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A Basic Review for Understanding the Important Role of Safety Instrumented Systems: Delivering through Lecture-based Classes

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ABSTRACT– A basic review is the process of studying a topic once more; thus, it can be used to understand something. In this case, safety instrumented systems are crucial and equipped by the reference to the six foundations, which include definition, knowledge base, terminology, structure, methodology, and epistemology, which was the background for the choice of the title. Therefore, it is necessary to understand the important role of safety-related systems, which are closely related to instrumentation and process control, through a lecture. This involves understanding several theories, in particular Bloom and Marzano's taxonomy. The research objectives are to work out the variety of sensors or detectors, to determine one of the many logic solvers, and to determine the final elements, especially emergency valves. The research methods are an algorithm of a researcher in conducting the research, in terms of performance, according to research objectives, and it was done in the form of a flow chart. The results are several flowchart structures to expose the stages of a brief explanation of the components of safety instrumented systems, including sensors, logic solvers, and final elements. The conclusion associated with research objectives is that the understanding of the important role of safety instrumented systems can be carried out through a lecture-based learning process.

Introduction

The chapter introduction consists of two important sub-chapters related to the title of the article, i.e., background and literature review. The background is an explanation of the reason for choosing the title, while the literature review is related to an explanation of a number of recent references that are used as the starting point for this article.

A. Background

A basic review is the process of going over a subject again in a study [1–3] so it can be used to understand something. In this case, safety-instrumented systems are crucial. There are six foundations of any scientific discipline: definition, knowledge base, terminology, structure, methodology, and epistemology. Knowing the meaning of the term of the system is knowledge and will make it easier to understand the topics contained in one of the systems [4]. Understanding one of many important and fundamental topics is the initial effort for a sustainable understanding of the other topics [5]. The understanding process is a stage in thinking that is categorized under Bloom's cognitive taxonomy [6]. The cognitive, affective, and psychomotor domains are a set of three hierarchical models used for classifying educational learning objectives into levels of complexity and specificity. Overall, the old version of the cognitive domain is based on the nature of the learning task. Based on these descriptions, it can be concluded that knowing the meaning of a term is a form of knowledge and is very basic, so students becoming familiar with industry standards is one of the requirements for the accreditation of a higher education institution [7].

The subject of safety instrumented systems (SIS), which are part of a system, covers a number of topics contained in it [8-16]. Applicative examples of the concept of the important role of the SIS have been implemented in physical form and installed, as well as published in the form of scientific papers or technical reports [8-17]. One of the many aspects of it is the investigation of the instrumentation and process control system on the steam purification system [17]. The SIS is one of the main process control topics with an important role in the major industries, besides programmable logic controllers (PLCs), distributed control systems (DCSs), and national standards and regulatory considerations in each country. The most important things in the world of process automation are instrumentation and control systems, from planning to implementation or from beginning to end [18]. Automation continuously provides opportunities for businesses, i.e., to realize improved operational performance through increased productivity and lower costs, including enhanced safety and reliability [19-22]. Therefore, it is necessary to convey the important role of the SIS, which is closely related to instrumentation and process control, by lecturing so that it is easy to understand [23, 24].

Based on the descriptions for implementing the conception of safety instrumented systems, the systems of instrumentation and process control were examined through the research objectives, namely (i) to describe the variety of sensors, (ii) to explain the logic solver, and (iii) to explain the variety of final elements. Description and explanation are done through a description of the definition, function, and types. After achieving the research goals, the research benefits are related to (i) the different sensors used as examples to explain the logic solver, (ii) the logic solver used as examples for the different final elements, and (iii) the different final elements used as examples for a basic review of how important safety instrumented systems.

B. Literature Review

The word "system" is often used in everyday conversation, discussion forums, and/or scientific documentation [23-25]. According to the Merriam-Webster dictionary, a network is defined as a group of devices or artificial objects or an organization forming a network, especially for distributing something or serving a common purpose [26]. This word is used for many things and in many fields, so its meanings are varied [25]. Systems theory was introduced in the 1940s by biologist Ludwig von Bertalanffy under the title "General Systems Theory" [27] and later developed by William Ross Ashby, who introduced the concept of "Cybernetics" [23, 25]. A system is defined as a unit consisting of entities, components, or elements that are connected for the ease of flow of matter, energy, and information for the achievement of a goal in the form of optimization conditions [25]. The term system is often used to describe a collection of interacting entities for which a mathematical model can often be made [23]. The system is also a set of interconnected parts and is in an area equipped with actuating items, a common example of an instrumented system for safety [8-17]. In the most general sense, a system is a collection of objects that have a relationship between them [25]. The systems can be either physical or conceptual, or a combination of both. The physical universes are composed of matter and energy, may embody information encoded in matter-energy carriers, and exhibit observable behavior, while conceptually, the systems are abstract systems of pure information that do directly exhibit "meaning but not behavior [23, 25].

The term "lecture" as a verb meaning "to read or deliver formal discourses" came into use during the 14th century. The lecture process can go on for any amount of time and cover any topic. The lecture is quite limited on that topic but versatile on the others. The many benefits and disadvantages of the lecture caused much debate over whether this strategy should still be used today. More benefits are obtained if a lecture can be carried out in many ways and cases. Lecturing is the old-fashioned method of delivering information verbally. This model is an oral tradition that represents and dates back to the Middle Ages [28]. Based on the focus on the process and philosophy of teaching, lecturing can be used as a practice for implementing high-order thinking skills (HOTS), and the HOTS have outperformed the entire subject content concept by focusing on several theories, in particular the Bloom and Marzano taxonomy [29].

Bloom's Taxonomy is one of the most widely recognized theories of levels of cognitive intelligence and has two main benefits for delivering a basic understanding. Firstly, it supports instructors in formulating learning objectives in behavioral terms to consider what learners can do as a result of instruction. Secondly, Bloom's Taxonomy can guide instructors to formulate more diverse tasks and contexts so that the transfer of knowledge and skills to learners is deeper and more varied [30]. Furthermore, there is a change in the nomenclature of Bloom's taxonomy. In the original version, the hierarchical order from the lowest to the highest was knowledge, comprehension, application, analysis, synthesis, and evaluation, but in the new nomenclature, it is reorganized to remember, understand, apply, analyze, evaluate, and create. Evaluation is at a lower level than synthesis (create), so creation is put at the highest level in the new nomenclature [31, 30]. When someone finds there is a deficiency in the basic understanding of the problem, possession of one of the disciplines will help someone get to a basic understanding, but it is not a complete guarantee [32].

Some descriptions of the state-of-the-art have been put forward and are very closely related to a basic understanding of the important guidelines of the SIS that can be achieved through the implementation of lectures. A lecture method is a process for understanding something as part of several stages of the thinking process. The thought process is an integral part of the new version of the cognitive domain of Bloom's taxonomy, including remembering, understanding, applying, analyzing, evaluating, and creating [4]. This paper describes the topics covering several instrumentations related to control systems for one or several processes. Some instrumentation for process control systems, including various sensors or detectors, logic solvers, and elements at the end in the form of actuators. All three are integral parts of the safety instrumentation system.

Materials and Methods

A. Materials for Studies

This sub-chapter relates to the title of the paper, which prioritizes the interrelationships of various scientific disciplines. Some of the most important readings are about:

(i) Bloom's taxonomy, which is about getting a basic understanding of an event, problem, or other forms through lectures [5, 4, 6, 31, 30, 19];
(ii) The important role of safety instrumented systems on the process in the industry; and
(iii) The topics of the instrumentation and process control for processing in some industries [18, 33], applied technology [20, 22], and education [28, 21, 29].

The elaboration of the six foundations is described in the following paragraphs: definition, knowledge base, terminology, structure, methodology, and epistemology.

The definition is a word that expresses the meaning, description, or main characteristics of people, things, processes, or activities. So, the definition is a series of words that aim to explain an object's meaning [34].

Knowledge is the fact or condition of knowing something with familiarity gained through experience or association [35]. In contrast, a knowledge base is seen when a person uses his mind to recognize certain objects or events that have never been seen or felt before [36].

Terminology is the technical or special term used in a business, art, science, or special subject.

The structure is something or a complex entity that is constructed of many parts or can be interpreted as how the parts of a system, object, event, or place are arranged so that the structure is one of the most used categories in science and technology [37].

Methodology is a body of methods, rules, or postulates employed by disciplines or can be interpreted as a particular procedure or set of procedures [37].

Finally, epistemology is the study or theory of the nature and grounds of knowledge, especially concerning its limits and validity [34, 37].

B. Methods for Learning by Means of Lectures

Several published papers explain that the research methods are an algorithm from a researcher in conducting the research, in the form of achievement and following research objectives. The form algorithm can be made into a flowchart [17, 38]. A structure of the flowchart showing the stages of research methods is shown in Figure 1.

Based on Figure 1, it is shown that there are three research objectives, i.e., to describe the variety of sensors, to explain the logic solver, and to explain the variety of final elements.

Results and Discussion

Safety Instrumented System (SIS) is an instrumentation and control system consisting of a series of equipment or systems. The SIS consists of sensors, logic solvers, and final elements that operate independently or separately from the Basic Process Control System (BPCS). The SIS is designed to work and bring the operation process to a safe state if a disturbance or emergency occurs before damage to vital facilities, loss of production, or work accidents occur. The BPCS is designed to continuously control all parameters in a production process system according to the desired value or setpoint. The difference between the SIS and the BPCS is that the SIS is only designed to work under certain conditions, for example, when the fluid level in a vessel increases beyond the safe limit. If left unchecked, it will result in damage to other important equipment.

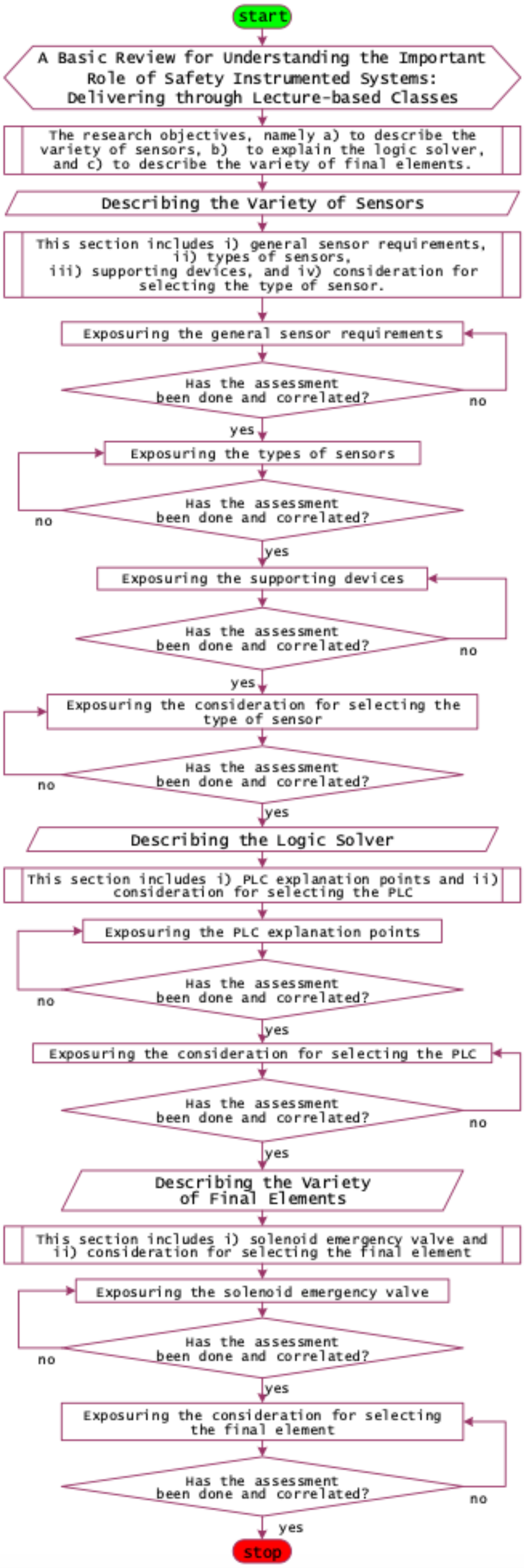

Figure 1. A structure of the flowchart showing the stages of research methods

The SIS response can be in the form of closing the intake valve or opening the exhaust valve, which is carried out simultaneously without adjusting the valve opening. The BPCS operates to ensure that all these parameters meet the normal operating conditions of a production process. Although designed to operate independently, both SIS and BPCS work together to ensure that equipment or facilities can operate smoothly and safely. Some control system parameters commonly regulated include flow rate, pressure, temperature, water level, and others. The relationship between SIS and BPCS is manifested in the form of interaction. The schematic interaction between BPCS and SIS is shown in Figure 2.

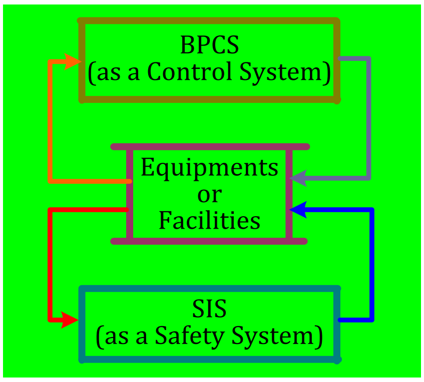

Figure 2. The schematic interaction between BPCS and SIS

Based on Figure 2, it can be explained that the BPCS is a control system, and the SIS is a safety system for equipment or facilities.

The SIS has been widely applied in the industrial world but has different names and terms, for example, emergency shutdown systems, safety interlock systems, and others. SIS consists of a series of systems or equipment that includes sensors, logic solvers, and final controllers. classified as sensors, including transmitters, switches, and others. The logic solver can be a PLC, relay, or other device. The final control device can be an emergency valve. SIS has been widely applied in the industrial world but has different names and terms, for example, emergency shutdown systems, safety interlock systems, and others. The SIS consists of a series of systems or equipment, which include sensors, logic solvers, and final elements. A series of components on the SIS is shown in Figure 3.

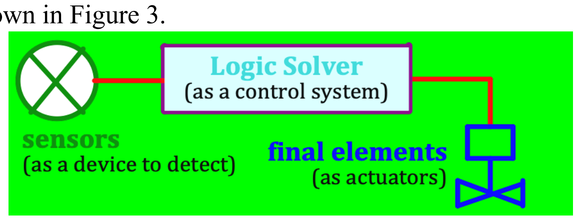

Figure 3. A series of components on the SIS

A. A variety of sensors

Sensors are important in any electronic instrumentation system for measurement and control. A sensor can be defined as a device that converts information from a given energy domain to the electrical domain. The energy domain can be considered a chemical and physical environment such as thermal, mechanical, radiant, optical, or magnetic. A sensor is a tool used to detect and measure all important parameters of a process, such as pressure, temperature, fluid level, flow rate, and others. Sensors are an inseparable part of the safety or protection system of an operating process. On the other hand, a smart sensor is an electronic device as instrumentation that takes input from the physical, chemical, or other environment and uses built-in compute resources to perform predefined functions upon detection of base or specific input and then for processing the data before passing it on. A structure of the flowchart as the exposure of the sensor section is shown in Figure 4.

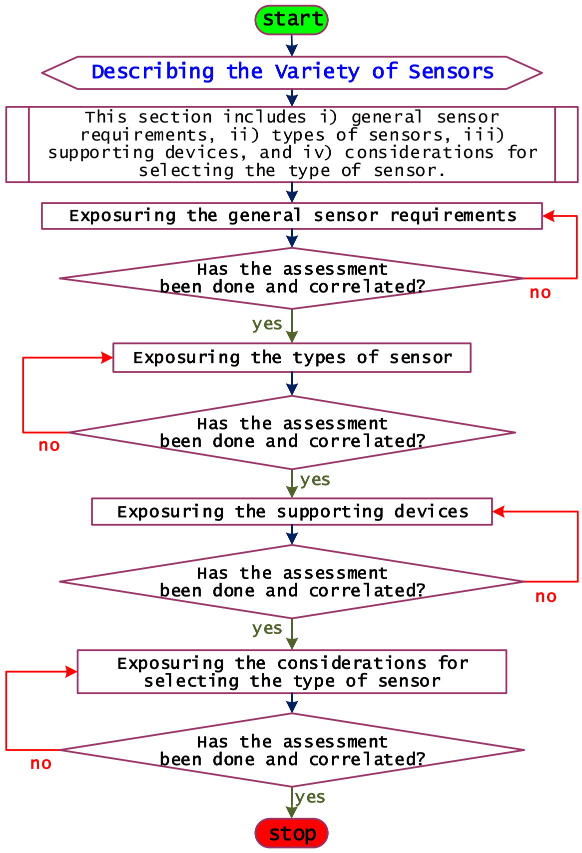

Figure 4. A structure of the flowchart as the exposure of the sensor section

Based on Figure 4, it can be exposed to this sensor section, including i) general sensor requirements, ii) types of sensors, iii) supporting devices, and iv) considerations for selecting the type of sensor.

A.1. General sensor requirements

Certain features are considered when choosing a sensor, namely: i) type of sens, i.e., the parameter such as temperature, pressure, or others that are being sensed by the sensor; ii) operating principle, i.e., the basic principle to operate the sensor; iii) power consumption, i.e., the power that is being consumed by the sensor to play an important role in defining the total power of the system; iv) accuracy, i.e., a key factor in selecting a sensor; v) environmental conditions, i.e., the basic condition is being used for choosing the quality of a sensor; vi) cost, i.e., the price paid to buy the sensor, can be used as a low-cost or high-cost sensor; vii) resolution and range, i.e., the smallest value that can be sensed and the limit of measurement are important; viii) calibration and repeatability, i.e., change of values with time and ability to repeat the measurements under similar conditions.

Some basic requirements of a sensor are:

- Range, i.e., indicating the limits of the input in which it can vary. In the case of temperature measurement, a thermocouple can have a range of 25 to 250 degrees Celcius;
- Accuracy, i.e., degreeing the exactness between actual measurement and true value, and accuracy is expressed as a percentage of full-range output;
- Sensitivity, i.e., the relationship between input physical signal and output electrical signal and the ratio of change in output of the sensor to a unit change in input value that causes a change in output;
- Stability, i.e., the ability of the sensor to produce the same output for constant input over some time;
- Repeatability, i.e., the ability of the sensor to produce the same output for different applications with the same input value;
- Response time, i.e., speeding the change in output on a stepwise change in input.
- Linearity, i.e., specifying the terms of percentage of nonlinearity, which is an indication of deviation of the curve of actual measurement from the curve of ideal measurement;
- Ruggedness, i.e., measuring the durability when the sensor is used under extreme operating conditions; and
- Hysteresis, i.e., defining the maximum difference in output at any measurable value within the sensor's specified range when approaching the point first by increasing and then decreasing the input parameter. Hysteresis is a characteristic that a transducer cannot repeat its functionality faithfully when used in the opposite direction of operation.

In choosing the right sensor equipment and in accordance with the system to be censored, it is necessary to pay attention to the sensor's general requirements, including linearity, sensitivity, and response time.

Many sensors produce a continuously changing output signal in response to a continuously changing input. For example, a heat sensor can generate a voltage according to its perceived heat. In such cases, it is usually possible to know exactly how the output changes compared to the input in the form of a graph. For example, an output relationship of two different heat sensors is shown in Figure 5.

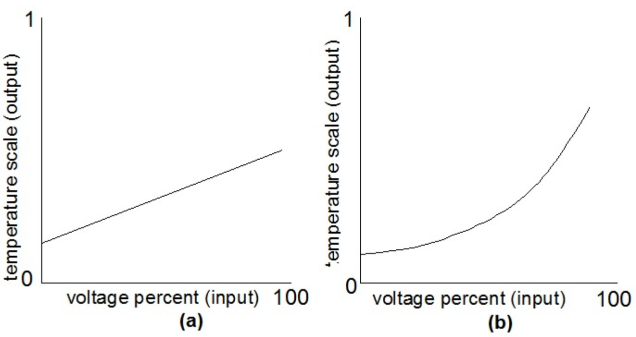

Figure 5. For example, an output relationship of two different heat sensors

Based on Figure 5, it can be explained that the straight line in (a) shows a linear response, while in (b) is a non-linear response.

Sensitivity will show how far the sensitivity of the sensor is to the quantity being measured. Sensitivity is often expressed as a number indicating "change in output versus unit change in input." For example, some heat sensors can have a sensitivity expressed as "one volt per degree," meaning a one-degree change in input will result in a one-volt change in output. Another heat sensor may have a sensitivity of "two volts per degree," which means it has twice the sensitivity of the first sensor. Sensor linearity also affects the sensitivity of the sensor. If the response is linear, the sensitivity will also be the same for the entire measurement range. For example, figure 5 (b) shows that the response will be more sensitive at high and low temperatures.

The response time on the sensor shows how quickly it responds to changes in input. For example, an instrument with poor frequency response is a mercury thermometer. The input is the temperature, and the output is the mercury position. A schematic response to changes in temperature slowly and quickly is shown in Figure 6.

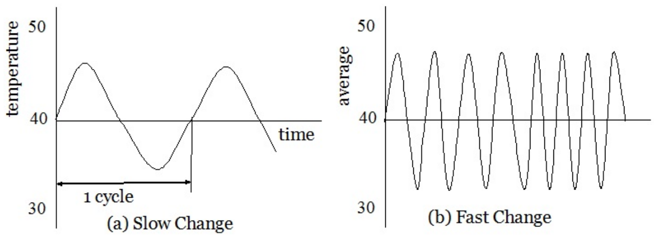

Figure 6. The schematic responses to changes in temperature slowly and quickly

Based on Figure 6, it can be explained that frequency is the number of cycles in one second and is given in hertz (Hz.). Therefore, at low frequencies, as shown in Figure 6 (a), i.e., when the temperature changes slowly, the temperature changes will occur continuously with time, and the thermometer will follow these changes continuously. However, suppose the temperature change is very fast, as shown in Figure 6 (b). In that case, there will be no major changes in the mercury thermometer because it is slow and will only show the average temperature.

A.2. The types of sensor

Various sensors exist, including pressure, temperature, and fluid level sensors.

Pressure sensor

Pressure is the force per area of the plane that is pressed perpendicularly. Detecting pressure converts the force exerted by the pressure media (gas or liquid) into a physical displacement. For example, it can move the pointer to relate to the calibrated scale or cause an electrically measurable response, such as a change in resistance or capacitance, which is proportional to pressure. The proven mechanisms for converting pressure to physical displacement include (i) the pressure-sensing diaphragm, capsule, Bourdon tube, and expanding bellows.

In international units (SI), the unit of pressure is Pa (pascal), equal to one kilogram per square meter. In contrast,

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other pressure units commonly used are (i) psi (pounds per square inch), i.e., approximately equal to 6895 Pa, (ii) bar, i.e., equal to 100,000 Pa, (iii) atm (standard atmosphere), i.e., equal 101,325 Pa, (iv) mmHg (millimeter of mercury), i.e., approximately equals to 133 Pa, (v) in Hg (inch of mercury), i.e., approximately equals to 0.49 psi, and (vi) Torr, i.e., 1 Torr is almost the same as mmHg and approximately equals to 133 Pa. The unit of force is Newton (N), and the surface area is a square meter (m^2). Several sensors or sensing elements are commonly used to measure pressure, including bellows and bourdon tubes.

Bellows

The bellows is a bent, deep, folded piece of metal formed from very thin-walled tubing. The bellows sensor element is formed from a thin piece of metal usually used in a process requiring low-pressure measurements. The system pressure that enters the bellows inside will vary so that the bellows will expand or contract. The end of the bellows is connected to a mechanical linkage, so when the bellows and linkage move, either an electrical signal or an indication of a pressure reading is generated.

The bellow types of commonly used materials are all copper-based alloys (beryllium copper, brass, bronze), phosphor bronze, stainless steel, all nickel-based alloys, and other metals that are suitable for the intended purpose of the gauge. Brass is a metal with good strength and ductility attributed to the properties of zinc and is made of an alloy of zinc and copper. It has better malleability than bronze. Bronze combines copper and additives such as tin (the main additive), manganese, and phosphorus. Criteria selection of material for bellows, i.e., strength, pressure range, hysteresis, corrosiveness due to environmental impacts, and ease of fabrication. Ranging to measure of the bellow type pressure gauge depends on the three main factors, namely (i) the effective area of the bellow, (ii) the spring gradient, and (iii) the material used to build a bellow. The primary application of the bellow type pressure gauge is the measurement of the low or small differential pressure.

The primary application of the bellow type pressure gauge is the measurement of the low or small pressure with a differential pressure range of 0.5 to 75 PSIG. However, some bellows can also measure high pressures of up to 800~1,000 PSIG when combined with a heavy-range spring. The diameter of the bellows ranges from 0.5 to 12 inches. A larger diameter means higher sensitivity and improvement in accuracy. The number of folds can vary from 5 to 20, and it has as many as 24 folds. More folds mean larger stroke lengths, and they generate larger forces.

Bourdon tube

The Bourdon tube is a non-liquid pressure measurement device. It is widely used in low-cost applications where static pressure measurement is required. Bourdon tube pressure gauge is a device used for sensing and measuring pressure, a sensing element for pressure due to its elastic nature, which Eugene Bourdon invented in 1849. The usual Bourdon tube contains a curved tube that opens. External pressure is input at one end and mechanically coupled to a needle showing a reading at the other. Bourdon Tube is made of a short-curved pipe with one closed end. When the bourdon tube is under pressure, it will "tighten up." The resulting changes will be proportional to the amount of pressure applied. This can be seen from the dial indicator listed on the bourdon tube device and can be worked for a pressure limit of up to 100,000 psi.

Temperature sensor

Temperature is the degree of hotness or coldness of an object. The temperature is a measure concerning a reference point, which is referred to as a reference point. The International unit for temperature is the Kelvin (K). Other temperature units commonly used are Fahrenheit (ºF) and Celsius (ºC). Many systems or several physical phenomena need the ability to sense temperature. Some have multiple internal sensors to ensure the electronics run within safe limits. Others need to sense temperature at a distance. The result is a wide variety of temperature sensors, each of which has a particular set of advantages and drawbacks. Guiding to the many different temperature sensors available and their features match up with different applications. The types of temperature sensors and choosing a temperature sensor are based on contact-based and non-contact. Contact-based sensors of temperature include a thermocouple, Resistance Temperature Detector (RTD), thermistor, and semiconductor temperature sensor, while based on non-contact sensors include a thermopile and infrared imager.

Resistance Temperature Detector (RTD)

An RTD is a temperature transducer whose metal resistance increases with increasing temperature. The metals used for these RTDs range from platinum, which is reusable, highly sensitive, and very expensive to compare with nickel, which is not reusable, more sensitive, and cheaper. RTD calculations can be noted from the typical value of small linear changes in resistance with temperature. In general, RTDs have response times from 0.5 seconds to 5 seconds or more. The slow response is due to the slow thermal conductivity, which brings the device into thermal balance with its surroundings. An RTD is represented as a wire whose resistance is monitored as a function of temperature.

The construction is similar to wire coils or wire strips to achieve small sizes and increase thermal conductivity to reduce response time. The main concept underlying temperature measurement with an RTD resistance temperature detector is that the electrical resistance of the metal varies with temperature. The balance of this variation is precise and repeatable, allowing consistent temperature measurement through resistance detection. The most frequently used material for RTDs is platinum due to its linearity, stability, and reproducibility. This RTD is an active transducer, namely a transducer that works without additional external energy but uses the energy to be converted itself. The working principle of this RTD is the change in the wire resistance value due to temperature changes.

Fluid level sensor

There are many fluid level measuring devices, such as laser or radar, ultrasonic, radioactive, differential pressure (d/p), displacer, and others.

Differential pressure (d/p) type

The differential pressure (d/p) type is the most commonly used for level measurement. In addition to being cheaper, installation is easier than other types. The installation of the fluid level gauge based on differential pressure type is carried out by connecting two small pipes to the surface of the tank or vessel. One part is installed at the bottom, and the other is installed at the top of the vessel, so there is a pressure difference or differential pressure. The d/p value will be influenced by the original height of the fluid in the vessel, where a level transmitter will later read this value.

Laser type

The laser beam from a light source is directed to the surface of the liquid, and then its reflection is detected using a laser light detector. The laser beam transmitter and detector must be in the same plane. The detector and laser beam are rotated. The detector is directed to always be in a position to receive light. Suppose the detector receives the incoming light. In that case, the liquid surface level can be determined by calculating the angular positions of the detector angle and the emitter angle.

A.3. Supporting devices

Some equipment that can be classified into supporting equipment includes transmitters and switches.

Transmitter

A transmitter is a continuation of the detection sensor, which is one process control system element. The instrument for measuring the magnitude of a process called a sensor is used (the part directly related to the measured medium). The transmitter then converts the signal received from the sensor into a standard signal. Based on the quantity that needs to be transformed, the transmitter can be classified as a pressure transmitter, temperature, surface elevation or level, flow, and others. Meanwhile, based on the type of output signal, the transmitter can be divided into pneumatic and electric transmitters. The transmitter can connect various receiving devices, such as indicating instruments, recording devices, and regulators, with a standard input signal.

The benefits of the signal sent by the transmitter in the form of a pneumatic signal or an electrical signal from the measurement results of the process to other equipment that needs it include, namely, i) Enables the transmission of signals over long distances and is fast and safe, ii) Other equipment such as indicators, recorders that work with the same signal standard, and iii) Reducing operating and maintenance costs. In addition, the transmitter signal is sent to a receiving device, such as a recorder or a pointer, in the form of a number scale. Therefore, based on the signal issued, the transmitter can be classified into two types: electric and pneumatic.

Electric transmitter

A transmitter sends electrical signals in two forms, current and voltage signals, where the working scale of the current signal is always 4-20 mA. As for the voltage signal, it can be 1 to 5 Vdc or 0 to 10 Vdc. First, the processed signal received by the sensor is converted into an electrical signal, and then the electrical signal is sent to receiving devices such as recorders, regulators, and pointers.

Pneumatic transmitter

In general, this pneumatic transmitter converts the amount of the processed signal into a pneumatic signal and sends the pneumatic signal to receiving devices such as recorders, pointers, and regulators. The signal generated by pneumatics ranges from 3 to 15 Psi or 0.2 to 1.0 kg/cm^2. Pneumatic transmitters can be used up to a distance of about 200 meters.

Switch

A switch is one of the sensors commonly used for SIS protection or safety systems. The selection of a switch compared to other analog sensors, such as transmitters, is usually based on the process to be controlled, which is relatively simpler in addition to being cheaper both from the price of the switch itself and from the cost of its construction. Based on the type of process or the amount received by the switch, there are several switches, including pressure switches, temperature switches, and level switches.

Pressure switch

The pressure of the liquid or gas will move the mechanical parts of the switch, such as pistons, spirals, or bellows, which will convert the pressure into mechanical force.

Temperature switch

One of the temperature sensors used is a bimetal, which is made of two metal plates with different coefficients of expansion (α) that are glued together. Due to the difference in expansion reactions, the bimetal will bend towards the metal with a lower expansion. The arch can be used to move the mechanical parts of the switch.

Level switch

The float level switch is one type that is often used. The buoy will move when the water level rises to a certain point. The movement of the float will move the mechanical part of the switch.

A.4. Considerations for selecting the type of sensor

Selection of the sensor type, design, and installation must meet the requirements set out in the SIS. Most systems are designed to operate in a fail-safe mode, i.e., when the power source is lost, the protection or safety system will maintain the system in a safe state. The following are some provisions that must be considered in the design and installation of a sensor referring to the SIS requirements, namely a) the fail-safe system mode should be normally closed and normally energized circuit, b) sensors should be connected directly to the logic system or logic system without passing through other interfaces or intermediaries, and c) sensors connected to a protection or safety system must be distinguished from BPCS sensors in their name or tagging, numbering system or color code.

B. The Logic Solver

There are various logic solvers commonly used for SIS protection or safety systems, one of which is a programmable logic controller (PLC). A logic solver consists of a set of electronic devices and devices capable of translating and processing various input signals into a command or output signal that an actuator will receive. In addition, a logic solver can handle stability and accuracy and eliminate dangerous state transitions in the production process. A structure of the flowchart as the exposure of the logic solver section is shown in Figure 7.

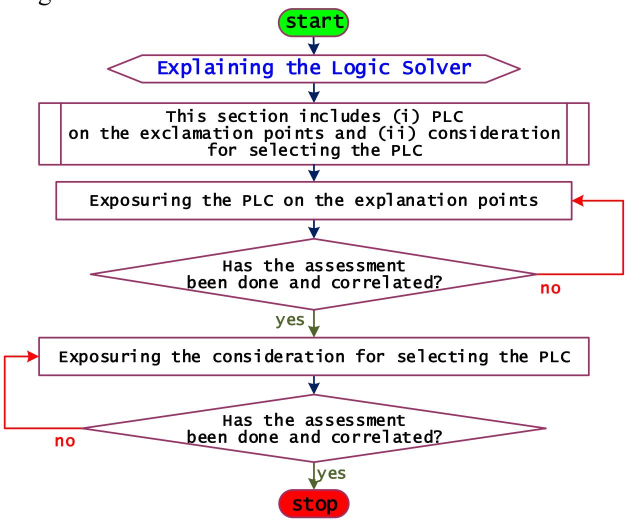

Figure 7. A structure of the flowchart as the exposure of the logic solver section

Based on Figure 7, it can be explained that the exposure of this logic solver section includes PLC on explanation points and considerations for selecting the PLC.

B.1. PLC on the exclamation points

PLC hardware is composed of three main components, i.e., a central processing unit (CPU), which has a processor and memory, input/output (I/O) modules, and a power supply. The central processing unit (CPU) is the heart of the PLC system. A CPU is a system based on a microprocessor that replaces controlling relays, counters, timers, and sequencers. The operating principle of the CPU can be briefly described as follows:

#1) The CPU receives and reads input data from various sensor devices, executes user programs stored in memory, and sends appropriate output commands to control output devices;

#2) A direct current (dc) power source is required to produce the low-level voltage used by the processor or I/O module and processor. This power supply may be housed in the CPU unit, or it may be as a separate unit, depending on the PLC system manufacturer and

#3) Most CPUs contain a spare battery that will keep the operating program in storage in case of a power supply failure.

The processor memory module is the main part of the CPU. Memory is where the control plan or program to be carried out is stored in the controller. The information stored in memory relates to how the input and output data are processed. The complexity of the program determines the amount of memory required. The control program is stored in electronic memory components, such as RAM and EEPROM. The processor unit reads and observes data from the input and output modules and stores its state in memory. Then, the processor unit reads the user program stored in memory and makes a decision that causes the output to change.

Memory can be classified into two categories: volatile and non-volatile. Volatile memory will lose the information it holds if the power supply operating it is cut off. The memory is volatile, easy to replace, and very suitable for some applications when backed up with battery backup. The non-volatile memory can retain information when the power supply is cut off. PLCs use many types of volatile and non-volatile memory devices.

Random Access Memory (RAM) is designed so that information can be written to or read from memory. Most controller parts now use CMOS-RAM with battery support for user program memory. RAM provides a good means for easy program creation and modification. Read-Only Memory (ROM) is designed so that information stored in memory can only be read and, under normal circumstances, cannot be replaced. The information contained in the ROM is placed by the PLC manufacturer for internal use and operation of the PLC. Erasable programmable read-only memory (EPROM) is designed so that it can be programmed after being completely erased using an ultraviolet light source. Electrically erasable programmable read-only memory (EEPROM) is designed to store some configuration data on the electronic device that is maintained even when a power source is disconnected, such as calibration tables or device configuration.

The I/O modules consist of input and output modules that form an interface with external devices connected to the controller. The purpose of this interface is to match the conditions of various signals received from or sent to external equipment. Input devices such as switches, transmitters, and others are connected to the input module terminals. Output devices such as control relays, magnetic contactors, solenoid valves, indicator lights, alarms, etc., are connected to the output module terminals. The type of input and output connected to the PLC can be divided into two, namely, digital or discrete and analog. The analog I/O module provides an interface for various analog signals covering a voltage range (e.g., 1 to 5 V) and a current range of 4 to 20 mA. Each port or terminal on the input and output modules is assigned a unique address. The processor uses this address to identify the location of the equipment for monitoring or controlling processes. The input and output addressing formats depend on the PLC being used and are usually found in. These addresses can be presented in decimal, octal, or hexadecimal form, depending on the number system used by the PLC.

The PLC system requires two power supplies. The first supply is obtained from outside the PLC, which provides the necessary power for the input equipment or output loads to operate and is provided by the PLC user. In contrast, the second power supply is provided internally as a module part of the PLC system. This power supply provides a direct internal current to operate the processor logic circuits and I/O devices. The voltage supplied will depend on the type of integrated circuit (IC) present in the system.

B.2. Consideration for selecting the PLC

General purpose PLC is not recommended for use in SIS because it has many weaknesses, one of which is the inability or absence of PLC functions for diagnostic purposes. To overcome these shortcomings, several PLC supply companies whom PLC users assist usually make modifications or adjustments to the general purpose of the PLC so that it can be used for SIS applications. Such PLCs are known as safety-configured PLCs. In contrast to safety-configured PLCs that come from general-purpose PLCs, safety PLCs were originally designed specifically for SIS applications, so they are recommended for use in SIS applications. The description of this final elements section includes PLC on the exclamation points.

C. Variety of the Final Elements

The final elements are equipment known as actuators used to execute commands from the logic solver to perform the SIS safety function by securing the system or operating process from the potential for unsafe or dangerous conditions. The action taken can be in the form of releasing energy or excess pressure, closing the incoming energy supply, or stopping equipment safely or safe shutdown. Some of the equipment included in the SIS final elements are emergency solenoid valves or emergency valves, circuit breakers or circuit breakers, and others. A structure of the flowchart as the exposure of the final element section is shown in Figure 8.

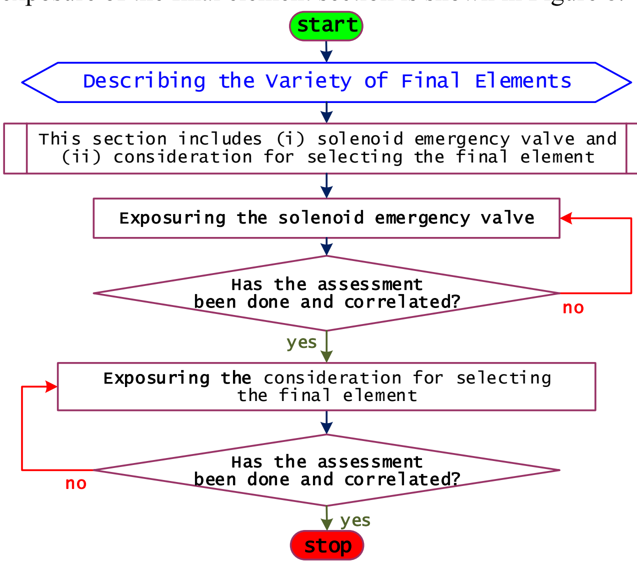

Figure 8. A structure of the flowchart as the exposure of the final element section

Based on Figure 8, it can be explained that the exposure of this final element section includes a solenoid emergency valve and consideration for selecting the final element.

C.1. A solenoid emergency valve

A solenoid valve combines a solenoid with a valve that works as a single unit that converts electrical signals into linear mechanical motion. The solenoid valve is driven by AC or DC electrical energy, which has a coil or coil of wire wrapped around a plunger or a long round soft iron that functions to move the plunger. Inside the solenoid valve are output, input, and exhaust holes. The input hole serves as a place for fluid or liquid to enter and exit through the output hole. At the same time, the exhaust hole serves as a channel to remove the trapped liquid when the plunger moves or changes position when the solenoid valve is working. When given a voltage, the coil will turn into a magnetic field and pull the plunger up, pressing the spring so that it will open the channel hole and flow through the valve. When the flow of electricity is disconnected, the plunger will return to its original position due to the push of the spring so that it will close the channel so that the flow will stop.

C.2. Consideration for selecting the final element

Final elements, mechanical equipment, usually experience the most problems among all SIS components because their operating designs are in direct contact with the process. Some problems that usually occur in the final element, especially the solenoid valve, include jammed or stuck and the occurrence of scaling or scaling. This problem occurs due to the operation of the solenoid valve, which is designed as an emergency valve that will only operate under certain conditions, so it is possible that the valve will not operate in the long term. To prevent this, the valve must be tested periodically to ensure its condition is ready to operate whenever needed.

Conclusion

Based on the results for determining the conclusion associated with a basic review for understanding the important role can be carried out through a lecture-based learning process, that is, the elaboration of instrumentation and process control. A brief explanation of the components of SIS includes sensors, logic solvers, and final elements. Some provisions that must be considered in the design and installation of a sensor refer to the SIS requirements, i.e., the fail-safe system mode should be a normally closed and normally energized circuit, sensors should be connected directly to the logic system without passing through other interfaces or intermediaries, and sensors should be connected to a protection or safety system. The safety-configured PLCs that come from general-purpose PLCs were originally designed specifically for SIS applications, so they are recommended for use in SIS applications. Finally, to prevent some problems that usually occur in the final element, the valve must be tested periodically to ensure its condition is ready to operate whenever needed.

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