INTEGRATED EXPLOSION PROTECTION APPARATUS FOR SUPERVISION AND CONTROL OF ADVANCED ELECTRICAL APPARATUSES

Inventors: Arnulf Krogedal, Sandnes (NO); Per Ole Torkildsen, Bryne (NO); Ole Kristian Brekken, Algard (NO)

Correspondence Address: ST. ONGE STEWARD JOHNSTON & REENS, LLC 986 BEDFORD STREET STAMFORD, CT 06905-5619 (US)

Application No.: 12/147,068
Filed: Jun. 26, 2008
Related U.S. Application Data: Continuation of application No. PCT/IB2006/054993, filed on Dec. 21, 2006.

The invention refers to an explosion protection system for electrical apparatuses and machineries, such as manipulators or industrial robots, located in hazardous environments, i.e. environments containing explosive concentrations of flammable gases, dusts or vapours, comprising an air supply that applies internal pressurized air into an explosion proof enclosure. The invention is achieved by a flow- and pressure sensor arranged as an integrated unit and designed to stand high dynamic forces by having low inertia, balanced arrangement of moving parts and a movement guide, e.g. an axle with a support guide, with low friction.

Diagram:
- Control cabinet
- Relay unit, ACRB
- Ex interface unit, AEXB
- Power and signal cables
- Air connection
- Flushing pressure line
- Operating pressure line
- Pressure adjustment
- Pressure gauge
- Maintenance pressure valve
- Zener barrier
- Flushing pressure orifice
- Operating pressure orifice
- Purge valve
- Purge unit
- Flexible hose
- HAZARDOUS AREA
- Purge sensor
- Exhaust
- Manipulator

- = Purged area

Publication Classification:
- Int. Cl.: F24F 11/00 (2006.01)
- U.S. Cl.: 454/238

Foreign Application Priority Data:
- Dec. 28, 2005 (SE) 0502927-7
Figure 6

- Maintenance min press 0.8mbar
- Purge valve "on" / "off"
- High air flow correct / not correct
- Approx. 2 seconds
- Power on to enclosure

Legend:
- Dark
- Green
- Red
INTEGRATED EXPLOSION PROTECTION APPARATUS FOR SUPERVISION AND CONTROL OF ADVANCED ELECTRICAL APPARATUSES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation pending International patent application PCT/IB2006/054993 filed on Dec. 21, 2006 which designates the United States and claims priority from Swedish patent application 0502927-7 filed on Dec. 28, 2005, the content of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to a system for explosion protection of electrical apparatuses and machineries, such as manipulators or industrial robots, located in hazardous environments, such as environments containing explosive concentrations of inflammable gases, dusts or vapours. The invention is especially related to systems that apply internal pressurized air into an explosion proof casing/housing and having a purging system.

BACKGROUND OF THE INVENTION

[0003] Advanced electrical apparatuses and automatic machineries as e.g. robots will normally consist of a complex design including electrical components as e.g. motors, relays, electrical cables etc and which are arranged in an enclosure consisting of sub-sections to withstand explosion from the operation environment.

[0004] According to the International and National Ex-Approval Standards IEC 79-2 (1983) the enclosure, ducts and coupling components should be able to withstand an overpressure to 1.5 times the maximum overpressure specified in normal service or 0.2 kPa (2 mbar), which is greater. According to IEC 79-2 the location, size and number of inlet and outlet orifices (air supply and sensors) can be sufficient to ensure efficient purging. The number of orifices, air supply and sensors, should be chosen with regard to the design and disposition of the protected apparatus, particular consideration being given to the needs of sub-compartments into which the apparatus might be divided.

[0005] One example of a pressurized enclosure consisting of serial-coupled sub-compartments or chambers are shown schematically in FIG. 1, see also “Electrical Instruments in Hazardous Locations” ISBN: 87664-376-4 1978, 2nd edition 1980.

[0006] The advantages of applying explosion protection based on air pressure and purging methods instead of other protection methods is that you obtain a more light, compact and cost effective solution based on that it is possible to apply standard non-ex components as e.g. motors etc. The pressurizing and purging protection method is a widely accepted protection concept for explosion protection. It is accepted world-wide and is relatively straightforward to comprehend.

[0007] The technique of pressurizing and purging enclosures of electrical apparatuses and machines, including robots, is to prevent the ingress of a flammable atmosphere. Purging is itself a widely accepted protection concept for explosion protection. The potentially ignitable capable apparatus as e.g. a robot is typically mounted inside an enclosure. The enclosure is then pressurized to a positive air pressure relative to the atmospheric pressure. A positive pressure of about 0.5 mbar is all that is required. In DE 2.228.598 is disclosed a protection enclosure for protection of manipulators, e.g. robot arms, consisting of serial-coupled sub-compartments and motors and electrical cables to stand gas or fluid materials. This patent does however not disclose any control or purge systems or any relief valve unit.

SUMMARY OF THE INVENTION

[0008] A problem with known systems for explosion protection of electrical apparatuses is that they are heavy, voluminous, expensive and has to be provided with a number of local detectors and units for ventilation and that the systems therefore cannot be optimally located.

[0009] Another problem is that the known systems can fail, that they are not sufficiently reliable.

[0010] Another problem is that the relief valve often will be blocked by dust or point.

[0011] Another problem is that the known systems do not obtain an optimal air consumption relief valve often will be blocked by dust or point.

[0012] The object of the present invention is to provide a pressure and purging controller and sensor apparatus that solves these problems and which is cost effective and reliable for application on advanced electrical apparatus and machineries as e.g. industrial robots and that contain a pressurized enclosure comprising sub-compartments linked together in a serial coupled set-up.

[0013] These and other objects are achieved according to the present invention by a control system as described in claim 1 and a flow- and pressure sensor as described in claim 12.

[0014] A flow and pressure/purging controller and sensor system according to the invention gives the following advantages over known and available control and sensor solutions:

[0015] the integrated robust and advanced flow and pressure sensor is to be applied to control environments, enclosures, with high dynamic forces that is present when e.g. a robot accelerate and/or stop,

[0016] a flow and pressure sensor and control system is to be applied in an enclosure comprising sub-compartments which are linked together in a serial coupled set-up,

[0017] the advanced and cost effective and reliable flow and pressure (Purge) sensor and control system is able to supervise both the inlet and outlet of the complete enclosure consisting of sub-compartments and does not need local sensors in each of the sub-compartments (ref. IEC 79-2 which describe system containing sub-compartments and local air supply and control by orifices),

[0018] that a relief valve is built in,

[0019] can be arranged at the most optimal place in the pressurized enclosure as e.g. on the upper arm of a robot manipulator and thereof obtain a simple and effective enclosure design consisting of sub-chambers as a serial coupled chamber,

[0020] the purge and pressure controller may include supervision of cable breakage and short circuits for the flow sensor,

[0021] the flow supervision is able to detect leakages before a purging sequence,

[0022] the flow and pressure sensor and control system may be optimized for ducts (tubes, hoses) containing
electrical cables and air supply, for purging and air pressure to obtain Ex-protection according to IEC 79-2 chapter 2.9 and 4.7.

[0023] the advanced flow- and pressure sensor and control system may obtain optimal air, and energy, consumption by having a combined control of the inlet and outlet air-flow and pressure level and thereof avoid arranging several local supplies and sensors to obtain a complete control of a complex enclosure comprising sub-compartments.

[0024] the advanced purge and pressure control system will be able to control several separate enclosures/machines simultaneously supervision of the air leakage level during operation mode and thereof secure an optimal air consumption as well as reduce the potential downtime of the system by giving feedback information about the status of the leakage level and thereof initiate need for preventive maintenance (as e.g. replacement of sealing etc).

[0025] the purge controller is able to control more than one enclosure and gives thereof possibility to apply optional equipments e.g. on a robot arm and which are arranged in a separate over-pressurized enclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The present invention will be described in more detail in the following, with reference to the attached drawings.

[0027] FIG. 1 illustrates schematically a typical pressurized enclosure consisting of serial-coupled sub compartments.

[0028] FIG. 2 shows a control system of an integrated purge- and pressure control system including a purge and pressure sensor and a relief valve unit.

[0029] FIG. 3 shows a relief valve.

[0030] FIG. 4 shows the relief valve and its surrounding equipment.

[0031] FIG. 5 shows a block diagram of the purge and pressure controller unit.

[0032] FIG. 6 shows a diagram of the status of purge P3 LED during flow sequence.

DETAILED DESCRIPTION OF THE INVENTION

[0033] FIG. 1 illustrates schematically a known example of a pressurized enclosure consisting of serial coupled sub compartments with communicating passages. An inflow of pressurized air is shown schematically to the left and an outflow of the air to the right.

[0034] FIG. 2 illustrates a system overview of the integrated purge and pressure control system that includes a purge and pressure sensor and relief valve unit. A control cabinet is arranged to control a purge valve and a maintenance pressure valve. In a hazardous area a manipulator (not shown) is located inside an enclosure. A purge sensor and an exhaust valve are arranged on the enclosure, that typically is divided in sub compartments. The purge sensor is electrically connected via a cable located in a flexible hose and via a Zener barrier to the control cabinet.

[0035] FIG. 3 illustrates the purge relief valve unit which is designed to take high airflow capacity during purging and to give a determined air leakage during operation. This leakage will keep the outlet clean from dust or contamination from powder and/or paint and it minimizes the friction in the valve.

Preferably the valve is designed for paint powder material application where contamination can impact the operation and reliability of the unit. Controlled leak air flow along the valve-guide and thereof makes the valve “float”. Moving parts in the valve are designed with low inertia and allows operation by acceleration higher than 10 m/s². The pressure drop through the valve is measured during purge sequence, and correct airflow is supervised by a sensor P3 (see FIG. 4).

[0036] FIG. 4 illustrates the purge and pressure sensors and the relief valve unit and their interconnections. The sensor P1 is used to detect possible build-up of pressure inside the enclosure, caused by e.g. clogged flame grid in the exhaust tube. The sensor P2 monitors the overpressure in the enclosure/robot interior in relation to the outside pressure during normal operation. The sensor P2b controls air pressure drop or leakages before reaching the P 2a level which activate shut down. The P2a sensor controls the leakage level during normal operation and thereof will be able to prevent uncontrolled downtime, i.e. “fail safe design”, by applying the feedback as an input for the preventive maintenance program (inspection and replacement of sealings, couplings etc).

[0037] An optional solution is to integrate an additional Air maintenance regulator valve to compensate for leakages and thereof avoid shut-down, see the “Maintenance Pressure Valve” in FIG. 2.

[0038] Another optional solution is to integrate an additional air maintenance regulator valve to compensate for leakages and thereof avoid shut-down as well as reduce air supply consumption by only activating the air supply when a minimum level is reached, not having a continuous air supply, see the “Maintenance Pressure Valve” in FIG. 2.

[0039] The sensor P3 monitors the air flow during the flushing/purging sequence by measuring Delta-P across the sensor nozzle.

[0040] FIG. 5 illustrates a block diagram of the purge and pressure controller unit. The unit has the following key control functions,

[0041] operates more than one enclosure, see S1, System 1 and S2, System 2,

[0042] controls the purge flow level, see sequence diagram in FIG. 6,

[0043] controls the pressure levels during Purging, i.e. max pressure level to avoid a too high pressure in the enclosure in order to meet safety regulations for pressurized enclosures,

[0044] controls minimum pressure level during operation to secure that the enclosure has a higher pressure level than the environment during operation of the machine/robot,

[0045] controls the leakage level during operation mode and thereof be able to prevent uncontrolled downtime, “fail safe design”, by applying the feedback as an input for the preventive maintenance program, inspection and replacement of sealings, couplings etc.

[0046] FIG. 6 illustrates that before starting the purge sequence. The controller checks for min pressure created by the maintenance pressure. If not min press: too big leakage

[0047] Min pressure OK: start purging by operating Purge Valve

[0048] Check for correct flow (delta pressure across purge relief valve)

[0049] If correct: Start countdown of preset time

[0051] Check high flow indicator off before giving signal for power on to pressurized enclosure.

[0052] In this specification the invention has been described with reference to specific embodiments. It will, however, be evident that variations and modifications may be made of the invention without therefore departing from the spirit and scope of the claims.

1. An explosion protection system for electrical apparatuses and machineries located in hazardous environments comprising:

- an air supply for applying internal pressurized air into at least one explosion protected proof enclosure having serially coupled sub-compartments and;
- a flow and pressure sensor arranged as an integrated purge and pressure unit, having a relief valve with a balanced arrangement of moving parts, a valve movement guide, a leak air flow system for establishing a leak air flow along the valve movement guide for reducing friction within the valve, and a membrane symmetrically arranged with respect to the guide;

said system conducting a purge sequence from time to time.

2. An explosion protection system according to claim 1, wherein the integrated purge and pressure unit includes a purge and pressure controller unit for controlling the flow and pressure level within the enclosure.

3. An explosion protection system according to claim 1, wherein the integrated purge and pressure unit includes a detector that detecting leak air flow before conducting a purge sequence.

4. An explosion protection system according to claim 1 further comprising a feedback sensor for monitoring the pressure within the enclosure, comparing it to the pressure outside of the enclosure, and generating a feedback signal.

5. An explosion protection system according to claim 1, further comprising a regulator valve for controlling the air pressure level and consumption within the enclosure during operation mode by activating the air supply when the pressure within the enclosure reaches a minimum level.

6. A flow and pressure sensor for an explosion protection system for electrical apparatuses and machineries comprising:

- a flow and pressure sensor arranged as an integrated purge and pressure unit having a relief valve with a balanced arrangement of moving parts, a valve movement guide, a device for establishing a leak air flow along the valve movement guide for reducing the friction within the valve, and a membrane symmetrically arranged with respect to the guide.

7. An explosion protection system according to claim 1 wherein said electrical apparatuses and machineries comprise manipulators.

8. An explosion protection system according to claim 1 wherein said electrical apparatuses and machineries comprise industrial robots.

9. An explosion protection system according to claim 1 wherein said hazardous environments contain explosive concentrations of inflammable gases.

10. An explosion protection system according to claim 1 wherein said hazardous environments contain explosive concentrations of dusts.

11. An explosion protection system according to claim 1 wherein said hazardous environments contain explosive concentrations of vapours.

12. An explosion protection system according to claim 4 further comprising a preventative maintenance system having at least one input.

13. An explosion protection system according to claim 12 wherein said feedback sensor further controls leak air flow to prevent uncontrolled downtime of the explosion protection system by applying the feedback signal as an input for the preventative maintenance system.

14. An explosion protection system according to claim 6 wherein said system further conducts a purge sequence from time to time.

15. An explosion protection system according to claim 6, wherein the integrated purge and pressure unit includes a detector that detects leakages before conducting a purge sequence.

16. An explosion protection system according to claim 6 wherein said electrical apparatuses and machineries comprise manipulators.

17. An explosion protection system according to claim 6 wherein said electrical apparatuses and machineries comprise industrial robots.

18. An explosion protection system according to claim 6, wherein the integrated purge and pressure unit includes a purge and pressure controller unit for controlling the flow and pressure level within the enclosure.

19. An explosion protection system according to claim 6 further comprising a feedback sensor for monitoring the pressure within the enclosure, comparing it to the pressure outside of the enclosure, and generating a feedback signal.

20. An explosion protection system according to claim 19 further comprising a preventative maintenance system having at least one input.

21. An explosion protection system according to claim 20 wherein said feedback sensor further controls leak air flow to prevent uncontrolled downtime of the explosion protection system by applying the feedback signal as an input for the preventative maintenance system.

22. An explosion protection system according to claim 6, further comprising a regulator valve for controlling the air pressure level and consumption within the enclosure during operation mode by activating the air supply when the pressure within the enclosure reaches a minimum level.