Engineering Standard

SAES-J-605 6 September 2008

Surge Relief Protection Systems

Instrumentation Standards Committee Members

Saudi Aramco DeskTop Standards

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1 Scope

This standard prescribes the minimum mandatory requirement for sizing, selection, installation, periodic test and inspection of liquid surge relief valves and surge relief systems. Non-metallic piping systems are excluded from the scope of this standard. Unsteady state transient analysis is not covered in this standard and it is assumed that a complete pressure profile of the system requiring protection will be performed by others and approved by the Manager, Process & Control Systems Department, Dhahran. Also, the scope does not cover compressor anti-surge protection.

This entire standard may be attached to and made a part of purchase orders.

2 Conflicts and Deviations

2.1 Any conflicts between this Standard and other applicable Saudi Aramco Engineering Standards (SAES's), Materials System Specifications (SAMSS's) Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Process & Control Systems Department, of Saudi Aramco, Dhahran.

3 References

The latest edition or revision of the following standards, specifications, codes, forms, and drawings shall to the extent specified herein, form a part of this standard.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-B-068	*Electrical Area Classification*
SAES-J-003	*Basic Design Criteria*
SAES-J-600	*Pressure Relief Devices*

SAES-J-601	*Emergency Shutdown and Isolation Systems*
SAES-J-700	*Control Valves*
SAES-L-132	*Material Selection for Piping Systems*

Saudi Aramco Forms and Data Sheets

8020-605-ENG	*ISS Surge Relief Valves*

3.2 Industry Codes and Standards

American National Standards Institute

ANSI S1.13	*Method for the Measurement of Sound Pressure Levels*
ANSI/FCI 70-2	*Control Valve Seat Leakage*

American Society of Mechanical Engineers

ASME B31.3	*Chemical Plant and Petroleum Refinery Piping*
ASME B31.4	*Liquid Transportation Pipelines*
ASME B31.8	*Gas Transportation Pipelines*
ASME SEC VIII D1	*Pressure Vessels, Division 1*

The International Society for Measurement and Control

ISA 75.01.01	*Flow Equations for Sizing Control Valves*
ISA RP75.23	*Considerations for Evaluating Control Valve Cavitation*

American Petroleum Institute

API SPEC 6D	*Specification for Pipeline Valves*

American Society for Testing and Materials

ASTM A216	*Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service*

International Electrotechnical Commission

IEC-60534-8-4	*Industrial Process Control Valves, Part 8-4: Noise Considerations Section 4: Prediction of Noise Generated by Hydrodynamic Flow*

International Organization for Standardization

ISO 15156 *Petroleum and Natural Gas Industries - Materials for use in H_2S Containing Environments in Oil and Gas Production*

4 Definitions

The following terms will be used frequently in this standard and related hydraulic studies. Design contractors shall adhere to this terminology in all documentation related to surge relief valves and systems.

Accuracy, rating: In process instrumentation, a number or quantity that defines a limit that errors will not exceed when a device is used under specified operating conditions.

Design Pressure: The design pressure is the highest pressure, at the maximum temperature expected during most severe plant operating conditions. This pressure is always equal to or less than the MAOP.

Effective Valve Closure Time: The period over which an Emergency Shutdown or Isolation Valve reduces the flow from 90% of its steady state to zero. In relation to Total Valve Closure Time, this is typically the last 15% opening for butterfly valves, 25% opening for ball valves and 30% opening for plug valves.

Flow Diversion: Any surge flow duration in excess of two minutes and up to four hours. This is also referred to as Line Pack.

Hysteresis: The maximum measured separation between upscale and down scale indications of the measured variable, during a full range transverse, i.e., dead band.

MAOP: The maximum allowable operating pressure is the maximum gauge pressure at which the piping system may be operated for a designated temperature. The MAOP is sometimes referred to as the MAWP (maximum allowable working pressure) and is the basis for the set pressure of the surge relief valve(s).

MATP: The maximum allowable transient pressure is the maximum gauge pressure permissible in the piping system under abnormal operating conditions. The MATP is not to exceed 110% of the rated MAOP. The MATP is sometime referred to as the MASP, the maximum allowable surge pressure.

Over Pressure: The pressure increase over the set pressure of the surge relief device allowed to achieve rated flow. Overpressure is expressed in pressure units or as a percent of set pressure. This is also referred to as percent rise over set pressure.

Peak Shaving: Any over pressure of a duration of less than two minutes.

Set Pressure: The gauge pressure at which the surge relief valve starts to open. In a modulating surge relief valve design, this is the pressure at which the valve begins to modulate. If the valve is of the on/off design, at this pressure plus the tolerance specified in the specifications, the surge valve will move to the full open position.

SRV: An abbreviation for surge relief valve.

Surge (Transient) Analysis: An engineering study that performs a hydraulic transient analysis of a specified system, usually through the use of specialized simulation software which models the system, fluid and operating conditions. The transient analysis will predict the time history of pressures and flows throughout a system as a result of applicable transient events. From the results, a specialist can determine whether surge protection is required, what form of surge protection is most suitable, its capacity and where it should be located as specified in this standard. The surge/transient analysis referred to in this Standard is specific to pipelines/piping systems.

Surge Pressure: The rapid change in pressure as a result of change in pipeline flow rates. In engineering terms, the conversion of kinetic energy (velocity) into potential energy (pressure).

Total Shut-Down Time: The time from manual or automatic initiation of the ESD to final closure of the ship, terminal or plant isolation valves.

Total Valve Closure Time: The total time for a valve to move from the fully open position to the fully closed position.

Wave Speed: The velocity of sound in the fluid flowing in a pipeline. This is the speed at which surge pressures are transmitted along a pipeline. Typical propagation velocities are 1,524 m/sec for water and 914 m/sec for crude oil lines.

5 Causes of Surge Pressure

Transient pressure waves are generated in a pipeline system whenever there is a sudden change in flow. The waves have both positive crests and negative troughs. The high pressure crest is commonly referred to as "surge pressure". Generally, a rapid change in flow is caused by:

- Pump start/stop
- Closure of Automatic Emergency Shutdown Valve (ZV/EIV)
- Closure of a pipeline Emergency Isolation Valve (OSPAS Class-1 or 2)
- Closure of a tank/vessel inlet isolation valve
- Closure of a looped pipeline(s)
- Rotating equipment overspeed or changeover operation

- Rapid change in position of flow or pressure control valves

With any of these events, both high and low surge pressure waves are generated. The prime concern is to protect the pipeline system from over pressure. A surge suppression system is normally installed to relieve the high pressure peaks that exceed the pipeline MATP.

In the case of inadvertent pump stop, the pump discharge pressure will drop rapidly due to decrease in pump head and the suction pressure will rise due to a reduction in fluid velocity. This standard defines any over pressure duration less than two minutes as "Peak Shaving". Consecutive surges of two minutes or less duration shall still be considered as "Peak Shaving".

In the case of an ESD, EIV, pipeline, tank inlet valve closure or a control valve failure to the closed position, the surge pressure waves may exist for an "Extended Period". This will depend on the proximity to pumps and the interaction of related instrumentation systems such as pump high discharge pressure trip, which may or may not be activated. This standard defines any surge pressure wave duration in excess of two minutes and up to four hours as an extended period. Furthermore, this standard defines such an application as "Flow Diversion". An example is surge relief valves at pressure reducing stations. Surge duration in excess of four hours is unlikely, therefore, need not be considered.

Commentary Note:

> *This standard does not assume that all flow diversion scenarios will last for four hours. The above is a definition only and by no means determines exactly how much flow diversion will occur, only that above 4 hours is unlikely. The time element is associated with ensuring that the SRV is adequately protected mechanically, with anti-cavitation trim, to account for extended periods of operation in severe service.*

For the purpose of selection and sizing of surge relief valves, surge studies shall be conducted to establish the duration and magnitude of the pressure rise. The transient analysis shall classify the surges into the two types described above. The analysis shall consider all of the above possible causes of surge pressure waves as applicable to the system under analysis. The analysis shall be based upon a pipe design factor of 0.72 irrespective of actual pipeline design factor.

Commentary Note:

> *ASME B31.4 specifies only a design factor of 0.72 for liquid pipelines. However, Saudi Aramco utilizes the design factors stipulated in ASME B31.8 specified for each area class to provide additional safety for the pipeline. However, ASME B31.8 paragraph 840.1.c stipulates that a design factor of 0.72 is safe for pressure containment in any location; however additional measures are necessary to protect the integrity of the line from the presence of other activities.*

6 Determination of Relieving Rates

As per ASME B31.4, paragraph 402.2.4, surge studies shall be conducted and surge relief systems shall be provided whenever the total pressure in the pipeline exceeds 10% above the MAOP, during abnormal operation. The surge analysis shall be based on single contingency failure modes. Dual contingencies are unlikely and shall not be used as the basis for computation of relieving rates.

Surge analysis studies shall be conducted assuming that process initiated shutdown signals for pump trips, due to low suction and high discharge pressures, will successfully stop the pumps. This is provided that such signals originate from an ESD system and that signal loops and ESD system meet the SIL assessment and design requirements of SAES-J-601.

The surge analysis conducted shall serve as the basis for determining the maximum relieving rates and the maximum relieving amounts. The transient analysis shall be presented as a plot of pressure vs. time and flow rate vs. time, for the contingency under study. The peak pressure and the peak relief rates shall be selected as the basis for sizing the surge relief system.

7 Selection of Surge Relief Valves

Surge relief valves are different from conventional relief valves in the sense that the surge valves have fast response time, high capacities and high set-point accuracy. The valves provide a choice of proportional, quick-open and on-off characteristics, with non-slam shut provisions. Direct spring loaded relief valves such as conventional relief valves are not acceptable for surge applications.

The surge relief valve system shall be totally self contained and require no external electric, pneumatic or hydraulic power source. Gas loaded systems are considered to be self-contained and require no external power source. Distinction must be made between gas loaded and pneumatic systems. A pneumatic system, consumes air/gas on a continuous basis or during the operation of the valve. A gas loaded valve is considered to consume zero power, if no loss of gas occurs during the opening and closing of the valve. As the valve opens, gas is compressed into an external or an internal plenum with no venting to atmosphere.

The valves shall be of the fail-safe design, i.e., fail to the open position. The fail-safe design shall be accomplished by a flow-to-open or spring-to-open type configuration. The designer shall specify the type, size and other relevant process data on ISS, 8020-605-ENG.

7.1 Sliding Plug Axial Valves

The axial surge relief valve is a general purpose, cost effective solution for most surge applications.

Gas loaded axial valves are acceptable for "Peak Shaving" applications which can tolerate a dynamic response time of 250 milliseconds or less. These valves are also acceptable for "Flow Diversion" in low to medium pressure drop service, if the calculations indicate that no cavitation is present or the vendor can provide an adequate anti-cavitation trim. Refer to section 8.3 for anti-cavitation requirements.

The axial valve may also be pilot operated. Pilot operated valves generally have a slower response time and are better suited for clean, single phase products. The transient analysis must demonstrate that a response time longer than two seconds is acceptable.

7.2 Y-Body Surge Valves

The Y-Body surge relief valve is similar in performance to the axial valves. The flow capacity is lower than a comparably sized axial valve, however, the valve recovery coefficient is slightly higher than the axial's. The Y-body is available in both gas loaded and pilot operated configurations. These valves shall be used in identical applications as mentioned in paragraph 7.1.

7.3 Globe Style Surge Valves

The globe style surge relief valve is a conventional control valve with a pilot operator. Because the pressure is not direct acting, and the actuator is external to the plug, the valve has a slower response time. Typically, the response time will be one second or more. The strength of the globe valve lies in its ability to handle high pressure drops. This type of valve can be provided with an anti-cavitation trim.

The globe surge valves shall not be used for "Peak Shaving" applications. Their applications shall be limited to the "Flow Diversion" when superior anti-cavitation performance is desired and slower operating times are acceptable. This type of valve can be fitted with modulating or snap-acting pilot.

7.4 Expandable Tube Valves

Gas loaded expandable tube valves have the fastest response time, typically, less than 250 milliseconds. For comparable body size, the flow capacity of an expandable tube valve is less than 20% of the axial flow valves. The failure mode may be to the closed position, which is not acceptable.

The simple design and the fast operating speed makes this valve ideal for applications such as tanker loading systems on jetties. However, due to their failure mode and the low capacity, applications must be justified. This type of valve shall be used only in "Peak Shaving" applications when none of the valves discussed above can meet the application needs. Prior approval by the General Supervisor, Process Instrumentation Division, Process & Control Systems Department, Dhahran, is required to employ this valve design.

7.5 Rate-of-Rise Surge Relief Valves

The rate-of rise surge valves are SRV's with differential pilots, which can detect the rate of change in pressure in the pipeline and then modulate the surge valve opening proportional to this rate, thus controlling the surge rate in the pipeline. This type of system is used primarily in liquid systems with very high bulk modulus or incompressible fluids, i.e., sea water and refined products.

Such systems are equipped with an MAOP override regulator which permits the rate-of-rise modulation of the surge valves to continue, until the MAOP is reached. At MAOP, the surge valve opening is proportional to the static pressure in the pipeline. Upon restoration of the pipeline pressure below the MAOP, control is re-established by the rate-of-rise pilot.

The rate-of-rise system, due to its complexity, shall be used only when surge studies justify the need for such a system. If a gas loaded pilot system is used, the system shall be fully compensated for change in gas density due to pipeline pressure excursions and ambient temperature.

The surge relief skid shall be equipped with an independent, self-contained test system to field check the differential pilot. The field test system shall generate a calibrated surge or dynamic rise in pressure for test purposes. The operation of the surge valve shall be verifiable at specified rate-of-rise set-point on the differential pilot.

7.6 Material Selection

Material selection shall be in accordance with API SPEC 6D, with the restrictions and exceptions noted below. For materials requirement for services not listed below, contact Process Instrumentation Division, Process & Control Systems Department, Dhahran.

7.6.1 Sweet Crude and Refined Products

Valve bodies for service temperature ranging from -28°C to +115°C shall be ASTM A216 WCC. Plug material shall be Electroless Nickel Plated ASTM A216 WCC. Seat trim material shall be AISI-316 SS. Wetted springs, if any, shall be of Chrome Vanadium or better. All dynamic valve plug seals shall be manufactured from Viton-GF. If anti-cavitation or cavitation resistant trim is required, the designer shall identify the proposed trim material on the specification sheets but AISI 300- or 400- series stainless steel shall be used as a minimum.

7.6.2 Wet Sour Crude

Valve bodies for service temperature ranging from -28°C to +115°C shall be ASTM A216 WCC. Plug and seat material shall be AISI-316 SS or 17-4PH SS. Wetted springs, if any, shall be made from N06600 material. All dynamic valve plug seals shall be manufactured from Viton-GF. If anti-cavitation or cavitation resistant trim is required, the designer shall identify the proposed trim material on the specification sheets but AISI 300- or 400- series stainless steel shall be used as a minimum. All material selection shall comply with ISO 15156.

7.6.3 Treated Sea Water

Valve bodies, plugs and seats for service temperature ranging from -28°C to +115°C shall be AISI-316L SS, super austenitic or duplex stainless steels (SSS). Wetted springs, if any, shall be made from N06600 material. All dynamic valve plug seals shall be manufactured from Viton-GF. If anti-cavitation or cavitation resistant trim is required, the designer shall identify the proposed trim material on the specification sheets but AISI 300- or 400- series stainless steel shall be used as a minimum.

7.7 Nitrogen Control System

For gas loaded valves a control system shall be provided to facilitate set-point changes, gas bottle replacement and instrumentation for alarms. The control panel shall have a viewing window and be field mounted in proximity to the surge valves. The panel shall be suitable for the area classification, as determined by SAES-B-068 and shall meet the requirements specified in SAES-J-003. The panel shall have the following minimum instrumentation:

- Dual, non-continuous bleed Nitrogen regulators with internal pressure relief and a cross over manifold.
- Nitrogen inlet/outlet pressure gauges with 1% or better accuracy.
- Low Nitrogen supply pressure transmitter.
- Hi/Low Nitrogen set-point pressure transmitter.
- Audible alarm, with acknowledge and reset push buttons only if the control panel is located at a manned surge station.
- Relief valve protection for instrumentation down stream of the regulators.
- Dry DPDT alarm contacts to pipeline SCADA system.

- All surge relief systems shall be monitored from a manned control facility. Sufficient instrumentation to monitor surge relief station operation and condition shall be provided.

In hydrocarbon service, when secure source of sweet gas is available, the sweet gas may be used in lieu of the Nitrogen bottles, if the minimum gas pressure is 30% above the highest anticipated surge relief set-point. When sweet gas is used, a gas conditioning system shall be installed that provides liquid knock-out and particle removal before connection to the surge relief system. Wiring and device selection shall conform to the area classification requirements. P&CSD review and approval are required before implementing sweet gas supply systems.

The Nitrogen regulators shall be selected such that the surge relief set-point can be maintained within 2% of set, for a temperature excursion of 40 to 150°F. If temperature compensating regulators are used, Nitrogen consumption per valve shall not exceed 2.0 SCFD. The selected vendors shall provide detailed calculations to substantiate the quoted steady state Nitrogen consumption. The daily consumption restriction does not apply to systems using sweet gas from a non-bottle supply source.

In installations where a single Nitrogen system is used to provide surge set-point to multiple valves, block and bleed valves shall be provided such that each surge valve can be individually isolated for testing and maintenance.

Nitrogen piping and tubing distribution system shall be designed to minimise nitrogen losses at connection points.

7.8 Plenum Design and Installation

Gas loaded SRV's have an internal or an external plenum to limit the pressure rise in the plug cavity due to the gas volume displacement of piston or jacket. The designer shall verify the plenum sizing calculations to insure that the pressure rise due to the valve moving to the full open position, does not exceed the set-point by 10%.

The external plenum shall be buried underground to minimize set-point drift due to thermal expansion of the gas. On offshore installations, where burial is not practical, a sunshade shall be provided. The plenum shall be fitted with a relief valve, if required, to provide protection from accidental over pressure, which may result from regulator failure. The MAOP of the plenum shall meet or exceed the MAOP of the pipeline at the point of installation. The plenum shall be constructed from carbon steel and be in compliance with ASME SEC VIII, Division 1.

7.9 Pilot Design and Installation

Two types of pilot valves are generally used in most surge relief applications. The on-off pilot is the simplest in design. In service where the surge relief valve discharges to an external tank, on-off pilots shall be used. The modulating pilot is generally more complex in design and shall be used for applications where the snap-action of the on-off pilots can lead to unstable pipeline operations. Station bypass at a pressure reducing stations is one such application. Pilot valves shall be used only in clean service, e.g., stabilized crude, refined petroleum products and processed water.

The pilot assembly shall be designed such that it shall not be susceptible to plugging from debris in the pipeline. Pilots shall be proof tested to the same test pressure as that of the surge relief valve and overpressure protection shall be provided in the pilot design. Only high capacity pilots with large flow areas shall be used. The pilot shall have separate sensing and supply ports. Filters shall be provided for both sense and supply lines. The pilot and the filters shall be manifold mounted with a minimum of external piping. The filters shall be replaceable with the surge relief valves on-line.

The main surge valve and its pilot system shall be of the fail safe design. The vendor shall guarantee that any single failure in the pilot sensing mechanism, pilot control mechanism, springs, pilot seals and actuator seals shall not prevent the valve from opening during pipeline over pressure conditions.

The pilot sensing accuracy shall be 1% of set pressure for modulating pilots. For snap-acting pilots 2% shall be acceptable. The combined (pilot, actuator & valve) maximum hysteresis shall be no more than 2% of set-point. The modulating span shall be a minimum of 2% of the set-point. Designer shall check that these allowances do not result in SRV's being operated above the MATP of the respective pipeline.

7.10 Seat Leakage

The maximum permissible seat leakage shall be in accordance with ANSI/FCI 70-2 Class-V. This leakage class meets the requirements for most surge applications.

8 Sizing of Surge Relief Valves

The SRV manufacturer shall furnish all valve-specific information required for system modelling, e.g., flow characteristics, response time, etc. It is also recommended that the Designer include the preliminary surge analysis report with the SRV purchase order. Coordination between the two parties will be required as the surge analysis is updated.

The size of the surge relief valve(s) is heavily dependent on the set pressure. Before sizing calculations can commence, the set pressure must be accurately determined. Care must be taken to select a surge set-point which is well above the normal steady state operating pressure. The location of the surge relief valve can also have an adverse impact on the surge set-point. A comprehensive surge analysis must be conducted before the surge set-point, header losses and relief station location can be finalized.

The set-point and capacity calculation guidelines presented below applies primarily to cross-country pipelines designed as per ASME B31.4. For in plant piping, such as transfer lines, designed as per ASME B31.3, there is no mandatory requirement for surge analysis or surge protection. However, pressure is not permitted to exceed 20% or 33% above the design pressure of the piping, depending on the duration of the over pressure condition. Please refer to ASME B31.3, section 302.2.4 for details. The effect of closing a valve inside a Terminal or Bulk Plant on the low-rated section of the line shall also be considered. Transient analysis on transfer lines of significant length should be conducted on a case by case basis. Distinction must be made between over pressure caused by transients and over pressure caused under static conditions. The latter is covered by SAES-J-600.

8.1 Surge Relief Set-points

As discussed above, an accurate assessment of surge relief set-point in a complex pipeline can only be arrived at by surge analysis. The following limits shall apply:

8.1.1 Set-point, Peak Shaving

The selected set-point shall not exceed the MAOP of the pipeline. A 10% transient rise above the set-point, to MATP, is permitted and should be accounted for in the capacity calculations of the SRV's. This restriction applies to single and multiple SRV installations. In the case of multiple valves, if a staggered set-point strategy is used, the highest set point shall not exceed the MAOP.

SRV setting below the MAOP is desirable and shall be selected whenever the surge analysis indicates its feasibility. However, to prevent activation of the surge system during normal operation, the set-point shall be at least 5% or 100 kPa (15 psig), which ever is greater, above the normal operating pressure.

8.1.2 Set-point, Flow Diversion

The set pressure plus the permissible rise over the set pressure, shall not exceed the MATP of the pipeline. When modulating valves are used, the set pressure shall be calculated as the MATP, minus the modulating range of the valve. Once again transient simulation shall confirm that the set pressure is sufficiently high enough, above the normal operating pressure to prevent accidental opening of the SRV's under non-surge conditions.

8.2 Capacity Calculations

Traditionally, simulation studies present data as a plot of pressure profiles at stated flow rates for different surge scenarios. The volumetric surge flow requirements, obtained from surge studies, at a given set pressure is then used to select the valve size. This method of sizing shall be used only for estimation purposes. The final sizing calculations shall be based on the conventional control valve formulas as per ISA 75.01.01.

Header exit/entry and branch piping losses shall be calculated at the maximum surge conditions and these values shall be incorporated in the computation of the net P across the SRV's. The computation for the valve flow coefficient, Cv, shall be based on the net P. The minimum Cv of the selected valve shall be at least 1.1 times the calculated maximum Cv. For Peak Shaving applications, the maximum allowable delta-P shall be calculated and used (instead of actual delta-P) for computing the maximum flow capacity.

The Designer shall provide the vendor with the application data necessary to confirm the valve sizing and selection. The valve selection and sizing shall be tentative until confirmed by the vendor. The vendor shall provide third party Certified Flow and Response Test data for the proposed valve assembly. Flow data on the proposed valve, if available from tests conducted by Saudi Aramco and validated by the Process Instrumentation Division, P&CSD, may be used in lieu of "third party" certification.

8.3 Cavitation and Flashing

ISA RP75.23 shall be used to determine cavitation and/or flashing conditions. Vendor shall provide test data to verify the Valve Recovery Coefficient (F_L) and Cavitation Index (σ). This information shall be used as follows:

When cavitation is present with a standard off-the-shelf trim, the vendor shall demonstrate that the cavitation is within the tolerable limits of the standard trim. Otherwise, a valve with a heavy duty cavitation resistant trim shall be used.

For Flow Diversion applications, an anti-cavitation trim with a suitable Kc shall be selected when cavitation is not within the tolerable limits of the standard trim as indicated by ISA RP75.23. Multi-stage trim shall be used, when required, to accomplish this task. The preferred flow direction shall be over the plug.

Commentary Note:

Distinction must be made between "cavitation resistant" and "anti-cavitation" trims. Cavitation resistant trims do not eliminate cavitation, instead the potential damage to the valve is minimized by selection of hardened trim materials. This can be a cost effective solution for valves which have short duty cycles and are dormant for more than 90% of the installed life cycle. The "anti-cavitation" trims on the other hand, eliminates the cavitation phenomena by dropping pressure in multiple stages or by tortuous path technology.

8.4 Surge Valve Noise Limitations

Noise calculations shall be in accordance with IEC-60534-8-4. The vendor shall guarantee that the measured sound level shall not exceed the limits specified below. The sound pressure level (SPL) shall be measured as per ANSI S1.13.

For Peak Shaving applications, the maximum calculated noise level shall not exceed 105 dbA, at maximum flow capacity. Heavier branch piping, tapered reducers and lower exit velocities shall be specified to limit valve noise to 105 dbA.

For Flow Diversion applications, the maximum calculated noise level shall not exceed 90 dbA at maximum flow capacity. The bulk of the hydrodynamic noise is caused by cavitation. Therefore, selection of an appropriate anti-cavitation trim shall be used to accomplish this task.

8.5 Exit Velocity

The exit velocity shall be calculated at the discharge flange of the surge valve, at the maximum design conditions. For all applications, the maximum allowable exit velocity shall not exceed 58 ft/sec.

8.6 Correction for Pipe Reducers

Whenever an SRV is mounted between pipe reducers, the calculated Cv for the selected valve shall be corrected for piping configuration. Vendor supplied, flow tested, correction factors for standard pipe reductions shall be used whenever this data is available. If no data is available, refer to ISA 75.01.01for the correction factors.

8.7 Liquid Viscosity Correction

The viscosity of most hydrocarbon fluids and water transported within the Saudi Aramco pipelines do not warrant correction. However, the vendor shall be consulted whenever the viscosity is larger than 100 SSU.

8.8 Back Pressure Effects

In surge applications, in most cases, the maximum flow requirement occurs when the back pressure is maximum. Therefore, the valve Cv shall be calculated at the maximum back pressure. Similarly, cavitation calculations shall include evaluation under the minimum outlet back pressure conditions. These values shall be extracted from the surge analysis, with single contingencies.

8.9 Multiple Valve Installation

Multiple valves shall be used when the design flow capacity or the exit velocity exceeds the largest available surge valve. In some cases, such as a surge valve relieving to a tank with limited capacity, multiple smaller valves are preferred, to guard against over filling the tank due to one valve failing. The designer shall calculate the number of valves required on the basis of the relief duration and the design criteria established by the project proposal. The minimum and maximum relief durations shall be determined by transient analysis using the worst case conditions and shall be reviewed and approved by P&CSD and the proponent organization.

In multiple valve installations, a mixture of different valve sizes and types are not permitted unless it can be shown by surge analysis, that the application requires a combination of valves suited for Peak Shaving and Flow Diversion. The design shall be reviewed by Instrumentation Unit of P&CSD. A written approval is also required from the Manager, Process & Control Systems Department, Dhahran.

8.10 Spare Valves

In single and multiple valve installations, an identical spare valve shall be provided to facilitate periodic testing and maintenance of the SRV's. The spare valve shall be in service during normal plant operation. However, the flow capacity of the spare valve shall not be included in station capacity calculation.

At a given time, only one surge relief valve may be taken out of service for testing and maintenance.

Exception:

> *In sectionalized cross-country pipelines where a large number of surge relief valves are required, some spare valves can be replaced by a few common offline spares instead of one spare for each SRV. The number of offline spares shall be agreed upon with the proponent organization based on logistics and economic considerations, e.g., total number of SRV's, distances between SRV's, etc. A piping branch with upstream and downstream isolation valves for the offline spare shall be required.*

9 Design Requirements for Surge Relief Piping

The branch piping in surge relief piping may be exposed to cavitation, flashing, noise and high fluid velocities. One or any combination of these factors can lead to severe vibration and consequently, structural damage. The SRV station shall be designed for maximum stiffness and minimum changes in flow direction. The Designer shall conduct structural analysis study to prove that the SRV design will provide stiff structure to withstand the surge conditions. The lateral transitions from the header to branch piping shall be radiused. Use of stub-end connections and any connections with sharp edges protruding into the headers are not permitted. The following guidelines shall be used in designing surge skids:

9.1 Inlet and Outlet Piping

For the Flow Diversion applications the inlet/outlet headers, branch piping, block valves and the surge relief valves shall be in the same horizontal plane. The branch piping shall be adequately supported to prevent vibration. Block valves shall be bolted to the skid.

For Peak Shaving applications, especially on jetties where space is restricted, the same horizontal plane condition may be relaxed. Prior approval, by the General Supervisor, Process Instrumentation Division, P&CSD is required.

Velocity limits in the branch piping shall be governed by SAES-L-132.

Drains on branch piping shall be provided per SAES-J-700, paragraph 9.2.5.

9.2 Block Valves

For hydrocarbon service, block valves shall be provided on both the inlet and outlet sides of the surge valves. The block valves shall be either quarter turn ball valve, or slab type gate valves. If gate valves are selected, the failure of the gate, shall be in the open position. For sizes up to 12 inches, the block valves shall have manual operators. For sizes above 12 inches, the operator shall be motorized or a portable power tool shall be employed, e.g., portable pneumatic actuator.

Block valves with manual operators shall be car sealed or locked open. Valves with motorized operators shall be provided with position indicators in the control room and shall be provided with a locking mechanism to prevent inadvertent closing.

For sea water and general water service, only the inlet block valve is mandatory. Outlet block valves are required only if the discharge header is elevated or filled with liquid under pressure.

All block valves, in any service, shall be of the full port design, no restrictions in the flow path is permitted. The block valves shall be of the same or larger size than the surge valve. All block valves shall be painted orange.

9.3 Surge Detection

Surge flow detection shall be provided. This may be accomplished by either direct or indirect means. The preferred method shall be to use an external proximity limit switch to monitor valve opening. If this option is not available on the selected valve, a thermal flow switch shall be provided on the outlet branch piping. The preferred mounting position for the switch shall be 45 degrees below the horizontal axis of the branch piping.

The switch in both cases, shall have dry DPDT contacts mounted in an enclosure suitable for the environment and area classification.

Note: *Instrument power supplied to dry contacts, for detection of flow or valve position, does not violate the "no electric power condition" specified in Section 7.*

9.4 Surge Relief Tank

When the surge relief station relieves to an external tank, the tank shall be sized for the worst reliving condition or maximum relieving volume. The tank shall be provided with high and high-high level alarms to avoid over filling the tank. Tank level and associated alarm signals shall be connected to a manned control room or SCADA system.

10 Testing and Inspection

Factory acceptance test is not mandatory for the standard off the shelf surge relief valves which are in frequent use within Saudi Aramco facilities and independent test reports have been reviewed and approved by P&CSD. Factory testing is required for complex rate-of-rise or modulating valves which are custom built to meet a particular application.

Surge valves shall be tested in-situ every twelve months. The testing procedure is quite different from safety relief valves in that flow through the valve is not mandatory during the test. The set-point at which the valve opens shall be checked by creating a static pressure upstream of the valve, with the inlet isolation valves fully closed. This pressure can be created by a manual or electric driven hydraulic pump. Each surge relief valve shall have a 3/8 inch or larger port with plug installed to facilitate the testing requirements.

For gas loaded valves, gas cylinder pressure shall be inspected on a weekly basis. For pilot operated valves filters shall be checked and replaced as necessary on a quarterly basis.

	Revision Summary
6 September 2008	Major revision.