

DEVICE FOR SEALING LEAKING FLANGE GASKETS

FIELD OF THE INVENTION

The invention relates to a sealing device for sealing a leaking flange gasket of a flange
5 connection between two pipe segments. The invention also relates to a method of sealing
a leaking flange gasket of a flange connection between pipe segments.

BACKGROUND OF THE INVENTION

Gas pipes and high-pressure gas pipes are found all over the world. One application area
10 is the petrochemical industry. A typical gas pipe is built up of several gas pipe segments
that are coupled in series by using so-called flange connections. Each end of the pipe
segment has a flange, which in a connection faces another flange. Both flanges are pro-
vided with corresponding holes through which bolts are to be provided, wherein on both
ends of the bolt there are provided at least one nut. Naturally, it can be assumed that one
15 side allows for the integration of the nut with the bolt. In at least one of the flanges there
may be provided an annular recess that is configured for receiving a gasket for sealing of
the flange connection, once the flanges are properly pressed together by bolts and nuts.

A common problem with particularly, but not only, high-pressure gas pipes is that the
flange connections start leaking. To resolve the leak, there exist two main techniques. The
20 first technique concerns the provision of a gas-tight housing around the leaking flange,
sealing against the pipes on both sides of the flange. The disadvantage of this technique
is that these housings may be very big, heavy, and expensive, because of the increased
pressure area. Due to the dimensions of the housing, this type of clamp is prone to hinder
its installation due to the crowded nature of these facilities. The second technique

concerns the injection of sealing compounds into clamps to contain the sealing compound. The disadvantage of this technique is that it requires re-injection over time and does not hold high-pressure gases well. In addition, this type of sealing results in increased separation forces in the flange connection during injection, which could result in higher stresses than allowed in the flange connection.

In view of the above-described problems and existing solutions there is a need for better resealing techniques.

SUMMARY OF THE INVENTION

The invention has for its object to remedy or to reduce at least one of the drawbacks of the prior art, or at least provide a useful alternative to prior art.

The object is achieved through features, which are specified in the description below and in the claims that follow.

The invention is defined by the independent patent claims. The dependent claims define advantageous embodiments of the invention.

In a first aspect the invention relates to a sealing device for sealing a leaking flange gasket of a flange connection between two pipe segments. The flange connection comprises:

- i) a first flange of a first pipe segment and having a receiving surface;
- ii) a second flange of a second pipe segment and having a further receiving surface configured for cooperating with the receiving surface of the first flange to enable the flange connection, the first flange and the second flange being formed such that an annular recess is formed between the flanges when the flanges are joined together;
- iii) a gasket placed in between the receiving surfaces of the flanges for sealing the flange connection, wherein the gasket is accessible from the annular recess;
- iv) a plurality of matching holes through said flanges being distributed around the circumference of the flanges, the plurality of matching holes being positioned such that each hole extends through the first flange, the annular recess and the second flange thus defining a space between the bolts and the flanges; and
- v) a plurality of bolts extending through the holes and being provided with nuts, wherein the nuts are tightened to press the flanges together by means of the bolts. The sealing device is characterized in that the sealing device comprises at least one sealing ring, a plurality of compression segments and a compression ring, wherein the at least

one sealing ring comprises a resilient material, wherein the sealing ring is shaped to be provided, in operational use of the sealing device, in abutment with the gasket and for sealing against the flanges and, optionally also the gasket, wherein shapes of the plurality of compression segments match each other like a puzzle while, in operational use of the sealing device, collectively substantially filling the space around and between the bolts and the flanges on both sides, wherein, in operational use of the sealing device, the compression ring is placed around the plurality of compression segments and configured for pressing the plurality of compression segments inwardly, which on their turn press against the at least one sealing ring to make the at least one sealing ring seal against the flanges for obtaining sealing of the flange connection.

The effects of the features of the sealing device in accordance with the invention are as follows. First of all, the invention provides a low-weight, compact solution by exploiting the annular space between the flanges. The first component to be added is the sealing ring, which needs to be provided in the annular recess such that it abuts the gasket that originally was supposed to seal the flange connection. This sealing ring should be a resilient material and needs to have at least one cut such that it can be provided around the gasket. It is advantageous when this cut is tilted relative to the orthogonal direction of the outer surface of the gasket. Pressing respective ends formed by these cuts then properly seals the sealing ring against itself. The sealing ring may be a one-part ring, but also comprise multiple parts that are mounted or fixed together. For example, one variant of such multi-part sealing ring is a two-part sealing ring of which one part comprises resilient material and the other part a harder material in order to support the sealing ring. This is further illustrated in the detailed description. Multi-part sealing rings as such are known to the person skilled in the art. Then, the space in the annular recess around the bolts is conveniently filled up with a plurality of compression segments that are formed so as to fit in between and around the bolts like a puzzle. Finally, the compression ring (of which mainly one specific embodiment is discussed in the description while many variations are possible) is provided around the plurality of compression segments for applying a pressure on these compression segments, which on their turn apply pressure on the sealing ring, which results in a proper resealing of the leaking flange connection. A major advantage of the current invention is that the pressure applied by the compression segments on the sealing ring does not significantly increase the separation forces, which could potentially induce stresses above the allowable limits of the flange. This is something the known injection sealing technique suffers from. The invention may render the need for a PED certificate superfluous. Also, sealant is not needed, which saves costs quite significantly.

Another advantage is that a re-sealed flange connection may be recompressed in case it would start leaking again, just by torquing the bolts. The invention's major benefit lies in its minimal projection from the flange's outer surface, which substantially diminishes the risk of interference with nearby obstructions.

- 5 To facilitate understanding of the invention one or more expressions are further defined hereinafter.

Wherever the wording "gasket" is used, this must be interpreted as any part that is used for sealing, it may comprise soft material, resilient material, swelling material, but also hard materials that are deformed by the pressure applied by the bolts in the flange connection.

Wherever the wording "pipe" is used, this must be interpreted as any tubular hollow structure, which facilitates transportation of fluid matter, such as gases and liquids.

Wherever the wording "flange" is used, this must be interpreted as a protruding rim at an end of pipe or pipe segment, which is configured for being mounting to a corresponding or matching flange of another pipe or pipe segment.

Wherever the wording "bolt" is used, this must be interpreted as any elongated fastening means, which can be tensioned at its ends.

Wherever the wording "nut" is used, this must be interpreted as any form of tensioning device, which cooperated with the bolt to facilitate tensioning.

- 20 Wherever the wording "sealing ring" is used, this must be interpreted as any ring-shaped structure, which is resilient enough to be used in the invention for sealing a leaking flange connection or even providing an extra seal to a non-leaking flange connection. It may have one or more cuts in order to allow it to be provided around the gasket.

25 Whenever the wording "resilient material" is used, this must be interpreted as any soft, elastic or flexible, material, which within the application of flange connections allows deformation to ensure a sealing effect. It goes without saying that in case of a multi-part sealing ring all parts must have some resilience or at least be flexible in order to allow for the sealing ring to be inserted and to have a sealing effect.

30 Whenever the wording "compression segments" is used, this must be interpreted as a plurality of segments, which together fill the space around the bolts within the annular recess

enough to allow the compression ring to be provided around it without it touching the bolts.

Whenever the wording “compression ring” is used, this must be interpreted as any annular structure that is capable of being provided around the compression segments, while applying an inwardly-directed pressure on the compression segments. It may comprise of one piece or multiple pieces that can be coupled together. In case of a multiple-piece solution one needs to have a gap between the pieces, which are being pulled towards each other during tensioning, in order to create the inwardly-directed pressure. This aspect is further explained in the detailed description.

10 In an embodiment of the sealing device in accordance with the invention at least one of the first flange and the second flange comprises a further annular recess in the respective receiving surface thereof, wherein the further annular recess is for partially housing the gasket to fix its position relative to the flanges facilitating sealing. There exist different types of flange connections. Some of them have a further annular recess on the receiving surface of the flange to contain at least part of the gasket, which the neighbouring flange may have the same annular recess. These two further annular recesses together then contain the gasket. Such gasket is typically called a ring-type-joint (RTJ) gasket and a flange connection comprising such gasket an RTJ-flange. Other flange connections, such as Raised Face flanges, do not have such annular recess on their receiving surfaces.

20 In an embodiment of the sealing device in accordance with the invention the plurality of compression segments comprises a metal, such as steel.

In an embodiment of the sealing device in accordance with the invention the compression ring comprises a plurality of ring sections that are connectible together so as to form the compression ring. This embodiment is easier to mount around an existing flange connection. There may be any two or more ring sections that jointly form the ring.

In an embodiment of the sealing device in accordance with the invention the compression ring comprises a further metal, such as steel.

In an embodiment of the sealing device in accordance with the invention the sealing ring comprises a seal ring and a support ring. The benefit of having a two-part sealing ring is that the soft material may extrude into gaps between parts if the gap is large enough. The backing ring may reduce the gap, as it is stiffer than the sealing material and more resistant to extrusion, which allows it to give the sealing material some “backing” to avoid

extrusion. The support ring (or maybe referred to as backing ring) can also be designed to expand when compressed radially, to cover even large gaps between steel parts. The extrusion effect becomes even more important when the temperature goes up and the sealing material becomes softer. The backing ring is not required if the gaps between the steel
5 rings are small enough that the sealing material would not extrude. More details are provided in the detailed description.

In an embodiment of the sealing device in accordance with the invention the sealing ring is shaped in accordance with Figs. 2, 5a, 5b, 5c, 6, 7, 8, 9, 10a, 10b, 11, 13-15. The detailed description will provide further structural details of the sealing ring.

10 In an embodiment of the sealing device in accordance with the invention the plurality of compression segments are shaped in accordance with Figs. 2, 4a, 4b, 5a, 5b, 5c, 6, 7, 8, 9, 13-15. The detailed description will provide further structural details of the compression segments.

In an embodiment of the sealing device in accordance with the invention the compression
15 ring is shaped in accordance with Figs. 2, 4b, 4c, 5a, 5b, 5c, 6, 7, 8, 9, 15. The detailed description will provide further structural details of the compression ring.

In an embodiment of the sealing device in accordance with the invention the plurality of compression segments are tightened together by means of screws that maybe pre-loaded with compression springs. This embodiment is advantageous in applications where thermal
20 effects play a significant role. More details are provided in the detailed description.

In an alternative embodiment compared to the previously-mentioned embodiment the compression springs may be left out, particularly where the screws act as springs themselves. Only when the screws are not flexible enough one may need to add the compression springs to get more stroke. Typically, when there are high-temperature fluctuations,
25 this flexibility could also be achieved by using longer screws or by making the compression rings thinner and allow them to stretch or flex.

In a second aspect the invention relates to a pipe comprising a plurality of pipe segments that are connected through respective flange connections, wherein at least one flange connection is provided with the sealing device according to any one of the preceding
30 claims. The invention provides significant advantages when re-sealing pipes having leaking flange connections, wherein the sealing has been breached. The resealing according to the invention leads to weight reduction, minimizes pollution, environmental hazards,

and asset downtime related to leaking flanges. Also, the invention provides a very compact solution compared to the prior art solutions, which also causes the device to less likely interfere with adjacent equipment.

- In a third aspect the invention relates to a method of sealing a leaking flange gasket of a flange connection between pipe segments. The method comprises steps of:
- providing a sealing device in accordance with any one of the claims 1 to 8;
 - placing the sealing ring around the gasket and in abutment with the gasket;
 - placing the plurality of compression segments around and between the bolts, the plurality of compression segments collectively substantially filling the space around and between the bolts and the flanges on both sides, and
 - placing the compression ring around the plurality of compression segments for pressing the plurality of compression segments together, which on their turn press against the sealing ring to make the sealing ring seal against the flanges.

The method is conveniently used to re-seal existing pipes having pipe segments that are connected with sealed flange connection.

BRIEF INTRODUCTION OF THE DRAWINGS

In the following is described example of embodiments illustrated in the accompanying drawings, wherein:

- Fig. 1 shows part of a test flange connection, which serves to illustrate the problem and the context of the current invention;
- Fig. 2 shows a first embodiment of the sealing device in accordance with the invention in an RTJ flange together with some enlarged views of the most important components of the sealing device;
- Figs. 3a-3l show consequent stages of applying the plurality of compression segments in the space between and around the bolts of the flange connection;
- Fig. 4a shows a flange connection, wherein both the sealing ring and the compression segments are provided between the flanges;
- Fig. 4b shows the flange connection of Fig. 4a, wherein three ring sections of the compression ring are provided around the compression segments;

- Fig. 4c shows the flange connection of Fig. 4a, wherein all ring sections of the compression ring are provided around the compression segments;
- Fig. 5a shows a cross-section of the flange connection, wherein all compression segments are provided around the sealing ring, and wherein four ring sections of the compression ring are provided around the compression segments, without being tightened;
- Fig. 5b shows a cross-section of the flange connection of Fig. 5b, wherein the four ring sections of the compression ring are tightened;
- Fig. 5c shows a sideview with cross-section in an orthogonal direction compared to Fig. 5b, illustrating abutment of the sealing ring and the gasket;
- Fig. 6 shows a flange connection comprising the sealing device of the invention, wherein one of the flanges is removed;
- Fig. 7 shows an RTJ-type flange connection having the first embodiment of the sealing device applied thereto, wherein also part of the pipe segments to which the flanges are connected are illustrated;
- Fig. 8 shows a Raised Face-type flange connection having a second embodiment of the sealing device applied thereto, wherein also part of the pipe segments to which the flanges are connected are illustrated;
- Fig. 9 shows a further embodiment of a sealing device in accordance with the invention;
- Figs. 10a-10b illustrates cross-sectional views of part of the sealing device of Fig. 9 and how it operates after application;
- Fig. 11 shows a flange connection that is ready to receive the sealing device according to Fig. 9;
- Fig. 12 shows part of the flange connection of Fig. 11, seen from a different view angle;
- Fig. 13 shows the part of Fig. 12 after application of the sealing ring and the compression segments in accordance with the further embodiment of Fig. 9;

- Fig. 14a shows an enlarged view of part of Fig. 13 when the sealing ring is not compressed by the compression segments;
- Fig. 14b shows an enlarged view of part of Fig. 13 when the sealing ring is being compressed by the compression segments; and
- 5 Fig. 15 shows the sealing device in accordance with the further embodiment of Fig. 9, wherein the compression ring is being tensioned by a screw having disc springs around its head end.

DETAILED DESCRIPTION OF THE EMBODIMENTS

- 10 Various illustrative embodiments of the present subject matter are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related
- 15 constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

- The present subject matter will now be described with reference to the attached figures.
- 20 Various systems, structures and devices are schematically depicted in the drawings for purposes of explanation only and to not obscure the present disclosure with details that are well known to those skilled in the art. Nevertheless, the attached drawings are included to describe and explain illustrative examples of the present disclosure. The words and phrases used herein should be understood and interpreted to have a meaning consistent with the understanding of those words and phrases by those skilled in the relevant
- 25 art. No special definition of a term or phrase, i.e., a definition that is different from the ordinary and customary meaning as understood by those skilled in the art, is intended to be implied by consistent usage of the term or phrase herein. To the extent that a term or phrase is intended to have a special meaning, i.e., a meaning other than that understood
- 30 by skilled artisans, such a special definition will be expressly set forth in the specification in a definitional manner that directly and unequivocally provides the special definition for the term or phrase.

The invention will be discussed with reference to the figures hereinafter.

Fig. 1 shows part of a test flange connection 99, which serves to illustrate the problem and the context of the current invention. The test flange connection 100 is of the earlier-mentioned RTJ type and comprises a first flange 110 and a second flange 120, which each
5 flange 110, 120 have a respective receiving surface 111, 121 for facing the other flange 110, 120. In both receiving surfaces 111, 121 there is provided an annular recess 113, 123 (referred to as further annular recess in the claims) in which a gasket 130 is retained. The receiving surfaces 111, 121 of the flanges 110, 120 are shaped such that an annular recess 140 is formed as illustrated. The flanges 110, 120 are provided with holes distrib-
10 uted around the circumference of the flange which are positioned such that the holes penetrated the first flange 110, the annular recess 140 and the second flange 120. Bolt are provided through said holes as illustrated and the annular recess 140 causes the bolts 150 to be partly visible. The bolts 150 are all provided with nuts 160 and these nuts are tightened such that the flanges 110, 120 press the gasket 130 into the respective (further
15 recesses) in the receiving surfaces of the flanges 110, 120. By this pressure the gasket 130 will typically deform and seal the flange connection. Even after tightening there will still be a gap 105 between the flanges 110, 120 as illustrated. Now, when the gasket 130 starts to wear out it may start leaking causing a leakage path 99 as illustrated by the thick double-curved arrow. The arrow 99 is directed away from the inside of the flange connec-
20 tion 100 to the outside. The inside of the flange connection 100 is in fluid communication with the inside of the pipe (not shown) and contain high-pressure gas in some applications. When leakage occurs, the flange connection 100 may need to be re-sealed, which is where the current invention kicks in and provides a very compact and robust solution compared to prior art techniques. Before the invention is discussed it is to be noted that
25 the invention effectively uses the space between the bolts 150 and the flanges 110, 120 within the annular recess 140 as will be explained in detail with reference to the remaining figures.

Fig. 2 shows a first embodiment of the sealing device 200 in accordance with the invention in an RTJ flange together with some enlarged views of the most important compo-
30 nents of the sealing device 200. The sealing device 200 comprises of three parts as illustrated. The first part is a sealing ring 210 typically comprising a resilient material, such as an elastomer, i.e., rubber. On the outside of the sealing ring 210 there are provided a plurality of compression segments 220. Each compression segment 220 is shaped such that match each other like a puzzle and form a ring-shaped element having holes equally dis-
35 tributed over the ring-shaped element, as illustrated. The plurality of compression

segments 220 are shaped to collectively and substantially fill the earlier-discussed annular recess 140 of the flange connection 100 as will be further illustrated hereinafter. In illustrated embodiment the plurality of compression segments 220 comprises roughly four different compression segments, namely a starter compression segment 220s that is to be placed first, multiple pairs of intermediate compression segments 220-1, 220-2, each pair being complementarily shaped to be placed around a bolt of the flange connection 100, and a termination compression segment 220t. The starter compression segment 220s and the termination compression segment 220t together form the same shape as one 220-1 of the pairs of intermediate compression segments 220-1, 220-2, as illustrated. The starter compression segment 220s and the termination compression segment face a before-last compression segment 220bl, which is shaped the same as the other one 220-2 of the pairs of intermediate compression segments 220-1, 220-2, as illustrated. Around the plurality of compression segments 220, there is provided a compression ring 230, which is built-up out of four similar individual parts 230-1, 230-2, 230-3, 230-4, as illustrated.

Figs. 3a-3l show consequent stages of applying the plurality of compression segments 220 in the space between and around the bolts 150 of the flange connection 100. In these figures unnecessary repetition of reference numbers is avoided for clarity purposes.

In Fig. 3a the sealing ring 210 is already applied in the gap between the flanges. In order to facilitate this the sealing ring 210 comprises a cut with a tilted surface relative to the surface of the gasket 130 with which it is abutted. Also, the starter compression segment 220s is already applied in Fig. 3a and the first intermediate compression segment 220-2 is being applied. In Fig. 3b the first intermediate compression segment 220-2 has been applied between the bolts and abutting the starter compression segments 220s. In Fig. 3c a second intermediate compression segment 220-1 has been applied. In Fig. 3d a third intermediate compression segment 220-2 is being applied. In Fig. 3e the third intermediate compression segment 220-2 has been applied. In Fig. 3f a fourth intermediate compression segment 220-1 has been applied. In Fig. 3g a fifth intermediate compression segment 220-2 has been applied. In Fig. 3h a sixth intermediate compression segment 220-1 has been applied. This process is further repeated and Fig. 3i shows the stage where the 14th intermediate compression segment 220-1 has been applied. In Fig. 3j the before-last compression segment 220bl is being applied and in Fig. 3k it has been applied. Finally, in Fig. 3l the termination compression segment 220t has been applied. This final piece of the plurality of compression segments 220 completes the puzzle and substantially fills the space between bolts and the flanges 110, 120 and the sealing ring 210. It is also important to note that due to the special shaping of the plurality of compression segments

the termination compression segments 220t also retains the starter compression segment 220s as well as its neighbouring compression segments 220bl, 220-2. The sealing device 200 is now ready for the application of the compression ring 230 around the plurality of compression segments 220.

5 Fig. 4a shows a flange connection 100, wherein both the sealing ring 210 (not visible) and the compression segments (220-1, 220-2) are provided between the flanges 110, 120. Fig. 4a complies with the stage illustrated in Fig. 3l. Fig. 4b shows the flange connection 100 of Fig. 4a, wherein three ring sections 230-1, 230-2, 230-3, of the compression ring 230 are provided around the compression segments 220-1, 220-2. It can be clearly ob-
10 served that the compression ring sections are T-shaped, such that they fit into the space that is left in the annular recess 140. Fig. 4c shows the flange connection 100 of Fig. 4a, wherein all ring sections 230-1, 230-2, 230-3, 230-4 of the compression ring 230 are provided around the compression segments 220. In the current embodiment the ring sections 230-1, 230-2, 230-3, 230-4 of the compression ring 230 are bolted together, but they also
15 may be coupled together by any other fastening technique known in the field.

Fig. 5a shows a cross-section of the flange connection 100, wherein all compression segments 220 are provided around the sealing ring 210, and wherein four ring sections 230-1, 230-2, 230-3, 230-4 of the compression ring 230 are provided around the compression segments 220, without being tightened. It can be observed that the holes in the compres-
20 sion segments 220 are larger than the diameter of the bolts 150. This is on purpose, because the compression segments 220 must be pressed against the sealing ring 210. This means that the holes must be large enough to allow some movement freedom of the compression segments 220 during tightening of the compression ring 230.

Fig. 5b shows a cross-section of the flange connection 100 of Fig. 5b, wherein the four
25 ring sections 230-1, 230-2, 230-3, 230-4 of the compression ring 230 are tightened together. The compression ring 230 presses on the compression segments 220 which on their turn press on the sealing ring 210, which on its turn presses on the gasket 130, but also on sidewalls (not shown) of the annular recess 140 (not shown), thereby sealing the flange connection 100. Fig. 5c shows a sideview with cross-section in an orthogonal direc-
30 tion compared to Fig. 5b, illustrating abutment of the sealing ring 210 and the gasket 130. The figure also serves to illustrate the various parts that were discussed in view of previous figures.

Fig. 6 shows a flange connection 100 comprising the sealing device 200 of the invention, wherein one 110 of the flanges 110, 120 is removed. The compression ring 230 is not tightened in this figure, but it does show all the components of the sealing device 200. The figure also illustrates how the sealing ring 210 comprises a split 210s which allows it to be
5 applied to the flange connection 100. Alternatively, there may be more than one split 210s.

Fig. 7 shows an RTJ-type flange connection 100-1 having the first embodiment of the sealing device 200 applied thereto, wherein also part of pipe segments 115, 125 to which the flanges 110, 120 are connected are illustrated. This figure gives a more complete view
10 of the flange connection 100-1, whereas the previous figures rather illustrate the gist of the invention concerning the flanges 110, 120 and the way it is sealed with the gasket 130.

Fig. 8 shows a Raised Face-type flange connection 100-2 having a second embodiment of the sealing device 200 applied thereto, wherein also part of the pipe segments 115, 125 to which the flanges 110, 120 are connected are illustrated. This figure will only be dis-
15 cussed in as far as it differs from Fig. 7. Instead of the gasket 130. In Raised Face-type flange connections like in this figure, the almost ring-shaped gasket 130-2 in the annular trench is replaced with a disc-shaped gasket 130. This disc-shaped gasket 130-2 extends from the inner wall of the pipe segments 115, 125 to beyond a bottom of the annular
20 trench 140 as illustrated. In order to be able to re-seal the disc-shaped gasket 130-2 when it leaks, the sealing ring 210 of Fig. 7 needs to be replaced with a pair of sealing rings 210-2, one on each side of the disc-shaped gasket 130-2, as illustrated. Furthermore, in the plurality of compression segments 220 in Fig. 7 needs to be replaced with a plurality of U-shaped compression segments 220-2 as illustrated. All other parts of the flange con-
25 nection 100-2 are substantially the same as in Fig. 7.

Fig. 9 shows a further embodiment of a sealing device 200 in accordance with the invention. This embodiment will be discussed in as far as it differs from Fig. 2. The difference resides in the type of sealing ring 210-3. The sealing ring 210-3 of this embodiment is a two-part sealing ring comprising two parts, namely a seal ring 210-3a and a support ring
30 210-3b. This will be further discussed in view of other figures. A further new aspect of Fig. 9 is that the compression ring comprises segments 230-1..230-4 that are tensioned with screws 240 that are provided with compression rings at their far end. More details about this aspect are discussed with reference to other figures.

Figs. 10a-10b illustrate cross-sectional views of part of the sealing ring 210-3 of Fig. 9 and how it operates after application. These figures illustrate that the sealing ring 210-3 comprises an inner part 210-3a that comprises a resilient material, such as rubber, and an outer part 210-3b that is pre-shaped in a bent form as shown in Fig. 10a. As already mentioned, the inner part 210-3a may also be called the seal ring. The outer part 210-3b is typically of a harder material, yet still having some resilience. As already mentioned, the outer part 210-3b may be called the support ring. Figs. 10a-10b also show part of the object against which the sealing ring 210-3 is supposed to seal. In the first embodiment that would be the gasket 130 as shown in Fig. 7. Yet it must be mentioned that the sealing ring of Figs. 10a and 10b just as well may be used in the embodiment of Fig. 8. Apart from adjustment of the dimensions the principle of operation is the same. In Fig. 8 the sealing is done against the disc-shaped gasket 130-2 (on both sides) and the material of the flanges 110, 120 around the annular recess 140 (on both sides).

The sealing ring 210-3 is used as follows. In Fig. 10a the sealing ring 210-3 is put in place and no pressure is yet applied to the sealing ring 210-3, while in Fig. 10b the compression segments 220 and the compression ring are applied and pressure is applied on outer part 210-3b as illustrated by the arrows. Under this pressure the outer part 210-3b straightens out and compresses the inner part 210-3a. During compression both the inner part 210-3a and the outer part 210-3b are expanding in width so that a proper seal effect is achieved. Fig. 10a also discloses a cavity 210c in the outer part 210-3b which facilitates bending of this part under pressure. More details are discussed with reference to other figures.

Fig. 11 shows a flange connection 100-1 that is ready to receive the sealing device 200 according to Fig. 9. Fig. 12 shows part of the flange connection 100-1 of Fig. 11, seen from a different view angle. The flange connection 100-1 of Figs. 11 and 12 is of the same type as in Fig. 7, which is a ring-type-joint-(RTJ)-type flange. In these figures none of the parts of the sealing device 200 have been applied yet. Both the bolt 150 and the gasket 130 are visible. The gasket 130 requires resealing in this example.

Fig. 13 shows the part of Fig. 12 after application of the sealing ring 210-3 and the compression segments 220 in accordance with the further embodiment of Fig. 9. The details of the sealing ring 210-3 are difficult to distinguish. Therefore, Fig. 14a shows an enlarged view of part of Fig. 13 when the sealing ring 210-3 is not compressed by the compression segments 220. Furthermore, Fig. 14b shows an enlarged view of part of Fig. 13 when the sealing ring 210-3 is being compressed by the compression segments 220. It must be noted that in Fig. 14a, where no significant pressure is applied there is an extrusion gap

210g visible between the sealing ring 210 and the edge(s) of the gap 105. In Fig. 14b, when pressure is applied (by the compression segments 220 and the compression ring (not shown)) and the earlier mentioned bending and widening of the sealing ring 210-3 takes places (indicated by the horizontal arrows) the gap has disappeared.

- 5 It must be stressed that there are many other sealing rings that may be used in the current sealing device 200. The current figures only serve to illustrate that the invention is not limited to any specific sealing ring.

Fig. 15 shows the sealing device 200 in accordance with the further embodiment of Fig. 9, wherein the compression ring 230 is being tensioned by a screw 240 having disc springs 241 around its head end. This embodiment is advantageous in case of significant thermal expansion of the compression segments 220. In case the compression ring 230 has been tightened around the compression segments 220 this thermal expansion will lead to an increased inwardly-directed pressure on the sealing ring 210, which may be detrimental to the sealing ring and cause new leakages. In this embodiment the problem of thermal expansion is resolved by tightening the individual compression ring segments 230-1, 230-2 with screws 240 that are pre-loaded with compression springs 241 as illustrated. When the screws 240 are tightened, thermal expansion of the compression segments 220 will lead to the creation or the enlargement of a compression ring gap 230g as illustrated.

As far as the compression ring gap 230g is concerned, it must be noted that one in fact always needs such gap (i.e., this applies to all embodiments in this specification) in order to be able to tighten the compression ring 230, when the compression ring segments 230-1, 230-2 touch each other and the gap 230g is gone, further tightening of screws 240 will not lead to further tightening of the compression ring 230. Even though these aspects considering tightening and required gaps are considered being part of the normal expertise and knowledge of a person skilled in the art, it is mentioned here for completeness.

The invention has been illustrated with reference to two main embodiments illustrated by the figures. However, the invention is also applicable to other types of flange connections. And although the invention was done within the field of high-pressure gas pipes at both low and high temperatures, the invention may also be applied to pipes transporting any other type of fluid, such as liquids, gases and mixtures thereof.

The embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. For example, variations are possible in the way

parts are connected or coupled. The connection ring as shown in the figures may also be replaced with other types of tensioning devices. One might even consider a tensioning device, which uses bolts accessible from the outside, wherein the bolts are able to apply a compressive force to each compression segment individually. Many options exist there
5 and all of those fall within the scope of the claims. What is important is that it is configured for applying a compressive force on the compression segments.

The person skilled in the art may easily find alternative solutions for tightening, tensioning, and mounting parts. The invention covers all these variants as long as they are covered by the independent claim. No limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that
10 the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does
15 not exclude the presence of a plurality of such elements. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. In the device claims enumerating several means, several of these means may be embodied by one and the same item of hardware.

C l a i m s

1. A sealing device (200) for sealing a leaking gasket (130) of a flange connection (100, 100-1, 100-2) between two pipe segments (115, 125), the flange connection (100, 100-1, 100-2) comprising:
 - 5 i) a first flange (110) of a first pipe segment (115) and having a receiving surface (111);
 - ii) a second flange (120) of a second pipe segment (125) and having a further receiving surface (121) configured for cooperating with the receiving surface (111) of the first flange (110) to enable the flange connection (100, 100-1, 100-2), the first flange (110) and the second flange (120) being formed such that an annular recess (140) is formed between the flange (110, 120) when the flange (110, 120) are joined together;
 - 10 iii) a gasket (130) placed in between the receiving surfaces (111, 121) of the flange (110, 120) for sealing the flange connection (100, 100-1, 100-2), wherein the gasket (130) is accessible from the annular recess (140);
 - 15 iv) a plurality of matching holes through said flanges (110, 120) being distributed around the circumference of the flange (110, 120), the plurality of matching holes being positioned such that each hole extends through the first flange (110), the annular recess (140) and the second flange (120) thus defining a space between the bolts (150) and the flange (110, 120); and
 - 20 v) a plurality of bolts (150) extending through the holes and being provided with nuts (160), wherein the nuts (160) are tightened to press the flange (110, 120) together by means of the bolts (150),

characterized in that the sealing device (200) comprises at least one sealing ring (110, 110-2), a plurality of compression segments (220, 220-2) and a compression ring (230), wherein the at least one sealing ring (110, 110-2) comprises a resilient material, wherein the at least one sealing ring (110, 110-2) is shaped to be provided, in operational use of the sealing device (200), in the annular recess in abutment with the gasket (130) for sealing against the flange (110, 120) and, optionally, also the gasket (130), wherein shapes of the plurality of compression segments (220, 220-2) match each other

- 30 like a puzzle while, in operational use of the sealing device (200), collectively substantially filling the space around and between the bolts (150) and the flange (110, 120) on both sides, wherein, in operational use of the sealing device (200), the compression ring (230) is placed around the plurality of compression segments (220, 220-2) and configured for pressing the plurality of compression segments (220, 220-2) inwardly, which on their turn
- 35 press against the at least one sealing ring (110, 110-2) to make the sealing ring (110, 110-2)

2) seal against the flange (110, 120) for obtaining sealing of the flange connection (100, 100-1, 100-2).

2. The sealing device (200) according to claim 1, wherein at least one of the first
5 flange (110) and the second flange (120) comprises a further annular recess (113, 123) in the respective receiving surface (111, 121) thereof, wherein the further annular recess (113, 123) is for partially housing the gasket (130) so as to fix its position relative to the flange (110, 120) facilitating sealing.

10 3. The sealing device (200) according to claim 1 or 2, wherein the plurality of compression segments (220, 220-2) comprises a metal, such as steel.

4. The sealing device (200) according to any one of the preceding claims, wherein the compression ring (230) comprises a plurality of ring sections (230-1..230-4) that are
15 connectible together so as to form the compression ring (230).

5. The sealing device (200) according to any one of the preceding claims, wherein the compression ring (230) comprises a further metal, such as steel.

20 6. The sealing device (200) according to any one of the preceding claims, wherein the sealing ring (210-3) comprises a seal ring (210-3a) and a support ring (210-3b).

7. The sealing device (200) according to any one of the preceding claims, wherein the sealing ring (110, 110-2) is shaped in accordance with Figs. 2, 5a, 5b, 5c, 6, 7, 8, 9,
25 10a, 10b, 11, 13-15.

8. The sealing device (200) according to any one of the preceding claims, wherein the plurality of compression segments (220, 220-2) are shaped in accordance with Figs. 2, 4a, 4b, 5a, 5b, 5c, 6, 7, 8, 9, 13-15.

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9. The sealing device (200) according to any one of the preceding claims, wherein the compression ring (230) is shaped in accordance with Figs. 2, 4b, 4c, 5a, 5b, 5c, 6, 7, 8, 9, 15.

10. The sealing device (200) according to claim 8 or 9, wherein the plurality of compression segments (220, 220-2) are tightened together by means of screws (240) that are pre-loaded with compression springs (241).

5 11. A pipe comprising a plurality of pipe segments (115, 125) that are connected through respective flange connections (100, 100-1, 100-2), wherein at least one flange connection (100, 100-1, 100-2) is provided with the sealing device (200) according to any one of the preceding claims.

10 12. A method of sealing a leaking gasket (130) of a flange connection (100, 100-1, 100-2) between pipe segments (115, 125), the method comprising steps of:

- providing a sealing device (200) in accordance with any one of claims 1 to 10;
- placing the at least one sealing ring (110, 110-2) around the gasket (130) and in abutment with the gasket (130);
- 15 - placing the plurality of compression segments (220, 220-2) around and between the bolts (150), the plurality of compression segments (220, 220-2) collectively substantially filling the space around and between the bolts (150) and the flange (110, 120) on both sides, and
- placing the compression ring (230) around the plurality of compression segments
- 20 (220, 220-2) for pressing the plurality of compression segments (220, 220-2) together, which on their turn press against the at least one sealing ring (110, 110-2) to make the at least one sealing ring (110, 110-2) seal against the flange (110, 120).