Overview. The proposed Water Hammer Fatigue Test Bench is a completely integrated system for performing pressure peak impulse testing on water-filled components. The design complies with Bosch document SL-0537 and is configured to generate controlled water hammer events at the test article while minimizing the detrimental effects of pulsation on the remainder of the hydraulic circuit.

1. System Description

The freestanding unit includes a dedicated test section with a full viewing window for observation of the unit under test. An adjacent enclosure houses the heating and pumping equipment, while the controls and computer hardware are mounted directly above this section for convenient operator access.

A 17 in touchscreen computer with keyboard is mounted on a rotating arm. This arrangement provides an accessible operator station while maintaining visibility of the test area and process data during operation.

A principal feature of the system is its ability to impart a water hammer effect to the test subject while protecting the main circulation loop from repeated shock loading. This is achieved by maintaining a high-flow primary loop and producing the test impulse in a controlled side stream routed through the test subject.

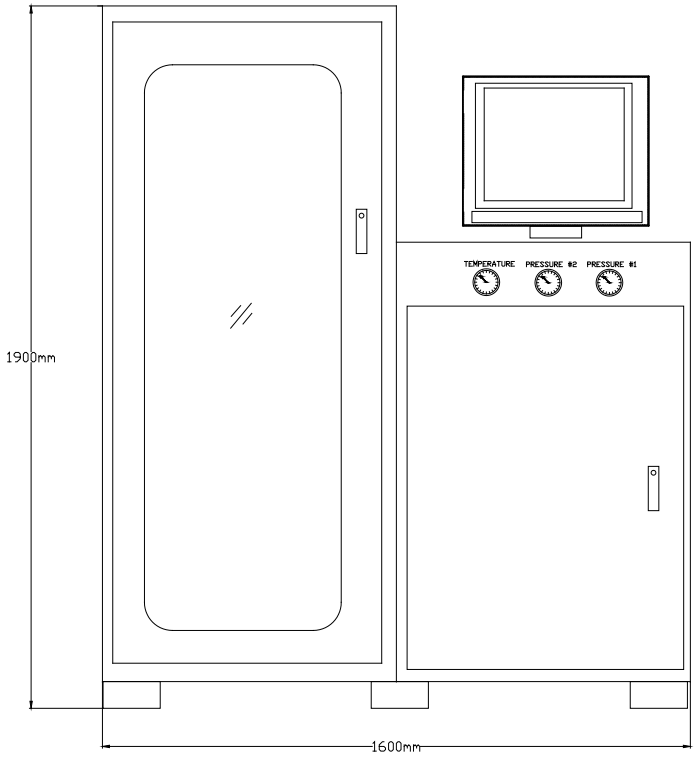

Figure 1

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2. Process Description

Plant water is connected through valve V-101, and the system is filled through day tank T-101. The day tank manages working volume by means of a float valve, allowing make-up water to compensate for evaporation losses during heated testing.

The main process stream is circulated by multi-stage turbine pump P-101, which is capable of pressures above 35 bar at flow rates greater than 35 LPM. System pressure is established using adjustable back-pressure regulator BPR-101, which is set above the required test pressure.

A continuous primary recirculation flow is maintained through the pump and back to the day tank at a rate of at least five times the flow through the test article. This high-flow primary loop reduces the influence of water hammer events on the balance of the system and improves hydraulic stability.

The primary loop returns to the day tank through recirculation heater JE-101, rated at 2.0 kW, to maintain fluid temperature within ±2 °C during the test sequence.

A controlled side stream is diverted to the unit under test through flow control orifice plate OP-101. This orifice maintains the test flow substantially below the main-loop flow rate. During filling of the test article, bypass valve V-107 may be opened to provide higher fill flow and reduce preparation time.

After passing through the test article, the side stream returns to the day tank through high-speed servo valve SV-101. This precision valve is capable of moving from fully closed to fully open in less than 20 ms. With the valve fully open, back pressure at the test article is less than 5 bar. With the valve fully closed, pressure rises to the level generated by the main pump. By cycling the valve rapidly, the system can generate programmed pressure spikes at any value between 5 and 35 bar.

This high-performance valve arrangement enables repeatable square-wave or sinusoidal pressure cycling and is well suited for accelerated fatigue testing of water-filled components.

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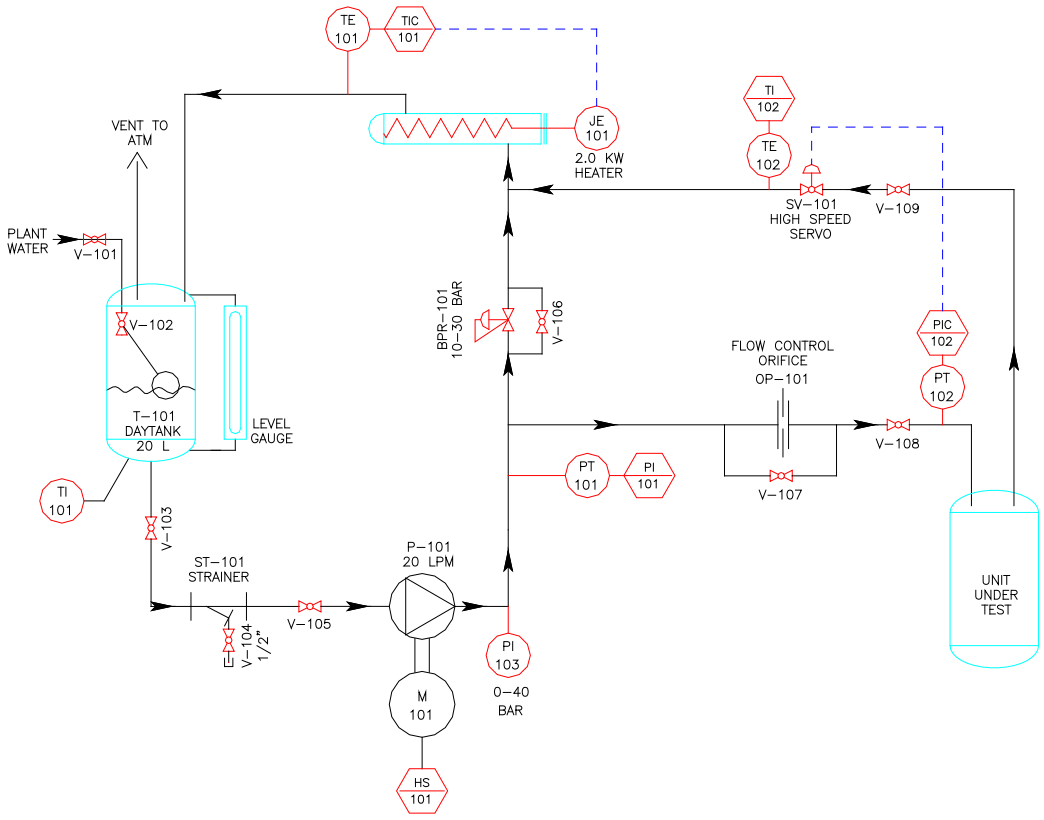

Figure 2

3. Computer Control System

The control system includes local pump start and stop functions, and the heater is interlocked with pump operation. All remaining operating variables are entered and monitored through the computer interface.

The operator interface consists of a 17 in full-color monitor mounted on a VESA arm with an attached keyboard tray. The PC is specified as a specialized Dell computer and may be replaced by any compatible PC operating under Windows XP for legacy support requirements.

The system is managed by a custom National Instruments LabVIEW program written specifically for this application. The interface displays live graphs of pressure, pressure setpoint, and temperature, and supports data recording at rates up to 100 Hz. Recorded data may be exported directly to a spreadsheet format.

The software accepts the upper and lower pressure limits for each cycle, total cycle count, and waveform parameters. In square-wave mode, the operator may set rise time, hold time, fall time, and dwell time. A sinusoidal mode is also available. During square-wave testing, ramp time may be adjusted down to 100 ms. The pressure transmitters specified for the system provide a response time of 10 ms.

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4. Performance Summary

Parameter	Value
Power supply	380 VAC, 3 phase, 50 Hz, 7 kW
Temperature range	Ambient to 60 °C ±2 °C
Heating rate	100 liters at 0.5 °C/min
Pressure range	5 to 35 bar
Pressure transducer	0 to 40 bar range, 0.1% FS accuracy, 10 ms response
Valve response time	20 ms
Recording rate	Up to 100 Hz

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