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## **902 TEST INSTRUMENT KIT**

### **Corrosion Testing**

The Electro-Guard model 902 is a portable test instrument kit designed to allow the user to check the solution potentials (voltages) of metal structures immersed in natural waters -- such as seawater, brackish water and most bodies of fresh water. The importance of checking solution potentials of metals exposed to water immersion is to determine the degree of exposure to and, therefore, the probability of attack by electrochemical corrosion. Such corrosive attack (often referred to as electrolysis in the boating industry) can lead to costly and sometimes dangerous deterioration of affected structures.

The model 902 portable corrosion test instrument allows the user to check immersed metal structures in the field. Typical structures to be checked are boats, ships, metal pilings and the underwater structures of piers and seawalls. The instrument, a Fluke model 70 digital multi-meter, is supplied in a protective carrying case (that floats) and includes a USN military specification A18001J zinc reference cell. The reference cell has twenty feet of test lead wire attached. A twenty-five foot long test lead extension and a hardened, plated steel, pointed test probe are also included in the kit.

Before attempting to take solution potential readings with this instrument, you should read the instruction booklet for the Fluke Model 70 multi-meter which is included in the test instrument kit. The Fluke instructions will provide a basic understanding of the principles of electrical measurements using a digital electrical test instrument and will familiarize you with the instrument's settings.

### **Taking solution potential readings**

1. Remove the cover from the instrument carrying case. The cover may be set aside or used to make a tilt stand for the instrument case. Plug the reference probe -- with or without the test lead extension -- into the black common banana jack of the Fluke 70 instrument. Plug the pointed test probe into the red positive (+) banana jack.
2. Lower the reference cell into the water so that the electrode is at least 12" below the water's surface. If there is significant wave action on the water's surface, lower the reference cell deeper to assure that it remains completely immersed. Often it is useful to loosely tie the test lead to some above water point on the structure to secure it. It is good practice to clean the reference electrode frequently. A thin oxide film can build up on the electrode's surface over time because of its exposure to air while being stored. If the film completely covers the electrode's surface, the electrode will give inaccurate readings. A light scrapping with a sharp edge or a light sanding should suffice to remove the film and expose the metallic zinc electrode surface.

3. Set the mode selector to DC volts. The instrument's DC voltage function is auto ranging and will usually indicate in the millivolt range (all numbers to the right of the decimal). Since a zinc reference cell is being used, most readings will be positive. If the negative symbol is displayed in the instrument window, the potential being indicated is negative to the reference cell. !CAUTION! It is important to observe and note whether a reading is positive or negative. Not observing and recording the polarity of a potential reading will likely lead to the wrong conclusion regarding the corrosion potential of the metal being surveyed.
4. Probe each item to be checked firmly with the pointed test probe and read the resulting potential on the instrument's display window. The surface of the metal being probed is often covered by paint, dirt, oil, corrosion products (rust, etc.) or a combination of these items. One should be careful when taking readings that the pointed probe has made an effective electronic contact to the metal being probed. The effectiveness of contact to the item being checked can usually be determined by probing the metal several times in slightly different locations. If good contact is being made, the readings will be consistent. Ideally, direct electronic contact by the instrument's probe should be made to the actual immersed metal item or structure being investigated. However, to do so is often difficult or impractical. It may be acceptable to probe an item or structure that is attached to the one which is being investigated, but this should be done with caution. When two or more metal objects are not metallurgically bonded, the electronic contact between them is always suspect. Effective metallurgical bonding is accomplished by properly executed welding, soldering, brazing, cladding and so forth. If these operations are done properly, there will be true electronic contact between the attached metal parts. However, methods of attachment that bring metal parts into close contact but do not result in a metallurgical bond can result in significant levels of electrical resistance between the parts. Examples of this type of attachment are bolting, clamping and riveting. If there is any significant electrical resistance between the metal part being probed and the actual immersed item or structure, erroneous readings will result.
5. Record each reading as it is taken. If the structure being investigated is large or complex requiring many solution potential readings to determine the structure's exposure to corrosion attack, a log and/or diagram of the readings should be made. From such a log or diagram one can often see a pattern of corrosion potentials emerge which can be useful for determining whether problems actually exist and what corrective action to take.
6. When finished with the instrument, the reference cell should be thoroughly washed with fresh water (if readings were taken in salt or brackish water), dried and returned along with any other test leads and probes used to the protective carrying case. Be sure to turn the Fluke mode switch to the "OFF" position.

## **Interpreting your readings**

If accurate, recorded solution potential readings are the cornerstone of an underwater metal structure corrosion survey (as they are), then interpretation of the readings is the rest of the building. A familiarity with basic electrochemical corrosion theory is necessary to obtain useful knowledge from the solution potential readings and their patterns that you have recorded. The information that follows may help in understanding these readings and patterns. You should consider utilizing the services of a qualified corrosion technician or engineer if you are uncertain

of the meaning or significance of the readings you have taken. If you have done a thorough, accurate job of taking and recording solution potential readings, a qualified corrosion specialist should be able to assist in determining the exposure to corrosion attack for the structure you have surveyed and make appropriate recommendations for any corrective actions necessary.

- Refer to the "Galvanic Series in Seawater" table which is included with these instructions. If you are taking a reading on an electrically isolated fitting and you know its metal alloy, compare your reading with the one indicated in the table for that alloy. If the potential indicated for the fitting is at or very near the potential indicated in the table for that alloy, the fitting is at its natural (freely corroding) potential. At that potential the metal may or may not be suffering corrosion damage depending upon the particular corrosion characteristics of its alloy in seawater. If the metal is 200 mV (millivolts) or more negative to the metal's natural potential, the metal is cathodically protected and should not be suffering active corrosion attack.\* If the metal is more than a few millivolts positive to the most positive potential for that metal in the table, the fitting is being influenced by some source of polarizing current. It might be electrically connected to another metal structure that has a more positive seawater potential by either a direct metal to metal contact, by an intermediary metallic structure or by wire. There is also the possibility that the fitting is being influenced by a stray electrical current the source of which would be an electrical fault in a DC electrical system. In any case, the metal is being polarized in a positive direction to its natural potential and is most likely suffering corrosion damage.

\* Though any potential that is more than 200 mV negative to a metal's natural potential is cathodically protected, it should not be taken that such a potential regardless of its magnitude is always an acceptable level of protection. There are several possible side effects of maintaining a potential that is too far negative of a metal's natural potential. Some of these possible side effects are: caustic corrosion (sometimes called cathodic corrosion) of aluminum, cathodic disbonding of coatings (paint), excessive build up of calcareous deposits on protected fittings, caustic attack to wood in contact with a protected fitting and brittle failure of high strength steel alloys from hydrogen embrittlement. The "Table of Metals Grouped by Compatibility" included with these instructions should be helpful in determining whether the particular metal structure you are surveying is at hazard from over protection. As long as the potential of a metal is within the range of potentials as indicated in the table for that metal, it should be protected without undesirable side effects.

- If you are taking a reading of a metal fitting or metal structure that is electrically connected to one or more other such fittings or structures, the potential you record will be a composite potential that is the result of the effect of the combined potentials of all of the connected metals. By referring to the Galvanic Series in Seawater table and by knowing the metal alloy of which each fitting or structure is composed, you can determine whether any particular metal is at risk for corrosion damage. For instance, if the composite reading is 200 mV or more negative to the metal that has the most negative natural potential of the connected metals, then all the connected metals are cathodically protected. If the composite potential is positive to the natural potential of the alloy of any connected metal fitting or structure, that fitting or structure is most likely suffering

corrosion damage. If the composite reading is positive to the metal alloy that has the most positive natural potential of the connected metal fittings or structures, polarization by a stray electrical current from a DC electrical system fault is indicated. All connected metals will most likely be suffering corrosion damage, very possibly severe corrosion damage.

The above examples are only a few of the many conclusions and interpretations that can be made by utilizing corrosion potential readings. They are meant only to be a rough guideline for the use of the instrument. They should help in resolving the less complicated corrosion questions. You should be able to determine whether the underwater metals in a particular boat are at hazard for corrosion attack and whether or not there is adequate cathodic protection being applied. If you anticipate that you will be doing a lot of corrosion testing or trying to do corrosion surveys of more complicated vessels or underwater structures and are not familiar with at least basic electrochemical corrosion and corrosion control theory, you should consider taking a course in corrosion and cathodic protection. Such courses are offered by some colleges and universities and, also, NACE (National Association of Corrosion Engineers). Also, the American Boat and Yacht Council conducts corrosion seminar courses several times a year at various locations in the U.S. Contact the ABYC in Ft. Washington, Maryland for a description of the seminar courses and their schedules.

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