We Claim:

1. A method for detecting in real-time a refrigerant charge loss in a refrigerant vapor compression system having a refrigerant circuit including a refrigerant compression device, a refrigerant heat rejection heat exchanger, an evaporator and an electronic expansion valve operatively associated with the evaporator, the method comprising:

determining whether both a sensed evaporator outlet superheat exceeds a target evaporator outlet superheat by at least a preset amount of superheat and a sensed degree of openness of the electronic expansion valve exceeds a preset degree of openness for a preset time of period;

if both the sensed evaporator outlet superheat exceeds the target evaporator outlet superheat by at least the preset amount of superheat and the sensed degree of openness of the electronic expansion valve exceeds the preset degree of openness for the preset time of period, determining whether at least one air temperature of a sensed supply air temperature of a flow of air having traversed the evaporator or a sensed return air temperature of a flow of air returning to the evaporator is changing at a rate less than a preset air temperature rate of change;

if the at least one air temperature of the sensed supply air temperature of a flow of air having traversed the evaporator or the sensed return air temperature of a flow of air returning to the evaporator is changing at a rate less than the preset air temperature rate of change, generating a service alarm indicating a loss of charge warning.

2. The method as set forth in claim 1 further comprising:

if the at least one air temperature of the sensed supply air temperature of a flow of air having traversed the evaporator or the sensed return air temperature of a flow of air returning to the evaporator is changing at a rate less than the preset air temperature rate of change, comparing a sensed suction pressure of refrigerant passing to a suction inlet to the compression device to a preset low suction pressure limit, and if the sensed suction pressure of refrigerant passing to a suction inlet to the compression device is less than the preset low suction pressure limit for a preset period of time, generating a shut down alarm warning an urgent system refrigerant recharge is required.

3. The method as set forth in claim 1 further comprising:

if the at least one air temperature of the sensed supply air temperature of a flow of air having traversed the evaporator or the sensed return air temperature of a flow of air returning to the evaporator is changing at a rate less than the preset air temperature rate of change,

determining whether a sensed speed of the compression device is at a maximum speed limit for the compression device for a predetermined period of time.

4. The method as set forth in claim 3 further comprising:

if the sensed speed of the compression device is less than the preset maximum speed limit for the speed of the compression device, comparing a sensed suction pressure of refrigerant passing to a suction inlet to the compression device to a preset low suction pressure limit, and if the sensed suction pressure of refrigerant passing to a suction inlet to the compression device is less than the preset low suction pressure limit for a preset period of time, generating a service alarm indicating an urgent system refrigerant recharge required warning.

5. The method as set forth in claim 3 further comprising:

if the sensed speed of the compression device is at the maximum speed limit for the speed of the compression device throughout a preset time interval, comparing a sensed current draw by the compression device to a maximum current draw limit.

6. The method as set forth in claim 5 further comprising:

if the sensed current draw exceeds a preset percentage of the maximum current draw limit, reducing the speed of the compression device to a lower speed at which the current draw associated with said lower speed is below the preset percentage of the maximum current draw limit.

7. The method as set forth in claim 6 wherein the preset percentage of the maximum current draw limit is at least 90% of the maximum current draw.

8. The method as set forth in claim 5 wherein the preset time interval is at least 3 minutes to 10 minutes.

9. The method as set forth in claim 1 further if both the sensed evaporator outlet superheat exceeds the target evaporator outlet superheat by a selected amount in range from at least 5°F (2.8°C) to 20°F (11.1°C) and the sensed degree of openness of the electronic expansion valve exceeds 90% of openness for at least 5 minutes, then determining whether at least one air temperature of a sensed supply air temperature of a flow of air having traversed the evaporator or a sensed return air temperature of a flow of air returning to the evaporator is changing at a rate less than a preset air temperature rate of change.

10. The method as set forth in claim 1 wherein the preset air temperature rate of change is 0.5°F (0.27°C) per minute.

11. The method as set forth in claim 2 wherein the refrigerant comprises a carbon dioxide refrigerant and the present low suction pressure limit is a pressure in the range from 120 pounds per square inch absolute (8.3 bars absolute) to 200 pounds per square inch absolute (13.8 bars).

12. The method as set forth in claim 11 wherein the preset low suction pressure limit is about 150 pounds per square inch absolute (10.3 bars).

13. A method for determining the actual refrigerant charge within a refrigerant vapor compression system having a closed loop refrigerant circuit and including a refrigerant compression device, the method comprising:

after the compression device has been off for a predetermined period of time, sensing a refrigerant pressure at a location within the closed loop refrigerant circuit;

sensing an outdoor ambient temperature;

if the sensed outdoor ambient temperature exceeds 88°F (31°C), calculating a refrigerant density using the sensed refrigerant pressure and the sensed outdoor ambient temperature;

multiplying the calculated refrigerant density with an internal volume of the closed loop refrigerant circuit, thereby determining a weight of refrigerant resident in the closed loop refrigerant circuit.

14. The method as set forth in claim 13 wherein sensing a refrigerant pressure at a location within the closed loop refrigerant circuit comprises sensing a compressor discharge pressure.

15. The method as forth in claim 13 further comprising comparing the calculated system refrigerant charge to a design system refrigerant charge; and if the calculated system refrigerant charge is less than a preset percentage of the preferred system refrigerant charge, generating an alarm flagging loss of refrigerant charge.

We claim:

1. A method for detecting in real-time a refrigerant charge loss in a refrigerant vapor compression system (10) having a refrigerant circuit including a refrigerant compression device (20), a refrigerant heat rejection heat exchanger (30), an evaporator (50) and an electronic expansion valve (55) operatively associated with the evaporator (50), the method comprising:

determining whether both a sensed evaporator outlet superheat exceeds a target evaporator outlet superheat by at least a preset amount of superheat and a sensed degree of openness of the electronic expansion valve (55) exceeds a preset degree of openness for a preset time of period;

if both the sensed evaporator outlet superheat exceeds the target evaporator outlet superheat by at least the preset amount of superheat and the sensed degree of openness of the electronic expansion valve (55) exceeds the preset degree of openness for the preset time of period, determining whether at least one air temperature of a sensed supply air temperature of a flow of air having traversed the evaporator (50) or a sensed return air temperature of a flow of air returning to the evaporator (50) is changing at a rate less than a preset air temperature rate of change;

if the at least one air temperature of the sensed supply air temperature of a flow of air having traversed the evaporator (50) or the sensed return air temperature of a flow of air returning to the evaporator (50) is changing at a rate less than the preset air temperature rate of change, generating a service alarm indicating a loss of charge warning.

2. The method as set forth in claim 1 further comprising:

if the at least one air temperature of the sensed supply air temperature of a flow of air having traversed the evaporator (50) or the sensed return air temperature of a flow of air returning to the evaporator (50) is changing at a rate less than the preset air temperature rate of change, comparing a sensed suction pressure of refrigerant passing to a suction

inlet to the compression device (20) to a preset low suction pressure limit, and if the sensed suction pressure of refrigerant passing to a suction inlet to the compression device (20) is less than the preset low suction pressure limit for a preset period of time, generating a shut down alarm warning an urgent system refrigerant recharge is required.

3. The method as set forth in claim 1 further comprising:

if the at least one air temperature of the sensed supply air temperature of a flow of air having traversed the evaporator (50) or the sensed return air temperature of a flow of air returning to the evaporator (50) is changing at a rate less than the preset air temperature rate of change, determining whether a sensed speed of the compression device (20) is at a maximum speed limit for the compression device (20) for a predetermined period of time.

4. The method as set forth in claim 3 further comprising:

if the sensed speed of the compression device (20) is less than the preset maximum speed limit for the speed of the compression device (20), comparing a sensed suction pressure of refrigerant passing to a suction inlet to the compression device (20) to a preset low suction pressure limit, and if the sensed suction pressure of refrigerant passing to a suction inlet to the compression device (20) is less than the preset low suction pressure limit for a preset period of time, generating a service alarm indicating an urgent system refrigerant recharge required warning.

5. The method as set forth in claim 3 further comprising:

if the sensed speed of the compression device (20) is at the maximum speed limit for the speed of the compression device (20) throughout a preset time interval, comparing a sensed current draw by the compression device (20) to a maximum current draw limit.

6. The method as set forth in claim 5 further comprising:

if the sensed current draw exceeds a preset percentage of the maximum current draw limit, reducing the speed of the compression device (20) to a lower speed at which the current draw associated with said

lower speed is below the preset percentage of the maximum current draw limit.

7. The method as set forth in claim 6 wherein the preset percentage of the maximum current draw limit is at least 90% of the maximum current draw.

8. The method as set forth in claim 5 wherein the preset time interval is at least 3 minutes to 10 minutes.

9. The method as set forth in claim 1 further if both the sensed evaporator outlet superheat exceeds the target evaporator outlet superheat by a selected amount in range from at least 2.8 °C (5 °F) to 11.1 °C (20 °F) and the sensed degree of openness of the electronic expansion valve (55) exceeds 90% of openness for at least 5 minutes, then determining whether at least one air temperature of a sensed supply air temperature of a flow of air having traversed the evaporator (50) or a sensed return air temperature of a flow of air returning to the evaporator (50) is changing at a rate less than a preset air temperature rate of change.

10. The method as set forth in claim 1 wherein the preset air temperature rate of change is 0.27 °C (0.5 °F) per minute.

11. The method as set forth in claim 2 wherein the refrigerant comprises a carbon dioxide refrigerant and the present low suction pressure limit is a pressure in the range from 8.3 bars absolute (120 psi absolute) to 13.8 bars (200 psi absolute).

12. The method as set forth in claim 11 wherein the preset low suction pressure limit is about 10.3 bars (150 psi absolute).