R1 42 01 02
Hydraulic design directive

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Introduction

This Directive specifies the minimum requirements for the hydraulic systems at Tata Steel IJmuiden. The regulations are based on many years of business experience in the design, manufacture, construction, commissioning, operation and maintenance of hydraulic systems.

The regulations in this document aim to mitigate risks for the following applications:

a) Health and safety
b) Process safety
c) Environment
d) Failure probability
e) Quality of the end product
f) Recovery time (unplanned downtime / lost production)

In addition, some regulations are based on business experiences with a strong positive impact on the reliability or total cost of ownership of hydraulic systems.

Scope & Application

This directive defines the principles and practices for the design, manufacture, construction, commissioning, use and maintenance of hydraulic systems for all installations managed by Tata Steel IJmuiden.

This directive applies to new installations and modifications to existing installations. In addition to this directive, other relevant Tata Steel IJmuiden Standards and Directives must be consulted and followed.

Regulations with regard to the operation of hydraulic systems and the safeguarding / releasing of pressure from hydraulic components are included in the QHSE 3.39 and the QHSE 3.41; http://ijmweb25:8168/page.aspx?page=VBHSE%20regelingen%20QHS

The purpose of this document is to provide directives for:

- Parties charged with planning, designing and / or manufacturing hydraulic systems, being Tata Steel IJmuiden, contractor or consultant;
- Suppliers of pipework, equipment and / or designs;
- Personnel charged with the commissioning, control or maintenance of hydraulic systems, being Tata Steel IJmuiden, contractor or consultant.

Law & Regulations

In the event of additional or conflicting hydraulic regulations, the strictest regulations will be leading at all times, ranked in the following priority:

1. European, National and regional regulations
2. Tata Steel Europe Code of Practice
3. Tata Steel IJmuiden standards
4. Tata Steel IJmuiden directives

The user of this directive should ensure that he consults the most recent version of the directive. The most recent version can be obtained via the Tata Steel IJmuiden Safety website, Regulations tab: http://veiligheid.tatasteel.nl/

The information in this directive has been compiled with great care. Nevertheless, there is a possibility that the published information is incomplete, incorrect, or contains errors. Although Tata Steel IJmuiden strives to publish all information as well as possible and without errors, Tata Steel IJmuiden cannot be held responsible for errors, damage or other consequences resulting from the use of this directive. Therefore no rights can be derived from this information.

Tata Steel expects a proactive approach from the users of this document. This means that users are expected to inform Tata Steel in writing or to ask for clarification should errors, omissions, inconsistencies or ambiguities be found in this directive. Tata Steel will clarify and / or correct these in the future.

Definitions & Abbreviations

CE	Conformité Européenne
CEC	Company Engineering Committee
EC	Engineering Committee
EN	European Norm
EU	European Union
HD	High pressure
ISO	International Organization for Standardization
LD	Low pressure
MTTDF	Mean Time To Dangerous Failure
MTTR	Mean Time To Repair
PPM	Parts Per Million
TIR	Tank Inspection Regime

1. General

These regulations are valid for all hydraulic installations at Tata Steel IJmuiden. They also apply to:

- The general regulations of Tata Steel such as delivery regulations, assembly regulations, welding standards etc;
- The specific formulated requirements of a project.

Deviation from the directives is only permitted after written approval from the Tata Steel project engineer hydraulics.

1.1 Medium

This directive is based on HLP oil according to EN ISO 6734-4, family H (hydraulic systems). Only ISO VG 32 oil should be used.

1.2 Delivery conditions

Unless otherwise agreed, installations are delivered as follows:

Complete hydraulic power units	Without liquid filling
Flanges on pipes and accessories	Protect against damage and dust by metal plates and soft rubber gasket
Pipework	See chapter piping
Accumulators	With a pre-fill pressure of 10 bar
Cylinders	See chapter cylinders

1.3 General requirements for hydraulic installations and units

Layout
Hydraulic installations and equipment (pump units, valve tables) must be placed outside the process installation. Only cylinders, hydraulic motors and pipes are integrated in the process installation.

Accessibility
All components in a unit must be located in such a way that they can be easily replaced without disassembling other components or pipes, and must be easily accessible for operation, adjustment and inspection. Pipe connections and flanges must be easily accessible for maintenance and installation.

Dimensions
The dimensions of all units must be determined in consultation with the Tata Steel project engineer hydraulics.

Marking of functions, parts and connections
An instruction drawing should be used to identify components, their movement and direction of movement. The drawing should be available at the moment of acceptance of the components or the unit. The instruction drawing and a copy of the schematic should be in A3 format laminated in plastic and hung on or near the appliance (see Technical Directive R1 05 80 01; chapter 5).

Drip trays
The following requirements apply to drip trays:

- The drip tray must have sufficient volume to collect all the leaking oil that is released during disassembly;
- The drip tray must be mounted on a slope;
- The oil drain connection must have a 1” BSP female drain stub and must be welded to the lowest point of the drip tray;
- Be placed at least 150 mm above the floor;
- The drip tray construction should be fully welded.

Foundation
The following requirements apply to the foundation:

- It serves for the assembly and adjustment of the units on the construction site bottom frame to be fitted with adjusting bolts;
- An underlayment (joint) space off ± 30mm must be taken into account;
- Mounting feet to the frame must be provided with sufficiently large mounting holes;
- The mounting feet should be positioned in such a way that vertical drilling of the anchor holes through the adjustable guides is possible;
- Anchors should be designed in accordance with section 12.13 (fixing units, clamping supports, etc.).

Transport and assembly
The following requirements apply to transport and assembly:

- Units must be equipped with appropriate lifting devices see R1 51 01 01;
- Units must be supplied complete with coupling or mating flange and welding nipple;
- Welding nipples must be sufficiently sealed to prevent the ingress of dirt and water during transport;
- Ball valve handles should be positioned so that the ball valves are closed when the handle is perpendicular to the direction of the pipe.

Test procedures
Prior to acceptance, all units must be tested on the supplier's premises. An expert from Tata Steel or an expert acting on behalf of Tata Steel must be invited to attend the acceptance test.
The test procedure as described below applies to all units:

- Components and electrical wiring should be checked;
- A pressure test on all pipes and bores with P = 0.95x1.5 x the design pressure or the maximum allowable pressure of the components;
- Pipes and bores should be tested for the flow rates occurring in the installation and the pressure drop should be normal;
- Valves, pressure switches, etc. should be tested for correct operation;
- The functioning of all circuits should be tested with a suitable load if necessary;
- Accumulators should be tested with nitrogen at the appropriate pre-fill pressure;
- The noise level of each unit should be measured;
- The entire pump is tested at maximum flow and maximum pressure, i.e. at maximum power;
- Tanks should be tested on leaks.

1.4 Sound

The working conditions checklist must be completed for each project. Among other things, noise sources in the project are assessed, from which it appears which measures must be included in the technical design.

When ordering new hydraulic power units and motors, it must be determined in advance whether there are workplaces in the vicinity where the noise produced is hindered. The distance to the noise source and exposure time are important here. The client and contractor must complete a noise datasheet in which the agreed noise requirements are recorded as well as the manner in which this is measured.

A sound specialist from the Tata Steel department SPME PTC MCE VGS must be consulted when completing this sound datasheet for large projects. The completed sound datasheet is part of the contract.

2. Pumps

2.1 General

For component selection of pump units see directive R1 42 01 03 “Part 3: Selection of pumps”.
For component selection of E-motors see directive R1 42 01 10 “Part 10: Appendix”, section 10.3.

See below an example of a pump unit (Figure 2-1 Pump unit).

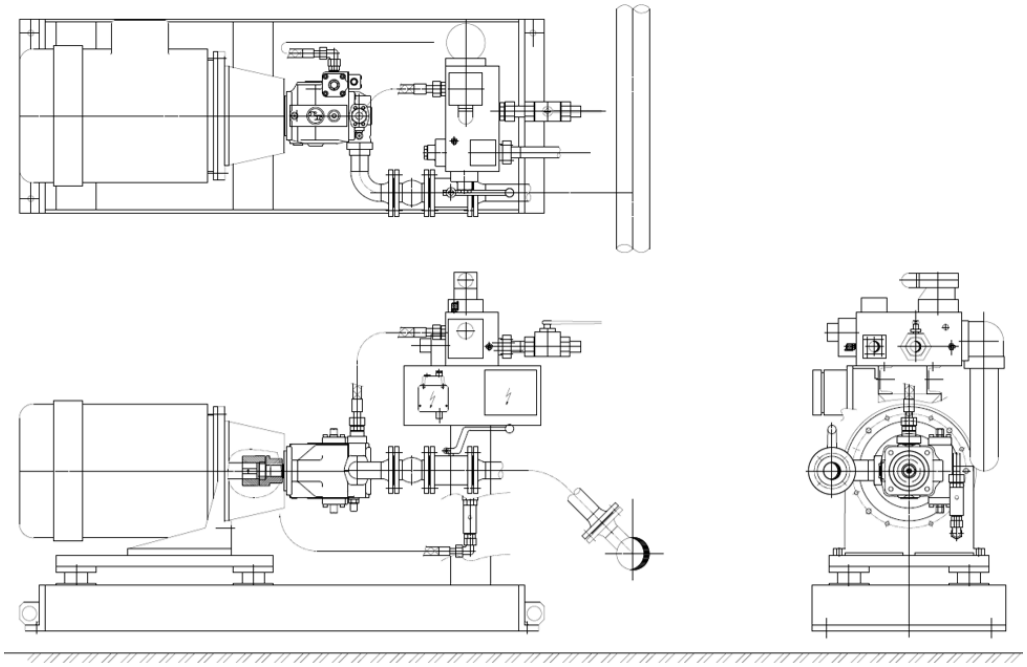


Figure 2-1 Pump unit

2.2 Pump units

The following requirements apply to hydraulic pump units that are in continuous operation:

- Lifespan at least 80 000 operating hours;
- Electric motor B5;
- Lantern base mounting with a large opening for visual inspection at the top or one on the sides and a hole for oil leakage at the lowest point (damping ring is not allowed);
- Flexible coupling type: GS, not divisible, provided with splines in the coupling halves;
- Pump, rotational speed 1000 rpm;
- Vibration damped setup to fixed world, vibration isolation greater than 80% @ 1000 rpm and greater than 85% @ 1500 rpm;
- The lowest possible noise production, noise production must be measured and reported (maximum 85 dBa allowed).

2.3 Main pumps

Main pumps must supply hydraulic power required to drive hydraulic motors and cylinders.

The following pumps are allowed:

- Piston pumps with variable displacement; up to 315 bar, 250 L / min;
- Piston pumps with fixed displacement; up to 315 bar;
- Vane pumps; up to 140 bar, 250 L / min;
- Gear pumps; up to 100 bar, 90 L / min.

2.4 Scope of application main pumps

Figure 2-2 Pump pressure and volume and **Error! Reference source not found.** serve as selection criteria for pump selection.

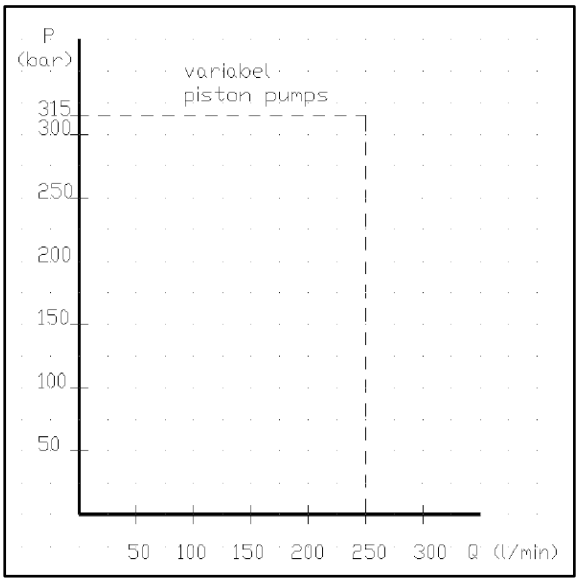


Figure 2-2 Pump pressure and volume pumps

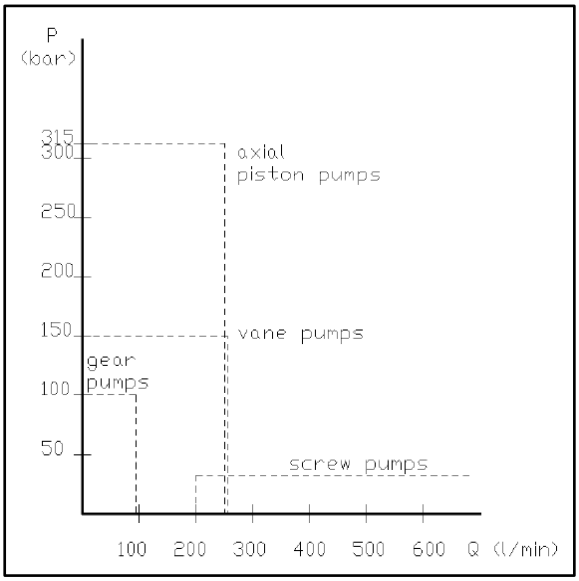


Figure 2-3 Pump pressure and for variable volume for fixed pumps

2.5 Pump connections

Suction side of pump should be provided with the following components, in the following order, seen from the perspective of the pump:

a) Minimess connection, as close to the pump as possible and as high in the suction as possible;
b) Pipe compensator / suction bellows (placed as close to the pump as possible);
c) Suction valve, by means of a ball valve or butterfly valve, provided with a proximity switch in the fully open position, in which the pump should be prevented from starting up when it is not fully open.

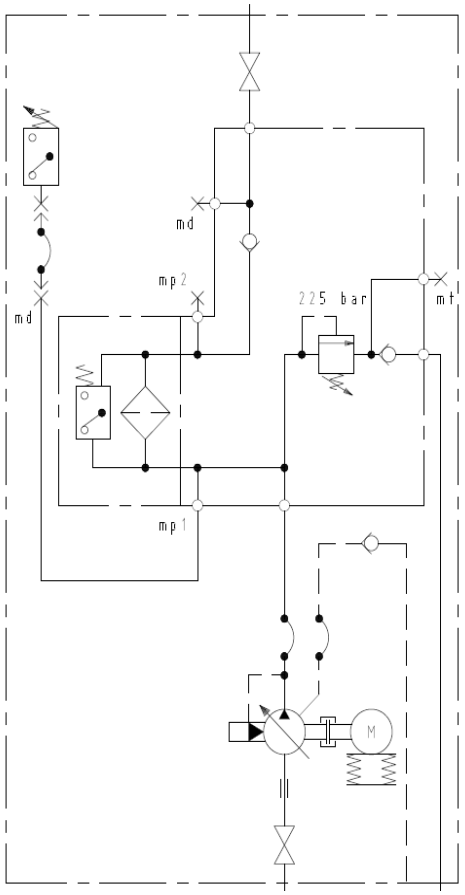


Figure 2-3 Diagram pump units

The pressure side of the pump must be provided with the following components, in the following order seen from the perspective of the pump:

a) Hydraulic hose;
b) Manifold block provided with:
    1. Safety valve;
    2. Non-return valve in the return line connection from safety valve to tank;
    3. Pressure switch to indicate hose rupture between pump and manifold block;
    4. Pressure filter (HD filter) with pressure resistant element and side flange connection;
    5. Non-return valve in main pressure line of manifold block;
    6. Shut-off valve in in the main pressure line pipe (in-line or on block are both allowed).

The drain side of the pump must be provided with the following items, in sequence seen from the perspective of the pump:

a) Hydraulic hose;
b) Non-return valve in line to central drain line.

2.6 Energy efficiency

The following applies to electrical control of pump units:

a) There should be no more pumps in operation than necessary for the process. Standby pumps are switched off and it must be possible to switch on the (standby) pumps if problems arise with pumps in operation. Overlapping time of operational pumps which are not necessary for stable operations should be limited to a maximum of 15 minutes.

b) Pumps with a shutdown time longer than 15 minutes must be shut down. They should be turned back on when needed.

In addition:

1. The switching frequency of pump and electric motor should meet manufacturer requirements;
2. Suction condition should be according to the manufacturer's requirements;
3. Service life of coupling between pump and electric motor for non-operating pump units should match the service life of pump unit in operation;
4. For switching frequencies higher than 1 x per half hour, the pump must be equipped with a low pressure start-up valve and an electric motor with soft starter, if the additional investment can be earned back within 18 months.

3. Accumulators

3.1 General

For hydraulic accumulators and accumulator safety blocks see also standard S1 42 01 01 “Tata Steel IJmuiden Standard Hydraulics”.

3.2 Assembly requirements

When mounting tables are used, they must be mounted upside down to make the safety block easily accessible. See Figure 3-1 Assembly chair

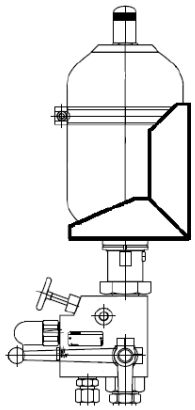


Figure 3-1 Assembly chair

3.3 Nitrogen filling

Checking and / or correcting accumulator nitrogen filling must be possible in a safe manner. Tools such as, for example stairs and mobile platforms are not allowed. See right for an example of an accumulator set (Figure 3-2 Accumulator unit).

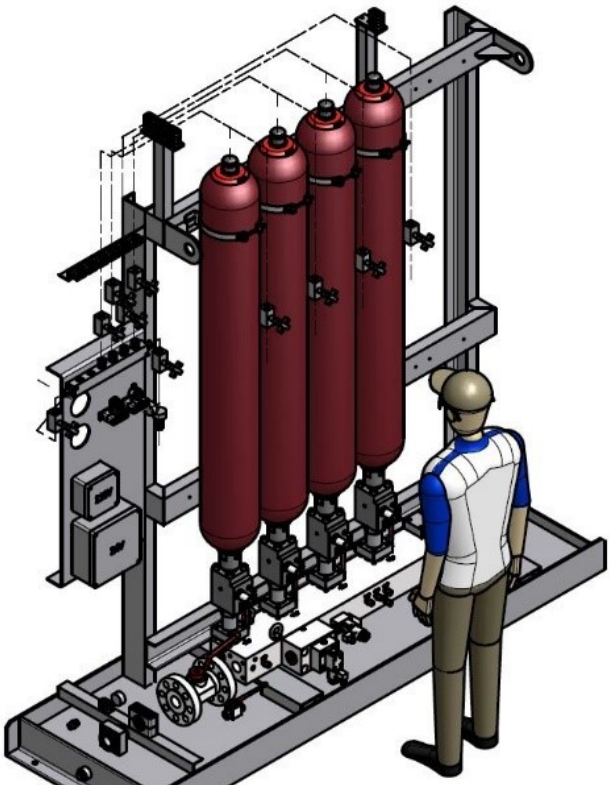


Figure 3-2 Accumulator unit

4. Tanks and peripherals

4.1 General

The hydraulic oil “Echina” used by Tata Steel does not appear to be a hazardous substance according to ADR (EU agreement on the transport of hazardous substances) but it is soil-contamination threatening and falls under category 3B, QHSE 5.24 (see also Tata Steel chemical substance card CS0532).

Tanks must be designed according to appendix R1420102 “Aboveground atmospheric storage tanks for hydraulic systems for Tata Steel IJmuiden, manual for order”.

Main design requirements according to this appendix are:

- Tanks must comply with national rules and regulations for safety and environmental protection;
- Tanks larger than 300 litres must comply with the Tata Steel QHSE 5.24 “Tank Inspection Regime”;
- Return oil flow speed in return tank lines must be lower than 1 m / sec.;
- Flow velocity in the tank should be less than 0.1 m / sec.

In addition, the following items must be arranged for new tanks:

- Permit;
- Classification according to PGS30 (national directives);
- Registration with the Tata Steel department PTC-KDT (tank inspection regime);
- First inspection before commissioning (KVI)

The end user must register new tanks for registration with Tata Steel department PTC's Kwaliteit Dienst Techniek (KDT) for initial inspection before commissioning (KVI). To this end, all necessary documents must be supplied in accordance with Tata Steel QHSE 5.24.

Drip tray

A drip tray under the tank is mandatory. Requirements are described in the national directives PGS30 (publication dangerous substances 30 version 2011). According to Tata Steel QHSE 5.24, mineral hydraulic oil falls under category 3B, heated fluid flash point >100 ^{o}C.

4.2 Marking

Supplier shall mount a supplier plate and Tank Inspection Regime (TIR) sign to tank:

Supplier plate
The following applies to supplier plates:
Engraved metal plate showing:

- Manufacturer name;
- Construction year;
- Nominal tank volume;
- Liquid used.

Tank Inspection Regime (TIR) sign
The following applies to TIR signs:
A sign in accordance with Tata Steel Standard S1 76 81 01 “marking media carriers” (See also order form for applying markings S1 76 81 01_ENNEX B identification plates).
Tank Inspection Regime sign must contain the following information:

- Tank Identification number from the TIR
- Used hydraulic oil…, used medium
- Volume… m^3

4.3 Heating equipment

Oil should be heated by a flow over a solenoid controlled pressure relief valve within a separate conditioning circuit. Tanks smaller than 500 dm^3 may be heated electrically and carried out without separate conditioning. The power of electric heating elements should be less than 0.75 Watt / cm^2. The heating elements should be installed horizontally above the bottom with enough space for efficient oil circulation.

5. Conditioning

5.1 General

When filling a hydraulic system, the new oil shall always pass a filter before it is allowed to enter the system (tank).

For component selection of conditioning systems see Tata Steel directive R1 42 01 04 “Part 4: Selection of conditioning equipment”.

5.2 Conditioning and prefill pumps

These provide the required output for conditioning the medium and / or for filling the suction lines of main pumps. The following pumps should be used:

- Vane pump (up to 250 L / min);
- Gear pump (up to 90 L / min);
- Worm pumps (from 200 L / min).

Specifications of pump units for conditioning and prefill pumps:

- Pump units must be set up on flexible pump mountings;
- The lowest possible noise production, noise production must be measured and reported (maximum 85 dBa allowed);
- Pump, rotational speed max 1500 rpm;
- When using a gear and vane pump, the pump and electric motor must be connected by means of a lantern piece without a damping ring;
- Electric motor in version B5 (possibly V1) for version with gear pumps or vane pumps, B3 for screw pumps;
- Lantern base mounting with a large opening for visual inspection at the top or one on the sides and a hole for oil leakage at the lowest point (damping ring is not allowed);
- Flexible coupling type: GS, not divisible, provided with splines in the coupling halves;
- With screw pumps, the assembly of E-motor and pump must be attached to a top frame or base plate using the mounting feet of the pump and motor;
- The pump foundation must be equipped with a drip tray;
- Vibration damped setup to fixed world, vibration isolation greater than 80% @ 1000 rpm. and greater than 85% @ 1500 rpm.

Suction side of pump should be marked with the following items, in in sequence seen from the pump:

a) Minimess connection, as close to the pump as possible and as high in the suction as possible;
b) A pipe compensator (suction bellows) make Stenflex type AS1 color code red or similar. Certified according to DIN 4809, fire safety according to EN ISO 15540/15541. The distance between compensator and pump connection should be kept as small as possible;
c) Suction shut-off valve, designed as a ball valve or butterfly valve, provided with a proximity switch in the fully open position, the pump should be prevented from starting up when not fully open.

The discharge side of the pump must be provided with the following items, in sequence seen from the pump:

a) Hydraulic hose or a flexible compensator if the pressure on the discharge side does not exceed 16 bar;
b) Pressure relief valve with the return oil flow through a separate line to the tank;
c) Pressure switch to indicate: hose rupture, closed main pressure line valve and a non-running pump;
d) Shut-off valve in main pressure line, (in-line or on block are both allowed).

5.3 Filter systems

Filter systems shall be designed as follows:

- The components used shall meet the required cleanliness condition. Required cleanliness conditions are stated in Tata Steel standard S1 42 01 01 “Tata Steel IJmuiden Standard Hydraulics”, paragraph 3.6 “Conditioning systems for mineral oil”;
- Filters according to Tata Steel directive R1 42 01 04 “Part 4: Selection of conditioning equipment”;
- Filters and elements must comply with NEN ISO 11170 and ISO 16889; β value 200;
- Low pressure filters (≤25 bar) should be used for: return, conditioning, drain and flushing functions;
- High pressure filters (> 25 bar) must be used for: high pressure lines and pilot lines;
- Filter covers should be placed in such a way that filter elements can be replaced ergonomically / safely. If necessary, a platform is allowed;
- All filters (except aeration filters) must have:
  - Nameplate.
  - Indication of type number, element type and filter fineness.
  - Electrical visual pollution indicator, fitted with plug according to ISO 4400 (min. 0.4 A).
  - Electro-visual pollution indicator with signal suppression at temperatures below 20°C.

5.4 System architecture

Large systems, nominal tank volume ≥ 2000 litres.

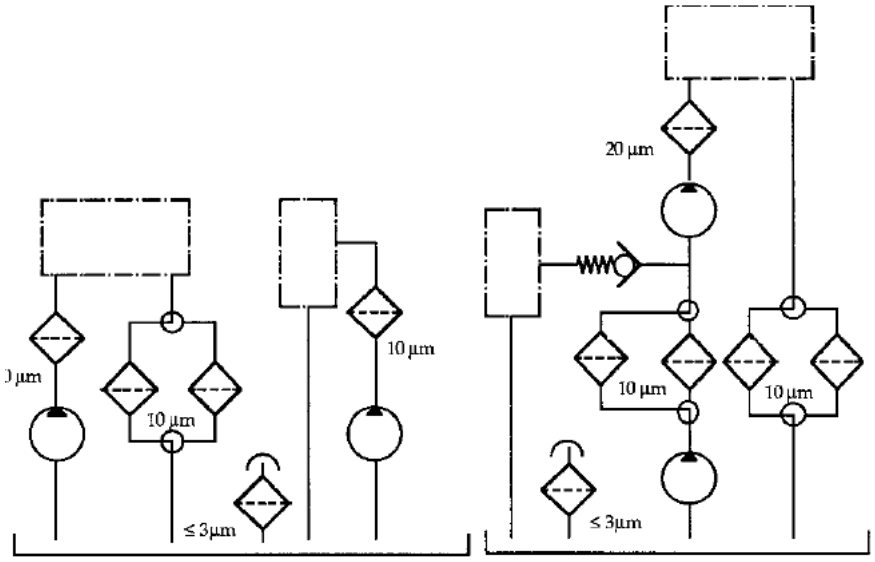


Figure 5-1 Filters in large systems (left) and filters in large systems with prefill pump (right)

These systems should be equipped with:

a.	Return filters:	Location:	In return line
		Type:	Double-switchable LD filter
		Capacity:	Maximum return volume flow
		Filter fineness:	10 microns
b.	Conditioning Filters:	Location:	In pressure pipe of conditioning system (after heating, before cooling)
		Type:	LD filter
		Capacity:	5-15% of nominal tank volume in dm3 / min *
		Filter fineness:	3 micron *

* Capacity of the conditioning system depends on ambient temperature, flow rate volume, environmental conditions (dirt and temperature), number of cylinders, etc.
When using pre-fill pumps, the pre-fill pump must be used in combination as a pre-fill pump and conditioning pump. The suction line of main pumps should be placed after the conditioning filter, see Figure 5-1 Filters in large systems (left) and filters in large systems with prefill pump (right) .

c.	Main Pressure filters:	Location:	In the discharge line of each pump
		Type:	HD filter
		Capacity:	Equivalent to pump output
		Filter fineness:	20 microns
d.	Aeration filters:	Location:	On the tank
		Type:	LD filter
		Capacity:	Equivalent to maximum possible air volume flow of pendant volume
		Filter fineness:	<3 microns (Filling and venting caps are not permitted).

Small to large systems, nominal tank volume ≥ 500 litres, in which servo valves are installed

See Figure 5-2 Filters in large systems with servo valves (left) and filters in large systems with servo valves and prime pumps (right)

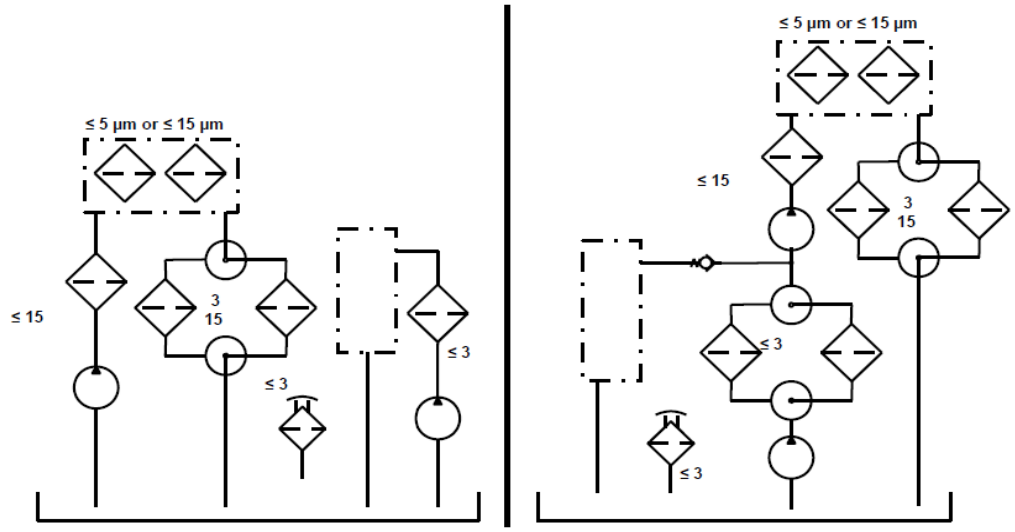


Figure 5-2 Filters in large systems with servo valves (left) and filters in large systems with servo valves and prime pumps (right)

These systems should be equipped with:

Equivalent to "Large systems, nominal tank volume ≥2000 litres" with the exception of pressure filters.
The following applies to the press filters:
When using servo valves with external control pressure:

a. Main Pressure filters:

Location:	in main flow to servo valves (if necessary)
Type:	HD filter
Capacity:	maximum capacity of servo valves
Filter fineness:	<15 microns

b. Press filters:

Location:	in main flow control oil
Type:	HD filter
Capacity:	maximum steering oil flow
Filter fineness:	<5 microns

When using servo valves with an internal control pressure:

a. Press filters:

Location:	In main stream to servo valves
Type:	HD filter
Capacity:	maximum capacity of the servo valves
Filter fineness:	5-15 micron depending on type of servo valve

Small to medium systems nominal tank volume 500-2000 liters in clean environment (see Figure 5-3 Filters in medium and small hydraulic systems)

These systems should be equipped with:
Equivalent to “Large systems, nominal tank volume ≥2000 liters”, where b “Conditioning Filters” is not applicable.

Small to medium systems nominal tank volume 500-2000 liters in dirty environment
See Figure 5-3 Filters in medium and small hydraulic systems

These systems should be equipped with:
Equivalent to “Large systems, nominal tank volume ≥2000 liters”.

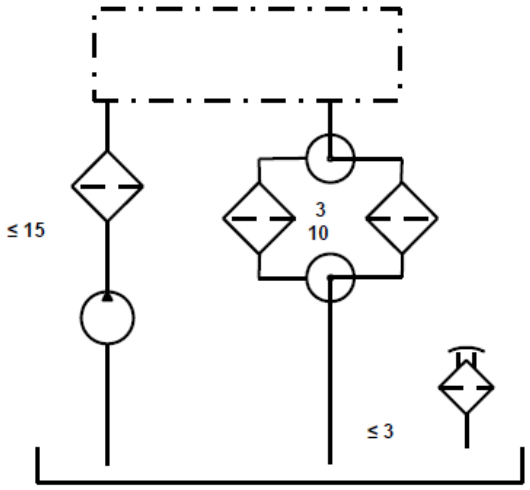


Figure 5-3 Filters in medium and small hydraulic systems

Small systems up to nominal tank volume 500 liters

These systems should be equipped with:

a. Return filters:

Location:	In return line
Type:	Double-switchable LD filter
Capacity:	Maximum return volume flow
Filter fineness:	10 microns

b. Main pressure filters, if critical for business operations:

Location:	In the discharge line of each pump
Type:	HD filter
Capacity:	Equivalent to pump output
Filter fineness:	20 microns

Filling and venting caps are permitted.

Small systems up to nominal tank volume 500 litres, in which servo valves are installed

These systems should be equipped with:

Similar to “Small systems up to nominal tank volume 500” with the exception of the pressure filter (s). The same exception applies to this as mentioned under “Large system with a nominal tank volume ≥ 2000 litres or more, in which servo valves are installed”.

5.5 Low pressure (LD) filters

The capacity of the filter must be calculated with a pressure drop of maximum 0.3 bar across the filter with a clean filter element and a viscosity of 32 cSt.

LD filters (≤25 bar) must be equipped with:

- By-pass valve;
- Drain option;
- Non-pressure resistant filter elements with synthetic (plastic or glass fiber) filter material;
- With switchable filters; Three-way valve with negative overlap and pressure compensation line;
- Non-return valve in the outgoing line to prevent oil backflow.

LD filters may be designed as a tank top filter.

5.6 High pressure (HD) filters

Capacity of the filter must be calculated with a pressure drop of maximum 1.5 bar across the filter with a clean filter element and a viscosity of 32 cSt.

HD filters (> 25 bar) must be equipped with:

- No by-pass valve;
- Drain option;
- Pressure-resistant filter elements of at least 210 bar, with synthetic (plastic or glass fiber) filter material;
- With switchable filters; Three-way valve with negative overlap and pressure compensation line;
- Non-return valve in the outgoing line to prevent oil backflow.

5.7 Aerators, fill filters and air dryers

Tanks should always be equipped with aerators and air dryers. The capacity must be adjusted to the maximum expected air shuttle volume. When using a dryer, an aeration filter must be placed between the dryer and the tank (in series with the dryer), i.e. an air filter in series with the dryer. Combined air dryers / filters in one housing are allowed.

6. Cooling systems

6.1 General

For component selection of conditioning systems see Tata Steel directive R1 42 01 04 “Part 4: Selection of conditioning equipment”.

6.2 Selection of cooling systems

Cooling systems must be equipped with oil / water coolers. If this is not possible, oil / air coolers should be used. Use of oil / air coolers is only permitted after written permission from a Tata Steel project engineer hydraulics.

Coolers must be equipped with:

- Pre-tensioned by-pass valve to prevent overpressure (bumps) in cooler;
- Possibility to be switched during operating situation.

When using oil-water coolers:

- With single-wall plate coolers, the water pressure must be higher than the oil pressure;
- In the case of single-wall plate coolers, a water sensor must be fitted in the oil return line after the cooler;
- With single-wall plate cooler system, a water guard must be provided at the lowest position near the tank;
- A water inlet temperature of 28 ° C should be used as a design principle;
- Water flow must be regulated by means of an electrically or pneumatically controlled open / close valve, placed in the discharge of cooling water. This valve must be provided with a by-pass valve;
- Cooling water system to be provided with a water filter in supply to cooler, with a fineness of 0.1 mm.

When using oil-air coolers:

- Noise level of the fan must not be higher than permitted in an environment where the cooler is placed;
- As a design starting point an air inlet temperature of 30 ° C should be used, or the maximum ambient temperature occurring on site if this is higher than 30 ° C;
- Controls to be designed in such a way that cooling fan runs for at least 5 minutes per 24 hours;
- Starting and stopping of the fan to be controlled by a temperature switch;
- Oil to flow through cooler only if cooling is necessary.

7. Valve cabinet, valve tables and manifold blocks

7.1 Components on valve tables

Valves should be mounted on manifold blocks. Manifold blocks should be grouped on valve tables. Tables must be made of UNP or thick-walled square hollow sections and be provided with base plates for anchoring. Tables must be preserved according to Tata Steel standard S3 10 56 01 “Corrosion control by preservation”, system T01 pre-treatment S01.

The table must be equipped with an oil collector on a slope (1: 100), mounted under manifold blocks. At the lowest point, the collection tray must be equipped with a horizontal drain containing a stopper plug. It must be possible to place a container or bucket under the drain.

Sequence of valves on valve tables must be the same as the spatial arrangement of machines.

Electro-Hydraulic pilot operated valves must be actuated with external control pressure. Control pressure must be achieved centrally by means of a pressure reducing valve or a separate control oil system.

It is allowed a maximum of 4 valves to be placed on top of each other by means of one screw connection. When stacking more than 4 valves, intermediate blocks must be used. See Figure 7-1 Module or intermediate block alongside (separate bolted).

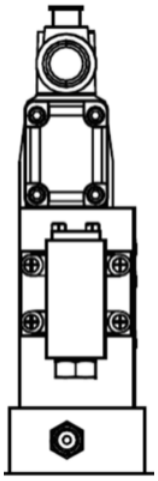


Figure 7-1 Module or intermediate block

Valve tables must be fitted with approved lifting points, taking into account that the lifting straps cannot touch components during lifting. See Tata Steel standard S1 79 00 02 “Hoisting chain and eye bolts and eye nuts”.

Manifold blocks must be provided with component identification tags and Valve stacks with actuator name plates (in Dutch). These plates must be placed with glue and rivets. Plates must be made of durable material.

Designs must be submitted to the Tata Steel hydraulic project engineer for assessment prior to manufacture.

7.2 Valve cabinets

Valve stands should be placed in cabinets. Material choice (stainless steel or steel) and preservation depends on local circumstances and requires written permission from a Tata Steel project engineer hydraulics. Enclosures must be IP55 in terms of dust and spray protection.

Components in cabinets must be easily accessible through robust doors of sufficient size. Doors must be lockable with robust toggle latches and a padlock (diameter 10mm). Door hinges are provided with lubrication points and doors have a name plate with cabinet coding on it.

P, T, X and Y pipe transits must be spray-proof (IP65) and run through the left or right side of the enclosure cabinet wall. A and B pipes > 30mm must run through the cabinet wall by means of a pipe manifold block, provided with flange connections.
Pipes P, X, A and B must be fitted with ball valves. Ball valve for P must be located on the outside of the cabinet, other ball valves must be located in the cabinet. Measuring points must be provided before and after ball valves. Valves are provided with nameplate with function title and component number.

T and Y pipes must be fitted with non-return valves and measuring points on both sides of the valve.

For components heavier than 15 kg and for accumulators, a lifting bracket must be provided inside the cabinet. It should be easy to disassemble an accumulator without disassembling installation parts such as pipes and cables. There must be LED lighting and a wall socket in the cabinet (220VAC). Cables to components are connected to a terminal block in a ROSE electrical connection box. Cables are oil resistant and fitted with a molded plug with LED indication and cable numbers.

In the cabinet there shall be a plastic schematic holder format A3 with a plasticized schematic and instruction drawings. A separate pressure gauge with measuring hose is mounted on the back wall of the cabinet. The cabinet must be provided with lifting points (eye bolts) on the outside.

The construction and foundation of valve tables and cabinets must be sufficiently stable to withstand the transfer of forces on the connecting lines.

7.3 Valves and / or control valves

All valves must have a type plate with the following information:

- manufacturer;
- type;
- symbol (gives a correct picture of the function of the valve);
- nominal pressure in bar;
- production and / or serial number.

7.4 Pilot pressure operated valves

Electric-hydraulic pilot operated valves should be provided with external pilot pressure and external drain ports (X and Y connections). Control pressure must be a reduced pressure of 25 bar.

7.5 Solenoid coils

Electro-hydraulic valves must be equipped with:

- In oil switching magnets that are suitable for 100% duty cycle;
- Solenoid voltage 24VDC;

In safety functions, emergency manual switch/lever on the valves is only permitted if, incorrect use can be prevented, they are provided with a cover that can only be removed with a special tool or wrench (in case the removal of the cover is made impossible by the use of a padlock)

7.6 Proportional valves

In the case of proportional valves with external electronics, the solenoids must be controlled by means of the corresponding electrical amplifier made by Bosch Rexroth, type VT-MSPA-2-2x / A5 / 000/000, controlled with Sollwert module made by Bosch Rexroth, type VT-SWMA-1- 1-1x 002, built into standard control cabinet according to Tata Steel drawings H17142 (for 2 valves) and H17143 (for 4 valves). If more than 4 valves are used, the control cabinet must be constructed in the same way as the cabinets according to the above mentioned drawings.

For proportional valves with internal electronics, the version with a 24 VDC supply voltage and control signal 4-20 mA must be used.

For the purpose of troubleshooting, a tool for manual control must be provided in order to electrically control the valve(s) manually, without using the normal PLC control. The manual control tool must be equipped with a power supply and control signal to enable the movement to take place at low speed*. This manual control tool must be placed in such a way that the movement is visible when operating.

*Low speed refers to the normal low speed level of the installation.

8. Manifold blocks

8.1 General

Manifold blocks must be constructed so that valves are mounted on top. Measuring points should be on the front or top. Exceptionally on left or right side. Piping connections are located on the rear, front, left, or right side. Small single valves (for example control valve up to NW 16, pressure valves up to NG25, controlled non-return valves up to NG 32) may be mounted on the front of a mounting block, see Figure 8-1.

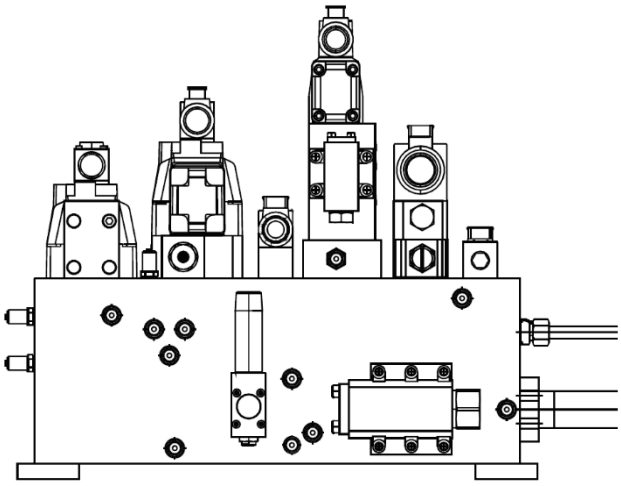


Figure 8-1 - Sample mounting block design

All components, including pipe connections and flanges, must be easily accessible and easy to disassemble. There must be sufficient space between components to make this possible. Valves must be replaceable with equivalent prescribed types from other manufacturers. Free space between valves is at least 20 mm. Components should be clustered on one block as much as possible. Mounting blocks should be made of steel.

Manifold blocks should be designed with Hydroman or a similar CAD program. Block design must be submitted for assessment to the involved Tata Steel project engineer hydraulics. Production of manifold blocks is only allowed after written approval from a Tata Steel project engineer hydraulics.

For checking, the complete manifold block design by Tata Steel project engineer must be hydraulically verifiable by means of drawings and / or 3D design.

Minimum wall thickness between ducts should be at least 5 mm for a diameter of 5-10 mm, at least 10 mm for a diameter of 10-60 mm and at least 15 mm for a diameter greater than 60 mm. For wall thickness between ducts and surfaces, a factor of 2 should be applied (10/20/30 mm).

Manifold block repairs are not allowed!

For sealing open bores, plugs must be used as prescribed in directive R1 42 01 08 “Selection of piping” section 8.11, table 8.34. All blind plugs must be fully visible and immediately demountable. The use of expanders is not allowed.

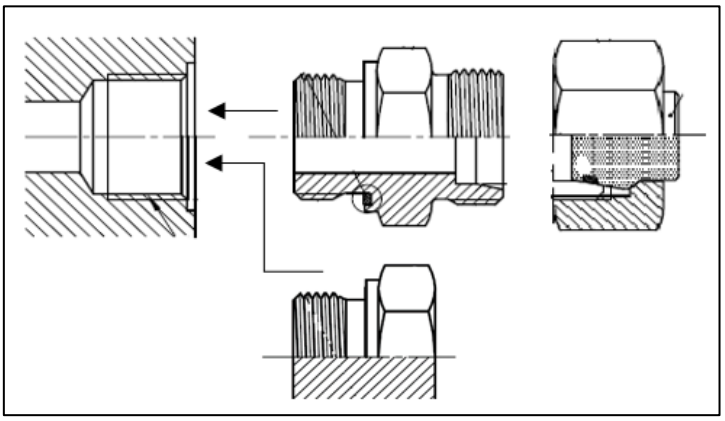


Figure 8-2 Sealing ports on manifold 1

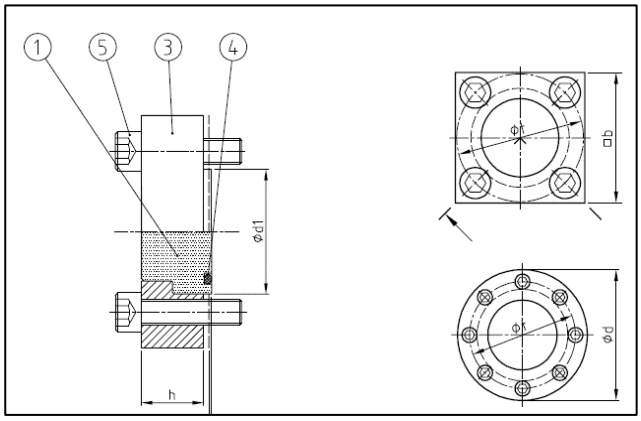


Figure 8-3 Sealing ports on manifold 2

A special (non-standard) intermediate plate / module block under a valve is only allowed after written permission from a Tata Steel hydraulic project engineer. Module blocks must have their own mounting bolts and shall not be mounted with extra-long mounting bolts from overhead valves. Bolts shall be made metrically and according to EN ISO 898-1.

Pipe connections and measuring points on manifold blocks must be provided with a engraved coding on the block and a glued & nailed resopal plate. This coding must be the same as coding on schematic.

8.2 Thread holes

Distinction between threaded holes:

- For the construction of components;
- For port connections on flat surfaces (general application);
- For port connections (if no flat surface is available).

Thread holes must be from the original thread cut. Re-tapping the workpiece can cause symmetrical inconsistencies and is not allowed.

Threaded holes with metric threads for fixing hydraulic components ISO 216

Table 1 - Thread dimensions and manufacturing requirements, metric thread

Metric thread	Thread pitch [mm]	Drill depth t ± 1 [mm]	Thread depth b ± 1 [mm]
M6	1.0	18	10
M8	1.25	25	15
M10	1.5	31	20
M12	1.75	35	22
M14	2.0	40	25
M16	2.0	45	30
M18	2.5	50	32
M20	2.5	53	35
M24	3.0	66	45
M27	3.0	69	48
M30	3.5	74	50

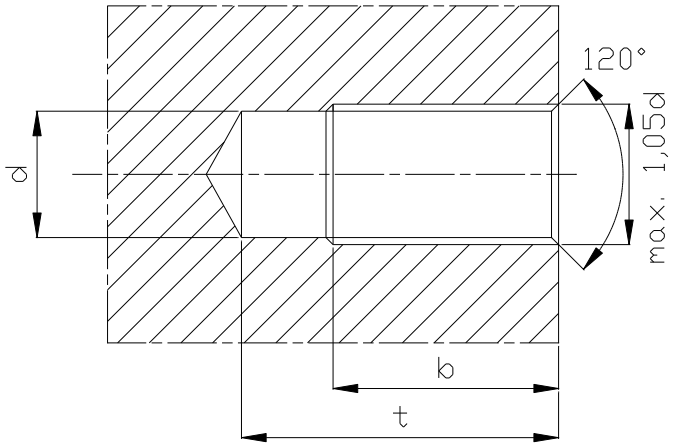


Figure 8-4 - Threaded holes, metric thread

Countersunk screw holes for parts that are provided with BSP male thread and soft seal before mounting in the block according to (designed according to DIN 3852 part 2 form X / DIN EN ISO 1179-2).
This design should **only** be used when flat mounting surfaces are not available.

Special attention should be paid to the squareness of the threads (> 0.05 mm) and the concentricity of the thread and the thread inlet (> 0.1 mm).

Table 2 - Thread dimensions and manufacturing requirements, BSP thread

Minimum drill [mm]	External pipe Diam. [mm]	Thread Pipe [inch]	Wire insert BSP [mm]		Minimum thread depth [mm]	Minimal drill depth [mm]
D.		d1	d7	toll.	b1	t1
4	6	1/8 "	9.8		8	13
5	8	1/4 "	13.2	+ 0.2	12	18.5
7	12	3/8 "	16.7	- 0	12	18.5
12	16	1/2 "	21		14	22
16	20	3/4 "	26.5		16	24
20	25	1 "	33.3	+ 0.3	18	27
25	30	1 1/4 "	42	- 0	20	29
32	38	1 1/2 "	47.9		22	31

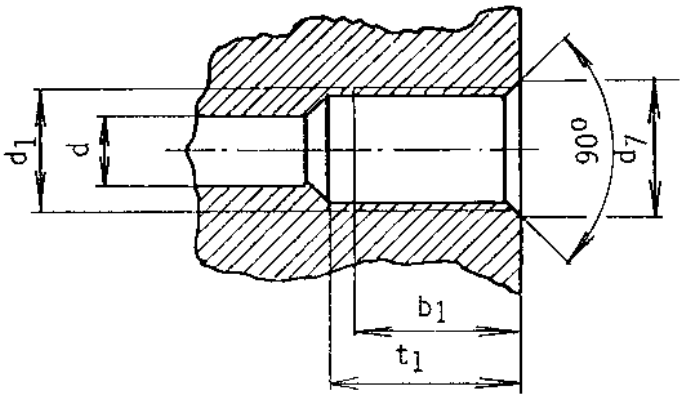


Figure 8-5 Threaded holes, BSP thread

Countersunk screw holes for parts which are provided with BSP male thread and soft seal before mounting in the block according to ((designed according to DIN 3852 part 2 form X / DIN EN ISO 1179-2)

This design should **only** be used if ground mounting surfaces are not available.

Special attention should be paid to the squareness of the threads (> 0.05 mm) and the concentricity of the thread and the thread inlet (> 0.1 mm).

Table 3 - Thread dimensions and manufacturing requirements, countersunk plugs

Minimum drill [mm]	External Diameter [mm]	Screw-thread pipe [inch]	Wire Bet piece BSP [mm]		Min. Wire depth [mm]	Min. drill depth [mm]	Countersunk [mm]	
d		d1	d7	toll.	b1	t1	d4	toll.
4	6	1/8 "	9.8		8	13	19	
5	8	1/4 "	13.2	+0.2 - 0	12	18.5	25	
8	12	3/8 "	16.7		12	18.5	28	
12	16	1/2 "	21		14	22	34	+0.4 - 0
15	20	3/4 "	26.5		16	24	42	
19	25	1 "	33.3	+0.3 - 0	18	27	47	
22	30	1 1/4 "	42		20	29	58	

Note:

- For pipe diameter 38 use standard flange connection;
- The depth of the cavity deviates from DIN 3852 / ISO 1179-2.

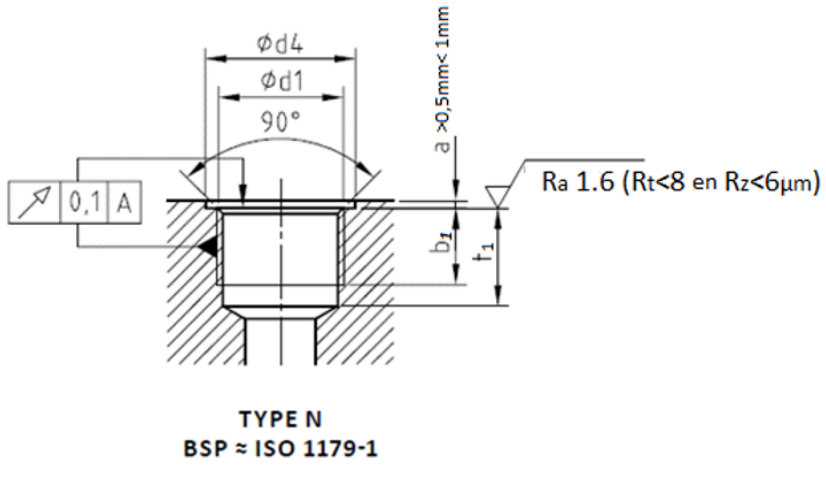


Figure 8-6 - Threaded holes with recessed plugs

8.3 Material specifications and processing instructions

Material

Manifold blocks should be made from materials listed in the table below.

Table 4 - Materials for manifolds

Material	Active ingredient	Norm	Product	Delivery condition
C22E	1.1151	EN 10083-2	Rolled steel	Normally annealed
S355J2 + N	1.0577	EN 10025-2	Rolled steel	Normally annealed
S355J2G3 + N	1.0570	EN 10250-2	Forged steel	Normally annealed
HYT 60	-	EN 10250-2	Forged steel	Normally annealed
P355GH + N	1.0473	EN 10028-2	Rolled steel	Normally annealed

Alternative materials are only allowed after written permission from the Tata Steel project engineer hydraulics

Material requirements for alternatives are:

- Delivery with 3.1 certificate according to EN 10204;
- Minimum yield strength: 235 MPa;
- Minimum tensile strength: 412 MPa;
- Delivery condition: Normally annealed;
- Minimum impact value: 23 J at 20°C;
- Ultrasonic examination according to Table 5 - Standards for materials and ultrasonic inspection.

Table 5 - Standards for materials and ultrasonic inspection

Material	Production method	Material norm	Ultrasonic norm	Level
Steel	Rolled	EN 10025	EN 10160	S2-E2
Steel	Forged	EN 10250	EN 10228-3	2

Surface condition

Processing of sealing surfaces:

- Valves: grinding
- Flanges: grinding
- Couplings and plugs: grinding and / or boring

Roughness requirements (according to ISO 1302)

Sharpen: R_a: 0.4 µm (Rt <3 µm or Rz <2.5 µm)
Boring: R_a: 1.6 µm (Rt <8 µm or Rz <6 µm)

Thread hole machining

Roughness Ra: 3.2 µm (Rt <16 µm or Rz <12 µm)

Processing of other surfaces and boreholes
Roughness Ra: 6.3 µm (Rt <32 µm or Rz <12 µm)

Basic length ("measuring length probe"), values of the parameter measurement probe, see Dutch practice directive 3638.
Ra <3.2 µm: 0.8 mm
Ra> 3.2 µm: 2.5 mm

General accuracy requirements
Flatness of the connection surfaces:
0.01 mm per 100 mm length.

Squareness of screw thread
90° angle threads on surfaces.
Perpendicularity <0.05 mm.

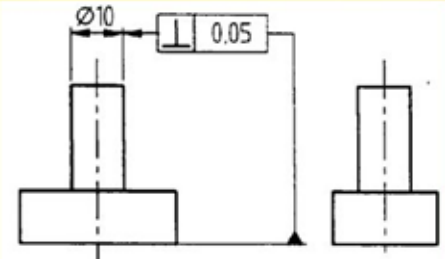
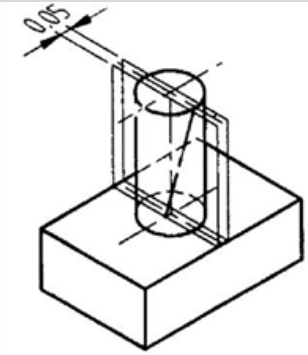
Tolerance indication on drawing	Tolerance zone	Statement
		The centerline of the cylinder should be in one direction perpendicular to the bottom surface. If a diameter sign is placed in front of the tolerance value, then it means that the perpendicularity is for all directions

Figure 8-7 - Tolerance on drawing

Figure 8-8 - Tolerance zone

Tolerances
General tolerances: ± 0.5 mm.
Precision of the location of the holes in the drilling pattern for the components: ± 0.2 mm.
Diameter of the boreholes: ± 0.1 mm or ± 1% for depth <5d, ± 2% for depth >5d.
Drilling depth ±1 mm.

Finish
- Round off sharp edges with a radius of 3 mm.
- Carefully clean manifold blocks internally and externally after machine treatment.

Delivery conditions
- Treated surfaces must be protected against corrosion, contamination and damage during storage and / or transport.
- Open holes shall be plugged with metallic plugs and / or equivalent sealing plate with soft rubber seal or blind flange.

Concepts and definitions
For roughness values: see ISO 1302.
For shape and placement tolerances: see NEN-ISO 2768.

8.4 Corrosion control of mounting blocks

Mounting manifold blocks should be protected against corrosion with oil resistant paint or chemically applied zinc. Chemical blackening and / or nickel plating is also allowed. Fe / Zn 12 / F according to NEN 12329 and other corrosion protections are only permitted after written permission from the Tata Steel project engineer hydraulics.

9. Cylinders

9.1 General

Tata Steel IJmuiden belongs to the heavy industry. Cylinders are exposed to harsh conditions, must have a high operational reliability and a long service life.

Standard cylinders must be used, as prescribed in Tata Steel directive R1 42 01 06 “Part 6: Selection of cylinders and hydraulic motors”.
If Tata Steel standard cylinders are impossible, “special cylinders” must be used. “Special cylinders” are only allowed after written permission from the Tata Steel project engineer hydraulics.

For each “special cylinder” a complete drawing package and maintenance instruction must be supplied, suitable for maintenance purposes.

Technical calculations for “special cylinders” must be submitted to Tata Steel for approval. Among other things, yield bore strength, rod buckling, bottom cover (detailed drawing), bolt connections, fastening and rod head must be submitted. In addition, a maintenance instruction must be provided for each cylinder with lubrication intervals, inspection points and adjustment data.

For component selection of cylinders see Tata Steel directive R1 42 01 06 “Part 6: Selection of cylinders and hydraulic motors”.

9.2 Design requirements

Cylinders should be designed to maximize service life with special attention to the rod seal. The Tata Steel Engineers are familiar with local conditions and (acting) forces of the installation. In consultation with the supplier, they decide on the choice of rod materials, seals, cylinder attachment points, hydraulic connections, buffering, measuring points, etc.

For cylinder design the following applies:

- Shear forces on cylinders are not allowed;
- Cylinder mount equal to MP5, MT4 and rod end with spherical plain bearing equal to CGAK (ISO6022);
- In a wet environment trunnion bearings must have lubrication points or to be connected to a lubrication system with intermittent lubrication;
- Horizontal or strongly inclined cylinders with a long stroke require special attention because of buckling of the rod under its own weight;
- Trunnion with shrink sleeves on shaft studs;
- Piston rods must be flame hardened;
- Piston rod coating material adapted to local conditions. Minimum requirement: 60 micron Nickel and 40 micron Chrome see Figure 9-1 Minimal piston rod coating. Choice of final coating only allowed after written permission from the Tata Steel project engineer hydraulics;

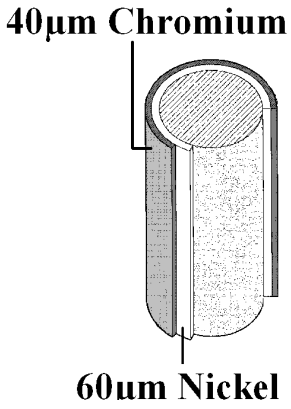


Figure 9-1 Minimal piston rod coating

- Chevron seals;
- Bronze rod bearing;
- Demountable rod eye;
- Roughness of the piston rod and sleeve according to the seal manufacturer's prescribed roughness requirement;
- Maximum piston speed 0.5 m/s;
- Connection cylinder shell to bottom and lid by means of bolts;
- Trunnion screwed to the mantle;
- Trunnion pins provided with central grease holes and a grease nipple on the tap.
- Trunnion tap fitted with shrink-fitted wear sleeves;
- Adjustable buffers on the bottom and rod side;
- Easily accessible stainless steel measuring points (for bleeding) on the bottom and rod side;
- The connection ports for hoses and / or pipes preferably BSP thread, in connection with the standardized hoses with DKOS coupling ISO 8434-2;
- Connections larger than 1 ½" BSP with flange connection pattern FS1 or FSP1 according to ISO 6162-1 2002 up to 35MPa or ISO 6162-2 from 35Mpa. Fitted with metric screws 8.8 or 10.9 with washer;
- O-rings with support ring;
- Minimess measuring couplings made of stainless steel;
- The method of locking the nut on the piston rod using a locking pin as shown in below Figure 9-2 Nut locking. After installation, glue the locking pin with loctite or tack weld.

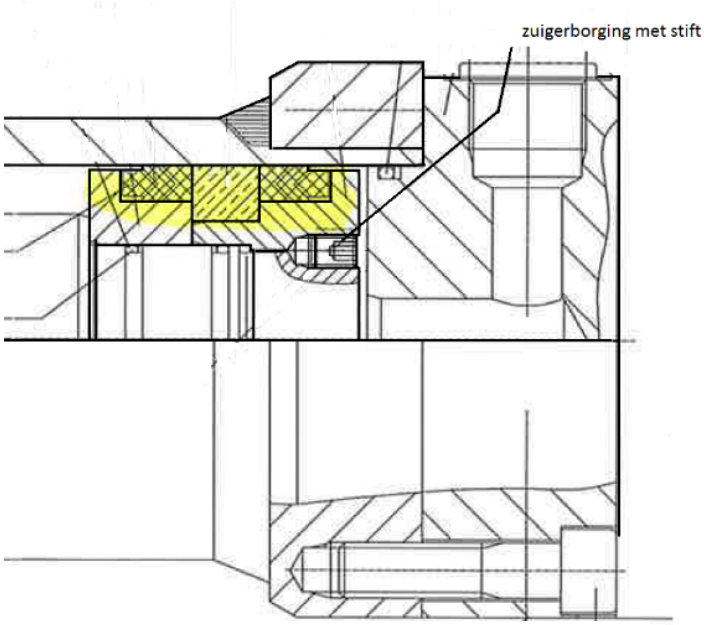


Figure 9-2 Nut locking

9.3 Quality control and assurance

All parts must be cleaned prior to installation. No dirt must remain in the cylinder during installation. Each cylinder should be tested, with clean oil ISO4406: 1999 cleanliness 16/14/12, with a pressure of 1.5x design pressure and a motion test with special attention to stick slip.
Results must be recorded in a report with pressure graphs. The manufacturer invites a Tata Steel QA / QC responsible engineer to test the finished cylinder.

The manufacturer must create and deliver a construction file/report to Tata Steel containing:

- calculations;
- drawings and parts lists;
- documentation of the used seals and other purchase parts;
- materials used with 3.1 certificates;
- welding method qualification;
- welders qualifications.

The dimensions, processing and tolerances must be checked according to the drawing and must be measured again by the manufacturer and supplied as a measurement report.

Test procedure for not standard cylinders
Every non-standard cylinder undergoes a factory acceptance test in which the cylinder on the rod side is loaded up to 2x the working pressure or the design pressure. During the acceptance test, the cylinder is moved back and forth several times to remove all the air from the cylinder, at low pressure (eliminating the danger of diesel effect).

The seals are tested by placing the cylinder in the middle position and then closing ball valve 2, see Figure 9-3 Cylinder test schedule.

The pressure is increased by increasing the rod side pressure to the design pressure.

At this pressure, ball valve 1 is closed and control valve 6 is moved to the middle position.

The pressure shall be measured and recorded at measuring points 3 and 4 for 10 minutes.

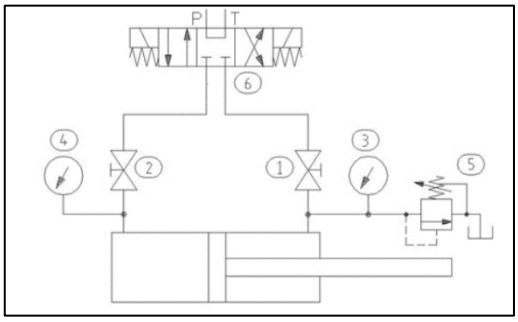


Figure 9-3 Cylinder test schedule

9.4 Delivery conditions

Cylinders must be internally clean for delivery and secured in a specially constructed box that protects the cylinder against transport damage. The cylinder must be delivered with the piston rod retracted.

All cylinder connections must be closed for shipping and storage. This must be carried out with a metallic plug or blind flange and a soft seal.

When storing the cylinder as a spare part, the cylinder with the piston rod retracted must be filled with 90% hydraulic oil and 10% nitrogen.

The cylinder must be preserved on the outside in such a way that it provides protection against corrosion for at least 15 years. See Tata Steel Standard coating system T01, pretreatment S01 Tata Standard S3105601.

10. Hydromotors

10.1 General

The selection of hydraulic motors should always be done in consultation with the Tata Steel project engineer hydraulics.

For hydraulic motors with a displacement volume greater than 1000 cc, which are used in an installation that is in operation 24 hours a day, a lifetime calculation must be made and submitted for approval to the Tata Steel project engineer hydraulics.

For hydraulic motors with a displacement volume between 1000 and 13,500 cc/rev, the required service life shall at least be 50,000 clock hours, for larger hydraulic motors or hydraulic motors that drive a process-critical installation / installation part, 100,000 clock hours.

Filter

Leakage oil connections of hydraulic motors must be equipped with a low pressure filter with electric-visual contamination indicator and by-pass valve. Switching value of the contamination indicator and opening pressure of the by-pass valve must not exceed the maximum housing pressure of the hydraulic motor.

Sizing of the filter shall be based on the normal leakage oil flow of the hydraulic motor at the given load and expected oil viscosity at cold start.

11. Measurement, regulation and control equipment

11.1 General

In hydraulic systems, a number of physical quantities must be monitored for control and monitoring (for example: pressure, temperature, flow and liquid level). These quantities must be converted into electrical signals by means of switches and sensors.

For component selection of measuring, regulating and control equipment see Tata Steel directive R1 42 01 07 “Part 7: Selection of measuring, regulating and control equipment”.

11.2 Scope and application

The observation of physical quantities in hydraulic systems is necessary because of:

Display of normal operating conditions.
For example:

- Control pressure;
- Availability of the system;
- Safe shutdown of system or subsystem.

Signals of deviations from normal operating condition.
For example:

- Tank level low;
- Oil temperature too high;
- Accumulator fluid level high or low;
- Accumulator pre-fill pressure low or high.

Control of certain sub-systems.
For example for switching on or off:

- Coolers;
- Filling pumps;
- Pressure (de) activation of pumps, pressurizing / pressurizing.

Disconnecting (sub) systems or switching on emergency systems for the protection of people and installation.
For example:

- Oil temperature too high;
- Tank level too low;
- Pressure too low (leakage / hose rupture);
- Release of emergency accumulator volume for automatic shutdown.

Visualizing the physical quantities to guarantee proper operation and maintenance. (e.g. with pressure measuring points)

11.3 Installation method of mechanical contacts and sensors

Sensors must be used with normally closed position (normally closed is fail safe). In this way "fail safe" electrical circuits are created, interruption of the circuit becomes immediately visible.

Sensors must be electrically powered separately and provided with emergency power supply.

Under no circumstances should a hydraulic power-off influence the electric power supply of sensors.

Overview of components
The part of measuring, regulating and control equipment deals with the following components:

- Pressure measurement (mechanical and electronic);
- Pressure gauges;
- Temperature measurement (mechanical and electronic);
- Thermometers;
- Liquid level measurement (mechanical and electronic);
- Water in oil signaling.

11.4 Pressure measurement

Pressure measurement in hydraulic systems should be used for the following situations:

Rapid determination of the prevailing pressure during commissioning and troubleshooting.
Permanently connected pressure gauges should be used if a continuous reading is necessary, such as at accumulator stations.

Determination of desired pressure levels or exceedances.
Necessary components must be connected to an additional measuring point of the system via a measuring coupling and minimess hose. With exception it is allowed to connect sensors directly on measuring couplings if a fast response time is required.

Generate an electrical analog signal proportional to a given pressure.
To be used in closed loop control for pressure or force control or for remote analog reading. For this purpose, pressure sensors or pressure switches with an analog output must be used.

Attenuation of pressure signals
Pressure measurements should be damped hydraulically. This must be realized by means of a measuring hose of at least 1m. Any excess length should be tied up properly. Short-term overshoots or undershoots can lead to unintentional control intervention or incorrect signaling. Programming delay is allowed for this (for example filter contamination signaling).

11.5 Temperature measurement

It must be possible to visually verify oil temperature on site by means of a thermometer or readout on the temperature switch.

12. Piping systems, shut-off valves and connections

12.1 General

This section describes requirements for material, assembly, mounting and finishing of pipe systems determined for hydraulic systems.

For component selection see Tata Steel directive R1 42 01 08 “Part 8: Selection of pipework”.

Shut-off valves
For an overview of shut-off valves that can be used in hydraulic applications, see Table 16 Selection table of shut-off valves and see Table 17 Selection table for pipes, pipe connections and other components.

12.2 Flow rates

For hydraulic systems the following “Table 6 - Flow rates" applicable. Maximum permissible flow velocities are indicated per pipe function.

Pipe design should not have negative consequences for functional requirements such as speed, force and dynamic behaviour.

Table 6 - Flow rates

Pipe function	Max. speed [m/s]	Comment
Suction pipe	0.5	for adjustable pumps
	0.8	For fixed pumps (depending on the inlet pressure and pump type)
Return line	2	
Drain line	1	
Pressure / function lines	5	Pipe diameter ≤ 30 x 4 mm
	4	Pipe diameter ≥ 38 x 5 mm

12.3 Testing

Hydraulic lines/piping should be tested on strength with a test pressure of 1.43 x design pressure. Testing must be carried out in accordance with Tata Steel standard S1 47 40 01 “General requirements for testing pipe systems”, and template Excel S1 47 40 01 “template test report” for the recording.

X-rays is the required NDT application.

12.4 Drain and vent

It must be possible to drain/bleed pipes at the lowest point and to (air) vent / aerate at the highest point.

12.5 Connections

High pressure pipe connections up to 315 bar must be carried out in accordance with *Table 7 - High pressure PN 250 & 315*

Table 7 - High pressure PN 250 & 315

<table>
<tr><th rowspan="2">Pipe [mm]</th><th rowspan="2">Hose with coupling (24° taper) [“]</th><th colspan="2">Connecting element</th><th rowspan="2">Shut off valves</th></tr>
<tr><th>Pipe – Pipe</th><th>Pipe – Block</th></tr>
<tr><td>12x2</td><td>1/4</td><td colspan="2" rowspan="6">Welding couplings with 24° taper according to R1 42 01 08 paragraph 8.11.
(Or Walterscheid Walform plus / Vossform sqr after agreement of Tata Steel project engineer hydraulics)</td><td rowspan="6">Connection 24° taper see R1 42 01 08, paragraph 8.6</td></tr>
<tr><td>16x2</td><td>3/8</td></tr>
<tr><td>20x2.5</td><td>1/2</td></tr>
<tr><td>25x3</td><td>5/8</td></tr>
<tr><td>30x4</td><td>1</td></tr>
<tr><td>38x5</td><td>1 (2x)</td></tr>
<tr><td>48.3x6.3</td><td rowspan="4"></td><td colspan="2" rowspan="4">Flanges according to Tata Steel drawing 697575 (or Avit FA/FK serie 3 according ISO 6164 after agreement of Tata Steel project engineer hydraulics)</td><td rowspan="4">Flange connection see R1 42 01 08, paragraph 8.6.</td></tr>
<tr><td>60.3x8.0</td></tr>
<tr><td>76.1x10.0</td></tr>
<tr><td>101.6x14.2</td></tr>
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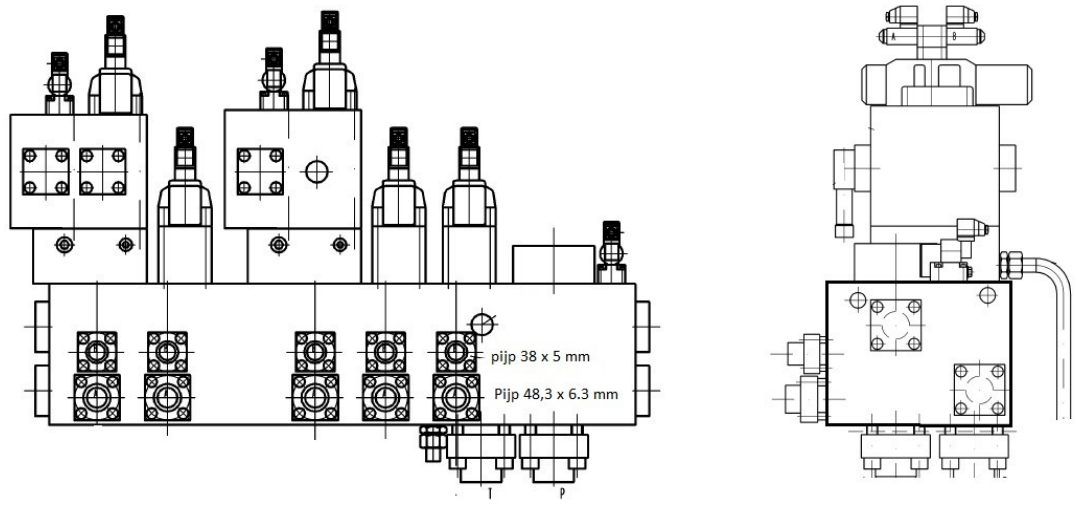


Figure 12-1 Flange connections OD 38 and larger

Low pressure pipe connections up to 16 bar must be carried out according to Table 8 - Low pressure up to PN 16.

Table 8 - Low pressure up to PN 16

<table>
<tr><th rowspan="2">Pipe [mm]</th><th rowspan="2">Hose with coupling (24° taper) [“]</th><th colspan="2">Connecting element</th><th rowspan="2">Shut off valves</th></tr>
<tr><th>Pipe – Pipe</th><th>Pipe – Block</th></tr>
<tr><td>8x1.5</td><td></td><td colspan="2" rowspan="7">Welding couplings with 24° taper according to R1 42 01 08 paragraph 8.11.
Or Walterscheid Walform plus / Vossform sqr (after agreement of Tata Steel project engineer hydraulics)</td><td rowspan="7">Connection 24° taper see R1 42 01 08, paragraph 8.6</td></tr>
<tr><td>12x2</td><td>1/4</td></tr>
<tr><td>16x2</td><td>3/8</td></tr>
<tr><td>20x2.5</td><td>1/2</td></tr>
<tr><td>25x3</td><td>5/8</td></tr>
<tr><td>30x4</td><td>1</td></tr>
<tr><td>38x5</td><td>1 (2x)</td></tr>
<tr><td>48.3x2.6</td><td rowspan="9"></td><td rowspan="9">Round flange according to DIN 2633</td><td rowspan="9">Square flange according to Tata Steel drawing 697576, round flange according to DIN 2633

(or SAE 3000PSI after agreement of Tata Steel project engineer hydraulics)</td><td rowspan="9">Flange connection see R1 42 01 08, paragraph 8.6.</td></tr>
<tr><td>60.3x2.9</td></tr>
<tr><td>76.1x2.9</td></tr>
<tr><td>88.9x3.2</td></tr>
<tr><td>101.6x3.6</td></tr>
<tr><td>114.3x3.6</td></tr>
<tr><td>139.7x3.6</td></tr>
<tr><td>168.3x4.5</td></tr>
<tr><td>219.1x5.9</td></tr>
</table>

Special designs

- In exceptional situations, reshapes such as Walterscheid Walform Plus or Vossform sqr are allowed after written permission from Tata Steel project engineer hydraulics.
- In exceptional situations, sleeves are according to Figure 12-2 permitted after written permission from Tata Steel project engineer hydraulics.
  As directives apply:
  - for P power lines: P-max. (static) maximum 250 bar
  - for A and B power lines: P-max. (dynamic) maximum 160 bar

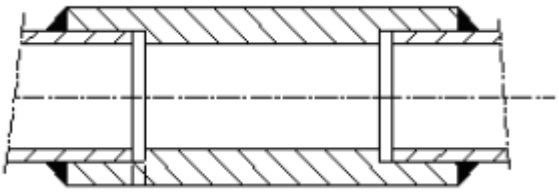


Figure 12-2 - Weld sleeve

12.6 General piping (steel and stainless steel)

See piping specification (pipe spec):

Table 9 Piping specifications

Name	Material	Pressure
HS16	Hydraulic Steel	16 bar
HS250	Hydraulic Steel	250 bar
HS315	Hydraulic Steel	315 bar
HSS16	Hydraulic Stainless Steel	16 bar
HSS250	Hydraulic Stainless Steel	250 bar
HSS315	Hydraulic Stainless Steel	315 bar

Cooling water pipes

For cooling water pipes see Tata Steel pipe class A010. Cooling water pipe must be provided with flow indicator and 500 µm strainer.

Connections and dimensions of the pipes

For the correct choice of pipe sizes and connections see “Table 7 - High pressure PN 250 & 315315" and "Table 8 - Low pressure up to PN 16”.

When flanges are used in vertically mounted pipelines, the bottom flange should contain the O-ring.

Clamping of pipelines

If water can leak into brackets, the distance between bracket and pipes must be filled with silicone sealant.

12.7 Stainless steel piping

Stainless steel pipework (including connecting parts) must be used to prevent external corrosion.

In a dry corrosive environment welding nipples and swivels must be made of stainless steel, nipples in steel.
In a wet corrosive environment welding nipples, swivels and nipples must be made of stainless steel.
Stainless steel piping and connections that are exposed to chlorine-containing substances must be fully packed in Densoleen, type S10 in combination with primer type HT and finished with Densoleen aluminum foil.

In a dry corrosive environment, valves should be made of stainless steel and nipples made of steel.
In a wet corrosive environment, valves and nipples must be made of stainless steel.

“Never seez pure nickel special®” from Bostik should be used on stainless steel - stainless steel contact surfaces.

12.8 Manufacturing and preservation of pipework

Before, during and after manufacturing, pipes must be plugged to prevent dirt particles from entering. Pipework should be stored in a dry and covered area.

Steel pipework must be preserved in accordance with Tata Steel Standard S3 10 56 01 “Corrosion control by preservation of steel”, system T01 pre-treatment S01.

12.9 Welding regulations

Weldings must be carried out in accordance with Tata Steel standard S1 45 04 01 “Execution and inspection of welding work”.

Butt welds should be checked by X-rays.
Fillet welds should be checked magnetically or by penetration inspection.
All welds (100%) must be visually inspected according to Tata Steel standard S1 474001 General regulations for testing pipe systems, paragraph hydraulics.

Butt welding
All butt weld root seams should be welded using a shielding gas using the TIG method. The butt weld coating can be welded with a covered electrode.

Up to an external pipe diameter of 25 mm, a penetration of max. 0.5 mm is permitted (see Figure 12-3 - Butt weld penetration depth). For larger pipe diameters, a penetration of max. 1 mm is permitted. Butt welds with excessive penetration must be corrected (milled) until permissible penetration is achieved.

Note:
On high pressure pipes, butt welding is allowed only on the pipe to flange connections. On low pressure (PN 16) pipes butt welds are allowed on pipe to flange connections and for pipe to pipe connections.

It must always be possible (after pipeline disassembly) to visually inspect pipelines internally and externally. The supplier must have inspection instruments available, such as an industrial endoscope.

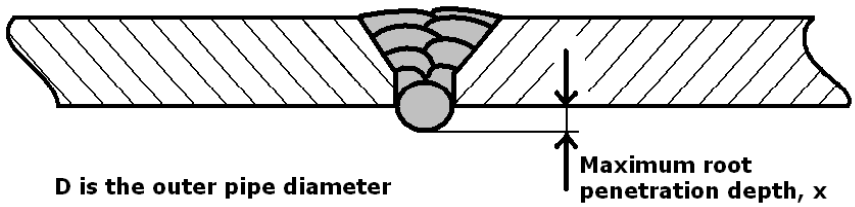


Figure 12-3 - Butt weld penetration depth

Fillet welding with weld sleeves
When using welding sleeves, the following regulations must be applied:

- 0.5 mm free space is required between pipe and welding sleeve, see Figure 12-4 Fillet weld with 0.5 mm clearance;
- Both pipe ends must be cut and deburred at right angles to the center line of the pipe;
- Before welding the welding sleeve, the pipe must be degreased for at least 5 cm on both sides of the weld inside and out.

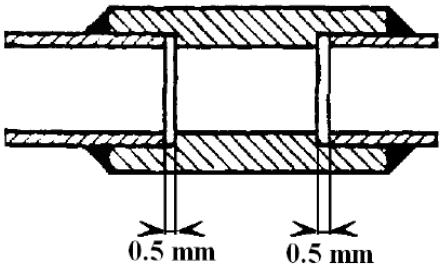


Figure 12-4 Fillet weld with 0.5 mm clearance

See the tables below for the weld dimensions for fillet welds for weld sockets.

Table 10 Weld dimensions for fillet welds for weld sleeves PN250

External Pipe Dimension	z	a
12	2.5	1.8
16	2.5	1.8
20	3	2.1
25	3.5	2.5
30	4.5	3.2
38	5.5	3.9
48.3	7	4.9
60.3	9	6.4
76.1	11	7.8
88.9	13	9.2
101.6	15	10.6

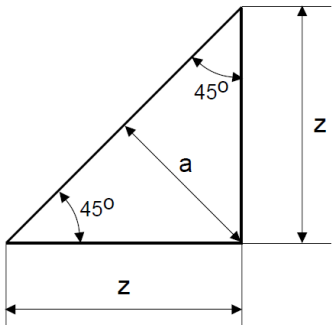


Figure 12-5 z and a size

Table 11 Weld dimensions for fillet welds for weld sleeves PN16

External Pipe Dimension	z	a
48.3	3	2.1
60.3	3	2.1
76.1	3	2.1
88.9	3.5	2.5
101.6	4	2.8

Temporary preservation after welding

For butt welds:
After welding, impurities such as oxides and welding beads must be removed. After the pipes have been thoroughly cleaned, the weld should be treated with preservation oil type Dinitrol 1101 or equivalent. Preservation oil should be applied internally and externally for at least 5 cm on either side of the weld. Preservative oil can be applied by immersion, brushing or spraying. The minimum layer thickness should be 5 to 10 µm.

For fillet welding the following applies:
After both fillet welds of the weld joint have been welded, the weld joints and both sides of the welds (minimum 5 cm on both sides) must be treated with preservation oil type Dinitrol 1101 or an equivalent product. The preservative oil should be applied internally and externally by brush or by spraying.

Pickling and preservation
CORROSION ON PIPES ARISING FROM UNCAREFUL TREATMENT MUST BE RE-PICKLED AND PASSIVATED ACCORDING TO SECTION 12.13

12.10 Pipe clamps and support structures

Pipe brackets must be used according to pipe spec. In corrosive environments, weld plates should be welded all around. When ambient temperature are equal or higher than 90^{o} C, aluminium brackets shall be used. Bolts and cover plates must be galvanized. In extremely corrosive environments, bolts and cover plates must be made of stainless steel. Stacking brackets is not allowed.

Pipe brackets should be placed as close as possible before and after bends. Maximum bracket support distance according to Figure 12-6 and Table 12 below shall not be exceeded.

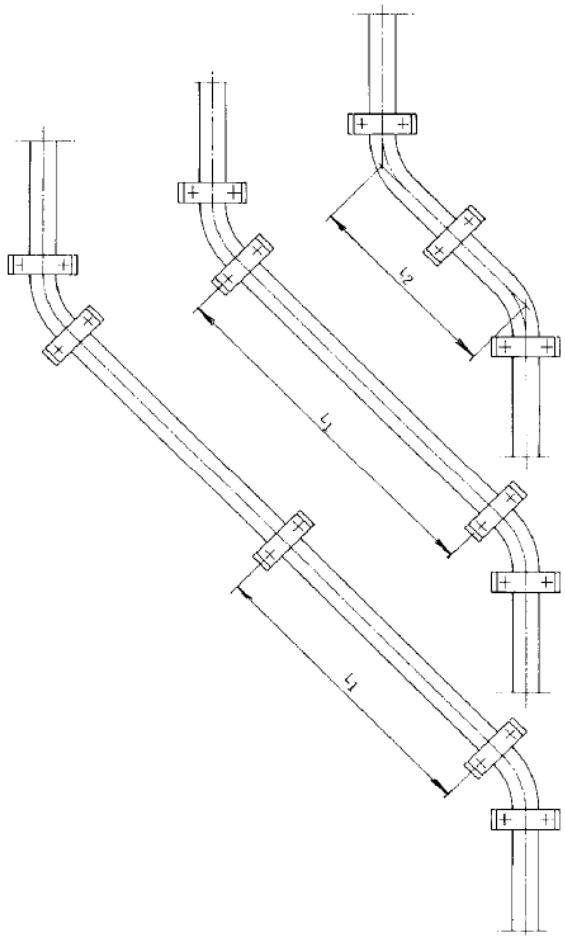


Figure 12-6 - Bracket distances

Table 12 - Maximum allowable bracket distances

Maximum pipe diameter [mm]	Maximum bracket distance [mm]	
	L1	L2
20	1000	750
25 - 48.3	1500	1200
≥ 60.3	2000	1500

Piping routes with an external pipe diameter greater than 38 mm OD must be fitted with pipe supports and welded pipe brackets.

Mounting rails (Stauff series S) also called C-rails are allowed up to and including pipe diameter 38 mm. See Figure 12-7 Mounting rails series S1 as an example.

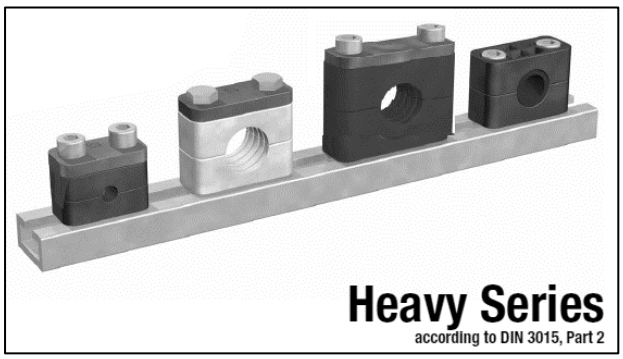


Figure 12-7 Mounting rails series S1

Support rail for pipe brackets must be made of galvanized steel or stainless steel due to corrosion.

12.11 Center distances for pipes

Minimum permitted distance between pipes must comply with the following Table 13 - Distance between pipes. Couplings and / or flanges must be mounted staggered.

Table 13 - Distance between pipes

External pipediameter	10	12	16	20	25	30	38	48.3	60.3	76.1	88.9	102	114	127	140	168	219.1
10	60	60	60	70	70	75	75	90	100	105	110	120	135	140	150	160	190
12		60	60	70	70	75	75	90	100	105	110	120	135	140	150	160	190
16			60	70	70	75	75	90	100	105	110	120	135	140	150	160	190
20				75	80	80	85	100	105	115	120	125	140	150	155	170	195
25					80	80	85	100	105	115	120	125	140	150	155	170	195
30						90	95	105	110	120	130	135	150	155	160	175	200
38							95	105	110	120	130	135	150	155	160	175	200
48.3								120	130	135	140	150	165	170	180	190	220
60.3									130	135	140	150	165	170	180	190	220
76.1										155	160	175	185	190	195	210	235
88.9											160	175	185	190	195	210	235
101.6												195	210	215	220	235	260
114.3													210	215	220	235	260
127														215	220	235	260
139.7															245	260	285
168.3																260	285
219.1																	320

12.12 Assembly examples

Pipe brackets should be placed as close as possible before and after bends.

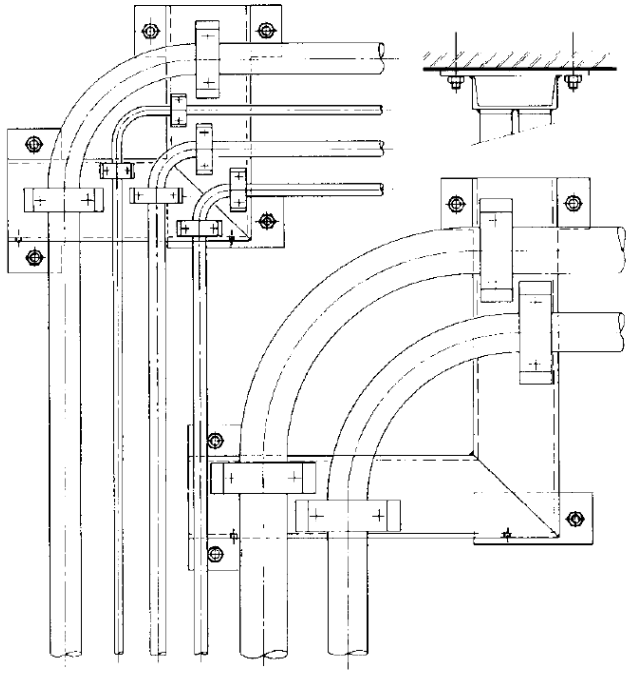


Figure 12-8 - Configuration of bracket bends

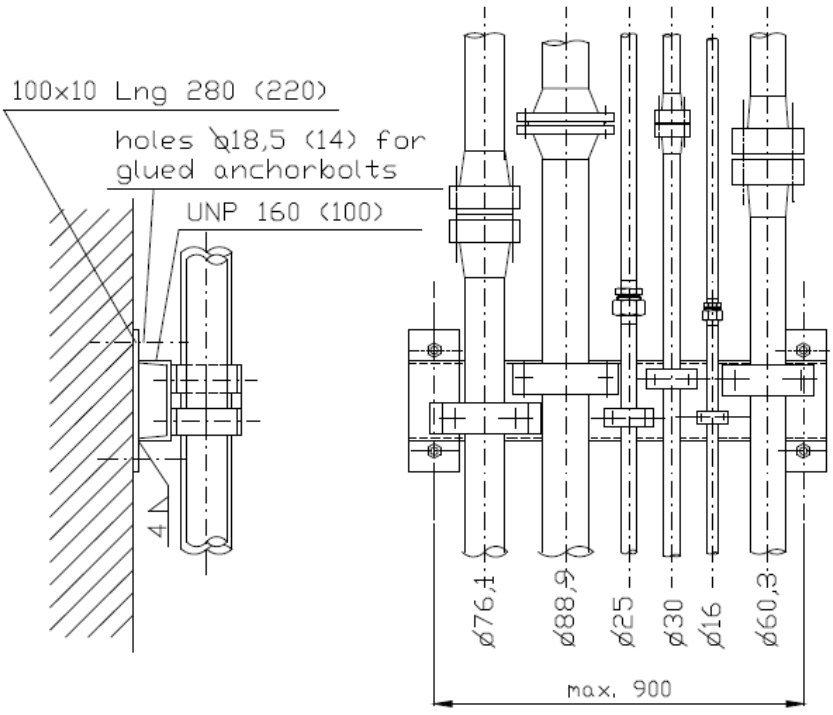


Figure 12-9 - Brackets for pipe routes

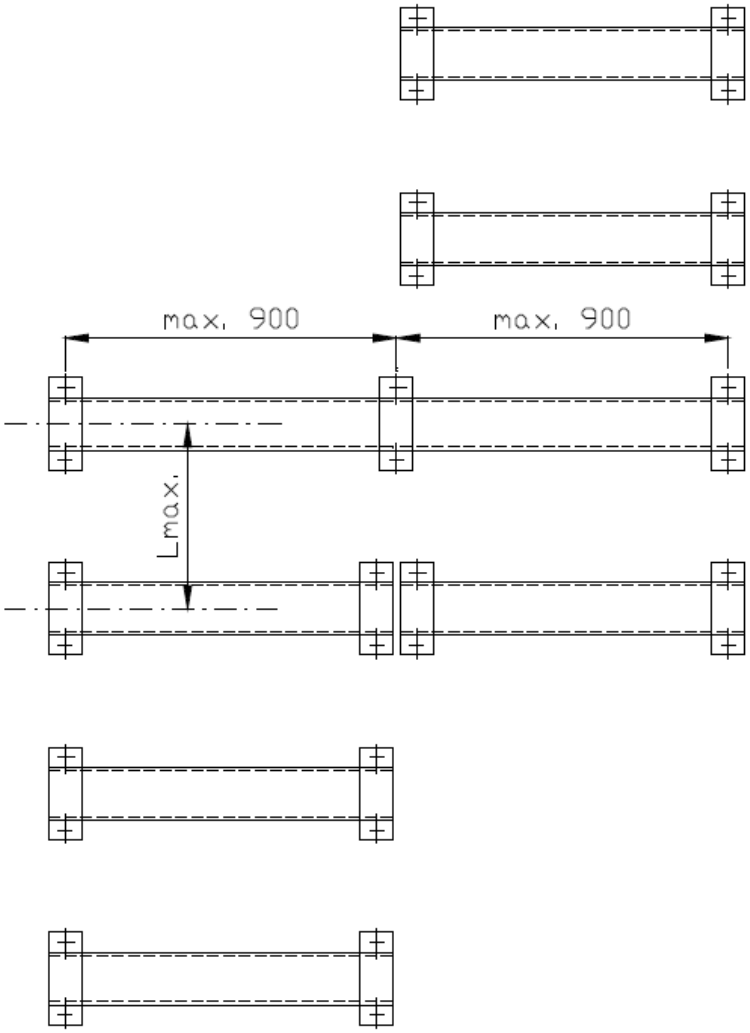


Figure 12-10 - Support distance for fixing points

Table 14 - Maximum distance from carrier profiles

External pipe diameter [mm]	Lmax [mm]
<25	1000
25 - 48.3	1500
> 48.3	2000

Weld connections

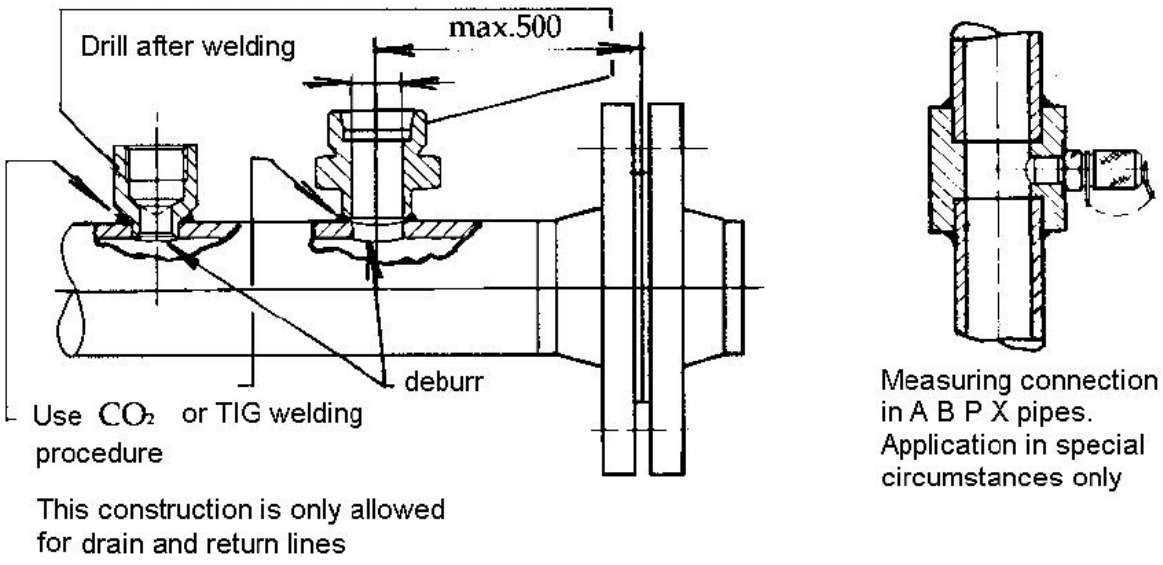


Figure 12-11 - Example of pipe connections

Table 15 - Maximum distance from carrier profiles

Pipe diameter [mm]	Maximum diameter weld coupling [mm]
≤ 38	20
≤ 48.3	30
≤ 60.3	38
≤ 76.3	38

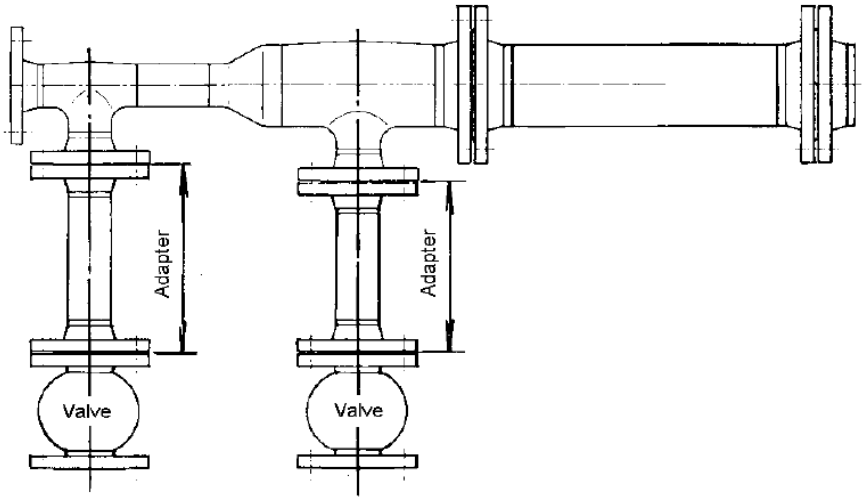


Figure 12-12 - Low pressure suction line

With fully welded suction line it must be possible to inspect all welds internally and externally. See Figure 12-11 above as an accessibility example of welding for post-processing for a suction pipe. All internal welds of suction lines should be ground smooth.

Flange connecting blocks for pressures up to PN 315

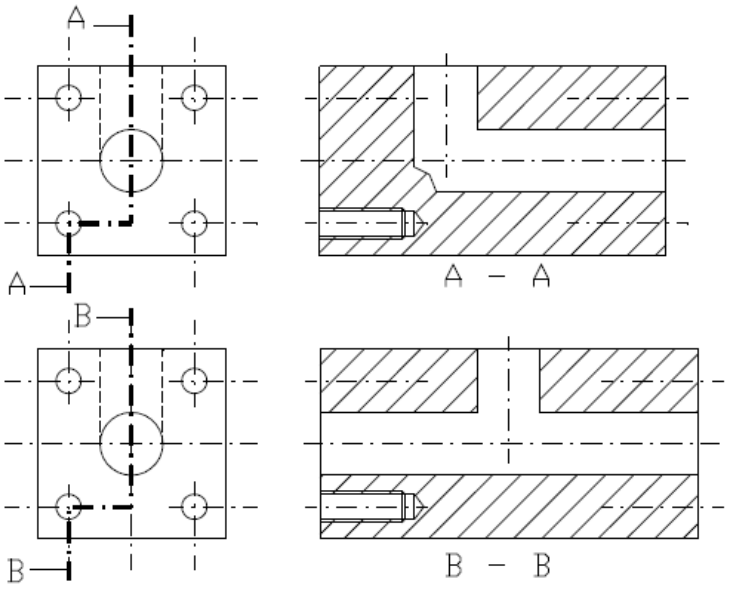


Figure 12-13 - High pressure flanges

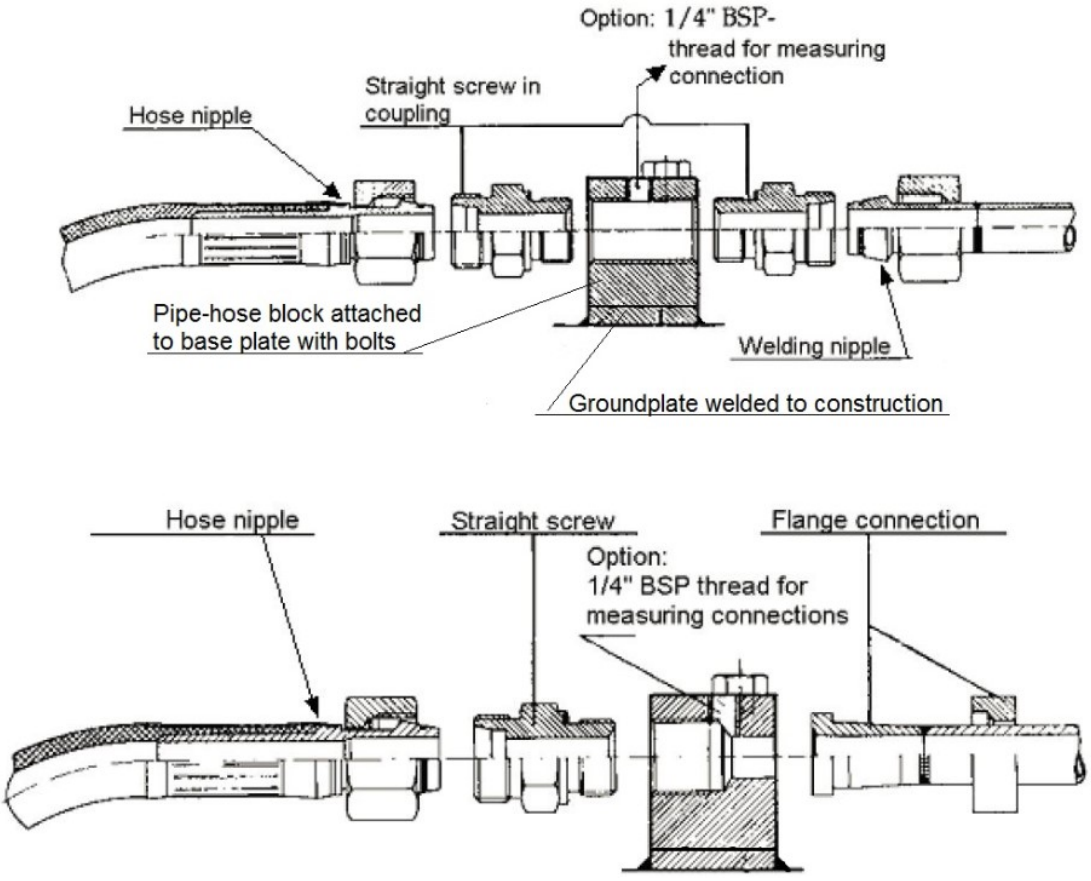


Figure 12-14 - Hose connections

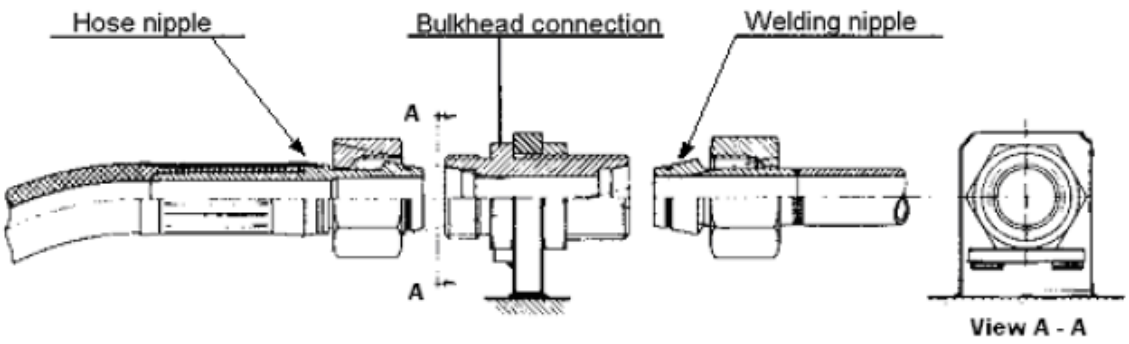


Figure 12-15 - Alternative hose connections

Alternative hose connections are only allowed after written permission from Tata Steel project engineer hydraulics

Installation examples of hoses

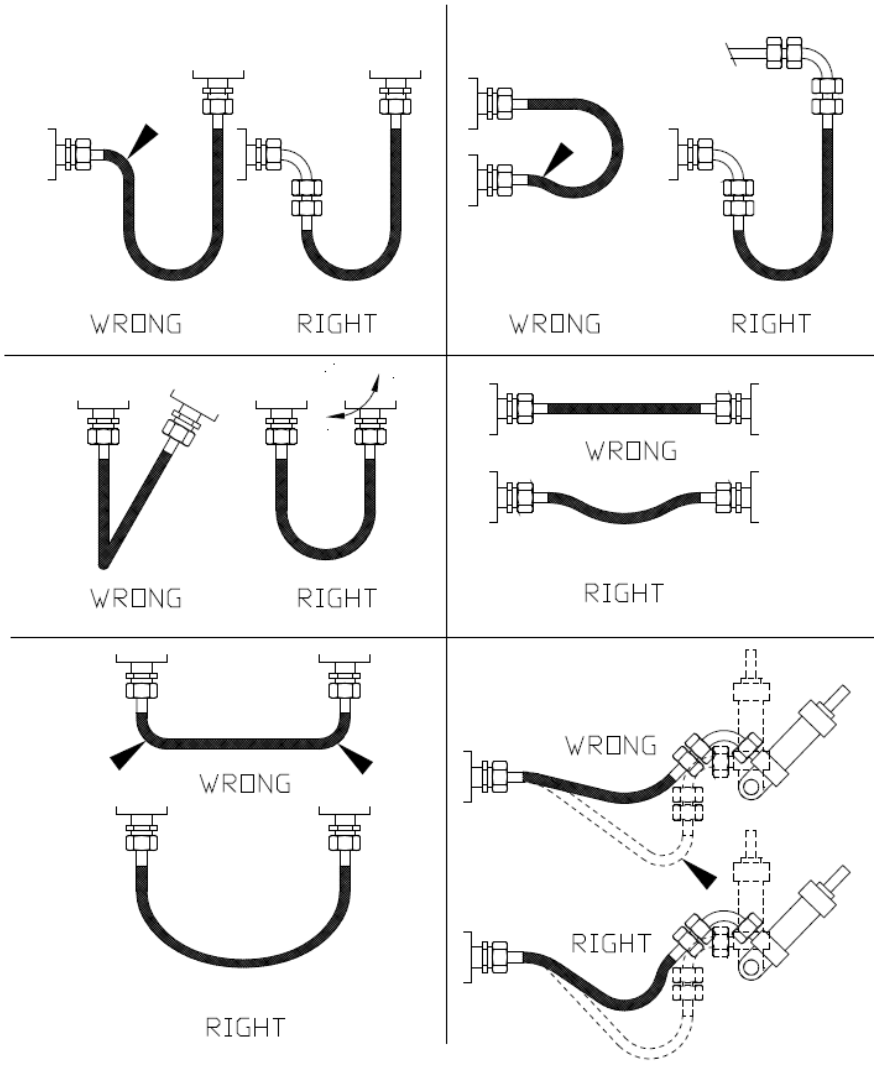


Figure 12-16 - Configurations of hose connections

12.13 Anchoring pipework and installation parts

Mounting light installation parts on concrete
When mounting light installation parts on concrete, anchor bolts should be used (for example for: pipe supports and manifold blocks). Holes, anchor bolts and mounting must be supplied / carried out by the supplier.

Mounting heavy installation parts on concrete
For anchoring heavy installation parts on concrete, chemical anchor bolts should be used (for example for: installation parts such as tanks, conditioning, pump sets and valve tables). Holes, chemical anchor bolts and mounting must be supplied / carried out by the supplier. The supplier's manual must be strictly followed.

12.14 Cleaning of pipework (pickling and flushing)

General
Prior to commissioning, hydraulic systems must be cleaned of all possible contaminations such as, for example: oxides, corrosion-stimulating particles, welding residues and preservatives.

Cleaning methods
Pipe cleaning is divided into two phases: pickling and flushing.
Pre-, interior, pickled, phosphated and oiled pipework does not need to be pickled again after welding unless corrosion has occurred during welding (which can be prevented by using backing gas). If not corroded, rinsing alone will suffice.

Cleaning of hydraulic pipework should be divided into two parts:
1) Pickling
2) Flushing

Pickling and passivation of steel pipes

General:

Circulation pickling and bath pickling are not allowed on the TATA Steel site.
Bath pickling is only permitted after written permission from Tata Steel project engineer hydraulics.

Pickling fluid: Only "Betona Aktiv" pickling liquids or equivalent (on phosphoric acid basis) are allowed.

Bath pickling:

After complete implementation of this process, parts of the pipelines can be dismantled pickled by immersion in a bath filled with "Betona Aktiv" pickling fluid. Pickling must be carried out according to the Betona instructions.

Conditions:
- After drying, oil the pipes internally (mineral oil) and seal off with metal plugs with a soft seal.
- After at least 5 hours, but within 24 hours, the outside of pipes must be treated with a primer based on Tata Steel Standard S3 10 56 01.
- Pipes must remain sealed until final assembly in the final system.

Pickling and passivation of stainless-steel pipes

In order to maintain the corrosion resistant property of stainless steel, the material should be handled with great care. A homogeneous oxide layer is strictly necessary.

Processing can result in an inhomogeneous oxide layer. This must be removed by pickling. Then a new homogeneous layer should be formed by passivation.

Pickling methods

In general, local treatment of the finished part is sufficient. Two methods can be distinguished:

Method 1:
Immersion in a pickling bath (pickling liquid = mixture of nitric acid and hydrofluoric acid);
- Heat the pickling liquid to approx. 60° C.
- Immerse the weld and the area surrounding the weld in the pickling bath.
- After sufficient treatment time, rinse carefully with water.

Method 2:
Stain-paste coating.
- Apply the pickling paste with a plaster trowel to the weld and the surrounding area of the weld (layer thickness approx. 2 mm).
- After sufficient treatment time, rinse carefully with water.

Passivate

Passivation takes place after pickling and rinsing with water. This process stimulates the rapid growth of a homogeneous oxide layer. Two methods are distinguished:

Method 1:
Immersion in diluted nitric acid.

- Immersion of the pipes in a bath filled with nitric acid (diluted with 1 part water) and a liquid temperature of 50° C for 30 minutes.
- After this treatment, rinse the weld and the area around the weld carefully with water.

Method 2:
Immersion or coating with a sodium nitrite solution.

- By immersing or brushing the weld and its surroundings in a 2% sodium nitrite solution in water.
- After this treatment, rinse the weld and its surroundings carefully with water.

Table 16 Selection table of shut-off valves

		Gekozen reeks																
	Uitwendige diameter	8	12	16	20	25	30	38	48,3	60,3	76,1	88,9	102	114	140	168	219	Opmerkingen
Benaming	DN / PN		6	10	15	20	25	32	40	50	65	80	80	100	125	150	200	
Kogelkraan voor koppeling met 24° conus (zie dl. 8.6)	250		x	x	x	x	x	x										Draadaansluiting (metrisch)
Kogelkraan met flensaansluiting (zie dl. 8.5)	16								x	x	x	x		x		x	x	
Kogelkraan met flensaansluiting (zie dl. 8.6)	250								x	x								Uitvoeren met zware handel
Kogelkraan voor grondplaatmontage (zie 8.6)	315			x		x		x										O-ring afdichting
Kogelkranen (deelbaar) voor flensaansluiting (zie dl. 8.6)	250									x	x		x	x				Pfanneschmidt

Table 17 Selection table for pipes, pipe connections and other components

PIJPEN, VERBINDINGSELEMENTEN EN TOEBEHOREN (PIJPEN, LASSOKKEN, STOMPEN, KOPPELINGEN, FLENZEN, LEIDINGCOMPENSATOREN EN LASBEUGELS)			GEKOZEN REEKS																								
		Uitw. Pijp-diameter	8	12	16	20	25	30	38	48,3	60,3	76,1	88,9	102	114		168	219	BSP- DRAADAANSLUITING								
R1 42 01 08	BENAMING	DN / PN		6	10	15	20	25	32	40	50	65	80	80	100	125	150	200	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	OPMERKINGEN
Paragraaf 8.8	Pijpen	10																x									
		16								x	x	x	x		x		x										
		250	x	x	x	x	x	x	x	x	x	x	x	x													
	Pijpen, roestvast staal	250		x	x	x	x	x	x																		
	Bevestigingsbeugelslasplaat			x	x	x	x	x	x	x	x	x	x	x	x		x	x									Zware serie toepassen
	Bevestigingsbeugelsrails			x	x	x	x	x	x	x	x																
	Lasoverschuifbussen	16							x	x	x	x		x													
		250		x	x	x	x	x	x	x	x	x	x														
Tekeningnummer 967.196	Aansluitstompen met inwendige schroefdraad	16					x												x								Tekeningnummer 967.196
							x													x							
									x												x						
									x													x					
										x													x				
										x														x			
												x													x		
Paragraaf 8.11	Rechte inschroefkoppeling	250	x																x								Zware serie toepassen
				x																x							
					x																x						
						x																x					
							x																x				
								x																x			
									x																x		

In R1 42 01 08 zijn ook flenzen PN40 en PN320 opgenomen (dit gegeven geldt ook voor het vervolg van deze tabel op de volgende pagina).

13. Electrical wiring of units

13.1 Scope and application

- Depending on the number of terminals, one or more terminal boxes are used per unit. The positioning of terminal boxes. Protection pipes and / or oil resistant hoses for cables, determined in consultation with Tata Steel project engineer hydraulics;
- All wiring is cabled and connected to terminal boxes;
- Only one cable to the terminal box per solenoid, pressure switch, level tester, etc. Except electric motors, can be directly connected;
- All contacts, including contacts that are not used, are connected via cable. All instruments in the cabinet must be grounded;
- When mounting on pump motor units, all electrical equipment must be installed on vibration isolators (silent blocks). See Figure 13-1 Electrical terminal box for an example. Item numbers in this text also refer to this drawing.

13.2 Terminal box

Performance:
Tightness class: IP 55
Oil resistant material plastic or stainless steel depending on the application and location of the equipment

13.3 Encodings

Terminal box coding
Glue a Resopal plate on the lid (WZW).
Font height at least 10 mm.

Terminal strip coding
The same number as in the previous paragraph for terminal coding.

Terminal coding, component side
The terminal coding will be provided by Tata Steel.
Code shields with consecutive numbers are already attached to one side.

Cable / wire coding
Wires should be marked on both ends of the wire (cable code). Conform the wiring diagram list and / or drawing. Cable numbers are provided by Tata Steel.

Wire coding
All cable core ends and wires connected to the terminal block and devices (none terminal block or solder strip) must have wiring codes, these will be supplied by Tata Steel or the main contractor.

13.4 Wires / Cables

Cables must be resistant to environmental conditions, at least oil resistant.
Resistance to ambient heat and radiation per application to check with project engineer Tata.
Cables must be fire resistant according to EN-EIC 60332-3-24 cat. C or better.
Cables used in an environment where people work must be halogen free.
Cables for control or measuring signals (0-10V, 4-20mA) must have shielding and twisted wires of at least 0.75 mm^2)

Cores of cables must be connected to the terminals with cable shoes.

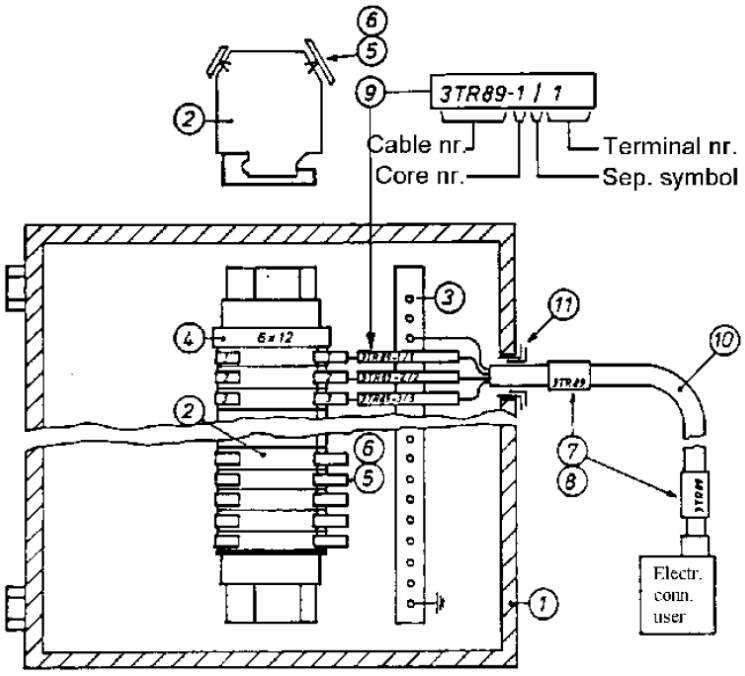
13.5 Cable entry in terminal box

Preferably apply wire sockets in the terminal box to the bottom surface. Alternative to the side face and in exceptional cases on the back but never at the top.
All cable connections on one side, so either left or right of the terminal rail.

13.6 Cable protection

Cables should be protected by steel pipes, bends not ruled out. The pipe must be fixed in such a way that oil or water does not penetrate.
The pipes must be protected at both ends with protective grommets; the classification must be logical and clear: misunderstandings about the correct connections (especially that of plugs!) should be impossible.

1. Terminal box
2. Terminal
3. Earth rail
4. Terminal rail coding
5. Terminal code shield
6. Terminal sockets
7. Synthetic cable coding sleeve
8. Synthetic terminal sockets
9. Core coding
10. VMvL cable
11. Cable inlet



14. References

This Tata Steel directive refers to:

Internal:

EC-33.3	Isolation & Immobilization - Mechanical
S1 42 01 01	Tata Steel IJmuiden Standard Hydraulics
S1 79 00 02	Standard lifting chain and eye bolts and eye nuts
S1 47 40 01	General requirements for testing pipe systems
S1 48 10 01	NDT percentages for metal pipes
S3 10 56 01	Conservation of steel
HS16	Hydraulic Steel 16 bar Pipe Spec
HS250	Hydraulic Steel 250 bar Pipe Spec
HS315	Hydraulic Steel 315 bar Pipe Spec
HSS16	Hydraulic Stainless Steel 16 bar Pipe Spec
HSS250	Hydraulic Stainless Steel 250 bar Pipe Spec
HSS315	Hydraulic Stainless Steel 315 bar Pipe Spec

External:

NEN-EN-ISO 4413	Hydraulics - General rules and safety requirements for systems and their components
ISO 4400	Hydraulics and pneumatics - Three-pole plugs with earth contact - Characteristics and requirements
NEN-EN-ISO 1302: 2002 and	Geometrical Product Specification (GPS) - Indication of surface condition in technical product documentation
NEN-ISO 2768-1: 1990	General tolerances - Part 1: Tolerances for linear and angular dimensions without separate tolerance designations
NEN-ISO 8434-2: 2007 and	Metal pipe connections for hydraulic, pneumatic and general applications - Part 2: Flange coupling with 37 ° flange rim
PED (97/23 / EC)	Applicable to the design, manufacture and conformity assessment of pressure equipment and assemblies with a maximum allowable pressure (PS) greater than 0.5 bar
NEN-EN 12285-2: 2005 and	Factory-made steel tanks - Part 2: Horizontal cylindrical single-wall and double-wall tanks for the above-ground storage of flammable and non-flammable water-polluting liquids
NEN-EN 10088-2: 2014 and	Stainless steels - Part 2: Technical delivery conditions for sheet and strip of corrosion-resistant steels for general use
NEN-EN 10204: 2004 and	Metal products - Types of inspection documents
ISO 15540: 2016 and	Ships and marine engineering - Fire resistance of hose assemblies - Test methods
ISO 15541: 2016 and	Ships and marine engineering - Fire resistance of hose assemblies - Requirements for the test bench
NEN-ISO 16889: 2008 / A1: 2018 and	Hydraulic Filters - Multiple pass method for assessing the filtering performance of a filter element
NEN-ISO 11170: 2013 and	Hydraulics - Sequence of tests for the verification of the performance characteristics of filter elements

NEN-EN-ISO 898-1: 2013 and	-Mechanical properties of carbon and alloy steel fasteners - Part 1: Bolts, screws and studs with specified property classes - Rough threads and metric fine threads
DIN 3852-2: 2014	Threaded ends and ports of fittings, valves and plug screws - Part 2: Dimensions for pipe threads
DIN 4809-1: 1986-11	Compensators made of elastomeric composite materials (rubber expansion joints) for water heating systems, for a maximum operating temperature of 100 ° C and a permissible operating pressure of 10 bar; Requirements and testing

15. Explanation

Version 1.0:
None.

Version 1.1:
Logo modified.

Version 1.2:
Version Update

Version 2.0:
Changes in all sections

Version 3.0:
Completely modified

Version 4.0:
Large-scale overhaul and new input

Version 5.0:
Large-scale overhaul and new input