

**Metal structure for supporting fluid ducts
and industrial facility comprising such a metal structure**

The present invention relates to a metal structure for supporting fluid ducts, of the type including: substantially vertical uprights, arranged in a regular horizontal mesh characterized by a first longitudinal direction and a second transverse direction; and a plurality of longitudinal beams and of transverse beams, arranged respectively in longitudinal and transverse directions, each beam connecting two consecutive uprights; the plurality of longitudinal beams comprising at least a first level of longitudinal beams, arranged along a first horizontal plane, said first level being capable of supporting a first transverse duct extending in the transverse direction; the plurality of transverse beams comprising at least one second level of transverse beams, arranged along a second horizontal plane, said second level being capable of supporting a second duct extending in the longitudinal direction; the second horizontal plane being located above the first horizontal plane.

Such a structure is in particular intended to belong to an industrial facility on land or at sea, placed on a fixed or floating support and comprising fluid ducts. Such a facility is for example a Floating Production, Storage and Offloading (FPSO) unit, a Floating Liquefied Natural Gas (FLNG) unit, or more generally an offshore unit such as a semisubmersible platform, which may for example be a Tension Leg Platform (TLP), an unloading buoy, a floating vertical column or a ship. In a variant, the facility is a fixed rigid structure of the "jacket" type or an oscillating structure subject to the seabed.

Units of the aforementioned type generally include a large number of pieces of equipment interconnected with one another. These pieces of equipment are for example connected to one another by fluid ducts, functional lines, such as electric lines, hydraulic transfer lines, and/or information transfer lines.

To manufacture such a unit, it is known to assemble a substructure, and subsequently to deposit the various elements, which are prefabricated separately, on said substructure. These elements in particular comprise a main chassis made from steel. Said chassis serves as mechanical support for a network of fluid ducts or lines. Due to the quantity of equipment to be connected, said network is generally very complex and comprises a large number of lines that intersect in all three dimensions.

In the state of the art, the lines are in particular fixed to the main chassis by collars, the shape and location of which depend on the geometry of the network. Yet during the manufacture of the facility, said network of lines is designed in parallel with other disciplines such as electricity, instrumentation, mechanical equipment and the structure.

Time constraints generally require the main chassis to be installed before finalizing the geometry of the network of lines, the fastening collars next being fixed individually on said chassis over the course of the development of studies of said network. Furthermore, the installation of each collar requires a special surface treatment, in particular anti-corrosion, due to the weather conditions to which the facility is subjected.

There is therefore a need to standardize devices for fixing the fluid ducts to the main chassis, so as to be able to develop the geometry of the network without creating additional steps for installing collars and anticorrosion treatments.

To that end, the present invention relates to a metal structure of the aforementioned type, such that it is devoid of longitudinal beams on the second horizontal plane, said second horizontal plane thus being capable of being passed through by the first duct above the longitudinal beams of the first level.

According to other advantageous aspects of the invention, the metal structure includes one or more of the following features, considered alone or according to all technically possible combinations:

- the plurality of longitudinal beams comprises a third level of longitudinal beams arranged in a third horizontal plane, located above the second horizontal plane; and the structure is devoid of transverse beams at said third horizontal plane, said third horizontal plane thus being capable of being passed through by the second duct (42) above the transverse beams of the second level;
- the metal structure includes several levels of longitudinal beams and several levels of transverse beams, vertically alternating;
- the metal structure further comprises at least one grid of longitudinal bars and transverse bars, arranged respectively in the longitudinal and transverse directions, each bar connecting two consecutive uprights, the longitudinal bars and transverse bars of said grid being coplanar and located above the plurality of longitudinal beams and transverse beams;
- the at least one grid includes at least one cross-shaped reinforcement, each end of said reinforcement being fixed to the middle of a longitudinal bar or transverse bar;
- each of the uprights includes an upper end provided with a suspension means from a chassis.

The invention further relates to an industrial facility comprising: a network of channels, extending in three dimensions; a main chassis mechanically connected to said network; and at least one metal structure as described above, said metal structure being fixed to the main chassis. Said network of channels comprises at least one fluid duct extending in the longitudinal direction and supported by at least one transverse beam of

said metal structure, and/or at least one fluid duct extending in the transverse direction and supported by at least one longitudinal beam of said metal structure.

According to other advantageous aspects of the invention, the installation includes one or more of the following features, considered alone or according to all technically possible combinations:

- at least one of the channels of the network comprises at least a longitudinal portion and a transverse portion, respectively extending in the longitudinal and transverse directions, said portions being connected by at least one vertical duct delimited by two elbows, the at least one longitudinal portion and the at least one transverse portion respectively being supported by at least one transverse beam and by at least one longitudinal beam of the at least one metal structure;

- the facility further comprises electric or instrumentation cables, deployed on at least one grid;

- the at least one metal structure is suspended from the main chassis.

The invention will be better understood upon reading the following description, provided solely as a non-limiting example and done in reference to the drawings, in which:

- figure 1 is a perspective view of a metal structure according to a first embodiment of the invention;
- figure 2 is a perspective view of a metal structure according to a second embodiment of the invention;
- figure 3 is a first partial view of a facility comprising a metal structure of figure 2; and
- figure 4 is a second partial view of the facility of figure 3.

Figures 1 and 2 show metal structures 10, 110 for supporting a duct, respectively according to a first and a second embodiment of the invention.

In the following description, the metal structures 10 and 110 are described at the same time, the shared elements being designated using the same reference numbers.

The metal structure 10, 110 is preferably made from steel. The metal structure 10, 110 includes uprights 12, longitudinal beams 14 and transverse beams 16. Optionally, as shown in figures 1 and 2, the metal structure 10, 110 further includes at least a first cable grid 18.

Figure 3 partially shows the structure 110 of figure 2, the cable grid 18 in particular not being shown.

The uprights 12 are substantially vertical, arranged in a regular horizontal mesh. Said mesh is characterized by a first longitudinal direction and by a second transverse

direction. Preferably, said longitudinal and transverse directions form an angle between 20° and 160° , said angle more preferably being equal or close to 90° .

In the embodiments of figures 1 and 2, an orthonormal base (X, Y, Z) is considered, X and Y respectively representing the longitudinal and transverse directions, Z representing the vertical.

The horizontal mesh of the uprights 12 is therefore formed by the intersections of a series of lines parallel to X and a series of lines parallel to Y. Preferably, the intervals separating said lines are identical, forming a square mesh.

In the embodiment of figure 1, the structure 10 is formed by a single structural unit 20, corresponding to a single cell of the horizontal mesh. Said structural unit 20 is delimited by four uprights 12, distributed over two lines parallel to X and two lines parallel to Y.

In the embodiment of figure 2, the structure 110 is formed by four structural units 20 alongside one another in a square, each of said units corresponding to a cell of the horizontal mesh. More specifically, the structure 110 includes nine uprights 12 distributed in three lines parallel to X and three lines parallel to Y. Each upright 12 belongs to one, two or four of the structural units 20.

According to variants that are not shown, the structures according to the invention are formed by a different number of structural units 20, alongside one another along X and/or along Y.

Preferably, an upper end of the uprights 12 is provided with means 21 for suspension from a main chassis, as will be described later. Said means 21 for example make it possible to fix the structure 10, 110 rigidly to the main chassis by welding or bolting.

The longitudinal beams 14 and the transverse beams 16 are respectively arranged along X and along Y. Each beam includes two ends, fixed to two consecutive uprights 12 along X or along Y.

In the embodiments of figures 1 and 2, the longitudinal beams 14 are distributed into three longitudinal levels 22, 24, 26. Likewise, in the embodiments of figures 1 and 2, the transverse beams 16 are distributed into three transverse levels 30, 32, 34. In a variant, the number of longitudinal levels and/or transverse levels is greater.

At each structural unit 20, each longitudinal level 22, 24, 26 is formed by two longitudinal beams 14 across from each other; and each transverse level 30, 32, 34 is formed by two transverse beams 16 across from each other.

The longitudinal beams 14 of each longitudinal level 22, 24, 26 define a horizontal plane. Likewise, the transverse beams 16 of each transverse level 30, 32, 34 define a horizontal plane.

For example, a first horizontal plane 36 is defined by a first longitudinal level 22 located the lowest. Like each longitudinal level, the first longitudinal level 22 is capable of supporting a first duct 40 (figure 3) extending in the transverse direction Y.

A second horizontal plane 38 is defined by a first transverse level 30 located the lowest. The second horizontal plane 38 is located above the first horizontal plane 36. Like each transverse level, the first transverse level 30 is capable of supporting a second duct 42 (figure 3) extending in the longitudinal direction Y.

A third horizontal plane 44 is defined by a second longitudinal level 24, capable of supporting a third duct 46 (figure 3) extending in the transverse direction Y.

The longitudinal levels 22, 24, 26 and the transverse levels 30, 32, 34 alternate along Z. The structure 10, 110 is devoid of longitudinal beams 14 at the height of the transverse levels 30, 32, 34 and is devoid of transverse beams 16 at the height of the longitudinal levels 22, 24, 26.

For example, the structure 10, 110 is devoid of longitudinal beams 14 at the second horizontal plane 38. Said second horizontal plane is thus capable of being passed through by the first duct 40 above the longitudinal beams 14 of the first longitudinal level 22.

Likewise, the structure 10, 110 is devoid of transverse beams 16 at the third horizontal plane 44. Said third horizontal plane is thus capable of being passed through by the second duct 42 above transverse beams 16 of the first transverse level 30.

The structure 10, 110 can thus support ducts 40, 42 with a large diameter, said diameter being limited by a gap 48 between two consecutive longitudinal levels or two consecutive transverse levels.

According to one preferred embodiment, the gap 48 is identical between all of the consecutive longitudinal levels and/or between all of the consecutive transverse levels.

According to another preferred embodiment, the gap 48 is identical for the longitudinal levels and for the transverse levels. In a variant, the longitudinal levels and the transverse levels have different gaps.

The first cable grid 18 is arranged above the longitudinal levels 22, 24, 26 and the transverse levels 30, 32, 34. Said first grid 18 includes a plurality of longitudinal bars 50 and transverse bars 52, which are coplanar and respectively arranged along X and along Y. As a structural unit 20, the first grid 18 includes two longitudinal bars 50 and two transverse bars 52 that are arranged in a square, each bar being fixed to two uprights 12.

Preferably, at a structural unit 20, the first grid 18 further includes a cross-shaped reinforcement 54. Each end of said reinforcement 54 is fixed to the middle of a longitudinal bar 50 or transverse bar 52.

The first grid 18 is in particular intended to support electric and instrumentation cables. In the embodiments of figures 1 and 2, the structure 10, 110 further includes a second grid 58 identical to the first grid 18 and fixed above said first grid. The structure 10, 110 thus includes two cabling stages.

Figures 3 and 4 are partial views of an industrial facility 120. Said industrial facility in particular comprises a network of channels 130, partially shown in figure 3. The network 130 for example includes the first 40, second 42 and third 46 ducts previously described.

The network 130 also includes channels 132 comprising longitudinal ducts 134 and cross-ducts 136, connected by vertical ducts 137 and elbows 138.

The facility 120 further comprises a main chassis 140, made from steel. The main chassis 140 in particular comprises vertical columns 142 and horizontal spacers 144, arranged in the upper part of said columns. The main chassis 140 also comprises oblique triangulation elements 146.

The main chassis 140 is intended to keep the network of channels 130 in place, which extends in all three dimensions.

The facility 120 further comprises several metal structures 110 as described above. The metal structures 110 are suspended from the spacers 144 by the upper ends of their vertical uprights 12.

The metal structures 110 are intended to support the pipes of the network 130 and to mechanically connect said channels to the main chassis 140. In particular, the longitudinal ducts 134 and the cross-ducts 136 of the ducts 132 are respectively supported by transverse levels 30, 32, 34 and by longitudinal levels 22, 24, 26 of said metal structures 110.

The facility 120 further comprises a network (not shown) of electric and instrumentation cables, supported by the cable grids 18, 58.

A method for manufacturing the facility 120 will now be described. The metal structures 110 are manufactured in a standard manner in a workshop, said manufacturing including surface treatments of the anticorrosion type. The gap 48, between two consecutive longitudinal levels or two consecutive transverse levels, is in particular chosen based on the maximum diameter of the lines of the network 130.

The main chassis 140 is assembled on site, for example on the deck of a floating unit of the FPSO or FLNG type. A plurality of metal structures 110 is next suspended from the spacers 144. According to one embodiment of the invention, the metal structures 110 are preassembled at a certain number of horizontal ducts 40, 42, 46, longitudinal and/or transverse, before being suspended from the chassis 140.

The network of channels 130 is next developed, in particular by connecting said horizontal ducts 40, 42, 46 by vertical ducts 137 and by elbows 138. Other horizontal ducts can also be added, on the transverse levels 30, 32, 34 and/or on the longitudinal levels 22, 24, 26.

The longitudinal or transverse direction of the horizontal ducts 40, 42, 46, 134, 136 is imposed by the level, transverse or longitudinal, that supports each of said ducts. In a channel 132, a change of direction in the horizontal plane therefore involves a change of vertical level. Said change in vertical level is reflected by the coupling of a longitudinal portion 134 and a transverse portion 136 by a vertical duct 137 delimited by two elbows 138.

The three longitudinal levels 22, 24, 26 and the three transverse levels 30, 32, 34 of the metal structures 110 generate great freedom in the development of the spatial geometry of the network of channels 130. It is therefore possible to define a network 130 with a complex shape, while being suitable for standardized support structures 110.

In parallel, the network (not shown) of electric and instrumentation cables is deployed on the cable grids 18, 58.

The metal structures 10, 110 previously described thus provide standardized support to the channels and the cabling of the facility 120, without imposing spatial constraints during the design of the network of channels 130.

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CLAIMS

1.- A metal structure (10, 110) for supporting fluid ducts, comprising:

- substantially vertical uprights (12), arranged in a regular horizontal mesh characterized by a first longitudinal direction (X) and a second transverse direction (Y), and
- a plurality of longitudinal beams (14) and of transverse beams (16), arranged respectively in longitudinal and transverse directions, each beam connecting two consecutive uprights,

the plurality of longitudinal beams comprising at least a first level (22) of longitudinal beams, arranged along a first horizontal plane (36), said first level being capable of supporting a first transverse duct (40) extending in the transverse direction;

the plurality of transverse beams comprising at least one second level (30) of transverse beams, arranged along a second horizontal plane (38), said second level being capable of supporting a second duct (42) extending in the longitudinal direction; the second horizontal plane being located above the first horizontal plane;

the structure being characterized in that it is devoid of longitudinal beams on the second horizontal plane (38), said second horizontal plane thus being capable of being passed through by the first duct (40) above the longitudinal beams (14) of the first level (22).

2.- The metal structure according to claim 1, wherein:

- the plurality of longitudinal beams comprises a third level (24) of longitudinal beams arranged in a third horizontal plane (44), located above the second horizontal plane (38); and

- the structure is devoid of transverse beams at said third horizontal plane, said third horizontal plane thus being capable of being passed through by the second duct (42) above the transverse beams of the second level (30).

3.- The metal structure according to claim 1 or claim 2, including several levels (22, 24, 26) of longitudinal beams and several levels (30, 32, 34) of transverse beams, vertically alternating.

4.- The metal structure according to one of the preceding claims, further comprising at least one grid (18, 58) of longitudinal bars (50) and transverse bars (52), arranged respectively in the longitudinal (X) and transverse (Y) directions, each bar connecting two consecutive uprights (12), the longitudinal bars and transverse bars of said grid being coplanar and located above the plurality of longitudinal beams and transverse beams.

5.- The metal structure according to claim 4, wherein the at least one grid includes at least one cross-shaped reinforcement (54), each end of said reinforcement being fixed to the middle of a longitudinal bar (50) or a transverse bar (52).

6.- The metal structure according to one of the preceding claims, wherein each of the uprights (12) includes an upper end provided with a suspension means (21) from a chassis (140).

7.- An industrial facility (120) comprising:

- a network (130) of channels (132), extending in three dimensions,
- a main chassis (140) mechanically connected to said network (130), and
- at least one metal structure (10, 110) according to one of the preceding claims,

said metal structure being fixed to the main chassis;

said network of channels comprises at least one fluid duct (42, 134) extending in the longitudinal direction (X) and supported by at least one transverse beam (16) of said metal structure (10, 110), and/or at least one fluid duct (40, 136) extending in the transverse direction (Y) and supported by at least one longitudinal beam (14) of said metal structure.

8.- The facility according to claim 7, wherein at least one of the channels (132) of said network (130) comprises at least a longitudinal portion (134) and a transverse portion (136), respectively extending in the longitudinal and transverse directions, said portions being connected by at least one vertical duct (137) delimited by two elbows (138),

the at least one longitudinal portion (134) and the at least one transverse portion (136) respectively being supported by at least one transverse beam (16) and by at least one longitudinal beam (14) of the at least one metal structure.

9.- The industrial facility according to claim 7 or claim 8, wherein the at least one metal structure (10, 110) is according to claim 4 or claim 5, said facility further comprising electric or instrumentation cables, deployed on the at least one grid (18, 58).

10.- The industrial facility according to one of claims 7 to 9, wherein the at least one metal structure (10, 110) is according to claim 6, said metal structure being suspended from the main chassis (140).