Testing of Titanium Electrode Products Companies (TELPRO) Embeddable Anode Material for Use in the Cathodic Protection of Atmospherically Exposed Steel Reinforced Concrete

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May 2000

Summary

Towards the end of 1999, TELPRO requested that a sample of their coated titanium proposed for embedding as an anode in the Cathodic Protection of atmospherically exposed steel reinforced concrete be evaluated in accordance with NACE Standard TM0294-94. The six months test in three specified electrolyte compositions ended May 2000 with no evidence for cell voltage rise in any solution over the full polarization period.

Accordingly the quality of TELPRO anode material is practical for the intended use and technically fully comparative to other materials in the marketplace.

Testing of TELPRO Embeddable Anode Material for use in the Cathodic Protection of Atmospherically Exposed Steel Reinforced Concrete

Introduction

TELPRO was formed in 1998 to market in Cathodic Protection and other applications, a mixed metal oxide coated titanium electrode. A range of accelerated corrosion tests were mounted on material of varying initial loading, culminating in the selection of one particular loading for its suitability in the Cathodic Protection of steel reinforced concrete. In the later part of 1999, a sample coated with the prescribed loading was given to Hayfield Technologies for evaluation in accordance with NACE Standard TM0294-94.

1. **Experimental**
   1.1. Material ó The NACE specification, paragraph 3.1.2 calls for a 20cm^2 surface area sample. Accordingly, samples of surface area 20cm^2 were cut, and a titanium wire stem attached by spot welding. Samples for evaluation, six in all, were cut and also the anodes for the reverse testing made likewise.
   1.2. In accordance with the NACE Standard, the samples were mounted in 1L beakers. The various electrodes were positioned by passing lead wires through a large rubber bung and to prevent any seepage of electrolyte to the outer terminal connections; both top and bottom of the rubber bungs were sealed with silicone rubber. A further hole was made adjacent to the anode to allow positioning of a Luggin probe. Solutions could breathe through both the Luggin probe and the tip of the beaker.
   1.3. Solutions ó The three solutions were made up in accordance with the NACE Standard in large beakers and in excess of the amount required in the 1L beakers.
   1.4. These were:
       1.4.1. 30 gpl Sodium Chloride in deionized water
       1.4.2. 40 gpl Sodium Hydroxide in deionized water
       1.4.3. Simulated pore water in sand, again using Analar quality chemicals

1.5. The sand used was purified white silica sand. The simulated pore solution was:

0.20% $Ca(OH)_2$
3.20% KCl
1% KOH
2.45% NaOH
93.15% deionized water

1.6. Temperature Control - As the test was carried out in a well ventilated but unheated building over a UK winter period, it was necessary to make arrangements for solution temperature to be maintained within the prescribed 20 ± 5 °. For this purpose the six beakers were placed in a plastic tray seated on a metal plate resting on top of a mantle heater. Space between the beakers was insulated with plastic foam, and slate tiles were placed around the four sides of the plastic tray. Even during periods of frost, the temperature of solution kept within the range 15° to 20° C.

1.7. There was little evidence of reaction during the test save small eruptions to the top of the sand presumably resulting from gas release. There was little consumption of electrolyte, the cells only requiring a small topping up with deionized water during the entire test period.

2. Electrical Supply ó A constant current power source was used, located indoors about 40m from the test cells, connected by 5A PVC insulated copper cabling. The maximum voltage from the supply unit was 30 volts. Just in case, as predicted in the example given in the NACE specifications, there should be significant rise in anode potential with time, a second pair of electrical leads was put in place if it became necessary to split the power between the six cells. This eventuality did not occur.

3. Results ó The test was started on November 22, 1999. Prior to the reverse current stage, the anodes were switched on in the normal anode mode while initial cell voltage was taken.

Voltages were as follows:

Cell	Solution	Voltage	
Cell 1 ó NaCl		2.6V	
Cell 2 ó NaCl		2.6V	These voltages were measured
Cell 3 óNaOH		1.9V	directly across the cells
Cell 4 ó NaOH		2.1V	
Cell 5 ó Pore solution		2.1V	
Cell 6 ó Pore solution		2.1V	
Total Cell Voltage:		13.4	

Initial total cell voltages measured remote from the test cells were:

Week 1
Date	Voltage
November 23, 1999	13.4V
November 24, 1999	13.36V
November 25, 1999	13.36V
November 26, 1999	13.36V
November 27, 1999	13.45V
November 28, 1999	13.40V
November 29, 1999	13.40V

Reverse Current ó As described in NACE Standard paragraph 4.5, the current on the test anode was reversed for 8 hours. This was a simple procedure, changing the position of the terminal connectors on top of the Titanium lead wires. Following completion of the short reverse current testing part, the test electrodes were made positive and current maintained at the preset 17.8mA throughout the following days. There was never any deviation in the preset current, as observed daily, but there was small variation of overall cell voltage of a few tenths of a volt, which appeared related to ambient temperature which varied from ó5° C to +25°C.

Final total cell voltages measured remote from the test cells were:

Week 25
Date	Voltage
May 9, 2000	13.2V
May 10, 2000	13.1V
May 11, 2000	13.2V
May 12, 2000	13.3V
May 13, 2000	13.2V
May 14, 2000	13.1V
May 15, 2000	13.1V

No significant change in total cell voltage occurred.

Discussion

The NACE Standard TM02294-94 is most detailed in all aspects. There is a requirement for accelerated current density testing in brine, in Sodium Hydroxide and in sand with simulated pore water. In essence the objective is to observe whether the proposed anode material is capable of passing a given charge density without failure or obvious degradation. The inference from the example cited in the standard is that anode electrode potential will rise slightly in Chloride solution and more so in sodium hydroxide solution. In the case of some coating compositions and initial loading this may well be the case. But TELPRO has chosen a mixed metal oxide with particular durability during Oxygen evolution as well as Chlorine. It is evident from the results obtained, that the particular coating composition chosen, and initial loading, shows no tendency over the ½ year of accelerated testing to any significant rise in operating cell voltage. On this basis, and provided material offered to the market is comparable to that evaluated at Hayfield Technologies, then it ought to be entirely practical for the embedded CP application.