11

Instrumentation and Control Systems

11.1. INTRODUCTION

11.1.1. General

Chapters 7 through 9 have already covered the processes involved in a chlor-alkali plant, along with some of the essentials of their control. This chapter goes into the details of control systems and hardware. The discussion, where differences exist, focuses primarily on the membrane-cell process. The chlorine and hydrogen processes are essentially the same regardless of the type of cell used. Control of absolute and differential pressures is especially important in the gas systems, and so the discussion is divided primarily according to operating pressure level. Membrane cells require extremely pure brine, and some of the operations used are not necessary with the other types of cell. Otherwise, mercury-cell brine systems are for the most part very similar to those in membrane-cell plants, but they require their own special features and precautions to prevent the escape of mercury into the environment. Diaphragm cells require approximately the same treatment of new brine, but, unlike the situation with the other cells, there is no direct recycle of the anolyte. Therefore, the discussion of brine systems follows the membrane-cell process, which is the most comprehensive of the three. The caustic systems for the three manufacturing processes are very different and are discussed separately.

The individual unit operations and equipment chosen for a particular manufacturing process can vary from one plant design to another. This is especially true in the design of the brine systems, where the quality and sources of the brine vary greatly among plants. Methods for using the products or transporting them to customers also have a major influence on the design. Other factors with significant effects on control system design are the general operating philosophy of the plant’s ownership and the particular design preferences of responsible engineers. It would be impossible to discuss all practical variations in process design and the resulting control systems. Thus, this chapter is restricted to a basic system design for each of the processing areas. Control engineers should be able to incorporate the changes necessary to suit individual projects.
The unit operations found in each area are discussed, covering control system design, instrument selection, and materials of construction. It is obvious that control systems engineers will have different opinions as to what controls, instruments, and materials are the best to be used for any application. The selections here emphasize simplicity of design and the use of quality equipment and materials of construction. This philosophy does not result in the lowest initial cost, but it has produced plants that are easy to start up and operate, with high onstream factors and long lives.

After a short general discussion, we cover here the major parts of the process in the sequence brine, chlorine, hydrogen, caustic liquor handling, and caustic evaporation. Small units are broken out in a series of drawings, and each drawing illustrates a particular function. Drawings illustrating given units may not show all the instrumentation that accompanies their units. They do show typical instrument hardware for the function in question. The drawings do not follow strict engineering flow diagram practice, but instrument representation and designation are conventional. Table 11.1 summarizes the grammar of designation of instrument functions.

Normal practice is to use a series of 2–4 letters to characterize each item. The first letter indicates the function under measurement or control. It is the function that matters, not the type of instrument. For example, differential pressure instruments are often used (with proper calibration) to measure the height of a level in a tank or the rate of flow of a material in a line. The designations used in these cases are L (level) and F (flow). The “succeeding letters” represent, in sequence:

1. simple readouts or passive functions;
2. output functions that actively influence the process.

An example of a simple readout is a pressure gauge. Using the first and third columns of Table 11.1, this is a pressure indicator, PI. An example of a device with a passive function is a restricting orifice placed in a line to limit the flow of a fluid without controlling it precisely. This would be designated FO. The active elements in the fourth column include such things as transmitters. If the variable is temperature, we have a TT. An example of a combination device is one that indicates the level in a tank and also manipulates other hardware to control that level—an LIC. The sequence of the letters follows the table. A control valve responding to a generated signal is designated by the single letter V. Self-actuated control valves bear the letters CV. Most control valves in the process industries will be equipped with positioners that receive control signals and then pneumatically apply the force necessary to drive the valve to the proper position. They improve response and control action. The standard followed here allows valve positioners to be included on the drawing or their presence to be assumed, with a signal shown as going directly to the valve. Here, we choose the latter, simpler option.

Finally, Table 11.1 allows the use of letters to modify those covered above. When a differential-pressure cell is used as such to measure and record the difference in pressure between two points, we modify the first letter and have a PDR. If the flow of one stream is to be held in constant ratio to that of a second while the value of the ratio is displayed, we have an FFIC.

Modifiers are also attached as required to succeeding letters. Alarms, for example, usually indicate that the value of a process variable is either too high or too low. The letters H and L modify “alarm” accordingly. Thus, a low-level alarm is an LAL. A switch that causes some action to be taken when a level is too high is an LSH. As in the case