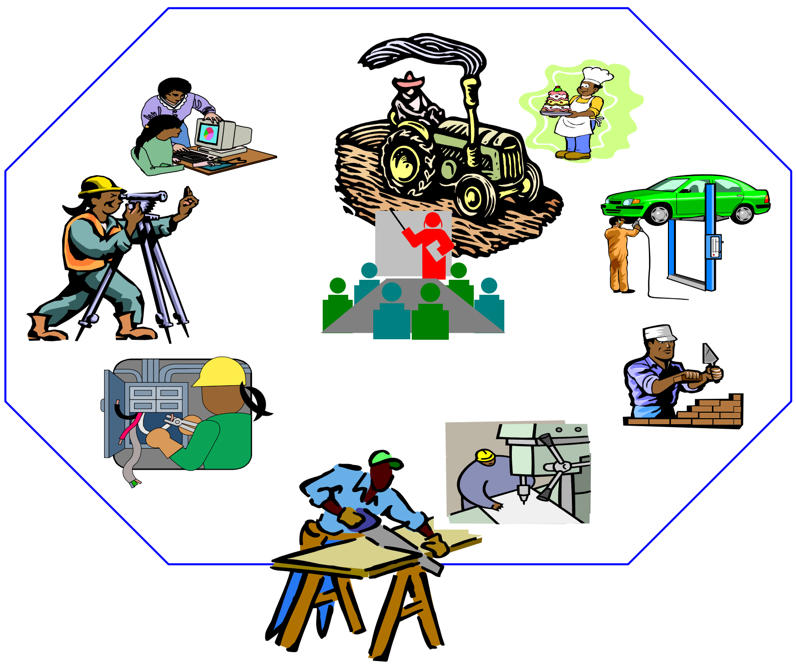
Diagnosing and Troubleshoot Instrumentation and Control Devices

Based on May, 2011 Version 2 OS and Dec, 2020 Version2 Curriculum



Module Title: Diagnosing and Troubleshoot Instrumentation and Control Devices

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L #16	LO #1- Plan and prepare for diagnosis of faults of instrumentation and control systems

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Following OHS policies and procedures
- Following instrumentation and control standards
- Gathering and analyzing history cards and relevant information
- Obtaining tools, equipment and testing devices needed to carry out work
- Consulting appropriate personnel to coordinated work
- Checking instrumentation and Control Systems defects
- Planning and preparing diagnosis of faults

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Follow OHS policies and procedures
- Follow instrumentation and control standards
- Gather and analyze history cards and relevant information
- Obtain tools, equipment and testing devices needed to carry out work
- Consult appropriate personnel to coordinated work
- Check instrumentation and Control Systems defects
- Plan and prepare diagnosis of faults

Learning Instructions:
1. Read the specific objectives of this Learning Guide. **2.** Follow the instructions described below. **3.** Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them. **4.** Accomplish the "Self-checks" which are placed following all information sheets. **5.** Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

Information Sheet 1- Following OHS policies and procedures

1.1 Following OHS policies and procedures.

Introduction

A health and safety program is a definite plan of action designed to prevent accidents and occupational diseases.. A health and safety program must include the elements required by the health and safety legislation as a minimum. Because organizations differ, a program developed for one organization cannot necessarily be expected to meet the needs of another. This document summarizes the general elements of a health and safety program.

1.1.1 Occupational health

occupational health is defined as the science and art devoted to the anticipation, recognition, evaluation and control of those environmental factors or stresses, arising in or from the place of work, which may cause illness, impaired health and well being, or significant discomfort and inefficiency among workers or among citizens of the community.

Industrial hygiene has been described as the "promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations by preventing departures from health, controlling risks and the adaptation of work to people, and people to their jobs.

1.1.2 Occupational health and safety

Occupational health and safety is a discipline with a **broad scope** involving many specialized fields. In its broadest sense, **it aims at**:

- The promotion and maintenance of the highest degree of physical, mental and social well- being of workers in all occupation;

- The prevention among workers of adverse effect on health caused by their working conditions;
- The protection of workers in their employment from risks resulting from factors adverse to health;
- The placing and maintenance of workers in an occupational environment adopted to physical and mental needs;
- The adaptation of work to humans. Successful occupational health and safety practice requires the collaboration and participation of both employers and workers in health and safety programmes, and involves the collaboration of issues relating to occupational medicine, industrial hygiene toxicology, education, ergonomics, engineering safety, psychology, etc

OHS guidelines

Guide line is an explanatory document providing detailed information on the requirement of legislation, regulation, standards, codes of practice or matters relating to occupational health and safety

the guide line although not intended as a regulatory instrument, is based on the regulatory frame work and provides information on necessary acceptable practice to achieve regulatory compliance , in many cases the guidelines will provide interpretation of intent of the legislation and describe the rational used in its development it may provide proactive programs or services that the regulatory and legislative requirement

A national framework for occupational safety and health management systems

National policy

A competent institution or institutions should be nominated, as appropriate, to formulate, implement and periodically review a coherent national policy for the establishment and promotion of OSH management systems in organizations. This should be done in consultation with the most representative organizations of employers and workers, and with other bodies as appropriate.

The national policy on OSH management systems should establish general principles and procedures to:

a) promote the implementation and integration of OSH management systems as part
b) of the overall management of an organization;
a) facilitate and improve voluntary arrangements for the systematic identification, planning, implementation and improvement of OSH activities at national and organization levels;
b) promote the participation of workers and their representatives at organization level;
c) implement continual improvement while avoiding unnecessary bureaucracy, administration and costs;
d) promote collaborative and support arrangements for OSH management systems at the organization level by labour inspectorates, occupational safety and health services and other services, and channel their activities into a consistent framework for OSH management;
e) evaluate the effectiveness of the national policy and framework at appropriate intervals;
f) evaluate and publicize the effectiveness of OSH management systems and practice by suitable means; and
g) ensure that the same level of safety and health requirements applies to contractors and their workers as to the workers, including temporary workers, employed directly by the organization.

With a view to ensuring the coherence of the national policy and of arrangements for its implementation, the competent institution should establish a national framework for **OSH management systems to:**

a) identify and establish the respective functions and responsibilities of the various institutions called upon to implement the national policy, and make appropriate arrangements to ensure the necessary coordination between them;
b) publish and periodically review national guidelines on the voluntary application and systematic implementation of OSH management systems in organizations; establish criteria, as appropriate, for the designation and respective duties of the

institutions responsible for the preparation and promotion of tailored guidelines on OSH management systems; and

c) ensure that guidance is available to employers, workers and their representatives to take advantage of the national policy.

The competent institution should make arrangements and provide technically sound guidance to labour inspectorates, OSH services and other public or private services, agencies and institutions dealing with OSH, including health-care providers, to encourage and help organizations to implement OSH management systems.

Occupational safety and health policy

The employer, in consultation with workers and their representatives, should set out in writing an OSH policy, which should be:

(a) specific to the organization and appropriate to its size and the nature of its activities;

(b) concise, clearly written, dated and made effective by the signature or endorsement of the employer or the most senior accountable person in the organization;

(c) communicated and readily accessible to all persons at their place of work;

(d) reviewed for continuing suitability; and

(e) made available to relevant external interested parties, as appropriate.

The OSH policy should include, as a minimum, the following key principles and objectives to which the organization is committed:

(a) protecting the safety and health of all members of the organization by preventing work-related injuries, ill health, diseases and incidents;

(b) Complying with relevant OSH national laws and regulations, voluntary programmes, collective agreements on OSH and other requirements to which the organization subscribes;

(c) Ensuring that workers and their representatives are consulted and encouraged to participate actively in all elements of the OSH management system; and

(d) Continually improving the performance of the OSH management system.

The OSH management system should be compatible with or integrated in other management systems in the organization.

Occupational safety and health objectives

Consistent with the OSH policy and based on the initial or subsequent reviews, measurable OSH objectives should be established, which are:

a) specific to the organization, and appropriate to and according to its size and nature of activity;
b) consistent with the relevant and applicable national laws and regulations, and the technical and business obligations of the organization with regard to OSH;
c) focused towards continually improving workers' OSH protection to achieve the best OSH performance;
d) realistic and achievable;
e) documented, and communicated to all relevant functions and levels of the organization; and
f) periodically evaluated and if necessary updated

1.1.2 Ethiopian environmental protection proclamations, regulations and standards

Proclamation on Environmental Impact Assessment

The Federal Government has issued a Proclamation on Environmental Impact Assessment (Proc. No. 299/2002) and the primary aim of this Proclamation is to make EIA mandatory for specified categories of activities undertaken either by the public or private sectors, and possibly, the extension of EIA to policies, plans and programs in addition to projects. Categories of projects that will require full EIA, not full EIA or no EIA are provided. To effect the requirements of this Proclamation, the former EPA, now MoEFCC, issued a Procedural and Technical EIA Guidelines, which provide details of the EIA process and its requirements.\

This legislation may be triggered by the proposed Addis Ababa Transmission and Distribution System Rehabilitation and Upgrading Project as certain components of the project are expected to fall under the category of projects that require full EIA or preliminary environmental assessment (PEA). The project components that will require full EIA (ESIA) or PEA will be identified in the Screening process.

Proclamation on Environmental Pollution Control

The Proclamation on Environmental Pollution Control (Proc. No. 300/2002) is mainly based on the right of each citizen to a healthy environment, as well as on the obligation to protect the environment of the Country. The primary objective of this law is to provide the basis from which the relevant ambient environmental standards applicable to Ethiopia can be developed, and to make the violation of these standards a punishable act. The Proclamation states that the "polluter pays" principle will be applied to all persons.

This legislation may be triggered by the subject project since it may cause some environmental pollution. Therefore, the Project Proponent/EEP and its Contractor(s) are responsible for preventing environmental pollution and taking remedial measures for any incidents that may occur during the project implementation.

Proclamation on Energy

Energy Proclamation (No. 810/2013) was issued in January 2014 to revise the Electricity Proclamation No.86/1997 based on the up-to-date national and regional development of energy regulations. The proclamation, under Article 4, provides the powers and duties of the Ethiopian Energy Authority (EEA), which was established by the Council of Ministers Regulation No.308/2014. The powers and duties of EEA, among several others, include the following:

- issue and renew license and certificate of competency in accordance with this Proclamation and regulations and directives issued hereunder;
- supervise the operations of licensees and holders of certificates of competency to ensure compliance with the provisions of this Proclamation and regulations and directives issued hereunder;
- formulate long-term, medium-term, and short-term energy efficiency and conservation strategy and program at national and sectoral levels;
- issue energy audit code, energy efficiency standards code, energy efficiency labeling code, grid code, customers' service code, technical inspection code, quality service standard code, building electrical installation code, technical standard code and other codes; and supervise the implementations of same;
- approve electric power purchase and network service agreements;

may enter the land or the premises in the holding of any person after securing prior permission from the person to carry out installation of new electricity supply, or to carry out activities required to connect, repair, upgrade, inspect or remove electrical lines;

shall have the right to cut or lop trees or to remove crops, plants or other things that obstruct the construction or operation of electrical works or may cause danger to electrical lines.

Article 17 deals with Compensation issue and states that the licensee shall pay compensation, in accordance with the relevant law, for damages caused to the property of a landholder while performing the activities provided under Article 16 of this Proclamation.

Article 18 contains provisions on Expropriation of Land and it states that where public interest so justifies, any generation, transmission, distribution and sale, import or export licensee may be made the beneficiary of an expropriation measure, taken in accordance with the relevant law, by the government over private land holdings.

Regulations on Electricity Operations

This Council of Ministers Regulations No. 49/1999 was issued in 1999 pursuant to Article 28(1) of the Electricity Proclamation No. 86/1997 to provide the regulations of electricity operations in the country. The Regulations are divided into six parts, which include requirements for Electricity Operation Licenses; Rights and Obligations of Licensees and Customers; Electricity Price and Tariff; Standards of Safety, Technical and Quality of Service; and Miscellaneous Provisions. The provisions most relevant for the subject project are described below.

As part of the general safety requirements, Sub-article 47(1) prohibits undertaking any type of construction work or growing trees under electric power lines or within the distance of horizontal clearance thereof. Under the safety requirements for Transmission Lines and Substations, Article 58 provides the requirements for Clearance from Buildings and Structures. Sub-article (1) states that the horizontal distance from conductors to any point of a building or structure shall, with maximum wind, be at least 4.5 meters. If the requirement stated under Sub-Article (1) cannot be fulfilled, the height of the conductor from the building or structure shall, at maximum temperature and with conductor broken in the neighboring span, be at least 5.5 meters. Similarly Article 59 provides the safety requirements for Clearance from Trees. According to Sub-article (1) the vertical distance of conductors from trees shall be at least 1.5 meters plus the minimum distance between live and un-energized parts. In the case of fruit trees the distance shall be 4m plus the minimum distance between live and un-energized parts as per Sub-article (2). The distances stated above shall be maintained in accordance with the expected growth of trees (Sub-article 3).

Importance of Occupational Health and Safety

Work plays a central role in people's lives, since most workers spent at least eight hours a day in the work place. Therefore, **work environment should be safe** and healthy. Yet this is not the case for many workers. Every day workers all over the world are faced with a multitude of health hazards, such as; dusts, gasses, noise, vibration, extreme temperature, etc.

The scope of occupational health and safety include:

- Recognition and anticipation of workers health problems in an industrial atmosphere;
- Evaluation of the recognized problem which encompasses mainly data collection, analysis, interpretation, and recognition;
- Development of corrective actions to eliminate or limit the problem.
- Generally, the work frame of industrial hygiene is wide and needs multidisciplinary approach. It requires the knowledge of physics, biology, chemistry, ergonomics, medicine, engineering and related science. It also requires public health management skills for proper communication and decision making.

Some common hazards that may be encountered in the workplace include:

Chemical Hazards

These include asbestos, coal dust, multitude of acids and alkalis, gases such as SO_2, CO_2, CO, NO_x, heavy metal poisonings such as lead and mercury and a long list of toxic substances such as pesticides, solvents and preservatives. These harmful chemical compounds in the form of solids, liquids, gases, mists, dusts, fumes, and vapor exert toxic effects after they get entrance by inhalation, absorption through direct contact with skin or ingestion. The most important of these is inhalation due to the speed with which toxic substances are absorbed and enter the blood stream. Please note that the degree of worker risk from exposure to any given substances depends on the nature and potency of the toxic effects and the magnitude and duration of exposure.

Biological Hazards

These include bacteria, virus, fungi, and other living organisms that can cause acute and chronic infections.

Physical Hazards

- Non-ionizing radiation e.g. microwaves, infra red, visible and ultra-violet light
- Ionizing radiation e.g. X-rays, gamma rays, beta particles, alpha particles from radon daughters
- Noise (usually measured in decibels dB) and vibration;
- Temperature, humidity etc

Ergonomic Hazards

The term is originated from two Greek words, ergon- meaning work and nomos meaning law. Ergonomics is, therefore, the study of law(s) governing work and its environment. Ergonomics includes human factors in engineering and it deals with the consideration of human characteristics, expectations and behaviors in the design of tools, equipment etc that people use in their work and everyday lives and the environment in which they work and live. Ergonomics related injuries and illness are ranging from eyestrain and headaches, musculoskeletal ailments such as chronic backache, neck and shoulder pain, etc. These and other related problems are avoided primarily by the effective design of a job or jobsite and by better- designed tools or equipment that meet workers needs in terms of physical environment and job tasks

Psychosocial Hazards

The term “stress” means the strain imposed on the worker by psychosocial influences associated with urbanization and works. Within the work environment itself, emotional stress may arise from a variety of psychosocial factors, which the worker finds unsatisfactory, frustrating or demoralizing, for example: Workers may be working in shifts that will expose them to unusual hours. They may upset their family’s life as a result of their work conditions.

Workers may be working with a person who is paid more but who is incapable of working. Financial incentives are too low, work overload, work under load, poor job management, career development, and lack of job security, etc

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided

I. Answer the following question as directed below

1. ______________is defined as the science and art devoted to the anticipation, recognition, evaluation and control of those environmental factors or stresses, arising in or from the place of work, which may cause illness, impaired health and well being(2%)
2. --------- is the “promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations by preventing departures from health. (2%)
3. Write at least three aim of Occupational health and safety (2%)
4. ____________is a material measure or physical property that defines or reproduces the unit of measurement of a base or derived quantity(2%)
5. ISA stands for (2%)
6. ____________(American National Standards Institute) (2%)
7. ASME stands for (2%)
8. NEC stands for (2%)

Answer the following question!

Note: Satisfactory rating - 8and 16points **Unsatisfactory - below 9and 16 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _________________________ Date: ______________

Score = ___________

Rating: _________

Information Sheet 2- Following instrumentation and control standards

2.1 Following instrumentation and control standards

Instrumentation and Control Standards Includes but not limited to Standard

A standard is a material measure or physical property that defines or reproduces the unit of measurement of a base or derived quantity. However, a standard also needs to be checked against a higher standard to establish its accuracy and traceability. Since the same argument would hold good even for the higher standard, this hierarchy of standards must lead to a level above which comparison is not possible.

- Regulations for consumers' electrical installations, 1969, issued by Ethiopian Electric Light and power Authority (EELPA), (now EEPCo)
- OIML (International Organization for Legal Metrology) Standards) or ES
- ISA (Instrumentation, Systems and Automation) Society (formerly Instrument Society of America)
- ANSI(American National Standards Institute)
- ASME (American Society of Mechanical Engineers)
- NEC (National Electrical Code)

2.1.1 Policy statement

An organization's occupational health and safety policy is a statement of principles and general rules that serve as guides for action. Senior management must be committed to ensuring that the policy is carried out with no exceptions. The health and safety policy should have the same importance as the other policies of the organization.

The policy statement can be brief, but it should mention:

- Management's commitment to protect the safety and health of employees.
- The objectives of the program.
- The organization's basic health and safety philosophy.
- Who is accountable for occupational health and safety programs.

- The general responsibilities of all employees.
- That health and safety shall not be sacrificed for expediency.
- That unacceptable performance of health and safety duties will not be tolerated.

The policy should be:

- Stated in clear, unambiguous, and unequivocal terms.
- Signed by the incumbent Chief Executive Officer.
- Kept up-to-date.
- Communicated to each employee.
- Adhered to in all work activities.

The following is an example of an occupational health and safety policy statement:

2.1.2 The general OH & S policies and procedures are as follows:

- No person shall be required or instructed to work in surroundings or under conditions that are unsafe or dangerous to his or her health.
- The employer shall be responsible for initiating and maintaining a safety and health program that complies with the US Army Corps of Engineers (USACE) safety and health requirements.
- Each employee is responsible for complying with applicable safety and occupational health requirements, wearing prescribed safety and health equipment, reporting unsafe conditions/activities, preventing avoidable accidents, and working in a safe manner.
- Safety and health programs, documents, signs, and tags shall be communicated to employees in a language that they understand.
- Worksites with non-English speaking workers shall have a person(s), fluent in the language(s) spoken and English, on site when work is being performed, to translate as needed.
- The Contractor shall erect and maintain a safety and health bulletin board in an area commonly accessed by workers. The bulletin board shall be maintained current, in clear view of on- site workers; and protected against the elements and

unauthorized removal. It shall contain at least the following safety and health information

General Safety Guidelines:

Follow the basic safety guidelines to prevent cuts, burns, electrical shock, and damage to eyesight. As a best practice here are some general safety guidelines:

- Remove your watch or any other jewelry and secure loose clothing.
- Turn off the power and unplug equipment before opening the case and performing service.
- Cover any sharp edges inside the computer case with tape.
- Never open a power supply.
- Know where the fire extinguisher is located and how to use it.
- Know where the first aid kit is located.
- Keep food and drinks out of your workspace.
- Keep your workspace clean and free of clutter.
- Lift heavy objects with your legs to avoid back injury.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. **Answer the following question as directed below each (2%)**

1. Write at least four personal protective equipment
2. ----------- is used for ear protection
3. What is the purpose of goggles/glasses
4. Workers should wear ------------- when working aboveground on building to protect head in which work is being done.
5. ------------- is worn to avoid such situations.
6. What is the purpose of safety belt/harness.
7. Employees should wear --------- for protecting feet while working or walking on job location.
8. ------------ are used in operations where in it becomes imperative to protect ones hands.

Answer the following question!

Note: Satisfactory rating 9 and 16 points Unsatisfactory - below 9and 16points

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: _______________

Information Sheet 3. Gathering and analyzing history cards and relevant information

3.1 Gathering and analyzing history cards and relevant information

Gathering and analyzing history card and relevant information help the technician to get full information about its work and to perform it works perfectly

Before you begin to troubleshoot any piece of equipment, you must be familiar with your organization's safety rules and procedures for working on electrical equipment. These rules and procedures govern the methods you can use to troubleshoot electrical equipment (including your lockout/ tagout procedures, testing procedures etc.) and must be followed while troubleshooting.

Next, you need to gather information regarding the equipment and the problem. Be sure you understand how the equipment is designed to operate. It is much easier to analyze faulty operation when you know how it should operate. Operation or equipment manuals and drawings are great sources of information and are helpful to have available. If there are equipment history records, you should review them to see if there are any recurring (chronic) problems. You should also have on-hand any documentation describing the problem. (i.e., a work order, trouble report, or even your notes taken from a discussion with a customer.)

Gathering information describe the process of acquiring knowledge .it is not the knowledge it self

There are different methods of information gathering

- Questionnaires ,surveys and checklist
- Personal interview
- Observation
- Focus group
- Case study

Data analysis is a process of inspecting, cleansing, transforming, and modeling data with the goal of discovering useful information, informing conclusions, and supporting decision making

Data integration is precursor to data analysis and data analysis is closely linked to data visualization and data dissemination

Steps for gathering information

Step 1 observation

Step 2 define problem area

Step 3 identify possible causes

Step 4 determine most probable cause

Step 5 test and repair

Step 6 follow-up

Step 1 – Observe

Most faults provide obvious clues as to their cause. Through careful observation and a little bit of reasoning, most faults can be identified as to the actual component with very little testing. When observing malfunctioning equipment, look for visual signs of mechanical damage such as indications of impact, scratched wires, loose components or parts lying in the bottom of the cabinet. Look for signs of overheating, especially on wiring, relay coils, and printed circuit boards.

Don't forget to use your other senses when inspecting equipment. The smell of burnt insulation is something you won't miss. Listening to the sound of the equipment operating may give you a clue to where the problem is located. Checking the temperature of components can also help find problems but be careful while doing this, some components may be alive or hot enough to burn you.

Pay particular attention to areas that were identified either by past history or by the person that reported the problem. A note of caution here! Do not let these mislead you, past problems are just that – past problems, they are not necessarily the problem you are looking for now. Also, do not take reported problems as fact, always check for yourself if possible. The person reporting the problem may not have described it properly or may have made their own incorrect assumptions.

When faced with equipment which is not functioning properly you should:

- Be sure you understand how the equipment is designed to operate. It makes it much easier to analyze faulty operation when you know how it should operate;
- Note the condition of the equipment as found. You should look at the state of the relays (energized or not), which lamps are lit, which auxiliary equipment is energized or running etc. This is the best time to give the equipment a thorough inspection (using all your senses). Look for signs of mechanical damage, overheating, unusual sounds, smells etc.;
- Test the operation of the equipment including all of its features. Make note of any feature that is not operating properly. Make sure you observe these operations very carefully. This can give you a lot of valuable information regarding all parts of the equipment.

Step 2 – Define Problem Area

It is at this stage that you apply logic and reasoning to your observations to determine the problem area of the malfunctioning equipment. Often times when equipment malfunctions, certain parts of the equipment will work properly while others not.

The key is to use your observations (from step 1) to rule out parts of the equipment or circuitry that are operating properly and not contributing to the cause of the malfunction. You should continue to do this until you are left with only the part(s) that if faulty, could cause the symptoms that the equipment is experiencing.

To help you define the problem area you should have a schematic diagram of the circuit in addition to your noted observations.

Starting with the whole circuit as the problem area, take each noted observation and ask yourself "what does this tell me about the circuit operation?" If an observation indicates that a section of the circuit appears to be operating properly, you can then eliminate it from the problem area. As you eliminate each part of the circuit from the problem area, make sure to identify them on your schematic. This will help you keep track of all your information.

Step 3 – Identify Possible Causes

Once the problem area(s) have been defined, it is necessary to identify all the possible causes of the malfunction. This typically involves every component in the problem area(s).

It is necessary to list (actually write down) every fault which could cause the problem no matter how remote the possibility of it occurring. Use your initial observations to help you do this. During the next step you will eliminate those which are not likely to happen.

Step 4 – Determine Most Probable Cause

Once the list of possible causes has been made, it is then necessary to prioritize each item as to the probability of it being the cause of the malfunction. The following are some rules of thumb when prioritizing possible causes.

Although it could be possible for two components to fail at the same time, it is not very likely. Start by looking for one faulty component as the wrong.

The following list shows the order in which you should check components based on the probability of them being defective:

- First look for components which burn out or have a tendency to wear out, i.e. mechanical switches, fuses, relay contacts, or light bulbs. (Remember, that in the case of fuses, they burn out for a reason. You should find out why before replacing them.)

- The next most likely cause of failure are coils, motors, transformers and other devices with windings. These usually generate heat and, with time, can malfunction.
- Connections should be your third choice, especially screw type or bolted type. Over time these can loosen and cause a high resistance. In some cases this resistance will cause overheating and eventually will burn open. Connections on equipment that is subject to vibration are especially flat to coming loose.
- Finally, you should look for is defective wiring. Pay particular attention to areas where the wire insulation could be damaged causing short circuits. Don't rule out incorrect wiring, especially on a new piece of equipment.

Step 5 – Test and Repair

Testing electrical equipment can be hazardous. The electrical energy contained in many circuits can be enough to injure or kill. Make sure you follow all your companies' safety precautions, rules and procedures while troubleshooting. Once you have determined the most probable cause, you must either prove it to be the problem or rule it out. This can sometimes be done by careful inspection however, in many cases the fault will be such that you cannot identify the problem component by observation and analysis alone. In these circumstances, test instruments can be used to help narrow the problem area and identify the problem component. There are many types of test instruments used for troubleshooting. Some are specialized instruments designed to measure various behaviors of specific equipment, while others like the multimeters are more general in nature and can be used on most electrical equipment. A typical multimeter can measure AC and DC Voltages, Resistance, and Current.

A very important rule when taking meter readings is to predict what the meter will read before taking the reading. Use the circuit schematic to determine what the meter will read if the circuit is operating normally. If the reading is anything other than your predicted value, you know that this part of the circuit is being affected by the fault.

Depending on the circuit and type of fault, the problem area as defined by your observations, can include a large area of the circuit creating a very large list of possible and probable causes. Under such circumstances, you could use a “divide and eliminate” testing approach to eliminate parts of the circuit from the problem area. The results of each test provides information to help you reduce the size of the problem area until the defective component is identified.

Once you have determined the cause of the faulty operation of the circuit you can proceed to replace the defective component. Be sure the circuit is locked out and you follow all safety procedures before disconnecting the component or any wires.

After replacing the component, you must test operate all features of the circuit to be sure you have replaced the proper component and that there are no other faults in the circuit. It can be very uncomfortable to tell the customer that you have repaired the problem only to have him find another problem with the equipment just after you leave.

Follow up: Although this is not an official step of the troubleshooting process it nevertheless should be done once the equipment has been repaired and put back in service. You should try to determine the reason for the malfunction.

- Did the component fail due to age?
- Did the environment the equipment operates in cause excessive corrosion?
- Are there wear points that caused the wiring to short out?
- Did it fail due to improper use?
- Is there a design error that causes the same component to fail repeatedly?

Through this process further failures can be minimized. Many organizations have their own follow-up documentation and processes. Make sure you check your organization’s procedures. Adopting a logical and systematic approach

You must be able to:

- work safely at all times, complying with health and safety legislation, regulations and the relevant guidelines
- plan the maintenance activities before you start them
- obtain all the information you need for the safe removal and replacement of the instruments and/or sensors
- obtain and prepare the appropriate tools and equipment
- apply appropriate maintenance diagnostic techniques and procedures
- use the appropriate methods and techniques to remove and replace the required instruments/sensors
- carry out tests on sensing elements and associated instruments
- deal promptly and effectively with problems within your control, and seek help and guidance from the relevant people if you have problems that you cannot resolve
- leave the work area in a safe and tidy condition on completion of the maintenance activities

Proceed by asking questions and finding answers to them.

State questions as simply as possible. Select questions which can be answered easily and will provide the maximum information to help find the fault. Answer the questions by Thinking, Observing, and Testing. Refer to experts, manufacturers, or agents. Check manuals, text books, catalogs, technical data sources. etc.

1. Make observations, tests, etc. from the simple to the complex, but always do the simple things first.
2. Think about failure the degree of failure, the causes of failure, the time course of the failure, and the combinations of failure. In other words, given the information at hand:

a. What is most likely to have failed?

b. What was the most probable cause of the failure?

c. How can the fault and the cause be corrected?

3. Keep records

History card preparation

History card	Perfect instrumentation control			
Tag no	PG-01			
ID No	1-003			
description	Pressure gage			
Maker	Fibig			
Range	0 to 60Kg/cm2			
Accuracy	*/- 0.35%			
Location	Lab	Work description	remark	Due date
SR NO	04 oct 11	calibrated	Ok	10 apr
	05 apr 11	Replaced part	ok	-

TO CALIBRATE A VALVE:

1. Place the loop in manual with a 0% output. Adjust the valve zero until the valve is at its full de-energized position.
2. Set the manual output at 100%. Adjust the valve span until the valve is at its full energized position.
3. Set the manual output at 50%. Verify that the valve is at its 50% position.

If a loop has been tuned with an improperly calibrated valve, recalibration may change the

process gain requiring retuning of the control loop.

- Check the valve dead band. Excessive dead band will cause an integrating process to oscillate and increase the stabilization time of a self-regulating process.
- Check for valve stiction. Stiction in a valve will cause oscillations in a self-regulating process.
- Check the gain of the valve. An oversized valve will magnify dead band and stiction problems.
- Check the tuning of the positioner. An aggressively tuned positioner can cause valve Cycling

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed each contain (3%)

1. why you Gathering and analyzing history card and relevant information
2. ______________a process of inspecting, cleansing, transforming, and modeling data with the goal of discovering useful information, informing conclusions, and supporting decision making
3. ______________is precursor to data analysis and data analysis is closely linked to data visualization and data dissemination
4. Write at least 3 methods of information gathering

1**Note: Satisfactory rating - 7and 12 points Unsatisfactory - below 7and 12points**

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Answer Sheet

Name: _________________________ Date: _______________

Information Sheet 4- Obtaining tools, equipment and testing devices needed to carry out work

Obtaining tools, equipment and testing devices needed to carry out work

Materials Include but not limited to:

- Sealing materials
- Pipes/tubes & fittings
- Wires and cables

Tools Include but not limited to:

- cutter
- shaper
- drill
- threading tool (assorted)
- tapping
- pliers (assorted)
- screw drivers (assorted)
- soldering iron/gun
- wrenches

Refer the above tools UC1 in level 1

Equipment/ testing devices

- communication equipment (e.g. 2-way radio, cell phone)
- configuration or programmer
- multi-meter
- calibrators
- signal generators and signal simulators
- oscilloscope
- Various instruments and control devices

Calibrator

A formal and technical definition of “calibrator” is “a measurement standard used in calibration.” This definition comes from the BIPM (Bureau International des Poids et Mesures or International Bureau of Weights and Measures), based in France. BIPM coordinates the worldwide measurement system and works to unify measurements around the world.

Calibrator is an instrument used as a reference (also called a standard), whose measurements are compared with the measurements of another instrument of lesser accuracy (called the device under test). The reason for doing the test is to determine whether the device under test (DUT) is as accurate as it’s supposed to be.

People refer to calibrators in various ways. The following terms are often used as synonyms:

Sometimes an instrument like a digital multimeter is used as a calibrator, but the functionality is the same comparing the measurements of a more accurate instrument with those of a less accurate instrument.

The accuracy ratio is typically four-to-**one (4:1).** That is, best practices state that the calibrator should be at least four times more accurate than the device under test.

Fig 1 a Variety of Calibrators

A calibrator is used to confirm whether a device under test (DUT) is operating within the measurement range specified by its manufacturer.

Use of calibrator

fig 2 Calibration Example

The image to the right illustrates the readout method for calibrating thermometers. A calibrated reference probe and probes under test or DUTs are submerged into a liquid at stable temperature. The temperature reading of the calibrated probe is compared to the readings of the probes under test.

General steps for using a calibrator:

1. Make a measurement with the instrument.
2. Make the same measurement with the DUT.
3. Evaluate the uncertainty of the measurement process.
4. Calculate the difference between the measurements. This will tell you the measurement error between the calibrator and the DUT.
5. Record the measurements and the results.
6. Continue these steps for as many measurement points as required by the calibration procedure.

When you have completed making the measurements and comparing them you can verify if the DUT error is less than the product specifications (in-tolerance) or not. If it isn't, you'll need to decide whether the DUT can be repaired or adjusted, and then re-calibrated to confirm that it performs within specification.

If a calibrator is used as a source (rather than as a measuring device), the process would be similar, but you would connect the DUT to the calibrator and send a known quantity (for example, 10 Volts in the case of an electrical calibrator or 100°C in the case of a temperature calibrator) from the calibrator to the DUT. You know how accurate the calibrator's source signal is, and therefore can look at how the signal appears on the DUT and calculate whether the DUT is within its specification.

Importance calibration

The process of tracking the accuracy of measurements from the lowest to the highest level is called traceability, and it's the process that enables measurements to be performed uniformly around the globe. It is also important to understand the quality of each comparison, which is communicated by the measurement uncertainty of each comparison. Without measurement uncertainty, measurement traceability does not exist.

Uniform measurements are important because not only do you want to trust that you're getting that pound of hamburger, you also want to trust that the nuts and bolts that hold bridges together have the proper metallurgical composition and are the correct size, or that the electronics in your cell phone perform the way they should.

On a larger level, measurement uniformity makes global trade possible. Calibration helps to ensure correct and uniform measurements and that is why calibration is important.

There are many different types of calibrators which include:

- **Temperature**
  - Thermocouple
  - Calibration bath
  - ITS-90 fixed-point cell
  - Dry-block
  - Infrared
- **Pressure**
  - Piston gauge
  - Deadweight tester
  - Pressure controller
  - Pressure comparator
  - Portable/handheld pressure
  - Air data
  - Electrical
  - RF
  - Humidity
  - Flow
  - Process

Temperature calibrator

A temperature calibrator calibrates devices that measure temperature. Common devices or workload to be calibrated include:

- Thermometers
- Temperature probes
- Temperature transmitters
- Temperature sensors
  - Platinum resistance thermometers (PRT or PT-100)
  - Resistance-temperature detectors (RTD)
  - Thermistors

o Thermocouples

The type of temperature calibration instrument selected for a particular calibration task depends on the type of sensor to be calibrated, the environment in which it is to be calibrated, and the required accuracy of the calibration.

Thermocouple calibrator

Thermocouples are sensors comprised of two wires made from different metals, connected to form a junction. Temperature is measured at the junction. There are many different types of thermocouples, with variations in the type of metal, temperature range, resistance, durability, and applications. They are commonly used in industry because they are inexpensive and cover a wide temperature range.

fig 3 Thermocouple Calibrator

In many cases, thermocouples are calibrated in situ but in some cases, a thermocouple might need to be removed and placed in a precision temperature source like a dry-well.

To perform a calibration, the technician follows a procedure similar to this:

1. Connect the thermocouple sensor to the calibrator or immerse it into a dry-well or bath.
2. Adjust the calibrator's temperature to each of the sensor's test points.
3. Record the temperature reading at each set point.

4. Compare the measured voltage of the thermocouple sensor to that of the temperature calibrator.
5. Repeat for each test point.

In addition to measuring thermocouple temperatures, a thermocouple calibration instrument might also be able to simulate temperature. This lets a technician verify if the thermocouple responds correctly to the temperature being sourced or supplied to it. Learn more about thermocouple calibrators.

Calibration bath

fig 5 Calibration Bath

A temperature calibration bath is an enclosure filled with fluid that maintains a uniform, constant temperature for calibrating a wide variety of sensors that require immersion into a stable temperature source. Baths are typically very stable—that is, able to hold the same temperature over time - and have a relatively large working volume for calibrating multiple sensors at once.

A temperature bath typically includes:

- Container to hold the bath fluid. The size of the container can vary to accommodate different types of fluids and sensors.
- Baths may use a wide variety of fluids depending on the required temperature. Examples of fluids include water, ethyl alcohol, silicone oil, mineral oil, or bath salts.

- The temperature controller controls the bath's temperature. It is important to understand the accuracy and temperature range of the bath and to match it with the right type of fluid.
- Various stands, rods, and clamps can be used to hold the probes being calibrated in the bath.

To perform a calibration using a temperature bath:

1. Set the bath temperature and wait for it to reach that temperature and become stable (temperature stays the same over time).
2. Insert the reference probe into the bath.
3. Insert the probes to be calibrated (DUTs) into the bath. An advantage of a bath is that it can support different types and sizes of probes.
4. Compare the measurements made by the reference probe with those made by the DUTs.
5. Repeat these steps for each temperature that needs to be checked.

ITS-90 fixed-point cell

fig 6 ITS-90 Fixed Point Cell

ITS-90 fixed-point cells are primary standards, also known as defining instruments of the ITS-90 (International Temperature Scale of 1990). Fixed-point cells are used to provide the highest temperature accuracy. They are used to calibrate standard platinum resistance thermometers (SPRTs).

ITS-90 fixed-point cells can be made of metal or quartz. Metal cells contain metals like mercury or copper, which maintain constant and intrinsic temperatures at freezing or melting points.

Triple point of water cells contain pure water and water vapor in a sealed quartz container. These cells achieve a temperature of 0.01 °C when their contents are in the “triple point” state where the water exists simultaneously as a liquid, a solid and a gas. Watch this video to see how the triple point of water is achieved.

Fixed-point cells perform calibrations by achieving a fixed temperature that is used as a very accurate reference to compare with the SPRT being tested.

To use a fixed-point cell:

1. Bring the cell to its fixed-point temperature.
2. Insert the thermometer to be tested.
3. Record the measurement.

Dry-block calibrator

fig 7 Dry-Block Calibrator

A dry-block, also known as a dry-well, calibrates temperature sensors like thermocouples, thermometers, thermistors, and RTDs in a liquid-free enclosure. Dry-blocks are used when the devices to be tested need both accuracy and portability.

A dry-block includes a container with a well for holding the devices under test. The well typically can accommodate a variety of removable inserts designed to hold the device(s). The dry block also includes a controller for setting and regulating the temperature in the well. Optionally it might also include a built-in reference thermometer.

To use a dry-block:

1. Insert the correctly sized well insert into the dry-block's well.
2. Insert the reference thermometer (if it's not built in or is desired for increased accuracy).
3. Insert the DUTs into the well insert.
4. Set the first temperature.
5. Compare the temperature(s) measured by the DUTs to the temperature measured by the reference thermometer.

Infrared calibrator

fig 8 Infrared Calibrator

An infrared calibrator, sometimes referred to as an infrared blackbody, calibrates infrared thermometers, thermal imagers and pyrometers. It includes a flat black surface that emits and absorbs electromagnetic radiation focused on it from the DUT. It also includes a display to show the temperature measurement and other information such as emissivity setting and stability.

To use an infrared calibrator:

1. Set the desired set-point temperature and wait until the unit reaches that temperature.

2. Turn on the DUT and aim the beam toward the center of the heated blackbody surface.

3. Record the measurement.

Pressure calibrator

A pressure calibrator calibrates devices that measure pressure. Common devices, or workload, that can be calibrated include:

- Analog and digital pressure gauges
- Digital test gauges
- Pressure transducers
- Barometers
- Relief valves
- Dial gauges
- Pressure switches
- Pressure sensors
- Pressure transmitters
- Down hole tools
- Relief valves

Pressure calibration instruments require a pressure supply, which typically comes from compressed gas (pneumatic) or compressed fluid (hydraulic). The pressure supply can be external (for example, it comes from a tank full of gas) or internal (such as a pump built into the instrument).

Piston gauge

fig 9 Piston Gauge

A piston gauge is also referred to as a pressure balance or a deadweight gauge. Workload (or things that can be calibrated) for this type of calibration instrument includes:

- Pressure controllers
- Deadweight testers
- Other piston gauges
- Portable and handheld pressure standards
- High accuracy barometers
- Air data test sets

A piston gauge typically includes:

- A piston-cylinder and platform
- Calibrated masses (weights) to mount on the piston
- Controller to set and adjust pressure
- Bell jar cover (in some cases)
- Various accessories (O-rings, valves, etc.)
- External pressure source

A piston gauge operates by balancing pressure from a weight mass, subjected to acceleration due to gravity, against a vertically mounted piston rotating in a cylinder. A technician loads a specific weight (mass) onto the piston, applies pressure to raise the piston above the piston gauge housing until it's "floating" and rotates the piston. When the force applied by the pressure and the force applied by the mass are in equilibrium, the piston "floats". At this point, the piston gauge is ready to make a measurement.

Deadweight tester

fig 10Deadweight Tester

A deadweight tester uses calibrated weights (masses) to apply pressure to a device under test (DUT) so that its pressure can be measured.

Deadweight testers calibrate a wide variety of pressure gauges and sensors. Parts of a deadweight tester typically include:

- Piston cylinder and platform
- Calibrated masses (weights)
- A reservoir for holding the pressure source (gas or liquid)
- A pump to generate and adjust the pressure

To perform a calibration with a deadweight tester:

1. Set the mass (weight) on the piston.
2. Increase the pressure under the piston until it floats while being rotated. Determine the reference pressure from the calibrator due to the environmental data and calibration data.
3. When the pressure stabilizes, take the measurement.

Pressure controller/calibrator

fig 11 Pressure Controller/Calibrator

A pressure controller/calibrator measures and controls the pressure in a test system. Most modern controllers reach stable pressure quickly and can cover a wide range of pressures. They are so accurate they can even replace piston gauges in some applications.

Pressure controllers calibrate workload (devices under test - DUTs) that includes:

- Digital test gauges
- Pressure transmitters
- Pressure transducers
- Dial gauges
- Pressure switches
- Portable calibrators
- Barometers
- Downhole tools

Many pressure controllers can be automated with calibration software and support remote communication through RS-232, GPIB, USB, and/or Ethernet ports. They can sometimes be rack-mounted. These features make them popular in manufacturing applications.

A pressure controller typically includes:

- Devices to measure and control pressure
- Display
- Keys and/or dials to enter and adjust data
- Port to which pressure can be applied

To use a pressure controller:

1. Connect it to a pressure supply.
2. Connect the DUT to a test port.
3. Use the instrument’s controls to adjust the pressure.
4. Take and record the measurement.
5. Move to the next test point and repeat the process.

See the benefits of a modular pressure controller in this video.

Pressure comparator

fig 11 Pressure Comparator

A pressure comparator supplies a precisely controlled pressure to both a reference gauge and DUT. Pressure comparators include mechanical components that generate and fine-tune pressure measurements. A comparator also includes a test port for a reference gauge and a second port for the DUT. A hydraulic comparator includes a fluid reservoir and a screw press for generating the pressure. A pneumatic comparator includes a pump for generating the pressure and a vent valve for releasing the pressure.

Pressure comparators calibrate devices or workload that includes:

- Dial gauges
- Pressure transmitters
- Pressure switches
- Relief valves

To use a pressure comparator:

1. Connect the reference gauge and the DUT.
2. Use a pump to apply pressure.
3. Use a screw press to adjust the pressure.
4. Take and record the measurement.
5. Move to the next test point and repeat the process.

Portable handheld pressure calibrator

fig 12 Portable Handheld Pressure Calibrator

A portable handheld pressure calibrator is typically small enough to hold in one hand, and it is often rugged enough to use in industrial environments. They are typically less accurate than bench pressure calibrators like those discussed above.

Portable pressure calibrators calibrate:

- Dial gauges
- Pressure transmitters
- Pressure switches
- Relief valves

A portable pressure calibrator typically consists of a display, ports for connecting test leads, and buttons to set and adjust the pressure parameters. As with all pressure calibrators, a pressure source is also required. This could be an external source or a built-in pump. These devices are often used in industrial environments and might be battery-powered, lightweight, and include a sturdy case.

To perform a test with a portable pressure calibrator:

1. Connect the instrument to the device under test (DUT).
2. Apply pressure to the DUT.
3. Record the measurement displayed on the instrument.
4. Move to the next test point and repeat the process.

Air data calibrator

fig 4.12 Air Data Calibrator

Air data calibrators calibrate avionics instrumentations such as:

- Altimeters
- Airspeed indicators
- Rate of climb meters
- Mach meters
- Air data computers
- Engine-based control systems

These instruments typically include keys and/or a dial and a display for setting and viewing pressures, plus electronics for measuring and controlling pressure. It might also include connectors for automating the calibration with calibration software.

To use an air data calibrator:

1. Set the appropriate unit of pressure.
2. Set the instrument to control the pressure.
3. When pressure is stabilized, set the instrument to make a measurement.
4. Make and record the measurement.
5. Move to the next test point and repeat the process.

Electrical calibrator

fig 14 Electrical Calibrator

An electrical or electronic calibrator calibrates electronic instruments. Electronic instruments typically measure some combination of voltage, current, resistance, inductance, capacitance, time and frequency. They might also include electrical power and phase.

An electrical calibrator typically provides output signals that are read by the DUT. It might also make precision measurements.

Typical instruments or workload that can be calibrated by an electrical calibrator includes:

- Digital multimeters
- Current clamps and clamp meters
- Thermocouples and RTDs
- Process calibrators
- Data loggers
- Strip and chart recorders
- Wattmeters
- Power harmonics analyzers
- Panel meters
- Graphical multimeters

Some calibration instruments can be purchased with options to handle additional workload like oscilloscopes and power quality analyzers.

An electrical calibrator typically includes input and output ports, keys and/or a dial to input parameters and make menu selections, and a display. It might include connectors for remote or automated operation. Some of these instruments can be partially or fully automated with software.

To use an electrical calibrator:

1. Connect the instrument to the device under test (DUT).

2. Set the DUT to the appropriate parameter (for example, 10 volts dc).
3. Set the instrument to output the appropriate source for that parameter.
4. Press a Start or Enter key on the instrument to begin the test.
5. Record the result.

Many electrical calibrators are laboratory instruments that sit on a bench and plug into a wall. For fieldwork, portable electrical or current instruments can be used, although they are typically not as accurate as the bench instruments.

fig 15 RF Calibrator

A radio frequency, or RF, calibrator

Calibrates radio frequency in instruments such as:

- Spectrum analyzers
- RF power sensors
- Modulation meters and analyzers
- Measurement receivers
- Frequency counters
- RF attenuators and components
- High-frequency oscilloscopes

RF calibration can be complex because of the number of tests required to calibrate this type of workload. Therefore, a system comprised of multiple instruments is typically required. Instruments found in a typical RF calibration system include:

- Signal generators
- Level generator

- Function generator
- Power meters
- Measuring receiver
- Spectrum analyzer
- RF and microwave counters
- Network analyzer
- Audio analyzer
- Oscilloscope
- Digital multimeter

These instruments might be individual pieces of equipment; however, in some cases, the functionality of multiple instruments might be combined in a single calibration instrument. Consolidating functions helps to reduce the possibility of error.

To use an RF calibrator, you connect it to the DUT and generate a series of signals such as RF output, leveled sine, modulated output, sweep output, frequency, power and more. Choosing the right kinds of cables is important to avoid excessive attenuation (reduction of the signal) and other unwanted effects. You might need to apply RF correction factors to account for measurement issues such as adapter insertion loss or splitter tracking errors.

Humidity Calibrator

fig 16 Humidity Calibrator

A humidity calibrator generates humidity to test sensors such as humidity probes that make critical measurements to protect against spoilage in industries such as pharmaceuticals, medical devices, semiconductors, chemicals, and food production.

A humidity calibrator typically includes:

- Chamber for holding the device under test (DUT)
- Display to show temperature and humidity setpoints and actual measurements
- Mixing insert to circulate air for temperature and humidity uniformity
- Container for holding water
- Desiccant cartridge to provide a source of low humidity

To use a humidity calibrator, follow these general steps:

1. Fill the designated container with distilled water.
2. Place the DUT(s) into the calibration chamber.
3. Set temperature and humidity.
4. Make sure the temperature and humidity are stable.
5. Make and record the measurements.
6. Do lower-relative humidity calibrations first and ramp up to the higher-humidity levels on each subsequent step.

See a product demonstration of the Fluke 5128A Humidity Generator in this video.

Flow calibrator

fig 17 Flow Calibrator

A flow calibrator calibrates devices that sense and control flow. Typical devices under test (DUTs) include flow meters and flow controllers used in process control applications, environmental quality/monitoring, medical/breathing systems, leak testing, and National Measurement Institutes.

These instruments may test gas flow or liquid flow. When testing liquid flow, the liquid can remain in an open container, but when testing gas flow, the gas must be contained.

A flow calibrator typically includes:

- A user interface comprised of a display and keypad
- Flow elements that make the actual flow measurements
- Various connectors

To use a flow calibrator:

- Make a leak-free plumbing connection between the DUT and the instrument.
- Pass the gas or liquid media through both devices, maintaining a steady-state flow.
- Compare the outputs of the instrument and the DUT over the same time period.

Some flow calibration instruments can be automated with calibration software. Automation enables you to take multiple readings at the same time from both the DUT and the instrument.

Process calibrator

The term "process calibrator" refers to a category of instruments used in process industries. A process industry is one that produces a product using ingredients in a batch, rather than manufactured with parts as an individual product. Examples of process industries include food and beverage, chemicals, pharmaceuticals, and petroleum.

- **Milliamp (mA) loop calibrators**. This category of tools might perform calibrations, troubleshoot control valves, or both.

- Documenting process calibrators**.** As the name implies, these tools perform calibrations and also document the results. This category of instrument typically sources and measures a wide variety of parameters that could include volts, frequency, ohms, thermocouples, and more.
- **Handheld temperature calibrators**. As the name states, these are handheld tools that source and measure temperature. They typically simulate outputs from temperature sensors and are used with a reference probe whose measurements are compared with those of the sensor under test. Learn more at our Temperature Calibrator page.
- Multifunction process calibrators**.** These instruments are designed for process professionals who work with a varied workload and need to calibrate various test and measurement instruments, so they require a wide variety of sourcing and measurement capabilities.
- Pressure gauge calibrators**.** This type of instrument typically includes a reference pressure gauge that is used as a reference to compare against the gauge being tested.

fig 17 Process Calibrators

Who uses calibrators

Calibration professionals are people who care about making accurate measurements and maintaining measurement quality to one degree or another. A variety of different job titles could be considered for people who perform calibrations.

Metrologist

Metrologists work in measurement science. A metrologist's responsibilities might include:

- Maintaining traceability of his company's instruments, measurements, and calibrations
- Maintaining calibration laboratory accreditation
- Developing and evaluating calibration systems
- Identifying and quantifying error sources that contribute to the uncertainty of results, to determine the reliability of measurement processes
- Redesigning or adjusting measurement capabilities to minimize errors
- Developing calibration methods
- Directing engineering, quality and laboratory personnel in measurement standards

You might find a metrologist in a calibration laboratory in a manufacturing company, or in a third-party calibration lab that specializes in performing calibrations on behalf of others. Governments typically have calibration laboratories staffed with metrologists.

Calibration engineer

This field of engineering supports activities like these:

- Analyzing inspection, measuring, and test equipment to determine the calibration requirements
- Determining the functions to be tested and their specifications, the methods to be used, and the measurement standards required
- Preparing and testing new calibration procedures.
- Setting appropriate calibration intervals to meet corporate reliability goals

Calibration engineers often work in calibration laboratories or calibration services companies, but you might also find them in process industries, labs or on the factory floor.

Calibration technician

A calibration technician performs tasks like these:

- Tests, calibrates and repairs instruments and equipment for conformance to standards
- Assists in formulating calibration standards
- Uses documentation to plan calibration procedures and determine the required equipment
- Sets up laboratory equipment to test, evaluate and calibrate other instruments and test equipment
- Disassembles instruments and inspects components for defects
- Aligns, repairs, replaces component parts and circuitry
- Assists engineers in formulating test, calibration, repair and plans to maintain the accuracy of instruments and equipment

Calibration technicians work in calibration labs, including third-party labs, large in-house labs and I&E shops.

Laboratory manager

A calibration laboratory manager typically performs these tasks:

- Supervises laboratory technicians
- May function as a metrologist in addition to being a business manager
- Works in an office but can go out to the field if needed
- Reviews data for consistency and acts as a dispatcher tech when a need for reactive maintenance is identified
- Responsible for lab throughput, turnaround time and on-time delivery

Lab managers work in calibration laboratories, including third-party labs, large in-house labs, I&D shops, and government labs.

manufacturing engineer performs:

- Production related activities, such as setting up and maintaining a production cell and equipment
- Preventive maintenance

- Troubleshooting performance and quality issues
- Equipment repair
- Calibration
- Software development
- Safety-related activities

Manufacturing engineers work for small, medium or large manufacturers.

Instrument technician

An instrument tech's responsibilities might include

- Installing, calibrating or maintaining instrumentation for a facility or region
- Completing the jobs assigned to him by the maintenance manager or instrumentation lead at larger companies
- Might also be an electrician

Instrument technicians typically work at large process companies (mills, pharmaceuticals, oil and gas, chemical processing)

How often should a calibrator be used

Another way to ask this question is, how often should you calibrate? The answer depends on the nature of your workload (the types of things you calibrate and how often), the quality standards you comply with, your requirements for accuracy, and your specific applications. Most of the instruments you calibrate will have calibration intervals recommended by their manufacturers. You might also decide to perform calibrations in a regular cadence, such as annually or biannually. If you frequently make critical measurements, you might want to calibrate even more often – even monthly.

Other factors that might influence how often you calibrate:

- Your organization is implementing a critical measuring project, such as taking a plant down for testing. If you work in an industry such as pharmaceutical, regulations might require you to calibrate before and after the project. Similarly, if your organization requires highly accurate measurements, you want to ensure that your measurement standards remain in tolerance.

- An instrument is impacted in some way that might affect its performance. For example, if an instrument is dropped, you might want to calibrate it to make sure it remains in good working order.

Of course, you will need to calibrate your equipment periodically, and that may mean taking it out of service while the calibration is being done. If calibrating a calibrator, in some cases, a modular type of calibrator could remain in service because you can swap out and calibrate the modules.

Automation of calibrators

Performing calibrations manually can be time consuming and also carries the possibility of user error. Automating the process can improve throughput significantly while also ensuring that the calibrations are performed consistently and without error.

Calibrators are typically automated with software. The calibration software includes a series of step-by-step commands, called procedures that tell the instrument what signals to output throughout the test. The procedure might also include illustrations that show a technician how to connect the instrument to the device under test (DUT). If a calibrator can be automated completely, the technician just connects it to a DUT, runs the appropriate procedure, and walks away to perform other tasks.

When should you upgrade an old calibrator?

For many calibration professionals, a calibrator just keeps getting better over the years. That's because over time the lab learns how the instrument behaves, so there is a general understanding, plus recorded data, of the instrument's drift rate, accuracy, and so forth.

However, no one wants to risk the downtime that results when a calibrator stops working. Careful planning is necessary to make decisions about the best time and/or reasons to replace an old calibration instrument.

In planning for a replacement purchase, you’ll want to understand how the old one is being used and what the risks are if it malfunctions. Mission-critical equipment should be replaced before a downtime situation occurs.

Here are some reasons you might want to replace an old calibrator:

- It’s obsolete or end-of-service, meaning the manufacturer no longer supports it
- It’s broken or damaged, and repairs are expensive or not possible
- Your workload has grown and/or changed and you need better capability
- You want to take advantage of features in newer calibration instruments
- You want an instrument that is easier for new technicians to learn to use
- You are offered a good deal on a new instrument, such as a trade-in program

Communication tools

A two-way radio is a radio that can both transmit and receive radio waves (a transceiver), unlike a broadcast receiver which only receives content. It is an audio (sound) transceiver, a transmitter and receiver in one unit, used for bidirectional person-to-person voice communication with other users with similar radios. Two-way radios are available in stationary (base station), mobile (installed in vehicles), and hand-held portable models. Hand-held two-way radios are often called walkie-talkies, handie-talkies or hand-helds. Two-way radios are used by groups of geographically separated people who need to keep in continuous voice communication, such as aircraft pilots and air traffic controllers, ship captains and harbormasters, emergency services personnel like firemen, policemen, and ambulance paramedics, taxi and delivery services, soldiers and military units, fast food and warehouse employees, and radio amateurs.

Fig 18 two way radio

Configuration/programmer

A **computer programmer**, sometimes called a **software developer**, a **programmer** or more recently a **coder** (especially in more informal contexts), is a person who creates computer software. The term computer programmer can refer to a specialist in one area of computers, or to a generalist who writes code for many kinds of software.

In communications or computer systems, a configuration of a system refers to the arrangement of each of its functional units, according to their nature, number and chief characteristics. Often, configuration pertains to the choice of hardware, software, firmware, and documentation. Along with its architecture, the configuration of a computer system affects both its function and performance

Configuration Vs programmer

Programming requires an understanding of the problem. For data sharing, the programmer needs to understand the data sharing devices, the operating system and communication protocols. For optimal data sharing, the programmer may need an in-depth knowledge of the device and memory interactions.

Configuration tools guide the programmer through the process using interactive methods. For data sharing, the configuration tools identify the options available for the selected target platform. For Poly-Platform, the platform specifics are pre-configured defaults which enable the programmer to quickly have the application running on the target.

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. **Answer the following question as directed bellow each contain (2%)**

1. _______ is an instrument used as a reference (also called a standard), whose measurements are compared with the measurements of another instrument of lesser accuracy (called the device under test).
2. Sometimes an instrument like a digital multimeter is used as a calibrator (True, False)

3. __________used to confirm whether a device under test (DUT) is operating within the measurement range specified by its manufacturer.

4. Write General steps for using a calibrator:

5. Define traceability

6. Without measurement uncertainty, measurement traceability does not exist.(True, False)

7. Calibration helps to ensure correct and uniform measurements and that is why calibration is important(True, False)

8. _____________calibrates devices that measure temperature.

9. _____________are sensors comprised of two wires made from different metals, connected to form a junction.

10. ___________ is an enclosure filled with fluid that maintains a uniform, constant temperature for calibrating a wide variety of sensors that require immersion into a stable temperature source.

11. ________________instruments require a pressure supply, which typically comes from compressed gas (pneumatic) or compressed fluid (hydraulic).

12. _______________ uses calibrated weights (masses) to apply pressure to a device under test (DUT) so that its pressure can be measured.

13. _____________measures and controls the pressure in a test system

14. Who uses calibrators?
    a) Mythologist
    b) Calibration engineer
    c) Calibration technician

d) Laboratory manager

e) Manufacturing engineer

f) All

Answer the following question!

Note: Satisfactory rating 3 and 5 points Unsatisfactory below 3 and 5 points

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: _______________

Information Sheet 5. Consulting appropriate personnel to coordinated work

5.1 Consulting appropriate personnel to coordinated work

Introduction

A consultant is engaged to fulfill a brief in terms of helping to find solutions to specific issues but the ways in which that is to be done generally falls to the consultant to decide, within constraints such as budget and resources agreed with the client.

5.1.1 Common types of consultation

In the business, and as of recently the private sphere, the most commonly found consultants are:

- **Strategy Consultants** working on the development of and improvements to organizational strategy alongside Senior Management in many industries.
- **Human Resources or HR Consultants** who provide expertise around employment practice and people management.
- **Internet Consultants** who are specialists in business use of the internet and keep themselves up-to-date with new and changed capabilities offered by the web. Ideally internet consultants also have practical experience and expertise in management skills such as strategic planning, change, projects, processes, training, team-working and customer satisfaction.
- **Process Consultants** who are specialists in the design or improvement of operational processes and can be specific to the industry or sector.
- **Public Relations or PR Consultants** dealing specifically with Public Relations matters external to the client organization and often engaged on a semi-permanent basis by larger organizations to provide input and guidance.
- **Performance Consultants** who focus on the execution of an intuitive or overall performance of their client.
- **Immigration Consultant** who helps through legal procedure of immigration from one country to other country.
- **Information Technology Consultants** in many disciplines such as Computer Hardware, Software Engineering or Networks.
- **Marketing Consultants** who are generally called upon to advice around areas of product development and related marketing matters.
- **Interim Managers** as mentioned above may be independent consultants who act as interim executives with decision-making power under corporate policies or statutes. They may sit on specially constituted boards or committees.

5.1.2 Electronic consultation

E-Consultation

Technology is having a major impact on the consultation arena. Using technology to consult is often referred to as Electronic or E-Consultation.

We use E-consultation

- E-consultation can give you rapid responses.
- E-consultation utilizes software that transfers data directly into databases, saving time and more because there is no need to manually input data.
- E-consultation enables us to explore some of the issues arising from consultation in more depth through tools such as bulletin boards, online discussion groups and chat rooms.
- Encourages participants into thinking their contribution does make a difference and is taken seriously by the Council
- E-consultation, particularly via the internet can be cheaper than sending out surveys by post (although e-consultation should be used as part of a range of methodologies to obtain a representative demographic)
- E-consultation can be used to gain feedback on policies, strategies and other consultation-related documents
- Better consultation with Hard to reach groups, i.e. consultation with young people - a large proportion of who have personal computers, internet access and mobile phones and do not tend to respond to traditional consultation techniques.
- It is an effective way of engaging people who are housebound.

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. **Answer the following question as directed below each contain (2%)**

1. What is the purpose of Electronic or E-Consultation.
2. ___________is engaged to fulfill a brief in terms of helping to find solutions to specific issues
3. Mention Common types of consultation
4. What is the purpose of E-consultation

. Answer the following question!

Note: Satisfactory rating 3and 4points Unsatisfactory below 3and 4points

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: ____________________________ Date: ____________

Score = ____________
~~Rating:~~ ____________

Short Answer Question

Information Sheet 6. Checking instrumentation and Control Systems defects

6.1 Checking instrumentation and Control Systems defects

Basic principles in checking instrumentation and control system defect

To identify a faulty section, follow the **guidelines** given below, along with a drawing and a meter:

- Check the incoming supply voltages first
- Check for voltages at the specific test points in circuit (as per manufacturers test point data sheet)
- Do dead test of circuit for integrity of protection devices and others
- In dead test, check for continuity of circuits, as intended, and check for insulation resistance
- If it's not possible to perform a dead test, connect the supply to the circuit and do a live test of circuit.

Generally, any electrical circuit can be differentiated in two sections:

- Power circuit
- Control circuit.

❖ It is always advisable to first check the power circuit. So, if the power circuit works, as it should, then Fault-finding the control circuit.

Power circuit check list:

- Incoming power to circuit and its integrity
- Check for correct functioning of protection devices
- Check visual cable continuity
- Check for any signs of flash or burning smell of devices.

Control circuit check list:

- Control circuit power first
- Check for proper functioning of relays, timers, and switches
- Check visual cable continuity
- Check for wire interconnections and terminal connections of circuit
- Check logical operational sequence of contactor switching
- Check for timer duration settings.

If the above criteria are checked and still the final device is not working, then test the final device**.**

Check / inspect instrumentation and control device

There are four grades of inspections defined in IEC 60079 - 17:

1. **Continuous supervision:-** Defined as frequent attendance, inspection, service, care and maintenance of the electrical installation by skilled personnel who have the knowledge and skills to maintain the equipment in accordance with IEC 60079 - 17 Clause 4. 5.

1 **Visual inspection**: - An inspection that identifies, without use of access equipment or tools, defects that would be apparent to the eye, such as missing bolts or damaged cables.

2 **Close inspection:-**Defined as an inspection that encompasses aspects covered by a visual inspection and identifies defects that are apparent only by the use of equipment and tools, such as loose bolts or damaged cable glands.

3 **Detailed inspection: -** Defined as an inspection that encompasses everything covered by a close inspection and identifies defects that are only apparent by opening the enclosure and using tools and test equipment. Detailed inspections can find loose terminations or incorrect grounds.

These inspections include all equipment located in the hazardous area, and any protection device located in the safe area. In practice, this is difficult and expensive to achieve. Some wiring systems may be routed in such a manner as to make inspection very difficult. Process plants have internal permitting procedures that must be followed when entering hazardous areas, adding further costs. And there is, of course, the time required to make inspections, to document work done, and to keep required records.

It's important to verify that an installation conforms to a detailed equipment list and circuit diagrams. These and any other documentation listing specific conditions of use must be made available for the inspector. Often the equipment list has not been updated with equipment changes as plant modifications are carried out, due to either failed equipment being replaced with alternatives, or new wiring additions.

If clarification has to be sought regarding the installation and associated documentation, this adds to the time taken to carry out the inspection. Reducing the number of equipment items reduces the burden of keeping equipment lists updated, and wireless instruments are one of best ways to address this issue.

2. Typical issues found during inspections include

Electronic test equipment is used to create signals and capture responses from electronic devices under test (DUTs). In this way, the proper operation of the DUT can be proven or faults in the device can be traced. Use of electronic test equipment is essential to any serious work on electronics systems.

Practical electronics engineering and assembly requires the use of many different kinds of electronic test equipment ranging from the very simple and inexpensive (such as a test light consisting of just a light bulb and a test lead) to extremely complex and sophisticated such as automatic test equipment (ATE). ATE often includes many of these instruments in real and simulated forms.

Generally, more advanced test gear is necessary when developing circuits and systems than is needed when doing production testing or when troubleshooting existing production units in the field.

The addition of a high-speed switching system to a test system's configuration allows for faster, more cost-effective testing of multiple devices, and is designed to reduce both test errors and costs. Designing a test system's switching configuration requires an understanding of the signals to be switched and the tests to be performed, as well as the switching hardware form factors available.

Types of test equipment

The following items are used for basic measurement of voltages, currents, and components in the circuit under test.

- Voltmeter (Measures voltage)
- Ohmmeter (Measures resistance)
- Ammeter, e.g. Galvanometer or Milliameter (Measures current)
- Multimeter e.g., VOM (Volt-Ohm-Milliameter) or DMM (Digital Multimeter) (Measures all of the above)
- RLC Meter e.g., RLC meter or Resistance, Inductance and capacitance meter (measure RLC values)

The following are used for stimulus of the circuit under test:

- Power supplies
- Signal generator

- Digital pattern generator
- Pulse generator

The following analyze the response of the circuit under test:

- Oscilloscope (Displays voltage as it changes over time)
- Frequency counter (Measures frequency**)**

Dimensional inspection hand tools are sometimes the best answer when you need to take measurements. They are both portable and precise, are generally cost-effective, and they can be used for a broad range of applications.

Types of Dimensional Inspection Hand Tools

1. **Calipers** - There are several different types of calipers designed to measure length, depth, internal, and external dimensions. Calipers can also be used to transfer dimensions from one object to another.
2. **Bore gages** - Take an internal diameter measurement or compare to a pre-determined standard.
3. **Fixed gages** - Used only to compare an object to a standard, fixed gages can measure attributes such as angle, length, radius, bore size, thickness, and other parameters.
4. **Micrometers** - These dimensional inspection hand tools can use mechanical, digital, laser, dial, or scale technology to precisely measure length, depth, thickness, diameter, height, roundness, or bore.
5. **Protractors** - Measure angles with a variable protractor or compare the angle of an object to a standard with an angle gage.
6. **Indicators** and **comparators** - The precision movement of a spindle or probe is amplified so the results can be displayed digitally or on a dial or column.
7. **Air metrology instruments** - Thickness, depth, diameter, roundness, taper, and bore can be measured by calculating changes in pressure or air flow.
8. **Ring gages** - Typically used as a pass/fail test, ring gages can be threaded, smooth, or tapered to test the size of pins, threaded studs, and shafts.
9. **Length gages** - Electronic or mechanical, these devices are used to measure or compare the length of an object.

10. **Thread gages** - The spacing, shape, size, and geometry of a thread can be verified or measured with a thread gage.

Common Control Loops

A sensor is a device that responds to or detects a physical quantity and transmits the resulting signal to a controller.

Sensors are often used in **close-loop** control to feed back the output of the system in order to generate proper control actions.

A transducer is a sensor that converts (transduces) one form of energy to another form, usually electrical signals.

Defining the Loop

Basic to any discussion of control loops is “feedback” control. In this control, the loop starts by measuring the process variable (PV). It then compares the PV to the desired value, that is, the set point (SP), and acts on the difference between SP and PV (error) using a control algorithm (typically PID). The loop then outputs to the final control element. The diagrams below indicate that the main elements of the loop are: transmitter/sensor (for measuring the PV) process controller (with an operator-entered SP and control algorithm) final control element (valve/actuator and accessories)

Loop checking

Loop Checking means, First we want to check the continuity of cable. Then whether 24 V DC or **4 – 20 mA** DC is coming from DCS or JB want to check. That is called loop Checking.

After installation of instruments we must check full loop(instrument-junction box-control room) to ensure that whether the instruments are working properly or not, and whether is it passing the signal or not, whether is it receiving the signal or not. before we start the plant we need to check loop. during the loop check we give some known input and check the corresponding output at other side(control room).if the output is corresponding to input, the loop is ok.if not means, something fault in between the loop. for example .if you want to check ON/OFF control valve, during the loop check, when you give 24 v dc from control room ,the valve must open fully, and when you give 0 v dc the valve must close.

Loop checking is the final process before the commissioning of the processing system . loop checking is the process that confirms the components wired correctly and also helps to ensure that the system is functioning as designed

The loop checking checks the connection between each component in the control loop. a control loop consists of transmitter, sensor, process controller, final control element

Loop checking & Procedure

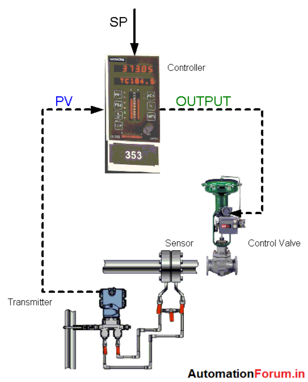


Fig 6.1 loop checking

Before start, the loop check include, first list the number of loops, test actions, the procedure for documenting the check and plan should specify the type and characterization of signal. For example, differential flow meter generates a signal that has a square root relationship between flow rate and differential pressure.

A factory acceptance of loop testing can be charted as shown below:

Loop testing procedure:

For loop checking the test to be carried out while there is no electric connection otherwise, the circuit to be tested should be isolated from the electric supply.

Earthing and Continuity test:

Earth resistance tests are required to confirm that the installed earthing system will cause the circuit protection devices to operate and maintain the integrity of the cable if there is a fault between the active parts and the exposed conductive parts.

The resistance from any point of the electric installation should be earthed. The resistance from the earthing electrode to the point where the main earthing conductor is connected to the neutral conductor of the supply system shall not exceed 5 ohms.

- Ensure that the electricity supply has been disconnected
- Connect an insulated copper conductor of suitable length(long lead) to one terminal of the ohm meter.
- Connect a standard length test lead to the other terminal of the ohm metre (short lead
- Connect the two leads together and zero the multimeter or if this is not possible. Record the resistance of the test lead

Main earth conductor:

- Connect the short lead to the earth electrode and measure the earth resistance of the main earthing conductor
- The resistance shall not exceed 5 ohms for the main earthing conductor

Earth continuity test:

- Using the long lead and zeroed meter, measure for each circuit, the earth conductor resistance from the circuit extremity to the switchboard.
- To confirm the measured values are less than those values as provided by table
- This test is applicable to all circuits, including socket outlets circuit, lighting circuits and fixed equipment circuits.

Insulation resistance test:

The insulation resistance tests to ensure there is no current flow between conductor and ground or insulation surface. If there is no current flow the wire could prevent electric shock hazards, fire hazards and equipment damage.

Test procedure:

- Ensure all protective device in the circuit is switched ON.

- Set the insulation tester to megaohms
- Connect an insulation tester cable to the main earth bar and the other cable to the active and neutral connected together. Do not perform tests between assets and neutrals.
- Measure the insulation resistance of the total installation, if the resistance is greater than 1 megaohm then the normal to work.
- If resistance is less than 1 megaohm disconnect the appliances. Then test the circuit separately to ensure that the insulation resistance of both the circuit and the appliances complies with the following
    - Not containing a heating element- is not less than1 mega ohm or
    - Containing a heating element-is not less than 0.01 mega ohm

Polarity test: Polarity tests are carried out to ensure that the correct connection of the active, neutral and ground conductors to the electrical equipment ensures that the switches are not installed in neutral conductors.

Test procedure:

- Isolate the active conductors by turning the main switch OFF and tagging
- Confirm the consumer and sub main cables by simply testing from the point of distribution board to the main switch board using an ohm meter and long test loads. Test result= 0 ohms
- Confirm the switching of the active conductors using an ohm meter with the long cable connected to the active conductor on the board and the short wire connected to the terminals of the switch as follows
- Switch ON = 0Ώ for both terminals, Switch OFF = 0Ώ for one terminal and infinite for the other terminal.
- With the MEN link in place, confirm the polarity of the sockets using a 10Ώ resistor and an ohm meter. Connect the 10Ώ resistor between the active circuit conductor and the neutral bus, then connect the multimeter cable to the ground terminal and the second cable to the active terminal. Test the resistance value for.

Fault loop impedance test: This test is performed to confirm that the impedance value of the fault loop of each circuit will be low enough to guarantee the operation of the protection device during a fault.

Test procedure

- Energize all circuits
- Using the fault loop impedance meter, proceed to the equipment to be tested and measure the impedance of the ground loop at this point. Repeat for other elements in the circuit
- The measured value must be less than the maximum values as in the Wiring Rules
- If an RCD works during the test, the results of the test can be considered satisfactory.

Ensure these steps before loop checking

1. Before carrying out the loop test or the sequence test, all related instruments must be calibrated, this can be seen from the instrument label. The final loop test will be performed to ensure that the instruments installed are functionally correct. Each transmitter and switch must not be re calibrated during the loop test, since all transmitters and switches are installed after the workshop calibration is completed.
2. When performing tests, two groups will be required, one in the field and other in the control room. The contractor is required to provide proper communication for all involved in test verification, i.e. field radios or walkie talkies
3. Associated alarms and trip actions of DCS/PLC and/or board-mounted instruments shall be checked during the loop test. When particular loop ties into DCS/PLC system, a technician may be required in the rack room for troubleshooting
4. When the interlocking inputs and / or outputs are associated with electrical equipment such as pump motors, compressors and valves, this sequence test shall be carried out together with the electrical and mechanical discipline to ensure the protection of the equipment.

Loop Test Procedure

1. Before performing the loop check, check the entire circuit to make sure all cables are connected. Check the appropriate voltages and instrument air pressure according to the manufacturer's recommended requirements.
2. To test the circuit, configure the air and / or electrical supply, as applicable, the air supply pressure for the control valves and other pneumatic actuators must be verified and configured correctly according to the specifications.
3. For electronic loops, check the polarities and measure the impedance of the loop before it is necessary. Before performing the loop test, the DCS must be de-energized and confirm that all field cables are connected correctly. Then the DCS.
4. must be energized again. The final circuit test must be performed to ensure that the installed instrumentation is functionally correct. Each transmitter and switch must not be recalibrated during the loop test, since all transmitters and switches are installed after workshop calibration
5. If a transmitter exists in a loop, the output signals equivalent to 0%, 50% and 100% of the range of the instrument will be generated in manual mode (dummysignals) to verify the function of the loop, such as variable zero variation of the transmitters or by connecting the standard DC current generator or the retaining nozzle and the fin in the pilot of the pneumatic transducers.
6. Connect a known precision source to the primary field transmitter. The assimilation of the measured variable is applied to the transmitter for reading at zero, half scale and full scale, according to the instructions recommended by the manufacturer. Note in the PLC system that the indication is shown as simulated. Also note on the MMI screens (Man Machine Interface) on the PC. You must indicate the appropriate actions in Screen and Alarm Screen
7. If there is a local controller mounted in a loop, the signal to verify the operation of the valve will be generated manually using the manual operation device in the controller before the automatic operation check. An automatic operation check will be performed by changing the set point of the controller.

8. Control loop: Place the controller in manual mode and simulate the signal of the process variable from 0%, 25%, 50%, 75% and 100% of the scale and note on the monitor that the process variable indication shows signals assimilated. Return the process variable to 0%, place the controller in automatic mode, set P.B. 100%, restart the time and derived to Minimum adjustment with 50% set point and make sure the controller is an indirect action. Simulate the process variable signal 0%, 25%, 50%, 75% and 100%, observe and record all the findings
9. For pressure switches and level interrupters, their contact must be made manually and / or interrupted to guarantee the corresponding responses of the instrument.

For thermocouple loops, check the burn characteristics by disconnecting the cables, and confirm that the polarity of the thermocouple extension leads is maintained when they are reconnected. To assist in the identification of the thermocouple extension cables, the following guidance is provided.

a) The negative extension cables are always colored in red as in the PER ANSI C96.1.

b) For the K-type thermocouple (Chromel / alumel), the negative cable is slightly magnetic. It has a lower resistance in ohms / feet for the same size cable.

c) For R type thermocouple (copper alloy / nickel copper), the negative wires are softer than the positive wire.11.For the loops of the resistance temperature detector (RTD), check the function of all the instruments and control valves in the circuit by connecting the resistor approximately 120 ohm in the terminal heads, and visually verify the correct connections when closing the terminal heads.

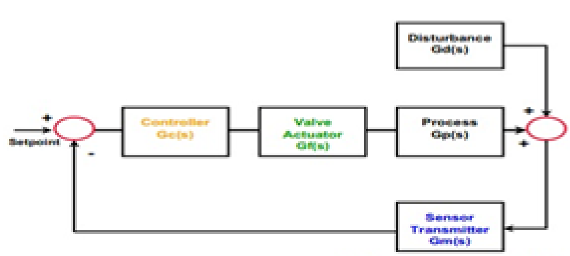


Fig 20 block diagram of feed back loop

Control Valves Loop Checks Procedure

1. For FF device commission FF segment prior to loop testing 12 by measuring resistance and DC voltage of segment conductor if all devices are connected otherwise only resistance will be recorded and voltage will be measured after all devices are connected and compare the results with FF segment checkout form.
2. Check and verify the DCS configuration for applicable points. Reference drawings are to be P&ID and ISS.
3. If any logic / interlocking are involved in applicable loop. Energize the solenoid valve by forcing the applicable ESD points on functional logic and same procedure to be carried out for DCS logic.
4. If instrument air supply is not available then, dry and clean air or nitrogen shall be used.
5. Apply the command from DCS for 0%, 25%, 50%, 75%, 100% and monitor the response of the valve from the field.
6. Verify the corresponding valve position.
7. Verify the controller action.
8. Verify the control valve action on increase signal.
9. Verify the control valve action on air supply failure.
10. Verify the control valve max / min travel stopper setting if applicable.
11. Check the hand wheel manual operation / function if applicable. Auto/ manual calibration is applicable.
12. Normally control valve loop test should be performed after completion of the external air supply piping works. In some cases when required, loop test can be executed without the internal air supply piping.
13. In case of air piping is not installed and tested then this exception item to be mentioned in the loop test exception log sheet prior to signing the loop folder.
14. Loop will be installed only and signed after the clearance of the punch list.

Loop checking procedure of Instruments

This article is about the loop checking procedure of all instruments like flow transmitter, valves, vibration, DCS loop, switchgear loop and remaining pressure and level types instruments.

List of tools and equipment in loop checking

Tools and equipment needed should be in good condition and must be checked by instrument supervisor prior to use. Calibration equipment shall comply with the saudiaramco standards requirements and provided with calibration certificate to support the readings of the calibrating equipment these includes but not limited to:

- HART Communicator
- Dead Weight Tester
- Air Compressor
- MC5 FF Multifunction Calibrator
- Test Gauges with Ranges per Specification
- Absolute Pressure Gauge
- Portable 120Vac, 60Hz Gasoline Powered Generator
- Pulse/Frequency Generator
- DC Power Supply Regulated 24Vdc Variable
- Nitrogen Tank w/ High Pressure Regulator
- Thermo Bath
- Hydrostatic Test Pump
- Set of Precision Weights
- Digital Thermometer
- Glass Thermometer
- Potentiometer
- Portable Pressure Calibrator (DRUCK)

- Process Calibrator
- Advanced Temperature Calibrator
- RTD Conversion Chart
- Circuit Tester
- Decade Resistance Box
- Digital Manometer (Mercury or Water Manometer)
- Mercury and Water Manometer
- Hand Pump
- Hygrometer (Humidity Tester)
- Air Regulator
- Pneumatic Comparator
- Vacuum Pump
- Oscilloscope
- Radio Communication Equipment (intrinsically safe as per approved)
- Multi meter
- Test Bench with clean, dry and oil free instrument air
- Set of Tools, Hose & Fittings
- Stop Watch
- Millivolt/Temperature conversion chart
- TK-3 (for checking of vibration element)
- Spirit Level
- BEAMEX MC5 Calibrator

All tools utilized in a classified area should be intrinsically safe and suitable for hazardous area

Operation title: - loop checking for on / off valves loops

Purpose	**To acquire the trainees with loop checking for on / off valves loops**
Equipment ,tools and materials	Supplies and equipment needed or useful for diagnosing and troubleshoot instrumentation and control Devices include these: • screw driver • Diagonal side cutter • Pliers • Knife • drill • shaper • cutter • Soldering iron • WRENCH • Digital Multi-tester • calibrator • oscilloscope • signal generator • various instrument and control device • configuration or programmer • DCS / ESD configuration • On/Off valve
Conditions or	• All tools, equipment's and materials should be available on time

situations for the operations	when required. • Appropriate material, working area/ workshop for loop checking on / off valves loops
Procedures	1. Apply OH &S PPE 2. Check and verify the DCS / ESD configuration for applicable points. 3. If any ESD logic / interlocking are involved in applicable loop to energized solenoid valve, should be prepared ESD points on functional logic and same procedure to be carried out for DCS logic. 4. If instrument air supply is not available then connect nitrogen cylinder. In big size of valve cases, big volume of nitrogen will be required then in that case on/off valves function test will be executed upon air supply availability. 5. Apply the command from DCS / field for open and close as applicable. 6. Verifying the corresponding valves position in DCS and field. 7. Verify the partial stroke function test of “ZV”. 8. Verify the valve action on air supply failure. 9. Check the hand wheel / hand jack manual operation / function as applicable. 10. Normally On/Off valve loop test should be performed after completion of the external air supply piping works. In some cases when required, loop test can be executed without air. 11. In case of air piping is not installed and tested then this exception item to be mentioned in the loop test exception log sheet prior to

	signing the loop folder. 12. Loop will be initiated only and signed after the clearance of the punch list. 13. Valve response time shall be recorded in loop record sheet
Precautions	• Care should be taken while connecting with electric power, assembling, fitting and adjusting instrumentation and control devices • Preparing materials, tools and equipment are according to inseminator command.
Quality criteria	• Did personal protective equipment worn diagnosing and troubleshoot instrumentation and control Devices • Did trainees fitting and adjusting the component of the machine proper without leakage • Checks the circuit safely using proper instrument • Mounts devices according to the given drawing • Installs electrical wiring according to the job requirements

Loop checking for on / off valves loops

LAP Test	Practical Demonstration

Name: ________________________________ Date: __________________

Time started: __________________________ Time finished: __________________

Instructions:

1. You are required to perform any of the following:

1.1. Diagnosing and troubleshoot instrumentation and Control Devices

1.2. Prepare equipment and material for diagnosing and troubleshoot instrumentation and Control Devices

2. Request your Trainer for evaluation and feedback

Operation title: loop checking Conventional Control Valves Loops

Purpose	To acquire the trainees with loop checking Conventional Control Valves Loops
Equipment ,tools and materials	Supplies and equipment needed or loop checking Conventional Control Valves Loops include these: • screw driver • Diagonal side cutter • Pliers • Knife • drill • shaper • cutter • Soldering iron • wrench • Digital Multi-tester • calibrator • oscilloscope

	• signal generator • various instrument and control device • configuration or programmer • communication equipment(2=way radio cell phone) • DCS / ESD configuration • Conventional Control Valves Loops
Conditions or situations for the operations	• All tools, equipment's and materials should be available on time when required. • Appropriate material, working area/ workshop for loop checking Conventional Control Valves Loops
Procedures	1. Apply OH&S PPE 2. Check and verify the DCS configuration for applicable points. Reference drawings are to be P&ID and ISS. 3. If any logic / interlocking are involved in applicable loop. Energize the solenoid valve by forcing the applicable ESD points on functional logic and same procedure to be carried out for DCS logic. 4. If instrument air supply is not available then, dry and clean air or nitrogen shall be used. 5. Apply the command from DCS for 0%, 25%, 50%, 75%, 100%

	and monitor the response of the valve from the field. 6. Verify the corresponding valve position. • Verify the controller action. Verify the control valve action on increase signal. Verify the control valve action on air supply failure. • Verify the control valve max / min travel stopper setting if applicable. • Check the hand wheel manual operation / function if applicable. Auto/ manual calibration is applicable. • Normally control valve loop test should be performed after completion of the external air supply piping works. In some cases when required, loop test can be executed without the internal air supply piping. • In case of air piping is not installed and tested then this exception item to be mentioned in the loop test exception log sheet prior to signing the loop folder. • Loop will be installed only and signed after the clearance of the punch list.
Precautions	• Care should be taken while connecting with electric power, assembling, fitting and adjusting instrumentation and control devices • Preparing materials, tools and equipment are according to inseminator command.
Quality criteria	• Did personal protective equipment worn diagnosing and troubleshoot instrumentation and control Devices • Did trainees fitting and adjusting the component of the machine

	proper without leakage • Checks the circuit safely using proper instrument • Mounts devices according to the given drawing • Installs electrical wiring according to the job requirements

Checking Conventional Control Valves Loops

LAP Test	Practical Demonstration

Name: _______________________________ Date: _________________

Time started: _________________________ Time finished: _________________

Instructions:

1. You are required to perform any of the following:

1.1. Diagnosing and troubleshoot instrumentation and Control Devices

1.2. Prepare equipment and material for diagnosing and troubleshoot instrumentation and Control Devices

2. Request your Trainer for evaluation and feedback

Operation title: loop checking procedure thermocouple / temperature transmitter loops

Purpose	To acquire the trainees with loop checking procedure thermocouple / temperature transmitter loops
Equipment ,tools and materials	Supplies and equipment needed or useful for loop checking procedure thermocouple / temperature transmitter loops include these: • screw driver • Diagonal side cutter • Pliers • Knife • drill • shaper • cutter • Soldering iron • wrench • Digital Multi-tester • calibrator • oscilloscope • signal generator • various instrument and control device • configuration or programmer • communication equipment(2=way radio cell phone) • DCS / ESD configuration • On/Off valve
Conditions or situations for the operations	• All tools, equipment's and materials should be available on time when required. • Appropriate material, working area/ workshop to diagnosing and troubleshoot instrumentation and control devices

Procedures	1. Apply OH&S PPE 2. Check and verify the DCS configuration for applicable points. • Simulate millivolt equivalent to the 0%, 25%, 50%, 75% and 100% of the transmitter / DCS range, by using "mv" source (simulator) at the thermocouple terminal head. • Verify the corresponding reading in the DCS / integral indicator of transmitter and remote indicator if applicable. • Alarm functions (in DCS) to be checked by simulating / varying the required signals. • Normalize all the connections prior to closing the terminal and confirm ambient temperature at integral indicator of temperature transmitter and at remote indicator if applicable to DCS.
Precautions	• Care should be taken while connecting with electric power, assembling, fitting and adjusting instrumentation and control devices • Preparing materials, tools and equipment are according to inseminator command.
Quality criteria	• Did personal protective equipment worn • Did trainees fitting and adjusting the component of the machine proper without leakage • Checks the circuit safely using proper instrument • Mounts devices according to the given drawing • Installs electrical wiring according to the job requirements

Loop checking procedure thermocouple / temperature transmitter loops

LAP Test	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions:

1. You are required to perform any of the following:

1.1. loop checking procedure thermocouple / temperature transmitter loops

1.2. Prepare equipment and material for loop checking procedure thermocouple / temperature transmitter loops

2. Request your trainer for evaluation and feedback

- Identify Power Supply and CPU LED status indicators
- Match processor LEDs with the status LEDs located in troubleshooting tables
- Once the status LEDs are matched to the appropriate table, simply
- move across the table identifying error description and probable causes
- Follow the recommended action steps for each probable cause until the cause is identified

Operation title:-loop checking procedure RTD /temperature transmitter loops

Purpose	To acquire the trainees with loop checking procedure RTD /temperature transmitter loops
Equipment ,tools and materials	Supplies and equipment needed or useful for loop checking procedure RTD /temperature transmitter loops include these: • screw driver • Diagonal side cutter • Pliers • Knife • drill • cutter • Soldering iron • wrench • Digital Multi-tester • calibrator • oscilloscope • signal generator • various instrument and control device • configuration or programmer • communication equipment(2way radio cell phone) • DCS / ESD configuration • On/Off valve
Conditions or situations for the operations	• All tools, equipment's and materials should be available on time when required. Appropriate material, working area/ workshop for loop checking

	procedure RTD /temperature transmitter loops
Procedures	1. Apply OH &S PPE 2. Check and verify the DCS / ESD configuration for applicable points. • Simulate resistance equivalent to the 0%, 25%, 50%, 75% and 100% of the transmitter /DCS range, by using decade resistance box or any other resistance simulator at the RTD terminal head. • Verify the corresponding reading in the DCS / integral indicator of transmitter and remote indicator if applicable. Alarm functions (in DCS) to be checked by simulating / varying the required signals. • Normalize all the connections prior to closing the terminal and confirm ambient temperature at integral indicator of temperature transmitter and in DCS. Special consideration shall be given to electrical connection of the RTD. • During loop checking, If the instrument is not accurate re – calibration should be done in calibration shop. Zeroing is not allowed.
Precautions	• Care should be taken while connecting with electric power, assembling, fitting and adjusting instrumentation and control devices • Preparing materials, tools and equipment are according to inseminator command.
Quality criteria	• Did personal protective equipment worn • Did trainees fitting and adjusting the component of the machine proper without leakage • Checks the circuit safely using proper instrument

	• Mounts devices according to the given drawing • Installs electrical wiring according to the job requirements

loop checking procedure RTD /temperature transmitter loops

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions:

1. You are required to perform any of the following:

1.1. loop checking procedure RTD /temperature transmitter loops

1.2. Prepare equipment and material for loop checking procedure RTD /temperature transmitter loops

2. Request your trainer for evaluation and feedback

Operation title: - switches loops checking (flow, level, pressure, temperature)

Purpose	To acquire the trainees with switches loops checking (flow, level, pressure, temperature)
Equipment ,tools and materials	Supplies and equipment needed or useful for loop checking procedure RTD /temperature transmitter loops include these: • screw driver • Diagonal side cutter • Pliers • Knife • drill • cutter • Soldering iron • wrench • Digital Multi-tester • calibrator • oscilloscope • signal generator • various instrument and control device • configuration or programmer • communication equipment(2=way radio cell phone) • DCS / ESD configuration • On/Off valve

	• switches loops checking (flow, level, pressure, temperature
Conditions or situations for the operations	• All tools, equipment's and materials should be available on time when required. • Appropriate material, working area/ workshop to diagnosing and troubleshoot instrumentation and control devices
Procedures	1. Apply OH &S PPE 2. Check and verify the DCS / ESD configuration for applicable points. 3. Simulate the contact operation (Make / Break) at the switch terminal block and verify the status in the DCS / ESD. However, ESD switch case actual 4. pressure simulation to be provided with hand pump. 5. ESD hand switches, Start / Stop, Open / Close shall be checked by operating the switch mechanism.
Precautions	• Care should be taken while connecting with electric power, assembling, fitting and adjusting instrumentation and control

	devices • Preparing materials, tools and equipment are according to inseminator command.
Quality criteria	• Did personal protective equipment worn diagnosing and troubleshoot instrumentation and control Devices • Did trainees fitting and adjusting the component of the machine proper without leakage • Checks the circuit safely using proper instrument • Mounts devices according to the given drawing • Installs electrical wiring according to the job requirements

Loop checking procedure RTD /temperature transmitter loops

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: _________________________ Time finished: ________________

Instructions:

1. You are required to perform any of the following:

1.1. Loop checking procedure RTD /temperature transmitter loops

1.2. Prepare equipment and material for loop checking procedure RTD /temperature transmitter loops

2. Request your teacher for evaluation and feedback

Operation title: vibration loops (with proximitors) loop checking procedure

Purpose	To acquire the trainees with loop checking procedure vibration loops (with proximitors)
Equipment ,tools and materials	Supplies and equipment needed or useful for vibration loops (with proximitors) loop checking procedure include these: • screw driver • Diagonal side cutter • Pliers • Knife

	• drill • shaper • cutter • Soldering iron • WRENCH • Digital Multi-tester • calibrator • oscilloscope • signal generator • various instrument and control device • configuration or programmer • communication equipment(2=way radio cell phone) • DCS / ESD configuration • On/Off valve • switches loops checking (flow, level, pressure, temperature • proximity sensor
Conditions or situations for the operations	• All tools, equipment's and materials should be available on time when required. • Appropriate material, working area/ workshop to diagnosing and troubleshoot instrumentation and control devices
Procedures	1. Apply OH &S PPE 2. Check and verify the VMS / DCS configuration for applicable points. • Connect a spare probe to extension cable of applicable proximitors.(If applicable) • Insert the probe into the TK-3 wobulator (Bently Nevada) and connect the Multi meter leads at proximitors terminals for check

	gap voltages.(If applicable). • Adjust the probe at approximately (-10Vdc) gap voltages and reset VMS rack.(If applicable • Simulate the signal by wobulator 0%, 50% and 100% of the range and verify the corresponding reading at VMS / DCS.(If applicable) • Verify the response of the high and high alarms at VMS / DCS as per P&ID. • Normalize the connection of extension cables. (If applicable) 3. Actual probe gap voltage shall be adjusted to -10Vdc and check the point shows normal in VMS / DCS after VMS rack reset.(If applicable
Precautions	• Care should be taken while connecting with electric power, assembling, fitting and adjusting instrumentation and control devices • Preparing materials, tools and equipment are according to inseminator command.
Quality criteria	• Did personal protective equipment worn diagnosing and troubleshoot instrumentation and control Devices • Did trainees fitting and adjusting the component of the machine proper without leakage • Checks the circuit safely using proper instrument • Mounts devices according to the given drawing • Installs electrical wiring according to the job requirements

vibration loops (with proximitors) loop checking procedure

LAP Test	Practical Demonstration

Name: _________________________________ Date: __________________

Time started: ___________________________ Time finished: __________________

Instructions:

1. You are required to perform any of the following:

1.1. Vibration loops (with proximitors) loop checking procedure

1.2. Prepare equipment and material for vibration loops (with proximitors) loop checking procedure

2. Request your trainer for evaluation and feedback

6.1.1 Pressure measurement and control loop

A **control loop** is the fundamental building block of industrial **control** systems. It consists of all the physical components and **control** functions necessary to automatically adjust the value of a measured process variable (PV) to equal the value of a desired set-point (SP).

.

Pressure is continuous physical force exerted on or against an object by something in contact with it or Pressure is the use of persuasion or intimidation to make someone do something.

Pressure is the force applied perpendicular to the surface of an object per unit area over which that force is distributed. Gauge pressure is the pressure relative to the ambient pressure. Various units are used to express pressure.

Pressure is probably one of the most commonly measured variables in the power plant. It includes the measurement of

- Steam pressure
- Feed water pressure
- Condenser pressure
- Lubricating oil pressure and many more.
- Pressure Control

In a pressure loop the dynamics of the sensor and process are fast compared to the actuator. Use P only control unless controlling to a Set Point is desired, then use PI

6.1.2 Level measurement and control loop

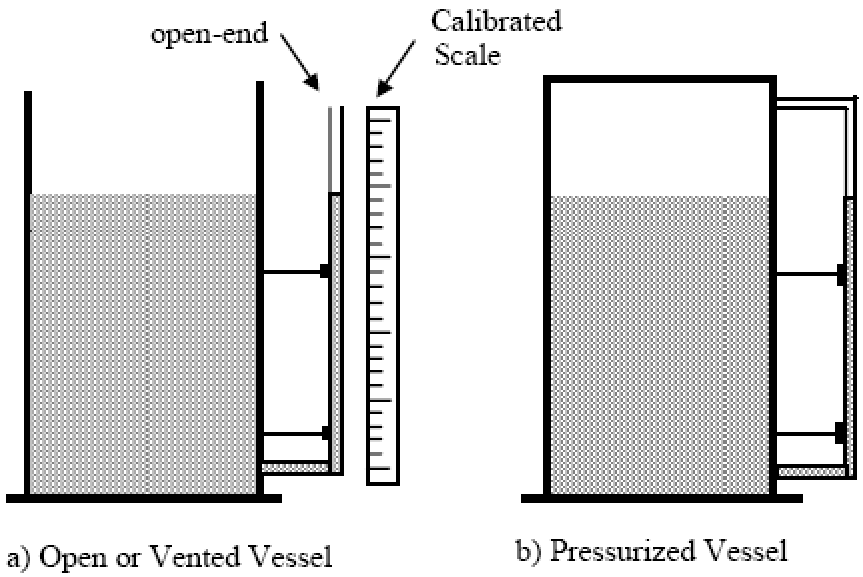
In all level measurement a sensing device, element, or system interacts with material inside a container. A wide variety of physical principles are used to measure level. Common types include sight, pressure, electric, sonic, and radiation-each of which we discuss here. We will also explore level switches and a level control application.

Sight-type Instruments

There are three common sight-type level sensors: glass gauges, displacers, and tape floats. Glass gauges are the most widely used instruments for measuring the level in a process tank.

Glass Gauges

Two types of level glass gauges are used to measure liquid level: tubular and flat. The tubular type works in the same way as a manometer, that is, as the liquid level in a vessel rises or falls the liquid in the glass tube will also rise or fall. The gauges are made of glass, plastic, or a combination of the two materials. The material from which the transparent tubes are made must be able to withstand the pressure in the vessel, and they are generally limited to 450 psi at 400°F. Fig shows two common applications of tubular sight glasses: an open or vented process vessel and



a pressurized vessel. For the pressurized tank, the upper end of the tube is connected to the tank. This creates an equilibrium pressure in both ends of the tube, and the liquid in the tube rises to the same level as the liquid in the vessel. A calibrated scale is normally mounted next to the sight gauge to indicate the level in the tank.

6.1.2 Flow measurement and control loop

the common types of flow measuring devices and instruments, such as orifice plates, venture tubes, flow nozzles, wedge flow elements, pitot tubes, annubars, turbine flow meters, vortex shedding devices, magnetic flow meters, ultrasonic flow meters, positive-displacement flow meters, mass flow meters, androtameters.

Flow Principles

Our discussion in this chapter will consider only a so-called ideal fluid, that is, a liquid that is incompressible and has no internal friction or viscosity. The assumption of incompressibility is usually a good approximation for liquids. A gas can also be treated as incompressible if the differential pressure driving it is low. Internal friction in a fluid gives rise to shearing stresses when two adjacent layers of fluid move relative to each other, or when the fluid flows inside a tube or around an obstacle. In most cases in process control, these shearing forces can be ignored in contrast to gravitational forces or forces from differential pressures.

Flow measurements can be divided into the following groups:

a) Flow rate
b) Total flow, and
c) Mass flow.

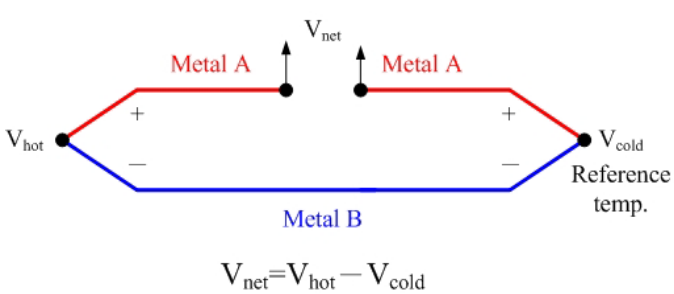
The choice of measuring device will depend on the required accuracy, flow rate, range, and fluid characteristics (i.e., gas, liquid, suspended particulates, temperature, viscosity, and so forth).

6.1.4 Temperature measurement and control loop

Temperature Sensors

Thermocouple is commonly used in sensing temperature. Seeback effect: as two distinct metals are connected together, the temperature difference between the "hot joint" and the "cold joint" (thermocouple) will induce a voltage. Temperature difference can be measured by measuring this voltage.

The **thermistor** is also used for temperature measurement. But the relation of voltage vs. temperature is often non-linear. There are temperature sensing ICs too.



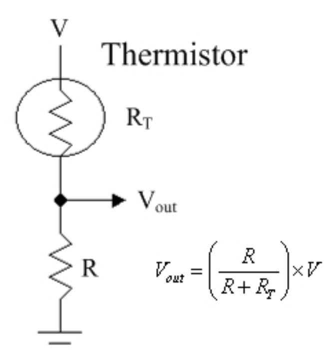


Fig a Thermocouple **Fig b Thermistor**

RTDs

In practice, however, only certain metals and semiconductors are used in process control for temperature measurement. This general type of instrument is called a resistance temperature detector or RTD. RTDs are the second most widely used temperature measurement device because of their inherent simplicity, accuracy, and stability.

The most common technologies for industrial temperature measurement are electronic in nature: RTDs and thermocouples. As such, the standards used to calibrate such devices are the same standards used to calibrate electrical instruments such as digital multimeters (DMMs).

However, there are some temperature-measuring instruments that are not electrical in nature.

This category includes bimetallic thermometers, filled-bulb temperature systems, and optical pyrometers. In order to calibrate these types of instruments, we must accurately create the calibration temperatures in the instrument shop.

6.1.5 Analytical measurement and control loop

Control Loop Analysis

Control loop measurements help to characterize how your power supply responds to changes in demand. You need your supply to respond quickly, but without excessive ringing or oscillation. By measuring the actual gain and phase of your circuit over a range of frequencies, you can gain confidence in the stability of your design – greater than relying on simulation alone. Using an oscilloscope, signal source and automation software, measurements can be made quickly and presented as familiar Bode plots, making it easy to evaluate margins and compare circuit performance to models.

Control loop analysis system

To simplify system configuration, Tektronix offers a Control Loop Analysis Kit combining the key pieces of equipment and software needed to measure the stability of your power supply design. The kit is built around 5 and 6 Series MSO oscilloscopes, and includes low-attenuation passive probes and control loop measurement automation software.

Oscilloscope-based response measurement setup

For power supply designs, closed loop response measurements should be made from near DC to a few MHz. While vector network analyzers are often used for response analysis, most VNAs are designed for RF measurements with starting frequencies around a megahertz. In contrast, oscilloscopes can measure down to DC and provide useful signal visibility. If anomalies turn up during your analysis, you can quickly jump into troubleshooting.

Several Tektronix oscilloscopes offer built-in signal sources that may be used to inject a signal into the loop's feedback through an isolation transformer. Two probes, applied across a low-value injection resistor, provide all the information the analysis software needs. It measures the stimulus and response amplitudes to calculate gain, and measures the phase delay between stimulus and response.

The general system for automated control loop response consists of:

- An oscilloscope with appropriate bandwidth
- Power supply frequency response automation software
- Two low-attenuation, low-capacitance probes
- A sinewave generator
- A transformer with flat response to isolate the sinewave generator from the DUT

Probe characteristics for control loop measurements

To avoid overdriving the control loop, the injection signal's amplitude must be kept low. Probe attenuation should be minimized to get the best sensitivity. At the same time, probe loading effects should be minimized. Durable, low-attenuation, low capacitance passive probes such as the TPP0502 are well-suited for these measurements with 2X attenuation, and 2 MΩ, 13 pF loading.

Continuous analytical measurement

Ionic impurities added to water (such as salts and metals) immediately dissociate and become available to act as charge carriers. Thus, the measure of a water sample's electrical conductivity is a fair estimate of ionic impurity concentration. Conductivity is therefore an important analytical measurement for certain water purity applications, such as the treatment of boiler feed water, and the preparation of high-purity water used for semiconductor manufacturing.

It should be noted that conductivity measurement is a very non-specific form of analytical measurement. The conductivity of a liquid solution is a gross indication of its ionic content, but it tells us nothing specific about the type or types of ions present in the solution. Therefore, conductivity measurement is meaningful only when we have prior knowledge of the particular ionic species present in the solution (or when the purpose is to eliminate all ions in the solution such as in the case of ultra-pure water treatment, in which case we do not care about types of ions because our ideal goal is zero conductivity).

Self-Check 6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed below (2%)

1. __________is a device that responds to or detects a physical quantity and transmits the resulting signal to a controller.

2. ___________is the process that confirms the components wired correctly and also helps to ensure that the system is functioning as designed
3. Why you perform loop checking
4. For loop checking the test to be carried out while there is no electric connection (True, False)
5. _____________ensure there is no current flow between conductor and ground or insulation surface.
6. What is the purpose of polarity test
7. Mention guidelines for checking instrumentation and control system defect
8. Pressure measurement include
9. Mention category of Flow measurements
10. _______________is also used for temperature measurement.
11. _____________is commonly used in sensing temperature.

Answer the following question!

Note: Satisfactory rating 12 and 22points Unsatisfactory below12and 22points

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: _____________

Answer Sheet

Name: __________________________ Date: _______________

Information Sheet 7. Planning and preparing diagnosis of faults

Planning and preparing diagnosis of faults

Planning and preparing

When planning and organizing how to do a job or correct a problem, first arrange the activities, people, or materials involved into a sensible order. For example, you might arrange them by priority ,sequence, position in the chain of command, or administrative functions. Whatever order you decide to use, plan and organize so that you proceed from the problem to a goal.

First you must determine the specific steps you must take to get the job done. List and figure the equipment, time, and manpower needed for the job. Try to foresee any problems that might arise. Ask yourself, Are time, equipment, or personnel scarce? Do the personnel assigned have the skills or knowledge to perform the assigned tasks?

Next list your plans in their order of importance. What must be done now? What can be left until later? By deciding the order in which you must carry out your plans, you can set up a plan of action.

A plan of action lists who will do what tasks at what period. Take time to write down a plan of action. Doing that will help you work around obstacles, such as times your people will be away from the work center.

Taking the following steps will allow you to plan for interruptions and still complete the assigned task in the most efficient and effective manner.

1. Identify action steps, resources, or obstacles involved in reaching a goal.
2. Prepare a schedule.
3. Set priorities.

Planning in Management

"Planning bridges the gap from where we are to where we want to go. It makes it possible for things to occur which would not otherwise happen"

Importance of Planning

- Planning provides directions
- Planning reduces the risks of uncertainty
- Planning reduces overlapping and wasteful activities
- Planning promotes innovative ideas

- Planning facilitates decision making
- Planning establishes standards for controlling.

Self-Check 7	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. answer the following question as directed (each 2 point)

I. **Answer the following question as directed below each contain (2%)**

1. Write steps /procedure of planning and organizing
2. A plan of action lists ____________and_________
3. mention importance of Planning

.

. Answer the following question!

Note: Satisfactory rating3 and 5 points Unsatisfactory below 3 and 5 points

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Answer Sheet

Name: _________________________ Date: _______________

LG #17	LO #2- Diagnose faults of instrumentation and control systems

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Using appropriate personal protective equipment
- Diagnosing faults or problems in instrumentation and control systems
- Managing contingency measures during unplanned events or conditions
- Recording fault and diagnosis result

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Use appropriate personal protective equipment
- Diagnose faults or problems in instrumentation and control systems
- Manage contingency measures during unplanned events or conditions
- Record fault and diagnosis results

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
4. Accomplish the "Self-checks" which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets

Information Sheet 1 Using appropriate personal protective equipment

1.1 Using appropriate personal protective equipment

- Ear muffs/plugs
- Goggles/glasses/face shield
- Safety belt/ harness
- Safety shoes
- Safety apparel/suit, hat, mask and gloves

PERSONAL PROTECTIVE EQUIPMENT (PPE)

This includes the protection of uncovered parts of the body where the entrance of contaminants is likely to occur. However, its misuse by management and employees has caused this alternative to be viewed with suspicion. When it is not feasible to protect the source of the hazard, or its path, its then becomes necessary to protect the employee from the environment. Available personal protective devices include:

Respiratory protective equipment: air purifying respirators (particulate-filter respirators and gas masks); air –supplied respirators (hose masks and airline respirators); and self-contained respirators (self breathing apparatus). Eye and face protection, including goggles and face shields. Protective clothing, including gloves, aprons, boots, coveralls. Protective creams and lotions, to help minimize skin contract with irritant chemicals. Ear protection, including ear plugs and muffs. PPE is the least effective method of controlling occupational hazards and should be used only when other methods cannot control hazards sufficiently

Worn appropriate personal protective equipment in line with standard Operating procedures.

Employees shall wear appropriate personal protective equipment (PPE) and protective clothing to protect them from hazards of instrumentation and control apparatus. Employees authorized or required to work on instrumentation and control systems shall be completely familiar with the PPE and protective clothing they need for adequate protection while working on such system.

The following are basic personal protective equipment's (PPE) that are always present on instrumentation and control systems to ensure safety of the working company:

Ear Muff/plug: An ear muff or ear plug is used for ear protection which dampens the noise to an acceptable decibel value. Even few minutes of exposure can lead to head ache, irritation and sometimes partial or full hearing loss.

Goggles/glasses/: Protective glass or goggles are used for eye protection, whereas welding goggles are used for welding operation which protects the eyes from high intensity spark.

Face mask: Working on same instrumentation and control systems or chemical cleaning involves minor hazardous particles which are harmful for human body if inhaled directly. To avoid this, face mask are provided which acts as shield from hazardous particle.

Safety hat Workers should wear approved hardhats when working aboveground on building to protect head in which work is being done. Workers shall wear hardhats when visiting or observing in areas where overhead is being done

Safety apparel/suit is very frequent and some chemicals are very dangerous when they come in direct contact with human skin. A chemical suit is worn to avoid such situations.

Safety belt/harness: operation includes maintenance and painting of high and elevated surfaces which require crew members to reach areas that are not easily accessible. To avoid a fall from such heightened area, safety harness is used. Safety harness is put on by the operator at one end and tied at a strong point on the other end.

Safety shoes Employees should wear shoes or boots that used for protecting feet while working or walking on job location.

Safety Hand gloves: are used in operations where in it becomes imperative to protect ones hands. Some of the gloves provided are heat resistant gloves to work on hot surface, cotton gloves for normal operation, welding gloves, chemical gloves etc.

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed bellow

1. Write at least four personal protective equipment(2)
2. ----------- is used for ear protection (2)
3. What is the purpose of goggles/glasses(2)
4. Workers should wear ------------- when working aboveground on building to protect head in which work is being done(2).
5. ------------- is worn to avoid such situations. (2)
6. What is the purpose of safety belt/harness. (2)
7. Employees should wear --------- for protecting feet while working or walking on job location. (2)
8. ------------ are used in operations where in it becomes imperative to protect ones hands. (2)

. Answer the following question!

Note: Satisfactory rating9 and 16 points Unsatisfactory below 9and 16 points

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: _________________

Information Sheet 2 Diagnosing faults or problems in instrumentation and control systems

2.1 Diagnosing faults or problems in instrumentation and control systems

Understand the procedures used in the instrumentation and control system diagnostics process

Trainer can research different approaches to fault diagnosis, routines to be followed from recording the fault, working from simple to more complex faults and tests in order to identify the issues. Group discussions will identify different approaches and requirements for different fault types. Trainer should also investigate the issues which affect organizations when systems develop faults such as; prioritizing jobs to reduce or avoid loss of data, loss of processing capability, loss of communications for example.

All of these activities can be undertaken in small groups which then feedback to the larger group where the findings can be recorded and discussed in order to identify good practice and common themes.

D diagnostic information:

Work content e.g.

- ✓ date
- ✓ name of person
- ✓ location of device
- ✓ location of fault
- ✓ error code
- ✓ symptom
- ✓ details of problem
- ✓ any parts used
- ✓ action taken
- ✓ problem history

- ✓ log
- ✓ diary
- ✓ pre-printed form

Paper-based or Electronic

Diagnose faults:

Follow procedures (e.g. response time for contacting customer, recording of fault and diagnosis, closing fault)

User appropriate tools, systems or manufacturer diagnostic software, meters for power and electricity related issue

Complete required document.

2.1.1 Troubleshooting

Troubleshooting is a step - by - step procedure whose purpose is to quickly and easily identify a problem in a system or process. Proper test instruments make the process smoother and make it possible to more easily identify secondary problems where they exist.

To troubleshoot a system, process, or equipment, start by collecting technical records from relevant sources. These include the OEMs, suppliers, contractors, operators, and maintenance departments.

2.1.2 Principle troubleshooting

- **Systematic approach** to locating the cause of a fault in an electronic circuit or system
  If your keyboard will not type, check to ensure that the cable is securely fastened to the keyboard port
- Determining which part of a system is responsible for a problem
  Sensing electrode, reference electrode, instrument, solution, measuring technique ... and operator. Unexpected solution chemistry, incorrectly prepared standardizing solutions, improper plotting of data, unsuitable reference

electrodes, operator error and poor choice of method account for many more problems than do instrument or electrode failure.

- **A logical** way of testing hardware or software in order to determine how to fix a problem

Logical Troubleshooting

Troubleshooting is done by one of the following methods:

- Case-study approach is used if a piece of equipment were known to have a chronic, or repetitive, problem. Check to see if it had reoccurred before looking for other problems.
- Logical analysis of given evidence. Data relating to the problemis gathered and used to isolate the case analytically. Because circuit theory is basic to design of medical equipment, it could be usedto deduce every problem with the hardware.

Systematic approach to troubleshooting uses both methods.

- Repair procedure will involve systematic disassembling and reassembling of the equipment.
- To disassemble the equipment, number each part as you remove it.

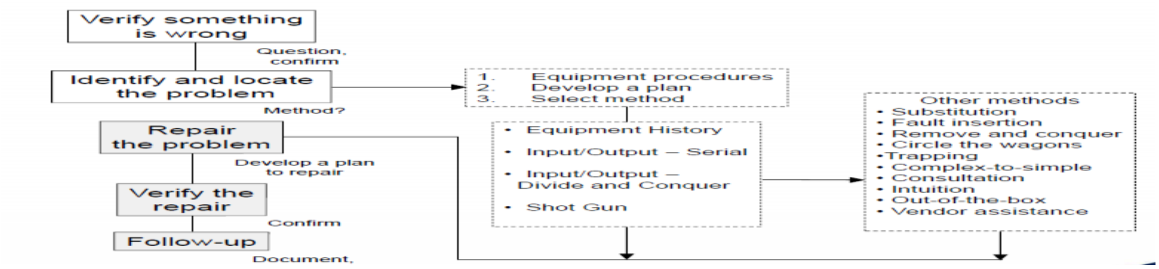
Then to reassemble, replace the parts in the reverse order, in order to be sure you are putting all the parts back together correctly

The steps of troubleshooting

1. Determine the Symptoms and analyze them.
   a. Listen, Think, Look, Smell, and Operate.
   b. Use all available sources of information: manuals, maintenance records, other people, the agent or manufacturer etc.
   c. State the symptoms as clearly and precisely as possible. Stating that a device does not work, while perhaps true, is not a clear, informative statement of symptoms.
2. Localize to a functional module. Think, Look, and Test.
3. Isolate to a circuit. Think, Look, and Test.

4. Locate the specific component or problem. Think, Look, and Test.
5. Determine the cause of the failure.
6. Replace or correct a defective component or problem and correct the causes of the failure.
7. Check for correct operation and calibration.
8. Complete the record keeping.
9. Review the entire troubleshooting and repair process. It is the best way to improve your troubleshooting skills.

Troubleshooting Framework Review



2.1.3 Sources of failure or poor performance in an instrument system

A failure in, or poor performance in an instrument system, can be the result of difficulties in any one of the system's three major components. As a general rule, failures are about equally distributed between the three components.

2.1.3.1 The operator

the end user typically makes the initial decision that a failure or malfunction has occurred Problems can be due to incorrect or improper operation, controls not set correctly, etc.

2.1.3.2 The environment

the total environment surrounding the instrument and operator—Problems can be related to environmental and other factors such as temperature, dirt, vibration, incorrect electrical or chemical interference, input exceeding the dynamic range, bad reagents, bad electrodes, etc.

2.1.3.3 The instrument

The device which performs a task such as measurement, control, etc. Failures fall into two general categories:

2.1.3.4 Mechanical fault (Non-electronic)

Loose or broken connections, dirt, corrosion, mechanical wear, etc. These are the most probable sources of instrument failures **Classification of the major faults of electrical machines and their symptoms**

Most of the surveys of failures in electrical rotating machines indicate that in general, failures are dominated by bearing and stator winding failures with rotor winding problems being less frequent. The reported percentage failure of components for the sample was as follows [Benbouzid 2000]:

- Bearing Related 41 %
- Stator Related 37 %
- Rotor Related 10 %
- Others 12%

The major faults of electrical machines can broadly be classified as the following:

a) Stator faults resulting in the opening or shorting of one or more of a stator phase winding
b) Abnormal connection of the stator windings
c) Broken rotor bar or cracked rotor end-rings
d) Static and/or dynamic air-gap irregularities
e) Bent shaft (dynamic eccentricity) which can result in a rub between the rotor and stator, causing serious damage to stator core and windings
f) Shorted rotor field winding, and
g) Bearing and gearbox failures.

These faults produce one or more of the symptoms as given below:

a) Unbalanced air-gap voltages and line currents
b) Increased torque pulsations
c) Decreased average torque
d) Increased losses and reduction in efficiency, and
e) Excessive heating

The diagnostic methods to identify the above faults may involve several different types of fields of science and technology.

They can be described as:

a) Electromagnetic field monitoring, search coils, coils wound around motor shafts (axial flux related detection)
b) Temperature measurements
c) Infrared recognition
d) Radio frequency (RF) emissions monitoring
e) Noise and vibration monitoring
f) Chemical analysis
g) Acoustic noise measurements,
h) Motor current signature analysis (MCSA)
i) Model, artificial intelligence and neural network based techniques

A. Bearing faults

The majority of electrical machines use ball or rolling element bearings. Each of these bearings consists of two rings, one inner and the other outer. A set of balls or rolling elements placed in raceways rotate inside these rings. Even under normal operating conditions with balanced load and good alignment, fatigue failures may take place. These faults may lead to increased vibration and noise levels. Flaking or spelling of bearings might occur when fatigue causes small pieces to break loose from the bearing. Other than the normal internal operating stresses, caused by vibration, inherent eccentricity, and bearing currents due to solid state drives, bearings can be spoiled by many other external causes such as:

a) Contamination and corrosion caused by pitting and sanding action of hard and abrasive minute particles or corrosive action of water, acid etc.
b) Improper lubrication; which includes both over and under lubrication causing heating and abrasion.
c) Improper installation of bearing. By improperly forcing the bearing onto the shaft or in the housing (due to misalignment) indentations are formed in the raceways.

B. **Stator or armature faults**

These faults are usually related to insulation failure. In common parlance they are generally known as phase-to-ground or phase-to –phase faults. It is believed that these faults start as undetected turn-to-turn faults, which finally grow and culminate into major ones. Almost 30-40% of all reported induction motor failures falls in this category.

Armature or stator insulation can fail due to several reasons. Primaries among these are:

a) High stator core or winding temperatures,
b) Slack core lamination, slot wedges and joints.
c) Loose bracing for end winding.
d) Contamination due to oil, moisture and dirt
e) Short circuit or starting stresses
f) Electrical discharges
g) Leakage in cooling systems

C. Broken rotor bar and end ring faults

Unlike stator design, cage rotor design and manufacturing has undergone little change over the years. As a result rotor failures now account for around 5-10% of total induction motor failures.

Cage rotors are of two types: cast and fabricated. Previously cast rotors were only used in small machines. However, with the advent of cast ducted rotors; casting technology can be used even for the rotors of machines in the range of 3000 kW. Fabricated rotors are generally found in larger or special application machines. Cast rotors though more rugged than the fabricated type, can almost never be repaired once faults like cracked or broken rotor bars develop in them.

The reasons for rotor bar and end ring breakage are several. They can be caused by:

a) Thermal stresses due to thermal overload and unbalance hot spots or excessive losses, sparking (mainly fabricated rotors).
b) Magnetic stresses caused by electromagnetic forces unbalanced magnetic pull, electromagnetic noise and vibration.
c) Residual stresses due to manufacturing problems.
d) Dynamic stresses arising from shaft torques, centrifugal forces and cyclic stresses.
e) Environmental stresses caused by for example contamination and abrasion of rotor material due to chemicals or moisture.
f) Mechanical stresses due to loose laminations, fatigued parts, bearing failure etc.

2.1.3.5 Electrical

Common Causes of Electric Motor Failures There are six main causes of electric motor failures:

1. Over-Current
2. Low Resistance
3. Over heating
4. Dirt
5. Moisture
6. Vibration

These causes are briefly explained below:

1. **Over-Curren**t

   (Electrical Overload): In different operating conditions, electrical devices will sometimes start to draw more current than their overall capacity. This unpredictable event will happen very suddenly and will greatly impact the motor. To avoid an over-current, there are some devices that need to be installed that can prevent it from happening. These devices are usually wired in the circuits and will automatically shut down the extra amount of current flowing in the circuit.

2. **Low Resistance**:

Most motor failures occur due to low insulation resistance. This issue is considered to be the most difficult one to tackle. In the initial stages of motor installation, the insulation resistance is observed to be more than one thousand mega ohms. After some time, the insulation performance starts to degrade at an alarming level because the resistance starts to decay gradually. After a lot of research, a solution has been found which can prevent low resistance failures. There are automatic devices that test insulation resistance from time to time and safeguard rotating equipment is installed that prevents such failures. It is important that the insulation performance is monitored at regular intervals.

3. **Over Heatin**g:

Excessive heat in motors can cause a number of performance problems. Overheating causes the motor winding insulation to deteriorate quickly. For every ten centigrade rise in temperature, the insulation life is cut in half. It has been concluded that more than 55% of the insulating failures are caused by overheating. Over heating occurs due to a number of factors. Every electric motor has a design temperature. If a motor is started off at a bad current value, it starts operating in a much warmer condition than the design temperature. It is very important that the motors should be matched with their ideal current values.

Overheating also occurs when an electric motor is forced to operate in a high temperature environment. This causes the rate at which heat can be conducted to reduce at an alarming rate. The area where electric motors are operating must have a proper cooling system and a ventilation system should be there in case the cooling system stops working.

4. **Dirt**:

Dirt is one of the major sources that cause damage to the electric motors. It can damage the motor by blocking the cooling fan which causes its temperature to rise. It can also affect the insulating value of the winding insulation if it settles on the motor windings. Proper steps should be taken to prevent the motors from dirt. Shielding devices are available which are used for this purpose.

5. **Moisture**:

   Moisture also affects the performance of electric motors. It greatly contributes in the corrosion of the motor shafts, bearings and rotors. This can lead to an insulation failure also. The motor inventory should be kept dry all the time.

6. **Vibration**:

   There are a number of possible causes of vibration, such as misalignment of the motor. Corrosion of parts can also cause the motor to vibrate. The alignment of the motor should **be checked to eliminate this issue.**

pneumatic

Troubleshooting Steps

The five-step troubleshooting process consists of the following:

1. Verify that a problem actually exists.
2. Isolate the cause of the problem.
3. Correct the cause of the problem.
4. Verify that the problem has been corrected.
5. Follow up to prevent future problems.

Action Items

Within the four general guidelines previously mentioned, there are several action items that are important to the successful achievement of the goal of troubleshooting:

1. **Verify that something is actually wrong**

   A problem usually is indicated by a change in equipment performance or product quality. Verification of the problem will either provide you with indications of the cause if a problem actually exists or prevent the troubleshooter from wasting time and effort on "ghost" problems caused by the operator's lack of equipment understanding. Do not simply accept a report that something is wrong without personally verifying the failure. A few minutes invested up front can save a lot of time down the road.

2. **Identify and locate the cause of the trouble**

   Trouble is often caused by a change in the system. A thorough understanding of the system, its modes of operation, and how the modes of operation are supposed to work, the easier it will be to find the cause of the trouble. This knowledge allows the troubleshooter to compare normal conditions to actual conditions.

3. **Correct the problem.**

   It is very important to correct the cause of the problem, not just the effect or the symptom. This often involves replacing or repairing a part or making adjustments. Never adjust a process or piece of equipment to compensate for a problem and consider the job finished; correct the problem!

4. **Verify that the problem has been corrected.**

   Repeating the same check that originally indicated the problem can often do this. If the fault has been corrected, the system should operate properly.

5. **Follow up to prevent further trouble.**

   Determine the underlying cause of the trouble. Suggest a plan to a supervisor that will prevent a future recurrence of this problem.

   This basic troubleshooting philosophy is the basis for the seven-step troubleshooting method discussed later. It reflects the basic strategy for troubleshooting, though each individual facility may require a different application of the strategy specific for the equipment and policies at that facility. An important point to remember as we discuss the seven-step methodology is that we are discussing a philosophy - not a procedure. Using the seven-step philosophy, a procedure could be developed that would provide the most cost-effective and efficient means for troubleshooting a particular piece of equipment in a given facility. However, this procedure would not necessarily be effective when used with different equipment or even the same equipment installed in a different facility.

Seven-Step

The seven-step troubleshooting method consists of the following seven steps:

1. Symptom recognition
2. Symptom elaboration
3. Listing of probable faulty functions
4. Localizing the faulty function
5. Localizing the trouble to a faulty component
6. Failure analysis
7. Retest requirements

2.1.3.6 (computer based) Electronic

a component or circuit failure. In general, the electronic portion of an instrument system is the most reliable part.

The first problem of troubleshooting is to determine whether the fault is in the Operation, Environment, or Instrument component of the instrument system.

The purpose of the methodology of troubleshooting is to gather information about the poor performance or failure of an instrument system in a logical and systematic manner.

You must find the answer to such questions as:

1. How does the system behave normally?

2. What are the conditions of failure?

3. What are the symptoms caused by the failure?

4. What is the cause of the failure? Then you must repair the system.

Troubleshooting requires a broad knowledge base: including electronics, physics, chemistry, optics, mechanics, measurement theory, equipment operation, etc.

Troubleshooting requires good practical skills:

1. Careful observation knowing what to look for, when to look, and where to look.
2. Effective utilization of instrument service manuals, and other sources of technical data.
3. Proper use of hand tools and small machinery—using the proper tool or machine for the task at hand and using them safely and correctly.
4. Good soldering techniques—use a good clean soldering iron and follow proper practice to prevent causing damage to delicate components, circuit cards, insulation, etc.
5. Knowledge of device assembly, disassembly, and component removal methods. Proceed cautiously and carefully, noting the order of things to prevent creating additional difficulties and to allow proper re-assembly.
6. Good safety awareness and practices---not only for the troubleshooter, but to note and change things which could be a hazard to an operator or user of the device.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed below (each 2 point)

1. ______________is a step - by - step procedure whose purpose is to quickly and easily identify a problem in a system or process.
2. Explain at least three Method of Troubleshooting
3. Mention steps of troubleshooting
4. How can failure in, or poor performance in an instrument system occur
5. Mention environment fault
6. Mention operator fault
7. Mention environment fault
8. Mention Mechanical fault
9. Mention (computer based) Electronic a component or circuit failure

. Answer the following question!

Note: Satisfactory rating 9 and 17 points Unsatisfactory below 9 and 17 points

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date______________

Information Sheet 3. Managing contingency measures during unplanned events or conditions

3.1 Managing contingency measures during unplanned events or conditions unplanned event or condition

Accident, malfunction unplanned events refers to event or upset conditions that are not part of any activity or normal operation of the project as has been planned

Four steps to manage unplanned event

1. assess and prioritize
2. tactics for tackling unplanned work
3. communicating about unplanned work
4. mitigating the problem

Contingency plan

Contingency plan is a plan devised for an outcome other than in the usual expected plan it is often used for risk management for expectation risk that, thought unlikely would have catastrophic consequences contingency plan are often devised by government or business. Identifying assess and respond to events that may disrupt instrument

A contingency plan is a process that prepares an organization to respond effectively and coherently to an unplanned event. A contingency plan can be also used as an alternative action plan if the original plan fails to generate the desired result.

Who produces a contingency plan

Development of a contingency plan is a team task, with involvement of staff from each functional area of a business. The plan must have support from the top down.

board's role in contingency planning

It is the responsibility of the board to ensure that a contingency plan is in place, and is reviewed regularly to ensure any changes are taken into consideration.

Typical events which require contingency arrangements

- Natural disasters such as fire, flood etc.
- Loss of data / IT security breach
- Fraud
- PR disaster
- Loss of key personnel
- Loss of key customers or suppliers

What problems might I encounter in developing a contingency plan, and how can I deal with them?

- The very nature of contingency planning is to look for events which are highly unlikely to happen. Staff can often see developing a plan to cope with these events as having a low priority.
    - Stress the urgency of contingency planning by highlighting that a disaster is as likely to happen tomorrow as six months from now.
- Staff can be so invested in “Plan A” that they don’t want to consider having to switch to a “Plan B”.
    - Stress that “Plan B” should be properly thought through.
- Staff can feel that their area of responsibility is the most important area within the organization.
    - By taking a team approach to the development of contingency plans, staff can challenge each other on the priority given to each area. Stress that essential business processes must be given priority, and that everyone has a role in this.

Steps in developing a contingency plan

- Identify potential risks
- Prioritize these by assessing what impact they might have on the operation of the organization
- Identify sources of outside assistance such as the emergency services. Involve relevant outside agencies in your plan
- Identify key milestones along the way to becoming fully operational and ways in which each will be achieved
- Test your plan. Run simulations to ensure your plan has the desired result. This will also include staff training to ensure their readiness
- Monitor the plan. Regularly review the plan to ensure it includes new potential risks.

Contingency planning steps

- identify scenarios
- set priorities and goals
- identify activities and tasks
- allocate resources
- allocate responsibilities
- set order of implementation
- ensure technical inputs
- develop procedures

Self-Check .3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part I answer the following question as directed bellow

1. ___________ refers to event or upset conditions that are not part of any activity or normal operation of the project as has been planned
2. ______________is a plan devised for an outcome other than in the usual expected plan it is often used for risk management.
3. Mention steps to manage unplanned event

. Answer the following question!

Note: Satisfactory rating 6 and 11 points Unsatisfactory below 6 and 11 points

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Answer Sheet

Name: ___________________________ Date: _______________

Information Sheet 4. Recording fault and diagnosis results

Recording fault and diagnosis results

The fault recording system is intended for measuring, computing, archiving and supplying electrical parameters of electrical installations in the normal operation and emergency modes. This information`s analysis allows to identify an emergency`s cause, assess the correctness of operation of relay protection and SIPS devices, and develop a set of measures to prevent any further development of the emergency mode.

Information from the fault recording system is used at the level of the facility where it is implemented within the context of operation of electrical installations being supervised and at the level of the System Operator within the context of investigation of any emergency events that occur.

Fig. shows a typical block diagram of the emergency event recording system (fault recording system) of a power generating company.

The fault recording system comprises the following principal components:

- RES-3 fault recorders
- Fault recording system server
- Fault recording systems local area network
- Universal time system

The RES-3 recorder is a microprocessor-based device that has a modular structure. The type and range of its modules is determined at the engineering stage in accordance with the technical requirements of the facility where it is meant to be implemented. RES-3 are installed in premises intended for installation of relay protection devices: relay cabinet / room (RCab) or main control cabinet / room (MCCab). Analog circuits of RES-3 (TI) are wired to measuring voltage and current transformers (VT and CT), external measuring transducers.

RES-3 registers binary signals (TS, TE) received from relay protection and automation devices, from cabinets for SIPS of electrical equipment, directly from the switching equipment (SE), and from the emergency signals and commands transmission devices. The RES-3`s activation for obtaining oscillograph records of electrical parameters of an emergency mode is effected on the basis of variation of values of analog input signals compared to the set point, and of variation of status of one or several binary input signals.

Types of data that RES-3 uses for data presentation:

- Instantaneous values of analog and binary signals with a sampling frequency of up to 2000 Hz per channel – for taking oscillograph records of regular and emergency modes
- Effective values at the power line frequency period – to serve as replacement data for the TDE SO hardware and software complex

The fault recording system server is a computer or server running the Microsoft Windows (Server) operating system.

The fault recording system server`s principal functions are as follows:

- Supplying of electrical parameters of normal operation modes of electrical equipment under OPC DA or IEC 60870-5-104 network protocols
- Storage and transmission of electrical parameters of electrical equipment`s emergency modes under the FTP network protocol with a safekeeping period of up to 3 years
- RES-3 recorders' configuration files.

The RES-3 recorders and the fault recording system server are combined into an fault recording process LAN based on the TCP / IP protocol stack. In order to interface the fault recording system LAN with LANs of third-party automated data systems of the facility where it is to be implemented the of virtual LAN (VLAN) technology is used.

The universal time system supplies the RES-3 with accurate time stamps for recording the electrical parameters with an accuracy of at least 1ms. This property allows to analyze information from several RES-3s not just from the same facility, but even from RES-3s of different facilities.

Additionally, the fault recording system includes an operator workstation (WKS) running the SignW application. The workstation is used to configure and diagnostic ate operability of the fault recording system, and communicate the captured parameters.

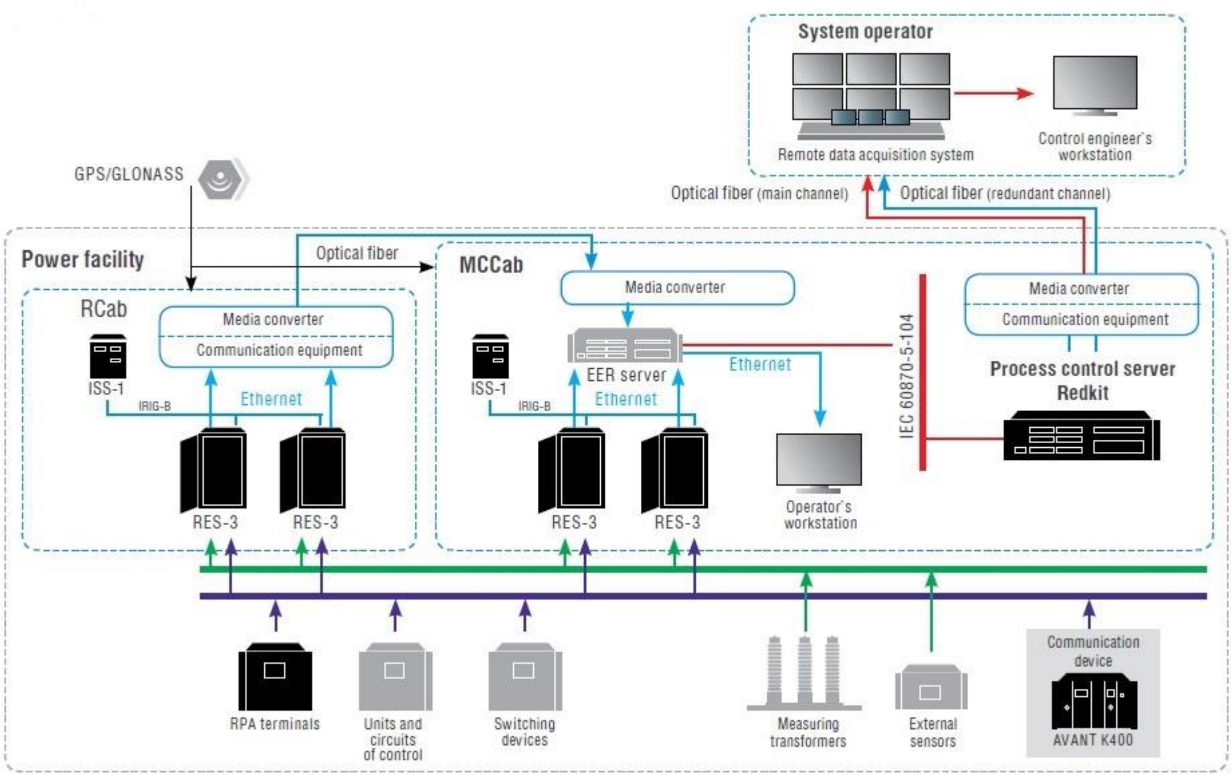


Fig 2.1 emergency event recording system (fault recording system) of a power generating company

Recording malfunction/fault component

Good records help to keep you proceeding in a logical sequence as well as keeping track of what has been done. Records help in the future by providing a reference in case of additional failures in the same or similar instruments. Records can be used to provide feedback to manufacturers and their agents. Records can be used to provide management information which help in making repair or replacement decisions. Records can be used to detect a problem in a particular instrument which may require a modification to correct

Fault recording sheet contain

- Record fault diagnosis data:
    - Issue and date of receipt
    - Details of fault
    - Solution or solutions attempted
    - Tests conducted and results
    - Successful outcome
    - Date of solution
    - If unresolved date of escalation to expert.
- **store fault diagnosis data:**
    - Manual recording on specified forms
    - Fault log book.

.

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I Answer the following question as directed below

1. mention purpose of Good fault recording techniques
2. fault recording sheet contain

. Answer the following question!

Note: Satisfactory rating 5and 8 points   Unsatisfactory below 5 and8 points

You can ask you teacher for the copy of the correct answers.

Score = ____________

Rating: _____________

Answer Sheet

Name: _________________________   Date: _______________

LG #18	LO #3 Rectify/correct defects in instrumentation control devices and system

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Isolating systems and associated equipment
- Making adjustments if necessary
- Replacing or correcting defective components or parts
- Responding to unplanned events or conditions
- Recording rectified/corrected defects/ malfunctions components and measures

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Isolate systems and associated equipment
- Make adjustments if necessary
- Replace or correcting defective components or parts
- Respond to unplanned events or conditions
- Record rectify/correct defects/ malfunctions components and measures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
4. Accomplish the "Self-checks" which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets

7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet1. Identifying appropriate shutdown procedure

Identifying appropriate shutdown procedure

Normal shutdown includes steps to render the systems safe, such as removal of hazardous process materials and inert (asphyxiating) gases. The systems might be cleaned as part of the shutdown; cleaning is often a process unto itself requiring its own set of startup, operation, and shutdown procedures.

General instructions for shutting instruments down for an extended period of time

General instructions for sequencing systems

1. Perform a maintenance/manual/Standby wash (Standby wash for MiSeq only) using Twenty 20 and NaOCl (if applicable), instructions are found in the instrument system guides
2. Perform another maintenance/manual/Standby wash (Standby wash for MiSeq only) using laboratory-grade water to remove Tween from the system
3. If possible, perform the above steps every 30 days

General instructions for all systems

1. Shut down procedures:
    - If employees will be in the lab, leave instrument powered on while idle
    - If lab is completely shutting down (no employees on site or possibility of power being shut off), power off the instrument via normal processes in the instrument system guide
2. Keep the instrument off until normal work schedules permit

Upon permanent return to work

1. Power on the instrument

2. Perform <u>two</u> maintenance/manual washes to rehydrate the fluidics system

Note: If additional maintenance/manual/Standby wash using laboratory-grade water was not performed prior to instrument shutdown, perform three maintenance/manual washes to rehydrate the fluidics system and run system checks to test the fluidics delivery

Difference between Process shutdown and Emergency Shutdown

What is Process shutdown (PSD)

Process shutdown (PSD) is defined as the automatic isolation and the activation of all part of a process. During a PSD the process remain pressurized.

Basically PSD consist of field mounted sensors. Valves and trip relays, a system logic unit for processing of incoming signals, alarm and MHI units. The system is able to process all input signals and activating output in accordance with the applicable cause and effect matrix chart

Typical action from PSD systems are:

1.Shutdown the whole process
2. Shutdown part of the process
3. Depressurize/Blow down parts of the process

What is Emergency Shutdown (ESD)

The **Emergency Shutdown (ESD)** shall minimize the consequences of emergency situations, related to typically uncontrolled flooding, escape of hydrocarbons, or outbreak of fire in hydrocarbon carrying areas or areas which may otherwise be hazardous. Traditionally risk analyses have concluded that the ESD system is in need of a high Safety Integrity Level, typically SIL 2 or 3.

Basically the system consists of field-mounted sensors, valves and trip relays, system logic for processing of incoming signals, alarm and HMI units. The system is able to process input signals and activating outputs in accordance with the Cause & Effect charts defined for the installation.

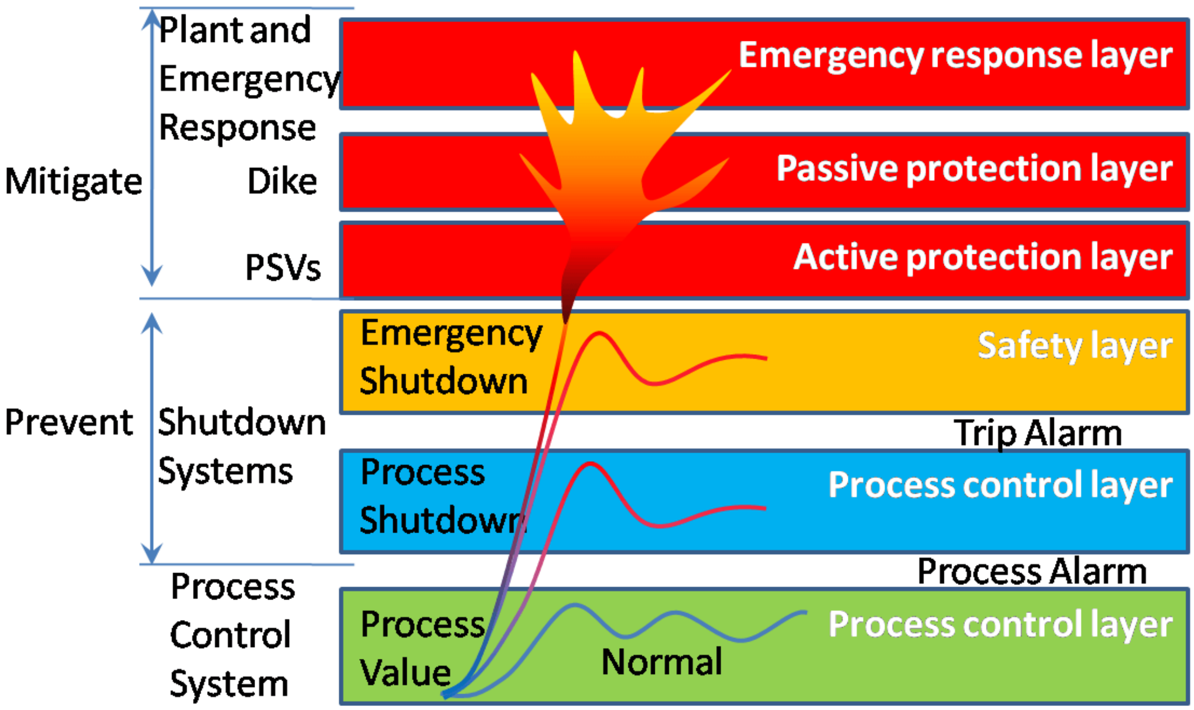


Fig 3 ESD

ESD can be automatically initiated by load shedding functions or manually by the operator through push button on the panel. ESD will shutdown and isolate all designated process related equipment, including inlet and outlet ESD valves. Depends on each project some plant will allow the power generation, utilities and fuel gas system keep running during this condition.

Typical actions from ESD system are:

1. Shutdown of part system and equipment
2. Isolate hydrocarbon inventories
3. Isolate electrical equipment
4. Prevent escalation of event
5. Stop hydrocarbon flow

6. Depressurize/Blow down parts of the process
7. Emergency ventilation control
8. Close watertight doors and fire doors

PSD vs ESD

Process shutdown (PSD) system is a part of plant (facility) safeguarding system with a purpose to minimize the frequency and consequences of excursions outside the facility operating envelope.

Emergency shutdown (ESD) system is a part of plant (facility) safeguarding system with a purpose to keep the process within the design envelope and to prevent the escalation of abnormal conditions into a major hazardous event.

PSD and ESD can be considered as effects, which are triggered by certain causes, the PSD and ESD are levels of shutdown which discriminate between the seriousness of the causes leading to the appropriate effects.

Process shut down could be attributed to any planned shut down of the unit. It is an anticipated one and planned to attend the process issues during the favorable situation such as unit feed limited due to downstream unit issues, feed quality affects the unit throughput etc. Otherwise shut down time to be planned according to the severity of the issue.

Whereas emergency shutdown, as the terminology explains it is a forced situation on the process unit. One has to act according to the situation. Using the available resources, plan to go for safe shutdown of the unit as per the SOP of the unit.

Application of mind relating to the situation is the most important aspect as emergencies are always different and may be the type of emergency occurs also new. A very good knowledge about the process, plant and facilities available in the unit are the must to handle ESD safely.

Process shutdown will be initiated if the control system capture any process abnormalities as defined in the control system design. This system will try to stop propagating the impacts of process abnormalities downstream.

Emergency shutdown will be mostly initiated originating from abnormalities leading to serious safety concerns such as Runaway reactions leading to excessive temperature.

Seven steps for a successful shutdown

Step 1: A comprehensive list

A checklist with every piece of equipment involved in the outage should be available for review. Every stakeholder should examine this list to ensure nothing is missing. Examples of assets for most plant checklists include:

- Agitators
- Airlocks
- Conveyors
- Doors
- Dust baggers.
- Gearboxes
- Man ways
- Mixers and blenders
- Motors
- Piping
- Pumps
- Valves.

This checklist should be periodically updated to add equipment installed since the last shutdown. It should also note:

- Equipment difficult to take offline in the past
- Bad actor assets since the last outage

- Special equipment such as cranes or generators needed to complete the required work.

This information should be included in the job plan for each equipment type.

Step 2: Have it in inventory

Ensure that all replacement parts, accessories and rebuilt equipment are in stock before the shutdown. The last thing any team needs is to have staff on hand to conduct maintenance, replacements and new installations only to be held up waiting for rebuilt equipment to return from a shop.

The team should encounter no surprises. Inventory should be up to date well before the outage date. Environmental controls are part of this inventory, including pressure gauges, temperature sensors and flush line components. Sealing equipment, such as packing, process seals, oil seals, new lubricants and lantern rings should be in stock and prepared for installation.

Step 3: Safety first

Safety should be the top priority during any outage. Before beginning work, all lock out/tag out (LOTO) procedures should be followed and personnel must wear all required personal protective equipment (PPE)

Because equipment is shut down, personnel may have a false sense of security. However, PPE is still required, especially for situations in which machinery or piping may retain hazardous, hot or corrosive liquids. Team leaders should review task and safety requirements with personnel participating in the work, including temporary staff onsite who may not be as familiar with this location's LOTO and PPE rules. A zero-tolerance LOTO and PPE policy should be enforced.

Step 4: Within current specifications

Double check that all equipment (new and rebuilt) is within current operating parameter specifications. When assets were specified, they met the requirements of the process at that time. Condition changes, such as fluid temperature, flow requirement or process fluid pH must be considered. Different parts or different equipment may need to be used.

For example, water flow from when a pump was specified was 100 gallons per minute. During operation and plant growth, the requirement at shutdown is 500 gallons per minute. Perhaps a larger pump should be installed. An outage is an ideal time to make this type of replacement.

Step 5: Inspect before installation

Personnel should inspect all equipment before anything is installed; look for wear or damage. Installing new components into a worn piece of equipment is almost always counterproductive. Demise of the new components begins immediately. Examples of this include:

- Packing installed in a pump with a worn shaft or sleeve or a damaged stuffing box wall will immediately begin to wear.
- With extreme damage, successful installation may not be possible.
- Installing a new mechanical seal into a system with a failing bearing or bearing isolator means the mechanical seal’s life will be shortened.
- Installing a new impeller on a worn shaft or with improper clearances because of casing wear or damage will result in poor operation and incorrect flow.

Step 6: Precise installation

While this step seems obvious, improper installation happens all the time. Reliability begins with the asset selection and correct installation. If installed imprecisely, failure begins at startup.

Installation issues include:

- Misalignment

- Soft foot — A soft foot exists when not all a machine’s feet sit flat on the supporting base, so that tightening the foot bolts distorts the machine case. This can make a machine difficult to align and a distorted case can result in poor overall machine performance, according to EASA.
- Improperly set packing
- Bearings installed with a hammer or without being properly heated
- Incorrect tightening of bolts or other fasteners
- Installing the wrong component
- Using the wrong lubricant.

Properly following job plans help prevent premature failure because of installation problems. An example of ways to properly install components is to use tools to install compression packing. Using tools and carefully following the correct job plan steps every time results in precise installation and provides the longest life for each component or asset

Step 7: Inspection before restart

The plant team should give everything one more look before restarting the plant or process. Even when every step is taken and every job plan is followed, stuff happens. A motor is bumped during work on another piece of equipment, causing misalignment. Housekeeping staff accidentally hits a piece of equipment. A wrench left on an asset may have fallen

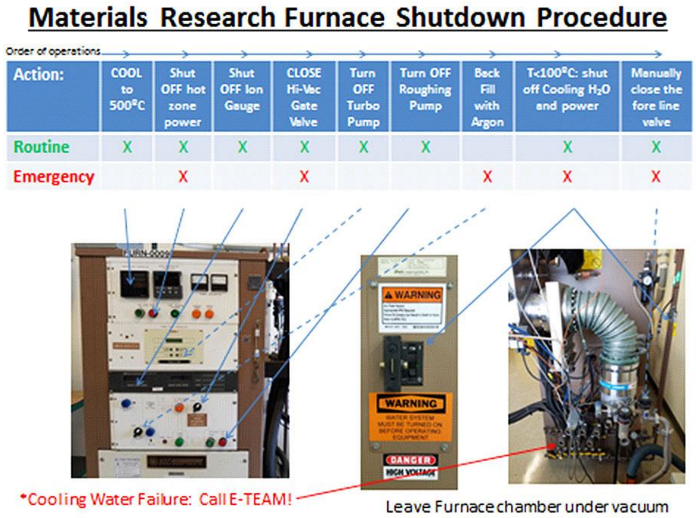


Fig 3 material research furnace shutdown procedure

Fig b emergency shut down procedure

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. **Answer the following question as directed below (each 10 point)**1.

1. List shut down procedure
2. What is the difference between emergency shut down procedure and process procedure

. Answer the following question!

Note: Satisfactory rating 11and 20 Unsatisfactory below11 and 20points points

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-2. Making adjustments

2.1 Making adjustments

Adjustment the correction or balancing of a measuring instrument in order to eliminate systematic measurement deviation. The measured value obtained from a measuring instrument is thus adjusted to match the known value of the test standard under specified reference conditions.

Adjustment the art of making an alteration or modification is an adjustment.

General Adjustment instructions Differential/Pressure/Vacuum Switch

Check proof pressure of switch on name plate or catalog. NEVER EXCEED THIS PROOF PRESSURE.

1. Note the adjustable range of switch (increasing or decreasing pressure) as listed in the catalog or on the name plate.
2. Check the catalog listing for actuation value of the switch.

To set the switch you need:

1. A pressure/vacuum source
2. A pressure/vacuum gauge

3. An electric continuity tester

Caution! -always change pressure setting gradually.

-always check switch setting before making any adjustments.

Step 1**.** Determine if the pressure/vacuum set point is on increasing or decreasing pressure.

Step 2. If the set point is on increasing pressure, then decrease the pressure/vacuum of the source starting at a point lower than the set point. Use maximum 1/4 turn on adjustment screw.

If the set point is on decreasing pressure, then increase the pressure/vacuum of the source starting at a point higher than the set point.

Step 3. Using the continuity tester and the pressure/vacuum gauge determine the actuation point of the switch.

Step 4. If the actuation point is above the desired value, turn the adjustment screw or knob per instructions in the pressure switch catalog to increase the actuation point, and if it is below, turn the adjustment screw or knob in the opposite direction to decrease it.

Step 5. For exact pressure/vacuum setting, cycle pressure/vacuum switch and make fine adjustments by repeating steps 2 through 4 (trial and error process) until the desired setting is obtained.

Note 1. For proper electrical connection follow colors of wire insulation or instructions on terminal code tag attached to switch.

Note 2. Dual control switches should be set one side at a time. Recheck both sides after final setting.

How To Adjust A Pressure Reducing Valve:

Knowing how to adjust a pressure reducing valve is an important part of any DIYer's toolkit. In this article, we'll start from scratch and walk you through the process. We'll also tell you everything you need to know about pressure reducing valves and why you might need to adjust yours in the first place.

How Do Pressure Reducing Valves Work?

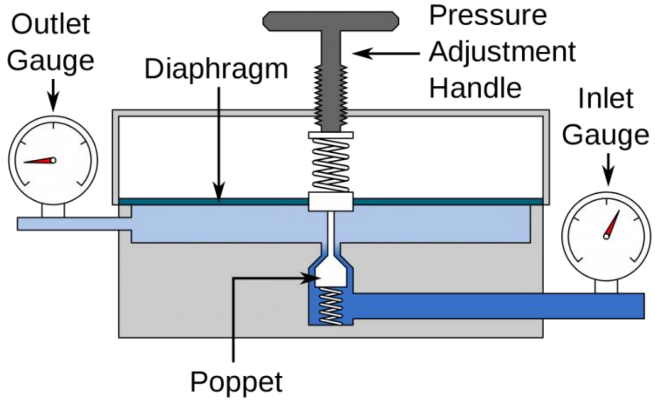


fig 2.3 Pressure Reducing Valves

As their name would suggest, pressure reducing valves control the flow of water into your home. Without a pressure reducing valve, this water would travel through your plumbing at a rate unsuitable for residential use.

.A pressure reducing valve is typically close to your water shutoff valve. You'll know you're looking at the valve because it will have a gauge nearby.

Inside the valve, there are a spring and diaphragm. These two elements interact with incoming water pressure, either contracting or enlarging the hole that your water ultimately passes through.

When the water enters the valve at a pressure greater than what it's been set to allow, the diaphragm and spring will contract and reduce the flow. The reverse is also true, however. If the water enters the valve at too low a pressure, the spring and diaphragm will expand and allow the water to exit through a larger hole.

Your pressure reducing valve setting will determine what it considers acceptable at both the upper and lower limits of its range.

If this doesn't make total sense to you, don't worry. The exact mechanics and physics of the process confuse even some experienced plumbers. What everyone does know is that the process works.

How to Adjust Your Pressure Reducing Valve

fig 2.wrench

You'll need a wrench of the right size to perform the adjustment.

Now that you have a good understanding of how pressure reducing valves work, you should have an idea of what's happening when you do the adjustments.

First Things First: Should You Adjust The Pressure?

If you're experiencing increased or decreased water pressure due to an abnormality in your municipal water supply's function, adjusting the valve may throw things out of wark when the system returns to normal.

Step 1: Locate The Valve

A pressure reducing valve usually resembles a bell or dome. As mentioned earlier, you'll usually see it alongside a gauge. It may be built right into your water meter. In most cases, however, you'll find the valve in the form of a separate device that lies **after** the meter within your home's water supply chain.

Step 3: Identify the Adjustment Method

Many valves have a nut, screw, or knob attached to them that allow you to do the actual adjusting. Turning the screw or knob clockwise typically increases the water pressure while turning it counter-clockwise lowers the pressure.

This may be counterintuitive since it's the opposite of how faucets work, so make sure you know what direction to turn in order to get your desired pressure.

Step 4: Use a Water Gauge To Test Your Pressure

Before you make any adjustments to your pressure reducing valve, you need to understand the existing circumstances. While you may know your pressure is too high due to symptoms such as dripping faucets, you want to get an exact reading on the pressure.

There are a few places you can attach the gauge to get a good reading. As long as the fixture is downstream of the valve, it's doesn't particularly matter. Many people attach the gauge to a water heater drain valve or simply a faucet.

Step 5: Understand Whether You Have A Closed Or Open System

Simply put, an open water heater system allows excess water pressure to make its way back into your cold water supply line and eventually out into the municipal water supply. A closed system does not allow excess pressure to make it back out into the municipal supply.

When thermal expansion occurs, this can be dangerous. To avoid this danger, you will have to match the pressure of your regulator to the pressure of your expansion tank.
It's not rocket science but it's good to know before you start making adjustments.

Step 6: Adjust Your Pressure Reducing Valve

Most valves have a locking nut. Once you unscrew this nut, you will be able to turn the adjustment screw, knob, or bolt. Adjust it until the pressure shown on your gauge reaches the desired level. For most residential purposes, that means a pressure below 80 psi. Do not make huge adjustments at once. Make no more than a quarter turn each time before taking a look at the gauge to see what effect you're having. Also, make note of the adjustments you make so that you can revert them if you happen to go too far.

Step 7: If Necessary, Adjust Your Thermal Expansion Tank Pressure

If you have a closed water heater system, you will also need to adjust the pressure on your thermal expansion tank. To do this properly, you'll need an air pressure gauge to test the existing pressure of your expansion tank. Attach the valve directly to the air inlet valve on the tank.

Once you've determined the pressure, use a hand pump to raise it to a pressure equal that of your home's water pressure. Don't use an air compressor; doing so risks damage.

Step #8: Detach the Water Gauge and Lock The Adjustment Nut

Make sure you lock the adjustment nut on your pressure reducing valve. This will prevent the screw from turning easily, which would undo your adjustments.

When to Replace Your Pressure Reducing Valve

It's recommended that you check your water pressure at least once per year to ensure it's at the desired level. As with most mechanical devices, however, your pressure reducing valve can begin to function improperly with time.

You'll know this is the case when adjustments to your valve do not result in changes to your water pressure. The pressure may be consistently high regardless of your efforts and you'll likely notice issues such as water hammers and dripping faucets.

If you think you need to replace your pressure reducing valve, you'd be smart to contact a professional to do the job. It can be a confusing process for inexperienced DIYers as it requires soldering, plumbing work, and potentially the installation of other equipment to mitigate any issues you come across.

Once the valve has been installed professionally, adjusting it on your own is fairly straightforward presuming you have a solid understanding of the steps outlined above.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed

1. Why you Adjustment the instrumentation and control device? (5%)

2.____________ is the art of making an alteration or modification

3. Mention General Adjustment instructions Differential/Pressure/Vacuum Switch

. Answer the following question!

Note: Satisfactory rating 4and 6points Unsatisfactory below 4and 6points

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: ______________

Information Sheet 3. Replacing or correcting defective components or parts

3.1 Replacing or correcting defective components or parts

How to troubleshoot sensors and instruments?

1. If the temperature sensor is not reading accurately, ensure that it is clean and free of debris. The conductivity cleaning brush and warm water with mild detergent can be used to scrub the temperature sensor if needed. Alternatively, you can use a toothbrush to clean the sensor.
2. If the instrument is reading any other value, the conductivity/temperature port on the cable may be contaminated. Refer to the Cleaning the Sensor Port section of this document for information on how to clean the port.
3. After cleaning the port, recheck the temperature reading. If the temperature reading is still not displaying °C without the sensor installed, there may be a problem with the cable and/or instrument. In this case, contact your local your instructor or any technician that have knowhow about it.

4. The conductivity calibration should be verified every day the instrument is used. However, the conductivity sensor is very stable and may hold its calibration for several weeks.

Fix the Problem

- Once you feel the problem has been isolated, develop a plan to repair the problem
- Inform Production of your repair plan
- Repair or recommend the repair of the problem
- Follow production area safety procedures and manufacturer specifications and procedures during repair
- Communicate closely with Production

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. **Answer the following question as directed below (each 2 point)**

1. How can you replacing or correcting defective components or parts(5)
2. How to troubleshoot sensors and instruments

. Answer the following question!

Note: Satisfactory rating 3 and 5 points Unsatisfactory below 3and 5 points

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: _______________

Information Sheet-4. Responding to unplanned events or conditions

4.1 Responding to unplanned events or conditions

Accidents, malfunctions, and unplanned events

Accidents, malfunctions, and unplanned events are accidents or upset events or conditions that are not planned as a part of routine Project activities during any Project phase. Even with the planning and application of mitigation, accidents, malfunctions, and unplanned events could occur during any phase of the Project. These could occur as a result of abnormal operating conditions, wear and tear, human error, equipment failure, and other possible causes. Many accidents, malfunctions, and unplanned events are preventable and can be readily addressed or prevented by good planning, design, equipment selection, hazards analysis and corrective action, emergency response planning, and mitigation.

The accidents, malfunctions, and unplanned events that have been selected based on experience and professional judgment are as follows:

- **Worker accident:** worker accidents may occur during either construction or operation, and may result in harm, injury, or death to one or more Project workers;
- **Fire:** consists of a fire in a Project component. The focus is on the consequence, and not the mechanism by which it occurs;
- **Hazardous materials spill:** spills of fuel, petroleum products, and/or other chemicals used on site or in Project components; and
- **Vehicle accident:** Project-related vehicle accidents that could occur on the road transportation network.

Accident and Incident Reporting

It is important that you report all accidents and incidents that result in injury, illness, or damage (however slight), to your supervisor immediately. UT/IJP can learn how to prevent them from occurring in the future. It is UT/IJP responsibility to investigate each incident, and your responsibility to report them when they occur.

Follow Up to Minimize Future Problems

- Document in history file
- Suggest changes, if needed
- Upgrade PM program
- Submit changes to update all documentation (As built)

Verify that the Problem Is Fixed

• Confirm that all repaired and associated parts of the system operate correctly, including

- Measurements
- Control
- Alarms
- Interlocks

• Confirm that the Operator is satisfied with the performance of the repaired system and understands how it is to operate under all conditions

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Answer the following question as directed below

1. 3xplain malfunctions,/ unplanned events
2. unplanned events could occur during any phase of the Project(True, False)
3. _____________may occur during either construction or operation, and may result in harm, injury, or death to one or more Project workers;
4. Hazardous materials spill like ___________,____,_____ used on site or in Project components

. Answer the following question!

Note: Satisfactory rating3 and 5points Unsatisfactory below3 and 5points

You can ask you teacher for the copy of the correct answers.

Score = ____________

Rating: _____________

Answer Sheet

Name: ___________________________ Date: _______________

Information Sheet-5. Recording rectified/corrected defects/ malfunctions components and measures

5.1 Recording rectified/corrected defects/ malfunctions components and measures

Keeping Records

We already know, that all diagnosed/troubleshoot and maintenance activities should be recorded.

There are several reasons for this:

- Technical alterations to the plant will be recorded. For example a pump of different capacity has been installed, this could effect the workings of the entire plant.

- Temporary repairs are identified as such, so that a permanent repair can be affected later. This should stop temporary repair to be seen as a permanent solution.
- Repeated repairs to the same equipment can be identified. If the same equipment needs to be repaired over and over, then possibly it is under dimensioned and can not cope with the task.
- Maintenance/ troubleshoot records can be a tool to adjust the man power required.
- Well kept maintenance records would also help to control the amount of materials used.
- Maintenance records can take different shapes and forrns, every company needs to find the sort of records that is most suited to their specific requirements. It may be a simple book into which all maintenance activities are entered or it could be preprinted forms that are filled in after the work is done.
- Whatever form it takes, maintenance records should be kept!!

Table 1 Recording rectified/corrected defects components and measures

Date	Name	fault	Parts used	comment	supervisor
25/2/2020	Bishoftu college	Open circuit	sensor	We avoid open circuit	signature

Record fault remedy outcomes and test results on:

- manual recording on specified forms;

- Fault log book.

Documentation for Troubleshooting

To successfully work with (and design) control systems, it is essential to be understand the documents that are typically used to illustrate process control and associated field instrumentation.

The documentation of process control and associated field instrumentation is normally created by the engineering firm that designs and constructs the plant. The company that commissioned the plant may have an internal documentation standard the engineering firm will be required to follow.

For an older installation, the plant documentation may only exist as a series of paper documents.

Self-documenting the automatic creation of documents that follow defined conventions for naming and structure. If the documentation generated by the control system does not follow standards that have been established for process control and instrumentation, then it may be necessary to manually create this documentation.

Current documentation is as important a troubleshooting tool as any test equipment or other tools

- Process & Instrument Diagrams – P&ID
- Instrument loop diagram
- Instrument maintenance records
- Instrument specifications and manuals
- Electrical – motor control schematics
- Interlock and alarm information
- System drawing
- Operational logs/procedures and data

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I answer the following question as directed below

1. what is the reason for recording unplanned events or conditions(5)
2. All diagnosed/troubleshoot and maintenance activities should be recorded (True, False).

. Answer the following question!

Note: Satisfactory rating3 and 5points Unsatisfactory below3 and 5points

You can ask you teacher for the copy of the correct answers.

Score = ____________
Rating: _____________

Answer Sheet

Name: ___________________________ Date: _______________

LG #19	LO #4 Testing corrected instrumentation and control systems
Instruction sheet	
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Testing Instrumentation & control systems • Recording test results • Preparing and completing reports This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Test Instrumentation & control systems • Record test results • Prepare and complete reports	
Learning Instructions:	

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
4. Accomplish the "Self-checks" which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets
7. Perform "the Learning activity performance test" which is placed following "Operation sheets" ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to "Operation sheets".

Information Sheet1. Testing Instrumentation & control systems

1.1 Testing Instrumentation & control systems

1.1.1Troubleshooting current loops

Perhaps the most fundamental diagnostic method for troubleshooting 4-20mA analog current loops is to measure current and/or voltage at different points in the circuit. Several types of test instruments are available for this purpose.

1.1.1.1 Using a standard milliammeter to measure loop current

Since the signal of interest is represented by an electric current in an instrumentation current loop circuit, the obvious tool to use for troubleshooting is a multi meter capable of accurately measuring DC milli amperes. Unfortunately, though, there is a major disadvantage to the use of a milli ammeter:

The circuit must be broken at some point to connect the meter in series with the current, and this means the current will fall to 0mA until the meter is connected (then fall to 0mA when the meter is removed from the circuit). Interrupting the current means interrupting the flow of information conveyed by that current, be it a process measurement or a command signal to a final control element. This will have adverse effects on a control system unless certain preparatory steps are taken.

Before breaking the loop to connect your meter, one must first warn all appropriate personnel that the signal will be interrupted at least twice, falling to a value of-25% each time.

- If the signal to be interrupted is coming from a process transmitter to a controller,
- ✓ The controller should be placed in Manual modes of it will not cause an upset in the process (by moving the final control element in response to the sudden loss of PV signal).
- ✓ Also, process alarms should be temporarily disabled so they do not cause panic.
- ✓ If this current signal also drives process shutdown alarms, these should be temporarily disabled so that nothing shutdown upon interruption of the signal.
- If the current signal to be interrupted is a command signal from a controller to a final control element,
- ✓ The final control element either needs to be manually over ridden so as to hold a fixed setting while the signal varies, or it needs to be by passes completely by some other device(s).
- ✓ If the final control element is a control valve, this typically takes the form of opening a bypass valve and closing at least one block valve:

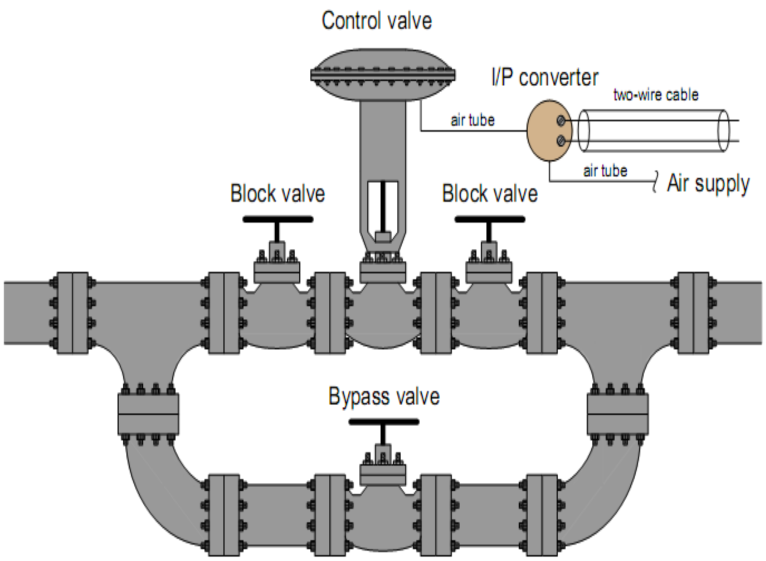


Fig 1.1.1.1 control valve

Since the manually-operated by pass valve now performs the job that the automatic control valve used to, a human operator must remain posted at the bypass valve to carefully throttle it and maintain control of the process. Block and by pass valves for a large gas flow control valve maybe seen in the following photograph:

fig 1.1.1 control valve

In consideration of the labor necessary to safely interrupt the current signal to a control valve in a live process, we see that the seemingly simple task of connecting a milli ammeter in series with a 4-20mA current signal is not as easy as it may first appear. Better ways must exist, no?

1.1.1.2 Using a clamp-on milliammeter to measure loop current

One better way to measure a 4-20mA signal without interrupting it is to do so magnetically, using a clamp-on milli ammeter. Modern Hall-effect sensors are sensitive and accurate enough to monitor the weak magnetic fields created by the passage of small DC currents in wires. Ammeters using Hall-effect sensors have are completely non-intrusive because they merely clamp around the wire, with no need to break the circuit. An example of such a clamp-on current meter is the Fluke model771, shown in this photograph:

Fig 1.1.1.2 clamp-on milliammeter

Note how this milli ammeter not only registers loop current (3.98mA as shown in the photograph), but it also converts the milliamp value into a percentage of range, following the 4to20mA signal standard.

One disadvantage to be aware of for clamp-on milli ammeters is the susceptibility to error from strong external magnetic fields. Steady magnetic fields (from permanent magnets or DC-powered electromagnets) maybe compensated for by performing a zero adjustment with the instrument held in a similar orientation prior to measuring loop current through a wire.

1.1.1.3. using test diodes to measure loop current

Another way to measure a 4-20mA signal without interrupting it involves the use of a rectifying diode, originally installed in the loop circuit when it was commissioned. A test diode maybe placed anywhere in series with in the loop in such a way that it will be forward-biased. During normal operation, the diode will drop approximately 0.7volts, as is typical for any silicon rectifying diode when forward biased. The following schematic diagram shows such a diode installed in a 2-wire transmitter loop circuit:

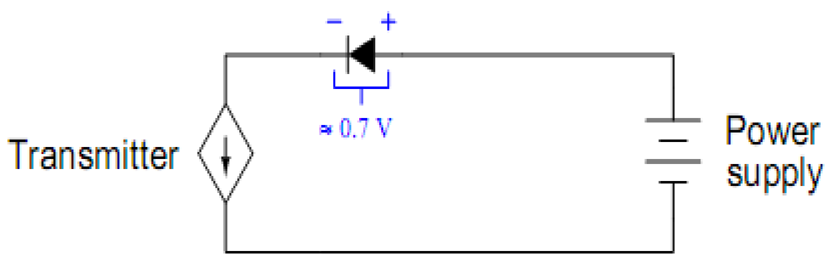
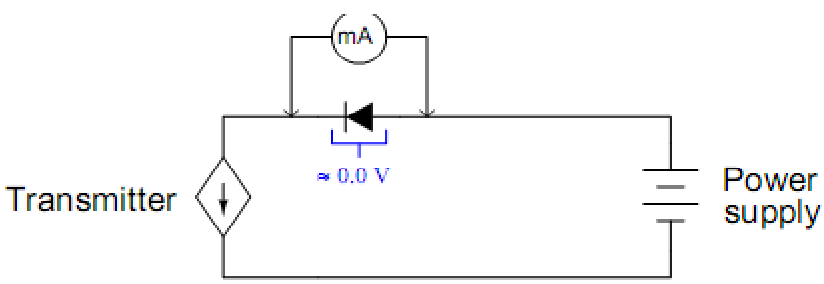


fig 1.1.1.4 test diodes

If someone connects a milli ammeter in parallel with this diode, however, the very low input resistance of the ammeters shorts past the diode and prevents any substantial voltage drop from forming across it. Without the necessary forward voltage drop, the diode effectively turns off and conducts 0mA, leaving the entire loop current to pass through the ammeter: All current goes through



When the milliammeter is disconnected, the requisite 0.7volt drop appears to turn on the diode, and all loop current flows through the diode again. At no time is the loop current ever interrupted, which means a technician may take current measurements this way and never have to worry about generating false process variable indications, setting off alarms, or upsetting the process. Such a diode may be installed at the nearest junction box, between terminals on a terminal strip, or even in corporate into the transmitter itself. Some process transmitters have an extra pair of terminals labeled Test for this exact purpose. A diode is already installed in the transmitter, and these test terminals serve as points to connect the milli ammeter across.

The following photograph shows an example of this on a Rose mount model 3051 differential pressure transmitter:

Fig 1.1.1.4 Rose mount model 3051 differential pressure transmitter:

Note the two test points labeled TEST below and to the right of the main screw terminals where the loop wiring attaches. Connecting an ammeter to these two test points allows for direct measurement of the 4-20mA current signal without having to un-do any wire connections in the circuit.

Transmitters equipped with analog meter movements for direct visual indication of the 4-20mA signal usually connect the analog milli ammeter in parallel with just such a diode. The reason for doing this is to maintain loop continuity in the event that the fine-wire coils inside the milli ammeter movement were to accidently break open.

Using shunt resistors to measure loop current

A similar method for non-invasively measuring current in a 4-20mA instrumentation circuit is to install a precision resistor in series. If the resistance value is precisely known, the technician merely needs to measure voltage across it with a voltmeter and use Ohms Law to calculate current:

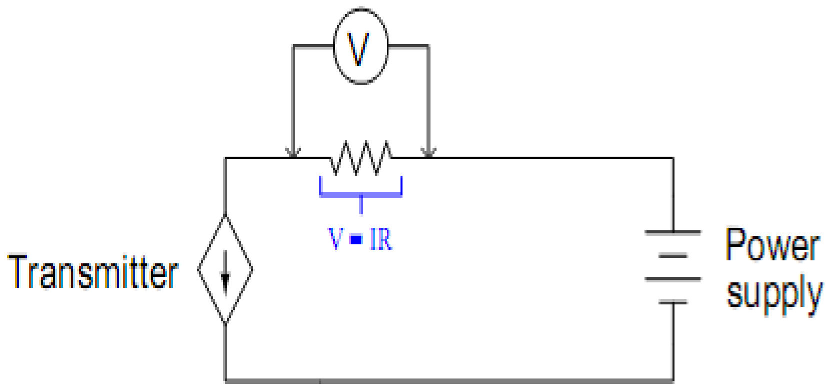


fig 1.1.1. shunt resistors

In electronics, such a precision resistor used for measuring current is often referred to as a shunt resistor. Shunt resistor values are commonly very small, for their purpose is to assist in current measurement without imposing undue voltage drop with in a circuit. It is rare to find a 250ohm resistor used strictly as a diagnostic shunt resistor, because the extra voltage drop (1to5volts, depending on the current signal level) may starve loop-powered instruments of voltage necessary to operate. Shunt resistor values also was 1ohm maybe found installed in 4-20mA current loops at strategic locations where technicians may need to measure loop current.

1.4.1.5 Troubleshooting current loops with voltage measurements

If neither component (diode or shunt resistor) is pre-installed in the circuit, and if a Hall-effect (clamp-on) precision milli ammeter is unavailable, a technician may still perform useful troubleshooting measurements using nothing but a DC voltmeter. Here, however, one must be careful of how to interpret these voltage measurements, for they may not directly correspond to the loop current as was the case with measurements taken in parallel with the precision resistor. Take for example this 4-20mA loop where a controller sends a command signal to an I/P transducer:

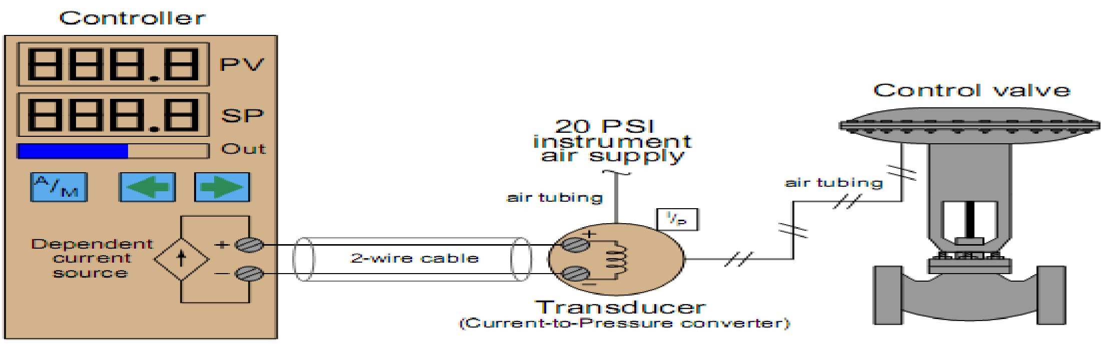


fig 1.1.1.5 an I/P transducer:

There is no standardized resistance value for I/P transducer coils, and so the amount of voltage dropped across the I/P terminals for any given amount of loop current will be unique for every different model of I/P. The Fisher model 567 I/P transducer built for 4-20mA signals has a nominal coil resistance of 176ohms. Thus, we would expect to see a voltage drop of approximately 0.7 volts at 4mA and a drop of approximately 3.5volts at 20mA across the I/P terminals. Since the controller output terminals are directly in parallel with I/P terminals, we would expect to see approximately the same voltage there as well (slightly greater due to wire resistance). The lack of known precision in I/P coil resistance makes it difficult to tell exactly how much current is in the loop for any given voltage measurement we take with a voltmeter. However, if we do know the approximate coil resistance of the I/P, we can at least obtain an estimate of loop current, which is usually good enough for diagnostic purposes.

If the I/P coil resistance is completely unknown, voltage measurements become useless for quantitative determination of loop current. Voltage measurements would be useful only for qualitatively determining loop continuity (i.e. whether there is a break in the wiring between the controller and I/P). Another example for consideration is this loop-powered 4-20mA transmitter and controller circuit, where the controller supplies DC power for the loop:

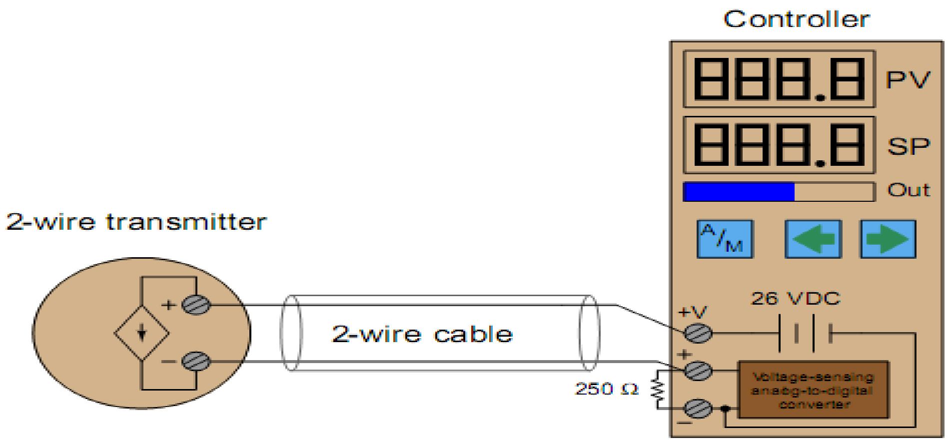


Fig1.1.1.7 2 way transmitter

It is very common to find controllers with their own built-in loop power supplies, due to the popularity of loop-powered (2-wire)4-20mA transmitters. If we know the transmitter requires a DC voltage source somewhere in the circuit to power it up, it makes sense to include one in the controller, right?

The only voltage measurement that directly and accurately correlates to loop current is the voltage directly across the 250ohm precision resistor. A loop current of 4mA will yield a voltage drop of 1volt, 12mA will drop3volts,20mA will drop 5volts, etc.

A voltage measurement across the transmitter terminals will show us the difference in voltage between the 26volt power supply and the voltage dropped across the 250ohm resistor. In other words, the transmitter's terminal voltage is simply what is left over from the source voltage of 26 volts after subtracting the resistors voltage drop. This makes the transmitter terminal voltage inversely proportional to loop current: the transmitter sees approximately 25volts at 4m A loop current (0% signal) and approximately 21 volts at 20mA loop current (100% signal). The use of the word approximate is very intentional here, for loop power supplies are usually non-regulated. In other words, the 26volt rating is approximate and subject to change! One of the advantages of the loop-powered transmitter circuit is that the source voltage is largely irrelevant, so long as it exceeds the minimum value necessary to ensure adequate power to the transmitter. If the source voltage drifts for any reason, it will have no impact on the measurement signal at all, because the transmitter is built as a current regulator, regulating current in the loop to whatever value represents the process measurement, regardless of slight changes in loop source voltage, wire resistance, etc. This rejection of power supply voltage changes means that the loop power supply need not be regulated, and so in practice it rarely is.

This brings us to a common problem in loop-powered 4-20mA transmitter circuits: maintaining sufficient operating voltage at the transmitter terminals. Recall that a loop-powered transmitter relies on the voltage dropped across its terminals (combined with a current of less than 4mA) to power its internal workings. This means the terminal voltage must not be allowed to dip below a certain minimum value, or else the transmitter will not have enough electrical power to continue its normal operation. This makes it possible to starve the transmitter of voltage if the loop power supply voltage is in sufficient, and/or if the loop resistance is excessive.

To illustrate how this can be a problem, consider the following 4-20mA measurement loop, where the controller supplies only 20volts DC to power the loop, and an indicator is included in the circuit to provide operators with field-located indication of the transmitter's measurement:

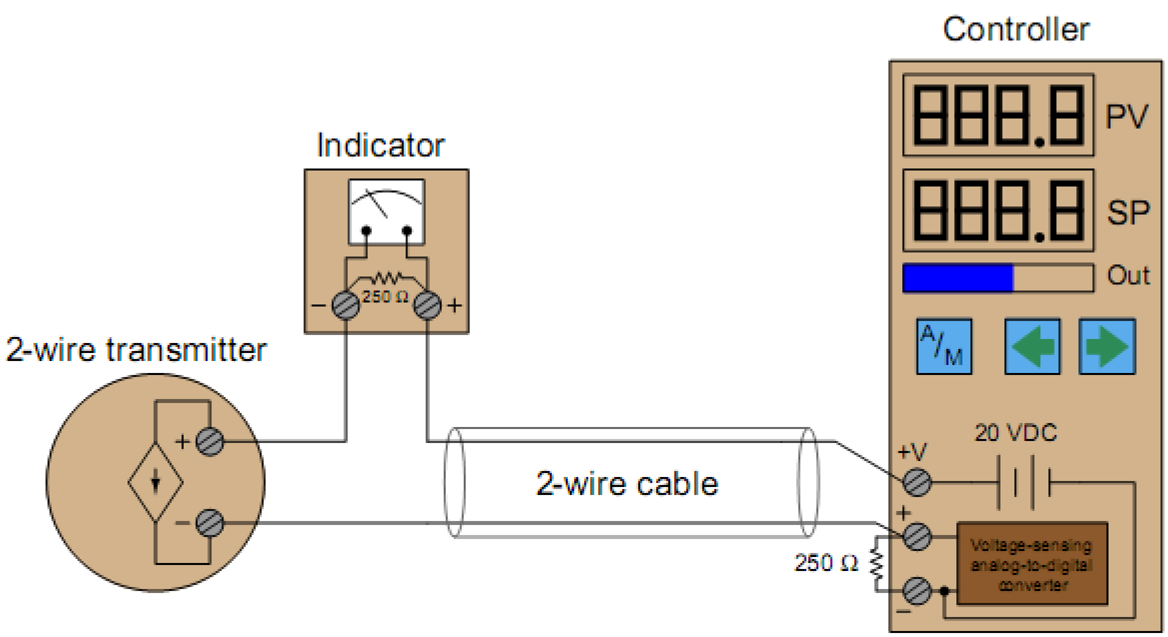


Fig way transmitter

The indicator contains its own 250ohm resistor to provide a 1-5volt signal for the meter mechanism to sense. This means the total loop resistance is now 500ohms (plus any wire resistance). At full current (20mA), this total resistance will drop (at least) 10volts, leaving 10volts or less at the transmitter terminals to power the transmitter's internal workings. 10volts may not be enough for the transmitter to successfully operate, though. The Rose mount model 3051 pressure transmitter, for example, requires a minimum of 10.5volts at the terminals to operate. However, the transmitter will operate just neat lower loop current levels. When the loop current is only 4mA, for example, the combined voltage drop across the two 250ohm resistors will be only 2volts, leaving about 18volts at the transmitter terminals: more than enough for practically any model of 4-20mA loop-powered transmitter to successfully operate. Thus, the problem of insufficient supply voltage only manifests itself when the process measurement nears 100% of range. This could be a difficult problem to diagnose, since it appears only during certain process conditions. A technician looking only for wiring faults (loose connections, corroded terminals, etc.) would never find the problem.

When a loop-powered transmitter is starved of voltage, its behavior becomes erratic. This is especially true of smart transmitters with built-in micro processor circuitry. If the terminal voltage dips below the required minimum, the microprocessor circuit shuts down. When the circuit shuts down, the current draw decreases accordingly. This causes the terminal voltage to rise again, at which point the micro processor has enough voltage to startup. As the micro process or boots back up again, it increases loop current to reflect the near-100% process measurement. This causes the terminal voltage to sag, which subsequently causes the micro processor to shut down again. The result is as low on/off cycling of the transmitter's current, which makes the process controller think the process variable is surging wildly. The problem disappears, though, as soon as the process measurement decreases enough that the transmitter is allowed enough terminal voltage to operate normally.

Using loop calibrators

Special-purpose electronic test instruments called loop calibrators are manufactured for the express purpose of 4-20mA current loop circuit troubleshooting. These versatile instruments are generally capable of not only **measuring current**, but also **sourcing current to unpowered devices in a loop**, and also **simulating the operation of loop-powered 4-20mA transmitters**.

A very popular loop calibrator unit is the Altek model334A, a battery-powered, hand-held unit with a rotary knob for current adjustment and toggle s witches for mode setting. The following illustration shows how this calibrator would be used to measure current in a functioning input signal loop:

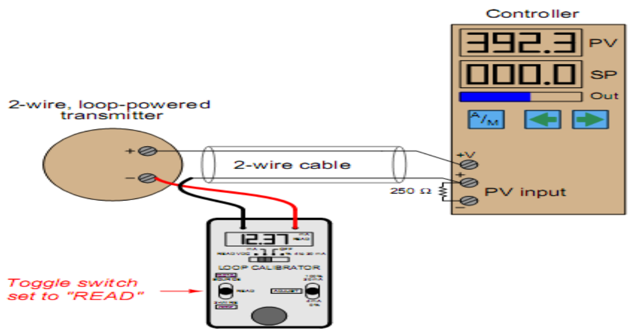


fig wire loop powered transmitter

Here, the loop wiring is broken at the negative terminal of the loop-powered transmitter, and the calibrator connected in series to measure current .If this loop had a test diode installed, the calibrator could be connected in parallel with the diode to achieve the same function.

Note the polarity of the calibrators test leads in relation to the circuit being tested: the calibrator is acting As an unpowered device (a load rather than a source), with the more positive loop terminal connected to the calibrators red test lead and the more negative terminal connected to the black test lead.

The same loop calibrator may be used to source (or drive) a4-20mA signal into an indicating instrument to test the function of that instrument independently. Here, we see the Altek calibrator used as a current source to send a 16.00mA signal to the PV (process variable) input of the controller:

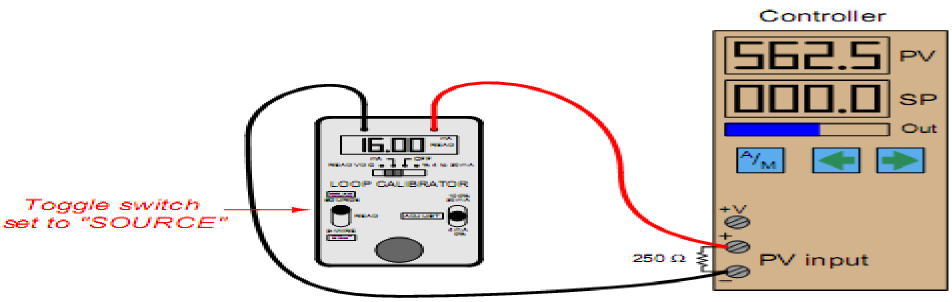


fig 1.1.1.1 toggle switch

No transmitter need be included in this illustration, because the calibrator takes its place. Note how the calibrator is used here as an active source of current rather than a passive load as it was in the last example. The calibrators red test lead connects to the controller's positive input terminal, while the black test lead connects to the negative terminal.

An alternative method of sourcing a known current signal into an indicating instrument that provides loop power is to set the loop calibrator to a mode where it mimics the electrical behavior ofaloop-powered2-wire transmitter. In this mode, the calibrator serves to regulate loop current at a user-determined value, but it provides no motivating voltage to drive this current. Instead, it passively relies on some external voltage source in the loop circuit to provide the necessary electromotive force

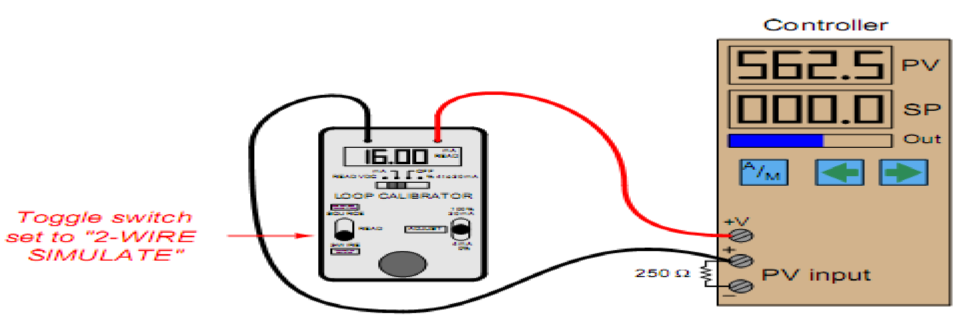


Fig1.1.1.1 toggele switch

Note the polarity of the calibrators test leads in relation to the controller: the red test lead connects to the positive loop power terminal while the black lead connects to the positive input terminal. Here, **the calibrator acts as a load**, just as a loop-powered transmitter acts as an electrical load.

This simulate transmitter mode is especially useful for testing a4-20mA loop at the end of the cable where the transmitter is physically located. After disconnecting the cable wires from the transmitter and re-connecting them to the loop calibrator (set to simulate mode), the calibrator maybe used to simulate a transmitter measuring any value within its calibrated range. A legacy loop calibrator still familiar to many instrument technicians at the time of this writing is the classic Transformation model 1040:

A modern loop calibrator manufactured by Fluke is the model705:

fig 1.1.1.1 modern loop calibrator

With this calibrator, them ensure, source, and simulate modes are accessed by repeatedly pushing a button, with the current mode displayed on the screen:

1.1.2 Sensors

Common sensor Problems

Smart Transmitters

- Check the configuration. Make sure the variable being transmitted is the one you want
- Check the calibration, do the units and range match the controller's units and range configuration for the process variable.
- Check the filtering. Is an excessive dampening time (time constant) specified.

Temperature Sensors

- Check the calibration, does the thermocouple type or RTD curve match the configuration of the controller.

- Check the installation, is the thermowell or sensing element sufficiently immersed in the medium. Is the thermocouple or RTD properly fitted for the thermo well. Is the temperature sensor in the right place. Is there buildup on the thermo well.

Pressure Sensors

- Check for plugged lines to the sensor.

Flow Sensors

- Verify that the mounting conforms to the sensor manufacturer's recommendations (e.g. straight runs of piping, environment, etc.)

1.1.3 Programmable logic controllers

The Controller

Common Controller Problems

- Does the controller have a high gain? Filtering on the process variable can help.
- Does the rate at which the PID block is being triggered match the loop update time.
- Has the controller output or input become saturated.

1.1.4 Control valves and final control elements

Final Control Elements

Common Valve Problems

- Check the regulator settings supplying instrument air to the valve actuator. Look for pinched air lines and air leaks. If the proper air supply is not being supplied to the actuator good control will be difficult to achieve. With today's emphasis on airinstrument air conservation and the lowering of plant wide air pressures some actuators may need to be upsized to provide sufficient force to operate the valve.
- Linkages are often used to connect the actuator to the valve stem. Loose linkages can result in process cycling. If a positioner is used also check the linkage used to connect the positioner feedback.
- Check that the actuator is properly calibrated. Calibration involves stroking the valve through its full travel to verify that the valve position corresponds with the controller output. To calibrate a valve:

1. Place the loop in manual with a 0% output. Adjust the valve zero until the valve is at its full de energized position.

2. Set the manual output at 100%. Adjust the valve span until the valve is at its full energized position.

3. Set the manual output at 50%. Verify that the valve is at its 50% position.

If a loop has been tuned with an improperly calibrated valve, recalibration may change the process gain requiring retuning of the control loop.

- Check the valve dead band. Excessive dead band will cause an integrating process to oscillate and increase the stabilization time of a self-regulating process.
- Check for valve stiction. Stiction in a valve will cause oscillations in a self-regulating process.
- Check the gain of the valve. An oversized valve will magnify deadband and stiction problems.
- Check the tuning of the positioner. An aggressively tuned positioner can cause valve cycling.

1.3.4 Computer operations

using different sensor the sensor diagnostic tools was used with previous version of windows. Microsoft recommends using the sensor explore to verify the installation of supported sensor use sensor diagnostic tools to test your driver, firmwar, and hardware functionality

1.3.5 Process and machinery operation

The Process

Common Process Problems

- What's changed? Ask the operator what is different today.
- Understand the Process.
- Is the process is non-linear, a change in process conditions may require different tuning.
- Set output limits to avoid integral windup or operating in low gain regions of your final control element.

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Instruction: I say true or false each (2%)

_______ **1.** The goal of troubleshooting is to repair or correct a fault in an instrument system.

_______ **2.** As a general rule, failures are about equally distributed between the three components.

_______ **3.** The first problem of troubleshooting is to determine whether the fault is in the Operation, Environment, or Instrument component of the instrument system.

_______ **4.** Troubleshooting requires a broad knowledge base and good practical skills.

_______ **5.** Millimeter not only registers loop current, but it also converts the milliamp value into a percentage of range, following the 4 to 20mA signal standard..

Instruction: II choose the correct answer for the following question's(2%

1.__________is The most fundamental diagnostic method for trouble shooting 4-20mA analog current loops.

a. To measure current at different points in the circuit.

b. to measure voltage at different points in the circuit.

c. To measure resistances at different points in the circuit

d. a & b

e. a & c

. Answer the following question!

Note: Satisfactory rating7 and 12points Unsatisfactory below 7and 12points

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: ___________________________ Date: _______________

Information Sheet-2. Recording test results

2.1 Test Results Recording Sheet

.Test Record Sheets shall be developed as required for specific tests. The Superintendent shall approve them after consultation with the Engineering and Maintenance Support Managers prior to being put to use. Where a Contractor carries out pre-operational testing, and the Contractor has an established system of Test Record Sheets, they may use them if approved by the Superintendent. These represent the minimum standard of test reporting required.

Note: CSBP shall have the opportunity to witness all tests carried out by the Contractor. Witnessing by CSBP is at CSBP's discretion and does not constitute approval of the test results.

How to test thermocouple

A thermocouple is a safety device that helps control the gas supply in gas-heated furnaces. When it stops working, the furnace's pilot light also turns off. For a basic test, attempt to turn on the pilot light again. If you're still unsure or don't have a working pilot light, test the thermocouple with a multimeter. Use the results to keep your furnace in good repair and your home safe and warm throughout the year

Method1

Turning on the Pilot Light

Locate the pilot light controls on the gas valve. Locate the gas tank, which is in the basement or lowest floor of your home. The pilot light is controlled by a small box with black, red, or white dials. It will also have a metal pipe running into it, carrying the gas supply.

Turn the pilot light on for 30 seconds. The control dial on the gas valve will be labeled. Spin it to the "Pilot" setting. Press the reset button on top of the box to turn on the pilot light. Hold the reset button between 30 to 60seconds to give the thermocouple time to heat up.

Release the button to see if the pilot light goes out. The pilot light should stay on after the reset. If it goes out, this is a sign that the thermocouple

Count to 20 and wait for the pilot light to go out. With the gas flow shutoff, the pilot light has to fade. If the flame is still there after 20 seconds, the gas supply isn't off. Adjust the dial and valve to try again.

Listen for clicking near the gas valve. The clicking comes from the spot where the gas supply pipe meets the gas valve box. If you hear clicking before the 20 seconds are up, it's a sign that your system needs repairs. Both the thermocouple and gas valve may be bad. Call a professional. Only professionals have the parts and legal licensing to replace a gas valve. They will replace the thermocouple when they do this.

Using a Multimeter

Locate the thermocouple on the gas control thermostat. The gas control thermostat will be on the outside of the gas tank, possibly on a nearby wall. Look for a flexible tube plugged into the side of the thermostat. It is often colored silver or red. The tube connects to the gas valve below the pilot light.

Remove the thermocouple with a wrench. Go back to the thermostat and locate the metal nut holding the thermocouple in place. Use a 7⁄16 in(11 mm) wrench to rotate the nut counterclockwise and free the thermocouple

Turn on the multimeter. For the test, the type of multimeter with red and black clamps is easiest to use. Flip on the multimeter's power switch. Spin the settings dial to change the measurement to Ohms, represented by the horseshoe-shaped symbol. This is used to measure electrical resistance. For more specific instructions on operating your multimeter, read the owner's manual. Tubing below the nut on the thermocouple. The tubing is either silver-colored or copper and the clamp should be applied directly onto it.

Start the pilot light to begin the test. Change the multimeter to volts first .Flip on the pilot light using the knob on the tank's gas valve. This is commonly done by turning the knob to the labeled "Pilot" setting and then holding down the reset button on top of the gas valve box. If your pilot light doesn't work, use the wrench to unscrew the thermocouple's other end. Use a lighter or torch to hold a flame under this end. This end appears needle-shaped and is designed to take on heat, so put the tip into the flame.

Check that the thermocouple reaches 25 millivolts. Give the thermocouple a minute to warm up. After the minute passes, check the multimeter's display. If it displays millivolts, it should read between 25 and 35. Ifit only displays volts, look for the meter to move slightly above 0.1 millivolt is equal to 1/1000 of a volt.

Replace the thermocouple if it is broken. A thermocouple that tests below25 millivolts won't be able to keep the pilot flame lit. Find a replacement by ordering online or stopping by a home improvement center. Thermocouples are universal, so the new one should fit into your gas heater without any trouble. Another option is to call a heating repair person near you. This is a great option if you need help making the repairs or suspect your system has other problems, such as a faulty gas valve.

A good pilot light flame is blue. A yellow or orange flame means the system needs to be cleaned. If your thermocouple is coated with a white, chalky material, this may indicate it's not functioning properly.

Be cautious when reinstalling the thermocouple. Over tightening it can prevent the flame from lighting.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I answer the following question as directed bellow

1 what is the purpose of recording? (5%)

. Answer the following question!

Note: Satisfactory rating 3 and 5 points Unsatisfactory below 3 and 5 points

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet 3. Preparing and completing reports

3.1 Preparing and completing reports

Reporting on instrument verification and calibration results

It is recognized that individual NHS's typically have internal guidelines for the production of reports, and this document is not meant to circumvent those guidelines. However, to enable the sharing of results across the hydrologic community at large and to facilitate the comparison of instrumentation, the following is suggested for consideration when writing those reports. Example reports for Approaches A and B can be found in

Executive Summary

- A brief description of the tested product(s), their purpose
- A brief (high level) description of the test procedures and results
- Include a statement on how the results compare to the NHS's specifications/standards

Objective and Approach of the Test

- a short statement that summarizes the purpose of the test
- a short narrative on how the test was conducted

Description of Instrument(s)

- Details of the product, its purpose, how it operates
- May include the manufacturer's product specifications

Test Procedures

- Details of the test procedures, including performance specifications being used
- Reference all instruments used as benchmarks for comparison, calibration
- Test results
- Details on the findings, including how the instrument(s) performed against the nhs performance specifications, against benchmark instruments, etc
- Include tables and graphs
- Test data and results to be stored in electronic format for sharing with other instrument users (format to be established by Project X members?)

Discussion of Results/Conclusions

• Non-technical narrative on the results – explanation of specific findings, reasons for non-typical product performance

• Conclusions based on the initial objective of the test

Related Observation/Comments

• Non-subjective statements on observations made on the product as part of the testing.

Definitions

Verification and validation*, in engineering or quality management systems, it is the act of reviewing, inspecting or testing, in order to establish and document that a product, service or system meets regulatory or technical standards.

Verification provision of objective evidence that a given item fulfils specific requirements

Validation verification, where the specific requirements are adequate for intended use It is sometimes said* that validation can be expressed by the query "Are you building the right thing?" and verification by "Are you building it right?" "Building the right thing" refers back to the user's needs, while "building it right" checks that the specifications are correctly implemented by the system.

Calibration* is a comparison between measurements – one of known magnitude or correctness made or set with one device and another measurement made in as similar a way as possible with a second device*.

The device with the known or assigned correctness is called the standard. The second device is the unit under test, test instrument, or any of several other names for the device being calibrated*.

Instrument Calibration can be called for:

- with a new instrument
- when a specified time period is elapsed
- when a specified usage (operating hours) has elapsed
- when an instrument has had a shock or vibration which potentially may have put it out of calibration
- sudden changes in weather
- whenever observations appear questionable

In general use, calibration is often regarded as including the process of adjusting the output or indication on a measurement instrument to agree with value of the applied standard, within a specified accuracy. For example, a thermometer could be calibrated so the error of indication or the correction is determined, and adjusted (e.g. via calibration constants) so that it shows the true temperature in Celsius at specific points on the scale. This is the perception of the instrument's end-user. However, very few instruments can be adjusted to exactly match the standards they are compared to. For the vast majority of calibrations, the calibration process is actually the comparison of an unknown to a known and recording the results.

Reports generally involve presenting your investigation and analysis of information or an issue, recommending actions and making proposals.

There are many different types of reports, including business, scientific and research reports, but the basic steps for writing them are the same. These are outlined below.

Step 1: Decide on the 'Terms of reference'

Step 2: Decide on the procedure

Step 3: Find the information

Step 4: Decide on the structure

Step 5: Draft the first part of your report

Step 6: Analyse your findings and draw conclusions

Step 7: Make recommendations

Step 8: Draft the executive summary and table of contents

Step 9: Compile a reference list

Step 10: Revise your draft report

You can also check our information on assignment writing for tips on planning, finding information, writing and reviewing your work.

Step-by-step guide to writing an assignment

Step 1: Decide on the 'Terms of reference'

To decide on the terms of reference for your report, read your instructions and any other information you've been given about the report, and think about the purpose of the report:

- What is it about?
- What exactly is needed?
- Why is it needed?
- When do I need to do it?
- Who is it for, or who is it aimed at?

This will help you draft your Terms of reference.

Step 2: Decide on the procedure

This means planning your investigation or research, and how you'll write the report. Ask yourself:

- What information do I need?
- Do I need to do any background reading?
- What articles or documents do I need?
- Do I need to contact the library for assistance?
- Do I need to interview or observe people?
- Do I have to record data?
- How will I go about this?

Answering these questions will help you draft the procedure section of your report, which outlines the steps you've taken to carry out the investigation.

Step 3: Find the information

The next step is to find the information you need for your report. To do this you may need to read written material, observe people or activities, and/or talk to people.

Make sure the information you find is relevant and appropriate. Check the assessment requirements and guidelines and the marking schedule to make sure you're on the right track. If you're not sure how the marks will be assigned contact your lecturer.

What you find out will form the basis, or main body, of your report – the findings.

For more on finding information:

Step 4: Decide on the structure

Reports generally have a similar structure, but some details may differ. How they differ usually depends on:

- The type of report – if it is a research report, laboratory report, business report, investigative report, etc.
- How formal the report has to be.
- The length of the report.

Depending on the type of report, the structure can include:

- A title page.
- Executive summary.
- Contents.
- An introduction.
- Terms of reference.
- Procedure.
- Findings.
- Conclusions.
- Recommendations.
- References/Bibliography.
- Appendices.
- The sections, of a report usually have headings and subheadings, which are usually numbered

Step 5: Draft the first part of your report

Once you have your structure, write down the headings and start to fill these in with the information you have gathered so far. By now you should be able to draft the terms of reference, procedure and findings, and start to work out what will go in the report's appendix.

Findings

The findings are result of your reading, observations, interviews and investigation. They form the basis of your report. Depending on the type of report you are writing, you may also wish to include photos, tables or graphs to make your report more readable and/or easier to follow.

Appendices

As you are writing your draft decide what information will go in the appendix. These are used for information that:

- is too long to include in the body of the report, or
- supplements or complements the information in the report. For example, brochures, spreadsheets or large tables.

Step 6: Analyze your findings and draw conclusions

The conclusion is where you analyze your findings and interpret what you have found. To do this, read through your findings and ask yourself:

- What have I found?
- What's significant or important about my findings?
- What do my findings suggest?

For example, your conclusion may describe how the information you collected explains why the situation occurred, what this means for the organization, and what will happen if the situation continues (or doesn't continue).

Don’t include any new information in the conclusion.

Step 7: Make recommendations

Recommendations are what you think the solution to the problem is and/or what you think should happen next. To help you decide what to recommend:

- Reread your findings and conclusions.

- Think about what you want the person who asked for the report should to do or not do; what actions should they carry out?
- Check that your recommendations are practical and are based logically on your conclusions.
- Ensure you include enough detail for the reader to know what needs to be done and who should do it..

Step 8: Draft the executive summary and table of contents

Some reports require an executive summary and/or list of contents. Even though these two sections come near the beginning of the report you won't be able to do them until you have finished it, and have your structure and recommendations finalized.

An executive summary is usually about 100 words long. It tells the readers what the report is about, and summarize the recommendations.

Step 9: Compile a reference list

This is a list of all the sources you've referred to in the report and uses APA referencing.

Step 10: Revise your draft report

It is always important to revise your work. Things you need to check include:

- If you have done what you were asked to do. Check the assignment question, the instructions/guidelines and the marking schedule to make sure.
- That the required sections are included, and are in the correct order.
- That your information is accurate, with no gaps.
- If your argument is logical. Does the information you present support your conclusions and recommendations?
- That all terms, symbols and abbreviations used have been explained.
- That any diagrams, tables, graphs and illustrations are numbered and labelled.
- That the formatting is correct, including your numbering, headings, are consistent throughout the report.

- That the report reads well, and your writing is as clear and effective as possible.

Fault reporting is a maintenance concept that increases operational availability and that reduces operating cost through three mechanisms.

- Reduce labor-intensive diagnostic evaluation
- Eliminate diagnostic testing down-time
- Provide notification to management for degraded operation

Maintenance requires three actions.

- Fault discovery
- Fault isolation
- Fault recovery

Fault discovery requires diagnostic maintenance, which requires system down time and labor costs.

Down time and cost requirements associated with diagnostics are eliminated for every item that satisfies the following criteria.

- Automated diagnostic
- Instrumented for remote viewing
- Displayed in the viscidity of supervisory personnel

Implementation

Fault reporting is an optional feature that can be forwarded to remote displays using simple configuration setting in all modern computing equipment. The system level of reporting that is appropriate for Condition Based Maintenance are critical, alert, and emergency, which indicate software termination due to failure. Specific failure reporting, like interface failure, can be integrated into applications linked with these reporting systems. There is no development cost if these are incorporated into designs.

- Sys log

- Event Log
- Power distribution unit

Other kinds of fault reporting involves painting green, yellow, and red zones onto temperature gages, pressure gages, flow gages, vibration sensors, strain gages, and similar sensors. Remote viewing can be implemented using a video camera. Fault reporting eliminates maintenance costs associated manual diagnostic testing.

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Answer the following question as directed below

1. Write Basic step of report writing
2. __________is a maintenance concept that increases operational availability and that reduces operating cost through three mechanisms.
3. _________ checks that the specifications are correctly implemented by the system.
4. _________is a comparison between measurements one of known magnitude or correctness made or set with one device and another measurement made in as similar a way as possible with a second device*.

5. Instrument Calibrated for

Answer the following question!

Note: Satisfactory rating 6 and 10 points   Unsatisfactory below 6 and 10 points

You can ask you teacher for the copy of the correct answers.

Score = ____________
Rating: _____________

Answer Sheet

Name: ____________________________ Date: _______________

Operation title: -Diagnosing and Troubleshoot Instrumentation and Control Devices

Purpose	To acquire the trainees with diagnosing and troubleshoot instrumentation and Control Devices

Equipment ,tools and materials	Supplies and equipment needed or useful for diagnosing and troubleshoot instrumentation and control Devices include these: • screw driver • Diagonal side cutter • Pliers • Knife • drill • shaper • cutter • Soldering iron • WRENCH • Digital Multi-tester • calibrator • oscilloscope • signal generator • various instrument and control device • configuration or programmer • communication equipment(2=way radio cell phone)
Conditions or situations for the operations	• All tools, equipment's and materials should be available on time when required. • Appropriate material, working area/ workshop to diagnosing and troubleshoot instrumentation and control devices

Procedures	1. Apply OH &S PPE 2. Identify instrumentation and control devices 3. Determine the Symptoms and analyze them. d. Listen, Think, Look, Smell, and Operate. e. Use all available sources of information: manuals, maintenance records, other people, the agent or manufacturer etc. 4. State the symptoms as clearly and precisely as possible. Stating that a device does not work, while perhaps true, is not a clear, informative statement of symptoms 5. Localize to a functional module. Think, Look, and Test. 6. Isolate to a circuit. Think, Look, and Test. 7. Locate the specific component or problem. Think, Look, and Test. 10. Determine the cause of the failure. 11. Explain the type of faults you diagnosed 12. Replace or correct a defective component or problem and correct the causes of the failure. 13. Check for correct operation and calibration. 14. Complete the record keeping. 15. Review the entire troubleshooting and repair process. It is the best way to improve your troubleshooting skills.. 16. Complete and report fault diagnosis and rectification activities 17. Record the result

Precautions	• Care should be taken while connecting with electric power, assembling, fitting and adjusting instrumentation and control devices • Preparing materials, tools and equipment are according to inseminator command.
Quality criteria	• Did personal protective equipment worn diagnosing and troubleshoot instrumentation and control Devices • Did trainees fitting and adjusting the component of the machine proper without leakage • Checks the circuit safely using proper instrument • Mounts devices according to the given drawing • Installs electrical wiring according to the job requirements

Diagnosing and troubleshoot instrumentation and Control Devices

LAP Test	Practical Demonstration

Name: _______________________________ Date: _________________

Time started: _________________________ Time finished: _________________

Instructions:

1. You are required to perform any of the following:

1.1. Diagnosing and troubleshoot instrumentation and Control Devices

1.2. Prepare equipment and material for diagnosing and troubleshoot instrumentation and Control Devices

2. Request your trainer for evaluation and feedback

Answer Key for self-check

Module Title: Operating a Butter Churning and Oil Production Process

LO #1- Plan and prepare for diagnosis of faults of instrumentation and control systems

:

Self-Check 1	Written Test

1. occupational health
2. aim of Occupational health and safety
    - The promotion and maintenance of the highest degree of physical, mental and social well- being of workers in all occupation;
    - The prevention among workers of adverse effect on health caused by their working conditions;
    - The protection of workers in their employment from risks resulting from factors adverse to health;
3. standard
4. (Instrumentation, Systems and Automation) Society (formerly Instrument Society of America)
5. (American National Standards Institute)

6. ASME
7. (National Electrical Code)

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. An organization's occupational health and safety policy
2. E
3. Occupational Hazards categorize as
    - Chemical Hazards
    - Biological Hazards
    - Physical Hazards
    - Ergonomic Hazards
    - Psychosocial Hazards
4. methods used to control health hazards in the work environment
    - Engineering controls
    - Substitution-changing the material
    - Change the process
    - Isolation:
    - Ventilation
    - Local exhaust ventilation
    - Administrative controls

5. general OH & S policies and procedures
    - No person shall be required or instructed to work in surroundings or under conditions that are unsafe or dangerous to his or her health.
    - Each employee is responsible for complying with applicable safety and occupational health requirements, wearing prescribed safety and health equipment, reporting unsafe conditions/activities, preventing avoidable accidents, and working in a safe manner.
    - Safety and health programs, documents, signs, and tags shall be communicated to employees in a language that they understand.
    - Worksites with non-English speaking workers shall have a person(s), fluent in the language(s) spoken and English, on site when work is being performed, to translate as needed.
6. Ventilation:

Self-Check 3	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Gathering and analyzing history card and relevant
2. Data analysis
3. Data integration
4. methods of information gathering are
    - Questionnaires ,surveys and checklist
    - Personal interview
    - Observation
    - Focus group
    - Case study

Self-Check -4	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. calibrator
2. True
3. A calibrator
4. General steps for using a calibrator:
   - Make a measurement with the instrument.
   - Make the same measurement with the DUT.
   - Evaluate the uncertainty of the measurement process.
   - Calculate the difference between the measurements. This will tell you the measurement error between the calibrator and the DUT.
   - Record the measurements and the results.
   - Continue these steps for as many measurement points as required by the calibration procedure.
5. traceability,
6. .True
7. True
8. temperature calibrator .
9. Thermocouples.
10. A temperature calibration bath .
11. Pressure calibration
12. deadweight tester
13. pressure controller/calibrator
14. F

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Choose the best answer

5. Electronic or E-Consultation.

6. A consultant

7. Common types of consultation are

- Strategy Consultants working
- Human Resources or HR Consultants
- Internet Consultants
- Process Consultants

8. E-consultation

- E-consultation can give you rapid responses.
- E-consultation utilizes software that transfers data directly into databases, saving time and more because there is no need to manually input data.
- E-consultation enables us to explore some of the issues arising from consultation in more depth through tools such as bulletin boards, online discussion groups and chat rooms.
- Encourages participants into thinking their contribution does make a difference and is taken seriously by the Council

Self-Check 6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. A sensor
2. loop checking
3. Checks the connection between each component in the control loop.
4. transmitter, sensor, process controller, final control element

5. True
6. The insulation resistance tests to ensure there is no current flow between conductor and ground or insulation surface.
7. Polarity tests
8. guidelines for checking instrumentation and control system defect
   - Check the incoming supply voltages first
   - Check for voltages at the specific test points in circuit (as per manufacturers test point data sheet)
   - Do dead test of circuit for integrity of protection devices and others
   - In dead test, check for continuity of circuits, as intended, and check for insulation resistance
   - If it's not possible to perform a dead test, connect the supply to the circuit and do a live test of circuit.
9. Pressure is probably one of the most commonly measured variables in the power plant. It includes the measurement of
   - Steam pressure
   - Feed water pressure
   - Condenser pressure
   - Lubricating oil pressure and many more.
   - Pressure Control
10. Flow measurements can be divided into the following groups:
    - Flow rate
    - Total flow, and
    - Mass flow
11. Thermistor
12. Thermocouple.

Self-Check 7	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. A plan of action lists who will do what tasks at what period.
2. Taking the following steps.
   - Identify action steps, resources, or obstacles involved in reaching a goal.
   - Prepare a schedule.
   - Set priorities.
3. Importance of Planning
   - Planning provides directions
   - Planning reduces the risks of uncertainty
   - Planning reduces overlapping and wasteful activities
   - Planning promotes innovative ideas
   - Planning facilitates decision making
   - Planning establishes standards for controlling.

LO #2- Diagnose faults of instrumentation and control systems	
Self-Check 1	**Written Test**

Directions: Answer all the questions listed below.

1. Personal protective equipment
   a. Ear muffs/plugs
   b. Goggles/glasses/face shield
   c. Safety belt/ harness
   d. Safety shoes
   e. Safety apparel/suit, hat, mask and gloves
2. Ear muff/plug
3. Protective glass or goggles are used for eye protection, whereas welding goggles are used for welding operation which protects the eyes from high intensity spark.

4. Safety hat
5. A chemical suit
6. To avoid a fall from such heightened area, safety harness is used. Safety harness is put on by the operator at one end and tied at a strong point on the other end.
7. Safety shoes
8. Safety hand gloves

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Troubleshooting
2. To troubleshoot a system, process, or equipment
   start by collecting technical records from relevant sources.
3. Troubleshooting is done by one of the following methods:
   - Case-study approach
   - Logical analysis of given evidence
4. **The steps of troubleshooting**
   - Determine the Symptoms and analyze them.
   - Listen, Think, Look, Smell, and Operate.
   - Use all available sources of information: manuals, maintenance records, other people, the agent or manufacturer etc.
   - State the symptoms as clearly and precisely as possible. Stating that a device does not work, while perhaps true, is not a clear, informative statement of symptoms.
   - Localize to a functional module. Think, Look, and Test.

- Isolate to a circuit. Think, Look, and Test.
- Locate the specific component or problem. Think, Look, and Test.
- Determine the cause of the failure.
- Replace or correct a defective component or problem and correct the causes of the failure.
- Check for correct operation and calibration.
- Complete the record keeping.
- Review the entire troubleshooting and repair process. It is the best way to improve your troubleshooting skills.

5. A failure in, or poor performance in an instrument system, can be the result of difficulties in any one of the system's three major components.
6. The operator the end user typically makes the initial decision that a failure or malfunction has occurred—Problems can be due to incorrect or improper operation, controls not set correctly, etc
7. environment and operator Problems
8. Mechanical fault (Non-electronic)
9. (computer based) Electronic a component or circuit failure. In general, the electronic portion of an instrument system is the most reliable part

Self-Check 3	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Accident ,malfunction unplanned events refers
2. Contingency plan
3. Four steps to manage unplanned event
   i. assess and prioritize
   ii. tactics for tackling unplanned work
   iii. communicating about unplanned work
   iv. mitigating the problem

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

3. Good fault records help
   - ✓ To keep you proceeding in a logical sequence.
   - ✓ Records help in the future by providing a reference in case of additional failures in the same or similar instruments.
   - ✓ Records can be used to provide feedback to manufacturers and their agents. Records can be used to provide management information which help in making repair or replacement decisions.
   - ✓ Records can be used to detect a problem in a particular instrument which may require a modification to correct

2. Fault recording sheet contain

- ✓ **Record fault diagnosis data**:

  Issue and date of receipt

  Details of fault

  Solution or solutions attempted

  Tests conducted and results

  Successful outcome

  Date of solution

  If unresolved date of escalation to expert.

- ✓ **store fault diagnosis data:**

  Manual recording on specified forms

Fault log book.

Self-Check3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Seven steps for a successful shutdown

- A comprehensive list
- Have it in inventory
- Safety first
- Within current specifications
- Inspect before installation
- Precise installation
- Inspection before restart

2. PSD vs ESD

Process shutdown (PSD) system is a part of plant (facility) safeguarding system with a purpose to minimize the frequency and consequences of excursions outside the facility operating envelope.

Emergency shutdown (ESD) system is a part of plant (facility) safeguarding system with a purpose to keep the process within the design envelope and to prevent the escalation of abnormal conditions into a major hazardous event.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Adjustment the correction or balancing of a measuring instrument in order to eliminate systematic measurement deviation.
2. Adjustment
3. General Adjustment instructions Differential/Pressure/Vacuum Switch
   1. Determine if the pressure/vacuum set point is on increasing or decreasing pressure.
   2. If the set point is on increasing pressure, then decrease the pressure/vacuum of the source starting at a point lower than the set point. Use maximum 1/4 turn on adjustment screw. If the set point is on decreasing pressure, then increase the pressure/vacuum of the source starting at a point higher than the set point.
   3. Using the continuity tester and the pressure/vacuum gauge determine the actuation point of the switch.
   4. If the actuation point is above the desired value, turn the adjustment screw or knob per instructions in the pressure switch catalog to increase the actuation point, and if it is below, turn the adjustment screw or knob in the opposite direction to decrease it.
   5. For exact pressure/vacuum setting, cycle pressure/vacuum switch and make fine adjustments by repeating steps 2 through 4 (trial and error process) until the desired setting is obtained.

Self-Check	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Choose the best answer (each 2 point)

1. Fix the Problem

- Once you feel the problem has been isolated, develop a plan to repair the problem
- Inform Production of your repair plan
- Repair or recommend the repair of the problem

- Follow production area safety procedures and manufacturer specifications and procedures during repair
- Communicate closely with Production

2. How to troubleshoot sensors and instruments?

- If the temperature sensor is not reading accurately, ensure that it is clean and free of debris. The conductivity cleaning brush and warm water with mild detergent can be used to scrub the temperature sensor if needed. Alternatively, you can use a toothbrush to clean the sensor.
- If the instrument is reading any other value, the conductivity/temperature port on the cable may be contaminated. Refer to the Cleaning the Sensor Port section of this document for information on how to clean the port.
- After cleaning the port, recheck the temperature reading. If the temperature reading is still not displaying °C without the sensor installed, there may be a problem with the cable and/or instrument. In this case, contact your local your instructor or any technician that have knowhow about it.
- The conductivity calibration should be verified every day the instrument is used. However, the conductivity sensor is very stable and may hold its calibration for several weeks.

Self-Check 4	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Accidents, malfunctions, and unplanned events are accidents or upset events or conditions that are not planned as a part of routine Project activities during any Project phase
2. True
3. Worker accident:
4. spills of fuel, petroleum products, and/or other chemicals

LO #3 Rectify/correct defects in instrumentation control devices and system

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Shutdown procedure
   - Never use any machine you have not trained to use.
   - Pull plug or throw switch to off position before cleaning or adjusting any machine.
   - Keep fingers, hands, spoons
   - Away from moving parts.
   - Wait until machine stops before moving cream or butter (any milk product).
   - Check all switches to see that they are off before plugging into the outlet.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part II Fill the black space

1. Adjustment.
2. Adjustment the art of making an alteration or modification is an adjustment.
3. . For proper electrical connection follow colors of wire insulation or instructions on terminal code tag attached to switch.(True, False)
4. pressure reducing valves
5. To Adjust Your Pressure Reducing Valve You'll need a wrench of the right size to perform the adjustment.

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. **To Fix the Problem**

- Once you feel the problem has been isolated, develop a plan to repair the problem
- Inform Production of your repair plan
- Repair or recommend the repair of the problem
- Follow production area safety procedures and manufacturer specifications and procedures during repair
- Communicate closely with Production

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. to Minimize Future Problems follow up
    - Document in history file
    - Suggest changes, if needed
    - Upgrade PM program
    - Submit changes to update all documentation (As built)
2. to verify repaired/fixed problem
    - Confirm that all repaired and associated parts of the system operate correctly, including
        - ✓ Measurements
        - ✓ Control
        - ✓ Alarms
        - ✓ Interlocks
    - Confirm that the Operator is satisfied with the performance of the repaired system and understands how it is to operate under all conditions

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. reasons for diagnosed/troubleshoot and maintenance activities should be recorded are
   - Technical alterations to the plant will be recorded. For example a pump of different capacity has been installed, this could effect the workings of the entire plant.
   - Temporary repairs are identified as such, so that a permanent repair can be affected later. This should stop temporary repair to be seen as a permanent solution.
   - Repeated repairs to the same equipment can be identified. If the same equipment needs to be repaired over and over, then possibly it is under dimensioned and can not cope with the task.
2. **Maintenance/ troubleshoot records**
   - can be a tool to adjust the man power required.
   - Well kept maintenance records would also help to control the amount of materials used.
   - Maintenance records can take different shapes and forrns, every company needs to find the sort of records that is most suited to their specific requirements. It may be a simple book into which all maintenance activities are entered or it could be preprinted forms that are filled in after the work is done.
3. The goal of troubleshooting is to repair or correct a fault in an instrument system.
4. operator,environment, instrument
5. The first problem of troubleshooting is to determine whether the fault is in the Operation, Environment, or Instrument component of the instrument system.
6. True
7. True

Instruction: II choose the correct answer for the following question's

1. D
2. D.

LO #4 Testing corrected instrumentation and control systems

Self-Check 1	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Instruction: I

1. True
2. True
3. True
4. True
5. D

Self-Check 2	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Test Record Sheets shall be developed as required for specific tests
2. Explain Method for testing thermocouple
   - ✓ Turning on the Pilot Light
   - ✓ Locate the pilot light controls on the gas valve.
   - ✓ Turn the pilot light on for 30 seconds.
   - ✓ Release the button to see if the pilot light goes out.
   - ✓ Count to 20 and wait for the pilot light to go out.

✓ Listen for clicking near the gas valve.

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page

1. **Basic step of report writing**

Step 1: Decide on the 'Terms of reference'

Step 2: Decide on the procedure

Step 3: Find the information

Step 4: Decide on the structure

Step 5: Draft the first part of your report

Step 6: Analyse your findings and draw conclusions

Step 7: Make recommendations

Step 8: Draft the executive summary and table of contents

Step 9: Compile a reference list

Step 10: Revise your draft report

2.Fault reporting

3.Validitation

4.Calibtation

5.Instrument can be calibrated

- with a new instrument

- when a specified time period is elapsed
- when a specified usage (operating hours) has elapsed
- when an instrument has had a shock or vibration which potentially may have put it out of calibration
- sudden changes in weather

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