RF LEVEL MEASUREMENT IN LINED VESSELS WITH GROUNDED SHELL

INTRODUCTION

Storage and process vessels for containing highly corrosive liquids are fabricated of metal, fiberglass or other plastic materials depending on the pressure rating required. The application of RF level measuring instrumentation in these vessels requires some special considerations and techniques for successful results. While there are some similarities between level applications in lined vessels and plastic vessels, the implementation techniques are different.

For corrosion resistance, metal vessels are generally lined with rubber, glass or plastic rather than fabricating the vessel of an expensive, and perhaps exotic metal. Various techniques are employed to line vessels. These include spray or brush-on coatings, heat fusion and sheet or film linings cemented in place with welded plastic seams.

Most, but not all, of the materials stored or processed in these vessels are electrically conductive. Hydrochloric, sulfuric and hydrofluoric acids and caustic in various concentrations are common applications.

NON-CONDUCTIVE MATERIALS

In a lined metal vessel (Figure 1), the capacitive measurement path is from the metal electrode through the electrode insulation (C_I), then through the measured material (C_M) and finally through the liner (C_L) to the electrically grounded metal shell of the vessel.

The total capacitance measured between the metal electrode and the grounded metal vessel depends on the individual capacitances of the electrode insulation (C_I), the measured material (C_M) and the vessel liner (C_L). This formula is:

$$C_T = \frac{C_I \times C_M \times C_L}{C_I C_M + C_I C_L + C_M C_L}$$

This formula becomes more complex if one substitutes the dielectric constants of each material into the formula, but the net result will show that the changing capacitance measured will be directly proportional to the changing level of the material in the vessel.

If the vessel is a horizontal cylinder or irregularly shaped, the measured capacitance with respect to level on the sensor will not be linear because of the variable distance between the electrode and the vessel wall. One way to solve this problem is to place a grounded, concentric tube around the measuring sensor. If corrosion problems or the high cost of the tube makes this choice undesirable, an alternate solution is to use another insulated electrode parallel to the measuring sensor. This reference electrode must be grounded (perhaps to the grounded metal vessel) and kept at a constant distance from the measuring sensor using insulated spacers.

CONDUCTIVE MATERIALS

The total capacitance output of the sensor in a conductive media is still a function of two capacitors in series: sensor insulation (C_I) and vessel liner (C_L). The measured material (C_M) is effectively eliminated from the capacitance equation because the conductive material has virtually no ability to store a charge. The total capacitance of a conductive fluid or solid is approximated by the following equation:

$$C_T = \frac{C_I \times C_L}{C_I + C_L}$$

The capacitance of an electrode varies with the choice of insulation. Table A shows the saturation capacitance for a variety of OMEGA level sensors. Note that saturation capacitance is the highest capacitance generated by an electrode which occurs in an infinitely conductive material. An enhanced performance electrode with PVDF insulation has 950 pF per immersed foot, while a general purpose electrode with TFE insulation has 76 pF per immersed foot.

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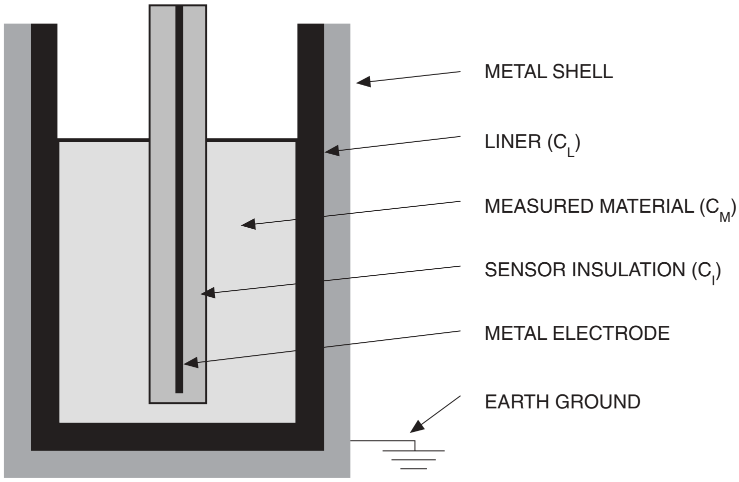

Figure 1 - Capacitive Measurement Path In Lined Metal Vessel

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