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PRE-OUTFITTING OF A PLATFORM SUPPLY VESSEL IN SECTION UNIT ASSEMBLY STAGE

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ABSTRACT

The shipbuilding industry is one of the heavy industries which directly has an impact on the micro and macroeconomic systems, through its power of evolution and the high amount of money invested in development, innovation and, last but not least, in workforce. It is well known the that the price of one ship is quite constant, as there are no big differences between shipyards. So, to resist in this market, the shipyards started to think of new ways of reducing the production costs, so they still remain competitive on the market. Thus, a permanent concern is the optimization of all technological stages, either on the part of the ship hull assembly or on the part of hull outfitting, in order to obtain a final product that satisfies the required quality level at the lowest possible price. Shipyards were forced to improve their business plan with assessing their own production processes, by reducing, as far as possible, the time on each of the intermediate cycle of production. All the modern shipyards, from all over the world, have now understood that, by adopting the concept of pre-outfitting or advance outfitting, the vessel building cycle time can be reduced and a substantial saving of costs, along with other benefits, can be achieved. This study shows an analysis that aims to improve the efficiency of productivity, effect of the new practice of pre-outfitting and piping assembly operations vs. old practice in outfitting. A calculation of the time saved by applying the pre-outfitting method for the engine room is presented

KEYWORDS: pre-outfitting, spool, saturation

1. Contextual issue

1.1. Brief overview of offshore ships

The Canadian company Atlantic Towing, specialized in granting dedicated service and offshore supply and towing, has contracted Damen company for the construction of four ships of the type of Platform Supply Vessels (PSV), one of which with functions of Inspection, Repair and Maintenance (IRM) (Fig. 1). The last ship, which will be the subject of this study, has some special features as compared to the other three vessels. In the first place due to the offshore crane of 100t it was implemented an additional ring dedicated to activate anti heeling system. These 4 vessels are built in Romania, three of the four ordered have been completed in the yard Damen Galati and one was subcontracted by Constanta shipyard until the time of the launch. Two of four vessels did the sea trials in the Black Sea and it has installed scrubber systems. [6]

Its basic functions are: Offshore Supply, Inspection Repair & Maintenance, Emergency Towing.

Classification: Det Norske Veritas 1A1 Offshore Service Vessel Towing Supply HL (2.8) DK (+) ICE-1C BIS CLEAN DESIGN NAU OSV(A) BWM-T E0 DYNPOS-AUTR Fire Fighter | OILREC SPS COMF – V (3).

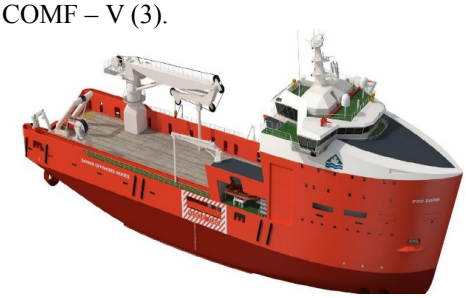

Fig. 1 PSV 5000 IRM Vessel

Vessels shall have in the percentage of 96 % the same systems.

In order to carry out the fitting of these systems on board of the ship, this was divided by the Engineering Department in section units and compartments, according to the Table 1, that shows the total number of initial spools and the allocation of such spools on section units but also in the engine room (E)107-040 emphasized by using bold font.

In the engine room, piping systems are designed similarly for all the four ships, having routed the same pipelines, using practically the same documentation with an order which benefit from the functions of the IRM, longitudinal coordinates do not match because of the additional ring. In relation to the Global Reference System which is located in the area of the stern (aft) additional ring, differs only coordinate value on the Ox axis, but from the point of view of a Local Reference System positioned in the area of the engine room, technically nothing differs at all four vessels in the fleet which are similar.

In the engine room are distributed 1994 spools from the original value of total spools number, meaning 12127 spools of PSV 5000 IRM Vessel.

Table 1 The total number of initial spools and the allocation on section units

Section	Spools by Input
E101-040	161
E102-040	64
E103-140	40
E103-240	71
E104-140	30
E104-240	45
E105-240	19
E106-240	17
E106-340	17
E106-440	19
E107-040	**1994**
...	…
TOTAL SPOOLS	12127

2. Old practice in outfitting vs New practice of pre-outfitting

The old technique of achieving of outfitting for new-building ship, with pipe spool and not only, consists in the completion of all the outfitting work after the hull of the vessel is done and is ready to launch it to the water.

After we made the hull of the ship on the jetty or in a dock and it was launched, the outfitting operations are started on the ship.

This implies that in order to start other types of job activity, those who work to the hull must complete the work so that the project itself will not stretch very much in time.

Such practices are still used in our days, but fortunately, there are fewer and fewer and more shipyards which understand the benefit of the advanced outfitting.

Modern shipyards, from all over the world, apply in our days a custom form the saturation in the early stages of modular and standardized erection of the hull of the vessel, having such a block section saturation but and even in the phase of section units, as shown as in Figure 2.

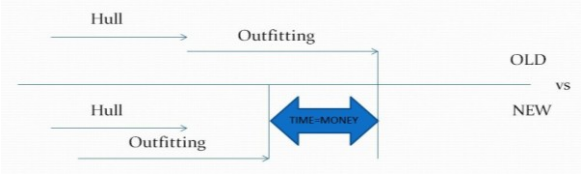

Fig. 2 Old / New practice of pre-outfitting

The modern practices of advanced outfitting involves an infrastructure which enables such type of approach, because a fair outfitting in these stages of hull erection does not realize the nodes in production workflow and for that it is necessary a preliminary investment in an infrastructure to enable the handling of the elements of the hull regarding the contribution of weight of the outfitting elements brought on section units and on the block sections.

Another issue to be dealt with, checked and controlled is the adaptation of the party of engineering: engineering support must have a vision on these production philosophies. Because an advance outfitting on the modular and standardized units cannot be achieved without a good documentation in accordance with the principles of the modern saturation and especially with the quality and deadlines imposed.

A special role is played by the service of acquisitions, which must ensure that the elements of the outfitting (as: valves, strainers, gaskets, etc.) will be at hand for the benefit of the production departments at the time for a proper monitoring of things in the production process; in consequence there may appear nodes on the production workflow which can cause delays and significant costs for a project.

3. Pre-outfitting benefits

Shorter production cycle. This is also evident from the model above because the saturation starts in parallel with the construction works of the ship hull, the total time calculated from the time of order signing up to the time of delivery of the product is reduced considerably. This helps the shipyard under which this activity is carried out to borrow for a period of one year a greater volume of work transposing by numerous contracts, leading in the end to a profit that keeps the player on the shipbuilding market quite uncertain especially in Western countries after the economic crisis and the oil price.

Better working conditions are carried out by the fact that the section units and block sections are carried out in the workshops, where working conditions are controlled, not depending on weather

or atmospheric conditions, therefore efficiency is not affected by temperature changes or weather in general. Workers also enjoy a well-lit and ventilated environment. In modern shipyards human factor has primacy in making decisions and always wants to ensure optimum levels of working conditions with results in productivity measurements.

Reduced interference between the work activities because if it is possible to reduce the number of pipefitters in certain areas when working and performing other job activities for example those which fit the electrical cables and the copper, etc. thus reducing the possibility of having a large number of workers carry out different activities on small spaces. This improves the working conditions and reduces the possibility of additional work due to the interference of direct routings of various routes: small pipe, spools, copper pipe, electrical wiring trays, etc.

Open area for items of oversized saturation or having considerable weights. This case is applied also to spools which have considerable dimensions and weights which must be handled using cranes or bridge cranes. Thanks to advanced saturation since the level of the section unit, avoid using mechanical straps, lifting tackle or other special tools, or the necessity of a larger number of workers which involves higher consumption of hours.

Down hand welding is a highly sought practice because the weld to over-the-head is very difficult to be achieved and it requires overqualified workers; it is also of a quality which is sometimes doubtful because of their difficult conditions of execution, of course it takes longer than in the case in which the same welding is carried out at position hand down. Of course, the section units can be overturned to 180 degrees using the lifting facilities: crane bridges, cranes, so the outfitting on section unit in a very early stage helps to save time and money per project.

The achievement of a smaller number of maneuvers with cranes by the simple fact that the worker can handle the entire spools tray to move it on the section unit, thanks to the open access, without having to use the crane for handling each spool in part, of course if the weight of spool requires the use of the infrastructure of the shipyard. Even if spools which must be fitted in a job are relatively small, their size or weight may be brought closer to the work area by a single operation of the crane, thus bringing down the moving time of workers in order to achieve the objective.

Reduced costs of overheads per project due to the fact that by Pre-Outfitting the work shall be reduced during the overall work per project, the shipyard that adopts this way of working may raise a greater number of projects in one year, which leads to a breakdown of the costs of overheads, which at the global level and annually are constant on several projects than in the case of the classic project which leads to an economy from the perspective of these expenses.

Less use of scaffolding which in the conventional methodology represents an important cost because it is erected for easy access in difficult areas such as: tanks, below decks, etc. required for fitting the spools and not only. So, it is economical from this point of view.

The warranty period for the buyer supply items is also affected by adopting a way of working or another, because, in general, this buyer supply items have a significant value and, in the case of an incident, after the ship has been in use, the shipyard must ensure 12-24 months warranty, upon their returning, the aggregates manufacturers provide a warranty between 18-24 months, so that in the event of a longlasting construction the shipyard assumes greater risks and can have significant losses from this point of view.

Lower costs for storage are made in the case of adopting saturation method in advance because are reduced the times of storage for each project, thus decreasing the value of blocked cash in the elements of the buyer supply.

Streamline costs for additional works of paint repairs, in tanks or voids. Due to the fact that the saturation is made at the level of the section unit, a high degree of outfitting items are assembled before starting blasting and painting operations, leading to substantial reduction of costs of the project and the part of the touch-ups from the company that is in charge of the painting. This leads to a major economy.

Another benefit is **the use of existing spaces available to the assets of the company in an efficient way**, due to the reduction of the time on the general cycle of work of a default project, it takes up less space in the halls of the production, the shims launching, in dry and wet docks, etc.

4. Required time to assembly a spool: Old/New practice

4.1. Section unit presentation of outfitting practices

In Figure 3 are represented the new proposal, in left side, and the old practice of outfitting, in the right side, for Port Side double bottom section.

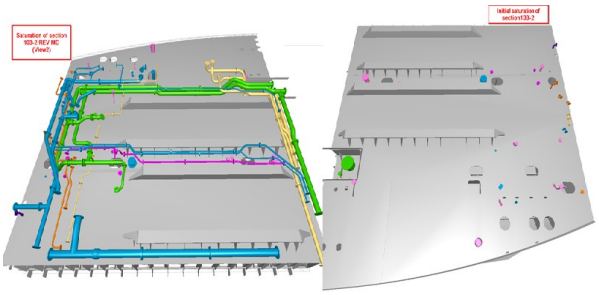

Fig. 3 Double bottom section New/Old practice

4.2. The activity of assembly of a spool

The information is spread out from the piping coordinator, who previously prepared the documentation, checking and complementing the 2D isometric drawings with other technical details necessary for the conduct of the activity of fitting of that pipeline, directly to foreman who, according to the loading level of his team, and depending on the difficulty and competences of the workers, shall designate a team to be in charge of this job.

Proper conduct of mounting a spool, as it appears from the production practices observed over my activity in the department include the following:

The preparation of the work place. Workers shall ensure that they have the necessary information (drawings), all necessary materials, to begin the work.

Identification, by measurements, of the exact position of the mounting place for the spool supports.

Coupling, if the spool is not the first element mounted on the section unit, should connect to spool link, continuing the line that the new spool mounted is found in the documentation. If the pipe spool is large, it requires the use of a crane if access is easy; on the other hand it can be used pickup with lifting hoists or mechanical straps in this purpose.

Achieving supports. Since it has been established the position, the shape and size of the supports, they can be made. This takes quite a long time because of the stages to be followed: measurements, calculations, cutting, sanded paint, welding, attaching screws in the points of welding, tightening screw with nut.

Spool assembling. After the supports are positioned and fixed in points of welding, the spool is positioned, depending on the necessary couplings and shall be fixed in the continuation of the first spool of the line, if necessary, achieving the shift mode agreed.

Permanent connections:

1. Butt welding.
2. Single sleeve connection with corner welding.
3. Sleeve connection of "Z" type used for galvanized pipes, also with corner welding.

Removable connections:

1. Flange coupling.
2. "Straub" connection or rubber bellows with clamps.

In accordance with each type of pipe spools, connections have performed training operations in order to weld or install screws with nuts.

4.3. The assembly of spool in Pre-Outfitting stage (The proposed method)

The spool 312L1024-43494 (figure 4), part of section unit 103-2 Engine room compartment, represents a straight bar with two flanges DN200 PN10 welded to the ends of a pipe ø219x7.1, having the length of 2331 mm, and the weight of 104 kg.

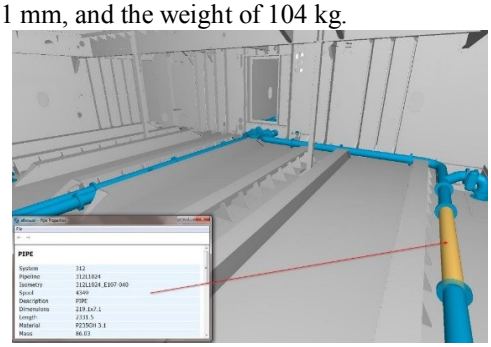

Fig. 4

The configuration is relatively simple for confection as it can be seen in Figure 4, representing a screen-catch from the 3D model (Nupas Cadmatic) the spool is easily accessible to be mounted if it is intended to be fitted in an incipient phase of the ship hull building. There are not involved costs of other job activities!

Table 2 Time estimation for all operations in spool assembly according to proposal practice

Item	Content	Time (min)	3 workers	Total (min)
Prepare documents and tools	Read Documentation	10	3	30
	Identify the area for spool mounting	10	3	30
	Take the decision for the next spool	10	3	30
	Find the spool in the pipe tray	10	3	30
Transport a pipe spool	Negotiating the crane	5	3	15
	Crane waiting	20	3	60
	Pipe manipulation	25	3	75
Make one support	Identify the position of the support	7	3	21
	Measure and Calculate	10	3	30
	Make the support	15	3	45
	Pick up the bolt/nuts	32	3	96
	Welding	10	2	20
		Total (hours)		8,033

4.4. The assembly of spool in Block section stage (The used method)

For the assembly of the same spool 312L1024-43494 (figure 5), theoretically on the same section unit (103-2) at a belated time, it involves mounting it in the blocksection stage. In this stage is involved a greater number of workers, in the team, to ensure safe and quality work, due to the weight of the spool and they lack the necessary means to control the handling of the spool. It is recommended for a worker to tamper with a maximum weight of 25 kg, due to the spool mass in excess of the least 100 kg, the team to build up this spool is made up of 4 workers, this choice is also due to the huge distance where spool should be handled and because of access conditions.

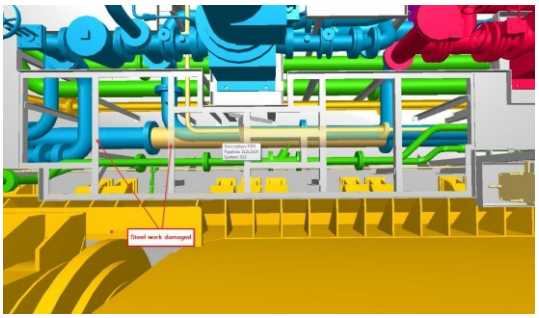

Fig. 5 Spool position in old practice [1]

The difference in costs between the method which was used in reality and the proposed method for assembly a particular spool is 22.3 hours (Table 3 and 4), which means higher costs with 278%.

Obviously, this is a particular case, the costs shall be detected by mounting smaller spools, but even if the report does not remain the same, additional costs general may not be less than 50%, according to literature [5]

Modular outfitting method plays an important role in shipbuilding to improve the effectiveness, saving man-hours and being more competitive in the world.

Based on literature, there are a 20% reduction in building time, a 52% improvement in man-hours [4,5], 54% reduction in overhead cost and 18% reduction in material costs [4].

It was shown that if the outfitting and the piping assembly operations are carried out in earlier stations instead of the block assembly station, this may increase the throughput by 33% [5].

Table 3 Time estimation for all operations in spool assembly according with old practice

Item	Content	Time (min)	4 workers	Total (min)
Prepare documents and tools	Read Doc.	10	4	40
	Identify the area for spool mounting	10	4	40
	Take the decision for the next spool	15	4	60
	Find the spool in the pipe tray	10	4	40
Transport a pipe spool	Negotiating the crane	5	4	20
	Crane waiting	20	4	80
	Transport pipe	10	4	40
	Transport the spool through the fore air lock	30	4	120
	Transport the spool through the ER to the final position	50	4	200
	Cutting the Steel work	10	4	40
Make one support	Identify the position of the support	15	4	60
	Measure and Calculate	13	4	52
	Make the support	15	4	60
	Pick up the bolt/nuts	52	4	208
	Welding	20	2	40
		Total (hours)		**18,33**

Table 4 Time estimation for extra scope of work

Additional work	Departments involved	Hours
Lock smith Facility	Repair the steelwork of floor plates + welding	8
Painting	Painting rework	4
	TOTAL COST	**12,0**

Moreover, the total time in the old version is 30 hours, in accordance with Table 3 and Table 4. Total time of old version, where the spool is assembled at a later stage, is approximately 20 hours longer than the new practice (Table 2) proposed in this paper work.

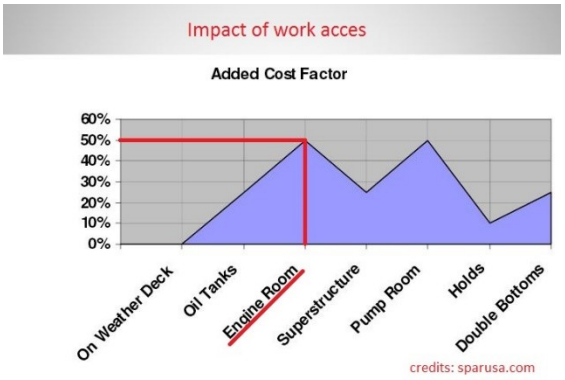

Fig. 6 Added cost factor diagram [3]

The costs which, from the calculations, take us to the following values, using the added cost factor from literature (Figure 6) are:
[total Engine Room spools] * [added cost factor] * [average hours per spool mounted] = [saved hours per project],

2001*0.5*7.7=7704 hours (Per project)

The shipyard has contracted four projects with the same arrangement and systems in Engine Room, so it can be saved:
[saved hours per project] * [number of projects] = [total hours saved by shipyard]

7704*4=30815 hours,

if it is turned into financial amounts.

As an indicative value of working hours, we chose the equivalent of 15 euros, without fees, which results in:

[total hours saved by shipyard] *[estimated man hour rate] = [estimated value of savings]

30.815*15 = 462.231 euro

5. Conclusion

It was resumed the work of the department (Fig. 7) for the preparation of the documentation for the production department, it was checked all the 2001 spools representing the piping of the dedicated engine

room. On average, estimate for this research work based on experience gained from work activities, for each spool were spent approx. 7 min., where:

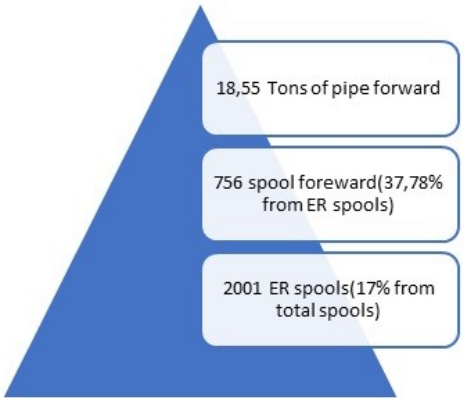

Fig.7 Graphical image of paper work

1. The identification in the framework of the album in which it was originally assigned, for each spool (1 min)

2. The identification of the position in the section unit under his 3D representation using Nupas Cadmatic (1 min)

3. The identification of mounting obstacles for each pipe spool (2 min)

4. Deciding distribution of each spool according to the pre-outfitting philosophy (3 min)

5. The table was changed according to the new position (1 min) and in orange we highlighted each line and column Remarks Obs. when spool was revised. The new position was noted in documentation, as done in the screenshot above.

Table 5 Centralization of revised data

No.	Album	Spools	Spools Pre-Outfitting	Total mass (kg)	Avg. spool mass (kg)
1	E107-0 System 333-022C	32	12	311,17	28,29
…	…	…	…	…	…
6	E107-0 System 311-021C	52	29	674,19	24,08
7	E107-0 System 311-021S_S103-1	36	30	1252,72	41,72
8	E107-0 System 311-021S_S103-2	8	6	226,57	37,76
…	…	…	…	…	…
106	E107-0 System 640-021S_S204-2	7	7	46	15,34
107	E107-0 System 650-021C	17			
108	E107-0 System 650-021S_S203-1	9	9	112	12,51
…	…	…	…	…	…
111	E107-0 System 670-022C rev b	120			
	TOTAL	2001	756	18,56	27,32

[number of spools checked] *[checking time for each spool]/ [1 hour] + [number of spools revised] *[time to note]/ [1 hour] = [total time for checking the spools]

2001*7/60+756*1/60=233+13=246 hours

There were necessary approximately 246 hours for the achievement of the tracking documents (attachment), but these hours may not be deducted from the total of the hours saved, because this operation anyway has been made or should be made, just that it must be carried out in accordance with the philosophy of the modern implementation of the saturation of the ship.

The result brings in a more advanced stage of saturation of more than 37%, according to the data from Table 5, spools originally granted by documentation belonging to the compartment Engine Room 107-0. Also, spools number that can be mounted in an advanced phase represents over 6% of total spools. All these spools totaling 18.55 tons of pipe, according to the average of a modified spool Pre-outfitting philosophy, is 27.32 kg.

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[8] Nupas Cadmatic.