CLAIMS

1. A method of cooling a boil off gas stream (01) from a liquefied cargo in a floating transportation vessel, said liquefied cargo having a boiling point of greater than -110 °C at 1 atmosphere and comprising a plurality of components, said method comprising at least the steps of:

- compressing a boil off gas stream (01) from said liquefied cargo in two or more stages of compression comprising at least a first stage (65) and a final stage (75) to provide a compressed BOG discharge stream (06), wherein said first stage (65) of compression has a first stage discharge pressure and said final stage (75) of compression has a final stage suction pressure and one or more intermediate, optionally cooled, compressed BOG streams (02, 03, 04) are provided between consecutive stages of compression;
- cooling and separating the compressed BOG discharge stream (06) to provide a cooled vent stream (51) as a gaseous stream comprising non-condensed components of the boil off gas and a cooled compressed BOG stream (08) comprising condensed components of the boil off gas, or

  cooling the compressed BOG discharge steam (06) to provide a cooled compressed discharge stream (07) and subsequently separating the cooled compressed discharge stream (07) to provide a cooled vent stream (51) as a gaseous stream comprising non-condensed components of the boil off gas and a cooled compressed BOG stream (08) comprising condensed components of the boil off gas;
- expanding, optionally after further cooling, a portion of the cooled compressed BOG stream (08) to a pressure between that of the first stage discharge pressure and the final stage suction pressure to provide an expanded cooled BOG stream (33);
- heat exchanging the expanded cooled BOG stream (33) against the cooled vent stream (51) to provide a further cooled vent stream (53) as an at least partly condensed stream;

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- separating the further cooled vent stream (53) to provide a vent discharge stream (55) as a gaseous stream and a cooled vent BOG return stream (57) as a condensed stream, or

expanding the further cooled vent stream (53) to provide an expanded further cooled vent stream (63) and passing the expanded further cooled vent stream (63) to a storage tank (50).

2. The method of claim 1 wherein the heat exchange of the expanded BOG stream (33) against the cooled vent stream (51) further provides an intermediate, cooled, compressed BOG stream (03) or a BOG recycle stream (35).

3. The method of claim 2 further comprising the step of:
- adding the BOG recycle stream (35) to an intermediate, optionally cooled, compressed BOG stream (02, 03a).

4. The method of any of the preceding claims further comprising the steps of:
- drawing a portion of the cooled compressed BOG stream (08) to provide a cooled compressed BOG side stream (31);
- expanding the cooled compressed BOG side stream (31) to provide an expanded cooled BOG stream (33);
- heat exchanging the expanded cooled BOG stream (33) against the cooled vent stream (51) to provide the further cooled vent stream (53).

5. The method of claim 4 further comprising the step of:
- heat exchanging the expanded cooled BOG stream (33) against a portion (08b) of the cooled compressed BOG stream (08) to provide a further cooled compressed BOG stream (09).

6. The method of claim 4 or claim 5 further comprising:

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- compressing the boil off gas stream (01) in the first stage (65) of compression to provide a first intermediate compressed BOG stream (02) as an intermediate compressed BOG stream;
- heat exchanging the expanded cooled BOG stream (33) with the first intermediate compressed BOG stream (02) to provide a cooled first intermediate compressed BOG stream (03) as an intermediate, cooled, compressed BOG stream;
- passing the cooled first intermediate compressed BOG stream (03) to the suction of a second stage of compression.

7. The method of claim 4 or claim 5 wherein the heat exchange with the expanded cooled BOG stream (33) further provides a BOG recycle stream, said method comprising the further steps of:
- compressing the boil off gas stream (01) in the first stage (65) of compression to provide a first intermediate compressed BOG stream (02) as an intermediate compressed BOG stream;
- adding the BOG recycle stream to the first intermediate compressed BOG stream (02) to provide a cooled first intermediate compressed BOG stream (03) as an intermediate, cooled, compressed BOG stream;
- passing the cooled first intermediate compressed BOG stream (03) to the suction of a second stage of compression.

8. The method of claim 4 comprising the further steps of:
- drawing a portion of the cooled compressed BOG stream (08) to provide an additional cooled compressed BOG side stream (11);
- expanding the additional cooled compressed BOG side stream (11) to provide an additional expanded cooled BOG stream (13);
- heat exchanging the additional expanded cooled BOG stream (13) against a portion (08b) of the cooled compressed BOG stream (08) to provide a further cooled compressed BOG stream (09).

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9. The method of claim 8 wherein the step of heat exchanging the expanded cooled BOG stream (33) with the cooled vent stream (51) further provides a BOG recycle stream (35).

10. The method of claim 9, further comprising the steps of:

- compressing the boil off gas stream (01) in the first stage (65) of compression to provide a first intermediate compressed BOG stream (02) as an intermediate compressed BOG stream;
- heat exchanging the additional expanded cooled BOG stream (13) with the first intermediate compressed BOG stream (02) to provide a cooled first intermediate compressed BOG stream (03a);
- adding the cooled BOG recycle stream (35) to the cooled first intermediate compressed BOG stream (03a) and passing the resulting stream (03b) to the suction of a second stage of compression.

11. The method of claim 9 wherein the step of heat exchanging the additional expanded cooled BOG stream (13) against a portion (08b) of the cooled compressed BOG stream (08) further provides an additional BOG recycle stream, said method further comprising the steps of:

- compressing the boil off gas stream (01) in the first stage (65) of compression to provide a first intermediate compressed BOG stream (02) as an intermediate compressed BOG stream;
- adding the additional BOG recycle stream to the BOG recycle stream (35) to provide a combined BOG recycle stream;
- heat exchanging the combined BOG recycle stream with the first intermediate compressed BOG stream (02) to provide a cooled first intermediate compressed BOG stream (03);
- passing the cooled first intermediate compressed BOG stream (03) to the suction of a second stage of compression.

12. The method of claim 1 comprising the further steps of:

- expanding the cooled vent BOG return stream (57) to provide an expanded cooled vent BOG return stream (59);

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- passing the expanded cooled vent BOG return stream (59) to a storage tank (50).

13. The method of claim 1 comprising the further steps of:
- expanding the cooled vent BOG return stream (57) to provide an expanded cooled vent BOG return stream (59);
- heat exchanging the expanded cooled vent BOG return stream (59) against the vent discharge stream (55) to provide a heat exchanged vent BOG return stream, a cooled vent discharge stream and a further vent discharge stream;
- expanding the cooled vent discharge stream to provide an expanded cooled vent discharge stream;
- passing the heat exchanged vent BOG return stream and the expanded cooled vent discharge stream to a storage tank (50).

14. The method of claim 5 or claim 8 comprising the further steps of:
- expanding the further cooled compressed BOG stream (09) to provide an expanded cooled BOG return stream (10);
- passing the expanded cooled BOG return stream (10) to a storage tank (50).

15. The method according to any of the preceding claims wherein the liquefied cargo is LPG, such as LPG comprising more than 3.5 mol% ethane.

16. The method of any of the preceding claims wherein the compressed BOG discharge stream (06) is cooled against one or more heat exchange fluid streams, such as a water stream, more particularly a seawater stream, an air stream, more particularly an ambient air stream and/or a refrigerant stream, to provide the cooled compressed BOG stream (08).

17. The method of any of the preceding claims wherein stages of compression (65, 75) are the compression stages of a multi-stage compressor.

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18. An apparatus to cool a boil off gas stream (01) from a liquefied cargo in a floating transportation vessel, said liquefied cargo having a boiling point of greater than -110 °C at 1 atmosphere and comprising a plurality of components, said apparatus comprising at least:

- a compression system (60) to compress a boil off gas stream (01) from a liquefied cargo, said compression system comprising two or more stages of compression comprising at least a first stage (65) and a final stage (75) to provide a compressed BOG discharge stream (06), wherein intermediate, optionally cooled, compressed BOG streams (02, 03, 04) are provided between consecutive stages of compression,
- a discharge heat exchanger (200) and optionally a discharge receiver (205) to cool and separate the compressed BOG discharge stream (06) to provide a cooled vent stream (51) as a gaseous stream comprising non-condensed components of the boil off gas and a cooled compressed BOG stream (08) comprising condensed components of the boil off gas, or

  a discharge heat exchanger (200) to cool the compressed BOG discharge stream (06) to provide a cooled compressed BOG discharge stream (07) and an accumulator to separate the cooled compressed BOG discharge stream (07) into a cooled vent stream (51) as a gaseous stream comprising non-condensed components of the boil off gas and a cooled compressed BOG stream (08) comprising condensed components of the boil off gas;
- a first discharge stream pressure reduction device (120) to expand a portion of the cooled compressed BOG stream (08), optionally after further cooling, to provide an expanded portion of the cooled compressed BOG stream (08);
- one or more vent heat exchangers (190, 190') to heat exchange an expanded, optionally further cooled, portion of the cooled compressed BOG stream (08), against the cooled vent stream (51) to provide a further cooled vent stream (53) as an at least partly condensed stream;
- a vent stream separator (150) to separate the further cooled vent stream (53) to provide a vent discharge stream (55) as a gaseous stream and a cooled vent BOG return stream (57) as a condensed stream, or

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a vent stream pressure reduction device (61) to expand the further cooled vent stream (53) to provide an expanded further cooled vent stream (63) and a storage tank (50) to contain the expanded further cooled vent stream (63).

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CLAIMS

1. A method of cooling a boil off gas stream (01) from a liquefied cargo in a floating transportation vessel, said liquefied cargo having a boiling point of greater than -110 °C at 1 atmosphere and comprising a plurality of components, said method comprising at least the steps of:
   - compressing a boil off gas stream (01) from said liquefied cargo in two or more stages of compression comprising at least a first stage (65) and a final stage (75) to provide a compressed BOG discharge stream (06), wherein said first stage (65) of compression has a first stage discharge pressure and said final stage (75) of compression has a final stage suction pressure and one or more intermediate, optionally cooled, compressed BOG streams (02, 03, 04) are provided between consecutive stages of compression;
   - cooling and separating the compressed BOG discharge stream (06) to provide a cooled vent stream (51) as a gaseous stream comprising non-condensed components of the boil off gas and a cooled compressed BOG stream (08) comprising condensed components of the boil off gas;
   - expanding, optionally after further cooling, a portion of the cooled compressed BOG stream (08) to a pressure between that of the first stage discharge pressure and the final stage suction pressure to provide an expanded cooled BOG stream (33);
   - heat exchanging the expanded cooled BOG stream (33) against the cooled vent stream (51) to provide a further cooled vent stream (53).

2. The method of claim 1 wherein the heat exchange of the expanded BOG stream (33) against the cooled vent stream (51) further provides an intermediate, cooled, compressed BOG stream (03) or a BOG recycle stream (35).

3. The method of claim 2 further comprising the step of:
   - adding the BOG recycle stream (35) to an intermediate, optionally cooled, compressed BOG stream (02, 03a).

4. The method of any of the preceding claims further comprising the steps of:
- drawing a portion of the cooled compressed BOG stream (08) to provide a cooled compressed BOG side stream (31);
- expanding the cooled compressed BOG side stream (31) to provide an expanded cooled BOG stream (33);
- heat exchanging the expanded cooled BOG stream (33) against the cooled vent stream (51) to provide the further cooled vent stream (53).

5. The method of claim 4 further comprising the step of:
- heat exchanging the expanded cooled BOG stream (33) against a portion (08b) of the cooled compressed BOG stream (08) to provide a further cooled compressed BOG stream (09).

6. The method of claim 4 or claim 5 further comprising:
- compressing the boil off gas stream (01) in the first stage (65) of compression to provide a first intermediate compressed BOG stream (02) as an intermediate compressed BOG stream;
- heat exchanging the expanded cooled BOG stream (33) with the first intermediate compressed BOG stream (02) to provide a cooled first intermediate compressed BOG stream (03) as an intermediate, cooled, compressed BOG stream;
- passing the cooled first intermediate compressed BOG stream (03) to the suction of a second stage of compression.

7. The method of claim 4 or claim 5 wherein the heat exchange with the expanded cooled BOG stream (33) further provides a BOG recycle stream, said method comprising the further steps of:
- compressing the boil off gas stream (01) in the first stage (65) of compression to provide a first intermediate compressed BOG stream (02) as an intermediate compressed BOG stream;

- adding the BOG recycle stream to the first intermediate compressed BOG stream (02) to provide a cooled first intermediate compressed BOG stream (03) as an intermediate, cooled, compressed BOG stream;
- passing the cooled first intermediate compressed BOG stream (03) to the suction of a second stage of compression.

8. The method of claim 4 comprising the further steps of:
- drawing a portion of the cooled compressed BOG stream (08) to provide an additional cooled compressed BOG side stream (11);
- expanding the additional cooled compressed BOG side stream (11) to provide an additional expanded cooled BOG stream (13);
- heat exchanging the additional expanded cooled BOG stream (13) against a portion (08b) of the cooled compressed BOG stream (08) to provide a further cooled compressed BOG stream (09).

9. The method of claim 8 wherein the step of heat exchanging the expanded cooled BOG stream (33) with the cooled vent stream (51) further provides a BOG recycle stream (35).

10. The method of claim 9, further comprising the steps of:
- compressing the boil off gas stream (01) in the first stage (65) of compression to provide a first intermediate compressed BOG stream (02) as an intermediate compressed BOG stream;
- heat exchanging the additional expanded cooled BOG stream (13) with the first intermediate compressed BOG stream (02) to provide a cooled first intermediate compressed BOG stream (03a);
- adding the cooled BOG recycle stream (35) to the cooled first intermediate compressed BOG stream (03a) and passing the resulting stream (03b) to the suction of a second stage of compression.

11. The method of claim 9 wherein the step of heat exchanging the additional expanded cooled BOG stream (13) against a portion (08b) of the cooled

compressed BOG stream (08) further provides an additional BOG recycle stream, said method further comprising the steps of:

- compressing the boil off gas stream (01) in the first stage (65) of compression to provide a first intermediate compressed BOG stream (02) as an intermediate compressed BOG stream;
- adding the additional BOG recycle stream to the BOG recycle stream (35) to provide a combined BOG recycle stream;
- heat exchanging the combined BOG recycle stream with the first intermediate compressed BOG stream (02) to provide a cooled first intermediate compressed BOG stream (03);
- passing the cooled first intermediate compressed BOG stream (03) to the suction of a second stage of compression.

12. The method according to any of the preceding claims comprising the further steps of:

- expanding the further cooled vent stream (53) to provide an expanded further cooled vent stream (61);
- passing the expanded further cooled vent stream (61) to a storage tank (50).

13. The method according to any of the preceding claims comprising the further step of:

- separating the further cooled vent stream (53) to provide a vent discharge stream (55) and a cooled vent BOG return stream (57).

14. The method of claim 13 comprising the further steps of:

- expanding the cooled vent BOG return stream (57) to provide an expanded cooled vent BOG return stream (59);
- passing the expanded cooled vent BOG return stream (59) to a storage tank (50).

15. The method of claim 13 comprising the further steps of:

- expanding the cooled vent BOG return stream (57) to provide an expanded cooled vent BOG return stream (59);
- heat exchanging the expanded cooled vent BOG return stream (59) against the vent discharge stream (55) to provide a heat exchanged vent BOG return stream, a cooled vent discharge stream and a further vent discharge stream;
- expanding the cooled vent discharge stream to provide an expanded cooled vent discharge stream;
- passing the heat exchanged vent BOG return stream and the expanded cooled vent discharge stream to a storage tank (50).

16. The method of claim 5 or claim 8 comprising the further steps of:
- expanding the further cooled compressed BOG stream (09) to provide an expanded cooled BOG return stream (10);
- passing the expanded cooled BOG return stream (10) to a storage tank (50).

17. The method according to any of the preceding claims wherein the liquefied cargo is LPG, such as LPG comprising more than 3.5 mol% ethane.

18. The method of any of the preceding claims wherein the compressed BOG discharge stream (06) is cooled against one or more heat exchange fluid streams, such as a water stream, more particularly a seawater stream, an air stream, more particularly an ambient air stream and/or a refrigerant stream, to provide the cooled compressed BOG stream (08).

19. The method of any of the preceding claims wherein stages of compression (65, 75) are the compression stages of a multi-stage compressor.

20. The method of claim 1 wherein the step of cooling and separating the compressed BOG discharge stream (06) comprises:
- cooling the compressed BOG discharge stream (06) against a heat exchange fluid in a shell and tube heat exchanger to provide a warmed heat exchange fluid, the cooled vent stream (51) and a cooled compressed discharge

stream (07) comprising condensed components of the boil off gas and passing the cooled compressed discharge stream (07) to a discharge receiver (205) which discharges the cooled compressed BOG stream (08); or

- cooling the compressed BOG discharge steam (06) in a plate-type heat exchanger (200) to provide a cooled compressed discharge stream (07) and separating the cooled compressed discharge stream (07) in a discharge receiver (205) to provide the cooled vent stream (51) and the cooled compressed BOG stream (08).

21. An apparatus to cool a boil off gas stream (01) from a liquefied cargo in a floating transportation vessel, said liquefied cargo having a boiling point of greater than -110 °C at 1 atmosphere and comprising a plurality of components, said apparatus comprising at least:

- a compression system (60) to compress a boil off gas stream (01) from a liquefied cargo, said compression system comprising two or more stages of compression comprising at least a first stage (65) and a final stage (75) to provide a compressed BOG discharge stream (06), wherein intermediate, optionally cooled, compressed BOG streams (02, 03, 04) are provided between consecutive stages of compression,
- a discharge heat exchanger (200) to cool the compressed BOG discharge stream (06) against a heat exchange fluid to provide a warmed heat exchange fluid and a cooled compressed discharge stream (07);
- a discharge receiver (205) to discharge the cooled compressed discharge stream (07) as a cooled compressed BOG stream (08) comprising condensed components of the boil off gas;

wherein either the discharge heat exchanger (200) or the discharge receiver (205) provide a cooled vent stream (51) as a gaseous stream comprising non-condensed components of the boil off gas;

- a first discharge stream pressure reduction device (120) to expand an optionally further cooled portion of the cooled compressed BOG stream (08) to provide an expanded cooled BOG stream (33);

- one or more vent heat exchangers (190, 190') to heat exchange the expanded cooled BOG stream (33), against the cooled vent stream (51) to provide a further cooled vent stream (53).

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