ASSESSING SAFETY RISKS FOR COMPARATIVE ASSESSMENT OF OPTIONS FOR DECOMMISSIONING OF SUBSEA INSTALLATIONS IN BRASIL

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ABSTRACT

The Comparative Assessment (CA) of the possible decommissioning options for a set of subsea installations has been considered by various regulatory agencies as a proper method to solve the problem of finding the preferred decommissioning option for subsea installations. DNV GL proposed the formation of a joint industry project (JIP) to conduct research on decommissioning of subsea installations in Brazil that lead to the "Guidelines for Risk-Based Comparative Assessment of Options for Decommissioning of Subsea Installations in Brazil", published in 2018. Regarding Safety Criteria the key references analyzed are UK BEIS and OG UK. BEIS recommend that quantitative risk assessment techniques should be employed, such as Potential Loss of Life (PLL) and Individual Risk Per Annum (IRPA). Besides, it also indicates that risk values should be obtained and compared against UK HSE risks tolerance criteria (max 10^{-3}/year for individual risk). This paper argues that in a Comparative Assessment, only relative risks among the various options need to be assessed and not "absolute" risks values. In addition, IRPA is not an adequate risk indicator for decommissioning options, not even the traditional PLL. In this paper, it is suggested that the PLL indicator should be used to measure the expected number of deaths during the option, using the probability of damage occurring over the period of time required for the decommissioning activities. In this case, the PLL is obtained as a probability and not as a frequency as in the traditional way. In addition, there is no risk acceptability criteria for PLL, so PLL values can only be compared with each other, but not with an acceptability criterion.

1. INTRODUCTION

DNV GL proposed the formation of a joint industry project (JIP) to conduct research on decommissioning of subsea installations in Brazil that lead to the "Guidelines for Risk-Based Comparative Assessment of Options for Decommissioning of Subsea Installations in Brazil", published in 2018 [1]. This paper refers to that publication as the "Guidelines". During the development of the Guidelines, an extensive research work was performed by DNV GL team in order to adapt or develop new methods used in Comparative Assessments for O&G subsea decommissioning activities in the world to the Brazilian reality, generating a set of sub-criteria aligned to the values of the Brazilian regulators, companies and the Brazilian society as a whole.

Several options are possible for the decommissioning of subsea installations, from the total removal to leave the structures/equipment in situ, passing by many possibilities of partial removal (Ex: removal of sections of a pipeline, removal of dynamic portion of a riser/flowline, etc). The Comparative Assessment is the process that allows the comparison of options in a single normalized scale, producing a ranked order of the options, which indicates the most preferred options and provide support to the decision making.

This paper focuses in assessing the risks for safety in comparative assessments for decommissioning of subsea installations, the analysis of some key decommissioning guidance documents and the proposal for the Brazilian Guidelines, adapted to the reality of a subsea decommissioning activity in Brazil.

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2. COMPARATIVE ASSESSMENT OF OPTIONS FOR DECOMMISSIONING OF SUBSEA INSTALLATIONS IN BRAZIL

The Comparative Assessment (CA) is a detailed analytical process that weighs up the pros and cons of alternative decommissioning options against several criteria considered relevant by the decision-makers. The CA of the possible decommissioning options for a set of subsea installations has been considered by various regulatory agencies as a proper method to solve the problem of finding the preferred decommissioning option for subsea installations [2], [3], [4].

The key objectives of the CA are: facilitate the decision-making process related to the choice of the preferred decommissioning option; identify the similarities and differences between two or more decommissioning options and indicate the causes of such differences and indicate the preferred decommissioning option and provide an ordered list of options ranked by preference against an agreed set of decision criteria [1].

The Guidelines for Risk-Based Comparative Assessment of Options for Decommissioning of Subsea Installations in Brazil are based on the five "typical" criteria: Safety, Environment, Societal, Technical and Economic, assessed in an integrated way based on multi-criteria decision analysis (MCDA). The definition of a good set of criteria and sub-criteria is one of the most important steps of a CA. OLIVEIRA, DOMINGUES et al [1] adapted some of the existing methods used in CAs in other parts of the world to the Brazilian reality and develop new methods to assess the performance of sub criteria to better match the requirements in Brazil.

Figure 1 presents the five criteria and sixteen sub-criteria proposed in the Guidelines [1], which are being successfully applied to real cases of subsea decommissioning in Brazil.

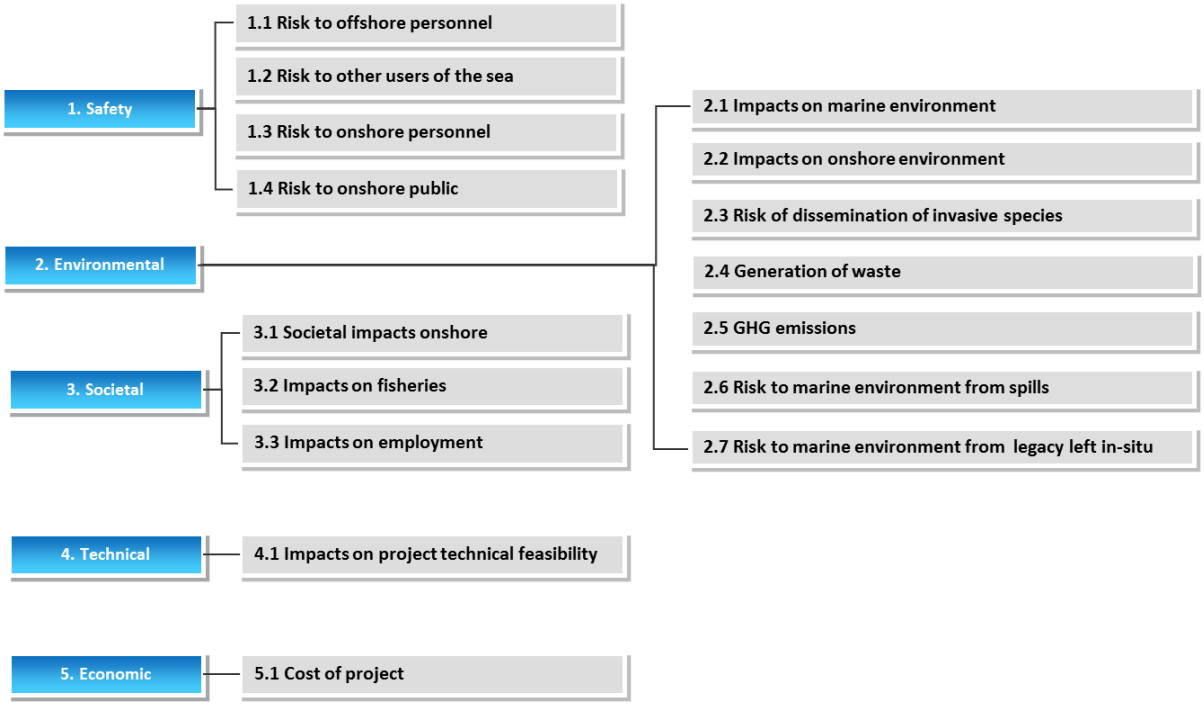

Figure 1 - Figure 1 – Criteria and Sub-Criteria Proposed in the Guidelines For Risk-Based Comparative Assessment Of Options For Decommissioning Of Subsea Installations In Brazil [1]

3. ASSESSING THE RISKS FOR SAFETY IN COMPARATIVE ASSESSMENT

The Safety Criterion is divided between four sub-criteria. According to the Guidelines [1]:

- Risk to Offshore Personnel:
  - Occupational risks during decommissioning activities: lifting operations accidents, swinging loads impact, dropped objects, cable under tension rupture, accidents during material handling, welding and cutting, and scaffolding accidents - structural collapse, accidents during marine operations such as ship collisions between offshore vessels or installations, vessels sinking during activities or during travels, helicopter accidents during travels, landing or taking off, man overboard, explosive handling accidents, diving accidents and others and
  - All external events/major hazards such as decommissioning vessels collision with passing vessels or platforms, decommissioning vessels collision with fishing vessels, sinking or grounding of decommissioning vessels, harbor accidents, fires, explosions, release of toxic material, dropped object over live pipeline, others.

- Risk to Other Users of the Sea:
  - All external events/major hazards such as decommissioning vessels collision with passing vessels or platforms, decommissioning vessels collision with fishing vessels and others and
  - Long term legacy risks, such as fishing vessels snagging, inspection vessels accidents during periodic monitoring, diving accidents during monitoring, others.

- Risk to Onshore Personnel:
  - Occupational risks in the dismantling shorebase/yard (swinging loads impact, rupture of cable under tension, working at height accidents, confined space accidents, dropped objects, road transfers accidents, others and
  - Fires, explosions, and toxic releases in the dismantling yard, contamination with NORM, others.

- Risk to Onshore Public:
  - Road traffic accidents involving transportation of decommissioning materials, fires/explosions/toxic releases with external effects (very low probability events), others.

During the development of the Guidelines, an extensive research has been conducted with the objective to propose the most appropriate way for the assessment of the performance measures of the decommissioning options in subsea installations in Brazil, for each criteria and sub-criteria. For the Safety Criterion some key references was analyzed, highlighting the Guidance Notes on Decommissioning of Offshore Oil and Gas Installations and Pipelines published by the UK BEIS - Department for Business, Energy and Industrial Strategy (former DECC - Department of Energy and Climate Change) [3], [4] and the OGUK Guidelines for Comparative Assessment in Decommissioning Programmes [5].

In [3] there is a specific annex providing a "Guide to Comparative Assessments". In this annex there is a recommendation that "*in assessing and comparing the safety risks of different options the general principles of risk management used within the industry should be applied*". And that quantitative risk assessment (QRA) techniques should be employed, such as Potential Loss of Life (PLL), Individual Risk Per Annum (IRPA) and Fatal Accident Rate (FAR) criteria.

Another recommendation regarding Safety is "*Comparison should be made with the risk levels generally supported by the Health & Safety Executive who define the maximum tolerable level of individual risk of*

fatality as 1 in 1000 per year, and for the broadly acceptable level of individual risk to be set in the range of 1 in 100,000 to 1 in 1 million per year" [3].

Decommissioning activities are mostly short-term operations that last from months to a couple of years, differently from E&P activities, that are long term activities, supposed to operate 24 hours a day for 25-30 years. So, the risk indicators used in comparative assessment must reflect such conditions, which is not the case of traditional PLL and IRPA [6]. Different decommissioning options may have tasks which require very different number of person-hours to be completed. PLL and IRPA are both based on long-term average frequencies, expressed on an annual basis, and therefore are not apt to reflect the durations of different tasks of each decommissioning option.

In the Guidelines [1] it is proposed the use of the PLL indicator to measure the expected number of fatalities during the realization of the decommissioning option. In this sense, for the occupational risks it must appropriately take into account the number of person-hours required to accomplish the tasks of each option; for the case of major risks which are characterized by an event frequency (for example, the risk of collision of a passing ship with decommissioning ships), the PLL for the option has to assess the probability that such an event happen during the time predicted for the execution of the option (its duration).

3.1 Comparative Assessment Mindset

In comparative assessments there is no need to perform an assessment of "absolute risk". There is no intention to search to minimize the risks of each option by proposing additional safety measures or barriers at this stage, but rather using the risk assessment as a tool to compare the options with respect to the risks they impose. After running the comparative assessment and finding the preferred option, a full risk assessment can be conducted for the chosen option, then with the view of reducing its risks to the ALARP condition.

So, at the comparative assessment development phase, only relative risks among the various options need to be assessed and this means that the values that are obtained this way cannot be used for compliance with legal requirements.

With this mindset, instead of defining the PLL as the long-term average rate of fatality per year, it was defined in the Guidelines as: "the average number of fatalities resulting from the (finite duration) activity". The risks to the workers during the operation of an offshore platform could be expressed by the equation below:

$$PLL = \sum_{i=1}^{n} fi\ X\ Ci\ (fatalities/year)$$

Where:

Pi is the probability of occurrence of the i^{th} accident scenario within the duration of the activity, and

Ci is the corresponding number of fatalities in the i^{th} accident scenario.

For a decommissioning activity, the frequency is not a proper way to express the risks between the two options. Considering the comparative assessment of two options, with a frequency greater than the other, but lasting much less: the overall risk of fatality may be smaller. The way proposed in the Guidelines is to express the Risks as probabilities of a fatal accident over the duration of the decommissioning option.

If f is the frequency of an event, considered constant in time, then the probability that the event will not occur within a certain time, ***t***, is given by:

$$P(T \geq t) = e^{-ft}$$

And the probability that the event will occur within ***t*** is:

$$P(T \leq t) = 1 - e^{-ft}$$

If f * t is small, then the probability of occurrence can be obtained by multiplying the frequency and the duration of the activity:

$$P(T \leq t) \approx f\ t$$

Therefore the PLL for a decommissioning option is given by:

$$PLL = Pi\ X\ Ci = fi\ X\ Di\ X\ Ci$$

Where:

f_i is the frequency of the accident,

D_i is the duration of the option, and

C_i is the calculated number of fatalities.

As a conclusion, the PLL can be used in the Comparative Assessment of decommissioning options using the probabilities and not the frequencies.

4. CONCLUSION

The CA of the possible decommissioning options for a set of subsea installations has been considered by various regulatory agencies as a proper method to solve the problem of finding the preferred decommissioning option for subsea installations.

The Guidance Notes on Decommissioning of Offshore Oil and Gas Installations and Pipelines published by the UK BEIS and the OG UK Guidelines for Comparative Assessment in Decommissioning Programmes recommend that quantitative risk assessment techniques should be employed, such as Potential Loss of Life (PLL) and Individual Risk Per Annum (IRPA). Besides, also indicates that risk values should be obtained and compared against UK HSE risks tolerance criteria (max 10^{-3}/year for individual risk).

This paper argues that IRPA is not an adequate risk indicator for decommissioning options, not even the traditional PLL. It is suggested that the PLL indicator should be used to measure the expected number of deaths during the option, using the probability of damage occurring over a period of time required for decommissioning activities. In this case, the PLL is obtained as a probability and not as a frequency.

It is also highlighted in this paper that at the CA development phase, only relative risks among the various options need to be assessed and not “absolute” risks values. The relative risks values will support the differentiating of the decommissioning options from the viewpoint of risk. Once the preferred option is elected, the full risk assessment of that option may be completed and additional risk reduction measures be implemented if necessary.

5. REFERENCES:

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