Electrohydraulic controls: commissioning and trouble shooting

The following notes give some general suggestions and cautions on the procedures to ensure the good operation of an electrohydraulic system, with particular reference to the closed-loop circuits, typical of modern electrohydraulic axes and of high-performance proportional components with integral analog and digital electronics. For more detailed information about specific components see the relevant technical tables. For proper operation of electrohydraulic components, following prescription must be respected.

1 HYDRAULIC SECTION
1.1 Tank and tubes cleaning
Power unit tank has to be accurately cleaned, removing all the contaminants and any extraneous object; piping has to be cold bended, burred and pickled. When completely assembled an accurate washing of the piping (flushing) is requested to eliminate the contaminants; during this operation the proportional valves have to be removed and replaced with by-pass connections, or on-off valves.

1.2 Hydraulic connections
The flexible hoses have to be armoured type on pressure line between powerpack and proportional valve and on return line from proportional valve. If their potential breakage may cause damages to any machine or system or can cause undue to the operator, a proper retention (as the chain locking at both the pipe-ends) or alternately a protecting carter must be provided. The proportional valve must be installed as close as possible to the actuator, to assure the maximum stiffness of the circuit and so the best dynamic performances.

1.3 Hydraulic fluid
Use only good quality fluids according to DIN 51524;525, with high viscosity index.

1.4 Fluid filtration
The fluids filtration prevent the wearing of the hydraulic components caused by the contaminants present in the fluid. Fluid contamination class must be in accordance with the prescribed temperature range (generically between 40 and 50°C) so that the fluid viscosity remains constant during operation. The operating cycle should start after the prescribed temperature has been reached.

1.5 Hydraulic drains and return lines
The function of drains is essential in all systems, because they define the minimum pressure level.

1.6 Fluid conditioning
A high-performance system must be thermal-conditioned to ensure a limited fluid temperature range (generically between 40 and 50°C) so that the fluid viscosity remains constant during operation.

1.7 Air bleeds
Air in the hydraulic circuits affects hydraulic stiffness and it is a cause of malfunctioning. Air bleeds are provided in the proportional valves and servocylinders; air dump valves have to be sized in order to avoid variable counter pressure < 1 bar; for this reason it is recommended to use multiple separated return lines directly connected to tank.

2 ELECTRONIC SECTION
2.1 Power supply
The voltage values to be within the following range (depending on the type of supply devices):

- for the piping unlight the connections;
- the system must be bled on start-up or after maintenance;
- use a precharged check valve (e.g. to 4 bars) on the oil general return line to tank to avoid emptying of the pipes following a long out of service.

2.2 Electronic calibrating
The calibration of the electronic circuits; it is recommended the use of suitable filters and voltage suppressors.

2.3 Suppression of interferences by electronic noise
Power pack will operate in the presence of the following phenomena:
- rectified AC power supply: the average nominal voltage: V = 24 Vdc;
- for the piping unlight the connections;
- the system must be bled on start-up or after maintenance;
- use a precharged check valve (e.g. to 4 bars) on the oil general return line to tank to avoid emptying of the pipes following a long out of service.

2.4 Electronic calibrations
The electronic calibration of the supply device must be sized in order to provide the correct voltage when all utilities require max current at same time; in general 50W max intake electrical power can be considered for each supplied valve.

2.5 Temperatures and environments
The voltage values to be within the following range (depending on the type of supply devices):

- the main source of contamination of an environment; proper air filters on the power unit tank to be always provided;
- the fluid when filling the tank (new fluid is contaminated) with filtration Group GL-15 (table L150) or similar.

3 COMMAND SIGNALS WIRING

4 SHIELD CONNECTIONS

5 TROUBLE SHOOTING TABLES
2.2 Electrical wiring

The power cables (coils, electronic adjusters or other loads) to be separated from the control cables (references and feedbacks, signal grounds) to avoid interferences. The electrical cables of the electronic signals must be shielded as indicated in section 8 with shield or cablebraid connected to the ground (according to CEI 11-17)

Recommended cable cross section:
- Supply and earth: 0.75 mm²
- Coils: 1 mm² (Lmax = 20 m); 1.5 mm² (for longer distance) of shielded type;
- Voltage reference and LVDT feedback: 0.25 mm² (Lmax = 20 m) of shielded type;
- Note: current reference signals options must be provided when greater lengths apply to reference and feedback connections;
- Suitable electronic units and transducers or voltage to current converters are available.

2.3 Suppression of interferences by electrical noise

When starting the system, it is always advisable to check that feedbacks, references and signal grounds are free from interferences and electrical noise which can affect the characteristics of the signals and generate instability in the whole system. Electrical noises are high non-stationary oscillations both on amplitude and frequency around the signal average value; they can be suppressed by shielding and grounding the signal cables, see section 9.

Most of electrical noises are due to external magnetic fields generated by transformers, electric motors, switchboards, etc.

2.4 Electronic calibrations

The valves with integral electronics normally don’t need any calibration by final customer because these operations have been already performed before delivery of component (the valves with integral electronics are used more and more for their easier servicing and improved reliability).

However, bias adjustment is allowed, to permit the regulation between the input reference electrical zero and the spool center position (actuator in a steady position); a new calibration can be executed with particular hydraulic conditions (i.e. cylinder with high differential ratio value and/or high pressure operations). When electronic regulators in Eurocard or other format are installed in the control unit, the setting procedures are shown on related technical tables; consult them carefully before proceeding with the start-up. Personalised calibrations in case of particular requirements can be carried out with the collaboration of Atos technical dept.

2.5 Temperatures and environments

Always check that the operating environment is compatible with the data given in the product tables. If necessary provide conditioning of the electronic cabinet. In particular the integral electronics cannot be used when ambient temperature is higher than +60°C or lower than -20°C (-40°C to +60°C for digital-TES, -LES versions with /BT options).

The connection of the command signal to the electronics is depending on the type of signal generated from the PLC or CNC. The following figures show the typical connections in case of common zero or differential command situations.

### COMMAND SIGNAL WIRING

The connection of the command signal to the electronics is depending on the type of signal generated from the PLC or CNC. The following figures show the typical connections in case of common zero or differential command situations.

#### COMMAND SIGNAL FOR OPTION /I

- Fig. A: Power supply and signal common zero
- Fig. B: Differential signals not connected with zero (floating)
- Fig. C: Common zero
- Fig. D: Differential input signals

#### SHIELD CONNECTIONS

The correct shielding of signal cables has to be provided to protect the electronics from electrical noise disturbances, which could affect the valve functioning. Examples of correct shielding criteria are shown in the following fig. E and F. The shielding connections of fig. G and H must be avoided because they could generate ground loops which enhance the noise effect.

#### CORRECT SHIELD CONNECTIONS

- Fig. E: Shield connected to the protected earth
- Fig. F: Shield connected to the same power supply GND

#### WRONG SHIELD CONNECTIONS

- Fig. G: Never connect the shield on both sides
- Fig. H: Never connect the shield to grounding facilities having different potential

Symbols:
- Standard earth
- Supply GND
- Protected earth
5 TROUBLE SHOOTING TABLES

To evaluate the fault and to find the defective component within an electrohydraulic system it is necessary a good cooperation between electronic and hydraulic engineers. Besides a good knowledge of the technical tables for each component, for performing analysis of the system it is necessary to evaluate the hydraulic scheme and the electric wiring diagram related to operation cycle. There is no general recipe for success in fault finding due to quite diverse nature of the electrohydraulic systems; however the following table provides a useful start point.

Notes:
- Most problems are solved by the replacement of defective components on site. The defective components can be repaired by the manufacturer.
- Following tables don’t consider a system design fault

5.1 Open loop applications

<table>
<thead>
<tr>
<th>PROBLEMS</th>
<th>CAUSES OF THE FAULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical/Hydraulic</td>
<td>Electrical /Electronic</td>
</tr>
<tr>
<td>Unstable axes movement</td>
<td>Defective pump Air in the circuit Fluid contaminated Insufficient piloting pressure of double stage valves Stick-slip effect due to excessive friction of cylinder seals Speed below minimum for hydraulic motors</td>
</tr>
<tr>
<td>Actuator overrun</td>
<td>Hose too elastic Remote controlled check valve not closing immediately Insufficient bleeding Internal leakages</td>
</tr>
<tr>
<td>Standstill or not controllable axes</td>
<td>Defective pump Proportional control valve blocked (dirt) Hand valves and settings not in correct position</td>
</tr>
<tr>
<td>Actuator running too slow</td>
<td>Internal pump leaks due to wear Flow control valve set too low</td>
</tr>
<tr>
<td>Insufficient output forces and torques</td>
<td>Excessive resistance in the return and delivery lines Operating pressure setting of control valves too low Excessive pressure drop across control valves Internal leaks of pump and valves due to wear</td>
</tr>
<tr>
<td>Line hammer during control operation</td>
<td>Switching time of proportional control valves too rapid Thrusts or orifices damaged No throttling before accumulator system Excessive masses and forces applied to drive</td>
</tr>
<tr>
<td>Excessive operating temperature</td>
<td>Insufficient lines cross section Excessive continuous delivery Pressure setting too high Cooling system not operative Zero pressure circulation inoperative during working intervals</td>
</tr>
<tr>
<td>Excessive noise</td>
<td>Filters blocked Foaming of the fluid Pump or motor mounting loose Excessive resistance in the suction line Proportional control valves buzz Air in the valve solenoid</td>
</tr>
</tbody>
</table>

5.2 Closed loop applications - static conditions

<table>
<thead>
<tr>
<th>PROBLEMS</th>
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<tr>
<td>Low frequency oscillations</td>
<td>Insufficient hydraulic power supply Insufficient piloting pressure Proportional valve defective due to wear or dirt</td>
</tr>
<tr>
<td>High frequency vibration</td>
<td>Foaming of the fluid Prop. valve defective due to wear or dirt Too high ∆ pressure across valve Air in the solenoid of the proportional valve</td>
</tr>
<tr>
<td>Short time peak (random) in one direction or both</td>
<td>Mechanical couplings not rigid Air in the solenoid of the proportional valve Proportional valve defective due to wear or dirt</td>
</tr>
<tr>
<td>Self amplifying oscillations</td>
<td>Hydraulic hoses too elastic Mechanical couplings not rigid Too high ∆ pressure across prop. valve Too high hydraulic proportional valve gain</td>
</tr>
</tbody>
</table>
### 5.3 Closed loop applications - dynamic conditions: step response

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Overshoot in one direction</td>
<td></td>
<td>Too high $\Delta$ pressure across valve</td>
<td>Axes card Derivative Gain set too low</td>
</tr>
<tr>
<td>Overshoot in both directions</td>
<td></td>
<td>Mechanical couplings not rigid Hoses too elastic Proportional control valve mounted too far from the actuators</td>
<td>Axes card Proportional Gain set too high Axes card Integral Gain set too low</td>
</tr>
<tr>
<td>Slow approach to set</td>
<td></td>
<td>Pressure Gain of the proportional control valve too low</td>
<td>Axes card Proportional Gain set too low Driver’s Bias current not correct</td>
</tr>
<tr>
<td>Drive unable to reach the set</td>
<td></td>
<td>Insufficient hydraulic pressure or flow</td>
<td>Axes card Integral Gain set too high Proportional and Derivate Gains set too low Driver’s Scale and Bias not correct</td>
</tr>
<tr>
<td>Unstable control</td>
<td></td>
<td>Actuator’s feedback transducer connection intermittent Hoses too elastic Air in the solenoid of the proportional valve to high friction</td>
<td>Proportional Gain set too high Integral Gain set too low Electrical noises</td>
</tr>
<tr>
<td>Inhibited control</td>
<td></td>
<td>Actuator’s feedback transducer mechanically uncalibrated Lack of hydraulic power</td>
<td>Lack of electrical power Lack of reference or feedback signal Cabling error</td>
</tr>
<tr>
<td>Bad repeatability and high hysteresys</td>
<td></td>
<td>Actuator’s feedback transducer connection intermittent</td>
<td>Axes card Proportional Gain set too high Integral Gain set too low</td>
</tr>
</tbody>
</table>

### 5.4 Closed loop applications - dynamic conditions: frequency response

<table>
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<tbody>
<tr>
<td>Amplitude damping</td>
<td></td>
<td>Insufficient pressure and flow</td>
<td>Axes card Proportional Gain too low Driver’s scale adjustments set too low</td>
</tr>
<tr>
<td>Wave amplifier</td>
<td></td>
<td>Hoses too elastic Proportional control valve too far from drive</td>
<td>Driver’s scale adjustment not correct</td>
</tr>
<tr>
<td>Time delay</td>
<td></td>
<td>Insufficient pressure and flow</td>
<td>Ramp time inserted Axes card derivative gain set too low</td>
</tr>
<tr>
<td>Vibrating control</td>
<td></td>
<td>Air in the solenoid of proportional valve</td>
<td>Axes card proportional and Derivative Gains too high Electrical noises Derivative Gain set too high</td>
</tr>
</tbody>
</table>