Industry, in general, has entered into a new age. This can be readily seen in the scientific and technological advancements that have brought about a number of very important changes in the basic structure of industry. For example, today, most products are manufactured using some type of automatically controlled processing equipment. This equipment is often complex, demanding a variety of skilled personnel to keep it in operation. Industrial technicians are constantly called upon to analyze problems, evaluate operations, and repair faulty systems and equipment. A wide range of experience is needed in different areas in order to cope with the ever-changing situations seen in the typical industrial business environment.

At one time, most industrial equipment could be easily placed into operation with just a few simple tools and some basic common sense. Today the situation differs in that a large part of our equipment and processes contain numerous control devices vital to the performance of precise automatic operations. This necessitates the need for technical personnel who are cognizant of current evaluation procedures, instrumentation calibration techniques and troubleshooting methods in order to keep things in a good state of repair and reliability. Obviously equipment breakdown will cause a production line to cease operation if the equipment is inoperative for any period of time. For this reason, preventative maintenance and operational efficiency of plant instrumentation have become more important with the increased dependency quality and maximum production.

Equipment reliability and evaluation relies heavily upon measurement techniques and instrument analysis. This is important because plant personnel are constantly called upon to evaluate equipment performance by measuring specific normal and abnormal operational conditions. Without question, the area of instrumentation is a vital component to the business of industry today.

The science of industrial instrumentation is a rather broad area of study that deals with the measurement, evaluation and control of process variables such as temperature, pressure, flow rate, fluid level, force, light intensity, humidity, etc. These variables are usually involved in a manufacturing operation of some type that eventually leads to a finished industrial product. Automation production operations are largely responsible for a major part of all instrumentation applications.

The primary areas of concern in instrumentation are pneumatics, electronics, mechanics and hydraulics. Each of these areas is individually unique, but they are all very similar in many respects. The systems concept is commonly used to show this relationship.

The Systems Concept

The systems concept is not particularly new to the study of industrial equipment or machinery. As illustrated below, this approach simply represents a diagrammed method of showing the intricate parts of a complex piece of equipment in some logical order. Through this approach, a “big picture” of the basic system is first presented. This idea is then used to show an interrelationship between various system parts.
Basic Block Diagram Illustrating the Primary Parts of a System

The role played by each block represents the second step of the systems concept. This role, or, more specifically, the function of each block, is much more meaningful when viewed in its composite form. The composite diagram of the system is then used as a general reference for the next step, which is component analysis of each block.

Component analysis represents the most sophisticated portion of study when dealing with plant instrumentation. This is often described as the “nuts and bolts” part of the operation or process. The intricate workings of discrete components are primarily included in this approach to the subject. A basic classification of similar component operations is also imperative at this point. As a general rule, one should now begin to see how the intricate pieces of a complex industrial system begin to fall into place.

**System Parts**

The essential parts of an operating system include an energy source, a transmission path, control, a load device and an optional indicator. Each part of the system has a specific role to play in the overall operation of the system. This role becomes extremely important when a detailed analysis of the system is to take place. Large numbers of discrete components are sometimes needed to achieve a specific block function. Regardless of the complexity of the system, each block must still achieve its function in order for the system to be operational. Being familiar with these functions and being able to locate them within a complete system are very important steps in understanding the operation of the entire system.

The *energy source* of a system has the primary responsibility of changing energy from one form into another form that is more useful. Primary forms of energy include such things as heat, light, sound, chemical, nuclear and mechanical energy. In its primary form, energy is not always useful to an operating system. For this reason, it is changed into something more useful by the energy source.

The *transmission path* of a system is rather simplified when compared with other system parts. Its sole responsibility is the transfer of energy. It simply provides a path for energy flow from the source to the load device. In some systems, this function is achieved by pipes or flexible tubes that connect the energy source to the load. In complex systems, there may be a number of alternate conduction paths between different components.

The *control section* of a system is generally considered to be the most complex part of the entire system. In its simplest form, control is used to turn a system on or off. The term “full control” or “two-state control” is used
to describe this operation. Control of this type may occur anywhere between the energy source and the load
device. In addition to this, a system may necessitate some type of partial control. This type of control usually
causes a gradual change to occur somewhere in an operating system. Changes in time, pressure and flow rate
are typical of this type of control.

The load of a system refers to a specific part, or number of parts, that are designed to achieve work. The term
“work”, in this case, refers to an operation that occurs when energy changes form. Typically, heat, sound, and
mechanical motion take place when work occurs. The load of a system generally consumes a large portion of
the energy produced by the source. The load is generally the most recognizable part of a system because of its
obvious work function.

The indicator of a system is designed to display typical operating conditions at numerous points throughout the
system. In some applications, an indicator is optional, while in others it is an essential part. In the latter case,
specific system operations are usually dependent upon indicator readings. The term “operational indicator”
usually applies to this type of application. Test indicators are also used to measure specific values in
maintenance and troubleshooting operations. Meters, gauges and chart recorders are frequently used to perform
this type of operation. To some extent, an indicator may add to the total load of an operating system.

**Fluid Power Systems**

The term “fluid power” is commonly used in industry to describe those systems that employ liquid or gas as a
means of controlling power. In ordinary usage, the terms “fluid” and “liquid” are commonly used
interchangeably. Scientifically speaking, the term fluid applies to both liquids and gases. In practice, the word
“hydraulic” is commonly used to describe liquid applications of fluid power while the term “pneumatic”
applies to gaseous applications. The operating principles behind these two distinct systems are very similar in
many respects.

**Hydraulic Systems**

In industry, hydraulic systems use liquid as a medium to transfer force between the source and load device. This
type of system is commonly found in equipment used in fabrication operations and material-handling processes.
Hydraulic systems are simple to operate, are normally very reliable and can be easily adapted to many
applications.

**Pneumatic Systems**

Pneumatic systems are commonly used in applications where air serves as a medium through which force is
transferred between the source and the load device. This type of system is commonly used to lift and clamp
products during machine operations, in process control applications and to power hand tools. Pneumatic
systems represent a unique form of fluid power that has an open-ended return line. Systems of this type derive
air from the atmosphere, compress the air to increase pressure, store the compressed air in a receiving tank,
distribute the air to do work and ultimately return it to the atmosphere.

**Electrical/Electronic Systems**

The development of electronic instruments that test, measure and control, industrial processes has gone through
a rather impressive growth pattern in recent years. It is now common practice for industrial technicians to
perform routine measurements using electronic instruments that were considered precision pieces of laboratory
equipment only a few years ago.
Many instrument people who are competent with mechanical/pneumatic instrumentation are lost when dealing with electronic instrumentation. Although the system concept remains the same for electronics, there are two good reasons for the confusion. First, plant personnel tend to shy away from electronics because they feel it is just too complicated. Second, unlike the working of mechanical equipment (which can be seen) electricity cannot be seen. Technicians must rely on elaborate symbolism. This discourages the novice. Much of the symbolism is highly mathematical, which is a further deterrent.

Because of the elaborate symbolism, many have felt that electronics cannot be understood unless the mathematical symbolism is first mastered. Electronics can be mastered in a qualitative way by a direct study of actual industrial instruments without prior study of mathematics or theory.

Summary

Plant technicians tend to be extremely competent when dealing with individual components or machines. Only a few individuals understand the interrelationships of the components or equipment when taken in conjunction with each other. This is called the “sense of system.” In essence, the sense of system knows how the system will react to change, or, the upstream and downstream effects produced at the point of change. For this reason, understanding industrial instrumentation takes on new importance. This allows industry to take full advantage of their resources through the sense of system concept.

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