

FORCE MOMENT REDUCING DEVICE (MR - D)
FOR USE WITH SELF ELEVATING DRILLING OR PRODUCTION RIGS,
VESSELS OR PLATFORMS
(OIL & GAS INDUSTRY)

DESCRIPTION

Field of the Invention

This invention relates to the design of an apparatus and a method called Force Moment Reducing Device (or 'MR-D') for reducing the force moment induced in a jack up rig (Unit) that arises from weather and environmental conditions. The maximum induced force moment determines the design of the leg and how structurally strong it is to be. When the force moment effect is reduced by the device in this invention, the jack up rig is able to work in harsher environment or deeper water compares with when it is not equipped with this device. Fundamentally, it is a different and innovative design/method enabling the reduction of stress in the leg structural members at the leg-hull interface. Not only is the design unique and innovative, the system as a whole is made very simple and pragmatic, a concept never used before by similar or related stress reducing systems such as the "Fixation system" or "Rack Chock system".

This invention, apart from performing its intended function for the Unit, is shareable among Units. Because its application is essentially different and more pragmatic and is used only when the weather or location conditions requires it, it is called the Force Moment Reducing Device and in short form known as "MR-D" to distinguish it from "Fixation system" or "Rack Chock system" used in some current rig designs.

A typical Fixation or Rack-Chock system used in a self-elevating or jack-up drilling rig or platform is depicted in **figure 1**. The following terminologies common in a Unit are defined below to assist in understanding the novel application of the MR-D.

Terminology	Description
Leg	The self-elevating drilling rig, platform or equipment system stands on ‘legs’ that are firmly preloaded in sea bed. The number of legs can be 3 or more. Such legs are often made with a lattice structure.
Rack	The solid piece of steel plate cut to rack profile shaped with gear teeth.
Chord plate	The reinforcement plate to make the rack as a strong structural element integral with the Leg structure.
Pinion, Driving Pinion or Jacking system	The driving element is in the shape of a gear pinion, and is powered by electric or hydraulic motor through a gear-chain to reduce rotational speed and increase torque force in an assembled unit commonly known as the ‘Jack Unit’.
Jack Case Structure	The structure connected to the body of the self-elevating drilling rig, vessel or platform to house the ‘Pinion Assemblies’ or ‘Jacks’ enabling the rig, platform, vessel or equipment system to self-elevate on the legs.
Fixation system	Typically known as the locking jaw with the leg rack element to hold and render the leg as an integral part of the rig body. It can fully or partially take over from the ‘Jack Unit’ in holding up the total weight of the elevated platform. Such a system is permanently fixed to the rig.
Rack Chock system	Typically known as the locking jaw with the leg rack element

	to hold and render the leg as an integral part of the rig body. It can fully or partially take over from the 'Jack Unit' in holding up the total weight of the elevated platform. Such a system is permanently fixed to the rig.
Power pack	The power system to support and drive the Fixation or Rack Chock system in order to operate it. It can be by means of hydraulic or electric.

Background of the Invention

To appreciate the novelty of the invention, it is important to know the current systems used on the Unit in countering the bending or force moment induced in the Unit. Fixation or Rack-Chock system are now used in conjunction with self-elevating drilling or production rigs, vessels or platforms (Unit). Its purpose is to 'lock' the legs with the Unit's hull so that they can be considered as one integral body therefore absorbing the leg bending or force moment substantially or totally at this engagement location thus eliminating contacts to a great extent between leg and upper and lower guides. It can also take over and support the lifted platform partially or fully.

Such apparatus described above and other variations of such design achieve their objective in reducing induced stress at the chord or braces, therefore the leg structural scantling can be reduced in design for specified weather and environmental conditions. In other words, the apparatus is then required to be applied most times, if not all times. This means it is a permanent fixture on the Unit.

A typical Fixation or Rack-Chock system is illustrated in **figure 1.0**. It shows its 'dis-engaged' and 'engaged' positions. **Figure 2.0** shows the typical location of such a Fixation or Rack-

Chock system on a Unit. The jack case or structure is normally designed to incorporate such a Fixation or Rack-Chock system.

Figure 3.0 shows, for a Fixation or Rack-Chock system permanently installed in a Unit, the mechanical and electrical outfits must also be permanently installed and distributed over the Unit in order the system can be activated for each leg.. The whole operating and control system requires a central power pack to be installed somewhere in/on the rig. The same picture shows a network of outfits (piping, conduit, cables etc) reaching out to the three legs to operate the Fixation or Rack-Chock device for each leg chord.

The background of the Invention is to provide an alternative and novel design to reduce stress at the leg members at the leg-hull interface in a simpler manner while having several advantages.

First significant difference and substantial advantage of the present invention is that the engagement with the leg occurs at a different 90 degree off-set location with a separate set of rack built integral with the rack-chord (see **figure 4.0**). Current design of Fixation of Rack Chock system engages the rack chord at both opposing teeth racks of the chord (see **figure 1.0**). Immediately, one can see the number of engagements is halved. The quantity of device-sets is reduced by half. Current fixation of rack chock system requires two engaging sets to be used on each rack chord of the leg.

Second significant difference and substantial advantage of the present invention is that the simplicity in design and operation of the MR-D unitized engagement unit (**see figure 5.0**) allows it to use compressed air to drive the system, apart from electric or hydraulic systems.. The selection of driving energy is a matter of choice by the buyer. However, if powered by compressed air, the Unit's existing compressed air system onboard alone can operate the system thereby eliminating permanently installed separate power packs, associated electrical controls and associated piping. Because of this flexibility of using compressed air as the

driving power, the primary upsides compared with the conventional systems include much less installation work, weight savings etc. not to mention the reduction of associated system and installation costs.

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Third significant difference and substantial advantage of the present invention is that when the MR-D system is employed, the design philosophy is not to take over the function of the jacking gear pinions which predominantly carry the weight or load of the platform, or the function of the upper and lower guides which provide an important counter force moment. It's primary function is to share in providing counter force moment reactions with the upper and lower guides and in some extent the pinions. (see **Figure 6.0 & 7.0**). Conventional Fixation or Rack Chock system once fully engaged theoretically takes over to counter the induced force moment in the leg and if the jacking gears pinions are fully unloaded, the whole platform weight is also on the fixation or rack chock device (see **Figure 8.0**) The net advantage is MR-D components are subjected to lesser stress and loads and thus the device is lighter and less massive in size promoting greater simplicity of the system. To effect this in design, specific proper engineering renders the device, when engaged with the leg rack chord, to be allowed to move a little in X and Y directions while restraining Z movement direction. In conventional Fixation or Rack Chock system, all 3 degrees of motions are restrained when engaged with rack chord.

Fourth significant difference and substantial advantage of the present invention is that MR-D system is designed so that it is not a permanent fixture of the Unit. This means if the Unit is to operate in a milder environment or say at lesser water depth in the ocean, and the induced force does not come close to the structural stress limits of the leg chord or braces, MR-D can be removed and be used for another Unit that requires it at another location of harsher environment. This sharing of MR-D system among identical Units is not only cost effective, but enhances the Unit's operational capability and flexibility. Such flexibility and portability cannot be found in current conventional fixation or rack chock systems.

Needless to say a MR-D system design and invention optimizes apparatus utilization. As a result, cost savings in capital machinery expenditure is obvious.

The difference between a typical Fixation or Rack-Chock system and now the Force Moment Reducing Device (MR-D) system can be clearly observed by referring to tabulated points or comments under 'Results and Discussions'.

The Objective of the Invention

The objective of the invention is to provide an improved, alternative and innovative design to reduce stress in leg members of self-elevating/jack up rig, vessel or platform (the Unit) in the leg-hull interface region and to enhance the Unit's capability.

The MR-D design will obviate or mitigate the aforementioned situation of high costs, construction/installation/operation complexity, lack of usage optimization in the case of a Unit with Fixation or Rack-Chock system. MR-D at least provides the public with a useful alternative and cost effective choice with several advantages.

Statement of the Invention.

The MR-D works on rigidly preventing the leg chords to move in the Z direction while allowing small movements in the X and Y directions during engagement with the rack chord.

The application of MR-D with small movements in X and Y directions allows the leg to still come into hard contact with upper and lower guides. Because it acts to partially counter the induced force moment, the net reactions at the guides will be reduced.

It is not intended for MR-D to take over the jacking pinions function of supporting the weight of the lifted platform. However, under the load of environment with the platform or lifted body being displaced horizontally, there will be some vertical load transfer from the pinions to MR-D chocks. When this happens the pinions loads can only reduce.

One should note that the application of MR-D when engaged with the rack chord is at an angle 90 deg offset from the rack face of the rack chord (see figures 4.0). This is unique to this invention and has the advantage of reducing the number of engagement chocks when compared with conventional Fixation or Rack Chock systems used on opposing rack design (see Figure 1.0)

Because the application of MR-D is linked to harsher environment and at upper limit water depth with higher induced forces in the legs, the provision of rack at 90 deg offset in the chord needs only be done at the top end of the legs of the Unit. Roughly, it is incorporated about at 15-20% of the leg length top end. At lower water depth, the application of MR-D is not required, and so no offset rack required. The typical offset rack built in a rack chord is best illustrated by figure 9. Other methods are also feasible and shall come under this invention to work with MR-D system.

The location where MR-D is placed can be near the top of the jack case or close to the main deck (see figures 6.0 and 7.0). For that matter, both locations can also be equipped with MR-D system if the force situation requires so. Such application arrangements are all part of the embodiment of this invention. Nine (9) MR-D sets will be required if the legs are triangle in section and there are 3 legs to each Unit (see figure 10) If installed at two level locations, 18 sets will be required.

Each MR-D set engaging one rack-chord of the leg of the Unit is basically made of the following components (see figure 11):-

- A modular structural box for sliding in and out of a 'slot hole' in the jack case structure (item 'a')
- Inside the modular box, the chock piece or element is located to slide internally (item 'b')
- Two sets of wedges are for vertical positioning and engagement with rack chord made integral with screw-sets (item 'c')
- The chock element has a compressible layer sandwiched to allow for lateral horizontal movement (item 'd'). This is optional.
- Screw-set for locating the chock during engagement and disengagement (item 'e')
- As a standard supply, power drive motors using a suitable gear box (worm gear arrangement is one option – item 'f') and powered by compressed air is to move the screws. The driving energy means can also be hydraulic as well or electric if required.
- Jack case has a slot-in hole (an integral structural box) and allows the modular engagement unit to slot-in in place (item 'g')
- The whole chock box is secured through stud/nut arrangement or similar (item 'h')

Results and Discussions

The following table highlights and compares the MR-D advantages over typical Fixation or Rack-Chock systems. The table is in no way meant to be an exhaustive exploration of all of the features of the invention, and many of those not discussed will become readily apparent to a skilled reader once the full scope of the invention is understood.

No.	Features	Invention	Conventional
1.	- MR-D chock element engages the rack-chord at 90 deg	This immediately reduces the number of engagement sets to half of that used in conventional	Two compartments are required to hold the Fixation of Rack Chock system and be made integral with jack

	offset angle to the rack plain and only one set per rack-chord of leg. - Minimum installation complexity.	fixation or rack chock system used on opposing rack chord. The modular slide-in installation is made very easy to install and has no surrounding piping, cables, and other complicated mechanisms to be installed and connected.	housing. This is complicated and involves much fabrication and in-situ installation works, and incorporates many separately installed mechanisms (hydraulic cylinders, power screws, MCC, piping, cables, junction boxes etc.) to operate each chock..
2.	Designed for use to enhance the Unit's operating capabilities and not necessary a permanent and operating feature	MR-D to be installed or applied only if there is a true requirement for its usage, as in the situation of harsher environmental conditions or deeper water depth for the unit to operate in. When operating at lesser environmental condition, there is no need for its application.	Fixation or Rack Chock system is designed to be permanently attached to a Unit thus making it not flexible and not sharable with other Units. In most cases, the need to apply the system at every water depth can become a cumbersome operational chore.
3.	Portability	Because it is removable from a Unit when not required and usable on other Units requiring it, its portability brings the total cost of a Unit down when shared with other Units.	Capital expenditure of each Fixation and Rack-Chock system adds to the Unit's total cost.
4.	Compressed air from Unit as motor driving energy	This eliminates fixed installation of distributed piping, electrical outfits to serve all three legs on a Unit with hydraulic pack unit (HPU). Operation is made much	A fixed system of Fixation or Rack Chock type requires fixed installation of distributed piping and electrical outfits all over the Unit plus MCCs and control consoles to serve three

		easier and cost savings is obvious not to mention substantial lower maintenance demands.	legs at three corners of the Unit. Maintenance and operation of the system becomes much more complex and expensive. (see <i>Figure 3.0</i>)
5.	System operation ease	MR-D unitized engaging sets work in one direction to engage or disengage after some pre-alignment of chock and only at upper limit water depths. Localized compressed air driven screws are easy to operate to complete the engagement or disengagement.	Engagement at every water depth is itself additional chore let alone the need to operate the system through MCC, HPU, movement controls etc. for chock alignment and engagement. There is also rig load transfer to the chock to be looked into.
6.	Designed to share and not take 100% the induced bending moment	From Fig. 6.0 & 7.0, MR-D is designed to take partial induced bending moment and therefore the chock element is not loaded to its limit or can be designed to be lighter.	From Fig. 8.0, the full induced bending moment is absorbed in a typical fixation system. This means the chock element must be designed for heavier duty.

Modifications of the Preferred Embodiments

While the invention has been described with particular reference to certain embodiments thereof, it will be understood that various modifications can be made to the above-mentioned embodiment without departing from the spirit and scope of the present invention. The examples and the particular proportions set forth are intended to be illustrative only.

The skilled reader will instantly realize that, although the examples have been described for the 'Force Moment Reducing Device' and in engagement with the legs with rack elements of a self elevating Unit, these aforementioned descriptions are merely illustrative and will vary depending on the application and the requirements of the Unit. An example of such variation is application of MR-D to the Unit's legs that are not made with racks but other shape sections such as cylindrical cones, rectangular pin-slots or something else so as to cause the intended engagement.

Information Disclosure References

Information relating to inventions that may have been previously filed in by others and that is of similar invention can only be determined after a search by the authority

THE INVENTOR'S CLAIMS

1. A self elevating drilling or production rig, platform, vessel or system (the **Unit**) suitable for off-shore oil and gas drilling or production and other operations comprising:
a hull or body of the Unit to be moved up or down vertically by the Jacking system or Jack Unit ; and

at end of travel of the hull, a holding system commonly known as Fixation or Rack Chock system is used and often this relieves the Jack Unit from its function of holding up the hull fully or partially;

characterized in that the Fixation or Rack Chock system is now replaced by the Invention called 'Force Moment Reducing Device' (or "MR-D") that is novel in design and performs to reduce stress induced from bending moment in the leg members by sharing the stress with the upper and lower guides but does not relieve the Jack Unit from holding up the hull when the hull is stationary and,

further characterized in that the Invention works on a different, novel and unique principle of contact enabling the system to engage with the Unit's leg rack-chord at an offset angle from the normal rack plate plane thus reducing the number of devices required engaging each rack-chord and,

further characterized in that the Invention allows the engagement device to move in X and Y directions in a horizontal plane and the only restraint is in the vertical direction. This effectively allows the leg to lean and rest on the upper and lower guides to provide the counter moment as does the MR-D.

2. A self elevating drilling or production rig, platform, vessel or system (the **Unit**) suitable for off-shore oil and gas drilling or production and other operations comprising:

a Fixation or Rack Chock system permanently installed and driven by a common or dedicated central power-pack to work the Fixation of Rack Chock systems at each leg of the Unit through a network of distributed piping and electrical outfits; and

characterized in that,by replacement, that the Invention renders simplicity in design which results in the engaging components and power drives being grouped together and modularized in a structural box that can easily be installed for quick operation or removed as a modular item, and

further characterized in that the Invention can be powered directly in-situ by the Unit's existing compressed air system onboard and applied through hand held air power tools and therefore eliminates a substantive volume of distributed piping and electrical outfits that would otherwise be required.

3. A self elevating drilling or production rig, platform, vessel or system (the **Unit**) suitable for off-shore oil and gas drilling or production and other operations comprising:

a Fixation or Rack-Chock system which is certified with the Unit to work at all times within the design operational limits of the Unit, or at least the majority part of its operating envelope;

characterized in that, by replacement, that the Invention is for enhancing the Unit's operating capability. The Unit is thus not dependent on the Invention within most of its operating envelope except toward the upper and more severe operating limit and,

further characterized in that the Invention with its components modularly housed in one structural box in engagement with rack-chord of leg allows it to be easily dismountable

or removed when not in use or the whole installation made temporarily non-functional when operating conditions do not require using it.

4. A self elevating drilling or production rig, platform, vessel or system (the **Unit**) suitable for off-shore oil and gas drilling or production and other operations comprising:

a Fixation or Rack Chock system permanently installed and operated through a wide network of distributed piping and electrical outfits across the Unit's body to reach out to the three leg locations requires a stringent program of maintenance and complex operational procedures to ensure proper system functionality, and,

characterized by replacement, that the Invention with its modular engagement units in structural boxes and made operable in-situ by Unit's existing compressed air system contributes greatly in reducing the level of maintenance and operation complexity.