International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 26 No. 2 May 2019, pp. 617-632

http://www.ijias.issr-journals.org/

Prioritization of Construction and Assembly Based on Commissioning Systems on FPSO Platforms

Marques Marcel[1], Duailibe Paulo[2], Morano Cássia[3], Matsumoto Roger[4], and Machado Cíntia[5]

[1]Department of Professional Master Degree in Industrial Assembly,
Universidade Federal Fluminense,
Niterói, Rio de Janeiro, Brazil

[2]Department of Professional Master Degree in Industrial Assembly,
Universidade Federal Fluminense,
Niterói, Rio de Janeiro, Brazil

[3]Department of Professional Master Degree in Industrial Assembly Universidade Federal Fluminense,
Niterói, Rio de Janeiro, Brazil

[4]Department of Professional Master Degree in Industrial Assembly Universidade Federal Fluminense,
Niterói, Rio de Janeiro, Brazil

[5]Department of Ports, Mechanical Engineering and Production Engineering Centro Federal de Educação Tecnológica
(CEFET/RJ) (COOPE), Itaguaí, Rio de Janeiro, Brazil

ABSTRACT: The Commissioning sector has been trying to implement the prioritization of the equipment's, instrumentation and piping installation and assembly activities based in its systems and subsystems. In general, the prioritization of these activities is carried out differently between the Construction and Assembly sector and the Commissioning sector. Thus, this work aims to analyze which of these prioritization approaches is the most effective in terms of project final delivery time, as it is verified that there are many conflicts regarding the prioritization of these activities between these two sectors. That said, it's important to state that the Construction and Assembly sector prioritizes the quantitative measurement of a certain period of work aiming financial responses, while the Commissioning sector prioritizes activities that are really essential and that impact the deployment of the FPSO (Floating Production Storage and Offloading) platform, so that it can start the process of obtaining the first oil. Hence, for the accomplishment of this work, the Experimental Study Method was used, in which 5 common subsystems between 2 similar FPSO platform projects were analyzed. In each case the prioritization of the installation and assembly activities of the equipment, instruments and pipes was elaborated respectively by the Construction and Assembly sector (project A) and by the Commissioning sector (project B). Comparative rundown curves were generated between projects A and B, where the manpower allocation efficiency generated by the Commissioning through the priority systems was verified.

KEYWORDS: Construction; Assembly; Conditioning; Commissioning; System and Subsystems; FPSO; Mechanical Completion.

1 INTRODUCTION

Despite the current situation of political and economic conflicts at both the national and international levels, proven reserves (properly proven geological studies for pre-salt oil extraction) on Brazilian soil are a reality that requires an increasing demand for construction and assembly projects within the Oil and Gas segment, which will tend to increase in the medium and long term. Among these projects, FPSO (Floating Production Storage and Offloading) is one of the most used for oil exploration in Brazil, as it continues to innovate its construction methods in order to be able to quickly and efficiently deliver the asset to the end customer, without compromising its constructability. That said, offshore construction and assembly enterprises, which in the present study is an FPSO, are subdivided into the following stages: basic design, FEED, detailed design, supplies or procurement, construction and assembly, conditioning or pre-commissioning, commissioning and final delivery.

In order to approach the commissioning work area and forms of FPSO platforms, it is necessary to first deal with the Construction and Assembly phase that "Is the phase of an industrial enterprise characterized by the pre-assembly, construction and assembly of equipment, systems and facilities" [1]. It is at this stage that the contracted company responsible for carrying out the assembly of the equipment begins its field activities. In the specific case of this work, it is related to the Construction and Assembly project and integration of structure, equipment / instruments, pipes, cables, among other items, of the FPSO platform modules. It should be emphasized that integration is understood as one of the processes necessary to ensure that several elements of the project are properly coordinated [2]. However, these items can only be considered mechanically complete when a series of requirements are met, among them are all the Construction and Assembly actions that were foreseen in the project and must have been completed and duly certified (without impediments, ie, "A" pendency). The impediments are those pendency's generated during assembly, for instance, of an equipment that somehow still encounters conditions that directly affect the safety of those who will operate it or even its own functionality and that of the process plant itself. After these aforementioned actions, an item of a certain subsystem can be considered mechanically complete by the Construction and Assembly sector.

In the case of the Commissioning, the first plans took place after World War II and come from the great increase of industrial production and the need to create mechanisms that would, in a certain way, guarantee a delivery date for the new plants. These plans were generated to allow and guarantee the transition from the plant performance test period to the operational period, within the deadline and quality required in the project [3]. Guimarães [4] brings a very detailed commissioning definition where it says that it is a structured set of knowledge, practices, procedures and skills simultaneously employed to a facility, focusing at making it operational according to the desired performance requirements, having as main objective to ensure the transfer of the installation from the manufacturer to the operator in a fast, orderly and safe way, certifying its operability in terms of performance, reliability and traceability of information. NORSOK Standard [5] complements this understanding in a very concise manner, ensuring that Commissioning is the functional verification of equipment and facilities that are grouped into systems, being started soon after conclusion of the Mechanical Completion of a system or part of it (subsystem). According to this same understanding, however, bringing a concept that is directly and explicitly addressed to the delivery of the enterprise to the final customer, we have another definition that says that Commissioning is "The well-planned, documented and managed engineering follow-up aimed at starting and transferring the utilities, systems and / or equipment to its respective final user, under satisfactory operational and safety conditions, taking into account the project requirements and their expectations " [6]. Applying these concepts to ships in a general way, since this paper deals with FPSO-type Commissioning, we have the explanation that historically, the term Commissioning refers to a series of preparation activities to ensure that ships would not face any operational failure during their lifetime. [7]. Souza [8] complements such information by stating that a ship must undergo several stages during the so-called Commissioning process, and in the course of which several equipment are installed and tested, problems are identified and corrected, and the crew is extensively trained. In this context, the conditioning or pre-commissioning and commissioning phases require special attention, as they will ensure the functional and safe operation of the whole enterprise. Therefore, the conditioning and commissioning phases occur during and, mainly, after the construction and assembly phase. At this phase, all the systems and subsystems of the plant are tested and parameterized in order to make it operational and safe, with all its functionalities working according to the established in the detailed design. Gandra [9] presents a very broad scope of commissioning, and its concept is very current, as can be seen in Figure 1:

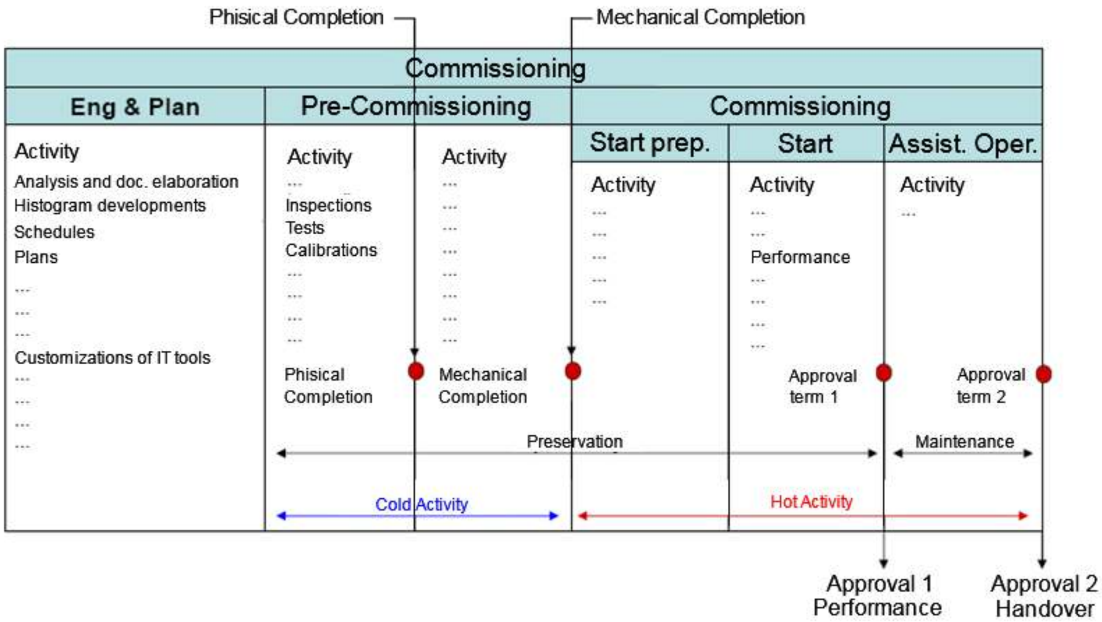

Fig. 1. Understanding Commissioning as a project phase [9]

Although widely applied by the construction and assembly industry, Commissioning presents itself as a potential research area, as it can be verified that there are few academic studies focused on this subject. One of the problems encountered at the commissioning of a plant is the prioritization of what should be commissioned. Often what happens is the commissioning of equipment or systems which will be used only at later stages, leaving behind systems or equipment that really should be prioritized at the moment, resulting in time loss. What generally occurs between the Construction and Assembly and Commissioning sectors is that, during the construction phase of the platform, the form of measurement occurs differently between these sectors. In the case of the Construction and Assembly sector, the measurement is performed according to quantitative parameters with a financial focus, while in the commissioning sector it is performed according to systems and subsystems for installation and assembly of equipment, instruments and piping. In this later case, the focus is on the quickest possible release of the platform. One way for the Commissioning sector to carry out its measurement is by proving that the so-called cold tests (Cold Commissioning) have been completed. These can be defined by "the set of measurements and tests of meshes only with the control tension, that is, without the working tension, in order to let the equipment of a system / subsystem in condition to come into operation" [3]. However, in order to be able to perform this type of test, all equipment / instruments relative to the same subsystem must be assembled by the Construction and Assembly sector in order to close a certain set of equipment / instruments (called a blank test for electrical items, loop test regarding instrumentation and test pack for piping), being that this often happens in a partial way, that is, not all of the items needed to perform these tests are properly assembled. This can occur for several reasons, but the most recurring reasons in the industrial sector is the lack of material (which was not prioritized by the Construction and Assembly sector to the supply sector) or even the assembly of a missing item. Often the Construction and Assembly sector doesn`t have financial interest in this activity at that time of the construction, resulting in a delay in the commissioning services due to the lack of mechanical complementation of the priority items for the Commissioning sector.

Due to these two distinct ways of directing manpower, the objective of this work is to compare the prioritization of systems and subsystems in the activities of installation and assembly of equipment, instruments and piping of an FPSO platform generated by the Commissioning sector, with activities prioritized by the Construction and Assembly sector, with the purpose of putting it into operation more efficiently in the deadline of the enterprise. This work only covers the final phase of module integration, until deployment of the FPSO platform from the dockyard. Thereby, it`ll be demonstrated through experimental studies applied to 5 priority subsystems of 2 similar FPSOs, which of the methods of directing labor in FPSO platforms projects, implemented by the Construction and Assembly and Commissioning sectors, is more effective regarding the deadline for the final delivery of the enterprise to the client. Each of these 2 methods was applied in a distinct FPSO project, the one used by the Construction and assembly sector denominated project A and the one applied by the Commissioning sector denominated project B.

2 METHODS

This research was based on an experimental methodology consisting of an empirical investigation that has as main objective the hypothesis testing which seeks to establish cause-and-effect relationships by direct manipulation of the variables related to the study object, seeking, in this way, to identify the phenomenon causes [10]. Project A was considered as the control group for the application of this method, where the labor directing was taken accordingly to the Construction and Assembly sector, and project B was considered the experimental group once it was where the Commissioning methodology was employed.

2.1 SAMPLING

The sample is a convenient portion of the universe (population); It`s considered to be an universe subset [10]. The nonprobability sampling method was employed, because it was the best fit to the way which the raw data were analyzed. This way, five subsystems considered of high importance for obtaining the first oil in these two projects were selected for analysis. The analysis was carried out by comparing progress rundown curves. Then, Malhotra [11] tells us that non-probabilistic sampling relies on the researcher's personal judgment and does not rely on probability to choose the sample elements. For the mentioned author, the researcher may select the sample arbitrarily, based on convenience, or make a conscious decision about which elements should be included in the sample. This research was based on intentional nonprobability sampling, in which the elements are selected based on the researcher`s personal judgment [12]. Gil [13] reiterates that this type of sampling consists of choosing a subgroup of the population which, based on the available information, can best represent the whole. However, the researcher needs to have a good knowledge of the type of subgroup selected. Nonetheless, if it does not have this knowledge, it is necessary to formulate hypotheses, which, in a way, compromises the representativeness of the sample.

2.2 VARIABLES, DELINEATION AND RESEARCH CLASSIFICATION

The two methodologies to be analyzed were used as independent variables, one in each different group i.e., the Construction and Assembly methodology was applied in the control group, considered in Project A, and the Commissioning methodology was applied in the experimental group, considered in Project B. With this, the dependent variables, whose effects were produced by the independent variables, are the delay or advance in pre-commissioning and commissioning activities, generated by the correct or inappropriate labor directing focused on the priority systems for the realization of the FPSO first oil.

Regarding the research delineation, this study can be considered as quasi-experimental, since the study has the control of two applied independent variables. Therefore, the quasi-experimental delineations bring together the study in which there may or may not be direct or indirect manipulations of the independent variables [12].

On the classification of the research, it can have its nature divided into two basic types, qualitative and quantitative, and also a mixture of these two research types [12]. Reiterating the importance of using the union of these two classifications, we have the assertion that "quantity and quality are immanent characteristics of all objects and phenomena and are interrelated" [13].

2.3 ADVANCE CONTROL SOFTWARE FOR CONSTRUCTION AND ASSEMBLY AND COMISSIONING SECTORS

All Construction and Assembly, Conditioning and Commissioning activities must be registered in some way. In the past, these records were done manually on sheets of paper, but today there are several types of software (database) that manage the activities and their results. Some of these programs are developed for general purposes, i.e., they may be used by several different companies, and others are customized to meet the particular needs of a singular company. Generic management systems are usually cheaper than custom systems, but they involve other costs that the customized ones do not require. NORSOK Standard [5] informs that these management systems, called PCS (Project Completion System), are computerized systems developed for the management of Mechanical Completion, Commissioning, Pending List and Preservation electronic documentation, organized by systems, subsystems, operation area, suppliers packages commissioning, the mechanical completion of these packages and / or by individual tags. This makes them essential for registration of the Construction and Assembly and Commissioning activities at all industrial enterprise. To better understand the steps within this kind of software, it is possible to visualize in Figure 2 the Mechanical Completion and Commissioning flow of a system and / or subsystem.

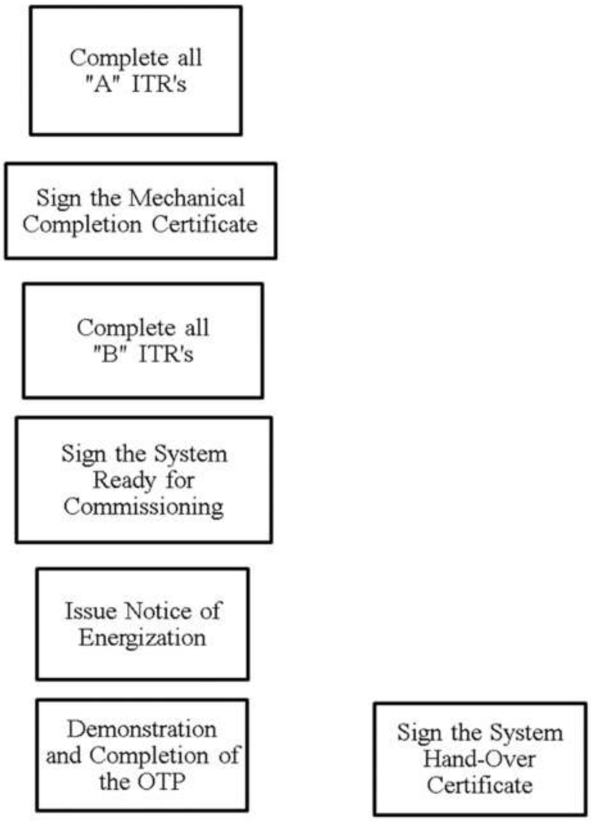

Fig. 2. Mechanical Completion Flow for Commissioning

Source: The author

2.4 RUNDOWN CURVES

During the execution of an enterprise, the manager`s main concerns are, among others, the cost reduction, project deadline and increase in productivity. To assist in the analysis of these and other variables, there are some advance and control tools. One of these tools is known by S-Curve, which is one of the most used resources among professionals working with industrial projects. This tool assists managers in controlling the progress of the project as a whole and also helps them to analyze each separate stage. Stonner [14] explains that the S-Curve is an excellent way of monitoring and managing information because it allows to compare, along its course, the progress made with what was foreseen, detects deviations and projects deadlines for the eventual re-scheduled services. Silva Filho and Miranda [15] says that the S-Curve, so called by its usual shape, allows programming and control of the production and available resources, especially the manpower and man-hour. Because of its objectivity, it is widely used and considers the percentage weight of each item, according to the adopted unit. Among the advance curves, there is also the so-called Rundown Curve, which is an unfolding of the S-Curve. Stonner [16] says that the Rundown curves are similar to the conventional advance Curves, but instead exhibit a decreasing shape. They are widely used to demonstrate the consumption of some contingency reserve.

However, in the present work, these curves will be applied to assess completion of the Construction and Assembly check sheets, Explosion proof equipment / instruments (Ex) and Pre-Commissioning which are incomplete over a given period of the project until the project deadline using the program Microsoft Excel 2010 as a database. And, in order to assist in the generation of these curves, it is important to perform data leveling once two different projects are being compared, even though they are very similar throughout the same phases of the project, each one has a different number of items to be installed, assembled or pre-commissioned during this period. In order to start a comparative Rundown curve it is ideal that the quantity of items to be compared starts from the same point, i.e., it has the same amount to be evaluated. Considering this information, a leveling formula of Project A, which had a larger quantity of items to be completed at this stage of the Project, was generated and applied, making it possible to evaluate the progress of this project in a proportional way and not simply a completion analysis of each item. For a better understanding of this scenario, formula (1) presents a mathematical way from which one can deduce such leveling:

$$\mathrm{Lev}_{\mathrm{proj.A}} = \left(\frac{\mathrm{Tpw1}_{\mathrm{proj.B}}}{\mathrm{Tpw1}_{\mathrm{proj.A}}}\right) \cdot \mathrm{Tpw2}_{\mathrm{proj.A}} \tag{1}$$

Where:

$\mathrm{Lev.}_{\mathbf{proj.A}}$ = Leveling of pending items at Project A.;

$\mathrm{Tpw1}_{\mathbf{proj.B}}$ = Total pending items at week 1 in Project B;

$\mathrm{Tpw1}_{\mathbf{proj.A}}$ = Total pending items at week 1 in Project A;

$\mathrm{Tpw2}_{\mathbf{proj.A}}$ = Total pending items at week 2 in Project A.

3 Presentation Of Projects A And B

3.1 Project A Characteristics

Petrobras granted a group of Offshore Oil and Gas companies the lease and operation of this FPSO unit for a period of 20 years. One of these companies was responsible for designing, building and commissioning this platform as an EPC contractor (Engineering, Procurement and Construction). This floating unit was installed in the Sapinhoá field, in the Santos Basin pre-salt, 310 kilometers from the coast. Following are some information about this FPSO features:

a) Production capacity: 150 thousand bpd (barrels per day);

b) Natural gas treatment capacity: 6 million m³ / day;

c) Storage capacity: 1.6 million barrels of oil;

d) Accommodation: 140 people;

e) Water depth: 2,140 meters;

f) Original hull type: converted from an oil tanker at CXG shipyard, China;

g) Injection water treatment: 180 thousand barrels / day.

The gas unused for reinjection in the field will be disposed of by a specific gas pipeline to the Monteiro Lobato Gas Treatment Unit (UTGCA), located in Caraguatatuba, on the coast of São Paulo. Nine producing wells and seven injector wells will be connected to this FPSO.

3.2 Project B Characteristics

According to information provided by the Petrobras website (Dec. 2015), the company granted a group of Offshore Oil and Gas companies the lease and operation of this FPSO unit for a period of 20 years. One of these companies was responsible for designing, building and commissioning this platform as an EPC contractor. This floating unit was installed in the Lula field (Tupi Northeast area), in the Santos Basin, 250 kilometers from the coast. Following are some information about this FPSO features:

a) Production capacity: 150 thousand bpd (barrels per day);

b) Natural gas treatment capacity: 6 million m³ / day;

c) Storage capacity: 1.6 million barrels of oil;

d) Accommodation: 180 people;

e) Water depth: 2.20 meters;

f) Original hull type: converted from a Very Large Crude Carrier (VLCC) tanker at the CXG shipyard in China;

g) Injection water treatment: 200 thousand barrels/day.

The full scope of the Lula Central project includes 18 wells, nine of which are producers, four WAG (water and gas) injectors and five water injectors.

3.3 DIFFERENT CHARACTERISTICS BETWEEN PROJECTS A AND B

These two floating units have very similar design features, but they are not 100% equal. There are some small differences between them that will be listed below:

a) The existing H_2S removal unit in Project A has been replaced by a second VRU (Vapor Recovery Unit) in Project IV;

b) The configuration of the risers is a bit different from one project to the other;

c) The water injection system increased from 180,000 barrels per day in Project II to 200,000 barrels per day in Project IV;

d) The platform hull is simple In Project A, while in Project B it uses double hull.

4 APPLICATION OF METHODOLOGIES IN PROJECTS A AND B

This chapter presents the application of the Rundown curves in five high priority subsystems for the FPSO deployment from the dockyard, and the results between planned and executed for the projects A (control group) and B (experimental group) were evaluated in each of these subsystems. At the end of this section, it is presented a summary of the analyzes performed in the other 4 subsystems.

4.1 HEATING MEDIUM SYSTEM

According to the operating procedure for the heating system, developed by the featured company, this structure installed in an FPSO is mainly driven by the Residual Heat Recovery Units, which are designed to recover residual heat from the exhaust gases produced at the gas turbines and using them to heat the system, providing a constant temperature of 130^{o}C to the FPSO consumers. The heating system has an approximate capacity of 90m3 of fresh water, inhibited with a design temperature and pressure of 160^{o}C and 17.2 bar, respectively. However, the tube bundle of the heat exchanger for this system is designed to withstand up to 560^{o}C.

This system is composed of some equipment and instruments that are of vital importance for its operation, such as:

a) 1 expansion vessel;

b) 3 electric centrifugal pumps responsible for the circulation of the system;

c) 3 waste heat recovery units;

d) 1 heat exchanger;

e) 3 waste collection baskets (protection for centrifugal pumps);

f) Various consumers and temperature controllers.

4.1.1 CONTROL GROUP – PROJECT A – HEATING MEDIUM SYSTEM

This was the group where the method of directing the manpower into the heating system was applied by the Construction and Assembly sector.

4.1.1.1 CONSTRUCTION AND ASSEMBLY

At the beginning of the integration phase of the project, the quantity of pending items to be carried out during this phase was analyzed through item checklist. It was considered pending item the ones which were incomplete at this stage as to the remaining time for completion of the works final phase. In order to complete all pending issues of this subsystem, a Planned and Actual Rundown curves were generated containing the quantity of pending items to inform the Construction and Assembly sector how many of these items should be completed per day to achieve the project objective in that subsystem deadline.

In this case, there were 266 pending items in the referred subsystem during this stage, however, after leveling with Project B, this number decreased to 62, thus matching to the Actual Curve start point. For this project, all its final activities were planned to be carried out in 23 weeks. After the generation of a curve demonstrating how the evolution of the Construction and Assembly activities should occur during this phase (Planned Curve), the control of the completion of these pending items was started and its evolution was introduced in the so-called Actual Curve. With the development and completion of the

Planned and Actual Curves, a comparison could be made, which allows a clear visual analysis of what was planned versus the Actual results, as shown in Figure 3 below.

Fig. 3. Heating Medium System – Construction and Assembly Planned x Actual curves – Project A.

Source: Author

It is possible, by examining what was planned in contrast to what was accomplished in the same chart, to analyze what happened in the activities of Construction and Assembly.

The two curves started with 62 pending items in week 1, showing little evolution until week 5. From week 6 onwards, it was achieved more significant progress, which continued up until week 23. Thereafter, the progress once again became slower, and maintained the slow pace until the completion of activities, which occurred only at week 32.

As a result, Project A's Construction and Assembly activities were delayed by 8 weeks, that is, approximately 56 days compared to what was planned at the beginning of the project's integration phase.

4.1.1.2 EXPLOSION PROOF EQUIPMENT / INSTRUMENTS

In order to initiate activities on explosion-proof equipment and instruments, it is necessary that the Construction and Assembly items check sheets have been completed and included in the Completions database, as shown previously in figure 2 (Chapter 2). In this case, there were 128 pending items prior to the application of the leveling. The leveling formula (1) was then applied and this number was reduced to 13, which can be compared later with the Actual curve. For this project, it was planned to carry out all its final activities within 23 weeks. After the generation of a curve demonstrating how the evolution of the Construction and Assembly activities should occur during this phase (Planned Curve), the control of the completion of these pending items was started and its evolution was introduced in the so-called Actual Curve. With the development and completion of the Planned and Actual Curves, a comparison could be made, which allows a clear visual analysis of what was Planned versus the Actual results, as shown in Figure 4 below.

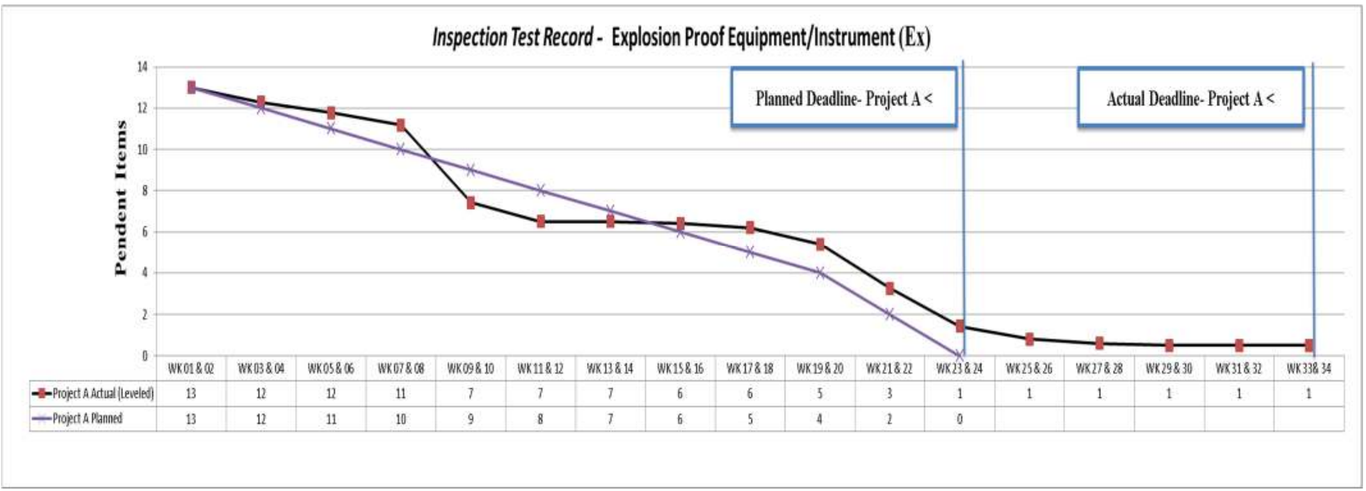

Fig. 4. Heating Medium System – Planned x Actual Curves for the Explosion Proof Equipment/Instrument – Project A

Source: Author

It is possible, by examining what was planned in contrast to what was accomplished in the same chart, to analyze what happened in the activities of Construction and Assembly.

Both curves started with 13 pending items at week 1, showing little evolution until week 7. From week 8 onwards, it was achieved more significant progress, which continued up until week 10. Thereafter, the progress once again became slower, up until week 20. After this week, the progress was faster but, again, stagnated at week 26 remaining with a pending item up until the deadline at week 34.

As a result, Project A's Explosion Proof Equipment/Instrument were delayed by 11 weeks, that is, approximately 77 days compared to what was planned at the beginning of the project's integration phase.

4.1.1.3 PRE-COMMISSIONING

In order to initiate Commissioning activities, it is necessary that both the Construction and Assembly items check sheets and the Explosion Proof Equipment/Instrument ones have been completed and included in the Completions database, as shown previously in figure 2. In this case, as was previously done in the pending items of the Construction and Assembly sector, there were 57 pending items prior to the application of the leveling. The leveling formula (1) was then applied and this number was raised to 71, which can be compared later with the Actual curve. For this project, it was planned to carry out all its final activities within 23 weeks. After the generation of a curve demonstrating how the evolution of the Construction and Assembly activities should occur during this phase (Planned Curve), the control of the completion of these pending items was started and its evolution was introduced in the so-called Actual Curve. With the development and completion of the Planned and Actual Curves, a comparison could be made, which allows a clear visual analysis of what was planned versus the Actual results, as shown in Figure 5 below.

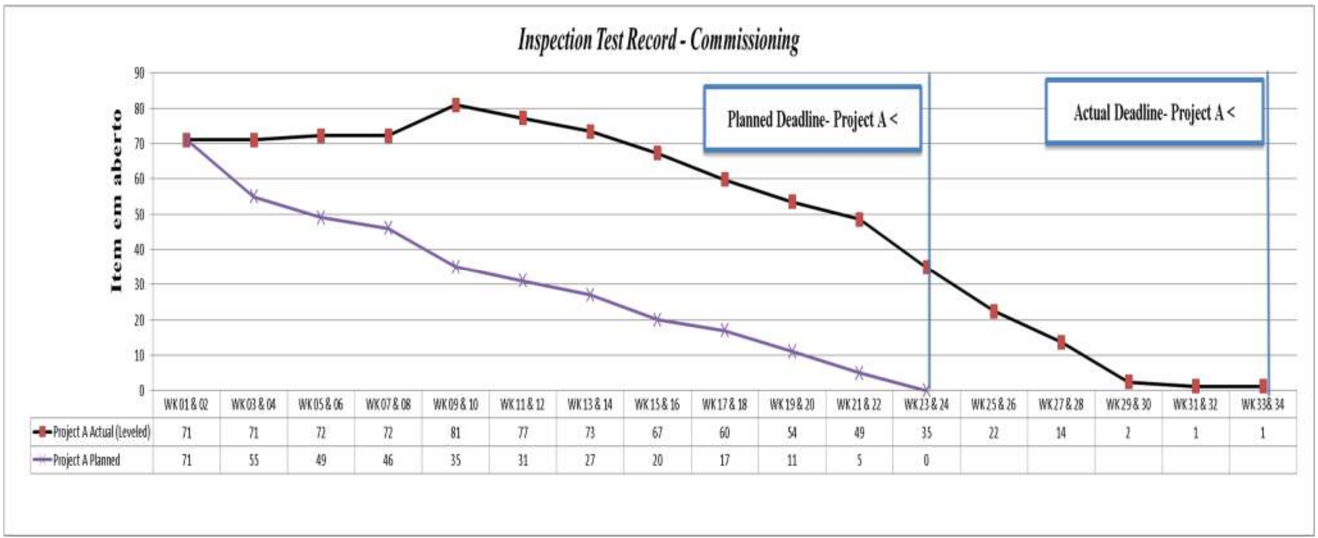

Fig. 5. Heating Medium System - Planned x Actual Curves for the Commissioning – Project A.

Source: Author

It is possible, by examining what was planned in contrast to what was accomplished in the same chart, to analyze what happened in the activities of Commissioning.

Both curves started with 71 pending items at week 1, keeping stagnated until week 4. Between weeks 5 to 10 there was an increase in the number of pending items, which can occur during the execution of an enterprise and, as this is an experimental work that uses real data generated during work evolution, one can observe this type of event. From week 11 until week 22 very slow progresses has been made. After week 23 to week 30, the progress improved significantly, but stagnated after this period until week 34, with 1 pending item.

As a result, Project A's Commissioning activities were delayed by 11 weeks, that is, approximately 77 days compared to what was planned at the beginning of the project's integration phase. The results were similar to the ones verified in the Explosion Proof Equipment/Instrument actual curve.

4.1.2 CONTROL GROUP – PROJECT B – HEATING MEDIUM SYSTEM

This was the group where the method of directing the manpower into the heating system was applied by the Commissioning sector.

4.1.2.1 CONSTRUCTION AND ASSEMBLY

At the beginning of the integration phase of the project, the quantity of pending items to be carried out during this phase was analyzed through item checklist. It was considered pending item the ones which were incomplete at this stage as to the remaining time for completion of the works final phase. In order to complete all pending issues of this subsystem, a Planned and Actual Rundown curves were generated containing the quantity of pending items to inform the Construction and Assembly sector how many of these items should be completed per day to achieve the project objective in that subsystem deadline.

In this case, there were 62 pending items in the referred subsystem during this stage, however, unlike Project A, the leveling formula was not used (1), because it only 2 projects will be compared and one of them has already been properly leveled to the other. For this project, it was planned to carry out all its final activities within 15 weeks. After the generation of a curve demonstrating how the evolution of the Construction and Assembly activities should occur during this phase (Planned Curve), the control of the completion of these pending items was started and its evolution was introduced in the so-called Actual Curve. With the development and completion of the Planned and Actual Curves, a comparison could be made, which allows a clear visual analysis of what was planned versus the Actual results, as shown in Figure 6 below.

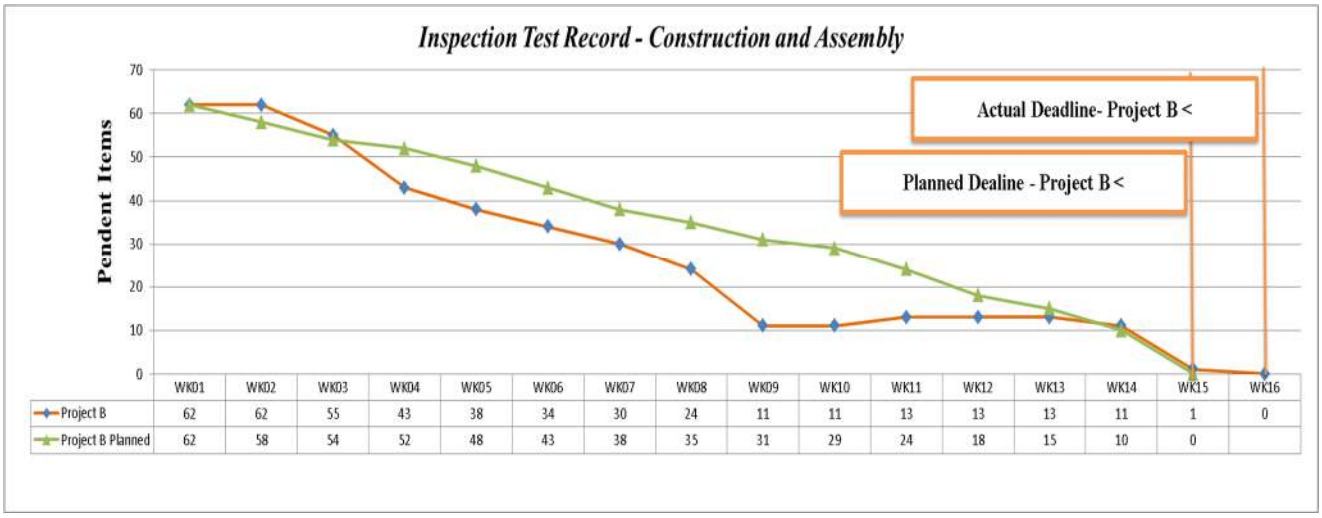

Fig. 6. Heating Medium System – Construction and Assembly Planned x Actual curves – Project B.

Source: Author

It is possible, by examining what was planned in contrast to what was accomplished in the same chart, to analyze what happened in the activities of Construction and Assembly.

Both curves started with 62 pending items at week 1 but, by week 2, the actual curve started to have a good daily advance in relation to the Planned Curve, crossing it at week 3. This means that the actual evolution is occurring faster than what was initially programmed. This evolution was noted until week 14, when the actual curve was delayed by only 1 pending item, repeating the same situation at week 15.

As a result, Project B's Construction and Assembly activities were delayed by only 1 week, resulting from 1 open item.

4.1.2.2 EXPLOSION PROOF EQUIPMENT / INSTRUMENTS

In order to initiate activities on explosion-proof equipment and instruments, it is necessary that the Construction and Assembly items check sheets have been completed and included in the Completions database.

For this project, it was planned to carry out all its final activities within 15 weeks. After the generation of a curve demonstrating how the evolution of the Construction and Assembly activities should occur during this phase (Planned Curve), the control of the completion of these pending items was started and its evolution was introduced in the so-called Actual Curve. With the development and completion of the Planned and Actual Curves, a comparison could be made, which allows a clear visual analysis of what was planned versus the Actual results, as shown in Figure 7 below.

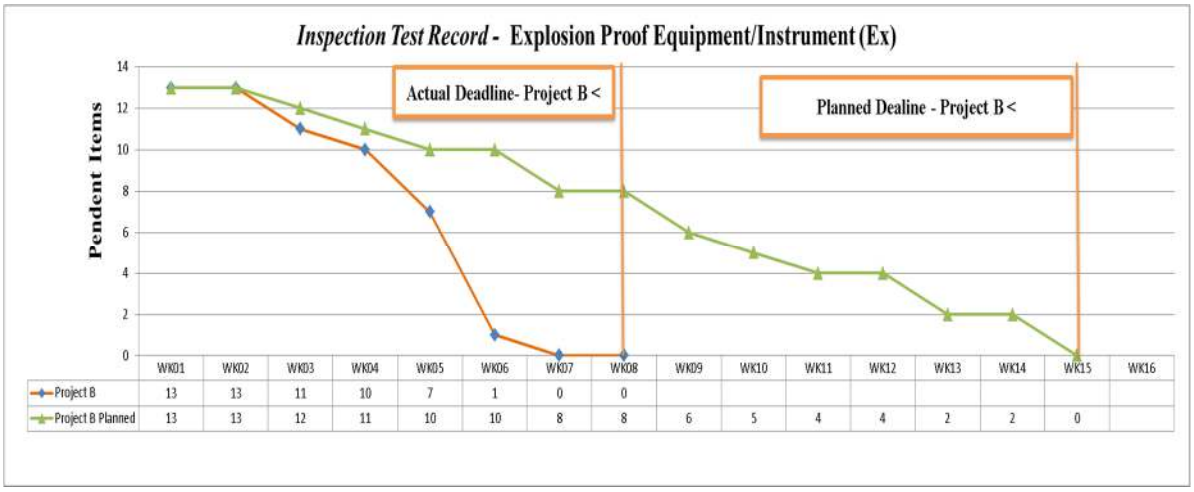

Fig. 7. Heating Medium System – Planned x Actual Curves for the Explosion Proof Equipment/Instrument – Project B

Source: Author

It is possible, by examining what was planned in contrast to what was accomplished in the same chart, to analyze what happened in the activities of Explosion Proof Equipment/Instrument.

Both curves started with 13 pending items at week 1 but, by week 2, the actual curve remains below the planned Curve, which means that the Actual Curve was more effective than what was initially programmed. This means that the actual evolution is occurring faster than what was initially programmed.

With this, it is verified that the activities in the Equipment and Explosion-proof Instruments of Project B had their conclusion as planned in week 15 of the project.

4.1.2.3 PRE-COMMISSIONING

In order to initiate Commissioning activities, it is necessary that both the Construction and Assembly items check sheets and the Explosion Proof Equipment/Instrument (when applicable) ones have been completed and included in the Completions database, as shown previously in figure 2.

For this project, it was planned to carry out all its final activities within 15 weeks. After the generation of a curve demonstrating how the evolution of the Construction and Assembly activities should occur during this phase (Planned Curve), the control of the completion of these pending items was started and its evolution was introduced in the so-called Actual Curve. With the development and completion of the Planned and Actual Curves, a comparison could be made, which allows a clear visual analysis of what was planned versus the Actual results, as shown in Figure 8 below.

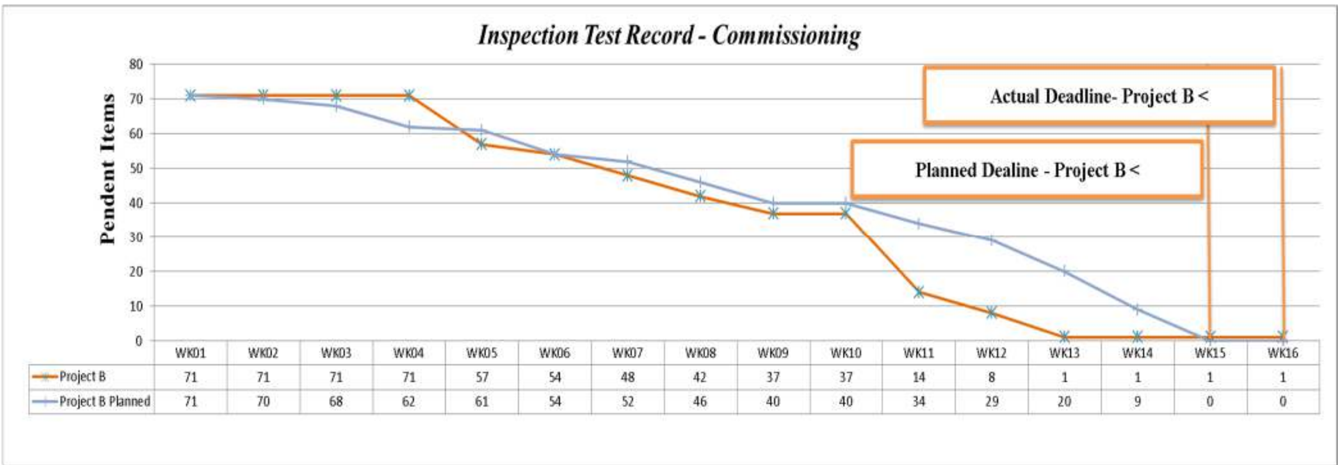

Fig. 8. Heating Medium System - Planned x Actual Curves for the Commissioning – Project B.

Source: Author

It is possible, by examining what was planned in contrast to what was accomplished in the same chart, to analyze what happened in the activities of Commissioning.

Both curves started with 71 pending items at week 1 maintaining stagnation in those values until week 4. From week 5 to week 13, a strong advance occurred, practically maintaining at all times the Actual Curve below the Planned Curve, which shows that the Actual Curve was faster than the planned during that period. Then, from week 13 to week 16 the number of pendency's stagnated at 1. Several reasons can be raised to explain what happened. For example, this item may be damaged and waiting for the supplier to perform an exchange or maybe, for some reason, it has not been delivered correctly to the workplace, among other possible cases.

As a result, Project B's Commissioning activities were delayed by 1 week when compared to what was planned. It should be noted that this delay occurred due to a single pending item.

4.1.3 DEVELOPMENT ANALYSIS OF THE A AND B PROJECTS

After obtaining all the planned x actual curves for the heating systems activities, taking into account the different ways in which the labor was directed by the Construction and Assembly and Commissioning sectors during the final stage of integration of the last installed module in the FPSO until the day it was deployed, some other curves were also developed to carry out a definitive comparison between these two groups.

For the realization of this final comparison all the previously generated curves for this subsystem are considered:

a) Curves Planned / Actual- Projects A and B - Construction and Assembly;

b) Curves Planned / Actual - Projects A and B - Explosion Proof Equipment / Instruments;

c) Curves Planned / Actual - Projects A and B - Commissioning.

With all these data compiled into the following 3 graphs, it is possible to understand and analyze which methodology, Construction and Assembly or Commissioning, is the most effective in terms of attending to the deadline of each of the two projects in question.

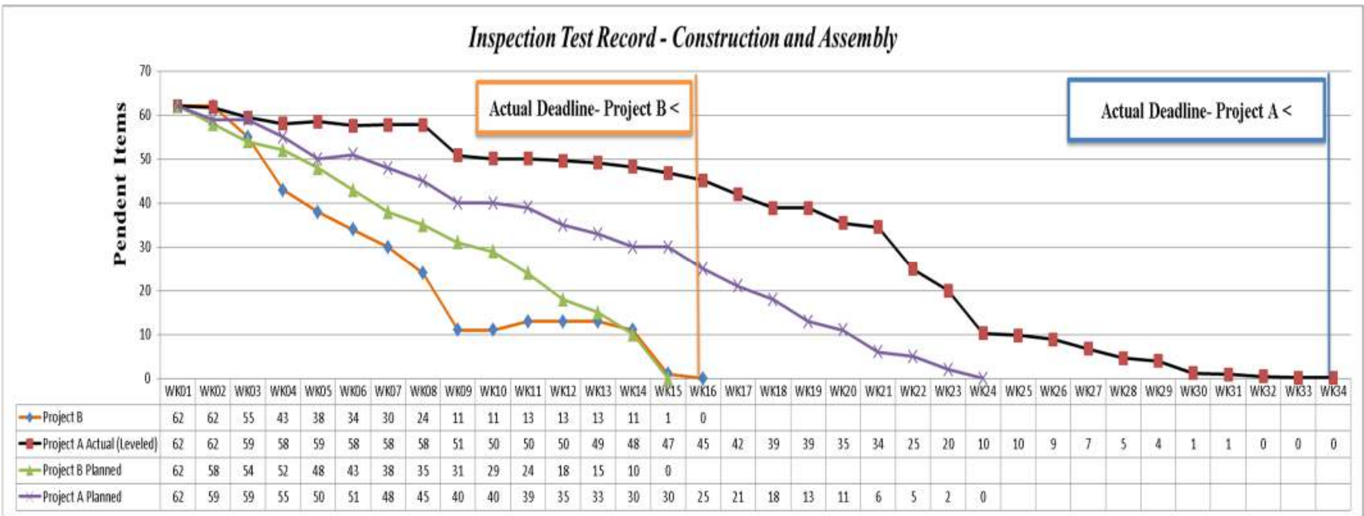

Fig. 9. Heating Medium System – Construction and Assembly Planned x Actual curves – Projects A and B.

Source: Author

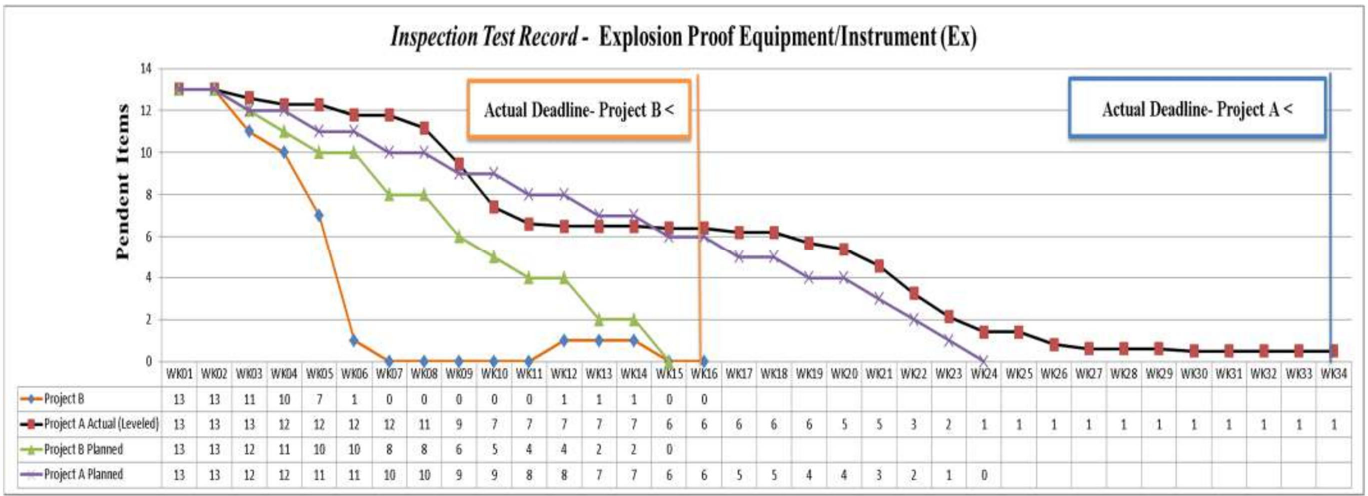

Fig. 10. Heating Medium System – Planned x Actual Curves for the Explosion Proof Equipment/Instrument – Projects A and B

Source: Author

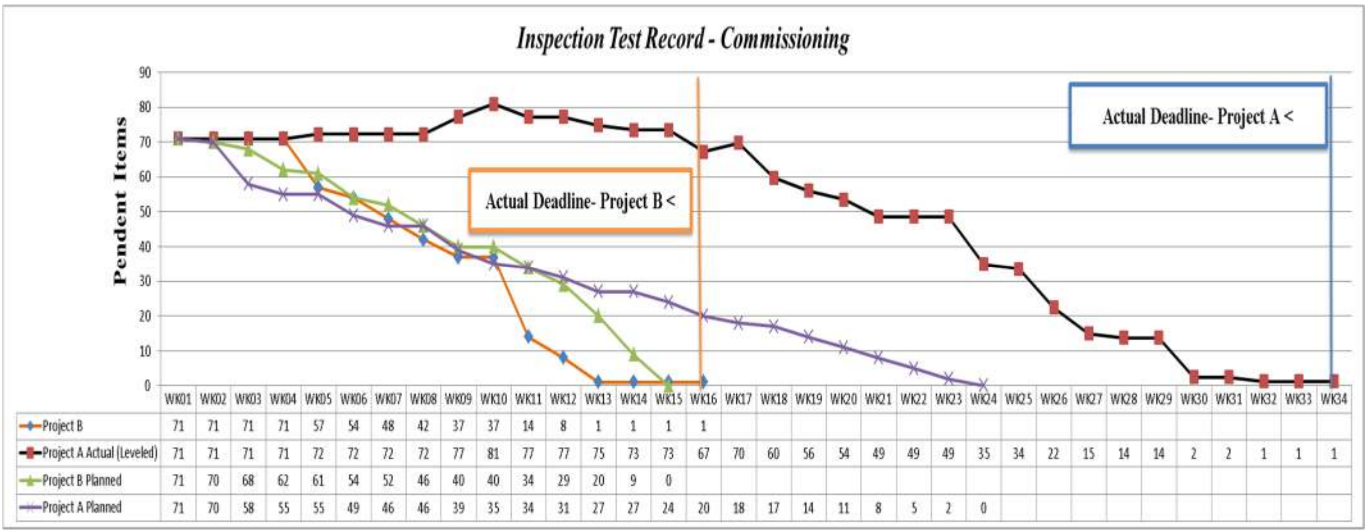

Fig. 11. Heating Medium System - Planned x Actual Curves for the Commissioning – Projects A and B.

Source: Author

4.2 Comparative Overview Of Pre-Commissioning Activities Between Projects A And B

At the end of the comparative analysis between these 5 subsystems a general table was created, containing the main data of the pre-commissioning activities that took place in projects A and B.

Table 1. General analysis of pre-commissioning activities for projects A and B.

GENERAL ANALYSIS OF PRE-COMMISSIONING ACTIVITIES TO PTOJECTS A AND B								
SYSTEM	PLANNED WEEK		ACTUAL WEEK		WEEK OF DELAYS		% OF DELAY	
	PROJ. A	PROJ. B	PROJ. A	PROJ. B	PROJ. A	PROJ. B	PROJ. A	PROJ. B
Heating Medium System	23	15	34	16	11	1	47,82%	6,67%
Cooling Medium System	23	15	34	13	11	0	47,82%	0,00%
Engine Start Air, Instrument Air and Distribution System	23	15	27	16	4	1	17,39%	6,67%
Sea Water Lift Pumps and Topsides Distribution System	23	15	34	16	11	1	47,82%	6,67%
HP Flare and LP Flare System	23	15	32	16	9	1	39,13%	6,67%

Through all the data generated in the comparative charts, it is possible to highlight some that had a very significant date discrepancy as, for example, the delay in the heating system that in project A had a discrepancy of 47.82% over the planned date, against project B that had only 6.67%. In a similar way we have the cooling system that in project A had a delay of 47.82% compared to the planned date against project B that had 0% of delay since it finished its activities of pre-commissioning 2 weeks before the planned date.

Based on the data presented in Chapter 4, it was possible to estimate a general percentage of projects A and B to verify which was most effective in terms of the completion period of the pre-commissioning activities. As a result, Project A obtained an average of 9 weeks of delay, i.e. approximately 39%. In project B, the approximate average delay was 1 week, that is, 6.67%.

5 CONCLUSION

According to the initial proposal, the objective of this work is to compare the prioritization of systems and subsystems in the installation and assembly of equipment, instruments and pipelines required by the Commissioning sector, with the activities prioritized by the Construction and Assembly sector, with the objective of putting the FPSO platform in operation more efficiently within the project deadline.

Therefore, 5 subsystems were compared through the rundown curves, between 2 similar projects of Construction and Assembly and Commissioning of FPSO platforms, which took place in Niteroi, Rio de Janeiro state. Through the result of this analysis, it could be verified that 2 similar projects can present completely different results through changes in the manpower directing (method generated by the Construction and Assembly or method generated by the Commissioning). This analysis was performed through 5 subsystems considered by the commissioning manager as a priority for the departure of the dock platform from the shipyard, towards the anchoring period, where most of the final commissioning tests take place.

It is concluded, therefore, based on the data generated in this work, that the method of directing the workforce through the prioritization of systems and subsystems in the activities of installation and assembly of equipment, instruments and pipelines elaborated by the Commissioning sector was more effective in terms of delivery time of the project than the direction elaborated by the Construction and Assembly sector.

Based on these data, it is suggested for future work the application of this method in other types of industrial facilities, in order to obtain a greater consolidation in its application.

REFERENCES

[1] FERREIRA, Miguel. GERENCIAMENTO DA QUALIDADE PELA CONTRATANTE NA MONTAGEM INDUSTRIAL DE PLANTAS DE PROCESSO, Universidade de São Paulo, p. 7 - 8, 1998.

[2] PMBOK 5ª Edition, A Guide to the Project Management Body of Knowledge, Project Management Institute, Inc., 2013.

[3] MATHEDI, Octávio. Práticas de Engenharia de Condicionamento e Comissionamento, Editora AGBook, 2010.

[4] GUIMARÃES, Alexandre, Processo de Comissionamento em Instalações Industriais, apostila FUNCEFET, Rio de Janeiro, 2013.

[5] NORSOK STANDARD, Mechanical Completion and Commissioning, disponível em: https://www.standard.no/en/sectors/energi-og-klima/petroleum/norsok-standard-categories/z-mc-preservation/z-007/.Acesso em: 05 de abril de 2016.

[6] JUNIOR, C. Carlos R. Análise do Processo de Comissionamento de Instalações de Produção de Óleo e Gás Offshore: Uma proposta de Indicadores de Performance, Dissertação de Mestrado apresentada ao Programa em Tecnologia de Processos Químicos e Bioquímicos da UFRJ, Agosto, 2014.

[7] SHAKOORIAN, Amirali, Performance Assessment of Building Commissioning Process as a Quality Assurance System, Degree Doctor of Philosophy in the College of Architecture Georgia Institute of Technology School of Building Construction, May, 2006.

[8] SOUZA, V., Bergson José. Modelo para Compatibilização de Projetos na Fase de Comissionamento Baseado em Confiabilidade e Risco, Universidade Federal de Pernambuco, 2013.

[9] GANDRA, Rodrigo Mendes, Comissionamento como uma ferramenta do processo de controle de qualidade em projetos industriais, Prática, p. 22-27, Janeiro, 2010.

[10] LAKATOS e MARCONI, Fundamentos de Metodologia Científica, Atlas, 5. Ed. – São Paulo, 2003.

[11] MALHOTRA, Naresh K., Pesquisa de Marketing: Foco na Decisão, tradução Opportunity Translations; revisão tecnica Maria Cecilia Laudisio e Guilherme de Farias Shiraishi - 3. ed. --Sao Paulo: Pearson Prentice Hall, 2011.

[12] OLIVEIRA, M. Ferreira, METODOLOGIA CIENTÍFICA: Um Manual Para a Realização de Pesquisas em Administração, Universidade Federal de Goiás, 2011.

[13] Gil, Antonio Carlos, Métodos e técnicas de pesquisa social, Atlas, 6. Ed. – São Paulo, 2008.

[14] STONNE, Rodolfo, Ferramentas de Planejamento, Editora E-papers Serviços Editoriais, 2001.

[15] FILHO S. P. Edgar; Miranda, A. W. Gilberto., Planejamento, Programação e Controle da Produção (Serviços) em Upgrade de Unidade Marítima, Shutdown de Plataforma de Exploração Semi-Submersível, XXVII Encontro Nacional de Engenharia de Produção, 2007.

[16] STONNE, Rodolfo, A Curva Rundown de Contingência, Disponível em: https://blogtek.com.br/curva-rundown-contingencia/. Acesso em dezembro de 2013.