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Islamabad

PRECISION INSTRUMENTATION

LEARNER GUIDE

National Vocational Certificate Level 4

Version 1 - November, 2019

NAVTTC

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- This section will include examples, photographs and illustrations relating to each learning outcome

- **Summary of modules**:
  - Thiscontains the summary of the modules that make up your learner's guide
- **Frequently asked questions**:
  - These have beenadded to provide further explanation and clarity on some of the difficult concepts and areas. This further helps you in preparing for your assessment.
- **Multiple choice questions for self-test**:
  - These are provided as an exercise at the end of your learner's guide to help you in preparing for your assessment.

Frequently Asked Questions

1. What is Competency Based Training (CBT) and how is it different from currently offered trainings in institutes?	Competency-based training (CBT) is an approach to vocational education and training that places emphasis on what a person can do in the workplace as a result of completing a program of training. Compared to conventional programs, the competency based training is not primarily content based; it rather focuses on the competence requirement of the envisaged job role. The whole qualification refers to certain industry standard criterion and is modularized in nature rather than being course oriented.
2. What is the passing criterion for CBT certificate?	You shall be required to be declared "Competent" in the summative assessment to attain the certificate.
3. How can I progress in my educational career after attaining this certificate?	You shall be eligible to take admission in the National Vocational Certificate Level-4 in Precision Instrumentation; and take admission in a level-5, DAE or equivalent course. In certain case, you may be required to attain an equivalence certificate from The Inter Board Committee of Chairmen (IBCC).
4. What is the importance of this certificate in National and International job market?	This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). These standards are also recognized worldwide as all the standards are coded using international methodology and are accessible to the employers worldwide through NAVTTC website.

5. Which jobs can I get after attaining this certificate? Are there job for this certificate in public sector as well?	You shall be able to take up jobs in the Precision Instrument in Industries in the functions of installation of different Instruments
6. What are possible career progressions in industry after attaining this certificate?	You shall be able to progress up to the level of supervisor after attaining sufficient experience, knowledge and skills during the job. Attaining additional relevant qualifications may aid your career advancement to even higher levels.
7. Is this certificate recognized by any competent authority in Pakistan?	This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). The official certificates shall be awarded by the relevant certificate awarding body.
8. Is on-the-job training mandatory for this certificate? If yes, what is the duration of on-the-job training?	On-the-job training is not a requirement for final / summative assessment of this certificate. However, taking up on-the-job training after or during the course work may add your chances to get a job afterwards.
9. What is the examination / assessment system in this program?	Competency based assessments are organized by training institutes during the course which serve the purpose of assessing the progress and preparedness of each student. Final / summative assessments are organized by the relevant qualification awarding bodies at the end of the certificate program. You shall be required to be declared “Competent” in the summative assessment to attain the certificate.
10. Does this certificate enable me to work as freelancer?	You can start your small business as a Instrumentation Installation & calibration. You may need additional skills on entrepreneurship to support your initiative.

PRECISION INSTRUMENTATION

Module-1
LEARNER GUIDE
National Vocational Certificate Level 4

Version 1 - November, 2019

Modules

Module 1:0714001037 Measure Process Variables

Objective of the module: The aim of this module is to develop advanced knowledge, skills and understanding to measure process variables.

Duration: 150 Hrs **Theory:** 30Hrs **Practical:** 120Hrs

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1: Operate Temperature Measuring Instruments	**The trainee will be able to:** Select the type of instrument to be operated Select measuring range of the instrument Connect the instrument to the process as per manual Verify accuracy of the instrument Record results Ensure good housekeeping & safe working practices at all times	Knowledge and explaining purpose and importance of temperature measurement in process industries. Classify types of temperature measuring methods: (a). Contact method (b). Non-Contact method Classify different temperature measuring instruments along with measuring ranges, tolerances, accuracy etc. such as of Bimetallic thermometer, Thermocouples, RTDs, Thermistors etc. Elaborate working principles of different types of temperature measuring instruments such as: Bimetallic thermometer, Thermocouples, RTDs, Thermistors etc.	Adjustable spanner set Allen key set (inch/mm) Computer Digital multimeter Digital Thermometer (0~400^{o}C) Digital thermometer (-10~400 ^{o}C) Electrician tool kit Flat Screw driver set General Tools kit Insulation Tester Multimedia projector Operations Manual Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Work Bench (8ftx4ftx3ft)

			Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses (0.01A to 20A) Insulation tape Lugs (1~10mm) Machine screw & nuts M3 to M12 Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Process SOPs Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers

			Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4
LU 2: Operate Pressure Measuring Instruments	**The trainee will be able to:** Select the type of instrument to be operated Select measuring range of the instrument Connect the instrument to the process as per manual Verify accuracy of the instrument Record results Ensure good housekeeping & safe working practices at all times	Knowledge and explaining purpose and importance of pressure measurement in process industries. Classify various types of pressure measuring methods: (a). Analogue (b). Digital Classify different types of pressure measuring instruments including measuring ranges and accuracy etc. of Bourdon Gauge, Bellows, Diaphragm, Load Cells/ Strain Gauges. Elaborate working principles of different types of pressure measuring instruments such as: Bourdon Gauge, Bellows, Diaphragm, and Load Cells/Strain Gauges.	Adjustable spanner set Allen key set (inch/mm) Computer Digital multimeter Electrician tool kit Flat Screw driver set General Tools kit Instrument air supply system Insulation Tester Multimedia projector Operations Manual Printer Safety goggles Safety harness belt Safety Helmet

			Safety mask Safety Shoes Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses (0.01A to 20A) Insulation tape Lugs (1~10mm) Machine screw & nuts M3 to M12 Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Process SOPs Equipment Maintenance Manuals Logbook Handbooks

			Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box File Printing paper A4
LU 3: Operate Flow Measuring Instruments	**The trainee will be able to:** Select the type of instrument to be operated Select measuring range of the instrument Connect the instrument to the process as per manual Verify accuracy of the instrument Record results Ensure good housekeeping & safe	Knowledge and explaining purpose and importance of flow measurement in process industries. Classify principles of flow measurement w.r.t.: (a). Velocity (b). Volumetric Flow (c). Mass Flow Classify different types of flow measuring instruments along with uses & applications (w.r.t. nature of fluid) of Differential Pressure Flow Meters, Velocity Flow Meters, and Positive Displacement Flow Meters etc. Elaborate working principles of different types of Differential Pressure Flow Meters, Velocity Flow Meters, Positive Displacement Flow Meters etc.	Adjustable spanner set Safety goggles Allen key set (inch/mm) Computer Digital multimeter Flat Screw driver set Insulation Tester Multimedia projector Operations Manual Printer Safety goggles Safety harness belt Safety Helmet

	working practices at all times		Safety mask Safety Shoes Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Lugs (1~10mm) Machine screw & nuts M3 to M12 Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire(70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Process SOPs Equipment Maintenance Manuals Logbook Handbooks

			Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4
LU 4: Operate Level Measuring Instruments	**The trainee will be able to:** Select the type of instrument to be operated Select measuring range of the instrument Connect the instrument to the process as per manual Verify accuracy of the instrument Record results Ensure good	Knowledge and explaining purpose and importance of level measurement in process industries. Classify different principles of level measurement: (a). Contact methods (b). Non-Contact methods Classify different level measuring instruments w.r.t. nature of fluid such as of Differential Pressure Method, Bubble Tube Method, and Ultrasonic Method. Elaborate working principles of different types of level measuring instruments such as: Differential Pressure Method, Bubble Tube Method, and Ultrasonic Method.	Adjustable spanner set Allen key set (inch/mm) Capacitance type level instrument Computer Digital multimeter Electrician tool kit Flat Screw driver set General Tools kit Insulation Tester Multimedia projector

	housekeeping & safe working practices at all times		Operations Manual Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Lugs (1~10mm) Machine screw & nuts M3 to M12 Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks

			Process SOPs Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4

Examples and illustrations

How is Temperature Measurement Important in Different Industries

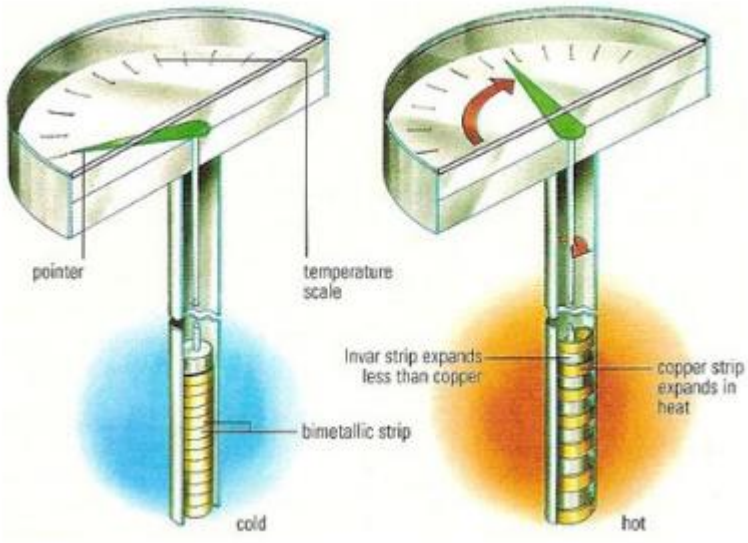
Temperature is one of the most important measurement parameters that is used for monitoring and control in various industries. It can be measured with the help of diverse temperature measurement devices. This post will discuss how temperature measurement is important in different industries. It will also detail different types of temperature measurement equipment.

- **Food and Beverage Processing:** Measurement and control of temperature is of utmost importance for both food and beverage processing manufacturers. Temperature is one of the important factors to consider during the bulk production of food items.
- In the **beverage industry**, temperature plays a vital role in deciding the quality of the final product. During the wine making or brewing process, the ambient temperature, as well as fermentation temperature, could have a positive or negative effect. Even in the process of milk pasteurization, the temperature is important to ensure the removal of harmful pathogens, such as Escherichia, Salmonella, and Listeria.
- **Plastic Production:** Temperature plays an important role in the plastic industry. During the manufacturing stages, for example thermoforming, or injection molding, several temperature ranges needs to be monitored to ensure a high product quality.
- **Metal Processing:** Be it any type of metal process plant, temperature measurement is always high on the list for operational excellence. Temperature measurement and analysis is plays a key role in metal processing, as well as monitoring. If the temperature measurement information is not correct, then it can affect quality of the final product, as well as endanger workplace security.

For more details please visit https://www.transmittershop.com/blog/know-about-industrial-process-temperature-measurement

	Tools Used to Measure Temperature **Liquid Expansion Thermometer** A standard thermometer is usually a bulb or a spring thermometer. Either work by having a liquid, either alcohol or mercury, enclosed in a vacuum and the liquid expands as the temperature rises. Colour alcohol or mercury rises along a scale in a bulb thermometer whereas expanding liquid rotates a spring to turn an indicator needle around along a circular scale on a spring thermometer. Thermometers now often have digital scale displays.

	Thermocouples Temperature is sometimes measured by a thermocouple. Two metal leads of dissimilar metals are placed in close proximity to each other, creating voltage. Changes in voltage correspond to changes in temperature. Thermocouples are used in industry, and are often connected to other devices that turn mechanisms off and on in response to certain temperatures. Thermocouples are not as accurate as thermometers. References: https://sciencing.com/instruments-measuring-temperature-4764.html https://www.mech4study.com/2018/06/different-types-of-temperature-measuring-devices.html Different methods of temperature measurement In industries temperature is a major physical quantity there are different methods of temperature measurement in industries. The different methods of temperature measurement are: 1. Mechanical 2. Electrical. **Mechanical methods:** **Mercury in glass thermometers** This consists of a glass tube of very fine bore joined to a reservoir at the bottom and sealed at the top. A measured quantity of mercury is the enclosed. When the thermometer is heated the mercury expands much more than the glass and is therefore forced to rise up in the tubing A scale is fixed at the side.



https://automationforum.co/different-methods-temperature-measurement/

Bimetallic Thermometer

Two metals whose coefficient of linear expansion is different are welded and rolled together to the desire thickness. The actual movement of a bimetal is its flexibility with one end fixed, a straight bimetal strip deflects in proportion to its temperature, to the square of its length and inversely with its thickens.

References:

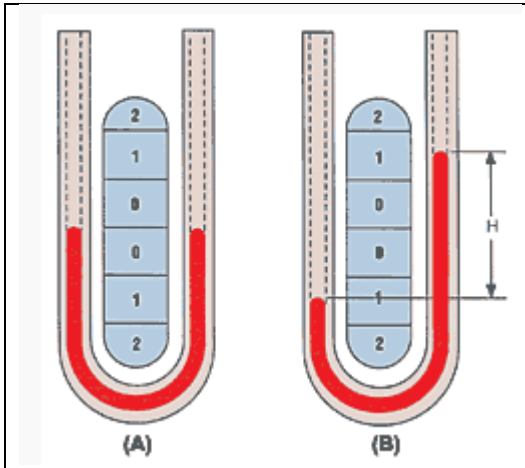
https://automationforum.co/different-methods-temperature-measurement/

https://onlinelibrary.wiley.com/doi/pdf/10.1002/9781118162569.app1

Video:

	Topic	Hyperlink
	Thermistor for measuring/controlling temperature	https://www.youtube.com/watch?v=9opuvLXAetI

	Introduction to pressure measurement It is time to know about pressure measurement. In general, pressure is represented as force per unit area. The measurement of pressure is one of the most important measurements, as it is used in almost all industries. Some important applications of pressure measurement is listed. **References:** http://instrumentationandcontrollers.blogspot.com/2010/10/introduction-to-pressure-measurement.html https://www.wika.us/solutions_gauge_innovation_why_it_matters_en_us.WIKA https://www.srpcontrol.com/the-importance-of-pressure-measurement/ **How Is Pressure Measured?** As with most measured, pressure measurement methods have varying suitability for different applications. Measurement engineers need to be familiar with several techniques in order to select the one



https://www.fierceelectronics.com/components/pressure-measurement-principles-and-practice

that is most appropriate for their specific requirements.

Deadweight Tester. The most fundamental pressure measurement technique, and favoured as well for primary calibration of pressure sensors, is the deadweight tester, or piston gauge (see Figure 1). This device uses calibrated weights (masses) that exert pressure on a fluid (usually a liquid) through a piston. Deadweight testers can be used as primary standards because the factors influencing accuracy are traceable to standards of mass, length, and time. The piston gauge is simple to operate; pressure is generated by turning a jackscrew that reduces the fluid volume inside the tester, resulting in increased pressure. When the pressure generated by the reduced volume is slightly higher than that generated by the weights on the piston, the piston will rise until it reaches a point of equilibrium where the pressures at the gauge and at the bottom of the piston are exactly equal. The pressure in the system will be:

$P = W/A$

where:

W = weight of piston plus weights

A = effective area of piston

References:

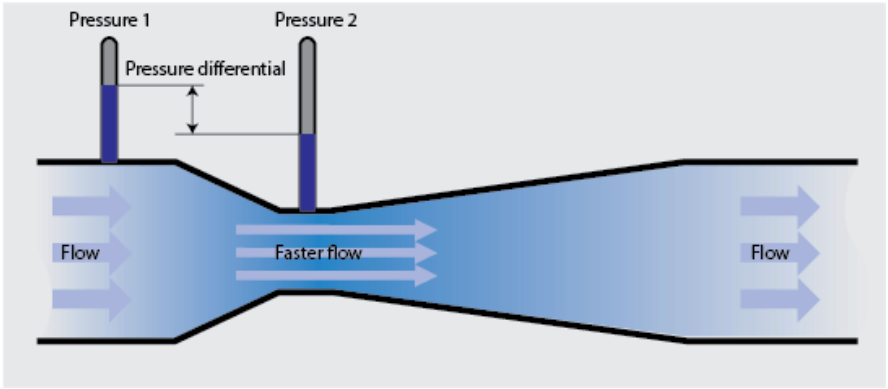
https://www.fierceelectronics.com/components/pressure-measurement-principles-and-practice

https://appmeas.co.uk/resources/pressure-measurement-notes/what-are-the-different-types-of-pressure-measurement/

https://courses.lumenlearning.com/physics/chapter/11-6-gauge-pressure-absolute-pressure-and-pressure-measurement/

Video:

	Topic	Hyperlink
	Pressure Measurement Manometers	https://www.youtube.com/watch?v=oXXGIFSmZRE



https://www.alicat.com/mass-flow-measurement-techniques-radar/

Flow Measurement

Due to the vast number and types of fluids (such as liquids, gases, saturated steam, superheated steam, wet steam, slurries, corrosives, and abrasives) that must be measured in industrial processes and exposed to a myriad of operating and ambient conditions (such as high and low pressures and temperatures), selection of an industrial flowmeter can be a formidable challenge.

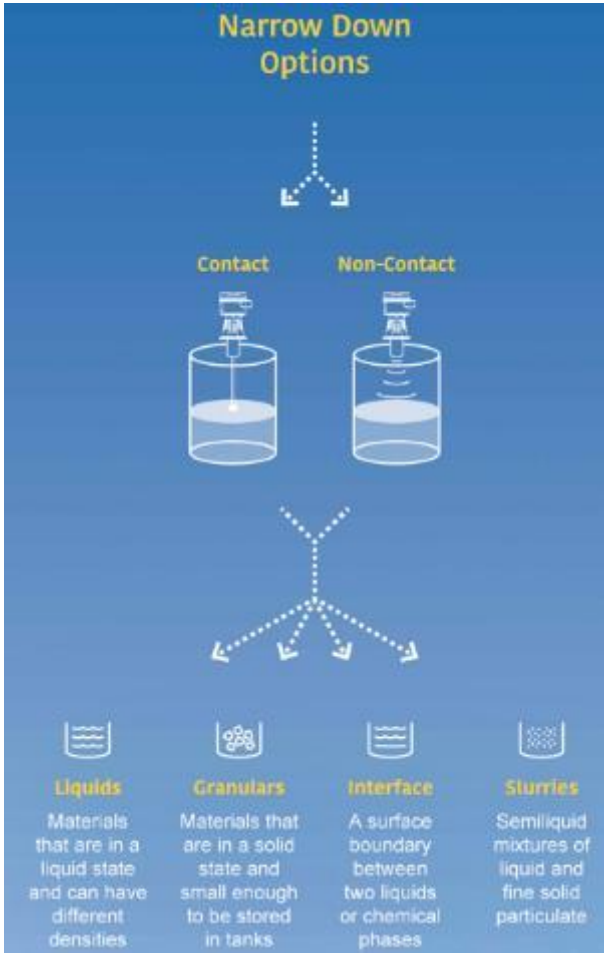
Fundamentals of Flow Measurement

Flow metering is measuring matter in motion. An understanding of flow measurement is based on an understanding of the medium and the characteristics of its motion. Since with flow there is motion, the measurement of flow is a dynamic measurement. In fact, flow measurement signals are described as "noisy," which is a recognition of the dynamic, changing nature of flow. A quality measurement is required under these conditions and can be made with an understanding of the flowing medium, how that medium moves in piping, and the

	effect of the piping on that motion. **Matter** In simplest terms, flow metering is the measurement of matter in motion. Matter occurs in three forms (phases): solid, liquid, and gas. Flow measurement is usually the measurement of moving matter in the liquid phase or the gas phase. Collectively, liquids and gases are known as fluids. However, it is not uncommon to have flow of matter in more than one phase: • Solids in liquid • Gases in liquids • Solids in gas • Liquids in gas • Solids and gases in liquid • Solids and liquids in gas **References:** https://www.globalspec.com/reference/10738/179909/chapter-4-fundamentals-of-flow-measurement https://www.emersonautomationexperts.com/2014/industry/oil-gas/importance-of-flow-measurement-for-separators/ https://www.bronkhorst.com/int/blog/the-importance-of-mass-flow-measurement-and-the-relevance-of-coriolis-technology-en/ https://en.wikipedia.org/wiki/Flow_measurement

Video:

	Topic	Hyperlink
	How Flow Meters Work	https://www.youtube.com/watch?v=_pL7bGEF52s



https://www.predig.com/whitepaper/level-measurement-technologies-process-control-industry

Level Measurement Technologies In The Process Control Industry

Few things are as ubiquitous in the process control industry as the need to measure the level of a process material in a container. Whether that material is water, waste water, petroleum, sugar, or any other form of liquid or solid, level measurement accuracy can be a determining factor in both profit margins and safety.

Categorizing Level Measurement Technologies

A good way to reduce the number of level measurement options is to categorize them into two broad categories: contact and non-contact. Then you can filter choices by the type of material they can measure.

Contact and Non-Contact

The characteristics of the process material being measured, such as tank size and shape, the pressure and temperature that the process requires, amount of material agitation, available power, etc., must be taken into account when determining if a contact or noncontact approach is the right option. One must consider whether the material is corrosive or tacky and could possibly cause damage to the measuring device, whether it is volatile and a contact sensor might create a safety hazard, whether the agitation, temperature, or pressure of the process material could affect the reading of or damage the contact sensor, and any other troublesome possibility. On the other hand, non-contact solutions may be outside of the budgetary constraints of the project or not provide the necessary level of precision.

	References: https://www.predig.com/whitepaper/level-measurement-technologies-process-control-industry https://instrumentationtools.com/why-measure-level/ https://www.fierceelectronics.com/components/principles-level-measurement

Video:

	Topic	**Hyperlink**
	What is a Level Sensor?	https://www.youtube.com/watch?v=EMotg3BQjlI

PRECISION INSTRUMENTATION

Module-2
LEARNER GUIDE
National Vocational Certificate Level 4

Version 1 - November, 2019

Module 2: 0714001038 Set up Process Controller

Objective of the module: The aim of this module is to develop advanced knowledge, skills and understanding to install pipe fixtures.

Duration: 150 Hrs **Theory:** 30Hrs **Practical:** 120Hrs

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1: Set up & adjust control loops	**The trainee will be able to:** Select the appropriate P&ID as per job requirement Confirm the specification of instrument as per job requirement Ensure the location of process controller as per P&ID/ job requirement Set up and adjust the process controller Verify the function of the process controller according to the SOP Provide feedback to the concerned personnel Record the job in the logbook/ relevant documents.	Knowledge and understanding of Occupational Health and Safety regulations, codes and practices in the workplace. Knowledge and application of problem-solving techniques in resolution of issues arising in D.C./A.C. Circuits by using instrumentation drawings, specification, standards and equipment manuals. Knowledge and understanding of control and manipulated variables.	Adjustable spanner set Allen key set (inch/mm) Computer Digital Leak tester Digital multimeter Ear Muffler/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Hand glove Helmet Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Monkey plier Combination plier Multimedia projector Nose plier

			Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Matric) Open End Spanner Set (Imperial) Open End Spanner Set (Matric) Operations Manual Overall Phase tester Philips Screwdriver set Pipe wrench set (8”/12”) Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver

			set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20 A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers

			Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4
LU 2: Set up & adjust advanced process control loops	**The trainee will be able to:** Identify process variables as per requirement Select appropriate P&ID as per job requirement. Confirm the process control loop of advance instrument as per job requirement Ensure the location of process controller as per job requirement Set up and adjust the advanced process controller. Verify the function of the advanced process controller as per manual. Provide feedback to the concerned personnel.	Knowledge and understanding of Open-Loop and Closed-Loop processes/systems. Knowledge and understanding of various types of control modes e.g. ON/OFF Control, Proportional Control, Proportional Derivative Control, PID Control. Knowledge and application of problem-solving techniques in resolution of issues arising in Temperature, Pressure, Level &Flow measurement components and systems. Knowledge of setting-up and adjust PID control loops	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter Ear Muffler/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Hand glove Helmet

	Record the job in the logbook/relevant documents		Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Monkey plier Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Matric) Open End Spanner Set (Imperial) Open End Spanner Set (Matric) Operations Manual Overall Phase tester Philips Screwdriver set Pipe wrench set (8”/12”) Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter

			Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20 A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400)

			WD-40 Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4
LU 3: Update control programmes	**The trainee will be able to:** Prepare inspection schedule for up gradation and prioritization Conduct inspections for the short comings in the existing process control programmes Conduct upgrading of control programmes as per given	Knowledge and understanding of installations procedures necessary in case of new updated versions of control programmes. Knowledge and understanding of control programmes functions/ functionalities. Knowledge and understanding of up gradation of control programmes.	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter

	requirement		Ear Muffler/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Hand glove Helmet Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Monkey plier Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Matric) Open End Spanner Set (Imperial) Open End Spanner Set (Matric) Operations Manual Overall Phase tester

			Philips Screwdriver set Pipe wrench set (8”/12”) Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape

			Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files

			Printing paper A4
LU 4: Verify control programmes	**The trainee will be able to:** Prepare verification plan for control programmes Verify up gradation of control programmes Provide feedback to the concerned personnel Record the job in the logbook & history card / relevant documents	Knowledge and understanding of tuning a PID Controller by following various steps involved in the process, such as: 1. Set all gains to zero. 2. Increase the P gain until the response to a disturbance is steady oscillation. 3. Increase the D gain until the oscillations go away (i.e. it's critically damped). 4. Repeat steps 2 and 3 until increasing the D gain does not stop the oscillations. Calculate the required PID tuning constants.	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter Ear Muffler/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Hand glove Helmet Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Monkey plier Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set

			(Matric) Open End Spanner Set (Imperial) Open End Spanner Set (Matric) Operations Manual Overall Phase tester Philips Screwdriver set Pipe wrench set (8”/12”) Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft)

			Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors

			Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4

Examples and illustrations

Common issues with power supply

There are a number of problems which may occur with the incoming power supply to a site. These problems cause voltage and current instability which can have a significant impact on equipment operation and power usage.

Voltage stability refers to the ability of a power system to maintain steady voltage levels after a disturbance. The main forms of voltage instability can be categorised as:

- Sustained under or overvoltage
- Transient events and
- Waveform distortion.

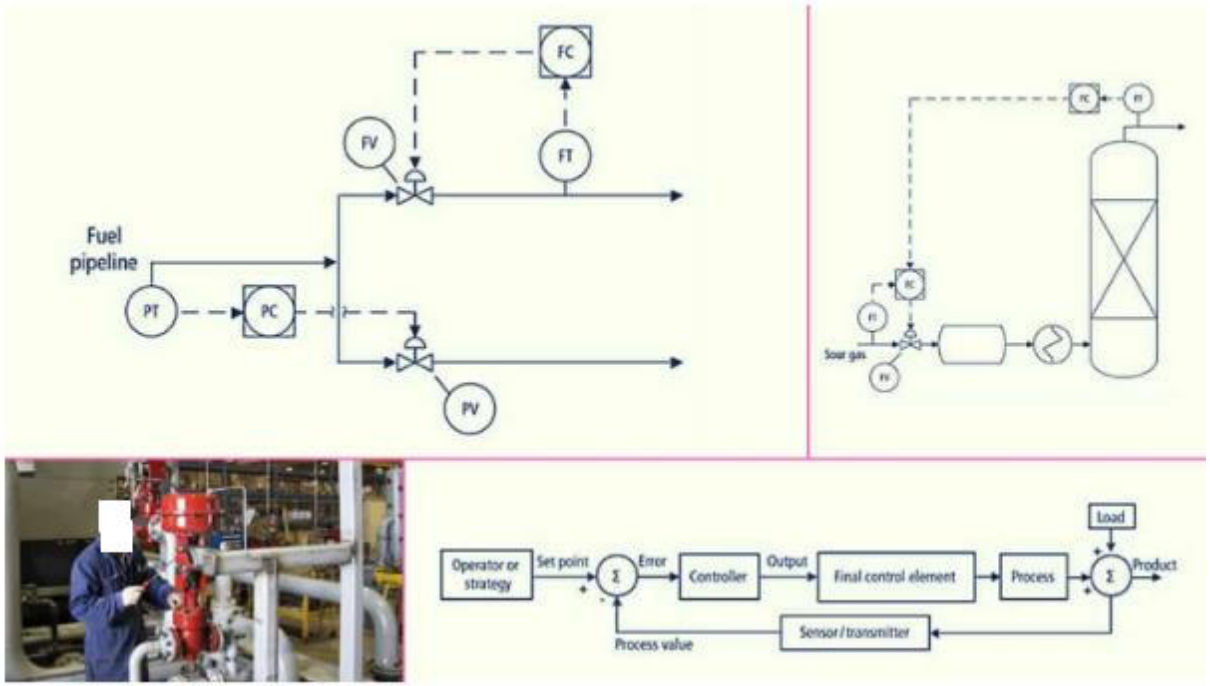
References:

https://www.captech.com.au/2016/05/06/common-issues-with-power-supply/

https://www.apc.com/salestools/VAVR-5WKLPK/VAVR-5WKLPK_R1_EN.pdf?sdirect=true

How to Fix Process Control Loop Problems

Plant engineers and technicians are frequently asked to tune the controller when a control loop's process value has prolonged or significant excursions from the set point. But in many instances, no amount of adjustment of the proportional-integral-derivative (PID) parameters will make the loop behave as desired. When tuning fails, it is time to look outside the PID for a solution.

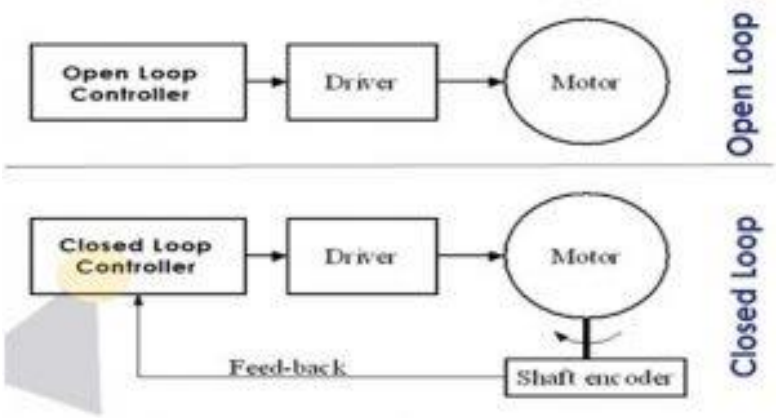


References:

https://automation.isa.org/how-to-fix-process-control-loop-problems-that-pid-tuning-cannot-correct/

https://www.dataforth.com/tuning-level-control-loops.aspx

Difference between Open Loop & Closed Loop Systems



http://engineering.electrical-equipment.org/panel-building/difference-between-open-loop-closed-loop-systems.html

Control systems are used to arrange and manage components in a way that the required condition or output is obtained. The word 'control' itself shows the command over any system. It is controlled when the systems is stable.

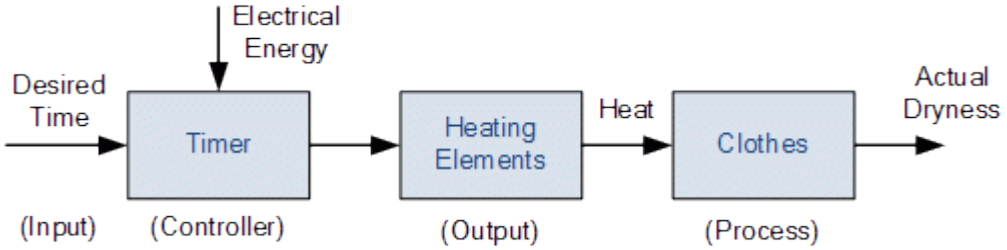
There are two attributes of control system:

1. Stability
2. Desired output

A control system can be functioned electrically, mechanically, pressure by fluid (gas or liquid), or it can be combination of these ways. In the preceding tutorial we introduced control systems, their principle of working, the variables involved in the functioning of control systems and the basic types.

In this tutorial we will be conferring over the major types of control systems namely: Open loop systems and closed loop systems. The tutorial will deal with the chief differences between the two types. Let's have a look on the basic working of the two systems:

Open loop control systems



https://www.electronics-tutorials.ws/systems/open-loop-system.html

An open-loop control system takes input under the consideration and doesn't react on the feedback to obtain the output. This is why it is also called a non-feedback control system.

There are no disturbances or variations in this system and works on fix conditions.

References:

http://engineering.electrical-equipment.org/panel-building/difference-between-open-loop-closed-loop-systems.html

https://www.electronics-tutorials.ws/systems/open-loop-system.html

https://www.fkit.unizg.hr/_download/repository/PMC_04_Controllers.pdf

How to Set-up a PID Controller

Tuning a PID controller can be difficult knowing where to start, and what direction to go. This article will provide solutions to both of these, setting up a PID controller from scratch and more!

To start, read “PID Controller Explained“, to learn what a PID controller is and how it works.

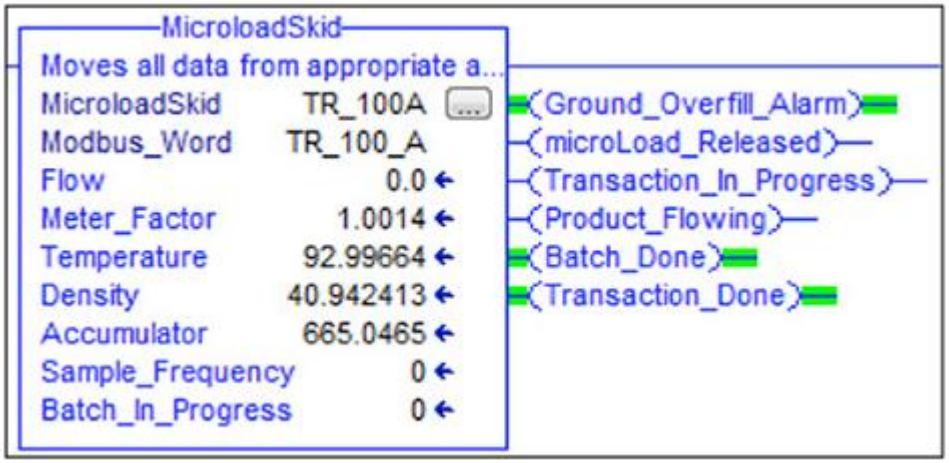
It is good to note early in this post, that there can be many values that work for the same device. The important thing is not to find the “perfect” values, but to find ones that meet the requirements, and provide desired control.

References:

https://pidexplained.com/how-to-tune-a-pid-controller/

https://www.industrialcontrolsonline.com/training/online/basics-pid-control-proportionalintegralderivative

Process Control System Configuration & Programming



http://www.englobal.com/automation_engineering_psc_configuration.html

Configuration and programming involves putting the process control design into “machine language.” The process control schemes are implemented by control modules that are configured to accomplish certain process control tasks. These process control tasks are downloaded to the controller. The controller monitors inputs from the field and the operator and takes actions based on the control scheme. These actions are carried out by various outputs connected to field instrumentation.

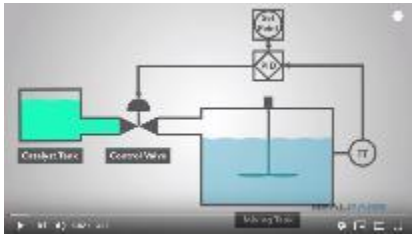
References:

http://www.englobal.com/automation_engineering_psc_configuration.html

https://www.controleng.com/articles/how-to-choose-the-correct-programming-language/

Videos:

	Topic	Hyperlink
	Understanding PID Control, Part 4: A PID Tuning Guide	https://www.youtube.com/watch?v=sFOEsA0Irjs
	Understanding PID Control, Part 1: What is PID Control?	https://www.youtube.com/watch?v=wkfEZmsQqiA

	How to Program a Basic PID Loop in ControlLogix	https://www.youtube.com/watch?v=XVYRT0Mbu7A

PRECISION INSTRUMENTATION

Module-3
LEARNER GUIDE
National Vocational Certificate Level 4

Version 1 - November, 2019

Module 3: 0714001039 Perform Fault Diagnosis

Objective of the module: The aim of this module is to develop advanced knowledge, skills and understanding to perform fault diagnosis.

Duration: 150Hrs **Theory:** 30Hrs **Practical:** 120Hrs

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU 1: Plan & prepare for fault diagnosis	**The trainee will be able to:** Interpret work requisition and verify by site inspection. Determine potential hazards for prevention in accordance with work plan. Plan the work in detail including sequencing and prioritizing Select appropriate tools and equipment in accordance with the job requirements. Coordinate requirements, including requests for isolations (if required). Follow the occupational health and safety standards.	Knowledge of P & ID/loop diagram. Knowledge of use of electronic and process test equipment during fault finding (i.e. multimeter, calibrator etc.) Knowledge of process variables and its units.	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter Ear Muffler/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Hand glove Helmet Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Monkey plier Multimedia projector Nose plier

			Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Matric) Open End Spanner Set (Imperial) Open End Spanner Set (Matric) Operations Manual Overall Phase tester Philips Screwdriver set Pipe wrench set (8”/12”) Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver

			set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners

			Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4
LU 2: Verify fault	**The trainee will be able to:** Identify faults through fault indicators in accordance with the work plan. Identify abnormalities in the system Verify abnormalities in the system Ensure personnel safety & plant security according to the work plan	Understand basic Electrical/ Electronic devices and circuits (i.e. Series & parallel circuits: amplifier, filter & signal conditioner etc.) Understand and interpret P&ID/ IFCD. Understand and interpret the electrical/ electronic circuit diagrams. Explain the testing of electrical / electronic components by using test equipment. (i.e. transistors, diodes, amplifiers etc.) Understand functionality of process instruments. (i.e. D/P transmitter, control valve, solenoid valve etc.) Distinguish faults in electronic cards (i.e. fuse below, dry solder, component burnout etc.) Understanding of electrical wiring and standards (i.e. domestic wiring, industrial wiring etc.) Describe Standard safety procedures and safe practices in process industry (i.e. use of PPEs) Understanding of system parameters (normal & abnormal). Understanding of fault diagnosis techniques (i.e. check wiring connection, check fuses, physical status of component etc.)	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter Ear Muffler/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Hand glove Helmet Instrument air supply system

			Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Monkey plier Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Metric) Open End Spanner Set (Imperial) Open End Spanner Set (Metric) Operations Manual Overall Phase tester Philips Screwdriver set Pipe wrench set (8”/12”) Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter Solder sucker Soldering / de soldering station

			Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals

			Logbook Handbooks Design Books/ Sheets Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4
LU 3: Diagnose fault	**The trainee will be able to:** Confirm system isolations, where appropriate, in accordance with the requirements. Disconnect suspected faulty components in accordance with the work plan Inspect system equipment, components and accessories for obvious faults in accordance with the	Understand basic Electrical/ Electronic devices and circuits (i.e Series & parallel circuits) Understand and interpret P&ID/ IFCD. Understand and interpret the electrical / electronic circuit diagrams. Explain the testing of electrical / electronic components using test equipment. (i.e. transistors, diodes, amplifiers etc.) Understand functionality of process instruments. (i.e. D/P transmitter, control valve, solenoid valve etc.) Identify faults in electronic cards (i.e. fuse below, dry solder, component burnout etc.) Understand electrical wiring and standards (i.e. domestic wiring, industrial wiring etc.) Describe Standard safety procedures and safe practices in	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter Ear Muffler/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles

	work plan. Identify appropriate fault finding / diagnostic techniques to determine the fault in accordance with the work plan. Carryout Test and measurement in accordance with manufacturer's instructions and job requirements.	process industry (i.e. use of PPEs) Understanding of system parameters (normal & abnormal). Understand fault diagnosis techniques (i.e. check wiring connection, check fuses, physical status of component etc.)	Grip Pliers Hand glove Helmet Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Monkey plier Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Metric) Open End Spanner Set (Imperial) Open End Spanner Set (Metric) Operations Manual Overall Phase tester Philips Screwdriver set Pipe wrench set (8"/12") Printer Safety goggles Safety harness belt Safety Helmet Safety mask

			Safety Shoes Side cutter Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape

			Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4
LU 4: Determine cause of fault/ Perform root cause analysis	**The trainee will be able to:** Collect relevant data regarding the fault Asses the acquired information for root cause analysis Make conclusion about	Knowledge and explaining reasons of fault occurred (i.e. loose connection, corrosion, line blockage etc.)	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter

	the nature and cause of the fault from available evidence & generate report		Earmuffs/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Hand glove Helmet Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Monkey plier Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Metric) Open End Spanner Set (Imperial) Open End Spanner Set (Metric) Operations Manual Overall Phase tester Philips Screwdriver set

			Pipe wrench set (8”/12”) Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Number strips Permanent marker

			PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4

Examples and illustrations

Electronic Testing Equipment and Their Types

The testing equipment used to detect faults in the operation of electronic devices by creating stimulus signals and capture responses from electronic devices under test is known as electronic test equipment. If any faults are detected, then identified faults can be traced an rectified using electronic testing equipment. Most often all electrical and electronic circuits are tested and troubleshooted to detect faults or abnormal functioning if any.

Basic Electronic Testing Equipments

https://www.elprocus.com/types-of-electronic-testing-equipments/

Therefore, testing equipment is necessary to find and analyze the circuit conditions, for checking electronic test equipment and maintenance in various industries. Many industries utilize different types of electronic test equipment ranging from the very simple and inexpensive to complex and sophisticated ones.

References:

https://www.elprocus.com/types-of-electronic-testing-equipments/
https://medium.com/@Adamu67981783/maintenance-and-repair-of-electronics-equipment-stp-221-4fe287c5208e

Process Control – Understanding the Basics

The difference between good control and bad control is the difference between success and failure. Process control begins with understanding your process variables. In manufacturing, a wide number of variables from temperature to flow to pressure can be measured simultaneously. All of these can be interdependent variables in a single process. Controlling each variable manually would be difficult, time-consuming, prone to mistakes and potentially hazardous. Fortunately, process control simplifies complex tasks, reduces variability and ensures the safety of your workers and equipment.

References:

http://www.mgnewell.com/wp-content/uploads/2016/05/Process-Control-Understanding-the-Basics.pdf
https://www.pacontrol.com/download/Process%20Control%20Fundamentals.pdf

Testing Electrical and Electronics Components and Devices

We all know the rule and importance of “Troubleshooting” in Electrical and Electronics Engineering. Most EE components and elements used in Electrical and Electronics equipments, devices and instruments are common in their functions and operations.

To be a good analyzer and troubleshooter, you must know the following basic techniques and has good skills in Electrical and Electronics troubleshooting, design and analyzing electric / electronic circuits. For this purpose, we have started a multimerer tutorial where we will use DMM (Digital Multimeter) and AVO Meter (Ampere-Voltage-Resistance Meter) or Multimeter (Digital/Analog) to test different electrical / electronics devices, instruments and components to find their terminals and condition such as are are they short, open, good or faulty.

In this basic multimeter tutorial, We will use digital and analog multimeter to check the following electrical and electronic components, devices, tools and instruments:

- Cable and Wires
- Switch/Push Buttons
- Fuse
- Capacitors & Inductors
- Resistors & Burnt resistors
- Diodes and LED
- Battery
- Transistors
- Relays

https://www.electricaltechnology.org/2014/01/testing-electrical-and-electronics-components-with-multimeter.html

In troubleshooting, we use different kinds of basic Electrical and Electronics Engineering Tools but the main and important tool is Multimeter. Now we will check the above mentioned components and devices with this tool one by one.

References:

https://www.electricaltechnology.org/2014/01/testing-electrical-and-electronics-components-with-multimeter.html
http://www.talkingelectronics.com/projects/Testing%20Electronic%20Components/TestingComponents.html

Instrumentation for Process Control

While sensors and valves are important in all aspects of engineering, they assume greatest importance in the study of automatic control, which is termed process control when applied in the process industries. Process control deals with the regulation of processes by applying the feedback principle using various computing devices, principally digital computation. Process control requires sensors for measuring variables and valves for implementing decisions. Therefore, the presentation of this material is designed to complement other learning topics in process control.

References:

http://www.pc-education.mcmaster.ca/Instrumentation/go_inst.htm

https://www.instrumentationtoolbox.com/2011/01/piping-and-instrumentation-diagrams-p-4.html

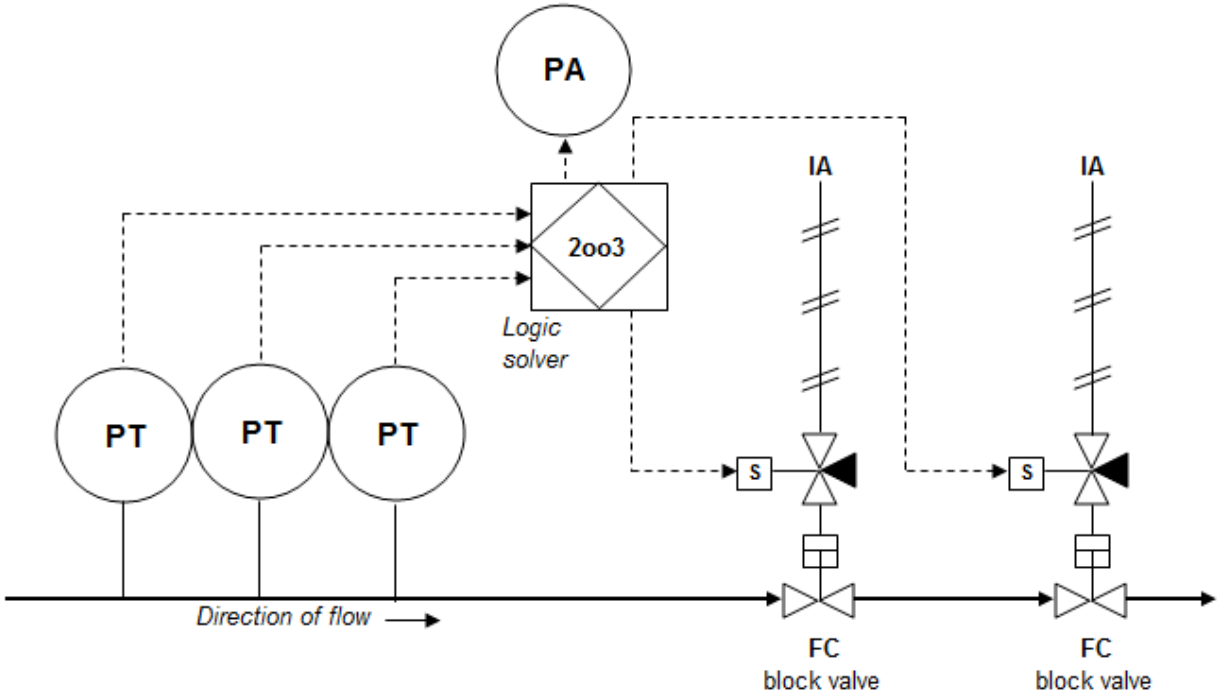
What is process variable and types of process variables?

Instruments are used to monitor and control a process to keep the process within a correct limit. The parameters or quantities that we wish to control at the correct limit are called Process Variables.A variable is something that can vary or change. Because process variables can and do change, instrumentation systems measure the variable then control the variable to keep the variable within the given limits.

Pressure, Temperature, Flow are the main three process variables in industries. The level is another process variable in industries.

Pressure variable:

Pressure is a term used to describe the amount of force applied to a specific unit area. Below shows a flow channel of fluid from a compressor.

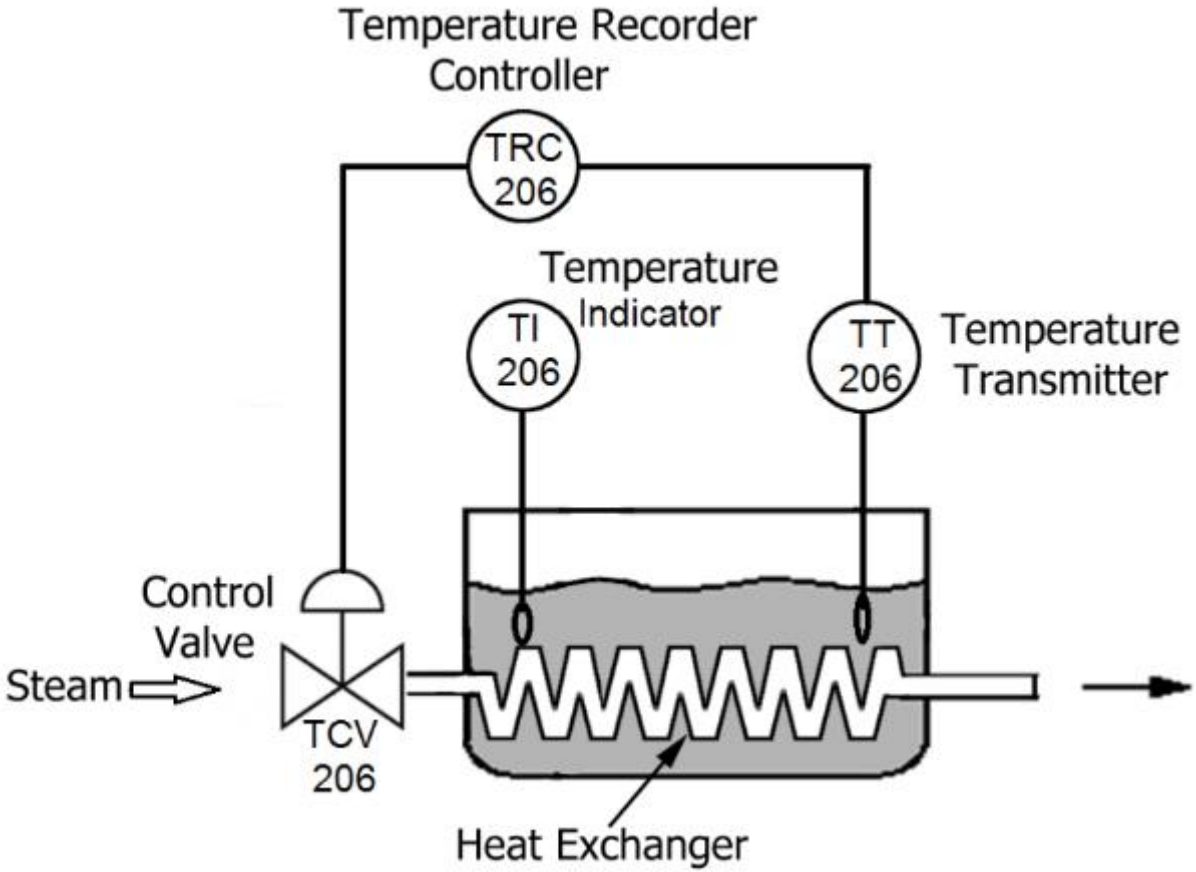


https://automationforum.in/uploads/default/original/2X/2/2bafb227149e3e4d8cfb2d43e04e3263029c8d1c.png

If you open the block valve, air is released to the atmosphere, so the pressure inside the receiver decreases. If you close the control valve, you keep the air inside the receiver and the pressure increases. The process variable that we are controlling is called PRESSURE.

Temperature variable:

Temperature is a measurement of how hot or how cold an object is. Below figure shows a temperature control unit.

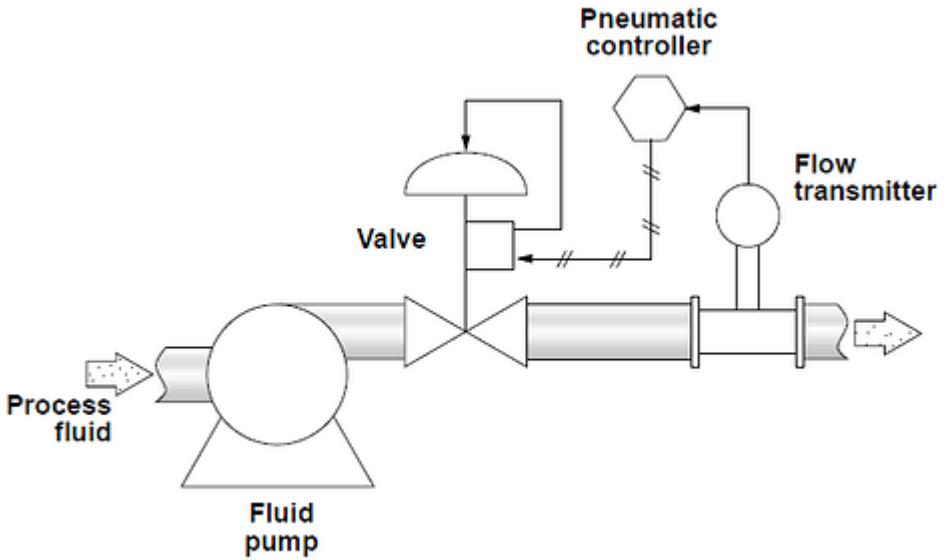


https://automationforum.in/uploads/default/original/2X/2/2c7f338b01c72482703de86ff71ed052cc6881f3.png

Water in the vessel is heated by the heat exchanger. Measuring the temperature the steam flow to the exchanger is controlled. Temperature changes when the amount of steam is changed. The process variable is called Temperature.

Flow variable:

Flow is the movement of fluid inside a pipe in a given direction. Figure below shows the flow control loop.

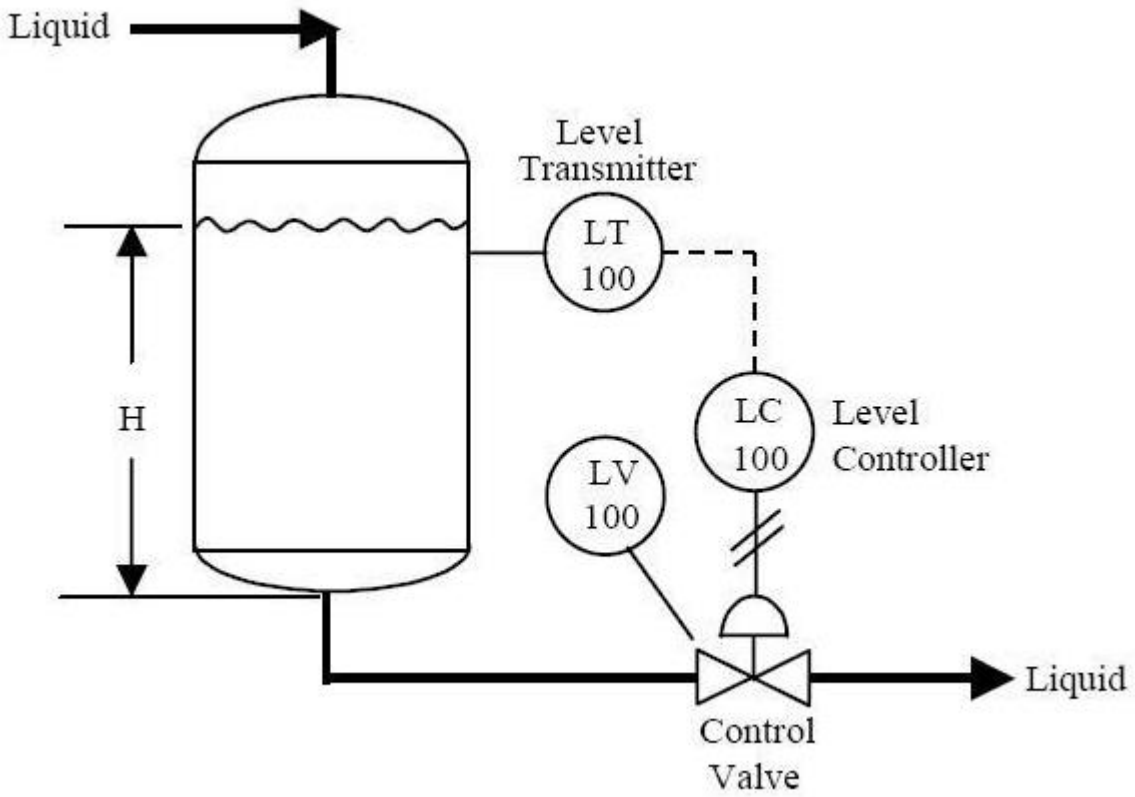


https://automationforum.in/t/flow-control-loop-basics/2708

A valve in the flow channel controls the flow through the pipeline. The greater the valve opening the greater the water flow inside the pipe. Here we are controlling the flow the fluid passing through the pipeline, so the process variable is flow.

Level variable:

The level in the tank change up and down depending up the fluid in the tank. A control valve is installed in the output line to control the level of the tank.



https://automationforum.in/uploads/default/original/2X/2/2aa8b127ae2b4a2326f2117b970f88537bb8cee0.JPG

The process variable is level. You can change the level by closing or opening the control valve. If you close the valve, the level increases. If you open the valve, the level decreases.

Reference:

https://automationforum.in/t/what-is-process-variable-and-types-of-process-variables/2818

Electrical wiring & Standards

Electrical power is transferred from generating stations to consumers at different voltage levels. Electrical power can be considered just like gas or water and same rule applies to its distribution i.e. proper pipeline and associated valves/switches.

Electrical wiring is a proper calculation-oriented process and wiring of every installation/facility varies according to its requirements and expectations. We will discuss the performance needs and protection schemes that should be installed within a good electrical wiring system of a home.

Following components are necessary for an efficient electrical wiring system:

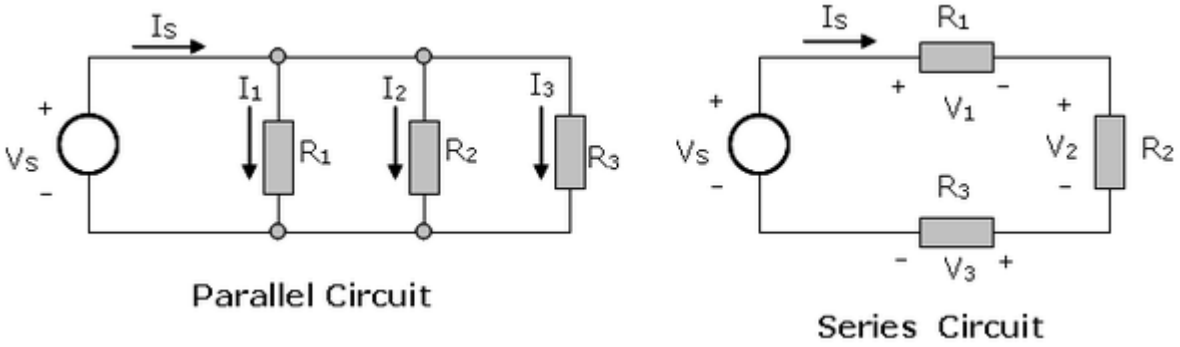
- Live and neutral connections from energy meter to the main consumer unit. A split consumer unit is also installed for more redundancy and user-friendly operations.
- Proper circuit breakers are part and parcel of a successful electrical supply system. Ring type circuits are installed for feeding the main sockets of consumer units.
- Lighting circuits are considered an important part of wiring system and they are radial in nature (most of the time). Miniature circuit breakers of proper rating (usually 6 amperes) are also installed for the protection purpose.
- Incomer to consumer unit grounding connections.
- Heavy duty electrical wiring backed by dedicated breakers (radial) for high power equipment like HVAC, cookers, heavy duty geysers etc.
- Two-way switches as desired.
- Outdoor connections (outside the premises) are also used for lighting purposes. Rating of the breaker governing these circuits should be tightly close to the maximum load to avoid power theft (in case).
- Very high-power equipment like storage heating equipment should be powered directly by the consumer unit.

Different Types of Electrical Wiring Systems

- Cleat wiring.
- Wooden casing and capping wiring.
- CTS or TRS or PVC sheath wiring.
- Lead sheathed or metal sheathed wiring.
- Conduit wiring.

Series & Parallel Circuit

The main **difference between series and parallel circuits** is that, in **series circuits**, all components are connected in **series** so that they all share the same current whereas, in **parallel circuits**, components are connected in **parallel** so that they all have the same potential **difference between** them



https://www.quora.com/What-is-the-difference-between-a-series-circuit-and-a-parallel-circuit

Color coding:

Color coding is an agreed upon standard and should be followed in every electrical wiring. A separate and distinguishable color is assigned to every conductor’s insulation and it aids in identification and fault clearance of a circuit.

Old Cable Colour Code		
	Single Phase	Three Phase
Phase Conductor (Line)	Red or Yellow or Blue	Line 1 Red Line 2 Yellow Line 3 Blue
Neutral Conductor	Black	
Protective Conductor (Earth)	Green-and-Yellow	

New Cable Colour Code		
	Single Phase	Three Phase
Phase Conductor (Line)	Brown	Line 1 Brown Line 2 Black Line 3 Grey
Neutral Conductor	Blue	
Protective Conductor (Earth)	Green-and-Yellow	

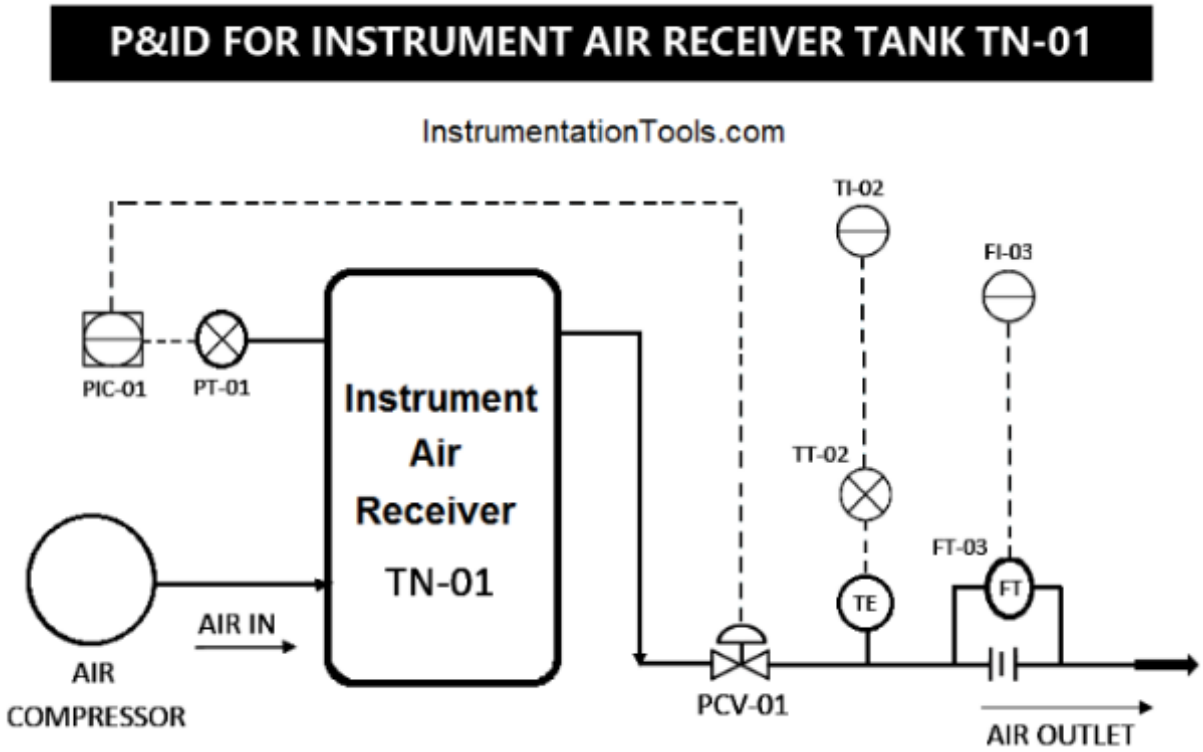
https://elise.ema.gov.sg/safety/about.html

Reference:

http://engineering.electrical-equipment.org/safety/domestic-electrical-wiring-protection.html

Instrumentation loop Diagram

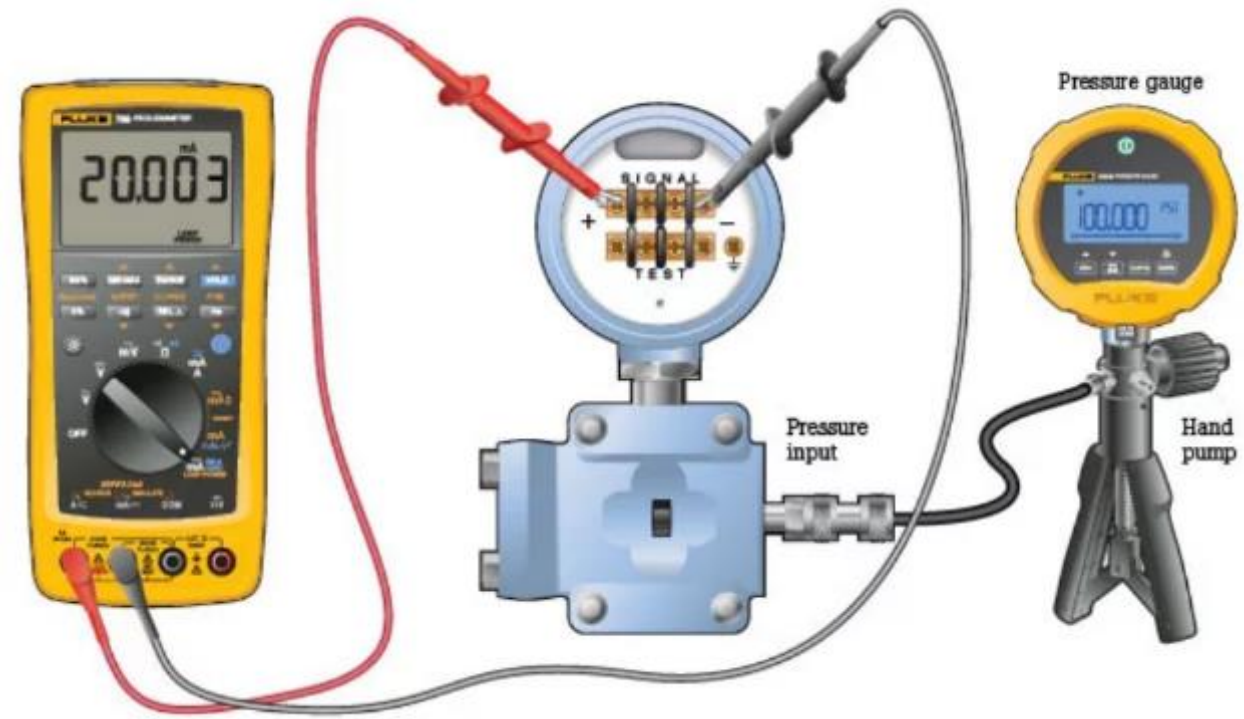
Instrumentation diagrams are used for understanding the process system. P&ID that is Piping and **instrument diagrams** or Process **instrumentation diagrams** show you each **loop** in the system, the **instruments** that comprise **loop** and identify all process variables. ... **Instrument Loop Diagrams** are used for this purpose.



https://instrumentationtools.com/instrument-loop-diagram/

Instrument Loop Testing

Loop check is an operational check of a control **loop**. Intended to find out the deficiencies in control **loop**/ field interface/ HMI. **Loop** checking is the final stage of a project commissioning. We can simply describe **loop** checking is a process to conform that a system works good as we planned

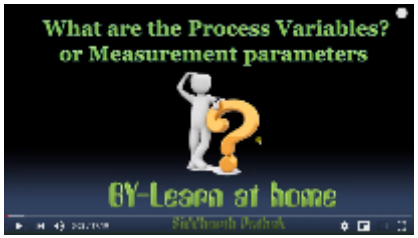
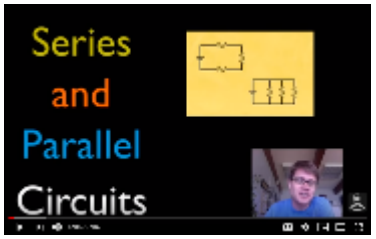


https://www.fluke.com/en-us/learn/best-practices/test-tools-basics/process-tools/using-loop-power-for-process-instrument-and-4-20-ma-loop-testing

Reference:

http://ocw.ump.edu.my/pluginfile.php/11228/mod_resource/content/1/ST%20Guidelines%20For%20Electrical%20Wiring.pdf

Videos:

	Topic	Hyperlink
	what are the process variables in instrumentation?	https://www.youtube.com/watch?v=HQbOE1pTfn0
	Series and Parallel Circuits	https://www.youtube.com/watch?v=x2EuYqj_0Uk
	LOOP TEST OF DIFFERENTIAL PRESSURE TYPE LEVEL TRANSMITTER	https://www.youtube.com/watch?v=Pl9X43ur9vU

PRECISION INSTRUMENTATION

Module-4
LEARNER GUIDE
National Vocational Certificate Level 4

Version 1 - November, 2019

Module 4: 0714001040 Carryout repair & maintenance of instruments

Objective of the module: The aim of this module is to develop advanced knowledge, skills and understanding to carryout repair & maintenance of instruments.

Duration: 150Hrs **Theory:** 30Hrs **Practical:** 120Hrs

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU 1: Perform Scheduled Maintenance	**The trainee will be able to:** Prepare maintenance schedule according to the relevant operational manual Fill up/ check maintenance schedule according to SOP Prepare job list of scheduled shutdowns Arrange tools and equipment according to the scheduled maintenance job list Raise work permit for each job Perform maintenance activity Conduct final inspection according to SOP Clean & store work area & tools to ensure good housekeeping Provide feedback to the	Knowledge and understanding of all types of maintenance as per SOP i.e. scheduled, corrective, preventive and documentation etc.	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter Earmuffs/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Grease gun Hand glove Helmet Hacksaw Frame Hammer (Ball Peen 250gm) Instrument air supply system Insulation Tester Lan cable cutter

	concerned personnel Prepare maintenance report of performed job Ensure good housekeeping & safe working practices at all times		Lugs punch (up to 10mm) Masonry Drill Set Monkey plier Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Metric) Open End Spanner Set (Imperial) Open End Spanner Set (Metric) Operations Manual Overall Offset Ring Spanner Set (Metric) Oil funnel Oil spray gun Phase tester Philips Screwdriver set Pipe wrench set (8”/12”) Pin punch set Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes

			Side cutter Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40

			Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4
LU 2: Perform Preventive Maintenance	**The trainee will be able to:** Prepare inspection plan for preventive maintenance Perform inspections according to plan Perform Servicing of equipment Ensure good housekeeping & safe	Knowledge of recording the ongoing maintenance in the Equipment History Card. Knowledge and understanding of equipment consumables/spares involved in preventive maintenance of a piece of instrument. Knowledge of inventory maintenance in order to ensure availability of necessary parts.	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter Earmuffs/ Plug Electrician tool kit

	working practices at all times		Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Grease gun Hand glove Helmet Hacksaw Frame Hammer (Ball Peen 250gm) Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Masonry Drill Set Monkey plier Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Metric) Open End Spanner Set (Imperial) Open End Spanner Set (Metric) Operations Manual Overall Offset Ring Spanner Set

			(Metric) Oil funnel Oil spray gun Phase tester Philips Screwdriver set Pipe wrench set (8”/12”) Pin punch set Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter Solder sucker Soldering / de soldering station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves

			Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black)

			File covers Box Files Printing paper A4
LU 3: Perform Corrective Maintenance	**The trainee will be able to:** Prepare plan for corrective maintenance Arrange alternate/ backup system at breakdown Study the log sheet/ history card thoroughly before corrective maintenance Arrange tools and equipment according to the job Raise work permit for each job Perform maintenance according to the SOP Check/ Run as per standard Provide feedback to the concerned personnel Prepare maintenance report of performed job Ensure good housekeeping & safe working practices at all times	Knowledge of various fault-finding and resolving/fixing techniques. Knowledge of P&ID and IFCD loop drawings. Knowledge of use of an appropriate test equipment necessary during operations, such as: multimeter& calibrator etc. Knowledge of all necessary documentation involved in process.	Adjustable spanner set Allen key set (inch/mm) Bench vice 4 inch Bench Vice 6 inch Computer Digital Leak tester Digital multimeter Earmuffs/ Plug Electrician tool kit Flat Screw driver set Flat Screw driver set General Tools kit Goggles Grip Pliers Grease gun Hand glove Helmet Hacksaw Frame Hammer (Ball Peen 250gm) Instrument air supply system Insulation Tester Lan cable cutter Lugs punch (up to 10mm) Masonry Drill Set Monkey plier

			Multimedia projector Nose plier Offset Ring Spanner Set (Imperial) Offset Ring Spanner Set (Metric) Open End Spanner Set (Imperial) Open End Spanner Set (Metric) Operations Manual Overall Offset Ring Spanner Set (Metric) Oil funnel Oil spray gun Phase tester Philips Screwdriver set Pipe wrench set (8”/12”) Pin punch set Printer Safety goggles Safety harness belt Safety Helmet Safety mask Safety Shoes Side cutter Solder sucker Soldering / de soldering

			station Soldering Machine Speakers Tape measures (0~50m) Test probes Tube cutter/ bender Watchmaker Screwdriver set Wire Cutter Work Bench (8ftx4ftx3ft) Cable tie (assorted sizes) Contact cleaner Cotton gloves Cotton waste Emery paper Fuses 0.01A to 20A Insulation tape Number strips Permanent marker PVC flexible pipe PVC tape Silicone Sealants & Adhesive Soldering wire (70/30) Teflon tape Emery paper (200-400) WD-40 Different Tags and Locks Equipment Maintenance Manuals

			Logbook Handbooks Design Books/ Sheets Pencils Erasers Pencil Sharpeners Paper Cutter Scissors Color Pencils White chart paper White Board Markers (red, blue, green, black) Permanent markers (black) File covers Box Files Printing paper A4

Examples and illustrations

MAINTENANCE CONCEPTS

Preventive maintenance (PM) is a time-based or interval-based planned service to detect and prevent potential failures and extend the life of equipment. It is planned maintenance of a plant and its equipment that is designed to improve equipment life and avoid any unplanned maintenance activity. PM includes painting, lubrication, cleaning, adjusting, and minor component replacement to extend the life of equipment and facilities.
Predictive maintenance (PdM) is the application of modern analytical techniques to decrease both the cost of maintenance and production downtime by means of early identification of imminent equipment failure (achieved through monitoring changes n condition). Its purpose is to minimize breakdowns and excessive depreciation. In its simplest form, predictive maintenance can be compared to the service schedule for an automobile. It is the key to reliability and integrity for a company.

General

Preventive maintenance has been around for many years. For instance, our ancestors sharpened their knives, packed animal fat in the hubs of wagons, cleaned pots after dying fabrics, and oiled their muskets. This is because, to keep equipment functional, maintenance is required.

In the US, the average equipment breakdown rate was about 20% in the 1950s, but in the 1990s, the rate went to about 60%. Why? The operator was taken out of the equation due to specialization. This meant fewer people were looking at the equipment less often.
Preventive maintenance is performed by:

- The production team through daily interaction with the equipment (touching, listening, etc.). This is called *Type 1 PM*.
- Maintenance through periodic and more complex tasks. This is called *Type 2 PM*.

Necessity for Preventive Maintenance

Why we do preventive maintenance:

- To minimize the number of failures of critical equipment
- To reduce the loss of production from equipment failures
- To acquire meaningful data from the equipment history so we can make more intelligent decisions on repair, overhaul, and replacement to maximize the return on capital employed
- To provide tasks for planning and scheduling for minimal production disruption
- To promote better safety, health, and environmental conditions for our workforce
- To reduce overtime costs and provide more economical use of maintenance mechanics due to working on a scheduled basis instead of an emergency basis to repair breakdowns
- To use timely, routine repairs to bring about fewer large-scale repairs
- To reduce product rejects, rework, and scrap through better overall equipment condition
- To identify equipment with excessive maintenance costs, indicating the need for corrective maintenance, operator training, or replacement of obsolete equipment
- To better care for assets and increase the life span of assets, thereby eliminating premature replacement of machinery and equipment
- To increase the life span of equipment

Preventive maintenance includes:

- Non-destructive testing
- Periodic inspections
- Lubrication tasks
- Preplanned maintenance activities

- Minor repairs

Major repairs are considered *corrective maintenance* and should be captured accordingly. Just remember that 25% of all PM is unnecessary, and 20% cause issues. Although PM can include cleaning, lubrication, testing, and scheduled replacements, the most important task in PM is *inspection*. Inspection helps to detect any early signs of changes in condition, which may be a warning of impending failure.

Risks of Preventive Maintenance

Preventive maintenance is not without risk. Sometimes, PM can cause failure soon after the PM is performed. Typically, the following are the types of errors or damage that can occur during PM and other types of maintenance outages:

- Damage to nearby equipment during a PM task
- Damage to the equipment receiving the PM task, to include such things as:
    - Damage during the performance of an inspection, repair, adjustment, or installation of a replacement part
    - Installing material that is defective, incorrectly installing a replacement part, or incorrectly reassembling material
- Reintroducing infant mortality by installing new parts or materials (parts with early failure rates)
- Damage due to an error in reinstalling equipment into its original location

Optimizing Preventive Maintenance

Preventive maintenance can always be improved. The following are ways to perfect maintenance:

1. Eliminate low-value tasks (waste)
2. Review PM-related failures shortly after they occur
3. Replace intrusive PM tasks with non-intrusive Condition based maintenance **(CBM)** or predictive maintenance
4. Clearly develop Type 1 and Type 2 PM tasks
5. Align Environmental Health Safety (**EHS**) requirements with specific PM tasks
6. Review PM procedures regularly to improve them

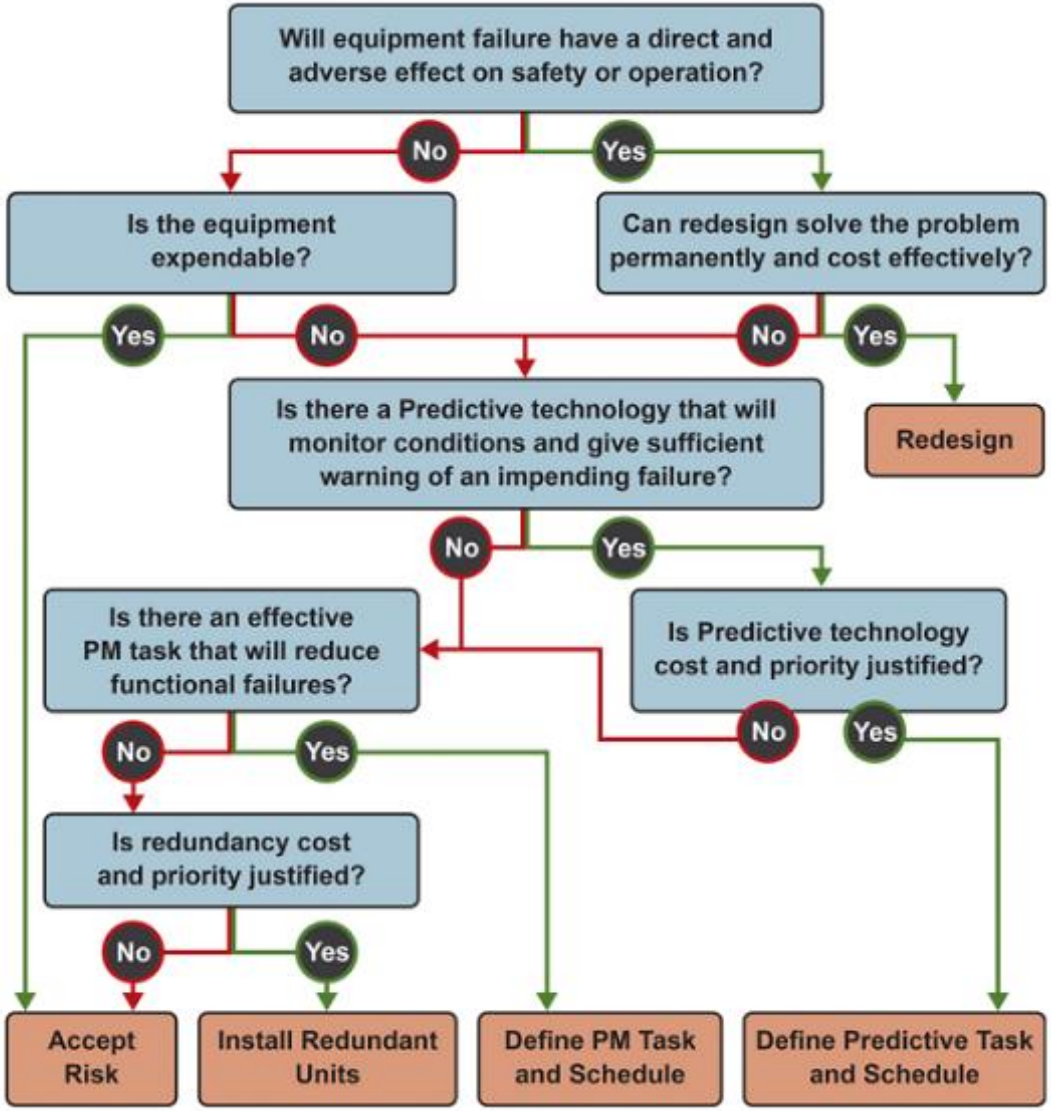

Will equipment failure have a direct and adverse effect on safety or operation?
No
Yes
Is the equipment expendable?
Can redesign solve the problem permanently and cost effectively?
Yes
No
No
Yes
Redesign
Is there a Predictive technology that will monitor conditions and give sufficient warning of an impending failure?
No
Yes
Is there an effective PM task that will reduce functional failures?
Is Predictive technology cost and priority justified?
No
Yes
No
Yes
Is redundancy cost and priority justified?
No
Yes
Accept Risk
Install Redundant Units
Define PM Task and Schedule
Define Predictive Task and Schedule

Figure 1: Choosing Reactive, Preventive, or Predictive Maintenance

Making PM Successful

The key to a successful preventive maintenance program is scheduling and execution. Scheduling should be automated to the maximum extent possible, which may mean having to update your systems with meter information. Priority should be given to preventive maintenance and a very aggressive program to monitor work and ensure it is completed according to a schedule that should be in place.
Start with your most critical equipment first and use it as a showcase to prove the value of PM. Before you start, develop baseline costs and failures to be able to compare to later. Three forms of data are needed to develop PM:

1. Manufacturer's recommendations
2. A review of breakdowns and repairs
3. Consultation with operators, mechanics, and supervisors

Inspections

Frequency of inspections is determined by the type of equipment, its age, its condition, and the consequences of failure. Most inspection frequencies are:

Table 1: Inspection Frequencies per Type of Preventive Maintenance

Inspection Frequency	Type
Daily	more suitable for Type 1
Weekly	more suitable for Type 1
Biweekly	more suitable for Type 2
Monthly	more suitable for Type 2
Quarterly	more suitable for Type 2
Semiannually	more suitable for Type 2
Annually	more suitable for Type 2

Reliability Measurement

The mean time between failures (MTBF) is a reliability measurement calculated by dividing the number of failures by the operating time. It usually is stated in hours. For most construction equipment, use meter hours. MTBF is calculated as

$$\frac{\text{total number of failures}}{\text{total operating hours}} =$$

i.e.: 15 failures in 12,000 hours = MTBF is 800 hours

Maintenance field uses of MTBF are:

1. Establishing failure-finding task frequency
2. Aiding in the determination of whether scheduled maintenance is worth executing
3. Assisting in determining a protective piece of equipment's desired availability

Preventive Replacements

To schedule preventive replacements, you must have these three conditions:

1. The total cost of replacement (parts, labor, and lost production) is less than the cost of failure.
2. You have a good idea of the average time between failures (MTBF) and can reasonably predict preventive replacement intervals.
3. The potential consequences of failure (other than costs) are far greater than the cost and loss required by preventive replacement.
    - Predetermined parts replacement should be minimal and done only where statistical evidence clearly indicates wear-out characteristics that can be predicted.

Lubrication

Lubrication is the essential for mechanical equipment. It is science, not an art. There are three primary types of lubrication:

- Lube oils
- Solids (mica, graphite, molybdenum disulfide, etc.)
- Greases (lube oil with organic or inorganic thickener)

Lubes are determined by their viscosity and their additives for service.
It only takes 20 ppm of water to halve the life of a bearing. Lube containers (drums) left outside collect moisture from the change in temperature, which can contaminate the contents. All fill containers should be sealed.
Over-greased bearings are often in more neglect than under-greased ones. Manufacturers specify lube amounts, but we often ignore them. This can lead to equipment failure. Lubrication check sheets contain the lubrication requirements of the equipment for the specified PM frequency. The mechanical, electrical, and instrumentation check sheets contain the steps required to perform a thorough examination of your equipment to identify any existing or potential equipment problems.

Improving Predictive and Preventive Maintenance

Steps to improving predictive and preventive maintenance (PPM) are as follows:

1. Acknowledge there is an issue or cost/impact of not doing PPM

    - Expensive parts shipment
    - Unscheduled downtime
    - Costly parts and materials
    - Excessive overtime
    - Missed deliveries

2. Establish a PPM or reliability policy

    - Define what PPM is and is not
    - Identify management, operation, and maintenance roles in supporting PM and PdM
    - Describe measures and monitoring processes
    - Have the policy signed and issued by management

3. Gain operational buy-in

    - Educate others on the need for commitment
    - Provide support and assistance for access to equipment
    - Provide a willingness to monitor and track metrics (results and processes)

4. Establish an equipment data record to document information

    - Model and type
    - Physical location of equipment
    - Name plate data and serial number
    - Asset or equipment number
    - Critical spare parts list
    - Update and modification records
    - Manufacture date
    - Modifications and dates

5. Assign PM type and criticality

- Differentiate between Type 1 (operator-performed) and Type 2 (maintenance-performed) PM tasks
- Based on failure consequences, identify the most critical equipment
- Determine which path is most logical: PPM, run-to-failure, or redesign

6. Develop checklists and job plans for PM

- Train internal personnel or contract PdM services
- Develop a consistent format
- Identify running versus stationary for scheduling
- Solicit feedback (actual condition), findings, comments, and corrections
- Define pass/fail (go/no-go) criteria for objective inspections
- Offer responses (okay, work order, adjusted)

7. Develop PM routes and work orders

- Create a work order format; use the Computerized Maintenance Management Systems (**CMMS**) format
- Organize PPM by scheduling for close proximity

8. Develop PM schedules (based on frequencies)

- Organize based on frequency
- *Examine manufacturer's recommendations along with failure frequencies
- Continue to change frequencies (monitor for condition changes)

9. Maintain equipment history and develop a close-out process

- Develop a process to record comments and findings
- Choose findings/activities that will initiate changes/review

10. Develop a reporting process

- Analyze PPM results
- Display and report monthly progress
- Track corrective actions from PPM inspections (**CP**, Cost of Preventive Maintenance)

- Develop a method to respond to problems or variances
- Have metrics in place
    1. % PM of total maintenance hours
    2. % PM schedule compliance
    3. MTBF on critical equipment
    4. % PM review (revised PM)
    5. % Corrective from PPM
    6. PM versus CM ratio

11. Organize PPM (suggested)

- PPM discipline is improved by dedicated personnel
- Assign most experienced tasks

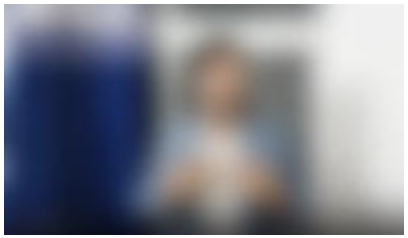
A quality preventive maintenance program requires a highly motivated preventive maintenance crew. To provide proper motivation, the following activities are suggested:

- Establish inspection and preventive maintenance as a recognized, important part of the overall maintenance program
- Assign competent, responsible people to the preventive maintenance program
- Monitor and follow-up on tasks to ensure quality performance and to show everyone that management does care
- Provide training in precision maintenance on specific equipment
- Set high standards
- Publicize reduced costs with improved up-time and revenues, which are the result of effective preventive maintenance
- Measure and audit

Reference:

https://www.myodesie.com/wiki/index/returnEntry/id/2965

Videos:

	Topic	Hyperlink
	PREVENTIVE MAINTENANCE	https://www.youtube.com/watch?v=qE-djQuO8LQ
	Breakdown Maintenance - Scheduled Maintenance - Preventive Maintenance - Predictive Maintenance	https://www.youtube.com/watch?v=TcCE9pBxe5Q
	Corrective Action' VS 'Preventive Action	https://www.youtube.com/watch?v=11669QoKDyc

PRECISION INSTRUMENTATION

Module-5
LEARNER GUIDE
National Vocational Certificate Level 4

Version 1 - November, 2019

Module 5: Perform advanced communication

Objective of the module: The aim of this module is to develop advanced knowledge, skills and understanding to perform advanced communication.

Duration: 40 Hrs **Theory:** 20Hrs **Practical:** 20Hrs

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU 1: Demonstrate professional skills	**The trainee will be able to:** Communicate within and outside the organization using effective communication skills Use different modes of communication to communicate e.g: presentation, speaking, writing, listening, visual representation, reading etc Use specific business terms used in the market Upgrade professional skills by attending trainings, webinars, conferences etc.	Knowledge and understanding about types of communication skills (i.e. Verbal communication, nonverbal cues speak volumes, visual communication) Knowledge and understanding about types of an organizational communication (i.e. Formal and informal communication Directional communication Internal and external communication Oral and written communication)	Pen/Pencils Papers Printers Notebook/ notepads Computer Multimedia Projectors USB White board Marker Dusters Display printing sketches /diagrams White board Board marker Duster Computer Projector
LU 2: Provide trainings at	**The trainee will be able to:**	Knowledge and Understanding to identify the working items.	Pen/Pencils Papers

workplace	Identify the training requirement of the working teams Conduct formal or informal training sessions to transfer knowledge and skills Manage the Training as per the needs of workplace Measure the efficiency of the Training Assess Trainees feedback.	Knowledge and Understanding to conduct formal sessions to transfer skills. Knowledge and Understanding to manage the training as per the needs of workplace. Knowledge and Understanding to measure the efficiency of job.	Printers Notebook/ notepads Computer Multimedia Projectors USB White board Markers Dusters Display printing sketches /diagrams White board Board marker Duster Computer Projector

PRECISION INSTRUMENTATION

Module-6
LEARNER GUIDE
National Vocational Certificate Level 4

Version 1 - November, 2019

Module 6: Establish and maintain the occupational health and safety system

Objective of the module: The aim of this module is to develop advanced knowledge, skills and understanding to establish and maintain the occupational health and safety system.

Duration: 40 Hrs **Theory:** 15 Hrs **Practical:** 25 Hrs

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU 1: Organize consultation process	**The trainee will be able to:** Identify and invite relevant personnel or other representative personnel into the development and maintenance processes. Handle issues raised through consultation according to issue resolution procedures. Verify results from the consultation process and make it available to relevant personnel.	Knowledge and understanding of personal development in an organization. Knowledge and understanding about how to perform maintenance processes. Knowledge and understanding about Handling issues Knowledge and understanding about how to analyze accident records. Knowledge and understanding about how to analyze ill health records.	Pen/Pencils Papers Printers Notebook/ note pads Computer Multimedia Projectors USB White board Markers Dusters PPE'S
LU 2: Design Occupational Health and Safety framework	**The trainee will be able to:** Identify hazards and risks correctly and confirm according to occupational health and safety legislation, codes of practice and prevailing trends.	Knowledge and understanding about how to Identify hazards and risks correctly Knowledge and understanding about how to develop procedure for ongoing identification of hazards, risks and integrated within work systems and procedures. Knowledge and understanding of laws and regulations on Health, hygiene and safety. Knowledge and understanding of standard operating procedures for Health, hygiene and safety.	Pen/Pencils Papers Printers Notebook/ note pads Computer Multimedia Projectors USB

	Develop procedure for ongoing identification of hazards and risks and integrated within work systems and procedures Develop occupational health and safety policies line with relevant legislation Incorporate and define occupational health and safety responsibilities and duties into job descriptions/statements Provide adequate resources in a timely and consistent manner Develop and implement measures to control assessed risks in accordance with the hierarchy of control, relevant occupational health and safety legislation, codes of practice and trends Implement interim solutions until a permanent control measure Record details clearly and efficiently according to organization policy and procedures and	Knowledge and understanding of operations and activities typically undertaken in the workplace. Knowledge and understanding of adequate resources in a timely and consistent manner. Knowledge and understanding about how to develop and implement measures to control assessed risks in accordance with the hierarchy of control, relevant occupational health and safety legislation, codes of practice and trends. Knowledge and understanding of Implement interim solutions until a permanent control measure. Knowledge and understanding about how to record details clearly and efficiently according to organization policy, procedures and relevant legislation.	White board Markers Dusters PPE'S Local laws and regulations on Health, hygiene and safety Standard operating procedures for Health, hygiene and safety Formats of reports

	relevant legislation		
LU 3: Design and implement an Occupational Health and Safety awareness training program	**The trainee will be able to:** Devise educational information on the occupational health and safety system and make it available to all relevant personnel Provide appropriate training to all relevant personnel to enable the implementation of safety procedures	Knowledge and Understanding about occupational health, Safety system of relevant personal Knowledge and Understanding about how to Implementation of safety procedure	Pen/Pencils Papers Printers Notebook/ note pads Computer Multimedia Projectors USB White board Markers Dusters PPE'S
LU 4: Establish, monitor and maintain Occupational Health and safety system	**The trainee will be able to:** Establish a system for keeping occupational health and safety records in accordance with legislative requirements Work activities are monitored to ensure that hazard identification and risk assessment and control procedures are effectively adopted Inadequacies in hazard identification, risk assessment and established risk control	Knowledge and Understanding about how to establish a system for keeping occupational health and safety records Knowledge and understanding about hazard identification and risk assessment	Pen/Pencils Papers Printers Notebook/ note pads Computer Multimedia Projectors USB

	measures are identified in accordance with the hierarchy of control and reported to designated personnel Amendments to procedures are undertaken through appropriate consultation methods		
LU 5: Establish and maintain a system for accident investigation	**The trainee will be able to:** A system is developed and implemented for reporting and investigation of all accidents/incidents in accordance with the policies and procedures Training is provided to employees responsible for accident investigation for effective implementation of accident investigation policy Policies and procedures for reporting and investigating all accidents/incidents are reviewed and updated as required	Knowledge and Understanding about how to develop a system and implemented for reporting and investigation of all accidents/incidents in accordance with the policies and procedures. Knowledge and Understanding about how to provide training to employees responsible for accident. Knowledge and Understanding about how to Investigate for effective implementation of accident investigation policy. Knowledge and Understanding about how to resolve hazards / Accidents Knowledge and Understanding about how to review policies and procedures for reporting and investigating all accidents/incidents and updated as required	Pen/Pencils Papers Printers Notebook/ note pads Computer Multimedia Projectors USB White board Markers Dusters PPE'S

LU 6: Evaluate the organization's Occupational Health and Safety system and related policies procedures and programs	**The trainee will be able to:** The effectiveness of the occupational health and safety system and related policies, procedures and programs is assessed according to the organization's occupational health and safety policy Improvements to the occupational health and safety system are developed and implemented Compliance with occupational health and safety legislation and codes of practice is assessed to ensure that legal occupational health and safety standards are maintained	Knowledge and Understanding about how to assess effectiveness of the occupational health and safety system and related policies, procedures and programs is according to the organization's occupational health and safety policy Knowledge and Understanding about how to develop improvements to the occupational health and safety system and implementation. Knowledge and Understanding about how to comply with occupational health and safety legislation and codes of practice is assessed to ensure that legal occupational health and safety standards are maintained	Pen/Pencils Papers Printers Notebook/ note pads Computer Multimedia Projectors USB White board Markers Dusters PPE'S Local laws and regulations on Health, hygiene and safety Standard operating procedures for Health, hygiene and safety Formats of reports

Module summary

Module	Learning Unit	Duration
Module 1: Measure Process Variables **Aim:** The aim of this module is to develop knowledge, skills and understanding to measure process variables	**LU 1:** Operate Temperature Measuring Instruments **LU 2:** Operate Pressure Measuring Instruments **LU 3:** Operate Flow Measuring Instruments **LU 4:** Operate Level Measuring Instruments	150 Hrs
Module 2: Set Up Process Controller **Aim:** The aim of this module is to develop knowledge, skills and understanding to set up process controller	**LU 1:** Set up & adjust control loops **LU 2:** Set up & adjust advanced process control loops **LU 3:** Update control programmes **LU 4:** Verify control programmes	150 Hrs
Module 3: Perform Fault Diagnosis **Aim:** The aim of this module is to develop knowledge, skills and understanding for fault finding and diagnosis	**LU 1:** Plan & prepare for fault diagnosis **LU 2:** Verify fault **LU 3:** Find fault **LU 4:** Determine cause of fault	150 Hrs
Module 4: Carry out Repair & Maintenance of Instruments **Aim:** The aim of this module is to develop knowledge, skills and understanding to carryout repair & maintenance of instruments	**LU 1:** Perform scheduled maintenance **LU 2:** Perform preventive maintenance **LU 3:** Perform corrective maintenance	150 Hrs

Module	Learning Unit	Duration
Module 5: Perform Advanced Communication **Aim:** The aim of this module is to develop knowledge, skills and understanding to perform advanced communication	**LU 1:** Demonstrate professional skills **LU 2:** Provide trainings at workplace	40 Hrs
Module 6: Establish & maintain the occupational health & safety system **Aim:** The aim of this module is to develop knowledge, skills and understanding to establish and maintain the occupational health and safety system	**LU 1:** Organize consultation process **LU 2:** Design occupational health and safety framework **LU3:** Design and implement an occupational health and Safety awareness training program **LU4:** Establish, monitor and maintain occupational health and safety system **LU 5:** Establish and maintain a system for accident investigation **LU 6:** Evaluate the organization's Occupational health and safety system and related policies procedures and programs	40 Hrs

Level-4 Short Questions/Answers

Module-1 Measure Process Variables

Questions	Answers
What is the main objective of a process control?	A process control is mainly used in order to control the physical parameters including temperature, pressure, flow rate, force, etc.
What is a process control system?	A process control system is generally used to maintain the parameters such as temperature, pressure, flow rate, force, etc constant in a system.

Why physical parameters are affected?	The physical parameters such as temperature, pressure, flow rate, force, etc in a process control system are affected due to both internal and external disturbances. As a result, constant corrective action is required to keep them at a constant value.
What transducers do?	A transducer basically converts a physical quantity such as temperature, pressure, force, flow rate, etc into electrical form such as voltage and current. A transducer is part of a large circuit. It produces the required output by operating along with several other elements.
What are common safety hazards in a facility?	This list is just a few of the most common safety risks found in a facility: • Slips, Trips, and Falls • Electrical hazards • Chemical hazards • Crane and forklift safety

Module-2 Set Up Process Controller

Questions	Answers
What is derivative controller?	Derivative controller is the controller that is also like high pass filter and is also phase lead controller and it is used to increase the speed of response of the system by increasing the damping coefficient
What is the input of a controller?	Controller is the block in the control system that controls the input and provides the output and this is the first block of the system having the input as the error signal.
What transducer converts?	A transducer basically converts a physical quantity such as temperature, pressure, and force, flow rate, etc. into electrical form such as voltage and current.
How many elements process control system consists?	A typical process control system consists of 4 elements. They are as follows:

	• Process • Measurement • Controller • Control element

Module-3 Perform Fault Diagnosis

Questions	Answers
When preventive maintenance done?	Preventive maintenances are not to be done very frequently, but it is advised, that, the preventive maintenance must be done at least once in the machines life. This imitation is caused due to very high costs of operation of preventive maintenance.
What are the bases of inspection frequency in maintenance?	The frequency of inspection of the processes gets decided on the basis of many factors. A few of them are, stresses experienced, fatigues, dirt, vibrational exposure, susceptibility to lose fittings and also overloading.
Which activities are counts under the periodic inspection?	There are many inspections counted under periodic inspection, namely, visual inspections, tear downs, overhauls and scheduled replacements of parts.
What is the ratio of preventive maintenance and total maintenance in general manufacturing industry?	The ratio of preventive maintenance and total maintenance, in case of primary-metal industry, the ratio is 1 : 2.37 men, in case of machinery manufacturing industry, the ratio is 1 : 2.69 men and in case of general manufacturing industry, the ratio is 1 : 10 men.

Module-4 Carryout repair & maintenance of instruments

Questions	Answers
What are the different types of maintenance?	Traditionally, 5 types of maintenance have been distinguished, which are differentiated by the nature of the tasks that they include: • Corrective maintenance

	• Preventive Maintenance • Predictive Maintenance • Zero Hours Maintenance (Overhaul) • Periodic maintenance (Time Based Maintenance TBM)
How do you define preventive maintenance?	Its mission is to maintain a level of certain service on equipment, programming the interventions of their vulnerabilities in the most opportune time. It is used to be a systematic character, that is, the equipment is inspected even if it has not given any symptoms of having a problem.
What is the difference between corrective and preventive maintenance?	Predictive maintenance tends to include direct measurement of the item. Example, an infrared picture of a circuit board to determine hot spots. While Preventive Maintenance includes the evaluation of particles in suspension in a lubricant, sound and vibration analysis of a machine.
What are the benefits of preventive maintenance?	Following are important benefits of a properly operated preventive maintenance program: • Production capacity is increased and the number of repairs are reduced • Better conservation of assets and increased life expectancy of assets, thereby eliminating premature replacement of machinery and equipment • Reduced overtime costs and more economical use of maintenance workers due to working on a scheduled basis instead of an emergency basis to repair breakdowns • Timely, routine repairs circumvent fewer large-scale repairs • Improved safety and quality conditions for everyone

Level-4 (Multiple Choice Questions)

Module-1 Measure Process Variables

Question	Answer
In optical pyrometer temperature is measured by	a) Photocell principle. b) Thermocouple effect. **c) Comparing the brightness of the source with the brightness of a standard source.** d) Pressure.
The desirable static characteristics of a measuring system are:	a) Accuracy and reproducibility. **b) Accuracy, sensitivity and reproducibility.** c) Drift and dead zone. d) Static error.
The ratio of maximum displacement deviation to full scale deviation of the instrument is called.	a) Static sensitivity. b) Dynamic deviation **c) Linearity** d) Precision or accuracy
Which of the following can be measured by 'Bolometers'?	**a) Thermal radiations** b) Electrical signals c) Optical inputs d) Temperature inputs
The temperature of a furnace can be measured by:	a) Bimetallic thermometer b) Mercury thermometer c) Clinical thermometer **d) Optical pyrometer**
_____can measure only level.	a) Bellow b) Diaphragm **c) Radioactive method** d) Strain gauge
_____can measure pressure directly.	a) Rotameter **b) Bourden tube**

	c) LVDT d) Strain gauge

Module-2 Set Up Process Controller

Question	Answer
The input of a controller is:	a) Sensed signal **b) Error signal** c) Desired variable value d) Signal of fixed amplitude not dependent on desired variable value
Negative exponential term in the equation of the transfer function causes the transportation lag.	**a) True** b) False
A process control system consists of _____.	a) 10 elements b) 6 elements c) 2 elements **d) 4 elements**
A transducer converts _____.	a) mechanical quantity to electrical form b) electrical quantity to physical form **c) physical quantity to electrical form** d) chemical quantity to physical form
A transducer is part of a large circuit and produces the required output.	**a) True** b) False
_____is used to measure pressure directly.	**a) Anemometer** b) Venturimeter c) Orifice d) Rotameter

Module-3 Perform Fault Diagnosis

Question	Answer
The time elapsed from the point the machine fails to perform its function to the point it is repaired and brought into operating condition is known as.	a) Day time **b) Break Down time** c) Faulty time d) Idle time
Total Productive maintenance (TPM) approach has the potential of providing almost a seamless integration between.	a) Production and Quality b) Quality and Maintenance **c) Production and Maintenance** d) Actual
Total productive maintenance aims at**.**	a) Less idle time b) Increase in productivity c) Idle time **d) Zero down time**
(Number of breakdowns / Available machine hours) =	a) Maintenance effectiveness **b) Frequency of breakdown** c) Effectiveness of maintenance planning d) Frequency of productivity
A systematic approach for maintenance is**.**	**a) Problem – Cause – Diagnosis – Rectification** b) Problem– Diagnosis – Cause – Rectification c) Problem – Measure – Diagnosis – Rectification d) Problem– Diagnosis – Measure – Rectification
Belt of an electric motor is broken, it needs	a) Scheduled maintenance b) Preventive maintenance **c) Corrective maintenance** d) Timely maintenance
The following is not a classification of maintenance**.**	a) Corrective maintenance **b) Timely maintenance** c) Scheduled maintenance

	d) Preventive maintenance

Module-4 Carryout repair & maintenance of instruments

Question	Answer
Which of the following is not an important condition for preventive maintenance?	a) Size b) Age c) Location **d) Oils used**
Which of the following is not material handling equipment?	a) Cranes b) Lifts **c) Tongs** d) Hoists
Which of the following are not counted among periodic inspection?	a) Tear downs **b) Oil burnings** c) Overhauls d) Replacement of parts
Preventive maintenance and its application is an expensive process.	**a) True** b) False
Frequency of inspection is not decided on the basis of overloading.	a) True **b) False**
Bearing of the shaft is broken, it needs	a) Scheduled maintenance b) Preventive maintenance **c) Corrective maintenance** d) Timely maintenance
Total productive maintenance aims at**.**	a) Less idle time b) Increase in productivity c) Idle time **d) Zero down time**

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