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Installation, commissioning and maintenance of hydraulic systems

1. General

1.1 Long service life and functional reliability of hydraulic systems and their components depend on correct handling.

Ensure trouble-free operation by observing the following points:

– The specific installation and operating instructions for the relevant components

– Special instructions in individual cases

– Technical data in the data sheet.

In addition, we would like to draw your attention to the following regulations:

– "Commissioning and maintenance of oil-hydraulic systems" (VDI 3027)

– German standard "Hydraulic systems" DIN 24 346

– ISO standard ISO 4413

2. Installation

2.1 Preparatory work for the installation

– Ensure that the system is clean!

- For the surroundings:
  Keep power units, line connections and components clean or clean them (e.g. pickling after, for example, processes have been carried out that involve heat, i.e. welding, hot bending, etc.)!
- For hydraulic fluids:
  Take care of contamination and humidity; contamination from the environment must not enter the tanks!
  Fill oil tanks only through filters, preferably system filters or portable filter stations with fine filters.
  Internal protective coatings, if any, must be resistant to the hydraulic fluid used!
- For parts taken from stock:
  The storage of parts that were not filled or treated with anti-corrosion fluid can lead to the formation of resin. Solve the resin using a grease solvent and renew the lubricating film.

– Check to see that all of the parts required for the installation are available!

– Take note of any transport damage!

2.2 Carrying out the installation

– Use lifting lugs and transport facilities!

– Do not apply force to prevent transverse forces and tension on pipes and components. The valve mounting surfaces must be perfectly even. The fixing screws must be tightened evenly at the specified torque.
Take care that pipes are adequately fixed!

– When selecting pipes, hoses and fittings/flanges, observe the correct pressure stage (wall thickness, material). Use only seamless precision steel pipes.

– Do not use hemp or putty as sealing materials! This may cause contamination and thus malfunction.

– To prevent external leakage, observe the installation instructions of the pipe fittings' manufacturer. We recommend the use of fittings with elastic seals.

– Make sure that hoses are properly laid! Rubbing and abutting of the lines must be prevented.

– Provide the correct hydraulic fluids.

- Mineral oils: HLP hydraulic oils according to DIN 51 524 part 2 are generally suitable for standard systems and components.
- Fast bio-degradable hydraulic fluids: VDMA 24 568.
  For these fluids, the system and components must be matched.
- Hardly inflammable hydraulic fluids: VDMA 24 317. For these fluids, the system and components must be matched. (Before filling in the special media, check, whether the system is compatible with the intended fluid.)

The following points must be observed in accordance with the relevant requirements:

– Viscosity of the hydraulic fluid

– Operating temperature range

– Type of seals used on the components fitted

3. Commissioning

When the installation has been carried out correctly, proceed with commissioning and functional testing.

3.1 Preparations for trial run

– Tank cleaned?

– Lines cleaned and properly installed?

– Fittings, flanges tightened?

– Lines and components correctly connected in line with installation drawings and circuit diagram?

Is the accumulator filled with nitrogen? Fill in nitrogen until the pre-charge pressure p_0 as specified in the circuit diagram is reached. (On the fluid side the system must be pressureless!). It is recommended that the gas pre-charge pressure is marked on the accumulator itself (e.g. self-adhesive label) and in the hydraulic circuit so that a comparative check is possible, if required.

⚠ **Caution!** Use only nitrogen as pre-charge gas!

Accumulators must comply with the safety regulations valid at the place of installation.

– Are the drive motor and pump properly installed and aligned?

– Is the drive motor correctly connected?

– Are filters with the prescribed filter rating used?

– Are filters fitted in the correct direction of flow?

– Has the specified hydraulic fluid filled up to the upper marking?

As the hydraulic fluids often do not comply with the required cleanliness, the fluids must be filled through a filter. The absolute filter rating of the filling filter should be at least that of the filters installed in the system.

3.2 Trial run

– For safety reasons, only personnel of the machine manufacturer and, if required, maintenance and operating personnel should be present.

– All pressure relief valves, pressure reducing valves, pressure controllers of pumps must be unloaded. An exemption to this are TÜV-set valves.

– Open isolator valves completely!

– Switch the system on briefly and check whether the direction of rotation of the drive motor matches the prescribed direction of rotation of the pump.

– Check the position of the directional valves and, if necessary, move the spool to the required position.

– Set the control spool to by-pass.

– Open suction valves of the pump. If required for design reasons, fill pump housing with hydraulic fluids to prevent bearings and parts of the rotary group from running dry.

– If a pilot oil pump is provided, commission it[1)].

– Start up the pump, swivel it from its zero position and listen for any noises.

– Swivel the pump slightly out (ca. 5°)[1)].

– Bleed the system
Carefully loosen fittings or bleed screws at high points in the system. When the escaping fluid is free from bubbles, then the filling process is completed. Re-tighten fittings.

– Flush the system; if possible, short-circuit actuators. Flush the system until the filters remain clean; check the filters!
With servo-systems, the servo-valves must be removed and replaced by flushing plates or directional valves of the same size. Short-circuit the actuators. During flushing, the hydraulic fluid in the complete hydraulic system should reach temperatures that are at least as high as later during operation. Change the filter elements as required.
Flushing continues until the required minimum cleanliness is reached. This can only be achieved by continuous monitoring using a particle counter.

– Check the system functions under no-load conditions, if possible, by hand; cold-test the electrohydraulic control.

– When the operating temperature has been reached, test the system under load; slowly increase the pressure.

– Monitor control and instrumentation equipment!

– Check the housing temperature of hydraulic pumps and hydraulic motors.

– Listen for noises!

– Check the hydraulic fluid level; if required, top up!

– Check the setting of pressure relief valves by loading or braking the system.

– Inspect the system for leaks.

– Switch off the drive.

– Retighten all fittings, even if there is no evidence of leakage.

⚠ **Caution!** Only tighten fittings when the system is depressurised!

– Is the pipe fixing adequate, even under changing pressure loads?

– Are the fixing points at the correct positions?

– Are the hoses laid so that they do not chamfer, even under pressure load?

– Check the fluid level.

– Test the system for all functions. Compare measured values with the permissible or specified data (pressure, velocity. Adjust further control components).

– Jerky movements indicate, amongst other things, the presence of air in the system. By briefly swivelling the pump in one or both directions with the actuator being loaded or braked, it is possible to eliminate certain air pockets. The system is completely bled when all functions are performed jerk-free and smoothly and the surface of the hydraulic fluid level is free from foam. Experience has shown that foaming should have ceased one hour after start-up at the latest.

– Check the temperature.

– Switch off the drive.

– Remove filter elements (off-line and full-flow filters) and inspect them for residues. Clean filter elements or replace them, if required. Paper or glass fibre elements **cannot** be cleaned.

– If further contamination is found, additional flushing is required to prevent premature failure of the system components.

– All the adjustments made are to be recorded in an acceptance report.

3.3 Commissioning of fast running systems

Such system can often not be commissioning using the normal measuring instruments (such as pressure gauges, thermometers, electrical multimeters, etc.) and standard tools. Optimization is also not possible.
These systems include, for example, forging presses, plastics injection moulding machines, special machine tools, rolling tools, crane controls, machines with electrohydraulic closed-loop control systems.
Commissioning and optimization of these systems often require more comprehensive measuring equipment to allow several measurements to be taken at a time (e.g. several pressures, electrical signals, travel, velocities, flows, etc.).

3.4 The most common faults occurring during commissioning

Apart from servicing, commissioning is very decisive for the service life and functional reliability of a hydraulic system.
For this reason, faults during commissioning must be avoided as far as possible.

The most common faults are:

– The fluid tank is not inspected.
– The hydraulic fluid is not filtered before being filled in.
– The installation is not checked before commissioning (subsequent conversion with loss of fluid!).
– System components are not bled.
– Pressure relief valves are set only slightly higher than the operating pressure (closing pressure differential is not observed).
– Pressure controllers of hydraulic pumps are set higher or to the same pressure as the pressure relief valve.
– The flushing time of servo systems is not adhered to.
– Abnormal pump noise is ignored (cavitation, leaking suction lines, too much air in the hydraulic fluid).
– Transversal loads on cylinder piston rods are not observed (installation error!).
– Hydraulic cylinders are not bled (damage to seals!)
– Limit switches are set too low.
– The switching hysteresis of pressure switches is not taken into account when settings are made.
– Hydraulic pump and hydraulic motor housings are not filled with hydraulic fluid prior to commissioning.
– Settings are not documented.
– Adjustment spindles are not secured or sealed.
– Unnecessary personnel present during commissioning of the system.

4. Maintenance

According to DIN 31 051 the term "maintenance" includes the following fields of activity:

– **Inspection**

Measures to recognise and assess the actual situation, i.e. recognise how and why the so-called wear reserve continues to decrease.

– **Maintenance**

Measures to preserve the nominal conditions, i.e. to take precautions in order that the reduction in the wear reserve during the useful life is kept as low as possible.

– **Repair**

Measures to restore the nominal condition, i.e. compensate for reduction in performance and restore the wear reserve.

Maintenance measures must be planned and taken in accordance with the operating time, the consequences of a failure and the required availability.

4.1 Inspection

The individual points to be inspected should be summarised for a specific system in so-called inspection lists in order that the inspections can be carried out adequately by employees with different qualification levels.

Important points of inspection are:

– Checking the hydraulic fluid level in the tank.
– Checking the heat exchanger (air, water) for effectiveness.
– Checking the system for external leakage (visual inspection).
– Checking the hydraulic fluid temperature during operation.
– Checking pressures
– Amount of leakage
– Checking the cleanliness of the hydraulic fluid

⚠ Caution!

Visual inspections can only give an approximation (clouding of the hydraulic fluid, darker appearance than at the time of filling, sediments in the fluid tank).

If conventional particle counting is impossible, the following three methods can be used for establishing the fluid cleanliness:

- Particle counts using electronic counting and sorting equipment.
- Microscopic examination.
- Gravimetric establishment of solids by means of finest filtration of a certain fluid volume (e.g. 100 ml) and weighing of the filter paper before and after the filtration process. This allows the establishment of the amount of solid particles in mg/l.

– Check the contamination of filters. A visual inspection of deep filters, which are widely used today, is **no** longer possible.
– Analyse the chemical properties of the hydraulic fluid.
– Check the temperature at points where bearings are located.
– Check the generation of noise.
– Test performance and velocity.
– Inspect pipes and hoses.

⚠ Caution!

Damaged pipes and hoses must be immediately replaced.

– Inspect accumulator stations.

4.2 Maintenance

In practice, inspection, maintenance and repair work is not as strictly separated as the definitions may suggest. Servicing is often done in conjunction with inspections.

For safety reason, pipe fittings, connections and components **must not** be loosened or removed as long as the system is pressurised.

Important service work is:

– Create a maintenance book
We recommend that a maintenance book is created to lay down the parts to be inspected.
– Check the hydraulic fluid level
  - continuously during commissioning
  - shortly after commissioning
  - later, at weekly intervals
– Inspect filters
  - during commissioning every two to three hours and, if necessary, replace them.
  - daily during the first week and replace them as required.
  - After one week, the filters should be cleaned as required.
  - Maintenance of suction filters:
    Suction filters require particularly thorough servicing. After the running-in period, they must be inspected at least once a week and cleaned, if necessary.

– Service the system fluid

- Maintenance intervals depend on the following operating factors:
  - Hydraulic fluid condition (e.g. water in oil, strongly aged oil)
  - Operating temperature and oil fill

  We recommend that the fluid be changed in dependence upon an oil analysis. With systems whose oil is not analysed at regular intervals the fluid should be replaced every 2000 to 4000 operating hours at the latest.
- Drain the system fluid at operating temperature and change it.
- Severely aged or contaminated system fluid **cannot** be improved by adding new fluid!
- Only fill in oil via filters that have at least the same separation capacity as the filters installed in the system, or use a system filter.
- Take samples of the system fluid to have the type, size and amount of particles analysed in the lab. Record the results.

– Check the accumulator for its pre-charge pressure; for this, the accumulator must be depressurised on the fluid side.

⚠ Caution!

Work on systems that include accumulators may only be carried out after the fluid pressure was unloaded.

Welding or soldering work or any mechanical work on accumulators is not permitted.

Improper repairs can lead to severe accidents. Repairs on hydraulic accumulator may therefore only be carried out by Rexroth Service service personnel.

– The operating temperature must be measured. An increase in the operating temperature indicates increasing friction and leakage.

– Leakage in the pipework
Leakage, especially with underfloor piping, represents, apart from loss of fluid, a risk for equipment and concrete floors.

For safety reasons, sealing work on the pipes may only be carried out when the system is depressurised. Leakage at points that are sealed with soft seals (O-rings, form seal rings, etc.) **cannot** be eliminated by tightening as these sealing elements are either destroyed or hardened. Sealing can only be achieved by replacing the sealing elements.

– Check main and pilot pressure

- Check interval: One week
- Document pressure corrections in the maintenance book.
- Frequent pressure adjustments indicate, among other things, wear of the pressure relief valve.

4.3 Repair

Locate and eliminate malfunction and damage.

– Fault localisation

A precondition for system repairs is successful, i.e. systematic fault search.

This requires in any case detailed knowledge of the structure and the operating principle of the individual components as well as of the entire system. The required documentation should be available and easily accessible.

The most important measuring instruments (thermometer, electrical multimeter, industrial stethoscope, stopwatch, rpm counter, etc.) should also be available in the vicinity of the system, especially in the case of large systems.

– Fault correction
When carrying out any work, observe strictest cleanliness. Before loosening fittings, clean the surrounding area.

Generally, defective components should not be repaired on site, since for the proper repair, the required tooling and the required cleanliness are usually not given on site. On site, only complete components should be changed whenever possible, in order

- to keep the time for which the opened system is exposed to ambient influences to a minimum,
- to keep the fluid loss as low as possible,
- to ensure the shortest possible downtime through the use of overhauled and tested components.

After failed components are located, it is essential to check whether the entire system or parts of the system have been contaminated by broken parts or larger amounts of abraded metal.

4.4 Repair and major overhaul of hydraulic components

Generally, it can be said that only the component manufacturer can carry out major overhauls in the most efficiently and reliably (same quality standard, trained personnel, test facilities, warranty, etc.).

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