

## **SOME ASPECTS REGARDING THE REPARATION METHODS USED IN OILFIELD EQUIPMENT**

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**Abstract:** Reparation and maintenance methods used in oilfield equipment domain, especially in the case of masts, are a constant subject that concerns specialists because of the big costs that they involve. For the oilfield equipment engineers, this problem has two important aspects: to prevent and to repair damages that can occur. So, a close technique is needed when reparation is executed, and this technique must provide five principal steps: I- to discover the damages; II- to determine the causes that produced damages; III- to evaluate the load-carrying capacity of the structure in its actual condition; IV- to estimate reparations that must be made; V- to choose and to describe in detail the reparation method.

### **1. GENERAL CONSIDERATIONS**

Service and maintenance methods used in oilfield equipment, especially in the case of masts, are a constant subject that concerns specialists, because of the big costs that they involve.

In the engineering practice, complex problems due to oilfield equipment's service occur. Some of these problems cannot be fully resolved by a theoretical manner and others require a strategic combination between the analytical calculus and the experimental measurements (non-destructive testing).

The latest developments in measurement techniques, the modern recording devices, the automated data acquiring and their evaluation, including the obtained images, are essential elements that contribute to the widespread use of the experimental analysis method and of the non-destructive testing in research and design.

These methods are very necessary in a various directions, like equipments` and structures` design, in order to save energy or raw materials, and to increase their functional safety. These methods are useful, also, for the surveillance of the operating systems, of the equipments and installations, with the purpose of ensuring the utmost safety and minimizing risks. Hence, the methods of the experimental mechanics and the non-destructive testing are very important and needful for the present and future risk management's strategies.

In parallel with design, a monitoring system during execution and during the normal functioning of the equipment is implemented. Since the execution stage, and especially during the normal functioning, all the measurements must give assurances that the equipments` behaviour is according to plan. The measured data are compared to design ones and, if it is necessary, the design data will be modified. I. e., the calculus vademecum will be remade and, after conclusions, the new technical characteristics of the equipment will be set: downgraded, operating under certain conditions etc

The periodical technical inspections have the role to establish non-repairable defects that may remain until the next technical expertise (certification period) and, also, those that affect the safe operation and for which the optimal constructive solution for repairing is indicated.

The operation's safety of machinery, equipments and drilling rigs` resistance structures depends on their condition, able to be determined by using a control method.

The repair work represents a set of specialized operations in order to investigate the appeared defects, to provide spare parts, to perform breakdown service and/or to replace

the defect components, and it is designed to bring the oil and/or intervention rig in a safe good working.

## **2. FUNDAMENTAL STAGES OF ANALYSIS**

The maintenance and the reparation of the metallic structures as masts from the oilfield equipment domain involve two fundamental aspects: prevention and cure. Between these two modes of intervention (prevention and cure), the first one has the biggest importance. In order to prevent a structure's degradation, an important attention to the following three aspects should be given: the materials' quality, the design's and project details' accuracy and the execution's quality.

If a structure's degradation could not be prevented, three solutions can be taken into account: a) abandonment; b) replacement; c) Damage repair; routinely, the repair solution is recommended.

The execution of reparations requires a thorough technique, involving five basic steps:

- step I– discovery of degradation;
- step II– determining the causes which produced degradation;
- step III– evaluation of work's load-carrying capacity in its current state;
- step IV– estimation of the repairs to be made;
- step V– choice and detailing of the repairing method.

## **3. DEGRADATIONS' DISCOVERY**

Taking into account that the metallic structures are submitted, during operation, to some dynamic loads, it is obvious that the probation test, made in the factory, will include a dynamic recording, specific for the operations made during practical functioning.

Comparing the metallic structure's dynamic response with degradations that include the initial dynamic response (realized in factory, as a probation test), it can be established the degraded metallic structure's resistance capacity and, consequently, the degradation's severity.

In order to make a reparation in a successfully manner, the degradation must be observed before it is too late, meaning before the structure breaks down. In practice, this specification seems to be simple and obvious but the facts may contradict it.

By example, a trivial deterioration like steel corrosion can be very hard to discover. The corrosion generally occurs in inaccessible areas of the structure, which can not be protected. In figure 1 is presented a defect that consists in the pitting corrosion of some mast's components.

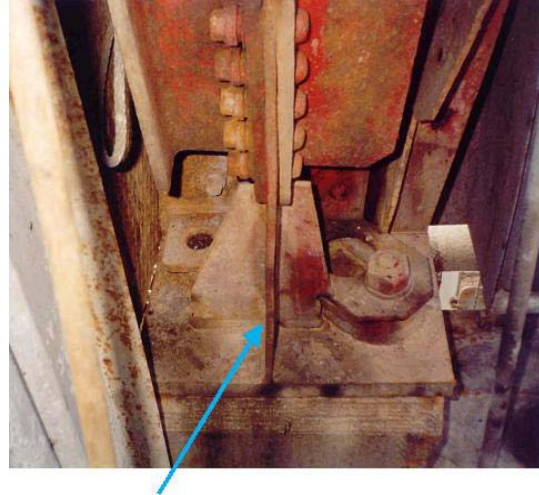
Also, after making the analysis of the resistance structure of a offshore drilling dynamic mast, one observed that a critical area is represented by the mast's base. After making the technical expertise, it was ascertained a gentle torsion of the mast's base brackets, as it can be seen in figure 2.

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It is important to note that the responsible person with structure's maintenance and reparation must have a thorough training that enables him to know where to look, how to look and what to look, with the purpose to be able to detect degradations.



*Fig. 1. Pitting corrosion*



*Fig. 2. Gentle torsion of the mast's base bracket*

Knowing what to look, where to look and how to look requires both knowledge of various kinds of degradation and knowledge of principal causes that produced those degradations; the practical and professional experience becomes essential.

#### **4. DETERMINING THE DEGRADATION'S CAUSES**

This is the most difficult and the most important step of all listed above. When the deteriorations' causes are not known, the best repairing methods can not be chosen or used.

However, there are frequent cases for which damage causes can not be identified because there are not enough data regarding their origin or because there are many destructive agents acting at the same time. In this situation, possible causes are eliminated step by step until the predominant cause is detected. This way, one can choose which repairing method will improve the actual state of the metallic structure and will prevent damage extension caused by all destructive agents

When it is not possible to find the responsible agent for structure's degradation, there must be chosen a method that would prevent further degradation caused by any agent.

Generally, the fact that the causes of a degradation are not known has an impact on repairing costs, which become significantly higher than the case it could be accurately determined. It is also possible, in this, case, to choose an inadequate repairing method.

In order to detect degradation causes, there are no rules and no general available methods. Each case is a particular problem that should be the subject to a particular diagnosis. However, experience allows the formulation of some conclusions regarding specific degradations. For example, cracks in beams located in the third part from the supports and having a route to 45° are produced by shear forces, while the open cracks located in the middle of the beam, at its bottom, are caused by bending moments.

#### **5. VALUATION OF THE ACTUAL LOAD-CARRYING CAPACITY**

In general, the metallic structures, examined in order to detect defects, are working. It must be established as soon as possible if they can be used without danger or whether it is better to reduce their use. If the load-carrying capacity is diminished, the proposal is to interrupt the use of the structure or to take measures to strengthen it. If the metallic structure is not in service, it is essential to know its load-carrying capacity and its safety margin.

The evaluation of the load-carrying capacity of a damaged metallic structure is in itself a problem.

In the case when is a doubt about the strength of a damaged metallic structure, the problem can be addressed by using three methods: pre-assessment evaluation method, the real stress analysis and the loading test.

**Pre-assessment evaluation method** is the most simple. It is to decide whether the strength of damaged elements is above a certain predetermined percentage of their previous strength. They should provide sufficient strength for safe operation of the whole structure. Also, using this method, those elements, having less resistance (lower percentage of default), of the damaged metallic structure, can be detected.

**The real stress analysis** involves the realization of a detailed analysis of stress and strain distributions in the real metallic structure, taking into account the section's reduction and the actual defects that occurred. The method is laborious, but necessary, especially if they require important and costly repairing or consolidations. Usually, the damage is evaluated using the pre-assessment evaluation method; if major repair or important consolidations are needed, then the structural strength is assessed again using a detailed analysis of loads and stress, taking into account all reinforcements.

**Loading test** is realized only when the previous method of calculation shows that, compared with the state of breaking, the safety coefficient has an acceptable value. It aims to eliminate the fearing that the real load does not lead to more serious structural damages. Experience shows that tests by loading do occur, usually, a load-carrying capacity exceeding the resulted one after calculation.

## **6. VALUATION OF REPAIRINGS**

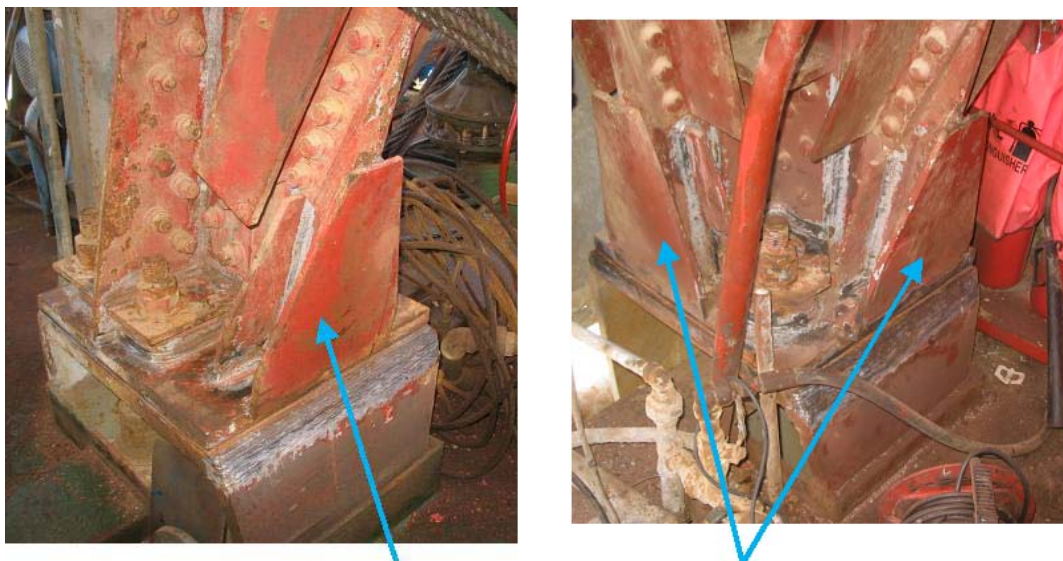
After determining the causes of degradation and after checking the load-carrying capacity of the construction, it must be decided whether:

- degradation may be allowed to continue;
- some measures are necessary or not, in order to use the structure in its real state;
- structure must be repaired or reinforced;
- structure is discarded or rebuilt (where degradation advanced over limit).

The decision will be taken by taking into account economic, aesthetic or safety factors. The final method for consolidation may vary from case to case, for different structural elements of the same structure.

## **7. SELECTION OF REPAIRING METHOD**

Compared with the first four steps, choosing a repairing method is somewhat easier. It must be chosen the least expensive process that reaches, in the most effective way, most of aims. For example, for the detected defect observed at the dynamic mast's base bracket, TD 320-43R, presented in figure 2, the least expensive method is the brackets' reinforcement, as it is shown in figure 3.



**Figure 3. Reinforcement of the dynamic mast's base brackets**

Except elementary cases, repairing works require a large number of fulfilled particular conditions. All these conditions must be provided and clearly set out in advance and in detail. Modifications and changes during the execution of repairing are costly and not always give satisfaction.

Because the repairing works are, in general, expensive and because they are realized, usually, by cutting down the structure during their effectuation, a serious analysis of their opportunity is required. Often a seriously damaged metallic structure, whose resistance is apparently weakened, continues to sustain the load operation. This is explained by:

- metallic structures are calculated, in general, using simplified procedures applied to their schematization. These simplifications lead to a coating calculus and to the increase of the structure's safety;
- structure's calculation is made, usually, in the elastic domain, and the plastic reserves are not taken into account in the case of a statically indeterminate structure;
- loads assumed by calculus are not always met in practice;
- in the design stage, there are chosen elements which standard dimensions are greater than those resulting from calculations;
- the resistance capacity of the metallic structure's material can increase over time due to its cold-working (hardening).

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