CLAIMS

1. A method for liquefying a feed gas stream rich in methane, comprising:

(a) providing the feed gas stream at a pressure less than 1,200 psia (8.3×10^6 Pa);

(b) providing a compressed refrigerant stream with a pressure greater than or equal to 1,500 psia (1.0×10^7 Pa);

(c) cooling the compressed refrigerant stream by indirect heat exchange with an ambient temperature air or water, to produce a compressed, cooled refrigerant stream;

(d) expanding the compressed, cooled refrigerant stream in at least one work producing expander, thereby producing an expanded, cooled refrigerant stream;

(e) mixing part or all of the expanded, cooled refrigerant stream with a make-up refrigerant stream in a separator, thereby condensing heavy hydrocarbon components from the make-up refrigerant stream and forming a gaseous expanded, cooled refrigerant stream;

(f) passing the gaseous expanded, cooled refrigerant stream through a heat exchanger zone to form a warm refrigerant stream;

(g) passing the feed gas stream through the heat exchanger zone to cool at least part of the feed gas stream by indirect heat exchange with the expanded, cooled refrigerant stream, thereby forming a liquefied gas stream; and

(i) compressing the warm refrigerant stream to produce the compressed refrigerant stream.

2. The method of claim 1, further comprising:

controlling a flow rate of the make-up refrigerant stream into the separator to maintain at least one pressure at a suction side of a compressor at a target value.

3. The method of claim 1 or claim 2, further comprising:

collecting the condensed heavy hydrocarbon components in the separator; and

discharging the condensed heavy hydrocarbon components to maintain a desired liquid level in the separator.

4. The method of any one of claims 1-3, further comprising:

prior to directing the feed gas stream to the heat exchanger zone, compressing the feed gas stream to a pressure no greater 1,600 psia (1.1×10^7 Pa), and then cooling it by indirect heat exchange with an ambient temperature air or water.

5. The method of any one of claims 1-4, wherein the feed gas stream is cooled to a temperature below an ambient temperature by indirect heat exchange within an external cooling unit prior to directing the feed gas stream to the heat exchanger zone.

6. The method of any one of claims 1-5, wherein the compressed, cooled refrigerant stream is cooled to a temperature below the ambient temperature by indirect heat exchange within an external cooling unit prior to expanding the compressed, cooled refrigerant stream in the at least one work producing expander.

7. The method of any one of claims 1-6, wherein the make-up refrigerant stream comprises a portion of the feed gas stream, a boil-off gas obtained from the liquefied gas stream, or any combination thereof, optionally wherein the make-up refrigerant stream comprises a mixture of methane with at least one component having a molecular weight heavier or lighter than methane.

8. A method for liquefying a feed gas stream rich in methane in a system having a first heat exchanger zone and a second heat exchanger zone, comprising:

(a) providing a compressed refrigerant stream with a pressure greater than or equal to 1,500 psia (1.0×10^7 Pa);

(b) cooling the compressed refrigerant stream by indirect heat exchange with an ambient temperature air or water to produce a compressed, cooled refrigerant stream;

(c) directing the compressed, cooled refrigerant stream to the second heat exchanger zone to additionally cool the compressed, cooled refrigerant stream below ambient temperature to produce a compressed, additionally cooled refrigerant stream;

(d) expanding the compressed, additionally cooled refrigerant stream in at least one work producing expander, thereby producing an expanded, cooled refrigerant stream;

(e) routing part or all of the expanded, cooled refrigerant stream to at least one separator, such as a separation vessel, and mixing said expanded, cooled refrigerant stream with a make-up refrigerant gas stream, to thereby condition the make-up refrigerant gas stream by condensing heavy hydrocarbon components therefrom and producing a gaseous overhead refrigerant stream;

(f) combining the gaseous overhead refrigerant stream with the remaining expanded, cooled refrigerant stream to form a cold primary refrigerant mixture;

(g) passing the cold primary refrigerant mixture through the first heat exchanger zone to form a warm refrigerant stream, whereby the warm refrigerant stream has a temperature that is cooler by at least 5 °F (-15.0 °C) of the highest fluid temperature within the heat exchanger zone, and wherein a heat exchanger type of the first heat exchanger zone is different from a heat exchanger type of the second heat exchanger zone;

(h) passing the feed gas stream through the first heat exchanger zone to cool at least part of the feed gas stream by indirect heat exchange with the cold primary refrigerant mixture,

thereby forming a liquefied gas stream; and

(i) compressing the warm refrigerant stream to produce the compressed refrigerant stream.

9. The method of claim 8, further comprising:

controlling a flow rate of the make-up refrigerant gas stream into the separator to maintain at least one pressure at a suction side of a compressor at a target value.

10. The method of claim 8 or claim 9, further comprising:

collecting the condensed heavy hydrocarbon components in the separator; and

discharging the condensed heavy hydrocarbon components to maintain a desired liquid level in the separator.