Impressed current cathodic protection system design pdf

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The technique of preventing corrosion Aluminum sacrificial anodes (light rectangular bars) mounted on the steel structure of the jacket. The zinc sacrificial anode (rounded object) is screwed to the bottom of the hull of a small boat. The pronunciation of the word cathodic cathodic protection (CP) is a method used to control the corrosion of the metal surface, making it a cathode of the electrochemical cell. A simple method of protection connects the metal, which must be protected, with the more easily corroded sacrificial metal to act as an anode. The sacrificial metal then corrodes instead of the protected metal. For structures such as long pipelines, where passive galvanic cathode protection is not adequate, an external source of DC electricity is used to provide sufficient current. Cathode protection systems protect a wide range of metal structures in different environments. Common are: steel water or fuel pipes and steel storage tanks such as home water heaters; steel piles of the pier; Hulls of ships and boats; offshore oil platforms and coastal hulls of oil oil fields; offshore foundations of wind farms and metal reinforcement bars in concrete buildings and structures. Another common application is in galvanized steel, in which the sacrificial coating of zinc on steel parts protects them from rust. Cathode protection can, in some cases, prevent the stress of corrosion cracking. The history of cathode protection was first described by Sir Humphrey Davy in a series of papers presented to the Royal Society in London in 1824. The first application was to HMS Samarang in 1824. The sacrificial iron anodes attached to the copper shell of the case below the valerian line dramatically reduced the rate of copper corrosion. However, a side effect of cathode protection was an increase in sea growth. As a rule, copper in corrosion releases copper ions, which have an anti-foling effect. As excess maritime growth affected the ship's productivity, the Royal Navy decided it was best to allow copper to corrode and have the advantage of reducing sea growth, so cathode protection was not used any further. Davy helped in his experiments by his pupil Michael Faraday, who continued his research after Davy's death. In 1834, Faraday discovered a quantitative link between weight loss of corrosion and electric current and thus laid the groundwork for the future use of cathode protection. Thomas Edison experimented with the current cathode protection on ships in 1890, but failed due to the lack of a suitable current source and anode materials. That would be 100 years after Davy's experiment, before cathode protection was widely used on oil pipelines in the United States - cathode applied to steel pipelines dating back to 1928 and more widely in the 1930s. Years. ship's hull, showing corrosion. Galvanic When applying passive cathode protection to a vulnerable metal surface where it is exposed to electrolyte, a galvanic anode is attached, a piece of more electrochemically active metal (more negative electrode potential). Galvanic anodes are chosen because they have a more active voltage than the metal target structure (usually steel). Concrete has a pH of about 13. In this environment, steel reinforcement has a passive protective layer and remains largely stable. Galvanic systems are the constant potential of systems that aim to restore the natural protective environment of concrete, providing a high initial current to restore passivity. It then returns to a lower current sacrifice while harmful negative chloride ions migrate from steel to positive anode. Anodes remain reactive throughout life (usually 10-20 years), increasing current when resistivity decreases due to corrosive hazards such as precipitation, rising temperatures or flooding. The reactive nature of these anodes makes them an effective choice. Unlike ICCP systems, steel is not a goal, but rather an environmental restoration. The polarization of the target structure is caused by the flow of an electron from the anode into the cathode, so the two metals must have a good electrically conductive contact. The driving force behind the cathode protective current is the difference in the electrode potential between the anode and the cathode. At the initial stage of high current, the potential of the steel surface is polarized (pressed) more negatively protects the steel, which hydroxide ion generation on the steel surface and ion migration restore the concrete environment. Over time, the galvanic anode continues to corrode, consuming anode material until eventually it should be replaced. Galvanic or sacrificial anodes are made in various shapes and sizes using alloys of zinc, magnesium and aluminum. ASTM International publishes standards for the composition and production of galvanic anodes. In order for galvanic cathode protection to work, the anode must have a lower (i.e. more negative) electrode potential than the cathode (the target structure that must be protected). The table below shows a simplified galvanic series that is used to select anode metal. The anode must be selected from material that is lower in the list than the material that needs to be protected. The metal potential for the Cu:CuSO4 reference electrode in a neutral pH (volts) carbon environment, Graphite, Coke 0.3 Platinum 0 to 0.1 mill scale on steel No 0.2 High silicon cast iron No 0.2 Copper, brass, bronze No0.2 Soft steel in concrete No0.2 Lead No0.5 Chugun (un graphized) 0.5 steel (rust) from 0.2 to 0.5 euros Soft steel (net) from 0.5 to 0.8 euros Pure Aluminum Alloy No.0.8 Aluminum Alloy (5% zinc) No1.05 zinc No1.1 Magnesium Alloy (6% Al, 3% n, 0.15% Mn) No1.6 Commercial Pure Magnesium No1.75 Impressive Current Systems Just impressed the current catodic protection system. The source of the DC electric current is used to drive a protective electrochemical reaction. In some cases, impressive modern cathode protection (ICCP) systems are used. They consist of anodes connected to a DC power source, often a transformer-cleaner connected to ac-current power. In the absence of a AC source, alternative energy sources such as solar panels, wind power or gas-electric generators can be used. Anodes for ICCP systems are available in a variety of shapes and sizes. Common anodes are tubular and solid rod shapes or continuous ribbons of various materials. These include high-silicon cast iron, graphite, mixed metal oxide (MMO), platinum and niobium coating wire and other materials. For pipelines, the anodes are located in ground beds, either distributed or in a deep vertical pit, depending on several factors related to the design and condition of the field, including the current distribution requirements. Cathode transformer protection units are often custom-made and equipped with a variety of functions, including remote monitoring and control, integrated current interruptors and various types of electrical hulls. The negative DC withdrawal terminal is connected to a structure that will be protected by a cathode protection system. The DC output cleaner positive cable is connected to the anodes. The AC power cable is connected to the straightener input terminals. The output of the ICCP system must be optimized to ensure that there is sufficient current to protect the target structure. Some cathode protective transformer-cleaning units are designed with transformer winding cranes and terminal jumpers to select the output of the ICCP voltage system. Cathode protective transformer-cleaning units for water tanks and used in other applications are made with solid state circuits to automatically adjust the operating voltage to maintain optimal current output or potential from structure to electrolyte. Analog or digital meters are often installed to show running voltage (DC and sometimes air conditioning) and current output. For onshore structures and other large complex target structures, ICCP systems are often designed with several independent anode zones with separate cathode transformer-cleaning circuits. Hybrid hybrid systems have been in use for more than a decade and include coordination, monitoring and high-recovery of ICCP systems with a lower and easier to maintain galvanic anodes. The system consists of wired galvanic anodes in arrays, usually 400 mm apart, which are then initially powered for a short period to restore concrete and and ion migration. Then the power supply is braved, and the anodes are simply attached to the steel as a galvanic system. If necessary, you can administer more powerful phases. As galvanic systems monitor the rate of corrosion from polarization tests and semi-cellular potential mapping can be used to measure corrosion. Polarization is not a goal for the life of the system. Hot Water Tank/Water Heater apps This technology is also used to protect water heaters. Indeed, electrons sent by an anode (made of titanium and coated with MMO) prevent rust inside the tank. For these anodes to be found to be effective, they must meet certain standards: the cathode protection system is considered effective when its potential reaches or exceeds the limits set by the cathode protection criteria. The cathode protection criteria used are the standard criteria of NACE SP0388-2007 (formerly RP0388-2001) of the National Association of Corrosive Engineers NACE. Pipelines Air refrigerated cathode protection purifier connected to the pipeline. Cathode protective markers above a gas pipeline in Leeds, West Yorkshire, England. Dangerous pipelines are usually protected by a coating supplemented by cathode protection. The impressed current cathode protection system (ICCP) for the pipeline consists of a DC power source, often a transformer straightener powered by AC and anode, or an array of anodes buried in the ground (an anode bed). The DC power source usually has a DC output of up to 50 amps and 50 volts, but this depends on several factors such as the size of the pipeline and the quality of the coating. A positive DC exit terminal will be connected through cables to the anode grille, while another cable will connect the negative straightener terminal to the pipeline, preferably through docking boxes, so that measurements can be made. Anodes can be installed in a dirt bed consisting of a vertical hole filled with conductive coke (a material that improves the performance and lifespan of anodes) or placed in a prepared trench surrounded by conductive coke and filling. The type and size of the soil depends on the application, location and resistance of the soil. The dc cathode protection current is then adjusted to the optimum level after various tests, including measuring the potentials of the pipe into the soil or electrode potential. Sometimes it is economically feasible to protect the pipeline using galvanic (sacrificial) anodes. This is often the case on smaller pipelines of limited length. Galvanic anodes rely on galvanic in rows of metals to drive cathode protective current from an anode to protected Water pipes from various pipe materials are also provided with cathode protection, where owners determine the cost of the cost for the expected extension of the pipeline's lifespan attributed to cathode protection. Ships and boats White spots visible on the hull of the ship are zinc blocks of sacrificial anodes. Cathode protection on ships is often carried out by galvanic anodes attached to the hull and by ICCP for larger vessels. Since ships are regularly removed from the water for inspection and maintenance, it is a simple task to replace galvanic anodes. Galvanic anodes are usually formed to reduce resistance in the water and are set flush to the body to also try to minimize resistance. Small vessels with non-metallic hulls, such as yachts, are equipped with galvanic anodes to protect areas such as suspension engines. Like all galvanic cathode protection, this application relies on a strong electrical connection between the anode and the item to be protected. For ICCP on ships, anodes are usually constructed from relatively inert material such as platinum titanium. The vessel provides constant power and anodes are installed on the outside of the hull. Anode cables are inserted into the ship by installing a compression seal and route to the DC power source. The negative power cable is simply attached to the body to complete the chain. The ICCP anode ship is washed away, minimizing the impact of resistance on the ship, and is located at least 5 feet below the light load line in the area to avoid mechanical damage. The current density required for protection is a function of speed and is taken into account when choosing the current capacity and location of the anode placement on the case. Some vessels may require special treatment, such as aluminium hulls with steel lamps creating an electrochemical cell where the aluminum casing can act as a galvanic anode and increasing corrosion. In such cases, aluminum or zinc galvanic anodes can be used to compensate for the potential difference between the aluminum body and the steel rebar. If steel fixtures are large, you may need a few galvanic anodes or even a small ICCP system. Marine cathode protection covers many areas, piers, harbors, marine structures. A variety of different types of structures leads to different systems for protection. Galvanic anodes are favorable, but ICCP can also often be used. Because of the wide variety of geometry of structure, composition and architecture, specialized firms are often required for structurally specific cathode protection systems. Sometimes marine structures require retroactive modification to be effectively protected by steel in concrete Application to concrete reinforcement is slightly different in that anodes and reference electrodes are usually concrete during construction when the concrete is poured. Conventional equipment for concrete buildings, buildings, and similar structures should use ICCP, but there are systems that use the principle of galvanic cathode protection as well, , , , 28 29 30 , although in the UK at least the use of galvanic anodes for atmospherically discovered reinforced concrete structures is considered experimental. For ICCP, this principle is the same as for any other ICCP system. However, in a typical atmospherically exposed concrete structure, such as a bridge, there will be many more anodes distributed in structure, as opposed to the array of anodes used on the pipeline. This makes for a more complex system and is usually an automatically controlled DC power source used, perhaps with the ability to remotely monitor and operate. For buried or flooded structures, the treatment is similar to the treatment of any other buried or submerged structure. Galvanic systems offer the advantage that they are easier to upgrade and do not need any management systems, as ICCP does. For pipelines built from a pre-emphasized concrete pipe cylinder (PCCP), techniques used for cathode protection are usually both for steel piping, except that the application capacity must be limited to prevent damage to the pre-stress wire. The steel wire in the PCCP pipeline is emphasized to the point that any wire corrosion can cause a failure. An additional problem is that any excessive hydrogen ions resulting from excessively negative potential can lead to hydrogen release into the wire, which also leads to failure. Failure of too many wires will result in a catastrophic failure of the PCCP. Therefore, the implementation of ICCP requires very careful monitoring to ensure satisfactory protection. An easier option is to use galvanic anodes, which are self-limiting and do not need control. Inland cathode protective vessels, piping and tanks that are used to store or transport liquids can also be protected from corrosion on their internal surfaces with cathode protection. You can use ICCP and galvanic systems. The general use of internal cathode protection is water storage tanks and the shell of power plants and tubular heat storage. Galvanized steel Galvanizing generally refers to hot-dipping galvanizing which is the way of coating steel with a layer of metallic zinc or tin. The galvanized coatings are quite durable in most environments because they combine the barrier properties of the coating with some of the benefits of cathode protection. If the zinc coating is scratched or damaged on the spot and the steel is exposed, the surrounding areas of the zinc coating form an open steel galvanic cell and protect it from corrosion. This is localized cathode protection - zinc acts as a sacrificial anode. Galvanization, when using the electrochemical principle of cathod protection, is not really cathode protection. Cathod protection requires that anode anode separate from the metal surface that needs to be protected, with an ion connection through the electrolyte and electronic connection via a connecting cable, bolt or similar. This means that any area of the protected structure in the electrolyte can be protected, while in the case of galvanized, only areas very close to zinc are protected. Thus, a large area of bare steel will be protected only at the edges. Cars Multiple companies market electronic devices, claiming to mitigate corrosion for cars and trucks. Corrosion experts believe they don't work. There are no peer-reviewed scientific tests and checks confirming the use of the devices. In 1996, the FTC ordered David McCready, the man who sold the devices, claiming to protect cars from corrosion, to pay restitution and banned the names Rust Buster and Ruster Evad. The electrode's test potential is measured by a reference electrode. Copper-copper sulfate electrodes are used for structures that contact the soil or fresh water. Silver/silver chloride/sea water electrodes or pure zinc electrodes are used for use in seawater. The methods are described in EN 13509:2003 and NACE TM0497 along with the sources of errors in voltage that appears on the meter display. Interpreting potential electrode measurements to determine the potential at the junction of the corrosive cell and electrolyte anode requires training and cannot match the accuracy of measurements made in laboratory work. The problem of hydrogen production The side effect of improperly applied cathode protection is the production of atomic hydrogen, which leads to its absorption in protected metal and the subsequent absorption of hydrogen welds and materials with high hardness. Under normal conditions, atomic hydrogen will combine on a metal surface to create a hydrogen gas that cannot penetrate the metal. Hydrogen atoms, however, are small enough to pass through a crystalline steel structure, and result in some cases to hydrogen embrittlement. Cathode disbonding Is the process of sucking the protective coatings out of the protected structure (cathode) due to the formation of hydrogen ions above the surface of the protected material (cathode). Disbondation can be exacerbated by an increase in alkaline ions and an increase in cathode polarization. The degree of diszoning also depends on the type of coating, with some coatings being affected more than others. Cathode protection systems should be operated so that the structure does not become overly polarized, as it also contributes to dysbond due to excessively negative potentials. Cathode disbonding occurs quickly in pipelines that contain hot liquids because the process is accelerated by the flow of heat. (quote is necessary) Cathode protective efficiency Protection systems (CP) on steel pipelines may be damaged due to the use of solid-film dielectric coatings such as plastic tape, shrinking pipeline sleeves, and factory applications of single- or several solid film coatings. This phenomenon is due to the high electrical resistance of these support films. The protective electric current from the cathode protection system is blocked or protected from reaching the main metal with a highly resistant film. Cathode screening was first identified in the 1980s as a problem, and technical documents on the subject have been regularly published since then. The 1999 report on the Saskatchewan crude oil spill of 20,600 barrels (3,280 m3) provides an excellent definition of the problem of cathode shielding: The triple situation with non-corrosive coating, dielectric coating and a unique electrochemical environment created under external coating, which acts as a CP C. electric current shielding shielding. The combination of tent and disbondment allows the corrosive environment around the outside of the pipe to enter the void between the outer coating and the surface of the pipe. With the development of this CP protection phenomenon, the impressed current from the CP system cannot access the exposed metal under the external coating to protect the surface of the pipe from the effects of an aggressive corrosive environment. The CP protection phenomenon causes changes in the potential gradient of the CP external coating system, which are even more pronounced in areas of insufficient or non-standard CP current emanating from the CP pipeline system. This produces an area on the pipeline insufficient CP protection against metal loss exacerbated by the external corrosion environment. Cathode shielding is mentioned in a number of standards listed below. The recently issued USDOT Title 49 CFR 192.112, in the Section Additional Requirements for the Construction of a Steel Pipe using an alternative maximum operating pressure requirement that the pipe be protected from external corrosion by an undisguised coating (see the coating section by standard). In addition, the NACE SP0169:2007 standard defines protection in section 2, cautions against the use of materials that create electrical shielding in section 4.2.3, warns against the use of external coatings that create an electric shield in section 5.1.2.3, and instructs readers to take appropriate action when the effects of electric ice shielding are detected on the operating pipeline in section 10.9. 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EN 13509:2003 - Cathode Methods of Measuring Protection EN 13636:2004 - Cathod Protection of Buried Metal Tanks and Related Pipelines EN 14505:1 2005 - Cathode protection of complex structures EN 15112:2006 - External cathode protection of the hull of the well EN 15280-2013 - Score a.c. probability of corrosion of the burrowed pipelines EN 50162:2004 - Protection from corrosion by stray current from direct current systems BS 7361-1:1991 - CATE PROTECTION SP0169:2013 - External corrosion control on underground or submerged metal piping systems NACE TM 0497 - Measurement methods Related to the criteria for cathodic protection on underground or submerged metal piping systems See also Wikimedia Commons has media related to cathodic protection. 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