Engineer MazinMaaroof

This research is done after my participating with * erection team in executing SMI Melt shop with capacity of V٠٠٠٠٠ Ton per year in Syria in٢٠١٠-٢٠١٢.

Engineer Mazin Maaroof
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١/٣/٢٠١٣

Abstract

Since I joined E.I.S.C which is an erection company in ١\٣\٢٠١٠ in Syria as senior piping engineer and static equipment installation, the company executed a large Melt Shop of capacity ٧٠٠٠٠٠Ton per year in Syria .This Melt Shop is manufactured by Italian company Danieli ,also Danieli supervised the erection procedure step by step and under their standard and also as per the international STD like ANSI,ASME,API,DIN,etc. I acquired good experience in pipe fabrication in, hydraulic system, water supply, gases, lime, etc. and their relative equipments. Therefore I found the hydraulic system as important part from the erection procedure to be worth full discussed and highlighted because it was very complex and got very special way in erection and fabrication . This document is reliable for any hydraulic system installation and pipe fabrication in a safe procedure.

Eng. MazinMaaroof

Senior Mechnical Engineer

HYDRAULIC POWER SYSTEMS (In Melt Shop/DanieliSTD)

SCOPE

This specification covers the hydraulic power systems required for various units in SMI Melt Shop in Syria as per DanieliSTD.And as I participated in the erection company of this Melt Shop as a piping senior supervisor and the installation of various equipments, the hydraulic system was one of most interesting system that should be taken into consideration, therefore this research is submitted.

The term “Hydraulic power systems” referred herein generally covers thefollowing:

- Hydraulic power units (reservoirs, pumps recirculating units, etc.)
- Valve stands
- Accumulator stands
- Interconnecting pipe work

This general specification does not cover on board of machine pipework andassociated equipment.

The hydraulic power systems covered herein are intended for actuation ofcomponents of various production and ancillary equipment in thesteel complexto achievespecificfunctions such as application of pressure/force /torque,generation of linear or rotary motion,control flow of fluids in pipes and ducts etc.

The design and construction of the hydraulic power systems shall be suitable inevery way for the service intended and shall be oriented towards maximizinginterchangeability and to minimize maintenance. Each system shall be completeand it will include accessories essential for proper installation,operation and maintenance, irrespective of whether such systems are mentioned in theTechnical and General Specification document.

STANDARDS

The hydraulic power systems shall be designed, manufactured, erected, testedand commissioned as per the standards laid down in thisspecification. Detailedinstructions on such aspects as are not indicated herein shall beas per thecodes and practices adopted by the ISO and EN standards.

DESIGN BASIS

The design should ensure that the components of the hydraulic power systemsare compatible with the hydraulic fluid selected at operatingconditions in the plant under atmospheric condition.
In selecting the hydraulic fluidsthe operating temperature of the systems shall be given carefulconsideration.

HYDRAULIC CIRCUITS

Each hydraulic circuit shall be designed to minimize surgepressure Suitable accumulator of adequate size shall be used to withstandmaximum rate of surgepressure rise as well as the peak surge pressure.All components shall be capable of withstanding the peak surge pressure.Each hydraulic circuitshall be designed tominimize generation of heat in thesystem by adequatelysizing.
The pipeworkand valves and by reducing bends andrestrictions but without sacrificing the functional efficiency of the system.Coolersshall be incorporated in the system to remove excess heat
in order to stabilizerequired viscosity.Design of each circuit shall be such as to achieve quick response to functional needs, economic operation of the system, minimum maintenance as well as shall ensure safety of the staff and equipment .The hydraulic system shall be designed taking into account the maximum pressure encountered .Each circuit shall incorporate a reservoir of adequate capacity, pumpingequipment, filters to eliminate undesirable particle of contaminates. Pipework,accessories and hoses, adequate cooling system to cool the hydraulic fluid where required, Accumulators, all valves and all necessary audio visual alarms, unless otherwise specified hydraulic equipment located in

unattended areas,basements, etc. shall have remote control facilities to ensure safety of the main equipment served.

EQUIPMENT

RESERVOIRS

Reservoir shall have a working volume adequate to contain all the fluid that will return from the system,maintain the fluid level within adequate working height limits during operation and feed the system for a minimum of three minutes at therated pumping capacity. The working volume of the reservoir shall form about ٨٠ per cent to ٩٠ per cent of the total volume of the reservoir, the balance being air space.

The minimum fluid level shall be at least ١٠٠ mm above the upper most point of the suction pump. The reservoir shall be designed and constructed to prevent entry of foreignmatter, including water. Reservoirs shall be fabricated from **structural steel of** adequate strength and thickness. Cast reservoirs shall not be used.Carbon steel reservoirs shall be painted according to Danieli When HFC fluid isused, stainless steel reservoir is suggested.

All reservoirs shall have provisions for oil filling and air breathing. Filler holesshall be provided with caps or covers. A breather hole shall be provided and shallbe protected by an air filter. The air filter shall be of sufficient capacity tomaintain approximate atmospheric pressure even at maximum demands of the hydraulic system and shall be so located as to be unaffected by splashes liquids and exit of reservoir fluid.
The reservoir shall be equipped with a fluid visual level indicator preferablylocated near the filler connection .Low level alarms shall be provided on each reservoir, unless specifically. Visual level shall be provided with indicators showing high and low

levels.Both the intake and return pipe shall be bought down below the minimumworking fluid level so as not to cause cavitations or aeration.Suitable provision shall be made for efficient cleaning of reservoir. A suitableopening with cover shall be provided, shall be suitable for a man to go into the tank.An accessible means shall beprovided to empty the reservoir. The reservoir bottom shall be

shaped to facilitateemptying and cleaning by providing minimum slope at the bottom.

PUMPS

Pumps shall be designed to meet the system operating pressures according tomanufacturer indications. Pump motors shall be adequate to operate of the system. Unless otherwise specified the main pumps shall be provided with at least onestand-by unit for each group. The stand-by pump shall be connected to the circuit and kept ready for operation. Direct-coupled pumps shall be securely mounted in a manner to assurealignment under normal operating conditions. The couplings and other power transmission equipment shall be designed as per General Specification forMechanical Machinery. The following information shall be permanently shown on metallic nameplates oneach hydraulic pump:

a) Manufacturer's name and address
b) Model and/or serial number
c) Maximum pressure

The direction of rotation of each pump shall be clearly indicated on the pumpwhere it can be readily seen.

VALVES

All valves shall be sized to meet the intended flow rates, consistent with lowpressure drop (according to manufacturer indications). Valves and other controlsshall be mounted on panels or valve stands or on the related power unit.

All directional valves shall be sub-plate mounted. Where practical, directionalvalve of large capacity shall be hydraulic pilot operated. If air pilot valves are used they shall have speed control plugs on air exhaust.Sub-plate "O" ring mounted valves shall have locating pins or non-symmetricalbolt holes for fool proof mounting.

Solenoid operated valves shall be designed, constructed and installed toeliminate destructive hammering of the solenoid or spool.Solenoid operated valves shall incorporate the following features:

a) Suitably sealed solenoid enclosure to prevent the entrance of plashingliquids and airborne contamination.

b) Non-dented manual over-rides which can be operated without removingthe solenoid covers but which cannot be operated accidentally.
c) Solenoids shall be continuous duty type
d) Solenoid indicating lights
e) Solenoid valve shall be equipped with plug type connectors (DIN standard)for ease of replacement and maintenance.All hydraulic valves, accessories and devices shall be plainly identified as to theitem shown on the diagram. Such identification shall be shown on a tag mountedadjacent to the component.All valves such as directional valves and flow control valves (operated manually,pneumatically, electrically, hydraulically or by any combination of theseactuators),

Relief valves, check valves and special valves such as brake valves,locking valves, pressure control valves prefill valves, popped valves, pressuresequence valves, servo-control valves etc. shall have frame sized ports,connection etc. conforming to ISO/CETOP standards.

ACCUMULATORS

The accumulator shall conform to the European directive PED for pressurevessels unless otherwise specified.
Design pressure of accumulators shall be at least that of thecircuit.

Marking

The following particulars shall be shown in a permanent and readily visible formon each hydraulic accumulator:
- Themanufacturer's/supplier's name and brief address
- The manufacturer's /supplier's product identification
- The rated pressure
- Date of manufacture (month/year)
- Manufacturer's serial number
- Total shell volume in liters
- Allowable temperature range in degrees Celsius

The following identification shall be given on the accumulator or on a label on theaccumulator:
- "Caution – Pressurized vessel. Discharge prior to disassembly"

- Gas pre-charge pressure

- “use only …… “(Pre-charge medium, e.g. nitrogen)

COOLERS AND HEATERS

Coolers shall be tube or plate type exchangers and shall be used where normaloperation of the system would raise the temperature of the fluid to over ٦٠°C. Thecooling medium may be air or water. Tube heat exchangers, plate heatexchangers and finned tubes shall be designed as per supplier's standards.
Heaters shall be used if the viscosity of the hydraulic fluid in cold seasons wouldaffect the pump operation adversely. The heaters shall preferably be of electricaltype, having a heating intensity of not more than ١ watt per sq. cm for stagnantoil and ٣ watts per sq. cm for flowing oil. This limitation is to prevent cracking ofthe hydraulic fluid due to local overheating.
Electrical heaters shall preferably be of cartridge type, suitable for mounting in reservoir or pipe and shall be thermostatically controlled. Heat exchangers shall be protected against excessive pressure or pressure surges by suitably providing pressure safety. Where HFC fluids are used, the temperature of the fluid shall be controlled so as not to exceed ٥٠°C.

FILTERS

Filters shall be provided for continuous removal, from the hydraulic fluid, ofcontaminants which are likely to cause malfunction of valves and actuators.Adequate filtration shall be provided in accordance with manufacturer’s recommendations. The filtration capacity shall be selected in order to maintain the followingcontamination level on the systems according to ISO ٤٤٠٦ class (NAS١٦٣٨):

- Standard ١٩/١٧/١٤ (NAS ٨)
- Servo valves ١٦/١٤/١١ (NAS ٥)

These filters shall have differential pressure switch connection and will give alsovisual indication of clogging. If any hydraulic circuit element demands forextremely fine filtration a separate filter suitable for that component shall be usedfor system economy.

Pressure line, return line and circulation line filters shall be so constructed andinstalled that the filter element can be changed for cleaning or replacementwithout disturbing the piping.
Component parts of filter in contact with hydraulic fluid shall be compatible with the fluid and resistant to the corrosive effects of moisture.

SEALING DEVICES

All sealing devices shall be of suitable materials which will not be adverselyaffected by the hydraulic fluid.Whenever possible, sealing devices shall be of the pressure sealing type.Sealing devices on reciprocating or rotating shafts shall prevent all leakage,except that required for lubrication of such devices, under all working conditions,without damaging shafts.Anti-extrusion back up rings shall be used and/or clearances in sealing glands shall be limited to prevent extrusion of the sealing material.

DEVICES FOR CIRCUIT CONTROL, PROTECTION AND SAFETY

Over-pressure capabilities and protection

Suitable type pressure valves shall be provided on the discharge side for pumpsand over pressure protection shall be provided elsewhere in circuits wheredamage to the equipment or hazards to personnel may result if design pressuresare exceeded: Check valves shall be provided on the discharge side of all pumps to prevent any back flow.Sequence control shall be primarily governed by mechanically actuated limitswitches, electronic timers, pressure switches, sequence valve or any other position sensing device.All pressure and flow controls shall be designed so that they are adjustable atthe system working ranges. A pressure check point shall be provided with eachpressure control valve.

Interlocks

The machinery and all connected equipment shall be brought to a safe stop uponfailure of electric power, control power, hydraulic power, or control components.If an unscheduled stop would result in an unsafe condition then the failure shallbe announced by alarms with the system kept in safe condition. Systems shall remain inoperative after restoration of service until controls are reset.Where there is more than one hydraulically or manually controlled device on anyindustrial equipment, whereby possible damage or personal injury may becaused by the failure of any one device to function properly, the circuits shall bearranged with protective interlocks. Means shall be provided to prevent uncontrolled movement of hydraulic actuators in all portions of the equipmentcycle including pump starting and idling. Electrically and pneumatically controlled hydraulic devices shall be applied in such a manner that in the event of electrical or pneumatic circuit failure

There will be damage to the equipment or danger to personnel. Protection of electrical devices shall conform to appropriate plant electricalstandards and shall be completely isolated from coolant, oils and dirt.

FLEXIBLE HOSE ASSEMBLIES

Flexible hose assemblies shall not be constructed from hoses which have beenpreviously used as part of a hose assembly. Flexible hose assemblies shall fulfillall performance requirements specified in the appropriate European and/orInternational standard(s).Recommendations on storage time for the flexible hose assemblies given by thehose manufacturers shall be considered.Considerations should be given to recommending a service life for hoseassemblies.

Installation

Installation of flexible hose assemblies shall:
- have the minimum length necessary to avoid sharp flexing and straining ofthe hose during the component operation. Flexible hoses should not bebent with a radius smaller than the recommended minimum bending radius
- minimize torsional deflection of the hose during the installation and use,e.g. as a result of a rotating connector jamming

- be located or protected to minimize abrasive rubbing of the hose cover
- be supported, if the weight of the hose assembly could cause undue strain.

If the failure of a flexible hose assembly constitutes a whiplash hazard, it shall berestrained or shielded. If the failure of a flexible hose assembly constitutes a fluid ejection hazard, it shall be shielded.

INTERCONNECTING PIPEWORK

GENERAL

These instructions cover special aspects regarding design construction andcommissioning of interconnecting pipe work for hydraulic power systems.For general instruction refer to General Specification for Pipe workwhichincludes also the Piping System Material (PSM).

PIPING DESIGN & SIZING

Design Considerations

The hydraulic pipe work shall conform to the piping system material PSMprepared for the specific project or to general specification for pipe work which is developed on the base of international codes (ASME-ASTM-DINSAE-CETOP).
All hydraulic interconnecting piping systems shall be designed for a nominal working pressure of ٢٥ per cent above the normal working pressureIndicative maximum span between supports shall not exceed the indication of thefollowing table unless otherwise indicated in the piping documentation:

Outside Diam. (mm)	٦ ÷ ٨	١٠ ÷ ٢٥	٢٠ ÷٥٠	**Over ٥٠**
Max Span (m)	١.٠	١.٥	٢.٠	٣.٠

Pipe clamps to be in any case installed at line ends and before and after changeof direction. Piping between actuating devices and control valves shall be as short as possible and rigidly mounted to eliminate vibration.Pressure gauges or gauge connections shall be

supplied at test points betweenmajor system components as follows: on power unit; between directional controls and actuators; and at other points where pressure change. Test points shall beindicated the hydraulic diagram and in the assembly drawings.

Pipe sizing

Interconnecting pipes shall be sized on the basis of technical and economicalvelocities taking into account the following parameters:

- pressure
- pressure drop
- absolute roughness of pipe
- type of service

Velocity of hydraulic fluids in steel pipes should not exceed generally the following values:

SERVICE	***PRESSURE (bar)***	***VELOCITY (m/s)***
Suction lines	All	١
Return lines	All	٣
Delivery lines	up to ٥٠	٤
	٥٠ ÷ ١٠٠	٤.٥
	١٠٠ ÷ ١٥٠	٥
	١٥٠ ÷ ٢٠٠	٥.٥
	٢٠٠ ÷ ٤٠٠	٦

The normal practice is to guarantee a maximum pressure drop of ١٠% of theoperational pressure at user T.O.P.

Suction lines shall be sized in order to guarantee the pumps required NPSH. Higher velocities are normally accepted for larger pipe size and for short branches.

MATERIALS AND DIMENSIONAL STANDARDS

Carbon steel pipes and butt weld fittings are supplied pickled clean and free fromoxide scale and carbon deposits, neutralized, phosphated and oiled inside. Pipeends shall be fitted with plastic

caps in order to avoid oxidation duringtransportation and storage at site. The plastic caps must be visible.
Stainless steel pipes and fittings are supplied not oiled but thoroughly clean andfree from dirty. Socket welding fittings are normally supplied black and prior to fabrication need to be thoroughly cleaned inside to remove oxide and debris.
If necessary batch pickling has to be used to eliminate oxide following the instruction submitted.
For piping material specification refer to the Piping System Material (PSM)prepared for the specific project or to General Specification for Pipe work. In any case, all the piping material for hydraulic pipe work shall be stored in sitewith particular care in order to avoid re oxidation and contaminations.
Stainless steel material shall be kept in segregated storage areas far fromcarbon steel materials.
Each piping component has to be inspected prior to fabrication and if neededaccurately cleaned or pickled following the instruction given.

FABRICATION AND ERECTION

Interconnecting pipework shall be installed following the project erectiondocumentation and the general instruction . The erection contractorshall check in advance the erection documentation with the foundation and thefinal position of the equipment before starting the spool drawing preparation andany fabrication activity.
Pipe fabrication will be performed in dedicated clean area. For field fabrication it is recommended to erect temporary barriers.
Prefabrication of the greatest number of pieces in workshops is advisable. Pipes should be kept covered both before and during their assembling upon the installation completion.
When butt welded fittings are used, welds should be made reasonablyaccessible also from inside of the pipes, in particular for large diameters. This willallow mechanical cleaning. When socket weld fittings are used, it's imperative todeburr the pipes and provide for a mechanical cleaning or pickling and passivation.
The piping assembly must be carried out accurately. Carefully free the pipe fromall burr, inside and outside. When dealing with cutting ring or special fittings,follow the instructions given by the manufacturer. When laying pipelines havinglong stretches without connected fittings, keep the maximum commercial length of the pipes. Connecting pipes must not hinder the accessibility to theinstruments, especially where there are hand controls for

adjustment or tuningdevices for checking. When the piping is higher than the hydraulic ports, installbleeders for venting. In case of sag provision for drainage shall be foreseen. Anadequate number of disassembly fittings must be installed (flanged joints, andpipe unions etc.) to allow flushing and testing.
Before proceeding to the installation of manifolds, look into the singlecomponents to make sure there are no foreign bodies. During hydraulic pipesassembly, care must be taken when performing cold bending. Do not cut ormake holes using a flame cutter. When cutting pipes, use cutting disc typeshears and after each cut, deburr and blow the machined piece, or even betteruse rotating wheel pipe cutter. For large size pipes, where the use of a flamecutter is unavoidable, it's essential to grind and deburr the cut, both externallyand internally, taking care to blow and perfectly clean the piece.
For butt welding connection adequate leveling according to piping specificationmust be executed.
Carbon steel pipes and fittings for hydraulic systems are generally suppliedpickled, passivated and oiled. In order to avoid oxidation of joints the firstwelding must be executed with TIG procedure (Argon gas). This way to proceedavoids the need of further pickling.All pipes and fittings shall be consequently thoroughly inspected before and afterfabrication. If some pipes, fittings or spools are found with oxide it has to bepickled again (pickling in tanks) following the instruction given. The disassembled pipes shall be cleaned with proper means (brushes,Tampons, compressed air, wooden mallets, etc.) to eliminate any foreign matteror considerable scaling.
After fabrication and prior to assembly, close the ends of the fabricated andcleaned parts with plastic plugs sealed with adhesive tape, in order to preventforeign matters or humidity from penetrating.Assemble all prefabricated or on-site manufactured pipes together with all thefittings and valves required for the circuit but do not secure them tightly. Thisensures the circuit completion and correctness and allows any necessarycorrection to be carried out. Finally assemble on site all parts and protect the exposed ends. Piping shall not be placed in a location on the machine where it will interfere with the adjustment, repair or replacement of controls or units.
Piping connections shall be readily accessible for maintenance. All piping shall be securely supported to avoid vibration or movement. Pipe andtubing lengths between supports shall be as per erection documentation. Piping shall not be welded to

supports. After assembly a thorough inspection will be carried out on the piping system to check eventual re-oxidation phenomena. If during final inspection of the fabricated and erected interconnecting pipingsome parts are found rusty then an in line pickling shall be performed.For the pickling procedure refer to Special instructions for in sitepickling. The final inspection will be carried out also for the on board piping in order toavoid any possible contamination.

TESTING OF ERECTED PIPING

The pipe work as erected shall be hydraulically tested according to design requirements.
The hydraulic test shall be carried out using a fluid type compatible with theselected final working fluid.The hydraulic test pressure shall be ١.٢ times the working pressure unlessotherwise indicated on the project documentation.Immediately after the hydraulic test, dismantle the fittings used for test andprepare the circuits for the commissioning.If flushing will be carried out in a further phase, the line shall be drained, driedand filled with dry nitrogen at ١÷٢ barg pressure.

COMMISSIONING

Circuits preparation

Facilities are normally foreseen in the piping design to facilitate flushing andcleaning connections. It is necessary, during the flushing and cleaning operation,to bypass components such as valves and cylinders. The Contractor has tocheck the erection documentation and to foresee all the necessary temporary fittings and blind flanges for the flushing circuit preparation. The flushing operation shall normally include also on board piping up to the flexible hoses connecting the hydraulic cylinders which have to be by passed on this basis the Contractor has to provide an operating sequence of how they propose to flush the system.
The Contractor has to provide authorized personnel with a markedcopy of the system schematic, showing where connections for flushingequipment will be installed. Information on how the system is to beinterconnected to form a continuous loop must be shown on these drawings.Prefabricated loops must be precleaned. All potential trouble spots where dirt may accumulate are to be identified for special attention. All valves, manifolds, cylinders,

system pumps and system reservoir must be bypassed during flushing and capped to prevent entry of dirt. The design of the flushing circuit must include provision for reversal of flow.
Contractor must furnish its own flushing pump; system pumps are not to be used. Pump flow must be high enough to create turbulent flow in every part of circuit during the cleaning phase. This level is to be determined by the followingformula,
assuming Reynolds Number (Re) to be greater than ١٠.٠٠٠ (minimumfluid velocity, ٤, ٥m/sec):

Re = (Q/d ×v)×٢١.٣٠٠ (Where: Q=flow(lpm)\ \ d=pipe ID(mm)\\ v= kinematics viscosity of the fluid(cSt)
The pump will most likely not be able to maintain the turbulent flow during the fluid flush phase. Flow can be maximized by circuit isolation during this phase.Sampling ports must be provided to permit samples to be taken ahead of filterswhen flushing in either direction (fluid sampling containers according to ISO ٣٧٢٢). The Contractor and Danieliauthorized personnel must agreebeforehand as to when and where samples are to be taken.
Because of danger and flaking, no rubber hoses are to be used for bypass during flushing.Where flushing all piping in series is not practical because of pressure drop,temporary manifolds may be installed with isolation valves to form parallelcircuits. However, the indicated turbulent flow velocity must be guaranteed.
Filters must be provided in order to detect “dirty” conditions; these filters must notbe fitted with bypass valves. Isolation valves must be provided so that filters can be changed without disturbing flow.
To facilitate the choice of the flushing pumps refer to the table here below. TheFlow rates refer to the various internal diameters of pipes assuming Re>١٠.٠٠٠,
Fluid Velocity>٤,٥ m/sec and Fluid Viscosity=٣٠ cSt.

Pipe ID (mm)	Viscosity (cSt)	Density (kg/m$^{٣-}$)	Minimum Fluid flow lpm	Re No.	Pressure drop bar/m	Fluid Vel m/s
١٠	٣٠	٩٠٠	١٥٠	١٠.٦١٥	١٦,١٦	٣١,٨٥
١٥ ٣٠	٩٠٠	٢٢٠	١٠.٣٧٩	٤,٦٠	٢٠,٧٦	
٢٠ ٣٠	٩٠٠	٣٠٠	١٠.٦١٥	٢,٠٢	١٥,٩٢	

٢٥٣٠ ٩٠٠ ٣٦٠ ١٠.١٩٠ ٠,٩٦
١٢,٢٣
٣٠ ٣٠٩٠٠ ٤٥٠ ١٠.٦١٥ ٠,٦٠ ١٠,٦٢
٤٠ ٣٠ ٩٠٠ ٥٨٠ ١٠.٢٦١ ٠,٢٤
٧,٧٠
٥٠ ٣٠ ٩٠٠ ٧٥٠ ١٠.٦١٥ ٠,١٣ ٦,٣٧
٦٥ ٣٠ ٩٠٠٩٥٠ ١٠.٣٤٢ ٠,٠٦ ٤,٧٧
٨٠ ٣٠ ٩٠٠ ١.٤٠٠ ١٢.٣٨٤ ٠.٠٤
٤,٦٤
١٠٠ ٣٠ ٩٠٠ ٢.٢٠٠ ١٥.٥٦٨ ٠,٠٣٤,٦٧
١٢٥ ٣٠ ٩٠٠ ٣.٥٠٠١٩.٨١٤ ٠,٠٢٤,٧٦
١٥٠ ٣٠ ٩٠٠ ٥.٠٠٠٢٣.٥٨٨ ٠,٠٢٤,٧٢

Hydraulic systems flushing preconditions

The Contractor shall supply all the auxiliary devices such as tanks, pumps, filters, valves, manifolds, thermal heaters, temporary bypasses and whatever required for proper field operations. It is a Contractor's responsibility the fluid handling and disposal.
The Contractor must provide assurance in writing that all spent chemicals will beproperly disposed off, including used filter cartridges. Customer EnvironmentalControl Department must be involved at this point.
All services to be provided by Customer to Contractor, such as a set-aside area,steam, electricity, water, etc. must be agreed upon in pre-bid meeting.The Contractor is expected to provide field test kit for analyzing dirty level insamples. This is to be used in determining when samples are ready to be sent to outside laboratory. All the chemical solutions, fluids, tools and the flushing operative sequence necessary to carry out the operations in the proper way will be charged to the account of the Contractor upon approval of the personnel authorized by DanieliThe Contractor will be held responsible for any problem caused by incorrect operation of the systems due to a not proper cleanliness

Flushing activities

The flushing fluid capacity to remove particles from the internal surfaces ofpiping is in proportion to the quantity of energy available as a result of the fluid pipe surface friction.

During flushing, every welded joint must be hammered with a ball peen hammerfor ٣٠ sec. during each phase of the schedule, including reverse flow. Contractoris responsible for any damage caused by hammering. Hammer in the direction of flow.Though vibrators may be used on low spots where dirt tends to accumulate,hammering is preferred. In addition, starting and stopping flow by suddenopening and closing ofvalves is a good assist.
Reverse flow is required during pickling, passivation and flushing phases, whenthe hammering is to be repeated in direction of flow.
The particles removed by the flushing should be caught with a filter with a high "β ratio". We consider fundamental that filters of major companies makers areemployed and also we do not recommend the use of lowfinesse filters followedby high finesse filters, as this is not economically convenient.
During flushing, contractor is to inspect lines frequently and to stop flushingimmediately if a leak occurs. Flushing fluid must be kept out of customer'ssewers.
After system has been drained of all fluids, system is to be purged with dry nitrogen. An authorized personnel is to verify completion of drying, after which system may be refilled with filtered system fluid for that portion of flush schedule.

System tank cleaning
Access cover is removed and the inside is swabbed with lint-free cloth. If reservoir is large enough for a person to enter, contractor's worker must wearclean white paper coveralls and white paper boots for manual wiping of insidewith lint-free cloth. Safety precautions for entering closed space must be observed. Access cover and new gaskets are to be reinstalled and checked later for leaks.

Final approval

Final samples, to be sent to an outside lab, must be analyzed according to ISO, report must be in ISO ٤٤٠٦ codeformat (expanding the code to threeranges correlating to ٢μm, ٥μm and ١٥μm). Minimum three samples for each loop circuit may be taken at any time after flushing begins with system fluid and after welded connections have beenhammered during this part of theschedule. If clean enough, sample may bedrawn for transportto outside lab. This sample is to be drawn by authorized personnel.
While test results are awaited, flushing is to continue. If sample

turnaround islonger than ٤ hrsauthorized personnel may waive testing byoutside lab and agree to useof field test kit
or field portable contaminated monitor and related reports (min. three reports for each loop circuit).

If sample results are within specifications (see par, below), flushing may stopand system can be drained. The Contractor will dispose of this contaminatedfluid.

The target cleanliness level for systems must be:

Type of system	Contamination Level ISO ٤٤٠٦- (Target) ٢µm-٥µm-١٥µm	FILTER ABSOLUTE FINENESS SUGGESTED Bx≥١٠٠
Hydraulic systems with Servo valves	١٥/١٣/١٠ (NAS ٤)	١÷٢
Hydraulic systems without servo valves	١٧/١٥/١٢ (NAS ٦)	٣÷٥

System filling with final fluid

Immediately after flushing is completed, all system components are to bereconnected after contractor's equipment has been removed.
In the case of flushing in which is used the same working fluid, this must be checked by the fluid Manufacturer before the filling on the following characteristics:

viscosity, acidity (T.A.N./S.A.N.)(Total Acid No-Strong acid No.)and water content. In case of these values are not into the range of new product, the Contractor must recondition or change the fluid. Before proceeding to fill-up the system, make sure that the fluid corresponds exactly to the requirements of the design.
All fluids on the market, with no exception, even the new ones and thosecontained in sealed container, are not perfectly clean. They should, therefore, befiltered.

Before proceeding to fill-up the tank, check accurately the tank cleanness. Filling must always be done through the appropriated external filter which has a better degree of absolute filtration as the ones mounted on the system. Be extremely careful of any accidental introduction of pollutants, dust, rags and various objects. Test perfect sealing and perfect functionality of the air filters mounted on the vents which permit the intake and emission of air as the level of the fluid rises and drops in the tank. Never mix fluids of different types or makes. If the hydraulic circuits are not immediately filled up with the final fluids all the lines shall be drained, dried and filled up with dry nitrogen at ١÷٢ barg pressure.

SAFETY AND ACCESSIBILITY

All equipment shall be protected against failing objects and operator's accidentalmovements from material handling and moving equipment aswell as excessivetemperature and detrimentaleffects such as water, scale, acid, dirt, dust or other environmental conditions. Automatic controls shall be located and protected to prevent accidental operation. Piping shall not be used to support directional valves. Hydraulic systems provided in the vicinity of open flames high temperatures, molten metal etc. (such as those for furnaces, cranes, coilers etc.) special protection shall be given to prevent breakout of fire in case of pressure breakout of the hydraulic fluid. These shall include selection of suitable seal, packing and fittings. Thermal insulation shall be provided for hydraulic systems operating in areas of high temperatures (>١٠٠°C).
Bladder or piston type gas accumulator shall be charged with nitrogen. Manual on-off valves shall be supplied at each valves stand onpressure line, non-return valve in return lines for safe isolation during maintenance.
Valves and other controls shall be mounted preferably on blocks or valve stands or on the related power unit.
Meter out flow controls shall be used except where high intensification may occur.
An emergency stop shall be provided and shall be readily accessible from theoperator's normal working position.
Means shall be provided to prevent rapid vertical drop or inclined slides or ramsof equipment when hydraulic power is shut-off in case ofoperation on vertical or inclined slides or ramps. All components should have a nameplate, standard symbolsand item numbersame as drawing.

INSPECTION AND TESTING

Hydraulic systems, inspections and testing shall conform to General
Specification for Quality Control.

DRAWINGS AND OTHER DOCUMENTS

DEFINITION OF ENGINEERING PHASES

BI = Basic information
It consists in the definition of basic requirements in terms of quality and quantityof fluids consumed by the users.
The data given during this phase are subject to confirmation during the following phases.

BD = Basic design
It consists in the definition of systems configurations. During this phase a complete check of process requirements of each plant unit has to be completed.

DD = Detail design
It consists in the development of construction engineering ant it allowspurchasing of components from the market and consequentfabrication anderection of the piping systems.
Drawings anddocuments forhydraulic discipline shall conform generally toISO ١٢١٩standard.

GENERAL

Following the instructions of this general specification the pickling activity on siteshould be avoided. In the case some pipes or fittings or theentire system require pickling the following procedures can betaken as reference.
It is in any case recommended to subcontract the pickling activities to specialized company.

CHEMICAL PRODUCTS TO BE USED FOR PIPES PICKLING OPERATIONS

There are many methods to perform the pickling operation, the simplest methodrecommended is, however, to use products

“ready to use”, such as BETONA orRIDEC ١٥٤.
These products do not require any preparation or particular knowledge for their use, as they offer the advantage of performing the pickling in a single operation. If these products are not available, it is recommended to have the pipes pickled by a specialized company, anyway taking care that, after the inhibited acid solution, passivation must be duly performed; the following products (or similar) to perform the pickling and neutralization/passivation of pipes are suggested

- P٣RST at ٥٠°C for degreasing
- Lutensol-ON٧٩-BASF (chemically pure) for degreasing
- HCl for pickling
- HF for pickling
- H٢SO٤ for pickling
- C٦H٨O٧ for pickling
- NaOH for neutralization
- NH٣OH for passivation
- NaNO٢ for passivation

The product concentrations depend on the Contractor proposed method.

PIPE PICKLING IN TANKS

Generally speaking, pickling will be carried out according to the followingoperating cycle:
Mechanically clean the pipes and fittings (with brushes, compressed air, woodenmallets, etc...) to eliminate any foreign matter or considerable scaling.
Clean by immersion in tanks containing strongly alkaline or similar solutionsuitable to removing grease, oil from the pipes surface. Wash under running water.
Protect the threading or other parts in order not to be attacked by the pickling bath with grease or other acid-resistant means.
Pickle by immersion in tanks containing acid solution.
The duration of these operation will depend on the solution concentration and onthe cleanliness of the surfaces, which must be free of scales, calamine andoxide.
During pickling, frequently move the prefabricated sections and fittings to assist the acid action on the surfaces and to remove any gas bubbles which could prevent the solution from coming into complete contact with the metal.
The neutralization treatment shall be carried out with a proper alkaline or similarsolution.

This treatment requires particular care because any acid solutionresidue would continue their corrosive action.
The passivation treatment shall be carried out with a proper passivation solution.
This treatment prevents rust formation after neutralization.
Apply the spray protection, suited to the flushing fluid, on the inner surfaces ofthe piping. This type of spray protection prevents internal rustprotection and it issoluble in the flushing fluid. Seal the pipes ends with suitable visible (not transparent) plugs. All the fluids shall be disposed following the local regulation.

PICKLING IN LINE

Generally speaking, pickling will be carried out according to the following operating cycle:
Prepare the circuit so as to link the delivery lines to the return ones, by-passingall the equipment, valves and users.
Disassemble those pipe parts which cannot be included in the pickling closedcircuit for specific system reasons.
These disassembled pipes shall beconnected together in separate, provisional circuits.
Pickle with chemical solutions circulating in the pipes by means of a specialcentral unit in compliance with the following operating cycle:

- degreasing with an alkaline or similar solution;
- washing with running water;
- pickling with an acid solution;
- neutralization with an alkaline solution;
- washing with running water;
- neutralization and passivation;
- drying

IMPORTANT:

If after the drying the system is not ready for flushing, pressurize the inner part ofthe piping with inert gas (e.g. Nitrogen, Helium), in order to avoid any corrosive action on the system.
The maximum time between Drying and Flushing to avoid the systempressurization with inert gas is ٣ hours; at any rate, this interval
must be alwaysapproved by authorized personnel.

PICKLING PROCEDURE FOR IN LINE PICKLING

Following procedure is a suggestion utilizing reagents and items easily to find onthe European market and takes in consideration to have alllaboratory equipment needed for here below describedanalysis (to be performed while executing the picklingoperation). Any other procedure, different from what describedhere below, could be still utilized achieving, nevertheless, thesame final target.
Contractor shall provide detailed copy of pickling procedure to Danieli for approval.
Piping pickling treatment forecasts the performance of here below describedoperations:

washing by means of water
washing by means of alkaline solution
pickling
passivation
drying

If at the end of the drying phase the piping has not to be submitted to furthertreatments (such as flushing operations), next phase will be:
piping system reconditioning followed by the required fluid filling.
If piping system reconditioning is expected to be made not immediately after thepickling operation conclusion, it is a must to perform an additional operation of lines conservation.

Washing by means of water.

Overall piping must be filled by water that will be flushed by means of the pickling unit pumps. Water will be heated up to ٦٠°C by means of steam injection during such recirculation. This in order to remove all materials presents inside the piping and not attached to it. Overall flushing circuit will be emptied after ٢-٣ hours of recirculation, and this fluid shall be stored inside a tank where to evacuate all drains to be sent for disposal.

Washing by means of alkaline solution

Purpose of this procedure is to remove all oils and greases present inside thepiping and to allow subsequent acid treatment to react betteragainst theoxidized layer.
To allow such washing the circuit will be filled by water that will be flushed by means of the same pickling unit. Then following reagents will beproportionated:

-SODIUM HYDROXIDE (NaOH) ١٠ Kg/cubic meter of water
-TRISODIUM PHOSFATE ($Na_3 PO_4$) ٥ Kg/cubic meter of water

Reagents will be solubilized inside the preparation tank of the pickling unit, this inorder to obtain a concentrated solution. Then, such solution will be added to thewater recirculating inside the circuit. This procedure will avoid reagents depositing inside the circuit if not perfectly solubilized
Same procedure will also be performed for any other reagent, even if notrecalled, to prepare all chemical solutions foreseen for picklingand passivationoperations. Above described adding will make the recirculatingsolution with the following chemical concentration:.

SODIUM HYDROXIDE (NaOH) ١%
TRISODIUM PHOSFATE (Na_3PO_4) ٠,٥%

This recirculating solution will be heated up to reach ٦٠-٧٠°C by means of steaminjection and it'll be kept in circulation for about ٢-٣ hours. After this period, this solution will be emptied and the circuit willbe washed bywater up until removing all traces of alkali, checking thewashing water free from any greases or oils traces.
Alkaline washing shall be repeated if in presence of oils or greases traces.
All discharged solutions shall be stored inside a disposal tank.

<u>Acid washing (citric treatment).</u>

Purpose of the acid washing is to solubilize the oxide layer present against theinside walls of the piping. When the previous alkaline washingand waterwashing is concluded, the circuit will be filled by water adding following reagents:

CITRIC ACID ($C_6H_8O_7$)	٣٠ Kg/cubic meter of water
RODINE INHIBITOR ٣١ A	١ Kg/cubic meter of water

Ammonia concentrated at ٢٥% will be added up until to have the solutionreaching a Ph value equal to ٣,٥.

Then, this solution will be heated up to reach ٧٥°C by means of steam injection.
Following analysis shall be randomly performed during this heating phase:

- ACIDITY CONTENT;
- FERROUS IRON;
- FERRIC IRON.

Following checking and analysis shall be performed during pickling operation:

١) definition of the total circuit volume (by means of the engineering);
٢) PH checking for the solutions used for piping circulation;
٣) Acidity content detection;
٤) Ferrous and ferric ion concentration verification.

With the operations here above described it is possible to:

a) Verify, through the total volume quantity definition, the quantity ofreagents to be deployed to obtain the exact solution concentration to beplaced in circulation inside the system and in accordance to theherebelow described specifications;

b) Check if there is always an active acid excess during the picklingexecution needed to solubilize all oxides present inside thecircuit;

c) Define when to stop the pickling operations through the verification ofthe iron stabilization (ferrous ferric) solubilized by the acid attack.
Washing procedure will be performed up until to stabilize the iron concentration,showing in this way no more oxides to solubilize. By the way, acid washingduration will not be less than ٤ hours.

Passivation

All oxides present against the inner parts of the piping have been removed oncecompleted the above here-described acid washing, leaving rawthe inner parts ofthe piping.

Leaving the piping in this condition means letting the inner parts of the piping to be subjected to oxidation, with consequent rust formation.
Purpose of the passivation phase is to create a protective layer on the inside walls of the piping, protecting them from oxidation. Solution temperature will be dropped down to ٦٠-٦٥°C andcitric acid (equal to٠,٥% or equivalent to ٥ Kg/cubic meter)and ammonia will be added to bring thesolution PH up to reach ٩,٢. Temperature for about ١ (one) hour. Then, sodium nitrite ($NaNO_٢$) in proportionof ٥ Kg/cubic meter of the solution will be added. Concentration of this reagent will be equivalent to ٠,٥% so this passivating solution will be kept in circulation for ٤ (four)hours keeping thetemperature steady. The circuit will be emptied once met this duration. Once emptied the circuit from this solution, the circuit shall be washed by meansof dematerialized water, with Ph value equal to ٩ adding a bitof ammonia, if thereare any doubts about complete removal of this solution (i.e. ifsensible volume of fluid is still inside the circuit). Then, the circuit will be emptied once more.
All removed solutions during passivation phase will be stored inside a disposal tank.
Pressurized nitrogen will be blown through the vent pipe to empty the circuit fully, opening and closing all discharging valves alternatively in orderto allow gas flowconcentration inside all various circuit branches. Next phase to be processed will be the drying operation.

Drying

Nitrogen will be inserted to empty the circuit as soon as the passivation phase isconcluded, opening all drains with a low nitrogen flow and, eventually, openingflanges connection in order to drain the solution as much as possible.

The moisture still present inside the circuit will be dried by nitrogen insertionheated up by means of suitable heaters. Gas moisture will be measured byhygrometer device at its exit while inserting the nitrogen, that will continue opening and closing alternatively all various circuit branchesand up until to havethe moisture level reaching a value lower than ٢-٣%.

Piping system reconditioning.

All temporary piping connection will be reconditioned as soon as the above here describedoperations, and/or flushing phase hasbeen completed. Particular care shall be taken to avoid piping contaminationduring such phase. Further phase will be circuit filling with the final fluid.

Lines conservation

Time frame between chemical treatment and further flushing operation, or circuitstart up with final fluid, shall be as short as possible to preventoxidation of innerpiping walls.

This is never achievable and the whole circuit shall be kept under apreservation state. The most suitable preservation state is achievable keeping thewhole circuitthe system will be started up. Then, nitrogen will be inserted inside the circuit up to reach apressure value of١-٢ barg once the drain valves have been shut. Such valueshall be detectedthrough the gauge installed along the circuit. Nitrogen pressure shall be checked ٢٤ hours later to verifythere are no leakageout from the circuit as well as the moisture content.

Heated nitrogen shall be inserted in the circuit if the detected moisture contentwill be higher from the defined value, then, once reached it, thecircuit will bepressurized once more.

This checking procedure will be performed on a daily basis for ٣ (three) consecutive days and up until this moisture content will remainconstant underthe stated values. If so, moisture content checking frequencycould be performedonce every two weeks, and keeping it up to the start up of thesystem.

A visual check of the piping condition, removing the flanged joints, shall beperformed every ٢ (two) months if the nitrogen preservation isforecasted longerthan ٢ (two) months.
A light nitrogen flow shall be kept running through the circuit avoiding aircontamination while performing this checking. A biweeklychecking shall beperformed as above here described once the circuit has beenpressurized bynitrogen after this visual check.

Finally,hydraulic system arrangements are very sophisticated, neat and should be supervised very carefully, cleanness is important in all steps, for piping and equipments, starting from the way of proper storage to the fabrication, assembly and installation otherwise fatal results maybe occurred. As I got the chance to supervise these procedures and witnessed these steps in SMI Melt shop erection, I acquired good experience so I liked to share it with the others who have the interest; therefore I submitted this research with the aid of practical and theoretical tools to get the advantages.

Senior Mechanical Engineer
MazinMaaroofNejim

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