BPS-1 Booster Pump Station - Control Specification

Document: BPS-1-CS, revision B. Fictional plant, written for the TiaMcp demo. All names, values and numbers are invented.

1 Purpose

This document describes the control functions of the booster pump station BPS-1. The station takes water from an open break tank and keeps the pressure in a small distribution network constant. It is the reference for the PLC program, the acceptance tests and the factory acceptance test (FAT) report.

2 Plant overview

The station consists of the break tank T-101 with the inlet valve XV-101, the two booster pumps P-101 and P-102 with variable speed drives, and the pressure header with the transmitter PT-201.

Tag	Equipment	Signal	Range
LT-101	Break tank level transmitter	4-20 mA	0-4.0 m
XV-101	Inlet valve from the mains, open/closed limit switches	DO + 2 DI	open / closed
P-101, P-102	Booster pumps with VFD: run command, running feedback, VFD fault, speed reference	2 DO, 4 DI, 2 AO	0-100 %
PT-201	Header pressure transmitter	4-20 mA	0-10 bar
ES-001	Emergency stop relay (healthy = TRUE)	DI	
H-001	Common alarm lamp	DO	

The break tank holds 8 m3 (2.0 m2 x 4.0 m). With the inlet valve open the mains deliver about 20 m3/h. One pump delivers about 20 m3/h at 4 bar; the nominal consumption is 12 m3/h.

3 Operating modes

3.1 Mode selection

The station shall have the operating modes Off, Manual and Auto, selected by the operator on the HMI. In mode Off all pump and valve outputs shall be switched off.

3.2 Manual mode

In mode Manual the operator shall start and stop each pump individually, and a started pump shall run at the manual speed setpoint. The dry-run protection, the high pressure trip and the emergency stop shall stay active in mode Manual.

3.3 Emergency stop

When the emergency stop circuit opens, all pumps shall stop and the inlet valve shall close within 0.5 s. After the emergency stop circuit has been closed again, the pumps shall restart only after the operator has acknowledged the alarm.

4 Tank level control

4.1 Refill

In modes Manual and Auto the inlet valve XV-101 shall open when the tank level falls below the refill start level (default 40 %). The inlet valve shall close when the tank level rises above the refill stop level (default 85 %).

4.2 High level

If the tank level exceeds the high level limit (default 95 %), the alarm A_HighLevel shall be raised and the inlet valve shall be closed.

4.3 Inlet valve supervision

If the inlet valve does not reach the commanded end position within 15 s, the alarm A_ValveFault shall be raised.

4.4 Mains pressure switch

If the station is equipped with the optional mains pressure switch PS-100, a missing mains pressure shall raise the warning A_MainsLow.

5 Dry-run protection

5.1 Low-low level

If the tank level falls below the low-low level (default 10 %), all pumps shall stop within 1 s and the alarm A_LowLevel shall be raised. The pumps shall not restart before the tank level has risen above the low-low level plus the restart hysteresis (default 10 %).

5.2 Level transmitter fault

If the level signal is out of range (wire break or short circuit), the alarm A_LevelSensor shall be raised, all pumps shall stop and the inlet valve shall close.

6 Pressure control

6.1 Pressure controller

In mode Auto the speed of the running pumps shall be controlled by a PI controller so that the header pressure follows the pressure setpoint (default 4.0 bar). At constant consumption the header pressure shall stay within 0.2 bar of the setpoint. The controller output shall be limited to the range from the minimum speed (default 30 %) to 100 %.

6.2 Consumption step

After a step of the consumption from 12 to 30 m3/h the header pressure shall not deviate more than 0.3 bar from the setpoint.

6.3 Pressure transmitter fault

If the pressure signal is out of range, the alarm A_PressureSensor shall be raised and the running pumps shall continue at the fallback speed (default 70 %).

7 Pressure protection

7.1 High pressure trip

If the header pressure exceeds the high pressure trip limit (default 6.0 bar), all pumps shall stop and the alarm A_HighPressure shall be raised. A high pressure trip shall remain active until the operator acknowledges it on the HMI.

7.2 Low pressure warning

If the header pressure stays below the low pressure limit (default 2.0 bar) for longer than 10 s while a pump runs, the warning A_LowPressure shall be raised.

8 Pump management

8.1 Duty and standby

In mode Auto one pump shall run as duty pump while the other pump is the standby pump. At every start of the station the available pump with the lower run hours shall become the duty pump. The duty pump shall

change over to the standby pump after the alternation time (default 24 h) of continuous running.

8.2 Assist pump

If the duty pump runs at 100 % speed for longer than the assist delay (default 10 s) and the header pressure is more than 0.3 bar below the setpoint, the standby pump shall be started as assist pump. The assist pump shall be stopped when the common speed stays below the assist stop speed (default 80 %) for 10 s.

8.3 Feedback supervision and failover

If a pump does not confirm running within the feedback timeout (default 5 s) after its start command, the alarm A_Pn_NoFeedback shall be raised and the pump shall be marked as unavailable. If the duty pump fails, the standby pump shall take over within 2 s after the failure has been detected. A VFD fault signal shall stop the pump and raise the alarm A_Pn_VfdFault.

8.4 Run hours

The PLC shall count the run hours and the number of starts of each pump.

9 Setpoint sets

The station shall provide the three setpoint sets Day, Night and Maintenance, which the operator loads as active setpoints on the HMI. Loading a setpoint set shall not stop running pumps.

10 Alarms

Every alarm shall switch on the common alarm lamp H-001 until it is acknowledged. All alarms shall be acknowledged with one acknowledge command on the HMI, and an alarm whose cause is still present shall stay active.

11 Setpoint sets (default values)

Parameter	Day	Night	Maintenance	Unit
Pressure setpoint	4.0	3.0	3.5	bar
Minimum speed	30	30	30	%
Refill start / stop	40 / 85	40 / 85	40 / 85	%
Low-low level / restart hysteresis	10 / 10	10 / 10	10 / 10	%
High pressure trip	6.0	6.0	6.0	bar
Alternation time	24	24	1	h