POLITECNICO DI TORINO

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A review of offshore platform failure statistics

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ABSTRACT

Traditionally, oil and gas fields are being developed all over the world on the continental shelf. Starting mid-twenty century, large hydrocarbon reserves were discovered in offshore areas and enforced to design, fabrication, construction, and installation of giant offshore platforms. Currently, there are numerous offshore platforms - both floating and fixed were build across the world oceans and seas, producing a substantial amount of crude oil and gas. Due to the specifics of the platforms (such as remoteness from the coast, the concentration of technological equipment and residential premises in a small area, difficulties in supplying people in the event of an accident, a high probability of a cascade development of an incident during the implementation of various initiating events, a high fire and explosion hazard of produced products, etc.), the integrity of offshore platforms is critical for complete service. The offshore platform or offshore drilling rig is a large structure with facilities for drilling wells to explore, extract, store and process oil and natural gas that lies in the rocks under the seabed. Many oil platforms will also have accommodations for their employees. Most often, oil platforms operate on the continental shelf, although they can be used in lakes, coastal waters, and inland seas. Depending on the circumstances, the platform can be attached to the ocean floor, consist of an artificial island or afloat. Remote subsea wells can also be connected to the platform with flow lines and umbilicals. These subsea solutions can consist of one or more subsea wells or reservoir centers for multiple wells. Although there are some international standards and codes for the building of the platforms, yet there is still room for continuous improvement.

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1. Introduction

Petroleum is one of the most important energy sources of age. In addition to being an energy source, it is also used as a raw material in the chemical industry. Petroleum is an important energy source for countries due to its use in many sectors. The rapid increase in oil consumption is leading to a decrease in reserves in the Black Sea. As an alternative to black reserves, accidents occur on the platforms used in the studies carried out at the bottom of the ocean for various reasons. An oil platform, offshore platform, or offshore drilling rig is a large structure with good drilling facilities for exploring, extracting, storing, and processing oil and natural gas contained in rock formations below the seabed. Many oil platforms will have facilities to accommodate the workforce.

Human error, technical failure, etc. for some reason, it is essential to reduce or prevent accidents and maintain the safety of life and property. There are various analytical methods and applications to determine the frequency of accidents, to determine the risk levels of accidents, to assess the post-accident situation, and to prevent/reduce the risk. There are various risk analysis methods applied according to the sector or problem to be addressed. In the second section, accidents that occur in open sea structures are identified and classified. The most common types of accidents have been placed in terms of the frequency of accidents. In the third section, the design platform is described. In the fourth section, an FPSO system was captured, a risk analysis was performed for the rotating tower system with the help of blurred cluster theory, and the results were evaluated in the last section. Accidents in the offshore oil and gas industry are mainly caused by human factors, climatic conditions, mechanical facilities, and technical lapses. Numerous offshore accidents have taken place over the past few decades, such as the Piper Alpha incident in the North Sea on July 6, 1988. This accident was caused by a compromised gas compression module, which resulted in a massive leakage of gas condensate. The leak on ignitions caused explosions and a pool fire on the platform. The first one occurred mainly due to the excessive application of pressure to the aft starboard drains storage tank, where pressure had risen to 10 bars. When the tank could no longer hold the pressure, a rupture occurred, and the fluid inside the tank began to leak. The leakage was followed by a second and more intense blast caused by contact between the spilled gas and an ignition source. The two explosions ultimately caused the destruction and sinking of the giant platform. As a result of the accident, 167 workers died immediately, and nine others were missing and presumed dead.

2. Platform designs and history

Offshore structures are types of systems built for oil and natural gas production in general. It is known that oil produced by offshore structures met 9% of world energy consumption in 1988, and this value reached 24% in 2000. Nowadays, this figure has risen even higher. It is estimated that as time progresses in the world, offshore construction technology will advance further. Among the reasons for this is the increasing trend of energy needs in the world, the decrease in energy reserves on land, and the loss of new oil deposits and new funding sources can be listed. Until the 1950s, shipbuilding and fishing technology were the first to come to mind when it came to offshore technology. However, today, oil and natural gas research on the open sea and parallel to this, extraction of these natural resources from the bottom of the oceans has become much more critical. The economic benefits of oil and natural gas production under the sea are significant. Mostly oil and natural gas drilling, for their extraction, processing, and transportation of the extracted raw material, it is necessary to design and manufacture tools and equipment that were not used until then. In this context, new technologies were needed, and studies on this subject have intensified.

There is an essential need for marine structures today, and their number is increasing day by day in this direction. Since 1940, offshore structures have been built as fixed structures. The water depth of these fixed offshore structures is also increasing. As this depth increases, new calculation methods have to be developed that can take this situation into account.

Offshore structures in the world have increased rapidly in recent years and spread over a wide area. Offshore structures are generally known as platforms. In addition to oil platforms, marine storage tanks, tanker loading platforms, marine structures built on piles, submarine pipelines, and offshore facilities built for wind energy are also included in the offshore group.

Considering that offshore activities include research, design, machinery manufacturing, building construction as well as maintenance and repair of the building during operation, the size of this field of activity arises. These subsea solutions can consist of one or more submarine wells or one or more various centers for multiple wells. Offshore drilling poses environmental challenges from both the hydrocarbons produced and the materials used during the drilling process. The disputes include the ongoing US offshore drilling debate. There are many different types of facilities where offshore drilling operations are carried out (Henderson D. and Hainsworth D., 2014). These include bottom-base drilling rigs (barges and swamp barges), combined drilling and production facilities for sub-base or floating platforms, and deep-sea mobile offshore drilling units (MODU), including semi-divers and drills. These can operate in water depths up to 3,000 meters (9,800 ft). In shallow waters, mobile units are fixed on the seafloor. However, in deeper waters (more than 1,500 meters (4,900 ft)), semi-divers or drills are kept at the required drilling site using dynamic positioning. Around 1891, the first sunken oil wells were built on Grand Lake St. Marys (aka Mercer County Reservoir) is drilled from platforms built on heaps in its freshwater. The broad but shallow reservoir was built from 1837 to 1845 to supply water to Miami and the Erie Canal. Around 1896, the first submerged oil wells in salt water were drilled in part of the Summerland area, which lies below the Santa Barbara Canal in California. The wells are drilled from the piers extending from the land to the channel. Other notable early wreck drilling activities occurred on the Canadian side of Lake Erie since 1913 and Caddo Lake in Louisiana in the 1910s. Shortly thereafter, wells were drilled in tidal zones along the Gulf Coast of Texas and Louisiana. Baytown, Texas, near the Goose Creek area, is one such example. In the 1920s, drilling was done from concrete platforms in Venezuela's Maracaibo Lake. The oldest seashore recorded in Infield's offshore database is the Bibi Eibat well, which flowed in Azerbaijan in 1923 (Jensen, F.V., 1996). The landfill was used to raise the shallow parts of the Caspian Sea. In the early 1930s, the Texas Company developed the first mobile steel barges for drilling in the bitter coastal areas of the bay. In 1937, Pure Oil Company (now Chevron Corporation) and its partner Superior Oil Company (now part of ExxonMobil

Corporation), 14 meters (1.6 m) from the water, 1.6 km offshore Calcasieu Parish, Louisiana, Provided unbiased reviews, articles, recommendations, and opinions.

It is essential to reduce or prevent accidents caused by reasons of life and property. There are various analysis methods and applications to determine the frequency of occurrence of accidents, to determine the risk levels of accidents, to evaluate the situation after an accident, and to prevent/reduce the risk. There are various risk analysis methods applied according to the sector or the problem being addressed. In the second chapter, accidents occurring in offshore structures are determined and classified. The most common types of accidents have been determined according to the frequencies of the casualties. In the third section, the design platform is described. The fourth chapter examines the types of fault identification and protection criteria and vessel impact analysis.

3. General Design

Offshore structures are steel, reinforced concrete, or other composite structures built offshore and in the marine environment, used for various purposes depending on the type of facility. In general, the essential offshore structures in the offshore industries are offshore platforms (with riser/pipeline system) to produce oil and natural gas and offshore wind turbines to generate clean electrical power.

Offshore platforms are used for exploration and extraction of oil and natural gas from the seabed.

Fundamentals of Offshore Structures.

There are four main technical activities in the development of offshore structures in the field of natural gas and oil. These:

- Engineering and design activities;
- Production and storage activities;
- Drilling work for good production;
- Provide the loading system (tank, pipes).

Four basic processes follow from the beginning to the end of an offshore structure:

- Transfer;
- Setup;
- Work;
- Structure Life.

Offshore structures generally consist of steel elements. The setup of the offshore structure is similar to the building stages of a ship, in the installation of these structures, the welding technology that combines sheet metal and some steel elements or the intermediate fasteners of steel elements are of great importance. Problems such as rupture of welding seams or failure of pins to fulfill their duties due to the loads that these structures will be affected by in the long term can cause a massive problem in the structure in the water. Therefore, care should be taken during the installation of the building.

Installation is done either by combining section by section in the sea or at the construction site as a whole.

Offshore structures are manufactured according to their intended use. The general purpose of offshore structures can be said to be the determination of natural resources, especially oil and natural gas, in the seas, their drilling, their extraction, and finally, their processing. The structures to be built for these operations must have specific properties to fulfill their functions. If the task of an offshore structure is the only detection of oil or natural gas, the loads to be exposed will be very different from the loads to be exposed to the offshore structure that will be drilled.

Structure Life

Just as every building has a lifetime, offshore structures also have a working life. However, offshore structures have different features than classical structures due to their working conditions. In general, terms, since these structures are intertwined with petroleum raw materials, the probability of fire, explosion, and such events is much higher than the probability of occurring in a typical structure. The material to be used in offshore structures must also be of very high quality and be of higher quality than the concrete or steel used in typical structures since it is in contact with seawater. The most important feature of these materials is that they must be resistant to corrosion.

Another problem related to the life of the building is the mistakes to be made during engineering and manufacturing. The slightest mistake during the design or the failure of the weld seam or fastener during manufacturing may cause the structure to fail to fulfill its task. This makes building life shorter than expected, which is undesirable.

Offshore Structure Types

Some criteria must be taken into account when determining the type of offshore structure to be built. When these criteria are considered in the most general sense, it can be said as the purpose of use of the building, the working area, and the environmental conditions it will affect.

There are four main types of open sea structures known today:

1. Drill Vessels;
2. Semi-Submersible Structures;
3. Submersible Structures;
4. Fixed Platforms.

About offshore platforms, these structures can be floating or fixed to the seabed, depending on the water depth (shallow, medium, deep), environmental, operational, and geotechnical conditions.

Offshore platforms are used for the exploration and development of natural resources under the sea, especially underwater oil mines. Offshore platforms are grouped under four headings.

1. Jacket Type Platform,
2. Gravity Type Platform,
3. Tension Platform,
4. Jack-Up Type Platform,

Figure 1. Jack up Type Platform

Source https://www.google.com/

These offshore platforms have their distinctive features. In the selection of the platform to be made, the depth of water in the place where the building will be built, the purpose of the building, and the necessary deck equipment according to the intended job play a role.

The general stability of gravity platforms under the influence of external loads from waves and wind is provided by their mass and ballast mass; therefore, it is not required their anchorage with piles to the seabed. Gravity platforms are used in sea areas where the strength of the base sea soil provides reliable stability of the structure (Khakzad, N., Khan, F. and Amyotte, P., 2011).

In the field of production of petroleum products and their subsequent processing, there are a large number of requirements due to high competition in the segment and risks accompanying this area. As a rule, the requirements of customers for organizations prescribe the presence of an ISO standard, API, or an integrated quality management system as a mandatory minimum. In addition to the necessary standards, which are universal for all enterprises, there are also noteworthy (industry) standards that determine the minimum requirements for a quality management system for organizations that produce products or provide services for use in a particular industry segment. The oil and gas industry includes the following standards:

1. ISO - quality management standard for the oil and gas industry [1];

2. API standards - a group of standards developed by the private organization American Petroleum Institute (American Petroleum Institute);

3. Industry standards of organizations. Internal standards of organizations employed in the oil and gas industry. As a rule, ISO is taken as the basis when writing these standards. From the above list, only the standards of the Petroleum Institute react most strongly to new trends in the segment, analyze political and economic decisions, draw conclusions from precedent accidents and events; therefore, the purpose of this work is to analyze the changes that have occurred in the 9th edition of the quality management specification of oil and gas industry producers.

The American Petroleum Institute (hereinafter API) was founded in 1924, in connection with the understanding of the US oil and gas equipment manufacturers of the importance of having uniform standards, regulating the safety requirements for equipment used in oil production. After 85 years, the Institute has published about 500 documents, including 70 specifications and standards for product certification. API standards and specifications found applied in over 70 countries around the world. 80% of API certified manufacturers and suppliers are located outside the US. A large number of API specifications and standards have been adapted to the ISO series.

Approximately 30 standards are specifications for product certification. The requirement of consumers of oil and gas equipment from suppliers of compliance of supplied equipment for compliance with API standards is becoming a priority for large Russian organizations. The absence of API series standards in the organization, as a rule, reduces the opportunity to participate in tenders on international and Russian platforms to a minimum. Unfortunately, today in Russia, about 140 manufacturers have API-certified products. For comparison, in Italy, the API license is used by five times more organizations, according to the Bulletin of the Technological University. China and the United States have over a thousand organizations.

The new 9th edition of the API Q1 specification [3]: Specification of the requirements for the quality management system of production organizations of the oil and gas industry, meets the requirements of the industry to improve the quality management system among production organizations. The new edition of the Q1 specification contains more than 93 new requirements, as well as five new sections compared to the 8th edition, which is based on the ISO standard. Additional benefits of the new edition include an increase in the implementation period by one year and a close relationship with the API Spec Q2 service quality management standard to facilitate quality requirements for organizations with operations on Q1 and Q2.

3.1. Main designing points.

Offshore structures have uncommon financial and specialized attributes. Monetarily, seaward structures are reliant on oil and gas creation, which is legitimately identified with a worldwide venture, which is, thus, influenced by the cost of oil. For instance, in 2008, oil costs expanded around the world, and thus, numerous seaward structure ventures were begun during that time-frame. In fact, ashore structure platform plan and development are a crossbreed of steel structure plan and harbor plan and development.

Just a predetermined number of staff of designing spotlight on seaward auxiliary designing, including the plan of fixed offshore stages, drifting or different sorts, and, maybe because of the set number of seaward basic activities in contrast with the quantity of typical steel basic undertakings, for example, private offices and industrial facilities. Likewise, offshore steel structure development relies upon persistent exploration and study drawn from around the globe. All the major worldwide organizations that work in the oil and gas business are keen on offshore structures. These organizations offer consistent help for innovative work that will improve the capacity of their designing firms and develop contractual workers to help their business needs.

Fixed offshore platforms are one of a kind structures since they reach out to the seafloor and their primary capacity is to hold the modern gear that administrations oil and gas creation and boring. (Mohamed A. El-Reedy (2012))

A strong plan of fixed seaward structures relies upon the exact determination of the applied burden and the quality of the development materials utilized. Most loads that along the side influence the stage, for example, wind and waves, are variable, so the area of the stage decides the meteocean information. Conventional Platform - Steel (sometimes concrete) supports attached to the bottom contain the oil rig, production equipment, accommodation, and additional bays. Such platforms are installed for long production times at a depth of 14 to 500 meters. Steel-supported platforms are not used in ice conditions.

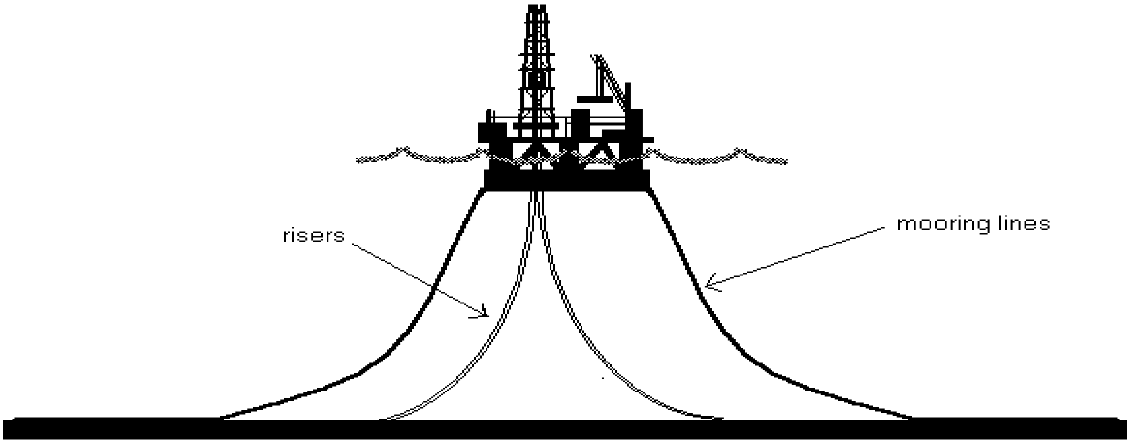

Figure 2. Conventional Platform.

Source: https://www.google.com/search?q=Conventional+Platform&rlz=1C1CHBD

1. Flexible Tower - Fixed platform with multi-section "flexible tower" base. The underwater section is a light and narrow structure that tapers towards the top. The flexible tower allows the platform to work at significant depths; the movable structure compensates for most of the effects of wind and sea

Figure 3. Flexible tower

Source: https://www.google.az/search?q Flexible tower

2. Platform TLP - The platform is held in the exact position of use by a tension cable system. This type of fastening allows you to directly attach wellheads to wells using rigid pipes (risers). However, such platforms are not adapted to heavy ice loads, and also do not have their own oil storage.

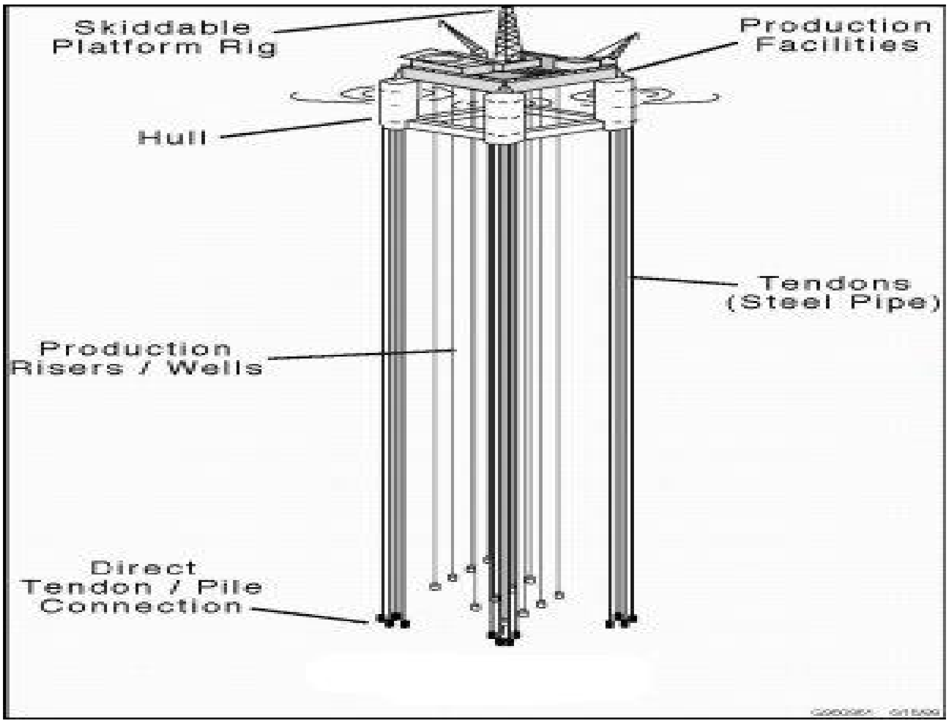

Figure 4. Platform TLP

Source: https://www.google.az/search?q=Platform+TLP++Platforms&tbm=isch&ve

3. SPAR-Type Platforms with an underwater cylindrical base are the largest offshore installations. Consists of a large cylinder that supports a typical rig topside. The cylindrical base is reinforced afloat with cables and ropes and stabilizes the platform, taking into account its movement on the water (Levy, J.K., and Gopalakrishnan, C., 2010).

Figure 5. Platform SPAR

Source: https://www.google.az/search?q=.+SPAR

3.2. Loads

Classification of loads- Loads are classified according to variability over time, application, and the response of the structure. Depending on the type of load, different load safety factors are assigned.

Permanent loads- Constant loads are acting during the entire period of operation of the load, the deviation of which from the nominal value is insignificant.

Constant loads include:

- dead weight of the structure;
- weight of superstructure structures and permanent functional equipment;
- loads due to soil pressure;
- deformations arising during construction;
- loads arising from concrete shrinkage or deformation caused by welding;
- loads from external hydrostatic pressure;
- loads arising from supports and / or soil settlements;
- restressing.

Loads and their combinations:

7.1 General

7.1.1 When determining the loads acting on platforms or their separate parts, the corresponding requirements of the joint venture must be applied 58.13330, SP 20.13330, SP 38.13330, and SP 14.13330 with additions, given below.

7.1.2 When determining the loads on platforms or their parts, Constants should include loads according to SP 20.13330 and SP 58.13330 with the following additions:

- ballast weight;
- hydrostatic pressure;
- efforts from post-stress, etc.

For temporary long-term loads should be referred to as SP 20.13330 and SP 58.13330 with the following additions:

- loads from towing platforms or their parts;

- loads on the VSP from the helicopter stand.

Loads according to SP 20.13330 and SP should be classified as short-term 58.13330 with the following additions:

- loads arising from the manufacture of platforms or their separate parts;
- transport loads within platforms or they're individual parts;
- pressure of solutions during cementation;
- loads from retaining ties when installing platforms or their separate parts;
- loads from landing and takeoff of helicopters, etc.

The special loads include SP 20.13330 and SP 58.13330 with the following additions:

- loads from falling objects;

When determining the loads on platforms or their parts, the following design conditions associated with the repeatability of loads:

- normal (operational), requiring consideration of normal loads (for example, as accompanying loads, as well as in calculations for the second group of limiting states);

- extreme, requiring consideration of extreme loads (for example, to assess the stability, strength of the structure and the soil base on based on calculations using reliability factors);

- special, requiring an account of abnormal climatic and emergency loads when considering individual limit states.

By the relative size of the zone of its influence of the load, each of these categories of design conditions should be subdivided into global (shared) and local (local). Climatic loads should be determined for the most unfavorable angle of propagation of natural phenomena (ice, waves, currents, wind, etc.).

Design values of climatic loads necessary appoint in the prescribed manner based on the analysis of the relevant characteristics of natural conditions at the place of manufacture, transportation, installation, and operation of platforms or their parts. SP (Draft, first edition)-For particular limit states, the safety factors for load γf for abnormal climatic and/or emergency loads should be taken equal to one.

Loads from environmental influences

Environmental loads can be repetitive, continuous, or both repetitive and continuous (Mitra, N.K., Bravo, C.E. and Kumar, A., 2008).

Environmental loads include:

- loads caused by wind;
- loads caused by the impact of waves;
- loads caused by the action of currents;
- loads resulting from marine fouling, snow or ice accumulation and their indirect effect on variable loads and other environmental loads;
- loads caused by the impact of floating ice;
- changes in ambient temperature that can cause stress or affect the properties of materials;
- loads arising from an earthquake.

Cyclic loads are time-varying, long-acting loads that can cause fatigue effects in structures. Loads from abnormal (emergency) effects- Loads from abnormal effects can lead to minor consequences (more often) or cause severe damage to the structure (very rarely).

Abnormal loads usually result from:

- collisions;
- falling objects;
- fires;
- explosions;
- unforeseen sediment of the soil;
- unforeseen erosion or erosion;
- unforeseen flooding.

Wind loads- Standard wind loads on platforms or they're individual parts should be determined taking into account the relevant provisions of the joint venture

Variable loads - acting during the entire period of operation (not including environmental loads), the value of which can vary.

Variable loads include:

- loads arising during operation, including loads from cranes, loads on the hook of a drilling rig, loads from various ballast, helicopters, products, stocks, etc .;
- the deadweight of temporary structures and equipment;
- loads arising during construction, transportation, and installation;
- all loads associated with movement, such as loads from the movement of the oil rig;
- functional changes in the operating temperature, which can cause stresses or affect the properties of materials.

Classification of loads in accordance with the variability of their direction of action in space Loads by the variability of the direction of their activities in space are divided into two groups:

- fixed (constant) loads, the direction of action and points of application of which does not change over time (Mokhatab S., Poe W and Speight J. 2006);
- free (temporary) loads, the direction of action, and points of application of which can change over time.

Loads that cannot be classified into any of these groups can be considered as consisting of a fixed and a free component. When considering freeloads, different load combinations must be considered (Khan F., Hashemi S.J., Paltrinieri N., Amyotte P., Cozzani V. and Reniers G., 2016: p.12). The design situation is determined by fixing the position of each freeload. Classification of loads depending on structural response Loads are classified depending on the reaction of the structure:

- static loads that cause a static reaction without significant acceleration of the structure or its elements;
- dynamic loads that cause significant acceleration of the structure or its elements, i.e., dynamic response.

NOTE - Regardless of whether the load is considered dynamic, it depends on the structure and the source that caused it. For simplicity, dynamic loads can often be viewed as equivalent static loads in which the dynamic effect, depending on the behavior of the structure, is accounted for by increasing the primary static load value accordingly or by adding a representative series of inertial loads appropriate to the type of structure.

3.3. API and ISO standards for platforms

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies (ISO member bodies). The development of International Standards is usually carried out by ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO are also involved in the work. Regarding electrotechnical standardization, ISO works closely with the International Electrotechnical Commission (IEC). International Standards are drafted by the rules given in the ISO / IEC Directives, Part 2 The main task of technical committees is to prepare International Standards. Draft International Standards adopted by technical committees are circulated to the member bodies for voting (Khan F.I., Sadiq R. and Husain T., 2002). Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote. Note that some of the elements of this International Standard may be the subject of patent rights. ISO cannot be held responsible for identifying any or all of the patent rights. International Standard ISO 13500 was prepared by Technical Committee ISO / TC 67 Materials, equipment and offshore platforms for the oil, petrochemical, and gas industries, Subcommittee SC 3 Drilling and completion fluids.

This International Standard applies to materials commonly used in drilling fluids for the oil and gas industry. These materials are used in large quantities, can be sourced from a variety of sources, and are available commercially. Products supplied from a separate source or limited source, as well as select products, are not considered International Standards are published to facilitate the transfer of information between buyers and manufacturers, ensuring the interchangeability of similar equipment and materials purchased from different manufacturers at different times, and an appropriate level of safety when the equipment or materials are used for their intended purpose (Kletz T.A., 1999). This International Standard sets out the minimum requirements and does not prevent anyone from purchasing or producing materials that meet the requirements of other standards. This International Standard is mainly based on API Spec 13A, 16th Edition, February 1, 2004. The development of International Standards is usually carried out by ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO are also involved in the work. Regarding electrotechnical standardization, ISO works closely with the International Electrotechnical Commission (IEC).

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- Part 1. Design and operation for meteorological conditions
- Part 2. Methods and design criteria for seismic conditions
- Part 3. Construction of superstructures
- Part 4. Geotechnical analysis and foundation design
- Part 5. Load control in design and construction
- Part 6. Offshore works
- Part 7. Retention systems for floating and mobile offshore structures

- ISO 19900, Oil and gas industry. General requirements for offshore facilities;
- ISO 19901 (all parts), Petroleum and natural gas industries. Special requirements for offshore facilities;
- ISO 19902, Oil and gas industries. Stationary steel offshore structures;
- ISO 19903, Oil and gas industries. Stationary reinforced concrete offshore structures;
- ISO 19904-1, Petroleum, and natural gas industries. Floating offshore structures. Part 1. Monohulls, semi-submersible drilling platforms, and rods
- ISO 19904-21), Oil and gas industries. They are floating offshore structures. Part 2. Platforms with vertical tension anchoring

- ISO 19905-1, Petroleum, and natural gas industries. Evaluation of mobile offshore structures depending on the place of work. Part 1. Moving jack-up rigs;
- ISO / TR 19905-22), Oil and gas industry. Evaluation of mobile structures of the continental shelf, depending on the place of work. Part 2. Explanation of jack-up rigs;
- ISO 19906, Petroleum and natural gas industries. Arctic offshore facilities
The series of International Standards for offshore facility types from ISO 19900 to ISO 19906 provides a general framework covering those aspects that relate to the design requirements and assessment of all offshore platforms used for oil and natural gas production worldwide. The intent is to provide levels of reliability that are suitable for offshore installations with or without personnel, regardless of the type of structure and the nature of the combination of materials used (Rouvroye J.. & van den Bliek, e.g., 2002).
ISO 13533 Petroleum and natural gas industries - Drilling and production equipment - Drill-through equipment (Petroleum and natural gas industries. Drilling and oilfield equipment. Drilling through equipment)
ISO 15156 (all parts) Petroleum and natural gas industries - Materials for use in H2S-containing environments in oil and gas production (oil and gas industry. Materials for use in environments containing hydrogen sulfide in oil and gas production)
ANSI / ASME B16.11 Forged Fittings, Socket-Welding, and Threaded (Forged fittings, welded and threaded)
ANSI / ASME B31.3 Process Piping
ANSI / ASME B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids (Pipeline transportation systems for liquids and suspensions)
ANSI / ASME B31.8 Gas Transmission and Distribution Piping Systems (Piping systems for transmission and distribution of gas)

API 75.02 Control Valve Capacity Test Procedure
API J517 Hydraulic Hose Fittings
API J343 Test and Test Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies (SAE 100R Series Hydraulic Hose and Hose Assemblies)
API Spec 5B Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing and Line Pipe Threads (US Customary Units) US measurements)]
ASTM D 1414 Standard Test Methods for Rubber O-Rings (Standard Test Methods for Rubber O-Rings)
DNV RP B401 Cathodic Protection Design
ISA 75.01.01 Flow Equations for Sizing Control Valves
SAE / AS 4059 Aerospace Fluid Power - Cleanliness Classification for Hydraulic Fluids (Aerospace hydropower. Classifications of the cleanliness of hydraulic fluids)

Loads and their combinations.

Traditional values- for different design situations (different groups of limit states), loads must be assigned different values (Khakzad N., Khan, F., and Amyotte P., 2011: p.926). These values are called normative. For some design situations, the load can have two common values: upper and lower. In cases where the effect of a lower load value is more dangerous for the structure, this value will be considered as the most unfavorable. Other guideline values are chosen in relation to some conditions, for example, the duration of exposure and geological phenomenon, and can be expressed as a specific part of the eigenvalue using the coefficient GOST R 54483-2011 (ISO 19900: 2002) Oil and gas industry. Offshore platforms for oil and gas production (Romero I. C., Özg Ökmen T., Snyder S., Schwing P., O'Malley B. J., Beron-Vera F. J., & Wetzel D. L. (2016). Where possible, loads and their abnormal changes should be established based on observations, laboratory tests, or field data. Other sources of information should also be taken into account, such as assumptions based on experience. The values obtained within this group of information are called nominal values. Constant load GOST R 54483-2011 (ISO 19900: 2002) Oil and gas industry. Offshore platforms for oil and gas production. General requirements have mostly unique regulatory significance. When the load is caused by the self-weight of the structure, the value of the standard value of the constant load GOST R 54483-2011 (ISO 19900: 2002) Oil and gas industry. Offshore platforms for oil and gas production. The general requirements will be obtained from the values of the geometric parameters and the average density of the material. In cases where errors in the values of permanent loads are essential, guideline values should be used and, if necessary, both the maximum and minimum guideline value should be determined. Variable loads GOST R 54483-2011 (ISO 19900: 2002) Oil and gas industry. Offshore platforms for oil and gas production. General requirements should be defined by the following values (Pate-Cornell M.E., 1993):

- an expected value of variable load GOST R 54483-2011 (ISO 19900: 2002) Oil and gas industry. Offshore platforms for oil and gas production. General requirements;
- frequently repeated value of GOST R 54483-2011 (ISO 19900: 2002) Oil and gas industry. Offshore platforms for oil and gas production. General requirements;
- constant (quasi-constant) value of GOST R 54483-2011 (ISO 19900: 2002) Oil and gas industry. Offshore platforms for oil and gas production. General requirements;
- estimated repetitive stress history (for fatigue analysis).

For particular purposes, other guideline values may be provided. If guideline values for variable or abnormal loads cannot be determined from statistical data or no relevant data are available, appropriate values can be established based on the available information. The normative value, in this sense, is the nominal value.

The typical values of environmental loads are usually determined based on a given probability of exceeding environmental conditions in one year. Alternatively, the environmental loading can be obtained over a specified return period based on appropriate data on the coincidence of hydro-meteorological conditions and provided that the safety factors are appropriately selected. When considering cyclic loads for the analysis of fatigue states, it is necessary, instead of determining a different standard value of the load, to establish the change in its value over time. It is essential to recognize that structural integrity is a comprehensive concept that includes models for action descriptions, structural analyzes, design rules, safety features, professional excellence, quality control practices, and national requirements. All of the above are related, so changing one aspect of the design alone can upset the balance of reliability inherent in the overall concept and the building system. Consequently, the implications of the changes in the overall reliability of all offshore structures must be considered. This series of international standards for offshore construction types is intended to provide a wide range of building configurations, materials, and technologies without hindering innovation. The following referenced documents are indispensable for the application of this document. For obsolete references, only the edition cited applies. For undated references, the most recent edition of the referenced document (including amendments) applies. ISO 2631-1, Mechanical vibration, and shock. Evaluation of the impact of vibration is not the entire human body (Nielsen, T.D. and Jensen, F.V., 2009).

General requirements.

ISO 2631-2, Mechanical vibration, and shock. Evaluation of the impact of vibration is not the entire human body. Part 2. Vibration in buildings (1 to 80 Hz)

ISO 13702, Petroleum and natural gas industries. Control and suppression of fires and explosions in offshore production facilities. Requirements and guidelines

ISO 19900, Petroleum and natural gas industries. General requirements for offshore facilities.

ISO 19901-1, Petroleum, and natural gas industries. Special requirements for offshore platforms. Part 1. Design and operation are taking into account meteorological conditions. ISO 19901-2, Petroleum, and natural gas industries. Special requirements for offshore platforms. Part 2. Methods and design criteria for seismic conditions. ISO 19901-6, Petroleum, and natural gas industries. Special requirements for offshore platforms. Part 6. Offshore works ISO 19902, Petroleum and natural gas industries. Stationary steel offshore structures ISO 19903, Petroleum and natural gas industries. Stationary reinforced concrete offshore structures. ISO 19904-1, Petroleum, and natural gas industries. Floating offshore platforms. Part 1. Monohulls, semi-submersible drilling platforms, and rods ISO 19905-1, Petroleum, and natural gas industries. Evaluation of mobile offshore structures depending on the place of work.

3.4. Building Materials

Building the main stages of construction are (Pate-Cornell M.E., 1993: p.215):

- manufacturing of a platform at onshore enterprises;
- transportation of the platform to the installation site at the field;
- installation and, if necessary, completion of the platform at the field;
- testing and testing of equipment and systems.

The choice and justification of the platform construction method must be made taking into account:

- platform structures;
- the production conditions of the manufacturer (the presence of slipways and hydraulic structures, lifting and transport and special floating equipment, characteristics of the water area);
- the presence and restrictions of transport links (roads and railways, waterways);
- natural and climatic conditions of the construction area;
- duration of the navigation period;
- the term for putting the platform into operation;
- environmental restrictions in the construction area.

The platform construction project should be based on the following requirements and principles:

- attraction of contractors with experience in the manufacture and construction of platforms or their components;

- attraction of domestic (if possible) enterprises, taking into account the prospects for their development;

- the use of advanced technologies and construction methods;

- coordination of the work of contractors for the manufacture, construction, transportation, and installation at the field;

- assessment and accounting of risks at all stages of construction;

- ensuring the quality of work at all stages of construction;

- ensuring the safety of work and industrial sanitation;

- prevention of environmental pollution.

Decommissioning, preservation, and dismantling

At the design stage, it is necessary to envisage measures for the platform decommissioning, conservation, and dismantling. The main stages of work are (Nielsen T.D. and Jensen F.V., 2009):

- performing the necessary surveys in the water area;

- examination of equipment and structural elements of the platform;

- development and approval of project documentation for the platform decommissioning, its conservation or dismantling;

- platform decommissioning;

- preservation or dismantling of the platform;

- transportation of the dismantled platform to the place of disposal or storage;

- acceptance of work performed. The choice and justification of the method for removing the platform from service, its conservation or dismantling must be made taking into account:

- type of platform construction;

- the results of the survey of equipment and structural elements of the platform at the current moment (Mitra, N.K., Bravo, C.E. and Kumar, A., 2008);

- climatic conditions of the work area, including the characteristics of the water area;

- the available technical means to carry out the work;

- duration of the navigation period;

- environmental restrictions in the area of work.

Design principles for limit states- The performance characteristics of the entire platform or part of it must be considered with reference to individual limit states, above which the structure ceases to meet the design criteria.

Categories of limit states- Offshore platforms, their structures, and foundations should be calculated using the limit state method, while calculations should be made for four groups of limit states:

- the primary limiting state, which characterizes the ultimate strength when exposed to loads (complete unsuitability of the platform, its structural elements, and foundation for operation); - the limiting state according to the criterion of suitability for regular operation, which meets the criteria for the normal functioning of the platform or durability; - limiting state according to the criterion of fatigue, which corresponds to the criterion of destruction under the action of cyclic loads; - a unique (emergency) limit state that corresponds to situations of an emergency or peculiar nature (Levy J.K. and Gopalakrishnan C., 2010).

The main limiting states for offshore platforms include:

- loss of overall strength or stability of the platform system - the base or part of its structure, considered as a rigid whole (for example, overturning);

- exceeding the strength of individual structural elements of the platform

1. In the manufacture of steel and aluminum building structures, steel, aluminum alloys, welding materials (electrodes, welding wire, fluxes, shielding gases), bolts and rivets are used. Steel building structures are mainly made of low-carbon and low-alloy steels of various profiles, aluminum - from aluminum alloys. Range of steel products. Elements of building structures are assembled from parts made of sheet and profile (angles, channels, I-beams, tees) rolled steel. A set of types of profiles with various sizes and geometric characteristics is called a range of

profiles. Rolled steel sheet for building structures is used in four groups (Kletz T.A., 1999):

In the manufacture of building steel structures, the following types of profile steel are used (Usman, A. & Khan, A.N., 2008.):

1. High-grade steel,
2. Channels,
3. Beams,
4. Bent profiles,
5. Steel for windows and lampposts.
6. Section steel is classified into:
7. Angular equal shelf, angular unequal, Strip, Round- square.

Gazprom Neft Shelf intends to achieve recoupment and reaching the rate of return of at least 17.5% for a project of the third category of complexity.

The advantages of this development method:

• experience in the construction of this structure;

• these rigs are designed not only for drilling wells but also for the production and storage of oil before it is sent to the place of the processing;

• direct shipping of oil to tankers. Disadvantages of floating and gravity installations:

• lack of space for placing equipment;

• dependence on climatic conditions;

• Installing subsea equipment on the seabed, drilling (from floating rigs), linking production units to the main platform, and servicing wells from floating rigs throughout the project are incredibly costly;

• The need for staff to stay on the platform for a long time.

Onshore drilling Extended reach drilling makes it possible to penetrate subsea oil and gas deposits by drilling from the shore and eliminates the need to build additional offshore structures and pipelines and carry out related work in areas characterized by the presence of ice and high seismic activity.

The 22-story structure was specially designed to drill long-bore directional wells required for the development of the Chayvo field, located more than 11 km offshore. Because the unit is located in a heated building, Yastreb personnel can work in comfortable conditions even when the sea is covered with a thick layer of ice. This technology can also be used for the development of hydrocarbons in the Arctic Ocean, located at great distances from the coast (Kletz T.A., 1999). The total costs for the implementation of the entire Sakhalin-1 project, which includes the Chayvo, Odoptu, and Arkutun-Dagi fields, amounted to $ 57 billion. The gross income is $ 148 billion. The state income is 40 billion dollars. Technology advantages:

• reduction of high capital and operating costs for large offshore structures, for the construction of pipelines;

• the ability to dramatically reduce the negative impact on ecologically sensitive coastal areas;

• drilling horizontal drainage shafts allow increasing the flow rate of a cluster of production wells while reducing their number.

Disadvantages of offshore drilling:

• technological disadvantages due to the long length of horizontal wells;

• high cost of some technical elements (the use of aluminum drill pipes, measurement systems while drilling, diamond and polycrystalline bits, etc.).

4. Failure identification types and Protection

The leading causes of offshore platform accidents are corrosion, mechanical damage, impacts, and collisions with ships/nets, storms, landslides, metal defects of pipes/fittings (metallurgical, manufacturing defects), others and unknown. The consequences of emergency events are the loss of oil or gas during its expiration, the ignition of a combustible product, injury or death of people, environmental pollution, etc. Even though the intensity of the growth in the construction of offshore platforms dates back to the beginning of the 21st century, accidents at these facilities have been known since the 70s of the last century. In total, since the mid-70s of the XX century, more than 30 significant accidents on offshore platforms with massive loss of life have been recorded. World Offshore Accident Database) gives you access to accident data for diverse offshore facility types. It has been curated since 1975 by experts at DNV GL, providing accident causes, location, social and economic impacts, etc. that prove invaluable for a variety of risk management initiatives.

Offshore accident data for oil and gas facilities

As a result of these accidents, more than 800 people died, damage caused estimated at hundreds of millions of dollars, and invaluable environmental damage as a result of uncontrolled emissions of oil and oil products. The platform design should take into account the possibility of emergencies, which alone or in combination with normal conditions can lead to the onset of the limit state. Potential risks to the structure and its elements include (Talebberrouane, M., Khan, F., Lounis, Z., 2016):

a) errors in design and manufacture due to lack of information, omissions, etc.;

b) the effect of abnormal loads;

c) operational failures that could lead to fires, explosions, overturning, etc.

The measures are taken to prevent such risks mainly include:

- careful planning of all phases of design, construction, and operation;
- elimination of the source of risks or avoidance of risks;
- design, taking into account risks.

When designing, it is necessary to provide for measures to minimize the consequences of possible risks. Design situations are usually dominated by one emergency, acting simultaneously with the anticipated normal operating conditions.

The platform design should take into account the possibility of emergencies, which alone or in combination with normal conditions can lead to the onset of the limit state. Potential risks to the structure and its elements include:

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When designing, it is necessary to provide for measures to minimize the consequences of possible risks. When considering specific risks, design situations should be defined. Design situations are usually dominated by one emergency, acting simultaneously with the anticipated normal operating conditions.

An accident can be defined as adverse events that cause damage to life and property that occur unexpectedly. Accidents occurring on the platforms are involuntary and previously unknown such as the platform becoming unusable or completely sinking.

The seafloors are rich in energy resources such as oil, natural gas, and minerals. Efforts to obtain these resources, which meet most of the world's energy needs, from the seafloor are becoming more and more widespread. With the oil and natural gas industry turning to marine resources, the importance of building and operating offshore structures has increased over time.

Offshore structures are among the most dangerous working areas because of the harsh environment they are in, and their operations require precision. Drilling, one of the most critical functions of the platforms, provides access to the hydrocarbon reservoirs on the seafloor with the help of various equipment. Due to the lack of precise information about the formation flow encountered during the drilling of the seabed accident is likely to occur during the drilling process, sudden and unwanted events such as leakage (kick) may occur. Leakage is defined as the entry of an uncontrolled formation flow into the drill pipe due to the pressure difference that may occur at the bottom of the well. (Walker, S., 2005) Different preventive methods are used to control well flow and against dangerous situations. These measures include protection pipes placed at different depths during drilling, cementing process, and explosion prevention systems at the excellent mouth (Blowout Preventer System - BOP). Among these, the explosion-proof system, which has the most critical place, is the last stage of the protection mechanism created. The system includes various circular preventers and mechanisms that can cut the pipes used during drilling. Risk analysis studies are carried out on explosion prevention systems, which have a significant place in ensuring security in platforms. (Walker, S., 2005)

Offshore platforms are structures used in the exploration and production stages of oil and natural gas resources on the seabed. In parallel with the increasing demand for energy resources in the seas, many functional and structural developments have been observed in the platforms. According to the Danish Offshore Center, the areas of use of offshore structures are listed as follows [1].

- Discovery of oil and natural gas reserves,
- Production activities,
- Bridges and passageways,
- The living quarters.

Factors such as its function, environmental loads to which it is exposed, the depth of the water it will work on affect the form and design of offshore structures. Considering all these factors, platforms are divided into many groups. Offshore structures can be classified as fixed, partially movable, and mobile platforms attached to the seabed. Fixed platforms are the type of platform used mostly in shallow waters. Jacket type platforms and gravity type reinforced concrete platforms can be given as examples of such structures. Instead of fixed platforms as the depth of the working water increases, Partially movable structures attached to the sea bottom have become more suitable for use. Rope towers, articulated towers, and strut platforms are examples. Finally, there are active structures used in deep waters. Semi-wrecks, floating production storage and loading vessels, and jack-type platforms are movable structures. (Wilson, A.G., and Huzurbazar, A.V., 2007).

Well- control is providing the flow and pressure balances of the equipment during drilling is called well control. The first method used for reasonable control is sludge flow. It is based on the principle that the mud stream has sufficient pressure to overcome the formation of flow pressure. If the pressure cannot be adjusted, explosion prevention systems, which are the second control barrier, come into play. These systems, which can stop the flow from the well, it plays a role in the safe continuation of the drilling by maintaining its balance.

Leakage and explosion - As the borehole moves into deeper layers, the formation pressure it encounters increases. If the pressure of the sludge flow is not sufficient to overcome the formation pressure, an uncontrolled hydrocarbon entry into the excellent pipe occurs. This event, called fugitive, is one of the most undesirable situations on platforms. Unpleasant conditions such as leakage and explosion affect the formation pressure and sludge flow pressure.

The explosion-proof system is a kind of safety barrier consisting of many valves, flow lines, and preventive mechanisms used for the safe progress of the operation during underwater drilling. The system, which is connected to the excellent mouth with one end, is connected to the steel pipeline called riser on the other hand. Explosion inhibitors are systems that provide access to the well, continue the drilling flow in a controlled manner, and cut off the hydrocarbon flow in emergencies. (Usman, A. & Khan, A.N., 2008):

Anti-explosion systems generally consist of three parts. These sections are listed as follows:

- Underwater riser package (Lower Riser Marine Package - LMRP),
- Preventive device (Blowout Preventer Stack - BOP Stack),
- Control system.

Underwater riser pack

The underwater riser package is one of the most critical parts of the system due to its ability to be detached from the anti-explosion assembly to ensure the safety of the platform in harsh weather conditions. The LMRP is connected to the assembly part with a hydraulic system-operated fitting, and this part is used for the separation of the LMRP in emergencies. Also, LMRP consists of circular preventers, valves, flexible connectors, and control pods.

Inside the hydraulic power unit on the water, there is a hydraulic fluid consisting of a mixture of water and soluble oil (www.dergipark.org.tr). This hydraulic fluid is used to perform the on-off functions of cutter type blockers and circular blockers. The hydraulic power unit supplies the hydraulic fluid from another reservoir pool. The opening and closing mechanisms of the cutter barriers and circular guards can be easily adjusted manually on the control panels. The central control unit provides the necessary electrical power. Pressure in accumulators via central control unit levels, the amount of sludge sent to the well, and well pressure level can be followed.

Electro-hydraulic cables on the platform are essential parts of the communication as they enable the signals sent from the control room to be transmitted underwater. Although cheaper than cables used in fully hydraulic systems, they are also smaller in size.

Hydraulic flow is sent underwater through a different line. Another equipment that forms the part of the control system on the water is accumulators. There must be one above the water and underwater accumulators. Accumulators generally consist of tubes containing hydraulic fluid under absolute pressure and provide the hydraulic flow required for the operation of the system.

Explosion-proof systems are the most critical security elements used against incidents such as explosion and leakage in underwater drilling operations. Risk analysis studies are carried out in this area to increase the security level of both the system and the platform. In this study, the risk analysis of the system has been made by applying the fuzzy DEMATEL method on explosion prevention systems. In this context, firstly, information was given about offshore structures and drilling operations.

In order to emphasize the importance of explosion-proof systems on platforms, dangerous situations that may occur during drilling are mentioned. Later, explosion prevention systems were defined, and each part constituting these systems was discussed separately. The working principle of each part of the system is mentioned.

After specifying the factors created as a result of the literature studies on the subject, the relationship matrices prepared by the experts with qualitative expressions were specified. By applying the DEMATEL method, the factors were grouped according to their degree of impact. In the study, the error factor that has the most impact on explosion prevention systems was determined as human error. Following this, inadequate inspections and tests and electrical and hydraulic system failures are included. The most affected factors among explosion inhibitors are welding mechanical error problems involving the failure of preventive mechanisms in the system (www.dergipark.org.tr).

The turret is the most crucial system for single point-connected FPSOs. FPSOs connected from a single point cannot be built without a turret. Because in FPSOs, which need flexible and mobile reamers (mostly composite) to work, rails cannot be brought together without a turret. Turrets; Available in different types, internal, external, and removable, permanently. 1. Rotating Tower (T): It provides anchoring from a single point and undertakes the windbreaker function of the FPSO. Rotating tower; It consists of a shaft, body, main bearing, sub-bed, and mooring net

(Zangana, F.S.A. 2012). 2. Fluid Transfer System (FTS): Typical multiple swivel combination. It transfers the fluid process and other signals from the rotary tower to the process areas on the FPSO. It is located on the rotating tower. 3. Tower Transfer System (TTS): It is located at the top of the tower. It turns with the tower. 4. Interface System (IS): It includes the swivel access structure, the mooring lines, and the flexibility under the tower and other equipment. System sub-components that may pose a risk for the rotary tower component of the turret system are listed as follows). Bolting Main tower bearing, Lower bearing assembly, Chain tension, Ship deck upper pivot bearing Tower top, Moonpool and rotating tower cavity, Mooring line, Connection float

4.1. Causes for failure

These factors are described by physical parameters and, where possible, on a database of statistical observations; in this case, the possible combinations of the values of various parameters must be determined. For these parameters, the corresponding design environmental conditions are assigned, which must take into account:

- the type of the designed structure;

- stages of arrangement (construction, transportation, installation, drilling, operation, etc.);

- limiting states.

Generally, two types of conditions should be established, taking into account:

- normal hydro-meteorological conditions that often occur during the life of the platform;

- extreme hydro-meteorological conditions that occur with a particular frequency or probability of occurrence. Extreme, regular, and other hydro-meteorological conditions should be determined based on the results of engineering surveys at the site or on the basis of other reliable data.

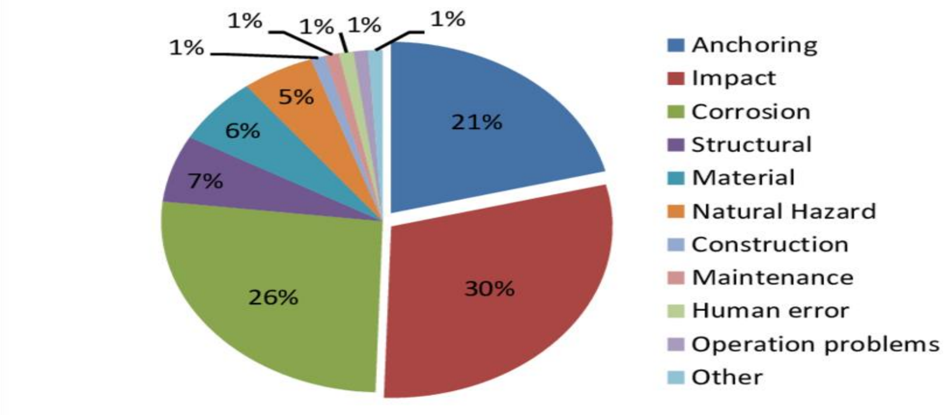

Diagram 1. Causes for failure

Source: https://www.google.az/search?q=Causes+for+failure+in+offshore+platforms

The impacts of the environment are determined by the calculated natural conditions. Extreme environmental conditions are usually characterized by a particular frequency in relation to operating conditions.

Vessel Impact Analysis (case study)

Generally, ships are divided into two categories when considering the risk of colliding with offshore structures:

· Passing vessels

· In-field vessels

Passing vessels are those high seas ships that are not subject to company command. Passing vessels should comply with the rules of safe navigation of the International Maritime Organization and the shipping lanes and maritime exclusion zones specified by the maritime regulations of Azerbaijan when using our water territory.

In-field vessels the ships authorized by the Operating company itself to enter the 500 m exclusion zone of the platform in order to perform some form of service to the platform or its infrastructure.

During the analysis of the vessel impact, when considering the design criteria, two types of impact must be considered: operational and accidental impacts. Operational impacts - are defined as those to be expected during the planned operation of authorized in-field vessels in the vicinity of platforms. Such impacts must be considered only for parts of the system that are exposed to vessel operations, subject to authorization. As these operations primarily supply the platform, the main areas of concern will be faces under the cranes.

Such impacts must be maintained in the service of the installation without adverse effects. The energy needed to be absorbed equivalent to a 3000t vessel moving at 0.7 m/s and must be fully absorbed by the platform; no energy sharing is allowed. In summary, all members must be able to sustain located where vessels are not excluded from operating nearby:

$E = \frac{1}{2} mav^2$

where m = 3000t; a = 1.1 (bow collision) or 1.4 (broadside collision) depending on orientation; v = 0.7m/s

All energy must be absorbed by the platform.

So, the energy level is between 0.80 MJ and 0.102 MJ.

Accidental impacts- are considered to result from passing vessels entering the facility at speeds higher than those specified for the operational impact event (in-field vessel speed). We represent the case of an out-of-control vessel and must be treated for all sides of the system. The impact energy, which must be dissipated without causing the installation to collapse completely, can be reduced to reflect the energy involved in the vessel's damage. The basic impact energy corresponds to a vessel of 5000 t moving at 2 m/s, which can produce up to 14MJ of energy depending on the direction of the vessel. This requirement may be reduced by operators by restricting either the movement of authorized vessels or the environmental conditions under which they may operate near the facility. It is recommended that the energy consumed by the system should not be less than 4MJ unless a specific installation-specific analysis of collision hazards and effects indicates that a lower value is appropriate. If the environmental conditions under which support vessels can approach are placed are limited, the platform benefits are available to limit significant wave height (Hw) to below 4 m. The reduced velocity (V [m/s]) of impact is given by:

$V = \frac{1}{2} Hw$

Limiting the displacement of vessels allowed to operate close to the platform results in significant energy reductions to be absorbed by the system. For example, increasing the vessel's allowable displacement from 5000 t to 3000 t reduces the demand for energy impact from 4MJ to 2.8MJ.

In summary;

Basic Energy $E = \frac{1}{2} mav^2$

where E is at least;

14MJ side collisions

11MJ end collisions

so, a = 1.4 or 1.1; m = 5000t; v = 2m/s

Reduced Energy –

Permitted: the displacement of the vessel (m) is limited

OR b) operations/limiting weather conditions imposed

For a) to be applied, energy to be absorbed by installation may be reduced to

$Er = 0.5 + m^2 (4.2 \times 10\text{-}7 - 5.6 \times 10\text{-}11m)$ MJ

For b) to be applied, $V1 = \frac{1}{2} Hw$

Therefore, to allow energy reduction, height must be less than 4 m, i.e., restrictions must act in such a way that when 4 m height is reached, vessels cannot approach. Two load cases must be included in development against the unintended impact event: the impact case period and the post-impact case. For the installation's the impact case period collapse, loads that may exist in combination with those caused by the impact must be avoided.

The vessel will sustain damage during the impact that will absorb substantial amounts of energy. This will focus on the vessel's position, design, and part of the hit layout. In the case of overall swaying and local bending and denting, the structure will undergo elastic and then plastic deformation. Under these loadings, members of the structure affected may be designed against collapse if they are essential to the structure's stability. Otherwise, local failure can be tolerated if it can be demonstrated that there would be no overall collapse, and re-distribution of the load would be appropriate. When members are impaired, they can pass large loads into the surrounding system, and they must be supported as well. It is a matter of judgment whether members should be designed to withstand or fail accidental loading under them and re-distribute loads to other parts of the structure. If the latter option is taken, there must be enough redundancy in the framework, but it can minimize the Reinforcement of areas remote from the impact zone.

It is particularly important that vessels are prevented from entering jacket structures. This is essential in order to prevent risers and conductors from being harmed and to prevent vessels from being trapped in the framework.

Typically, structural responses to environmental loads are investigated, taking into account the range of potential combinations of environmental parameters and taking into account the relationship taking into account the proximity of the wave period to the period of natural vibrations of the structure. For example, for two different states of rough seas, it is possible that waves with a lower wave height but a longer or shorter associated period will have a more significant impact on the structural elements of the platform (Usman, A. & Khan, A.N., 2008).

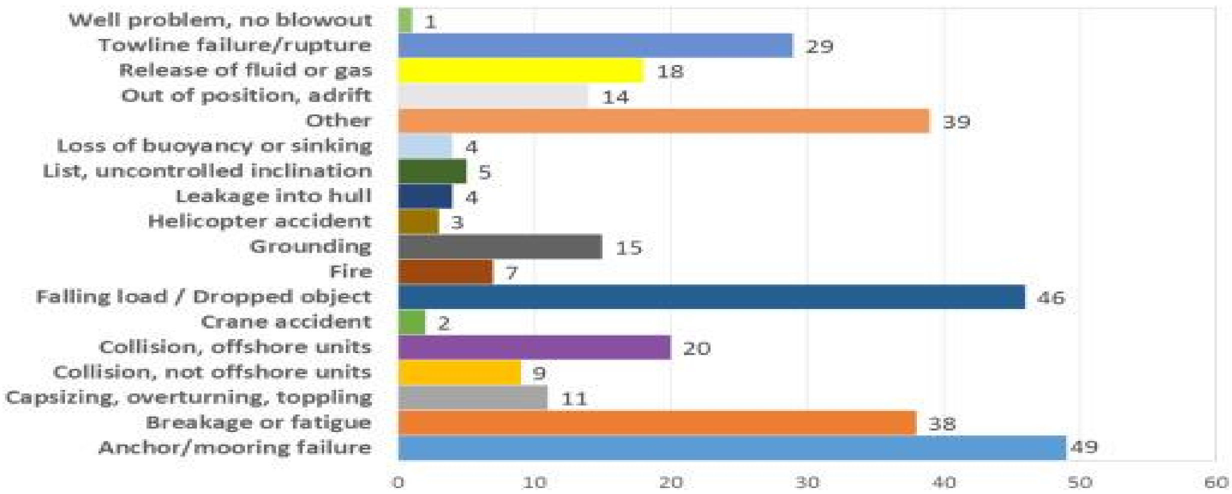

Figure 6. Offshore oil and gas incidents

Source: https://www.sciencedirect.com/science/article/pii/S0029801819302471

Wave forces on structures can be calculated by means of computer programs such as SESAM, also with the help of other small programs. In order to calculate, programs apply the Stoke's fifth order wave theory.

During the calculations, the following values are used:

Drag coefficients (C_d) and Mass coefficient (Cm):

Above means sea level values: $C_d = 0.6$ $C_m=2.0$

Below mean sea level values: $C_d = 0.6$ $C_m=2.0$

The total force on a tubular element of the platform is calculated by the following formula, known as the Morison equation:

$$F = F_D + F_M = 0.5 \times \rho \times C_D \times D \times L \times u2 + C_M \times \rho \times \frac{\pi}{4} \times D^2 \times L \times a$$

Where, F_D is the drag force, and the second F_M is the inertia force. Inertia force can also be called as an added mass contribution. For C_d and C_m, the above-mentioned values will be considered. Those values are used according to UK practice. The density of seawater ρ is 1025 kg/m^3. (Dr. W Visser, 1993)

(u) is the maximum wave particle velocity and (a) is the acceleration at still water level (z=0) expressed in terms of the total wave height H, T is regular wave period:

$$u = \frac{\pi \times H}{T}; \qquad a = \frac{2 \times \pi^2 \times H}{T^2}$$

4.1.1 Natural causes (corrosion and environment)

Corrosion is the decay that metallic materials undergo upon contact with various media as a result of the transition of their constituent elements into a state of combination with environmental substances. This process can be called ant metallurgy because, as a result, the metals return to their natural state. The natural state is represented by the combination of metal elements with other elements, in particular with oxygen, from which it obtains a metallic material through the introduction of energy. This energy is then transferred back to the environment during the corrosion process.

Corrosion is expected in the energy, transportation, chemical, food, oil, and mechanical industries. The damage it does is enormous because it covers the intrinsic value of the corroded metal, the cost of replacing it, and the cost of preventing the destructive process. Simply put, these are all called direct costs. Indirect costs are associated with costs associated with a reduced metal useful life, loss of production, pollution, production interruptions, sudden failure, or explosion. Indirect costs are difficult to predict and often exceed direct costs (Timashev, S. & Bushinskaya, A., 2016).

Positive effect on corrosion- Corrosion does not always mean only damage and loss. There is also structural corrosion when a corrosive attack on metals is carried out to:

1. Emphasize its microstructure;
2. Create a wrinkled or glossy surface;
3. Cover with protective layers;
4. Get matrix type;
5. Perform selective material removal;
6. Generate hydrogen;
7. Create artistic decorations.

Corrosion of metallic material can be of two types:

Wet corrosion - when metallic material is in contact with an environment containing water;

Dry corrosion - when, instead of the environment, gaseous atmospheres are formed at high temperatures.

There are other media, such as salts, molten metals, or non-aqueous solutions, the aggressive action of which cannot be divided into one of two classes. In these cases, corrosion phenomena can take on distinctive aspects of both forms of corrosion.

The different types of corrosion also apply to the mechanism that controls this phenomenon. In wet corrosion, the mechanism is an electrochemical type in which the corrosion process is the product of an anodic dissolution process of a metallic material (with the release of electrons) process in which chemical particles are present in the environment.

Thus, wet corrosion can be described by the laws of thermodynamics and kinetics of electrochemistry. In dry corrosion, a chemical type is used instead of a mechanism. This phenomenon is described by the laws of thermodynamics and kinetics of heterogeneous reactions. Taking into account the stage of the relative growth of oxide layers on the metal surface as an electrochemical mechanism, the kinetics of the process is very complex, since it is associated with several factors (Spouge J., 1999):

1. Adhesion and degree of compactness of the oxide film;
2. Porosity;

3. Control type (ionic or electronic) and conductivity value.

Various methods are used to protect metals from corrosion: alloying of metals, treatment of a corrosive environment, electrochemical Protection, application of metallic and non-metallic coatings.

Alloying metals - make it possible to obtain corrosion-resistant alloys that are superior in resistance to the base metal. Examples include copper alloys (brass and bronze), alloying copper with aluminum to improve corrosion resistance in atmospheric conditions, alloying steel with chromium and nickel to create chromium-nickel alloys.

Processing Of Corrosive Environment - The corrosive environment is treated to reduce its aggressive effect on metal. However, such treatment is advisable with small volumes of electrolytes. Treatment of the medium consists of introducing corrosion inhibitors into the medium or in reducing the content of the depolarizer in electrolytes.

Corrosion inhibitors, introduced into a corrosive environment in small quantities, ultimately prevent metal corrosion or significantly reduce its rate. Depending on the nature of the medium, inhibitors act as inhibitors of acid or alkaline corrosion, corrosion in neutral solutions, in non-aqueous media. In general, inhibitors are organic compounds. In water and neutral aqueous solutions, corrosion inhibitors of steel and cast iron are also sodium nitrite, chromates, and dichromates, phosphates together with chromates. They are all added to concentrations from 0.01% to several percent (Walker S., 2005).

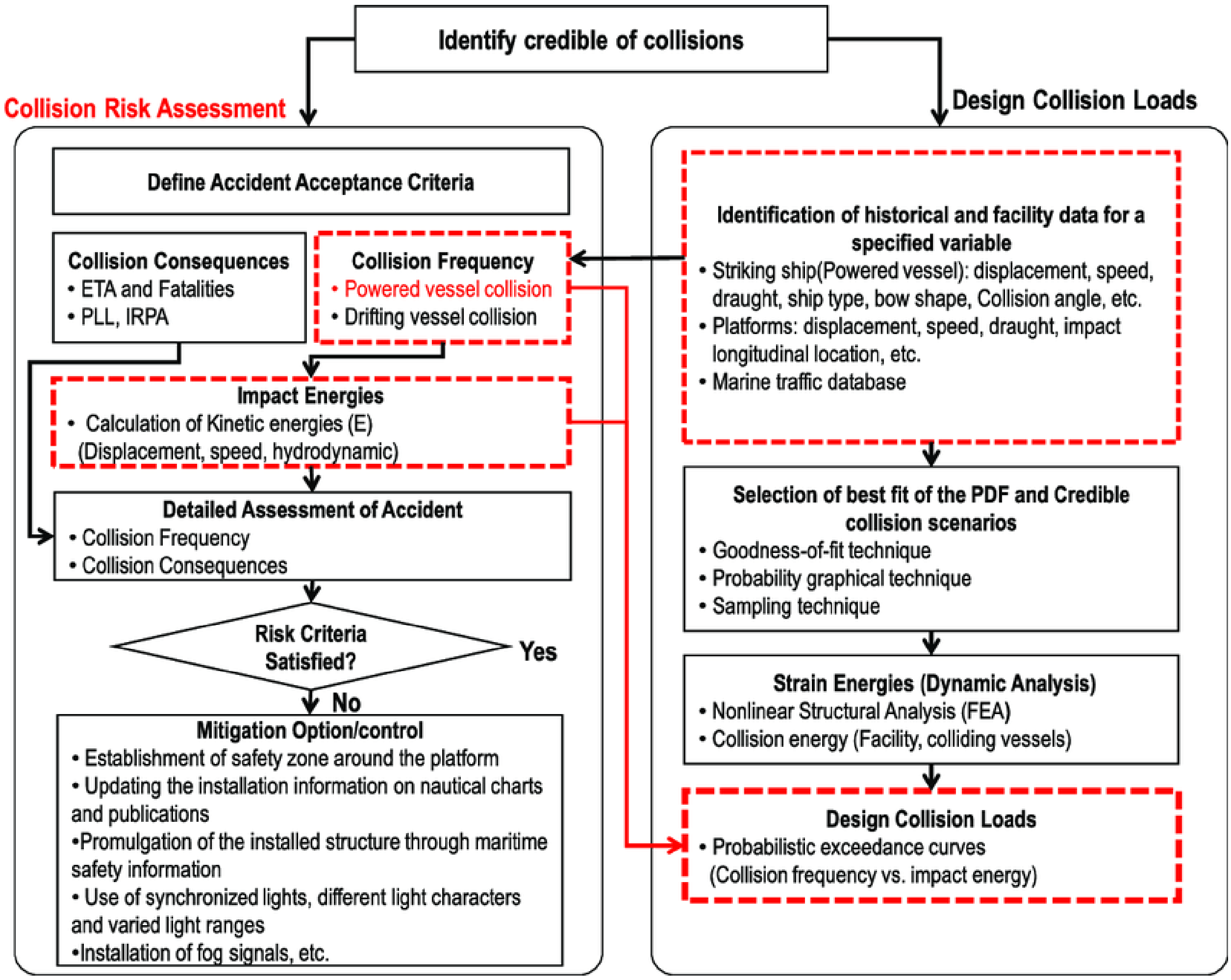

Table 2. Risk assessment

Source: https://www.researchgate.net/figure/Risk-assessment-flowchart-for-ship-to-offshore-platform-collision_fig1_323492089

Wind

The loads on the platform due to the effect of the wind must be taken into account in relation to both the calculation of the overall strength and stability of the platform and the calculations of its individual structural elements. When conducting engineering surveys, information specific to the area of operation should be determined on the speed, direction, and duration of the wind. The wind is usually characterized by the average speed over a specified time interval at a given elevation above mean sea level. In individual cases (for example, when designing flexible structures such as flare booms), the frequency spectrum is essential and must be taken into account. It is necessary to take into account wind changes in height and direction in space. NOTE In general, steady-state wind speed during peak wave loads is used for global strength and stability calculations in conjunction with wave loads. The maximum gusts of wind during a design storm are used in the calculations of structures of topsides and individual structural elements (Spouge J., 1999).

Waves

Loads caused by waves acting on the structure must be taken into account in relation to both the calculation of the overall strength and stability of the platform and the calculations of its individual elements. When conducting engineering surveys, it is necessary to determine information specific to the area of operation, including the following data:

- characteristics of sea waves, including height, period, duration, direction, and spectrum of waves;
- long-term statistics on these characteristics.

Sea level fluctuations and sea depth

When conducting engineering surveys, it is necessary to determine the depth of the sea, the marks of the tides, ebb tides, and the values of the wind surge and surge, as well as possible long-term fluctuations in sea level during the operation of the platform, caused by other reasons. The possibility of soil subsidence during the operation of the field must also be taken into account when determining the calculated values of the sea depth.

Currents- If necessary, phenomena such as tidal and wind currents, global circulation, confinement, and eddy currents should be considered.

Currents are characterized by speed, direction, and change with depth.

Marine fouling- The design should take into account marine fouling of structures, characterized by thickness, roughness, density, and variability with depth. Provision should be made for the use of anti-fouling systems throughout the life of the platform or periodic cleaning of structures. NOTE In most marine regions, fouling occurs on submerged platform structures. Marine fouling contributes to a significant increase in surface roughness, size, and mass, which, in turn, increases the loads caused by waves, currents, and structural vibrations (Wilson, A.G. and Huzurbazar, A.V., 2007: p.2007).

Ice and snow- in areas of operation where ice may appear in the sea, appropriate studies of the ice situation should be carried out, and Fire and Explosion Prevention and Suppression General guidance on fire protection measures and fire and explosion prevention and suppression are provided in the General EHS Guidelines. The most effective way to prevent fires and explosions at offshore oil and gas facilities is to prevent the release of flammable materials and gases and into fast detection and elimination of leaks. Potential sources of ignition should be minimized, and a sufficient distance between potential sources of ignition and combustible materials should be maintained. Offshore oil and gas facilities need to be classified into hazardous areas based on accepted international practice and according to the likelihood of release of flammable gases and liquids. Appropriate measures to prevent and extinguish fires and explosions at offshore oil and gas facilities should include the following (Spouge J., 1999):

• Creation of a passive fire safety system at the facility to prevent the spread of flame in the event of an accident:

Provision of passive fire protection of load-bearing structures, construction of fire-resistant walls, and fire-resistant partitions between premises. o Design of supporting structures taking into account explosive load, or the construction of explosion-proof walls.

The main types of accidents on offshore drilling rigs are accidents during lifting operations and with falling objects (about 70% of the total number of accidents). Also, a significant number of accidents fall on accidents associated with leaks and release of hazardous substances (over 6.5%) and loss of control over wells (7.5 - 8.5%), accidents of anchor systems (about 4.5%), fires (about 4%) and ship heaps (about 4%) (Walker S., 2005).

4.1.2. Causes due to fire

Of the considered types of accidents at offshore structures, 57 cases of collisions (21.5%), 40 cases of emissions, and leakages of produced products were noted emissions (15.0%), 28 fire accidents (10.5%), and 13 explosion accidents (4.9%). Seventy accidents (26.3%) were caused by bad weather conditions. Systematized analysis of statistical data on accidents and accidents, causes and measures to prevent them, as well as violations of the requirements of regulatory documents identified in the process of technical investigation of the causes of accidents at offshore oil and gas platforms, indicates that 70% of the causes of accidents and injuries are organizational, and about 50% of the measures recommended by the commissions during the technical investigation of the causes of accidents essentially relate to the improvement of industrial safety and labor protection management systems. The transportation of oil and petroleum products by sea and river methods in terms of transportation volume ranks second after central pipeline systems. (Rouvroye J.. & van den Bliek, e.g., 2002).

The platform should provide for the creation of at least two fire departments. The personnel included in these units must undergo training in the prescribed manner. The list of equipment for fire departments should include:

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) sets of equipment for firefighters (breathing apparatus, firefighter suits, helmets, battery lamps, safety cables);

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) sets of firefighting tools;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) air-foam fire extinguishers;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) powder fire extinguishers;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) fire hoses and nozzles; JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) of international standard fire connections.

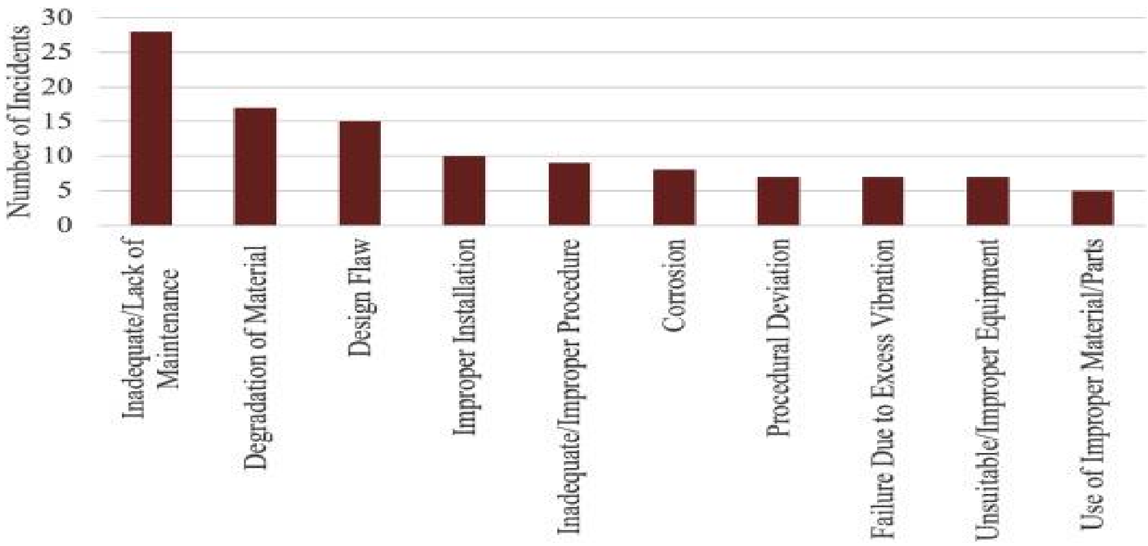

Diagram 2. Fire Failure

Source: https://dergipark.org.tr/tr/download/article-file/1044681

5. Prevention methods of failures

Traditional methods of flaw detection practically do not provide reliable detection of fatigue phenomena in the metal structure due to the insignificant geometric dimensions of the incipient defects. The dimensions of the loading concentration zones are large and significantly exceed the dimensions of a single defect (4). For example, the magnetic colorimetric method is traditionally used to detect loading concentrations only in areas with specific structural features of the structure. Several authors believe that there can be no accident in this since all structures are built according to the same laws and principles of theoretical mechanics and resistance of materials. In assessing the defectiveness of metal (i.e., in the main field of application of non-destructive testing methods), flaw detection methods guarantee high reliability and reproducibility of control only in the conditions of stationary automatic flaw detection equipment of the manufacturer of the metal structure (Walker S., 2005). Operational control of equipment in a mass examination is carried out with manual flaw detectors that do not provide high performance and reliability, as well as reproducibility, not to mention the possibility of automatic generation of reports and filling in the database. Proposed monitoring system by contactless magnetometer method.

Table 3. Quantitative and qualitative risk analysis tools

Analysis Method	Details
Analysis by expert	Uses information from previous experiences centered on the same or similar applications. This approach is classified as a qualitative analysis
Hazard and Operability Study (HAZOP)	Design review technique used for hazard and design deficiencies' identification affecting the system operability. Uses guide words (i.e., more, less, early, late) to describe the deviations. Performed by a multi-discipline team, including a safety specialist to lead the Study

Source:**https://www.researchgate.net/publication/321137529_Failure_analysis_of_the_offshore**

SPE-196952-MS is intended to provide monitoring of the condition of the caisson equipment without stopping it, to notify of the emergence of a critical situation in the process equipment, and to automatically prevent accidents. The particular relevance of these methods is associated with their accuracy, high information content, high productivity, and, mainly, with the possibility of contactless testing (Usman, A. & Khan, A.N., 2008). Their advantage in identifying metal fatigue is very significant. Reducing the risk of pipeline accidents is achieved through the timely identification and elimination of the leading causes of accidents: - factory defects in metal; - defects in welding and assembly works during pipeline construction; - metal defects arising during operation under the influence of natural factors (stress corrosion cracking - SCC, hydrogen embrittlement, ground movement, etc.) (Timashev, S. & Bushinskaya, A., 2016). One of the promising areas of technical diagnostics of pipelines is non-contact magnetometry for analyzing the degree of mechanical stress concentration and monitoring of local concentrators under operating conditions. From this point of view, the method of magnetic tomography is very promising, which is based on the Villari effect and makes it possible to observe the development of a defect from stress concentration to the appearance of the risk of transition to the limiting state [RD 102-008-2002]. This allows you to quickly respond to possible emergencies and prevent failures even at the stage of the emergence of the risk of accidents. The principle diagram of the monitoring system using the method of contactless magnetometry includes the following stages: - making a decision; - outputting information about the technical condition; - analyzing input data; - collecting and transmitting signals - measurements using a set of sensors from 10 to 100 pcs, per one signal processing unit. If necessary, sensors are installed in the anomaly zones to conduct continuous monitoring of the condition of caisson pipelines. An alarm system and informing about the adoption of standard decisions are installed in the control room. The dispatcher team is trained both on-site and in the service company. Data collection is carried out by the regulations. In the process of machine learning of the monitoring system, a step-by-step loading of the caisson tank is carried out, during which typical levels of magnetic response are recorded, which are taken as reference indicators. The monitoring system accumulates a "knowledge base" and, if the set thresholds are exceeded, issues a warning to the control room. Exceeding the threshold value will indicate a critical growth of the detected defect. A system for monitoring the technical condition of the caisson lining by the method of contactless magnetometer has been created.

During the maintenance of the caisson, the non-destructive testing specialists determine the state of the technological equipment. Critical, dangerous, and nascent defects are identified. The required scheduled or emergency repairs are in progress.

5.1.1. Remedies and prevention of corrosion (anodization)

Various treatments are used to slow down corrosion damage to metal objects exposed to weather conditions, salt water, acids, or other corrosive environments. Some unprotected metal alloys are incredibly vulnerable to corrosion, such as those used in neodymium magnets, which can crack or crumble even in dry, temperature-resistant rooms if not adequately treated to prevent corrosion.

Surface treatment

When surface treatments are used to inhibit corrosion, great care must be taken to ensure complete coverage without gaps, cracks, or pinholes. Small defects can act as an Achilles' heel, allowing corrosion to penetrate and cause extensive damage even if the outer protective layer remains intact for a period of time (Walker, S., 2005).

Coatings applied

Galvanized surface- Electroplating, painting, and enameling are the most common types of anti-corrosion treatments. They work by creating a corrosion-resistant material barrier between the destructive environment and the material of construction. Beyond cosmetic and manufacturing concerns, trade-offs are possible between mechanical flexibility and abrasion and high-temperature resistance. Coatings usually only fail in small areas, but if the coating is nobler than the substrate (such as chrome on steel), the galvanic vapor will corrode any exposed area much more quickly than an uncoated surface. For this reason, it often makes sense to cover the plate with an active metal such as zinc or cadmium. If the zinc coating is not thick enough, the surface quickly becomes unsightly with apparent rust. The calculated resource directly depends on the thickness of the metal coating.

The electrification portal made of corrosion-resistant steel= Roller or brush painting is preferable for confined spaces; it will be better for large areas such as steel decks and quays. Flexible polyurethane coatings such as Durabak-M26 can provide an anti-corrosion seal with a robust slip-resistant membrane. Painted coatings are relatively easy to apply and dry quickly, although temperature and humidity can change drying times.

Reactive coatings- If the environment is under control (especially in recirculating systems), corrosion inhibitors can often be added. These chemicals form an electrically insulating or chemically impermeable coating on exposed metal surfaces to inhibit electrochemical reactions. Such techniques make the system less susceptible to scratches or coating imperfections, as additional inhibitors can be available wherever the metal is exposed. Corrosion inhibiting chemicals include some hard water salts (Roman water systems are known for their mineral deposits), chromates, phosphates, polyaniline, other conductive polymers, and a wide range of specially formulated surfactant-like chemicals (such as long-chain organic molecules with ionic end groups).

This escapement is anodized yellow. Aluminum alloys are often surface treated. The electrochemical conditions in the bath are carefully controlled so that homogeneous pores several nanometers wide appear in the metal oxide film. These pores allow the oxide to become much thicker than the passivation conditions allow. At the end of the treatment, the pores are closed, forming a harder-than-usual surface layer. If this coating is scratched, normal passivation processes take over to protect the damaged area (Romero, I. C., Özg ökmen, T., Snyder, S., Schwing, P., O'Malley, B. J., Beron-Vera, F. J.,& Wetzel, D. L. 2016).

Anodizing is very resistant to weathering and corrosion, so it is usually used for building facades and other areas where the surface will regularly come into contact with elements. Although flexible, it needs to be cleaned frequently. If left uncleaned, the edges of the panel will appear naturally. Anodizing is the process of converting an anode to a cathode by bringing a more active anode into contact.

Biofilm coatings- A new form of protection was developed by applying certain types of bacterial films to the surface of metals in highly corrosive environments. This process significantly increases the corrosion resistance. Alternatively, antimicrobial-producing biofilms can be used to inhibit sulfate-reducing bacteria corrosion of mild steel.

5.1.2. Other prevention methods

In the operator platform and the emergency control center, as well as in prominent places on the platform, plans for the general location of the ROP shall be permanently posted, on which for each deck it shall be clearly shown:

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) location of control posts;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) location of fire-resistant structures;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) premises equipped with fire alarm installations;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) of the premises and zones protected by fire extinguishing installations, water irrigation, and water curtains, indicating the location of devices and fittings to control their operation;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) location of fire hydrants;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) location of primary extinguishing means; JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) access routes to various rooms and to platform decks with an indication of escape routes, corridors, and doors (Wilson A.G. and Huzurbazar A.V., 2007);

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) ventilation scheme, including the location of dampers and fan control posts, as well as identification numbers of fans;

JV project Offshore fixed platforms for oil and gas production on the continental shelf. Fire safety requirements (first edition) of the location of the documents specified in clause 22.3 of this joint venture. In a separate folder, kept in an easily accessible place, there should be instructions for the maintenance and use of all means and installations for extinguishing and localizing a fire. Plans and documents should be updated continuously, and any changes in the platform fire safety system should be made to them within a month. Routine maintenance and preventive maintenance of fire alarm and fire extinguishing installations, smoke protection systems, fire warning, and evacuation management should be carried out in accordance with a schedule drawn up on the basis of the technical documentation of the manufacturers and the timing of repair work. These works must be carried out by specially trained personnel or a specialized organization that has permission for this type of activity.

During the period of maintenance or repair work related to the shutdown of installations (individual lines, detectors), the necessary measures must be taken to protect the structures, premises, and technological equipment of the platform from fires (Rouvroye, J.. & van den Bliek, E.G.., 2002).

5.1.3. Reinforcement of platform steel during the lifetime

The use of unalloyed steel (i.e., mild steel or carbon steel), from which most of our fasteners and assembly products are made, requires corrosion protection. In most environments, the corrosion rate of carbon steel (typically around 20 μm per year (μm / year) in rural outdoor areas and up to 100 μm / year in coastal areas) is usually too high to achieve satisfactory results with this material. In product development, the loss of base material is usually not considered. Therefore, Hilti offers a wide range of suitable and rational solutions for the corrosion protection of carbon steel products. However, in an alkaline environment, iron and steel are usually stable. This explains, for example, the fact that reinforcement made of carbon steel is already sufficiently protected against corrosion in the alkaline environment of the surrounding concrete. Steel with at least 10% chromium is called stainless steel. The addition of chromium leads to the formation of a stable and very thin (several nanometers) oxide layer (passivation layer) on the metal surface. Therefore, stainless steel does not corrode and does not stain when in contact with water, unlike carbon steel. However, under certain circumstances, the passivation layer can degrade, leading to a localized form of corrosion, such as pits. Pitting corrosion, which is the main form of corrosion that occurs on stainless steel, does not provide an accurate estimate of product life, unlike zinc-coated products. In general, for each specific application, it is necessary to select a stainless steel grade that would retain stability and will not corrode under appropriate environmental conditions. The resistance of stainless steel to pitting corrosion can be roughly estimated using the "PREN" value (Pitting resistance equivalent number). The PREN value depends on the chemical composition of the steel and takes into account the amount of chromium, molybdenum, and nitrogen contained in the steel. In the scientific literature, there are various methods of calculating this indicator. Most commonly used the following formulas: PREN =% Cr + 3.3 x% Mo (for stainless steels with molybdenum content less than 3%)

PREN =% Cr + 3.3 x% Mo + 30 x% N (for stainless steels with molybdenum content equal to or more than 3%)(Pate-Cornell, M.E., 1993).

The type and size of the protector are selected to ensure the durability required current output by the protector, technological product, and convenient and easy assembly. The following types can be used to protect the offshore structure protector: long-lasting, bracelet, etc. A type of protector that is widely used for long-term protection of large structures operation: offshore platforms, flyovers, etc., is a boom with round and refectory profile. The main advantage of such a protector uniform current distribution and gives a high yielded protector current and has high efficiency. Optimal the distance between the bottom of the protector and the surface of the cathode is 250mm - 350mm. When calculating and designing protective protection, the type and the size of the anode to ensure the required service life. Dwight's formulas determine the resistance here for relatively extended anodes:

$$R=\left(\frac{\rho}{2\pi L}\right) * [\ln\left(\frac{4L}{r}\right) - 1]$$

$$R=(\rho/2\pi L) * [\ln\left(\frac{2L}{r}\right) - 1]$$

$$R=(\rho/2\{\ln [2L/r(1 + \sqrt{1 + (\frac{r}{2L})2)]} + r/2L- \sqrt{1 + \left(\frac{r}{2L}\right) 2)]}$$

$$R=\frac{\rho}{2S}$$

$$r = \sqrt{\rho}/\pi$$

The anode resistance is determined as follows:

where p is the specific resistance of the medium,

L is the anode length, m;

r - radius of the anode profile, m.

p I - resistivity of seawater.

p 2 - resistivity of bottom soil, h - sea depth, m;

When the anode current flows, the calculation is carried out according to Ohm's law:

- In minus 1.05 V. Therefore, the change in potential between the protector and construction at the initial time of 0.45 V. A change in this potential, sufficient for cathodic polarization of the structure (Nielsen, T.D. and Jensen, F.V., 2018).

6. Abandonment & Decommissioning (end life of platform)

Decommissioning of offshore hydrocarbon field facilities (offshore oil platforms, established wok and structures) is the last stage of the life cycle of field development. In European legislation, decommissioning is the reuse, recycling, and disposal of offshore end-of-life complexes of field facilities or their parts. In US law, the decommissioning of offshore oil and gas facilities for the development of a hydrocarbon field is a process of terminating offshore oil operations in an offshore field and the return of the ocean and seabed to its original state. As of May 31, 2013, the total number of production platforms in the Gulf of Mexico was estimated at 2,900. ~~In the period 2002-2003. Removed from the Gulf of Mexico: 795 anchor blocks, 1037 topsides, four floating complexes.~~ There are currently more than 1,500 offshore facilities in the North Sea, including small steel platforms weighing less than 100 tons, large reinforced concrete gravity structures, or steel weighing up to 0.5 million tons, floating installations, subsea production systems, etc. The platform decommissioning, conservation, or dismantling project should be based on the following requirements and principles:

- attracting contractors with experience in performing these types of work;
- attraction of domestic (if possible) contractors, taking into account the prospects for their development;
- the use of advanced technologies and work methods;
- assessment and accounting of risks at all stages of work;
- ensuring the quality of work at all stages of work;

- ensuring the safety of work and industrial sanitation;
- prevention of environmental pollution.

In the period from 2016 to 2020 in the UK sector, 157 offshore complexes will cease production in the Norwegian sector - 18. By 2020, the UK plans to decommission 60% of the complexes that worked at the beginning of 2012, Norway - 15%. In the UK, due to the historical development of its shelf, the market for decommissioning fields will dominate in the next 10-20 years. At the moment, the calculations for me experts agree that work on the shelf to decommission the infrastructure of nearly two hundred fields will cost the industry \$ 43 billion to \$ 50 billion. These figures will largely depend on the method of decommissioning, as well as on many other factors (age of the field, distance from the coast, etc.).

At the current stage, four Decommissioning Plans have already been approved and implemented. In the next five years, approximately 30% of all sections of the country's continental shelf will be dismantled. Dismantling each component of offshore platform infrastructure is a costly and laborious process that requires advance and detailed planning. Participants in the process must be familiar with the pervasive list of regulatory and legal mechanisms that include the process of decommissioning deposits. However, apart from the approval of the Decommissioning Plan, the mining companies are no other legal issues need to be determined in advances, such as the distribution of responsibilities enshrined in the Operating Agreement, the risks of potential litigation with contractors, and compliance with international, regional and local environmental laws. Thus, due to the lack of comprehensive legislative regulation of the decommissioning of deposits, Russia should now begin to develop this area (Nielsen, T.D. and Jensen, F.V., 2009).

Moreover, further introduction of the necessary regulatory measures will require a revision of the existing legal regulation of the oil and gas industry. Project financing issues should be included in the initial stages of companies' access to offshore operations countries; it will be necessary to revise the qualifications required to access the deposits (Pate-Cornell M.E., 1993).

7. Conclusion

As in every sector in the industry, risk and safety analysis methods are widely and effectively applied in the marine sector. There are various analysis techniques according to the nature of the problem addressed in risk and safety analysis. In cases where the values of the error rates/probabilities/frequencies of the subcomponents that cause the error/accident in a system are not numerical (exact) data, classical risk analysis techniques fall short. In this study, risk analysis methods and their application areas are briefly mentioned.

The results and recommendations obtained from the study carried out for this purpose are presented below:

In the thesis study, the offshore structures that have found application areas in the world are classified, their geometric and structural features are introduced, and the conditions and conditions in which each class is preferred have been examined. In the design of offshore structures, it is essential to determine the loads and predict the behavior of the structure against loads. Air temperature, water temperature, seawater currents, wave properties, wind data such as sea conditions, and earthquake conditions must be determined correctly. To determine them correctly, it is necessary to have data accumulation for many years.

In this study, the general characteristics of these loads and the parameters needed to determine them are presented. The vessel impact analysis has been conducted. The offshore building design is quite different from typical building type structures and requires special knowledge and expertise in this field.

There are benefits in terms of the following points come to the fore when designing an offshore structure:

• Environmental conditions of the offshore structure, collection of wave data, current to know the situation, to examine the wind graphs in the region,

• Determination of design wave, wind, and current characteristics, Calculation of hydrodynamic forces and wind forces arising from waves and currents that may affect the structure,

• Considering the earthquake force, ice, and snow force and the forces arising from temperature difference according to the region where the building is located,

• Analysis of the effects that occur during the operation, transportation, and sinking of the building, Fatigue analysis that may occur in the fasteners of the structure, the ground analysis required for grounded structures.

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