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Tata Steel IJmuiden Standard Hydraulics

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1. Introduction

This mandatory Standard sets out the minimum requirements for hydraulic systems within Tata Steel IJmuiden. It represents the Tata Steel IJmuiden policy on the best practice for the design, fabrication, erection, commissioning, use and maintenance of hydraulic systems.

The requirements in this document have the aim to minimise the risk to acceptable levels in the following areas:

a) Health and Safety
b) Process safety
c) Environment
d) Probability of Failure (Production stoppage)
e) Quality of the end product
f) Mean Time To Repair (unplanned downtime / production loss)

Furthermore some requirements are best practices that have a strong positive impact on the reliability or total cost of ownership of hydraulic systems.

1.1. Scope & Application

This Standard defines the principles and practices to be applied in the design, fabrication, erection, commissioning, use and maintenance of any hydraulic system and is mandatory across all sites operated by Tata Steel IJmuiden.

This Standard is applicable to new machinery and modifications to existing machinery. In addition to this standard, other relevant Tata Steel IJmuiden standards must be followed based upon their field of application.

Requirements concerning the disconnection / depressurisation of hydraulic components are defined in the Code of Practice referred to as 'Isolation & Immobilisation – Mechanical' (EC-33.3, chapter 7.5).

The aims of this document are to provide policy:

- For those parties undertaking conceptual and detailed design and manufacture of hydraulic systems, whether they are Tata Steel IJmuiden, contractor or consultant.
- On the obligations of the vendor supplying equipment and/or design.
- On the obligations of personnel that commission, operate or maintain hydraulic systems, whether they are Tata Steel IJmuiden, contractor or consultant.

1.2. Legal & Mandatory compliance

In the case of hydraulic requirements which complement or contradict each other, the most stringent requirements shall prevail at all times, according to this order of priority:

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

The user of this Standard must ensure himself that he is using the most recent version of the standard. The most recent version can be retrieved via the Tata Steel IJmuiden safety website under Regulations: http://veiligheid.tatasteel.nl/.

The information in this standard has been compiled with great care. Despite this, it is possible that the information published here is incomplete or incorrect or may contain errors. Although Tata Steel does its best to provide all information as good and error-free as possible, it cannot be held responsible for any errors, damage or other consequences resulting from the use of this standard. Therefore no rights can be derived from the information.

Tata Steel expects a proactive approach from the users of this document. This means that users are obliged to inform Tata Steel in writing or to request clarification in case of errors, omissions, inconsistencies or ambiguities in this standard, so that Tata Steel can correct any errors, omissions, inconsistencies or ambiguities.

2. Definitions & Abbreviations

Table 1, Abbreviations

ALARP	As Low As Reasonably Practicable
CE	Conformité Européene (European Conformity)
CEC	Company Engineering Committee
EC	Engineering Committee
EN	European Norm
EU	European Union
ISO	International Organization for Standardization
PS	Maximum pressure for which the equipment is designed, as specified by the manufacturer
MTTDF	Mean Time To Dangerous Failure
MTTR	Mean Time To Repair
PPM	Parts Per Million
PED	Pressure Equipment Directive
PGS	Publicatie Gevaarlijke Stoffen
SHE	Safety, Health & Environment

3. Requirements

This chapter lists mandatory requirements imposed by this standard.

3.1. Scope

Requirement
The design of hydraulic installations shall be performed according to NEN-EN- ISO 4413. The requirements that are adopted in this standard are an extension of ISO 4413.

3.2. General Requirements

Requirement
Equipment that is under pressure – or has the potential to be so – shall comply with the scope of the European Pressure Equipment Directive.
Excessive pressure peaks in hydraulic systems that can lead to system failures with serious consequences, including personal harm, are not permitted. Pressure peaks are not allowed to exceed the component's maximum allowable pressure.
Measures to prevent risk or spreading of fire shall be taken based on a risk assessment according to Tata Steel Engineering Code Of Practice 'Fire prevention and protection equipment' (EC-10.2).

Requirement
The physical function sequence on the valve tables and manifolds must match the sequence on the drawing scheme.
It must be possible by use of measuring points to determine the pressure for each connection between components without disconnecting the components.
Pressure measure points must be standardized according to Appendix 1.
Materials used for hydraulic equipment shall be suited for use in the specific circumstances, conditions and environment the equipment is exposed to. For example taking into account the corrosion that can be expected. Materials shall be approved by Tata Hydraulics engineer.
Application of new technology shall be validated by a risk based technology qualification method. For example by applying method DNVGL-RP-A203.
The use of drip trays to prevent environmental spills is mandatory for pumps valve and filter tables as specified in the PGS15.

3.3. Documentation

Requirement
The hydraulic system documentation as specified in chapter 7 of the NEN-EN-ISO 4413 shall be transferred to Tata Steel before preliminary acceptance certificate.
Hydraulic diagrams must comply with the specifications as stated in the Technical Guideline R1 05 80 01, in particular chapter 5 "hydraulic diagram drawings and calculations". For CAD drawing specifications, refer to Technical Guideline R1 05 80 02. Hydraulic diagrams shall comply with NEN-ISO 1219-2.
The set value of each adjustable component and the pre-charge pressure of accumulators shall be checked during commissioning and will be indicated on the as-built drawings.
All hydraulic symbols must be in accordance with NEN-ISO 1219-1.
Flow-time diagram shall be provided before start of detail engineering. Necessary emergency functions and the associated energy storage, for safe operation during electric power failure and electrical control failures, must also be made visible in a flow-time diagram.
The supplier must prove that the installation performs according to the specifications through a commissioning plan approved by Tata Hydraulics Engineer.

3.4. Immobilisation for maintenance

Requirement
During the design phase, it must be determined which (sub) systems or functions must be taken out of operation for maintenance. The design of the hydraulic system shall facilitate safe immobilisation.
The (sub) systems to be switched off must have their own pump station that can be switched off. If this is not possible, the relevant (sub) systems or functions must be capable of being isolated in such a way that the hydraulic energy supply (also from return and drain lines) can be stopped and residual energy can be removed. It must be possible to safely switch off machine zone(s) for production and inspection procedures as described in Work Instructions (WI's). Resources must be made available so hydraulic function(s) can be switched off according to "required performance levels" (PLr's). Protection against re-starting must be possible by placing a standard safety pad lock 10 mm. For safe disconnection, the following embodiments shall be considered: - Hydraulic Pressure Stop (HPS) to stop hydraulic energy supply. - Hydraulic Pressure Release (HPR) to drain hydraulic energy. - Hydraulic Pressure Lock (HPL) to lock hydraulic potential energy.
These isolation functions must be designed in such a way that the energy supply cannot be switched on again if there is a single fault in the isolation function. The single fault must be signalled by an acoustic alarm.
Securing undesired energy supply from the return and drain lines shall be achieved by carrying out this separate (sub) system or function with separate return filters.
The implementation of isolation functions requires approval from Tata hydraulics Engineer.

3.5. Hydraulic fluids

Requirement
Only the application of mineral oil is allowed, unless a risk assessment results in the mandatory application of a fire resistant fluid.
Mineral Oil HLP ISO VG 32 will be supplied by Tata Steel or as specified by Tata Steel Lubrication Engineer. For testing purpose the supplier must use an HLP oil approved by Tata Steel lubrication engineer.

3.6. Conditioning systems for mineral oils

Requirement
All hydraulic systems must be designed to maintain a minimum fluid cleanliness level of ISO 17/13/10 for proportional and for servo systems or ISO 18/15/12 for all other, thereby complying with NEN-ISO 4406.
All hydraulic systems with mineral oil shall be designed to maintain a fluid operating temperature in the reservoir of 40 °C ± 5 °C.
Design must be such that when the mineral oil temperature exceeds 65 °C a high temperature alarm is generated and the agreed shutdown procedure is activated. For any other media the temperatures must be specified in the project description.
The water content of mineral oil shall not exceed 300 parts per million (PPM).

3.7. Hydraulic accumulators

Requirement
All hydraulic accumulators must fulfil the PED approval requirements and Tata Steel Standard S1 30 04 01.
All new or to be replaced hydraulic accumulators shall have a pressure class of at least 330 bar.
Only gas-loaded membrane, bladder and piston accumulators are permitted.
Nitrogen must be used for the pre-charge of accumulators.
In addition to the risk assessment according to NEN-EN-ISO 4413 a specific risk analysis shall be performed to determine the risk of explosive decompression and/or uncontrolled release of compressed gases (for instance as caused by fire) and the additional measures to mitigate the consequences of an explosive decompression and/or uncontrolled release of compressed gases (for instance gases used in gas pre-charged accumulators).

3.8. Hydraulic accumulator safety and shut off blocks

Requirement
Accumulator safety and shut off blocks are required by the European Pressure Equipment Directive for accumulators with a capacity equal or greater than 4 dm^3.
All accumulator safety and shut off blocks must fulfil the PED approval requirements and Tata Steel Standard S1 30 04 01.
Accumulator safety and shut off blocks are standardized in order to maintain and operate them safely. The meaning of standardized is specified in the requirements below:

Requirement
All accumulator safety and shut off blocks must be fitted with a manual shut-off valve, manual drain and a safety valve (safety valve according to European Pressure Equipment Directive).
All hydraulic accumulators must be fitted to the accumulator safety and shut off block in such a way that the flow between the accumulator and the safety valve cannot be interrupted. For type and make of accumulator safety valves and shut-off blocks, see Appendix 2.

3.9. Accumulator filling systems

Requirement
The gas pressure of an accumulator must be checked periodically, using a pre-charge that is fit-for-purpose.

Hydraulic accumulator pre-charge valves are standardized, see Appendix 3.

3.10. Piping and hoses

Requirement
All piping and connectors shall comply with Tata Steel pipe specification.
Hose assembly shall fulfil the requirements presented in Appendix 4.
Connecting ports with thread shall be equipped with cylindrical BSP thread according to DIN 3852-2, form E or NEN-ISO 1179-2, form E.
Non flanged fluid connectors shall be of the 24° cone type connector with weld on nipple with O-ring according to ISO 8434-1 heavy duty type S. Cutting rings are not allowed. Stud ends according to ISO 8434-1 type E. Walterscheid walform+ connectors can be allowed in systems <=250 bar and pipe outside diameters smaller or equal to 30mm, after approval by Tata Hydraulics engineer.
Marking of pipelines shall be according to Tata Steel Standard S1 76 81 01.
Pipe welding must be executed according to Tata Steel Standard S1 45 04 01.
Piping and hoses shall be flushed according to Appendix 5.

3.11. Manifolds

Requirement
Use of manifolds is mandatory.
Manifold blocks shall be mounted separate from the machine in a dustproof cabinet outside the safety zones.
The manifold shall be fabricated as a one-piece construction.
Component stacks on manifold blocks are limited to 3 components maximum.
Manifold blocks for hydraulic application at Tata Steel IJmuiden, must be made of forged steel with mechanical properties according to Tata Equipment Quality Department specifications. As an exception: cast steel material with adequate mechanical properties can be used after approval of the Tata Hydraulics engineer.
The hydraulic manifold blocks shall be Ultrasonically Tested before drilling the hydraulic channels. For forged steel blocks the quality class must be level 2 or better (NEN EN 10228-3, table 5 “quality class, recording level and acceptance criteria for normal probes”). For manifold blocks made of cast steel US test acceptance criteria must be severity class 1, (indications <= 5 mm) (NEN EN 12680-3, table 1 “maximum permissible indicated dimensions of discontinuities – volumetric reflectors”).

3.12. Valves

Requirement
Directional, flow, and pressure control valves shall be of the manifold mounted and/or sandwich mounted type. For mounting surfaces see “mounting surfaces” below.
Mounting surfaces of functional valves shall be according to the following specifications: **Directional control valves and sandwich valves:** CETOP RP 121 H DIN 24340 A ISO 4401. Cartridge valves: ISO 7368 **Pressure controls:** Relief valves: DIN 24340 E ISO 6264 AR/AS/AT CETOP RP121H Exception: non-pilot operated relief valves from BoschRexroth, special BoschRexroth mounting surface. Cartridge valves: ISO 7368 **Reducing and sequence valves:** DIN 24340 D ISO 5781 CETOP RP 121 H Cartridge valves: ISO 7368 **Pilot operated check valves:** DIN 24340 D ISO 5781 CETOP RP 121H **Flow control valves pressure compensated:** DIN 24340 A (NG6) or G (NG10 and 16) ISO 4401 (NG 6) CETOP RP121H ISO 6263 (NG 10 – 16)

Requirement
Shut-off valves shall be installed in P, A, B and X lines.
Check-valves shall be installed in T and Y lines.
Shut-off and control valves shall be accessible without entering a safety zone.
In safety functions the use of manual overrides on valves and/or manual (emergency) valves is only allowed when they are prescribed based on a risk assessment and measures have been taken to avoid unintended use. The use of manual overrides and/or manual (emergency) valves and measures to avoid unintended use shall be approved by Tata Hydraulics engineer. Spool valves size NG25 and 32 must have external X and eternal Y. The pilot pressure for these valves must be reduced to 30 bar.

3.13. Safety Valves

A safety valve protects the system against excessive pressure (higher than design pressure). Excessive pressure can lead to component failure with a profound effect on human health, environment and assets as a result. Therefore:

Requirement
Safety valves are to be incorporated in each hydraulic system for maximum pressure setting as required by ISO 4413.
All safety valves must have a proven Mean Time To Dangerous Failure (MTTDF) of 150 years.
Permitted pressure and capacity of all safety valves are defined in Appendix 2.

4. References

This Tata Steel Standard refers to:

Internal:

EC-33.3	Engineering Code of Practice Isolation & Immobilisation – Mechanical
EC-10.2	Engineering Code of Practice Fire prevention and protection equipment
R1058001	Drawing rules for Tatasteel
R1058002	TataSteel_CAD-Drawingrules_V62
S1300401	Ordering realisation and inspection of pressure equipment
S1450401	Execution and inspection of welding work.
S1768101	The marking of pipelines

External:

DIN 20024	Fluid Systems - Hoses And Hose Assemblies - Test Methods
DIN 3852-2:2014	Stud ends and ports of fittings, valves and plug screws - Part 2: Dimensions for pipe thread
EN 97/23/EC2014/68/EU	European Pressure Equipment Directive
NEN-EN-ISO 4406:1999	Hydraulic fluid power -- Fluids -- Method for coding the level of contamination by solid particles
NEN-EN-ISO 4413:2010	Hydraulic fluid power -- General rules and safety requirements for systems and their components
NEN-EN-ISO 6802:2005	Rubber and plastics hoses and hose assemblies with wire reinforcements -- Hydraulic impulse test with flexing
NEN-EN-ISO 6803:2017	Rubber or plastics hoses and hose assemblies -- Hydraulic-pressure impulse test without flexing
NEN-EN-ISO 8434-1:2007	Metallic tube connections for fluid power and general use -- Part 1: 24 degree cone connectors
NEN-EN-ISO 1219-1:2012	Graphical symbols and circuit diagrams
NEN-EN-ISO 1179-2:2013	Connections for general use and fluid power -- Ports and stud ends with ISO 228-1 threads with elastomeric or metal-to-metal sealing -- Part 2: Heavy-duty (S series) and light-duty (L series) stud ends with elastomeric sealing (type E)
NEN-EN-ISO 1219-2:2012	Circuit diagrams
NEN-EN-ISO 12151-2	Connections for hydraulic fluid power and general use - Hose fittings - Part 2: Hose fittings

	with ISO 8434-1 and ISO 8434-4 24° cone connector ends with O-rings
DNVGL-RP-A203:2017	Technology Qualification
PGS 15:2016 versie 1.0	Opslag van verpakte gevaarlijke stoffen
NEN-EN 12680-3:2011	Founding - Ultrasonic testing - Part 3: Spheroidal graphite cast iron castings
NEN-EN 10228-3:2016	Non-destructive testing of steel forgings - Part 3: Ultrasonic testing of ferritic or martensitic steel forgings

5. Explanation

Version 1.0:
This Hoogovens Standard replaces HO Standards:
42.00.01.141
42.00.01.143
42.00.01.145
42.00.01.361

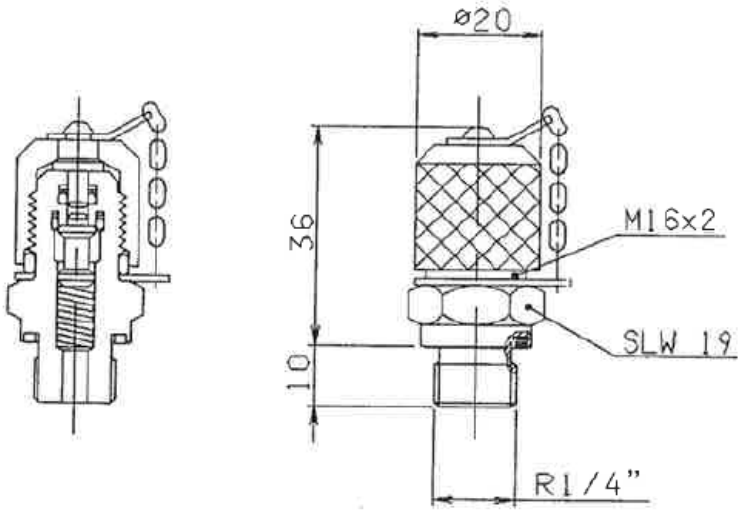
Version 2.0:
Logo adapted Hoogovens changed into Corus.
Various texts and tables adjusted.

Version 3.0:
Logo Adapted Corus into Tata Steel
EPE accumulators and safety blocks removed.
Accumulator gas filling valve Hydac adjusted. Type numbers adjusted.
Type number HYDAC accumulator safety block with flange connection adapted
Safety proportional valve adapted

Version 4.0:
Olear accumulators and safety blocks removed
Hydac adapter nipple specification updated First English version

Version 5.0 (2018):
Complete update of the standard;
Requirements in this document have been reviewed according the current criteria for standards and guidelines of Tata Steel IJmuiden.
Scope of the standard has been extended to all hydraulic topics instead of only accumulators and accessories.

Appendix 1 – Pressure measure points



Material:	Steel galvanized and yellow chromated
Max. working pressure:	630 bar
Max. allowable temperature:	90 °C
Valve seal:	Viton
Seal screw- in connection:	Perbunan
Permitted manufactures:	Stauff, Hydrotechniek, Parker E.O., AVIT
Type :	See drawing 1
Screw-in size:	1/4 "BSP
Measuring connection:	M16 x 2 max. presssure 400 bar, M16 x 1 ½ max. pressure between 400 and 630 bar.
Remarks:	Pressure measure point shall be equipped with piston valve. Equipped with metal guard cap.

Appendix 2 – Mandatory safety valves & accumulators

Table 2, Permitted directly controlled, groundplate-mounted safety valves

Symbool	DN mm	PN bar	Instelbereik max. in bar	Q l/min	Fabrikaat	Type
3	6	315	100	25	Rexroth	DBDS-6-P-1.X/100
3	6	315	315	25	Rexroth	DBDS-6-P-1.X/315
3	10	315	100	60	Rexroth	DBDS-10-P-1.X/100
3	10	315	315	60	Rexroth	DBDS-10-P-1.X/315
3	20	315	100	160	Rexroth	DBDS-20-P-1.X/100
3	20	315	315	160	Rexroth	DBDS-20-P-1.X/315
3	30	315	100	250	Rexroth	DBDS-30-P-1.X/100
3	30	315	315	250	Rexroth	DBDS-30-P-1.X/315

Table 3, Permitted feed-foward controlled, groundplate mounted safety valves

Symbool	DN mm	PN bar	Instelbereik max. in bar	Q l/min	Fabrikaat	Type
4	10	315	5 - 100	100	Rexroth	DB10-2-5.X/100X
4	10	350	5 - 315	100	Rexroth	DB10-2-5.X/315X
4	10	350	3 - 70	100	Vickers	CG2V-6BW1.X
4	10	350	3 - 350	100	Vickers	CG2V-6GW1.X
4	25	350	4 - 100	300	Rexroth	DB20-2-5.X/100X
4	25	350	4 - 315	300	Rexroth	DB20-2-5.X/315X
4	25	350	4 - 70	300	Vickers	CG2V-8BW-1.X
4	25	350	4 - 350	300	Vickers	CG2V-8GW-1.X
4	30	350	4 - 100	400	Rexroth	DB30-2-5.X/100X
4	30	350	4 - 315	400	Rexroth	DB30-2-5.X/315X

Table 2, Permitted intermediate plate type safety valves

Symbool	DN mm	PN bar	Instelbereik max. in bar	Q l/min	Fabrikaat	Type
5	10	315	315	60	Vickers	DGMC-5-PT-GH-B-3.X
6	10	315	315	60	Vickers	DGMC-5-AT-GH-BT-GH-3.X
7	10	315	315	60	Vickers	DGMC2-5-AB-GH-BA-GH-3.X
5	10	315	315	60	Rexroth	ZDB-10-VP-2-4.X/315
6	10	315	315	60	Rexroth	Z2DB-10-VC-2-4.X/315
7	10	315	315	60	Rexroth	Z2DB-10-VD-2-4.X/315
8	25	315	100	300	Rexroth	Z2DB-22-VD-2-2.X/100
8	25	315	315	300	Rexroth	Z2DB-22-VD-2-2.X/315

Table 3, Permitted proportionally controlled safety valves

Symbool	DN mm	PN bar	Instelbereik max. in bar	Q l/min	Fabrikaat	Type
9	6	350	100	1	Rexroth	DBET-5.X/100G24Z4M
9	6	350	350	1	Rexroth	DBET-5.X/350G24Z4M
10	10	350	100	150	Rexroth	DBEM10-5.X/100YG24Z4M
10	10	350	350	150	Rexroth	DBEM10-5.X/350Y24Z4M
10	25	350	100	300	Rexroth	DBEM20-5.X/100YG24Z4M
10	25	350	350	300	Rexroth	DBEM20-5.X/350YG24Z4M

Table 4, Bladder Type accumulators

PN	Nominal size in liter	Accumulator connection	Preferred supplier and type
		BSP	HYDAC**
330	2.5	1 1/4"	SB330-2,5-A4/112U-330A
330	4	1 1/4"	SB330- 4 -A4/112U-330A
330	10	2"	SB330-10 -A4/112U-330A
330	20	2"	SB330-20 -A4/112U-330A
330	32	2"	SB330-32 -A4/112U-330A
330	50	2"	SB330-50 -A4/112U-330A

** De Hydac FPU-1 adapter A13 must be supplied with the accumulator for maintenance.

Table 5, Accumulator safety blocks for pipe mounting

PN bar	DN mm	Accumulator connection BSP	Hydac Type
330	20	1 1/4"	SAF20M-12-N-330-S12
330	20	2"	SAF20M-12-N-330-S13
330	32	2"	SAF32M-12-N-330-S309

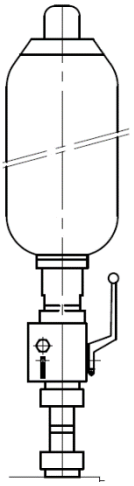
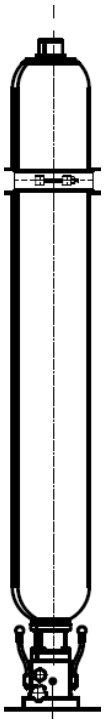
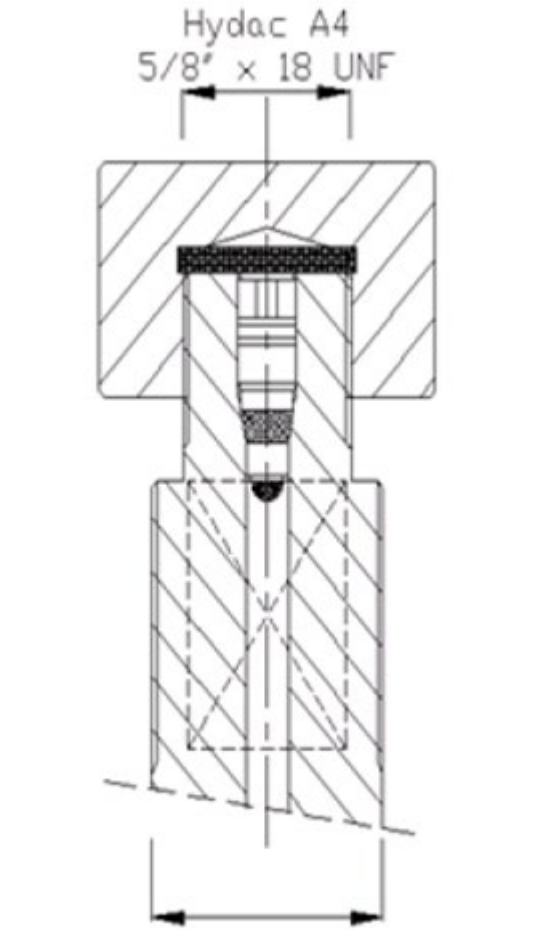


Table 6, Accumulator safety blocks for manifold mounting

PN bar	DN mm	Aansluit. accu BSP	Hydac Type
330	32	1 1/2" SAE	SA25A10T330/2/2114521



Appendix 3 – Pre-charge valve



Appendix 4 – Hydraulic hoses and hose-assemblies, specification TATA Steel IJmuiden

Hoses and hose-assemblies are to be specified based on maximum working-pressure 350 bars/35MPa/5000 psi, with a safety factor 4 related to minimum burst pressure.

Hoses with inner diameter up to and including 3/4 "= 19 mm: dimensions, pressures and other requirements must at least meet EN856 type 4SP.

Hoses with inner diameter 1"- 25,4 mm and 1 ¼"= 31,8 mm : dimensions, pressures and other requirements must at least meet EN856 type R13.

Inner lining/ outer cover must be resistant to media that can come into contact with. Tests according to ISO 1817. Extra requirement to this test: The inner lining must show no softening or porosity after completion of the test. Chemical resistance of inner- and outer cover must also be proven in the field.

Hoses fitted with 24 cone connector with O-ring and nut according to ISO 12151-2 straight Female Heavy Duty series (also called DKOS). Material of connectors shall be suited for application.

Tests according to EN856. This means the hose and hose assemblies must at least meet the requirements in EN856 and to the standards referred to in this standard:

- Static test of hose-assemblies: Test pressure according to ISO7751 and ISO 1402, applied during at least 30 seconds.

- Dynamic test of hose-assemblies (impulse test): According to ISO 6803, high pressure test, test pressure shall be according to EN 856. Hose assembly shall withstand a minimum of 500.000 impulse-cycles.

All test certificates from the above mentioned tests must be presented to and approved by customer.

Hose assembly shall be cleaned:

- After cutting of the hose: cleaning by blowing through with compressed air,
- After assembly: cleaning by means of pigging, two times from both sides of the assembly, each time with a clean pig.
- After cleaning the hose-ends have to be covered with caps.

Marking according to EN856. Extra on the hose: maximum work pressure in bar or Mpa, pressure unit must be marked.

No pinpricking allowed.

Appendix 5 – Flushing piping and hoses

Flushing

General

On behalf of the flushing procedure the pipes and hoses are coupled into a closed loop system and cleaned by filtering the flushing fluid (ISO VG32). The flushing fluid will be used afterwards as the first fill of the system.
The contractor must have and use a separate flushing unit adequate for the hydraulic system.
It is not allowed to use the pumps of the new hydraulic system for flushing without previous permission of the hydraulic engineer involved. Exception: secondary flushing after (servo) valves are mounted.

Flushing conditions

- Tata Steel should receive a flushing plan for approval before the flushing is started. In this document the supplier indicates clearly the composition of the flushing circuit. As well as the diameter and length of the pipe lines to be flushed. The parameters of the flushing unit must also be mentioned in the plan.
- The minimum flushing speed should be 7 m/s.
- The flushing speed applies to all assembled components of the string to be flushed.
- The temperature of the flushing oil (ISO VG32) should be between 50 °C and 65 °C.
- Before the actual flushing starts the cleanliness of the oil in the tank must meet the target level.
- Flushing filters must be provided with reliable dirt-indicators and by-pass valves. The filter rating must meet the specified contamination level.
- Flushing should take place with intervals, i.e. after each hour 5 minute stop.
- The minimal flushing time is:
    - for steel pipes up to 50 m length: 2,5 hours;
    - for stainless steel pipes: 1,5 hour;
    - for each 25 m extra the flushing time should be prolonged by half an hour.
- The flushing can be stopped if the specified contamination level is achieved but not before the minimum flushing time.
- The cleanliness is determined on the basis of a fluid sample.
- The flushing fluid should contain no more than 2% of water and may not be polluted by chemical agents.

Determination of the cleanliness according to ISO 4406:99

The following levels of cleanliness are demanded:

Normal system

ISO 4406 Cleanliness code 16/14/12 (100 ml sample volume)		
Size [µm]	**Particle count range / mL**	**SAE AS4059 code**
> 4	400 - 600	6A
> 6	90 - 150	5B
> 14	20 - 40	6C

Systems with servo valves

ISO 4406 Cleanliness code 14/12/10 (100 ml sample volume)		
Size [µm]	**Particle count range / mL**	**SAE AS4059 code**
> 4	90 - 150	4A
> 6	20 - 40	4B
> 14	5 - 10	4C

Sampling during flushing procedures

General
Cleanliness analysis should be done with a real-time particle counter and in presence of a Tata Steel supervisor. Calibration certificate must be present and not older than one year. The calibration must be performed according to ISO 11171 and the sampling according to ISO 4021.

Sampling location
The sampling point is always located at the end of the flushing circuit but before the flushing filter.
The sampling point must be located directly on the pipe (without connectors).

Sampling
Taking samples for final approval must be done after consultation of a Tata Steel supervisor. Contractors must have all the sampling equipment available.

Costs
All costs of the flushing and sampling are borne by the contractor.