6 SURGE CONTROL SYSTEM

6.1 GENERAL

6.1.1 Scope

1 The Part specifies the requirements for the design, manufacture, construction, installation, testing and commissioning of complete surge protection systems, including flywheels, surge vessels, compressors, air valves and necessary accessory items.

2 Related Sections and Parts are as follows:

This Section
Part 1,..... General
Part 2,..... Submersible Pumps
Part 3,..... Centrifugal Pumps

Section 1, General
Section 8, Drainage Works
Section 10, Instrumentation, Control and Automation
Section 21, Electrical Works

6.1.2 References

1 The following standards or revised/updated versions and documents of other organisations are referred to in this Part:

ASME VIII Div. 1,. Boiler and Pressure Vessel Code, Design and Fabrication of Pressure Vessels

BS 449,..... The use of structural steel in building (EN 1993- Eurocode 3: Design of steel structures)

BS 729 (ISO 1459, 1460, 1461) Specification for hot dip galvanized coatings on iron and steel articles (ISO 1460 -Metallic coatings — Hot dip galvanized coatings on ferrous materials — Gravimetric determination of the mass per unit area ; ISO 1461 - Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods)

BS 970 (ISO 683) Specification for wrought steels for mechanical and allied engineering purposes (ISO 683 - Heat-treatable steels, alloy steels and free-cutting steels)

BS 1387 (ISO 65) Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads; (EN 10255 Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions)

BS 2872,..... Specification for copper and copper alloy forging stock and forgings; (EN 12165 Copper and copper alloys. Wrought and unwrought forging stock; EN 12420 Copper and copper alloys. Forgings)

BS 3601 (ISO 2604) Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes; (EN 10216-1 Seamless steel tubes for pressure purposes. Technical delivery conditions - Non-alloy steel tubes with specified room temperature properties; EN 10217-1 Welded steel tubes for pressure purposes. Technical delivery conditions - Electric welded and submerged arc welded non-alloy steel tubes with specified room temperature properties; ISO 2604 Steel products for pressure purposes — Quality requirements: ISO 9327-1 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 1: General requirements; ISO 9327-2 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 2: Non-alloy and alloy (Mo, Cr and CrMo) steels with specified elevated temperature properties; ISO 9327-3 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 3: Nickel steels with specified low temperature properties; ISO 9327-4 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 4: Weldable fine grain steels with high proof strength; ISO 9327-5 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 5: Stainless steels; ISO 9328-1 Steel flat products for pressure purposes — Technical delivery conditions — Part 1: General requirements; ISO 9328-2 Steel flat products for pressure purposes — Technical delivery conditions — Part 2: Non-alloy and alloy steels with specified elevated temperature properties; ISO 9328-3 Steel flat products for pressure purposes — Technical delivery conditions — Part 3: Weldable fine grain steels, normalized; ISO 9328-4 Steel flat products for pressure purposes — Technical delivery conditions — Part 4: Nickel-alloy steels with specified low temperature properties; ISO 9328-5 Steel flat products for pressure purposes — Technical delivery conditions — Part 5: Weldable fine grain steels, thermomechanically rolled; ISO 9328-6 Steel flat products for pressure purposes — Technical delivery conditions — Part 6: Weldable fine grain steels, quenched and tempered; ISO 9328-7 Steel flat products for pressure purposes — Technical delivery conditions — Part 7: Stainless steels; ISO 9329-1 Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 1: Unalloyed steels with specified room temperature properties; ISO 9329-2 Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 2: Unalloyed and alloyed steels with specified elevated temperature properties; ISO 9329-3 Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 3: Unalloyed and alloyed steels with specified low temperature properties; ISO 9329-4 Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 4: Austenitic stainless steels; ISO 9330-1 Welded steel tubes for pressure purposes — Technical delivery conditions — Part 1: Unalloyed steel tubes with specified room temperature properties; ISO 9330-2 Welded steel tubes for pressure purposes — Technical delivery conditions — Part 2: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties; ISO 9330-3 Welded steel tubes for pressure purposes — Technical delivery conditions — Part 3: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified low temperature properties; ISO 9330-6 Welded steel tubes for pressure purposes — Technical delivery conditions — Part 6: Longitudinally welded austenitic stainless steel tubes)

BS 5304..... Code of practice for the safety of machinery (BSI PD 5304 -Guidance on safe use of machinery)

BSI PD 5500..... Specification for unfired pressure vessels

EN 1092..... Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated

ISO 1217 ..... Displacement compressors — Acceptance tests

ISO 1460 ..... Metallic coatings — Hot dip galvanized coatings on ferrous materials — Gravimetric determination of the mass per unit area

ISO 1461 ..... Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods

ISO 2604 Steel products for pressure purposes — Quality requirements; (ISO 9327-1 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 1: General requirements; ISO 9327-2 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 2: Non-alloy and alloy (Mo, Cr and CrMo) steels with specified elevated temperature properties; ISO 9327-3 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 3: Nickel steels with specified low temperature properties; ISO 9327-4 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 4: Weldable fine grain steels with high proof strength; ISO 9327-5 Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 5: Stainless steels; ISO 9328-1 Steel flat products for pressure purposes — Technical delivery conditions — Part 1: General requirements; ISO 9328-2 Steel flat products for pressure purposes — Technical delivery conditions — Part 2: Non-alloy and alloy steels with specified elevated temperature properties; ISO 9328-3 Steel flat products for pressure purposes — Technical delivery conditions — Part 3: Weldable fine grain steels, normalized; ISO 9328-4 Steel flat products for pressure purposes — Technical delivery conditions — Part 4: Nickel-alloy steels with specified low temperature properties; ISO 9328-5 Steel flat products for pressure purposes — Technical delivery conditions — Part 5: Weldable fine grain steels, thermomechanically rolled; ISO 9328-6 Steel flat products for pressure purposes — Technical delivery conditions — Part 6: Weldable fine grain steels, quenched and tempered; ISO 9328-7 Steel flat products for pressure purposes — Technical delivery conditions — Part 7: Stainless steels; ISO 9329-1 Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 1: Unalloyed steels with specified room temperature properties; ISO 9329-2 Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 2: Unalloyed and alloyed steels with specified elevated temperature properties; ISO 9329-3 Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 3: Unalloyed and alloyed steels with specified low temperature properties; ISO 9329-4 Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 4: Austenitic stainless steels; ISO 9330-1 Welded steel tubes for pressure purposes — Technical delivery conditions — Part 1: Unalloyed steel tubes with specified room temperature properties; ISO 9330-2 Welded steel tubes for pressure purposes — Technical delivery conditions — Part 2: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties; ISO 9330-3 Welded steel tubes for pressure purposes — Technical delivery conditions — Part 3: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified low temperature properties; ISO 9330-6 Welded steel tubes for pressure purposes — Technical delivery conditions — Part 6: Longitudinally welded austenitic stainless steel tubes)

6.1.3 System Description

1 Hydraulic Design. Surge control devices are to be provided where necessary at all pumping stations. The Contractor shall assume no inertia assistance from any air valves fitted. Air valves will not be accepted as a primary means of surge suppression. Flywheels may be used. In the case of multiple pumping mains separate surge suppression systems shall be provided for each main. The design shall include for the worst case i.e. surge conditions existing when the system is pumping at maximum rate and a power failure occurs. Surge analysis shall be based on the friction factor used for new pipelines. Pump manufacturer shall carry out surge analysis for the whole system including the pipe work within the pumping station.

2 System Design. The following types of system may be used for surge protection:

(a) flywheels. These shall be used where there is sufficient reserve capacity of liquid in the wet well or surge tower {see (b)} at all times to allow the flywheel to continuously recharge the main with liquid

(b) surge towers. Their use is only applicable when the total head developed by the pump is low

(c) hydropneumatic atmospheric surge vessels. Their use is only applicable when the static head in the rising main is low. They shall incorporate a dip tube and a float air valve which allows air in and out of the vessel depending on the liquid level in the vessel.

(d) bladder type pressure vessels. Their use is only applicable when no negative pressures occur in the main in either a surge condition or normal operation

(e) hydropneumatic surge vessels with compressors. Their use is only applicable where there is a substantial static head in the rising main

3 Air Valves. Air valves shall be installed on the rising main as specified or required to optimise the hydraulic efficiency of the main. They shall comply with Section 8 Part 5.

6.1.4 Submittals

1 In addition to the submittal requirements of Part 1 of this Section, the Contractor shall submit data and information as the following paragraphs.

2 Design Data:

(a) Hydraulic Calculations. The Contractor shall submit a complete computer based hydraulic transient analysis showing the performance of the surge control system under various model scenarios. Normal operating modes and the sudden shut down of the pump following a power failure shall be simulated. The program shall have the facility to model the characteristic of the different manufacturer's air and reflux valves, and any other proprietary equipment

(b) structural calculations. Structural calculations for the design of the pressure vessel and its supports shall be provided.

3 Shop drawings: Shop drawings shall be provided for the fabrication and erection of the whole system, including air compressors, air valves, surge vessels. Layout drawings, pressure vessel calculations, schematic drawings and electrical drawings shall be provided. Catalogue pages, manufacturers' detail instructions, templates and installation methods shall be provided.

4 Operation and Maintenance Manuals and Instructions. The Contractor shall include all the documentation required by Part 1 of this Section on the surge protection system in the operation and maintenance manuals. A copy of the surge analysis and site tests as described below shall also be included. Documentation for the compressors in accordance with ISO 1217 shall be provided

6.1.5 Quality Assurance

1 Both the Company carrying out the surge analysis and the software used for the computer transient analysis shall have a proven record in surge analysis. Software used shall be a recognised water industry standard.

2 The Contractor shall employ Third Party Agency (TPA) to oversee the design, fabrication and testing of pressure vessels as defined in PD 5500. The independent testing authority shall report direct to the Engineer.

6.1.6 Warranty

1 In addition to the guarantee requirements of Part 1 of this Section, the Contractor shall ensure that the Company carrying out the surge analysis provides a warranty of the performance of the entire surge protection system. This shall not in any way relieve the Contractor of his contractual obligations.

6.2 PRODUCTS

6.2.1 Design Conditions and Performance Characteristics

1 Unless specified otherwise in the particular Project Specification, transient surge pressures shall be limited as the following paragraphs.

2 Positive (over) pressure - Positive surge pressures shall not exceed the design pressure of the pipeline, taking into account any de-rating for temperature. The rating of pipeline restraints and thrust blocks shall be considered in limiting the positive pressure.

3 Negative (under) pressure - Negative surge pressures shall not exceed the following:

(a) GRP, and cement lined ductile/cast iron and steel-limit 1 metre of vacuum (-1 metre)

(b) Bitumen lined ductile/cast iron and steel-limit 3 metres of vacuum (-3 metres)

(c) uPVC, ABS, HDPE, MDPE - limit 3 metres of vacuum (-3 metres).

4 Stress cycling. Certain types of plastic pipeline can fail prematurely due to duty cycling. Where the pump start/stop cycling is likely to be high this should be considered.

5 Pipeline Manufacturer's Recommendations. In all instances the recommendations of the pipeline manufacturer with respect to positive and negative pressures and stress cycling must be followed. Pipeline seals must be included in these recommendations.

6 Surge Vessels. These must be designed, inspected and tested in accordance with PD 5500 Code 2 with a 2.0 mm corrosion allowance Design pressure ratings shall be 1.25 times the greatest pressure the vessel will be subject to. Vertical vessels shall be used wherever possible for sewage. Any supports or plinths shall designed for the vessel to be completely full of liquid.

7 Surge protection equipment shall be chosen in the following order of preference:

(a) flywheel – to be used in all cases where high head is involved to protect against valve slamming,

(b) surge vessel

(c) combination of flywheel and surge vessel

6.2.2 Materials

1 Surge Towers. If these are constructed in concrete, then Section 8 shall apply. If in the same material as the pipeline, then the specifications applying to the pipeline shall apply.

2 Surge vessels. These shall be constructed from steel in accordance with PD 5500.

3 Coatings. Surge vessels shall be coated internally with an epoxy paint system of minimum thickness 300 microns. The system shall be proven in use in this application. The external coating system shall be in accordance with paint system in Section 8 Part 8.

6.2.3 Fabrication

1 Flywheels. These shall comply with the requirements of Part 3.

2 Surge Towers (stand pipes). These may be constructed in concrete, G.R.P or steel. The top of the tower shall be vented back to the wet well or through a suitable de-odouriser. An emergency overflow shall be provided, routed to a drain. They shall be capable of withstanding the maximum pressure generated by the pumps or surge transients, assuming the tower is full of liquid. Means shall be provided for draining the tower and cleaning it out.

3 Hydropneumatic Atmospheric Surge Vessels. These shall be constructed in steel as specified above for surge vessels. They shall include the following features:

(a) facility for draining the vessel. If possible, this shall be using the pressure pipeline

(b) manway access if the vessel is large enough to accommodate this, or inspection hatch for cleaning the vessel out

(c) air/float valve on top of the vessel. This shall be readily accessible for cleaning and maintenance

(d) vent back to the wet well or a suitable drain for the above valve

(e) pressure gauge with isolating cock to measure the maximum and minimum pressures

(f) flanges shall be to BS EN 1092 PN 16.

4 Bladder Type Pressure Vessels. These shall be constructed in steel as specified above for surge vessels. They shall include the features (a) (b) (e) and (f) described in 3 above and in addition the following:

(a) food grade iso-butyl rubber bladder. This shall have a guaranteed life of three years in contact with the liquid pumped and at the specified temperatures

(b) bladder pressurisation valve and gauge. This is for recharging the bladder. Access ladders/platforms shall be provided as necessary.

5 Hydropneumatic Surge Vessels with compressors. The vessel shall be constructed in steel as specified above. The vessel shall include the features (a) (b) (e) and (f) described in 3 above and in addition the following:

(a) liquid level gauges

(i) tubular glass, liquid-level gauges with 20 mm tube outside diameter shall be provided. The minimum viewing length shall be 600 mm per gauge. Sufficient gauges shall be provided to view the entire operating range of water levels in the pressure vessel. Threaded 20 mm connections shall be provided. Isolation valves with ball checks shall be provided to prevent loss of liquid upon gauge breakage. Valves shall be of an offset pattern with integral bonnet. Valve bodies shall be bronze. A drain cock shall be provided on the lower valve. Valves shall have pressure ratings of 1.5 times the maximum surge pressure anticipated, or NP 16, whichever is greater

(ii) flanges shall be provided, NP 16 for the maximum and minimum level probe locations, respectively.

(b) safety relief valves. These shall comply with the PD 5500 and shall be capable of passing air and water. Valves shall have a bottom inlet and side outlet. The inlet shall incorporate a calibrated spring set to allow the valve to open at the vessel design pressure.

(c) air pipework. Air piping shall be galvanised to BS 729 and conform to BS 1387 or BS 3601, of a minimum of 25 mm diameter. A brass ball valve shall be provided as a block valve at the pressure vessel. Brass check valves shall be provided in the air line. All shall be rated for 16 bar.

(d) air compressor assembly

(i) the compressor unit shall be self-contained and consist of a single-acting, two-

(ii) stage, if necessary, air-cooled, reciprocating-type compressor motor with V-belt drive and regulation, on a fabricated steel skid. Valves shall be of stainless steel and shall be easily removed or inspected without use of special tools.

(iii) the compressor shall be driven by an electric motor which shall comply with Section 21

(iv) the air inlet filter silencer shall be of the dry replaceable cartridge type

(v) the compressor shall shut down at unsafe oil level and shall not restart without adding oil

(vi) if necessary, the compressor shall be provided with finned tube, air-cooled intercooler to remove the heat of compression. The compressor shall have an automatic centrifugal starting unloader valve which will cause the pressure in the compressor cylinders to be vented to atmosphere upon compressor stopping, thereby allowing the compressor to start against minimum load

(vii) rotating parts shall be guarded in conformance with BS 5304

(viii) the oil sump on each compressor shall be fitted with a valve and drain extension pipe of sufficient length to enable the oil to be drained without spilling over the base. Sumps containing 1.0 or less may be fitted with a capped pipe.

(e) automatic air volume control system

(i) the automatic air volume control system, in conjunction with pressure vessel-mounted sensor probes and the air compressor unit, shall control the air/water ratio in the hydropneumatic pressure vessel and maintain the air/water ratio within a range compatible with the surge control system design and established system static and maximum operating pressures

(ii) contacts shall be provided for remote indication of excessive high or low water level in the vessel. Capacitance type level probes with a probe well plumbed to the side of the hydropneumatic vessel shall be provided as Section 10. A control panel with all necessary controls, relays and time delay circuits to actuate the air add/vent solenoid valves, and signal a high or low tank water level shall be provided.

(f) Solenoid Valves

(i) solenoid valves of sizes 5 mm through 40 mm for air service shall have forged bronze bodies to BS 2872 with Teflon seats. Internal plunger, core tube, plunger spring, and cage assembly shall be stainless steel BS 970 Part 1 316 S12. Solenoid enclosures shall be IP 68. Valve actuators shall be 240Va.c. Seals shall be Teflon. Valves shall have a maximum operating pressure and a maximum differential pressure of 16 bar. Solenoid valves shall be energised to open.

6.2.4 Factory Inspection and Testing

1 The Contractor shall secure from the pump manufacturer certification that the following inspections and tests have been conducted at the factory and submit to the Engineer prior to shipment.

2 Surge Vessels. These shall be inspected and tested in accordance with ASME VIII Div.1 sewer class (Welding, Non Destructive Testing (NDT), Hydro test, etc.)

3 Compressors. These shall be inspected and tested in accordance with ISO 1217.

4 Motors and control panels. These shall be inspected and tested as described in Section 21.

5 Control System. This shall be inspected and tested as described in Section 10.

6.2.5 Spare Parts and Tools

1 The Contractor shall provide from the specialist manufacturers of the surge equipment all the spares and tools required during the commissioning and maintenance periods as specified in Part 1, including those required below.

2 Special tools, if required for normal operation/or maintenance of any component of the surge control system, shall be supplied with the equipment.

3 Air Valves. A complete seal/gasket set shall be provided for each air valve installed.

4 Control panels and control systems.

5 Compressors.

6.3 INSTALLATION AND COMMISSIONING

6.3.1 Installation

1 All equipment shall be installed and commissioning in accordance with the manufacturer's recommendations and under the supervision of the surge control system supplier's factory trained personnel.

2 Clearance of 1 meter (minimum) all around the vessel shall be provided for inspection and maintenance.

6.3.2 Site Inspection and Testing

1 Surge protection system performance shall be verified by field tests at pumping rates specified for each pressure main and for power failure at the maximum pumping rate. The surge control system supplier shall provide a chart recorder and pressure transducer system to develop a permanent record for each pressure main test.

END OF PART