MANUAL

EQUIPMENT AND TOOLS FOR MAINTENANCE: Mechanical Maintenance Equipment, Tools and Bolt Tensioning

DEP 70.08.10.11-Gen.

December 1998

DESIGN AND ENGINEERING PRACTICE

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The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 GENERAL

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 and existing oil refineries, chemical and gas plants.

This is a revision of the DEP of the same number dated April 1990*; a summary of the main changes is given in (1.5).*

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP/SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors nominated by them (i.e. the distribution code is "C", as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants and gas plants.

If national and/or local regulations exist in which some of the requirements may 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 as regards 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 with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

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

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

The Principal is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. 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 revision has been mainly editorial, the main change being the removal of references to MESC numbers since many were obsolete and were considered unnecessary.

2. GENERAL

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

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 and industrial environment around the site.

In selecting the numbers and types of machines, equipment and tools to be purchased, available specialized contracting services in the vicinity of the site shall be considered, so that expected utilization is at a high level.

The Contractor shall develop a tool and equipment inventory and a workshop layout based on the requirements of the Principal, using this DEP for guidance only. The proposal shall then be presented to the Principal for approval.

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. Mobile diesel engine driven units shall have flame arrestors.

3. WORKSHOP AND SERVICE CENTRES

3.1 GENERAL

If supporting services cannot be obtained locally, then each location should establish a workshop to deal with emergency repair, day-to-day maintenance and shutdown work. Irrespective of the ownership of the facility it is essential to establish that the necessary facilities for the expected workload are available.

For each location, a fit-for-purpose, well-designed and properly located workshop fulfils an important function for the maintenance organization. In many environments a number of maintenance activities are carried out more efficiently and safely in the workshop than in the field.

3.2 CENTRALIZATION

The Principal shall decide what maintenance facilities should be available centrally or locally. The following guidelines are given to assist in this decision.

Generally, centralization of the engineering maintenance disciplines together in the main workshop provides for better utilization 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 combined with it under one roof. Inspection, rotating equipment and other advisory services should be in fairly close proximity. Access to the workshop from outside the plant, particularly for delivering materials, should be considered.

3.4 SIZE AND LAYOUT

For medium-sized locations, a suggested size and layout of a centralized workshop complex with adjoining material warehouse is shown in Appendix 1, for guidance only.

In considering the size and layout of a workshop, the following points should be considered:

- the volume and nature of the maintenance work to be done at the workshop;
- easy movement of equipment into and out of the workshop;
- clear identification of IN and OUT bays;
- easy movement of equipment during repairs, e.g. movement between the machine shop and welding area;
- separation of the noise-making and "dirtier" activities from the others, e.g. pipe/plate handling, welding;
- accessibility to documentation. Drawings, spare parts and historical data, either in electronic and/or hard copy form, should be easily available;
- offices should be located to allow close supervision.

3.5 MAIN 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 rotors.

In the fabrication shop, main activities include the following:

1) pipeline welding and inspection;
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.

3.6 MAIN FACILITIES

Apart from the workshop equipment suggested in later sections, each main workshop should have the following facilities:

- two electrically operated overhead cranes with a capacity of 10 t each should be provided for the mechanical and electrical workshops. A separate pneumatically or electrically operated overhead crane with a capacity of 5 t can serve the welding area. Refer to DEP 34.17.00.32-Gen. for crane load design.
- 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;
- water and tool air shall be available as ring mains throughout the workshop building;
- steaming facilities to be provided;
- proper drainage systems to be included;
- social amenities shall be included;
- offices inside the workshop shall be restricted to direct supervisory personnel, and the necessary documentation and data communication/computer terminals;
- extension of the documentation room to include sufficient space for training, particularly of the interactive self-teaching type, should be considered.

3.7 MAINTENANCE EQUIPMENT AND TOOLS

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.

Before any machinery, equipment or tools are procured, their expected utilization should be considered in relation to local contractor services and outsourcing possibilities. Because of changing technology, an occasional review of the type, number and sizes of installed equipment, as well as available specialized services, should be made.

After the type and size of equipment or tool has been selected, only the best available for the purpose, in terms of quality and cost, shall be purchased. Service and spare parts availability in the location shall also be investigated.

Though this DEP sectionalizes the maintenance equipment and tools into workshop and field, it is to be recognized that the actual split has to be decided at each location. Several equipment items and tools can be employed both in the field and in the workshop. In many cases, for centralization purposes, storage and custody can be better administered by a central workshop toolstore.

4. WORKSHOP EQUIPMENT AND TOOLS

4.1 WORKSHOP MACHINES

Workshop machinery should be inspected by a specialized inspection agency at the Manufacturer's works and after installation. (Some of these agencies also provide services in the field of 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. A second lathe with a centre distance of approximately 1 000 mm could be selected to accommodate the maximum diameter expected. To accept impellers complete with long shafts and allow the impeller to swing over the bed, a very large lathe of heavy construction would be required. Although it is appreciated that, for accuracy reasons, it is preferred to have as many surfaces as possible machined during one clamping operation, a lathe with considerably smaller centre distance may be employed if the workpiece is turned around in the lathe after machining from 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 percent). However, the point to consider is whether operators are familiar with or can be trained in using the new machine.

A balancing machine has been advised, but the actual size of the machine to be installed depends on the size and equipment envisaged to be balanced. It is normally expected that the balancing of high-speed rotors and/or large compressors and turbines is left to an outside agency or, if required, the Manufacturer.

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

The list of suggested workshop machines is given in (4.3) and specifications are given in Appendix 2.

4.2 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 HSE Committee.

4.3 LIST OF WORKSHOP EQUIPMENT SUGGESTED FOR A MEDIUM SIZE SITE

(For a description of the equipment see Appendix 2)

Item 1	Lathe, universal, centre distance approximately 500 mm
Item 2	Lathe, universal, centre distance approximately 1 000 mm
Item 3	Lathe, universal, centre distance approximately 3 000 mm
Item 4	Milling machine, universal, horizontal, table size 1 000 mm x 250 mm
Item 5	Milling machine, universal, table size 350 mm x 250 mm
Item 6	Shaping machine, medium-duty, nominal stroke 450 mm
Item 7	Slotting machine, stroke approximately 125 mm
Item 8	Radial drilling machine, 40 mm
Item 9	Drilling machine, pedestal type, 32 mm (2 pcs)
Item 10	Drilling machine, bench type, 13 mm (2 pcs)
Item 11	Balancing machine (optional)
Item 12	Boring machine (optional)
Item 13	Lapping machine for mechanical seal rings
Item 14	Test bench for safety and relief valves
Item 15	Hydraulic press, 100 t

Item 16 Surface table, 1 800 mm x 1 200 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
Item 25 Pipe-bender, hydraulic, hand-operated or electric
Item 26 Plate-bending machine (optional)
Item 27 Plate-shearing machine (optional)
Item 28 Grinding machine, bench type, wheels 150 mm dia.
Item 29 Grinding machine, pedestal type, wheels 200 mm or 300 mm dia.
Item 30 Gasket cutter
Item 31 Hydraulic test pump (2 pcs)
Item 32 3 transformers or rectifiers for stick welding and 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 ("hot tapping")
Item 48 High-pressure cleaning equipment
Item 49 Oxygen/acetylene carriage
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 Bolt-tensioning equipment (optional); see Appendix 4

5. FIELD TOOLS AND EQUIPMENT

5.1 GENERAL

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 maintenance staff at each location.

A suggested list of field tools and equipment has been given in Appendix 3.

6. MOBILE AND HEAVY MAINTENANCE EQUIPMENT

6.1 GENERAL

Before selecting mobile and heavy equipment for the maintenance department, a preliminary evaluation of locally available contractor services shall be undertaken. Because of the high initial costs involved, it is important that such items of equipment are, or are expected to be, effectively utilized.

The mechanical maintenance department should be able to arrange for the equipment mentioned in (6.2) be available at short notice. The number and range of equipment will be dependent on the size and expected need of the individual location, and also on accessibility, routine or plant shutdown conditions.

6.2 LIST OF HEAVY AND/OR MOBILE EQUIPMENT

6.2.1 Mobile crane, diesel-driven, truck-mounted on rubber tyres

Telescopic boom, length 40 m
Lifting capacity 40 t - 50 t, preferably hydraulic
Hydraulic outriggers

6.2.2 Truck crane with hydraulic telescopic boom

Lifting capacity 15 t - 20 t
Boom length 5.6 m - 12.6 m
Optional attachment: Work platform to accommodate 2 men/200 kg

6.2.3 Mobile crane, hydraulic, mounted on wheeled carrier and rear castors

Three-position telescopic jib
Lifting capacity approximately 2 t
Height of hook approximately 2.5 m

6.2.4 Fork lift truck, diesel-driven

Lifting capacity 3 t
Lifting height 3 m

6.2.5 Truck, 5 t with front winch

6.2.6 Truck, with hydraulic "elephant" arm

6.2.7 Trailer, 4-wheeled

Length approximately 8 m
Capacity 10 t or sufficient to carry heaviest tube bundle

6.2.8 This item only to be considered when contractor services are not available.

Mobile crane, diesel-driven, truck-mounted on rubber tyres or caterpillar tracks, with capacity and boom length sufficient to reach the highest point and to lift the heaviest part of equipment that may have to be removed for maintenance.

6.2.9 Heat Exchanger Bundle Puller (optional)

An hydraulic device for pulling bundles out of their shells onto a cradle. Bundle pullers can be a self-propelled type, for low level exchangers, or be lifted by heavy lift crane for high level exchangers. The bundle puller is particularly useful in cramped sites.

6.2.10 "Manlift"

A mobile mechanized and self-elevating platform for reducing scaffolding requirements. The self-elevating platform has a reach of about 10 metres, and can be mounted on a van. The

platform can lift at least 2 men, and can be used for an on-stream pipe thickness or insulation inspection.

6.2.11 Catalyst Vibrator

Transportable, skid mounted, capable of 4 to 5 separations.

6.2.12 Vacuum Truck (optional)

7. REFERENCES

In this DEP, reference is made to the following publications.

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

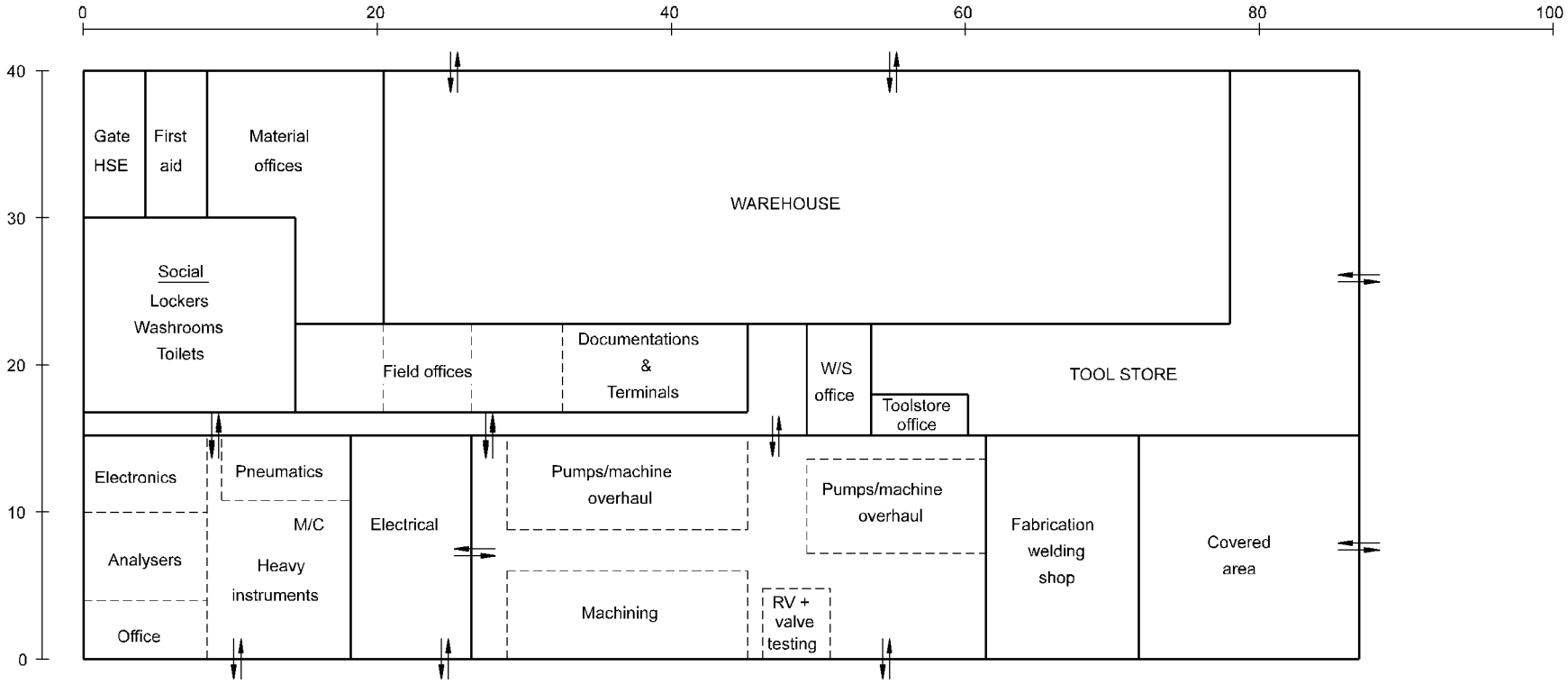
Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Noise control	DEP 31.10.00.31-Gen.
Piping - general requirements	DEP 31.38.01.11-Gen.
Hot-tapping on pipelines, piping and equipment	DEP 31.38.60.10-Gen.
Electric motors - Cage-induction and synchronous type	DEP 33.66.05.31-Gen.
Minimum requirements for design and engineering of buildings	DEP 34.17.00.32-Gen.
Cleaning of equipment	DEP 70.10.80.11-Gen.
Recommendations for safety in welding and cutting	Shell HSE publication

BRITISH STANDARDS

Bolting for flanges and pressure containing purposes	BS 4882

Issued by
British Standards Institution,
389 Chiswick High Road,
London W4 4AL,
England

APPENDIX 1 TYPICAL LAYOUT OF MAINTENANCE WORKSHOP



Dimensions are in m.

APPENDIX 2 DESCRIPTION OF WORKSHOP ITEMS

Item 1 Universal centre lathe - light-duty

Distance between centres approximately 500 mm. Horsepower rating should be sufficient to allow cutting at high speed and feed rates, with carbide-tipped tools or throw-away inserts. The bed guide ways shall be hardened and precision-ground. Scales and rules shall be supplied with SI graduations except when Imperial graduations are specifically required. Accuracy shall be in accordance with BS or equivalent specifications.

Drive: Electric

The following technical data should be supplied by the Manufacturer for bid evaluation by the client:

centre height
swing over bed and saddle
swing in gap (diameter x width)
spindle: bore and type of nose
tail-stock spindle diameter
motor kW
spindle speeds, number and range
feeds: cross and longitudinal, number and range
threads
floor space required
mass

Accessories should included:

face plate
4-jaw independent chuck
3-jaw self-centering chuck
steady rest
follow rest
thread cutting indicator (metric, module, DP)
4-way tool post
lamp, low voltage
cooling system
rotating centre for tail-stock
a set of centres and sleeves; fixed
a set of spanners and keys
taper turning attachment

a set of standard accessories and tools

Item 2 Universal centre lathe - medium-duty

Distance between centres approximately 1 000 mm. A gapped bed may be acceptable. Hollow shaft drive required.

Other details as for Item 1.

Item 3 Universal centre lathe - heavy-duty

Distance between centres preferably not more than 3 000 mm. A gapped bed is acceptable. Hollow shaft drive required.

Dimensions should be related to the sizes of refinery equipment installed. The lathe may have to accept complete impeller and shaft assemblies for work to be done on the shaft or the impeller face, (see 4.1 for selection of lathes.)

Other details as for Item 1.

Item 4 Universal milling machine, horizontal type

Table size approximately 1 000 mm long x 250 mm wide. The maximum angle of table swivel should be between 30° and 45°. The milling head should be suitable for milling horizontally, vertically and at any angle in between, possibly with separate attachment.

Drive: Electric

The following technical data should be supplied by the Manufacturer for bid evaluation by the client:

spindle speeds, number and range
maximum distances: centre spindle to table top and
centre spindle to bottom overarm
table traverse: longitudinal, cross and vertical
maximum angle of swivel
number and range of feeds: longitudinal, cross and vertical
motor kW, for spindle, feed and cooling pump drives
floor space required
mass

Accessories should include:

a set of milling arbors, complete for cylindrical cutters

a set of milling arbors, complete for face cutters
a set of adapters, complete for cutters with cylindrical and morse-tapered shanks
vertical milling attachment
slotting attachment
universal dividing head, suitable for automatic drive with tail-stock
self-centering 3-jaw chuck for dividing head and table machine vice
a set of spanners
lamp, low voltage
cooling system
a set of standard accessories and tools

Item 5 Universal milling machine

Table size approximately 350 mm long x 250 mm wide. Suitable for milling horizontally, vertically and at any angle in between. Manual feed of table in all directions,

Drive: Electric

Other details as for Item 4.

Item 6 Shaping machine, medium-duty

Nominal stroke approximately 450 mm.

The table; made in one piece shall be accurately machined on all sides and be provided with T-slots on top and side faces and have manual and automatic feed both in the transverse and vertical direction.

Drive: Electric

The following technical data should be supplied by the Manufacturer for bid evaluation by the client:

ram: maximum stroke and number and range of speeds
table: dimensions of the top surface
traverse - longitudinal and vertical
cross feed range per cut
distance, table to ram
T-slots: number and width
tool head: down feed
max. tool section
vice: open width of jaws
motor kW

floor space required
mass

Accessories should include:

swivel base machine vice, with graduations
adjustable angle plate
lamp, low voltage
a set of standard accessories and tools

Item 7 Slotting machine for cutting key-ways

Stroke approximately 125 mm. Swivel table with graduations - 1 500 mm. Provision for slotting under an angle of 10° Longitudinal and cross traverse of table approximately 100 mm.

Drive : Electric

Item 8 Radial drilling machine

Maximum drilling capacity in steel, approximately 40 mm diameter.
Maximum radius of spindle from centre of column approximately 1 200 mm.

Spindle travel between 150 mm and 250 mm. Attachment for automatic feeds.

Drive: Electric

The following technical data should be supplied by the Manufacturer for bid evaluation by the client:

drilling radius
distance, spindle to base plate
base plate working surface: suitability for floor pit construction
vertical movement of arm
spindle speeds and feed
taper in spindle: e.g. morse
arm rotation
motor kW for arm rotation
spindle
arm-raising
coolant pump
floor space required

Accessories should include:

box table
drill chuck and arbor
sleeves e.g. morse taper
machine vice
tool extractor
lamp, low voltage
cooling system
a set of standard accessories and tools

Item 9 Drilling machine, pedestal type (2 pcs)

Maximum drilling capacity in steel 32 mm diameter. Hand-feed and power-feed.

Drive: Electric

The following technical data should be supplied by the Manufacturer for bid evaluation by the client:

spindle travel
spindle nose to table
drilling speeds in r/min
power feeds in mm/r.
maximum drilling depth
distance centre spindle to pillar
table dimensions, T slot arrangement
maximum vertical adjustment of table

Accessories should include:

drill chuck and arbor
plain vice
cooling system
lamp, low voltage
a set of morse taper sleeves

Item 10 Drilling machine, bench type (2 pcs)

Drilling capacity in steel: 13 mm diameter. Hand-feed only.

The following technical data should be supplied by the Manufacturer for bid evaluation by the client:

maximum traverse of spindle
spindle speeds
centre distance spindle to pillar
distance from spindle to table
surface of the table

Accessories should include:

chuck and arbor
machine vice
lamp, low voltage

Item 11 Balancing machine

High speed balancing is best carried out at Manufacturer's shop, or by an outside agency. However, a suitable machine for balancing low speed rotors of widely varying designs, sizes and masses should be considered.

A combination of belt and head stock drive is recommended.

Selection of size depends on size of rotors envisaged to be balanced, whereby rotor mass, diameter and length are determining factors.

It is recommended that the vendor's training course is included in the scope of order, so that selected Workshop and Field staff can be familiarized with the use of the machine. In addition, the machine maintenance course may be considered for the appropriate instrument technicians (at remote locations).

Item 12 Boring machine (optional)

For locations where no appropriate contractors are locally available, the purchase of a boring machine may be considered.

Item 13 Lapping machine

Suitable for lapping mechanical seal rings and valve seats, etc. of all types of materials.

With a gearbox and a large-diameter bearing to give adequate support to the lap plate.

Specification:

cast iron lapping plate, diameter 610 mm
variable speed
water-cooled lapping plate

Accessories:

one serrated cast iron lap plate,
three conditioning rings with roller yokes,
abrasive tank and pump,
splash guards,
three blank work holders, felt pads and hand pressure weights,
monochromatic light in self-contained carrying case,
set of optical flats of fused quartz,
polishing plate, 304 mm diameter,
lapping abrasives, initial supply
lapping cycle timer,
operating and maintenance instructions.

Lapping machines can also be supplied with pneumatic pressure equipment instead of hand weights.

Drive: Electric

Item 14 Test bench for safety and relief valves

1. The main use of the test stand is for setting the popping pressure of safety and relief valves.

   The stand must have two to four test stations. Hydraulic clamping facilities on all but one station are preferred for ease of handling, but suitable flanged nozzles are acceptable. On the largest station, a replaceable pipe spool may be used, for large flange sizes/ratings.

   In some cases stands may be fitted with tanks to provide sufficient capacity so that popping can take place without causing damage to the seat (due to slamming shut), especially applicable to larger orifice valves. If nitrogen is used as the test medium, ensure adequate ventilation is provided.

2. Test bench for pressure and vacuum valves

   This test bench is required for testing pressure and vacuum valves used on storage tanks, to pressures up to +200 mm water and vacuum up to -50 mm water. The bench may have one to four stations. Manual clamping, with replaceable pipe spools to accommodate flange variations, is acceptable.

   A low pressure controlled air supply, a vacuum pump, and a U-tube water manometer are required.

A range of calibrated gauges shall be available and selected according to the seat pressure of the valve to be tested. Ideally the gauge should be chosen so that the test pressure is approximately in the mid-range of the gauge.

3. Alternatively, as conventional pressure gauges on test stands often fail due to load variations, the use of digital precision pressure indicators can be considered. A measuring cell with an optical sensor provides pressure-related signals to a microprocessor-controlled circuit, producing linearized, stable data for transmission and display.

Item 15 Hydraulic press

Vertical all-steel construction, with a vertically adjustable work table, hand-operated 2-stage pump.

distance between uprights	- max.	900 mm
stroke of main ram	- approx.	200 mm
capacity	-	100 t

Work table to have central hole min. 80 mm dia and T slots.

Item 16 Surface table

Surface table for marking out, accuracy of surface within 0.125 mm per metre.

Dimensions approximately 1 800 mm x 1 200 mm

Requirements:

Heavy-duty steel stand with levelling screws to prevent round material from rolling off. Supplied with protective covers.

Accessories:

1. 2 surface plates, very close-grained cast iron, scraped and stiffly ribbed for strength and accuracy.

   Dimensions: one piece - 300 mm x 300 mm
   one piece - 600 mm x 600 mm

   Protective covers to be included.

2. 4 V-blocks, cast iron, machined on all outer surfaces, accurately finished in pairs.

Angle of Vees - 90°

Dimensions: 2 V-blocks, width across top of V-50mm
2 V-blocks, width across top of V-150mm

3. 2 angle plates, non-adjustable.
Tough, close-grained cast iron, machined all over, accuracy within 0.125 mm per metre.

For squareness of external faces set at 90°.

Dimensions: 250 mm x 150 mm x 150 mm.

Item 17 Thread cutting machine

1. Capacity for line pipe - ¼" - 2" NPT/BSPT
Capacity for bolts - ½" - 2" UNC or metric

Rotary die head, tangential dies.

Drive: Electric

The Manufacturer should supply information on the number of speeds and spindle speeds.

2. A mobile machine for external thread cutting may also be appropriate.

Item 18 Metal cleaning cabinet

Suitable for pumps, gearboxes or other machine parts.

Typical data:

useful inner turning cycle -	1 450 mm diameter
useful height-	685 mm
doorframe-	1 100 mm x 830 mm
admissible grid load -	800 kg
outer dimensions -	1 890 mm long x 1 630 mm wide x 1 670 mm high
mass -	800 kg
voltage -	380 V

Filter installation:

liquid contents-	450 litres
capacity of pump motor -	5.6 kW
jet pressure -	4 bar
circulation -	18 m^3/h
electric heating - (separate cable)	2 kW

The objects to be cleaned are placed in a rotating basket. An alkaline cleaner, concentration 1-2%, is jet-sprayed at a temperature of 80 °C and a pressure of 4 bar from all sides on the rotating material.

Time required for cleaning: 10-15 min.

Item 19 Cleaning table (optional)

Suitable for purification of machine elements or other components, provides continuous filtration of the cleaning liquid.

Item 20 Grit-blasting cabinet (optional)

The required roughness of the surface to be treated is achieved by the choice of the shot-blasting medium and by the accurate regulation of the shot-blasting pressure.

Good results have been obtained using glass beads as a blasting medium. They create a mat finish and improve the appearance. It also provides good adhesion for coatings and can be applied to all types of materials.

Item 21 Hot air oven

Electric oven for heating up coupling halves, etc., to assist assembly; temperature approximately 100 °C; capacity 650 mm x 650 mm x 800 mm deep.

Item 22 Induction heating apparatus

The apparatus is suitable for heating up to 100°C, rings, couplings, bearings, etc., to assist assembly.

Electronically controlled within the range 55°C - 110°C,

With automatic demagnetizing.

Typical data:

dimensions	-	320 mm x 110 mm x 285 mm min.
voltage	-	220 V
amperage	-	max. 15 A
mass	-	23 kg
heating-up time	-	approx. 1 minute up to 100°C for hole diameter 50 mm
capacity	-	internal diameter 10 mm external diameter 350 mm
width of part	-	max. 120 mm

Item 23 Hack-sawing machine - Heavy-duty

Cutting capacity at 90°-300 mm diameter with hydraulic saw control.

Manufacturer should supply the following information:

number of strokes per min
blade size
motor power in kW

Accessories:

lamp, low voltage
cooling system
setting bar
angle vice
work support stand and clamps
automatic cut-out switch

Item 24 Band-sawing machine - medium-duty, horizontal.

Designed to use all types of band saw blades.

Cutting capacity 300 mm diameter,

Equipped with:

automatic shut-off (in the event of band breakage)
automatic band tension (hydraulic)
variable band speed

power head elevation
vice, manually adjustable, for angle cuts
coolant system
chip removal
power-driven brush, to keep saw clean
roller table

NOTE: For cutting heat exchanger bundles, a large machine with a cutting capacity of approximately 1500 mm would be needed.

Item 25 Pipe-bender

Hydraulic hand-operated	for ½" - 2" diameter line pipe
electric	for 2" - 4" diameter line pipe

The pipe bender shall be complete with hydraulic pump, ram, bending frame, pipe supports with pins, and bending-segment shoes for the specified pipe diameters.

To be furnished with a carrying kit for storage and transportation.

Manufacturer should supply the following information:

ram pressure, ram stroke and time required for 90° bends in the respective pipe diameters

Item 26 Plate-bending machine (optional)

Purchase of this item should only be considered if its practical use is envisaged.

The machine should be suitable for rolling plates of maximum 10 mm thick and approximately 1250 mm wide. Diameter of rolls approximately 250 mm.

NOTE: Greater thickness may be rolled within the capacity specified above when plate widths are reduced.

Item 27 Plate-shearing machine (optional)

Purchase of this item should only be considered if its practical use is envisaged.

Machine should be suitable for shearing sheet metal of a maximum thickness of approximately 10 mm, cutting lengths maximum 2000 mm.

Item 28 Grinding machine - bench type

Electrically-driven bench grinding machine, equipped with 2 wheels of maximum diameter 150 mm. One wheel for roughing and the other for finishing, also suitable for hard metal. Machine to be provided with wheel guards, eye-protection shields and adjustable work

rests.

Item 29 Grinding machine - pedestal type

Double-ended pedestal grinding machine having the spindle mounted on taper roller bearings. Equipped with two tool grinding wheels diameter 200 mm or 300 mm. One wheel for roughing and the other for finishing.

Machine to be provided with: wheel guards, eye-protection shields, adjustable work rests, a twist drill grinding attachment for drills up to 40 mm, and a bowl for cooling medium.

Drive: Electric

Item 30 Gasket cutter

A pneumatically operated gasket cutter to cut gaskets of irregular shape out of sheets.

Typical data:

Cutting capacity:	steel	-	1.3 mm
	stainless steel	-	1 mm
motor capacity		-	0.2 kW
speed		-	3 000 r/min
mass		-	1.1 kg
air consumption		-	0.25 m^3/min

Item 31 Hydraulic test pump

1. Double-ram, complete with pressure gauges and cistern, but without delivery hoses.
   - for pressures up to 240 bar;
   - for pressures up to 400 bar.

   capacity cistern - approx. 45 litres
   pressure gauges - different ranges up to 560 bar

2. Portable hydraulic hand-operated test pump. (Four pieces minimum for new locations.)

   A two-stage pump with two pistons positioned concentrically.

   Water storage (5 litres) tank base.

   Low-pressure piston up to 70 or 170 bar;
   High-pressure piston up to 400 bar.

Item 32 Three transformers or rectifiers or AC/DC power source for shielded metal arc welding (SMAW) and gas tungsten arc welding (GTAW).

Suitable for use in workshop and field.

Preferably 3-phase machine.

Current range: for welding 25 A - 350 A
for gouging 100 A -600 A (one piece required).

Power source static output characteristic: constant current type. Duty cycle at maximum nominal output: 60%. Remote-controlled.

For transformers, open voltage, highest insulation class. Transformer to be equipped with safety relay switch.

For GTAW, auxiliary high-frequency unit is required, remote-controlled.

The above equipment shall be suitable for outdoor use (dripwater-tight).

Item 33 Rectifier with power source, static output characteristic- constant potential for gas metal arc welding (GMAW)

For use inside workshop.

3-phase machine. Current range: 100 A - 450 A. Duty cycle at maximum nominal output: 60%. Remote-controlled. With feed unit for 0.9 mm, 1.0 mm and 1.6 mm wire.

Item 34 Mobile diesel-powered AC/DC welding generator on 4 wheels for outdoor use - Minimum 2 sets for new locations

Current range: 35 A - 400 A. Duty cycle: 60%. Remote-controlled.

Auxiliary power depending on local voltage. Noise level in accordance with DEP 31.10.00.31-Gen.

Item 35 Electrode cabinet

1. Electrically-heated.
   Automatically controlled temperature up to 370°C. Capacity approximately 20 packets.
   Power supply compliant with the local voltage system and regulations.
2. Heated storage cabinet for welding electrodes. Temperature approximately 100°C. Capacity approximately 100 packets.

Item 36 Cylinder manifolds for oxygen and gas (acetylene, propane or shielding gas)

The manifolds should be suitable for 2 x 3 cylinders of acetylene gas and for 2 x 5 cylinders of oxygen. Separate manifolds should be supplied for other gases in the numbers required. The manifolds shall be installed separately on the outside wall of the workshop at some distance from the welding area. The cylinders shall be protected from direct sunlight.

Offtake stations shall be installed inside the welding shop.

Each manifold shall be wall-mounted and consist of a main regulator and two lengths of suitable collecting pipe, each provided with a main valve.

Each cylinder connecting point shall have one valve and an expansion arm with appertaining fittings. The manifolds may be mounted on a wooden wall panel.

The acetylene gas cylinder connecting point shall have a high-pressure sintered flash back arrester. Other gases shall also have flash back arresters as required by local practice and/or regulations.

The construction materials for the gas cylinders shall be steel and for oxygen cylinders copper.

Regulators shall be fitted with safety/relief valves, cylinder gauges and working gauges.

NOTE: Manifolds and offtake stations shall be designed in accordance with local requirements and safety regulations.

Item 37 Plasma cutting machine (optional)

This machine is only required when frequent cutting of alloy and non-ferrous metal is envisaged.

Item 38 Fuel gas welding and cutting set

Comprising 6 welding torches, 1 cutting torch and 1 heating torch.

Item 39 Pipe cutting and bevelling machine

Incorporating a self-centering cutting chain, which is rotated by means of a reciprocating pneumatic cylinder, acting upon a fixed roller chain wrapped around the circumference of the pipe. The machine may also be rotated manually.

Range of pipe sizes: DN 100 to DN 300.

Item 40 Plate cutting machine - mobile (optional)

Mechanized trolley rail-mounted plate cutter, with oxy-acetylene flame cutting.

Item 41 Fume extraction unit (optional)

Mobile, comprising a fan unit, cantilever arm, flexible hose and a steel frame to carry the fan, with a flared hood and exhaust hose.

Item 42 Preheat and post-weld heat treatment equipment (optional)

Preheating and post-weld treatment equipment, consisting of control cabinet with strip chart recorder, range of heating elements (fingers), cables etc.

Item 43 Work benches

Heavy-duty, size 2 000 mm long x 800 mm wide x 900 mm high. Work top to be made of hard wood 50 mm thick or steel plate 10 mm thick with steel angle sides.

With a steel supporting frame, bottom shelf and steel drawer.

One bench vice, capacity 100 mm, and one pipe vice, capacity 100 mm, to be mounted on opposite corners.

Item 44 Tool cabinets

A variety of tool cabinets are commercially available and should be selected locally to suit requirements. Machine tools should be stored in cabinets near the lathes; cabinets are also required for other activities, e.g. pump repair, piping and welding areas. The counter in the tool store may be constructed using the tops of some of these cabinets.

Item 45 Bench vice

With parallel jaws, plain screw, stationary base. Width of jaws, maximum opening, depth of jaws and total number required to be indicated locally.

Item 46 Pipe vice

A pipe vice on a portable tripod stand for pipe diameters 3 mm - 60 mm and/or 3 mm to 115 mm.

Hinged type, self-locking.

Item 47 Branch drilling machine ("hot tapping")

For all hot tapping operations, reference shall be made to DEP 31.38.60.10-Gen. "Guidelines for repair welding and/or hot tapping on piping systems and equipment under operating conditions".

A hot tapping machine for making branch connections into piping under operating pressure.

Typical data:

Type 1 capacity: 12 mm to 100 mm diameter branches, boring bar travel - 460 mm, hand-operated, or air motor drive, automatic adjustable feed rate, mass - 15.0 kg

Type 2 capacity: 3"-12" diameter branches, boring bar travel - 1070 mm, air motor drive, mass - 230 kg (including air motor)

A complete set of accessories and adapters to allow tapping machine to handle standard flanged valves, cutters and cutter holders.

Item 48 High-pressure cleaning equipment (optional)

Refer to DEP 70.10.80.11-Gen. for high pressure cleaning equipment.

At the workshop, high pressure jet cleaning shall be carried out in a separate cleaning bay, nearby the workshop building.

The contracting of out these cleaning activities to specialist cleaning service contractors should be considered.

Item 48a Mobile steam cleaner (optional)

This unit can be used to degrease and clean heavily soiled surfaces such as pipe insulation cladding, lubricating oil auxiliary skids, concrete floors, etc.

Hydro Steam Cleaner, complete with flat nozzles, wire brushes, etc. Unit to be mounted on a manually operated trolley.

In locations where steam supply is not available, an electrically heated steam cleaning unit should be considered. The cleaning unit should be should be of the type described above, with a self-contained water tank and electrical heater. The electrical safety features shall be approved by the Principal.

Item 49 Oxygen/acetylene carriage (2 pcs)

Consisting of a pipe frame to carry one oxygen cylinder and one acetylene cylinder, together

with hoses, gauges and torch. When in use, the carriage should be stable in the vertical position.

Fitted with pneumatic or solid rubber tyres and with hooks for lifting the assembly by crane.

Item 50 Pipe cutter and beveller

A portable pipe cutting and bevelling machine complete with gas cutting torch, carried on a rear-mounted saddle and having means for angular adjustment of the torch.

The saddle which clamps to the pipe has a geared ring, around which the cutting torch is rotated by means of a geared handwheel drive.

Range of pipe sizes: DN 100 - DN 300. Larger sizes can be handled if required.

Item 51 Air compressor

Portable rotary air compressor, delivery 0.28 m^3/s of oil-free air at 6.8 bar.

Diesel-driven.

Mounted on an all steel frame, fitted with four pneumatic tyred wheels, with automotive steering.

Provided with an automatic control device to reduce the speed of the engine when the desired maximum pressure is reached. Self-contained storage tank with relief valves.

Instrument panel with all necessary pressure and temperature gauges.

Noise level in accordance with DEP 31.10.00.31-Gen.

Item 52 Sump pump

Air-operated sump pump (supply: 3-6 bar (ga) air).

Open impeller type, centrifugal pump driven by rotary vane air motor. Capacity 10 m^3/hr at 3 m lift.

Item 53 Rotary grinder for valves fitted in position (optional)

Rotary grinder suitable for grinding/reseating most types of valves in situ.

Valve seat size ranges: 100 mm - 250 mm, 150 mm - 300 mm, 300 mm - 600 mm, depending on local requirements.

The grinder should be designed for compressed air drive, but may be operated manually.

Both motor and hand crank are supplied as standard equipment, together with an appropriate set of accessories.

In-situ grinding/machining is usually available as a specialist service, e.g by the valve Manufacturer.

Item 54 Heat Exchanger tube end puller (optional)

A hydraulic tool which consists of a set of jaws which are to be inserted into the ends of tubes required for renewal. By retracting a tie-rod, the jaws are forced into the tube material, and simultaneously the tube end is pulled out of the tube sheet. Available for either softer material like Al Brass and also for carbon steel tubes.

Item 55 Tube expanding equipment

Expanding equipment should be selected and specified to suit the tubes in the equipment installed.

1. Heat-exchanger tube expanders, for power use.

   For each size of expander, a spare mandrel and a set of spare rollers will be required. The following accessories should also be included:

   Tube cutter
   Grooving tools
   Tube drifts
   Tube wall reducing tool
   Flaring tool

   Note: Hydraulic expanders are also available, and may be selected. These do not have the attendant noise of the pneumatic mandrels and have been proven in the nuclear and process industry where more exotic metals like titanium have been difficult to expand. However, it should be noted that the expansion groove design from the drilled holes in the tube sheet should be modified to allow hydraulic expansion. The normal TEMA groove design is based on a rolling expansion procedure.

2. Furnace tube expanders, complete with air-driven motors, spares, couplings, drill heads, cutter heads, etc. These should normally be included in the furnace vendor's scope of supply, and need only be ordered otherwise.

APPENDIX 3 DESCRIPTION OF FIELD TOOLS

1. BASIC TOOLS

1.1 MEASURING TOOLS

- Micrometers, sets of internal, to cover approximately the following ranges:
  25 mm - 55 mm, 50 mm - 210 mm and 200 mm - 825 mm.
  Graduated to read hundredths of a millimetre, or when specifically required, thousandths of an inch.
- Micrometers, sets of outside, to cover approximately the following ranges: 0-25, 25-50, 50-75, 75-100, 100-125, 125-150 and 150-225 mm or larger. Graduated to read hundredths of a millimetre, or when specifically required, thousandths of an inch.
- Micrometer, tripoint for internal measurement, 6-12 and 11-20 mm.
- Caliper, vernier for outside and inside measurement, sizes 150, 300 and 600 mm.
- Caliper, U-type thickness gauge, 300 mm for wall thickness measurement of piping beyond flanges.
- Caliper, inside, firm joint, 200 mm, 300 mm and 600 mm.
- Caliper, outside, firm joint, 150 mm, 200 mm, 300 mm and 600 mm.
- Caliper, inside thread, 100 mm and 150 mm.
- Screw thread angle gauge for metric, BA and ACME.
- Screw pitch gauge for metric, UNC, UNF, UNS 322.1.
- Screw thread tool gauge, ACME.
- Screw thread gauge, UNF.
- Depth gauge, vernier, 150 mm x 0.02 mm.
- Combination set, 300 mm to read from 0°-180°.
- Dial gauge, set, graduated in hundredths of a millimetre or when specifically required, thousandths of an inch.
- Magnetic base for dial gauge.
- Surface gauge, universal.
- Feeler gauges, set with 13 blades:
  0.05 mm - 1.00 mm thick; 100 mm and 300 mm long.
- Clearance gauge, feeler gauge, box, range as required.
- Wire gauge, Nos 1 to 36.
- Calliper, thickness gauge, u-type.
- Rules, steel straight 300 mm, 600 mm and 1 250 mm.
- Rules, steel folding, length 1 m.
- Rules, steel pocket, length 2 m.
- Tape, measuring, lengths 10 m, 20 m and 30 m.
- Straight edges, lengths 1 000 mm and 2 000 mm, bevelled and square edge.
- Squares, flat:
  200 mm x 130 mm, 300 mm x 175 mm, 500 mm x 280 mm, 1 000 mm x 300 mm.
- Flange squares, for flanges 200 mm and smaller, 250 mm - 300 mm and 350 mm - 400 mm (metric) and 350 mm - 400 mm (metric).

- Scriber for marking out, double-ended.
- Scriber for marking out, pocket model.
- Bench levels, length 300 mm and 600 mm.
- Square block level, length 200 mm.
- Divider, 150 and 300 mm.
- Bevel protractor, with vernier scale, 150 mm blade.
- Beam trammels, range 900 mm with scriber and calliper points.

1.2 HAND TOOLS

- Beam trammels, range 900 mm with scriber and calliper points
- Hammers with handles:

  A selection should be made from the following: ball pein, cross pein, carpenter claw, blacksmiths, boiler scaling, instrument maker, pin-pointed, copper, nylon-faced, hard rubber, sledge.
- Files in standard packs, with handles:

  A selection should be made from the following: Shape: flat, half-round, round, square, three-square Surfaces: bastard, second cut, smooth Available lengths: 150 mm, 200 mm, 250 mm and 300 mm.
- Files, fine cut 150 mm.
- Needle files, set.
- Rotary files, set coarse, medium, fine.
- Wood rasps, bastard and smooth, 300 mm, 350 mm and 400 mm.
- Cold chisel, octagon shank, types: cross cut, diamond point and flat.
- Cold cutting chisel with handle.
- Caulking tools.
- Bearing scrapers, set of three cutting edges.
- Scrapers, engineers, set of half-round, flat, triangular types.
- Hacksaw frame, adjustable, 300 mm with blades.
- Spanners, adjustable, length 150 mm, 200 mm and 300 mm:

  A full range of the following spanners should be available:
  open end driving, 15° angle; driving ring, offset, 12-point; structural open end, offset handle; double open end, 15° angle; double ring, double offset, 12-point; single ring, straight, 12-point.
- Key wrenches, in wallet, for hexagon socket screws.
- Pipe wrenches, adjustable, capacity 200 mm, 350 mm and 600 mm.
- Socket set, in box with ratchet, extension bars, etc., 20 mm to 50 mm.
- Friction wheel wrenches.
- Impact wrenches, 18 mm and 25 mm square drive.
- Socket sets for manual use or air-driven impact wrenches.
- Pipe cutters, three-wheel type, capacity up to 100 mm.
- Pipe flange spreader. Heavy duty for raised face flanges, ASME rating classes 150 and 300 up to size DN 600.

- Pipe screwing tongs, chain type for pipe sizes up to DN 300.
- Pliers:

  A selection can be made from the following types: combination; flat nose straight and bent; round nose short and long; side-cutting; gas, snipe nose; water pump; circlip.
- Pincer, carpenter's.
- Tweezer, instrument-maker's, length 125 mm.
- Nipper, cutting diagonal, length 150 mm and 200 mm.
- Nipper, end cutting.
- Nipper, side cutting for wire.
- Screwdrivers, a full range should be available including: instrument-maker's, offset, screwdrivers for recessed head and impact screwdrivers.
- Puller hydraulic, 2-arm, capacity 40 mm - 215 mm.
- Puller, gear race and sprocket, automatic adjustment 3-arm, capacity up to 150 mm.
- Extractor, bearing, internal race for bearings up to 115 mm.
- Packing extractors, flexible.
- Gasket cutter; hand-operated.
- Soldering irons, 43 V, 75 W and 150 W.
- Centre keys (drill drifts).
- Drifts, 10-25 mm.
- Punch, with handle.
- Punch, hollow, range 11-32 mm.
- Punch, metal workers.
- Plumb bob.
- Centre punches.
- Figure stamps for marking metal, sets in a box, figure sizes 6 mm and 12.5 mm.
- Letter stamps for marking metal, sets in a box, letter sizes 6 mm and 12.5 mm.
- Packing knife, 200 mm long.
- Pocket knife.
- Trimming knife, Stanley No. 99 E.
- Broad hatchet, 350 mm handle.
- Scissors, 300 mm.
- Shears, brass foil, 200 mm.
- Shears, tinmans, straight, 350 mm.
- Shears, tinmans, offset, 300 mm.
- Magnet, pocket.
- Mirror, inspection.
- Wedges, copper, 300 x 500 mm.
- Wedges, steel, 300 x 50 mm.
- Claw bars, chisel end.

- Crow bars, pinch point.
- "C" clamp, heavy duty.
- Key-seat clamps.

2. DRILLS AND THREAD CUTTING TOOLS

- Breast drill, capacity 0-15 mm.
- Hand drill, capacity 0-7 mm.
- Ratchet drill.
- Ratchet drilling pillar.
- Centre drill, combined drill/countersink.
- Twist drills, parallel shank, $^{1}/_{16}$" - $^{1}/_{2}$" x $^{1}/_{64}$", set.
- Twist drills, parallel shank, 1-13 x 0.5 mm, set.
- Twist drills, MT shank, $^{9}/_{16}$" - 1" x $^{1}/_{32}$";
  1 $^{1}/_{16}$" - 2" x $^{1}/_{16}$";
  2 $^{1}/_{8}$" - 3" x $^{1}/_{8}$".
- Twist drills, MT shank, 14-25 mm x 0.5;
  26-50 mm x 1.0;
  50-75 mm x 2.0.
- Masonry drills, carbide tipped, metric.
- Reamer, hand, taper pin, straight fluted 3 mm -16 mm.
- Reamer, hand, API taper, $^{1}/_{8}$" - 2".
- Reamer, hand, expanding.
- Reamer, bridge, spiral fluted.
- Screw extractor, set, range $^{3}/_{16}$"-$^{3}/_{4}$".
- Stud extractor, set, range $^{1}/_{4}$"-$^{3}/_{4}$".
- Taps, BS, parallel, set.
- Taps, BS, conduit, set.
- Taps, metric, set.
- Taps, UNC, set.
- Taps, UNS, 8-thread series, set.
- Taps, UNF, set.
- Taps, API, set.
- Wrenches for taps and reamers.
- Dies, metric, round, adjustable.
- Dies, UNC, round, adjustable.
- Dies, UNF, round, adjustable.
- Die stocks, round.

- Dies, rethreading, UNS, 8-thread series.
- Dies, rethreading, UNC.
- Dies, rethreading, UNF.
- Ratchet die stock complete, API 5L.

3. WELDING ACCESSORIES

Electrode holders and arc cutting torches, fully insulated for AC/DC welding to cover the range of welding equipment specified.

- Plug, cone and bush connector, male and female.
- Clamps, current return with lever action.
- Quick fit lugs for 400 A and 600 A cable.
- "0" clip pliers.
- Hand shields.
- Helmets, flip front.
- Filter glasses, packs.
- Spatter-resistant clear lens.
- Bocal goggles in metal box.
- "Optishield" spectacles.
- Goggle lens.
- Reversible gauntlets.
- GL2 TIG gloves.
- Jackets, chrome leather, waist length.
- Aprons, chrome leather.
- Peaked caps, leather, adjustable to size.
- Chipping hammers.
- Wire brushes, 3-row.
- Wire brushes, 3-row, stainless.
- Clamp-type cable lugs.
- Portable screens, soft PVC.
- Mobile grinding machines:

  a) 20 cm diameter disc - pneumatic or electric, 42 V, all stroke, double-insulated;

  b) 10 cm diameter disc - electric, 42 V, all stroke, double insulated.
- Portable pipe cutting and bevelling machine, oxy-gas, complete with chain for cutting pipe up to 12 inch. Extra chain lengths can be supplied for larger diameter pipes.
- Welding and cutting set oxy-acetylene, also suitable for oxy-propane.
- Hand cutter, 90° oxy-acetylene or propane attachments.
- Cutting nozzles, size 1/16".
- Cutting head assemblies.
- Shanks.

- Welding heads, injector type.
- Heating blow pipes, propane.
- Welding cable complete with lugs and couplings.
- Acetylene hose, complete with couplings.
- Oxygen hose, complete with couplings.
- Electrode holder.
- Regulator, acetylene.
- Regulator, oxygen.
- Regulator, propane.
- 2 pcs roller blocks, standard type 2" - 20":

  Roller blocks, steel construction with miniature turning rolls, bench model with 4 adjustable settings, 2" - 5", 4½" - 10", 8" - 14" and 12" - 20".
- 2 pcs roller blocks, quick-release type 2" - 24":

  Roller blocks, steel construction taking pipes from 2" - 24" diameter in 3 settings with a rating of 1 tonne per unit.
- 4 pcs adjustable pipe stands

4. ELECTRIC-DRIVEN TOOLS

- Electric drill, portable, 42 V, all stroke, double-insulated,1-phase with 3-jaw chuck and key and thread drill spindle. Capacity in steel 13 mm diameter.
- Electric drill, portable, 42 V, all stroke, double-insulated, 1-phase with 3-jaw chuck and key, with morse-taper socket with arbor.
  Capacity in steel 25 mm diameter.
- Electric grinders, straight-type, 42 V, all stroke, double-insulated, wheel diameter 40 mm.
- Electric grinder, angle-type, 42 V, all stroke, double-insulated, disc diameter 170 mm.

5. AIR-DRIVEN TOOLS

- Drills, non-reversible, air-driven, pistol grip, drilling capacity 13 mm.
- Drills, reversible, air-driven with safety roll throttle, drilling capacity 32 mm.
- Grinder, portable, air-driven with grip handle, wheel diameter 100 mm or 150 mm with wheel guard.
- Surface grinder, portable, air-driven, wheel diameter approximately 150 mm with wheel guard.

  Portable air-driven grinder with set of small grinding/ milling tools in various shapes.
- Impact wrenches, reversible, air-driven Sockets for impact wrenches.

  Extension bar to connect sockets with impact wrench.

  Dimensions to be decided locally. Refer to Appendix 4.
- Caulking and chipping hammers.

6. HYDRAULIC TOOLS

Bolt tensioning

The principle and operation of hydraulic bolt tensioning equipment is described in Appendix 4.

Hydraulic power wrenches

1. Torque controlled hydraulic power wrench, square drive 1", capacity approximately 3 000 Nm, unit complete with hydraulic supply and return hoses, a set of nut drive heads (female, 12 point), and 1" square drive adaptor suitable for standard drive sockets. For hydraulic unit, see 3. below.
2. As above, but capacity approximately 10 000 Nm, 1½" square drive.
3. Hydraulic power unit, air driven (5-6 bar (ga) supply) suitable for above, complete with torque control cut-out. Alternatively, if Hydraulic Bolt Tensioning equipment is available, the hydraulic power unit may be useable for this application. Specifications to be verified, and hose adapters ordered.

7. CONDITION MONITORING EQUIPMENT

In the selection of condition monitoring equipment, the rotating equipment specialist should be consulted. Appropriate equipment would include the following:

- hand held vibration meter;
- vibration/frequency analyser;
- shock pulse meter;
- stroboscope;
- alignment tools, including optical alignment;
- field balancing equipment.

Computerized data logging/trapping equipment used in association with the above are also available.

8. SPECIAL AND MISCELLANEOUS TOOLS AND SERVICES

"Elliot" tube tester

This is used for pressure testing of individual tubes of a fin-fan cooler bundle.

Leak sealing

Usually provided as a service by specialist firms, principally for the on-stream sealing of leaks in flanges. Sealing is accomplished with the high pressure injection of chemical compound.

Gas stoppers

Inflatable rubber stoppers used for gas-freeing and isolation purposes.

Freezing of section of piping with liquid nitrogen to allow isolation and hot work repairs to be carried out.

Cold welding compound

Chemical compound, for the temporary repair of, for instance, joints in low pressure services.

Ventilators, exhaust fans

For internal ventilation of vessels, tanks, etc. during maintenance work.

Process equipment ventilation equipment

1. **Air extractors** (min. 4 pcs for new locations)

   Light alloy cast construction fan type extractors, suitable for mounting on column/vessel manways, with slotted flanges on both faces of unit, safety grilles, and driven by air motor - 3-6 bar (ga) air supply.

2. **Air eductors** (min. 4 pcs for new locations)

   Light alloy sheet/cast construction venturi-type air eductors, suitable for mounting on column/vessel nozzles (6"/8") or in manways. Air supply 3-6 bar (ga).

Flange facing machine (optional)

1. Suitable for on-site machining of flange face, capacity 4"-24", air driven (3-6 bar (ga)), fine feed adjustment, spiral groove finish.
2. As above, but capacity 24"-60".

9. HOISTING AND LIFTING ACCESSORIES

Where applicable, safe working loads shall be legibly marked on each item and test certificates provided according to local requirements.

Manila rope, three-strand, quality 1, coil diameter 24 mm or 26 mm

Wire rope, steel galvanized, 6 x 37, on a wooden reel.

Wire rope slings, steel with two soft eyes, 6 x 36:

safe working load	length of sling in m
1.8 t	3, 4, 5 or 9
2.7 t	2, 6 or 9
7.1 t	3, 6 or 9

Flat wire mesh slings (for heat exchanger bundles). Safe working load 5 t, 6 t or 9 t.

Flat polypropylene slings with reeving end fittings. Safe working load approximately 3 t, 6 t or 12 t.

Plate clamps, 6 000 kg.

Bull dog grips for six-strand right-hand ordinary lay wire rope dimensions according to selected rope diameters.

Shackles, large Dee and small Dee, safe working load according to local requirements.

Pulley block with swivel hook, steel, single-, double- and triple-sheave, dimensions according to local requirements.

Pulley block with swivel eye, snatch, single-sheave.

Pulley block for wire rope.

Winches, hand operated, rope travelling Tirfor T-13 1500 kg Tirfor T-15 3 000 kg complete with operating handle and wire rope.

Chain hoist, hand-operated, capacity 1 t, 3 t and 5 t.

Air-driven hoist, capacity 1 t and 2 t.

Jack, hydraulic, capacity 20 t.

Jack, hydraulic, centre hole ram-type, capacity 100 t.

Jack, screw-type, short lift, capacity 5 t.

Compact hydraulic jacks, suitable for use in cramped working conditions, low headroom requirements. 4 pcs. each of capacity 5 t, 10 t and 25 t.

APPENDIX 4 BOLT TENSIONING EQUIPMENT

1. GENERAL

Bolted flange connections can in general be tightened by means of spanners, impact tools or torque wrenches. When applying these conventional methods most of the effort is wasted in overcoming friction due to roughness of thread or friction of nut on flange, and the bolt may even be twisted.

These methods of tightening have little or no control on the value of stress in each individual bolt, and will result in an uneven gasket seating pressure. Moreover, when flanged connections are leaking, additional force is often applied to the bolts in the area where the leak occurs. This can result in deformation of the flange or its facing, thus increasing the tendency to leak.

An improved method for the tightening of bolted flange connections which are exposed to severe operating conditions or where a proper stress distribution in the bolts is required for other reasons (3.), is the application of hydraulic bolt-tensioning equipment.

The equipment induces the load axially, by stretching the stud bolts within the elastic range to supply the required bolt loading. Because bolt loads are uniformly applied and controlled, the need for periodically knocking up and re-tightening is eliminated. The net result will be tighter joints for longer periods and an extended life for the bolts before they need to be changed.

A further advantage of bolt tensioning is that it reduces the need for `hot bolting' after start-up and the pre-loosening of bolts during shutdown procedures to ensure that they can be undone when required at shutdown.

Hydraulic bolt-tensioning equipment has been available for many years from a number of mainly equipment Manufacturers. Improvements in the performance of this type of equipment has led to its increased use, particularly in large units with severe operating conditions and sometimes the presence of hydrogen in the process stream.

It has developed to the stage where a high-quality joint can be obtained.

2. THE HYDRAULIC BOLT-TENSIONING TECHNIQUE

2.1 General

The principle of tightening bolts and nuts by bolt tensioning is that the bolt shanks are stretched in the cold condition by means of hydraulic oil pressure. The elongation produced in the bolt can be made to correspond to the calculated bolt load required to make the flanged joint.

Whilst the bolts are elongated, the nuts can easily be run down the thread by hand, until they bear against the flange. When the hydraulic pressure is released the bolt extension is retained over its active length between the nuts and the required bolt load is obtained (2.3).

A jacking tool screws onto one end of the bolt, therefore the bolts need an additional length of thread protruding out of the hexagonal nut at one end by about 1 d to 1½ d. After the tightening procedure is complete the extended thread lengths shall be protected against the effects of corrosion to allow the nuts to be subsequently unscrewed. In the loosening procedure the bolts are stretched again and the nuts unscrewed just as easily providing the threads have been protected.

The hydraulic pressure is supplied by a high-pressure oil pump via a distribution ring main to a number of jacking tools. The number of tools used depends on the application or the total number of bolts to be tightened.

2.2 Number of jacking tools (or tensioners)

Theoretically, the number of jacking tools should equal the number of bolts. However, for accessibility reasons it is most unlikely that all stud bolts in a flange connection can be tensioned simultaneously, even in those cases where bolts are accessible from two sides and the tensioning tools can be placed on alternative sides of the flange. Therefore,

completion of tensioning in only one cycle is practically impossible.

Tool manufactures have developed different tensioning schemes for stepwise tensioning.

Principally they all aim to create an even stress distribution over the stud bolts when not all tensioned in the same cycle (e.g. when half of the bolts have been tightened they will suffer a decrease in preload when the rest are being tightened).

2.3 Calculation of hydraulic pressure

For a detailed calculation of loads to be applied to obtain the required bolt stresses, data shall be obtained from the Manufacturer of the selected tool. For this reason a practical example of calculation is not included, but the factors involved are indicated.

The hydraulic pressure required to operate the jacking tools is obtained by multiplying the calculated bolt load by a factor and dividing this by the effective lifting area of the jacking tool.

The factor is required to compensate for the loss of load which occurs when the bolts take up the strain after the hydraulic pressure is released and the bolts and nuts deform slightly as they relax.

The value of this factor is related to the bolt dimensions L/D. It can be seen in Figure 2 that long slender bolts have the lowest value for the factor, indicating that the loss of load will be less. Short bolts of large diameter conversely have a high factor and therefore require a high initial bolt load. Control over the final load is then less predictable and consequently bolt tensioning of such bolts is not recommended.

The required stress in the bolt will be obtained from the flange calculations, whilst tool details and the load factor will be provided by the Manufacturer of the tensioning equipment.

Additionally if the flange joint will be subjected to high temperatures, the initial calculated bolt load can be increased by the amount necessary to ensure an adequate working life for the joint, considering loss of bolt load due to the effect of `creep' on the bolts. For these conditions bolts of adequate tensile strength combined with resistance to creep should be selected to give a reasonable working life without the need for re-tightening or risk of overstressing the flange.

Gasket relaxation should be incorporated as well.

To compensate for the "neighbour unloading" effect during the first cycle and to minimize the number of cycles required, the pressure "A" used during the first cycle will be higher than the pressure "B" required for the theoretical case of 100% tools (where all bolts are simultaneously at the required stress level).

The initial `A' pressure is normally 15% to 20% higher than the pressure `B' actually required.

Hydraulic pressure B = f_b / f_{max} x load factor x oil pressure at max. work load,

where f_b = actual stress required in bolts,

f_{max} = stress that would be applied to the bolts at max. work load.

The load factor can be found in Figure 2.

During major shutdowns, actual bolt stresses should be checked on a selective basis to verify the relaxation assumptions made during the design stage. Critical joints especially should be monitored and local hydraulic stress procedures should be updated to incorporate actual findings.

The actual operating temperature, piping stresses and fluctuating environmental conditions (e.g. wind and rain) may have an impact on relaxation which have taken place during operation.

3. APPLICATIONS FOR BOLT TENSIONING

Hydraulic bolt tensioning shall be applied in the services and sizes specified in DEP 31.38.01.11-Gen.

4. PREPARATION FOR THE ASSEMBLY OF FLANGE JOINTS

4.1 General

Apart from the bolt-tensioning procedure there are several interdependent factors which are essential to obtain a good performance from a bolted flange connection. These are:

gaskets - selection, specification of seating stress and installation instructions;

flanges - surface finish;

bolting - material, stresses and bolting procedure.

Gaskets shall be suitable for the operating conditions and remain flexible under a varying load due to fluctuations in pressure and temperature. If spiral-wound gaskets are to be applied, extra care shall be taken not to damage the face of the gasket.

If solid metal gaskets are to be applied, the maximum allowable hardness shall be specified explicitly.

Flange surface finish shall comply with the piping material specification. Seating surfaces shall be free from damage, grease, protective coating, etc. The back of the flange at the nut seating area should be smooth finished.

Bolts to ensure consistent performance and to match the puller. It is essential that bolts and nuts supplied for use with the tensioning equipment comply with a precise specification for tolerance and fit in accordance with BS 4882 class 2A/2B.

NOTE: For protection in high-temperature and corrosive conditions, nickel or chromium plated bolts provided with stainless steel nuts have been used, but this application should be discussed with the Principal.

The gasket seating stress depends on the type of gasket selected and the flange geometry which should be incorporated in the calculations to obtain the required bolt load.

It has been experienced that due to difficult high-temperature conditions, some critical flange connections could not be properly sealed when using normal bolting material. The cause was invariably found to be excessive creep of the bolts. Such exceptional conditions may be corrected by the use of Nimonic Alloy 80 A.

Nimonic alloy has the same thermal expansion coefficient as ferritic steel flange material and its higher tensile strength will allow smaller diameter bolting compared with other material. The exceptional creep resistance of Nimonic alloy will also allow a low initial bolt load thereby reducing the stresses in bolt and flange material. Its application should however be carefully considered because of its characteristics at high temperature.

In preparation for the application of bolt-tensioning equipment the following information shall be available for each individual flange to be tightened:

- the required bolt stress, from the flange calculation, load factor and hydraulic pressure(s);
- the size and number of tools to be applied;
- the maximum work load that can be applied by the tool at maximum oil pressure;
- provision of bolts with extra threaded lengths fitted with anticorrosion caps.

All the relevant information and bolt-tensioning details should be recorded for each application for subsequent reference and re-application.

4.2 Procedure for bolt-tensioning

The application of bolt-tensioning equipment shall be in strict accordance with the Manufacturer's instruction manual and safety procedures.

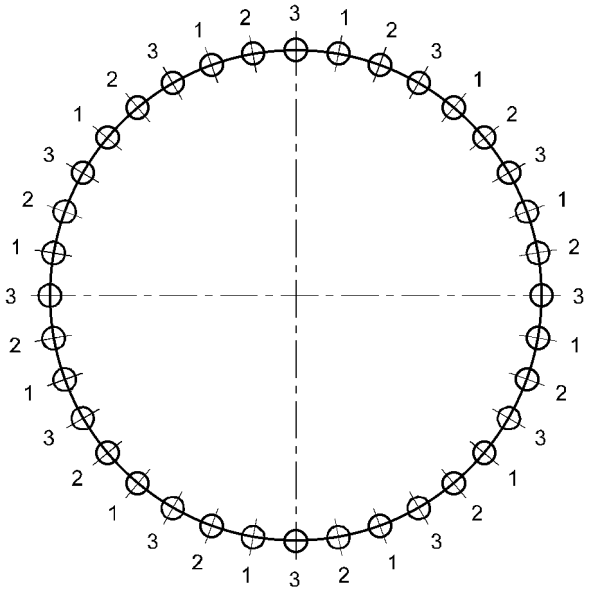
The personnel using the equipment shall be adequately trained in its application.

The tightening of the bolts is carried out in a number of stages or cycles, depending on the number of tools that can be applied simultaneously (2.2). A suggested sequence is given in Figure 1.

To facilitate loosening of the nuts when required at some later date, it will be necessary to treat the thread of the bolts with an anti-seize compound before fitting the nuts. The extended threaded part shall also be covered with suitable caps to prevent damage during operation of the plant. The Manufacturer's instructions shall always take preference.

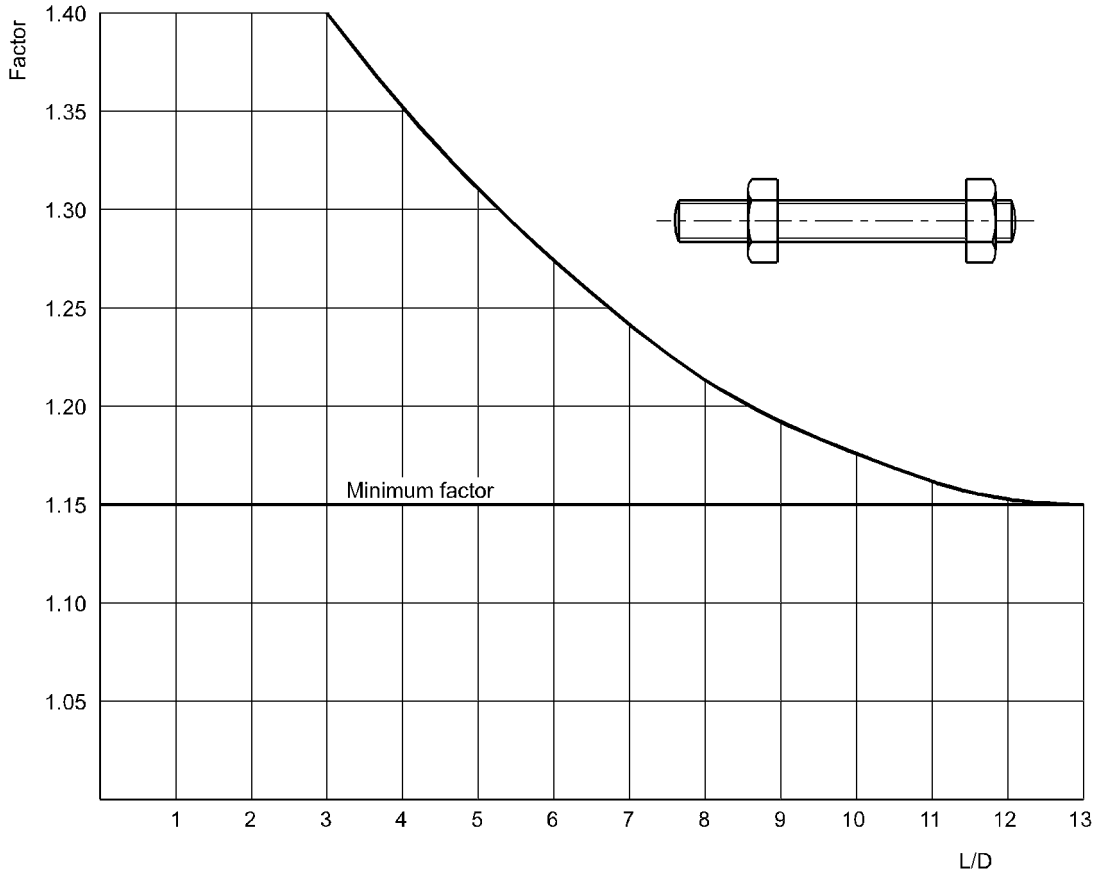
5. FIGURES

Figure 1 Suggested bolting-up sequence and number of tools to be applied



Bolting sequence for 36 bolt flanges
using 12 tensioners

Figure 2 Load factor in relation to bolt dimensions



Note: Factors indicated above are for illustration purposes only and shall not be used for detailed calculations.