Hyamaster® SPS

Intelligent single and multiple pump control system with continuous speed control by frequency inverter, with PLC SIMATIC® S7

Fields of Application

- Industry: process loops, industrial water supply, cooling, lubrication and other process engineering applications.
- Energy supply: cogeneration plants, heat transfer stations, district heating.
- Water management: water extraction, water treatment, water supply, waste water disposal.

Performance Data

Number of pumps: standard:
1 to 4, different pump sizes possible.
Motor ratings: up to 650 kW
Number of frequency inverters: 1 to 4
Mains voltages: 3 x 400 V ± 10 %
3 x 500 V ± 10 %
3 x 690 V ± 10 %
Mains frequency: 50 Hz/60 Hz

Functional Description

The Hyamaster SPS control system is specially designed for pumps with three-phase motors of all designs and makes. It consists of a programmable logic controller (**S**peicher **P**rogammierbare **S**teuerung, **SPS**) with **o**perator **p**anel (**OP**) and all necessary power components such as master switch, frequency inverter, contactors, fuses and control voltage transformer. All components are installed in a control cabinet. A characteristic feature of the Hyamaster SPS control system is its high flexibility. Both during commissioning and operation, parameters can be set without an external programming device, by entering them on the operator panel OP7. The wide selection of well-proven functions for a large variety of problems which sometimes only emerge in the everyday operation of the pumping system are activated by simply setting the requisite parameters. Complicated and thus expensive modifications critical to the operation of the system are not required.
The modular design of both software and hardware ensures:

- reliable solutions for all situations occurring in hydraulic systems.
- high availability
- adaptation to changing system requirements
- manual and automatic operation via OP7 and field bus.

Hyamaster SPS

- uses two independent PI controllers and optimized switching algorithms to control:
  - pressure
  - flow rate
  - temperature
  - differential pressure
  - liquid level
  - differential temperature

  Additional functions, e.g.: combination of different controlled variables, bad-value selection and redundancies are possible.
- effects self-optimizing control of:
  - start-up and shutdown of additional pumps
  - pump changeover
  - function check
- monitors automatically; the process is kept up in the best possible way.
  - performance range monitoring
  - lack of water
  - fault behaviour
  - overload
- communicates via field bus and/or volt-free contacts
  - operation and fault, pumps and frequency inverters
  - 4 analog standardized signal inputs
  - controller operational message
  - remote acknowledgement, etc.
  - general fault message

Hyamaster SPS 4 - 300 / 4 FU / A / IP 42
Number of pumps (1-4)
Motor rating x 10
1 to 4 frequency inverters
Radio interference suppression level
EN 55011 (none / A / B)
Enclosure IP (00 / 42 / 54)

Other Variants on Request

- Motor rating
- Number of frequency inverters
- Voltage
- Enclosure
- Customer specification
- Teleservice
- Number of pumps
- Additional control functions e.g. for additional auxiliary pumps, valves, etc.

TÜV CERT DIN EN ISO 9001

General Member of European Foundation for Quality Management

Operator Panel

The LCD plain text display of the Operator Panel (OP7) shows operating status, parameters, help texts and faults in various levels. The first and the last function key, respectively, serve to page up and down within a level.

As an option, the operator panel OP7 can also be installed directly in a control room, so that the Hyamaster SPS with manual and automatic operating mode, with operation and fault messages and parameterization can be monitored and operated directly at the OP7. Maximum cable length without RS 485 Reapeter: approx. 50 m.

Display Levels

The plain text display is organized in levels.

Entry level

- Unacknowledged faults
- Operating status messages

Display level

- Control mode selected for the pumps, i.e. manual, 0, automatic
- Pump operating mode i.e. OFF, direct, frequency inverter 1, frequency inverter 2, etc.
- Feedback values and set values, parameter sets 1 and 2
- Rotational speed of frequency inverter operated pumps
- Set-value analysis, parameter sets 1 and 2
- Analog values (feedback values of analog inputs)
- Works and order number
- Software versions
- Time and date
- Operating hours counter of pumps and frequency inverters

Menu level

- Pump menu
- Quick menu
- Fault menu
- Operating status message menu
- Parameter menu

Fault level

- Any faults registered are displayed in plain text.

Basic Equipment of Control Cabinet

Housing and internal equipment
- Steel sheet housing: Colour: RAL 7032
- Type of protection IP 54 for indoor installation, internal equipment in type of protection IP 42
- Ventilation of control cabinet by filter fan
- Lockable master switch, operated from the front
- Current distribution and protection by fuses-overload contactors
- Frequency inverter(s)
- Control transformer 400/230V AC
- PLC modules and display module incl. 24V DC power supply unit (max. 100 mA available, e.g. for supplying a pressure / differential pressure transmitter).

Analog inputs
- 4 analog inputs 0/4-20 mA; 0/2-10V

Digital inputs (24 VDC)
- Automatic ON/OFF
- Monitoring lack of medium
- Changeover to second parameter set
- Remote acknowledgement
- Pump changeover
- Peak-load limitation

Digital outputs (relay, max. 230 V AC/1A)
- General fault message (NC contact)
- General "system operational" message

Auxiliary energy
- for transmitter 24 V DC, max. 200 mA

Overall safety concept

Monitoring the pumps and the hydraulic system
- Overcurrent monitoring
- Full motor protection by PTC resistors or bimetall switches for automatic control mode, monitoring and message for manual control mode
- Dry-running protection

Fault response
- Pump failure: changeover to standby pump
- Frequency inverter failure: changeover to direct operation, or shutdown of all pumps or changeover to second frequency inverter (if available)
- Monitoring of measuring signal: live-zero (4-20 mA) or (2-10 V)
  If measuring signal fails:
  message, fault contact, hold pump speed or shut down system (user-definable)

Protective measures to prevent fault conditions
- Pump changeover time freely selectable
- Function check time freely selectable

Operating modes
Manual operating mode per pump in direct (i.e. mains) or frequency inverter controlled operation via operator panel OP7, menu-driven, or via data busHand operating mode per pump in direct (i.e. mains) operation (frequency inverter operation if direct operation is not provided for). In this case the pumps are operated electromechanically, to ensure emergency operation in the event of a PLC failure.

Optional Extras

Displays and operating facilities (on front panel)
- Operating hours counter per pump (in addition to software counter)
- Ammeter per pump
- Manual speed adjustment at control panel of frequency inverter (in addition to manual operating mode via operator panel OP7)
- Voltmeter with phase changeover
- Phase lamps
- Lockable front frame with transparent window (IP 54)
- Frequency inverter display
- Gate / butterfly valve control per pump
- Control of bypass valve
- Hand-0-automatic switch per pump

Remote transmission on terminal blocks (DDC messages)
- Operation and fault per pump, volt-free, max. 230 V, max. 1 A
- Operation and fault per frequency inverter, volt-free, max. 230 V, max. 1 A
- Position message of hand-0-automatic switch per pump, volt-free, max. 230 V, max. 1 A
- Repair switch per pump (on the pump)
- Isolating amplifier for analog inputs and outputs: Feedback value 1, Feedback value 2, external set value

Remote transmission by data bus (DP bus)
Messages to control room (Send)
- Operation and fault per pump and frequency inverter
- Control modes and operating modes per pump
- Measuring signals, set values and rotational speeds
- Operating status and fault messages of the system as a whole

Commands from control room (Receive)
- Automatic, manual pump operation, direct (i.e. mains) or frequency inverter controlled, with remote speed control or stopping
- Remote acknowledgement, system start-stop
- Remote measuring signals and remote set point setting
- Commands concerning the system as a whole

Internal control cabinet elements
- Double marking of electrical components
- Light and socket connected before master switch per switchboard section
- Lightening (overvoltage) protection of power input
- Mains monitoring: phase failure/inversion, under-/ overvoltage
- Control cabinet heater with thermostat
- Wire marking with terminal number
- Wiring layout matched to circuit diagram layout

Variants on request
- Other voltages
- Higher power ratings
- Additional DDC messages
- Higher types of protection
- Soft starter
- Different motor ratings
- Component specifications
- Additional functions

Notes for Planning

Caution Special VDE guidelines and regulations of the local energy supply companies as well as local regulations must be adhered to.

Measuring and control line	Cross-sectional area	Version	
Feedback value transmitter (16 D)	3 x 0.75 mm^2	shielded	
Other feedback value transmitters	.. x 0.75 mm^2	shielded	
PTC resistor (per motor)	2 x 0.75 mm^2	shielded	
DDC lines (24 V DC)	.. x 0.75 mm^2	shielded	
DDC lines (230 V AC)	.. x 0.75 mm^2		
DDC lines, analog (0/2-10V or 0/4-20mA)	.. x 0.75 mm^2	shielded	

Motor power cables for standardized motors 3 ~ 400 V/50 Hz

(M) kW	≈ A	Minimum cross-section mm^2	Starting method	Version Minimum cross-sections
1.1 - 4	2.6 - 8.5	4 x 1.5	d.o.l.	DIN VDE 0100, Part 430, supplement 1; current-carrying capacity of PVC-insulated cables and conductors, type of installation B 2 for an ambient temperature of 30 °C
5.5 - 7.5	11.5 - 15.5	2 x 4 x 1.5	Y Δ	
11	22.5	2 x 4 x 2.5		
15 - 18.5	30 - 36	2 x 4 x 4		
22	43	2 x 4 x 6		
30	58	2 x 4 x 10		
37 - 45	72 - 85	2 x 4 x 16		
55	104	2 x 4 x 25		
75	142	2 x 4 x 35		
90	169	2 x 4 x 50		
110 -	on request			

The motor cable must be shielded to ensure compliance with EMC specifications concerning emissions. The motor must be earthed separately.

Total rated power

Total rated power = Motor rating x number of motors (incl. standby units, if any)

Heat Losses

The heat losses generated by the frequency inverters are dissipated into the **control unit room** by filter fans. It may be necessary to extract some or all that heat from the room. Heat losses amount to roughly 3 - 5 % of the rated motor power.

Control Cabinet Dimensions (for Planning only)

Hyamaster SPS with one frequency inverter

(M) kW	with 2 pumps W H D mm	with 3 pumps W H D mm	with 4 pumps W H D mm
1.1 - 4	800 1000 300	800 1000 300	800 1000 300
5.5 - 7.5	800 1000 300	800 1200 300	800 1200 300
11 - 15	800 1800 400	800 1800 400	1200 1800 400
18.5 - 22	800 1800 400	800 1800 400	1200 1800 400
30 - 45	1200 1800 400	1200 1800 400	1800 2000 500
55 - 75	1800 2000 500	2000 2000 500	on request
90	2000 2000 600	2000 2000 600	on request
110	on request	on request	on request

Control cabinet dimensions Hyamaster SPS with 3 or 4 frequency inverters on request

Hyamaster SPS with two frequency inverters

(M) kW	with 2 pumps W H D mm	with 3 pumps W H D mm	with 4 pumps W H D mm
1.1 - 4	800 1200 300	800 1200 300	800 1200 300
5.5 - 7.5	1200 1800 400	1200 1800 400	1200 1800 400
11 - 15	1200 1800 400	1200 1800 400	on request
18.5 - 22	1600 1800 400	1600 1800 400	on request
30 - 37	1600 1800 400	1800 2000 500	on request
45	1800 2000 500	2000 2000 500	on request
55 - 75	2400 2000 500	2800 2000 500	on request
90	on request	on request	on request

Accessories

Pressure transmitter

	Measuring range (bar)	Max. pressure (bar)
Auxiliary energy 24 V DC (available from PLC power supply unit) Analog output; 4 - 20 mA; 2-wire design; max. working resistance 600 Ohm Ambient temperature -20 °C to +70 °C Pressure connection via olive-ring pipe union for 6 mm pipe Product temperature -20 °C to +100 °C	0 - 1 0 - 2.5 0 - 4 0 - 6 0 - 10 0 - 16	25

Pressure/Differential pressure transmitter

	Measuring range (bar)	Max. pressure (bar)
(Wall-mounted) Auxiliary energy 24 V DC (available from PLC power supply unit) Analog output; 4 - 20 mA; 3-wire design; max. working resistance 500 Ohm Ambient temperature -10 °C to +50 °C Pressure connection via olive-ring pipe union for 6 mm pipe Max. product temperature +70 °C	0 - 1 0 - 2.5 0 - 4 0 - 6 0 - 10 0 - 16	16 25 25 25 25 25

Flow rate transmitter

	Max. measuring range (m^3/h)	DN	PN
Magnetic-inductive measuring principle (MIF): Compact design Auxiliary energy 230 V AC Analog output; 0/4 - 20 mA; adjustable; max. working resistance 750 Ohm Pulse output; adjustable; 0 - 1000 pulses/unit Conductivity of medium handled ≧ 5 μ s/cm Flanged connection Ambient temperature -10 °C to +60 °C Product temperature -25 °C to +130 °C	12 24 36 60 120 180 240 420 600 1080 1800	25 32 40 50 65 80 100 125 150 200 250	30 30 30 30 30 30 16 16 16 10 10
Ultrasonic measuring principle: - Measurement pick-up Flanged connection Product temperature - 20 °C to +100 °C - Measuring transducer (wall-mounted) Auxiliary energy 230 V AC Analog output 0/4 -20 mA; max. working resistance 1000 Ohm Frequency output 0 - 3.3 kHz Pulse output 0 - 15 Hz	18 30 45 75 100 180 260 700 1500 2000	32 40 50 65 80 100 125 150 200 250	40 40 50 16 16 16 16 16 16 16

Flow control unit

	Setting range (cm/s)	
Calorimetric measuring principle, for dry-running protection incl. transducer - Measurement pick-up Sensor connection G 1/2 A Product temperature -25 °C to +80 °C - Measuring transducer (mounted in control cabinet) Auxiliary energy 230 V AC Volt-free output; one change-over contact; max. 230 V, max. 1 A	approx. 3 - 300	

Accessories

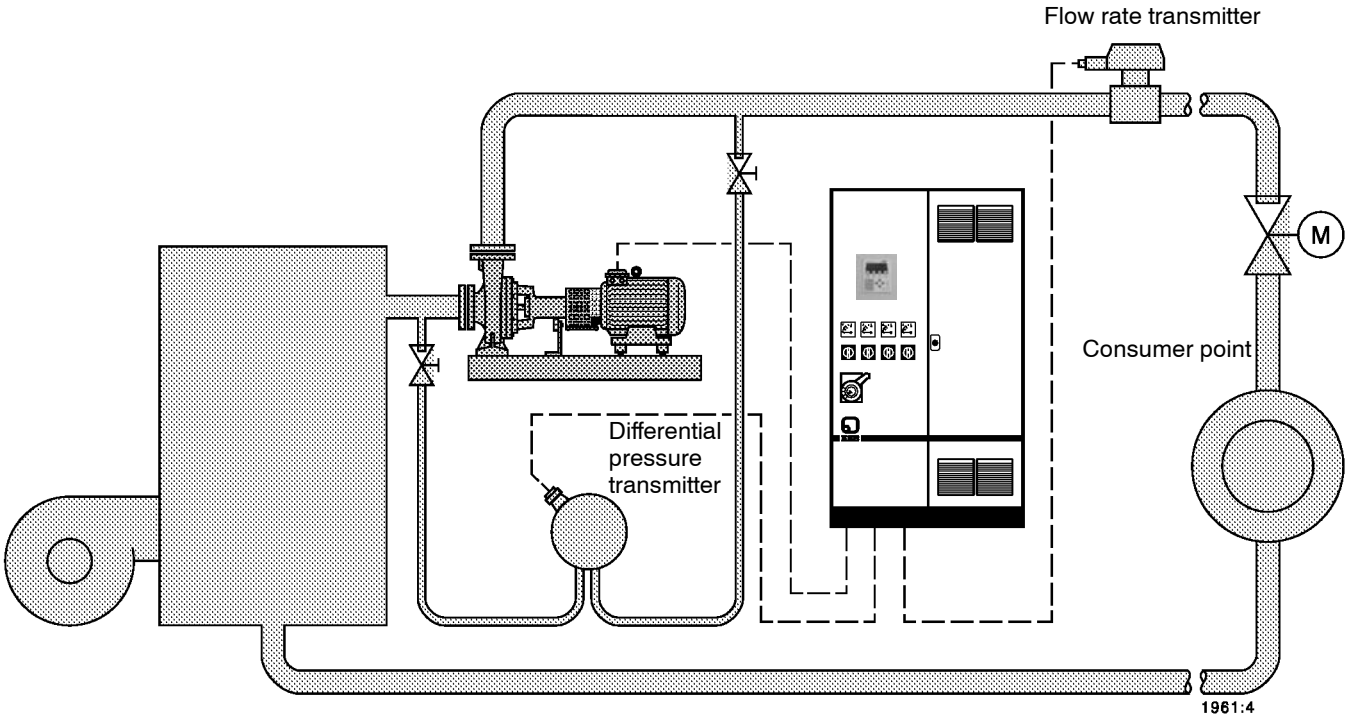
Level transmitter

	Measuring range (mm)	
Capacitive measuring principle Auxiliary energy 24 V DC (available from control system) Analog output; 4 - 20 mA; 2-wire design; max. working resistance 600 Ohm Threaded connection G 1 1/2 A Ambient temperature -10 °C to +60 °C Product temperature -50 °C to +100 °C Bar electrode: made of steel; fully insulated	1000 to 4000 (Please indicate required bar length in purchase order)	
	Measuring range (bar)	
Hydrostatic measuring principle Auxiliary energy 24 V DC (available from control system) Analog output; 4 - 20 mA; 2-wire design; max. working resistance 600 Ohm Threaded connection G 1 1/2 A Pressure sensor for vertical installation Length of connecting pipe: 1 - 20 m Ambient temperature -20 °C to +60 °C Product temperature -20 °C to +80 °C	0 - 0.1 to 0 - 20 Please indicate required measuring range and length of connecting pipe in purchase order)	

Temperature sensor

	Measuring range (°C)	
Clip-on sensor	0 to +120	
Immersion-type sensor with 100 mm stainless steel immersion sleeve ∅ 15 R 1/2 A max. test pressure 25 bar	0 to +120	
Immersion-type sensor with transducer with 160 mm stainless steel protective sleeve ∅ 9 PN 16	-20 to +350	

Example: Heat-/District heat supply system with DFS curve



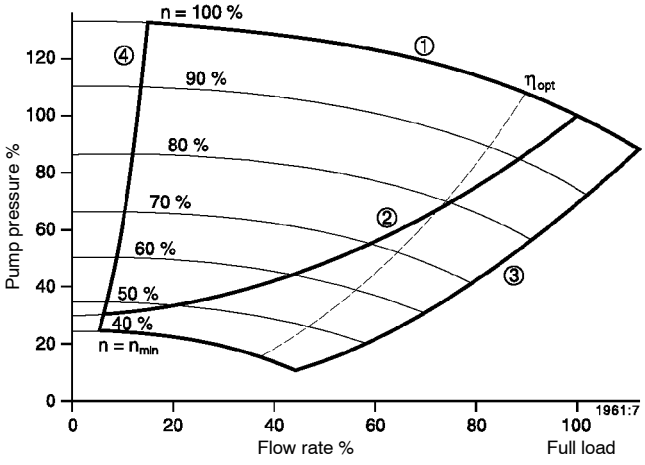
Control task:

Maintaining the differential supply pressure at all bad-value points, even with changing operating conditions and interferences, without requiring measuring points at the far end of the heating system.

In many heat / district heat supply systems, it is difficult to detect bad-value points (points where the supply pressure is too low at times) in the piping system. The **DFS** curve (**d**ifferential pressure control with **f**low-dependent **s**et point adjustment) allows optimized control without information about bad-value points.

With the help of differential pressure and flow rate measurements, the flow-dependent influence of pipe friction losses is compensated. The pumps are in continuously variable operation from low-load operation with small pump heads to full-load operation with high heads. The feedback signals can be tapped in the pumping station, obviating the complex and defect-prone transmission of measurements taken at the bad-value points.

In a later extension, the differential pressure signal of the bad-value points can be determined via the bus. In this case, control by DFS curve serves as a back-up operating mode if there is a fault in bus communication. This makes for a considerable increase in the operating reliability of the pumping station.



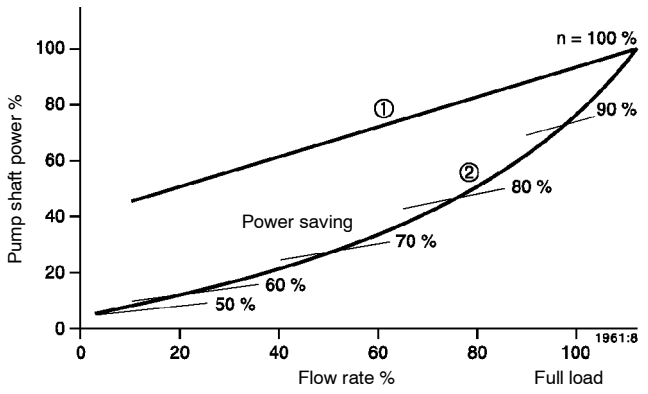
η_{opt} Optimum pump efficiency curve

① Pump characteristic curve at fixed speed (n = 100 %)

② Duty point curve of pump in controlled operation on frequency inverter (n = variable)

③ Limit for continuous operation (max)

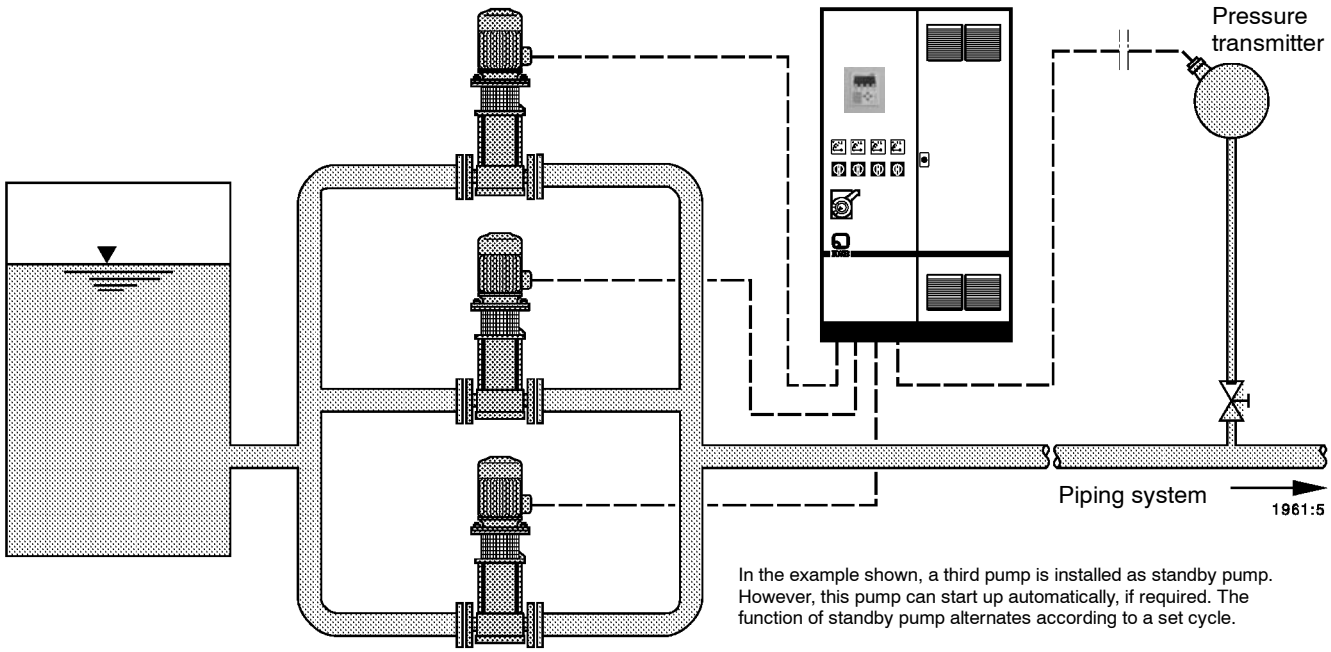
④ Operating limit (min)



① Power input curve at fixed speed (n = 100 %)

② Pump power input curve for controlled operation at frequency inverter (n = variable)

Example: Supply system with peak-load operation



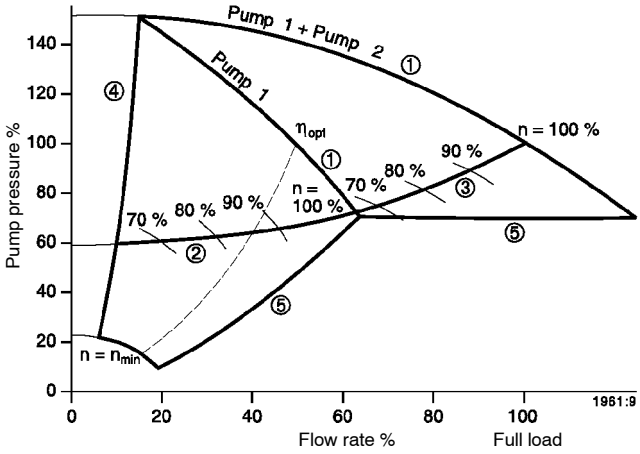
In the example shown, a third pump is installed as standby pump. However, this pump can start up automatically, if required. The function of standby pump alternates according to a set cycle.

Control task:

Maintaining constant pressure at a point of reference despite widely differing and fluctuating consumption.

Splitting the total flow rate onto several pumps allows a proportionate reduction in pump and frequency inverter power. Efficiencies in part-load operation are higher than when using a full-load pump.

Pressure is kept constant by infinitely variable speed adjustment of one pump. This base-load pump provides the required flows up to its max. capacity. For higher consumption, a peak-load pump is switched on automatically. Pressure, however, is still regulated by the base-load pump. Pressure deviations, which occur when the peak-load pumps are switched on or off, generally do not affect the process.



η_{opt} Optimum pump efficiency curve

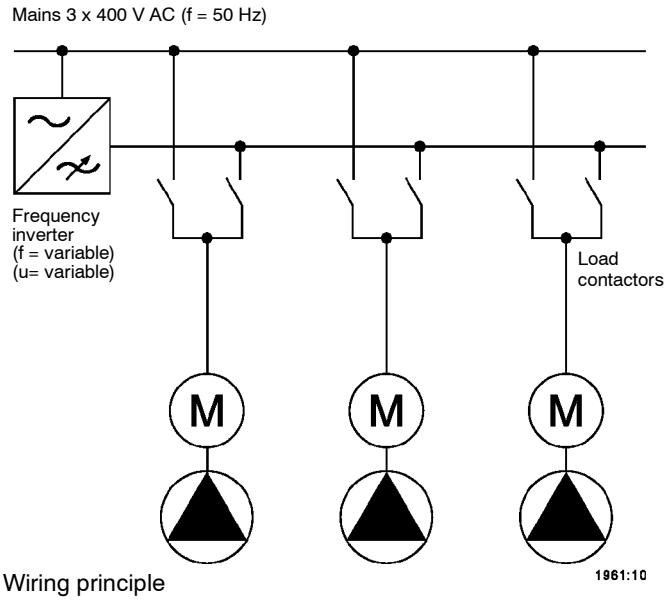
① Pump characteristic curve at fixed speed (n = 100 %)

② Duty point curve of pump in controlled operation at base load on frequency inverter (n = variable)

③ Duty point curve for controlled operation with 1 peak-load pump directly connected to the mains (n = 100 %) and 1 base-load pump connected to a frequency inverter (n = variable)

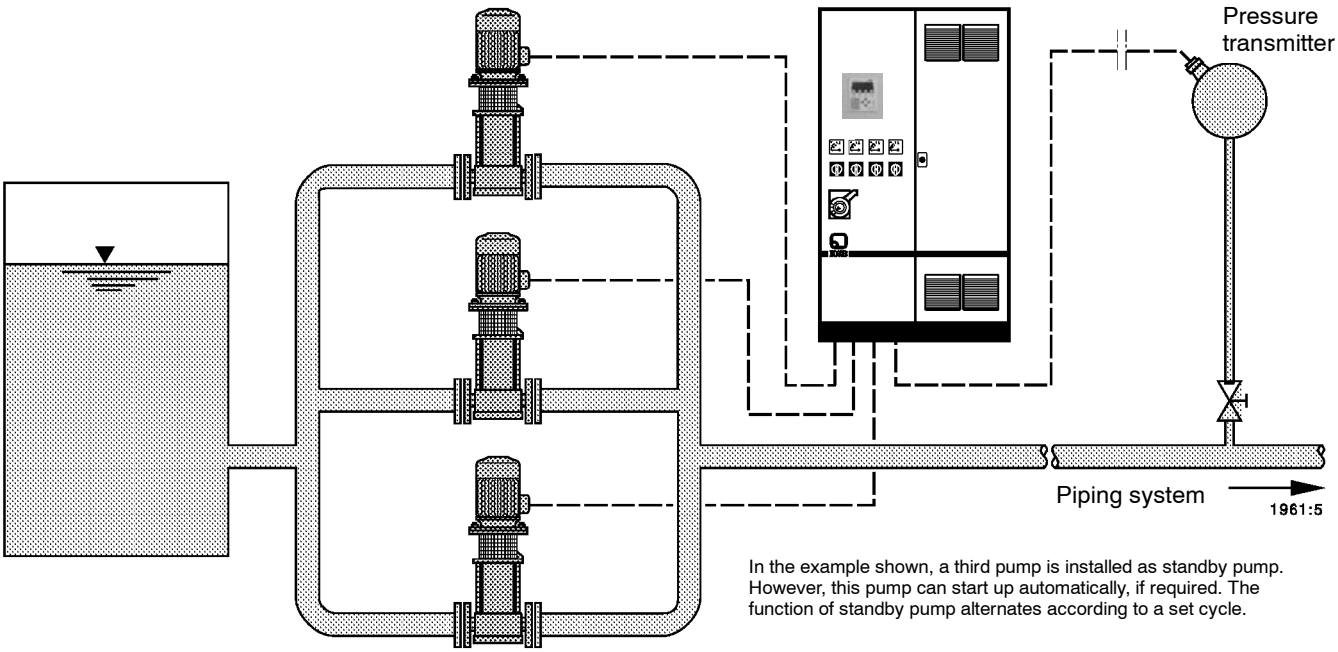
④ Limit for continuous operation (min)

⑤ Operating limit (max)



Wiring principle

Example: Supply system with two frequency inverters



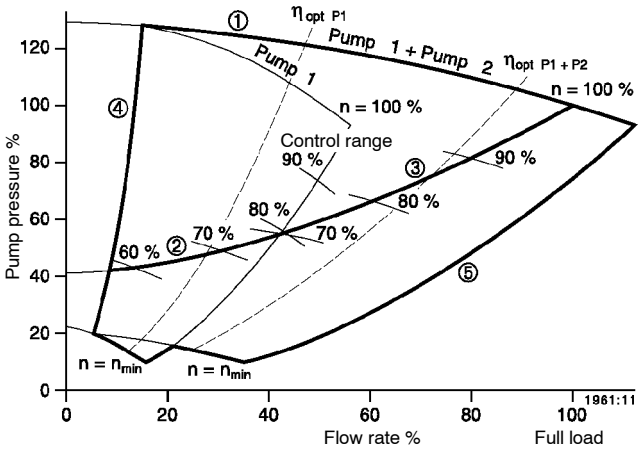
In the example shown, a third pump is installed as standby pump. However, this pump can start up automatically, if required. The function of standby pump alternates according to a set cycle.

Control task:

Maintaining constant pressure at a point of reference, even with changing operating conditions and interferences.

In conventional pumping systems, unwanted pressure fluctuations occur, due to changes in inlet pressures, quantities tapped and pressure losses in the supply system, which are compensated by a high-level distributing tank.

In the present expample, the Hyamaster SPS takes on the function of the high-level tank in maintaining constant supply pressure at a point of reference. Two pump sets with one frequency inverter each, running both in single and parallel operation, cover the entire flow range from minimum flow to full load. The pumps operate in the best-efficiency range. The second frequency inverter also serves as a standby unit.
In this case, the second pump is in direct (i.e. mains) operation as a peak-load pump. The set value is then increased in accordance with the operating limit (max.) of one pump, so that the pumps run reliably within the allowable control range again.



η_{opt} Optimum pump efficiency curve

① Pump characteristic curve at fixed speed (n = 100 %)

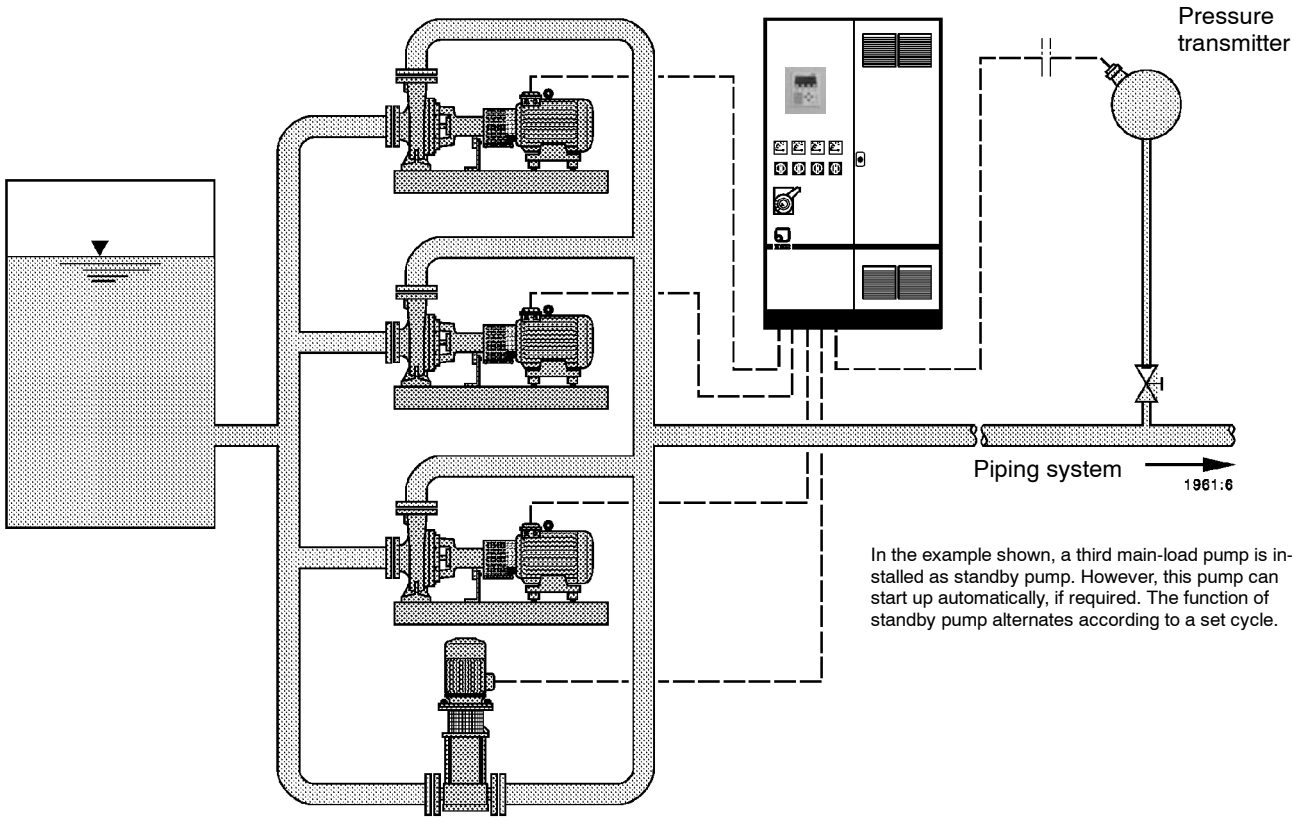
② Duty point curve of pump in controlled operation at base load on frequency inverter (n = variable)

③ Duty point curve of two parallel pumps in controlled operation at peak load on two frequency inverters (n = variable)

④ Limit for continuous operation (min)

⑤ Operating limit (max)

Example: Low-load and main-load pumps with 2 frequency inverters



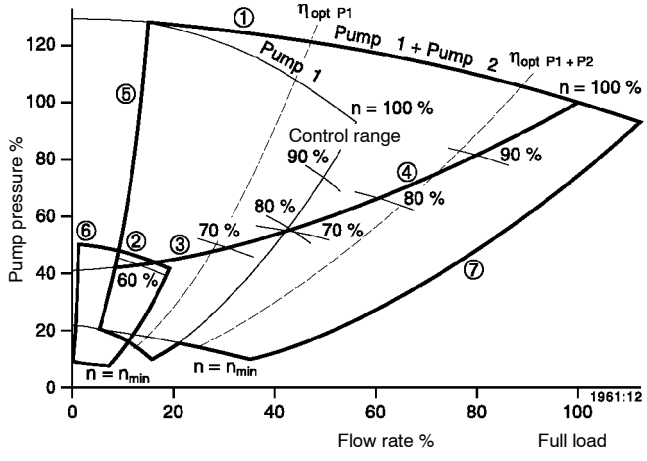
In the example shown, a third main-load pump is installed as standby pump. However, this pump can start up automatically, if required. The function of standby pump alternates according to a set cycle.

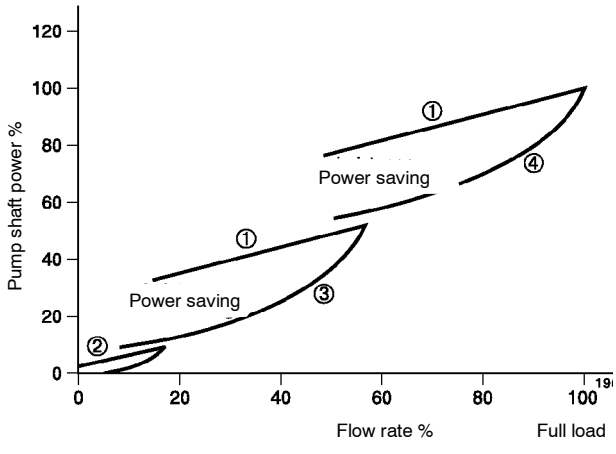
Control task:

Optimizing the low-load operation of the hydraulic system.

Even at low speeds, continuously speed-controlled pumps require a certain minimum flow rate ⑤. In many cases, however, these minimum flows are much too high. To avoid pump damage in the long run, the flow rate must not fall below this limit in continuous pump operation.

In the low-load range below this limit, a hydraulic bypass is normally used.However, the flow routed through this bypass cannot be used. A low-load pump which is rated for this flow range and operates at optimum efficiency, can expand the control range of the entire system to include this low-load range.





η_{opt} Optimum pump efficiency curve

① Pump characteristic curve at fixed speed (n = 100 %)

② Characteristic curve of low-load pump (n = 100 %)

③ Duty point curve of main-load pump in controlled operation at base load on frequency inverter (n = variable)

④ Duty point curve of two parallel main-load pumps in controlled operation at peak load with two frequency inverters (n = variable)

⑤ Limit for continuous operation (min), main-load pump

⑥ Limit for continuous operation (min), low-load pump

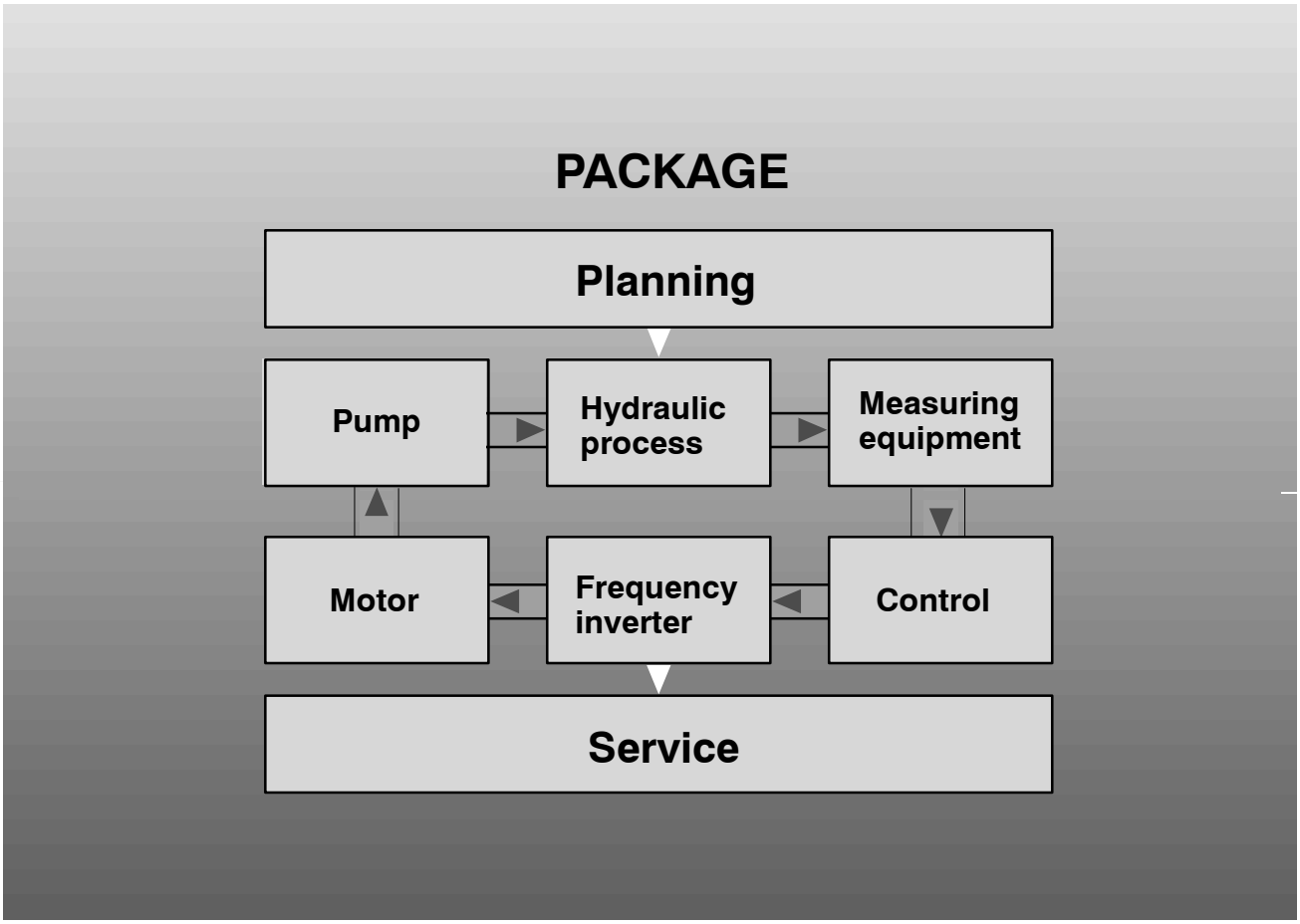
⑦ Operating limit (max)

① Pump power input curve at fixed speed (n = 100 %)

② Power input curve of low-load pump (n = 100 %)

③ Power curve of pump in controlled operation at base load with 1 main-load pump on frequency inverter (n = variable)

④ Power curve of pump for controlled operation at peak load with 2 main-load pumps in parallel on two frequency inverters (n = variable)



KSB offers a comprehensive service package comprising system planning of pumps, valves and switchgear, delivery, installation and commissioning as well as technical support during system operation.

1.7.2004

1964.5/2 - 10

KSB Aktiengesellschaft
67225 Frankenthal • Johann-Klein-Str. 9 • 67227 Frankenthal (Germany)
Tel. +49 62 33 86 0 • Fax +49 62 33 86-34 01 • www.ksb.com