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OFFSHORE BUMPER SYSTEM AND METHOD OF MANUFACTURING

The present invention relates to offshore bumper systems for use in protection of offshore structures from damage from contacts with vessels such as boats, barges and the like and in particular, an offshore bumper system for attachment to offshore structures where said system is of the type using resilient elements to absorb shock.

In the exploration and development of offshore petroleum reserves, it is sometimes necessary to erect platforms located miles off shore. These platforms form a base on which drilling, exploration and storage activities can occur. Some of these platforms have legs or other types of support structure which extend down into the water. To transport men and material to and from these platforms, it is necessary to dock vessels alongside. In some situations, these vessels are small. In others, the vessels are quite large and contact between these larger vessels and the platform leg structure can weaken or otherwise damage either the structure or the vessel itself.

To protect these platforms from damage due to contact by vessels operating near the platforms, systems have been designed which are attached to the platform adjacent the water level and operate to fend off vessels

and absorb shocks from vessels coming into contact with the platform.

One system which has been used for years in the industry has been known as the Lawrence Allison system. This system utilizes a vertically standing piece of pipe or other structural member which is supported from the platform at the water level. The pipe typically has its upper end supported from the leg of the platform at a position above the high tide level and the lower end connected to the platform at a position below the low tide level. The system utilizes a plurality of rubber vehicle tires with the vertically standing structural member extending through the center of the tires to form a stack of tires which absorb shocks from contact with vessels. Some of these Lawrence Allison systems leave the outer surfaces of tires exposed, and some have a cylindrical metal skin or can supported around the outside of the tires and spaced away from the central support by the tires. In the latter case, the tires resiliently separate the outer contact skin from the inner central support.

Other prior art systems include the one shown in the United States patent to Pogonowski 3,564,858, issued February 23, 1971. This patent discloses boat landing systems for offshore structures in which a frame is supported from the legs of the platform. A spring support is provided on the upper end and on the lower end, a circular snubber or cuff of resilient material is used in a mounting to permit limited movement of the frame both horizontally and arcuately.

Other systems, such as is disclosed in the U. S. patent to Files 4,005,672, issued February 1, 1977, utilize a shock-absorbing element on the upper support. A bottom joint is disclosed formed by a resilient cylinder positioned between two cylindrical members to permit angular displacement at the bottom.

In addition the U.S.patent to Files, 4,109,474, issued August 29, 1978, utilizes a plurality of rubber bumper rings with top and bottom mounted shock cells.

In other prior art systems, the outer can or contact surface is resiliently separated from the central structural support by a pre-formed rubber element. In one such system, the outer protective shield or can and the central support are coaxially positioned. A solid rubber element extends the length of the outer shield and occupies less than 360° but at least 180° of the annular space formed between the outer shield and the central support. In these devices, the rubber element has a constant radial thickness positioned in the annular space on the side from which contact with vessels normally occurs.

Although these bumper systems have been quite satisfactory in many applications, they have not proved entirely satisfactory where large impact loads must be absorbed to protect the platform. In the previous designs, resilient elements surrounding vertical posts were utilized to absorb energy. When these elements were made of a sufficient toughness to prevent their destruction by contact with vessels, the energy absorbing capacities were substantially diminished, and in some applications, were negligible. Various designs for shock elements with relief portions were also attempted to return the energy absorbing capacity. These designs have not proved entirely satisfactory.

In addition even though these prior bumper systems have performed satisfactorily, in many ways unappreciated by the industry, their design has contained aspects which were redundant and which added to the overall costs of the systems. These systems, for example, failed to appreciate and/or accommodate

into the design cost savings and size reduction which could be accomplished if the limited directions from which contact forces are applied to the system are taken into account. Further, these systems utilized complicated manufacturing and fabrication techniques which were unnecessary. In the past, these systems have been expensive to manufacture and install and as a consequence have not proven entirely satisfactory.

According to one aspect of the invention there is provided a bumper assembly for connection to an offshore structural member to provide protection to said structural member from contact by vessels such as boats and barges, said assembly comprising upper and lower support arms for connection to said structural member, a vertically extending cylindrical tubular contact member of sufficient length to span an area of contact with an outer surface for engagement by vessels, a support member axially extending through said contact member and supported from said arms, means resiliently separating said contact member and said support member, said separating means positioning said contact member with respect to said support member with the axis of said contact member radially spaced from and extending parallel to the axis of said support member.

According to a second aspect of the invention there is provided a bumper assembly for connection to an offshore member to provide protection to a structural member from contact by vessels such as boats and barges, said assembly comprising upper and lower arms for connection to said structural member, a vertically extending contact member of sufficient length to span an area of contact and with an other surface for engagement by vessels, at least one support member extending into said contact member and supported from said support arms,
means resiliently separating said contact member and said

at least one support member, said separating means positioning said contact member with respect to said support member with the axis of said contact member radially spaced from and extending parallel to the axis of said support member.

The invention further provides a method of fabricating a bumper assembly comprising the steps of:

forming at least two resilient annular bumper elements having cylindrical eccentric openings extending therethrough,

connecting each of said bumper elements to the exterior of separate structural members each structural member having an external wall of like shape and size to the opening in said elements,

forming a support member subassembly by rigidly joining said at least two structural members carrying bumper elements in a spaced relationship by means of a connector member,

inserting the subassembly into an outer protector, such that the axis of the outer protector is radially spaced from and extends parallel to the axis of the structural members and the connector member, and

connecting support arms to the ends of said subassembly.

By way of example, embodiments according to the invention of a bumper assembly and a method of manufacturing thereof will now be described with reference to the accompanying drawings, in which:-

Fig. 1 is a side elevation of the shock absorbing system of the present invention shown attached to the leg of an offshore platform;

Fig. 2 is a view similar to Fig. 1 showing the shock absorbing system of Fig. 1 partially in section;

Fig. 3 is a sectional view taken on line 3-3 of Fig. 2 looking in the direction of the arrows;

Fig. 4 is a sectional view taken on line 4-4 of Fig. 2 looking in the direction of the arrows;

Fig. 5 is a view similar to Fig. 2 of a second embodiment of the present invention.

Fig. 6 is a perspective view of a subassembly of the shock absorbing element;

Fig. 7 is a perspective view of a subassembly of a support column;

Fig. 8 is a perspective view of a subassembly similar to Fig. 6 comprising the third embodiment; and

Fig. 9 is a section taken on line 9-9 of Fig. 8, looking in the direction of the arrows.

The invention can best be understood by referring to the drawings. The drawings disclose by way of example three separate embodiments of the invention. In describing the invention by referring to Figures, the same reference numerals will be used to identify corresponding parts of the system in all of the views.

The embodiment shown in Figures 1-4 will be described initially. In Figure 1, a shock absorbing bumper assembly 10 is shown in a exemplary installation attached to a vertically extending structural member 12. The structural member 12 can be the leg or other structural portion of an offshore platform, jack-up, submersible or semi-submersible rig or the like. It is also envisioned that structural member 12 could represent a portion of a pier or piling of a dock, wharf or the like.

Assembly 10 is shown attached to the structural member 12 at the water level. Assembly 10 is positioned to provide protection for the structural member 12 by fending off boats, barges and other vessels which may, by accident or necessity, come into contact

with the structural member 12. It is also envisioned that the assembly 10 could be utilized to protect fluid carrying conduits, such as standpipes and the like, from damage due to impact from vessels.

The assembly 10 is supported from the member 12 by upper and lower horizontally extending support assemblies 14 and 16, respectively, and an optional tension member assembly 18. The assembly 10 is designed to provide a contact surface spaced away from the member 12 and has resilient means for absorbing the shock imparted to the assembly by vessels contacting the assembly. The assembly reduces the maximum shock loads transferred to the members 12 by contact with the vessel.

As shown in the embodiment of FIGURES 1-4, the upper and lower support assemblies 14 and 16 comprise upper and lower generally horizontally extending arms 20 and 22. In the present embodiment, the upper arm 20 is shown welded by means of a flange 21 to the structural member 12 and consists of a piece of hollow structural tubing. The lower arm 22 is of similar construction to the upper arm 20 and is attached to the structural member 12 by means of a clamp assembly 23 as shown. It is envisioned, of course, that the arms 20 and 22 could be formed from other materials besides hollow structural tubing such as box beams, I-beams, channels, and the like. It being important only that the arms 20 and 22 have sufficient structural integrity to support the assembly 10 in place and withstand the loads applied by contact between the assembly 10 and vessels. It is also envisioned that either or both of the upper or lower arms 20 and 22 could have a shock cell of the type described in United States Patents Nos. 4,005,672 or 4,109,474 ~~(and shown in the embodiments of FIGURES 10-12)~~ connected thereto to provide additional shock absorbing capacity. For simplicity,

the details of the shock cell and its connection to the arms 20 and 22 is not shown, it being understood, of course, that the mounting would be in accordance with the teachings of the above-mentioned patents whose specification is incorporated herein by reference for that purpose. The optional tension member 18 is connected to the member 12 at 24 in the manner described in United States Patent 4,109,474, whose specification is incorporated herein by reference.

Each of the arms 20 and 22 have upper and lower shock absorbing connector assemblies 26 and 28, respectively, supported from the ends thereof. The details of these shock absorbing connector assemblies will be described hereinafter.

The assembly 10 has a contact assembly 30 which is supported from the arms 20 and 22. Assembly 30 is shown in FIGURE 1 as being positioned in a vertically extending attitude and is the portion against which vessels contact during use of the bumper system.

The contact assembly 30 comprises a vertically extending support column 34 connected to and spanning between the upper and lower shock absorbing connector assemblies 26 and 28. A cylindrical outer protector 32 is positioned to enclose a portion of the column 34.

The outer protector 32 is eccentrically positioned around the column 34 and is spaced therefrom as will be hereinafter described in more detail.

In the embodiment shown, the outer protector 32 extends vertically through the area in which contact between vessels and the assembly usually occurs and is of sufficient length to accommodate changes in water level such as those due to tides. The outer protector 32 in the embodiment shown is held in position by support chains 36. These chains 36 are positioned on

opposite sides of the column 34 and have one end connected to the outer protector 32 and the other end connected to the upper connector assembly 26.

As can be seen in FIGURE 2, the outer protector 32 is separated from the column 34 by upper and lower shock rings 38 and 40, respectively. In the embodiment shown, the outer protector 32 is a cylindrical member which can be formed from a length of standard tubing. The inner column is likewise formed from pipe. The outer protector 32 and inner column 34 are positioned with their center lines parallel but not coaxial. The center line of the outer protector 32 is displaced to the right as shown in FIGURES 2 and 3 from the center line of column 32.

The arrow identified as F in FIGURE 2 represents normal direction of force applied by vessels coming into contact with the system. The center line 35 of the column 34 is displaced in the direction of arrow F (or in the direction of the normal force applied by a vessel) from the center line 33 of the outer protector 32. This displacement of the center line 35 increases the size of the thickness of the annular space between the outer protector 32 and the column 34 on the side nearest the force vector F. This eccentric placement of the outer protector 32 and column 34 also decreases the thickness of the annular space on the side of the column 34 away from the arrow F. The maximum thickness of the annular space is shown in FIGURES 2 and 3 as A whereas the minimum annular thickness is shown as B.

In one example of the first embodiment, the outer protector 32 is 30-inch diameter pipe, the column 34 is 10-inch diameter pipe, and the axes of the two parts are separated by a distance of approximately a little over 5-1/2 inches. The annular thickness A will be approximately 14 inches while the annular thickness B

will be approximately 2-3/4 inches. Thus, on the side on which shock forces are normal to the system the annular space is a maximum, and in the example given, the maximum thickness if five times larger than the minimum. It should be understood that the dimensions are exemplary only and others could be selected as desired.

Both the upper and lower shock rings 38 and 40, respectively, are made from resilient material and are shaped to closely conform to the annular space formed between the column 34 in outer protector 32. The upper shock ring 38 is shown in FIGURE 3. In this embodiment, the shock rings 38 and 40 are each connected, for example, by bonding to the exterior surface of the column 34 to support the rings in a vertical position. In addition, a plurality of clearance openings 42 can be formed through the rings.

By constructing the rings of resilient material in the shape shown in FIGURES 2 and 3, additional resilient shock absorbing material is positioned on the side of the column 34 where the compression loads are normally the highest. It is to be appreciated that shock loads applied to the system in the reverse direction of arrow F will be minimal since that side of the system is positioned facing the platform. It is envisioned, of course, that the shock rings 38 and 40 could be formed without the openings 42 and alternatively could be bonded to the interior wall of the outer protector 32 if desired. It is also envisioned that the rings could be mechanically connected to the column instead of by bonding.

The rings 38 and 40 are axially spaced a distance shown in FIGURE 2 as C. This spacing leaves the outer protector unsupported between the two rings. The protector is selected to be

positioned so that the contact with vessels will occur in the unsupported space between rings 38 and 40. In addition, outer protector 32 is selected of a size and material so that it will deflect into the annular space to position 32 as shown in FIGURE 2 in phantom lines upon contact with a vessel. Thus, the outer protector 32 itself provides a shock absorbing effect in addition to the shock absorbing effect of compressing rings 32. In addition, increasing the thickness of the annular space provides more clearance and allows the use of outer protectors which are more resilient and less stiff, thus, increasing the shock absorbing capacity of the overall system.

The details of the construction of the connector assembly 26 is shown in FIGURES 2 and 4. The construction of connector 26 is typical for the connector 28. Connector assembly 26 utilizes a shock ring 44 identical in construction to the shock rings 38 and 40. Ring 44 is bonded to the exterior of the column 34. Shock ring 44 however is located 180° from the position of rings 38 and 40 so that the maximum thickness of the ring 44 is on the platform side of the column between the column 34 and the upper arm 20. A cylindrical retainer assembly is formed on the end of the arm 20 to house and contact the outer surface of the shock ring 44. This cylindrical retainer is formed in two semi-cylindrical halves 46a and 46b. The halves are bolted together by suitable fasteners and flanges are provided thereon which allows for disassembly. It is to be understood of course that elements 46a and 46b could be designed in segments other than halves.

A pin member 50 extends through suitable guide openings in the half 46a and extends through one of the openings 42 in the ring 44. This pin 50 prevents

rotation of the shock ring 44 within the upper cylindrical assembly and maintains the bumper system in proper alignment. As can be seen in FIGURES 2 and 4, the thickest portion of the ring 44 is positioned on the side of the column 34 where it is of most use in providing compressive shock absorbing functions from forces in the direction of arrow F.

In operation, a vessel will come into contact with the outer protector 32 and impart shock forces to the system 10 in the direction of arrow F. These forces are absorbed in the system by compression of shock cells if they are present, compression of rings 44 in connector assemblies 26 and 28, compression of rings 38 and 40 in contact assembly 30 and by deflection or bending of outer protector 32. These elements each add together to increase the overall shock abosrbing capacity of the bumper system.

In FIGURE 5, a second embodiment of the bumper assembly is shown as 110. This embodiment illustrates two variations in the system 10 which can be used either individually or together with any of the embodiments herein. First, assembly 110 does not utilize upper and lower shock absorbing connectors 26 and 28 but rather uses the conventional upper and lower rigid mechanical connections 126 and 128, respectively. These connectors 126 and 128 are not designed to provide a substantial shock absorbing function and can be used where none is required.

Second, in assembly 110, the inner column 134 is separated from the eccentrically positioned outer protector 132 by upper and lower shock rings 38 and 40, identical to those shown in FIGURES 1-4. In addition, a centrally positioned resilient member 160 is bonded to the exterior of the inner column 134 and is positioned approximately intermediate the rings 38 and 40. This member 160 is cylindrical in shape and is spaced

away from the inside wall of the protector 132 on the side adjacent to the force arrow F. This resilient member 160 becomes effective upon deflection of the shock absorbent rings 38 and 40 and bending of the member 132 to a point where the interior wall of the member 132 comes into contact with the outer surface of the ring 160. This ring 160 provides a second stage of shock absorbing action within the column itself.

Columns 34 are fabricated in sections. First, a short section of pipe 34a, as shown in FIGURE 6, is bonded to the interior of a shock ring to form a shock ring subassembly 62. Once a plurality of these shock ring assemblies 62 have been fabricated, they can be connected together by welding the lengths of pipe together as shown in FIGURE 7 and properly orientating the rings as required. The fabrication of support column 34 can be accomplished by axially aligning two subassemblies 62a and 62b with their respective rings 180° out of phase with each other. The sections 34a can be welded together at 70. A top cap 71 can be welded on the upper end of the short section of pipe of 62a with the cap 71 orientated over the thickest part of the ring on 62a. Next, a section of pipe 72 can be welded at 74 to the end of the pipe section of 62b. This pipe 72 is selected in length to fit the application of the system. Next, subassembly 62c is welded at 76 in place with its ring orientated like subassembly 62b. Subassembly 62d is welded at 78 to subassembly 62c with the ring of 62d orientated like subassembly 62a. A lower stab 80 (or other lower connecting assembly) can be welded at 82 to subassembly 62d. Once assembled as shown in FIGURE 7, the ring of subassembly 62a becomes ring 44 in connector 26. The ring in subassembly 62b and

62c becomes rings 38 and 40, respectively, while the ring in subassembly 62d becomes the ring in connector 28.

By fabricating column 34 in this manner from subassemblies 62, variations in axial spacing of the rings in systems 10 and 110 can be easily accommodated by lengthening the section of pipe 72 or by adding spacers between the subassemblies 62 and 62b or between 62c and 62d. This method provides for flexibility in design of systems from standard subassemblies, eliminating expensive molds and equipment for customized and specialized parts. In addition, this method allows the use of reasonable lengths of pipe for bonding operations to the individual rings. Further, a ring such as 160 can be formed in a subassembly 160a and this subassembly 160a can be welded at the center of pipe 72 as shown in FIGURE 5.

A third embodiment of a portion of the shock assembly is illustrated in FIGURES 8 and 9. In FIGURES 8 and 9 a shock ring subassembly 262 is illustrated. This shock ring subassembly can be utilized in a system similar to that shown in FIGURES 1-7 to replace the shock rings 36, 38, and 44 in the same manner in which subassembly 62 is installed and used in the first embodiment.

Subassembly 262 comprises a short section of pipe 234a to which is bonded a ring 256 of resilient material. The ring 256 in the preferred embodiment has upper and lower coincident grooves 250 and 252, respectively. These grooves are positioned as shown in FIGURE 8 and are spaced an equal distance from the periphery of the cylindrical ring 256. The grooves 250 and 252 are designed
to cause the rings when installed and in use to approximate a uniform spring rate within the designated range of deflection. In operation forces are normally

applied to the ring 256 in compression. When a force is applied the grooves 250 and 252 will collapse or close progressively to provide a uniform spring rate as the resilient material is deformed. The grooves 250 and 252 preferably each have a width W which is 30 to 50% of the designed deflection. Designed deflection as utilized herein means the distance the right is designed to be deflected during normal operation. The grooves 250 and 252 additionally have a combined depth (D1 + D2) which is 30 to 50% of the total thickness T of the ring 256. The walls of the groove are tapered as shown to provide the progressive collapsing of the grooves during deformation of the ring.

As an exemplary embodiment, the ring 256 has a 27-1/2 inch outer diameter and a thickness T which is twelve inches. The pipe section 234a is 10-3/4" diameter pipe and the axes of the pipe and the resilient ring 256 are offset 5-5/8" from each other. Grooves 250 and 252 in this embodiment are identical in construction. The grooves 250 and 252 have a depth of two inches or a combined depth of four inches. The width of the grooves 250 and 252 is four inches. The combined angle of the walls of the groove is 60°. Designed deflection is ten inches.

Although various embodiments of the present invention have been illustrated in the accompanying drawings and described in the foregoing detailed description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions within the scope of the invention as defined in the appended claims.

Reference is made to our copending applications divided from this application, the divisional applications being Nos. 8224226 entitled "Offshore bumper assembly", 8224227 entitled "Bumper element and connector for a bumper assembly" and No. 8302650 entitled "Offshore bumper system and method of manufacturing".

CLAIMS

1. A bumper assembly for connection to an offshore structural member to provide protection to said structural member for contact by vessels such as boats and barges, said assembly comprising upper and lower support arms for connection to said structural member, a vertically extending cylindrical tubular contact member of sufficient length to span an area of contact and with an outer surface for engagement by vessels, a support member axially extending through said contact member and supported from said arms, means resiliently separating said contact member and said support member, said separating means positioning said contact member with respect to said support member with the axis of said contact member radially spaced from and extending parallel to the axis of said support member.

2. A bumper assembly for connection to an offshore member to provide protection to a structural member from contact by vessels such as boats and barges, said assembly comprising upper and lower arms for connection to said structural member, a vertically extending contact member of sufficient length to span an area of contact and with an outer surface for engagement by vessels, at least one support member extending into said contact member and supported from said support arms, means resiliently separating said contact member and said at least one support member, said separating means positioning said contact member with respect to said support member with the axis of said contact member radially spaced from and extending parallel to the axis of said support member.

3. An assembly as claimed in Claim 1 or Claim 2 wherein the separating means comprise a pair of axially spaced means.

4. An assembly as claimed in Claim 3 wherein each of said axially spaced means conforms to the shape of the

annular space formed between said support and contact members.

5. An assembly as claimed in Claim 3 or Claim 4 wherein said axially spaced means each has a cylindrical shaped outer surface of a shape corresponding to the interior wall of said contact member and each of said axially spaced means has a cylindrical interior surface conforming to the exterior surface of said support member.

6. An assembly as claimed in any one of Claims 3 to 5 wherein said interior surfaces of said pair of axially spaced means are bonded onto the exterior of said support member.

7. An assembly as claimed in any one of Claims 3 to 6 wherein each resilient means comprises a body with a circular cross-section periphery, upper and lower surfaces, and upper and lower coincident grooves spaced a substantially equal distance away from the periphery of the body and extending into the body from the upper and lower surfaces by a distance sufficient to approximate a uniform spring rate in the body.

8. A bumper assembly as claimed in any one of Claims 3 to 7 wherein said pair of axially spaced means couple the contact member and the support member to provide an unsupported length of said contact member between said resilient means.

9. A bumper assembly as claimed in any preceding Claim wherein each support arm comprises an axially operable shock cell.

10. A method of fabricating a bumper assembly comrpising the steps of:

forming at least two resilient annular bumper elements having cylindrical eccentric openings extending therethrough,

connecting each of said bumper elements to the exterior of separate structural members each structural

member having an external wall of like shape and size to the opening in said elements,

forming a support member subassembly by rigidly joining said at least two structural members carrying bumper elements in a spaced relationship by means of a connector member,

inserting the subassembly into an outer protector such that the axis of the outer protection is radially spaced from and extends parallel to the axis of the structural members and the connector member and

connecting support arms to the ends of said subassembly.

11. The method of Claim 10 wherein said step of connecting comprises bonding said elements to said structural members.

12. A method of protecting a member on a marine structure substantially as hereinbefore described with reference to the accompanying drawings.

13. A bumper assembly for use on a marine structure substantially as hereinbefore described with reference to and shown in the accompanying drawings.

14. A method of fabricating a bumper assembly substantially as hereinbefore described with reference to the accompanying drawings.

The text of the specification has been reproduced by photocopying the applicants original typescript. It may contain a few amendments which are difficult to read. The original typescript containing these amendments may be inspected on the premises of the Patent Office

PATENTS ACT 1977

SPECIFICATION NO 2054093B

The following corrections were allowed under Section 117 on 25 October 1983.

Front page, Heading (72) Inventors *for* Clarence Thomperson *read* Clarence Thomerson

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