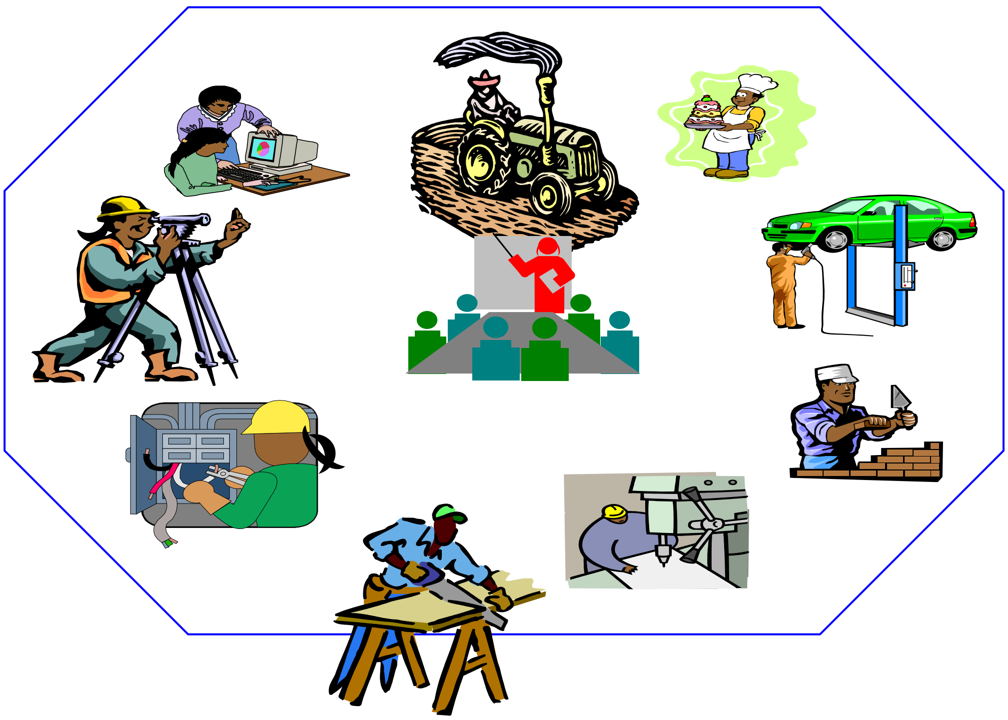
INSTRUMENTATION AND CONTROL SERVICING Level-III

Based on May, 2011 V2 OS and Dec, 2020 V1 Curriculum



Module Title: **Calibrating instrumentation and control Devices**

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LG #20	LO #1- Plan and prepare for calibration

Instruction sheet

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

- planning and preparing calibration
- Following OH & S policies and procedures for calibration
- Identifying instrumentation and control devices to be calibrated
- Obtaining and checking necessary materials required for calibration
- obtaining and checking Tools, equipment and testing devices needed for calibration
- Checking instrumentation and control devices
- Following Instruction and calibration standards

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:

- plan and preparing calibration
- Follow OH & S policies and procedures for calibration
- Identify instrumentation and control devices to be calibrated
- Obtain and check necessary materials required for calibration
- obtain and check Tools, equipment and testing devices needed for calibration
- Check instrumentation and control devices
- Follow Instruction and calibration standards

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,

If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- planning and preparing calibration

There are as many definitions of calibration as there are methods. According to ISA's The Automation, Systems, and Instrumentation Dictionary, the word calibration is defined as "a test during which known values of measurand are applied to the transducer and corresponding output readings are recorded under specified conditions." The definition includes the capability to adjust the instrument to zero and to set the desired span .An interpretation of the definition would say that a calibration is a comparison of measuring equipment against a standard instrument of higher accuracy to detect, correlate, adjust, rectify and document the accuracy of the instrument being compared. Typically, calibration of an instrument is checked at several points throughout the calibration range of the instrument. The calibration range is defined as "the region between the limits within which a quantity is measured, received or transmitted, expressed by stating the lower and upper range values." The limits are defined by the zero and span values .The zero value is the lower end of the range. Span is defined as the algebraic difference between the upper and lower range values.

The calibration range may differ from the instrument range should be determined from a combination of factors. These factors include:

- Requirements of the process
- Capability of available test equipment
- Consistency with similar instruments at your facility
- Manufacturer's specified tolerance

Calibrate is to:-

- Ensure performance is acceptable within the required tolerance limits for intended use
- Comply with regulations
- Save time
- Save money
- Defend data integrity

It makes sense that calibration is required for a new instrument. We want to make sure the instrument is providing accurate indication or output signal when it is installed. Instrument error can occur due to a variety of factors: drift, Environment, electrical supply, addition of components to the output loop, process changes, etc. Since a calibration is performed by comparing or applying a known signal to the instrument under test, errors are detected by performing a calibration. An error is the algebraic difference between the indication and the actual value of the measured variable.

Typical errors that occur include Zero and span errors are corrected by performing a calibration. Most instruments are provided with a means of adjusting the zero and span of the instrument, along with instructions for performing this adjustment. The zero adjustment is used to produce a parallel shift of the input-output curve. The span adjustment is used to change the slope of the input-output curve. Linearization error may be corrected if the instrument has a linearization adjustment. If the magnitude of the nonlinear error is unacceptable and it cannot be adjusted, the instrument must be replaced.

To detect and correct instrument error, periodic calibrations are performed. Even if a periodic calibration reveals the instrument is perfect and no adjustment is required, we would not have known that unless we performed the calibration. And even if adjustments are not required for several consecutive calibrations, we will still perform the calibration check at the next scheduled due date. Periodic calibrations to specified tolerances using approved procedures are an important element of any quality system.

Calibrations Performs by:-

A control system technician (CST) is a skilled crafts person who knows pneumatic, mechanical, and electrical instrumentation. He or she understands process control loops and process control systems, including those that are computer-based. Typically, he or she has received training in such specialized subjects as theory of control, analog and/or digital electronics microprocessors and/or computers, and the operation and maintenance of particular lines of field instrumentation. A CST performs calibration, documentation, loop checks, troubleshooting, and repair or replacement of instrumentation. These tasks relate to systems that measure and control level, temperature, pressure, flow, force, power, position, motion, physical properties, chemical composition and other process variables

Calibration Intervals

Time between any two calibrations of measuring and test instruments is known as the calibration interval and must be established and monitored by the user in accordance with own requirements. Essential criteria for determining the calibration interval include:

- Measured quantity and permissible tolerance
- The extent to which the measuring and test equipment is subject to stressing
- Frequency of use

- Ambient conditions
- Stability of previous calibrations
- Required measuring accuracy
- Company-specific requirements
- specified by the quality assurance system

We recommend a calibration interval of 1 to 2 years for use under normal conditions. We recommend a calibration interval of 1 year for measuring instruments which are used on a regular basis for audits, evaluating work safety and assuring the quality of products and services, as well as under severe ambient conditions

An interpretation of the definition would say that a calibration is a comparison of measuring equipment against a standard instrument of higher accuracy to detect, correlate, adjust, rectify and document the accuracy of the instrument being compared.

Typically, calibration of an instrument is checked at several points throughout the calibration range of the instrument.

The calibration range is defined as "the region between the limits within which a quantity is measured, received or transmitted, expressed by stating the lower and upper range values." The limits are defined by the zero and span values.

Calibration and ranging are two tasks associated with establishing an accurate correspondence between any instrument's input signal and its output signal.

Calibration versus re-ranging

To calibrate an instrument means to check and adjust (if necessary) its response so the output accurately corresponds to its input throughout a specified range.

In order to do this, one must expose the instrument to an actual input stimulus of precisely known quantity. For a pressure gauge, indicator, or transmitter, this would mean subjecting the pressure instrument to known fluid pressures and comparing the instrument response against those known pressure quantities. One cannot perform a true calibration without comparing an instrument's response to known, physical stimuli.

To range an instrument means to set the lower and upper range values so it responds with the desired sensitivity to changes in input.

For example, a pressure transmitter set to a range of 0 to 200 PSI (0 PSI = 4 mA output; 200 PSI = 20 mA output) could be re-ranged to respond on a scale of 0 to 150 PSI (0 PSI = 4 mA; 150 PSI = 20 mA).

- The zero value is the lower end of the range.
- Span is defined as the algebraic difference between the upper and lower range values.

The calibration range may differ from the instrument range, which refers to the capability of the instrument.

For example, an electronic pressure transmitter may have a nameplate instrument range of 0–750 pounds per square inch, gauge (psig) and output of 4-to-20 milliamps (mA). However, the engineer has determined the instrument will be calibrated for 0-to-300 psig = 4-to-20 mA. Therefore, the calibration range would be specified as 0-to-300 psig = 4-to-20 mA.

In analog instruments, re-ranging could (usually) only be accomplished by re-calibration, since the same adjustments were used to achieve both purposes.

In digital instruments, calibration and ranging are typically separate adjustments (i.e. it is possible to re-range a digital transmitter without having to perform a complete recalibration), so it is important to understand the difference.

THE CHARACTERISTICS OF A CALIBRATION

Every calibration should be performed to a specified tolerance. The terms tolerance and accuracy are often used incorrectly. In ISA's The Automation, Systems, and Instrumentation Dictionary, the definitions for each are as follows:

Accuracy: The ratio of the error to the full scale output or the ratio of the error to the output, expressed in percent span or percent reading, respectively.

Tolerance: Permissible deviation from a specified value; may be expressed in measurement units, percent of span, or percent of reading.

As you can see from the definitions, there are subtle differences between the terms. It is recommended that the tolerance, specified in measurement units, is used for the calibration requirements performed at your facility. By specifying an actual value, mistakes caused by calculating percentages of span or reading are eliminated. Also, tolerances should be specified in the units measured for the calibration.

For example, you are assigned to perform the calibration of the previously mentioned 0-to-300 psig pressure transmitter with a specified calibration tolerance of ±2 psig. The output tolerance would be:

(2 psig/300 psig)*16 mA = 0.1067 mA

The calculated tolerance is rounded down to 0.10 mA, because rounding to 0.11 mA would exceed the calculated tolerance. It is recommended that both ±2 psig and ±0.10 mA tolerances appear on the calibration data sheet if the remote indications and output milliamp signal are recorded.

Note the manufacturer's specified accuracy for this instrument may be 0.25% full scale (FS).

Calibration tolerances should not be assigned based on the manufacturer's specification only.

Calibration tolerances should be determined from a combination of factors. These factors include:

- Requirements of the process
- Capability of available test equipment
- Consistency with similar instruments at your facility
- Manufacturer's specified tolerance

Self-Check -1	Written Test

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

I. Choose the best answer (each 2point)

1. ________the ratio of the error to the full scale output.
   A. Accuracy B. Tolerance C. A & B D) None
2. ____________re-ranging could (usually) only be accomplished by re-calibration, since the same adjustments.
   A. In analog instruments B. In digital instruments C. A&B D. None
3. ___________is defined as "the region between the limits within which a quantity is measured, received or transmitted, expressed by stating the lower and upper range values."
   A. Accuracy B. Calibration tolerances C. The calibration range

II. Part II fill the blank space

1. List down why needed calibration? (5%)
   ____________________________________,________________________________
   ____________________________________,________________________________
   ____________________________________,________________________________
   ____
2. Who performer calibration? (4%)

____________________________,_____________________,_____________________

Answer the following question!

Note: Satisfactory rating - 8 and above Unsatisfactory - below 8

You can refer correct answer from last page of LG

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: _____________

2.1 Safety Guidelines

The best way to provide a safe operating environment is to make personnel and equipment safety part of the planning process. You should examine every aspect of the system to determine which areas are critical to operator or machine safety. If you are not familiar with PLC system installation practices, or your company does not have established installation guidelines, you should obtain additional information from the following sources.

- NEMA — The National Electrical Manufacturers Association, located in Washington, D.C., publishes many different documents that discuss standards for industrial control systems. You can order these publications directly from NEMA. Some of these include: ICS 1, General Standards for Industrial Control and Systems ICS 3, Industrial Systems ICS 6, Enclosures for Industrial Control Systems
- NEC — The National Electrical Code provides regulations concerning the installation and use of various types of electrical equipment. Copies of the NEC Handbook can often be obtained from your local electrical equipment distributor or your local library.
- Local and State Agencies — many local governments and state governments have additional requirements above and beyond those described in the NEC Handbook. Check with your local Electrical Inspector or Fire Marshall office for information.

Health and Safety Policy

Your Company Name is committed to the goal of providing and maintaining a healthy and safe working environment, with a view to continuous improvement.

This goal is only achievable by adherence to established objectives striving to exceed all obligations under applicable legislation, and by fostering an enthusiastic commitment to health, safety and the environment within Your Company Name personnel, contractors and visitors.

In particular:

- Management, working in cooperation with the Joint Health and Safety Committee, will strive to take all reasonable steps to reduce workplace hazards to as low as reasonably achievable.
- Supervisors and managers are held accountable for the health and safety of all employees under their supervision. This includes responsibility for applicable training

and instruction, appropriate follow up on reported health and safety concerns, and implementation of recommended corrective action. This accountability is integrated into the performance appraisal system.

- Supervisors, workers and visitors are expected to perform their duties and responsibilities in a safe and healthful manner, and are accountable for the Health and Safety of themselves and others.
- Your Company Name is committed to providing all necessary training and instruction to ensure that appropriate work practices are followed on the job, and to promote their use off the job.
- If necessary, Your Company Name will take disciplinary action where individuals fail to work in a healthy and safe manner, or do not comply with applicable legislation or corporate policies and procedures.

Health, safety, the environment and loss control in the workplace are everyone's responsibility. Your Company Name expects that everyone will join in our efforts to provide a healthy and safe working environment on a continuous day to day basis. Only through the dedication and efforts of all individuals can Your

Company Name succeeds in providing a healthy safe working environment.

Occupational Health and Safety in Workplaces

Duties of Workers

One of your most important responsibilities is to protect your Health and Safety as well as that of your co-workers. This booklet will discuss some of your duties under the occupational Health and Safety legislation and help you to make your workplace safer and healthier.

The law requires

Workplaces under the jurisdiction are governed by your provincial legislation.

The legislation places duties on owners, employers, workers, suppliers, the self-employed and contractors, to establish and maintain safe and healthy working conditions. The legislation is administered by your provincial legislation. Your officials are responsible for monitoring compliance.

Duties of Your Employer

Your employer is responsible for providing you with safe and healthy working conditions. This includes a duty to protect you from violence, discrimination and harassment. You must cooperate with your employer in making your workplace safe and healthy.

You're Responsibilities

- You must also comply with the legislation. You have responsibilities to:
- protect your own Health and Safety and that of your co-workers;
- not initiate or participate in the harassment of another worker; and
- Co-operate with your supervisor and anyone else with duties under the legislation.

You're Rights

The legislation gives your three rights:

- The right to know the hazards at work and how to control them;
- The right to participate in occupational health and safety; and
- The right to refuse work which you believe to be unusually dangerous.

You may not be punished for using these rights. An employer can be required to legally justify any action taken against a worker who is active in Health and Safety.

You're Right to Know

The Act requires your employer to provide you with all the information you need to control the hazards you face at work. For example, chemicals at the workplace must be listed. You are entitled to review this list. Your employer must train you to safely handle the chemicals you will work with. If you are inexperienced, you must receive an orientation which includes;

- What to do in a fire or other emergency;
- First aid facilities;
- Prohibited or restricted areas;
- Workplace hazards; and
- Any other information you should know.

You must also be supervised closely by a competent supervisor.

You're Right to Participate

You have the right to become involved in occupational Health and Safety.

The legislation encourages employers and workers to work together to maintain a healthy and safe workplace. Employers at workplaces with (ten or more – consult your provincial act) workers must set up an occupational health committee of employer and worker representatives.

Committees have duties to:

- Regularly inspect the workplace;
- Conduct accident investigations;

- Deal with the health and safety concerns of employees;
- Investigate refusals to work;
- Meet at least (four times a year – consult your provincial act); and return minutes of each meeting to the division.

Committee members are entitled to five days (consult your provincial legislation) of unpaid educational leave each year to take occupational Health and Safety courses.

They may attend courses provided by the Division without loss of pay or benefits.

Certain types of workplaces with less than (ten – consult your provincial act) employees must have a worker Health and Safety representative. The representative must be selected by the workers at the workplace. He or she has many of the responsibilities of an occupational health committee.

You're Right to Refuse

You have the right to refuse to do work which you believe is unusually dangerous.

The unusual danger may be to you or to anyone else. An unusual danger could include such things as:

- A danger which is not normal for your occupation or the job;
- A danger under which you would not normally carry out your job; and/or
- A situation, for which you are not properly trained, equipped or experienced.

To exercise this right, use the following guidelines.

Once you believe that the work you have been asked to do is unusually dangerous, you should inform your supervisor. Make sure that the supervisor understands that you are refusing to do the disputed job for health and safety reasons. Work with the supervisor to attempt to resolve the problem.

If the problem cannot be resolved by the supervisor to your satisfaction, and no worker health and safety representative or occupational health committee exists at the workplace, your supervisor should phone the Division and ask for advice. You also have the right to contact the Division at any time.

The supervisor has the right to assign you to other work (at no loss in pay or benefits) until the matter is resolved.

Do not leave the site without the permission of your employer.

If a committee exists at the workplace, contact your local representative and ask for help. Your supervisor should contact the co-chairpersons and ask them to investigate. They will try to resolve the matter. If they cannot resolve the matter to your satisfaction, they will convene for an emergency committee meeting. The committee will investigate and prepare a report on the refusal. You have the right to continue to refuse until:

- Measures have been taken to satisfy you that the job is now safe to perform; or
- Your occupational health committee has investigated and ruled against your refusal.

If the committee rules against your refusal, you have the right to appeal the ruling to an occupational health officer. The officer will investigate and prepare a report on the disputed work. If you disagree with the decision of the officer, you may appeal to the director of the Division.

An employer cannot assign another worker to do the disputed job unless the replacement worker is advised in writing:

- Of the refusal and the reasons for it;
- Of the reasons why the employer believes that there placement worker can do the disputed job safely;
- That the replacement worker also has the right to refuse; and
- Of the steps to follow when exercising this right.

Safe Work Procedure

A Safe Work Procedure is a written step-by-step description of how a particular task is to be performed that is used during performance of the work by the person performing the work (or by two people doing the work – one reading and one doing). Examples of procedures include: equipment start-up or shut-down procedures; normal operating procedures; written operating instructions; abnormal operating procedures, emergency procedures, special test procedures, maintenance procedures, construction installation procedures, calibration procedures, hydrostatic test procedures, and inspection procedures.

Safe Work Practice

Safe Work Practices are written descriptions of how work is generally carried out and allow flexibility in how the work is accomplished. Due to the diversity of circumstances and situations within JACOS, the information contained in Safe Work Practices cannot be considered complete or applicable in every situation.

Supervisors and employees must refer to federal and provincial health and safety legislation, and industry practices to ensure that the work is accomplished safely.

Development

Procedures should be developed for high-hazard work or where historical information, legislation, a Hazard Assessment dictates.

Practices should be developed for commonly used equipment or process that does not necessarily follow a step by step order.

Employees, Supervisors, and Management will be involved in the development and/or review of these Safe Work Procedures and Practices.

All Safe Work Procedures and Practices will be developed using the standard JACOS Safe Work

Procedure and Practice format and are based on a job hazard assessment.

Review

Employees, Supervisors, and technical experts will periodically review Safe Work Procedures and Practices to ensure that they are complete, accurate and applicable on a minimum 3 year bases or when warranted.

Availability

Safe Work Procedures and Practices applicable to the work being performed will be available to all employees at the work site.

Action Guidelines

IHI Aerospace has established the following action guidelines to put its basic policies into practice, based on its five fundamental safety rules.

- Specify OH & S targets to achieve this policy; establish and implement action schedules.
- Strive to reduce risks and to identify factors that lead to hazards by applying OH & S risk assessment activities to all business activities.
- Establish and adhere to voluntary guidelines to ensure compliance with OH & S regulations and customer agreements.
- Improve health and safety awareness through health and safety training and in-house information activities.
- Periodically review the OH & S management system to ensure constant improvements.

- Pay particular attention to the following points, based on the specific characteristics of IHI Aerospace's operations.
  - ✓ Prevent accidents and disasters involving the handling of explosives and pressurized gas.
  - ✓ Prevent falls or accidents caused by hazardous operations.
  - ✓ Prevent accidents and disasters involving the handling of hazardous substances and chemicals.
  - ✓ Provide inexperienced employees with safety training and comprehensive instruction in work procedures.
  - ✓ Institute improvements to create a safe, comfortable workplace.
  - ✓ Eliminate accidents in commutes to and from the workplace.

2.2 Ethiopian environmental proclamations and regulations

Environmental pollution control (Proclamation no. 300/2002) Proclamation No. 300/2002 on Environmental Pollution Control primarily aims to ensure the right of citizens to a healthy environment and to impose obligations to protect the environment of the country. The law addresses the management of hazardous waste, municipal waste, the establishment of environmental quality standards for air, water and soil; and monitoring of pollution. The proclamation also addresses noise as one source of environmental pollution and it seeks for standards and limits for noise providing for the maximum allowable noise level taking into account the settlement patterns. In general, the Proclamation provides a basis from which the relevant environmental standards applicable to Ethiopia can be developed, while sanctioning violation of these standards as criminally punishable offences

Furthermore, it empowers the Federal Environmental Protection Authority or the Regional Environmental Authority to assign environmental inspectors with the duties and responsibilities of controlling environmental pollution. In order to ensure implementation of environmental standards and related requirements, inspectors belonging to the EPA or the relevant regional environmental agency are empowered by the Proclamation to enter, without prior notice or court order, any land or premises at any time, at their discretion. Such wide powers are derived from Ethiopia's serious concern and commitment to protecting the environment from pollution.

Solid waste management proclamation (Proclamation no. 513/2007)

This proclamation came into force on February 2007 with an objective of implementing effective solid waste management in the country. The Proclamation recognized the existing solid waste management problems in the country and emphasizes the need to prevent environmental pollution that may result from the disposal of solid waste. Environmental Protection Authority (replaced by Ministry of environment, forest and climate change (MEFCC) and now by EFCCC) is responsible for initiating and overseeing the implementation of overall policies, strategies and guidelines on solid waste management. Capacity building is also an area of intervention by the federal and regional environmental entities to foster sound management of waste in the country.

Regional environmental agencies and urban administrations are also responsible for drawing out their plans as regards the implementation of the Proclamation and monitoring efficacy. In this proclamation the following provisions pertinent to the treatment and disposal of hazardous waste management has been provided: As regards to inter-regional movement of solid wastes:

- Regional states may require any transit of solid waste through their region to be packed and transported in conformity with the directives and standards issued by the concerned environmental agency.
- Each urban administration shall in conformity with the relevant environmental standards, ensure that solid waste disposal sites are constructed and properly used and managed. As regards to the transportation of solid waste:
- Without prejudice to the mandate of the appropriate agency to register, undertake annual registration and technical inspection of the motor vehicles as well as to issue a driving license, the conformity of any vehicle or equipment with the specifications set by concerned environmental agency shall be ascertained by the relevant urban administration prior to its use for solid waste management,
- Each urban administration shall ,without prejudice to the weight and size of the vehicles determine under the relevant laws, set standards to determine the skills of drivers and appropriateness of the equipment and equipment operators and to prevent overload of the solid wastes As regards to the construction of waste disposal sites
- Urban administrations shall ensure that a solid waste disposal site that was under construction or was constructed prior to the coming into force of this proclamation is subjected to environmental auditing as per the relevant laws.
- Urban administration shall ensure that any new solid waste disposal site being constructed or an existing solid waste disposal site undergoing any modification has had

an environmental impact assessment according to the relevant law. As regards to the auditing of solid waste disposal sites

- Each urban administration is responsible for ensuring that an environmental audit is carried out on every existing solid waste disposal sites.

The owner of any solid waste disposal site shall make the necessary modification if the environmental audit made under sub-article (1) of this article shows that it's continued operation poses a risk to public health or the environment.

- The authority may prescribe environmental criteria to determine the alternative use of a solid waste disposal site that has ceased operation or is abandoned. As regards to civil liabilities
- The owner of any solid waste disposal site shall, regardless of fault, be liable for any damage caused to the environment, human health or property in the course of its operation and after its closure
- Without prejudice to sub-article (1) of the article ,exemption from liability shall be granted only when certified that it is the victim himself or a third party for whom the owner of the solid waste disposal site is not responsible that has caused the damage
- Any claim for damage under sub-article (1) of this article shall be barred by a period of limitation unless thought within two years from the date on which the occurrence of the damage is known

The major intents of the proclamation, as described in the preamble and objective, are maximizing the economic and social benefits of waste as well as promoting decentralized waste management services which also include a more strong involvement of the community and public at all level in the delivery of waste management services. The proclamation considers waste as a resource, and accords due attention to the issue of waste recycling.

Proclamation no.1090/2018 a proclamation to provide for hazardous waste management and disposal control

This is one of the recently introduced environmental legislations that specifically deal with hazardous wastes, the proclamation in its preamble elucidated hazardous waste as one of the most crucial environmental problems in Ethiopia. It stated the importance of prevention and control of these type wastes and emphasized the need for creation of a system to control the generation, storage treatment, recycling and reuse as well as transportation and disposal of hazardous wastes to prevent harm to human and animal health as well as the environmental.

The proclamation defined "hazard" as the inherent characteristics of a substance, agent, or situation having the potential to cause adverse effects or damage to human or animal health, the environment, biodiversity and property and has determined the categories and characteristics of hazardous waste in annex I and annex II respectively. The objectives of this proclamation are stated as;

- Create a system for the environmentally sound management and disposal of hazardous Waste
- Prevent the damage to the human or animal health, the environment, biodiversity and property due to the mismanagement of hazardous waste.

Further its scope of application is also stated as:

- Waste that belong to any category contained in Annex One of this Proclamation, and waste possesses any of the characteristic contained in Annex Two; as well as on those wastes that might be categorized as hazardous waste by the directive to be issued by the Ministry;
- Person, who generates, reuses, recycles, stores, transports, or disposes hazardous waste at large in nation. The proclamation within its 24 articles has dealt with all character and management of hazardous wastes.

Proclamation no 1075/2018 industrial chemical registration and administration proclamation One of the most important recent environmental legislations particularly focusing on solving environmental problems associated with chemical industry. The proclamation in its preamble elaborated that Ethiopia, being in the process of economic transformation from agricultural to industrial led economy steadily increases the demand of imported or domestically produced chemicals.

In light of this it is found important to put in place a system to prevent and control of adverse effects to the human and animals health as well as environment safety that may arise from mismanagement of the chemicals in the process of production, importation, exportation, transportation, storage, and use of industrial chemicals.

It provided a definition of “Industrial chemical” as any chemical that is used for industrial, educational and training, research and transfer purposes, with the exclusion of pharmaceutical and medical, food and food additives, agricultural, chemical weapons and radioactive chemicals.

Its scope of application extends to any person who is engaged in the transaction of industrial chemicals while its objectives are

- Establishing a national system for registration and administration of industrial chemicals; and
- Preventing and controlling the adverse effects arising from the mismanagement of chemicals to the human and animals health as well as environment safety that may occur in the transaction of industrial chemicals The legislation has five parts covering eighteen articles in which the acquisition, transportation utilization, monitoring and disposal mechanisms are well articulated.

Addis Ababa city waste management, collection & disposal regulation

This is an elaborate piece of legislation (Regulation No 13/2004) which has 9 parts and 37 articles. Among the key concerns of this regulation are environmental pollution and public health related issues as well as the economic importance of waste. The general spirit of the regulation is the promotion of a more decentralized, participatory and private sector driven waste management service delivery in the City. The regulation also provides, among others, for the establishment of governmental organizations dedicated for waste management related affairs both at the City, Sub-City and Kebele levels.

As expected, the regulation stipulates general provisions that assume detail guidelines and directives to be developed at a later stage to enable the proper implementation of the regulation. The regulation gives a clear definition for the term “hazardous waste”. Article 13 which refers to the management and disposal of hazardous wastes, for example, stipulates that a directive shall be issued on this issue. The regulation also stresses the need to have special authorization from the City’s Environmental Protection Authority, although specific tools that will be used in enforcing these provisions are not indicated.

Notwithstanding the key roles residential and business establishments in the City play in achieving the objectives stated in the regulations, it is more explicit about the responsibility of the generators than on the commitment of the government. Likewise, Article 27 that refers to “Safety and Health of Online Workers” stipulates that taking care of the safety and health of online workers is the responsibility of the employer, although it does not provide for specific instruments to be employed to ensure its proper adherence. It is also worthwhile to note that Article 29, which is about incentives, explicitly promotes the use of appropriate technology for recycling and reduction of waste, but it is silent about the need to provide incentives to those that adopt and/or promote OHS practices.

Public health proclamation (200/2000) The Public Health Proclamation (200/2000) comprehensively addresses aspects of public health including among others, water quality control, waste handling and disposal, availability of toilet facilities, and the health permit and registration of different operations. The Proclamation prohibits the disposal of untreated solid or liquid hazardous wastes into water bodies or the environment that can affect human health.

The labour law proclamations 1156/2019 The former labour Proclamation No.377/2003 is repealed and substituted by a new Proclamation 1156/2019. The new labor legislation consists of much of the provisions of the previous labor law with some improvements and additions made to it. The new legislation have made important improvements on protecting child labor by increasing the minimum age for young workers to be 15 years old (versus the previous 14 years) and have introduced a new sub-article (14h) prohibiting Sexual Harassment or Sexual Assault at workplace to prevent GBV.

Proclamation 1156/2019 is also the prevailing law protecting public and workers safety. The proclamation covers health and safety at work, harmonious industrial relation and minimum workplace standard and addresses workplace vulnerability. Article 92-93 of the proclamation defines obligation of employers and employees in work place including assignment of safety officers and committee. The Labour Proclamation provides a responsibility to employers to protect occupational safety, health and create better working environment for their workers. Article 92 states that "An employer shall take the necessary measure to safeguard adequately the health and safety of the workers…" The proclamations have details about the safety and health of workers. For instance, it forces employers to

- Take appropriate steps to ensure that workers are properly instructed and notified concerning the hazards of their respective occupations and the precautions necessary to avoid accident and injury to health;
- Ensure that directives are given and also assign safety officer; establish an occupational, safety and health committee of which the committee's establishment, shall be determined by a directive issued by the Minister;
- Provide workers with protective equipment, clothing and other materials and instruct them of its use; etc.

This new Labour Law protects Children against Child Labour abuse. The new Proclamation No. 1156/2019, Article 89 prohibited employment of less than 15 years. This proclamation states “It is prohibited to employ persons under 15 years of age”. It is also prohibited to employ young workers which on account of its nature or due to the condition in which it is carried out, endangers the life or health of the young workers performing it. "Young worker" means a person who has attained the age of 15 but is not over the age of 18 years (Article 89 Sub-Article 1).

In addition to enacting its labor codes, Ethiopia is also a signatory to the international UN conventions and has ratified the major international human rights instruments. Ethiopia has also ratified the following ILO conventions:

- Forced Labour Convention No.29 /1930;
- Freedom of Association and Protection of the Right to Organize Convention, No.87/1948;
- Employment Service Convention, No.88/1948;
- Right to Organize and Collective Bargaining Convention, No.98/1949;
- Abolition of Forced Labour Convention, No.105/1957;
- Minimum Age Convention No. 138 /1973; Occupational Safety and Health Convention, No.156/1981;
- Termination of employment Convention, No.158/1982;
- The Rights of the Child Convention (1989); and
- The Worst Forms of Child Labour Convention No.182/1999.

Self-Check -2	Written Test

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

Directions: Choose the best answer

1. What is your right? (have 5 point)
2. The unusual danger may be to you or to anyone else. An unusual danger could include such things as: (have 5 point)
3. What are duties of committees? (Have 5 point)
4. What are your responsibilities? (Have 5 point)

Note: **Satisfactory rating – 10 and above** **Unsatisfactory - below 10 points**

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information sheet 3- Obtaining and checking necessary materials required for calibration

3.1 Standard connecting cables with plugs, connectors

Standard connectors are used to connect devices, machine, and separate spare parts with different accessories. Unless the connectors properly calibrated they cannot fit or match to the required parts. If they calibrated properly must match or fit with the device to connect correctly, thus why calibration is so necessary, wherever the spare part is manufactured, since the standard is similar and correctly Calibrated they must fit to their corresponding devices or accessories.

- Pneumatic pipe and tube Connectors are accessories instruments which used to join tubes and instrumentation circuit.
- Connecting cables with accessories/plugs are essential parts of instrumentation system to energize electrically operated devices

Pneumatic pipe and tube Connectors

Figure 3.1 Different types of Pipes/tubes & fittings

Selection of correct Cable Type and Size

Both, the type of cable and its size have to be carefully selected. Wrong selection can result in cables suffering mechanical damage, cables overheating, excessive volt drop, high power loss and more.

Selection of Cable Type

The cable to be installed must be suitable-for the purpose and the location it is intended. High temperature, mechanical impact, corrosive substances and presents of water may all do damage to cables. Before deciding on the type of cable we want to install, we must assess the situation and select a cable type that can withstand a given hazard. For example, if a cable is to be installed in a very hot location, then ordinary PVC insulated. Cable would not be a wise choice. A mineral insulated cable, FP 200 cable or similar should be selected. Likewise, if a cable is in a location where it is likely to be exposed to mechanical damage (impact), armored cable should be used. Alternatively the cable should be protected by conduit or trucking.

In short, the type of cable used for a given installation must be suitable for this special installation. Care must be taken in selecting a suitable cable type.

Selection of conductor size

Once the type of cable is selected, we must now decide on the size of the conductors. A too small conductor will result in:-

- overheating -damage to cable -fire risk
- high volt drop
- high power loss

These effects are not desirable, since they could damage the installation and cost money. On the other hand, if we select too big a conductor, the installation cost will be unnecessary high.

To find the correct conductor size; we will have to do some calculations. The "Wiring Regulations" contain information that will be needed to carry out these calculations. It is best to do this step by step.

Step 1 Find the design current

The design current is the current that flows in an electrical circuit under normal operating conditions. This current may be quoted by the manufacturer, or it needs to be calculated.

- For single phase circuits: I =P/U
- For 3-Phase circuits 1= P/U • 1.73 • cos <p

Step 2 Select a suitable fuse size

It is the usual practice to select the next standard fuse rating above the design current, for example if the design current was *28.8A* a 30 A fuse would be selected.

3.2 Sealing materials

Sealants are materials used to connect and seal pipes and tubes to prevent leakage of liquids and gases.

Determine the quantity of each sealing item to be paid for by actual measurement of the number of linear m ft of in-place material that has been approved.

Small seals, especially those made of engineered plastic, can be extremely difficult to install. U-shaped grooves that require kidney-beaning of seals to fit into place can be an issue, as can sharp edges that may cause nicks. Regardless of the problem, the result is the same: Improper installation leads to leaks and lost productivity.

This article details the proper installation of O-Ring energized piston and rod seals, including recommendations for preventing deformation, proper heating methods, lubrication and friction considerations, installation tools, and calibration.

An O-Ring energized seal consists of a plastic sealing jacket, most commonly of Polytetrafluoroethylene (PTFE). This provides wear resistance and friction properties but is not elastic. It therefore needs to be energized by an elastomer seal, usually an O-Ring.


***Figure 3.2 piston* seal**

There are four steps to take prior to installing *any* type of piston seal or rod/shaft seal:

- Ensure the bore or rod/shaft has a lead-in chamfer. If not, use a calibration sleeve.
- De-burr and chamfer sharp edges and cover the tips of screw threads.
- Remove machining residue, such as chips and dirt. Carefully clean all parts.
- Seal installation is easier if the bore or rod is oiled. Use a lubricant compatible with the seal, the O-Ring, and the application. Do not use lubricants containing solid particles.

Closed Groove Piston Seal Installation

To properly seat an O-Ring energized piston seal into a closed groove; the plastic element of the seal must be expanded. The resulting deformation leaves a diameter increase that needs to be calibrated.

Heating the seal immediately prior to expansion can facilitate this process, making calibration easier. Generally, plastic seals are heated with steam, with a hot air gun, by submersion in oil, or by submersion in water. Many plastics, such as PTFE, the material most commonly used in O-Ring energized seals, are resistant to temperatures above 200°C, but operator safety usually limits the heat used to less than 100°C.

Some plastics, such as ultra-high molecular weight polyurethane, nylon, and thermoplastic polyurethane, though, should not be heated to above 80°C, and others not exposed to hot water or steam. This should be checked before installation. After heating and installation, thermal contraction of the plastic element of the seal during cooling assists in bringing the jacket back to the correct diameter.

When a high amount of friction is present during installation, lubrication of both the jacket and installation tool is recommended. The lubricant used must be compatible with both the plastic element of the seal, the O-Ring and the application. Generally, using the system fluid is preferable. Lubricants containing solid particles should never be used.

To install an O-Ring energized piston seal into a closed groove without tools, first stretch the O-Ring by applying two pieces of woven or plastic packing band. Then place the O-Ring into the piston-seal groove, ensuring it's not twisted. Use the same method to expand the jacket, stretching it over the piston and into the groove.

To install an O-Ring energized piston seal into a closed groove *with* tools, first insert the O-Ring into the piston-seal groove using the method described above. Then place an installation cone over the piston and align it with the seal groove. Place the jacket and an expanding pusher in position. Then rapidly expand the seal over the installation cone and into the groove. Remove the cone and the pusher.

Using tools can reduce seal deformation. Shorter expansion time limits seal-diameters increases, facilitating seal resizing. Sharp-edged installation tools should never be used as they can nick the seal.

Figure 3.3 Split Groove Piston Seal Installation

Several factors should be considered when installing an O-Ring energized piston seal into a split groove. For seals with a flat O-Ring contact area, it's best to place the O-Ring into the groove and press the jacket axially onto it, keeping the parts in place until the housing groove is closed. Heating the plastic element of the seal before installation, or stretching it using a cone or similar implement, can aid in proper installation.

For O-Ring energized seals with a concave O-Ring contact area, assemble the O-Ring or O-Rings inside the seal jacket, slide the assembly onto the groove, and keep the parts in place until the housing groove is closed. Again, heating the plastic element of the seal prior to installation can facilitate the process.

Calibrating Piston Seals

Calibration is necessary to ensure a piston and seal can be inserted into a cylinder without damaging the plastic element of the seal. In a closed-groove assembly, this means the jacket must be sufficiently reduced in diameter to provide uniform contact with the O-Ring. Compressing the jacket to the bore diameter usually involves a calibration sleeve and can be performed as a separate installation step or when the piston is inserted into the bore.

3.3 Pipes/tubes & fittings

Installing, maintaining, and troubleshooting plumbing systems requires specific knowledge of industry standardized measurements, construction codes, and specialized components of plumbing systems. While locally adopted plumbing codes apply to these systems and components, manufacturer installation and use instructions should be followed. Many common plumbing parts and materials like pipes and fittings do not come with instructions and should be sized and installed to comply with locally adopted plumbing and building codes.

A pipe or fitting's ability to hold pressure, survive hot or cold temperatures, and endure natural elements is limited by its chemical composition, wall strength, and integrity of the sealing method used to join individual components. Schedule is the term used in referring to "plastic" (PVC, ABS, CPVC) pipe's wall thickness, with lower numbers representing thinner walled pipes. The most common sizes used in residential construction are Schedule 40 (thinner wall used in drain, waste and vent applications) and Schedule 80 (thicker wall used in pressurized water applications). Several material types are approved for use in piping system that serve different purposes in a complete plumbing system to include water supply, and waste, drain and vent (DWV). The following table indicates the type of plumbing system that various types of piping are generally allowed in residential and light commercial construction:

Table 3.1 types tubes

Common Material Types	Supply	Waste	Drain	Vent
Copper	Yes	No	No	No
PEX	Yes	No	No	No
PVC	Yes*	Yes	Yes	Yes
CPVC	Yes**	No	No	No
ABS	No	Yes	Yes	Yes
Cast Iron	No	Yes	Yes	Yes
No-hub	No	Yes	Yes	Yes
Galvanized Pipe	Yes	No	No	No
Black Iron Pipe***	No	No	No	No

American standard thread used in pluming and piping systems. It may also be referred to as MPT or MNPT for male external threads and FPT or FNPT for female internal threads. A thread sealant of some type should always be used to obtain a leak free seal (except for NPTF).

Figure 3.4 National pipe thread (NPT)

Similar to bushings, adapters are used to convert pipes and fittings from one size to another. Unlike bushings, adapters can allow for conversion from slip to thread applications an, in some cases,piping material type to another

Figure 3.5 Adapter

Bushings 	This fitting allows a pipe or fitting to be reduced to a smaller size and are made to be inserted into a pipe, inside slip, or female thread. Bushings outside diameter can be male thread or male slip with the inside diameter, being of the same style (slip or thread) as the outside, dictating the size the piping system is reduced to.
Caps 	Caps, like plugs, are designed to seal off unused plumbing system branches or unused component outlets, but have female slip fittings or threads.
Clean-Outs 	Clean-Outs are threaded plugged access points in a DWV system used for clearing clogged lines with augers and inspecting DWV systems with cameras. Plumbing system codes dictate how many clean-outs should be in a waste system by the length of run and the amount of turns in the system.

This fitting

Compression fittings 	Compression fittings are sometimes used to install plumbing system components and make quick repairs on smooth outside diameter pipes like PVC and copper. Compression fittings require that a soft brass metal sleeve in copper applications, and Teflon or pliable washer in PVC applications, is compressed around the piping material by an adjustment nut to seal the fitting.
Couplings 	Couplings are designed to join two pipes of equal diameter. Couplings can be slip-to-slip or female thread to female thread.
Elbows 	Elbows normally create a 90° or 45° change in direction of a piping system. 22-1/2° fittings are also available for some piping systems. Depending on the material, elbows come in female slip-to-female slip, female slip-to-female slip, slip-to-female thread, slip-to-male thread. PVC and Copper female slip-to-male slip elbows are referred to as street elbows and they are used for close turns and swivel to fit connections.
Iron Pipe Size (IPS) 	Older pipe sizing system still in use by some industries, including PVC pipe manufacturers.
Plugs 	Plugs are male thread or male slip and designed to seal off unused plumbing system branches or unused component outlets.
Sanitary Tees 	Sanitary Tees should be used when connecting a horizontal run, such as a waste arm to a vent stack or vertical riser. They are only used to go from the horizontal to vertical plane.
Wyes 	Wyes are Y-shaped fittings that allow one pipe to be joined to another at a 45 degree angle. Wyes are not used in water supply systems, but are common in DWV systems where hard turns slow the flow of waste.
Unions 	Unions facilitate the removal and repair of system components and consist of one fitting having a swivel nut which attaches to the other fitting which has a male threaded adapter with a flange or compression type seal.
Tees 	Tees connect pipes at 90 degree angles divide the flow of a single line into two or more. Tees can also be used to reduce the size of a branch feeding off of a main line. Tees are normally fitted with female threads in each direction.
Tee-Wyes 	Tee-Wyes are similar to standard wyes but provide an additional 45 degree branch.

Figure 3.4 different size of joints

Table 3.2 different types of tubes

Nominal Pipe Size	Outside Diameter	Wall Thick. (Sch 40)	Wt. Per Ft. (Sch 40)	Wall Thick. (Sch 80)	Wt. Per Ft. (Sch 80)
1/8	0.405	0.068	0.245	0.095	0.315
1/4	0.540	0.088	0.425	0.119	0.535
3/8	0.675	0.091	0.568	0.126	0.739
1/2	0.840	0.109	0.851	0.147	1.088
3/4	1.050	0.113	1.131	0.154	1.474
1	1.315	0.133	1.679	0.179	2.172
1-1/4	1.660	0.140	2.273	0.191	2.997
1-1/2	1.900	0.145	2.718	0.200	3.631
2	2.375	0.154	3.653	0.218	5.022
2-1/2	2.875	0.203	5.793	0.275	7.661

Pipe fittings are components used to join pipe sections together with other fluid control products like valves and pumps to create pipelines. The common connotation for the term fittings is associated with the ones used for metal and plastic pipes which carry fluids. There are also other forms of pipe fittings that can be used to connect pipes for handrails and other architectural elements, where providing a leak-proof connection is not a requirement. Pipe fittings may be welded or threaded, mechanically joined, or chemically adhered, to name the most common mechanisms, depending on the material of the pipe

Self-check 3	Written Test

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

Give short answer for the following question

Q1. Why we select the size of cables? (Have 3 point)

Q2. What is sealing materials? (Have 2 point)

Q3. Write the name for the following figure? (Each has 2 point)

- 
- 
- 
- 

Answer the following question!

***Note:* Satisfactory rating 7 and above** **Unsatisfactory below 7 points**

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

Score = ___________
Rating: ____________

Information sheet 4. Identifying instrumentation and control devices to be calibrated

4.1 Sensors/Transmitters/Transducers

Some of the main differences between the terms pressure sensor, transducer, and transmitter. The terms pressure sensor, pressure transducer and pressure transmitter are somewhat interchangeable in the industrial world. Pressure sensors can be described with a 4-20mA output signal and pressure transducers with a millivolt signal. Once the details are described to define the output signal and application, the proper term can be set. Here is a quick guideline on the terms and some benefits and limitations for each.

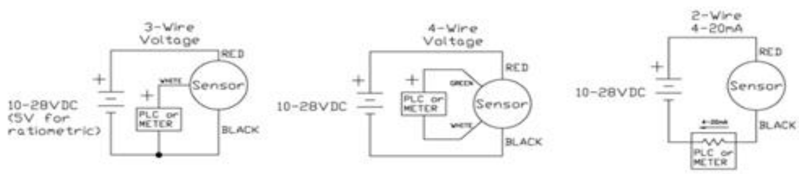


Figure 4.1 Pressure sensors a 4-20mA output signal and pressure transducers

PRESSURE SENSOR

Millivolt (mV) output signal (also a general term for all pressure types) a device that measures pressure. The millivolt output signal can typically be used ten (10) to (20) feet away from the electronics without significant signal loss. The signal is proportional to the supply. A 5VDC supply with a 10mV/V output signal produces a 0-50mV output signal. Older technologies such as bonded foil strain gage or thin film technology produce 2-3mV/V (millivolts per volt), whereas MEMS technology can produce 20mV/V reliably. Millivolt output signals give the design engineer the flexibility to condition the output signal as their system needs it and can reduce package size and cost.

Figure 4.2 pressure sensor

Pressure transducer

High level voltage or frequency output signal including 0.5 to 4.5V ratio metric (output signal is proportional to the supply), 1-5V and 1-6 kHz. These output signals should be used within twenty (20) feet of the electronics. Voltage output signals can offer low current consumption for remote battery operated equipment such as wellhead SCADA systems. Supply voltages are typically from 8-28VDC, except for the 0.5-4.5V output, which requires a 5VDC regulated supply. Older voltage output signals, such as 0-5V, do not have a "live zero" where there is signal when the sensor is at zero pressure. The risk is that the system does not know the difference between a failed sensor with no output and zero pressure.


Figure 4.3 Pressure transducer

Pressure transmitter

Current output signal, i.e. 4-20mA (4 to 20mA), the current, rather than the voltage, is measured on the device, rather than the voltage; TE pressure transmitters are two wire devices (red for supply, black for the ground). 4-20mA pressure transmitters offer good electrical noise immunity (EMI/RFI), and will need a power supply of 8-28VDC. Because the signal is producing current, it can consume more battery life if operating at full pressure.


Figure 4.4 Pressure transducer

4.2 Indicators both analogue and digital

Analogue Indicator

An indicator on which the value of the physical quantity measured is indicated by an index and graduated scale, one of which is fixed and the position of the other is a continuous function of the magnitude of the physical quantity being measured.

On analogue indicators the indication after resetting shall be within 0.2 scale interval of zero


Figure 4.5 Analogue indicattor

Digital Indicator

An indicator on which the value of the physical quantity measured is represented by a series of aligned digits which change abruptly such that no indication can be obtained between digits; a digital indicator does not have graduation lines.

On digital indicators, the indication after resetting shall be zero.


Figure 4.6 Digital indicattor

4.3 Controllers including PLC controlled devices

Type of control systems in which the system elements are dispersed but operated in coupled manners: -

Fault Tolerant System: - A system which is designed to carry out its assigned function even in the presence of one or more faults in the hardware or software.

Final Control Element: - The final control element is often an on/off valve or a control valve but may be another device such as a pump.

Mean Time between Failures: - This is the average time between failures of the different components that make up a system including the time to repair the fault.

Mean Time to Repair: - This is the average time taken to identify and repair a fault.

4.4 Control valves

Control valves are industrial valves specifically designed to control liquid media and gases transmitted through a pipeline.

The operation principle of control valves is based on the need for a permanent change of flow path by way of changing the size of the orifice of the valve. Control valves can be operated manually, by means of a pneumatic single-piston actuator, electrically, by a solenoid or a diaphragm actuator.

In most cases, control valves tend to leak even when fully closed. This occurs due to the peculiar design features of these valves. Manufacturing methods and techniques help to minimize the leakage to acceptable levels. In this case, the valve is referred to as a “shutoff” control valve.

Control valves are applied in a variety of environments: water and heat supply systems, oil and gas pipelines, the chemical industry, combined heat and power stations, hydroelectric power stations and nuclear power stations, etc.

The main structural components of a control valve are

- Body,
- Trim and

- Actuator. The trim controls fluid flow. Trims have different designs and they are selected according to control process requirements and operating medium characteristics.

Taking into account that control valves are often installed in pipelines with aggressive and abrasive media, high pressure and high temperature conditions and under conditions of cavitation, the trim sees heavy use and wears out relatively quickly. Many manufacturers produce control valves with trims constructed as separate units. This design strategy has a number of advantages:

- The capability to repair or replace the trim without valve removal makes trim assembly, fitting and finishing in the course of control valve installation or repair less labor-intensive;
- The trim can be made of different materials than other body parts, thus providing better corrosion and erosion resistance;
- For various operating media and working conditions, different trims can be installed into a typical control valve body.

Figure 4.7 Control valve

4.5 Actuators

An actuator is a component of a machine that is responsible for moving and controlling a mechanism or system, for example by opening a valve. In simple terms, it is a "mover".

An actuator requires a control signal and a source of energy. The control signal is relatively low energy and may be electric voltage or current, pneumatic, or hydraulic fluid pressure, or even human power. Its main energy source may be an electric current, hydraulic pressure, or pneumatic pressure. When it receives a control signal, an actuator responds by converting the source's energy into mechanical motion. In the electric, hydraulic, and pneumatic sense, it is a form of automation or automatic control.

Figure 4.8 Electric valve actuator controlling ½ needle valves

4.6 Recorders

Recording precipitation automatically has the advantage that it can provide better time resolution than manual measurements, and it is possible to reduce the evaporation and wetting losses. Three types of automatic precipitation recorders are in general use, namely

- The weighing recording type,
- The tilting or tipping-bucket type and
- The float type.

Only the weighing type is satisfactory for measuring all kinds of precipitation, the use of the other two types being for the most part limited to the measurement of rainfall. Some new automatic gauges that measure precipitation without using moving parts are available. These gauges use devices such as capacitance probes, pressure transducers, and optical or small radar devices to provide an electronic signal that is proportional to the precipitation equivalent. The clock device that times intervals and dates the time record is a very important component of the recorder. Because of the high variability of precipitation intensity over a 1 min timescale, a single 1 min rainfall intensity value is not representative of a longer time period. Therefore, 1 min rainfall intensity should not be used in a temporal sampling scheme, such as one synoptic measurement every one or three hours. Very good time synchronization, better than 10 s, is required between the reference time and the different instruments of the observing station.

4.7 Annunciator associated with the installed devices

In industrial process control, an annunciator panel is a system to alert operators of alarm conditions in the plant. Multiple back-lit windows are provided, each engraved with the name of a process alarm.

Lamps in each window are controlled by hard-wired switches in the plant, arranged to operate when a process condition enters an abnormal state (such as high temperature, low pressure, loss of cooling water flow, or many others).

Single point or multipoint alarm logic modules operate the window lights based on a preselected is an 18.1 or custom sequence. In one common alarm sequence, the light in a window will flash and a bell or horn will sound to attract the operator's attention when the alarm condition is detected.

The operator can silence the alarm with a button, and the window will remain lit as long as the process is in the alarm state. When the alarm clears (process condition returns to normal), the lamps in the window go out.

Annunciator panels were relatively costly to install in a plant because they had dedicated wiring to the alarm initiating devices in the process plant.

Since incandescent lamps were used, a lamp test button was always provided to allow early detection of failed lamps. Modern electronic distributed control systems usually require less wiring since the process signals can be monitored within the control system, and the engraved windows are replaced by alphanumeric displays on a computer monitor.

Behavior of alarm systems, and colors used to indicate alarms, are standardized. Standards such as is an 18.1 or en 60073 simplify purchase of systems and training of operators by giving standard alarm sequences.

Principle

Whenever there is a change of input contacts from normally open to close or from normally close to open position, annunciator changes from rest condition to alarm condition. Hence there is an immediate recognition of fault input which will have a corresponding visual and audio alarm as per the particular selected program sequence.

The base unit of alarm annunciator has four programmable keys for mute, acknowledge, reset & test function.

- On pressing the Mute key the internal buzzer can be deactivated.
- Acknowledge key is used to accept the fault condition,
- Reset key enables to reset the alarm annunciator to its default state and
- Test key helps to perform the complete test of the system

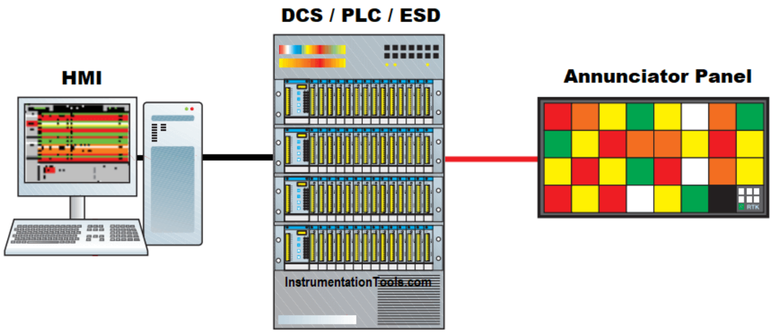


Figure 4.9 Annunciators vs. SCADA alarm systems

SCADA systems were formerly considered the preferred alternative to discrete annunciators. A software-based solution, with almost endless ability to analyze, present and process alarms, has the potential for replacing discrete alarms switches altogether. However, software carries its own reliability risks.

New annunciator panels are utilizing long lasting and bright LEDs that significantly reduce the cost and maintenance of the panels. These new versions of the traditional system are still preferred over computer based systems especially in critical plants like nuclear power generation, oil and gas.

In addition to the above, latest annunciator designs now feature clever electronics to give them very high immunity to noise, and can therefore reduce the amount of false alarms due to noise.

4.8 Process switches

Another type of instrument commonly seen in measurement and control systems is the process switches. The purpose of a switch is to turn on and off a device like heaters, motors, valves etc… with varying process conditions.

Usually, switches are used to activate alarms to alert human operators to take special action or can be used to trip or initiate interlocks.

In other situations, switches are directly used as control devices like there is level switch installed in a tank to prevent damage of a pump, pump will be automatically stopped/tripped when level reaches low in the tank.

Process Switch with Alarms

The following P&ID of a compressed air control system shows both uses of process switches:

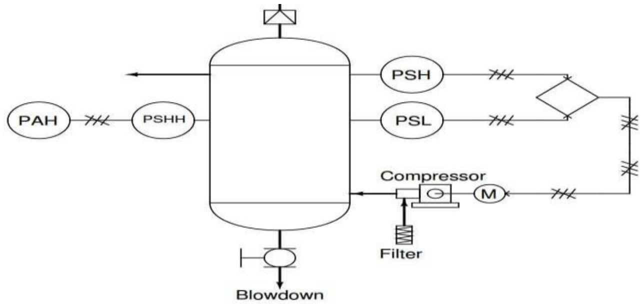


Figure 4.10 P&ID of a compressed air control system

The “PSH” (pressure switch, high) activates when the air pressure inside the vessel reaches its high control point. The “PSL” (pressure switch, low) activates when the air pressure inside the vessel drops down to its low control point.

Both switches feed discrete (on/off) electrical signals to a logic control device (symbolized by the diamond) which then controls the starting and stopping of the electric motor-driven air compressor.

Another switch in this system labeled “PSHH” (pressure switch, high-high) activates only if the air pressure inside the vessel exceeds a level beyond the high shut-off point of the high pressure control switch (PSH).

If this switch activates, something has gone wrong with the compressor control system, and the high pressure alarm (PAH, or pressure alarm, high) activates to notify a human operator.

All three switches in this air compressor control system are directly actuated by the air pressure in the vessel: in other words, these are direct process-sensing switches allowing us to build on/off control systems and alarms for any type of process.

Example of Process Alarms and Switches

For example, the chlorine wastewater disinfection system shown earlier may be equipped with a couple of electronic alarm switches to alert an operator if the chlorine concentration ever exceeds pre-determined high or low limits:

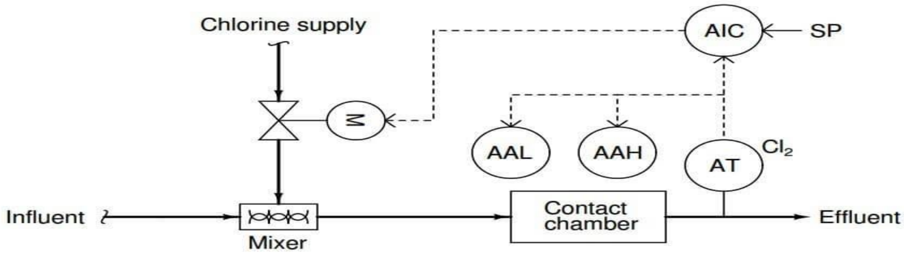


Figure 4.11 chlorine wastewater disinfection systems

Self-Check 4	Written Test

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

I. give short answer for the following?

1. What are three types of automatic precipitation recorders? (Have 3 point)
   - ______________________________
   - ______________________________
   - ______________________________.
2. The main structural components of a control valve are? (Have 3 point)
   - ____________________________
   - ____________________________
   - ____________________________.
3. _______________ are industrial valves specifically designed to control liquid media and gases transmitted through a pipeline. (Have 3 point)
4. _______________ is a component of a machine that is responsible for moving and controlling a mechanism or system. (Have 3 point)

. Answer the following question!

Note: Satisfactory rating 6 and above Unsatisfactory below 6

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

Answer Sheet

Name: ___________________________ Date: ______________

Score = ____________
Rating: ____________

Information sheet 5. **Obtaining and checking Tools, equipment and testing devices needed for calibration**

5.1 Tools,

5.1.1 Pliers (assorted)

These made from metal with insulators in the handle and are used for cutting, twisting, bending, holding, and gripping wires and cables.

Figure 5.1 different types of pliers

5.1.2 Screw drivers (assorted)

These tools are made of steel hardened and tempered at the tip used to loosen or tighten screws with slotted heads. They come in various sizes and shapes.

Figure 5.2 different types screw driver

5.1.3 Soldering iron/gun

Soldering irons are device that convert electrical energy to heat energy through systematical designed high resistive wire as heating elements. They are used to solder electronic circuits or connecting wires and other materials using soldering leads as well as using other catalysts that aids either to increase strength of connection or to clean contacts.

Figure 5.3 different types of soldering iron

5.1.4 Wrenches (assorted)

The wrenches most often used in maintenance are classified as open-end, box-end, socket, adjustable, ratcheting and special wrenches. The Allen wrench, although seldom used, is required on one special type of recessed screw. Solid, nonadjustable wrenches with open parallel jaws on one or both ends are known as open-end wrenches. Box-end wrenches are popular tools because of their usefulness in close quarters. They are called box wrenches since they box, or completely surround the nut or bolt head.

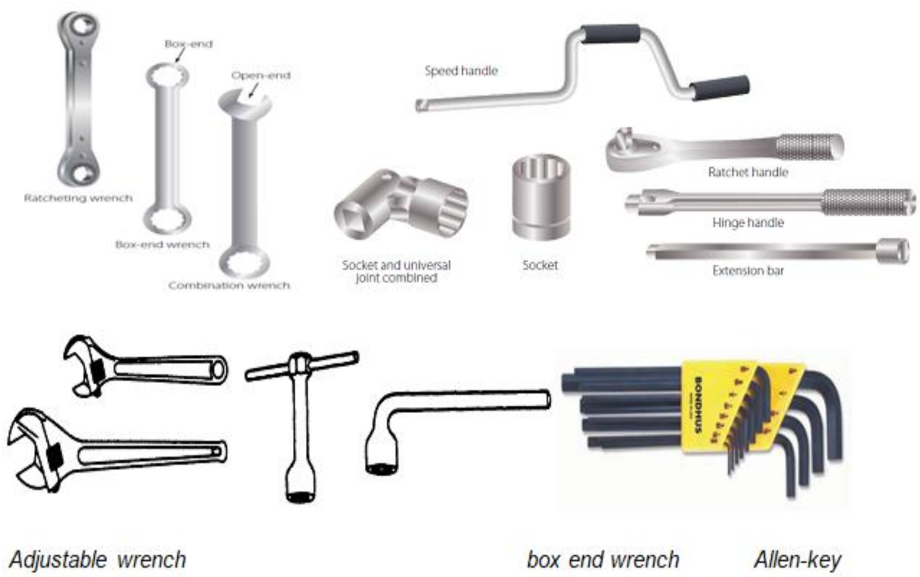


Figure 5.4 Different types *wrenches*

5.1.5 Water level

It is a device used for measuring or machining surface elevation of locations is too far apart for a sprit level to span. Alcohol such as ethanol is often used rather than water because alcohols have low viscosity and surface tension.

It is used for measuring angles of 90: (Right angle) Measurements in mile meter are marked in its scale. it is used to measure 90 right angle accurately.

Figure 5.5 Different types of water level

5.1.6 Tri-square

Measuring angles frequently you will have to determine angles between parts or units of aircraft. In layout work, it is also sometimes necessary to measure angles. The tools most frequently used for measuring angles are Tri-squares, the combination set, angle gages, and levels.

Figure 5.6 Tri-square

5.1.7 Measuring tape

They are extended easily or coiled in their cases for stowage, and you can conveniently carry one of these in your pocket. Another thing, they are not as bulky to handle as the large steel tapes. You have to pull the FLEXIBLE STEEL TAPE, shown in figure 85, from its case by hand. When you want it back in the case, wind it with a crank. Tapes of this type are long, flexible steel rules, usually furnished in 3m, 8m, and 15m- lengths.

Figure 5.7 measuring tape

5.1.8 Calipers

Layout and measuring devices are precision tools. They are carefully machined, accurately marked and, in many cases, are made up of very delicate parts. When using these tools, be careful not to drop, bend, or scratch them. The finished product will be no more accurate than the measurements or the layout; therefore, it is very important to understand how to read, use, and care for these tools.

A **vernier scale** is a device that lets the user measure more precisely than could be done unaided when reading a uniformly divided straight or circular measurement scale. It is a scale that indicates where the measurement lies in between two of the marks on the main scale. Verniers are common on sextants used in navigation, scientific instruments used to conduct experiments, machinists' measuring tools (all sorts, but especially calipers and micrometers) used to work materials to fine tolerances. An ordinary vernier caliper has jaws you can place around an object, and on the other side jaws made to fit inside an object. These secondary jaws are for measuring the inside diameter of an object. Also, a stiff bar extends from the caliper as you open it that can be used to measure depth. Gauges are several type, they may include stain gage, dial gauge and combination gauge….etc.

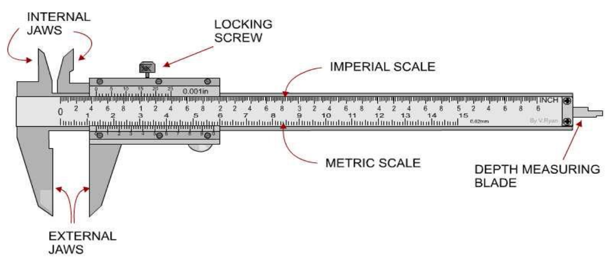


Figure 5.8 **vernier scale**

5.1.9 Gauges

Used in determining the size of wires/conductors, the gauge ranges from 0 to 60 awg (American wire gauge).

Figure 5.9 wire gauge

5.2 Equipmen/testing devices

5.2.1 Calibration bench

Calibration Bench is the ultimate multifunction calibration station from Time Electronics. Each calibration bench is custom-made to meet specific user requirements. Offering versatility and precision it is ideal for laboratories and workshops in need of multi-product testing and instrument calibration that meets the highest industry standards.

A wide range of modules can be fitted to the primary console creating a highly flexible system that is both functional and easy to use. Further expansion can be achieved by adding the secondary console, mounted under the primary.

Calibration modules cover

- Electronic signal
- Temperature
- Loop and pressure applications.
- Power supplies
- DMMs
- Oscilloscopes and
- Signal generator

Functions are clearly defined on each module and a competent technician will quickly master the operation of the system without training or constant reference to manuals. Various fittings, functions, and additional devices can be added to Calibration Bench to create a comprehensive work environment.

Figure 5.10 Calibration Bench

Pressure: Ranges from vacuum to 600bar. Also available is an Automatic Pressure Calibrator that allows 4 preset points to be selected at the push of a button, or by Easy Cal remote control.

Power: Variable AC mains, variable DC and fixed quad or dual DC supplies can be fitted.

Loop and Temperature: High accuracy loop calibrator modules with source measure and sink functions. Temperature calibrators capable of measuring and simulating RTDs/thermocouples

External Options: Pneumatic and hydraulic handheld calibration pumps, dry block calibrators, solder stations, vices, laboratory furniture, and more.

5.2.2 Air condition Equipped room

For calibration purpose calibration bench and equipment's are not sufficient by themselves, depending on the requirement or types of calibration and essentiality to perform correct and standardized calibration there are also additional requirements. Air condition equipped room is a room which installed with device that help to maintain internal temperature of the room to optimum level as required for specific/ desired purpose. This is very necessary particularly in laboratory during calibration and test to control or avoid undesired intervention of environmental phenomenon.

In addition there are several areas that require air conditioning situation. Typical applications that benefit from precision air conditioning include:

- Medical equipment suites (MRI, CAT scan)
- Hospital facilities (operating, isolation rooms)

Requirements during calibration:

- Clean rooms
- Laboratories
- Data centers
- Server and computer rooms
- Telecommunications (wiring closets, switch gear rooms, cell sites)
- Printer/copier/CAD centers

5.2.3 Air supply equipment or instrument

Compressor: Compressors used for instrument air delivery are available in various types and sizes, from rotary screw (centrifugal) compressors to positive displacement (reciprocating piston) types. The size of the compressor depends on the size of the facility, the number of control devices operated by the system, and the typical bleed rates of these devices. The compressor is usually driven by an electric motor that turns on and off, depending on the pressure in the volume tank. For reliability, a full spare compressor is normally installed.

Power Source: A critical component of the instrument air control system is the power source required to operate the compressor. Because high-pressure natural gas is abundant and readily available, gas pneumatic systems can run uninterrupted on a 24-hour, 7-day per week schedule. The reliability of an instrument air system, however, depends on the reliability of the compressor and electric power supply. Most large natural gas plants have either an existing electric power supply or have their own power generation system. For smaller facilities and remote locations, however, a reliable source of electric power can be difficult to assure. In some instances, solar-powered battery-operated air compressors can be cost effective for remote locations, which reduce both methane emissions and energy consumption. Small natural gas powered fuel cells are also being developed.

Dehydrators: Dehydrators, or air dryers, are an integral part of the instrument air compressor system. Water vapor present in atmospheric air condenses when the air is pressurized and cooled, and can cause a number of problems to these systems, including corrosion of the instrument parts and blockage of instrument air piping and controller orifices. For smaller systems, membrane dryers have become economic. These are molecular filters that allow oxygen and nitrogen molecules to pass through the membrane, and hold back water molecules. They are very reliable, with no moving parts, and the filter element can be easily replaced. For larger applications, desiccant (alumina) dryers are more cost effective.

Volume Tank: The volume tank holds enough air to allow the pneumatic control system to have an uninterrupted supply of high pressure air without having to run the air compressor continuously. The volume tank allows a large withdrawal of compressed air for a short time, such as for a motor starter, pneumatic pump, or pneumatic tools, without affecting the process control functions.

5.2.4 Power supply equipment

A **power supply** is an electronic device that supplies electric energy to an electrical load.

The primary function of a power supply is to convert one form of electrical energy to another. As a result, power supplies are sometimes referred to as electric power converters.

Some power supplies are discrete, stand-alone devices, where as others are built into larger devices along with their loads. Examples of the latter include power supplies found in desktop computers and consumer electronics devices.

Figure 5.11 digital DC PS,   analog DC PS,   Digital dual PS

Power supplies are categorized in various ways, including by functional features.

Example

Regulated power supply is one that maintains constant output voltage or current despite variations in load current or input voltage.

Unregulated power supply can change significantly when its input voltage or load current changes.

Adjustable power supplies allow the output voltage or current to be programmed by mechanical controls (e.g., knobs on the power supply front panel), or by means of a control input, or both.

Generally depending on the voltage Types of Power Supplies:

DC power supply: A DC power supply is one that supplies a constant DC voltage to its load. Depending on its design, a DC power supply may be powered from a DC source or from an AC source such as the power mains.

AC-to-DC supply: Some DC power supplies use AC mains electricity as an energy source. Such power supplies will sometimes employ a transformer to convert the input voltage to a higher or lower AC voltage. A rectifier is used to convert the transformer output voltage to a varying DC voltage, which in turn is passed through an electronic filter to convert it to an unregulated DC voltage.

An instrument to be calibrated

The manufacturer usually does the initial calibration on its equipment. Subsequent calibrations may be done in-house, by a third-party lab, or by the manufacturer. The frequency of recalibration will vary with the type of equipment. Deciding when to recalibrate a flow meter, for example, depends mainly on how well the meter performs in the application. If liquids passing through the flow meter are abrasive or corrosive, parts of the meter may deteriorate in a very short time. Under favorable conditions, the same flow meter might last for years without requiring recalibration. As a rule, however, recalibration should be performed at least once a year. Of course, in critical applications frequency will be much greater.

Signal generator

A signal generator is an electronic device that generates repeating or non-repeating electronic signals in either the analog or the digital domain. It is generally used in designing, testing, troubleshooting, and repairing electronic or electro acoustic devices, though it often has artistic uses as well.

There are many different types of signal generators with different purposes and applications and at varying levels of expense. These types include function generators, RF and microwave signal generators, pitch generators, arbitrary waveform generators, digital pattern generators and frequency generators. In general, no device is suitable for all possible applications.

Traditionally, signal generators have been embedded hardware units, but since the age of multimedia PCs, flexible, programmable software tone generators have also been available.

A function generator is a device which produces simple repetitive waveforms. Such devices contain an electronic oscillator, a circuit that is capable of creating a repetitive waveform. (Modern devices may use digital signal processing to synthesize waveforms, followed by a digital to analog converter, or DAC, to produce an analog output). The most common wave form is a sine wave, but saw tooth, step (pulse), square, and triangular waveform oscillators are commonly available as are arbitrary waveform generators (AWGs). If the oscillator operates above the audio frequency range (>20 kHz), the generator will often include some sort of modulation function such as amplitude modulation (AM), frequency modulation (FM), or phase modulation(PM) as well as a second oscillator that provides an audio frequency modulation waveform.



Figure 5.12 PSG Analog Signal Generator, Function-generator, Tone-generator-and-wire-tracker

5.2.5 Oscilloscope

An oscilloscope is a laboratory instrument commonly used to display and analyze the waveform of electronic signals. In effect, the device draws a graph of the instantaneous signal voltage as a function of time.

An oscilloscope's primary function is to provide a graph of a signal's voltage over time. Usually the Y axis represents the voltage and the X axis time. This is useful for measuring such things as clock frequencies, duty cycles of pulse-width-modulated signals, propagation delay, or signal rise and fall times based on the input to its probes.

Figure 5.13 Analog Oscilloscope

A typical oscilloscope can display alternating current (AC) or pulsating direct current (DC) waveforms having a frequency as low as approximately 1 hertz (Hz) or as high as several megahertz (MHz). High-end oscilloscopes can display signals having frequencies up to several hundred Gigahertz (GHz). The display is broken up into so-called horizontal divisions (hor div) and vertical divisions (vert div). Time is displayed from left to right on the horizontal scale. Instantaneous voltage appears on the vertical scale, with positive values going upward and negative values going downward.

The oldest form of oscilloscope, still used in some labs today, is known as the cathode-ray oscilloscope. It produces an image by causing a focused electron beam to travel, or sweep, in patterns across the face of a cathode ray tube (CRT). More modern oscilloscopes electronically replicate the action of the CRT using a liquid crystal display (liquid crystal display) similar to those found on notebook computers. The most sophisticated oscilloscopes employ computers to process and display waveforms. These computers can use any type of display, including CRT, LCD, and gas plasma.

In any oscilloscope, the horizontal sweep is measured in seconds per division (s/div), milliseconds per division (ms/div), microseconds per division (s/div), or nanoseconds per division (ns/div). The vertical deflection is measured in volts per division (V/div), milli-volts per division (mV/div), or micro-volts per division (μV/div). Virtually all oscilloscopes have adjustable horizontal sweep and vertical deflection settings.

In the design and construction of circuits, the oscilloscope is a very handy equipment, electronic labs cannot do without it. Its functions are:

- Show and calculate the frequency and amplitude of an oscillating signal.
- Shows the voltage and time of a particular signal. This function is the most used in all labs.
- Helps to troubleshoot any malfunction components of a project by looking at the expected output after a particular component.
- Shows the content of the AC voltage or DC voltage in a signal.

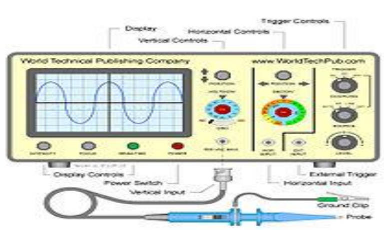


Figure 5.14 Oscilloscope

5.2.6 Standard gauges

The standard gauge is a widely used railway track gauge. Approximately 55% of the lines in the world are used this gauge.

Pressure gauges are manufactured in many configurations and sizes from 50mm up to 300 mm dial size in ranges of 2.5 kPa up to 100,000kPa with brass or stainless steel wetted parts. Scales can be offered in different units.

Regarding application several types of standard gauges are there.

General Purpose Pressure Gauges: - The ASG Series of General Purpose pressure gauges guarantees long life & durability for indoor, outdoor and harsh environmental conditions.

Figure 5.15 pressure gauge

Low Pressure Gauges: - Low pressure gauges operated by a capsule system and only suitable for use on air and some gases. Pressure ranges from -2.5-0 kPa up to 0-60 kpa pressure or vacuum. Offered with stainless steel casing and brass connections for the use on non-corrosive applications, but can be offered with stainless steel wetted parts on request. Dial sizes available are 63mm, 100mm and 150mm

Test Gauge: - Precision test gauges manufactured to the highest standard in quality. Used for the testing of industrial gauges or equipment of the same standard. For quality control testing requirements it is not always necessary to use a primary standard such as a dead weight tester, therefore a secondary standard such as a test gauge can be used, being a more convenient and economical method of testing.

Safety Pattern Pressure Gauges:- These gauges are generally used within the gas industry are designed with operator safety in mind in case of a bourdon tube rupture and that no projectiles will blow out from the front of the gauge. Safety pattern construction consists of a front baffle wall, Perspex window and a blowout disc in the rear of the case. Dial sizes available are 100mm and 150mm with pressure ranges up to 100,000 kPa.

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 (each 2 point)

1.________ for quality control testing requirements it is not always necessary to use a primary standard such as a dead weight tester.

A. Test Gauge B. Low Pressure Gauges C. Standard gauges D. All

2.______ is an electronic device that supplies electric energy to an electrical load.

A. AC-to-DC supply B. power supply C. Volume tank D) none

3.______ is device that converts electrical energy to heat energy.

A. compressor B. soldering iron/gun C. pressure switch D) all

4. ______________ high accuracy loop calibrator modules with source measure and sink functions.

A. Loop and Temperature B. Recorders C. Control valves D. All

5. _____________ is indicated by an index and graduated scale

A. Analogue indicators B. digital indicators C. A & B D. none

Answer the following question!

Note: Satisfactory rating 6 points Unsatisfactory below 6 points

You can refer at the end of this UC for the copy of the correct answers.

Operation sheet one - Analog Oscilloscope Procedures:

The purpose of this operation is to introduce students to the basic tools used by engineers and technicians in analyzing electronic equipment: the function generator, the analog oscilloscope, and the digital oscilloscope.

During this operation, the student will use the function generator to generate a number of signals and to analyze those signals using either of the 'oscilloscopes'. The student will become familiar with the basic waveforms -- sine, square, and triangle waves -- and the components of the waveforms -amplitude, period, and frequency.

Equipment:

Qty	Equipment
1	Leader LFG-1300S Function Generator
1	BNC to 2 alligator clips cable
1	Tektronix 2225 Analog Oscilloscope
1	Tektronix P6103 10X probe
1	Hewlett-Packard 54502A Digital Oscilloscope
1	HP 10430A 10X probe

Overview:

In this part of the lab, you will use the function generator to generate a signal and then use the analog oscilloscope to make some measurements of the data. If you need any assistance in identifying or configuring the equipment, please see the on-duty GSA.

Function Generator Setup:

1. Turn on the function generator.
2. Make sure that the Sweep, Amplitude Modulation, and DC offset groups are turned OFF.

Note: The Sweep and Amplitude Modulation buttons should be in the OUT position, and the DC offset knob should be pushed IN.

1. Select a TRIANGLE wave.
2. Set frequency to 1.0 kHz.
3. Set the amplitude knob to 12 o'clock.
4. Make sure all the attenuation buttons are OUT.

5. Attach the BNC end of the cable to the BNC socket in the function generator's Output Group.
6. Tie back the black lead alligator clip by clipping the black alligator clip to the insulated wire to avoid short circuits and blown fuses.

Analog Oscilloscope Setup:

1. Turn on the power to the oscilloscope.
2. Connect the Tektronix 10X probe to the Channel 1 input on the oscilloscope.
3. Tie back the black lead on the probe, then expose the hook and clip it to the red alligator clip on the function generator cable.
4. Set CH1/BOTH/CH2 switch to CH1.
5. In the Vertical Control Group, set the Channel 1 AC/GND/DC switch to GND.
6. Use the CH1 vertical position knob to move the ground (0V) reference (horizontal line) to the center line on the screen.
7. After referencing the signal to ground, set the AC/GND/DC switch to AC.
8. Intensity knob: adjust the signal intensity and focus to a comfortable level, by using the intensity and focus knobs, respectively.

Note: Keep the signal intensity to within a reasonable range to minimize the chances of burning the phosphor and damaging the display screen.

9. Set the Volts-per-Division knob to 2 V/div.

Note: you are using a 10X probe, so be sure to take all readings from the 10X position.

10. Set the NORMAL/INVERT switch to NORMAL.
11. Set the ADD/ALT/CHOP switch to ALT.
12. Set X1/ALT/MAG to X1.
13. Set the seconds-per-division knob to 0.1 ms/div.
14. Set the rising/falling-edge switch to positive.
15. Set the trigger-mode switch to AUTO.
16. Set the trigger-source switch to VERT MODE.
17. Set the trigger-coupling switch to AC.

Note: If the signal is still running, try adjusting the trigger level or holdoff knobs.

18. Make sure that the 'cal' knobs on the V/div and S/div knobs are both pushed in and turned all the way to the right. They will click into position. This is so the scope will be calibrated properly.

Procedures:

Step1. Using the settings completed above, answer the following questions.

1. What is the setting on the Volts/Div control knob? _______ volts/div
2. How many vertical divisions from peak-to-peak? _______ div
3. What is the peak to peak voltage (Vpp)?

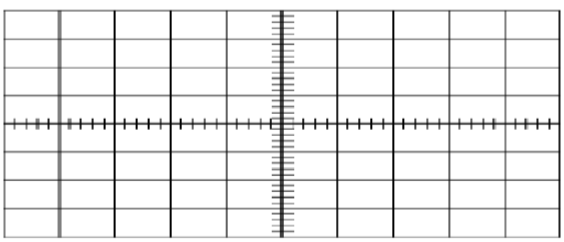
   Vpp = _______ volts/div * _______ div = _______ volts

4. What is the setting on the Sec/Div control knob? _______ ___ seconds/div
5. How many horizontal divisions from positive going crossing to positive going crossing? _______ div
6. What is the period of the signal (T)?

   T = _______ seconds/div * _______ div = _______ ___ seconds

7. What is the frequency of the signal (f)? _______ ___ hertz
8. Draw the displayed signal on Graph 4.1.

Be neat, to scale, and concise. Be sure to note the (scale) V/div and Sec/div settings.



Graph 4.1

Step2. Next you will adjust the function generator to output another signal and repeat the measurements in Step 1.

2. Generate a square wave between 5 and 10 kHz with an amplitude setting of 3 o'clock.
3. Adjust the V/div and Sec/div settings to maximize the display of the signal on the CRT. Make sure you show the signal from peak-to-peak and at least one full cycle (period) of the signal.
4. What is the setting on the Volts/Div control knob? _______ volts/div
5. How many vertical divisions from peak-to-peak? _______ div
6. What is the peak to peak voltage (Vpp)?

   Vpp = _______ volts/div * _______ div = _______ volts

7. What is the setting on the Sec/Div control knob? _______ ___ seconds/div

8. How many horizontal divisions from positive going crossing to positive going crossing?
_______ div

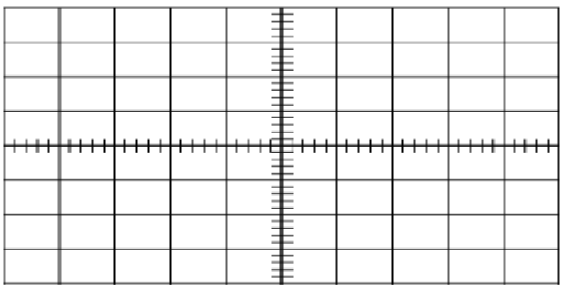
9. What is the period of the signal (T)?

T = _______ sec/div * _______ div = _______ ___ seconds

10. What is the frequency of the signal (f)? _______ ___ hertz.

11. Draw the displayed signal on Graph 4.2.

Be neat, to scale, and concise. Be sure to note the (scale) V/div and Sec/div settings.



Graph 4.2

step3. In this part of the lab, you will experiment with the triggering of the analog oscilloscope. You will need to make some changes to the controls of the analog oscilloscope and the function generator, and you will then have to answer a few questions.

1. Set TRIGGER MODE to NORM.
   Set TRIGGER SOURCE to CH1.
2. Turn the TRIGGER LEVEL knob all the way to the right.
   Turn the TRIGGER HOLDOFF knob all the way to the right.
3. Generate a 1.4 kHz sine wave with the function generator; setting the amplitude knob all the way to the left. Then display the signal on the oscilloscope.
4. On the oscilloscope, turn the horizontal position (coarse) knob until the left edge of the trace is shown.
5. While watching the display, turn the TRIGGER LEVEL knob to the left until you get a steady display.
6. Keep turning the TRIGGER LEVEL knob to the left, and watch the trigger level go down. Note that the oscilloscope ceases to trigger when the level moves below the signal.
7. Set the TRIGGER LEVEL as close to the top of the signal as possible while still retaining a steady picture.

8. What is the peak-to-peak voltage (Vpp)? _______ volts
9. On the function generator, depress the 10 dB attenuation button.
10. Use the TRIGGER LEVEL knob to steady the display. It's a delicate adjustment, so watch the screen carefully while you turn the knob to the left.
11. (Why did the signal run or disappear? (not steady or not locked)
12. Without changing the V/div setting, what is the new Vpp? _______ volts
13. Using the formula on page 3, calculate the attenuation in dB? _______dB (note sign!)
14. Disconnect the analog oscilloscope, and turn off the power.

Operatiion sheet two:	**Digital Oscilloscope Procedures:**

Overview:

In this part of the operation, you will use the function generator to generate a signal and then use the digital oscilloscope to make some measurements of the data. If you need any assistance in identifying or configuring the equipment, please see the on-duty GSA.

Digital Oscilloscope Setup:

1. Generate a 6kHz triangle wave with the amplitude turned fully to the right using the function generator.
2. Connect the HP probe to the Channel 1 input on the oscilloscope, then connect the probe to the red lead from the function generator.
3. Press the AUTOSCALE button to make the oscilloscope automatically adjust its settings.
4. Select the Channel menu by pressing the CHAN button.
   i. Select Channel 1.
   ii. Set v/div to 5.0 v/div, if it is not already set.
   iii. Set offset to 0 volts, if not already set.
   iv. Select AC. Select 1MΩ Ω, if not already set.
   v. Select More by pressing the button to the right of the more label.
   vi. Make sure that 10:1 is selected. If not, use the wheel to set it.
   vii. Press the More button.
5. Select the Time base menu by pressing the TIME BASE button.
   i. Set the time base to 50 µ µs/div, if not already set.
   ii. Set delay to 0 seconds.
   iii. Select reference: center, if not already set.
   iv. Set window: off, if it is on.
   v. Select realtime.
6. Select the Trigger menu by pressing the TRIG button.
   i. Select AUTO.
   ii. Select EDGE.
   iii. Select source: channel 1.
7. Select the Display menu by pressing the DISPLAY button.

i. Select NORM.
ii. Set persistence: 'minimum' or 'single'.
iii. Set No. of screens: 1. Select GRID.
iv. Set connect dots: ON.

PROCEDURES:

Step1. Using the settings completed above, answer the following questions.

1. Select the Δt/Δv menu by pressing the Δ Δt/Δ Δv button.
2. Select Vmarkers and Tmarkers.
3. Select Vmarker 1, then use the data entry wheel to set the marker at the bottom of the signal.
   Be sure to adjust the voltage level not the channel number.
4. Similarly, set Vmarker 2 to the top of the signal.
5. Read ΔV at the bottom of the screen.
   i. Vmarker 1: ________ ___ volts
   ii. Vmarker 2: ________ ___ volts
   iii. ΔV: ________ ___ volts
6. Using the same procedure as for the Vmarkers, set the ΔT start marker to either a positive or negative peak.
7. Similarly, set the ΔT stop marker to the next positive or negative peak. (Choose the same polarity as you did in Step 1.2.)
8. Read ΔT and 1/ΔT (period and frequency) at the bottom of the screen.
   i. Start Marker: ________ ___ seconds
   ii. Stop Marker: ________ ___ seconds
   iii. ΔT (period): ________ ___ seconds
   iv. 1/ΔT (frequency): ________ ___hertz
9. Turn the markers off.

Step2. Using the automatic measurement capability of the digital oscilloscope, you will repeat the measurements you made in Step 1.

1. Press the blue shift button, press button 1 (Vpp), and then press button 1 for channel 1 when 'c#' appears at the bottom of the screen in reverse text.
2. Measure Vpp: ________ ___ volts

Note: If 'm#' or 'f#' appears in reverse text at the bottom of the screen, use the entry wheel to change this to 'c#'. If this fails, try hitting RECALL and CLEAR simultaneously to reset the oscilloscope. You would then need to restart with the pressing the AUTOSCALE in the digital oscilloscope setup section.

3. Press the blue shift button, press button 9 (Freq.), and then press button 1 for channel 1 when 'c#' appears at the bottom of the screen in reverse text.

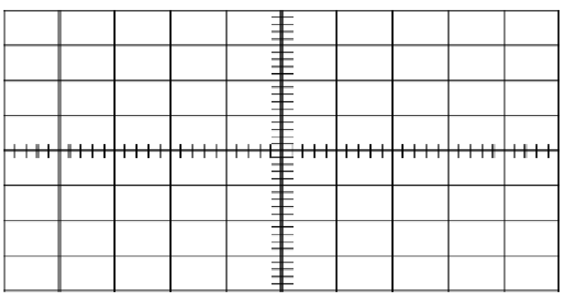
   Measure Frequency (f): _______ ___ hertz

4. Press the blue shift button, press button s-V (period) to the right of button 9, and then press button 1 for channel 1 when 'c#' appears at the bottom of the screen in reverse text.

   Measure Period (T): _______ ___ seconds

5. Draw the displayed signal on Graph 4.3.

Be neat, to scale, and concise. Be sure to note the (scale) V/div and Sec/div settings.



Graph 4.3

1. To clear the measurements from the screen, press the blue shift button and then press the clear button.
2. Disconnect the digital oscilloscope from the function generator and turn it off.
3. Make sure all probes and connectors are disconnected from the equipment and neatly placed on the shelf above the work area.
4. Be sure to turn off both oscilloscopes and the function generator.

Information sheet 6. Checking instrumentation and control devices

6.1 Items to check and calibrate

Thermocouple or RTD actuated temperature indicators, recorders or controllers. Leave the instrument on the bench, switched on and connected to the calibrator using the correct extension cable. With RTD instruments use copper wire. Wait 10-20 minutes for both to attain room temperature. Inject a minimum of four signals spread through the useable range plus one near your working temperature. Record the indications as found – and as left if you make any calibration adjustments.

The working environment of an instrument may be a few tens of degrees different from that on the bench. If you suspect that the calibration performed at the two locations do not agree, calibrate first at the working location then on the bench at normal room temperature.

I have dealt in a previous column with the problems of perfectly good instruments and thermocouples combined with mismatched or misconnected thermocouple extension cable. This brings stealthy errors that can come and go within minutes or hours. You may detect these by calibrating on site and injecting the calibration signal into the extension cable at the thermocouple head, having first disconnected the thermocouple.

Say you are calibrating an RTD actuated instrument on the plant from the sensor location. You are adding (usually three) wires into the circuit that were not there at the bench calibration. If the wires have equal resistance, say as in a three-core copper cable, you will get the same result as a bench calibration. Any unbalance in the sensor wiring can introduce measurement errors. Check the instrument specification for the effects of resistance and resistance unbalance.

Alarm settings: After you have calibrated your instrument use your run-up box or calibrator in ramping mode to check where alarms trip in relation to their settings. Check dead zones too by approaching slowly from below and above the settings.

Temperature transmitters and signal conditioners. The same principles apply as for indicators. Inject the simulated process signal at the input. You will not usually have an indication. You are looking for a linear dc output (e.g. 4 – 20mA) corresponding to the temperature range of the intended sensor.

Connect your precision multimeter to the output and compare a range of precise input signals with their corresponding analog output signals. Remember that some low cost transmitters and signal conditioners reproduce any input non-linearity (e.g. from thermocouples) at the high level output.

Retransmission signals from controllers etc. can be treated like outputs from transmitters and signal conditioners but you have to compare these outputs with the values in the controller that they represent. E.g. Process temperature, set-point, deviation from set-point or percentage output.

Advanced features of calibrators

some advanced calibrators can:

- Ramp the output up and down at a controlled rate.
- Inject and display an input signal and display the output of the device under test at the same time.
- Capture data in memory for uploading through a PC interface for archiving, printing and analysis. (Note that the calibrator cannot see and capture plant instrument indications. You still need to read by eye and write or key them in.)
- Calibrate and configure Hart communicating transmitters. These carry a digital signal riding on the analog output signal wires.

6.2 Control signal and temperature sensor calibration

Control signals are put out by controllers and expect to be obeyed by such final control devices as motorized valves, electro pneumatic valves, motor drives and SCR heater controllers. How well they are obeyed is often pretty rough and non-linear. Check at this stage while not called calibration is important to control performance.

You can inject simulated control signals into these devices and see what the output does. Be wary about what their feedback signals (if any) represent. They will likely be linear mimics of the control signal rather than a measure of what you are trying to deliver, e.g. fuel flow or electric power. You may be more assured by noting valve travel, dead zone, fan speed, heater current etc but this will not amount to a proportional delivery of heat. With electro heat you can use an accurate clamp-on rms ammeter to check your heater ammeters. Then you can do a quick I^2R calculation to determine heater power given that heater resistance is reasonably constant.

Calibration of temperature sensors is done much less frequently than calibration of instruments. It can be slow and tedious but no less important.

Sensors are usually replaced only when they burn out or break. As their calibration drifts over time,

operators sometimes adapt instinctively by adjusting controller set-points to maintain good results or product. The revised settings will not be reliable when the sensor is replaced.

The two wires inside a thermocouple may come together, sometimes intermittently, some way back from the hot junction and the controller will receive a reduced signal. The controller will respond and turn up the temperature but will not show the increase. It takes an alert operator or an independent alarm device to detect overheating.

Plants that use more than one type of thermocouple may put in a spare thermocouple or plug in a spare controller that is a mismatch. During maintenance an interchange of type J and K is not uncommon, and the indications are not wildly different.

Check critical sensors once or twice a year at their working temperature. Tag them with the type and any known calibration errors.

A **liquid bath calibrator** is a common choice up to 250 °C (480 °F). A **dry block calibrator** (a heated metal block with deep holes for the sensors) is useable up to about 600°C (1112°F)

A **fluidized bed** of alumina particles can be used up to some1100 °C (2012°F). Up to about 1600 °C (2912 °F) specially designed furnaces are used The temperatures are controlled using a platinum RTD or a platinum/rhodium thermocouple.

Sensors with a heavy metal protection tube can pull heat out of the calibrator and may have difficulty reaching the exact temperature indicated by the controller. Insert the sensor deep and if practicable remove the tube. Make sure that all of the wire-wound sensing section of an RTD lies deep in the hot zone.

Self-Check 6	Written Test

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

Give short answer for the following question

1. What is some advanced calibrators can: (Have 4 point)

a. ________________________________

b. _________________________________

c. ___________________________________

d. _______________________________________

2. ____________ are put out by controllers and expect to be obeyed by such final control devices as motorized valves, electro pneumatic valves, motor drives and SCR heater controllers. (Have 2 point)

Note: Satisfactory rating 3 and above Unsatisfactory below 3

You can check you at the end of this UC for the copy of the correct answers.

Information sheet 7. Following Instruction and calibration standards

7.1 ISA (Instrumentation, Systems and Automation) Society (formerly Instrument Society of America)

The International Society of Automation (ISA), formerly known as The Instrumentation, Systems, and Automation Society

The Society includes the following:-

- Engineers
- Technicians
- Businesspeople
- Educators and
- Students

The society is more commonly known by its acronym, ISA, and the society's scope now includes many technical and engineering disciplines. ISA is one of the foremost professional organizations in the world for setting standards and educating industry professionals in automation. Instrumentation and automation are some of the key technologies involved in nearly all industrialized manufacturing. Modern industrial manufacturing is a complex interaction of numerous systems. Instrumentation provides regulation for these complex systems using many different measurement and control devices. Automation provides the programmable devices that permit greater flexibility in the operation of these complex manufacturing systems.

In addition to the member-driven aspects of the ISA, major ISA interests and products are divided into departments headed by a department vice president.

These departments are:

- Automation & Technology
- Industries & Sciences
- Image & Membership
- Professional Development
- Publications
- Standards & Practices
- Strategic Planning
- Web

Technical divisions

ISA's technical divisions, established for the purpose of increased information exchange within tightly focused segments of the fields of instrumentation, systems, and automation are organized under the Automation & Technology or Industries & Sciences Departments, depending upon the nature of the division.

The divisions in the Automation & Technology Department are:

- Analysis
- Automatic Control Systems
- Computer Technology
- Management
- Process Measurement &Control
- Robotics & Expert Systems
- Safety
- Telemetry & Communications
- Test Measurement

Industries & Sciences Divisions are*:*

- Aerospace Industries
- Chemical & Petroleum Industries
- Construction & Design
- Food & Pharmaceuticals Industries
- Mining & Metals Industries
- Power Industry
- Pulp & Paper Industries
- Water & Wastewater Industries

7.2 ANSI (American National Standards Institute)

The American National Standards Institute (ANSI)is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States. The organization also coordinates U.S. standards with international standards so that American products can be used worldwide.

ANSI accredits standards that are developed by representatives of other standards organizations, government agencies, consumer groups, companies, and others. These standards ensure that the characteristics and performance of products are consistent, that people use the same definitions and terms, and that products are tested the same way. ANSI also accredits organizations that carry out product or personnel certification in accordance with requirements defined in international standards.

ANSI's members are government agencies, organizations, corporations, academic and international bodies, and individuals. In total, the Institute represents the interests of more than 125,000 companies and 3.5 million professionals.

Process

Though ANSI itself does not develop standards, the Institute oversees the development and use of standards by accrediting the procedures of standards developing organizations. ANSI accreditation signifies that the procedures used by standards developing organizations meet the Institute's requirements for openness, balance, consensus, and due process.

ANSI also designates specific standards as American National Standards, or ANS, when the Institute determines that the standards were developed in an environment that is equitable, accessible and responsive to the requirements of various stakeholders.

Voluntary consensus standards quicken the market acceptance of products while making clear how to improve the safety of those products for the protection of consumers. There are approximately 9,500 American National Standards that carry the ANSI designation.

- The American National Standards process involves: consensus by a group that is open to representatives from all interested parties
- Broad-based public review and comment on draft standards
- Consideration of and response to comments
- Incorporation of submitted changes that meet the same consensus requirements into a draft standard
- Availability of an appeal by any participant alleging that these principles were not respected during the standards development process.

7.3 ASME (American Society of Mechanical Engineers)

The American Society of Mechanical Engineers (ASME) is a professional association that, in its own words, "promotes the art, science, and practice of multidisciplinary engineering and allied sciences around the globe" via "continuing education, training and professional development, codes and standards, research, conferences and publications, government relations, and other forms of outreach." ASME is thus an engineering society, a standards organization, a research and development organization, a lobbying organization, a provider of training and education, and a nonprofit organization. Founded as an engineering society focused on mechanical engineering in North America, ASME is today multidisciplinary and global.

ASME has over 130,000 members in 158 countries worldwide.

ASME is one of the oldest standards-developing organizations in America. It produces approximately 600 codes and standards covering many technical areas, such as fasteners, plumbing fixtures, elevators, pipelines, and power plant systems and components. ASME's standards are developed by committees of subject matter experts using an open, consensus-based process. Many ASME standards are cited by government agencies as tools to meet their regulatory objectives. ASME standards are therefore voluntary, unless the standards have been incorporated into a legally binding business contract or incorporated into regulations enforced by an authority having jurisdiction, such as a federal, state, or local government agency. ASME's standards are used in more than 100 countries and have been translated into numerous languages.

The largest ASME standard, both in size and in the number of volunteers involved in its preparation, is the ASME Boiler and Pressure Vessel Code (BPVC). The BPVC provides rules for the design, fabrication, installation, inspection, care, and use of boilers, pressure vessels, and nuclear components. The code also includes standards on materials, welding and brazing procedures and qualifications, nondestructive examination, and nuclear in-service inspection.

7.4 NEC (National Electric Code)

The National Electrical Code (NEC), or NFPA 70, is a regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States. It is part of the National Fire Codes series published by the National Fire Protection Association (NFPA), a private trade association. Despite the use of the term "national", it is not a federal law. It is typically adopted by states and municipalities in an effort to standardize their enforcement of safe electrical practices. In some cases, the NEC is amended, altered and may even be rejected in lieu of regional regulations as voted on by local governing bodies.

The "authority having jurisdiction" inspects for compliance with these minimum standards.

7.5 IEC (International Electro-technical Commission)

The International Electro technical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

The International Electro technical Commission is an organization which was formed as a result of the Resolution of the Chamber of Government Delegates at the International Electrical Congress of St. Louis (U.S.A.), in September 1904.

The name of the organization is the International Electro technical Commission. The abbreviated title is "the IEC". The organization is constituted as a corporate association with legal entity in accordance with Articles 60 et seq. of the Swiss Civil Code.

The work of the IEC is conducted under the IEC Statutes and Rules. These IECEx Conformity Mark Licensing Regulations are subordinate to the IEC Statutes and Rules with the IEC Statutes and Rules taking precedence over any requirement contained within these IECEx Conformity Mark Licensing Regulations, should a conflict arise.

The IECEx Scheme is the Scheme of the IEC for Conformity Assessment to Standards relating to Equipment for Use in Explosive Atmospheres, as provided for in accordance with Article 2 of the IEC Statutes and Rules, 2001 edition, (incorporating amendments approved by Council in 2004 and 2005).

Self-Check 7	Written Test

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

Give short answer for the following question

a. What is IEC? (Have 3 point)
b. What is ASME? (Have 3 point)
c. Instrumentation, Systems and Automation Society includes (Have 4point)
    a. ______________________________
    b. ______________________________
    c. ______________________________
    d. ______________________________
    e. ______________________________

Note: Satisfactory rating above 6 Unsatisfactory below 6

You can check you at the end of this UC for the copy of the correct answers.

LG #21 LO #2- Calibrating instruments and control devices
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
- Checking normal function of devices
- Conditioning instrumentation and control devices to be calibrated
- Diagnosing fault/s or problem/s in the device
- Calibrating or adjusting instrumentation and control devices
- Responding to unplanned Events or conditions

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:

- Using appropriate personal protective equipment
- Checking normal function of devices
- Conditioning instrumentation and control devices to be calibrated
- Diagnosing fault/s or problem/s in the device
- Calibrating or adjusting instrumentation and control devices
- Responding to unplanned Events or conditions

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 sheet 1 Using appropriate personal protective equipment

1.1 Using appropriate personal protective equipment

Personal Protective Equipment (PPE) is anything used or worn by a person to minimize risk to the person's health or safety and includes a wide range of clothing and safety equipment. PPE includes boots (safety shoes, face masks, hard hats (helmet), ear plugs, respirators, gloves, safety harnesses and high visibility clothing

Classification of PPE

- Head and Ear Protection
- Face and Eye Protection
- Respiratory Protection
- Hand, Foot & Leg Protection
- Body or Torso Protection, Protective Clothing
- Fall Protection

PPE and Other Safety Equipment

Service personnel must know what PPE is required for a specific task and wear it while completing the task. PPE includes fall protection, arc flash protection, fire rated clothing, hot gloves, boots, and protective eyewear, among other items. PPE is designed to help minimize exposure to inherent system hazards.

Identification of potential hazards is crucial to the process of selecting the appropriate PPE for the task at hand. All personnel working on or near PV systems should be trained to recognize hazards and choose the appropriate PPE to eliminate or reduce those hazards.

Rubber-insulating gloves, often referred to as "hot gloves," are the first line of defiance against electric shock. They should always be worn with protective leather gloves over them and inspected before each use.

Additionally, OSHA requires the gloves to be re-certified or replaced at regular intervals, beginning six months after they are placed in service.

It is very important to observe safe working practices throughout. This includes:

- Wearing appropriate PPE.
- Following working at heights procedures.
- Follow required isolation and lock-out procedures before measurements.
- Keep workplace clean and tidy.
- Use the proper tool properly.
- Follow manufacturer's safety instructions for all equipment.

Self-check 1	Written Test

Directions: For the following questions, say TRUE if the statement is correct and FALSE if it is incorrect (wrong).

1. All personnel working on or near PV systems should be trained to recognize hazards.
2. PPE is designed to help minimize exposure to inherent system hazards.
3. Service personnel must know what PPE is required for a specific task and wear it while completing the task.

Note: **Satisfactory rating – 2 and above points, Unsatisfactory - below 2 points**

Information Sheet 2 Checking normal function of devices

Introduction

Checking is commonly used to verify grounding and bonding connections in electrical systems. These tests also verify the proper operation of disconnecting means and the function of overcurrent protection devices like fuses and circuit breakers.

Checking normal functions of devices

PV systems should be thoroughly tested at the time of calibrating and periodically over their lifetime to ensure proper performance and safe operation. Baseline measurements at the time of system commissioning are compared to the system ratings and expectations for acceptance, and serve as a baseline for comparison with future measurements.

Changes in test results over time are used to track system degradation, and identify problems that require attention or service for safety or performance reasons.

Circuits or components that are modified or replaced should be retested accordingly.

There are several types of electrical tests conducted on PV systems that are used to verify NEC requirements and system performance.

Many of these tests can be conducted with common electrical test equipment, while some measurements require special meters and instruments. In many cases, system performance information is measured, recorded and displayed by PV system inverters or charge controllers, and can be used to verify system functions and proper operation.

The following summarizes common types of testing conducted on PV systems what information it provides:

- **Continuity and resistance testing** verifies the integrity of grounding and bonding systems, conductors, connections and other terminations.
- **Polarity testing** verifies the correct polarity for PV dc circuits, and proper terminations for dc utilization equipment
- **Voltage and current testing** verifies that PV array and system operating parameters are within specifications.
- **Insulation resistance testing** verifies the integrity of wiring and equipment, and used to detect degradation and faults to wiring insulation.

- **Performance testing** verifies the system power and energy output are consistent with expectations. These tests also require measurements of array temperature and solar irradiance. For stand-alone or hybrid PV systems incorporating energy storage and additional energy sources, the following additional tests may be conducted**:**
  - ✓ Measurements of battery voltage, capacity and specific gravity.
  - ✓ Verification of charge controller set points and temperature compensation.
  - ✓ Verification of charging current and load control functions.
  - ✓ Verification of performance and wiring integrity for other sources, such as generators.

Multi-function PV system testers are now available, such as the Seaward PV150, that conduct many of the recommended tests, including continuity and resistance, polarity, voltage and current tests, and insulation resistance tests. By combining these test functions into single instruments, testing personnel avoid having to purchase, carry and maintain multiple meters. Multi-functional PV system testers simplify and speed up testing.

These instruments can also store data for later retrieval and processing into commissioning test reports that become part of the system documentation record. See Figure 2.1.

Figure 2.1 the Seaward PV150 handheld meter provides multiple PV array testing functions.

Self-Check 2	Written Test

Directions: For the following questions, say TRUE if the statement

is correct and FALSE if it is incorrect (wrong).

1. Seaward PV150 is multi-function PV system tester.
2. Performance testing verifies the correct polarity for PV dc circuits.
3. Polarity testing verifies the system power and energy output.

***Note:* Satisfactory rating – 2 and above points, Unsatisfactory - below 2 points**

Information Sheet 3 Conditioning instrumentation and control devices to be calibrated

Introduction Mixed-signal integrated circuits (ICs) for sensor signal conditioning is widely used today in sensor applications such as pressure, temperature and position monitoring. In these signal conditioners, the conditioning of the output signal from the sense element is performed with mixed-signal circuits, which are a combination of analog and digital circuits. Moreover, the actual conditioning of the sense-element signals is implemented in the digital domain. The conditioned signal is the output of the sensor signal conditioner. The sensor output is transmitted to a control or monitoring system either in analog or digital form. If an analog form of transmission is used, the processed digital signal must be converted back to analog form. This article examines the calibration of sensor signal conditioning algorithms implemented in signal conditioners that transmit data in analog form. Note that sensor calibration includes the sense-element non-idealities as well as signal-conditioner non-idealities, such as offset and gain errors. The calibration scheme will take care of analog signal-chain errors of the analog circuit that are in front and back of the digital circuits. Sensor signal conditioners The electrical output of a sense element is usually small in value and has non-idealities, such as offset, sensitivity errors, and nonlinearities. These non-idealities cause errors in measurements. Sensor signal conditioners are used to minimize these non-idealities. An example of these types of conditioners is the PGA400-Q1 from Texas Instruments. Mixed-signal conditioners Figure 3.1 shows a block diagram of a mixed-signal conditioner with analog output. Mixed-signal conditioners implement front-end analog circuitry to connect with a sense element. Because the output of a sense element is usually very small, the front end consists of a gain stage followed by an analog-to-digital converter (ADC). The ADC is used to digitize the output of the sense element, which means that flexible techniques of digital signal processing can be used to condition the sense element signal. The gain stage may consist of single-ended differential amplifiers or instrumentation amplifiers, which depends on the sense-element pin out.

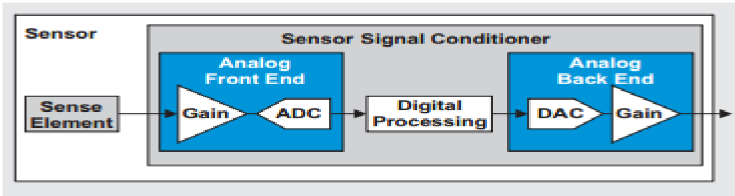


Figure 3.1 Block diagram of a mixed-signal conditioner

After the data from the front end is conditioned by the digital circuitry, it is sent to the back end for transmission to a control or monitoring system. The transmission of the conditioned signal can occur in either analog or digital form. In order to transmit the conditioned digital signal in analog form, a digital-to-analog converter (DAC) with a buffer or gain stage converts the digital value into analog form. Again, the PGA400-Q1 is an example of this type of signal conditioner. Errors in analog signal chain The sense-element output is usually a signal with a very low span; in other words, the range of its output signal is small. Because of this, the conditioning of the sense element output starts with a gain stage. As a result, the sense-element output is subject to different sources of amplifier errors such as input offset, gain and nonlinearity errors. These errors are in addition to the offset and nonlinearity errors inherent to the sense element itself. The signal conditioners discussed in this article also have analog outputs that are typically generated with a DAC followed by a gain stage. This means that the conditioned signal is also subject to amplifier errors such as input offset, gain and nonlinearity errors in the analog output stages. These errors in the sensor conditioner occur as a result of mismatches between devices and components inside the IC. The errors can become exacerbated by how large a gain is applied to the sense element output signal, or to the conditioned output signal prior to being transmitted to the control or monitoring system.

Note that signals from sense elements have non-idealities. Therefore, the sense-element output is corrected for these non-idealities during sensor manufacturing, often with the help of a signal conditioner. It is during this calibration process that the errors in the analog signal chain are taken into consideration. Figure3.2 illustrates an example of an uncalibrated sensor signal conditioner and the desired output of a calibrated sensor conditioner with respect to the sense element input signal. Note that the uncalibrated output includes non-idealities of both the sense element and analog circuits in the signal conditioners signal flow. Two-step calibration process The two-step calibration process consists of:

- Calibration of the back-end analog circuit errors this calibration accounts for errors introduced to the signal after being conditioned by the digital circuits and converted back to analog form.
- Calibration of the front-end analog circuit errors this calibration accounts for input offset, gain and nonlinearity errors introduced in the signal from the sense element prior to being digitized. Figure 3 shows the sections within the sensor conditioner that are related to the two-step calibration process.

The order of the calibration process matters because the calibration of the back-end analog circuits provides the “desired” output values needed for the calibration of the sense element and the front-end analog circuits. Back-end circuit calibration The calibration goals for the back-end and front-end analog circuits are nearly the same—to reduce errors introduced by the analog signal chain non-idealities and thereby improve accuracy of the sensor output. However, the data points used to calibrate the back-end circuits come from within the sensor conditioner, not the sense element. To truly calibrate the back-end circuits, the DAC and the rest of the output analog circuitry has to be isolated from the digital signal-conditioning circuits. The external calibration system then writes to the DAC directly and measures the output of the back-end analog circuits (output pin of the signal conditioner). Standard curve fitting algorithms are used to curve-fit the data. This curve is used to determine the DAC value required in the calibration of the sense-element output. Note that the number of data points needed for this calibration depends on the non-idealities present in the back-end analog circuits. Since the data points are controlled by the user and not the sense element, the calibration is usually done with only a few data points. Additionally, if the back-end analog circuit behavior changes with temperature, this process must be repeated at different temperatures. Once the transfer function of the back-end analog circuit and the desired DAC codes are determined, these DAC codes are then incorporated in the calculations for the calibration of the front end.

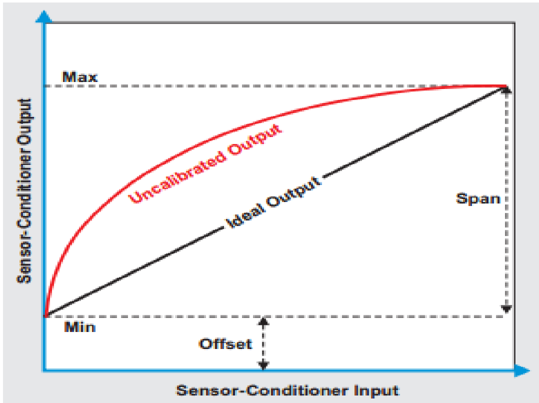


Figure 3.2 Ideal output of a calibrated sensor versus the signal from the sense element

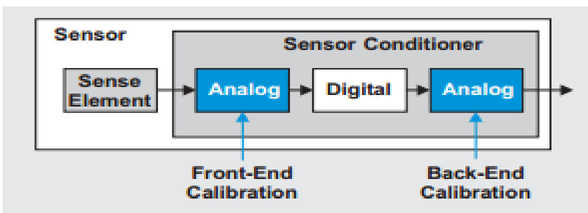


Figure 3.3 Sensor calibration requires both front-end and back-end curve fitting

Front-end calibration Front-end calibration depends largely on the output signal linearity of the sense element. Moreover, since the calibration of the sensor is performed by the manufacturer, time and cost are also driving factors. As mentioned earlier, different methods, depending on the desired accuracy of the sensor, can be implemented. In general, the sensor conditioner uses mathematical algorithms to calibrate the sensor output when the sense element is excited by the specific stimulus related to the application (pressure and temperature, for example). The number of measurements depends on the capability of the sensor conditioner to process the data, as well as the time required to calibrate the sensor. For example, the frontend of a pressure sensor could be calibrated by measuring the output of the ADC at three input signal points. Standard curve-fitting techniques can be used to determine the desired transfer function from ADC output to DAC input. This is accomplished using the ADC data and DAC code calculated during calibration of the back-end circuits

Self-Check .3	**Written Test**

Directions: For the following questions, say TRUE if the statement

is correct and FALSE if it is incorrect (wrong).

1. The conditioning of the output signal from the sense element is performed with mixed-signal circuits, which are a combination of analog and digital circuits.
2. Standard curve fitting algorithms are used to curve-fit the data.
3. the back-end analog circuits provides the "desired" output values

.Answer the following question!

Note: Satisfactory rating 2 and above points **Unsatisfactory below 2 points**

You can refer at the end of this UC for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: _______________

Information sheet 4. Diagnosing fault/s or problem/s in the device

4.1 Diagnosing fault/s or problem/s in the device

The main idea of fault diagnosis is to determine the type, size and location of the fault as well as its time of detection, based on the available measurements of the system. A general scheme of model based fault diagnosis is shown in Figure 4.1. Usually, fault diagnosis is achieved in a two-stage process.

First, a signal called residual is generated using available input–output measurements from the system under consideration. When the system is fault free, then residual should be zero or close to zero, and otherwise when the fault is presented, residual should be different from zero. Residual could be scalar signal carrying information of a single fault or vector carrying information of multiple faults. The type of the residual generator varies from an analytical mathematical model to a black-box model of the system.

The second stage is the decision-making process where residuals are examined for the likelihood of faults. The type of the decision-making mechanism varies from a simple threshold to a number of sophisticated statistical approaches.

Types of Faults Consider an open-loop dynamic system separated into three parts:

- Actuator plant dynamics and sensor(s) with input u(t) and measured output y(t) as depicted in Figure 4.1
- In fault diagnosis of dynamic systems, it is important to model all effects that can lead to alarms or false alarms. Faults can occur in the actuator(s), in the component(s) or parameter(s) of the plant dynamics and in the sensor(s). Modeling error(s) can be introduced between the actual system (actuators, plant dynamics and sensors) and its mathematical model.
- Finally, system noise (also called unknown input) and measurement noise should be taken into consideration to avoid triggering false alarms.

The dynamic system shown in Figure 4.1 can be described using the continuous linear state. Where x is the state vector, u is the input vector, y is the measured output vector, d is noise or unknown input vector, f is the fault vector and w is the modeling error vector. Term Ed models the unknown inputs to the actuator(s) and to the plant dynamics, Kf models the actuator and component(s) or parameter(s) faults and Rw models the modeling errors to the actuator(s) and to

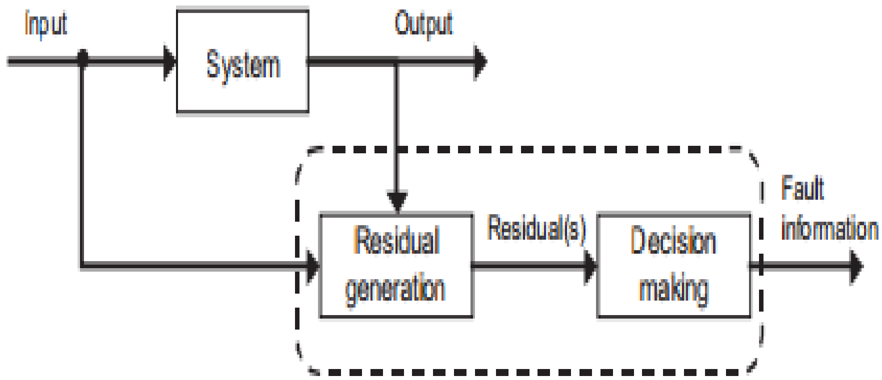


Figure 4.1 General scheme of model-based fault diagnosis

Self-Check 4	Written Test

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

Part I Fill the black space

1. _________ plant dynamics and sensor(s) with input u(t) and measured output y(t) (2%)
2. In ____________ of dynamic systems, it is important to model all effects that can lead to alarms or false alarms.

Answer the following question!

Note: Satisfactory rating 1.5 and above Unsatisfactory below 1.5

You can refer at the end of this UC for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: ______________

Every measuring instrument is subject to ageing as a result of mechanical, chemical or thermal stress and thus delivers measured values that change over time. This cannot be prevented, but it can be detected in good time by calibration.

The Egyptians already knew this almost 5000 years ago. The workers calibrated their yardsticks by comparing them with a “royal cubit” (approx. 52.36 cm) made of stone and thus managed to achieve, for example, side lengths on the Cheops pyramid of 230.33 m which differ from each other by only about 0.05 per cent.

Definition

In the process of calibration, the displayed value of the measuring instrument is compared with the measuring result of a different measuring device which is known to function correctly and accurately and which itself has been made to coincide directly or indirectly with a national (or international) reference instrument (standard) (Fig. 5.1). One talks about verification when the calibration has been carried out or supervised by an official body. Both of these variants are purely intended for determining the quality of the displayed values. No intervention to the measuring instrument itself is allowed. With adjustment, it is understood that there is an intervention to the measuring device in order to minimize a detected measuring deviation. Typically, adjustment is followed by a further calibration, in order to check and document the final state of the measuring instrument following the intervention.

Period of validity

In contrast to verification, which will lose its validity after a period of time set by law, the validity period of a calibration is subject to practical specifications such as manufacturer’s instructions, requirements of a quality assurance standard or in-house and customer specific regulations.

Fig. 5.1: Accredited calibration laboratory for the measurement parameter “temperature”

Calibration must also be carried out when the measuring instrument is used for the preparation of products which are subject to official supervision such as drugs or foodstuffs.

Significance

As part of a survey of 100 management executives of international companies, the Nielsen Research Company established in 2008 that due to faulty calibrations, manufacturing companies were losing more than 1.7 million dollars annually on average and those companies with a turnover of more than a billion dollars as much as 4 million dollars.

In connection with limitations on resources and the required increase in efficiency of manufacturing processes, calibration is increasingly gaining in importance. Increasing the measuring accuracy may result in raw material savings and fewer emissions of pollutants, for example, by supplying exactly the right amount of oxygen during a chemical reaction.

Fig. 5.2: Calibration of pressure measuring instruments with a portable calibrator

The calibration of measuring instruments can sometimes also be relevant to safety: if pressure or temperature sensors (in the chemical industry, for example) do not provide correct values, the incorrect control of chemical processes may even result in a risk of explosion (Fig. 5.2). At the very least, the importance of calibration can be seen in everyday examples such as in household gas or water meters and in fuel gauges at petrol pumps.

In this topic, the basics of calibration and calibration technology will be presented. It will describe which rules, methods and reference instruments are suitable for professional calibration. Pressure and temperature measuring instruments will serve as application examples.

Traceability and calibration hierarchy

Hierarchy of the standards and calibration services

To be able to compare measuring results, they must be “traceable” to a national or international standard via a chain of comparative measurements. To this end, the displayed values of the measuring instrument used or a measurement standard are compared over one or several stages to this standard. At each of these stages, calibration with a standard previously calibrated with a higher-ranking standard is carried out. In accordance with the ranking order of the standards from the working standard or factory standard and the reference standard to the national standard the calibration bodies have a calibration hierarchy. This ranges from the in-house calibration laboratory to the accredited calibration laboratory and to the national metrological institute (Fig. 5.3).

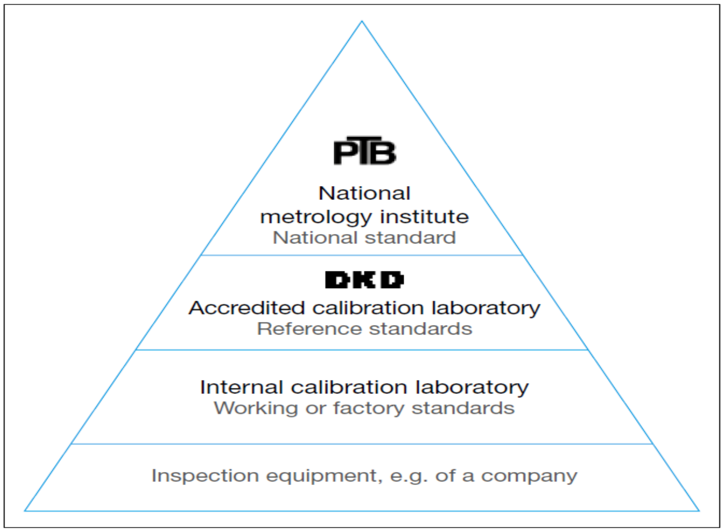


Fig. 3: Calibration hierarchy described by the example of Germany

Traceability in practice

The German Calibration Service DKD (DeutscherKalibrierdienst) designates the following as essential elements of traceability:

- The chain of comparison must not be interrupted.
- In each stage of the calibration chain, the measurement uncertainty must be known so that the total measurement uncertainty can be calculated. As a rule, a higher-ranking measuring instrument should have a measuring accuracy three to four times higher than the instrument calibrated by it.
- Each stage of the calibration chain must be documented as must the result.
- All bodies carrying out a stage in this chain must prove their competence by means of accreditation.
- Depending on the required measuring accuracy and technical requirements, calibrations must be repeated at appropriate intervals

Calibration on an international level

BIPM

On an international level, the BIPM (International Bureau of Weights and Measures, abbreviation of French: Bureau International des Poised Measures) coordinates the development and maintenance of primary standards and the organization of international comparative measurements. Decisions about the representation of the primary standards are made by the CGPM (General Conference for Weights and Measures, abbreviation of French: Conference General Des Poised Measures). The participants of the conferences, which take place every four to six years, are the representatives of the 51 signatory states of the international Meter Convention and the representatives of those 26 associated member states without full voting rights.

National metrological institutes

On a national level, institutes are responsible in most cases for metrology. They maintain the national standards to which all calibrated measuring instruments can be traced and ensure that these primary standards are comparable on an international level.

Accredited calibration laboratories

Accredited calibration laboratories often take on calibration as external service providers for those companies that do not have the required equipment themselves. However, they themselves can also be part of a company and calibrate all measuring instruments within it.

To this end, they are equipped with their own working or factory standards which are calibrated at the proper time intervals with the smallest possible measurement uncertainty using the reference standard of the appropriate national metrological institute or other accredited calibration laboratories.

Professional calibration

The professional execution of calibrations is governed by various standards, regulations and directives. For a measuring instrument to be calibrated in the first place, it must fulfill certain basic requirements. The physical conditions under which calibration can be carried out must also be known and taken into account.

Under these conditions, it is possible to select a calibration procedure suitable for the requirements.

Standards, regulations and calibration directives

In essence, regulations for the calibration of measuring instruments take effect whenever a company decides to observe a standard or directive for its calibration or when it manufactures products whose production is subject to legal regulations.

Quality assurance standards

Of great importance for quality assurance are standards and directives such as the ISO 9000 series of standards, which is being implemented more and more frequently in all industrialized nations. In Clause 7.6 “Control of monitoring and measuring equipment” of the ISO 9001:2008 standard “Quality management systems – Requirements”, there is a specific requirement that any inspection equipment that directly or indirectly affects the quality of the products must be calibrated. This includes, for example, test equipment used as a reference in measurement rooms or directly in the production process.

The ISO 9000 standards do not stipulate a validity period for calibrations – which would not make a lot of sense given the different technologies of measuring devices – but they do specify that any inspection equipment must be registered and then a distinction must be made as to whether or not it must be regularly calibrated. Inspection plans must be drawn up in which the scope, frequency, method and acceptance criteria are defined. Individual calibrations are to be documented in detail. Labels on the measuring instruments (Fig. 5.3) or appropriate lists must show when each piece of inspection equipment needs to be recalibrated.

Fig. 5.4: Calibration sticker on a mechanical pressure gauge

It is essential to recalibrate when a measuring instrument has been altered or damaged during handling, maintenance or storage.

Requirements for measurement management systems

Closely related to the ISO 9000 series of standards in terms of its structure is the ISO 10012:2004 standard “Measurement management systems – Requirements for measurement processes and measuring equipment”. It defines the requirements of the quality management system that can be used by companies in order to establish confidence in the measurement results obtained. In measurement management systems, it is not only the measuring device but the entire measuring process that is considered. This means that those responsible not only have to determine the measurement uncertainty during calibration, but also have to verify and evaluate the measurement uncertainty in use. To this end, statistical methods are also used.

Industry-specific directives

In addition to such universal standards, individual sectors of industry have their own directives for the quality assurance of measuring devices, for example the automotive industry.American automobile manufacturers have developed the QS 9000 directive in which the ISO 9000 standards have been substantially supplemented by industry and manufacturer specific requirements, and in part tightened.

In the meantime, the American QS 9000, the German VDA 6.1 and other country-specific regulations have been combined to some extent in the international ISO/TS 16969 standard. This saves many suppliers multiple certifications.

Legal provisions

Quality assurance standards and directives must only be observed by companies that want to be certified. The situation is completely different when, for example, drugs, cosmetics or foodstuffs are being manufactured. Here legal regulations, whose compliance is controlled by state agencies, often apply. Due to international trade relations, the regulations of the American Food and Drug Administration (FDA) are important. Thus, the *Code of Federal Regulation* (CFR) requires the "calibration of instruments, apparatus, gauges, and recording devices at suitable intervals in accordance with an established written program containing specific directions, schedules, limits for accuracy and precision, and provisions for remedial action in the event accuracy and/or precision limits are not met". European laws have similar stipulations.

Self-Check 5	**Written Test**

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

Part I Fill the black space

1. The _________________ of calibrations is governed by various standards, regulations and directives. (2%)
2. ____________and _______ must only be observed by companies that want to be certified. (2%)
3. In the process of__________, the displayed value of the measuring instrument is compared with the measuring result of a different measuring device which is known to function correctly and accurately and which itself has been made to coincide directly or indirectly with a national (or international) reference instrument (standard) (2%)

Answer the following question!

Note: Satisfactory rating 3 and above Unsatisfactory below 3 points

You can refer at the end of this UC for copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ Date: _______________

Information Sheet 6 Responding to unplanned Events or conditions

ACCIDENTS, MALFUNCTIONS AND UNPLANNED EVENTS

Accidents, Malfunctions and Unplanned Events refers to events or upset conditions that are not part of any activity or normal operation of the Project as has been planned by North cliff. Even with the best planning and the implementation of preventative measures, the potential exists for accidents, malfunctions or unplanned events to occur during any Project phase, and if they occur, for adverse environmental effects to result if these events are not addressed or responded to in an environmentally appropriate manner. Many accidents, malfunctions and unplanned events are, however, preventable and can be readily addressed or prevented by good planning, design, emergency response planning, and mitigation. By identifying and assessing the potential for these events to occur, North cliff can also identify and put in place prevention and response procedures to minimize or eliminate the potential for significant adverse environmental effects, should an accidental event occur. The Project is being designed, and will be constructed and operated, according to best practice for health, safety, and environmental protection to minimize the potential environmental effects that could result from the Project, as well as those that could result from accidents, malfunctions or unplanned events. Prevention and mitigation will be accomplished by the following general principles:

- Us e best management practices and technology for carrying out the Project while controlling permitted/allowable releases to the environment and consequent environmental effects;
- Incorporate safety and reliability by design, and application of principles and practices of process and mine safety management;
- Develop and apply procedures and training aimed at safe operation of the facilities that prevent or avoid the potential upsets that might lead to accidents, malfunctions or unplanned events; and
- Implement effective emergency preparedness and response.

Self-Check 6	**Written Test**

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

1. Write general principles of Prevention and mitigation to be accomplished? (4%)

   a. ____
   ____
   ____

   b. ____
   ____
   ____

   c. ____
   ____
   ____
   ____

   d. ____
   ____
   ____

Answer the following question!

Note: Satisfactory rating 6 and 10 points Unsatisfactory below 6 and 10 points

You can refer at the end of this UC for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: ___________________________ Date: _______________

LG #22 LO #3- Inspecting and testing calibrate instrumentation and control devices
Instruction sheet

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

- Undertaking final inspections for conformation of calibration
- Checking and testing instrumentation and control devices
- preparing/completing report

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:

- Undertake final inspections for conformation of calibration
- Check and testing instrumentation and control devices
- prepare/complete report

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 sheet 1 Undertaking final inspections for conformation of calibration

MEASURING AND TEST EQUIPMENT CALIBRATION

Definitions

- Metrology
- Measuring & Test Equipment (M&TE)
- Calibration
- Measurement Standard
- Accuracy and Precision



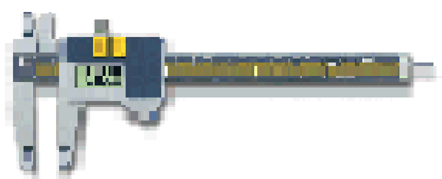
Calibration System

- MIL-STD-45662 Military Standard – Calibration System Requirements.
- ISO 10012 – Measurement Management Systems – Requirements For Measurement Processes And Measuring Equipment.
- ANSI Z540 – Calibration & Measurement & Test Equipment – General Requirements
- Must Be An Integral Part Of The Quality System

Suggested Practices

- Written Description Of The Calibration System
- Listing Of All Standards Used
- Established Calibration Intervals
- Mandatory Recall Of Inspection And Test Equipment
- Measuring And Test Equipment Properly Identified To Reflect Calibration Status
- Maintain Historical Records Of Inspection And Test Equipment Calibration
- Utilize Standards Whose Accuracy Is Certified As Traceable To U.S. Or International Standards

- Written Calibration Procedures, Which Specify The Accuracy Of The Equipment Being Calibrated And The Accuracy Of The Standards Used
- Utilize Standards That Have A Higher Accuracy Level Than The Accuracy Requirements Of The Equipment Being Calibrated
- Control Of Outside Calibration Sources
- Environmental Controls
- Out Of Tolerance Conditions
- Control Of Inactive M&TE
- Use Of Tamper Proof Seals
- Storage And Calibration Facilities
- Customer Furnished M&TE
- Employee Owned M&TE
- M&TE Must Be Adequate To Permit Reliable Inspections



CONTROL OF INSPECTION, MEASURING, & TEST EQUIPMENT

PURPOSE:

To establish and maintain the documented procedures used to control, calibrate, and maintain inspection, measuring, and test equipment.

EXPLANATION:

The supplier shall develop procedures for the proper use and validation of inspection equipment.

SUPPLIER RESPONSIBILITIES:

The supplier shall establish and maintain documented procedures to control, calibrate, and maintain inspection, measuring, and test equipment (including test software) used by the supplier to demonstrate the conformance of product to the specified requirements. Inspection, measuring and test equipment shall be used in a manner which ensures that the measurement uncertainty is known and is consistent with the required measurement capability.

Where test software or comparative references such as test hardware are used as suitable forms of inspection, they shall be checked to prove that they are capable of verifying the acceptability of product, prior to release for use during production, installation, or servicing, and shall be rechecked at prescribed intervals. The supplier shall establish the extent and frequency of such checks and shall maintain records as evidence of control.

Where the availability of technical data pertaining to the inspection, measuring, and test equipment is a specified requirement, such data shall be made available, when required by HTNA, for verification that the inspection, measuring, and test equipment is functionally adequate.

Note: The term "measuring equipment" includes measurement devices.

Control Procedure:

The supplier shall:

- Determine the measurements to be made and the accuracy required, and select the appropriate inspection, measuring and test equipment that is capable of the necessary accuracy and precision.
- Identify all inspection, measuring and test equipment that can affect product quality, and calibrate and adjust them at prescribed intervals, or prior to use, against certified equipment having a known valid relationship to internationally or nationally recognized standards. Where no such standards exist, the basis used for calibration shall be documented.
- Define the process employed for the calibration of inspection, measuring and test equipment, including details of equipment type, unique identification, location, and frequency of checks, check method, acceptance criteria and the action to be taken when results are unsatisfactory.
- Identify inspection, measuring and test equipment with a suitable indicator or approved identification record to show the calibration status.
- Maintain calibration records for inspection, measuring and test equipment.
- Assess and document the validity of previous inspection and test results when inspection, measuring or test equipment is found to be out of calibration.
- Ensure that the environmental conditions are suitable for the calibrations, inspections, measurements and tests being carried out.

- Ensure that the handling, preservation and storage of inspection, measuring and test equipment is such that the accuracy and fitness for use is maintained.
- Safeguard inspection, measuring and test facilities, including both test hardware and test software, from adjustments which would invalidate the calibration setting.

Inspection, Measuring, and Test Equipment Records:

The Supplier Quality System Requirements reflect the International standards Calibration/Verification Records.

Records of the calibration / verification activity on all gages, measuring, and test equipment, including employee-owned gages, shall include:

- Revisions following engineering changes (if appropriate).
- Any out of specification reading as received for calibration.
- Statement of conformance to specification after calibration.
- Notification to customer if suspect material has been shipped.

Self-check 1	**Information sheet**

Direction: give short answer for the following question

1. List the records of the calibration / verification activity on all gages, measuring, and test equipment. (4%)
   a. ____
   b. ____
   c. ____
   d. ____

2. The ______________________System Requirements reflect the International standards Calibration/Verification Records. 2%

***Note:* Satisfactory rating – 3.5 points** **Unsatisfactory - below 3.5 points**

Score = ____________
Rating: _____________

Name: ___________________________ Date: ________________

Information sheet 2. Checking and testing instrumentation and control devices

Visual and Technical Checking of Instrumentation and Control System

This article defines the minimum requirements for initial inspection, loop check, and commissioning of control systems during new plant construction, as well as those inspections, loop checks, and commissioning that might be necessary following major revisions/modifications or repair.

This document outlines specific steps that need to be taken in the course of commissioning. The document is organized so that key sections may be extracted to be used as instructions for that identified task, these tasks shall be coordinated by Process Controls Engineering.

This standard applies globally to all control systems undergoing initial inspection, loop checking, and commissioning.

Visual inspection of devices

Typically, physical inspection is the first task to be performed once an instrument is turned over from construction. Physical inspections do not have to be done in conjunction with loop checking but depending on manpower and instrument location, physical inspections and loop checking may be done at the same time. At a minimum, physical inspections must be documented to provide evidence of what was checked and whether the device passed or failed. It is recommended that field inspection reports be filled out for every piece of instrumentation. Failed devices shall be corrected before proceeding to loop check.

General Inspection Checks:

- Transmitter support stands installed
- Proper wiring, glancing, and conduit connection such as low point drains, grounding, shielding and terminations, and bottom cabinet entry
- Verify proper labeling of all tags, warning signs, pressure ratings, etc…
- Confirm all covers, screws, fittings, etc. are installed and properly tightened
- Look for signs of moisture and/or corrosion in electrical conduit and process impulse line
- Wire terminations are tightened

Pressure Transmitters Checking:

Verify sensing line size, material, slope, tap orientation, adequate supports, etc.

- Proper installation of all compression fitting.
- Root valves installation and location.
- Manifold valve selection and proper installation.
- Verify sufficient impulse line length for heat transfer.
- Verify loop seals where required.
- Verify configuration according to specification sheet.
- Instrument accessible for routine maintenance and correctly supported
- Environment acceptable, vibration, heat, splash, etc.
- Heat traced if necessary.
- Verify proper electrical connections.

DP (level and flow) Transmitters and orifice plate Checking:

- Verify beta ratio and flow direction for orifice plates directly from the handle or nameplate.
- Verify sensing line size, material, slope, tap location, adequate supports, etc.
- Verify HI/LO pressure tap location relative to gas or liquid measurement.
- Proper installation of all compression fitting.
- Root valves installation and location.
- Manifold valve selection and proper installation.
- Inspect and confirm all sealed capillary sensing systems used for level measurement against instrument specification.

- Verify sufficient impulse line length for heat transfer.
- Verify loop seals where required.
- Verify configuration according to specification sheet.
- Instrument accessible for routine maintenance.
- Instrument correctly supported.
- Environment acceptable, vibration, heat, splash, etc.
- Heat traced if necessary.
- Verify proper electrical connections.

Temperature Element/ Transmitters Checking:

- Verify insertion length within process pipe and ensure firm contact with bottom of well.
- Verify that either RTD or T/C elements are connected and properly terminated to the transmitter
- Verify T/C element type and extension wire type according to specification
- Verify proper grounding and shielding according to specification and electrical installation drawings
- Confirm that all threaded connections are tight (for example, nipple-union-nipple, head cover and gasket)
- Verify transmitter configuration according to specification sheet
- Instrument accessible for routine maintenance
- Instrument correctly supported
- Environment acceptable, vibration, heat, splash, etc.
- Heat traced if necessary
- Verify proper electrical connections

Control Valves Checking:

- Verify control valve flow direction.
- Ensure proper installation of all tubing, fittings, and solenoid valves.
- Verify positioner and solenoid wiring for proper connections and tagging.
- Inspect overall installation of valve body and actuator. Look for signs of overstressed piping or improper actuator installation causing unnecessary stress.
- For rotary valves, ensure actuator rotation is indexed correctly with valve rotation.
- Verify installation of bug screens or other means of preventing water ingress for all vented openings.
- Check fails action.
- Verify start-up flush kit has been removed where applicable.
- Verify all other ancillary valve equipment functions properly.
- Verify configuration according to specification sheet.
- Instrument accessible for routine maintenance, actuator removal, bonnet and plug removal, hand wheel operation, positioner maintenance, and solenoid maintenance.
- Valve stroke is within specified time
- Proper support.
- Correct packing for application.
- Packing gland properly tightened.
- Verify all covers, screws, fittings, etc., are installed and properly tightened.

Field Switches Checking :

- Verify installation location, confirm against P&ID
- Verify wiring: NO/ NC contacts
- Verify wiring labeling
- Instrument accessible for routine maintenanc

- Verify all covers, screws, fittings, etc., are installed and properly tightened

Programmable Electronic System (PES) Staging Requirements

The tasks to be performed to fully commission an entire control/safety and independent safety system are outlined in Figure 1, Task Flow Diagram. All steps will be clarified with references to other standards when the content falls outside the scope of this standard.

The intent of this standard is to provide the minimum requirements for initial inspection, loop check, and commissioning of a control system. The objectives of this standard are as follows:

- Verify the proper physical installation (wiring, grounding, labels, tags, pressure ratings, area classification) of instruments.
- Ensure wiring is landed on the proper termination and verify overall wiring loop integrity.
- Verify proper calibration range, engineering units, tag name, and diagnostics.
- Verify PES input range.
- Verify all logic including the interlock system
- Verify pre-alarms, bad quality, maintenance bypass switches, and proper configuration of HMI displays.
- Verify and confirm proper operation of the instrument and sensor according to supplier and Air Products specifications.
- Verify proper installation, power and grounding, backup power, network communications, system diagnostics, and operational functionality of the PES.
- Verify auxiliary systems (Foreign Device Interfaces, Historians, and Billing Systems).
- Verify remote access and remote control if applicable.

The following documents shall be available on site and shall be the latest revision:

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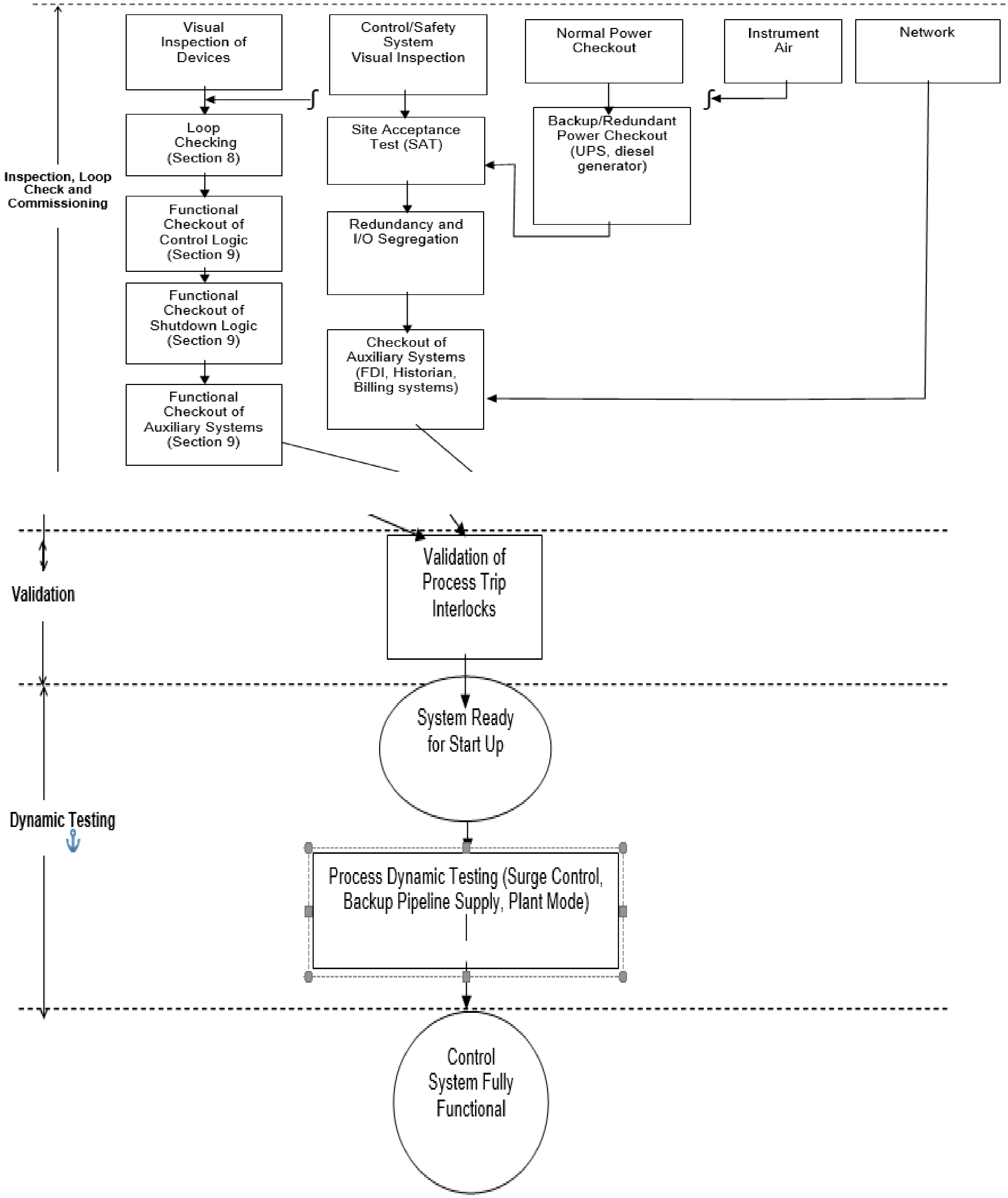
Inspection, Loop Check and Commissioning
Visual Inspection of Devices
Control/Safety System Visual Inspection
Normal Power Checkout
Instrument Air
Network
Loop Checking (Section 8)
Site Acceptance Test (SAT)
Backup/Redundant Power Checkout (UPS, diesel generator)
Functional Checkout of Control Logic (Section 9)
Redundancy and I/O Segregation
Functional Checkout of Shutdown Logic (Section 9)
Checkout of Auxiliary Systems (FDI, Historian, Billing systems)
Functional Checkout of Auxiliary Systems (Section 9)
Validation
Validation of Process Trip Interlocks
System Ready for Start Up
Dynamic Testing
Process Dynamic Testing (Surge Control, Backup Pipeline Supply, Plant Mode)
Control System Fully Functional

Self-Check 2	Written Test

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

Part I Fill the black space

1. List some of field switches checking (3%)
2. List some of temperature element/ transmitters checking: (3%)
3. Control Valves Checking: (3%)

Answer the following question!

Note: Satisfactory rating 5 and above Unsatisfactory below 5 points

You can refer at the end of this UC for the copy of the correct answers.

Score = ____________

Rating: ______________

Answer Sheet

Name: ___________________________ Date: _______________

Information sheet 3. Preparing/completing report requirements

People communicate in their spare time and in the professional area. They communicate either in oral or in written form. If they communicate about technical topics, this process is called technical communication. If they communicate in written form, they write or read “technical reports”. If the technical report is communicated in oral form, it is a presentation to an audience. Therefore all documents in the following list are technical reports, if they deal with a technical subject:

- Reports about laboratory experiments
- Construction and design reports
- Reports about testing and measurements

Technical reports shall be written so that they reach your readers. This requires a high level of systematic order, logic and clarity. These understandability aspects must already be taken into account, when you plan the necessary work steps. This is the only way to perform all work steps accurately. As a result all facts about the described items or processes and the thoughts of the writer of a technical report become clear for the reader without any questions and without doubt.

In technical a systematic approach is used to solve tasks and larger projects. Tasks are solved in the sequence planning, realization and checking. This approved approach should be applied in a similar way when creating technical reports. Here the necessary work steps can be grouped in the phases planning, creation and finishing (with check-ups). However, before describing the single measures in the planning process we will present a general overview of all required work steps to create a technical report.

General overview of all required work steps

The following checklist 3-1 shows all required work steps.

Checklist 3-1 required work steps to create technical reports

- Accept and analyze the task
- Check or create the title
- Design a 4-point-structure
- Design a 10-point structure

- Search, read and cite literature
- Elaborate the text (on a computer)
- Create or select figures and tables
- Develop the detailed structure
- Perform the final check
- Print copy originals or create pdf file
- Copy and bind the report
- Distribute the report to the defined recipients

This work steps to be performed partly parallel overlapping

When you write a technical report, there is nearly always a task, which you either selected yourself or it was defined by someone else. You should analyze this task precisely during the planning of the technical report, checklist 3-2.

Checklist 3-2 analysis of the task to write a technical report

- The task defined may by:-
  - ✓ A professor or an assistant (in case of a report written during your studies)
  - ✓ A supervisor
  - ✓ The development team
  - ✓ A consulting company
  - ✓ A customer
  - ✓ You yourself (e.g. If you write an article for a scientific journal)
- Understand the task correctly
- Belongs to the target group
- Write the report for appropriate person
- Take notes accordingly
- The report may contain contents
- Please write that down!

The difference is in the way the results are reported, in the first case, a specific value is reported and in the second, it is reported as either in or out of tolerance (specification,) the minimum information that must be supplied is illustrated by the content of a typical NIST report. Note that a NIST report of test generally has nothing to do with calibrations, A NIST Report of Calibration gives

- The value of the item calibrated
- The uncertainty of the calibration for the accepted reference standard and details about the overall uncertainty
- The conditions under which the measurements were carried out, and
- Any special information regarding the calibration, it does not include uncertainties for effects of transport to and from the calibrating laboratory, drifts with time, effects of environmental conditions (i.e., temperature, humidity, barometric pressure, etc.) Sometimes, these errors may be greater than the reported uncertainty of the calibration, generally, calibration transfer techniques are one of the following types,

Self-Check 3	Written Test

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

Part I Fill the black space

1. List the technical reports? (Have three point)
2. Write a technical report the task defined may by: (4%)

Answer the following question!

Note: Satisfactory rating 5 and above Unsatisfactory below 5 points

You can refer at the end of this UC for the copy of the correct answers.

Score = ____________

Rating: _____________

Answer Sheet

Name: ___________________________ Date: _______________

AKNOWLEDGEMENT

We wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this TTLM.

We would like also to express our appreciation to the TVET instructors and respective industry experts of Regional TVET Bureaus, TVET College/ Institutes, BEAR II Project, Bishoftu Management Institute Center, UNESCO and Federal Technical and Vocational Education and Training Agency (FTVET) who made the development of this curriculum with required standards and quality possible.

This TTLM developed on December 2020 at Bishoftu Management Institute Center.

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13. https://www.eurotherm.com/heat-treatment-articles/calibrating-and-testing-control-components-on-your-heat-process/
14. https://paktechpoint.com/visual-and-technical-checking-of-instrumentation-and-control-system/
15. https://journals.sagepub.com/doi/pdf/10.1177/0020294013510471

Answer Key for self-check

LG #20 LO #1- Plan and prepare for calibration

Self-Check -1	**Answer sheet**

I. Part one

1. A 2. A 3. C

II. Part two

1. List down why needed calibration? (5%)
   - Ensure performance is acceptable within the required tolerance limits for intended use
   - Comply with regulations
   - Save time
2. Who performer calibration? (4%)
   - A control system technician (CST) is a skilled crafts person who knows pneumatic, mechanical, and electrical instrumentation.

Self-Check -2	**Answer sheet**

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

1. What is your right? (Have 5 point)

b. The right to know the hazards at work and how to control them;

c. The right to participate in occupational health and safety; and

d. The right to refuse work which you believe to be unusually dangerous.

1. The unusual danger may be to you or to anyone else. An unusual danger could include such things as: (have 5 point)
   - A danger which is not normal for your occupation or the job;
   - A danger under which you would not normally carry out your job; and/or
   - A situation, for which you are not properly trained, equipped or experienced.
2. What are duties of committees? (Have 5 point)
   - Regularly inspect the workplace;
   - Conduct accident investigations;
   - Deal with the health and safety concerns of employees;
   - Investigate refusals to work;

- Meet at least (four times a year – consult your provincial act); and return minutes of each meeting to the division.

3. What are your responsibilities?
   - You must also comply with the legislation. You have responsibilities to:
   - protect your own Health and Safety and that of your co-workers;
   - not initiate or participate in the harassment of another worker; and
   - Co-operate with your supervisor and anyone else with duties under the legislation

Self-check 3	**Answer sheet**

Q1. Why we select the size of cables? (Have 3 point)

- overheating -damage to cable -fire risk
- high volt drop
- high power loss

Q2. What is sealing materials? (Have 2 point)

- Sealants are materials used to connect and seal pipes and tubes to prevent leakage of liquids and gases.

Q3. Write the name for the following figure? (Each has 2 point)

-  Elbows  Couplings  Unions  Tee-Wyes

Self-Check 4	**Answer sheet**

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

I. gives short answer for the following?

1. What are three types of automatic precipitation recorders? (Have 3 point)
   - The weighing recording type,
   - The tilting or tipping-bucket type and
   - The float type.
2. The main structural components of a control valve are? (Have 3 point)

- Body,
- Trim and
- Actuator.

3. Control valves are industrial valves specifically designed to control liquid media and gases transmitted through a pipeline. (Have 3 point)
4. An **actuator** is a component of a machine that is responsible for moving and controlling a mechanism or system. (Have 3 point)

Self-Check 5	**Answer sheet**

1. A 2. B 3. C 4. A 5. A

Self-Check 6	**Answer sheet**

1.
   i. Ramp the output up and down at a controlled rate.
   ii. Inject and display an input signal and display the output of the device under test at the same time.
   iii. Capture data in memory for uploading through a PC interface for archiving, printing and analysis. (Note that the calibrator cannot see and capture plant instrument indications. You still need to read by eye and write or key them in.
   iv. Calibrate and configure Hart communicating transmitters. These carry a digital signal riding on the analog output signal wires.
2. Control signals

Self-Check 7	**Answer sheet**

1. The International Electro technical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.
2. The American Society of Mechanical Engineers (ASME) is a professional association that, in its own words, "promotes the art, science, and practice of multidisciplinary engineering and allied sciences around the globe" via "continuing education, training and

professional development, codes and standards, research, conferences and publications, government relations, and other forms of outreach.”

3.

a. Engineers
b. Technicians
c. Businesspeople
d. Educators and
e. Students

LG #21 LO #2- Calibrating instruments and control devices

Self-Check 1	Answer sheet

1. True 2. True 3. True

Self-Check 2	Answer sheet

1. True 2. False 3. False

Self-Check 3	Answer sheet

1. True 2. True 3. True

Self-Check 4	Answer sheet

1. Actuator 2. fault diagnosis

Self-Check 5	Answer sheet

1. professional execution
2. Quality assurance standards, directives
3. calibration

Self-Check 6	Answer sheet

1.
   a. Us e best management practices and technology for carrying out the Project while controlling permitted/allowable releases to the environment and consequent environmental effects;
   b. Incorporate safety and reliability by design, and application of principles and practices of process and mine safety management;
   c. Develop and apply procedures and training aimed at safe operation of the facilities that prevent or avoid the potential upsets that might lead to accidents, malfunctions or unplanned events; and
   d. Implement effective emergency preparedness and response.

LG #22 LO #3- Inspecting and testing calibrate instrumentation and control devices

Self-Check 1	Answer sheet

1.
   a. Revisions following engineering changes (if appropriate).
   b. Any out of specification reading as received for calibration.
   c. Statement of conformance to specification after calibration.
   d. Notification to customer if suspect material has been shipped.
2. Supplier Quality

Self-Check 2	Answer sheet

Answer Sheet

Score = ____________
Rating: ____________

Name: ___________________________ Date: ____________

1.
   a. Verify installation location, confirm against P&ID
   b. Verify wiring: NO/ NC contacts
   c. Verify wiring labeling
   d. Instrument accessible for routine maintenanc
   e. Verify all covers, screws, fittings, etc., are installed and properly tightened
2.
   a. Verify insertion length within process pipe and ensure firm contact with bottom of well.

b. Verify that either RTD or T/C elements are connected and properly terminated to the transmitter
c. Verify T/C element type and extension wire type according to specification
d. Verify proper grounding and shielding according to specification and electrical installation drawings
e. Confirm that all threaded connections are tight (for example, nipple-union-nipple, head cover and gasket)
f. Verify transmitter configuration according to specification sheet
g. Instrument accessible for routine maintenance
h. Instrument correctly supported
i. Environment acceptable, vibration, heat, splash, etc.
j. Heat traced if necessary
k. Verify proper electrical connections

3.

   a. Verify control valve flow direction.
   b. Ensure proper installation of all tubing, fittings, and solenoid valves.
   c. Verify positioner and solenoid wiring for proper connections and tagging.
   d. Inspect overall installation of valve body and actuator. Look for signs of overstressed piping or improper actuator installation causing unnecessary stress.
   e. For rotary valves, ensure actuator rotation is indexed correctly with valve rotation.
   f. Verify installation of bug screens or other means of preventing water ingress for all vented openings.
   g. Check fails action.
   h. Verify start-up flush kit has been removed where applicable.
   i. Verify all other ancillary valve equipment functions properly.
   j. Verify configuration according to specification sheet.
   k. Instrument accessible for routine maintenance, actuator removal, bonnet and plug removal, hand wheel operation, positioner maintenance, and solenoid maintenance.
   l. Valve stroke is within specified time
   m. Proper support.
   n. Correct packing for application.

o. Packing gland properly tightened.
p. Verify all covers, screws, fittings, etc., are installed and properly tightened.

Self-Check 3	**Answer sheet**

Answer Sheet

Name: ____________________ Date: ______________

Score = ___________
Rating: ____________

1.
   a. Reports about laboratory experiments
   b. Construction and design reports
   c. Reports about testing and measurements

2.
   a. A professor or an assistant (in case of a report written during your studies)
   b. A supervisor
   c. The development team
   d. A consulting company
   e. A customer
   f. You yourself (e.g. If you write an article for a scientific journal)