

## **Description**

### **ANODE ASSEMBLY AND METHOD**

## **Technical Field**

[01] This invention concerns the protection of steel in concrete using sacrificial anode assemblies wherein the assemblies are embedded in cavities formed in the concrete, and, more specifically, where the cavities are mechanically formed for the purposes of accommodating the sacrificial anode assemblies.

## **Background**

[02] Reinforced concrete structures sometimes suffer deterioration because the reinforcing steel corrodes. This is often caused by chloride contamination or carbonation of the concrete. Sacrificial anodes are used to inhibit the corrosion of steel in concrete. Sacrificial anode assemblies embedded in cavities in concrete will typically comprise a sacrificial metal that is less noble than steel (electrochemically more negative than steel) such as zinc, an activator to maintain sacrificial metal activity, a backfill to accommodate the products of sacrificial metal dissolution and a ductile elongated metal conductor to connect the sacrificial metal element to the steel or to a power supply.

[03] In some cases, (typically the case when a consumed activator is used), the backfill and activator will be assembled with the sacrificial metal and conductor in a factory and this assembly will then be installed on site by embedding it in a cementitious mortar in a cavity formed in the concrete. In cavities formed as the result of corrosion damage, the sacrificial anode assembly will be tied to the steel before substantially filling the cavity with a concrete repair material to restore the concrete properties and profile. In other cases, an anode cavity (for example, a drilled hole) may be mechanically formed for the purpose of installing a sacrificial anode assembly and in this case the anode cavity will be substantially filled with the assembly (see Repair Application Procedure 8 published by the American Concrete Institute at [www.concrete.org/general/RAP-8.pdf](http://www.concrete.org/general/RAP-8.pdf)).

- [04] More recent developments include assembling the sacrificial anode assembly within an anode cavity. For example, a sacrificial metal element may be embedded directly in a backfill in the anode cavity (WO/2007/039768). The anode cavity may also open into a larger cavity formed as the result of corrosion damage to protect the steel in the adjacent undamaged concrete (WO/2010/043908).
- [05] Embedded sacrificial anodes for reinforced concrete structures need to be activated if they are to provide protection to the reinforcing steel. Activators for sacrificial anodes may be described as consumed activators or catalytic activators.
- [06] An example of an activator that is consumed is hydroxyl ions. These react with the sacrificial metal element to produce a soluble species. A problem with this form of activation is that the functional life of the sacrificial anode assembly also depends on the quantity of activator present. Such activators are generally pre-assembled in an anode - backfill assembly. Another problem is that some of these activators such as potassium and sodium hydroxide may react with the constituents of the surrounding concrete to cause a deleterious expansive effect known as alkali silica reaction.
- [07] Examples of catalytic activators include halide ions and sulphate ions (WO/2006/043113). These ions render passive films on a sacrificial metal element unstable, but they are not substantially consumed in the process. The functional life of the sacrificial anode assembly is not dependent on the quantity of activator. However a problem with this form of activation is that these activators are also aggressive to the reinforcing steel.
- [08] Sacrificial anode assemblies are sometimes used with a power supply to deliver an impressed current treatment (WO/2006/097770). This can be used to draw chloride ions present in the concrete to the sacrificial metal element to activate the anode assembly. In this case activation of the sacrificial metal element may be achieved only using aggressive contaminants already present in the concrete.

## Disclosure of Invention

- [09] An objective of the present invention is to provide a method of using a catalytic activating agent or a catalytic activator in a manner that does not place the reinforcing steel at risk of having substantial contact with the catalytic agent or activator once a sacrificial anode assembly or assemblies are located in the anode cavities which are formed within concrete.
- [10] Another objective of the present invention is to provide a method of using a consumed activator in a manner that does not place the concrete at risk of having substantial contact with the consumed activating agent when a sacrificial anode assembly is located in an anode cavity formed in concrete.
- [11] In a first aspect, this invention provides a method of protecting steel in concrete using a sacrificial metal element and an activator and a backfill and at least one spacer, the method comprising the steps of:  
 forming an anode cavity in the concrete for the purposes of installing a sacrificial anode assembly therein;  
 locating the sacrificial metal element and activator in the backfill in the anode cavity;  
 spacing the activator away from the sides of the anode cavity with the spacer; and  
 passing a current from the sacrificial metal element to the steel in the concrete to protect the steel in the concrete with at least one conductor connected to the sacrificial metal element,  
 wherein  
 the backfill is a pliable and viscous backfill and does not harden before the installation process is completed, and  
 the backfill accommodates the products of sacrificial metal dissolution, and  
 the sacrificial metal element comprises a metal less noble than steel.
- [12] The sacrificial metal element and the activator are preferably assembled together prior to embedment in the anode cavity. The activating agent may be applied as a coating to the sacrificial metal element or may be intermixed with the sacrificial metal element. An activating coating will comprise a binder and the activating agent. One example of the binder is calcium sulphate which also acts as an activator. Another example of the binder is an outdoor

metal paint that may be thinned with an organic solvent. In this case the binder is inert and the quantity of an inert binder is preferably kept below 20% of the dry coating weight.

- [13] The activating agent or activator may be any of the known activators for sacrificial anodes in concrete. The activating agent is preferably a catalytic activating agent. Examples of suitable activating agents or activators are disclosed in WO/2006/043113.
- [14] The quantity of activating agent included with the sacrificial metal element should preferably be sufficiently small such that if it is distributed uniformly throughout the anode cavity, it will be diluted to a concentration that will be insufficient to present any substantial corrosion risk to the steel in the concrete or to the concrete in which the anode cavity is formed. Thus any corrosion risk presented to the steel by the activator or risk presented to the concrete when the sacrificial metal element has been consumed will be negligible.
- [15] The spacer(s) is preferably a resilient spacer(s). The resilient property may be achieved using either metal or plastic. The spacer may be a resilient plastic spacer. A metal spacer is preferably insulated and this may be achieved using a polymer. The spacer preferably comprises a non-conductive material. The spacer may substantially comprise a polymer to impart resilience or insulate the resilient component.
- [16] The spacer is preferably coupled to the sacrificial metal element with a coupling mechanism. The spacer is preferably assembled with the sacrificial metal element and the activator prior to embedment in the anode cavity.
- [17] The spacer is preferably a housing spacer that includes a bore or aperture into which the sacrificial metal element may be located. In use, the spacer preferably holds the sacrificial metal element in a spaced arrangement in the cavity. The spacer preferably holds or captively retains the sacrificial metal element and activator away from the walls of the anode cavity. This may be achieved by sizing the anode cavity in the concrete and the spacer such that the spacer grips the sacrificial metal element and exerts pressure between the walls of the anode cavity when it is located in the cavity. In this example,

the spacer is placed under compression in the anode cavity and the pressure between the spacer and the walls results in the spacer gripping the walls using friction.

- [18] The anode cavity is a three dimensional space. The spacer(s) preferably locates the sacrificial metal element and activator at the centre of at least one dimension of the anode cavity. The spacer(s) may locate the sacrificial metal element and activator at the centre of two dimensions of the anode cavity.
- [19] The backfill may be any of the known backfills for use with sacrificial anodes embedded in cavities in concrete. For example, the backfill may be a powder mixed with water to produce a paste when installing the anode assembly, an example of which would be a weak air entrained cement mortar paste. Other examples of the backfill are disclosed in WO/2007/039768. The backfill preferably retains its pliable and viscous properties for at least 48 hours and more preferably retains these properties for a longer period of time (e.g. one month) that renders it practical to store the backfill in a container or more specifically a cartridge. An example of such a backfill is a lime mortar paste. The backfill is preferably placed in the anode cavity and an assembled sacrificial metal element, activator and spacer are preferably pressed into the backfill in the anode cavity.
- [20] The anode cavity is preferably a cored or drilled hole or a cut chase in the concrete. The sacrificial metal element preferably consists of zinc or a zinc alloy. To pass current from the sacrificial metal element to the steel a conductor is attached to the sacrificial metal element. The conductor may be a steel or titanium wire. The sacrificial metal element is preferably cast around a portion of the conductor. The conductor may be attached directly to the steel to deliver a galvanic current, or may be connected through a power supply to the steel to deliver an impressed current which may precede a subsequent galvanic current. When the conductor is to be connected directly to nearby steel it is preferable that the conductor is an elongated ductile conductor with a length greater than 250mm.
- [21] In another aspect this invention provides a steel reinforced concrete protector for use in the method described in the first aspect of this invention, the steel reinforced concrete protector comprising an anode assembly and a separate

backfill wherein

the anode assembly comprises a sacrificial metal element and an activator and at least one spacer, and

the at least one spacer includes a plurality of outwardly extending members that extend away from the centre of the sacrificial anode assembly to an outer limit, and

the at least one spacer defines at least one space between the activator and a line connecting two adjacent outer limits of the outwardly extending members, and

the sacrificial metal element comprises a metal less noble than steel, and

the backfill is a pliable and viscous backfill to fill the space defined by the at least one spacer and the activator.

- [22] During the production of prototypes of sacrificial metal element/activator assemblies, it was discovered that such assemblies may deteriorate in contact with the air. This limits the shelf life of a sacrificial anode assembly that contains an activator. A further objective of the present invention is to provide a method of increasing the shelf life of the sacrificial anode assembly, containing an activator, that would normally deteriorate once the sacrificial metal element and the activator are exposed to air and/or moisture in the air.
- [23] In another aspect this invention provides a method for increasing a shelf life of a sacrificial anode assembly comprising the steps of:  
 assembling a sacrificial metal element less noble than steel with an activator to maintain an activity of the sacrificial metal element to form the sacrificial anode assembly; and  
 sealing the sacrificial anode assembly within a package that is substantially free of at least one of  
 oxygen, water vapour and carbon dioxide  
 to increase a shelf life of the sacrificial anode assembly.
- [24] In one method of extending the shelf life of an anode assembly comprising a sacrificial metal element less noble than steel and an activating agent the anode assembly is located in a container, the air is sucked out of the container under vacuum and the opening to the container is sealed.

- [25] The preferred process is known as vacuum packing and is used in the food processing industry. In this case the container will be a bag. The bag will have at least one face that is dimpled to facilitate the flow of air out of the bag under vacuum. When the required vacuum is achieved, the opening of the bag is sealed by heating and melting the plastic together.
- [26] A spacer and an elongated connector may be assembled with the sacrificial metal element and activator. The plastic forming the plastic bag should not be punctured during the vacuum packing process and more than one layer of plastic may be used to prevent the bag from puncturing.
- [27] In the place of vacuum packing the anode - activator assembly or assemblies, the assembly may be sealed in an inert gas in a plastic bag. For example, oxygen and/or water vapour may be removed from the gas in the plastic bag to preserve the life of the anode assembly in the bag. Examples of an inert gas include dry nitrogen and argon.
- [28] A method of protecting steel in concrete using one or more sacrificial anode assemblies comprising a sacrificial metal element, an activator, a pliable viscous backfill and a conductor, may involve exposing steel at an area requiring concrete patch repair, forming an anode cavity comprising a cored or drilled hole in the concrete adjacent to an area of patch repair for the purposes of installing the sacrificial anode assembly therein, embedding the sacrificial metal element and activator in the backfill in the cavity, spacing the activator off of the inwardly facing surface of the anode cavity with a spacer and connecting the sacrificial metal element to the steel exposed in the adjacent patch repair with an elongated ductile conductor of sufficient length to run from the sacrificial metal element to the steel without being spliced that is assembled with the sacrificial metal element prior to embedding the sacrificial metal element. The activator is preferably a catalytic activator and a spacer is preferably assembled with the catalytic activator and sacrificial metal element to create a space that is filled with the backfill between the activator and the walls of the cored or drilled hole. The catalytic activator and spacer are preferably assembled with the sacrificial metal element.

### **Brief Description of Drawings**

- [29] This invention is now illustrated further with reference by way of example to the drawings in which:
- [30] Figure 1 shows a section through an assembly comprising a spacer, a sacrificial metal element, an activator and a conductor.
- [31] Figure 2 shows an isometric view of the spacer described in Figure 1.
- [32] Figure 3 shows a top plan view of the spacer described in Figure 1.
- [33] Figure 4 shows a section through a repaired steel reinforced concrete element that illustrates the use of the sacrificial anode assembly.

### **Preferred Embodiments**

- [34] Figure 1 shows an example of an assembly comprising a cylindrical sacrificial metal element 3 with an elongated ductile conductor 4 and a spacer comprising a cylindrical body 1, fins or outwardly extending members 2 and nubs or protrusions 5. The sacrificial metal element may be coated with a catalytic activating agent 6, or the catalytic activating agent may be included within the sacrificial metal element or injected into a porous assembly at a later time. The protrusions 5 on the spacer make contact with the sacrificial metal element and create a gap between the spacer and the sacrificial metal element to allow electrolyte to connect most of the surface of the sacrificial metal element to the concrete. The coiled elongated ductile conductor 4 facilitates the connection of the sacrificial metal to the steel without the need to splice additional conductors during installation.
- [35] Figures 2 and 3 provide more views of the spacer in Figure 1. This example of the spacer comprises a generally elongate cylindrical body 1 which has both a leading end and a trailing end. The central bore of the spacer facilitates insertion of the sacrificial metal element 3 in the spacer. When the sacrificial anode assembly is inserted into an anode cavity provided with an electrolytic backfill, the backfill provides communication between the sacrificial metal element 3 and the adjacent concrete. The spacer is designed to surround and at least partially encase and enclose the sacrificial metal element 3 and prevent both the leading end surface as well as the perimeter

side surface of the sacrificial metal element 3 from directly contacting with the concrete, i.e., as generally shown in Figure 1, the leading end surface of the sacrificial metal element 3 is spaced axially inwardly and away from the leading end of the spacer so as to avoid contact with the concrete.

- [36] The exterior surface of the spacer has a plurality of radially outwardly extending retaining members or fins 2 which facilitate spacing and generally centring of the spacer, and thus centring of the sacrificial anode assembly, radially with respect to the walls or inwardly facing surface of an anode cavity as well as retention of the sacrificial anode assembly within the cavity. In this example, these members 2 taper away from the trailing end of the sacrificial anode assembly to facilitate insertion of the assembly into an anode cavity. They extend to an outer limit that creates a space between the outer limit of these members and the activator of the sacrificial anode assembly that may be filled with the backfill.
- [37] The interior surface of the spacer has one or more nub(s), protrusion(s) or annular member(s) 5 located for engagement with the at least one annular groove or recess formed in the sacrificial metal element 3 for coupling, connecting and captively retaining the sacrificial metal element 3 to the spacer. It is to be appreciated that a variety of other types of conventional coupling mechanisms or arrangements, for reliably coupling or connecting the sacrificial metal element 3 to the spacer may be utilized instead of the at least one annular groove or recess and the one or more nub(s), protrusion(s) or annular member(s) without departing from the spirit and scope of the present invention. For example, separate protrusions may be formed on the exterior of the sacrificial metal element 3 that would engage a mating groove(s), hole(s), recess(es) or indentation(s) formed in the interior surface of the spacer.
- [38] Figure 1 shows a plurality of nub(s), protrusion(s) or annular member(s) 5, supported by the interior surface of the body 1 of the spacer, received within the annular groove or recess of the sacrificial metal element 3 so as to facilitate a reliable but a relatively loose interconnection there between. An annular gap is formed between the exterior surface of the sacrificial metal element 3 and the interior surface of the body 1 of the spacer. This gap

permits the electrolytic backfill to directly contact and electrochemically couple and connect the sacrificial metal element with the concrete.

- [39] The size of the gap, located between the interior surface of the spacer and the exterior surface of the sacrificial metal element, is preferably sufficient so that the gap is at least partially filled with a small quantity of the conductive electrolytic backfill. By providing a gap between the spacer and the sacrificial metal element and using a conductive electrolytic backfill which is sufficiently pliable to penetrate into the gap, the otherwise negative effect of the spacer, on the current output of the sacrificial anode assembly, becomes negligible. This effect is dependent on the conductivity and fineness of the backfill and the presence of the activating agent. The effect of the spacer on current output is not significant when the gap is about 1 mm and lime putty is used as a backfill. Other methods of mitigating the effect of the spacer on current output include forming additional holes or slots within the body 1 of the spacer.
- [40] The spacer is preferably formed using a plastic. The plastic needs to be sufficiently stiff such that it does not collapse under the weight of the sacrificial metal element. A cylindrical cavity formed in concrete will typically be up to 50mm in diameter and up to 300mm in depth to receive a sacrificial anode assembly. Examples of a plastic that may be used to produce a plastic spacer using an injection moulding method include acetyl and polypropylene.
- [41] While the sacrificial anode assembly described above is generally cylindrical in shape, it is to be appreciated that the assembly may also have a cross section that is triangular, rectangular, pentagonal, hexagonal, or some other desired shape.
- [42] One challenge with off site or pre-application or integration of an activating agent or an activator 6 with the sacrificial metal element 3 is that the activating agent or the activator 6 typically begins reacting with the sacrificial metal element 3 as soon as the activating agent or the activator is applied to or mixed with the sacrificial metal element in the presence of oxygen and water vapour. Furthermore, it is to be appreciated that carbon dioxide may also react with the sacrificial metal element to form a metal carbonate passivating layer on the sacrificial metal element. In order to minimize such

reaction(s), it is necessary to package the coated sacrificial metal element 3, or the sacrificial metal element with the integral activating agent or the activator, generally within an environment which is free of reactive gasses or within a container shortly after combining the sacrificial metal element with the catalytic activating agent or the activator, e.g., typically within 14 days after assembling or combining those components with one another.

- [43] A preferred method of gas free packaging of the sacrificial anode assembly is a conventional vacuum packaging process in which the sacrificial anode assembly is vacuum sealed within an evacuated plastic bag or container. Other methods of inert packaging of the sacrificial anode assembly are envisioned and contemplated, such as packaging the sacrificial anode assembly in a quantity of a non-reactive gas(es), such as nitrogen, or argon, which is sealed within the sealed container along with the sacrificial anode assembly. Examples of suitable containers for packaging the sacrificial anode assembly include sealed plastic bags, both hard or soft plastic containers, metal containers, etc.
- [44] Figure 4 shows an example of a sacrificial metal element 11 and a spacer 12 embedded in a backfill 13 located within an anode cavity 14 that may be, for example, a 28 mm diameter by 50 mm deep hole which is mechanically drilled or otherwise bored or formed within a concrete element 20. The sacrificial metal element 11 may be coated with a catalytic activating agent or catalytic activator. The anode cavity 14 opens into an adjacent cavity 15 that was formed because of corrosive damage. In this adjacent cavity 15, a steel bar 16 was exposed and cleaned, in a conventional manner. The elongated ductile conductor 17 interconnects the sacrificial metal element 11 with the steel bar 16 in order to deliver a galvanic protection current from the sacrificial metal element 11 to reinforcing steel (not shown) located within the concrete 20 that is connected to the steel 16.
- [45] To install the sacrificial anode assembly in this example, the cavity 14 is cored or drilled into the concrete 20. Then a sufficient quantity of the pliable, electrolytic backfill 13 is placed within the cavity 20. Next, the sealed, evacuated container containing a pre-assembled sacrificial anode assembly is opened and the sacrificial anode assembly is inserted into the backfill 13

located within the cavity 14, the leading end of the spacer 12 first, so that the conductor 17 remains located outside the cavity 14. If a pre-assembled sacrificial anode assembly is not available, then the sacrificial anode assembly should preferably be assembled on site for insertion as a sacrificial anode assembly into the cavity. The conductor 17 is then connected to a desired piece of the steel 16 in a conventional manner.

- [46] A first end of the elongated ductile conductor 17 is formed or embedded within or otherwise connected with the sacrificial metal element 11 while the second opposite end of the elongate conductor 17 is sufficiently long so as to facilitate a secure electrical clamping or connection with the steel bar 16, for example, via a conventional cable tie 18 which makes and maintains the electrical connection there between in a secure and substantially permanent manner. Steel or stainless steel tie wire may also be used to secure the connection. Once the sacrificial anode assembly is installed, as generally described above, then the adjacent cavity 15 is filled with an appropriate concrete repair material 19 so that both the sacrificial anode assembly and the steel bar are embedded within and substantially covered by the concrete repair material 19. During such repair, a cavity 14 is typically drilled at 500 mm intervals in the concrete 20 around the periphery of cavity 15 and a sacrificial anode assembly located within each one of those cavities and connected, as described above, so as to provide the desired galvanic current protection
- [47] The sacrificial metal element 11 is a metal less noble than steel, and preferably comprises either zinc or a zinc alloy. The sacrificial metal element 11 is preferably cast as a cylindrical shaped body, but it is to be appreciated that the sacrificial metal element 4 may be shaped into a variety of other shapes or configurations, such as regular polygon prisms. The sacrificial metal element 11 generally has a constant cross section along its length, but the cross-sectional shape of the sacrificial metal element 11 may vary depending upon the particular application. A sacrificial metal element 11, that is designed to fit within a 28 mm diameter by 50 mm long cavity, will typically have a diameter or width of 18 mm and a length of 40 mm.

- [48] It is to be appreciated that the diameter of the cavity 14 is preferably smaller than the outer diameter of the retaining members 2 (see Fig, 3) so that the retaining members 2 can engage with and be deflected somewhat by the inwardly facing surface of the cavity 14 and frictionally retain the sacrificial anode assembly within the cavity 14, even in an overhead cavity. Typically, the cavity 14 will have a length which is somewhat longer than a total axial length of the sacrificial anode assembly.
- [49] The elongated ductile connector 17 facilitates convenient connection of the sacrificial metal element 11 to the steel without the need to splice any additional conductor directly to the sacrificial metal element 11 during the installation process. The connector 17 may be a steel or a titanium wire. The connector 17 typically has a length of between 250 and 400 mm and a diameter of between 0.7 and 2 mm. The connector 17 is preferably at least partially embedded within the trailing end of the sacrificial metal element 11 and may extend the entire length of the sacrificial metal element 11. More preferably, the sacrificial metal element 11 is cast around at least a portion of connector 17 with the connector 17 extending out from the trailing end of the sacrificial metal element 11 for a sufficient distance to facilitate ease of connection of the remote free end of the connector 17 with the steel 16.
- [50] In one example the sacrificial metal element 11 is assembled with the catalytic activating agent or catalytic activator. That is, either the exterior surface of the sacrificial metal element 11 is coated with the catalytic activating agent or the catalytic activator, e.g., a compound(s) containing halide ions and sulphate ions, or alternatively, the catalytic activating agent or catalytic activator is intimately mixed with and dispersed within and throughout the sacrificial metal element.
- [51] The quantity of the catalytic activating agent or catalytic activator to be included with the sacrificial metal element should preferably be sufficient to provide the desired ion flow between the sacrificial metal element and the concrete but insufficient to create a significant corrosion risk by the catalytic activating agent or catalytic activator to the steel once the sacrificial metal element has been consumed. Preferably the quantity of catalytic activating agent or catalytic activator is such that if it were to be uniformly distributed

within the cavity 14, the catalytic activating agent or catalytic activator would be diluted to a concentration that is insufficient to present a corrosion risk to steel embedded within the concrete 20. For a chloride activator, this equates to a quantity of less than 1.6 kg of chloride ions per cubic meter of anode cavity.

- [52] Ideally the catalytic activating agent or the catalytic activator is applied to or integrated into the sacrificial metal element prior to packaging the sacrificial anode assembly for shipment and subsequent sale or installation. This allows the installation process of the sacrificial anode assembly within a cavity, at the installation site, to proceed at a faster rate than if the catalytic activating agent or the catalytic activator was manually applied to each sacrificial metal element, on site, prior to installation or was injected into a porous anode body after installation.

## Claims

1. A method of protecting steel in concrete using a sacrificial metal element and an activator and a backfill and at least one spacer, the method comprising the steps of  
forming an anode cavity in the concrete for the purposes of installing a sacrificial anode assembly therein,  
locating the sacrificial metal element and activator in the backfill in the anode cavity,  
spacing the activator away from the sides of the anode cavity with the spacer,  
and  
passing a current from the sacrificial metal element to the steel in the concrete to protect the steel in the concrete with at least one conductor connected to the sacrificial metal element,  
wherein  
the backfill is a pliable and viscous backfill and does not harden before the installation process is complete, and  
the backfill accommodates the products of sacrificial metal dissolution, and  
the sacrificial metal element comprises a metal less noble than steel.
2. A method as claimed in claim 1 wherein the at least one spacer captively retains the sacrificial metal element and the activator within the anode cavity in a spaced relationship from an inwardly facing surface of the anode cavity.
3. A method as claimed in any of claims 1 to 2 wherein the at least one spacer includes a plurality of members extending radially outwards to the inwardly facing surface of the anode cavity and these members engage with an inwardly facing surface of the anode cavity once the assembly is located within the anode cavity.
4. A method as claimed in any of claims 1 to 3 wherein the at least one spacer is a resilient spacer placed in compression.
5. A method as claimed in any of claims 1 to 4 wherein the spacer locates the sacrificial metal element and activator at the centre of at least one dimension of the anode cavity.
6. A method as claimed in any of claims 1 to 5 wherein the activator is assembled

with the sacrificial metal element prior to locating the sacrificial metal element and activator in the anode cavity.