THE HYDRAULIC SERVO-ACTUATOR INTERLOCKS AND CONTROLS

H. Dijkhuizen

1. GENERAL

The hydraulic servo-actuator Interlocks and Controls System (ICS)) forms a part in a Fast Ejection System (FES) to be installed in the Russian accelerator at Serpukhov.

The servo-actuator is used to bring a septum magnet into a pre-selected position, which can be programmed as a function of time. The servo-actuator will be installed in the accelerator tunnel, while, for reasons of limited access, the rest of the equipment is located outside the tunnel in the Pumping Room (PR) and in the Local Control Room (LCR) at a distance of ~150 meters. The ICS takes care of the correct functioning of the servo-actuator and the involved complex hydraulic circuit. In addition it combines the interlock requirements necessary for switching the correct input signal to the servo-amplifier. For practical reasons the ICS has been split up into three parts :

1. Control unit
2. Signalization unit for the interlocks
3. Repeaterrelay rack for the interlocks

These 3 units will be installed in the PR, but remote control from the LCR is included.

2. THE ICS CONTROL UNIT (drawing 362-100-0, 362-001-1, 362-301-2)

To come to a preprogrammed operation of the servo-actuator in the FES the following operations must be controlled by the ICS :

1. Hydraulic circuit under pressure
2. Servo-actuator must be mechanically unlocked
3. Switching the programmed input signal to the amplifier

3. THE HYDRAULIC CIRCUIT

The hydraulic circuit is supplied by 1 or 2 pumps in parallel. Both pumps are started by star triangle switches. These switches, each located in a separate rack, with the necessary fuses and interlock circuits are energized from the ICS by intermediate 24 D.C. relays. The

switches are delivered by the manufacturer of the hydraulics.

The ICS is operating from a 24 D.C. supply. It can only be switched on in the PR by energizing R1. The supply voltage is then applied to all controls, interlocks and its signalization. A built-in flashing circuit will flash the interlock signalization until pushing "Reset", whereafter, if the interlocks are O.K., the signalization is constant illuminated.

After this one should select which pump(s) should be used, pump 1, 2 or both together. This selection can only be made in the PR (R24, R25). To cancel a selection both push-buttons must be pushed at the same time. Coupled with the pump-selection is the opening of the corresponding suction valve. This opening is only possible if the 220 V~ deviated from the 380 V~ of each pump is switched on. The following controls are available in the PR and in the LCR.

Pump 1 on/off

Pump 2 on/off

Servo-actuator lock/unlock

Servo-amplifier control manual/program

After switching on the supply voltage, the controls mentioned above are automatically in the PR (R_{11}). By pushing the LCR-button in the control room the controls can be switched over to the LCR under the following conditions :

1. Actuator mechanically locked (R_8)
2. Actuator on servo-stop exterior (R_2)
3. Servo-amplifier input on manual (R_{16})
4. PR stroke magnifier on "zero" (R_3)
5. LCR stroke magnifier on "zero" (R_4)

The same requirements must be fulfilled for switching the controls from LCR to PR. One should keep in mind that "servo-stop ext." is by-passed (R58) as an interlock if :

1. Servo-amplifier input on manual and (R_{16})
2. Signal is under a specific predetermined value, the so-called "base-line"-level (signal generated in the programmer).

After the selection "PR" or "LCR" control, the pump(s) that has been preselected in the PR as described before, can be started under the following conditions :

1. Servo-actuator locked
2. " " on servo-stop
3. Stroke magn. PR on "zero"
4. " " LCR " "
5. Servo-amplifier input on "manual"

} R10

6. The "emergency" switch-off circuit must be "O.K." (R_{19}).

7. The various valves must be in the following position :

(The ref. valve number indication is according to the drawing "The pump group hydraulic circuit).

oil supply valve open (41)
oil return valve open (42)
leak oil return valve open (43)
valve first accumulator open (47)
oil supply valve test-bench closed (44)
oil return valve test-bench closed (45)
leak oil return valve test-bench closed (46)
oil filling valve closed (40)
actuator oil leak return valve open (62)
actuator oil return valve open (63)
actuator oil supply valve open (65)
actuator oil supply servo-valve open (66)
actuator leak oil return valve open (67)

The signals of the valve positions are transmitted through the interlock repeater relay rack and summarized by R_{21}.

8. The following interlocks must be "O.K." (R_{22}) :

oil level tank too high (10)
oil level tank too low (11)
valve main return filter open (83)
nitrogen pressure first accumulator normal (94)
" " second " " (98)
" " third " " (100)
" " return " " (102)
oil level shaft lubrification too high (73)
oil level " " too low (74)
nitrogen pressure shaft lubrification normal (104)
oil temp tank too high (12)
" " " too low (13)
oil return pressure too high (95)
" " " too low (96)
piston position first accumulator normal (3)
" " second " " (50)
" " third " " (61)
" " return " " (60)
oil supply pressure too high (93)
oil return pressure too high (101)
leak oil return pressure too high (103)
shaft temp. too high (75)
oil leak actuator too high (68)
oil leak pump station too high (4)
return oil filter Δ p too high (80)
leak return oil filter Δ p too high (81)
oil supply filter servo Δ p too high (64)
water filter p too high (85)
"servo-stop ext." (71)
" int. (72)

mechanical stop ext. (70)
mechanical stop int. (73)
accelerometer
tank position

9. The following interlocks must be "O.K." within ~30 sec. after a pump-start (R_{23}) :

   oil pressure too low (92)
   water pressure normal (107)
   air pressure normal (108)
   waterflow too low (84)
   oil flow shaft lubrication too low (76)
   water pressure normal (77)

10. The following interlocks must be "O.K." before the corresponding pump can be started :

    380 V ~ on
    supply valve open
    pressure too high

11. The following interlocks must be "O.K." within ~30 sec. after the corresponding pump-start (R_{26}, R_{27})

    suction valve open
    pump-switch in triangle
    by-pass valve closed

12. Between both pumps a time-delay interlock inhibits the start of both pumps within ~60 sec (R_{34}).

Coupled with any pump-start are :

1. The connection of the to the output of the servo-amplifier (R_{65}).
2. The start of the shaft lubrication pump (R_{33})
3. The main by-pass valve closes (R_{33})
4. The water supply valves are opening (R_{33})
5. A time-delay is started, which will make an automatic reset after ~30 sec, whereafter the by-pass for the various delayed interlocks is taken out (R_{35}, R_{36}, R_{37}).

When a pump motor-switch changes its position from star to triangle, its by-pass valve closes automatically (R_6, R_7). The following interlock conditions, active during the pump(s) starting procedure, are by-passed when the oilpressure comes within the normal operating range (pressure between interlock "pressure too low and too high") (R_{18}).

1. Actuator on servo-stop
2. Stroke magnifiers on "zero" position
3. Actuator locked
4. Servo-amplifier on "manual" control.

When the hydraulic circuit has the normal operating pressure the actuator may be unlocked under the following conditions :

1. Actuator on servo-stop
2. Stroke magnifiers in "PR" and"LCR" on "zero"
3. Servo-amplifier under "manual" control
4. Start by-pass interlocks out

Pushing the "unlock" button will energize the magnet valve of the security air-cylinder, whose piston releases the piston of the main air-cylinder. When this piston has been released, the magnet valve of the main air-cylinder is energized and it unlocks the actuator, by pulling its own piston up, which will be automatically locked in its upper position by the piston of the security air-cylinder. The reverse "locking" action can be done, if the 3 first conditions, mentioned above, are fulfilled.

Automatic locking will occur if :

1. Servo is "unlocked"
2. Actuator on "servo-stop"
3. Any interlock signal, indicating a faulty situation

After unlocking the actuator, one can switch to "program" if :

1. Stroke magnifiers on "zero"
2. Actuator on "servo-stop"

The second condition is in programmed operation an interlock, which would immediately act, when "program" is pushed. Therefore this interlock is by-passed during ~0,5 sec after pushing "program". During this time the actuator will move automatically from the "servo-stop" to the position, determined by the minimum input-signal of the program, the so-called "base-line" (R_{58}).

Some other modes of operation may be selected from the actuator test-panel, i.e. :

1. Electronics alone
2. Pumps only (complete hydraulic dircuit without electronics)
3. Test-bench

These selections can only be made if :

1. Actuator locked
2. Actuator on servo-stop
3. Amplifier on manual control
4. Stroke magnifiers on "zero"
5. Pumps off
6. Control from PR

When the selection "test-bench" has been chosen, the various valves should be in the following positions :

oil supply valve closed (41)
oil return valve closed (42)
leak oil return valve closed (43)
valve first accumulator open (47)
oil supply aalve test-bench open (44)
oil return valve test-bench open (45)
leak oil return valve test-bench open (46)
oil filling valve closed (40)
actuator oil leak return valve closed (62)
actuator return valve closed (63)
actuator oil supply valve closed (65)
actuator oil supply servo-valve closed (66)
actuator leak oil return valve closed (67)

Switching "off" the ICS, i.e. the 24 V d.c.,is only functioning after closing the suction valves, which can be done by pushing the dual push-button selector P_1 and P_2 at the same time (R_{24}, R_{25}).

4. The repeater relay-rack (drawing 362-200-4, etc.)

As a general rule in the FES an interlock has the following functions in the system :

1. it must protect the related equipment
2. it should signalize its state
3. any appearing fault should be memorized by the signalization.

As these various functions cannot be realized by the interlock contact itself, a repeater relay is introduced for each interlock. The basic configuration of such a relay is given in drawing 362-101-4. All contacts, which may be subject to different interconnecting, are for overall flexibility available on terminal strips, where they can be crossconnected according to the various requirements.

The + 24 V d.c. will each time be routed over the interlock to one side of the relay. If the interlock is O.K. the "0" 24 V d.c. can be applied to the other side of the relay by pushing "Reset" on the control unit. The relay is then energized and will be maintained over contacts 1-3. Contact 5,6,7 is taking care of the signalisation. Contact 6 will be connected to the corresponding lamp, while the flashing signal will be connected to contact 6. This signal is routed over the terminal strips because the flashing signal may be connected according to the selected mode of the hydraulic circuit. Contact 9-11 is used as the interlock contact. Some 300 free terminals are available for spare crossconnections.

5 Signalisation of Interlocks (drawing 362-305-2)

All signal-lamps are centralized on one panel. The lamps are supplied from the repeater relays in the following way :

"O.K." ——→ continuous illumination
"Fault" ——→ flashing

The lamp groups "normal" or "testbench" and pump 1 and pump 2 are operating according to the selected mode on resp. the testpanel and the control unit.

Nombre de pièces	Désignation	Pos.	Matière	Observations
III II I				

Mod.	Date	Nom	Tolérances générales
A			de à ±
B			de à ±
C			de à ±
Ensemble		S. Ensemble	

Dessiné 21-05-70 J.Brauchet
Contrôlé
Vu Dykstra
Remplace
Remplacé par

Echelle

HYDRAULICS I+C
CONTROL UNIT FOR HYDRAULICS ACTUATOR

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Dossier N.S
Dossier N.S
Dossier N.S

362-100 -0

INPUT AMPLIFIER
" BASELINE"
OR PROGRAM ON + 0,5 sec.

SUCTION VALVE P1 CLOSED
SUCTION VALVE P2 CLOSED
OFF 24V (P.R.)

24V SUPPLY
L.C.R. PERMISSION
ON 24V (P.R.)

INTERLOCKS + CONTROLS ENERGIZED
SERVO AMPLIFIER ENERGIZED

CANCEL (P.R.)
ELECTRONICS (P.R.)
PUMPS ONLY (P.R.)
TEST BENCH (P.R.)

P.R. CONTROL (P.R.)
L.C.R. CONTROL (L.C.R.)
SERVO LOCKED

SERVO UNLOCKED
STROKE MAGNIFIER "0" (L.C.R.)
STROKE MAGNIFIER "0" (P.R.)

PROGRAM (L.C.R.)
MANUAL (L.C.R.)
PROGRAM (P.R.)
MANUAL (P.R.)

INPUT AMPLI "PROGRAM"
INPUT AMPLI "MANUAL"

UNLOCK (P.R.)
LOCK (P.R.)
UNLOCK (L.C.R.)
LOCK (L.C.R.)

SERVO "UNLOCK"
SERVO "LOCK"

ON/OFF P2 (P.R.)
ON/OFF P1
ON/OFF P2 (L.C.R.)
ON/OFF P1

EMERGENCY O.K.

P2 SELECTED

220 V≂ ON
SUCTION VALVE P2 OPEN

60 sec.
60 sec.

P_2
BY-PASS CLOSED

BY-PASS CLOSED
P_1

220 V≂ ON
SUCTION VALVE P1 OPEN

P1 SELECTED

SHAFT LUBRFICATION PUMP START
DISCHARGE VALVE CLOSED
WATERVALVES OPEN

TORQUE MOTOR INTERLOCK

PUMP 1
380 V ≋ ON
SUPPLY VALVE OPEN
SUCTION VALVE OPEN
PUMP SWITCH IN Δ
BY-PASS VALVE CLOSED
PRESSURE TOO HIGH

PUMP 2
380 V ≋ ON
SUPPLY VALVE OPEN
SUCTION VALVE OPEN
PUMP SWITCH IN Δ
BY-PASS VALVE CLOSED
PRESSURE TOO HIGH

OIL SUPPLY VALVE OPEN (41)
OIL RETURN VALVE OPEN (42)
LEAK OIL RETURN VALVE OPEN (43)
VALVE FIRST ACCUMULATOR OPEN (47)
OIL SUPPLY VALVE TEST BENCH CLOSED (44)
OIL RETURN VALVE TEST BENCH CLOSED (45)
LEAK OIL RETURN VALVE TEST BENCH CLOSED (46)
OIL FILLING VALVE CLOSED (40)
ACTUATOR OIL LEAK RETURN VALVE (62)
ACTUATOR OIL RETURN VALVE OPEN (63)
ACTUATOR OIL SUPPLY VALVE OPEN (65)
ACTUATOR OIL SUPPLY SERVO VALVE OPEN (66)
ACTUATOR LEAK OIL RETURN VALVE OPEN (67)

OIL SUPPLY VALVE CLOSED (41)
OIL RETURN VALVE CLOSED (42)
LEAK OIL RETURN VALVE CLOSED (43)
VALVE FIRST ACCUMULATOR OPEN (47)
OIL SUPPLY VALVE TEST BENCH OPEN (44)
OIL RETURN VALVE TEST BENCH OPEN (45)
LEAK OIL RETURN VALVE TEST BENCH OPEN (46)
OIL FILLING VALVE CLOSED (40)
ACTUATOR OIL LEAK RETURN VALVE CLOSED (62)
ACTUATOR OIL RETURN VALVE CLOSED (63)
ACTUATOR OIL SUPPLY VALVE CLOSED (65)
ACTUATOR OIL SUPPLY SERVO VALVE CLOSED (66)
ACTUATOR LEAK OIL RETURN VALVE CLOSED (67)

OIL LEVEL TANK TOO HIGH (10)
" " " " LOW (11)
VALVE MAIN RETURN FILTER OPEN (83)
NITROGEN PRESSURE FIRST ACCUMULATOR (94)
" " SECOND " (98)
" " THIRD " (100)
" " RETURN " (102)
OIL LEVEL SHAFT LUBRIFICATION TOO HIGH (73)
" " " " TOO LOW (74)
NITROGEN PRESSURE SHAFT LUBRIFICATION (104)
OIL TEMPERATURE TOO HIGH (12)
" " TOO LOW (13)
OIL RETURN PRESSURE TOO HIGH (95)
LEAK OIL RETURN PRESSURE TOO HIGH (96)
PISTON POSITION FIRST ACCUMULATOR (3)
" " SECOND " (50)
" " THIRD " (61)
" " RETURN " (60)
OIL SUPPLY PRESSURE TOO HIGH (93)
OIL RETURN PRESSURE TOO HIGH (101)
LEAK OIL RETURN PRESSURE TOO HIGH (103)
SHAFT TEMPERATURE TOO HIGH (75)
OIL LEAK ACTUATOR TOO HIGH (68)
OIL LEAK PUMP STATION TOO HIGH (41)
OIL RETURN FILTER ΔP TOO HIGH (80)
LEAK OIL RETURN FILTERN ΔP TOO HIGH (81)
OIL SUPPLY FILTER SERVO ΔP TOO HIGH (64)
WATER FILTER ΔP TOO HIGH (85)

SERVO-STOP EXT. (71)
SERVO STOP INT (72)
MECH. STOP EXT. (70)
MECH STOP INT (73)
ACCELEROMETER (70)
TANK POSITION

OIL PRESSURE TOO LOW (92)
WATER PRESSURE NORMAL (107)
AIR PRESSURE NORMAL (108)
WATER FLOW TOO LOW (84)
OIL PRESSURE SHAFT TOO LOW (71)
OIL FLOW SHAFT TOO LOW (76)
WATER PRESSURE NORMAL (77)
DISCHARGE VALVE CLOSED

INTERLOCK BY-PASS

≃2sec.
≃30sec.

AUTOMATIC RESET AFTER ≃30 sec

Nombre de pièces III	II	I	Désignation	Pos.	Matière	Observations

Mod.	Date	Nom	Tolérances générales
A			de à ±
B			de à ±
C			de à ±

Ensemble | S. Ensemble

INTERLOCKS + CONTROLS

SERVO ACTUATOR LOGIC DIAGRAM

Echelle

Dessiné	24-09-70	J. Bratchet
Contrôlé		
Vu		Dijkhuizen
Remplace		
Remplacé par		

Dossier N°
Dossier N°
Dossier N°

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362-001-1

HYDRAULIC - ACTUATOR CONTROL UNIT •

PUMP 1
НАСОС 1

FLOW

PUMP
НАСОС

ON • ВКЛ OFF • ВЫКЛ

PUMP SELECTOR

PUMP 1
НАСОС 1

PUMP 2
НАСОС 2

PUMP 2
НАСОС 2

FLOW

PUMP
НАСОС

ON • ВКЛ OFF • ВЫКЛ

EMERGENCY

OFF • ВЫКЛ

SERVO

INPUT

SERVO INPUT

MANUAL
РУЧН. PROGRAM

ON • ВКЛ ON • ВКЛ RESET

STROKE

ACTUATOR

MAGNIFIER

1 2 3 4 5 6

STROKE COUNTER

ACTUATOR

LOCK UNLOCK

CONTROL

LOCAL REMOTE

CERN PS/FES

362-1

Nombre de pièces			Désignation	Pos.	Matière	Observations
III	II	I				

Mod.	Date	Nom	Tolérances générales
A			de à ±
B			de à ±
C			de à ±

Ensemble | S. Ensemble

Hydraulic-actuator control unit

Echelle 1:1

Dessiné 23.9.70 H. Ruegg
Contrôlé
Vu

Remplace
Remplacé par

Dossier N° | Dossier N° | Dossier N°

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362-301-2

HYDRAULIC ACTUATOR SIGNALISATION

- OIL FILLING VALVE CLOSED
- OIL LEVEL TANK TOO LOW
- OIL LEVEL TANK TOO HIGH
- OIL TEMP TANK TOO LOW
- OIL TEMP TANK TOO HIGH
- WATER PRESSURE TOO LOW
- WATER FLOW TOO LOW
- WATER FILTER ΔP TOO HIGH
- NITROGEN PRESSURE FIRST ACCUMULATOR NORMAL
- NITROGEN PRESSURE SECOND ACCUMULATOR NORMAL
- NITROGEN PRESSURE THIRD ACCUMULATOR NORMAL
- NITROGEN PRESSURE RETURN ACCUMULATOR NORMAL
- PISTON POSITION FIRST ACCUMULATOR NORMAL
- PISTON POSITION SECOND ACCUMULATOR NORMAL
- PISTON POSITION THIRD ACCUMULATOR NORMAL
- PISTON POSITION RETURN ACCUMULATOR NORMAL
- VALVE FIRST ACCUMULATOR OPEN
- OIL SUPPLY PRESSURE TOO HIGH
- OIL SUPPLY PRESSURE TOO LOW
- OIL RETURN PRESSURE TOO HIGH
- LEAK OIL RETURN PRESSURE TOO HIGH
- OIL SUPPLY FILTER SERVO ΔP TOO HIGH
- RETURN OIL FILTER ΔP TOO HIGH
- LEAK RETURN OIL FILTER ΔP TOO HIGH

- OIL LEAK ACTUATOR TOO HIGH
- OIL LEAK PUMPS TOO HIGH
- VALVE MAIN RETURN FILTER OPEN
- AUTOMATIC DISCHARGE VALVE CLOSED

- NITROGEN PRESSURE SHAFT LUBR. TOO HIGH
- OIL LEVEL SHAFT LUBR. TOO HIGH
- OIL LEVEL SHAFT LUBR. TOO LOW
- SHAFT TEMPERATURE TOO HIGH
- OIL FLOW SHAFT LUBR. TOO LOW

- AIR PRESSURE NORMAL
- MECHANICAL STOP EXTERIOR
- SERVO STOP EXTERIOR
- SERVO STOP INTERIOR
- MECHANICAL STOP INTERIOR
- ACCELERO METER
- TANK POSITION

NORMAL		TEST BENCH
OPEN	OIL SUPPLY VALVE	CLOSED
OPEN	OIL RETURN VALVE	CLOSED
OPEN	LEAK OIL RETURN VALVE	CLOSED
CLOSED	OIL SUPPLY VALVE TEST BENCH	OPEN
CLOSED	OIL RETURN VALVE TEST BENCH	OPEN
CLOSED	LEAK OIL RETURN VALVE TEST BENCH	OPEN
OPEN	ACTUATOR OIL SUPPLY VALVE	CLOSED
OPEN	ACTUATOR OIL SUPPLY SERVO VALVE	CLOSED
OPEN	ACTUATOR OIL RETURN VALVE	CLOSED
OPEN	ACTUATOR LEAK OIL RETURN VALVE	CLOSED
OPEN	ACTUATOR LEAK OIL RETURN VALVE	CLOSED

PUMP 1	PUMP 2
380V ≋	380V ≋
SUCTION VALVE OPEN	SUCTION VALVE OPEN
SUPPLY VALVE OPEN	SUPPLY VALVE OPEN
PUMP SWITCH IN TRIANGLE	PUMP SWITCH IN TRIANGLE
BYPASS VALVE CLOSED	BYPASS VALVE CLOSED
PRESSURE TOO HIGH	PRESSURE TOO HIGH

CERN PS/FES

362-3

Nombre de pièces			Désignation	Pos.	Matière	Observations
III	II	I				

Mod.	Date	Nom	Tolérances générales
A			de à ±
B			de à ±
C			de à ±

Ensemble — S. Ensemble

Dessiné 24.9.70 H. Lange
Contrôlé
Vu

Echelle 1:1

Remplace
Remplacé par

Hydraulic-actuator signalisation

Dossier N° Dossier N° Dossier N°

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362-305-2