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ELECTRICAL INSPECTION OF PROTECTIVE COATINGS APPLIED TO CONCRETE SURFACES

Protective coatings applied to concrete structures have been in existence for decades. The concrete structure's useful life can be increased many times over, provided the selection of coating material meets the environmental requirements and is applied properly. This paper reviews the use of electrical holiday detectors as an aid in the assurance of proper coating application. Three types of commercially manufactured electrical holiday detectors are readily available to the industry. The low voltage (wet sponge) type of holiday detector which is applicable for use on high dielectric protective coating with maximum dry film thickness of 20 mils (.51 mm) and both pulsating & continuous DC high voltage (spark type) holiday detectors that can be used successfully on high dielectric strength protective coating with dry film thickness' ranging from a few mils to fractions of an inch.

Hydroscopic particles of moisture present in most concrete structures allow a sufficient electrically conductive path for the applied energy from the holiday detector circuit to flow in the concrete structure and through voids in the protective coating to the exploratory electrode as it passes over the coated surface.

An electrical holiday detector is a device which locates areas or points on a coated conductive concrete substrate where there is a great difference in electrical resistance between the exploratory electrode on the coated surface and the underlying structure. The fact that most protective coatings used on concrete structures are highly resistant to a flow of electrical current makes this method of testing quite practical.

A practical holiday detector consists of an electrical energy source such as a battery or high voltage coil, an exploring electrode and a connection from the energy source to the coated concrete substrate. The device should be equipped with an audible alarm to signal current flow through the apparatus.

In general there are two types of so-called "spark" type holiday detectors which apply test voltage to the surface of protective coatings. The most commonly used one in the industry is the "pulsating DC" type with output voltages ranging from 1,000 volts to 40,000 volts. The other holiday detector high voltage output is "continuous DC" with volt ranges from 1,000 volts to 15,000 volts.

In brief, the pulsating type holiday detector is used for the electrical inspection of most protective coatings ranging from a few mils to fractions of an inch in thickness and in virtually all climatic conditions. The continuous DC types holiday detectors primarily used on coating thickness' ranging from approximately 10 mils (.25 mm) to 50 mils (1.27 mm) where the ground and substrate electrical resistance to current flow is extremely high and contaminated moisture on the coating surface is virtually non-existent.

A third type holiday detector commonly used for electrical inspection of protective coating is the "wet sponge" low voltage detector. The applied voltage to the protective coating is less than 100 volts DC, utilizing an exploratory electrode consisting of a cellulose sponge dampened with an electrically conductive liquid such as tap water. When small amounts of current flows through the device an audible signal is activated.

PULSATING DC HOLIDAY DETECTOR

The pulsating type holiday detector allows for high voltage testing with less electrical stress to protective coating than continuous DC detectors. The electrical pulses are generated between 20 cps. and 60 cps. Each electrical pulse is "on" for a time period between 20 microseconds and 200 microseconds.

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CONTINUOUS DC HOLIDAY DETECTOR

The continuous DC holiday detector allows for high voltage testing where the combination of high electrical resistance is present in both the substrate and the ground return of the electrical circuit. This type detector is used particularly where it is impractical to make direct electrical contact with embedded reinforcing steel in the concrete structure and the coating surface is clean and dry. This type holiday detector should not be used where continuous contaminated moisture is present on the surface of the coating because of current tracking. When current tracks through the contaminated moisture, the actual point of coating discontinuity is usually difficult to locate. Testing with continuous DC inspection voltages applies greater electrical stress to the protective coating because the voltage is applied continuously.

TESTING VOLTAGES

Spark type detector

Proper electrical inspection voltages have long been a matter of great discussion among coating manufacturers, applicators and consumers. In brief, it is the consensus of the industry that the high voltage spark should be able to bridge an air gap between the exploring electrode and the underlying concrete structure at least twice as great as the cured coating thickness. Voltage adjusted at the job site takes into consideration every aspect of the output circuit in relation to: (1) Ground resistance (2) Structure resistance (3) Coating thickness (4) Capacitance losses (5) Barometric pressure and (6) Electrode configuration.

An alternative to setting test voltages in the field is to use the formula developed by the National Association of Corrosion Engineers International (NACE) and incorporated into several Standards. The formula for thin film coatings applied to 30 mils (.76 mm) thickness is $V=525\sqrt{T}$ where "T" is the coating thickness in mils. Example: a coating 25 mils (.64 mm) thick would work out to an inspection voltage of 2600 volts. For thicker applied coating the Constant changes to 1250. Example: a coating 125 mils (3.175 mm) thick would work out to an inspection voltage of 14,000 volts.

Manufacturers of the protective coating should always be consulted by the consumer with regards to dielectric strength of properly cured coatings and recommendations of maximum test voltages to be used on every formulated coating. Do not exceed the coating manufacturers recommendations of test voltages.

ELECTRICAL GROUNDING

Proper grounding of the holiday detector to the coated concrete substrate is essential in order to complete the electrical circuit of the holiday detector.

1. For optimum electrical grounding of all types of holiday detection equipment, directly connect to the reinforcing steel embedded in the concrete structure. In some cases it may be necessary to expose the steel structure and directly connect the ground wire in order to obtain proper grounding of the holiday detector.
2. An alternative grounding method to a concrete structure is to place a 2' X 2' piece of ordinary metallic window screen wire flat upon the concrete surface. Place wet sand bags over the entire metallic surface and connect the ground wire to the screen wire. The wet sand bags placed upon the screen wire assures intimate contact of the screen wire against the concrete surface. This grounding method is usually sufficient for either the low voltage "wet sponge" or high voltage "spark type" holiday detectors. Check the electrical circuit of the detector by touching the exploratory electrode to the bare concrete substrate and observe the audible signal. No audible signal means inadequate grounding and a better ground must by obtained or the signal sensitivity increased.
3. Another grounding method, when electrical testing with high voltage "spark type" detectors on concrete structures that are completely coated (no exposed concrete), utilizes the same method as described in paragraph #2 above. When metallic screen wire is placed on top of the protected coating

and connected to the holiday detector ground system, a capacity effect allows current to flow in the detector circuit when a discontinuity (holiday) is encountered. Always check the circuit by making a pinhole in the coating and locating it with the holiday detector.

LOW VOLTAGE "WET SPONGE" DETECTOR

A low voltage "wet sponge" holiday detector, (below 100 volts DC) equipped with an audible signal device, can be used to electrically inspect thin film protective coating by using an exploratory electrode, consisting of a cellulose sponge dampened with a conductive liquid such as water, to push the liquid film over the coated surface. When a discontinuity (holiday) is encountered, DC energy will flow through the liquid to the substrate thus completing the circuit, causing an audible signal to be energized.

Recommended points to be included in a specification for electrical inspection of thin film coating with a low voltage "wet sponge" detector are:

1. The voltage, between the electrode (sponge) and the cement substrate upon which the protective coating lies, should not exceed 100 volts DC measured between the electrode sponge and the coated substrate when the detector is in normal operating position.
2. The ground wire of the detector must be connected to the reinforcing steel embedded in the concrete substrate. (see paragraph #2 "ELECTRICAL GROUNDING" section)
3. The protective coating surface must be dry prior to conducting the electrical inspection. If the coating surface is exposed to an environment where electrolytes might form, such as salt particles, the coating surface should be cleaned with fresh water and allowed to dry completely.

It is the consensus of the industry that ordinary potable tap water will suffice to wet the exploratory electrode of the low voltage holiday detector when inspecting protective coating thickness' of 10 mils (.25 mm) or less. When testing of protective coatings 10 mils (.25 mm) to 20 mils (.51 mm), the use of a non-sudsing wetting agent must be added to the potable water. A wetting agent such as Eastman Kodak Photo Flo is an excellent product for this purpose and is readily available in leading camera stores world wide. Recommended amounts are 1 ounce (.0296 liters) to 1 U.S gallon (3.7854 liters).

Wetting agents help break down surface tensions of the liquid and allow faster and better penetration of the water into discontinuities, resulting in superior testing. The use of a wetting agent at all times would not adversely effect electrical inspection. In fact, since protective coatings are often applied where portions of the coating thickness is greater than 10 mils (.25 mm), when that thickness is specified, the wetting agent would better assure water penetration into all discontinuities.

It is not recommended that low voltage (wet sponge) detectors be used for the electrical testing of protective coating having a dry film thickness in excess of 20 mils (.51 mm). It is also completely ineffective for inspection of prefabricated films such as PVC or PE protective linings.

An electrical holiday detector should be used, as soon as time and conditions permit, after coating has been applied and properly cured and, if possible, again prior to final project completion. The holiday detector should never be used to evaluate the quality or the usefulness of the protective coating. When electrical inspection is conducted at the time of coating application, voids in the coating can be readily located and repaired, plus, it allows the applicator the opportunity to develop better coating application techniques. Electrical inspection prior to project completion for any repairs to the protective coating due to damage that occurred during construction.

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