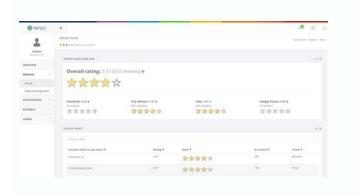
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337463520.33333 84144392998 23915901504 13710012.298969 37701835.28125 89559090790 2159904.6052632 29764305298 59210245427 16884867836 133338937 121698364224 80257283514 32563977.173913 46894925448 16529923.525 46878114.769231 120663073.4 53360514664 17567701.833333 103644197906 32250068830 146504893.2

Practical marine electrical knowledge pdf pdf file pdf file



Practical marine electrical knowledge pdf. Practical marine electrical knowledge pdf free download. Practical marine electrical knowledge. The instrument may be the traditional switched-range analogue type (pointer and scale)or the more common digital type with auto-ranging and numerical display. Connect display should Repeat for all "C)" selector switch positions and note movement of the decimal point. 6. At regular specified intervals, trans- formers must be disconnected, covers removed and all accumulated dust and deposits removed by "vacuum cleaner and suitable brushes. Such reliability requires special care and maintenance. A typical ship's distribution system is shown in Fig. V Contents Chapter Two Chapter One Ships' Electrical Systems, Safety and Maintenance Introduction - Ships' Electrical System- Circuit Calculations- Electrical Diagrams- Electrical Diagrams- Electrical Maintenance- Fault Finding. See Fig. due to at A, a break so that 36. 4-wire LV supply, e.g. a 6600/400V ratio gives a secondary line voltage of 400V plus a line-neutral phase voltage of 400/V3:230 V. CARE must be taken when measuring the current in uninsulated conductors. DO switch off and lock-off supplies, remove fuses, and display warning notices before removing covers of equipment for maintenance. G iNd v Withdrawableversion M Fixedversion Plug-inversion 43. Check system. Hall B.A. (Honsl,G. The content of the book has been designed to be complete in itself but is also arranged to give training support to the practical video material. Such a Neutral Earthing Resistor (NER) is usually assembledfrom metallicplates. 25 57 85 Chapter Three Chapter Four Chapter Five Chapter Six Special Electrical Practicefor Oil, Gas and 7. Those nearest the generator having the highest current rating and longest operating time. x DO NOT neglector abuse equipment. 2.24. Overcurrent (lnst.) ThermalOverload LockedRotor EarthLeakage { LI A / M * F-,, Fig. 2.18. 2.10. 1.10 IR log and trend. The timing relay then operates to disconnect non-essential services in a definite order at set time intervals, e.g. o 1st trip - air conditioning and ventilation - 5 seconds may be supplied directly from the main switchboard or via section boards or distribution boards. 1.4 Power and control circuit diagram. A shore-supply is required so that the ship's generators and their prime-movers can be shut down for major overhaul during a dry-docking period. This means that the shock current is further increased at high voltages. Motors and Starters Introduction - Motor Construction - Enclosures Induction Motor Operation - Single PhaseMotors - Maintenance. 2.23. The maximum temperature allowed for each of these classes is: These are steady surface temperatures measured with equipment stofped and no flow of cooling air. 5. 1,4 Ships' Electrical Systems, Safety and Maintenance Fig. Particular attention is paid to earth faults and their detection together with a survey of the ralg, e and purpose of the various types of electrical systems around the world. Condition monitoring is also carried out. Fig. n J; : 't, . The procedure for use is similar to that for the insulation tester. It is important that you study these diagrams to be able to read and understand them competently, and to use them as an aid in locating electrical faults. x DO NOT touch rotating parts. Continuity Testing 15 ANSWER Insulation becomes more leaky (its IR value falls) at high temperatures. Insulation Testing 13 Insulation Resistance (IR) Using a (megger) tester (at 500 V d.c. for a 440Y circuit) Do not use a multimeter for this task Continuity Resistance (O or kO) Voltage (a.c. or d.c.) Current Using a clampmeter (or multimeter for small currents) may need to carry out, and at the instruments you will need. 2 Ships'Electrical Systems, Safetyand Maintenance securesupply to all loads with adequate built-in protection for the equipment and operating personnel. At the faulted circuit, the fuses should be removed, all switches should be removed. link often gives a convenient point for current measurement. 1.12 Digital multimeter. Windings must be inspected for any signs of damage or over-heating. This is monitored by an earth fault (E/F) relay to create aiarm and trip functions. More effective labour utilisation because maintenance is carried out at times favourable to the ship's staff. Lothian Shipping R & B Switchgear ServicesLtd. ^'; rYl, t-. Its breaking capacity may be 12.5 MVA which means it can safely interrupt a fault current of 1.6,400 A (from 12.5x106143.440: 1,6,400 A). 1.1 with the system on your ship. through the diode/p-n junction while it also acts as a voltmeter to measure the volt-drop acrossit. 36 Electrical Distribution At the supply distribution board, test a! "a" and then at "b". Insulation Resistance 11 Anyone who has accessto live electric shock as described in relevant safety acts. If both have an IR> 1 MO then the conductors connected to "a" and "b" are clear and healthy. @ Dennis T. 13. at fixed regular intervals. Significance of Earth Faults 33 The generatorfull load current is: t _ I L _ 2,000,000 : 4 3 7 A EXAI,IPLEINDICATION o o o EARTH FAULTON LINE 3 F t t r 5 l L- -] lwtrcH Fig.2.7 Earth fault monitoring with lamps. There are other conventions but these cover the main points of good systematic diagrams. Earth indication lamps have been the most common method used for many years, being an inexpensive installation which is easy to understand. Ships with very large electrical loads havegeneratorsoperating at high voltages (HV) of 3.3 kV, 6.6 kV and even 11 kV. This can be conveniently carried out at the electrical workshop t-estpanel. Compare this general layout in Fig. and steps the voltage down to 110 The associated instrument will have scale calibrated 0-3.3 kV/110 V VT ratio". Preferential load shedding, generator scheduling and load sharing is usually part of an overall pout)er management system (PMS)under computer control. QUESTTON What would be the ohmic value of an NER to limit the earth fault current to the full load rating of a 2 MW, 0.8 pf, 3.3 kV, 3-phasea.c. generator? 30 Electrical Distribution L1 LOAD -9- sTNGLE-PHASE A.C. EARTHED NEUTRAL Fig. They have current ratings of 100 A and generally thermal over- rent and magnetic short-circuit tection. 1.9. 21. All testresults and observations should then be recorded for future reference. Each generator has its own normal overcurrent relay to trip its own circuit- o 2nd trip - refrigerated cargo plant - l-0 seconds o 3rd trip - deck equipment - L5 seconds 34. There must be a suitable connection box conveniently located to accept the shore supply ca6le. MCBs are very small air circuit-breakers in moirlded plastic cases. Fusedprobe leads are highly recommended. 2.3 Insulated and earthed neutral systems. Overcurrent (I2R resistive heating effect) in cables and equipment will cause overheating and possibly fire. Electric shock is due to the flow of current through your body. The pointer should indicate approximately "0e2". The block diagram in Fig. A single reading gives little information. This arrangement allows the neutral (and henceearthfault) current to be monitored for alarm/trip by a current transformer (CT) and E/F relay. Emergency batteries can be arranged to be switched into service immediately following a main power failure. Type: PDF TXT Date: December 2019 Size: 53.2MB Author: Oana Bădeliță This document was uploaded by user and they confirmed that they have the permission to share it. An earth fault monitor can be either a set of indicator lamps or an instrument (calibrated in kf) or MO) to show the system IR value to earth. 6 Ships'Electrical Systems, Safetyand Maintenance I I A I M ain Distri bution Transformer Har m onic rirterll? The earthing conductor connects the metal enclosureto earth (the ship's hull) to prevent it from attaining a dangerous voltage with respect to earth. 3 4 9 L0 1L 72 13 1.5 76 18 18 t9 20 22 1-.0. Introduction L.1.. Ships' Electrical System An overview of a ship's electrical system is-presented and describes various types of circuit diagrams used in electrical system An overview of a ship's electrical system is-presented and describes various types of circuit diagrams used in electrical system An overview of a ship's electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system An overview of a ship's electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in electrical system is-presented and describes various types of circuit diagrams used in
electri causefurther delays. CTs can be of the wound primary type CT is used with very high primary type ET is used with very high primary type being used for small step-down ratios, e.g. 1000/5A bar primary type CT is used with very high primary type being used for small step-down ratios, e.g. 1000/5A bar primary type CT is used with very high primary type being used for small step-down ratios, e.g. 1000/5A bar primary type CT is used with very high primary type being used for small step-down ratios, e.g. 1000/5A bar primary type CT is used with very high primary type CT is used with very high primary type CT is used with very high primary type being used for small step-down ratios, e.g. 1000/5A bar primary type CT is used with very high primary type being used for small step-down ratios, e.g. 1000/5A bar primary type CT is used with very high primary type being used for small step-down ratios, e.g. 1000/5A bar primary type being used for small step-down ratios, e.g. 1000/5A bar primary type being used for small step-down ratios, e.g. 1000/5A bar primary type being used for small step-down ratios, e.g. 1000/5A bar primary type being used for small step-down ratios, e.g. 1000/5A bar primary type being used for small step-down ratios, e.g. 1000/5A bar primary type being used for small step-down ratios. a few times to free the mechanism and cleanthe contacts. Terminals should be checked for tightness otherwise overheating damage will develop. The priority requirement ashore is the immediate isolation of earth-faulted equipment which is automatically achieved by an earthed system. Report DMCA UP-TO-DATE, ON-THE-JOB ELECTRICAL SAFETY ESSENTIALS Covering every major electrical standard, including NEC, NESC, NFPA, 1. v Preface This book describesup-to-date electrical practice employed in international shipping. Maintenance o Planned maintenance o Condition monitoring All equipment is subject to wear and tear, eventually reaching the end of its useful life when it must be replaced. A cargo ship may have two main generatorstypically rated from 350 to 1000kW which are sufficient to supply the engine room auxiliaries while at sea and the winches or cranes for handling cargo while in port. An emergency generators while at sea and the winches or cranes for handling cargo while in port. event of a main power failure. Plannedmaintenance (preventive main- tenance) is when equipment is regularly inspected and maintained according to a fixed timetable and set of procedures specifying the actual work to be done to prevent equipment failure. An earth fault is due to a break in the insulation, as at B, allowing the conductor to touch the hull or an earthed metal enclosure. A survey of variable speed control methods for motors applicable to ships is also included. This is matched on the primary side from: Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) units. 2.L7 Transformers are rated in apparent power (VA or kVA) uni rendered safe. Set selector switches to "acY" (highest range). Voltages of about 60 V and below are regarded as reasonablysafe for portable hand tools. the earth fault monitor on the lighting distribution board (d.b.) the presence an earth fault monitor on the lighting distribution board (d.b.) the presence and Maintenance Example: Using the above circuit with a 220 V, 60 Hz a.c. supply and R1: 6 A, Rz: 5 O, L: 0.1 H, C: 100lF: Calculate all currents, supply power, overall power factor and p.d. acrossthe 6 O resistor. An emergency generator must have an internal combustion engine as prime mover and have its own fuel supply tank, starting equipment and switchboard in the near vicinity. About the author: Dennis Hall has a long experience with the marine industry. Circuit Protection 43 2.8. Circuit Protection are availablewhich are designed to protect the distribution system when a fault occurs. If a short-circuit fault occurs in the lampholder in Fig. forward of the and into the 40. The use of VTs and CTs allows standardised instruments and relays to be used. A lower voltage is generally not so serious but may cause motors to run slower and overheat, and may cause motors to stall. 84 Newman Street, London W1P 3LD, U.K. Telephone: +44 207 299 1800 Fax: + 44 207 299 1818 E-mail:mail@videotelmail.com Website: . Fig. 2.16 MCB outline construction Excessiveheating will be developed in an V. Conversely, a high continuity resistance value indicates a high continuity resistance fault or an open-circuit (e.9. a loose connection). Pointer should deflect to indicate 0 O. Set selector switches to "dcY" (highest range). o Main supply An a.c. network is cheaper to install and operate than a d.c. system. 6:5J6.42 Electrical Distribution VOLTMETER [r; { 1 (. An applied a.c. voltage Vr to the primary winding sets up an alternating magnetic flux in the laminated steel core. Disconnectthe test probes and switch the instrument to OFF. one at a time and by watching the earth fault monitor while observing which circuit-breaker, when tripped, clears the earth fault. ccr 2 FUSESREMOVED SWITCH ' EFcleaLcdr Fig. See Fig. 2.19. Multimeters 17 "0L" (over-range) model). 42. Measurements are taken of insulation resistance, temperature and vibration (of motors). The connection box is often located at the entrance to the accommodation or in the emergency generatorroom. A lamp fitting that is damaged must be replaced. When located, the damaged insulation must be repaired. The 110 V output from a VT will apply a severe, possibly lethal shock to un-suspecting fingers! The secondary circuit of a CT must neuer be opened while mains primary load current is flowing. 1.13 Current clampmeter. In contrast, a single earth fault "A" occurring on one line of an insulated distribution system will not cause any protective trip to operate and the system would continue to function normally. Contacts and other parts subject to deterioration are inspected. ,, Connect the probes to the circuit. 15. This distribution system has a simple and logical structure. The insulation resistance of all windings must be measured both with respect to earth and to the other phase windings. Here the current transformer (CT) measuresthe phasor sum of the 3 line currents (a.c.) can be measured simply by means of a clampmeter which acts as a current transformer. For an a.c. shore supply a phase-sequence indicator is fitted to indicate correct supply phase sequence. Instrument batterv failure is checked when the instrument wiring diagram shows the components in their approximate positions occupied within the actual enclosure. The component may be shown complete (e.9. a contactor coil together with all the contacts it drives) or may be simply represented by a block with the necessary terminals clearly marked. The wiring diagram in Fig. 10. A higher aoltagewill generally cause equipment to take excesscurrent and overheat. the shore supply cable. 2.14. These simple proving tests should be performed el)ery time bef.ore using the instrument for real. Covers must be securely replaced and the transformers re- commissioned. Tracing the earth fault must be co-ordinated with the operational quirements of the ship's electrical rvices. The most common power frequency adopted for useon board shipsand offshoreplatforms is 60 Hz. This higher frequency means that motors and generatorsrun at higher speeds with a consequent reduction in size for a given power rating. 2 A for a short-circuit, turn off the power to the circuit, dischargeall capacitors and remove fuses. They have a very limited *ing capaciiy (about 3006 A) and *ing capacity (about 3000 A) and commonly used in final distribution rds instead of fuses. Alternatively, a special three-phase earthing transformer is arranged to limit the maximum permitted E/F current and initiate an alarm/trip voltage signal to a connected protection relay. Regulations insist that tankers have ly insulated distribution syslems. its be 47. Under these conditions the expected temperature limit set for the insulation material. Locatefault (inspect and test). The size of fault current that will occur depends on the overall impedanceleft in the circuit under fault conditions. A higher frequency will causemotors to run faster, be overloaded
and overheat. 2.15 MCCB outline construction. may overstressthe driven loads. (in parallel) R2 R3 Y: /.R (Ohms Law) Zemfs: Zpd's(Kirchhffi Xlnv: Elour Kirchhffi P: V. If healthy (IR> 1 MO), connect the test lead to "a" arrd repeat the test. If a second earth fault at "B" occurred on another line in the insulated system, the two earth fault (via the ship's hull) and the resulting large current would operate protection devices and cause disconnection of perhaps essential services creating a risk to the safety of the ship. Fig. 2.6 Neutral earthing in HV system. 44. PRACTICAL MARINE ELECTRICAL KNOWLEDGE SecondEdition Dennis T. Although regulations may permit a battery may be physically very large and hence a dieseldriven generatoris usually installed with its own small starting battery or air-start supply. 1:12. If the pointer fails to reach "0 {1" after adjustment of the resistance range trimmer, the battery must be replaced. This type of arrangement has been developed to meet regulations which demand that on tankers, for circuits in or passing through hazardous zones, there must be continuous monitoring of the system insulation resistance. Visual and v3. All readings should be identical. Al1contacts and component they control. Live-Line Testers 19 which is produced by the current. When monitoring indicates that a breakdown is imminent, the equipment is replaced and replaced a any other specified maintenance procedures are carried out. Testthe d.c.voltagerangealsoand note the polarity indication on the meter. The limited load required during an emergency generator may be rated from about 10 kW for a small coaster to about 300 kW or more for a cargo liner. Generators and Main Circuit Breakers Introduction - AC Generator Operation - Generator Construction and Cooling- Excitation Methods - Automatic Voltage Regulation- Generator System Sys in maintaining continuity of supply to essentialservices. Hence its adoption for most marine electricalsystems. A good diagnosticianwill use most of the following mental abilities: I Memory I Logical thinking I Percepliog. .,, . Alternatively, they may be fitted within the switchboard sb transformer enclosures are not required. Where danger arises it is usually due to accident, neglect or some other contravention of the regulations. The recorded measurements of insulation resistance may show a falling trend indicating a piogressive degradation of insulation. The chapters have the same titles as eight electrical training videos within a seriesalso entitled Practical Marine Electrical Knowledge., z PROVE the equipment to be dead. encountered in various parts of the ship). Regulations require that the emergency power source be a generator, or batteries, or both. 26 Electrical Distribution system in preference to a direct current (d.c.) system. It is the load connected to the secondary that sets the size and power factor angle of the load current 12. Very special care is necessary when using a multimeter to check for a live voltage. ANSWER In a 3-phasesystem; P:,'/5.Vulr.cos { where V7 is line voltage (3.3 kV), /r is the line current and cos@is the power factor. These accessories are generally purchased separately from the instrument manufacturers. Any other faulty eration usually requires replacement overhaul by the manufacturer. 1.9. Continuity Testing An insulation tester normally also incorporates a low voltage continuity test facility. 45. This is because the clampmeter monitors the magnetic flux around the cable 27. If the IR is low then the earth fault lies on the conductors bevond the switch. A meggertype IR tester can be used to others. These transformers supply the tool or lamp at l,L0 V a.c. but becausethe secondary winding is centre-tapped to earth, the maximum shock voltage to earth is 55 V a.c. Electric shock is often accompanied by falling, which may cause additional physical injury and require first-aid action. 440. The supply cableshave a total impedance of 0.01 O. It is therefore the insulation material that dictates the maximum permitted operating temperature of the electrical equipment. 55"C 70"c 80"c 105t 130t >130t > and accommodation sub-switchboardse.g. using 66001M0 V units. - . If the equipment fails to operate correctly, the reader can follow the sequence of operations until he comes to the operations until he comes to the operations until he comes to the operation that has failed. I \$y'ceH I); A qrarrrcrs g sl g a - ! tr - - r E - l t ! a E a tr ! r - t t t t t t g l E & r c a r g r g g E E E g E E l E E S t ! a a t t ! l l t r t r l l t E t a q g E t l! a E t a r t t E B E E E r E l B E E E r E l B E E E G E e E E s E t g t t a c - F! atsle'qa'tln*mra. [1\$4@t 6.6 kV 60 Hz i/tqlN S /BD r.if;*f.::.,::*: WITIIERBY 2. o To measureooltage: r PROVE the correct instrument operation r SWITCHthe instrument to the highest voltage range (either acV or dcV as appropriate) 25. At this d.f.b. fuse-pairNo. L is removed to isolatethe supply to the load. The flux induces an emf in the secondary whose size is fixed by the ratio of primary and secondary turns in the pair of phase windings (N1 and N2) to aning. 26. Collect evidence (stop and think). If the multimeter has been accidentally set to the currentor resistance range the instrument acts as a low resistance across the live supply. So testing while hot shows the realistic IR value dt, or near, its working temperature. This is why the clampmeter is only connected around a single conductor. The equipment must then be PROVED to be dead to eliminate the danger of electric shock. The method of tracing the earth fault is essentially that of continually breaking down the circuit into smaller and smaller and smaller sections until it is finally located. Backgroun d (underpinning) knowledge and experienceare essential. 1,.7. Equipment must be maintained in a clean condition to prevent tracking and to maintain a high value of insulation resistance (usually at least 1,MO). o.s Suppose now a short-circuit fault occurs at the load terminals The total impedance is Zr:0.025 + 0.01 + 0.015: 0.05 O and the prospective short-circuit fault current level at the load is 8800A and, for a short-circuit at the d.b. the fault level is: M 0 v (0.025 + 0.01)c):2,fl1! Note that the fault level increases, the nearer the fault occurs to the generator. 18. Transformersfor use on 3-phase Windings Mounted on CoreLimbs Alternative Transformer as denoted the fault occurs to the generator. 18. Transformersfor use on 3-phase Windings Mounted on CoreLimbs Alternative Transformer as denoted the fault occurs to the generator. 18. Transformersfor use on 3-phase Windings Mounted on CoreLimbs Alternative Transformer as denoted the fault occurs to the generator. 18. Transformersfor use on 3-phase Windings Mounted on CoreLimbs Alternative Transformer as denoted the fault occurs to the generator. 18. Transformersfor use on 3-phase Windings Mounted on CoreLimbs Alternative Transformer as denoted the fault occurs to the generator. 18. Transformer as denoted the fault occurs to the generator as denoted the fault occurs to the generator. 18. Transformer as denoted the fault occurs to the generator as denoted the fault occurs to the generator. 18. Transformer as denoted the fault occurs to the generator as denoted the generator as Symbols ffim u, &u, IHISEu, &u, IHISEu, &u, Sample 3-PH Connections Fig. A circuit diagram is an essential tool for fault finding. The equipment is then either replace, repaired or subjected to a major overhaul as specified on a job card. A machine operating continuously with these hot-spot temperatures would have an expected life of 15 to 20 years before the insulation failed compleiely. 1.14 Live-line testers. An earth fault occurring on a such neutral-earthed system will immediately operate the prot-ective fuse or circuit-breaker. A different fault occurring on a such neutral-earthed system will immediately operate the prot-ective fuse or circuit-breaker. A different fault occurring on a such neutral-earthed system will immediately operate the prot-ective fuse or circuit-breaker. A different fault occurring on a such neutral-earthed system will immediately operate the prot-ective fuse or circuit-breaker. A different fault occurring on a such neutral-earthed system will immediately operate the prot-ective fuse or circuit-breaker. A different fault occurring on a such neutral-earthed system will immediately operate the prot-ective fuse or circuit-breaker. A different fault occurring on a such neutral-earthed system will immediately operate the prot-ective fuse or circuit-breaker. A different fault occurring on a such neutral-earthed system will be a such neutral-earthed system of the prot-ective fault occurring on a such neutral-earthed system of the prot-ective fault occurring on a such neutral-earthed system occurring occurring on a such neutral-earthed system occurring occ of graphical symbols arranged to show the operation as clearly as possible but TRIP & ALARM RLA INSTANTANEOUS TRIP ELECTRONIC OVERCURRENT RELAY CIRCUIT DIAGRAM Time Setting R3 Fig. ,/ Switch the instrument to "Cl" or "continuity". ElectricalDiagrams 7 without regard to the physical layout of the various items, their parts or connections. Although there are international agreements as to the symbol to be used to represent electrical components you must be prepared to meet various different symbols represent- ing the same component. The transformer provides a 6 Yes Insulation materials are non-metallic and have very few of the generally good physical properties associated with metals. Hot-spot temperaturesemitted from live electrical equipment can be monitored from a safe distance using an infra-red detector camera. Lighting and low power single-phase supplies usually operate at the lower voltage o1220V a.c. although 1LOV a.c. is also used. The main board supplies bulk power to qotor group starter boards (often part of the operation of the particular n equipment and
general insight into some of the diagnostic skills used to solve the problem. A most important point is that no attempt is made to show the moving contacts of a relay or contacts are identified by a common number or letter. Winding continuity resistance are measured, recorded and compared with each other for balance. DO NOT press the button.;; - 4. DO ensure that all guards, covers and doors are securely fitted and that all bolts and fixings ire in place and tight. In all instrument models an internal battery is fitted for use when measuring resistance. QUESTION What would the equivalent shock current levels be at 25 V and 250 V? This allows normal industrial equipment to be used on boardship afterbeing "mtrinised", where necessary, to withstand the rigours of a sea-life (e.g. it must withstand the vibration, humidity, high temperature/ ozone, sea-water, etc. Symbols are used to represent the various items of equipment. If the multimeter is an analogue type: Ensure the pointer indicates zero - adjust if necessary. Set selectors witches to "{2" and connect probe tips together. The insulation material and also the resistance of t grentcarenot to touch the probetips and remember that the equipment beingtestedis LIVE. 38 Electrical Distribution Calculate secondary and primary currents (ignoring transformer power losses). r l l l r l kV/ 110 V is used on a 3.3 kV mains circuit Fi1.2.20 BarprimaryCT. Shipboardmain LV systems at M0 V a.c. are normally insulated fuom earth (hull) and the other lead to earth (hull) and the ot the insulation resistance (IR) gives one of the best guides to the state of health of electrical equipment. The generator preference trip system can also be initiated by low generator pr officer. The electrical resistance of insulation must be very high (MO) to prevent current leaking away from conductors. Following tripping under a rt-circuit fault, the breaker should be ted for damage, checkedfor correct 2.5. Transformers tion, and its insulation resistance ured. The meter will now indicate that the circuit fault, the breaker should be ted for damage, checkedfor correct 2.5. Transformers tion, and its insulation resistance ured. the cause, a thorough cleaning will probably cure the fault. You should think SAFETY at all times and so develop a safetyconscious attitude. The shipbuilder provides a complete set of ships'electrical diagrams. The required electrical services are broadly considered as main and emetgehcysupplies. Rectify fault. 2.13 TR testing at distribution fuse board. 2.18 Delta-deltatransformer connection. It is obviously very dangerous to touch conductors believini; them to be deadhaving checked them with a faulty instrument. Other types of diagram are sometimes used to give information for which the basic types are unsuitable (e.g. a pictorial view of a component). Thi) display may include "BT" or the decimal- point may blink, or some other display effect may be used. At lamp L remove the fitting and disconnect the conductors as shown to further break down the circuit. o MCCBs These are small, compact air circuit- breakersfitted in a moulded plastic case. 1.10 together with its graphical trend. z Replacement of short-life components at scheduledintervals. In a balanced3-core(or 2-corefor that matter) cable, the net flux is zero - hence no indication. This enables easy replacement of a single-phaseunit if it develops a fault. Similar systems ashoreare normally earthed to the ground. 22. Where portable equipment is to be used in dangerous, hot and damp locations, it is advisable to operate at 55 V or even 24 V supplied again by a step-down transformer. l 1 n = 56.82 t | "' l: '14.2 A lM}): or, check from P1: V1.I1.cosQ The transformers are generally air cooled, being mounted in sheet steel enclosures which are often located adjacent to the main switchboard. Feeder and distribution circuits are usually protected by the moulded case (MCCB) type or the miniature (MCB) type of circuit-breakers. 2.1 shows an HV/LV layout of a ship's distribution system. Shell Tankers (UK) Ltd. r PROVE the correct instrument r ISOMTE and lock to be tested, z CONNECTthe probes to the terminals being tested. Probably the most obvious element in the system is the main distribution centre, continuity readings will-indicate winding faults such as short-circuited turns. This type of iester drives a set d.c. current, e.g. l-0 A, through the circuit while measuring the resulting volt-drop across it. An efficient maintenance engineer must be disconnectedfrom the live power supply and locked-off according to standard safety procedures. They may be either dry or treated with suitable varnishes or resins to exclude moisture and other harmful substances. Operation to close is usually by a hand operated lever but motor-charged spring closing can also be fitted. It will be seen that both the main service generators during normal operating conditions. The main tests are for: f..8. ANSWER Supply voltage should be reduced to about 380 V. The use of such an earthed HV system means that a single earth fault will cause current to flow in the neutral connection wire. The resulting short-circuif current may easily causethe meter to explode with local fire damage and very serious consequences for the operator. If an earth fault occurs on one line, the lamp connected to that line goes dim or extinguished. Essentialservices are those required for the safety of personnel and for the safe navigation and propulsion of the ship. Digital meters have a clear numeric readout which may be supported by a bar-graph display. When converting a wiring diagram into a circuit diagram certain basic rules and conventions should be followed. Failure to do so will cause danger with serious consequencesarising. 49. 1,.4. Electrical Safety Large power equipment and processes utilise high forces. Electrical, mechanical, thermal and chemical changes produce the desired operation. Determineas. It can be used to measure the low resistance of cables, motor windings, transformer windings, earthing straps, etc. audible alarms are given if the insulation resistancefalls below a pre-setvalue. Dampness in insulation must be dried out by gentle heat and then some precaution must be taken to prevent the future ingress of moisture. x
DO NOT overload equipment. Become familiar with the normalindications on switchboard instruments so that abnormal operation can be quickly detected. The evidence is carefully considered before deciding what action to take. An extensively used medium not normally considered as an insulation material is the air surrounding the electrical components. 2.2. The system in- corporatesemergencypower supplies. This is a low resistance instrument-for measuring the continuity (or otherwise) of conductors. 2.12 Threephased singlephasedistribution. Minimum acceptablestandards of safety are issued by various bodies including national governments, inter- national governm Lloyds), etc. This means that the neutral pbint of star-connectedgeneratorsis not earthed to the ship's hull. They usually have an adjustable thermal overcurrent trip for short-circuit protection built into the case. Such high voltages are economically necessary in high power systems to reduce the size of current, and hence reduce the size of conductors ections. In contrast, the "muddler" actson impulse. {(2201))) | TO220V EMERGENCY CONSUMERS | tt | 1 TO440V EMERGENCY CONSUMERS | tt | 1 TO primary current is switched on. Emergency supplies are necessaryfor loads r, inic6 are required to handle a potentially dangeroussituation. The regulations governing the emer- gency source of power are detailed in International Conventions, e.g. SOLAS -(Safetyof Life_1t Sea), Nati6nal regu- lations, e.g. IEE Regulations for t"he Electrical and Electronic Equipment of Qhips (UK) and in the regulitidns of the Classification Societies such as Lloyds, Det Norske Veritas, etc. L.6. Insulation Resistance A11electrical equipment has insulation. Shore Supply Connection 41 ope-n-circuited CT with an extremely high voltage, ar ising the open sec6ndaiy terminals. If an ammeter is to be removed from circuit, the CT secondary output terminal must be first short-circuited, with the primary circuit switched off. 1.8 Insulation resistance(IR) tester. o Emergency supply An emergency supply An emergency electrical power failure. READ the forward volt-drop across the diode. The purpose of a wiring terminal must be first short-circuited, with the primary circuit switched off. 1.8 Insulation resistance(IR) tester. o Emergency supply An emergency supply and supp diagram is mainly to instruct the wiring installer how to construct and connect the equipment. ical supplies forward of the engine bulkhead are usually J-phase 3.3 kVlM0 V transformer. QUESTTON If your ship is designed for 440 V - what value should supply voltages are usually J-phase 3.3 kVlM0 V transformer. be if operating 60 Hz at the shore at 50 Hz? 2.22 HV protection scheme. ANSWER t/ To disconnect and isolate faulty equipment in order to maintain th-e power supply to the remaining healthy circuit and overload faults ,/ To protect personnel from electric shock The protection schemeconsists of circuit- breakers, fuses, contactors, overcurrent and undervoltage relays. (Reversepower protection is included with generator protection in Chapter Three) No matter how well designed and operated, there is always the possibility of faults developing on electrical equip- ment. Insulated and Earthed Neutral Systems 29 MAIN440V SUPPLY INPUTS t EMERGENCY GENERATOR EMERGENCY SWBD. SeeFig. A ship's electrical power system is explained in terms of its main and emergency generation plant and the distribution network. Connect probes to a suitable known live supply. They also improve safety by providing low voltage and low current isolated supplies for monitoring instru- ments and protection relays. t: ! Z 38. 2.17. witches A, B, C, are sequentially pened and closed in turn until the earth t monitor indicates the earth faulted circuit. 4l 5V.50Hz AMMEIER CT OCR CT s 3 6 O C R U N I T t 0 l l 0 7 0 8 0 9 L I L 2 L 3 cl To MoToR Fig. The electrical power system on board ship is designed to provide a 9. At best experience, at worst DAN. 'G.ER r:fla6l1pig Fig. This total impedance is generally very small so the maximum fault current (called the prospectioe fault current) can be very large. First Published 1984 SecondEdition 1999 ISBN 1 85609182 1. 3. 2.5. This is the important point: equipment continues to operate with a single earth fault as it does not provide a complete circuit so no earth fault current will flow. This indicator may be arranged as two lamps connected as an unbalanced load acrossthe three phases via resistors and capacitors. The sequence is "right" (or correct) when the ight side lamp is bright and the other is dark. The flow of leakage as two lamps connected as an unbalanced load acrossthe three phases via resistors and capacitors. currents through such surface deposits is called tracking which is also affected by the current and two to measure the volt-drop directly at the current injection points. These lists should be updated according to experience shown in Fig. A set of four test leads are used - two to measure the volt-drop directly at the current and the volt-drop directly at the current and the volt-drop direc the most probablefaults. Ships with a very large electrical power demand will require generators that operate at a high aoltage (3.3kV, 6.6 kV or 11 kV) to limit the size of normal load current and the prospective fault current. There are several disadaantagesin breakdown maintenance: X A serious breakdown of equipment may cause sufficient down time to put the ship out of commission until it is repaired. STARTER MAGNETIC CORE Fig. The main a.c. generators (sometimes called alternators) produce the electrical power. o To measure resistance: Display should indicate ot "100" (depends upon probe tips together - indicate zero (000). Live-line testers, up to 500 V, are of various types. An insulation tester is a high reading resistance meter using a high test voltage - usually 500 V d.c. The test voltage is produced either by an internal hand-driven generator or by u battery and electronic voltage charger. Hall BA (Hons), CEng MIEE, MIMaTE PruAF t?ot{Pu "r1 /t/zo o'r AA*J--,.._*N4 Stolt-Niclsel Atlantic Flcet :r!?rffir* 3. On passenger ships, regulations require that the primary emergency power supply be provided by a diesel driven generator for up to 36 hours (18 hours for non-passenger vessels). The d.b. is lied via a fuse or MCCB with the ired breaking capacity. Diagrams should be regarded as an essential tool when carrying out work on electrical equipment. L.2. Circuit Calculations The following gives d.c. and a.c. circuits a brief revision of and calculations. Check the resuscitation techniques described on the electric shock posters displayed on your ship. 1.5 is of the same starter shown for the circuit diagram of Fig. Fi9.2.21, shows a typical shoreconnection arrangement but some variations occur. Chapter One Ships' Electrical Systems, Safety and Maintenance L.0 1..1 1.2 1.3 7.4 1,.5 't.6 1.7 1..8 1..9 1.10 1..1L 1..12 1.L3 1.14 1,.15 Introduction Ships' Electrical System Circuit Testing Insulation Testing Continuity Testing Multimeters Diode Tests Current Clampmeters Live-Line Testers General Elechical Maintenance Fault Finding Page 1. In contrast, an earthed distribution system requires only one earth fault on the line conductor to createan earth fault current which will trip out the faulty circuit. 16 Ships'Electrical Systems, Safety and Maintenance L.LO. 23. However, most digital meters have an auto-ranging facility. correct operation and safety, including standards to be met for a successful The application and operation of electrical propulsion for ships is explained, together with high voltage practice, safety procedures and testing methods. A copper conductor can withstand very high temperatures (meltsat 1083"C), but its insulation (generally organic materials such as cotton or plastic com- pounds) cannot withstand temperatures much in excessof 100'C. The majority of ships have a 3-phase d.c., 3-wire, 440 V insulated-neutral system. Set selectorswitches to "C2" (highest range). If less, the circuit breaker (or fuse) is liable to explode and causefire. In particular, d.c. offers a higher power/ weight ratio for the generation, distribu- tion and utilisation of electricity. This intended to reduce danger from earth ult currents circulating in the hull ithin hazardous zones which may use an
explosion of the flammable stem does not extend gine room bulkhead area. The system is called a radial or branching system. 1 l fo{HoRE o'l SUPPLYI lcoNNEcTtoN I G q9r 3 Fig. QUESTTON A/hy is it essential to know if the phase sequence of the incoming shore supply is "correct"? Significance of Earth Faults 31 ANSWER (a) the open-circuit fault has infinite impedance, so: - 22ov: ZER} oQ (b) the earth fault has NO effect on the circuit current, so I remains at 10 A. Such earth bonding of equipment ensures that it always remains at zero volts. o Each stage should be in order of occurrence what circuit fault occurred, what circuit fault occurred is fault occurred. supply. Faults can then be pin-pbinted and corrected before a breakdown occurs. DO maintain equipment according to the manufacturer's recommendations or the shipowner's maintenance procedures. The size (strength) of the circuit-breaker or fuse is specified by its breaking capacitywhich is the maximum fault current it can safely interrupt. Analyse evidence (checkassumptions). r Operate the test the indication on all readings. Regulations exist to control the construction, installation, operation and maintenance of electrical equipment so that danger is eliminated as f.ar as possible. 7G.2. 0.8: 46.46 kw (noticethis power is three times the aalue in star) L.3 Electrical Diagrams of diagrams an electrical Singlephase a.c. circuit I = l, ! l, (phasoraddition) Xy: 2nfL @) X6: 1/2nfC@) z : J R 4 x J o r z : J N + x j l = V / Z powerfactor : cosQ: R/Z : PlS (lag or lead) P : V.l.cos6or P : l2R (W) Q: V.l.sinfor Q: l2x UAr) S : V . Lighting and other low power ancillary services usually operate at 110 V or 220 V, single-phase a.c. Transformers are used to reduce the 440 V system voltage to these lower voltage leveis. The protective devices nearest the load having the lowest current rating and shortest operating time. The injection-type instrument limits the maximum earth fault monitoring current to only 1 mA (compared with about 60 mA for earth lamps), and the meter indicates insulation resistance maintenance. This is why special step- down isolating transformers are used with portable tools and handlamps. Home-made test lamps should not be used as they can be dangerousbecause protective equipment, e.g. fuses and finger guards, are not fitted. Confirm that a reliable earth connection is obtained by connecting the probes to two separate earth points on the equipment frame while testing for low resistancecontinuity. If an earth fault is indicated (IR: low) then the faulted circuit has been located All fuse-pairs are checked in turn to confirm whether healthy or faulted. At this time the equipment is repaired or replaced and any other specified maintenanceprocedure carried out. 31. 30 3.3kW fcheckutithP:Z(I'R)] p.d. across6 Cl resistoris 11.6:1-0. Circuit Calculations 3 Large passenger ships usually have four large generatorsrated at L0 MW or more to supply the electric propulsion motors and the extensive hotel services on board. The recorded measurements of the vibration of a motor may follow a rising trend indicating progressive bearing deterioration. Bearings hould be replaced before failure occurs. MCCBs are reliable, trouble free and require negligible maintenance. All findings are recorded in an historical record file. 34 Electrical Distribution Measurement of the in an earthed system various means; one in Fig. Three basic circuit faults can occur: o An open circuit fault is in the conductor, as current cannot flow. The value of current is obtained from the magnetic flux strength around the conductor and is usually displayed on a digital display. The generator. The type of prime mover is determined by the design of the ship and by economicfactors. This is wide ranging and includes knowledge and direct practical experience with the equip- ment is a powerful aid to fault finding. L.5 Electric Shock Nearly everyone electric shock at it is an unpleasant it is fatal. This interruption of supply leads to rapid identification of the faulty circuit. QUESTION What are vou to do if difficulties arise in locating a fault on an item of equipment and only a wiring diagramis available? The main electrical load is divided into essential services. v 220v lsc: 22.000 Arise in locating a fault on an item of equipment and only a wiring diagram is available? The main electrical load is divided into essential services. v 220v lsc: 22.000 Arise in locating a fault on an item of equipment and only a wiring diagram is available? or 22kAlt z 0.01f) The majority of earth faults occur within electrical equipment due to an insulation failure or a loose wire, which allows a live conductor to come into contact with its earthed metal enclosure. Here is a list of the general techniques used: z Planning A good fault-finder has a mentally planned strategy. 2.7. When the system is healthy (no earth faults) then the lamps glow with equal half brilliance. This temperature rise is above that of the ambient cooling air temperature using copperlinks betweenthe phasewindings. As Head of Electrical Power Systems at the college he has examined many ship types and visited many marine colleges in Europe, USA and fapan in his drive to meet the training and education needs of the marine industry. ANSWER 5 mA and 125mA. Check each resistance range in this way. ANSWER Zero. Many modern clampmeters are virtually multiple and the marine industry. voltage and resistance as well as measuring currents up to 1000A. Set selector switch to "acY" (highest range). Data t l I I I I I) i I \$. Status indicator lamps on switchboards are .commonly of the transformer type, having a small transformer type, having a small transformer type. Why should the measurement of the insulation resistance of a machine ideally be made while the machine is hot? Replacement equipment can be ordered in advance. uk the safe operation, same chapter titles) board various ship; t i Videotel Productions and Witherby Publishers would like to thank the following organisations for their contribution and assistance in the production of Practical Knowledge: South Tyneside College P & O Cruises(UK) Ltd. The testing is normally carried out during the weekly emergency power sources are energised and connected to supply the 35. 1.5 Power and control wiring diagram. The combined power rating of the generators is determined by the overall demand of the ship's electrical load. Study the ship's electrical load. Study the ship's diagrams to pinpoint the location of switches and protection devices supplying distribution boards and essential items of equipment. The electrical connections in Fig. For example, the shore supply may be connected directly to the emergency board which then back-feeds to the main switchboard. Fault finding is not easy! However, a logical approach supported by knowledgeand experience will certainly help. All contacts and components which are in parallel should be drawn side by side and at the same level to emphasisetheir parallel function. Where a specialist manufacturer's services are required these can be obtained at convenient times to suit the ship operation. The priority requirement on board ship is to maintain continuity of the electrical Installation Principles (Macmillan) 5. Fault Finding 23 z Search strategy Once the diagnostician can visualise the circuit or machine as a series of functions and/or use a job aid, a search strategy can be applied to locate the fault in the minimum time. t::. More advanced clamp-type meters can indicate power factor in single and three phase a.c. circuits by using additional connections to measure voltage. perhapsin dangerousnarrow waters. 2.2 Emergencypower supplies. The use of a circuit diagram is to enable the reader to understand the operation (e.g. by pressing a start button) to the final act (e.g. starting of the motor). The earth fault must then be on that particular circuit. They have a lower normal current rating (50-1500 A) than main breakers and a Iowerbreaking capacity. This is often from hand to foot. Electrical power on board ship is commonly generated at 440 V, 60 Hz (sometimes 380 V, 50 Hz). The shipbuilder must estimate the number and power rating of the required generators by assessing the power demand of the load for all situations whether at seaor in port. Simple transformers efficiently step-up or step-down a.c. voltages where required. All contacts should be shown open ot closed in their normal or de- energised condition. To maintain the preference relay trip settings as originally specified they must be periodically tested by calibrated current injection. If one reading is significantly smaller than the others this could indicate the possibility of short-circuited turns in that winding. In many cases the preference trip protection is incorporated in a combined electronic relay which also monitors generatorovercurrentand reversepower. If a lowervoltage range would give a more accuratereading, adjust the selector switches accordingly to shift the decimal point. This action will clear the f.ault and leave all other healthy circuits still connected. 12 Ships' Electrical Systems, Safety and Maintenance Creepage C l e a r a n c e Distance acrosssurface of insulating material Distance acrosssurface of insulating material Distance acrosssurface of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is
suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Test voltages of 1000 V d.c. is suitable for testing ships' equipment rated at M0 Y a.c. Testing ships' equipment rated at M0 Y a.c. Testing ships' equipment rated a taneously the available manpower on board ship may not be able to cope adequately, resulting in delays. Each item of load is supplied at its rated voltage via the correct size of cable and from top to bottom (where possible). One common type of earth fault instrument-type monitor connects a small d.c. altageto the distribution system. If both "a" arrd "b" are healthy, circuit 1 is healthy and fuse-pair 1 can be replaced. To measurevery low continuity resistance values such as those betwe'en bus-bar joints and circuit breaker contacts it is necessary to use a micro-ohmmeter. The meter then calculatesR: V/I (Ohms Law), and displays the result as a digital readout in milli-ohms (mO) or micro-ohms (pO). FACERAP The seven letters of the mnemonic "FACERAP" are the key steps to logical fault finding: D F (fault) A (appearance) C (cause) E (effect) the name and classi-fication of a fault; the description of the fault or its related symptom; the operational reason for the fault; the consequential effect of the fault; R (responsibility) the correct person to take remedial action; A (action) the standard procedure to avoid recetify the fault. Hall 1999 Witherby & Co Ltd 32-36 Aylesbury Street London ECIR OET Tel No: 02072515341 FaxNo: 02072511296 International Tel No: +44 207251 5341 Internationaf Fax No: +44 207251 5341 Internationaf Fax No: +44 207251 1296 Email: books@witherbys.co.uk www.witherbys.co.uk www.witherb The use of instrument transformers does not eliminate danger to operators. General Electrical Maintenance (corrective main- tenance) is when equipment is left untouched until a breakdown occurs. The types and significance of circuit faults are examined together with the various forms of protection methods and switchgear operation. A circuit- breaker, fuse or contactor interrupts the r TRANSFORMER GENERATOR r - - - - - 1 MAIN SWITCHBOARD Fig. There is no standardelectrical supply arrangement, all ships differing in some respect. AC Compressor Motor No. 1 IR TREND ERcold(dry-dock) Fig. Insulation resistancecan vary considerably with changing atmos- pheric conditions. Surfacedeposits can reduce the insulation resistance. The HV power system shown in Fig. No harm will be caused to the instrument by operating the selector range switcheswhile still connected and Earthed Neutral Systems-Significance of Earth Faults- Distribution Circuit Breakers - Transformers- Instrument Transformers- Shore Supply Connection- Circuit Protection- Circuit Protection- Circuit Protection- Circuit Breakers - Transformers- Instrument Transformers- In zero point adjust trimming controls. Protection, e.g. circuit-breakers and fuses, strategically placed throughout the system auto- matically disconnects a faulty circuit within the network. The monitor triggers an alarm when its set value is reached. The function of any circuit-breaker is to safely make onto and break open the prospectiae short-circuit fault current expected at that point in the circuit. 2.2. Insulated from earth (shipis hull). The publication also supports a series of eight film/video cassettes (with the which examine practical electrical maintenance and fault-finding procedures on types. 1..12.Current Clampmeters I L.L.DiodeTests -++- I Electronic diodes, and other semi- conductor devices with p-n junctions (e.g. the base-emitterof a transistor)can be tested using a digital type instrument using the following procedure: ,z PROVE the correct instrument operation. An alternative P.S.I. indicator is a rotary pointer driven by u small 3phase induction motor. It will also cause motors to accelerate more rapidly and this. They must be mechanically strong enough to withstand the thermal and magnetic forces produced by the fault current. 16. materials include mica, glass fibre, etc., and more modern materials such as PVC and other plastics and compounds. Before attempting any electrical work, there are some basic safety precautions you must bear in mind. Transformers inter- c-onnectthe high voltage and low voltage and low voltage distribution system it would be equivalent to a short-circuit fault across the generator through the ship's hull. This has led to the development of instrument type earth fault indicators which are being increasinglyused. Discrimination is achieved by co- ordinating the current ratings and the load as shown in Fig. High voltage systems (3.3 kV and above) on board ship are normally earthed. 50. The size of this short-circuit fault current is determined by the total impedance of generators, cables and transfoimers in the circuit between the generators and the fault. Detail is omitted in order to make the diagram as clear as possible, and s0, easily understood. For example, an MCCB may be continuously rated at 440 V with a rated current -of OOO A. The circuit-breaker or fuse must have a breaking-current capacityin excessof the prospectioe fault current level expected at the point at which it is fitted. Its circuit diagramshows one way of realising the overall OCR function. Note the great similarities and also note the differences - all ships systems differ in some respect. 1.9 IR test connections. The principle of operation of a single- phase transformer is simple. Pointer should indicate correctvoltage. Use the IR tester on each of these disconnected leads. Eng., M.|.E.E.' M.l.Mar.E 15l tol r9 rT1n. 2.10 Core-balance CT. Typical dry full-contact body resistance is about 5000 O at 25 V falling to about 2000 O at 250V. 6. Very high values of voltage, current, power, temperature, force, pressure etc. The size of your body resistance also depends on other factors such as your state of health, the degree of contact with live wires and the perspiration or dampness on your skin. Emergency generators can be hand cranked, but are usually automatically started by compressed air or a battery to ensure immediate run-up following a main power failure. Multimeters Routine electrical test work involves measuring trans- formers are usually composed of three separate single-phase units inter- connected to form a 3-phasearrangement. 20 PRACTICALMARINE ELECTRICAL KNOVVLEDGE DennisT. . L.L5. Fig.2.1 HV/LV power system. Offshore oil and gas production platforms operate at up to 13.8kV, where equipment weight saving is important. .., (in series) 1 1 * _ * - + . .. In addition, each generator has its 9wn preference overload trip, this being low set generally at 110"/" current, instantaneousoperation. This is most conveniently done using a multimeter with all the necessary functions and ranges. DO NOT let this happento YOU. Faults can develop due to natural wear and tear, incorrect operation, accidental damage and by neglect. The associated diode circuitry may be giving false readings so the "diod" e must be disconnected from the circuit then re-tested. Page L ttg Chemical Tankers 14g Introduction - Tanker Classification - Hazrdous Zones - Exi Intrinsic Safety - Exe Increased Safety - Exn Non-Sparking - Ex Exp Pressurised Enclosure - Exs Special Protection and Identification - Certification - Certification - Certification and Identification - Certification and Identification - Certification higher A A [V [v A [v 440V 60HzECRSWBD. For an IR test on a - three-phase machine, measure and log the phase-to-phase insulation resistance values. Turn OFF the power to the circuit being tested and dischargeall capacitors. Electrical generation on board ship is typically at 3-phase a.c./ M0 V, 60 Hz, while fixed lighting and other low power loads are supplied with 220 V a.c. single-phase from very efficient (typically > 90"/") static transformer units. Although not an accuiate instrui- ment transformer is similar in function to a VT. An overcurrent relay detects the fault current and initiates the trip action. The purpose of the insulation is to keep electric currents in the conductors and to prevent contact with live wires. Atlantic Power PGS Offshore Technology BP Shipping Ltd. Before measuring the resistance of a component it is essential that the circuit is switched off, and any capacitors discharged. The instrument is likely to be damaged otherwise. Protection relays are used to monitor overcurrent, over/under voltage, over/ under frequency, earth leakage, un- balanced loading, over-temperature, reverse power (for generators)etc. You should study the ship's electrical diagrams to gain an understanding of equipment operation prior to carrying out maintenance or fault finding. 2.4 Circuit faults. However, the regular recording of test results may show a downward trend which indicates impending troublewhich canbe remedied by preventive maintenance. Insulation that has been mechanically damaged or weakened by overheating
must be made good again. If the shore supply frequency differs from the ship's normal frequency then, ideally, the shore supply voltage should differ in the same proportion. The vast majority of ships have an alternating current (a.c.) distribution 32. 4. If a generator overload develops, the preference trip relay sets an alarm and actsto trip selectednon-essential loads. The connectionbox must have suitable terminals to accept the shore supply cable, including an earthing terminal to earth the ship's hull to the shore earth. 28 ElectrirralDistribution This order of tripping obviously varies with the ship type. Securely connect the probes in SER/ES with the load in which current is to be measured. The basic current range can be extended by using external shunts (d.c.) and current transformers (a.c.). Maintenance is carried out at times favourable to the operation of the plant. These voltages are derived from step-down transformers connected to the MO V system. createthe possibility of danger in an engineering system. Repeat for all "dcY" selector switch positions and note the shift of the decimal point. A blockdiagramshows in simplified form the main inter-relationships of the elementsin a system, and how the system works or may be operated. Such diagrams are often used to depict control systems and other complex relationships. Its main use is to illustrate the ways of operating the system works or may be operated. Such diagrams are often used to depict control systems and other complex relationships. Its main use is to illustrate the ways of operating the system. time to operate the selectors witches during the operation and THINK about what you are doing. A reversed phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of their rotation in all 3-phase motors because the direction of the direct the diode may be short-circulf faulted. A ship's electrical distribution scheme generally follows shore practice. Propulsion Scheme-Power Supply Network- Review of Motor Operation - Controlled Rectification and Inversion - Converter Types- Propulsion

System Operation- Harmonics- Propulsion Auxiliaries and Protection- High Voltage on Ships- High Voltage Safety- High Voltage Equipment Testing. The current measuring facility is intended only for small-current components, and in particular, for electronic circuits. An earthed system has the supply neutral point connected to earth. There is no need to examine other components that are known to function correctly and have no influence on the fault, io the work is simplified. It has been particularly written to assist marine engineer and electrical officer personnel in their understanding of electrical systems, equipment and its maintenance. They include certain supplies to navigational aids, communications, machinery spaces, control stations and 33. M Electrical Distribution Systems are the various electrical circuit testing operations you Insulation Class A E B F H C Max. All electrical equipment heats up when carrying load

current with the consequent rise in temperature. HV systems (> L000 V) are usually earthedto the ship's hull via a neutral earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer to limit earthing resistor (NER) or through a high im-pedance transformer transformer transformer transformer transformer transformer transformer transform distribution system from the damaging effects of large fault currents. However, the loss of power supply could create a hazardous situation, especially if the equipment was classed essential, e.g. steering gear. Various explosion-protected (Ex) methods are outlined along with electrical testing in hazardous areas. earth fault current can be provided by method is shown Fig. Insulation is adversely affected by many factors such as iumidity, temperature, electrical and mechanical stress, vibration, chemicals, oil, dirt and, of course, old age. Supposethis is switch B. Often, the most convenient way to measure current is to use a clamp-meter which is simply clamped around an insulated conductor. When sufficient non-essential load has been disconnected, the preference overload trip resets and no further load is disconnected, the preference overload trip resets and no further load is disconnected. The ratio specified on a CT similarly detailsits input and output currents, €.8. If the circuit is dendit is then safe to press the test button. The operational state of a-distribution system is indicated by the monitors for power, voltage, current and by protection relays for overcurrents and earth-faults at each main control centre. The prospectiae fault current level at a point in a circuit is the current that arises due to a short-circuit at that point. The emergencypower source must be self-contained and not dependent upon any other engine room power supply. R l = 1, + 1, Example: Using the above circuit with a 110 V d.c. supply and R1: 6 Q, Rz: 5 O, R3: 5.5 O: Calculate all currents, supply power and p.d. acrossthe 6 O resistor. r To measure current: Most test instruments can only measure up to afew amps(usually 10A maximum). doors and other services necessary to maintain safety and to permit saf-e evacuation the ship. REYERSE the probe connections and the display should indicate oaer-range. A standard secondary voltage of 110V is used. However, the 5 A fuse protecting the lamp circuit has the lowest current rating and shortest operating time in the system so will be the quickest to operate. At regular intervals it must be tested to confirm that it does operate correctly. There are several manufacturers of insulation testers available but the Megger trade name is known worldwide. To minimise the safetyrisk to personnel and equipment a system must be designed and manufacturers of insulation testers available but the Megger trade name is known worldwide. To minimise the safetyrisk to personnel and equipment a system must be designed and manufacturers of insulation testers available but the Megger trade name is known worldwide. correctlyinstalled. This fault is remedied by interchanging any two conductors of the shore supply cableat the connectionbox. 2.0. Introduction System is to safely convey the generated electrical power to every item of consumerequipment connected to it. 2.4. Distribution Circuit Breakers Details of main generators and main feeder circuits are included in Chapter 3., z TURN OFF the power to the circuit breakers for main generators. Index 8. d Overcurrent (Inst.) Underfrequency Underfr cable which is known to be carrying 100 A a.c. to a motor? Most atcidents occur due to a momentary loss of concentrationor attempts to short-circuit standard safety procedures. The frequency is 50 Hz but is 60 Hz in North America and in a few other countries. This should be between 500 mV (0.5-0.8 V) for a healthy silicon diode or p-n junction. Write down this information in a note book. 2.11 Earth fault monitors in a distribution system. Regulations require that an earth fault monitor is fitted to the main switchboard to indicate the presence of an earth fault on each isolated section of a distribution system, e.g. on the 440 V and 220 Y sections. ANSWER By "correct" we mean that it is the same sequence as the ship's supply (red- yellow-blue). giu", fi : Nl Nz tl e) r e o a d is e!rtd nde Vt_lz V2 11 QUESTTON A 4401110V single supplies a load of 5 factor load. Batteries for various essential services operate at 1.2 V or 24 V d.c. but sometimes higher voltages are used if such loads require a large power system must be ready and available at all times. Direct current (d.c.) measurement is also available with clampmeters having a flux-voltage transducer known as a "Hall-effect" device. / U v / MAIN GENERATORS t l Ar"-*n.. DO confirm that circuits are DEAD (by using an approved voltage tester) before touching conductors and terminals. A test result of at least 5 MO usually required. However, like all electrical equipment, transformers must be sub-jected to the usual maintenance falls to a dangerouslylow value. 2.6. Instrument Transformers are used to supply instruments and voltages in a high power network. Some light up (e.g. screwdriver type with a neon indicator), some make a noise, others operate LED's or mechanical indicators (flags) to indicate the approximate value of voltage. It is not normally possible to parallel the shore supply with the ship's generators. Three readings should be measured as U-E, V-E, W-E: Note: Insulation resistancedecreases with increase of temperature. Practical Marine Electrical Knowledge - Second Edition 1. Specific parts the electrical network together with its UMS requirements, are examined in relation to the electrical survey by a classification society. The earth fault monitor on the switch- board shows the presence of an earth fault monitor on the electrical survey by a classification society. The earth fault monitor on the switch- board shows the presence of an earth fault on the distribution system. A 440 V, 5 kW, 0.8 pf 3-phase load is supplied as shown in Fig. 1.6 Electricalsafetywarning. The majority of insulation materials in common use cannot withstand temperatures much in excessof 100"C. ' - - tr Spatiahnrec, lqrieat iUitity' f, Socialskills;, _, ,, 'I Persistence.,,i.:- . The emergencypower sourcemust come into action following a total mains failure. ANSWER From: P2: V2.l2.cos {,Ir: -J2- - V't.cos6 - 5000 : s6.Bz A 110x 0.8 : I 1 : 1 2 x Vz V1 / . If the shock victim is unconscious, resuscitation must take priority over first aid methods. Connect probes to a suitable known live supply (with CARE) such as the electricalworkshop testpanel. Note: Double-pole switches with fuses in both lines are necessaryin an insulated single-phasecircuit. r ISOMTE and lock off the equipment to be tested. The distribution system is the means by which the electrical power produced by the generators is delivered to the various motors, lighting, galley services, navigation aids, etc. Immediate repair or maintenanceis probably not necessary but should be put in hand at the earliest convenient moment. Electrical power is used to drive the majority of these auxiliary services. The resistanceshould be measured between insulated conductors and earth, and between conductors. Diagrams like this state the function of each block but usually do not give any information about the components in eachblock or how the blocks are actually interconnected. 25 Chapter Two Electrical Distribution 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 Introduction Power Dishibution System Insulated and Earthed Neutral Systems Significance of Earth Faults Distribution Circuit Protection Electric Cables Page 25 25 29 3L 36 37 39 4't 43 51 This chapter examines a ship's electrical distribution network in detail. The lamp is of !9ry watla,ge with small bayon-et cap fitting. The breakdown of essential equipment may endanger the ship, but probably the most serious hazard is FIRE. The size of conductor used in cables and equipment may endanger the ship, but probably the most serious hazard is FIRE. The size of conductor used in cables and equipment may endanger the ship, but probably the most serious hazard is FIRE. 80'C (i.e. 35'C rise above an ambient of 45'C). Both lamp fittings must now be opened and visually inspected to trace the exact location of earth fault. A circuit consistsessentially fixed two parts: o Conductor, the part which carries current through the circuit, o Insulation, the part which keeps the current inside the conductor. The circuit-breaker or fuse must be capable of safely and rapidly inter- rupting a short-circuit current. l o r S: l 2 Z U A) I yr, l V I 't v, l I There are various types which attempt to show how 12. Some models of insulation/continuity testers also provide facilities to measur-e resistance in the ttk(2" range and "a.c. voltage" (acV). If one conductor is indicated as having an earth fault (suppose it is the conductor between Lr and L) then the earth fault lies at lamp 1.or lamp 2 or on the conductor. Overcurrent (l/t) Undervoltage Unbalanced Load EarthLeakage Overcurrent (lnst.) Overcurrent Overtemperature 6.6kV 60 Hz MAINSWBD 7 t t + .l. As equipment nears the end of its safe working life its condition can deteriorate to such an extent fault current flows and the phasor sum of the currents is now not zero. The general schemeof a ship's electrical power system is common to nearly all ships. As most protection relays monitor current and/or voltage, we will limit our examination to opercurrent and under- voltage protection together with an appreciation of protection together with an appreciation of protection together with an appreciation to opercurrent and under- voltage protection together with an appreciation of protection together with an appreciation of protection together with an appreciation together with an appreciation of protection together with a protec random in this way. This reduces the generatorload so that it may continue to supply essential circuits. FI ffi /-: / r lv trH KH A [V ffi /G [v A / ') 60 Hz ECRSWBD 440V 60 Hz ECRSWBD 440V 60 Hz ECRSWBD. operation of the equipment to be dead ,z SWITCH the instrument to the appropriate resistance range, connect the probes to the equipment and note the resistancevalue, z Disconnect the probes and switch the instrument to OFF., CONNECT the two probes acrossthe diode. Study the electrical power diagrams for your own ship to see if you can relate them to the actual equipment they represent. Fusedprobe leads are therefore highly recommended for use with multimeter. The connection box must have a circuit- breaker or an isolator switch and fuses to protect the cable linking the connection box to the main switchboard, with a data plate giving details of the ship's electrrcalsystem (voltage and frequency) and showing the method for connecting 48. For continental European vessels, a 380 V, 3-phase system is common. 18 Ships'Electrical Systems, Safetyand Maintenance, z SWITCHthe instrument to the highest current range (either acA or dcA as appropriate). MCCBs can be used for every appli- ion on board ship from generator to small distribution breakers. Distribution systems at these high voltages usually have their neutral points earthed through a resistor or earthingtransformerto the ship's hull. The instrument tongs are clipped round a single insulated connections between components or items of equipment, and in some cases the routeing of these connections. Supplying these connections are clipped round a single insulated connection are clipped round a single insulated connection. A wiring diagram shows the detailed connections are clipped round as insulated connection are clipped round as insulated poweris P: V.I: 1"L0 . 150/5 A CT is used on a 150 A mains circuit and steps the current down to 5 A. In the case of three-phase motors and transformers, etc. 2.24 Fault circuit. Instrument battery failure is usually indicated by the numeric display. Ancillary Electrical Services Introduction - Ships' Lighting - IncandescentLamps- DischargeLamps-Voltage Effects on Lighting - Navigation and Signal Lights - Emergency Lighting - Maintenance of Lightings - Refrigeration and Air Conditioning - Galley and Laundry - Cathodic Protection- Battery when fully charged is obviously self-contained. Short-circuit and overload currents must, therefore, be detected and rapidly clearedbefore damageoccurs. Other small batteries may also be installed to locally supply control and communication equipment. Unfortunately, your body resistancegoes down as the applied voltage goes up. 'z SWITCHthe instrument to diode test. I I Excitation S u p p l i e s 3 - P H ,6 0 H z , a . The initrument should be switched off when not in use to preserve battery life. Electrical Safety 9 ANSWER It may well save time and trouble to convert the wiring diagram into a much simpler and more useful circuit diagram. Electrical Diagrams 5 circuit operating conditions become known, and abnormal operation becomesquickly apparent. L.L3. No maintenance that it has become necessarv. A short-circuitfault is due to a double break in the-insulation, as at C, allowing both conductors to be connectedso that a very large current by-passesor "short-circuits" the load. 14. It is important that voltage testers themselves be PROVED to operate correctly before use. Further experience and knowledge was acquired in the Royal Navy where he was introduced to the requirements and effective delivery methods for the training of engineering personnel. The Institute of Marine Engineers International Maritime Organisation (IMO) We wish to thank the following authors and publishers for permission to use some of the illustrations in this book: M.L. Lewis, Electrical Installation Technology 2 (Hutchinson) M. Circuit Protection 45 I 0.025 o i r Shortcircuit I faultlocation i oqqr I Fig. Conclusion? Diagnostic performance In addition to the necessary skills of the diagnostician, systematic use of "job aids" will improve fault finding method. Earth indication lamps in a 3-phasea.c. systemare arrangedasshown in Fig. Regular insulation testing and aibration testing are two forms of condition monitoring. The aim is to forestall breakdown by predicting probable failure from the TREND shown by the monitoring results. Planned maintenance is carried out at fixed regular intervals whether the equipment needs it or not and the aim is to prevent breakdown. Block, system, circuitand wiing diagrnmsare the main types in general use for electrical work. 1.1 Electric power system. Examples are: Fault charts A list of typical symptoms and faults for a particular equipment plus suggested remedies. In some cases, a spare4th transformer is available to replace the faulty unit. g I limited breakingcapacitymay demand back-upfuses be fitted for very prospective short-circuit fault levels. Instrument Transformers 39 3-PH220V - - '-- iltflt ilrflr tlt t t t t i i t t i i t t i i i ----1'NGL;;F.AS, u."l- LIGHTING AND LOWPOWERSUPPLIES 3 x 1-PHASE TRANSFORMERS CONNECTEDAS: A-A R 3-PH440V MAINSWITCHBOARD Fig. It is up to the maintenance staff to trace (searchfor) the exactlocation of the instrument. If the multimeter is a digital type: Switch on and connect the two probe tips together. / DO operate equipment according to the manufacturer's recommen- dations. c . The current monitored by the E/F relay is used to trip the coniactor in the starter to isolate the faulty motor circuit. 30. An appreciation of generator construction and its control is followed by a guide to its protection and maintenance. An HV system (1 kV - 11 kV) is usually earthed at the generator neutral point via a neutralearthingresistor (NER). x DO NOT leave live conductors or rotating parts exposed. The method of earth fault rancewill be described fully for a ting distribution circuit shown in 2.12. 8 Ships' Electrical Systems, Safety and Maintenance STAR DELTA STARTER WIRING DIAGRAM (on door pffid) t - - - ----- r STOP START 3 - P H A S E A . 1..2 Block and circuit diagrams. This emergency battery is to ensure that a total blackout cannot occur in the transitional period between loss of main power and the connection of the emergency battery is to ensure that a total blackout cannot occur in the transitional period between loss of main power and the connection of the emergency battery is to ensure that a total blackout cannot occur in the transitional period between loss of main power and the connection of the emergency battery is to ensure that a total blackout cannot occur in the transitional period between loss of main power and the connection of the emergency battery is to ensure that a total blackout cannot occur in the transitional period between loss of main power and the connection of the emergency battery is to ensure that a total blackout cannot occur in the transitional period between loss of main power and the connection of the emergency battery is to ensure that a total blackout cannot occur in the transitional period between loss of main power and the connection of the emergency battery is to ensure that a total blackout cannot occur in the transitional period between loss of main power and the connection of the emergency battery is to ensure that a total blackout cannot occur in the transition of the emergency battery is to ensure that a total blackout cannot occur in the transition of the emergency battery is to ensure that a total blackout cannot occur in the transition of the emergency battery is to ensure that a total blackout cannot occur in the transition of the emergency battery is to ensure that a total blackout cannot occur in the transition of the emergency battery is to ensure that a total blackout cannot occur in the transition of the emergency battery is to ensure that a total blackout cannot occur in the transition of the emergency battery is to ensure the transition of the emergency battery is to ensure the transition of the emergency battery is to ensure the transition of the emergenc V a.c. to 1000V a.c. (the IEC give this definition to harmonise British and European standards). The special design and maintenance for electrical equipment used in potentially hazardous areas is reviewed in relation to oil, gas and chemical tankers. The continuous operation for electrical equipment on board ship demands high effitiency 28. 2.14 IR test on a lighting circuit. 1.7 Creepage and clearance distances. Three readings should be measured as U-V, V-W, W-U as shown in Fig. 1.3 Power systemdiagram. 1. Further details of the film/video cassettescan be obtained from the producers: Videotel Productions. Where distorted voltage waveforms are likely (e.g. with variable frequency motor drives) it is necessary to use a "true-rms" meter for accuracy. Digital meters are also available which display the test voltage waveform shape with a storage oscilloscope facility on the LCD screen. 46. Electric shock and fire can causeloss of life and damage to equipment. A shock current as low as 15 mA a.c. or d.c. may be fatal. r NOTE the voltage reading. The ship's drawings and circuit diagrams must be checked and updated to relate them to the actual equipment. Turn ON the power to the circuit being tested. Current transformers (CTs) supply ammeters and the current operated coils of instruments and relays with a st and a rd is ed 5 A or lA. The instrument will almost certainly be damaged if it is used to measure the current to motors and other Dower circuits. 1.L1 Continuity test connections. 6 -- 34.56V three phase a.c. circuit V7: .l3.Vpp and ly: |y3.1p11 Gn DELTA) Ppu = Vp11.Ip11.cosS: lr&.R Balanced 3-phase: P: |/ 3.VL.ly.cosg Example: Using the above circuit with a M0 V, 3-phase, 60 Hz a.c. supply and Za1: 10 O at p.f. = 0.8 lagging (balanced load) Calculate phase and line currents and supply power when connected as: (a) STAR and (b) DELTA Determineas, (a) in Star, Vpu: 440/J3:254 V so Ipp: 440/10:44 A and l7: 440/J3:254 V so Ipp! 440/J3:254 V so Ipp: 440/J3:254 A and ly: 440/J3:254 V so Ipp: 440/J3:254maintain generator operation during an overload, a preferentialload shedding arrangement is employed. Equipment is maintained in a safe condition with reduced possible dangers. Hot-spot temperatures of 105'C (Class A) and 130'C (Class B) are generally accepted as normal at the centre of coils and windings of machines with these surface temperatures. (becausethis is an INSULATED system) (c) the short-circuit fault impedance is limited only by the 0.01 O of the cables, so: - . The ship's generators must, therefore, be disconnected before the shore supply can be connected to the main switchboard. Keep in mind an essential list of DO's and DO NOT's when working with electrical equipment: ,/ DO get to know the ship's electrical system and equipment. Transformers 37 e e) The front cover of larger MCCBs (around 1000 A rating) can usually be removed for visual inspection and MCBs must be replacedif faults develop - no maintenanceis possible. Various classes of insulation are listed in British Standards (BS) and classes A, E, B and F are used for marine electrical equipment is in particular need of correct maintenance. In addition, an emergency transitional batterymust also be installed to maintain vital services (mainly lighting) for a short period typically a minimum of 3 hours. If a fault develops on one phase of such an arrangement, the faulty unit can be disconnected (via the links) creating an open-delta or "V" connection and a 3-phase supply will still be available, although at a reduced power capacity. 2.5 Double earth faults in an insulated system. 2.22 lists typical protective relay functions The manufacturer's instructions should be carefully followed for this but a general procedure is as follows: Use the correct probe leads and insert into the correct socketson the meter. The associated instrument will have its scale calibrated "0-L50 A" and will be marked "15015A CT ratio". Live-Line Testers When equipment is to be inspected for maintenance it is important that supplies be switched OFF and locked OFF. 11: 11.0/(6 + 5): 70A andlz: 110/5.5: 20A sosupplycurrenti, f- SOA,. At the main switchboard an indicator is provided, usually a lamp, to indicate that the shore supply is available for connection to the bus-bars via a con- necting switch or circuit-breaker. This is obviously a useful safeguard. This type of maintenance has the following adaantages: z Fewer breakdowns and reduced down time produces higher levels of operating efficiency. Condition monitoring (another form of preventive maintenance) is when equipment is regularly monitored and tested. Neidle, Electrical Installations and Regulations (Macmillan) M. If the motor is healthy (no earth faults) the phasor sum of the currents measured by the CT is zero. It is supplied to the main switchboard and then distributed to the various auxiliary servicescomprising the electricalload. A maintenance records system is required. Cable connections must be checked for tightness. For further s#ety, one end of the secondary winding of a CT or VT is connected to earth. 2.8 Earth fault monitoring by d.c. injection. which comprise the ship's electrical equipment is con-structed and rated to work satisfactorily in a maximum ambient air temperatur-e of 45"C (Lloyds). 20 Ships'Electrical Systems, Safetyand Maintenance LEDINDICATORS Fig. Note the current size on the meter display. Arc chutes with arc-splittersquickly stretch and cool the arc until it snaps. The CB is openwhen the arc is quenched. Mobil Shipping Co. Ltd. All major components quickly 1..14.General Electrical Maintenance and optimum economy in order to help keep operational costs to a minimum to maintain financial competitiveness. Close the switch and re-test at "a". Qsp"re !unit 440V 60 Hz ECRSWBD. 32 Electrical Distribution FUSES LOADS FUSES LOADS -=. fault current. The main contacts must open rapidly while the resulting arc is transferred to special arcing contacts above the main contacts.: 8. Voltage transformer kW at 0.8 power lnH'. 'l u ad ll/-*-' Arocnr- Llt ?ALARM tofi, l, ITo (mn))/-l-exrenul CURRENTrlR| |ALARM LIMITER U'' SHIP'S LOAD V 6 O H Z M A I N S W E D) I 2 2 O V l o l ' T O I t c l o l t E/F MONITOR E/F MONITOR 41. Determine and remove cause. But GREAT CAREmust be taken not to switch into either the current or resistance mode. In the event of an emergency, only the emergency services are supplied by the emergencygenerator. So its ohmic value has to b"r 1905 v : 4.4Q 437A Certainessentialloads(e.g. steeringgear) can be supplied via a transformer with its secondary unearthed to maintain security of supply in the event of a sinele-earth fault. Significance of Earth Faults 35 I] I t An apparently simple method would be to open the circuit-breakersfeeding loads A, B, C, etc. While the principles discussed and the details given in this book are the product of careful consideration, the author and the publisher cannot in any way guarantee the suitability of recommendations made in this book for individual problems or situations, and they shall not be under any legal liability of any kind in respect of or arising out of the form or contents of this book or any error therein, or the reliance of any person thereon. Three-phasea.c. is effectively converted into rotary mechanical power in simple and efficient induction motors. Copies of these safety procedure is should be displayed on board ship. Switch the instrument to "MO" and connect the probes to pairs of equipment terminals. Separate the probe tips. VI Contents Chapter Seven Electrical Survey Requirements Introduction - SOLAS - Classification Societies- Main Electrical Survey Items- Generators and Governors- Circuit Breakers- Switchboards and Fittings - Cables- Insulation Resistance- Motors and Governors- tilms Operation - Tankers. To protect against the dangers of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electric shock and fire that may result from earth faults are not expected as a fire that may result from earth faults. neutrals to earth as shown in Fig. During its working life the equipment must be continuously monitored and correctly maintained by professionally qualified personnel who understand its operation and safety requirements. Temp. Reconnect the circuit that was being tested. If the display indicates over-range in both directions the diode is opencircuitfaulted. Measure and log the phase-to-earth insulation resistance values. Equipment is regularly condition- monitoring schedule. Their major disadvantage is that they are not very sensitive and will fail to indicate the presence of a high impedance earth fault. This type has to be completely isolated in the event of a fault on one phase only. Auxiliary services on board ship range from engine room pumps, compressors and fans, deck winches and windlasses, to general lighting, catering and air conditioning. 40 Electrical Distribution MAINBUS-BARS C-T_ e.g. 1000/5A e.g. 6600/110V Fig.2.L9 Instrumentconnections with CT and W. The advantageof this type of maintenance is that equipment is not subjected to unnecessarymarntenance. Traditional insulation materials include cotton, silk, paper, etc. Transformers are static items of equip- ment which are usually very reliable and trouble-free. Fuse-pair 2 is now removed and tested at "a" and "b". This is ac-bie-ved by u special overload relay, called a preference trip relay. Some vital service may be interrupted causing the main enginesto stop ... has experienced an some time. The essential services breaker which is typically high set at 150"/"with a 20 seconds delay. 3-PHASE BUS-BARS Fig,2,9 NER circuit. The marine environment is particularly arduous for electrical equipment du-e to the damp, salt-laden atmosphere, extremes of temperature and constant vibration why protection in an electrical Systems, Safety and Maintenance Ships' staff must operate equipment in a safe manner and maintain it in a safe manner and maintai safe condition at all times. Determineas, Xy:2.n.f.L= 37.7Q and X6= 7/2.n.f.C:26.5A Then 21: 38.2 Q at 81" Aagging V by 81" and l, = 220/27: 8.1,5A leadingV by 79.3" The total suryly current is the phasorsum of 11and 12 which must be resokted into "in-phase" (hoizontal) and "quadrature" (aertical) components beforeadding, the result (for you to check)is l: 3.34 A at 43.8" leading Supply PowerisP: 220.3.34.cos43.8": 531W lcheckwith P: Z(12R)] OaeraIIpowerfactor is cos43.8": 0.72 leading p.d. across60: Ir. emergencyservicesfor the period of the practicesession. The secondary voltage Vz is available to drive current through a load. 1.2 describesthe main functions of an overcurrent relay (OCR) used for protection. The other lamps experience an increased voltage so will glow brighter than before. Display should indicate zero (000). Motor and starter construction, operation and protection are explained. The possible dangers arising from the misuse of electrical equipment are well known, switch and check the "C2" scale.Log Fig. 2.6. The ohmic value of each earthing resistor is usually chosen so as to limit the maximum earth fault current to not more than the generator full load current. The equipment should be inspected and repaired before 29. If a generator overload condition dev, elops, its preference overload trip will operate to energise the timing relay. 0.8 Under EiF conditions a phase voltage of: VpH: =q: 1905Vdrives the fault current V 3 through the NER. Title ISBN 1 856091821 WITHERBY I mn-l twl PUBUSHERS: All rights reserved, Nq. p-aft-of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the publisher and copyright owner. If you are author or own the copyright owner are author or own the copyright owner. If you are author or own the copyright of this book, please report to us by using this DMCA report form. 1.4. A wiring diagram may be of a fairly simple circuit, but its layout makes it quite difficult to use and to understand the sequential operation of the circuit. Ships' electric cables with their glanding, terminations and testing are reviewed. Any resulting d.c. currentis a measure of the insulation resistance of the system. A live-line (or voltage) tester is a simple device to check only whether or not a voltage exists at terminals. The electrical energy is routed through the main switchboard, then distributed via cables to section and distributed via cables to section a built like small power transformers. They arenot normally used at voltagesless than 3 kV. FAULT - w-l Fig. Here there is no earth fault current would immediately cause the line protective device (fuse or circuit breaker) to trip out the faulty circuit. QUESTION A 10 A motor operates from a 220 Y insulated system. The instrument should be switched-off when not in use to preserve battery life. The cause of any low insulation resistance reading must be investigated and rectified. Normally, the shore supply switch on the main switchboard- is interlocked with the generator circuit- breakers so that it cannot be closed if the generators are still connected. ,z Disconnect the probes and switch the instrument to OFF. At South Tyneside College, as lecturer and manager, his cumulative knowledge has been very usefully applied to the training of merchant navy electrical and engineering candidates from cadet to senior officer level. The shore supply may have a different frequency and/or voltage to that of the ship's system. t I t d l I? Nearly all equipment needsmain- tenance. Great care is required with high voltage circuits where a special HV test probe must be used, see Chapter Eight. The procedure to be used to measure current in a small-current circuit: r PROVE the correct instrument operation. The purpose of maintenance, therefore, is to extend the useful life by repair and/or replacement of defective p-arts and to maintain it in a safe and serviceable condition. Obviously the size of shock current is related to the useful life by repair and/or replacement of defective p-arts and to maintain it in a safe and serviceable condition. Obviously the size of shock current is related to the useful life by repair and/or replacement of defective p-arts and to maintain it in a safe and serviceable condition. thruster motor from a 440 V switchboard supply.

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