DISCUSSION ON THE LIFE EXTENSION OF OFFSHORE PRODUCTION FACILITIES

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Summary

Many offshore production facilities in Brazil have exceeded their estimated design life. Yet, there are no current specific rules on life extension in Brazil, as there are in other countries. The present work describes some of the international ways of approach to the matter and illustrates the Brazilian panorama on age of production installations, considering lifetime since construction or conversion. Then, it presents a discussion on whether construction or conversion should be taken into account when evaluating lifetime for ageing process reasons, giving an enlightening look at the pros and cons.

Abstract

For offshore production platforms that reach the limit of its design life, in general, options may be: decommissioning, repair, re-rating, or extending the life of the installation.

However, in Brazil, the life extension discussions are still incipient, though some platforms in operation already exceeded their estimated design life with no specific studies on life extension. It is shown in the present work that some safety regulators around the world have been discussing the matter for a longer time.

Facing this scenario, the Superintendence of Operational Safety and Environment (SSM) of Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP) conducted a survey on offshore production platforms in Brazil, considering year construction, conversion, operating time and validity of the concession agreements.

Herein, it is presented that many platforms have reached their expected life, and that on-going studies on life extension assessment in general focus on structures and hulls, but do not consider topsides nor cargo system. Additionally, this work exhibits a brief discussion on local rules, on what could be good parameter to trigger or require a formal life extension assessment, as well as brings debate on since when does lifetime may be evaluated: construction or conversion.

The inception of the present study coincided with the first applications to ANP on extension of current concession contracts. On the whole, domestic and international scenarios indicate the importance of evaluating a regulatory frame on this subject. For this reason, this study is completed with a brief summary of what the local rules on life extension and how it is discussed around the world by other regulators.

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1. Introduction

The Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP), the regulator of the oil industry in Brazil, has identified mechanical integrity issues in offshore production and drilling facilities since 2009, when operational safety enforcements [1] have begun. Mechanical integrity management has been constantly among ANP safety audits [2] and inevitably, one would infer that the older platforms were those more impaired regarding mechanical integrity. However, despite the obvious deduction, it was concluded that there was no particular focus on equipment or facilities integrity management by the end of their design life (defined as the assumed period for which a structure is used for its intended purpose with anticipated maintenance, but without substantial repair being necessary [3]).

Audits’ findings have been indicating the design life of most offshore production facilities is typically 25 years. Thus, impelling the regulatory agency to search what would be an appropriate and fair treatment to uphold in cases which facilities exceed design life.

The increasing demands from regulatory side stimulated the hiring of some offshore units for recovery campaigns. Units for Maintenance and Safety (UMS) connect to production platforms through a gangway and are equipped with mechanical and electrical workshops, cranes, warehouses, painting and maintenance areas for parts and equipment, as well as accommodations for those who perform the services [4]. In addition, the purpose of UMS is not used for its intended purpose with anticipated maintenance, but without substantial repair being necessary [4]. In addition, the purpose of UMS is not exclusive for mechanical integrity repairs, but they also may execute some changes, which would enable production increase deploying new technologies or adapting existing units to receive wells with different fluid characteristics from those originally designed.

Nevertheless, refurbishment is not the only approach to provide continuous safe operations throughout the extended life of production platforms, since degradation and obsolescence are some aspects of ageing, but not all (e.g. organizational issues). Furthermore, material degradation has to do not only with material properties or operational / environmental conditions, but also with maintenance practices [5], which cannot be handled by UMS.

Safety team ANP concerns has recently been amplified as the operators who signed the first contracts in 1998 began to anticipate, in 2014-2015, applications to extend their oil and gas concessions [6]. The motivation of applications would be that the early renewal of contracts would be important for companies to justify long-term investments [7]. Currently, the Agency is studying the conditions and paradigms necessary for the renewal of the round zero contracts through three contracts related to onshore areas, shallow and deep water. The fields in the offshore area are Marlim (deep water, in the Campos Basin) and Ubarana (shallow water, in the Potiguar Basin) [8]. Indeed, for the Revitalization Project Marlim field, the Agency has accepted the proposal to replace the nine platforms currently in operation by two new Floating Production Storage and Offloading vessel (FPSO) in 2020 [9]. However, opposite to the regulator expectations, contract extension applications may not always consider a revitalization or exchange of existing facilities [10].

Thus, the subjects of "aging" and "life extension" are definitely under study of ANP safety team to ensure that the concessions extension process goes hand in hand with validation of life extension process. In 2015, so as to declare the regulator concern on the theme, ANP addressed the matter in its annual workshop with the industry [11]. The Brazilian industry also began to put this issue on the agenda, promoting discussions among players, including classification, as in the “FPSO Workshop - how to extend operating life”, in 2013, organized by the Brazilian Petroleum, Gas and Biofuels Institute (IBP) and the Society of Petroleum Engineers (SPE). In 2015, agendas at conferences on mature fields, as in OTC Brazil 2015 [6]. In 2016, companies are discussing solutions to extend the life of subsea projects and production facilities during a seminar in OTC, Houston [12].

Considering the actual requests for extending contracts, the age of Brazilian offshore production installations and the experience of other countries, so ANP has been pursuing what is being raised in international events (e.g. FPSO Asset Integrity Management and Life Extension Forum, 2015, London, by Bis Group) and how other regulatory bodies cope with the matter. Although Brazilian safety regulations do not directly demands a life extension program for offshore production installations, since 2007 the ANP Resolution 43/2007 has established the Safety Regimen – not only but also – for offshore production facilities through the performance-based Technical Regulation SGSO [1].

Although the rules are not explicit on life-extension, they are clear that all seventeen safety management practices are valid throughout the life cycle of the installations. Hence, ultimately the subject is not at all loose in regulation. Nevertheless, indeed ANP is concerned with possible gaps and then is investigating further on industry and regulatory best practices. Thus, in order to contribute to the continuous improvement of offshore industry safety culture, the present work aims to present current related panorama, bringing light to the life-extension theme and identifying topics for discussion on how the matter could be held in the near future.

2. Regulatory aspects

The safety management practices stated at Technical Regulation SGSO [1] are valid throughout the life cycle of the installations, such that integrity management is considered as a continuous process, since design phase until
deactivation. Additionally, the Technical Regulation SGSO inside one of its management practices describes requisites, which must be considered in order to promote safety during design phase. It is known that 20 to 25 years is a usual period estimated for investment purposes [13], and then design takes into account integrity assurance during this estimated life. During safety audits in production offshore facilities conducted by ANP in Brazil, it has been observed that design life is in general established as 25 years. As, in general, Brazilian contracts expire in 30 years, accordingly design life could represent a good indicator to trigger to operators address formal assessments as a way to evidence continuity of safe operations throughout the desired life extension.

Håbrekke et al [14] propose a scope of items to be taken into account on documenting safety of ageing facilities, maintaining adequately safety level by means of a maintenance program. Their study is grounded on a project report [15] based on a two year (2008-2010) research of PSA (Petroleum Safety Authority Norway, Norwegian regulator on safety, emergency preparedness and working environment in the Norwegian petroleum industry) focusing on ageing challenges related to process risk and major hazards. Overall, they recommend attention to three aspects of ageing: material degradation, obsolescence and organizational issues.

The theme of life extension is wide and ANP is starting to gather information through its established safety audits, as well as via workshops with industry [11] and literature review. It can be observed that the concern of other regulators worldwide on life extension started, as there was a large number of old offshore facilities operating in their seas, as illustrated by the study undertaken for PSA based on an industry workshop and a review of recommendations made to the United Kingdom Health and Safety Executive (UK HSE) on life extension [16]. The next sections bring a brief description of how some of the members of the International Regulators’ Forum [17] cope with the subject.

2.1. Other regulatory bodies

As the number of older offshore installations in service on the continental shelves of Norway and United Kingdom was increasing, the respective regulators started around year 2006 to study somewhat of ageing process [18]. At that time, major concerns relied on integrity aspects [16, 18, 19]. Over time focus was expanded, such that besides material degradation, regulators started to shed light also on obsolescence and organizational issues [14].

Reports show that in 2006 the average age of semi-submersible installations operating on the United Kingdom continental shelf was considered high, with many exceeding their estimated design life (usually 20 years) and some being around 30 years old, such that the UK HSE believed that the provisions for maintaining integrity should be periodically reassessed in order to consider ageing processes [19]. Also around 2006, HSE has started discussion with interested parties, among which included the Norwegian Petroleum Directorate (NPD), pursuing to adopt consensual actions in dealing with the matter [19].

Likewise, studies show that since 2006 PSA already funded works on development of a possible underlying philosophy for regulating ageing installations and life extension in the Norwegian sector [16]. Meanwhile, it was believed inspection was a key topic for the continuity of safe operations of older installations, bearing in mind that inspections intervals, methods and their reliability influence the safety of the installations [16].

It is important to note that the Norwegian Oil and Gas Association established in 2008 recommended guideline for the assessment and documentation of service life extension of facilities [20], which objective was to give guidance to the process of evaluating and documenting prudent operation and optimum resource exploitation in the life extension of facilities. Thus, if there is any intention of using facilities installed on the Norwegian Continental Shelf beyond design life, then a formal life extension application is required. The cited guideline [20] gives direction for development of applications for consents for life extension, recommending a methodology for evaluating life extension focusing on the process the Operator needs to accomplish in order to assess if the barriers will fulfill their functions, if it is safe to operate and if the facilities effectively exploits the resources in the life extended period. On the whole, it must be ensured the following: the compliance with Operators own requirements for life extension, management of the barriers throughout the period, maintenance of acceptable risk levels throughout the period, acceptable management of aging processes through maintenance management and management of change, compliance with the regulations throughout the period. According to the guidelines, evaluating life extension involves, among other steps, risk evaluations and documentation of the process. Risk evaluation considers risk assessment, emergency preparedness and response, external environment, occupational health and working environment, as well as organizational and human factors.

Similar to some extent to ANP, the Australian National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) does not have specific rules on life extension. Ageing aspects are somehow considered in the Safety Case and its periodic reviews. Nevertheless, that regulatory body uses a themed audit tool as a review of the systems and processes operators use to identify and address any changes in risk due to time related events on the facilities. The tool considers the application of improved knowledge, codes and standards and analytical techniques, bearing in mind that even though it may be unreasonable to expect old facilities to meet all current codes, it is reasonable to expect that operators demonstrate their knowledge on what is and what is not met, as well as identification of resources to provide mitigation or technical justification for not meeting current philosophy. The risk associated with not meeting current philosophies and best practices should be assessed in a formal safety analysis. The scope of the specific audit includes the following topics: Policy and Strategy; Personnel and Information; Planning, Implementation, Monitoring and Future Work (if there is any intention on specific life extension piece of work once the
facility reaches its original design life); Structural Aspects; Mechanical and Piping Aspects (firewater system, power generation, flare), Electrical Aspects (emergency/main generators, instrumentation calibration, circuit breakers, wiring, exhausts), Major Accident Hazards Mitigation Aspects (fire/explosion protection, ship impact, HVAC, detection systems).

3. Brazilian present panorama and perspectives

Herein this section it is presented the Brazilian scenario by the end of 2015, as well as an essay of future prospects on the number of production offshore installations regarding their operational lifetime and their respective associated concession agreements validity.

3.1. Age of production facilities

The number, type and operating time of production platforms in Brazil were based on official documents in compliance with the Resolution ANP 43/2007, such as DSO (stands for Operational Safety Document), as well as on other information obtained through surveys carried out by ANP.

The following data were raised in the end of year 2015. By that time there were 146 operational production facilities in Brazil, in service or not at that time, i.e., the installation was considered as operational whether in work or if there was any intention to retake its operations.

Production installations are designed to operate for 15 to 30 years, but in general for an estimated period of 25 years. Therefore, taking the typical design life of 25 years as a parameter, and considering the year of construction as the starting point to count their lifetime, it is possible to sort facilities in three categories, as illustrated in Figure 1: those with age above 25 years; a group about to reach 25 (say between 15 and 25 years); and those with less than 15 years. The three figures in the present study are represented with use of the same color scale, say green for young installations, yellow for those about to reach 25 years and finally red for facilities with more than the typical design life of 25 years.

![Figure 1. Distribution of production installations in groups of lifetime (end of 2015).](image)

Figure 1 shows that in the end of 2015, 106 of production installations already had more than 25 years since their construction dates, which accounts for more than a half of the Brazilian fleet. Also, 13% was reaching a lifetime equal to that typically design life of 25 years and finally 14% had equal to or less than 15 years since their erection dates, which represents 19 and 21 installations, respectively.

Figure 2 identifies the number of operational production installations in Brazil, accordingly to the decade of their construction.

![Figure 2. Decade of construction of operational production facilities in Brazil.](image)
As it can be seen in Figure 2, from the group with more than 25 years the majority is concentrated in the 80s with 60 installations, followed by 45 in the 70s and only 2 in the 60s. Those installations not so old but not young totalize 20 units. Since 2000, 22 platforms were constructed, representing the group with age equal to or less than 15 years, as indicated by the color green.

Regarding localization, in Brazil an old installation is not necessarily associated to brownfields. Likewise, the contrary is not necessarily true, which means that there are recently constructed facilities producing in brownfields. Figure 3 aims to demonstrate the distribution of production platforms among Brazilian basins, considering their age.

![Figure 3. Offshore production installations per basin.](image)

Figure 3 presents ageing state of much of the infrastructure in Brazilian offshore oilfields. In fact, as each Brazilian basin has several fields, such that a graphic of installations per field would be confuse, then Figure 3 illustrates the information per basin. Left side of the graphic are the basins aside to Brazilian northeastern region. The more to the right in Figure 3 a basin is, the more to the south it is.

For instance, Sergipe-Alagoas basin (shallow-waters) has 21 production facilities, 80% of its total, with more than 25 years, but also four installations within 16 to 25 years and one less than 16 years. It can be observed that among all basins, Campos has the majority of platforms with advanced age. Nevertheless, the old fixed platforms frame found in this shallow-water basin presents challenges other than those to be overcome by the contract renewal proposals in the deep-water Campos basin. For instance, in Marlim field, inside Campos basin, the replacement of ageing floating production units was recently proposed [9].

Looking to percentage instead of raw numbers, Ceará basin is the case for which most of its production assets are operating during period over than typical design life, since 100% of its installations have more than 25 years since construction.

Note has to be made that the majority of production facilities in northeast region does operate unmanned, with periodic embarks of maintenance crew. On the other hand, almost all platforms associated to southeast region are manned.

### 3.2 Age of Concession Agreements

The periods of concession agreements in Brazil were obtained from a survey conducted by ANP based on official documents in compliance with Ordinance ANP 90/2000 (superseded by Resolution ANP 17/2015 [21]), which
approved the Technical Regulation of Plan for Development, as well as on official data from Brazil Oil & Gas Bidding Rounds [22].

In 1997, the Brazilian Law 9.478/97 [23] was published establishing the end of Petrobras’ monopoly, bringing basis to petroleum market opening. Afterwards, in 1998, the so called “Bidding Round Zero” [24] took place, which was the set of negotiations carried out to determine the participation of Petrobras in that new scenario. Previously, Petrobras was the only company in service of the government monopoly which played the part of oil and gas prospecting, exploration and production activities. Then, in August 1998, Round Zero endorsed Petrobras rights by means of concession agreements on production fields and exploration blocks with commercial discovery or that company had made exploratory investments. As a result, contracts were signed by Petrobras and ANP agreeing upon concessions of 27 years’ term, which are about to finish.

Therefore, the time elapsed during offshore operations is different of concession time, since operations had begun years before contracts from Bidding Round Zero were signed. Indeed, the fact that operations had been carried out long before Law 9.478/97 was published implies that under the scope of 27 years contracts there are platforms with 30 and 40 years in service.

Figure 4 shows the number of production installations according to sedimentary basin and years up to expiration of concession agreements.

Figure 4 shows that from the 26 installations in Sergipe-Alagoas Basin presented in Figure 3, a total of 25 are located in areas where concession agreements are going to end in the next 10 years, i.e., almost all fields are related to Bidding Round Zero. There is only one platform associated to a contract that expires in the next 11-20 years. On the other hand, in Santos Basin 9 out of 12 platforms are related to recent contracts with expiration dates defined to the next 21-30 years. Nevertheless, Campos Basin has approximately 80% of its platforms operating in fields linked to contracts that will expire soon, in the next 10 years.

Aiming to identify if there were installations constructed over 25 years (see Figure 3) operating under concession agreements expiring in the next 10 years (see Figure 4), then Figure 5 was developed. This graphic has a color scale defined such as to identify age of construction, and to segregate the category “over 25” for better realization of what ageing stage the platforms are.
Thus, the difference between Figure 3 and Figure 5 is that instead of showing the age of platforms by the end of year 2015, Figure 5 presents the age by the end of the concession agreements made in Bidding Round Zero. Consequently, the bar related to Sergipe-Alagoas Basin in Figure 5 shows that two installations will have less than 20 years (since construction) by the end of concession agreements term, while other two will have ages between 21 and 25 years, six will have around 26 and 35 years, 14 facilities with age of 36-45 years, and eventually one will be over 46 years.

Looking through the ageing process, one could consider accounting for the lifetime of a production installation the period after its conversion, instead of its construction, since while in quayside an appropriate overhaul campaign is supposed to occur. Then, Figure 6 was developed with the purpose to show the same idea as Figure 5, but considering conversion as a time basis to start counting lifetime.

The aforementioned conversion may be applicable whether to tankers or drilling rigs, adapting them into production facilities. It can be observed that some bars did not change from Figure 5 to Figure 6, which means no conversion for those platforms. However, it is worth knowing on Campos Basin that the scenario is less alarming when conversion is assumed as initial date to assess ageing, noticing that instead of 42 only 18 facilities would have age over design life.

In order to forecast potential future demands on ageing aspects and requests on life extension, Figure 7 and Figure 8 were built considering concessions expiring in the next 11 to 20 years, from agreements made by occasion of Bidding Rounds 2 and 3. The difference between Figure 7 and Figure 8 resides on construction against conversion basis, i.e., it follows the same pattern as Figure 5 and Figure 6.
Figure 7. Age of installations at the end of 2nd and 3rd rounds agreements (construction basis).

Figure 8. Age of installations at the end of 2nd and 3rd rounds agreements (conversion basis).

If platforms operating in areas under Bidding Round Zero are not considered for the purposes of Figure 7 and Figure 8, then scenario is remarkably other than the one found for Bidding Round Zero (see Figure 5 and Figure 6). Figure 7 shows only few cases of an installation having age over typical design life of 25 years. But, considering conversion dates, Figure 8 shows no drawbacks at all.

4. Conclusions

By the end of 2015 there were 146 offshore production facilities operating in Brazilian waters, from which 106 production platforms have 25 years of life after construction. This is an expressive number, but when conversion (instead of construction) is considered as the time basis to start counting ageing, then the scenario is quite different. Therefore, considering a typical value of 25 years for design life, then a large number of facilities is reaching an age, in which a decision has to be taken, that is whether to deactivate or to go through a life extension process. This life extension process is not yet specifically regulated, i.e., there is no current formal way of enforcement on life extension. Nevertheless, regarding contractual extension applications, ANP has been requesting some safety studies on life extension, such as: analysis of the obsolescence of critical equipment, control system and automation; technical and economic analysis of conformance to the current safety philosophy; study on knowledge maintenance, as workforce is renewed; and analysis of current state of structures and equipment in comparison to design expectations.

On the other hand, independently of the existence of any official frame of enforcement, a life extension process can be formally carried out by operators through technical formal assessments, in order to assure the safety barriers in place are adequate, up-to-date, integrate. After all, in 25 years many issues may change, such as technologies, engineering best practices, culture and values (e.g. safety philosophy and policies), personnel, operational and environmental conditions, rules.

Recent findings from ANP safety audits indicate that some (not all) of those ageing aspects are occasionally being addressed, but still not compiled in a structured formal assessment for a life extension program. In general, mechanical integrity is the more addressed subject, when it comes to ageing assessment. For instance, recent investigations into the accident occurred with the FPSO Cidade de São Mateus in February 2015 [25] revealed that whilst the hull had been built in 1989 and conversion occurred in 2007, no replacement nor upgrade of cargo systems were implemented. However, it was found that before operations started a hazard and operability safety study (HazOp)
was elaborated specifically for the cargo systems, bringing attention to life extension for some components at a significant degradation stage, e.g., cargo valves, which eventually failed contributing to that major accident.

Therefore, a discussion on what should be considered as a basis to trigger assessment of ageing aspects, whether conversion or construction date. As demonstrated at the present work, clearly there is a high difference when changing the perspective, in favor to conversion. However, lessons learned, the actions which are expected to occur during pre-operation phases may not always be fully accomplished. Furthermore, not accomplished actions may not be adequately managed, leading to unknown or uncontrolled risks. Further thoughts on this theme should be given, but history already taught that maybe life extension concerns should start before operations, at conversion phase, as a preparedness continuous process, and not be a subject to be addressed only when a proposed age is achieved.

Thus, the current ultimate question to be answered is if the operators do assure a proper safety level to continue safe operations throughout a life extension. Furthermore, how it is assured. Nevertheless, it is believed and always encouraged the operators should be able to answer that question to themselves in the first place, but not of course at the expense of one day having to respond to the regulator.

The data and opinions included on this paper are the sole responsibility of its authors and do not necessarily reflect ANP’s institutional opinions.

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6. References


