

APPARATUS FOR INSTALLATION OF ULTRAVIOLET SYSTEM FOR BALLAST
WATER TREATMENT IN EXPLOSIVE ATMOSPHERE OF SHIPBOARD PUMP
ROOMS AND OFFSHORE PLATFORMS

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FIELD OF THE INVENTION

This invention relates to UV systems for ballast water treatment installed aboard ship and on offshore platforms within pump rooms having an explosive atmosphere.

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BACKGROUND OF THE INVENTION

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Ultraviolet systems have long been used for water treatment including treatment of ballast water for biocidal and bactericidal effects. UV systems require high power and voltage that prevents system installation in an explosive atmosphere of oil tanker pump rooms and on oil/gas offshore platforms. UV systems for such tankers and platforms are built into large containers which are difficult to install in confined spaces aboard ship and on platforms. The present invention has for its chief objective a solution to the problems of installing high power and voltage UV ballast water treatment systems aboard oil tankers or on oil/gas offshore platforms having pump rooms with explosive atmospheres.

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The invention also provides a UV reactor with water flow path to increase effectiveness of UV radiation in ballast water treatment.

SUMMARY OF THE INVENTION

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In one aspect, the present invention provides for equipment installed in pump rooms aboard tankers, on offshore platforms, as well as in any explosive atmosphere where UV water treatment systems are used. In a preferred embodiment of the invention, a UV reactor protected with explosive enclosures is installed in a shipboard

pump room, for example, for biocidal and bactericidal treatment of water while related UV reactor controlling and operating systems are installed in the ship's engine room or other non-hazardous area. In this aspect of the invention, a UV reactor comprises an elongate shell defining a reaction chamber which is fitted with a plurality of UV lamps extending through the reaction chamber. Electrical power connections to the lamps are provided at each end of the shell along with control sensors for pressure, temperature and lamp intensity. Explosive enclosures are provided at each end of the reactor shell for locating the power connections in a non-explosive atmosphere. The UV reactor thus protected with non-explosive atmosphere is then installed within a pump room or other space having an explosive atmosphere. Power supply and operating controls for the UV reactor are located outside the pump room typically being placed in a ship's engine room.

In another aspect of the invention, a UV reactor suitable for installation in hazardous areas comprises a reactor shell having a plurality of UV lamps, inlet and outlet pipes, and an internal water flow path from inlet to outlet through the lamps to maximize effectiveness of UV radiation for biocidal and bactericidal effects. UV lamps emit radiation into the inlet and outlet ballast water flow paths through the reactor thereby extending the time period of ballast water exposure to radiation, and consequently improving biocidal and bactericidal effect of such radiation.

Specific examples are included in the following description for purposes of clarity, but various details can be changed within the scope of the present invention.

OBJECTS OF THE INVENTION

An object of the invention is to provide a UV water treatment system for

installation in an explosive hazardous area.

Another object of the invention is to provide a UV system for ballast water for installation in explosive atmosphere of shipboard pump rooms and oil/gas well offshore platforms.

5 Another object of the invention is to provide a high power UV system for biocidal and bactericidal effects in ballast water suitable for for installation in an explosive atmosphere.

Another object of the invention is to provide a high power UV water treatment system where a UV reactor with explosive enclosures is installed in hazardous area
10 and operating and control components are installed in a non-hazardous area.

Another object of the invention is to provide a UV reactor with a ballast water flow path for increasing effectiveness of UV treatment.

Other and further objects of the invention will become apparent with an understanding of the following detailed description of the invention or upon
15 employment of the invention.

BRIEF DESCRIPTION OF THE DRAWING

A preferred embodiment of the invention has been chosen for detailed description to enable those having ordinary skill in the art to which the invention
20 appertains to readily understand how to construct and use the invention and is shown in the accompanying drawing in which:

Figure 1 is a plan view of a ballast water UV reactor according to the invention showing internal components.

Figure 2 is a side elevation view of the reactor of Figure 1.

25 Figure 3 is an end elevation view of the right end of the reactor of Figure 1.

Figure 4 is an enlarged elevation view of an end flange for the UV reactor of Figure 1.

Figure 5 is a section view taken along line 5-5 of Figure 4.

Figure 6 is a section view in elevation of an adapter for mounting an end of a
5 UV lamp and its quartz glass tube in the flange of Figure 4.

Figure 7 is a section view in elevation of an end cover for enclosing the adapter of Figure 6.

Figure 8 is a section view in elevation of assembly of adapter, quartz glass tube with UV lamp, and end cover for the reactor of Figure 1.

10 Figure 9 is a side elevation of an explosive enclosure cover for the ends of the reactor of Figure 1.

Figure 10 is an elevation view of the inside mounting flange of the enclosure of Figure 9.

Figure 11 is an elevation view of the outside cover flange of the enclosure of
15 Figure 9.

Figure 12 is a schematic view of the UV reactor installed in explosive atmosphere of a pump room of an oceangoing oil tanker with reactor control and operating components installed in the ship's engine room.

20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, the present invention is directed to a UV water treatment system 10 comprising a reactor 12, inlet 14 and outlet 16 lines for water flow through the reactor, a plurality of UV treatment lamps L-1, L-2, and L-3 within the reactor, covers 18 for opposite ends of each UV lamp, explosive enclosures 20
25 for each end of the reactor, and control and operating components 22 (Fig 12).

The reactor comprises a main body cylindrical shell 12a preferably fabricated of titanium with a diameter of from 300mm to 600mm depending on desired flow rate capacity of the apparatus. Annular flanges 12b are welded to ends of the main body shell. The total length of the reactor from flange to flange is 1500mm.

5 Inlet pipe 14 is welded at 90° peripherally to the surface of the lower part of the shell, is sized to correspond with main body flow capacity, and is fitted with flange 14a for connection to a ballast water supply line. Outlet pipe 16 is similarly welded at 90° peripherally to the surface of the upper part of the shell, is sized to correspond with main body flow capacity, and is fitted with flange 16a for connection
10 to a ballast water discharge line. The main body and inlet and outlet pipes are designed for a working pressure of 10 bars, and a test pressure of 15 bars.

Component mounting flanges 24 shown in Figs 2, 4, and 5 are secured to the main body annular flanges by suitable bolt fasteners through bores 24a. Cylindrical shell 12a together with component flanges 24 define a reaction chamber 13 where
15 UV treatment of water occurs. Each component flange has a plurality of openings 24b for mounting the ends of quartz glass tubes for UV lamps L-1, L-2, and L-3 together with mounting adapters 26 (Fig 6) connecting the glass tubes to flange 24. The component flange 24 also has ports 24c, 24d, and 24e (Fig 4) for passing pressure, temperature, and lamp intensity sensors into the reactor chamber. These
20 include ports for installation of UV sensors 24e at each end of the reactor, and temperature sensor 24d and pressure switch 24c at one end.

In a preferred embodiment, three UV lamps L-1, L-2, and L-3 extend through the reactor chamber between component flanges 24 and quartz glass mounting adapters 26. Component flanges 24 are preferably made of titanium and covered
25 with a gasket on its exterior face to meet regulatory requirements for explosive

enclosures.

As shown in Figures 6 and 8, an elongate open ended cylindrical quartz glass tube 28 supports UV lamp L through substantially the full length of the reactor between component flanges 24. The quartz tubes are optically transparent, take a test pressure of 15 bars, protect and separate the UV lamps from water in the reactor chamber, and withstand shaking and vibration of the vessel. The lamp is rated at up to 35kW, emits UV radiation at 254nm at 16% efficiency, i.e., producing 16kW of UV radiation per 100kW input. Normal power input for the lamp is up to 35kW. The lamps do not produce ozone, other oxidants or chemicals.

An adapter sleeve 26 has a stepped outer surface including threaded lower level 26a for assembly within component flange opening 24b (Fig. 5) with adapter shoulder 26b and gasket engaging flange surface 24. Adapter shoulder 26b accommodates a pair of torque bolts (not shown) in bores 26c the heads of which enable tightening of the adapter 26 to flange 24 with a suitable spanner.

The inner surface 26d of the adapter has a beveled entry 26e for ease of inserting an end of glass tube 28, and has first and second O-rings 26f, 26g in recesses for sealing against the exterior surface of glass tube 28. A portion 26h of the inner surface of shoulder 26b is threaded to receive a locking collar 30 preferably made of a section of plastic pipe for the purpose of compressing the second O-ring 26g to bulge into firm sealing contact with glass tube 28. The inside edge of retaining collar is tipped with a slip coating such as Teflon or has a graphite gasket to avoid distortion of second O-ring when being compressed. The outer edge of retainer collar has spanner notches (not shown) for assembly of collar and adapter. In practice it is desirable for the collar to be hand tightened for appropriate bulging of second O-ring against the glass tube. The locking collar pressurizes and expands

the second O-ring for stopping leakage of water past the glass tube and into the adapter.

As best shown in Figures 6, 7, and 8, end covers 32 secured to component flanges 24 enclose each adapter 26 and glass tube 28 containing UV lamp L. End cover 32 comprises a cylindrical body 32a open at inner end 32b and closed by an outer end panel 32c. A flange 32d with bores 32g encircles the open end for securing the cover to component flange 24 with suitable fasteners such as bolts (Figure 4). End cover encloses the entire adapter including upper level shoulder 26b. Cylindrical body 32a is fitted with nipples 32e defining openings 32f through body wall for passing air cooling nozzle 34 directed at UV lamp L, electric power leads E for UV lamps, and signal cables (shown in Fig 12). Nipples are metallic and are designed to hold 10 bar operating pressure. End covers are preferably fabricated of stainless steel and prevent ballast water leakage from the reaction chamber in the event of glass tube breakage. Accordingly, the covers are designed to the same pressure class as the reactor shell, i.e., 10 bars.

The cover end panel 32c has a nipple 32e for fitting nozzle 34 (Fig 8) that extends into the opening of glass tube 28 carrying UV lamp L. The nozzle directs cooling air to UV lamp sockets in the event lamp sockets build up high temperatures inside the lamp tube for cooling the socket to an appropriate working temperature. Cooling air is piped from instrument air supply controlled by regulators in the engine room. Lamp socket cooling air is drawn in and exhausted through the same ducts as cables and purging air described below in connection with Figure 12.

In a preferred arrangement according to the invention shown in Figs 1 and 2, medium pressure UV lamps L-1, L-2, and L-3 extend across both inlet pipe opening 14 and outlet pipe opening 16 for emitting radiation in the direction of water entering

and exiting reactor chamber. Optimally, UV lamps L-2 and L-3 shown in Figures 1 and 2 extend across inlet opening, and lamp L-1 extends across the outlet opening of reactor chamber.

Water flow through the reactor chamber is shown by arrows in Figures 1 and 3 where water circulates about the exterior of quartz tubes and UV lamps. Turbulence spins the particles, viruses, bacteria, and algae so they are illuminated from all sides when passing UV radiation. The lower UV lamps, L-2 and L-3, emit UV light into water flowing through inlet pipe 14 so the UV intensification starts already in the inlet pipe and increases the treatment process. Similarly, upper UV lamp L-1 is positioned so it emits light into the outlet pipe and furthers the treatment process of water flowing out of the reactor. The UV dose (Uv^d) is the result of UV intensity at 254 nm (I) multiplied by retention time in the equipment (T). By placing UV lamps to treat water in inlet and outlet pipes, the retention time increases to improve treatment.

As shown in Figures 1, 2, and 9-12, explosive enclosures 20 entirely cover the ends of the reactor for providing a non-explosive atmosphere for high power electrical connections of UV lamps. Each enclosure comprises an imperforate cylindrical shell 20a body with inner annular flange 20b for connection to component flange 24, and outer annular flange 20c for mounting end closure plate 20d. A set of nipples 20e affixed to shell wall 20a define openings 20f for passing control and operating utilities into the enclosure for operating and monitoring UV lamp performance. In a preferred arrangement, end closure plate is fitted with a ceramic terminal as a connection point of electric power supply lines and UV lamps to facilitate assembly and maintenance of UV lamps. When assembled with reactor, each explosion enclosure is capable of maintaining internal 70 millibar overpressure

of protective gas with respect to pump room atmosphere. The protective gas is preferably air. The total working length of UV reactor with explosive enclosures is 2000mm.

Shipboard installation of the apparatus is shown in Figure 12 where bulkhead
5 B separates pump room and engine room. The apparatus can also be used in explosive atmospheres in refineries and gas plants.

The reactor 12 with explosive enclosures 20 is installed in pump room, with power panel, control panel purge pressurization control panel in the engine room. Operating cables and protective gas pipes for electric power, purging air, lamp
10 cooling air, and control electric circuit pass through safety bulkheads in approved penetration sleeves S. Preferably, protective gas for purging and maintaining pressure in explosive enclosures is air. Other gasses such as nitrogen or inert gas may be used if available.

A first conduit duct 48 extends through penetration sleeve S for carrying
15 instrument cables 40 and purging and cooling air pipes 42 from the engine room to the reactor. First conduit 48 extends the full length of reactor 12 with junction box 48a and with branch line 48b entering explosive enclosure 20' through one of its nipples 20e. First conduit terminal portion 48c enters explosive enclosure 20" through a nipple 20e.

20 A second conduit duct 50 extends through penetration sleeve S' for carrying lamp power cables 44 and a purging air, and cooling air exit pipe 46.

Conduit 50 passes through penetration sleeve S' and extends full length of reactor through junction box 50a with branch line 50b entering enclosure 20', and terminal portion 50c entering enclosure 20".

25 Conduits 40 and 50 provide safe passage for electric cables and protective

gas pipes from non-hazardous area (ship's engine room) through penetration sleeves into hazardous area (ship's pump room) for entry into explosive enclosures in order to operate and monitor the UV reactor. Purging air line 52 with pressure relief valve extends between explosive enclosures 20' and 20" so that the enclosures
5 are purged in series.

The instrument cable bundle 40 consists of the UV sensor cables to each end of the reactor, temperature switch cable, and pressure switch cable all drawn from the control panel direct to each of the instruments through first conduit duct 48. Signal cables for monitoring during testing and commissioning of the reactor also
10 pass through duct 48.

The purging air pipe 42 is drawn from the Purge Pressurization Control panel through conduit duct 48 to the first explosive enclosure 20' (Fig 12). Since purging must be in series, purging pipe 52 is installed between the explosive enclosures and has pressure relief valve 54 to prevent overpressure in the system. Purging air is
15 provided by a purge system to remove gas that may be present when explosive enclosures 20' and 20" are closed. Through line 42, purging air flows in series to enclosure 20', through line 52, and to enclosure 20". Exhaust purging air from the second explosive enclosure 20" is piped through second conduit duct 50 and returned to the engine room at pipe end 46.

20 The lamp cables bundle 44 is drawn from the power panel through sleeve S and second conduit duct 50 to explosive enclosures 20', 20" where they are connected to ceramic terminals and through the terminals to the lamps.

In use, operation begins with a purging of explosive enclosures with air to the extent of a five-fold volumetric flow of air in series first through enclosure 20' in
25 Figure 12, through pressure relief valve 54, then through enclosure 20" and to

exhaust pipe 46. When purge is complete, and 70 millibar pressure is held, control panel sends a signal to power panel for powering the UV lamps.

Power input per reactor is 400v, 3ph, 38kW at 80A and is provided to the UV lamps from power panel and control panel via ceramic junction boxes mounted on the inside of end flanges 20d. The power panel converts inlet power to the power required by the UV lamps and maintains a balanced burning of the lamps to provide the maximum UVC output.

Cooling air for lamp sockets may advantageously flow through line 42, conduit 48 into explosive enclosures, and enter nozzle 34 (Fig 8). Exhaust cooling air flows through a nipple 32e in end cover 32 and through explosive enclosure nipples 20e (Fig 2) then entering conduit 50 for exhaust in the engine room.

Test water specified by IMO for certification tests of ballast water treatment equipment has typically a UV transmission of 70-90% at T1 (i.e., 1 cm), or absorbance of 0.16 to 0.05 ABS/cm. The ballast water treatment apparatus of the present invention subjected to IMO certification tests using this very low quality test water had the desired biocidal and bactericidal effects.

The foregoing apparatus is fully consistent with IEC and US Coast Guard regulations and specifications for such equipment and its installation.

Various changes may be made to the structure embodying the principles of the invention. The foregoing embodiments are set forth in an illustrative and not in a limiting sense. The scope of the invention is defined by the claims appended hereto.

What is claimed is:

1. An apparatus for treating water in explosive atmosphere of oil tanker pump room and of off-shore platforms comprising a reactor defining a treatment chamber having opposed ends, inlet and outlet openings through the reactor for flow of water through the treatment chamber, a plurality of water treatment lamps enclosed in glass tubes mounted between opposed ends and extending through the chamber, an end cover secured to the reactor in covering relation to ends of the glass tubes, an explosive enclosure secured to each end of the reactor, each explosive enclosure comprising a shell with means for attachment to the reactor, means for purging the explosive enclosures to fill the enclosures with non-explosive gas at an atmospheric overpressure, means for supplying electric power originating in a non-explosive atmosphere to the reactor lamps through the explosive enclosures so that the powered reactor operates in explosive atmosphere without risk of igniting the explosive atmosphere.
2. An apparatus as defined in claim 1 in which the reactor has an operating pressure of 10 bars.
3. An apparatus for treating water in explosive atmosphere of oil tanker pump room and of off-shore platforms comprising an open ended reactor shell, a component flange mounted at each open end of the reactor shell to form a reactor defining a treatment chamber, inlet and outlet openings through the reactor shell for flow of water through the treatment chamber, a plurality of UV water treatment lamps enclosed in glass tubes extending through the chamber between component flanges, adapter means engaging the ends of the glass tubes for mounting the tubes and

lamps between component flanges, an end cover secured to the component flange in covering relation to the adapter means and the ends of the glass tubes, an explosive enclosure secured to the component flange at each end of the reactor, each explosive enclosure comprising a shell with inner flange for attachment to the component flange, and an outer flange cooperating with the shell to define the explosive enclosure, means for purging the explosive enclosures to fill the enclosures with non-explosive gas at an atmospheric overpressure, means for supplying to the reactor lamps electric power originating in a non-explosive atmosphere and passing through the explosive enclosures so that the powered reactor operates in explosive atmosphere without risk of igniting the explosive atmosphere.

4. An apparatus as defined in claim 3 in which the UV lamps is rated at up to 35kW, and emits radiation at 254nm at 16% efficiency.

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5. An apparatus for ultraviolet (UV) treatment of water in explosive atmosphere of oil tanker pump room and of off-shore platforms comprising an open ended reactor shell, a component flange mounted at each open end of the reactor shell to form a reactor defining a treatment chamber, inlet and outlet lines into the reactor shell for flow of water through the treatment chamber, a plurality of water treatment UV lamps enclosed in glass tubes extending through the chamber between component flanges, the UV lamps extending past inlet and outlet openings for UV treatment of water flowing in inlet and outlet lines, adapter means engaging the ends of the glass tubes for mounting the tubes and lamps between component flanges, an end cover secured to the component flange in covering relation to the adapter means and the

ends of the glass tubes, an explosive enclosure secured to the component flange at each end of the reactor, each explosive enclosure comprising a shell with inner flange for attachment to the component flange, and an outer flange cooperating with the shell to define the explosive enclosure, means for purging the explosive enclosures to fill the enclosures with non-explosive gas at an atmospheric overpressure, means for supplying to the reactor lamps electric power originating in a non-explosive atmosphere and through the explosive enclosures and end covers so that the powered reactor operates in explosive atmosphere without risk of igniting the explosive atmosphere.

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6. An apparatus as defined in claim 5 in which the adapter means is in the form of a sleeve with inner surface having bevelled entry for receiving the glass tube end, having first and second O-rings for sealing against the glass tube, and having a locking collar for pressing and bulging one O-ring for sealing engagement against the glass tube, and the adapter having an outer surface with means for securing the adapter to the component flange.

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7. An apparatus as defined in claim 5 wherein water flow through the reactor chamber circulates in turbulence about the exterior of tubes and UV lamps and spins particles, viruses, bacteria and algae entrained in the water so they are illuminated from all sides when passing UV radiation, and further wherein UV intensification starts in the inlet line, and continues as water flows out of the reactor from the outlet line.

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8. An apparatus for ultraviolet treatment of water in explosive atmosphere of oil

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tanker pump room and of off-shore platforms comprising an open ended reactor shell, a component flange mounted at each open end of the reactor shell to form a reactor defining a treatment chamber, inlet and outlet openings through the reactor shell for flow of water through the treatment chamber, a plurality of water treatment
5 ultraviolet lamps enclosed in glass tubes mounted between component flanges and extending through the chamber, adapters having a bevelled entry bore for receiving the ends of the glass tubes for securing tubes and lamps to component flanges, end covers secured to the component flange in covering relation to ends of the glass tubes, the end covers defined by a body shell and flange for securing the cover to
10 the component flange, the end covers having a first opening for passing electric power to the lamps, and a second opening for passing a cooling air nozzle directed at a lamp, an explosive enclosure secured to the component flange at each end of the reactor, each explosive enclosure comprising a shell with inner flange for attachment to the component flange, and an outer flange cooperating with the shell
15 to define the explosive enclosure, means for purging the explosive enclosures to fill the enclosures with non-explosive gas at an atmospheric overpressure, means situated in a non-explosive atmosphere for supplying electric power to the lamps through the explosive enclosures and end covers so that the powered reactor operates in explosive atmosphere without risk of igniting the explosive atmosphere.

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9. An apparatus as defined in claim 8 in which the end covers have a working pressure of 10 bars.

10. An apparatus for ultraviolet treatment of water in explosive atmosphere of oil
25 tanker pump room and of off-shore platforms comprising a reactor defining a

treatment chamber, inlet and outlet openings through the reactor shell for flow of water through the treatment chamber, a plurality of UV water treatment lamps enclosed in glass tubes extending through the chamber, an end cover secured to the reactor in covering relation to the ends of the glass tubes, an explosive enclosure
5 secured to the component flange at each end of the reactor, each explosive enclosure comprising a shell with inner flange for attachment to the component flange, and an outer flange cooperating with the shell to define the explosive enclosure, first and second conduit means interconnecting the explosive enclosures through a safety bulkhead to a compartment having a non-explosive atmosphere, a
10 gas purging line extending between explosive enclosures, means in the compartment for supplying purging gas through the first conduit into one explosive enclosure and through the purging line to the other explosive enclosure for purging explosive gas from the explosive enclosures and filling them with non-explosive gas at atmospheric overpressure, a purging gas exhaust line from the other explosive
15 enclosure passing through the second conduit for exhausting purging gas in the compartment, pressure temperature, and lamp sensor lines originating in the compartment and passing through the first conduit for monitoring and controlling reactor operation, means for supplying to the reactor lamps electric power originating in the compartment and passing through the second conduit to explosive enclosures
20 so that the powered reactor operates in explosive atmosphere without risk of igniting the explosive atmosphere, while power supply and reactor controls operate in non-explosive compartment atmosphere.

11. An apparatus as defined in claim 10 in which the reactor is located in an oil
25 tanker pump room and in which the compartment is the tanker engine room.