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EXPLOSION-RESISTANT DEVICES AND COVER ASSEMBLIES FOR A HAZARDOUS ENVIRONMENT

Abstract

An explosion-resistant device for a hazardous environment is provided. The device includes an enclosure. The enclosure includes a body, a projected rim extending away from the body and defining an opening, and rim threads positioned on a surface of the projected rim. The device further includes a cover assembly including a joint that includes a first portion and a second portion, the first portion affixed with the body. The cover assembly further includes a cap including a cap top and a cap side extending from the cap top, the cap side further including cap threads complementary to the rim threads. The cover assembly also includes a radial support affixed with the second portion and obstructing the cap from dislocating out of the radial support. The cover assembly is rotatably coupled with the enclosure via the joint.

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Background/Summary

BACKGROUND

[0001] The field of the disclosure relates generally to explosion management, and more particularly, to explosion-resistant devices and cover assemblies.

[0002] Field devices, such as sensors, analyzers, and interfaces, are used in various industrial devices, systems, and/or methods. In environments in which explosive substances, such as alcohols and/or petroleum products, are present or may potentially be present, (e.g., a hazardous environment) hazards of igniting the explosive substance via electronic equipment within the field devices may exist. Some field devices may be involved with explosive substances, such as sensors for a production process, where the explosive substances are within the precursor, intermediate product, incidental product, and/or final product. Additionally, the environment for such devices may contain explosive substances, for example, gases, which could be ignited by the electronic equipment of the devices and/or by an explosion originating from within the devices.

[0003] Known explosion management systems and methods are disadvantaged in some aspects, and improvements are desired.

BRIEF DESCRIPTION

[0004] In one aspect, an explosion-resistant device for a hazardous environment is provided. The explosion-resistant device includes an enclosure sized to enclose equipment therein and including a body. The enclosure further includes a projected rim extending away from the body and defining an opening, the opening providing an access to the equipment. The enclosure also includes rim threads positioned on a surface of the projected rim. The explosion-resistant device further includes a cover assembly including a joint that includes a first portion and a second portion, the first portion affixed with the body. The cover assembly further includes a cap including a cap top and a cap side extending from the cap top, the cap side further including cap threads complementary to the rim threads. The cover assembly also includes a radial support affixed with the second portion and obstructing the cap from dislocating out of the radial support. The cover assembly is rotatably coupled with the enclosure via the joint.

[0005] In another aspect, a cover assembly of an explosion-resistant device for a hazardous environment is provided. The cover assembly includes a joint including a first portion and a second portion, the first portion configured to be affixed with an enclosure of an explosion-resistant device. The cover assembly also includes a radial support affixed with the second portion. The cover assembly further includes a cap including a cap top and a cap side extending from the cap top. The radial support includes a support projection projecting from an interior surface of the radial support, the cap side further including a side projection positioned adjacent to an end of the cap side opposite from the cap top, the side projection projecting from an exterior surface of the cap side, the support projection positioned between the cap top and the side projection and obstructing the cap from dislocating out of the radial support. The cover assembly is configured to rotatably couple with the enclosure via the joint.

[0006] In one more aspect, a method of assembling an explosion-resistant device for a hazardous environment is provided. The method includes forming a cover assembly. The cover assembly includes a joint including a first portion and a second portion. The cover assembly further includes a cap including a cap top, and a cap side extending from the cap top, the cap side further including cap threads. The cover assembly also includes a radial support affixed with the second portion of the joint and obstructing the cap from dislocating out of the radial support. The method further includes affixing the cover assembly with an enclosure of an explosion-resistant device, the enclosure sized to contain equipment therein and including a body. The enclosure further includes a projected rim extending away from the body and defining an opening providing an access to the equipment, and rim threads positioned on a surface of the projected rim and complementary to the cap threads. Affixing the cover assembly further includes affixing the first portion of the joint with the body.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0007] These and other features, aspects, and advantages of the present disclosure will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings.

[0008] FIG. **1**A is a left perspective view of an example explosion-resistant device.

[0009] FIG. **1**B is a right perspective view of the explosion-resistant device shown in FIG. **1**A.

[0010] FIG. **1**C is a perspective view of the explosion-resistant device shown in FIG. **1**A with its cover assembly open.

[0011] FIG. **1**D is an enlarged view of a portion of the explosion-resistant device shown in FIG. **1**A, where the portion is indicated as **1**D in FIG. **1**A.

[0012] FIG. **1**E is a right perspective view of the portion shown in FIG. **1**D.

[0013] FIG. **2**A is a left perspective view of an example cover assembly of the explosion-resistant device shown in FIG. **1**A.

[0014] FIG. **2**B is a right perspective view of the cover assembly shown in FIG. **2**A.

[0015] FIG. **2**C is a perspective view of a latch pin and a loop in an example latch of the cover assembly shown in FIG. **2**A.

[0016] FIG. **3**A is a front perspective view of a first joint portion in an example joint of the cover assembly shown in FIG. **2**A.

[0017] FIG. **3**B is a rear perspective view of the first joint portion shown in FIG. **3**A.

[0018] FIG. **3**C is a perspective view of a joint pin in the joint of the cover assembly shown in FIG. **2**A.

[0019] FIG. **3**D shows an example radial support of the cover assembly shown in FIG. **2**A.

[0020] FIG. **3**E is a right perspective view of the radial support shown in FIG. **3**D.

[0021] FIG. **4**A is a rear perspective view of an example cap of the cover assembly shown in FIG. **2**A.

[0022] FIG. **4**B is a right perspective view of the cap shown in FIG. **4**A.

[0023] FIG. **5**A is a side perspective view of the cover assembly shown in FIG. **2**A with a segment of the radial support removed.

[0024] FIG. **5**B is a cross-sectional view of the explosion-resistant device shown in FIG. **1**B along cross-sectional line **5**B-**5**B as marked in FIG. **1**B.

[0025] FIG. **5**C is an enlarged view of a portion of the explosion-resistant device shown in FIG. **5**B, where the portion is indicated as **5**C in FIG. **5**B.

[0026] FIG. **6**A is a cross-sectional view of a portion of the explosion-resistant device along cross-sectional line **6**A-**6**A as marked in FIG. **1**A, when the cap is threaded to the projected rim in the enclosure of the explosion-resistant device.

[0027] FIG. **6**B shows the explosion-resistant device when the cap is unthreaded from the projected rim.

[0028] FIG. **6**C shows the explosion-resistant device when the cover assembly is open.

[0029] FIG. **7** is a flow chart of an example method of assembling an explosion-resistant device as described in FIGS. **1**A-**6**C.

DETAILED DESCRIPTION

[0030] The disclosure includes explosion-resistant devices and cover assemblies for a hazardous environment. As used herein, an explosion-resistant device is configured to be used in an environment, where explosive substances are or.may be present, and is configured to be compliant with standards stipulated for such an environment. Within the present disclosure, the resistance to explosion and/or flammability risks, including from electronic instrumentation, is described as explosion resistance. Method aspects will be in part apparent and in part explicitly discussed in the

following description.
[0031] Electronic instrumentation (e.g., electronic measurement instruments and displays) may assist in high quality, safe, and/or efficient process management. In environments in which explosive and/or flammable substances may be present (e.g., in a hazardous environment), electronic instrumentation may pose an explosion risk. In particular, when using electronic instrumentation to conduct field analyses of process substances with flammability and/or explosion risks, the electronic instrumentation may pose a risk of ignition. For example, flammable and/or explosive gases to be analyzed by electronic instrumentation may be ignited if the flammable and/or explosive gases come into contact with components of the electronic instrumentation.
[0032] A device that operates within hazardous environments presents a risk of explosion via ignition of a surrounding gas or vapor dusts, fibers, or flyings. Such hazardous environments may arise, for example only, in petroleum refineries, petrochemical plants, grain silos, wastewater, and/or treatment facilities among other industrial facilities, where volatile conditions are produced in the ambient environment and present a heightened risk of fire or explosion. An occasional or continuous presence of airborne ignitable gas, ignitable vapors or dust, or otherwise flammable substances presents substantial concerns regarding safe and reliable operation of such facilities overall, including, but not limited to, safe operation of the device such as containing sparks within the device to prevent possible fire or explosion. As such, a number of standards have been promulgated relating to electrical products used in explosive environments to improve safety in hazardous locations in view of an assessed probability of explosion or fire risk.
[0033] For example, Underwriter's Laboratories (“UL”) standard UL 1203 sets forth Explosion-Proof and Dust-Ignition-Proof Electrical Equipment criteria for hazardous locations. Electrical equipment manufacturers may receive UL certification of compliance with the applicable rating standards for hazardous locations, and UL certification is an important aspect of a manufacturer's ability to successfully bring products to market in North America or any other market accepting UL standard 1203.
[0034] The National Electric Code (NEC) generally classifies hazardous locations by class and division. Class I locations are those in which flammable vapors and gases may be present. Class II locations are those in which combustible dust may be found. Class III locations are those which are hazardous because of the presence of easily ignitable fibers or flyings. Class I, Division **1** covers locations where flammable gases or vapors may exist under normal operating conditions or under frequent repair or maintenance operations, or where breakdown or faulty operation of process equipment might also cause simultaneous failure of electrical equipment. Division 1 presents a greater risk of explosion than, for example, Division 2 where flammable gases or vapors are normally handled either in a closed system, confined within suitable enclosures, or are normally prevented by positive mechanical ventilation.
[0035] The International Electrotechnical Commission (IEC) likewise categorizes hazardous locations into Class I, Zone 0, 1, or 2 representing locations in which flammable gases or vapors are or may be airborne in an amount sufficient to produce explosive or ignitable mixtures. As defined by the IEC, a Class I, Zone 0 location is a location in which ignitable concentrations of flammable gases or vapors are present continuously or for long periods of time. A Class I, Zone 1 location is a location in which ignitable concentrations of flammable gases or vapors are likely to exist because of repair or maintenance operations or because of leakage or possible release of ignitable concentrations of flammable gases or vapors, or is a location that is adjacent to a Class I, Zone 0 location from which ignitable concentrations of vapors could be communicated.
[0036] Electronic instrumentation may exist in hazardous environments which may include flammable and/or explosive substances, such as in petrochemical production facilities. Thus, in addition to the hazards of electronic instrumentation generating internal ignition, the electronic instrumentation may pose further risk to external environments.
[0037] Further, some external environments may pose additional risk to electronic instrumentation.

For example, ignition sources external to the electronic instrumentation may present a risk to the electronic instrumentation. In such environments, it is desirable to prevent an ignition of flammable and/or explosive substances within the external environment (and outside of the electronic instrumentation) from entering the electronic instrumentation.

[0038] In order to comply with standards for a hazardous environment, such as ICE standard 600079, and for safety of the personnel in the field, field devices may be housed in an enclosure. Threads are integral and critical in explosion proof or resistant. An opening is needed for access to the field devices. When unused, the opening needs to be sealed with threaded covering, where the threads provide a flame pathway that allows hot gases produced by an internal explosion to cool before reaching and igniting surrounding atmosphere in the hazardous environment. Therefore, when closing the covering onto the opening, the threads need to be intact and to be engaged with corresponding threads on the opening of the enclosure. Further, the covering needs to meet the required wall thickness to withstand the pressure from explosion. For relatively large field devices included in the enclosure, the opening is relatively large for the access needed in maintenance and/or operation. Therefore, the covering may become relatively heavy and large to meet the needs for explosion management. For example, the covering may have a diameter of 13.5 inches (34.29 cm) or greater and a weight of 20 lb. (9 kg) or greater. To maneuver such a large and heavy covering while ensuring intactness and engagement of threads is challenging or even unmanageable for a field worker. In addition, due to the weight and the size of the covering, an accidental drop of the covering may injure the field worker and/or damage the covering. Further, pressure may build up inside the enclosure. The built-up pressure may launch the covering into air the moment when the cover is removed from the enclosure, causing injury to the field worker and/or damage the covering.

[0039] Explosion proof devices, cover assemblies, and methods described herein solve the above-described problems in known explosion resistant devices. The cover assembly described herein is rotatably coupled with the body of the enclosure. In the cover assembly, the cap is retained by the radial support. As a result, the cap along with the cover assembly is retained with the body when the cover assembly is open from the enclosure, reducing or eliminating accidental drop of the cap and therefore the likelihood of injury to the worker or damage to the cap. In addition, a latch and/or a joint of the cover assembly increases the strength of the cap being retained with the cover assembly and the enclosure, thereby ensuring the cap being retained with the cover assembly and the enclosure even under pressurized conditions. Retaining the cap with cover assembly and the enclosure is also advantageous in increasing the ease in installing or removal of the cap, where the radial support, instead of a worker, bears the weight of the cap. The cover assembly facilitates the alignment of the threads of the cap with the threads on the enclosure, further increasing the ease in engaging the cap onto the enclosure and reducing the likelihood of cross threading and damage to the threads caused by cross threading. The burden to lift the cover, engage the cap threads with the rim threads, and align the cap with the opening is alleviated or removed from the worker, and the safety of the equipment and the worker is increased.

[0040] FIGS. **1**A-**1**E show an example explosion-resistant device **100** for a hazardous environment. FIG. **1**A is a left perspective view of explosion-resistant device **100**. FIG. **1**B is a right perspective view of explosion-resistant device **100**. FIG. **1**C shows explosion-resistant device **100** with a cover assembly **102** of explosion-resistant device **100** being open. FIG. **1**D is a left perspective view of a portion of explosion-resistant device **100** indicated as **1**D in FIG. **1**A. FIG. **1**E is a right perspective view of the portion.

[0041] In the example embodiment, explosion-resistant device **100** includes an enclosure **104** sized to contain equipment **106** therein. Equipment may be industrial instruments used in a hazardous environment, such as chromatographic devices. Enclosure **104** includes a body **108**. Enclosure **104** further includes a projected rim **112** extending away from body **108** and defining an opening **110** that provide access to equipment **106**. Enclosure **104** also includes rim threads **114** positioned on a

surface of projected rim **112**. In the depicted embodiment, rim threads **114** are positioned on an exterior body surface **113** of enclosure **104**. In some embodiments, rim threads **114** may be positioned on an interior body surface **115** of enclosure **104**.

[0042] In the example embodiment, enclosure **104** further includes cover assembly **102**. Cover assembly **102** includes a cap **116** and a radial support **118**. Cover assembly **102** further includes a joint **120** configured to rotatably couple cover assembly **102** with enclosure **104**.

[0043] In operation, cover assembly **102** is coupled with enclosure **104** via joint **120**. Cover assembly **102** may be opened from enclosure **104** or closed with enclosure **104** by swinging cover assembly **102** about joint **120**, where cover assembly **102** rotates around an axis defined by joint **120**.

[0044] FIGS. **2**A-**2**C show example cover assembly **102**. FIG. **2**A is a left perspective view of cover assembly **102**. FIG. **2**B is a right perspective view of cover assembly **102**. FIG. **2**C is a perspective view of a fastening assembly in an example latch **202** of cover assembly **102**. In the example embodiment, cover assembly **102** includes cap **116**, radial support **118**, and joint **120**. Cover assembly **102** further includes latch **202** (also see FIGS. **1**B and **1**E). Latch **202** includes a first latch portion **208-1** and a second latch portion **208-2** (also see FIG. **1**B). In the depicted embodiment, first latch portion **208-1** is positioned on radial support **118**, and second latch portion **208-2** is positioned on body **108**. In some embodiments, the positioning of first latch portion **208** and second latch portion **208** may be reversed, where first latch portion **208** is positioned on body **108** and second latch portion **208** is positioned on radial support **118**. First and second latch portions **208** define latch apertures **109** (FIG. **2**B and also see FIG. **1**E), which are sized to receive a latch pin **212** therethrough. Latch **202** further includes a loop **204**. Loop **204** is couplable with latch pin **212** at ends of latch pin **212**. In some embodiments, cover assembly **102** does not include a latch **202**.

[0045] In operation, to close cover assembly **102** onto enclosure **104**, cover assembly **102** is rotated to the closed positioned. Cap **116** is rotated such that cap threads **401** (see FIG. **4**A described later) engage with rim threads **114** on the projected rim **112** of enclosure **104**. The coupling between cover assembly **102** and enclosure **104** is strengthened by latch **202**. After first latch portion **208** is positioned adjacent second latch portion **208**. Latch pin **212** is inserted into latch apertures **109** defined in first and second latch portions **208**, thereby holding first latch portion **208** and second latch portion **208** together. One end of loop **204** is attached to a first end of latch pin **212**. The other end of loop **204** is placed onto a second end of latch pin **212** to retain latch pin **212** to be positioned in latch apertures **109** (see FIGS. **1**B and **1**E). In opening cover assembly **102**, latch **202** may be unlatched by removing an end of loop **204** from latch **202** and then removing latch pin **212** from latch apertures **109**. Unlatching of latch **202** may be performed after cap **116** has been unthreaded from projected rim **112**, such that latch **202** continues to hold radial support **118** and cap **116** with body **108**, even when enclosure **104** is pressurized, thereby increasing the safety of the worker and intactness of cap **116** by preventing cap **116** from flying outwards due to the pressure.

[0046] FIGS. **3**A-**3**E show example joint **120**. FIG. **3**A is a front perspective view of a first joint portion **301** of joint **120**. FIG. **3**B is a rear perspective view of first joint portion **301**. FIG. **3**C is a perspective view of a joint pin **303** of joint **120**. FIG. **3**D is a left perspective view of radial support **118** and a second joint portion **301** of joint **120**. FIG. **3**E is a right perspective view of radial support **118** and second joint portion **301**.

[0047] In the example embodiment, joint **120** includes first joint portion **301-1** and second joint portion **301-2** (also see FIG. **1**A). Joint apertures **305** are defined in first joint portion **301** and second joint portion **301**. First joint portion **301** further defines a fastener aperture **311** sized to receive a fastener **218** (see FIG. **2**A) therethrough. Joint **120** further includes joint pin **303**. Joint pin **303** may include an enlarged end **308**-*e* and a second end **308**-*s* opposite enlarged end **308**-*e*. Second end **308** defines a groove **310**. Joint pin **303** further includes a stopper **312**. In the depicted example, stopper **312** forms into a ring or an arc. Ends of stopper **312** are received in groove **310**

when stopper **312** is coupled with joint pin **303**.
[0048] In operation, joint **120** is assembled onto body **108** by coupling first joint portion **301-1** with second joint portion **301-2** such that joint apertures **305** are aligned. Joint pin **303** is inserted into joint apertures **305** and stopper **312** is placed into groove **310**. Second joint portion **301** may be formed integral with radial support **118** or support segment **302** (see FIG. **3**D), via methods such as casting and machining. Alternatively, second joint portion **301** may be coupled with radial support **118** or support segment **302** via methods such as welding. The cover assembly **102** assembled joint **120** is fastened to body **108** of enclosure **104** by inserting fastener **218** into fastener apertures **305** and a corresponding faster aperture **122** (see FIG. **1**D) defined in body **108** and fastening cover assembly **102** with body **108** via fastener **218**. Example fastener **218** may be a screw.
[0049] A cover assembly **102** with a joint **120** positioned on the left side and a latch **202** positioned on the right side of the enclosure is depicted for illustration purposes only. Joint **120** may be positioned on the right side such that cover assembly **102** opens and swings toward right. A cover assembly **102** may include a plurality of latches **202** distributed around projected rim **112**.
[0050] Referring to FIGS. **3**D and **3**E, in the example embodiment, cover assembly **102** includes radial support **118**. In the depicted example, radial support **118** includes two support segments **302**. Support fasteners **304** joins support segments **302**. In some embodiments, radial support **118** may be in one single piece or may be in three or more segments with support fasteners **304** joining support segments **302**. The diameter of radial support **118** may be adjusted when radial support **118** is formed with multiple support segments **302**. Radial support **118** may form into an annular ring. Radial support **118** further includes a support projection **306** projecting from an interior surface **316** of radial support **302**. Support projection **306** is formed as an annular raised ring. Support projection **306** defines support recesses **318** in radial support **118** adjacent support projection **306**.
[0051] FIGS. **4**A and **4**B show cap **116** of cover assembly **102**. FIG. **4**A is a rear perspective view of cap **116**. FIG. **4**B is a right perspective view of cap **116**. In the example embodiment, cap **116** includes cap threads **401**. Cap **116** includes a cap top **402** and a cap side **404** extending from cap top **402**. Cap side **404** is annular. Cap top **402** may include ridges **406** and define top recesses **407** between neighboring ridges **406**. Top recesses **407** are shaped to receive a tool to facilitate the turning of cap **116**. In the depicted example, cap threads **401** are positioned on an interior side surface **410** of cap side **404** and rim threads **114** are positioned on exterior body surface **113** (see FIG. **1**E) of body **108** such that cap threads **401** are female threads and rim threads **114** are male threads. In some embodiments, positioning of cap threads **401** and rim threads **114** is reversed, where cap threads **401** are positioned on an exterior side surface **414** of cap side **404** and rim threads **114** are positioned on interior body surface **115** of body **108**. Cap side **404** further include a side projection **418**. Side projection **418** may be positioned adjacent to an end **420** of cap side **404** opposite from cap top **402**. Cap side **404** may include a plurality side projections **418**. A side recess **408** is defined on exterior side surface **414** of cap side **404**. Side recess **408** may be continuous and form into a ring. Side recess **408** may be positioned on cap side **404** with two side projections **418** bordering side recess **408**.
[0052] In the example embodiment, cap **116** may be fabricated from metal such as aluminum or steel. Cap **116** may be manufactured by methods such as casting, machining, or stamping.
[0053] In operation, to assemble cap **116** with radial support **118**, cap **116** is positioned with support segments **302** such that side projection **418** is received in support recess **318** and support projection **306** is received in side recess **408**. Support segments **302** are coupled together by support fasteners **304**.
[0054] FIGS. **5**A-**5**C show radial support **118** being coupled with cap **116**. FIG. **5**A is a side view of cover assembly **102** with one of support segments **302** removed. FIG. **5**B is a portion of a cross-sectional view of explosion-resistant device **100** along cross-sectional line **5**B-**5**B as indicated in FIG. **1**B. FIG. **5**C is an enlarged view of a portion of explosion-resistant device **100**, where the portion is indicated as **5**C in FIG. **5**B.

[0055] In the example embodiment, outer diameter **502** of cap side **404** at side projection **418** is greater than inner diameter **504**-*p* of radial support **118** at support projection **306** and smaller than inner diameter **504**-*o* of radial support **118** at some of other interior locations of radial support **118**. As such, with a side projection **418** positioned further interior than support projection **306**, support projection **306** obstructs cap **116** from dislocating from radial support **118** when a force, such as a force from pressure inside enclosure **104**, is applied in the direction of being outwards from body **108**. Cap side **404** may include a second side projection **418-2** bordering side recess **408** and being at a side opposite first side projection **418-1** such that support projection **306** is received in side recess **408** and positioned between first side projection **418-1** and second side projection **418-2**. Second side projection **418** prevents cap **116** from being rotated too far toward body **108** in threading cap **116** onto projected rim **112**. In the depicted embodiment, body **108** includes a ledge **506** (FIG. **5**C, also see FIG. **1**E). Ledge **506** prevents cap **116** from being rotated too far toward body **108**. In some embodiments, body **108** does not include ledge **506**.
[0056] In the example embodiment, inner diameter **504**-*p* of radial support **118** at support projection **306** is smaller than outer diameter **502** of cap side **404** at first side projection **418** and second side projection **418**. Accordingly, radial support **118** obstructs cap **116** from dislocating out of radial support **118** from either end of cap side **404**, and vice versa, cap **116** also obstructs radial support **118** from dislocating out of cap **116**.
[0057] In the example embodiment, side recess **408** may be formed as an annular recess. The annular raised ring formed by support projection **306** and the annular recess formed by side recess **408** may be concentric such that a longitudinal axis **508** of cap side **404** and a longitudinal axis **510** of radial support **118** are aligned. A width **520** of side recess is greater than a width **522** of support projection **306**. Translational movement of cap **116** is limited to moving in the range of width **520** of side recess **408**.
[0058] FIGS. **6**A-**6**C show cover assembly **102** at various positions. FIG. **6**A shows the threaded position where cap **116** is threaded onto projected rims **112**. FIG. **6**B shows the unthread position, where cap **116** is unthreaded from projected rims **112**. FIG. **6**C shows an open position, where cover assembly **102** is open from body **108**.
[0059] In the example embodiment, when cap **116** is unthreaded from projected rim **112** or cover assembly **102** is open, cap **116** is retained with radial support **118**, thereby eliminating or reducing the likelihood that cap **116** falls and causes injury to a worker or damage to cap **116**. To thread cap **116** onto body **108**, cover assembly **102** is swung back to face projected rim **112**.
[0060] Referring back to FIGS. **5**B and **5**C, in the example embodiment, cover assembly **102** is advantageous in increasing the ease in threading cap **116** onto projected rims **112**. When cover assembly **102** is coupled with enclosure **104**, first joint portion **301** of joint **120** affixes radial support **118** with body **108** at one side and latch(es) **202** may attach radial support **118** at the other side. Radial support **118** is positioned around projected rim **112**. Positions of joint **120** and latch(es) **202** on body **108** may be adjusted such that longitudinal axis **510** of radial support **118**, along with longitudinal axis **508** of cap side **404**, aligns with longitudinal axis **512** of projected rim **112**. When cap **116** is assembled with radial support **118**, longitudinal axis **510** of radial support **118** and longitudinal axis **508** of cap side **404** are aligned (see FIG. **5**B). When radial support is place on projected rim **112**. the aligned longitudinal axes **510**, **512** is also aligned with longitudinal axis **512** of projected rim **112**. With the axes aligned, cap threads **401** engage with rim threads **114** with an increased ease, thereby reducing the likelihood of damaging cap threads **401** and/or rim threads **114** from cross threading.
[0061] In the example embodiment, a gap **524** is provided between support projection **306** and cap side **404**. The width of gap **524** is selected to balance the need to provide space for the axial movement of cap **116** and the need to limit radial movement of cap **116** in aligning and engaging threads **114**, **401**. Gap **524** provides space for the axial movement of cap **116** without cap side **404** scraping radial support **118**. In the meantime, gap **524** is selected for the self-alignment of cap

threads **401** and rim threads **114**, where gap **524** is relatively small to limit the radial movement of cap **116**. In some embodiments, a lubricant (not shown) such as a lubricative material or a lubricating coating may be applied on the surface of support projection **306** and/or the surface of cap side **404** to reduce the friction between the surfaces.

[0062] FIG. **7** is a flow chart of an example method **700** of assembling an explosion-resistant device for a hazardous environment. In the example embodiment, method **700** includes forming **702** a cover assembly. Example cover assemblies are cover assemblies **102** described herein. Method **700** also includes affixing **704** the cover assembly with an enclosure of an explosion-resistant device.

[0063] At least one technical effect of the assemblies, systems, and methods described herein includes (a) a cover assembly with a cap retained by a radial support; (b) a cover assembly rotatably coupled with an enclosure of an explosion-resistant device via a joint; (c) self-alignment of threads by the cover assembly; and (d) a latch in a cover assembly that increases the strength of the cover being retained with the enclosure.

[0064] Example embodiments of explosion resistant devices, assemblies, and methods are described above in detail. The systems and methods are not limited to the specific embodiments described herein but, rather, components of the systems and/or operations of the methods may be utilized independently and separately from other components and/or operations described herein. Further, the described components and/or operations may also be defined in, or used in combination with, other systems, methods, and/or devices, and are not limited to practice with only the systems described herein.

[0065] As used herein, an element or step recited in the singular and proceeded with the word “a” or “an” should be understood as not excluding plural elements or steps, unless such exclusion is explicitly recited. Furthermore, references to “example” or “one example” of the present disclosure are not intended to be interpreted as excluding the existence of additional examples that also incorporate the recited features. Further, to the extent that terms “includes,” “including,” “has,” “contains,” and variants thereof are used herein, such terms are intended to be inclusive in a manner similar to the term “comprises” as an open transition word without precluding any additional or other elements.

[0066] Although specific features of various embodiments of the invention may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the invention, any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing.

[0067] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

Claims

1. An explosion-resistant device for a hazardous environment, comprising: an enclosure sized to enclose equipment therein and comprising a body, the enclosure further comprising: a projected rim extending away from the body and defining an opening, the opening providing an access to the equipment; and rim threads positioned on a surface of the projected rim; and a cover assembly comprising: a joint comprising a first portion and a second portion, the first portion affixed with the body; a cap comprising: a cap top; and a cap side extending from the cap top, the cap side further comprising cap threads complementary to the rim threads; and a radial support affixed with the

second portion and obstructing the cap from dislocating out of the radial support, wherein the cover assembly is rotatably coupled with the enclosure via the joint.

2. The explosion-resistant device of claim 1, wherein the radial support comprises a support projection projecting from an interior surface of the radial support, the cap side further comprising a side projection positioned adjacent to an end of the cap side opposite from the cap top, the side projection projecting from an exterior side surface of the cap side, the support projection positioned between the cap top and the side projection and obstructing the cap from dislocating out of the radial support.

3. The explosion-resistant device of claim 2, wherein the support projection comprises an annular raised ring, the cap side defining a side recess, the annular raised ring being concentric to the side recess and received in the side recess.

4. The explosion-resistant device of claim 1, wherein the cover assembly further comprises a latch configured to removably couple the radial support with the body.

5. The explosion-resistant device of claim 1, wherein the cap side comprises a first side projection and a second side projection and defines a side recess positioned between the first side projection and the second side projection.

6. The explosion-resistant device of claim 5, wherein the radial support comprises an annular raised ring concentric to the side recess, an outer diameter of the cap side at the side recess being smaller than an inner diameter of the radial support at the annular raised ring.

7. The explosion-resistant device of claim 1, wherein the radial support comprises a first support segment, a second support segment, and one or more support fasteners joining the first support segment with the second support segment.

8. The explosion-resistant device of claim 1, further comprising a lubricant applied to the radial support and/or the cap side.

9. A cover assembly of an explosion-resistant device for a hazardous environment, comprising: a joint comprising a first portion and a second portion, the first portion configured to be affixed with an enclosure of an explosion-resistant device; a radial support affixed with the second portion; and a cap comprising: a cap top; and a cap side extending from the cap top, wherein the radial support comprises a support projection projecting from an interior surface of the radial support, the cap side further comprising a side projection positioned adjacent to an end of the cap side opposite from the cap top, the side projection projecting from an exterior side surface of the cap side, the support projection positioned between the cap top and the side projection and obstructing the cap from dislocating out of the radial support, and wherein the cover assembly is configured to rotatably couple with the enclosure via the joint.

10. The cover assembly of claim 9, wherein the support projection comprises an annular raised ring, the cap side defining a side recess, the annular raised ring being concentric to the side recess and received in the side recess.

11. The cover assembly of claim 9, wherein the cover assembly further comprises a latch configured to removably couple the radial support with the enclosure.

12. The cover assembly of claim 9, wherein the cap side comprises a first side projection and a second side projection and defines a side recess positioned between the first side projection and the second side projection.

13. The cover assembly of claim 12, wherein the radial support comprises an annular raised ring concentric to the side recess, an outer diameter of the cap side at the side recess being smaller than an inner diameter of the radial support at the annular raised ring.

14. The cover assembly of claim 9, wherein the radial support comprises a first support segment, a second support segment, and one or more fasteners joining the first support segment with the second support segment.

15. The cover assembly of claim 9, further comprising a lubricant applied to the radial support and/or the cap side.

16. A method of assembling an explosion-resistant device for a hazardous environment, the method comprising: forming a cover assembly, wherein the cover assembly includes: a joint including a first portion and a second portion; a cap including: a cap top; and a cap side extending from the cap top, the cap side further including cap threads; and a radial support affixed with the second portion and obstructing the cap from dislocating out of the radial support; affixing the cover assembly with an enclosure of an explosion resistant device, the enclosure sized to contain equipment therein and including a body, the enclosure further including: a projected rim extending away from the body and defining an opening providing an access to the equipment; and rim threads positioned on a surface of the projected rim and complementary to the cap threads, wherein affixing the cover assembly further comprises affixing the first portion of the joint with the body.

17. The method of claim 16, wherein forming the cover assembly further comprises: selecting a gap between the cap side and the radial support to facilitate self-alignment of the cap side with the projected rim.

18. The method of claim 16, wherein forming the cover assembly further comprises: positioning a side projection of the cap side adjacent to a support projection of the radial support such that the support projection obstructs the cap from dislocating out of the radial support; and assembling the radial support by joining a first support segment with a second support segment via one or more fasteners.

19. The method of claim 16, wherein the radial support includes an annular raised ring, the cap side defining a side recess, and forming the cover assembly further comprises: positioning the annular raised ring in the side recess.

20. The method of claim 16, wherein the cover assembly further includes a latch configured to removably couple the radial support with the body.