

CLAIMS

1. A vacuum system, comprising:
 - at least one cryopump;
 - a plurality of sensors associated with said at least one cryopump each of said plurality of sensors being configured to sense an operating condition of said at least one cryopump;
 - diagnostic circuitry configured to receive signals sampled from at least some of said plurality of sensors and to receive a step of regeneration when the sampled signals were sampled from the plurality of sensors, said diagnostic circuitry comprising a diagnostic model of said cryopump, said diagnostic model being derived from historical data of a plurality of cryopumps of a same type operating over a plurality of regeneration and servicing time periods and being configured to relate values of said sampled signals from said at least some sensors and the steps of regeneration when the sampled signals were sampled to a probability of said pump failing within a predetermined time, said diagnostic circuitry being configured to apply said sampled signals and said step of regeneration when said sampled signals were sampled to said diagnostic model and to determine said probability of said at least one cryopump failing within said predetermined time from an output of said model.
2. A vacuum system according to claim 1, wherein at least some of said plurality of signals include at least some of: a first temperature of a first stage of said cryopump, a second temperature of a second stage of said cryopump, a time since a last regeneration, a speed of a motor of said cryopump, inputs to heater circuitry, and a time for said cryopump to cool down to said first temperature.
3. A vacuum system according to any preceding claim, said vacuum system comprising a plurality of cryopumps, said diagnostic circuitry being configured to receive signals from each of said plurality of cryopumps and to determine a probability of each of said cryopumps failing.

4. A vacuum system according to any preceding claim, wherein said diagnostic circuitry is responsive to detecting a probability of said at least one cryopump failing being above a predetermined threshold value for a set time to output a warning indicating said pump should be replaced at a next scheduled preventive maintenance.
5. A vacuum system according to any preceding claim, said vacuum system comprising an input for receiving signals from a remote diagnostic system and an output for outputting signals to said remote diagnostic system.
6. A vacuum system according to claim 5, said vacuum system being configured to periodically output data collected from at least some of said sensors along with data indicative of maintenance performed on said at least one cryopump to said remote diagnostic system.
7. A vacuum system according to claim 6, said vacuum system comprising an input for receiving data from a service engineer indicative of a condition of a pump that is replaced during said maintenance period, said vacuum system being configured to output said data indicative of said condition of said replaced pump as part of said periodically output data.
8. A vacuum system according to any preceding claim, said vacuum system comprising an input configured to periodically receive updates to said diagnostic model.
9. A vacuum system according to claim 8, when dependent on any one of claims 5 to 7, said vacuum system comprising an input configured to periodically receive said updates to said diagnostic model from said remote diagnostic system.

10. A method of monitoring a vacuum system, said vacuum system comprising at least one cryopump, said method comprising:

sampling a plurality of signals indicative of operating conditions of said at least one cryopump from sensors associated with said cryopump:

inputting at least some of said signals and a step of regeneration when said signals were sampled to a diagnostic model of said cryopump, said diagnostic model being derived from historical data of a plurality of cryopumps of a same type operating over a plurality of time periods, at least some of which include at least one of regeneration, servicing and failure of said pump, said diagnostic model relating signals to a probability of said pump failing;

determining from an output of said model a probability of said at least one cryopump failing.

11. A method of generating a diagnostic model for a type of cryopump, said method comprising:

inputting into a current version of the diagnostic model data collected from sensing operating conditions of a plurality of cryopumps of said type from a database storing said sensed operating conditions of said plurality of cryopumps sampled over a plurality of time periods at least some of time periods including at least one of regeneration, servicing and failure, to generate a plurality of probabilities of said cryopumps failing within a certain time;

determining an accuracy of the plurality of probabilities and altering the current version of the diagnostic model to improve the accuracy of the plurality of probabilities; and

repeating said steps until the accuracy reaches a desired value; and

outputting the version of the diagnostic model that provided said desired value of accuracy.

12. A method according to claim 11, wherein prior to inputting said data into said current version of the diagnostic model said signals are filtered to remove outlying data.

13. A method according to claim 11, or 12, wherein prior to inputting said received signals into said current version of the diagnostic model said signals are filtered to remove signals sampled a predetermined time before and after a regeneration of said cryopumps.

14. A method according to claim 11, further comprising:
while using the diagnostic model, receiving additional data for an additional cryopump of said type;
adding said additional data to said database;
inputting into a current version of the diagnostic model data in said database including said additional data to generate a plurality of probabilities of said plurality of cryopumps and said additional cryopump failing within a certain time;
determining an accuracy of the plurality of probabilities and altering the current version of the diagnostic model to improve the accuracy of the plurality of probabilities; and
repeating the steps of generating the plurality of probabilities of said plurality of cryopumps and said additional cryopump failing, determining an accuracy of the plurality of probabilities and altering the current version of the diagnostic model to improve the accuracy of the plurality of probabilities until the accuracy reaches a desired value; and
generating the version of the diagnostic model that provided said desired value of accuracy.

15. A method according to claim 14, further comprising receiving data indicative of a condition of a pump replaced following said diagnostic model indicating said pump would fail within a predetermined time, said data being input to said current version of the diagnostic model