

DEP SPECIFICATION

**MECHANICAL AND ELECTRICAL MAINTENANCE
EQUIPMENT AND TOOLS**

DEP 70.08.10.11-Gen.

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the selection of equipment and tools to cover a normal range of mechanical maintenance work on new oil and gas production facilities, gas handling facilities, oil refineries, chemical processing and gasification sites.

This DEP will assist in determining the possible choices for:

1. Fixed items of equipment
2. Loose items of equipment
3. Portable equipment
4. Testing equipment
5. Tools
6. Utility service requirements
7. Space allocation
8. Functional layouts

This is a revision of the DEP of the same number dated February 2013; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets (). Other documents referenced by this DEP are listed in (7).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2013. The following are the main, non-editorial changes.

Section	Change
6.2.12.2	Changed wording to refer to Static Electricity DEP 80.64.10.11-Gen. for guidance on selection of vacuum tanker hoses.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
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Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

Dimensions used in Appendices:

Note that only metric dimensions are given in Appendices. Use of corresponding USC values will depend on level of adoption of metric standards in location country.

2. GENERAL

This DEP is intended to assist in furnishing the mechanical and electrical maintenance team with the necessary tools and equipment, both in the workshops and in the field, and in deciding on the optimum arrangement and layout of a workshop complex to suit its particular needs.

This DEP is intended to cover the requirements for any size of refinery, plant or installation. The final arrangement of the workshops and the selection of equipment will depend on many factors, including the location, industrial environment and competencies of craftsmen potentially available around the site.

The final selection of tools and equipment will be dependent on the maintenance and repair policy that results from and is based on strategies, policies and considerations as indicated below.

2.1 MAINTENANCE VISION AND STRATEGY

During the early stages of the project, a Maintenance Vision shall be determined.

As a result of the Maintenance Vision, strategic choices will be made (but not be limited to) and separate Strategies may be developed regarding the themes noted below:

1. Contracting and procurement strategy,
2. Sparing philosophy,
3. Warehousing philosophy and stocking of spares,
4. Contractor strategies (i.e., maintenance execution, lifting and transportation of large equipment for repair, etc.),
5. Resultant staffing levels of maintenance department,
6. Required level of expertise and minimum manning levels to be able to repair strategic equipment in house.

These strategies and resulting policies will be dependent on the availability of a competent workforce in the area (the Principal's or Contractor's) and logistical constraints. These strategies shall take the following into account:

1. Complexity of the process equipment in the plant

For each piece of equipment or component, the following shall be assessed:

- a. Availability, required competency and skills of technicians (own and/or Contractor's) to repair equipment and components and ability to develop/maintain competency and skills over time;
- b. Availability or presence of OEM expertise for complex items, including expected time to mobilise.

2. Required competency of workforce

For the required competency of the workforce, the following shall be determined:

- a. Depending on the required experience of the Principal's or Contractor's personnel, training requirements and training matrices shall be developed with competency assurance.
- b. Availability of Contractor personnel for hire in the vicinity, taking into account:
 - i. Competency assurance.
 - ii. Quality assurance (QA)/Quality control (QC).
- c. Quality and expertise of local Contracting firms to execute specialised work.

3. Logistical capabilities, constraints in infrastructure, availability of off-site third party workshops and/or Contractors shall be investigated to determine to what extent work can or should be done by third parties and the risks involved:
 - a. Availability, quality and expertise of specialised work contracting services (workshops) in the vicinity of the site shall be considered in selecting the numbers and types of machines, equipment and tools to be purchased, in order to optimise their expected utilisation.
 - b. Infrastructure of location and surrounding area. Poor infrastructure may prevent specialised transport and necessitate extra sparring or competency for repair of plant equipment with requisite tools and equipment and workshop repair area. For the logistics, the level and quality of roads, harbour(s), railroads, transportation companies, and air transport shall be investigated.
 - c. Transportation possibilities and time lag to send and receive parts for (overseas) repair.
 - d. Availability of specialised support service Contractors, e.g., specialists for heavy lifting, industrial cleaning, rotating equipment, etc.
4. Level of competition and choice in Contractor firms.

If there is limited competition, in-house specialisation may be considered.
5. If chemical cleaning and/or vacuum extraction disposal of waste is outsourced to a Contractor, the Contractor shall be certified to be in accordance with local laws and international environmental requirements.
6. Customs
 - a. Speed of customs clearance;
 - b. Import duties for spares or repaired equipment;
 - c. Import levies on spares also produced in the host country. Quality and cost of these spares may dictate preference of repair over replacement by locally produced spares or high import duties.

Based on the considerations above, the maintenance and repair strategy, and the Contracting Strategy, an ensuing plan shall be developed with the requirements for workshops, service centres and tool sheds. The type, extent and number of maintenance equipment and tools shall also be established. The next sections of this DEP can be used as guidelines for the selection of appropriate maintenance equipment and tools.

2.2 DESIGN CONTRACTOR SCOPE

The design Contractor shall develop a tool and equipment inventory and a workshop layout based on the requirements, strategies and policies of the Principal, using this DEP for guidance during the design phase of the project. The Principal shall set up a team of experienced personnel, future users or initial maintenance team members on site during the project phase to be involved in the design, studies and selection of the above. The Contractor shall use this team to advise, align and test or verify proposed designs and equipment and tools lists.

The proposal shall include but not be limited to:

1. Functional layout of the main workshop and possible satellite workshops, vehicle workshop, cleaning yard and/or vessel yard;
2. Logistical flow studies and resulting plans;
3. Management of noise levels
4. Heavy (fixed) maintenance equipment;
5. Movable equipment;

6. Portable equipment that may be used inside the plant;
7. Testing equipment including electrical testing area needs;
8. Tools:
 - a. Main workshop tools
 - b. Vehicle and/or vessel tools list
 - c. Tool cabinets and standard layout of tool boards (shadow boards)
 - d. Satellite workshops tools
 - e. Field tools per technician
9. Utility service requirements for tools;
10. Layout of utility connections in the workshops and areas where maintenance tools will be used.
11. Storage and handling of chemicals such as cleaning agents, oils etc as well as the disposal of similar materials when used or contaminated.

The proposal shall be presented to the Principal for approval.

2.3 TOOLS GENERAL

All electrically-driven machine tools and hand tools shall be suitable for the local power supply standard of voltage and frequency, i.e., without additional transformers. All required electrical tools in the plant shall adhere to the safety requirements and work permit procedures for the location taking account of national requirements, e.g., ATEX in European Union.

Mobile diesel engine driven units shall have flame arrestors.

Air driven tools shall be suitable for the available local pneumatic pressure (tool air) in the plant and workshop(s).

Battery powered tools shall either be suitable for use in the production part of the site or be restricted for use only in designated safe areas unless a correctly completed clearance, safety certificate and any additional precautionary measures have been carried out. Compliance with national requirements, e.g., ATEX also applies to battery powered tools.

3. WORKSHOP AND SERVICE CENTRES

3.1 GENERAL

The requirement for workshops and tools shall be determined based on the decision for which services and for which specialised work support can or cannot be obtained locally. A decision based on available third party expertise and workshops/yards shall take into account the repair and maintenance of the vehicles and vessels required for transport (e.g., tugs, support and supply vessels, etc.).

Each location should establish a workshop to execute emergency repair, routine maintenance and shutdown work. Irrespective of the ownership of the facility, it is essential to establish that the necessary facilities are available for the expected workload.

A fit-for-purpose, well-designed and properly located workshop fulfils an important function for the maintenance organisation. In many environments, a number of maintenance activities can be carried out more efficiently and safely in the workshop than in the field.

3.2 CENTRALISATION

Based on the general plant layout, risk areas, the nature of work, the maintenance strategy, and the ensuing policies for maintenance execution, the Principal shall decide which maintenance facilities should be available centrally or locally, and which facilities are suitable to be contracted out. The following guidelines are given to assist in this decision.

Generally, centralisation of the engineering maintenance disciplines together in the main workshop provides for better utilisation of men, machines and tools.

For larger locations, the possibility of setting up satellite service centres and combining these with process centres should be assessed. Their closeness to the process centres allows good communication between operators and the plant maintenance crews.

For medium-sized locations, satellite tool caddies would be the better alternative. These should contain sufficient tools to allow the maintenance crews to carry out minor repairs on site, without having to bring back everything to the main workshop.

3.3 LOCATION

The main workshop should be located at a safe distance from the plant in accordance with DEP 34.17.00.32-Gen. It should be closely linked with the material store and, if possible, be combined with it under one roof. Inspection, rotating equipment and other advisory services should be in close proximity. Access to the workshop from outside the plant, particularly for delivering materials, should be considered.

3.4 SIZE AND LAYOUT

Size, layout and capacity of the workshop(s) shall be based upon the nature and expected extent of maintenance work to be executed, taking large repair work during turn-around maintenance into account as well. Design of the workshop shall take the logistic flow, electrical power and tool air, temporary or intermediate lay down requirements (inspection area for hold and witness points) of the repair into account. The design shall be such that the flow of equipment under repair is logical and does not clutter the workshop, and that the flow of repair of one type of equipment does not cross, or interfere with, the repair of another type of equipment (e.g., pump repair with heat-exchanger re-tubing).

Continuous improvement processes, e.g., Kaizen or 6 Sigma, or equivalent methodology shall be considered to maintain a structured, neat and disciplined workshop.

For medium-sized locations, examples with suggested size and layout of a centralised workshop complex with adjoining material warehouse are shown in (Appendix A), for guidance only.

In evaluating the size and layout of a workshop, the following points shall be considered:

1. The volume and nature of the maintenance work to be done at the workshop;
2. Easy movement of equipment into and out of the workshop taking maximum possible equipment size into account;
3. Clear identification of IN and OUT bays;
4. Combination of lay-down areas for large equipment due for repair and lay-down areas for large spare equipment of spares warehouse;
5. Cleaning yard and facilities, including all power, water and containment;
6. Combination of mechanical, electrical and/or instrument workshops in one building;
7. Temporary storage area or lay-down area for equipment in repair awaiting (overdue) spare parts;
8. Lay-down area or pellet racks for storage space for individual components or equipment under repair to separate individual repair jobs (spare parts, components and consumables) and to prevent mixing or losing parts between jobs. This may be a result from the 5S or Kaizen approach or study;
9. Storage area and containment for oils and solvents readily accessible (including storage for used oil and chemicals);
10. An outside sun-protected free-air vented-storage facility or cabinet for large and small gas bottles (full and empty) attached by a manifold and infrastructure supplying all necessary workbenches with required gasses, taking separation requirements for oxygen and combustible gases into account. It shall be ensured that oxidising gases and combustible/non-compatible gases are stored in a safe manner and at a sufficient distance from one another;
11. Required vicinity of the Spares Warehouse and combined services (i.e., cranes, receive and dispatch area and personnel, transportation bays, etc.);
12. Possible sharing of building and services of the main workshop and Spares Warehouse;
13. Requirements for Inspection facilities of repaired equipment;
14. Easy movement of equipment during repairs (e.g., movement between the machine shop and welding area);
15. Logistical flow of repair sequence of equipment;
16. Overhead cranes are to be of sufficient capacity and able to access all required areas of the workshop. This shall also take into account the required handling activities of the involved equipment including as rotation from horizontal to vertical position and vice versa;
17. Separation of the noise-making and "dirtier" activities from other activities (e.g., pipe/plate handling, welding);
18. Separation of areas where stainless steel is being handled from carbon steel areas;
19. Requirement of "clean areas" (e.g., repair of mechanical seals);
20. Fixed equipment shall be placed in such a way as not to interfere with the logistical flow of items for repair;
21. Provision and capacity of electrical power shall be designed in such a way that ample power shall be available and sufficient power points will be on hand during maximum load activities when a maximum of fixed equipment and loose tools will be in use. Determining requirements for power consumption shall take heating and cooling requirements for the workshop and office buildings into account.

NOTE: Testing facilities for electric motors may require a dedicated electrical supply depending on the motor sizes required to be tested onsite.

22. Accessibility to documentation. Drawings, spare parts and historical data, in either electronic and/or hard copy form, should be easily available.
23. Offices and archives or documentation libraries should be located to allow close supervision.
24. Amenities building with showers, changing rooms, etc.
25. Provision of and easy access to Safety equipment such as First Aid kits, emergency showers (if chemical contamination could be an issue) and/or eyebaths / wash facilities (where welding or grinding activities take place).

3.5 MAIN MECHANICAL ACTIVITIES

The main activities of the mechanical workshop can be divided into three sub-shops:

- Machine shop
- Fabrication shop
- Millwright or overhaul shop

In the machine shop, main activities include the following:

1. Machining of pump casings, tube sheets, machining of gasket grooves, eccentric boring, line boring, facing, turning, etc.;
2. Machining square, rectangular, facing, drilling, key way cutting, etc.;
3. Turning, facing, different types of threading, shaft machining, casing boring, inside threading;
4. Balancing of fans, rotors and impellers.

In the fabrication shop, main activities include the following:

1. Pipe spool welding and inspection and pipe bending;
2. Structural fabrication;
3. Retubing or renewal of heat exchangers, repair of exchanger shells, tube sheet repairs, etc.;
4. Repair of machine components, rebuilding, etc.;
5. Plasma arc cutting;
6. Arc air gouging;
7. Various gas welding, brazing, etc.;
8. Limited sheet metal work;
9. Hard facing.

In the millwright shop, main activities include the following:

1. Repair and overhaul of all kinds of pumps, mixers, valves and other equipment;
2. Repair/testing/reconditioning of mechanical seals;
3. Repair/reconditioning and testing of various types of safety relief valves.
4. Hydro test of PV-equipment taking into account connection to suitable drain sized for maximum volumes of water to be discharged and the possibility of that demineralised water will have to be used for some materials

3.6 MAIN COMMON FACILITIES

Apart from the workshop equipment indicated in (4), each main workshop shall have the following facilities:

1. Two electrically operated overhead cranes with a capacity of 30 t each to serve both

the mechanical and electrical workshops. A separate pneumatically or electrically operated overhead crane with a capacity of 5 t may serve the welding area. Refer to DEP 34.17.00.32-Gen. for crane load design.

2. Relief valve testing shall be done in an enclosed area to be provided with pneumatic or electrically operated lifting facilities of which the runway beam shall be extended into the mechanical workshop.
3. Water and tool air shall be available as ring mains throughout the workshop building. Capacity and plug-in points shall be designed to cater for a full turnaround (TA) workload.
4. Steaming facilities.
5. Proper drainage systems sized to cater for peak loading (e.g., during turnarounds).
6. Social amenities.
7. Offices inside the workshop shall be restricted to direct supervisory personnel, and shall have the necessary documentation and data communication/computer terminals.
8. Extension of the documentation room shall include sufficient space for training. Additionally, consideration should be given to the interactive self-teaching type in particular.

3.7 ELECTRICAL WORKSHOP FACILITIES

3.7.1 General

The following recommendations for electrical workshops are normally applicable to a new process plant facility when located in an area where comparable overhaul/repair services may be unavailable from local industry.

Where supporting services are available from local industry, the workshop and the equipment installed may be reduced to meet the specific plant's outstanding needs in terms of day-to-day maintenance, shutdown activities and emergency repairs.

The electrical workshop is a facility dedicated to the maintenance, repair and testing of electric motors, switchgear, handheld electrical equipment, temporary lighting, high voltage and/or low voltage protection relays, etc. The electrical workshop usually forms part of a complex of facilities which include the workshops for the mechanical and instrumentation disciplines.

As indicated above, the maintenance tasks carried out in the electrical workshop are varied and require sufficient floor space and adequate access to the plant. The most space-consuming activity is the overhaul of electric motors, especially during a shutdown period when a number of motors may need to be overhauled at the same time. For reasons of access and safety, part of the facility should be dedicated to a motor laydown area (external) and a motor test bench (bay). The workshop will also require sufficient space for the storage of tools, site test equipment and frequently used spares.

3.7.2 Electrical workshop activities

The floor space for the electrical workshop should be at least 250 m², based upon the need to perform the following tasks, see (Appendix A) for example layouts:

- a) Inspection, maintenance and repair of low voltage motors and high voltage motors up to 1.0 MW (1400 HP)

NOTE: The rewinding of electric motors is normally carried out in a third-party repair facility.
- b) Test running of low voltage motors up to 185 kW (250 HP) at no-load (horizontal or vertical mounting).
- c) Inspection, maintenance and repair of electrical equipment, e.g., lighting fittings, distribution boards, small generators (up to 150 kVA) and temporary supplies equipment.

- d) Testing and repair of various types of protection relays (LV/HV).
- e) Training of electrical maintenance staff

Typical space requirements:

- a) Supervisor's office
- b) Main workspace
- c) Test room (clean workshop)
- d) Motor test bay (or test bench)
- e) Battery charging room or segregated area
Forced extract ventilation, floor / wall surfaces suitable for chemicals being handled and eyewash facilities may be required depending on battery types being serviced
- f) Store for consumables and test equipment (HVAC controlled)
- g) Equipment cleaning area (motors etc., external to the workshop)
- h) Equipment laydown area (external to workshop)

To facilitate the foregoing activities, the workshop should at least be provided with the permanent services listed below.

For details of the maintenance equipment to be installed in the workshop reference is made to (Appendix B) and (Appendix D).

Permanent Services:

NOTE: Alternative voltages, test sockets, and other provisions may be agreed upon locally where national standards do not follow IEC standards.

- a) Electric motor driven hoist, capacity 10 t, and rail mounted.
NOTE: May be not required, if area is also serviced by common workshop cranes.
- b) Equipment air (air driven tools) and potable water supply (Hot and Cold).
- c) Socket outlets for general use, rating 16 A, 2P + E, IEC 60309.
- d) Socket outlets for welding purposes, rating 63 A, 3P + E, IEC 60309.
- e) Socket outlets for test purposes meeting the following requirements:
 - 1) Rating 32 A, 3P + N + E, switched
 - 2) MCB and 30 mA residual current device, IEC 60309.
 - 3) Rating 63 A, 3P + N + E, switched
 - 4) MCB and 30 mA residual current device, IEC 60309.
- f) Power supplies with local isolation for fixed items of electrical equipment.
- g) Lighting installation to meet functional requirements of area.
- h) Main switchboard with sufficient capacity to serve the total workshop facility including the mechanical and instrument workshop when forming part of the total complex (refer to DEP 33.67.01.31-Gen. for switchgear requirements).
- i) Concrete surfaced laydown area, outside the workshop, for cleaning electric motors with steam or high-pressure water and instrument air outlets. The area shall be provided with a contaminated water drain connection.
- j) Fire fighting and first aid equipment.
- k) HVAC systems for the supervisor's office, staff offices, test room and workshop, depending on climatic conditions.

NOTE: A 30 mA residual current device shall protect each of the circuits for the general purpose outlets. Welding outlets will normally require higher earth leakage setting e.g., 100 mA due to inherently higher leakage currents that can be expected.

3.7.3 Test room

The test room facilities should be designed for testing protection relays, small general items of electrical and electronic equipment and transformer oil sampling. The test room shall have a floor area of at least 24 m² (250 ft²)

The room should be provided with workbenches and power supplies as generally described below. Example layouts are given in (Appendix A). For details of fixed electrical equipment refer to (Appendix B) and (Appendix D). For details of the electrical test equipment to be provided, refer to (Appendix E).

Test bench power supplies (wall mounted above each bench):

Eight general socket outlets, rating 16 A, 2P + E, 220-240 V (ac), IEC 60309;

Two socket outlets, rating 32 A, 3P + N + E, 380-415 V (ac), IEC 60309;

One socket outlet, rating 16 A, 2P + E, 42 V (ac), IEC 60309.

All power outlets, with the exception of the 42 V (ELV) (ac) outlet, shall be equipped with MCB and 30 mA residual current device protection.

The 42 V (ac) socket outlets shall be supplied via a dedicated isolation transformer.

NOTE: Alternative voltages, test sockets, and other provisions may be agreed upon locally where there are different national standards that must be followed.

Power supplies shall be provided with local isolation switches for fixed items of electrical test equipment.

Cabinets shall be provided for the storage of test equipment, test data and records.

3.7.4 Motor test bay

The motor test bay is a segregated area of the electrical workshop with facilities specifically designed for the safe testing of electric motors and shall have a minimum floor area of at least 18m².

The motor test bay shall be fenced off from the remaining workshop area with the control and monitoring panel located outside the fence within visual range (Appendix A, A3).

The general requirements for the motor testing facilities are listed below. For detailed requirements for the switchboard and socket outlets, refer to (Appendix L):

- Steel mesh fence with sliding gate access.
- Steel bedplate (fixings for clamps and bolts for vertical and horizontal motors).
- Socket outlets (3) 3 P.E. for connection of motor under test.
- Motor test control switchboard in accordance with DEP 33.67.01.31-Gen.
- Warning lamp (flashing during testing).
- Emergency stop push button, mounted inside motor test bay and one stop push button mounted at the control panel.
- Common earthing busbar (wall-mounted inside test bay).

3.7.5 Earthing requirements

The workshops shall be provided with a common earthing ring with a cross-sectional area of at least 70 mm² (2/0 AWG). Additional specific earthing requirements for the electrical workshops are:

- All metallic fixed items of electrical equipment, including test benches, shall be earthed to the common earthing ring via a protective conductor with a cross-sectional area of at least 16 mm². (4 AWG)

- An earthing busbar shall be installed inside the test bay and shall be connected to the common earth ring via two separate protective conductors, each with a cross-sectional area of at least 25 mm². (2 AWG)
- All items of electrical equipment including the motor bedplate and the surrounding fence shall be earthed to the earthing busbar via protective conductors, each with a cross-sectional area of at least 16 mm². (4 AWG)
- All earthing connections shall be physically protected and the terminations shall be visible to facilitate inspection.

For details of typical earthing arrangements, refer to the standard drawings S 68.003 and S 68.004 listed in (5).

3.7.6 Lighting installation

Fluorescent lighting fittings are normally used for general lighting. However, in the main workshop and exterior areas, high-pressure sodium fittings supplemented with fluorescent fittings, where appropriate, may be selected. Attention shall be given to the resultant overall colour temperature of lighting system and its suitability for extended working under such light. Possible stroboscopic effects between fluorescent lighting and rotating machines such as lathes or milling machines can be addressed through use of local incandescent or LED lights.

In addition to the general lighting, local lighting may be required for workbenches and machines where more detailed work is performed. In these situations, wall mounted adjustable fittings should be used. The power supply circuit to these local, adjustable fittings shall be protected by a 30 mA residual current device.

A proportion (typically 25 %) of the normal lighting shall be connected to the emergency lighting system and, where applicable, supplemented with escape lighting at exit doors.

Where local national regulations prescribe more onerous emergency or escape lighting schemes then the local national requirements shall be followed.

3.7.6.1 Illuminance levels

The illuminance levels, measured at the working plane of 1 m (3.3 ft) above the floor level in a horizontal plane, should be at least as follows:

Area	Illuminance (lux)	
	Normal	Emergency
Workshop:		
General	250	5
Battery charging area	250	-
Motor test bay	250	-
Store room	150	-
Work benches	400	-
Office	400	-
Test room:		
General	250	5
Test benches	400	-

4. WORKSHOP EQUIPMENT AND TOOLS

4.1 MAINTENANCE EQUIPMENT AND TOOLS

Prior to any procurement of machinery, equipment or tools, the expected utilisation should be considered in relation to local Contractor services and outsourcing possibilities as determined in the strategies and policies, see (2).

In selecting type and size of equipment or tools, factors such as quality, cost and service /spare parts availability at the location shall be considered.

Although this DEP sectionalises the maintenance equipment and tools into workshop and field, the actual split shall be decided at each location. Several equipment items and tools may be employed both in the field and in the workshop. In many cases, for centralisation purposes, storage and custody may be better administered by a central workshop tool store.

A system shall be designed to control integrity (with regular maintenance and checks), calibration and certification of all maintenance tools and equipment. Training of the Principal's staff or outsourcing to Specialised Contractors to execute these tasks shall be dependent on logistics and local availability of skills and expertise.

Based on practical experience gained in several production facilities, a selection of types and sizes of workshop equipment is proposed to cover a normal range of maintenance work. Some of these lists of tools and equipment are shown as examples in (Appendix B).

4.2 WORKSHOP MACHINES

Workshop machinery should be inspected by a specialised inspection agency at the Manufacturer's workshop and after installation.

NOTE: Some of these agencies also provide services in the evaluation of quotations when a company specialist is not available.

The suggested selection of lathes is based on the experience that the majority of the machine work can be accommodated by a lathe with a centre distance of 500 mm (20"). A second lathe with a centre distance of approximately 1000 mm (39") could be selected to accommodate the maximum diameter expected. To accept impellers that are complete with long shafts and allow the impeller to swing over the bed, a very large lathe of heavy construction would be required. Although, for accuracy reasons, as many surfaces as possible should be machined during one clamping operation. A lathe with considerably smaller centre distance may be employed if the work piece is turned around in the lathe after machining on one side has been completed.

Computer operated numeric control lathes or milling machines should be considered, as these enhancements are of only marginal incremental cost (10 %). However, the point to consider is whether operators are familiar with or can be trained in using the new machine.

A balancing machine should be acquired, but the actual size of the machine to be installed depends on the size and equipment envisaged to be balanced. The balancing of high-speed rotors and/or large compressors and turbines should normally be left to an outside agency or, if required, the Manufacturer.

All machinery should be delivered with a set of commissioning spares and six sets of complete instruction manuals, spare parts documents, wiring diagrams, hydraulic system schemes, etc., to enable trouble-shooting on-site.

The list of suggested workshop machines is provided in (4.4) and specifications are given in (Appendix B).

4.3 WELDING EQUIPMENT

For welding activities and handling of cylinders, reference shall be made to "Recommendations for Safety in Welding and Cutting", published by the Shell HSSE Committee.

4.4 LIST OF WORKSHOP EQUIPMENT SUGGESTED FOR A MEDIUM SIZE SITE

For examples of a description of the equipment, see (Appendix B).

- | | |
|---------|--|
| Item 1 | Lathe, universal, centre distance approximately 500 mm (20") |
| Item 2 | Lathe, universal, centre distance approximately 1000 mm (39") |
| Item 3 | Lathe, heavy-duty, centre distance approximately 2000 mm but less than 3000 mm (10 ft) |
| Item 4 | Milling machine, universal, horizontal, table size 1000 mm x 250 mm (39" x 10") |
| | Milling machine, universal, table size 1000 mm x 300 mm (39" x 12") |
| Item 5 | Milling machine, universal, table size 350 mm x 250 mm (12" by 10") |
| Item 6 | Shaping machine, medium-duty, nominal stroke 450 mm (18") |
| Item 7 | Slotting machine, stroke approximately 160 mm (6") |
| Item 8 | Radial drilling machine, 40 mm and 75 mm (1 ¾ ") |
| Item 9 | Drilling machine, pedestal type, 32 mm (2 pcs) (1 ½ ") |
| Item 10 | Drilling machine, bench type, 13 mm (2 pcs) (1/2") |
| Item 11 | Balancing machine (optional) |
| Item 12 | Horizontal and vertical Boring machines (optional) |
| Item 13 | Lapping machine |
| Item 14 | Test bench for safety and relief valves |
| Item 15 | Hydraulic press, 100 t |
| Item 16 | Surface table, 1800 mm x 1200 mm, complete with accessories |
| Item 17 | Thread cutting machine (2 types) |
| Item 18 | Metal cleaning cabinet |
| Item 19 | Cleaning table (optional) |
| Item 20 | Grit blasting cabinet (optional) |
| Item 21 | Hot air oven |
| Item 22 | Induction heating apparatus |
| Item 23 | Hack-sawing machine |
| Item 24 | Band-sawing machine, medium-duty (vertical and horizontal) |
| Item 25 | Pipe-bender, hydraulic, hand-operated or electric |
| Item 26 | Plate-bending machine |
| Item 27 | Plate-shearing machine |
| Item 28 | Surface and cylindrical grinding machines, bench type, wheels 150 mm (6 in)diameter |
| Item 29 | Surface and cylindrical grinding machines, pedestal type, wheels 200 mm or 300 mm diameter (8 in to 12 in) |
| Item 30 | Gasket cutter |
| Item 31 | Hydraulic test pump (2 pcs) |
| Item 32 | 3 transformers or rectifiers for stick welding and Tungsten Inert Gas (TIG) welding |

Item 33	Rectifier with constant potential for gas metal arc welding
Item 34	Mobile diesel-powered AC/DC welding generator
Item 35	Electrode cabinet (2 pcs)
Item 36	Cylinder manifold for oxygen and gas
Item 37	Plasma cutting machine (optional)
Item 38	Fuel gas welding and cutting set
Item 39	Pipe cutting and bevelling machine
Item 40	Plate cutting machine, mobile (optional)
Item 41	Fume extraction unit, mobile (optional)
Item 42	Preheat and post-weld heat treatment equipment (optional)
Item 43	Work benches
Item 44	Tool cabinets
Item 45	Bench vice
Item 46	Pipe vice
Item 47	Branch drilling machine (e.g., for "hot tapping")
Item 48	High-pressure cleaning equipment
Item 49	Oxygen/acetylene carriage Gas bottle caddy
Item 50	Pipe cutter and beveller, portable
Item 51	Air compressor
Item 52	Sump pump
Item 53	Rotary grinder for valves
Item 54	Heat exchanger tube end puller
Item 55	Tube expanding equipment
Item 56	Portable in-situ flange facing machine (internally and externally mounted)
Item 57	Portable in-situ milling machine
Item 58	Tool, drill and cutter grinding machines
Item 59	Profile cutting machine (for fabrication works)
Item 60	Plate rolling machine Bolt-tensioning equipment

4.5 TOOLS AND EQUIPMENT FOR ELECTRICAL MAINTENANCE

4.5.1 General

A listing of typical requirements for tools intended for general maintenance and testing of plant electrical equipment is included in (Appendix E) and (Appendix F).

In addition, there will normally be a requirement for special tools and test apparatus designed for the maintenance of specific items of electrical equipment, e.g., a tool set for switchgear maintenance. These tools and instruments should be included in the order for the particular equipment.

NOTE: For HV substations, there will be a requirement for items of test equipment, e.g., voltage test sticks and phasing sticks.

4.5.2 Personal tools and instruments

In general, the technician requires a set of personal tools and basic test instruments to assist in day-to-day maintenance activities. A listing of typical requirements is included in (Appendix G).

4.6 TRAINING AND COMPETENCY DEVELOPMENT

For all tools, the competencies and training requirements for personnel using these tools shall be considered and aligned with the expected level of competency of available personnel.

The identified competency levels of future personnel using the tools and equipment may influence the choice of complexity of the tools and equipment.

Where required, training material shall be developed or requested from the Supplier to train users in the correct use of tools and equipment. A generic training matrix shall be designed to determine the required and available competence per technician in using the required tools and equipment.

5. FIELD TOOLS AND EQUIPMENT

The requirements for field tools and equipment differ even more than for workshops. The type, sizes, and quantities needed at each location should be determined by the (future) maintenance staff at each location.

A suggested list of field tools and equipment is given in (Appendix C).

5.1 PORTABLE ELECTRICAL EQUIPMENT

5.1.1 General

The listing of typical portable and transportable electrical equipment is included in (Appendix E) and (Appendix F).

Equipment, tools and power supply cables shall be subject to inspection and test at a frequency based on the recommendations of the Manufacturer and local conditions of usage.

A registration system shall be implemented to control the inspection and test work.

Damaged equipment or cables shall not be used until permanent repair or replacement has been effected.

The storage, issue and maintenance of the portable and transportable electrical equipment should be the responsibility of the electrical workshop supervisor.

5.1.2 Welding apparatus

For electric arc welding requirements, reference shall be made to IEC 60974 and the Shell Safety Committee Publication *Welding and Cutting*.

Preference shall be given to direct-current welding equipment.

If alternating-current welding equipment is used, the open circuit voltage between the electrode holder and the work piece shall be limited to 50 V maximum. If a separate voltage-limiting device (relay) is used it shall be housed in an enclosure which requires the use of a tool to gain access. Alternatively, alternating-current welding equipment which is switched automatically to a direct-current output voltage when operating on open circuit is acceptable.

5.1.3 Diesel/gasoline driven generator sets (transportable)

5.1.3.1 General applications

Transportable generators may be used to supply power to locations where there is no local mains power supply, e.g., tank farms. Unit ratings will normally be in the range of 2.5 kVA to 5 kVA.

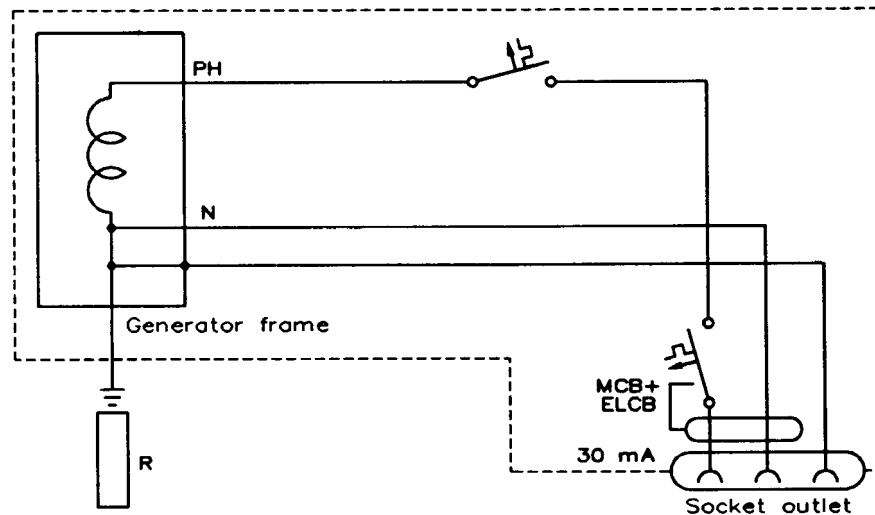
When generators are used in areas where there are no earthing facilities, the generator shall be equipped with an insulation-monitoring relay. This relay shall be arranged to disconnect the output power in the event of insulation failure of the connected equipment. Refer to Figure 1b.

Where local earthing facilities are available, e.g., plant-earthing electrode pits, then the neutral point of the generator shall be connected to the electrode via a flexible protective conductor and bolted connection. This is the preferred solution.

The output of the generator shall be provided with a circuit breaker providing overcurrent and overload protection together with a 30 mA residual current device (see Figure 1a).

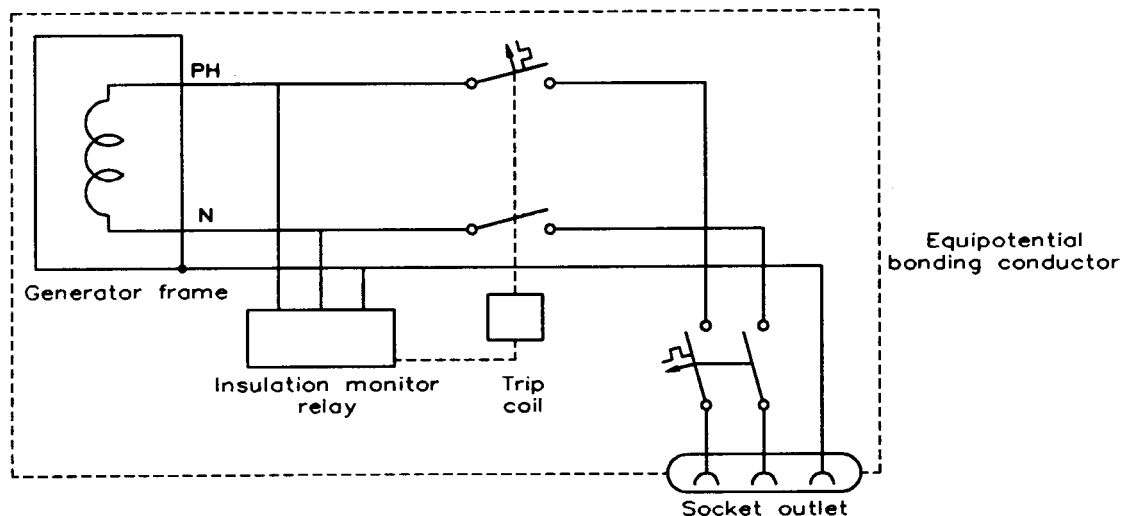
NOTE: This protection will only function when generator neutral output is earthed correctly.

All generators should be labelled with information as to type of protection fitted and if an earth connection is required.



- NOTES:
1. R = the earth electrode resistance = U/I ohm (100 ohm maximum)
where U = safe to touch voltage
 I = nominal trip current of residual current device (RCD).
 2. The cable between the generator and the outgoing circuit shall be protected against mechanical damage since it is not protected by the residual current device (RCD).

a) Earthed systems (TN-S)



- NOTES:
1. The generator and distribution circuit shall be connected as indicated.
 2. An insulation-monitoring relay shall be installed which shall automatically disconnect all phases of the generator output if the insulation breaks down.
 3. Overcurrent and short circuit protection for the generator shall be located as close as possible to the generator.
 4. The phase(s) and neutral of the outgoing circuit shall be disconnected by the protective devices.

b) Unearthed systems (IT)

Figure 1 Mobile generators in temporary installations

5.1.3.2 Welding generators

Transportable welding generators are often provided with an auxiliary single phase winding supplying a 110 V or 220/230 V socket outlet for the use of hand held tools, e.g., grinders. These generators are constructed with the auxiliary winding insulated from the main winding and the frame. As these generators are not normally intended to be earthed and are not normally equipped with an insulation monitoring relay, the connection arrangement for the auxiliary socket outlet indicated in Figure 2 will provide an acceptable safe system.

Only Class 2 hand tools to IEC 60745 shall be used in association with welding generator auxiliary supplies and only one tool per socket i.e., splitter or spider boxes are not permitted. However, extension leads may be joined to allow supply to reach worksite.

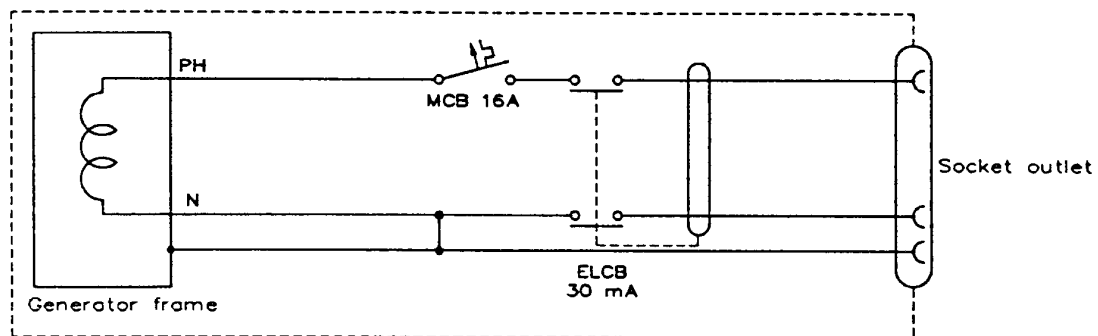


Figure 2 Welding generator - auxiliary power supply socket