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Norwegian Embassy
Islamabad

GENERATOR MECHANIC

LEARNER GUIDE

National Vocational Certificate Level 3

Version 1 - November, 2019

NAVTTC

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Published by
National Vocational and Technical Training Commission
Government of Pakistan

Headquarter
Plot 38, Kirthar Road, Sector H-9/4, Islamabad, Pakistan
www.navttc.org

Responsible
Director General Skills Standard and Curricula, National Vocational and Technical Training Commission
National Deputy Head, TVET Sector Support Programme, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Layout & design
SAP Communications

Photo Credits
TVET Sector Support Programme

This document has been produced with the technical assistance of the TVET Sector Support Programme, which is funded by the European Union, the Federal Republic of Germany and the Royal Norwegian Embassy and has been commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in close collaboration with the National Vocational and Technical Training Commission (NAVTTC) as well as provincial Technical Education and Vocational Training Authorities (TEVTAs), Punjab Vocational Training Council (PVTC), Qualification Awarding Bodies (QABs)s and private sector organizations.

Document Version
November, 2019
Islamabad, Pakistan

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Introduction

Welcome to your Learner's Guide for the *Generator Mechanic* Programme. It will help you to complete the programme and to go on to complete further study or go straight into employment.

The *Generator Mechanic* programme is to engage young people with a programme of development that will provide them with the knowledge, skills and understanding to start this career in Pakistan. The programme has been developed to address specific issues, such as the national, regional and local cultures, the manpower availability within the country, and meeting and exceeding the needs and expectations of their customers.

The main elements of your learner's guide are:

- **Introduction:**
  - This includes a brief description of your guide and guidelines for you to use it effectively
- **Modules:**
  - The modules form the sections in your learner's guide
- **Learning Units:**
  - Learning Units are the main sections within each module
- **Learning outcomes**:
  - Learning outcomes of each learning units are taken from the curriculum document
- **Learning Elements:**
  - This is the main content of your learner's guide with detail of the knowledge and skills (practical activities, projects, assignments, practices etc.) you will require to achieve learning outcomes stated in the curriculum
  - This section will include examples, photographs and illustrations relating to each learning outcome
- **Summary of modules**:
  - This contains the summary of the modules that make up your learner's guide
- **Frequently asked questions**:
  - These have been added 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.

Overview of the program

Course: *Generator Mechanic Level 3*	**Total Course Duration:** 670 Hours
Course Overview:	
In this training program trainee will learn and acquire specialized knowledge and particle skills required to function as a Generator mechanic both at domestic and commercial levels. Generator Mechanic will responsible to maintain safety, maintain tools & equipment, identification of faults, diagnose mechanical faults, repair/replace mechanical components, electrical AC Installation, diagnose electrical fault, as per the procedures involved. The specific objectives of developing these qualifications are as under: • Improve the overall quality of training delivery and setting national benchmarks for training of generator mechanic in the country • Provide flexible pathways and progressions to learners enabling them to receive relevant, up-to-date and recent skills • Provide basis for competency-based assessment which is recognized and accepted by employers • Establish a standardized and sustainable system of training for generator mechanic in the country	

Module Title and Aim	Learning Units	Theory Days/hours	Workplace Days/hours	Timeframe of Modules
Module 1: **Apply Work Health and Safety Practices (WHS)** **Aim:** This unit describes the skills to work with safety and participate in hazard assessment activities, follow emergency procedures and participate OHS practices in process	**LU1.** Implement safe work practices at work place **LU2.** Participate in hazard assessment activities at a work place **LU3.** Follow emergency procedures at workplace **LU4.** Participate in OHS consultative processes	**04**	**16**	**20**
Module 2: **Identify and Implement Workplace Policy and Procedures** **Aim:**	**LU1.** Identify workplace policy & procedures **LU2.** Implement workplace policy & procedures **LU3.** Communicate workplace policy &	**02**	**08**	**10**

This unit describes the skills and knowledge required to develop and implement a workplace policy & procedures and to modify the policy to suit changed circumstances. It applies to individuals with managerial responsibilities who undertake work developing approaches to create, monitor and improve strategies and policies within workplaces and engage with a range of relevant stakeholders and specialists.	procedures **LU4.** Review the implementation of workplace policy & procedures			
Module 3: **Communicate at Workplace** **Aim:** This unit describes the performance outcomes, skills and knowledge required to develop communication skills in the workplace. It covers gathering, conveying and receiving information, along with completing assigned written information under direct supervision.	**LU-1:** Communicate within the organization **LU-2:** Communicate outside the organization **LU-3:** Communicate effectively in workgroup **LU-4:** Communicate in writing	**02**	**08**	**10**
Module 4: **Perform Computer Application Skills** **Aim:** This unit describes the skills and knowledge required to use spreadsheet applications, prepare in page documents, develops familiarity with Word, Excel, Access, PowerPoint, email, and computer graphics basics. It applies to individuals who perform a range of routine tasks in the workplace using a fundamental knowledge of spreadsheets, Microsoft office and computer graphics in under direct supervision or with limited responsibility.	**LU1.** Prepare In-page documents as per required information **LU2.** Prepare Spreadsheets as per required information **LU3.** Use MS Office as per required information **LU4.** Perform computer graphics in basic applications **LU5.** Create Email account for communications	**02**	**08**	**10**
Module 5: **Manage Personal Finances** **Aim**: This unit of competency describes the outcomes required to manage develop, implement and monitor a	**LU1.** Develop a personal budget **LU2.** Develop long term personal budget **LU3.** Identify ways to maximize future	**02**	**08**	**10**

personal budget in order to plan regular savings and manage debt effectively.	finances			
Module 6: **Carryout Basic Electrical Alternate Current (AC) Installation** **Aim:** After completing this learning module, the learner will be able to lay cables, perform single & three phase connections, basic electric wiring and wiring test for carrying out basic electrical alternating current (AC) installation.	**LU1.** Lay cables **LU2**. Perform single-phase Connection **LU3.** Perform three phase Connection **LU4**. Perform Basic Electrical wiring **LU5**. Conduct wiring Test	**20**	**80**	**100**
Module 7: **Repair/Replace Mechanical Components** **Aim:** After completing this learning module, the learner will be able to replace fuel pump, oil pump, fan belt, radiator, oil filter and change cam shaft, crank shaft, valve train components, timing belt and change injector for generator maintenance & repair	**LU1.** Replace fuel / Injection pump **LU2.** Replace oil pump **LU3.** Replace fan belt **LU4**. Replace Radiator **LU5.** Change oil filter **LU6**. Change air filter **LU7.** Change Connecting Rod **LU8**. Change cam shaft	**40**	**230**	**270**

	LU9. Change crank shaft **LU10**. Change valve train Components **LU11.** Change Timing Belt / Timing Gear **LU12**. Change Injector/automizer **LU13**. Change/repair cylinder head **LU14.** Change/repair cylinder block			
Module 8: **Repair/Replace Electrical Components** **Aim:** After completing this learning module, the learner will be able to repair self- starter, replace faulty parts, replace governor, replace cooling fan motor and inspect warning system.	**LU1.** Repair Self-Starter **LU2.** Replace faulty parts of main alternator **LU3.** Change gauges on display panel **LU4**. Repair/ replace governor **LU5**. Replace warning sensors **LU6**. Replace main alternator bearings **LU7**. Change Spark plugs	**34**	**136**	**170**
Module 9: **Install new Generator** **Aim:** After completing this learning module, the learner will be able to maintain supply in accordance with the requirements of industry regulations and established	**LU1**. Adopt manufacture procedure **LU2**. Interpret foundation drawing **LU3.** Hoist generator	**17**	**53**	**70**

procedures. It encompasses the operation, connection and disconnection as well as assessing load assuring the appropriateness of all generators for the required outcome.	**LU4.** Level generator **LU5**. Distribute electrical load **LU6.** Install change over switch **LU7**. Connect earthing			
	TOTAL	**123**	**547**	**670**

GENERATOR MECHANIC

Module-6

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Module 6: Carryout Basic Electrical Installation (Alternating Current-AC)

Objective of the module: After completing this learning module, the learner will be able to lay cables, perform single & three phase connections, basic electric wiring and wiring test for carrying out basic electrical alternating current (AC) installation.

Duration:	**Total hours**	**100**	**Theory**	**20**	**Practical**	**80**

Learning Unit	Learning Outcomes	Learning Elements	Materials (Tools & Equipment) Required

LU1. **Lay cables**	**.** Interpret electrical drawing/document **.** Identify cables **.** Lay cables **.** Perform earthing	**Knowledge and understanding of :** • Electrical Drawing/Equipment, familiarize with standard electrical symbols, reading pattern, identify polarity, name and values, • Types of electrical cables such as 1.Coaxial cable 2.Direct buried cable 3.Flexible cable 4.Communication cable 5.Heliax cable 6.Nonmetallic sheathed cable 7.Metallic sheathed cable or armored cable 8.Multicore cable 9.Paired cable 10.portable cord 11.Ribbon cable 12.Shielded cable 13.twinax cable 14.Twisted pair • types of cables with respect to core, and diameter according to load. • Size of cables,	• . Cables of different sizes • . Micrometer • . Electrical drawing • . Earthing materials (coal, salt, copper plates, GI pipe, earth continuity conductor, copper nut bolts etc.) • . Electrical tool kit

		• Standard Wire Gauge SWG. • Identifying cables • Laying Cables • Earthing, importance of earthing, types of earthing, wire used in earthing, Earthing materials (coal, salt, copper plates, GI pipe, earth continuity conductor, copper nut bolts etc.)	
LU2. **Perform single-phase Connection**	. Select cable gauge . Select cables colors . Connect cables . Insulate Joints	**Knowledge and understanding of:** • Gauges of cables, American wire gauge, standard wire gauge • Single phase connection, importance of single-phase connection. • Number of wires in a single-phase connection • color of cables • Types and techniques of joints Such as 1.Britannia joint 2.Straight joint 3.Tee joint 4.Western union joint 5.Married joint • Importance of insulation, insulating joint, how to insulate electrical joints, • Connecting cables, Insulating joints	• . Cable different sizes • . Electrical tool kit • . Micro meter • . Insulating materials

LU3. **Perform three phase Connection**	**.** Select cable Gauge **.** Select cables colors **.** Connect cables **.** Insulate Joints	**Knowledge and understanding of:** • three phase connection • importance of three phase connection, • Star connection, • Delta connection, • Number of wires in star and delta connection, • Color/sequence of cables in three phase connection • Describe various types of core insulation (single, two, three & four core cable) • Connecting cables • Insulating joints	• Cable different sizes • . Electrical tool kit • . Micro meter • . Insulating materials
LU4. **Perform Basic Electrical wiring**	**.** Measure cables as per requirement **.** Connect cables **.** Perform joints **.** Insulate Joints	**Knowledge and understanding of:** • Conductor and insulator, properties of conductor and insulator, • Types of wiring Such as 1.Cleat wiring 2.Wooden casing and capping wiring. 3.CTS or TRS or PVC Sheath wiring. 4.Lead sheathed or metal sheathed wiring. 5.Conduit wiring including surface conduit wiring and concealed conduit wiring. Advantages and disadvantages of various electrical wiring, Procedure of various electrical wiring types. • Measurement of Length and diameter of cable according to load and distance. • Performing joints	Cable different sizes . Electrical tool kit . Micro meter . Insulating materials . Wiring materials

		• Insulating joints	
LU5. **Conduct wiring Test**	**.** Operate multi-meter for voltage and current **.** Perform continuity test **.** Perform polarity test **.** Perform earthing test **.** Perform insulation test **.** Record test results	**Knowledge and understanding of:** • Various wiring test • Multimeter, measurements taken with multimeter, • Series test lamp, why is it used, • Testing procedures for continuity and polarity test • Functions of Megger/earthing tester, types of megger, • testing procedure for earthing and insulation test by Megger/earthing tester • Recording test results.	• . Multi mater • . Megger • . Insulation tester • . Series test lamp

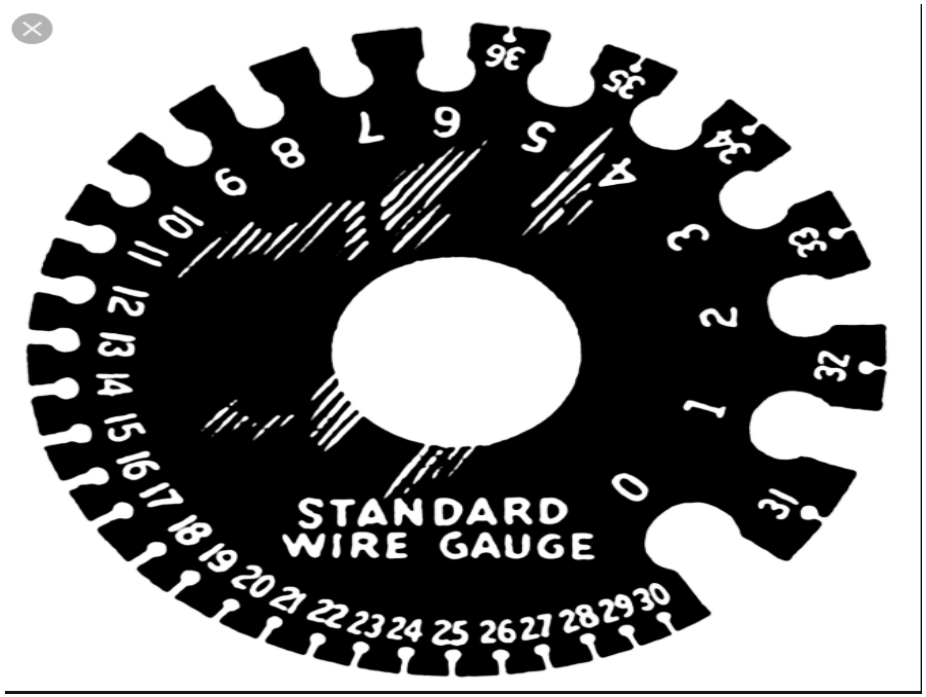
Examples and illustrations:

Electrical cable types:

- Coaxial cable – used for radio frequency signals, for example in cable television distribution systems.
- Communications cable
- Direct-buried cable
- Flexible cables
- Helix cable
- Non-metallic sheathed cable (or nonmetallic building wire, NM, NM-B)
- Metallic sheathed cable (or armored cable, AC, or BX)

- Multicore cable (consist of more than one wire and is covered by cable jacket)
- Paired cable – Composed of two individually insulated conductors that are usually used in DC or low-frequency AC applications
- Portable cord – Flexible cable for AC power in portable applications
- Ribbon cable – Useful when many wires are required. This type of cable can easily flex, and It is designed to handle low-level voltages.
- Shielded cable – Used for sensitive electronic circuits or to provide protection in high-voltage applications.
- Single cable (from time to time this name is used for wire)
- Submersible cable
- Twin ax cable
- Twin-lead – This type of cable is a flat two-wire line. It is commonly called a 300 Ω line because the line has an impedance of 300 Ω. It is often used as a transmission line between an antenna and a receiver (e.g., TV and radio). These cables are stranded to lower skin effects.
- Twisted pair – Consists of two interwound insulated wires. It resembles a paired cable, except that the paired wires are twisted

Standard Wire Gauge:



Standard Wire G

https://en.wikipedia.org/wiki/Standard_wire_gauge

Wire Gauge / Gage Conversion Chart

S.W.G. (Inches)	Wire Number (Gauge)	A.W.G. or B&S (Inches)	A.W.G. Metric (MM)
0.276	2	0.257627	6543
0.232	4	0.2043	5189
0.192	6	0.162	4115
0.16	8	0.1285	3264
0.144	9	0.1144	2906
0.128	10	0.1019	2588
0.116	11	0.0907	2304
0.104	12	0.0808	2052
0.08	14	0.0641	1628
0.072	15	0.0571	1450
0.064	16	0.0508	1291
0.056	17	0.0453	1150
0.048	18	0.0403	1024
0.036	20	0.032	8128
0.032	21	0.0285	7239
0.028	22	0.0253	6426
0.024	23	0.0226	5740
0.022	24	0.0201	5106
0.02	25	0.0179	4547
0.018	26	0.0159	4038
0.0148	28	0.0126	3200
0.0124	30	0.01	2540
0.0116	31	0.0089	2261
0.0108	32	0.008	2032
0.01	33	0.0071	1803
0.0092	34	0.0063	1601
0.0084	35	0.0056	1422
0.0076	36	0.005	1270
0.0068	37	0.0045	1143
0.006	38	0.004	1016
0.0052	39	0.0035	889
0.0048	40	0.0031	787

Wire Gauges / Gages Arranged In Columns As Follows:
AWG= American Wire Gauge
B&S= Brown & Sharpe
SWG= Imperial Standard Wire Gauge-(British legal standard)

Wire Gauge /Gage :

Values are stated in approximate decimals of an inch excluding the metric numbers. As a number of gauges are in use for various shapes and metals, it is advisable to state the thickness in thousands when specifying in gauge number. Metric wire gauge is 10 times the diameter in millimeters.

http://freetechnicalcharts.com/Wire_Gauge_Chart.php

Steps for Performing Continuity Test:

1. Turn the dial to Continuity Test mode (). It will likely share a spot on the dial with one or more functions, usually resistance (Ω). With the test probes separated, the multimeter's display may show OL and Ω.
2. If required, press the continuity button.
3. First insert the black test lead into the COM jack.
4. Then insert the red lead into the VΩ jack. When finished, remove the leads in reverse order: red first, then black.
5. With the circuit de-energized, connect the test leads across the component being tested. The position of the test leads is arbitrary. Note that the component may need to be isolated from other components in the circuit.
6. The digital multimeter (DMM) beeps if a complete path (continuity) is detected. If the circuit is open (the switch is in the OFF position), the DMM will not beep.
7. When finished, turn the multimeter OFF to preserve battery life.

Continuity testing overview:

- Continuity is the presence of a complete path for current flow. A circuit is complete when its switch is closed.
- A digital multimeter's Continuity Test mode can be used to test switches, fuses, electrical connections, conductors and other components. A good fuse, for example, should have continuity.
- A DMM emits an audible response (a beep) when it detects a complete path.
- The beep, an audible indicator, permits technicians to focus on testing procedures without looking at the multimeter display.
- When testing for continuity, a multimeter beep based on the resistance of the component being tested. That resistance is determined by the range setting of the multimeter. Examples:
    - If the range is set to 400.0 Ω, a multimeter typically beeps if the component has a resistance of 40 Ω or less.
    - If the range is set 4.000 kΩ, a multimeter typically beeps if the component has a resistance of 200 Ω or less.
- The lowest range setting should be used when testing circuit components that should have low-resistance value such as electrical connections or switch contacts.

https://www.fluke.com/en/learn/best-practices/test-tools-basics/digital-multimeters/how-to-test-for-continuity-with-a-digital-multimeter

How to Use a Megger Insulation Tester:

A Megger insulation resistance tester is especially useful when you have carried out electrical work on your home and want to make sure you didn't damage insulation or make a wiring mistake. The Megger company registered the name Megger in May 1903 and today offers a wide variety of IR testers. Failed or damaged insulation can cause a circuit breaker to trip or fuse to blow and may result in a severe electrical shock to people coming in contact with poorly insulated wire or a metal part touching it. Using a Megger to test insulation resistance helps reduce such dangers.

Step 1

Switch off power to the circuits you are testing. If you are not sure which breakers or fuses control the circuits, switch off the main breaker. Place a note on the breaker panel advising others not to switch on the power because you are working on the circuits. Lock the switch closed if possible.

Step 2

Prepare a table in which you can record the insulation values that result from your tests. For a 110-volt circuit, leave spaces for the test results of the insulation between the black wire and the white wire and the insulation between each wire and ground. For a 220-volt circuit, leave spaces for the test results of the insulation between each of the three wires and the other two and between each of the three wires and ground. For a piece of equipment such as a circuit breaker or an appliance, leave space for insulation values between each terminal and the other terminals and each terminal and ground.

Step 3

Select 500 volts DC or 1000 volts DC as the test voltage on your Megger, depending on the model you are using. Check whether your model has an integrated voltage tester for live circuits. If it doesn't, check the circuits to be tested with a voltage tester to make sure they are not live.

Place the positive and negative probes of the Megger on the two conductors or terminals between which you are testing the insulation resistance. If you are testing insulation resistance to ground, place the positive probe on the ground wire or the grounded metal junction box and the negative probe on the conductor or terminal. Energize the Megger for 1 minute. Read the value of the resistance at the end of the minute test and note it in your table. Continue with this testing procedure until you have values for all the spaces of your table.

Step 4

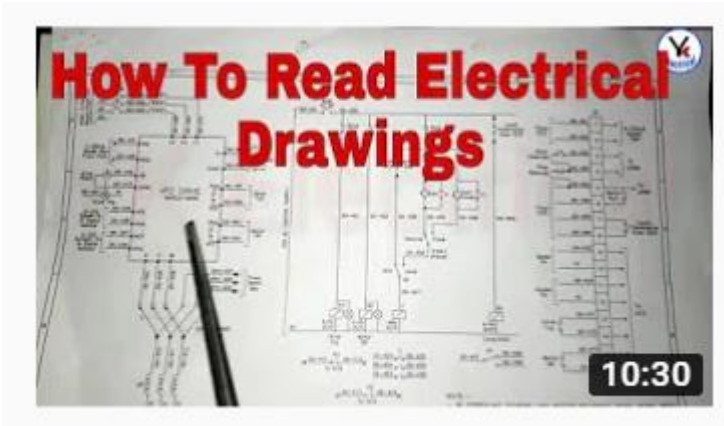
Examine the resistance values you have entered in your table. According to the National Electrical Code, all values should be over 25 megohm. If one of the values differs substantially from all the others, check your connections and repeat the tests. If a value is below 25 megohm, check the circuit for the cause of the poor insulation resistance value.

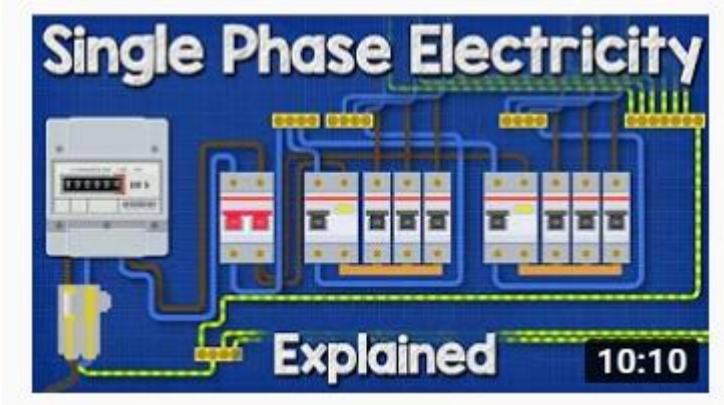
Insulation Resistance Tester, Megger
https://megger.com/products/insulation-testing/insulation-resistance-testing-lt;-1-kv

References:

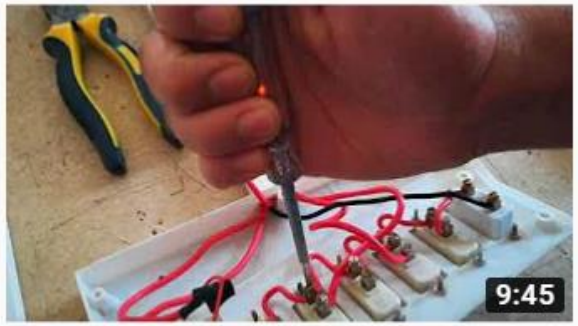
1. https://www.systemswire.com/electrical-cable-types/
2. https://www.fluke.com/en/learn/best-practices/test-tools-basics/digital-multimeters/how-to-test-for-continuity-with-a-digital-multimeter
3. https://www.hunker.com/13414113/how-to-use-a-megger-insulation-tester

VIDEOS

	How to read electrical drawing https://www.youtube.com/watch?v=01SI2bntiP4

	How to install ground earthing https://www.youtube.com/watch?v=EcaED7kMYII
	Single phase connection explained https://www.youtube.com/watch?v=W0_1xRqT8uU

	Three phase installation tutorials https://www.youtube.com/watch?v=EFikTPK045o
	How to check continuity with multimeter https://www.youtube.com/watch?v=J5MM6q0XxFE

	How to make polarity test for electrical installation https://www.youtube.com/watch?v=eNfkl8Ax74k

	How to check earthing with megger https://www.youtube.com/watch?v=9MJtGxa8X6Q
	How to check cable insulation with megger https://www.youtube.com/watch?v=v0TsCtGh3nA&t=547s

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GENERATOR MECHANIC

Module-7

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Module 7: Repair/Replace Mechanical Components

Objective of the module: After completing this learning module, the learner will be able to replace fuel pump, oil pump, fan belt, radiator, oil filter and change cam shaft, crank shaft, valve train components, timing belt and change injector for generator maintenance & repair

Duration	**Total hours**	**270 hours**	**Theory**	**40 hours**	**Practical**	**230 hours**

Learning Unit	**Learning Outcomes**	**Learning Elements**	**Materials (Tools & Equipment) Required**
LU1. **Replace fuel Injection pump**	**.** Select tools and equipment **.** Replace fuel pipes **.** Replace fuel filter **.** Replace the fuel injunction pump **.** Calibrate injection pump **.** Reinstall calibrated injection pump	**Knowledge and understanding of** • tools and equipment used for replacing fuel injection pump • fuel pipes • fuel filter • fuel injection pump, different types of injection pump such as 1.common rail fuel injection pump 2. Distributor (rotary) fuel injection pump 3.In-line fuel injection pump 4.Distributor injection pump • phasing and calibration • calibrating an injection pump • installation of injection pump	• . Fuel injection pump • . Fuel pipe • . Fuel filter • . Socket box • . Ring spanner set

LU2. **Replace oil pump**	**.** Select Tools and equipment **.** Remove oil pump **.** Repair / Replace faulty components of oil pump	**Knowledge and understanding of:** • Selecting tools and equipment for replacing oil pump • Describe different types of oil pump such as 1.Gear pump 2.Gear rotor pump • Removing oil pump • Repairing/Replacing faulty components of oil pump	○ . Oil pump ○ . Tool kit
LU3. **Replace fan belt**	**.** Collect tools and equipment **.** Identify size of fan belt **.** Replace fan belt **.** Adjust fan belt	**Knowledge and understanding of:** • **Collecting tools and equipment for replacing fan belt** • fan belt • different type of fan belts such as 1.V belt 2.Surpentine belt • Identifying size of fan belt • Replacing fan belt • Adjusting fan belt	• . Fan belt • . Ring spanner set • . Adjustment lever

LU4. **Replace Radiator**	**.** Arrange tools and equipment **.** Uninstall the radiator **.** Clean and flush radiator **.** Repair radiator **.** Reinstall radiator	**Knowledge and understanding of:** • Arranging tools and equipment for replacing radiator • various radiators (single & double tubes) • servicing techniques of radiator • Uninstalling the radiator • Cleaning and flushing the radiator • Reinstalling the radiator • different chemicals for internal cleaning/flushing	○ . Radiator ○ . Flushing materials ○ . Radiator pressure cap ○ . Radiator bottle ○ . Tool box
LU5. **Change oil filter**	**.** Collect tools and equipment **.** Select proper size of oil filter **.** Remove oil filter **.** Install oil filter	**Knowledge and understanding of:** • Collecting tools and equipment for changing oil filter • different types of oil filter and its functions • Selecting proper size of oil filter • Removing oil filter • procedure for replacing oil filter	• . Oil filter • . Filter chain
LU6. **Change air filter**	**.** Collect tools and equipment **.** Select proper size of air filter **.** Remove air filter **.** Install air filter	**Knowledge and understanding of:** • Collecting tools and equipment for changing air filter • sizes of air filter and its functions • Selecting proper size of air filter • Removing air filter • procedure of replacing air filter	• . Air filter

LU7. **Change Connecting Rod**	**.** Select tools and equipment **.** Remove engine from main alternator **.** Dismantle engine **.** Remove connecting rod **.** Repair /replace connecting rod	**Knowledge and understanding of** • Selecting tools and equipment for changing connecting rod • connecting rod and its functions • importance of connecting rod components • Removing engine from main alternator • dismantling procedure of engine • Removing connecting rod • Repairing/Replacing connecting rod	• . Generator engine • . Connecting rod with its accessories • . Toolkit
LU8. **Change cam shaft**	**.** Identify tools and equipment **.** Remove tippet cover **.** Remove cam shaft **.** Repair and replace cam shaft	**Knowledge and understanding of:** • Identifying tools and equipment for changing cam shaft • cam shaft and its functions • Removing tippet cover • dismantling procedure of cam shaft • Repairing and Replacing cam shaft	○ Generator engine ○ . Cam shaft with its accessories ○ . Toolkit

LU9. **Change crank shaft**	. Identify tools and equipment . Remove fly wheel . Open main big end . Remove Timing plate and timing gear / Pulley . Remove hosing . Remove main oil seal plate, remove crank shaft . Repair and replace Crank shaft	**Knowledge and understanding of:** • Identifying tools and equipment for changing crank shaft • crank shaft an its functions • functions of flywheel • dismantling procedure of flywheel, • Opening main big end • Removing timing plate and timing gear/pulley • Remove hosing • dismantling procedure of crank shaft • Repairing and replacing crank shaft	Generator engine . Crank shaft . Toolkit
LU10. **Change valve train components**	. Identify tools and equipment . Remove tippet cover, atomizer pipe timing belt, rocker and head bolt . Dress/ Polish valve and valve seats . Replace head gas kit . Reinstall valve train component	**Knowledge and understanding of:** • Identifying tools and equipment for changing valve train components. • valve train • grinding /polishing of valve and valve seat • head gas kit • Replacing head gas kit • Reinstalling valve train component .	• . Valve train with accessories • . Head gas kit • . Head assembly • . Valve lapping stick and paste • . Tool kit

LU11. **Change Timing Belt / Timing Gear**	. Identify tools and equipment . Identify timing marks . Loose the adjustment bolt . Remove the timing belt/gear . Reinstall the timing belt / gear	**Knowledge and understanding of:** • Identifying tools and equipment for changing timing belt/timing gear • timing belt/timing plate/timing gear • identifying timing marks • dismantling procedure of timing belts, timing gear and pulley • mounting techniques of timing belts/gear	• . Timing belt • . Timing gear • . Timing chain • . Tool Box
LU12. **Change Injector/atomizer**	. Identify the tools and equipment . Remove the injection pipe . Remove the mounting bolt of injector . Remove the injector . Calibrate the injectors . Install the injectors	**Knowledge and understanding of:** • Identifying the tools and equipment for changing injector/atomizer • injector/atomizer • . functions of injector/atomizer • . dismantling procedure of injector/atomizer • . calibration techniques of injector/atomizer • Installing the injectors	• . Injector/atomizer • . Injector pressure tester • . Tool kit

LU13. **Change/repair cylinder head**	. Identify tools and equipment . Repair Valve seat . Perform Top overhaul . Perform head tightening sequence	**Knowledge and understanding of** • Identifying tools and equipment for changing/repairing cylinder head • cylinder head • components in cylinder head • facing and decarburizing techniques of cylinder head • Repairing valve set • Performing top overhaul • installation techniques of cylinder head • performing head tightening sequence	○ . Cylinder head ○ . Tool Kit ○ . Torque wrench
LU14. **Change/repair cylinder block**	. Identify tools and equipment . Perform major overhaul . Change sleeve . Perform Honing . Replace piston and piston rings	**Knowledge and understanding of:** • Identifying tools and equipment for changing/repairing cylinder block • cylinder block • components in cylinder block • piston and piston rings. • Performing major overhaul • Changing sleeve • Perform Honing • installation techniques of piston and piston rings.	○ . Cylinder block ○ . Sleeves ○ . Piston & piston rings ○ . Honing machine ○ . Toolkit

Examples and illustrations:

Purpose of Fuel Injection System:

The performance of diesel engines is heavily influenced by their injection system design. In fact, the most notable advances achieved in diesel engines resulted directly from superior fuel injection system designs. While the main purpose of the system is to deliver fuel to the cylinders of a diesel engine, it is how that fuel is delivered that makes the difference in engine performance, emissions, and noise characteristics.

Unlike its spark-ignited engine counterpart, the diesel fuel injection system delivers fuel under extremely high injection pressures. This implies that the system component designs and materials should be selected to withstand higher stresses in order to perform for extended durations that match the engine's durability targets. Greater manufacturing precision and tight tolerances are also required for the system to function efficiently. In addition to expensive materials and manufacturing costs, diesel injection systems are characterized by more intricate control requirements. All these features add up to a system whose cost may represent as much as 30% of the total cost of the engine.

The main purpose of the fuel injection system is to deliver fuel into the cylinders of an engine. In order for the engine to effectively make use of this fuel:

i. Fuel must be injected at the proper time, that is, the injection timing must be controlled and
ii. The correct amount of fuel must be delivered to meet power requirement, that is, injection metering must be controlled.

However, it is still not enough to deliver an accurately metered amount of fuel at the proper time to achieve good combustion. Additional aspects are critical to ensure proper fuel injection system performance including:

- Fuel atomization—ensuring that fuel atomizes into very small fuel particles is a primary design objective for diesel fuel injection systems. Small droplets ensure that all the fuel has a chance to vaporize and participate in the combustion process. Any remaining liquid droplets burn very poorly or are exhausted out of the engine. While modern fuel injection systems are able to produce fuel atomization characteristics far exceeding what is needed to ensure complete fuel evaporation during most of the injection process, some injection system designs may have poor atomization during some brief but critical periods of the injection phase. The end of the injection process is one such critical period.

- Bulk mixing—While fuel atomization and complete evaporation of fuel is critical, ensuring that the evaporated fuel has sufficient oxygen during the combustion process is equally as important to ensure high combustion efficiency and optimum engine performance. The oxygen is provided by the intake air trapped in the cylinder and a sufficient amount must be entrained into the fuel jet to completely mixed with the available fuel during the injection process and ensure complete combustion.
- Air utilization—Effective utilization of the air in the combustion chamber is closely tied to bulk mixing and can be accomplished through a combination of fuel penetration into the dense air that is compressed in the cylinder and dividing the total injected fuel into a number of jets. A sufficient number of jets should be provided to entrain as much of available air as possible while avoiding jet overlap and the production of fuel rich zones that are oxygen deficient.

The primary purposes of the diesel fuel injection system are graphically represented in Figure 1.

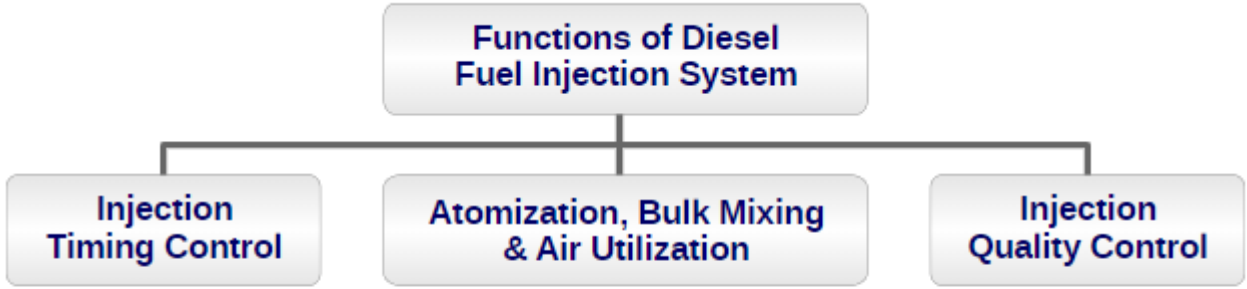


Figure 1. Main Functions of Diesel Fuel Injection System

https://www.dieselnet.com/tech/diesel_fi.php

Connecting Rod:

The connecting rod transfers the entire generated power out of the combustion process from the piston pin to the crankshaft and converts the reciprocating energy into rotating energy that drives either the propeller or the generator.

Connecting Rod Function:

The “connection piece” between the piston and the crankshaft is the connecting rod. Like all other engine parts that are directly involved into the combustion process, the connecting rod is highly stressed. The conrods alternating, comparative stress is mainly feuded by 3 different forces:

- the acceleration force, from the combustion process
- the mass force, from the piston and the piston pin
- the bending force, caused by the conrod angle

With a share of approximately 80%, the connecting rod shaft is mainly loaded by dynamically acting compression stresses out of the combustion process. The remaining 20% are dynamically acting bending loads. This results in a very complicate stress profile in the connecting rod eye (or small end) while engine operation.

The connecting rod shaft can be manufactured in a "H"- or "O-profile" (round cross section). Today´s engines - with high specific outputs - are equipped with fully machined conrods. For manufacturing reasons, they have an O-profiled shaft.

For the lubrification of the piston pin as well as for the piston cooling, the conrod shaft is very often drilled longitudinally.

The upper end of the connecting rod is the connecting rod eye. This accommodates an undivided piston bolt bearing - the so-called small end bearing. The lower end of the connecting rod is divided into two halves, as the connecting rod is guided through the cylinder from above - the so-called big end bearing.

Initially the big end bearings were divided horizontally. When the specific output of the engines increased, larger surfaces for the bearing became necessary and they developed conrods with diagonally splatted big ends in order to pull the conrod upwards with its foot through the cylinder liner.

In order to avoid that the big end bearing housing must be opened during maintenance of the piston, todays modern connecting rods are

divided between conrod shaft and big end bearing housing. Additionally, an intermediate plate allows to change the compression ratio of the engine by different thickness of this plate.

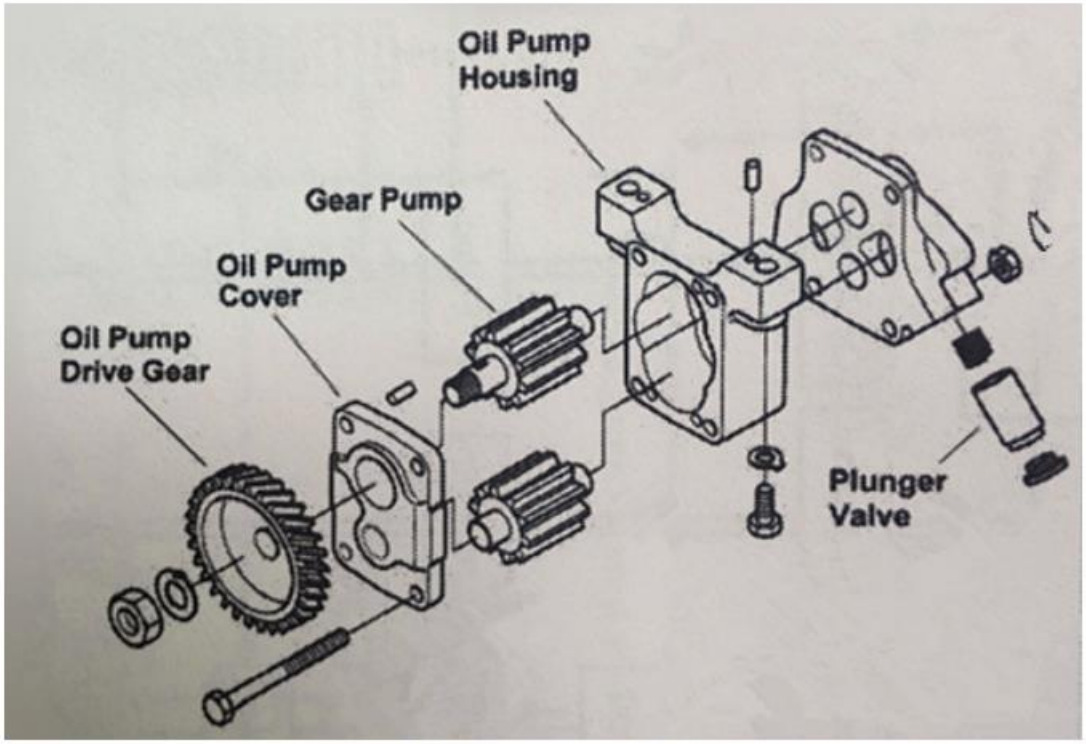
The screwed connection of the big end bearing housing is one of the most difficult connections for screws due to the high asymmetric load on them. This led into dynamic bending stresses that must be handled by the tightening forces. Because of this, the tightening procedure needs extremely high attention.

Due to the cranking of the conrod during combustion and compression - inside the cylinder - the big end bearing is subject to asymmetric forces which creates asymmetric and dynamic wear and tear. Therefore, the ovality of the big end bearing houses has to be checked on a regular basis. Due to the high forces, the mating surface between the lower half and the upper half of the big end bearing housing need´s the highest grade of planarity, in order to avoid fretting wear and tear.

In case of diagonally split big ends shearing forces have to be absorbed by means of a toothed joint face.

Maintenance of Oil Transfer pump for Generator:

Oil pump is an important part of diesel generator. In the process of using the diesel genset, only regularly checking and maintaining the oil transfer pump can guarantee the normal operation of the generating set.



Oil pump assembly

Maintenance Tips:

1. Before installing the oil transfer pump on diesel generating set, check whether the model and specification are correct or not; remove rust preventive oil and choose the appropriate thickness gasket. In order to avoid piston running improperly, the gasket should avoid too thin or thick, and the tightening torque should be uniform to prevent damage to the oil pump.

2. The coarse filter core within the oil pump is easily blocked by cotton and other dirt, you should regularly check and clean it. If the strainer is damaged, you should repair or change it timely.

3. There is a rubber seal between the hand oil pump piston and the hand oil pump body. Do not remove the rubber. If the rubber ring is damaged, you should replace it timely.

4. Ensure the elasticity of “Four spring” for plunger oil transfer pump. “Four spring” is divided into piston spring, tappet (roller) spring, oil inlet valve spring and oil outlet valve spring. If the spring elasticity is weakened or broken, you should replace it timely or add pad to adjust to avoid causing damage to the diesel generator.

5. The hand oil pump of the generator set must be pressed back after using, at the same time, tightening the button to prevent oil leakage that is caused because the pressure is not tight between the hand oil pump and the rubber ring.

6. After using the oil transfer pump for a long time, checking the parts. If the phenomenon like the wear, sag, and pocking mark appear on the valve surface, it should be repaired timely or replaced.

7. When the diesel generator set is in the state of parking for a long time, to prevent the piston and the pump body or the tappet and the tappet suit from being corroded by water, the rust preventive measures must be taken. When the generator set is power off, you should replace the lubricating oil (contains water, diesel oil and other impurities) in the sump of fuel injection pump.

Fan Belt Replacement:

Engine belt replacement is considered to be part of scheduled maintenance included in a facilities Planned Maintenance Program. This includes inspection and replacement components that can fail under loaded conditions for extended amounts of time. Always replace belts when required by the manufacturer.

The two common types of generator engine belts used are:

V Belt – This style belt is commonly with smaller or older applications. The V-belt has been created in the shape of a triangle to reduce belt slippage. Generally, one V-belt drives one component (such as water pump or alternator).

Serpentine Belt – Also known as Multi-V, Poly-V or Multi -Rib belt. One belt is used to drive multiple engine components. Newer engine applications use the serpentine belt system. These systems often use automatic belt tensioners to maintain correct belt tension.

Inspection

Belt inspection is performed in addition to belt replacement at scheduled intervals. Inspections should be performed in accordance with engine and belt manufacturer guidelines.
When inspecting engine drive belts for wear, the general rule of thumb for each style of belt is:

V-Belt – Discard belt if any horizontal or vertical cracks are visible.

Serpentine Belt – Horizontal cracks on belt ribs are acceptable as long as the crack does not extend into the belt backbone. If crack extends into back bone it must be replaced. Replace belt if any vertical cracks are visible between ribs.

Steps to Change an Engine's Coolant:

The coolant system is a crucial part for **diesel generator**, in order ensure the engine coolant to be good in cooling and anti-corrosion, the replacement of coolant and clearing of cooling system are required every 2,000 hours or 2 years, whichever comes first.

Warning: At operating temperature, engine coolant is hot and under pressure, and coolant steam can cause personal injury. Do not remove the pressure cap on the radiator until the engine stops and coolant temperature goes below 50℃. Slowly unscrew the pressure cap to release the cooling system pressure.

Warning: The anti-rust additive in the coolant contains alkali. Avoid skin contact with it to prevent personal injury.

(1) Stop the engine and wait until the temperature of the coolant falls to below 50℃. slowly unscrew the pressure cap to release the cooling system pressure and remove it. Loosen the drain cock on the radiator to completely drain the coolant in the **radiator**.

(2) Loosen the water drain cock on the engine (on the fuel pump side and near the flywheel housing), as well as the water drain cock on the water pump, and completely drain the coolant in the cooling system

(3) Clean the cooling system according to the following steps.

A. Install and screw up all the drain cocks and plug, and add the sodium carbonate solution (or the mixture of sodium carbonate and water that is available in market) into the cooling system from the coolant filter.

Caution: Each 23 L of water should be mixed with 0.5KG sodium carbonate. Do not use caustic cleaner, or it will do harm to aluminum parts.

Caution: Purge the air in the coolant system while adding the cleaning fluid. Pour the cleaning fluid slowly to avoid air block. The cleaning fluid should be added up to the bottom of the filter in the radiator and wait for about 3–5 minutes for a full purge of air.

B. Start the engine and keep it running for 5 minutes after the cleaning fluid temperature has gone up to above 80℃, then stop the engine and completely drain the cleaning fluid in the cooling system.

Caution: During the whole cleaning process the pressure cap should not be on and the engine runs without the cap on.

C. Add clean water into the cooling system.

Caution: Pour clean water slowly to avoid air block. Clean water should be added up to the bottom of the filter in the radiator and wait for about 3–5 minutes for a full purge of air.

D. Start the engine and keep it running for 5 minutes after the water temperature has gone up to above 80℃, then stop the engine and completely drain the clean water in the cooling system.

Caution: If the discharged water is still dirty, clean the cooling system again according to the aforesaid steps until discharged water becomes clean.

(4) After the cleaning, tighten the water drain cock on the radiator, and tighten the drain cocks on the engine and water pump

(5) Add coolant. Fill the cooling system with proper coolant. The total engine coolant capacity is 56L

Caution: The actual amount of coolant should refer to the equipment date.

Caution: Add coolant slowly to avoid air block. Coolant should be added up to the bottom of the filter in the radiator or meet the requirement of the equipment manufacturer. Wait for about 2–3 minutes for a full purge of air.

(6) Install the pressure cap on the radiator, start and run the engine until coolant temperature reaches 80℃, then stop the engine and check and wait until the coolant temperature falls to below 50℃. then open then pressure cap and recheck the coolant level. Supplement properly, if necessary.

Replacing air filter element

(1) Blow off dirt on the filter with compressed air.

(2) Remove the filter cover, remove and scrap the element.

(3) Cover the compressor inlet from inside the air filter body with clean stuff to prevent dirt from entering the intake system.

(4) Clean the inside of the filter body.

(5) Check the new filter element for any defects and remove the covering stuff from the compressor inlet. Install the new element and make sure a sound seal at both ends.

(6) Install the air filter cover and the service indicator.

Caution: Be sure that both end faces of the air filter are reliably sealed without leakage after the air filter element has been changed.

Steps to Fix Diesel Generator Camshaft Damage:

Common damage characteristics of diesel generator set camshaft

The diesel generator set camshaft has a valve train camshaft and a fuel injection pump camshaft. The damage of the fuel pump camshaft in use is similar to that of the camshaft in the valve train, mainly including cam profile wear and camshaft bending. These damages will directly affect the timing of the gas distribution of the diesel generator set and the timing of fuel supply, affecting the normal working quality of the diesel generator set, resulting in overloading of other cylinders and seriously damaging the safety of the diesel generator set. Therefore, it is particularly urgent to timely repair and repair the damage of the cam surface of the diesel generator set and reduce the failure rate. The following is a brief introduction to the main damage characteristics of the diesel generator set camshaft.

1. Diesel generator set cam face wear

When the camshaft is at rated speed, the linear speed is up to 1.3 m/s. During the oil supply process of driving the plunger upward, the friction and pressure of the cam surface are quite large due to the compression pressure of the fuel and the spring pressure. When the point of death is turned, the back side of the cam is subjected to the impact of the elastic force. Therefore, there are different degrees of wear on both sides of the cam, especially on the side of the cam lift, in addition to the wear, and a little fatigue pit. When the cam wears up to 0.3 mm, it will obviously

affect the accuracy of the oil supply time and the fuel injection continuous angle, resulting in poor engine fire, power and economy. When there is a pit in the surface of the genset cam, the surface roughness will decrease, and if it continues to be used, it will accelerate the wear.

2. Diesel generator set camshaft neck wear

The journal and the inner ring of the ball bearing are tightly fitted and generally do not wear. After the individual shafts wear out, the radial clearance is increased, which affects the speed regulation performance of the engine.

3. Diesel generator set cam keyway wear

Generally, it is not common. In some cases, the installation of the transmission bushing is loose, so that the impact occurs during operation and wear. After wear, the oil supply time will lag behind.

4. Diesel generator set camshaft broken

The broken part is mostly on the tapered cylinder of the shaft head. This is because a small number of camshafts have inherent defects during manufacture, fatigue wear during operation, and finally lead to breakage or jamming or breaking of the plunger, causing the camshaft transmission torque to rise significantly, exceeding the permissible stress of the camshaft, due to the conical head taper. The section of the part is small and it is easy to break here.

Common damage causes and maintenance methods for camshafts of diesel generator sets

Damage to the camshaft of the diesel generator set will directly affect the timing of the valve timing and fuel supply timing of the diesel generator set, and damage the normal operation of the generator set in severe cases. Therefore, it is very important to eliminate the cause of the damage of the cam surface of the diesel generator set and reduce the failure rate. The reasons for the damage of the diesel generator set are analysed, and the maintenance method of the camshaft is discussed to improve the maintenance quality of the camshaft of the fuel injection pump of the diesel generator set.

Common causes of damage to camshafts of diesel generator sets

1. When the oil pump is assembled, if the axis of the push rod is deflected during the assembly process, the roller and the camshaft cam are not in line contact, but a point contact occurs, resulting in uneven force, causing the roller to roll poorly, resulting in the roller and the cam. Work surface wear is intensified.

2. The lower body of the fuel injection pump and the cam are pressure-lubricated, and the oil is supplied to the lower body of the pump through the hollow bolt, the small copper pipe for supplying oil, and the joint body, and the cam and the roller are lubricated, which is often caused by the blockage of the hollow bolt, the small copper pipe and the joint body. The oil is not smooth, the heat generated by the cam and the roller

cannot be lost in time, initially causing the cam and the roller to be injured. The roller copper sleeve is worn out of excess, and the roller rolling on the cam causes the impact on the roller, which aggravates the wear of the copper sleeve and the positioning pin, sometimes Causes the copper sleeve to lock on the pin. Sliding friction occurs between the roller and the cam, as the roller forms an irregular ellipse and the top of the cam is severely damaged.

3. The clearance between the valve body and the push rod is too large. Due to improper fitting of the push rod, the clearance between the valve body and the push rod is too large, and the clearance between the push rod and the roller pin is too large, which can cause the guide pin to be poorly guided, and the roller axis and the cam axis are deviated, resulting in deviation The gas distribution roller is indexed at a small angle to injure the camshaft valve cam.

Diesel generator set camshaft inspection method

1. Check the axial clearance of the camshaft, press the camshaft end, tilt the cam axial side, adjust the hands to "0", and then move the cam shaft to the other side. The indication value of the hands is the axial direction. The gap (0. 05~0. 15 mm is normal). If the axial clearance exceeds the specified value, it can be adjusted by replacing the adjustment spacers of different thicknesses. If the axial clearance is too large, replace the thinner gasket; if the axial clearance is too small, replace the thicker gasket. If the camshaft is left at 0. 05 mm, the right gasket (thickness is also 0. 05 mm) is taken out and placed on the left.

2. Check the camshaft curvature. If the degree of curvature exceeds 0.05 mm, the method of cold pressing should be used for repeated straightening. It is not advisable to use a hammer (hand hammer) to hard-hit. There are only two cases of camshaft bending: one is the bending of the central part of the camshaft; the other is the bending of the end of the camshaft (the end connected to the automatic oil feeder), which is equipped with a gear-driven type of oil supply. When the automatic advancer is used, the front end of the camshaft is most often bent. This kind of bending makes the tapered roller bearing set at the front end of the camshaft the most powerful, which makes the bearing race "out of the circle", the bearing cover loose and outward, the camshaft turbulence increases, the cam, the tappet ball The wear of the timing gears that mesh with each other in the gearbox is accelerated. In severe cases, the bearing roller support frame may be broken, the lubricating oil in the pump may leak from the loose bearing cover edge, the timing gear may be cracked, etc., therefore, the cam the bending of the shaft must be straightened in time.

3. Check the journal at the oil seal of the camshaft. If the depth of the groove is more than 0. 10 mm, repair repair is required. Check the cooperation of the camshaft keyway and the semicircle key. Check the camshaft taper and threads. If it is rough or damaged, use a stone to grind or replace the camshaft. Check the cam on the camshaft and replace the camshaft if it is damaged, deformed or severely worn. The amount of cam wear should not exceed 0.5 mm. Check the radial runout of the camshaft. If it exceeds 0.5 mm, it should be cold-pressed. Check the camshaft axial clearance. If it exceeds 0.15 mm, adjust or replace the camshaft.

4. Grinding the cam profile and roller, the roller and cam profile ensure uniform contact during assembly; the pusher body and the pump lower body should be carefully cleaned before inspection and check whether the roller surface is pocked or scratched, and its rotation and roller axle whether the up and down movement is flexible and whether the gap is too large.

References:

1. https://www.dieselnet.com/tech/diesel_fi.php
2. https://www.diesel-engine-motor-service.com/es/sobre-seco/24-support.html
3. https://www.dieselgeneratortech.com/diesel-generators/How-to-Fix-Diesel-Generator-Camshaft-Damage.html
4. https://www.dieselgeneratortech.com/diesel-generators/maintenance-of-oil-transfer-pump.html
5. https://www.dieselserviceandsupply.com/Services/Belt-Replacements.aspx

Videos:

	How to install an engine oil pump https://www.youtube.com/watch?v=OVZoEV47E5w

	How to replace a radiator https://www.youtube.com/watch?v=MeruAZebIeU
	Crank shaft, cam shaft install method https://www.youtube.com/watch?v=tHWG-w7JkkU
	Changing timing belt of a generator https://www.youtube.com/watch?v=-j3huIhbqkY

GENERATOR MECHANIC

Module-8

LEARNER GUIDE

National Vocational Certificate Level 3

Version 1 - November, 2019

Module 8: Repair/Replace Electrical Components

Objective of the module: After completing this learning module, the learner will be able to repair self- starter, replace faulty parts, replace cooling fan motor and inspect warning system.

Duration:	**Total hours**	**170**	**Theory**	**34**	**Practical**	**136**

Learning Unit	Learning Outcomes	Learning Elements	Materials (Tools & Equipment) Required
LU1. **Repair** **Self-Starter**	**.** Identify tools and equipment **.** Check the self-starter relay **.** Check self- starter switch contacts (cut-out) **.** Check starter loose connections **.** Check self- starter armature **.** Check starter field coil for short circuit **.** Check drive system of self-gear **.** Check self- starter bushes	**Knowledge and understanding of:** • Identifying tools and equipment for repairing self-starter • self –starter, function of self-starter and main parts of self-starter. • Self-starter relay, switch contacts, armature, field coil, drive system, bushes. • Types of self-starters like 1.Direct-on-line (DOL) **starter**. 2.Star- delta **starter**. 3.Soft **starter**. 4.Rheostat control **starter** for rotor wound motor.	• **.** Self-starter • **.** Multimeter • . Tool kit

LU2. **Replace faulty parts of main alternator**	. Select tools and equipment . Replace carbon-bushes . Replace of self-excitation system . Replace Automatic Voltage Regulator (AVR) . Replace alternator terminal block (connection plate)	**Knowledge and understanding of:** • Selecting tools and equipment for replacing faulty parts of main alternator • Various types of main alternator (statically and dynamically induced EMF) • Automatic Voltage Regulator and Function of Automatic Voltage Regulator (AVR), • Functions of various alternator parts such as 1.Rotor and stator 2.Diode assembly 3.Voltage Regulator • Replacing carbon brushes • Replacing of self-excitation system, • Replacing Automatic Voltage Regulator (AVR) • Replacing alternator terminal block (connection plate)	• . Main alternator • . Carbon brushes • . Diodes • . AVR • . Tool kit
LU3. **Change gauges on display panel**	. Identify tools and equipment . Replace temperature gauge . Replace oil pressure gauge . Replace AC Ampere meter . Replace DC charging gauge . Replace revolution per minute (RPM) meter	**Knowledge and understanding of:** • Identifying tools and equipment for changing gauges on display panel • Temperature gauge, Oil pressure gauge, DC charging gauge, • AC ampere meter, AC voltmeter, Frequency meter • RPM Meter, Hour meter. • Replacement techniques of temperature gauge, Oil pressure gauge, • Replacement techniques of AC ampere meter. • Replacement techniques of DC charging gauge. • Replacement techniques of RPM meter. • Replacement techniques of AC voltmeter.	• Temperature gauge • . Oil pressure gauge • . AC Ampere meter • . DC charging gauge • . Revolution per minute (RPM)

	. Replace AC volt meter . Replace frequency meter . Replace hour meter	• Replacement techniques of frequency meter. • Replacement techniques of hour meter	meter • . AC volt meter • . **Frequency** meter • . Hour meter • . Tool kit
LU4. **Repair/ replace governor**	. Identify tools and equipment . Remove fuel pipe lines . Remove timing plate . Remove fuel injection pump gear . Repair Governor . Install Governor	**Knowledge and understanding of:** • Identifying tools and equipment for repairing/replacing governor • Repair/replacement techniques of fuel pipe line. • Repair/replacement techniques of timing plate • Repair/replacement techniques of fuel injection pump gear • Repair/replacement techniques of governor • Installing a governor	• . Governor • . Tool kit

LU5. **Replace warning sensors**	**.** Select tools and equipment **.** Remove and replace temperature sensors **.** Remove and replace oil pressure sensors **.** Remove and replace fuel sensors	**Knowledge and understanding of:** • Selecting tools and equipment for replacing warning sensors • Replacement technique of temperature sensor. • Replacement technique of oil pressure sensor • Replacement technique of fuel sensor	• . Tool kit
LU6. **Replace main alternator bearings**	**.** Arrange tools and equipment **.** Dismantle main alternator **.** Pull out the bearings **.** Install bearings	**Knowledge and understanding of:** • Arranging tools and equipment for replacing main alternator bearings • Dismantling the main alternator • Replacement techniques of main alternator bearings	• . Main alternator. • Bearing Puller • . Bearing • . Tool kit
LU7. **Change Spark plugs**	**.** Arrange tools and equipment **.** Remove the spark plug cables **.** Remove spark plugs **.** Install spark plugs	**Knowledge and understanding of:** • Arranging tools and equipment for changing spark plugs • Removing the spark plug cables • Replacement techniques of change spark plugs	• **.** Spark plugs • . Spark plug spanner

Examples and illustrations:

Alternator. Construction and Working:

The machine which produces 3 phase power from mechanical power is called an alternator or synchronous generator. The working of an alternator is based on the principle that when the flux linking a conductor changes, an emf is induced in the conductor.

ice a DC generator, an alternator also has an armature winding and a field winding. **B**ut there is one important difference between the two.

In a DC generator, the armature winding is placed on the rotor in order to provide a way of converting alternating voltage generated in the winding to a direct voltage at the terminals through the use of a rotating commutator.

The field poles are placed on the stationary part of the machine. Since no commutator is required in an alternator, it is usually more convenient and advantageous to place the field winding on the rotating part (i.e., rotor) and armature winding on the stationary part (i.e., stator).

An alternator has 3, -phase winding on the stator and a DC field winding on the rotor. This DC source (called exciter) is generally a small DC shunt or compound generator mounted on the shaft of the alternator.

Rotor construction is of two types, namely;

- Salient (or projecting) pole type
- Non-salient (or cylindrical) pole type

In salient pole type alternator, salient or projecting poles are mounted on a large circular steel frame which is fixed to the shaft of the alternator.

In cylindrical pole type alternator, the rotor is made of a smooth solid forged-steel radial cylinder having a number of slots along the outer periphery.

COMPONENTS

The main components of an alternator are

- the stator winding,
- the rotor, the regulator and
- the rectifier.

Alternator Operation

The rotor winding is energized from the DC exciter and alternate N and S poles are developed on the rotor.

When the rotor is rotated in the anti-clockwise direction by a prime mover, the stator or armature conductors are cut by the magnetic flux of rotor poles. Consequently, e.m.f. is induced in the armature conductors due to electromagnetic induction.

The induced e.m.f. is alternating since N and S poles of rotor alternately pass the armature conductors. The direction of induced e.m.f. can be found by Fleming right-hand rule and frequency is given by;

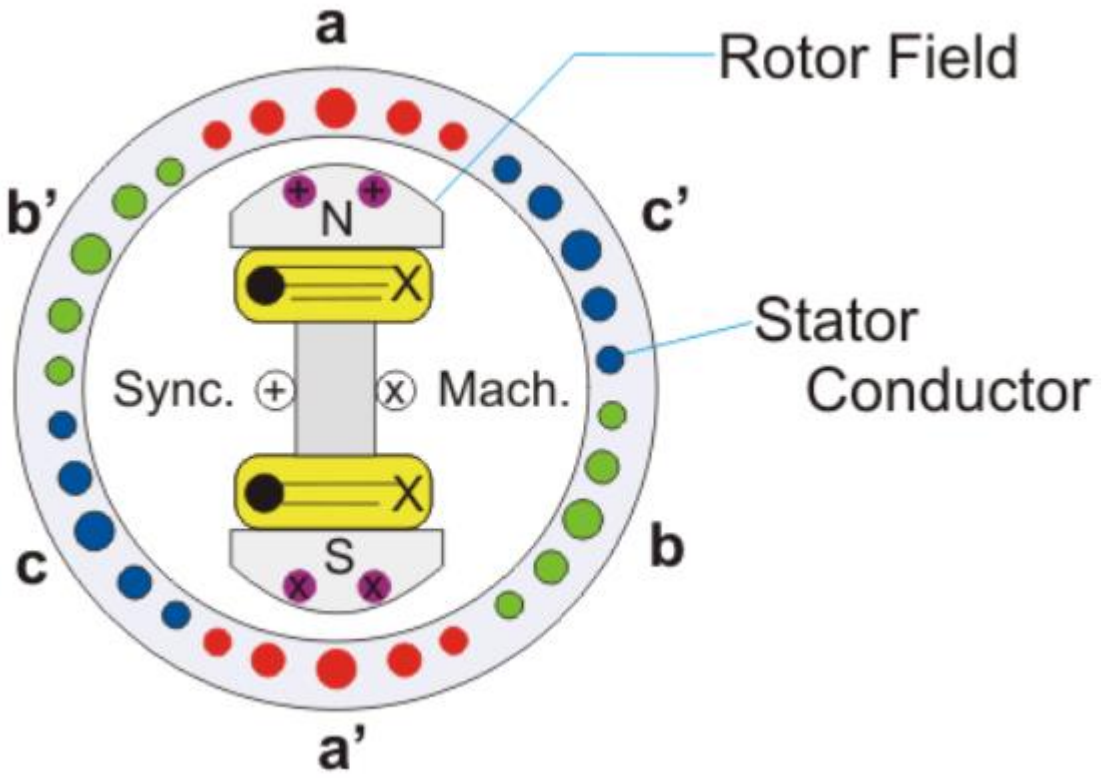
$$f = PN / 120$$

where N = speed of the rotor in p.m.

P = number of rotor poles

The magnitude of the voltage induced in each phase depends upon the rotor flux, the number and position of the conductors in the phase and the speed of the rotor.

When the rotor is rotated, a 3-phase voltage is induced in the armature winding. The magnitude of induced e.m.f. depends upon the speed of rotation and the DC exciting current. The magnitude of e.m.f. in each phase of the armature winding is the same. However, they differ in phase by 120° electrical.



Alternator

https://www.electrical4u.com/construction-of-alternator/

Automatic Voltage Regulator:

The automatic voltage regulator is used to regulate the voltage. It takes the fluctuate voltage and changes them into a constant voltage. The fluctuation in the voltage mainly occurs due to the variation in load on the supply system. The variation in voltage damages the equipment of the power system. The variation in the voltage can be controlled by installing the voltage control equipment at several places likes near the transformers, generator, feeders, etc., The voltage regulator is provided in more than one point in the power system for controlling the voltage variations.

Working Principle of Voltage Regulator:

It works on the principle of detection of errors. The output voltage of an AC generator obtained through a potential transformer and then it is rectified, filtered and compared with a reference. The difference between the actual voltage and the reference voltage is known as the error voltage**.** This error voltage is amplified by an amplifier and then supplied to the main exciter or pilot exciter.

Thus, the amplified error signals control the excitation of the main or pilot exciter through a buck or a boost action (i.e. controls the fluctuation of the voltage). Exciter output control leads to the controls of the main alternator terminal voltage.

Application of the Automatic Voltage Regulator:

The main functions of an AVR are as follows.

- It controls the voltage of the system and has the operation of the machine nearer to the steady state stability.
- It divides the reactive load between the alternators operating in parallel.
- The automatic voltage regulators reduce the overvoltage's which occur because of the sudden loss of load on the system.
- It increases the excitation of the system under fault conditions so that the maximum synchronizing power exists at the time of clearance of the fault.

When there is a sudden change in load in the alternator, there should be a change in the excitation system to provide the same voltage under the new load condition. This can be done by the help of the automatic voltage regulator. The automatic voltage regulator equipment operates in the exciter field and changes the exciter output voltage, and the field current. During the violent fluctuation, the ARV does not give a quick response.

References:

1. https://www.electricaleasy.com/2014/02/AC-generator-alternator-construction-working.html

2. http://blitztek.co.za/automatic-voltage-regulators-avr-2/

VIDEOS:

	Generator Self-starter Repair https://www.youtube.com/watch?v=CkVzSOkdFFs
	Repair an alternator https://www.youtube.com/watch?v=hmx2fHdmBIw

	Governor Repair https://www.youtube.com/watch?v=32B6ZadItjk
	Alternator repair. Noisy bearings replacements https://www.youtube.com/watch?v=kep6ewppqLE

	Generator maintenance, spark plug change https://www.youtube.com/watch?v=Te0lnYy8wbQ

GENERATOR MECHANIC

Module-9

LEARNER GUIDE

National Vocational Certificate Level 3

Version 1 - November, 2019

Module 9: Install new Generator

Objective of the module: After completing this learning module, the learner will be able to maintain supply in accordance with the requirements of industry regulations and established procedures. It encompasses the operation, connection and disconnection as well as assessing load assuring the appropriateness of all generators for the required outcome.

Duration:	Total hours	70	Theory	17	Practical	53

Learning Unit	Learning Outcomes	Learning Elements	Materials (Tools & Equipment) Required
LU1. Adopt manufacture procedure	**.** Identify Gross weight of the generator **.** Identify foundation holes of generator as per Manufacturer **.** Ensure holes in concrete base	**Knowledge and understanding of:** • Generator installation manual that contains 1. General information about Generator installation, before installation, Generator location, Generator mounting and support, unpacking, lifting the generator, Muffler extension installation, fuel system, electrical connections, battery Installation. 2. Installation that includes Transfer switch, unpacking, mounting 3. Operation that includes Basic standby electric system, standby circuit isolation method, total circuit isolation method, connection diagram, wire recommendations. • Identifying gross weight of generator • Identifying foundation holes of generator as per Manufacturer manual • Ensuring holes in concrete base	• . Generator • . Multimeter

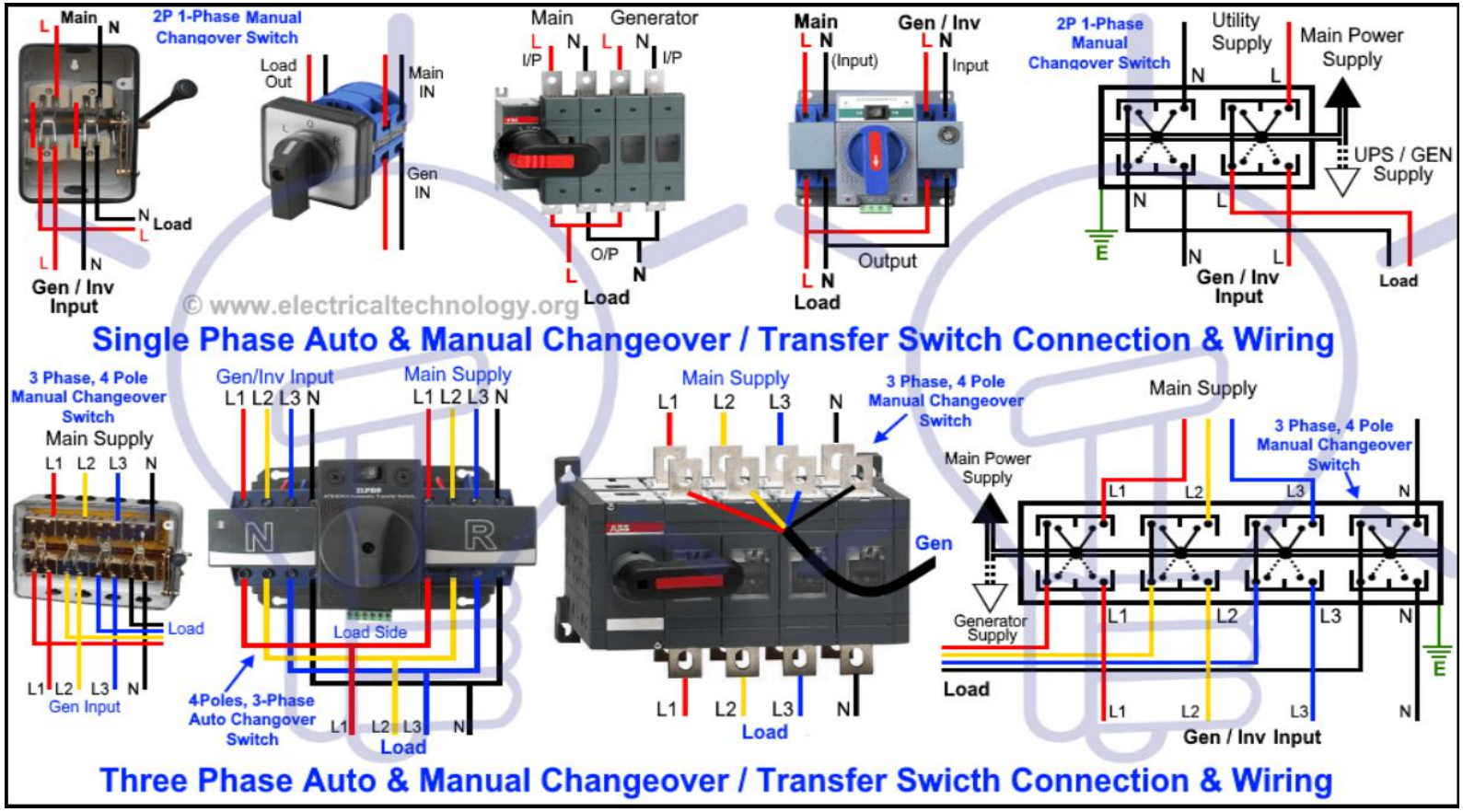
LU2. **Interpret foundation drawing**	**.** Measure distance between foundation holes **.** Measure diameters of foundation holes **.** Compare diameters of foundation bolts as per specification	**Knowledge and understanding of:** • Foundation drawing • Measuring distance between foundation holes • Measuring diameters of foundation holes • Comparing diameters of foundation bolts as per specification	• . Foundation drawing • . Foundation Generator
LU3. **Hoist generator**	**.** Locate loading hooks of generator **.** Secure ropes and balance generator **.** Place generator on concrete foundation with chain pulley	**Knowledge and understanding of:** • Locating loading hooks of generator • Steel ropes/cotton ropes • Securing ropes and balance generator • Lifting techniques of generator including manual lift method and lifting with equipment • Placing generator on concrete foundation with chain pulley	• . Chain pulley • . Tool kit
LU4. **Level generator**	**.** Put foundation bolts in foundation holes **.** Level generator length and width wise **.** Fill holes in base with concrete	**Knowledge and understanding of:** • Putting foundation bolts in foundation holes • Leveling techniques • Mixing of concrete ratio	• . Chain pulley • . Level meter • . Tool box

LU5. **Distribute electrical load**	**.** Estimate total electrical load **.** Distribute load on each phase equally	**Knowledge and understanding of:** • Load calculation. • Conversion of KW to KVA. • Neutral balancing, distributing load on each phase equally	• . Clamp on Meter • . Multimeter • . Electrical tool kit
LU6. **Install change over switch**	**.** Mount change over switch/ATS on wall **.** Connect load side with changeover switch **.** Connect generator output with changeover switch **.** Connect external power source with changeover switch	**Knowledge and understanding of:** • Change over switch/Automatic transfer switch (ATS), Functions of Change over switch, importance of change over switch. • Different types of Manual and automatic Change over switch/ATS. • Installation procedure of change over switch/ Automatic Transfer Switch (ATS) • Wiring of single-phase manual transfer/changeover switch • connecting single phase automatic changeover/ATS • Wiring of three phase manual transfer/changeover switch, installation of three phase automatic transfer/change over switch, • installation of three phase manual transfer/change over switch, connecting generator with ATS/change over switch	• . Change over switch/ATS • . Rawal bolts • . Electrical tool kit
LU7. **Connect Earthing**	• Arrange tools and equipment • Ensure earthing as per standards • Connect earth cable with generator body	**Knowledge and understanding of :** • Arranging tools and equipment to connect earthing • Connections of earthing as per standards • Connecting earth cable with generator body	

Examples and illustrations

Manual and Automatic Changeover / Transfer Switch Wiring & Connection:

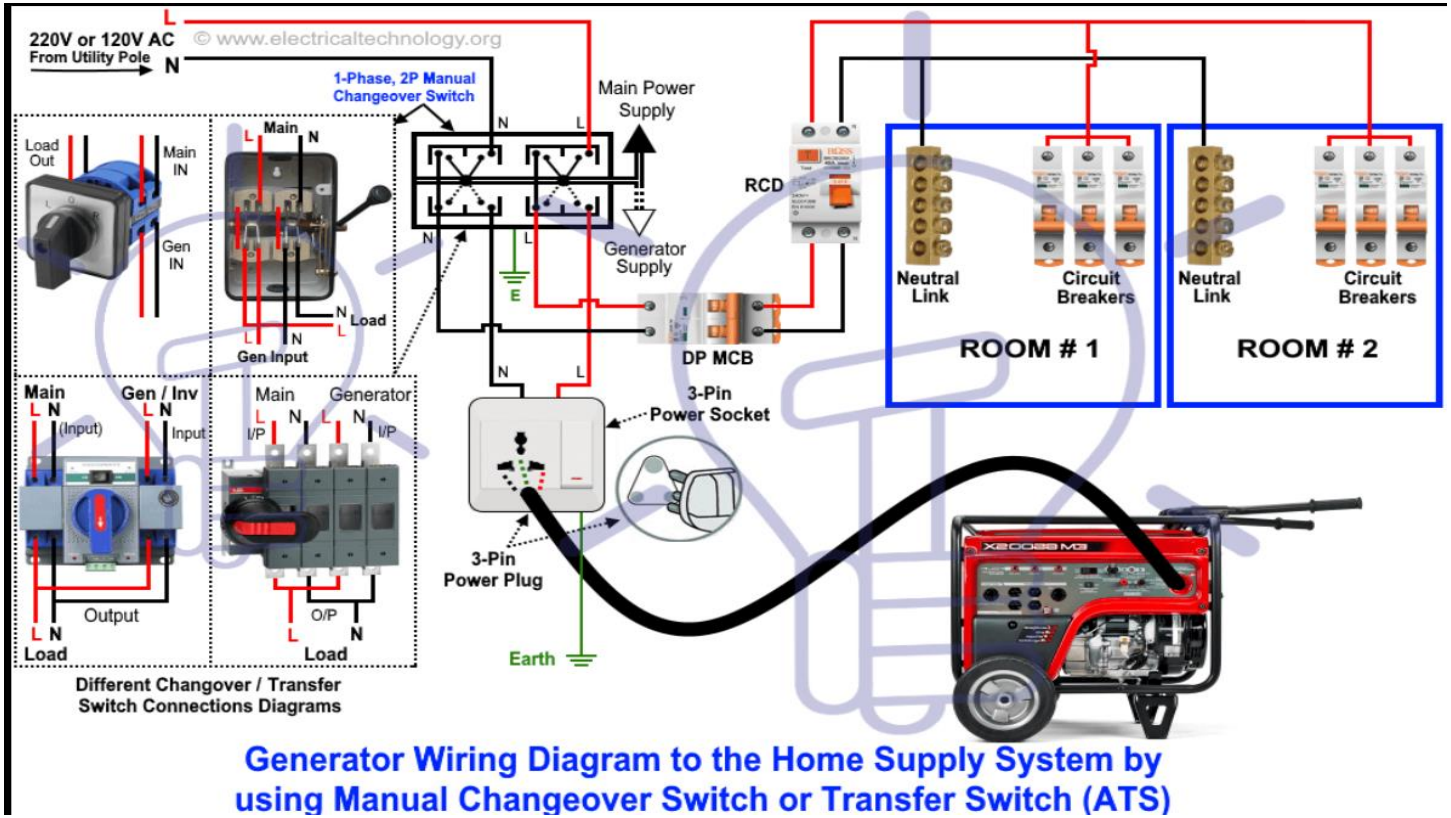
The following fig shows different single phase and three phase connections for manual and automatic changeover and transfer switches. Let's explain one by one in detail as follow.



How to Wire Single Phase Manual Transfer / Changeover Switch

In fig below, different connection and wiring diagrams are shown for a two pole, single phase manual changeover switch. The upper portion of the changeover switch is directly connected to the main power supply while the lower first and right connections slots are connected to the backup power supply like generator or inverter. The left side of lower slots are connected to the main board as load.

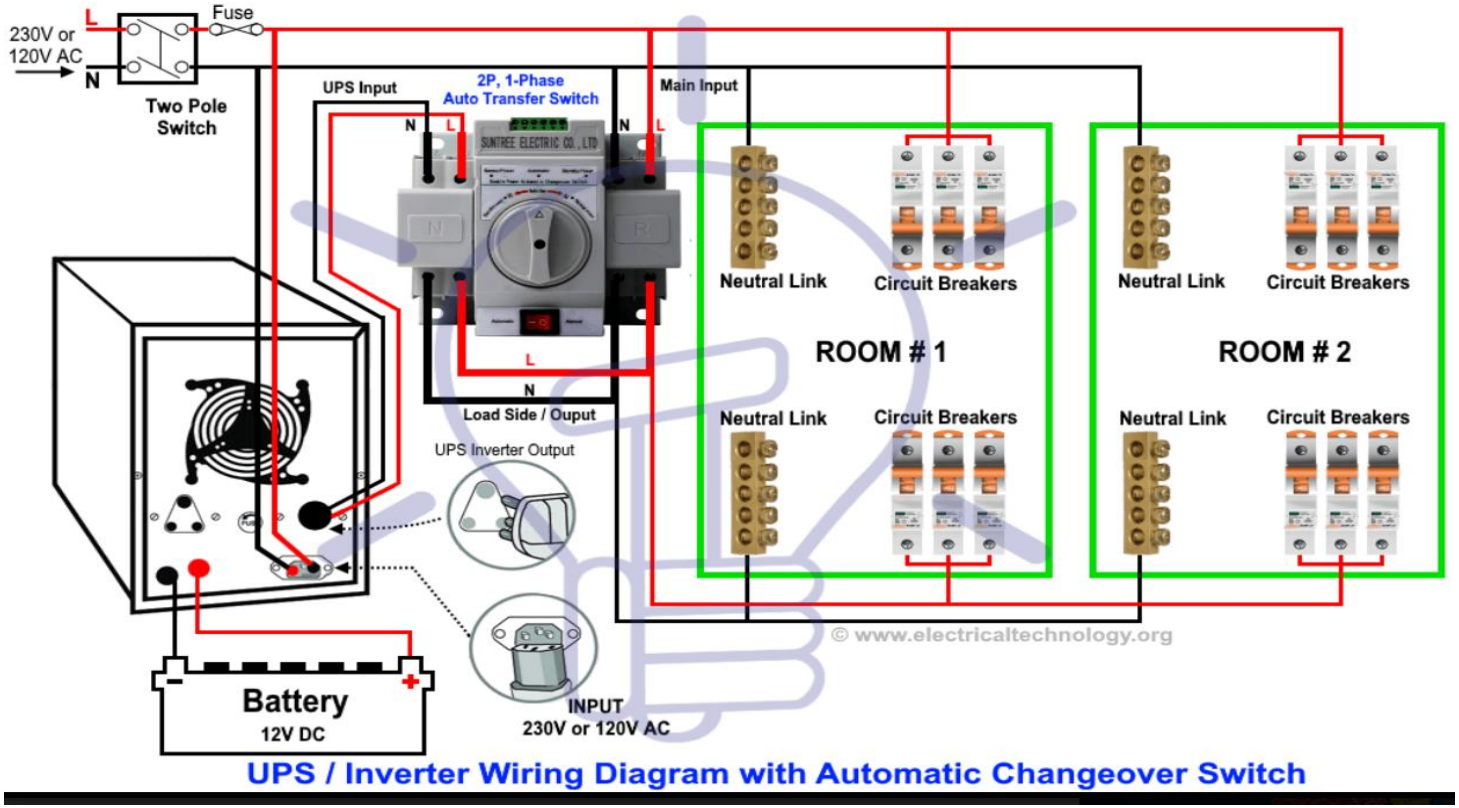
In case of power failure, the manual changeover switch can be changed to the generator / inverter position. This way, power supply will continue to the load points through the inverter or generator. When power supply restores from the power house, simply switch back the changeover switch position to the “Main Power Supply”.



How to Connect Single Phase Automatic Changeover / Transfer Switch (ATS):

If you are tired of manual operation of changeover switches, ATS is the best alternative to use then. In the following fig 3, the backup power of batteries is connected to main distribution board through 2-Pole, single phase automatic changeover or transfer switch (ATS) and UPS / Inverter.

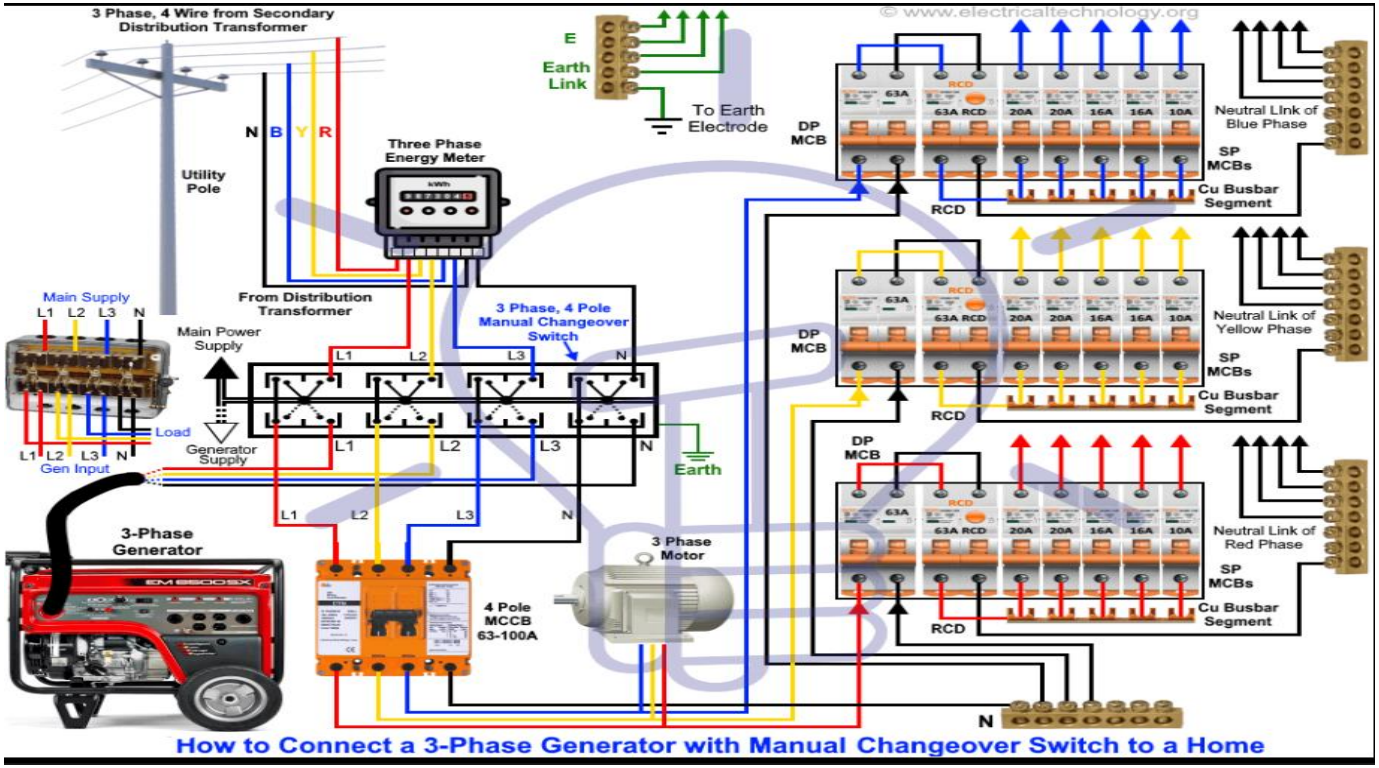
The working and operation of this circuit as same as above expect the automatic changeover switch (ATS) will detect the utility power when restores from the power house and automatically transfer from the Generator / Inverter to the Main Power supply. In case when utility power is not available, the ATS will transfer the switching position to the Inverter, hence electrical appliances will be still in operation mode without interruption through the stored power in the batteries.



How to Wire Three Phase Manual Changeover/Transfer Switch

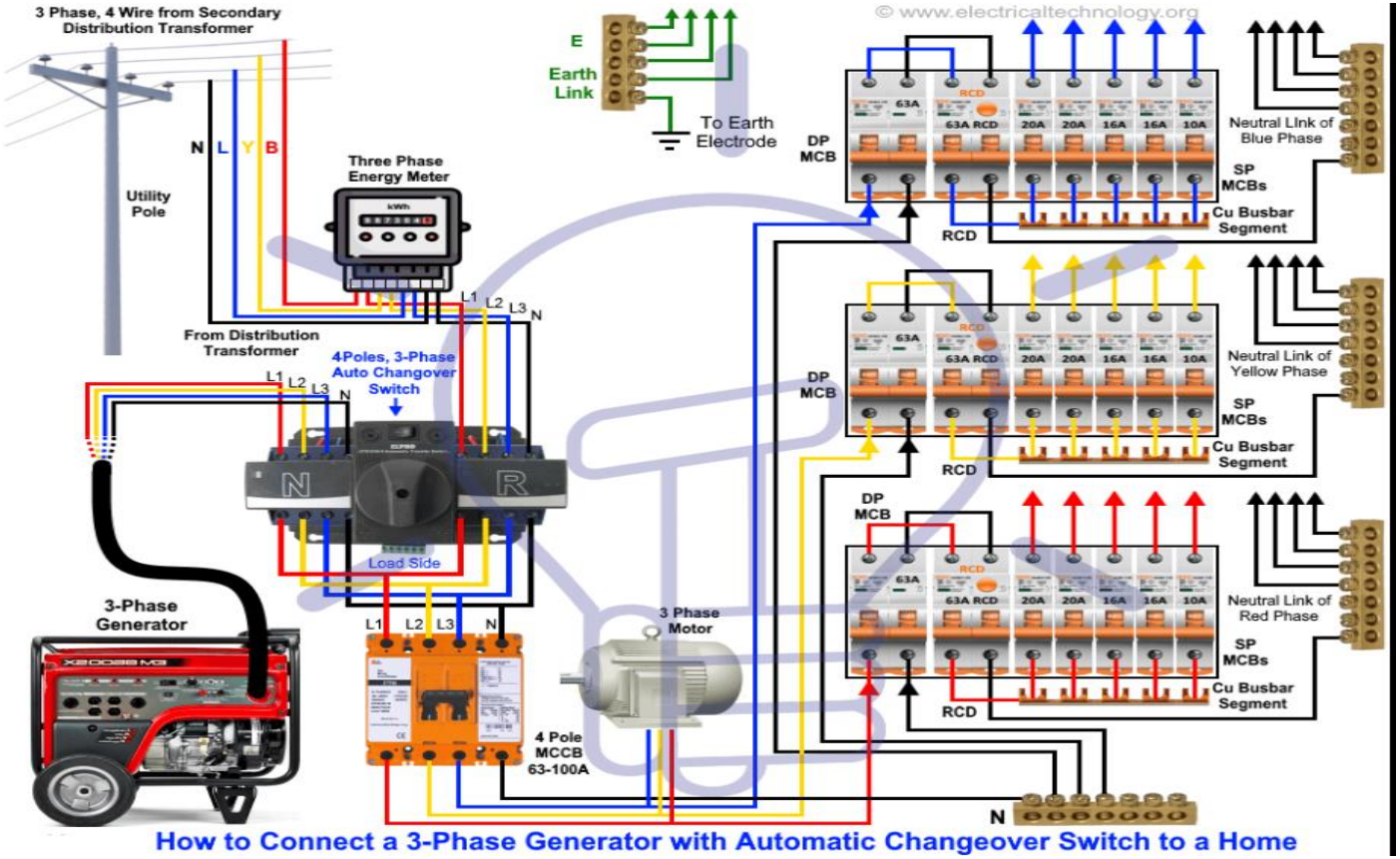
Fig below shows that how to wire four poles, three phase manual changeover switch to the main distribution board. This is the same connection as we discussed above for single phase wiring expect that there are three phase wires instead of line and neutral. The three-phase utility power as (L_1, L_2, L_3 & N) are directly connected to the upper side of manual changeover switch, while the backup power of three phase generator is connected to the first four (right) slots of at lower side. The left side four slots connection points are connected to the load then.

Since the operation is manual, you have to change the changeover lever to the appropriate position manually to restore the power i.e. Change the lever position the “Generator Supply” when main power is not available and then back to the “Main Power” when utility power restores.



How to Install Three Phase Automatic Transfer/Changeover Switch:

Fig below shows 4-Poles, 3-Phase automatic transfer switch (ATS) connection to the main distribution board. All the wiring connections are same as above for manual operation of three phase changeover switch but the switching operation is automatic.
In case of emergency breakdown, the automatic transfer switch will automatically divert the switching position to the “Generator Supply” and when the main supply restores, it will transfer the power flow to the “Utility Power” when using emergency generator set for backup power.



Standby Installed and Portable Generators

Occupational Health and Safety Administration (OSHA) requires all combustion engine driven generators be grounded to the earth. This includes both stationary and portable models serving emergency, prime and continuous applications.

Impedance grounding the generator has both safety and equipment benefits listed below:

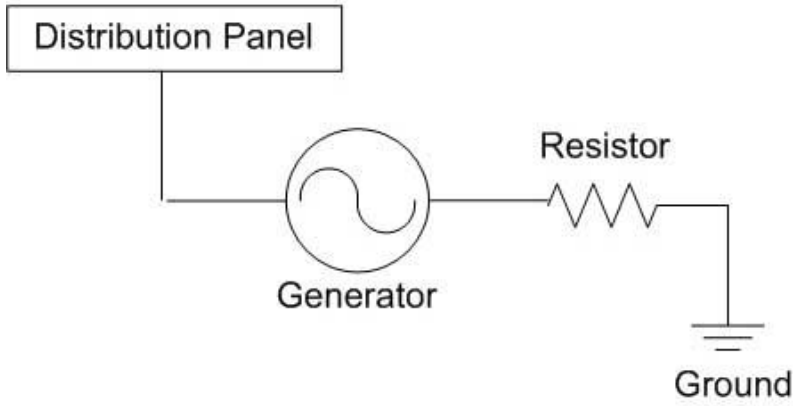
- Reduce burning and melting effects in electrical equipment (switchgear, transformers, cables and rotating machines) during ground fault
- Reduce mechanical shock in components and circuits that are exposed to ground fault
- Reduce electrical shock hazard to personnel who caused or in close proximity of ground fault
- Reduce line voltage dip that can occur when clearing ground fault
- Secures control of transient over-voltages while avoiding a facility shutdown

Some common methods are described for grounding a generator. Transformer and capacitor configurations are used in the impedance grounding configurations. The transformer configuration is featured. This is a general guideline, you should always consult a certified electrician or electrical contractor to make sure you end up with safe and properly grounded generator set prior to operation.

The direct earth grounding method is the simplest method. In this method, the grounding wire or strap is attached to the alternator on one end and an earth ground on the other end. This method is used in small portable generator applications.

Impedance grounding configurations are generally used for larger applications. Impedance is defined as the total resistance the circuit offers when energized. Components that offer resistance in grounding circuits are transformers, conductors, grounding rods, and electronic components.

Low Impedance Grounding:



A resistor is installed between the generator and grounding rod. This resistor is called a neutral grounding resistor. The grounding resistor limits the fault current when one phase of circuit shorts or arcs to ground.

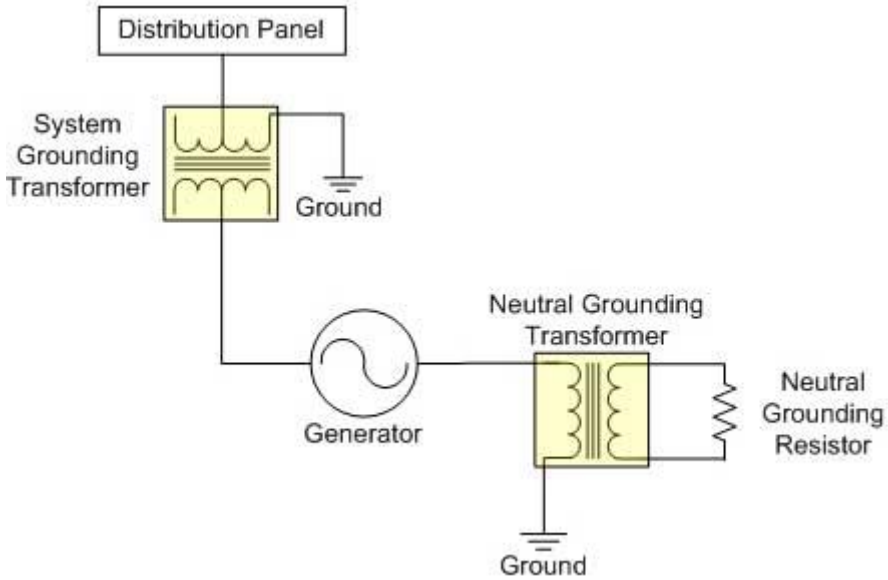
The resistors commonly limit current from 200 to 400 amps. Many resistor manufacturers classify any resistor that limits current to 25 amps or greater as low resistance. An example of resistor specification is 1200V L-N, 200A 10 seconds. This resistor's impedance allows 1200 volts with 200 amps of current for 10 seconds before overheating.

Grounding resistors can handle 10% of their rated load continuously. A 200-amp resistor can handle 20 amps continuously without overheating. Over current devices can be installed in the circuit to prevent resistor heat damage.

Some considerations when designing Low Impedance Grounding circuit are:

1. Phase to ground currents limited 200 to 400 amps
2. Reduces arching and arch flash hazards associated with phase ground
3. Reduces damage to rotator and stator
4. Does not prevent operation of over current devices
5. Ground fault detection system is not required
6. Can be used on medium or high-voltage systems

High Impedance Grounding:



High impedance grounding circuits utilize a neutral grounding transformer for generator protection. Generator ground is connected to input of primary winding of neutral grounding transformer with a path to ground.

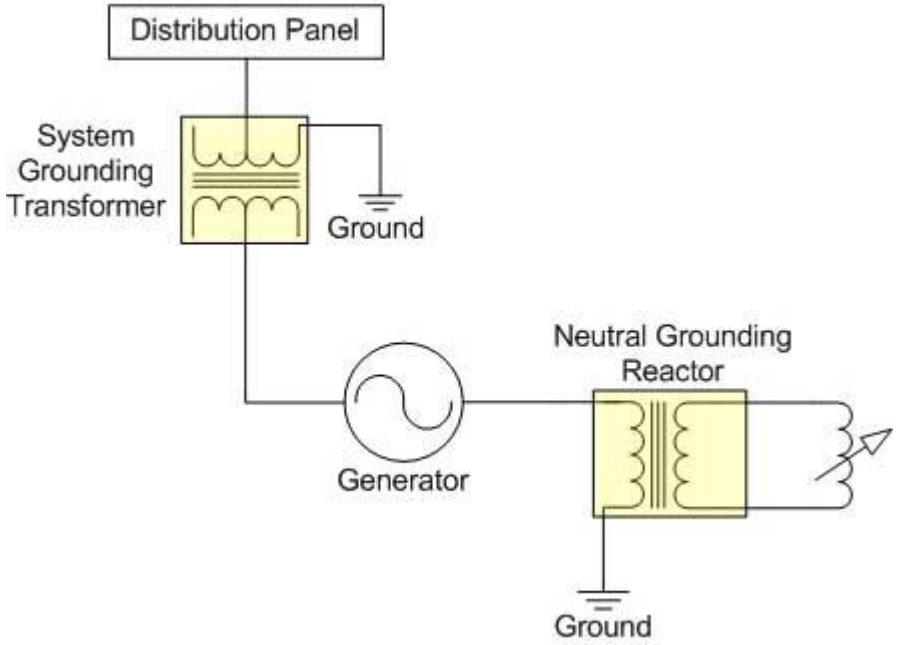
Neutral grounding resistor is connected across the secondary windings of the neutral grounding transformer. The configuration uses the principle of reflected impedance which protects the generator.

System grounding transformer primary winding is connected to the generator. Secondary windings supply the distribution panel and supply path to ground in the event of a system fault.

Some considerations when designing high impedance grounding circuit are:

1. Phase to ground currents limited 5 to 10 amps
2. Reduces arching and arch flash hazards associated with phase to ground
3. Eliminates damage to rotator and stator
4. Prevent operation of over current devices until fault can be located
5. Requires ground fault detection system
6. Can be used on low or medium voltage systems

Compensated Grounding



Compensated grounding systems can also be referred to as reactance or resonant systems. This system is designed much the same as the high impedance system.

System grounding transformer primary winding is connected to the generator. Secondary windings supply the distribution panel and supply path to ground in the event of a system ground fault.

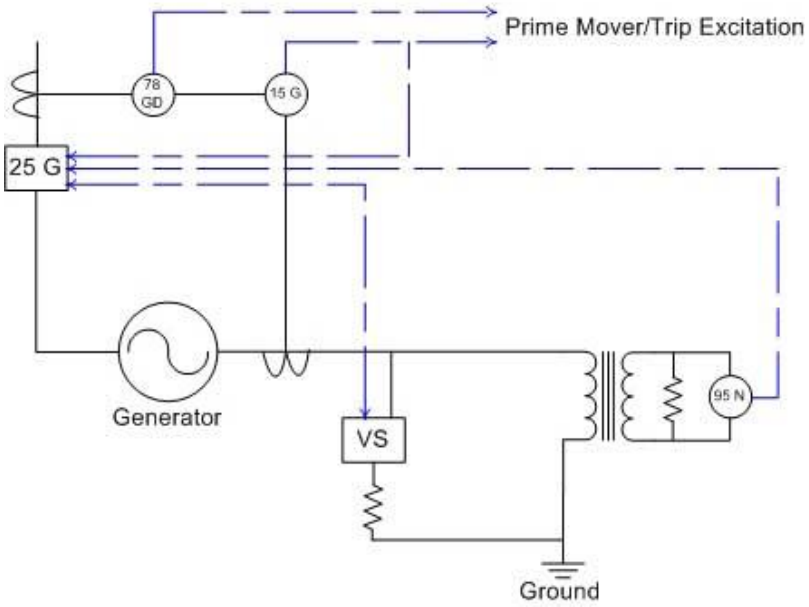
Neutral grounding reactor replaces the neutral grounding transformer and resistor used in high impedance grounding circuits. The reactor is a combination of a transformer with a Peterson coil attached to a grounding transformer. Peterson coil allows system tuning.

When system inductance and capacitance matches, the system is 100% tuned or fully compensated. If reactor impedance does not match capacitance, the system is turned off.

Some considerations when designing a compensated grounding circuit are:

1. More expensive that high or low impedance system because of addition of neutral grounding reactor
2. Uses system grounding transformer for system grounds
3. Uses reflected impedance design as the high impedance systems
4. No generator damage from ground faults
5. Reactor is tuned against generator capacitance to ground. Ground fault currents can be less than 1 amp

Hybrid Grounding



Hybrid grounding systems are designed to allow for the benefits of both the high impedance and low impedance grounding systems. Ground faults accomplish minimal damage to generator and system components.

In the event of a generator ground fault, the system will utilize the high impedance grounding portion of the circuit to minimize generator damager. This system is safer for the generator because it is never left in the ungrounded state as with low impedance systems.

This configuration provides the benefits of low impedance systems because all ground faults will have selective coordination providing minimal damage at the point of the fault. Ground fault current is limited to the sum of the low impedance system.

References:

1. https://www.electricaltechnology.org/2018/11/automatic-manual-changeover-transfer-switch.html
2. https://www.dieselserviceandsupply.com/Generator-Grounding-Methods-Requirements.aspx

VIDEOS:

	Hoisting a generator https://www.youtube.com/watch?v=DRcGVaeXzcI

	Load calculation of generator https://www.youtube.com/watch?v=l3Xj9fXVG2w
	Change over switch connection with generator https://www.youtube.com/watch?v=ThFgjdgaW78

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. What are the entry requirements for this course?	The entry requirement for this course is 8th Grade or equivalent.
4. 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-3 in Leather Products Development Technician (Pattern Maker). You shall be able to progress further to National Vocational Certificate Level-4 in Heavy Construction Machinery Operator Course; and take admission in a level-5, DAE or equivalent course (if applicable). In certain case, you may be required to attain an equivalence certificate from The Inter Board Committee of Chairmen (IBCC).
5. If I have the experience and skills mentioned in the competency standards, do I still need to attend the course to attain this certificate?	You can opt to take part in the Recognition of Prior Learning (RPL) program by contacting the relevant training institute and getting assessed by providing the required evidences.
6. What is the entry requirement for Recognition of Prior Learning program (RPL)?	There is no general entry requirement. The institute shall assess you, identify your competence gaps and offer you courses to cover the gaps; after which you can take up the final assessment.
7. Is there any age restriction for entry in this course or Recognition of Prior Learning program (RPL)?	There are no age restrictions to enter this course or take up the Recognition of Prior Learning program
8. What is the duration of this course?	The duration of the course work is 1,510 hrs. (11 months)
9. What are the class timings?	The classes are normally offered 25 days a month from 08:00am to 01:30pm. These

	may vary according to the practices of certain institutes.
10. What is equivalence of this certificate with other qualifications?	As per the national vocational qualification's framework, the level-4 certificate is equivalent to Matriculation. The equivalence certificate can be obtained from The Inter Board Committee of Chairmen (IBCC).
11. 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.
12. 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 local or overseas construction companies in heavy machinery operator job profile.
13. 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.
14. 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.
15. 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.
16. How much salary can I get on job after attaining this certificate?	The minimum wages announced by the Government of Pakistan in 2019 are PKR 17,500. This may vary in subsequent years and different regions of the country. Progressive employers may pay more than the mentioned amount. The heavy Machinery Operator normally earns 20,000 to 25,000 in the start.
17. Are there any alternative certificates which I can take up?	There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.
18. What is the teaching language of this course?	The leaching language of this course is Urdu and English.
19. Is it possible to switch to other certificate programs during the	There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.

course?	
20. 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.
21. Does this certificate enable me to work as freelancer?	You can start your small business by purchasing your own heavy construction machine and can start earning 50,000 per month. You may need additional skills on entrepreneurship to support your initiative.

Test Yourself (Multiple Choice Questions)

MODULE	**6**	Carryout Basic Electrical Installation (Alternating Current-AC)		
Question	**1**	In single core cables armoring is not done to	A	Avoid excessive sheath losses
			B	Make it flexible
			C	Either of the above
			D	None of the above
Question	**2**	Earth wire or ground wire is made of	A	Copper
			B	Aluminum
			C	Iron
			D	Galvanized steel

Question 3 The objective of earthing is

A To provide as low resistance possible to the ground

B To provide as high resistance possible to the ground

C To provide flow of positive sequence currents

D To provide flow of negative and zero sequence currents

Question 4 Which is the most type of wiring used in domestic applications?

A Conduit wiring

B Cleat wiring

C Batten wiring

D TRS wiring

Question 5 Megger is a

A Source of emf

B Source to measure high resistance

C Type of null detector

D Current carrier

MODULE 7 Repair/Replace Mechanical Components

Question 1 The plunger of a jerk type pump is driven by a

A Crankshaft

B **Camshaf**t

C Pully

D Both A and C

Question 2 In the following system, lubricating oil is carried in separate tanks from where it is fed to the engine

A Mist lubrication system

B Wet sump system

C **Dry sump system**

D Splash system

Question 3 The following part is not lubricated by pressure feed system

A Timing gears

B **Valve rods and push rods**

C Rockers arms

D Honey comb

Question 4 In _____ radiator, each tube contains individual fins surrounding it.

A **Gilled type**

B Honey comb

C Tubular type

D B and C

Question 5 The following is considered as best antifreeze solution

A **Ethylene glycol**

B Distilled glycerin

C Methanol

D Denatured alcohol

MODULE	**8**	Repair/Replace Mechanical Components		
Question	**1**	An alternator is also called	A	Synchronous generator
			B	Turbo generator
			C	Asynchronous generator
			D	Generator
Question	**2**	Three phase alternators are invariably Y-connected because	A	Magnetic losses are minimized
			B	Less turns of wire are required
			C	Smaller conductors can be used
			D	Higher terminal voltage is obtained

Question 3	Windings of star-delta starter while starting and during running are connected in	A	Star, delta
		B	Delta, delta
		C	Star, Star
		D	Delta, Star
Question 4	An Ampere meter measures:	A	Current
		B	Voltage
		C	Frequency
		D	Power
Question 5	Which one of the following measures voltage?	A	Voltmeter
		B	Ampere meter
		C	Frequency meter
		D	Hour meter

MODULE	**9**	Install New Generator		
Question	**1**	Active power and apparent power are respectively represented by?	A	KW and KVAR
			B	KVAR and KVA
			C	KVA and KVAR
			D	KW and KVA
Question	**2**	What is connected load?	A	Installed electrical load in the premises of the consumer.
			B	Maximum load a consumer draw
			C	Load drawn by a consumer at any instant
			D	Load drawn at peak times.

Question 3 The function of change over switch is:

A To transfer electricity from power grid to local generator

B To increase the voltage of the system

C To increase frequency of the system

D To increase current of the system

Question 4 The foundation for generator must be able to withstand:

A Installation's weight

B Apparent power

C Real power

D Reactive power

Question 5 ATS Stands for:

A Ampere transfer switch

B Automatic transfer switch

C Auto turbine switch

D After transfer switch

Answers

MODULE 6: Q1.a Q2.d Q3.a Q4.a Q5.b

MODULE 7: Q1.b Q2.c Q3.b Q4.a Q5.a

MODULE 8: Q1.a Q2.b Q3.a Q4.a Q5.a

MODULE 9: Q1.d Q2.a Q3.a Q4.a Q5.b

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