more components of the vacuum system. Also, a flexible seal between the flapper and the valve body can wear over time, which can also alter the conductance performance of the vacuum system, and, in particular, the valve.

SUMMARY

[0004a] According to a first aspect, the present disclosure provides a method for calibrating a valve in a vacuum system, comprising: measuring conductance of the valve as a function of angular valve position; determining a conductance map or function for the valve by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position; storing the conductance calibration map or function for use during operation of the valve, wherein a difference between the measured valve conductance and the pre-defined metric of conductance versus angular valve position is used in determining the conductance map or function; during operation, receiving a set point angular valve position based on a desired conductance of the valve, and setting actual angular valve position of the valve based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position; determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein if the actual angular valve position is relatively low and the actual system conductance is greater than the reference system conductance, in a low-conductance valve, the diagnostic indication is that a flapper seal of the low-conductance valve is worn.

[0004b] According to a second aspect, the present disclosure provides a method for providing a diagnostic indication in a vacuum system using a valve, the method comprising: receiving a set point angular valve position based on a desired conductance of the valve; setting actual angular valve position of the valve based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of

conductance versus angular valve position; determining an actual system conductance; determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein, if the actual angular valve position is relatively low and the actual system conductance is greater than the reference system conductance, in a low-conductance valve, the diagnostic indication is that a flapper seal of the low-conductance valve is worn.

[0004c] According to a third aspect, the present disclosure provides a method for calibrating a valve in a vacuum system, comprising: measuring conductance of the valve as a function of angular valve position; determining a conductance map or function for the valve by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position; and storing the conductance calibration map or function for use during operation of the valve wherein a difference between the measured valve conductance and the predefined metric of conductance versus angular valve position is used in determining the conductance map or function; during operation, receiving a set point angular valve position based on a desired conductance of the valve; and setting actual angular valve position of the valve based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position; determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein if the actual angular valve position is relatively low and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is that deposition by-products have accumulated on at least one of a valve wall and a flapper of the valve.

[0004d] According to a fourth aspect, the present disclosure provides a method for calibrating a valve in a vacuum system, comprising: measuring conductance of the valve as a

function of angular valve position; determining a conductance map or function for the valve by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position; and storing the conductance calibration map or function for use during operation of the valve wherein a difference between the measured valve conductance and the predefined metric of conductance versus angular valve position is used in determining the conductance map or function; during operation, receiving a set point angular valve position based on a desired conductance of the valve; setting actual angular valve position of the valve based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position; determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a low-conductance valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.

[0004e] According to a fifth aspect, the present disclosure provides a method for calibrating a valve in a vacuum system, comprising: measuring conductance of the valve as a function of angular valve position; determining a conductance map or function for the valve by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position; and storing the conductance calibration map or function for use during operation of the valve wherein a difference between the measured valve conductance and the predefined metric of conductance versus angular valve position is used in determining the conductance map or function; during operation, receiving a set point angular valve position based on a desired conductance of the valve; setting actual angular valve position of the valve based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position; determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in

the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.

[0004f] According to a sixth aspect, the present disclosure provides a method for providing a diagnostic indication in a vacuum system using a valve, the method comprising: receiving a set point angular valve position based on a desired conductance of the valve; setting actual angular vale position of the valve based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of conductance versus angular valve position; determining an actual system conductance; determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein if the actual angular valve position is relatively low and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is that deposition by-products have accumulated on at least one of a valve wall and a flapper of the valve.

[0004g] According to a seventh aspect, the present disclosure provides a method for providing a diagnostic indication in a vacuum system using a valve, the method comprising: receiving a set point angular valve position based on a desired conductance of the valve; setting actual angular vale position of the valve based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of conductance versus angular valve position; determining an actual system conductance; determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the

difference between the actual system conductance and the reference system conductance for the system; wherein if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a low-conductance valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.

[0004h] According to an eighth aspect, the present disclosure provides a method for providing a diagnostic indication in a vacuum system using a valve, the method comprising: receiving a set point angular valve position based on a desired conductance of the valve; setting actual angular vale position of the valve based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of conductance versus angular valve position; determining an actual system conductance; determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.

[0005] According to an ~~first aspect~~embodiment, a method for calibrating a valve in a vacuum system is provided. According to the method, conductance of the valve as a function of angular valve position is measured. A conductance map or function for the valve is determined by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position. The conductance calibration map or function is stored for use during operation of the valve.

[0006] A difference between the measured valve conductance and the predefined metric of conductance versus angular valve position can be used in determining the conductance map or function. During operation, a set point angular valve position based on a desired conductance of

the valve can be received. Actual angular valve position of the valve can be set based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position. An actual system conductance and a difference between the actual system conductance and a reference system conductance for the system can be determined. A diagnostic indication of a fault in the system can be generated based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system. If the actual angular valve position is relatively low and the actual system conductance is greater than the reference system conductance, in a low-conductance valve, the diagnostic indication can be that a flapper seal of the low-conductance valve is worn. If the actual angular valve position is relatively low and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication can be that deposition by-products have accumulated on at least one of a valve wall and a flapper of the valve. The relatively low angular valve position can be below 20 degrees. If the actual angular valve

position is relatively high and the actual system conductance is less than the reference system conductance, in a low-conductance valve, the diagnostic indication can be at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system. If the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication can be at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system. The relatively high angular valve position can be greater than 50 degrees.

[0007] According to another ~~aspect~~embodiment, a method for providing a diagnostic indication in a vacuum system using a valve is provided. According to the method, a set point angular valve position based on a desired conductance of the valve is received. An actual angular valve position of the valve is set based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of conductance versus angular valve position. An actual system conductance and a difference between the actual system conductance and a reference system conductance for the system are determined. A diagnostic indication of a fault in the system is generated based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system.

[0008] If the actual angular valve position is relatively low and the actual system conductance is greater than the reference system conductance, in a low-conductance valve, the diagnostic indication can be that a flapper seal of the low-conductance valve is worn. If the actual angular valve position is relatively low and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication can be that deposition by-products have accumulated on at least one of a valve wall and a flapper of the valve. The relatively low angular valve position can be below 20 degrees. If the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a low-conductance valve, the diagnostic indication can be at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system. If the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication can be at

CLAIMS

1. A method for calibrating a valve in a vacuum system, comprising:

measuring conductance of the valve as a function of angular valve position;

determining a conductance map or function for the valve by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position; ~~and~~

storing the conductance calibration map or function for use during operation of the valve, wherein a difference between the measured valve conductance and the pre-defined metric of conductance versus angular valve position is used in determining the conductance map or function;

during operation, receiving a set point angular valve position based on a desired conductance of the valve, and setting actual angular valve position of the valve based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position;

determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system; and

generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein

if the actual angular valve position is relatively low and the actual system conductance is greater than the reference system conductance, in a low-conductance valve, the diagnostic indication is that a flapper seal of the low-conductance valve is worn.

~~2. The method of claim 1, wherein a difference between the measured valve conductance and the predefined metric of conductance versus angular valve position is used in determining the conductance map or function.~~

~~3. The method of claim 2, further comprising, during operation, receiving a set point angular valve position based on a desired conductance of the valve; and setting actual angular valve position of the valve based on the received set point angular valve position and the~~

~~difference between the measured valve conductance and the predefined metric of conductance versus angular valve position.~~

~~4. The method of claim 3, further comprising determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system.~~

~~5. The method of claim 4, further comprising generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system.~~

~~6. The method of claim 5, wherein, if the actual angular valve position is relatively low and the actual system conductance is greater than the reference system conductance, in a low-conductance valve, the diagnostic indication is that a flapper seal of the low-conductance valve is worn.~~

~~7.~~2. The method of claim ~~6~~1, wherein the relatively low angular valve position is below 20 degrees.

~~8. The method of claim 5, wherein, if the actual angular valve position is relatively low and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is that deposition by-products have accumulated on at least one of a valve wall and a flapper of the valve.~~

~~9. The method of claim 8, wherein the relatively low angular valve position is below 20 degrees.~~

~~10. The method of claim 5, wherein, if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a low-conductance valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.~~

~~11. The method of claim 10, wherein the relatively high angular valve position is greater than 50 degrees.~~

~~12. The method of claim 5, wherein, if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.~~

~~13. The method of claim 12, wherein the relatively high angular valve position is greater than 50 degrees.~~

~~14.~~3. A method for providing a diagnostic indication in a vacuum system using a valve, the method comprising:

receiving a set point angular valve position based on a desired conductance of the valve;

setting actual angular valve position of the valve based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of conductance versus angular valve position;

determining an actual system conductance;

determining a difference between the actual system conductance and a reference system conductance for the system; and

generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein,

if the actual angular valve position is relatively low and the actual system conductance is greater than the reference system conductance, in a low-conductance valve, the diagnostic indication is that a flapper seal of the low-conductance valve is worn.

~~15. The method of claim 14, wherein, if the actual angular valve position is relatively low and the actual system conductance is greater than the reference system conductance, in a low-conductance valve, the diagnostic indication is that a flapper seal of the low-conductance valve is worn.~~

~~16.~~4. The method of claim ~~15~~3, wherein the relatively low angular valve position is below 20 degrees.

5. A method for calibrating a valve in a vacuum system, comprising:

measuring conductance of the valve as a function of angular valve position;

determining a conductance map or function for the valve by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position; and

storing the conductance calibration map or function for use during operation of the valve wherein a difference between the measured valve conductance and the predefined metric of conductance versus angular valve position is used in determining the conductance map or function;

during operation, receiving a set point angular valve position based on a desired conductance of the valve; and setting actual angular valve position of the valve based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position;

determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system; and

generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein

if the actual angular valve position is relatively low and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is that deposition by-products have accumulated on at least one of a valve wall and a flapper of the valve.

6. The method of claim 5, wherein the relatively low angular valve position is below 20 degrees.

~~17. The method of claim 14, wherein, if the actual angular valve position is relatively low and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is that deposition by-products have accumulated on at least one of a valve wall and a flapper of the valve.~~

~~18. The method of claim 17, wherein the relatively low angular valve position is below 20 degrees.~~

~~19.~~7. ~~The~~ A method for calibrating a valve in a vacuum system, comprising: ~~of claim 14,~~

measuring conductance of the valve as a function of angular valve position;

determining a conductance map or function for the valve by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position; and

storing the conductance calibration map or function for use during operation of the valve wherein a difference between the measured valve conductance and the predefined metric of conductance versus angular valve position is used in determining the conductance map or function;

during operation, receiving a set point angular valve position based on a desired conductance of the valve; setting actual angular valve position of the valve based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position;

determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system; and

generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein~~,~~

if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a low-conductance valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.

~~20.~~8. The method of claim ~~19~~7, wherein the relatively high angular valve position is greater than 50 degrees.

~~21. The method of claim 14, wherein, if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a non-~~

~~sealing valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.~~

~~22. The method of claim 21, wherein the relatively high angular valve position is greater than 50 degrees.~~

9. A method for calibrating a valve in a vacuum system, comprising:

measuring conductance of the valve as a function of angular valve position;

determining a conductance map or function for the valve by comparing the measured valve conductance to a predefined metric of conductance versus angular valve position; and

storing the conductance calibration map or function for use during operation of the valve wherein a difference between the measured valve conductance and the predefined metric of conductance versus angular valve position is used in determining the conductance map or function;

during operation, receiving a set point angular valve position based on a desired conductance of the valve; setting actual angular valve position of the valve based on the received set point angular valve position and the difference between the measured valve conductance and the predefined metric of conductance versus angular valve position;

determining an actual system conductance and determining a difference between the actual system conductance and a reference system conductance for the system; and generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein

if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.

10. The method of claim 9, wherein the relatively high angular valve position is greater than 50 degrees.

11. A method for providing a diagnostic indication in a vacuum system using a valve, the method comprising:

receiving a set point angular valve position based on a desired conductance of the valve;

setting actual angular vale position of the valve based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of conductance versus angular valve position;

determining an actual system conductance;

determining a difference between the actual system conductance and a reference system conductance for the system; and

generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein

if the actual angular valve position is relatively low and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is that deposition by-products have accumulated on at least one of a valve wall and a flapper of the valve.

12. The method of claim 11, wherein the relatively low angular valve position is below 20 degrees.

13. A method for providing a diagnostic indication in a vacuum system using a valve, the method comprising:

receiving a set point angular valve position based on a desired conductance of the valve;

setting actual angular vale position of the valve based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of conductance versus angular valve position;

determining an actual system conductance;

determining a difference between the actual system conductance and a reference system conductance for the system; and

generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein

if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a low-conductance valve, the diagnostic indication is at least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.

14. The method of claim 13, wherein the relatively high angular valve position is greater than 50 degrees.

15. A method for providing a diagnostic indication in a vacuum system using a valve, the method comprising:

receiving a set point angular valve position based on a desired conductance of the valve;

setting actual angular vale position of the valve based on the received set point angular valve position and a difference between the measured valve conductance and a predefined metric of conductance versus angular valve position;

determining an actual system conductance;

determining a difference between the actual system conductance and a reference system conductance for the system; and

generating a diagnostic indication of a fault in the system, the diagnostic indication being based on the actual angular valve position of the valve and the difference between the actual system conductance and the reference system conductance for the system; wherein

if the actual angular valve position is relatively high and the actual system conductance is less than the reference system conductance, in a non-sealing valve, the diagnostic indication is at

least one of an at least partial blockage in a conduit of the system and degradation of a pump in the system.

16. The method of claim 15, wherein the relatively high angular valve position is greater than 50 degrees.