20	2 glisante	23.950	8.700	21.473

21	1 glisanta	24.300	0.000	2.706
20	2 glisante	27.450	-8.700	23.397
20	2 glisante	27.450	-5.100	23.397
20	2 glisante	27.450	-1.600	23.397
20	2 glisante	27.450	1.600	23.397
20	2 glisante	27.450	5.100	23.397
20	2 glisante	27.450	8.700	23.397
20	2 glisante	30.950	-8.700	25.322
20	2 glisante	30.950	-5.100	25.322
20	2 glisante	30.950	-1.600	25.322
20	2 glisante	30.950	1.600	25.322
20	2 glisante	30.950	5.100	25.322
20	2 glisante	30.950	8.700	25.322
20	2 glisante	33.750	-9.800	30.116
20	2 glisante	33.750	-5.900	30.116
20	2 glisante	33.750	-1.600	30.116
20	2 glisante	33.750	1.600	30.116
20	2 glisante	33.750	5.900	30.116
20	2 glisante	33.750	9.800	30.116
20	2 glisante	37.250	-9.800	32.273
20	2 glisante	37.250	-6.300	32.273
20	2 glisante	37.250	-1.600	32.273
20	2 glisante	37.250	1.600	32.273
20	2 glisante	37.250	6.300	32.273
20	2 glisante	37.250	9.800	32.273
20	2 glisante	42.150	-9.300	33.560
20	2 glisante	42.150	-6.300	33.560
20	2 glisante	42.150	-1.600	33.560
20	2 glisante	42.150	2.700	33.560
20	2 glisante	42.150	6.300	33.560
20	2 glisante	42.150	9.300	33.560
20	2 glisante	44.950	-9.300	35.202
20	2 glisante	44.950	-6.600	35.202
20	2 glisante	44.950	-1.800	35.202
20	2 glisante	44.950	3.300	35.202
20	2 glisante	44.950	6.600	35.202
20	2 glisante	44.950	9.300	35.202
20	2 glisante	47.750	-9.300	36.843
20	2 glisante	47.750	-6.600	36.843
20	2 glisante	47.750	-1.600	36.843
20	2 glisante	47.750	3.300	36.843
20	2 glisante	47.750	6600	36.843
20	2 glisante	47.750	9.300	36.843
20	2 glisante	50.200	-7.650	31.754
20	2 glisante	50.200	-3850	31.754
20	2 glisante	50.200	-1	31.754
20	2 glisante	50.200	7.650	31.754
20	2 glisante	50.200	3.850	31.754
20	2 glisante	50.200	1	31.754
20	2 glisante	55.000	-8.100	35.999

20	2 glisante	55.000	-5.750	35.999
20	2 glisante	55.000	-2.750	35.999
20	2 glisante	55.000	2.550	35.999
20	2 glisante	55.000	5.750	35.999
20	2 glisante	55.000	8.100	35.999
20	2 glisante	59.200	3850	28.617
20	2 glisante	59.200	-8100	28.617
20	2 glisante	59.200	-5.300	28.617
20	2 glisante	59.200	-3.500	28.617
20	2 glisante	59.200	-1	28.617
20	2 glisante	59.200	1	28.617
20	2 glisante	59.200	5.750	28.617
20	2 glisante	59.200	8.100	28.617
20	2 glisante	61.600	-5100	30.544
20	2 glisante	61.600	-2700	30.544
20	2 glisante	61.600	2.700	30.544
20	2 glisante	61.600	5.100	30.544
20	2 glisante	61.600	0.000	30.544
20	2 glisante	65.800	0.000	30.179
20	2 glisante	65.800	-2700	30.179
20	2 glisante	65.800	2.700	30.179
20	2 glisante	68.800	-2.700	31.298
20	2 glisante	68.800	2.700	31.298
20	2 glisante	68.800	0.000	31.298
20	2 glisante	71.200	2.700	24.145
20	2 glisante	71.200	1600	24.145
20	2 glisante	71.200	-1.600	24.145
20	2 glisante	71.200	-2700	24.145
20	2 glisante	74.200	-1.600	21.415
20	2 glisante	74.200	0.000	21.415
20	2 glisante	74.200	1.600	21.415
20	2 glisante	76.600	0.000	12.661

I°Sub-group 37-48-38-66

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	5.391
29	pontil	-3.900	4.500	5.391
29	pontil	-3.900	-2.700	5.391
29	pontil	-3.900	-4.500	5.391
28	pontil long	-2.400	-10.700	47.395
28	pontil long	-2.400	10.700	47.395
28	pillar2	-1.200	10.700	48.566
28	pillar2	-1.200	-10.700	48.566
28	pillar2	0.000	10.700	49.738
28	pillar2	0.000	-10.700	49.738
20	2 glisante	5.700	8.100	15.101
20	2 glisante	5.700	4.500	15.101
20	2 glisante	5.700	1600	15.101
20	2 glisante	5.700	-1600	15.101
20	2 glisante	5.700	-4.500	15.101
20	2 glisante	5.700	-8.100	15.101
21	1 glisanta	6.000	0.000	2.034
21	1 glisanta	7.800	0.000	2.098
20	2 glisante	8.100	8100	23.611
20	2 glisante	8.100	3.300	23.611
20	2 glisante	8.100	-3.300	23.611
20	2 glisante	8.100	-8.100	23.611
21	1 glisanta	11.000	0.000	2.213
20	2 glisante	11.300	5.700	35.692
20	2 glisante	11.300	-5.700	35.692
20	2 glisante	14.100	-8100	26.009
20	2 glisante	14.100	-3300	26.009
20	2 glisante	14.100	3.300	26.009
20	2 glisante	14.100	8.100	26.009
21	1 glisanta	14.500	0.000	2.338
21	1 glisanta	16.600	0.000	2.413
20	2 glisante	16.950	-8.700	19.380
20	2 glisante	16.950	-5.700	19.380
20	2 glisante	16.950	-3300	19.380
20	2 glisante	16.950	3.300	19.380
20	2 glisante	16.950	5.700	19.380
20	2 glisante	16.950	8.700	19.380
21	1 glisanta	20.100	0.000	2.539
20	2 glisante	20.450	-8.700	30.567
20	2 glisante	20.450	-3.300	30.567
20	2 glisante	20.450	3.300	30.567
20	2 glisante	20.450	8.700	30.567
20	2 glisante	23.950	-8.700	21.377
20	2 glisante	23.950	-6.100	21.377
20	2 glisante	23.950	-3300	21.377
20	2 glisante	23.950	3.300	21.377
20	2 glisante	23.950	5.700	21.377
20	2 glisante	23.950	8.700	21.377

21	1 glisanta	24.300	0.000	2.689
20	2 glisante	27.450	-8.700	22.375
20	2 glisante	27.450	-5.100	22.375
20	2 glisante	27.450	-1.600	22.375
20	2 glisante	27.450	1.600	22.375
20	2 glisante	27.450	5.100	22.375
20	2 glisante	27.450	8.700	22.375
20	2 glisante	30.950	-8.700	23.374
20	2 glisante	30.950	-5.100	23.374
20	2 glisante	30.950	-1.600	23.374
20	2 glisante	30.950	1.600	23.374
20	2 glisante	30.950	5.100	23.374
20	2 glisante	30.950	8.700	23.374
20	2 glisante	33.750	-9.800	27.101
20	2 glisante	33.750	-5.900	27.101
20	2 glisante	33.750	-1.600	27.101
20	2 glisante	33.750	1.600	27.101
20	2 glisante	33.750	5.900	27.101
20	2 glisante	33.750	9.800	27.101
20	2 glisante	37.250	-9.800	28.221
20	2 glisante	37.250	-6.300	28.221
20	2 glisante	37.250	-1.600	28.221
20	2 glisante	37.250	1.600	28.221
20	2 glisante	37.250	6.300	28.221
20	2 glisante	37.250	9.800	28.221
20	2 glisante	42.150	-9.300	28.325
20	2 glisante	42.150	-6.300	28.325
20	2 glisante	42.150	-1.600	28.325
20	2 glisante	42.150	2.700	28.325
20	2 glisante	42.150	6.300	28.325
20	2 glisante	42.150	9.300	28.325
20	2 glisante	44.950	-9.300	29.177
20	2 glisante	44.950	-6.600	29.177
20	2 glisante	44.950	-1.800	29.177
20	2 glisante	44.950	3.300	29.177
20	2 glisante	44.950	6.600	29.177
20	2 glisante	44.950	9.300	29.177
20	2 glisante	47.750	-9.300	30.029
20	2 glisante	47.750	-6.600	30.029
20	2 glisante	47.750	-1.600	30.029
20	2 glisante	47.750	3.300	30.029
20	2 glisante	47.750	6600	30.029
20	2 glisante	47.750	9.300	30.029
20	2 glisante	50.200	-7.650	25.528
20	2 glisante	50.200	-3850	25.528
20	2 glisante	50.200	-0.650	25.528
20	2 glisante	50.200	7.650	25.528
20	2 glisante	50.200	3.850	25.528
20	2 glisante	50.200	0.650	25.528
20	2 glisante	55.000	-8.100	28.238

20	2 glisante	55.000	-5.750	28.238
20	2 glisante	55.000	-2.750	28.238
20	2 glisante	55.000	2.550	28.238
20	2 glisante	55.000	5.750	28.238
20	2 glisante	55.000	8.100	28.238
20	2 glisante	59.200	3850	22.018
20	2 glisante	59.200	-8100	22.018
20	2 glisante	59.200	-5.300	22.018
20	2 glisante	59.200	-3.500	22.018
20	2 glisante	59.200	-0.650	22.018
20	2 glisante	59.200	0.650	22.018
20	2 glisante	59.200	5.750	22.018
20	2 glisante	59.200	8.100	22.018
20	2 glisante	61.600	-5100	23.261
20	2 glisante	61.600	-2700	23.261
20	2 glisante	61.600	2.700	23.261
20	2 glisante	61.600	5.100	23.261
20	2 glisante	61.600	0.000	23.261
20	2 glisante	65.800	0.000	22.603
20	2 glisante	65.800	-2700	22.603
20	2 glisante	65.800	2.700	22.603
20	2 glisante	68.800	-2.700	23.184
20	2 glisante	68.800	2.700	23.184
20	2 glisante	68.800	0.000	23.184
20	2 glisante	71.200	2.700	17.736
20	2 glisante	71.200	1600	17.736
20	2 glisante	71.200	-1.600	17.736
20	2 glisante	71.200	-2700	17.736
20	2 glisante	74.200	-1.600	15.576
20	2 glisante	74.200	0.000	15.576
20	2 glisante	74.200	1.600	15.576
20	2 glisante	76.600	0.000	9.140

II°Sub-group 76-77-55

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	5.529
29	pontil	-3.900	4.500	5.529
29	pontil	-3.900	-2.700	5.529
29	pontil	-3.900	-4.500	5.529
28	pontil long	-2.400	-10.700	48.118
28	pontil long	-2.400	10.700	48.118
28	pillar2	-1.200	10.700	48.968
28	pillar2	-1.200	-10.700	48.968
28	pillar2	0.000	10.700	49.817
28	pillar2	0.000	-10.700	49.817
20	2 glisante	5.700	8.100	14.704
20	2 glisante	5.700	4.500	14.704
20	2 glisante	5.700	1600	14.704
20	2 glisante	5.700	-1600	14.704
20	2 glisante	5.700	-4.500	14.704
20	2 glisante	5.700	-8.100	14.704
21	1 glisanta	6.000	0.000	1.979
21	1 glisanta	7.800	0.000	2.026
20	2 glisante	8.100	8100	22.751
20	2 glisante	8.100	3.300	22.751
20	2 glisante	8.100	-3.300	22.751
20	2 glisante	8.100	-8.100	22.751
21	1 glisanta	11.000	0.000	2.109
20	2 glisante	11.300	5.700	33.954
20	2 glisante	11.300	-5.700	33.954
20	2 glisante	14.100	-8100	24.490
20	2 glisante	14.100	-3300	24.490
20	2 glisante	14.100	3.300	24.490
20	2 glisante	14.100	8.100	24.490
21	1 glisanta	14.500	0.000	2.200
21	1 glisanta	16.600	0.000	2.255
20	2 glisante	16.950	-8.700	18.071
20	2 glisante	16.950	-5.700	18.071
20	2 glisante	16.950	-3300	18.071
20	2 glisante	16.950	3.300	18.071
20	2 glisante	16.950	5.700	18.071
20	2 glisante	16.950	8.700	18.071
21	1 glisanta	20.100	0.000	2.345
20	2 glisante	20.450	-8.700	28.192
20	2 glisante	20.450	-3.300	28.192
20	2 glisante	20.450	3.300	28.192
20	2 glisante	20.450	8.700	28.192
20	2 glisante	23.950	-8.700	19.519
20	2 glisante	23.950	-6.100	19.519
20	2 glisante	23.950	-3300	19.519
20	2 glisante	23.950	3.300	19.519
20	2 glisante	23.950	5.700	19.519
20	2 glisante	23.950	8.700	19.519

21	1 glisanta	24.300	0.000	2.455
20	2 glisante	27.450	-8.700	20.243
20	2 glisante	27.450	-5.100	20.243
20	2 glisante	27.450	-1.600	20.243
20	2 glisante	27.450	1.600	20.243
20	2 glisante	27.450	5.100	20.243
20	2 glisante	27.450	8.700	20.243
20	2 glisante	30.950	-8.700	20.967
20	2 glisante	30.950	-5.100	20.967
20	2 glisante	30.950	-1.600	20.967
20	2 glisante	30.950	1.600	20.967
20	2 glisante	30.950	5.100	20.967
20	2 glisante	30.950	8.700	20.967
20	2 glisante	33.750	-9.800	24.156
20	2 glisante	33.750	-5.900	24.156
20	2 glisante	33.750	-1.600	24.156
20	2 glisante	33.750	1.600	24.156
20	2 glisante	33.750	5.900	24.156
20	2 glisante	33.750	9.800	24.156
20	2 glisante	37.250	-9.800	24.968
20	2 glisante	37.250	-6.300	24.968
20	2 glisante	37.250	-1.600	24.968
20	2 glisante	37.250	1.600	24.968
20	2 glisante	37.250	6.300	24.968
20	2 glisante	37.250	9.800	24.968
20	2 glisante	42.150	-9.300	24.822
20	2 glisante	42.150	-6.300	24.822
20	2 glisante	42.150	-1.600	24.822
20	2 glisante	42.150	2.700	24.822
20	2 glisante	42.150	6.300	24.822
20	2 glisante	42.150	9.300	24.822
20	2 glisante	44.950	-9.300	25.439
20	2 glisante	44.950	-6.600	25.439
20	2 glisante	44.950	-1.800	25.439
20	2 glisante	44.950	3.300	25.439
20	2 glisante	44.950	6.600	25.439
20	2 glisante	44.950	9.300	25.439
20	2 glisante	47.750	-9.300	26.057
20	2 glisante	47.750	-6.600	26.057
20	2 glisante	47.750	-1.600	26.057
20	2 glisante	47.750	3.300	26.057
20	2 glisante	47.750	6600	26.057
20	2 glisante	47.750	9.300	26.057
20	2 glisante	50.200	-7.650	22.063
20	2 glisante	50.200	-3850	22.063
20	2 glisante	50.200	-0.650	22.063
20	2 glisante	50.200	7.650	22.063
20	2 glisante	50.200	3.850	22.063
20	2 glisante	50.200	0.650	22.063
20	2 glisante	55.000	-8.100	24.227

20	2 glisante	55.000	-5.750	24.227
20	2 glisante	55.000	-2.750	24.227
20	2 glisante	55.000	2.550	24.227
20	2 glisante	55.000	5.750	24.227
20	2 glisante	55.000	8.100	24.227
20	2 glisante	59.200	3850	18.779
20	2 glisante	59.200	-8100	18.779
20	2 glisante	59.200	-5.300	18.779
20	2 glisante	59.200	-3.500	18.779
20	2 glisante	59.200	-0.650	18.779
20	2 glisante	59.200	0.650	18.779
20	2 glisante	59.200	5.750	18.779
20	2 glisante	59.200	8.100	18.779
20	2 glisante	61.600	-5100	19.776
20	2 glisante	61.600	-2700	19.776
20	2 glisante	61.600	2.700	19.776
20	2 glisante	61.600	5.100	19.776
20	2 glisante	61.600	0.000	19.776
20	2 glisante	65.800	0.000	19.114
20	2 glisante	65.800	-2700	19.114
20	2 glisante	65.800	2.700	19.114
20	2 glisante	68.800	-2.700	19.535
20	2 glisante	68.800	2.700	19.535
20	2 glisante	68.800	0.000	19.535
20	2 glisante	71.200	2.700	14.904
20	2 glisante	71.200	1600	14.904
20	2 glisante	71.200	-1.600	14.904
20	2 glisante	71.200	-2700	14.904
20	2 glisante	74.200	-1.600	13.046
20	2 glisante	74.200	0.000	13.046
20	2 glisante	74.200	1.600	13.046
20	2 glisante	76.600	0.000	7.636

III°Sub-group 49-68-63

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	5.527
29	pontil	-3.900	4.500	5.527
29	pontil	-3.900	-2.700	5.527
29	pontil	-3.900	-4.500	5.527
28	pontil long	-2.400	-10.700	48.231
28	pontil long	-2.400	10.700	48.231
28	pillar2	-1.200	10.700	49.174
28	pillar2	-1.200	-10.700	49.174
28	pillar2	0.000	10.700	50.118
28	pillar2	0.000	-10.700	50.118
20	2 glisante	5.700	8.100	14.908
20	2 glisante	5.700	4.500	14.908
20	2 glisante	5.700	1600	14.908
20	2 glisante	5.700	-1600	14.908
20	2 glisante	5.700	-4.500	14.908
20	2 glisante	5.700	-8.100	14.908
21	1 glisanta	6.000	0.000	2.007
21	1 glisanta	7.800	0.000	2.059
20	2 glisante	8.100	8100	23.135
20	2 glisante	8.100	3.300	23.135
20	2 glisante	8.100	-3.300	23.135
20	2 glisante	8.100	-8.100	23.135
21	1 glisanta	11.000	0.000	2.151
20	2 glisante	11.300	5.700	34.652
20	2 glisante	11.300	-5.700	34.652
20	2 glisante	14.100	-8100	25.066
20	2 glisante	14.100	-3300	25.066
20	2 glisante	14.100	3.300	25.066
20	2 glisante	14.100	8.100	25.066
21	1 glisanta	14.500	0.000	2.252
21	1 glisanta	16.600	0.000	2.313
20	2 glisante	16.950	-8.700	18.548
20	2 glisante	16.950	-5.700	18.548
20	2 glisante	16.950	-3300	18.548
20	2 glisante	16.950	3.300	18.548
20	2 glisante	16.950	5.700	18.548
20	2 glisante	16.950	8.700	18.548
21	1 glisanta	20.100	0.000	2.414
20	2 glisante	20.450	-8.700	29.028
20	2 glisante	20.450	-3.300	29.028
20	2 glisante	20.450	3.300	29.028
20	2 glisante	20.450	8.700	29.028
20	2 glisante	23.950	-8.700	20.156
20	2 glisante	23.950	-6.100	20.156
20	2 glisante	23.950	-3300	20.156
20	2 glisante	23.950	3.300	20.156
20	2 glisante	23.950	5.700	20.156
20	2 glisante	23.950	8.700	20.156

21	1 glisanta	24.300	0.000	2.535
20	2 glisante	27.450	-8.700	20.961
20	2 glisante	27.450	-5.100	20.961
20	2 glisante	27.450	-1.600	20.961
20	2 glisante	27.450	1.600	20.961
20	2 glisante	27.450	5.100	20.961
20	2 glisante	27.450	8.700	20.961
20	2 glisante	30.950	-8.700	21.765
20	2 glisante	30.950	-5.100	21.765
20	2 glisante	30.950	-1.600	21.765
20	2 glisante	30.950	1.600	21.765
20	2 glisante	30.950	5.100	21.765
20	2 glisante	30.950	8.700	21.765
20	2 glisante	33.750	-9.800	25.123
20	2 glisante	33.750	-5.900	25.123
20	2 glisante	33.750	-1.600	25.123
20	2 glisante	33.750	1.600	25.123
20	2 glisante	33.750	5.900	25.123
20	2 glisante	33.750	9.800	25.123
20	2 glisante	37.250	-9.800	26.024
20	2 glisante	37.250	-6.300	26.024
20	2 glisante	37.250	-1.600	26.024
20	2 glisante	37.250	1.600	26.024
20	2 glisante	37.250	6.300	26.024
20	2 glisante	37.250	9.800	26.024
20	2 glisante	42.150	-9.300	25.946
20	2 glisante	42.150	-6.300	25.946
20	2 glisante	42.150	-1.600	25.946
20	2 glisante	42.150	2.700	25.946
20	2 glisante	42.150	6.300	25.946
20	2 glisante	42.150	9.300	25.946
20	2 glisante	44.950	-9.300	26.632
20	2 glisante	44.950	-6.600	26.632
20	2 glisante	44.950	-1.800	26.632
20	2 glisante	44.950	3.300	26.632
20	2 glisante	44.950	6.600	26.632
20	2 glisante	44.950	9.300	26.632
20	2 glisante	47.750	-9.300	27.318
20	2 glisante	47.750	-6.600	27.318
20	2 glisante	47.750	-1.600	27.318
20	2 glisante	47.750	3.300	27.318
20	2 glisante	47.750	6600	27.318
20	2 glisante	47.750	9.300	27.318
20	2 glisante	50.200	-7.650	23.159
20	2 glisante	50.200	-3850	23.159
20	2 glisante	50.200	-0.650	23.159
20	2 glisante	50.200	7.650	23.159
20	2 glisante	50.200	3.850	23.159
20	2 glisante	50.200	0.650	23.159
20	2 glisante	55.000	-8.100	25.487

20	2 glisante	55.000	-5.750	25.487
20	2 glisante	55.000	-2.750	25.487
20	2 glisante	55.000	2.550	25.487
20	2 glisante	55.000	5.750	25.487
20	2 glisante	55.000	8.100	25.487
20	2 glisante	59.200	3850	19.791
20	2 glisante	59.200	-8100	19.791
20	2 glisante	59.200	-5.300	19.791
20	2 glisante	59.200	-3.500	19.791
20	2 glisante	59.200	-0.650	19.791
20	2 glisante	59.200	0.650	19.791
20	2 glisante	59.200	5.750	19.791
20	2 glisante	59.200	8.100	19.791
20	2 glisante	61.600	-5100	20.863
20	2 glisante	61.600	-2700	20.863
20	2 glisante	61.600	2.700	20.863
20	2 glisante	61.600	5.100	20.863
20	2 glisante	61.600	0.000	20.863
20	2 glisante	65.800	0.000	20.198
20	2 glisante	65.800	-2700	20.198
20	2 glisante	65.800	2.700	20.198
20	2 glisante	68.800	-2.700	20.665
20	2 glisante	68.800	2.700	20.665
20	2 glisante	68.800	0.000	20.665
20	2 glisante	71.200	2.700	15.780
20	2 glisante	71.200	1600	15.780
20	2 glisante	71.200	-1.600	15.780
20	2 glisante	71.200	-2700	15.780
20	2 glisante	74.200	-1.600	13.826
20	2 glisante	74.200	0.000	13.826
20	2 glisante	74.200	1.600	13.826
20	2 glisante	76.600	0.000	8.099

	IV°Sub-group 43-73			
Type of support	**Device used**	**x**	**y**	**Load**
29	pontil	-3.900	2.700	5.516
29	pontil	-3.900	4.500	5.516
29	pontil	-3.900	-2.700	5.516
29	pontil	-3.900	-4.500	5.516
28	pontil long	-2.400	-10.700	48.141
28	pontil long	-2.400	10.700	48.141
28	pillar2	-1.200	10.700	49.084
28	pillar2	-1.200	-10.700	49.084
28	pillar2	0.000	10.700	50.028
28	pillar2	0.000	-10.700	50.028
20	2 glisante	5.700	8.100	14.885
20	2 glisante	5.700	4.500	14.885
20	2 glisante	5.700	1600	14.885
20	2 glisante	5.700	-1600	14.885
20	2 glisante	5.700	-4.500	14.885
20	2 glisante	5.700	-8.100	14.885
21	1 glisanta	6.000	0.000	2.004
21	1 glisanta	7.800	0.000	2.056
20	2 glisante	8.100	8100	23.100
20	2 glisante	8.100	3.300	23.100
20	2 glisante	8.100	-3.300	23.100
20	2 glisante	8.100	-8.100	23.100
21	1 glisanta	11.000	0.000	2.148
20	2 glisante	11.300	5.700	34.602
20	2 glisante	11.300	-5.700	34.602
20	2 glisante	14.100	-8100	25.032
20	2 glisante	14.100	-3300	25.032
20	2 glisante	14.100	3.300	25.032
20	2 glisante	14.100	8.100	25.032
21	1 glisanta	14.500	0.000	2.249
21	1 glisanta	16.600	0.000	2.310
20	2 glisante	16.950	-8.700	18.524
20	2 glisante	16.950	-5.700	18.524
20	2 glisante	16.950	-3300	18.524
20	2 glisante	16.950	3.300	18.524
20	2 glisante	16.950	5.700	18.524
20	2 glisante	16.950	8.700	18.524
21	1 glisanta	20.100	0.000	2.411
20	2 glisante	20.450	-8.700	28.993
20	2 glisante	20.450	-3.300	28.993
20	2 glisante	20.450	3.300	28.993
20	2 glisante	20.450	8.700	28.993
20	2 glisante	23.950	-8.700	20.133
20	2 glisante	23.950	-6.100	20.133
20	2 glisante	23.950	-3300	20.133
20	2 glisante	23.950	3.300	20.133
20	2 glisante	23.950	5.700	20.133
20	2 glisante	23.950	8.700	20.133

21	1 glisanta	24.300	0.000	2.532
20	2 glisante	27.450	-8.700	20.938
20	2 glisante	27.450	-5.100	20.938
20	2 glisante	27.450	-1.600	20.938
20	2 glisante	27.450	1.600	20.938
20	2 glisante	27.450	5.100	20.938
20	2 glisante	27.450	8.700	20.938
20	2 glisante	30.950	-8.700	21.742
20	2 glisante	30.950	-5.100	21.742
20	2 glisante	30.950	-1.600	21.742
20	2 glisante	30.950	1.600	21.742
20	2 glisante	30.950	5.100	21.742
20	2 glisante	30.950	8.700	21.742
20	2 glisante	33.750	-9.800	25.098
20	2 glisante	33.750	-5.900	25.098
20	2 glisante	33.750	-1.600	25.098
20	2 glisante	33.750	1.600	25.098
20	2 glisante	33.750	5.900	25.098
20	2 glisante	33.750	9.800	25.098
20	2 glisante	37.250	-9.800	26.000
20	2 glisante	37.250	-6.300	26.000
20	2 glisante	37.250	-1.600	26.000
20	2 glisante	37.250	1.600	26.000
20	2 glisante	37.250	6.300	26.000
20	2 glisante	37.250	9.800	26.000
20	2 glisante	42.150	-9.300	25.924
20	2 glisante	42.150	-6.300	25.924
20	2 glisante	42.150	-1.600	25.924
20	2 glisante	42.150	2.700	25.924
20	2 glisante	42.150	6.300	25.924
20	2 glisante	42.150	9.300	25.924
20	2 glisante	44.950	-9.300	26.610
20	2 glisante	44.950	-6.600	26.610
20	2 glisante	44.950	-1.800	26.610
20	2 glisante	44.950	3.300	26.610
20	2 glisante	44.950	6.600	26.610
20	2 glisante	44.950	9.300	26.610
20	2 glisante	47.750	-9.300	27.296
20	2 glisante	47.750	-6.600	27.296
20	2 glisante	47.750	-1.600	27.296
20	2 glisante	47.750	3.300	27.296
20	2 glisante	47.750	6600	27.296
20	2 glisante	47.750	9.300	27.296
20	2 glisante	50.200	-7.650	23.142
20	2 glisante	50.200	-3850	23.142
20	2 glisante	50.200	-0.650	23.142
20	2 glisante	50.200	7.650	23.142
20	2 glisante	50.200	3.850	23.142
20	2 glisante	50.200	0.650	23.142
20	2 glisante	55.000	-8.100	25.469

20	2 glisante	55.000	-5.750	25.469
20	2 glisante	55.000	-2.750	25.469
20	2 glisante	55.000	2.550	25.469
20	2 glisante	55.000	5.750	25.469
20	2 glisante	55.000	8.100	25.469
20	2 glisante	59.200	3850	19.778
20	2 glisante	59.200	-8100	19.778
20	2 glisante	59.200	-5.300	19.778
20	2 glisante	59.200	-3.500	19.778
20	2 glisante	59.200	-0.650	19.778
20	2 glisante	59.200	0.650	19.778
20	2 glisante	59.200	5.750	19.778
20	2 glisante	59.200	8.100	19.778
20	2 glisante	61.600	-5100	20.849
20	2 glisante	61.600	-2700	20.849
20	2 glisante	61.600	2.700	20.849
20	2 glisante	61.600	5.100	20.849
20	2 glisante	61.600	0.000	20.849
20	2 glisante	65.800	0.000	20.185
20	2 glisante	65.800	-2700	20.185
20	2 glisante	65.800	2.700	20.185
20	2 glisante	68.800	-2.700	20.653
20	2 glisante	68.800	2.700	20.653
20	2 glisante	68.800	0.000	20.653
20	2 glisante	71.200	2.700	15.771
20	2 glisante	71.200	1600	15.771
20	2 glisante	71.200	-1.600	15.771
20	2 glisante	71.200	-2700	15.771
20	2 glisante	74.200	-1.600	13.818
20	2 glisante	74.200	0.000	13.818
20	2 glisante	74.200	1.600	13.818
20	2 glisante	76.600	0.000	8.095

	V°Sub-group 45			
Type of support	**Device used**	**x**	**y**	**Load**
29	pontil	-3.900	2.700	4.130
29	pontil	-3.900	4.500	4.130
29	pontil	-3.900	-2.700	4.130
29	pontil	-3.900	-4.500	4.130
28	pontil long	-2.400	-10.700	36.800
28	pontil long	-2.400	10.700	36.800
28	pillar2	-1.200	10.700	38.047
28	pillar2	-1.200	-10.700	38.047
28	pillar2	0.000	10.700	39.294
28	pillar2	0.000	-10.700	39.294
20	2 glisante	5.700	8.100	12.349
20	2 glisante	5.700	4.500	12.349
20	2 glisante	5.700	1600	12.349
20	2 glisante	5.700	-1600	12.349
20	2 glisante	5.700	-4.500	12.349
20	2 glisante	5.700	-8.100	12.349
21	1 glisanta	6.000	0.000	1.664
21	1 glisanta	7.800	0.000	1.733
20	2 glisante	8.100	8100	19.545
20	2 glisante	8.100	3.300	19.545
20	2 glisante	8.100	-3.300	19.545
20	2 glisante	8.100	-8.100	19.545
21	1 glisanta	11.000	0.000	1.855
20	2 glisante	11.300	5.700	29.979
20	2 glisante	11.300	-5.700	29.979
20	2 glisante	14.100	-8100	22.097
20	2 glisante	14.100	-3300	22.097
20	2 glisante	14.100	3.300	22.097
20	2 glisante	14.100	8.100	22.097
21	1 glisanta	14.500	0.000	1.988
21	1 glisanta	16.600	0.000	2.068
20	2 glisante	16.950	-8.700	16.640
20	2 glisante	16.950	-5.700	16.640
20	2 glisante	16.950	-3300	16.640
20	2 glisante	16.950	3.300	16.640
20	2 glisante	16.950	5.700	16.640
20	2 glisante	16.950	8.700	16.640
21	1 glisanta	20.100	0.000	2.202
20	2 glisante	20.450	-8.700	26.554
20	2 glisante	20.450	-3.300	26.554
20	2 glisante	20.450	3.300	26.554
20	2 glisante	20.450	8.700	26.554
20	2 glisante	23.950	-8.700	18.766
20	2 glisante	23.950	-6.100	18.766
20	2 glisante	23.950	-3300	18.766
20	2 glisante	23.950	3.300	18.766
20	2 glisante	23.950	5.700	18.766
20	2 glisante	23.950	8.700	18.766

21	1 glisanta	24.300	0.000	2.362
20	2 glisante	27.450	-8.700	19.829
20	2 glisante	27.450	-5.100	19.829
20	2 glisante	27.450	-1.600	19.829
20	2 glisante	27.450	1.600	19.829
20	2 glisante	27.450	5.100	19.829
20	2 glisante	27.450	8.700	19.829
20	2 glisante	30.950	-8.700	20.892
20	2 glisante	30.950	-5.100	20.892
20	2 glisante	30.950	-1.600	20.892
20	2 glisante	30.950	1.600	20.892
20	2 glisante	30.950	5.100	20.892
20	2 glisante	30.950	8.700	20.892
20	2 glisante	33.750	-9.800	24.376
20	2 glisante	33.750	-5.900	24.376
20	2 glisante	33.750	-1.600	24.376
20	2 glisante	33.750	1.600	24.376
20	2 glisante	33.750	5.900	24.376
20	2 glisante	33.750	9.800	24.376
20	2 glisante	37.250	-9.800	25.568
20	2 glisante	37.250	-6.300	25.568
20	2 glisante	37.250	-1.600	25.568
20	2 glisante	37.250	1.600	25.568
20	2 glisante	37.250	6.300	25.568
20	2 glisante	37.250	9.800	25.568
20	2 glisante	42.150	-9.300	25.899
20	2 glisante	42.150	-6.300	25.899
20	2 glisante	42.150	-1.600	25.899
20	2 glisante	42.150	2.700	25.899
20	2 glisante	42.150	6.300	25.899
20	2 glisante	42.150	9.300	25.899
20	2 glisante	44.950	-9.300	26.806
20	2 glisante	44.950	-6.600	26.806
20	2 glisante	44.950	-1.800	26.806
20	2 glisante	44.950	3.300	26.806
20	2 glisante	44.950	6.600	26.806
20	2 glisante	44.950	9.300	26.806
20	2 glisante	47.750	-9.300	27.712
20	2 glisante	47.750	-6.600	27.712
20	2 glisante	47.750	-1.600	27.712
20	2 glisante	47.750	3.300	27.712
20	2 glisante	47.750	6600	27.712
20	2 glisante	47.750	9.300	27.712
20	2 glisante	50.200	-7.650	23.647
20	2 glisante	50.200	-3850	23.647
20	2 glisante	50.200	-0.650	23.647
20	2 glisante	50.200	7.650	23.647
20	2 glisante	50.200	3.850	23.647
20	2 glisante	50.200	0.650	23.647
20	2 glisante	55.000	-8.100	26.333

20	2 glisante	55.000	-5.750	26.333
20	2 glisante	55.000	-2.750	26.333
20	2 glisante	55.000	2.550	26.333
20	2 glisante	55.000	5.750	26.333
20	2 glisante	55.000	8.100	26.333
20	2 glisante	59.200	3850	20.644
20	2 glisante	59.200	-8100	20.644
20	2 glisante	59.200	-5.300	20.644
20	2 glisante	59.200	-3.500	20.644
20	2 glisante	59.200	-0.650	20.644
20	2 glisante	59.200	0.650	20.644
20	2 glisante	59.200	5.750	20.644
20	2 glisante	59.200	8.100	20.644
20	2 glisante	61.600	-5100	21.873
20	2 glisante	61.600	-2700	21.873
20	2 glisante	61.600	2.700	21.873
20	2 glisante	61.600	5.100	21.873
20	2 glisante	61.600	0.000	21.873
20	2 glisante	65.800	0.000	21.354
20	2 glisante	65.800	-2700	21.354
20	2 glisante	65.800	2.700	21.354
20	2 glisante	68.800	-2.700	21.973
20	2 glisante	68.800	2.700	21.973
20	2 glisante	68.800	0.000	21.973
20	2 glisante	71.200	2.700	16.850
20	2 glisante	71.200	1600	16.850
20	2 glisante	71.200	-1.600	16.850
20	2 glisante	71.200	-2700	16.850
20	2 glisante	74.200	-1.600	14.841
20	2 glisante	74.200	0.000	14.841
20	2 glisante	74.200	1.600	14.841
20	2 glisante	76.600	0.000	8.728

VI°Sub-group 1-10-12-29

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	1.161
29	pontil	-3.900	4.500	1.161
29	pontil	-3.900	-2.700	1.161
29	pontil	-3.900	-4.500	1.161
28	pontil long	-2.400	-10.700	14.021
28	pontil long	-2.400	10.700	14.021
28	pillar2	-1.200	10.700	16.999
28	pillar2	-1.200	-10.700	16.999
28	pillar2	0.000	10.700	19.977
28	pillar2	0.000	-10.700	19.977
20	2 glisante	5.700	8.100	9.328
20	2 glisante	5.700	4.500	9.328
20	2 glisante	5.700	1600	9.328
20	2 glisante	5.700	-1600	9.328
20	2 glisante	5.700	-4.500	9.328
20	2 glisante	5.700	-8.100	9.328
21	1 glisanta	6.000	0.000	1.263
21	1 glisanta	7.800	0.000	1.427
20	2 glisante	8.100	8100	16.431
20	2 glisante	8.100	3.300	16.431
20	2 glisante	8.100	-3.300	16.431
20	2 glisante	8.100	-8.100	16.431
21	1 glisanta	11.000	0.000	1.719
20	2 glisante	11.300	5.700	28.225
20	2 glisante	11.300	-5.700	28.225
20	2 glisante	14.100	-8100	22.529
20	2 glisante	14.100	-3300	22.529
20	2 glisante	14.100	3.300	22.529
20	2 glisante	14.100	8.100	22.529
21	1 glisanta	14.500	0.000	2.037
21	1 glisanta	16.600	0.000	2.229
20	2 glisante	16.950	-8.700	18.149
20	2 glisante	16.950	-5.700	18.149
20	2 glisante	16.950	-3300	18.149
20	2 glisante	16.950	3.300	18.149
20	2 glisante	16.950	5.700	18.149
20	2 glisante	16.950	8.700	18.149
21	1 glisanta	20.100	0.000	2.547
20	2 glisante	20.450	-8.700	31.032
20	2 glisante	20.450	-3.300	31.032
20	2 glisante	20.450	3.300	31.032
20	2 glisante	20.450	8.700	31.032
20	2 glisante	23.950	-8.700	23.227
20	2 glisante	23.950	-6.100	23.227
20	2 glisante	23.950	-3300	23.227
20	2 glisante	23.950	3.300	23.227
20	2 glisante	23.950	5.700	23.227
20	2 glisante	23.950	8.700	23.227

21	1 glisanta	24.300	0.000	2.930
20	2 glisante	27.450	-8.700	25.766
20	2 glisante	27.450	-5.100	25.766
20	2 glisante	27.450	-1.600	25.766
20	2 glisante	27.450	1.600	25.766
20	2 glisante	27.450	5.100	25.766
20	2 glisante	27.450	8.700	25.766
20	2 glisante	30.950	-8.700	28.305
20	2 glisante	30.950	-5.100	28.305
20	2 glisante	30.950	-1.600	28.305
20	2 glisante	30.950	1.600	28.305
20	2 glisante	30.950	5.100	28.305
20	2 glisante	30.950	8.700	28.305
20	2 glisante	33.750	-9.800	34.011
20	2 glisante	33.750	-5.900	34.011
20	2 glisante	33.750	-1.600	34.011
20	2 glisante	33.750	1.600	34.011
20	2 glisante	33.750	5.900	34.011
20	2 glisante	33.750	9.800	34.011
20	2 glisante	37.250	-9.800	36.858
20	2 glisante	37.250	-6.300	36.858
20	2 glisante	37.250	-1.600	36.858
20	2 glisante	37.250	1.600	36.858
20	2 glisante	37.250	6.300	36.858
20	2 glisante	37.250	9.800	36.858
20	2 glisante	42.150	-9.300	38.837
20	2 glisante	42.150	-6.300	38.837
20	2 glisante	42.150	-1.600	38.837
20	2 glisante	42.150	2.700	38.837
20	2 glisante	42.150	6.300	38.837
20	2 glisante	42.150	9.300	38.837
20	2 glisante	44.950	-9.300	41.002
20	2 glisante	44.950	-6.600	41.002
20	2 glisante	44.950	-1.800	41.002
20	2 glisante	44.950	3.300	41.002
20	2 glisante	44.950	6.600	41.002
20	2 glisante	44.950	9.300	41.002
20	2 glisante	47.750	-9.300	43.168
20	2 glisante	47.750	-6.600	43.168
20	2 glisante	47.750	-1.600	43.168
20	2 glisante	47.750	3.300	43.168
20	2 glisante	47.750	6600	43.168
20	2 glisante	47.750	9.300	43.168
20	2 glisante	50.200	-7.650	37.381
20	2 glisante	50.200	-3850	37.381
20	2 glisante	50.200	-0.650	37.381
20	2 glisante	50.200	7.650	37.381
20	2 glisante	50.200	3.850	37.381
20	2 glisante	50.200	0.650	37.381
20	2 glisante	55.000	-8.100	42.728

20	2 glisante	55.000	-5.750	42.728
20	2 glisante	55.000	-2.750	42.728
20	2 glisante	55.000	2.550	42.728
20	2 glisante	55.000	5.750	42.728
20	2 glisante	55.000	8.100	42.728
20	2 glisante	59.200	3850	34.180
20	2 glisante	59.200	-8100	34.180
20	2 glisante	59.200	-5.300	34.180
20	2 glisante	59.200	-3.500	34.180
20	2 glisante	59.200	-0.650	34.180
20	2 glisante	59.200	0.650	34.180
20	2 glisante	59.200	5.750	34.180
20	2 glisante	59.200	8.100	34.180
20	2 glisante	61.600	-5100	36.602
20	2 glisante	61.600	-2700	36.602
20	2 glisante	61.600	2.700	36.602
20	2 glisante	61.600	5.100	36.602
20	2 glisante	61.600	0.000	36.602
20	2 glisante	65.800	0.000	36.353
20	2 glisante	65.800	-2700	36.353
20	2 glisante	65.800	2.700	36.353
20	2 glisante	68.800	-2.700	37.830
20	2 glisante	68.800	2.700	37.830
20	2 glisante	68.800	0.000	37.830
20	2 glisante	71.200	2.700	29.258
20	2 glisante	71.200	1600	29.258
20	2 glisante	71.200	-1.600	29.258
20	2 glisante	71.200	-2700	29.258
20	2 glisante	74.200	-1.600	26.027
20	2 glisante	74.200	0.000	26.027
20	2 glisante	74.200	1.600	26.027
20	2 glisante	76.600	0.000	15.423

VII°Sub-group 3-13-30				
Type of support	**Device used**	**x**	**y**	**Load**
29	pontil	-3.900	2.700	1.581
29	pontil	-3.900	4.500	1.581
29	pontil	-3.900	-2.700	1.581
29	pontil	-3.900	-4.500	1.581
28	pontil long	-2.400	-10.700	17.331
28	pontil long	-2.400	10.700	17.331
28	pillar2	-1.200	10.700	20.126
28	pillar2	-1.200	-10.700	20.126
28	pillar2	0.000	10.700	22.921
28	pillar2	0.000	-10.700	22.921
20	2 glisante	5.700	8.100	9.893
20	2 glisante	5.700	4.500	9.893
20	2 glisante	5.700	1600	9.893
20	2 glisante	5.700	-1600	9.893
20	2 glisante	5.700	-4.500	9.893
20	2 glisante	5.700	-8.100	9.893
21	1 glisanta	6.000	0.000	1.339
21	1 glisanta	7.800	0.000	1.492
20	2 glisante	8.100	8100	17.129
20	2 glisante	8.100	3.300	17.129
20	2 glisante	8.100	-3.300	17.129
20	2 glisante	8.100	-8.100	17.129
21	1 glisanta	11.000	0.000	1.766
20	2 glisante	11.300	5.700	28.938
20	2 glisante	11.300	-5.700	28.938
20	2 glisante	14.100	-8100	22.850
20	2 glisante	14.100	-3300	22.850
20	2 glisante	14.100	3.300	22.850
20	2 glisante	14.100	8.100	22.850
21	1 glisanta	14.500	0.000	2.065
21	1 glisanta	16.600	0.000	2.244
20	2 glisante	16.950	-8.700	18.252
20	2 glisante	16.950	-5.700	18.252
20	2 glisante	16.950	-3300	18.252
20	2 glisante	16.950	3.300	18.252
20	2 glisante	16.950	5.700	18.252
20	2 glisante	16.950	8.700	18.252
21	1 glisanta	20.100	0.000	2.544
20	2 glisante	20.450	-8.700	30.951
20	2 glisante	20.450	-3.300	30.951
20	2 glisante	20.450	3.300	30.951
20	2 glisante	20.450	8.700	30.951
20	2 glisante	23.950	-8.700	23.017
20	2 glisante	23.950	-6.100	23.017
20	2 glisante	23.950	-3300	23.017
20	2 glisante	23.950	3.300	23.017
20	2 glisante	23.950	5.700	23.017
20	2 glisante	23.950	8.700	23.017

21	1 glisanta	24.300	0.000	2.903
20	2 glisante	27.450	-8.700	25.399
20	2 glisante	27.450	-5.100	25.399
20	2 glisante	27.450	-1.600	25.399
20	2 glisante	27.450	1.600	25.399
20	2 glisante	27.450	5.100	25.399
20	2 glisante	27.450	8.700	25.399
20	2 glisante	30.950	-8.700	27.782
20	2 glisante	30.950	-5.100	27.782
20	2 glisante	30.950	-1.600	27.782
20	2 glisante	30.950	1.600	27.782
20	2 glisante	30.950	5.100	27.782
20	2 glisante	30.950	8.700	27.782
20	2 glisante	33.750	-9.800	33.285
20	2 glisante	33.750	-5.900	33.285
20	2 glisante	33.750	-1.600	33.285
20	2 glisante	33.750	1.600	33.285
20	2 glisante	33.750	5.900	33.285
20	2 glisante	33.750	9.800	33.285
20	2 glisante	37.250	-9.800	35.956
20	2 glisante	37.250	-6.300	35.956
20	2 glisante	37.250	-1.600	35.956
20	2 glisante	37.250	1.600	35.956
20	2 glisante	37.250	6.300	35.956
20	2 glisante	37.250	9.800	35.956
20	2 glisante	42.150	-9.300	37.746
20	2 glisante	42.150	-6.300	37.746
20	2 glisante	42.150	-1.600	37.746
20	2 glisante	42.150	2.700	37.746
20	2 glisante	42.150	6.300	37.746
20	2 glisante	42.150	9.300	37.746
20	2 glisante	44.950	-9.300	39.778
20	2 glisante	44.950	-6.600	39.778
20	2 glisante	44.950	-1.800	39.778
20	2 glisante	44.950	3.300	39.778
20	2 glisante	44.950	6.600	39.778
20	2 glisante	44.950	9.300	39.778
20	2 glisante	47.750	-9.300	41.810
20	2 glisante	47.750	-6.600	41.810
20	2 glisante	47.750	-1.600	41.810
20	2 glisante	47.750	3.300	41.810
20	2 glisante	47.750	6600	41.810
20	2 glisante	47.750	9.300	41.810
20	2 glisante	50.200	-7.650	36.158
20	2 glisante	50.200	-3850	36.158
20	2 glisante	50.200	-0.650	36.158
20	2 glisante	50.200	7.650	36.158
20	2 glisante	50.200	3.850	36.158
20	2 glisante	50.200	0.650	36.158
20	2 glisante	55.000	-8.100	41.236

20	2 glisante	55.000	-5.750	41.236
20	2 glisante	55.000	-2.750	41.236
20	2 glisante	55.000	2.550	41.236
20	2 glisante	55.000	5.750	41.236
20	2 glisante	55.000	8.100	41.236
20	2 glisante	59.200	3850	32.930
20	2 glisante	59.200	-8100	32.930
20	2 glisante	59.200	-5.300	32.930
20	2 glisante	59.200	-3.500	32.930
20	2 glisante	59.200	-0.650	32.930
20	2 glisante	59.200	0.650	32.930
20	2 glisante	59.200	5.750	32.930
20	2 glisante	59.200	8.100	32.930
20	2 glisante	61.600	-5100	35.231
20	2 glisante	61.600	-2700	35.231
20	2 glisante	61.600	2.700	35.231
20	2 glisante	61.600	5.100	35.231
20	2 glisante	61.600	0.000	35.231
20	2 glisante	65.800	0.000	34.942
20	2 glisante	65.800	-2700	34.942
20	2 glisante	65.800	2.700	34.942
20	2 glisante	68.800	-2.700	36.328
20	2 glisante	68.800	2.700	36.328
20	2 glisante	68.800	0.000	36.328
20	2 glisante	71.200	2.700	28.077
20	2 glisante	71.200	1600	28.077
20	2 glisante	71.200	-1.600	28.077
20	2 glisante	71.200	-2700	28.077
20	2 glisante	74.200	-1.600	24.957
20	2 glisante	74.200	0.000	24.957
20	2 glisante	74.200	1.600	24.957
20	2 glisante	76.600	0.000	14.779

VIII°Sub-group 4-14-33-34

Type of support	Device used	x	y	Load
29	pontil	-3.900	2.700	1.033
29	pontil	-3.900	4.500	1.033
29	pontil	-3.900	-2.700	1.033
29	pontil	-3.900	-4.500	1.033
28	pontil long	-2.400	-10.700	13.205
28	pontil long	-2.400	10.700	13.205
28	pillar2	-1.200	10.700	16.373
28	pillar2	-1.200	-10.700	16.373
28	pillar2	0.000	10.700	19.541
28	pillar2	0.000	-10.700	19.541
20	2 glisante	5.700	8.100	9.457
20	2 glisante	5.700	4.500	9.457
20	2 glisante	5.700	1600	9.457
20	2 glisante	5.700	-1600	9.457
20	2 glisante	5.700	-4.500	9.457
20	2 glisante	5.700	-8.100	9.457
21	1 glisanta	6.000	0.000	1.281
21	1 glisanta	7.800	0.000	1.455
20	2 glisante	8.100	8100	16.779
20	2 glisante	8.100	3.300	16.779
20	2 glisante	8.100	-3.300	16.779
20	2 glisante	8.100	-8.100	16.779
21	1 glisanta	11.000	0.000	1.765
20	2 glisante	11.300	5.700	29.021
20	2 glisante	11.300	-5.700	29.021
20	2 glisante	14.100	-8100	23.265
20	2 glisante	14.100	-3300	23.265
20	2 glisante	14.100	3.300	23.265
20	2 glisante	14.100	8.100	23.265
21	1 glisanta	14.500	0.000	2.104
21	1 glisanta	16.600	0.000	2.308
20	2 glisante	16.950	-8.700	18.807
20	2 glisante	16.950	-5.700	18.807
20	2 glisante	16.950	-3300	18.807
20	2 glisante	16.950	3.300	18.807
20	2 glisante	16.950	5.700	18.807
20	2 glisante	16.950	8.700	18.807
21	1 glisanta	20.100	0.000	2.647
20	2 glisante	20.450	-8.700	32.261
20	2 glisante	20.450	-3.300	32.261
20	2 glisante	20.450	3.300	32.261
20	2 glisante	20.450	8.700	32.261
20	2 glisante	23.950	-8.700	24.208
20	2 glisante	23.950	-6.100	24.208
20	2 glisante	23.950	-3300	24.208
20	2 glisante	23.950	3.300	24.208
20	2 glisante	23.950	5.700	24.208
20	2 glisante	23.950	8.700	24.208

21	1 glisanta	24.300	0.000	3.054
20	2 glisante	27.450	-8.700	26.909
20	2 glisante	27.450	-5.100	26.909
20	2 glisante	27.450	-1.600	26.909
20	2 glisante	27.450	1.600	26.909
20	2 glisante	27.450	5.100	26.909
20	2 glisante	27.450	8.700	26.909
20	2 glisante	30.950	-8.700	29.610
20	2 glisante	30.950	-5.100	29.610
20	2 glisante	30.950	-1.600	29.610
20	2 glisante	30.950	1.600	29.610
20	2 glisante	30.950	5.100	29.610
20	2 glisante	30.950	8.700	29.610
20	2 glisante	33.750	-9.800	35.620
20	2 glisante	33.750	-5.900	35.620
20	2 glisante	33.750	-1.600	35.620
20	2 glisante	33.750	1.600	35.620
20	2 glisante	33.750	5.900	35.620
20	2 glisante	33.750	9.800	35.620
20	2 glisante	37.250	-9.800	38.648
20	2 glisante	37.250	-6.300	38.648
20	2 glisante	37.250	-1.600	38.648
20	2 glisante	37.250	1.600	38.648
20	2 glisante	37.250	6.300	38.648
20	2 glisante	37.250	9.800	38.648
20	2 glisante	42.150	-9.300	40.780
20	2 glisante	42.150	-6.300	40.780
20	2 glisante	42.150	-1.600	40.780
20	2 glisante	42.150	2.700	40.780
20	2 glisante	42.150	6.300	40.780
20	2 glisante	42.150	9.300	40.780
20	2 glisante	44.950	-9.300	43.084
20	2 glisante	44.950	-6.600	43.084
20	2 glisante	44.950	-1.800	43.084
20	2 glisante	44.950	3.300	43.084
20	2 glisante	44.950	6.600	43.084
20	2 glisante	44.950	9.300	43.084
20	2 glisante	47.750	-9.300	45.387
20	2 glisante	47.750	-6.600	45.387
20	2 glisante	47.750	-1.600	45.387
20	2 glisante	47.750	3.300	45.387
20	2 glisante	47.750	6600	45.387
20	2 glisante	47.750	9.300	45.387
20	2 glisante	50.200	-7.650	39.323
20	2 glisante	50.200	-3850	39.323
20	2 glisante	50.200	-0.650	39.323
20	2 glisante	50.200	7.650	39.323
20	2 glisante	50.200	3.850	39.323
20	2 glisante	50.200	0.650	39.323
20	2 glisante	55.000	-8.100	44.986

20	2 glisante	55.000	-5.750	44.986
20	2 glisante	55.000	-2.750	44.986
20	2 glisante	55.000	2.550	44.986
20	2 glisante	55.000	5.750	44.986
20	2 glisante	55.000	8.100	44.986
20	2 glisante	59.200	3850	36.009
20	2 glisante	59.200	-8100	36.009
20	2 glisante	59.200	-5.300	36.009
20	2 glisante	59.200	-3.500	36.009
20	2 glisante	59.200	-0.650	36.009
20	2 glisante	59.200	0.650	36.009
20	2 glisante	59.200	5.750	36.009
20	2 glisante	59.200	8.100	36.009
20	2 glisante	61.600	-5100	38.573
20	2 glisante	61.600	-2700	38.573
20	2 glisante	61.600	2.700	38.573
20	2 glisante	61.600	5.100	38.573
20	2 glisante	61.600	0.000	38.573
20	2 glisante	65.800	0.000	38.332
20	2 glisante	65.800	-2700	38.332
20	2 glisante	65.800	2.700	38.332
20	2 glisante	68.800	-2.700	39.903
20	2 glisante	68.800	2.700	39.903
20	2 glisante	68.800	0.000	39.903
20	2 glisante	71.200	2.700	30.869
20	2 glisante	71.200	1600	30.869
20	2 glisante	71.200	-1.600	30.869
20	2 glisante	71.200	-2700	30.869
20	2 glisante	74.200	-1.600	27.469
20	2 glisante	74.200	0.000	27.469
20	2 glisante	74.200	1.600	27.469
20	2 glisante	76.600	0.000	16.280