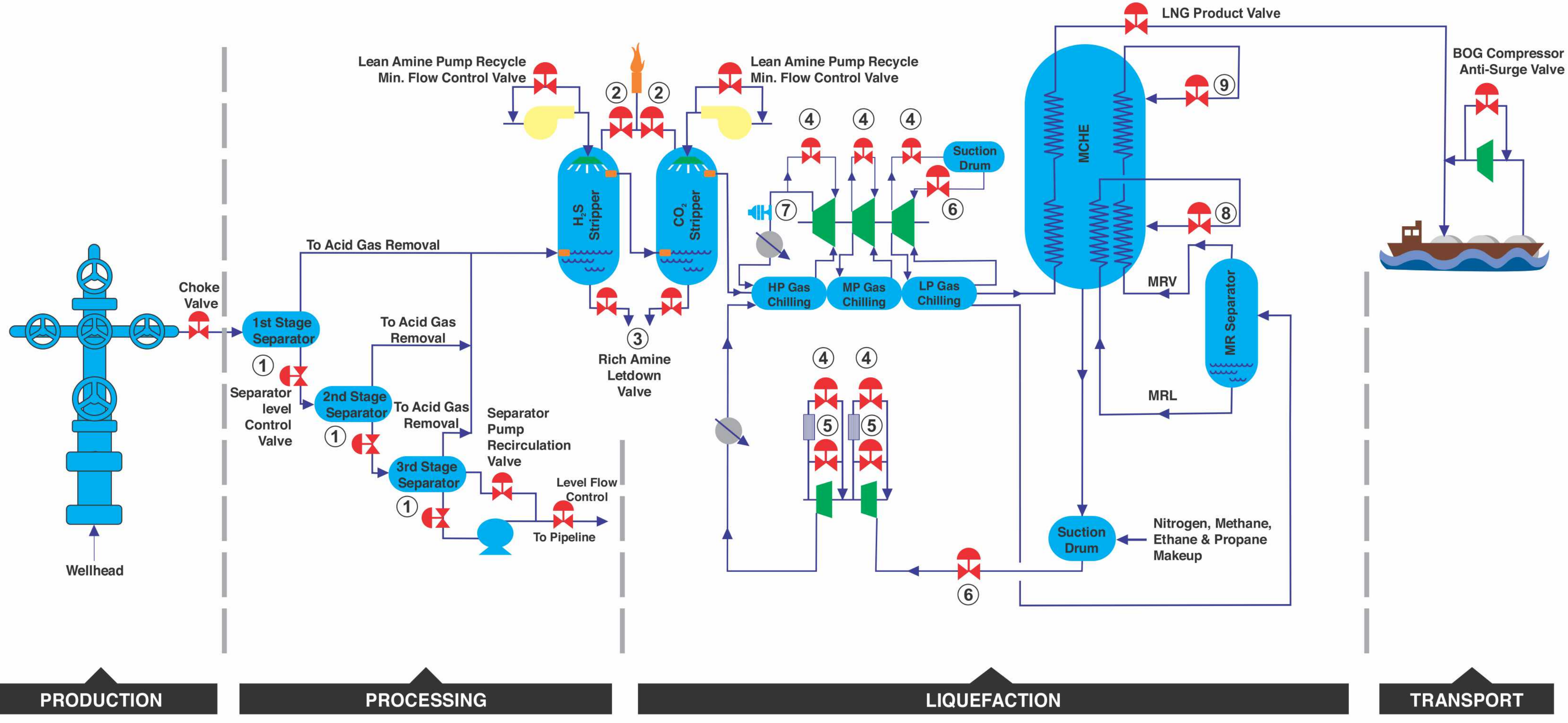
KOSO

Control Valves in LNG

Figure 1: Typical LNG Liquefaction Circuit and Critical Control Valve Applications

Propane Precooled Mixed Refrigerant (C3MR) Process



1. Separator level Control Valve
2. Gas-to-Flare Blowdown Valve
3. Rich Amine Letdown Valve
4. Compressor Anti-Surge Control Valve
5. Hot Gas Bypass Valve
6. Suction Pressure Throttle Valve
7. Propane Desuperheater
8. Warm JT Valve
9. Cold JT Valve

KOSO has vast experience in LNG applications of control valves. KOSO is known for its exemplary product range and world class quality in meeting the LNG application challenges. The critical requirements of design, material selection and testing are not a challenge for KOSO, but a thing of proven processes established in Engineering, Design and Operation.

Different Liquefaction Technologies

Mixed Refrigerant (C3MR) Process

The Propane Precooled Mixed refrigerant (C3MR) process is one of the important liquefaction technologies. Natural gas from the acid gas removal unit is dried and precooled to about -35 °C by propane. After precooling, it passes up through a tube circuit in the main cryogenic heat exchanger (MCHE) where it is liquefied and sub-cooled between -150 °C to -162 °C by a mixed refrigerant (MR) flowing down on the shell-side.

To precool the natural gas, propane is compressed to a high pressure such that it can be condensed by ambient air or cooling water. Liquid propane is then let down in pressure in a series of stages, further reducing its temperature and allowing it to precool the natural gas.

In the MCHE, the feed gas is further cooled and liquefied using a refrigerant comprised of a mixture of nitrogen and light hydrocarbons (i.e. methane, ethane and propane). The mixed refrigerant (MR) is compressed and cooled against vaporizing liquid propane. It is then allowed to circulate as MR liquid and MR vapor in the tubes of the MCHE and expanded into the shell side of the MCHE to liquefy and sub-cool the natural gas.

Cascade Process

Another liquefaction technology is the Cascade Process (figure 2). This process consists of three pure refrigerants which have different boiling temperature; methane, ethylene and propane. At first the natural gas is cooled to -35 °C in the propane cycle, further cooled to -90 °C in the ethylene cycle and finally liquefied to -155 °C in the methane cycle.

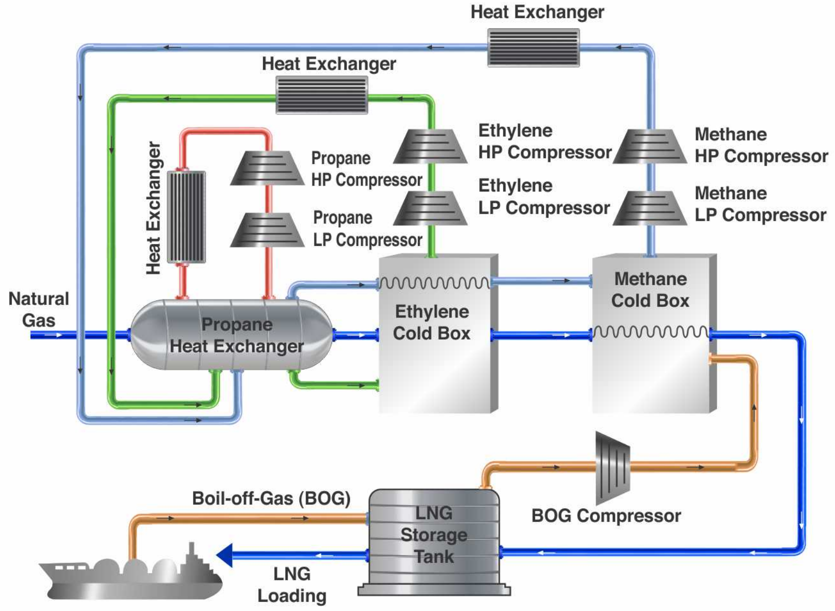


Figure 2 : Cascade Process
(The MCHE in C3MR is replaced by the Cascaded Cold Boxes)

KOSO products for LNG Applications

From the sour gas treatment to gas loading in the carrier, each stage offers unique challenges, but team KOSO is all set to tackle those challenges with unmatched expertise and experience for the most arduous control valve applications. The product range from Globe valve to Desuperheaters offers solution to various control valve requirements applicable in LNG industry. The solutions from Rotary valve to velocity controlled Vector™ trim are suitable for low pressure to high pressure drop applications. The state of the art manufacturing centers worldwide have the capabilities to meet challenging customer specifications for its design, manufacturing, quality assurance and testing. The well satisfied customers around the globe are the inspiration for us to be the leading supplier in the LNG industry.

Separator Level Control valve

The separator level control valves control the level of oil and water in the separator (figure 3). The valve can have severe erosion from solid particles and entrained sand. Flashing and Cavitation can occur due to low P2 pressures. Water Level Control valve has the most severe cavitation risk. Tungsten Carbide trim offers excellent erosion resistance from Sand Accelerated Erosion.

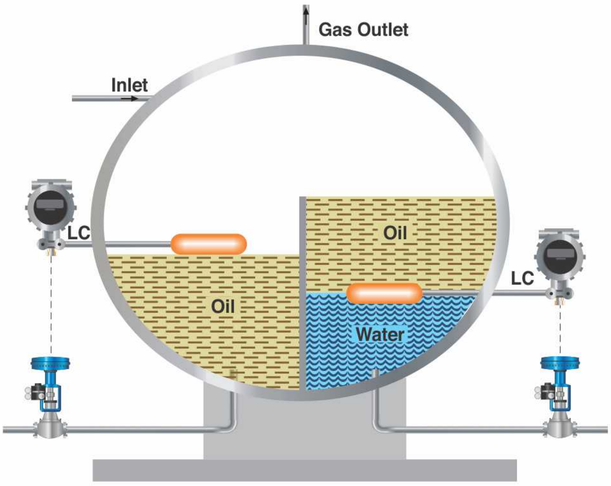


Figure 3 : Separator tank installed with level control valves

Koso's HF-LCV trim (figure 4) is the best fit for Separator Level control application. It is available in solid tungsten carbide and shrouded plug seat design for seat area protection.The Stem scrapper and Plug scrapper rings will protect the stem sealing and resilient plug seal respectively. The impact resistant, stainless steel cage (Brick Stopper) is a unique feature for the protection of tungsten carbide trim. Optionally the tungsten carbide sleeve can also be provided for the protection of outlet run area. The detrimental body erosion can be avoided by full or partial overlay with Inconel 625.

Figure 4 : Valve with HF-LCV trim

Gas to flare or Blowdown Header Discharge valve

Normally the gas is sent to flare or blowdown header during plant start-up, shutdown and pressure control. The most severe challenge from this application is noise control. Multiple valves may get discharged to the same header, so back pressure may be variable as well. The sizing and selection of valve should be as per ISA guidelines following the Kinetic Energy rule.

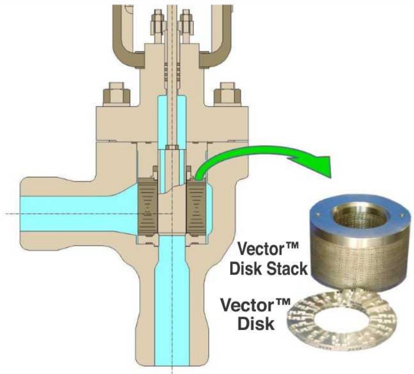


Figure 5 : Flare valve with Vector™ trim

The other challenges are tight shutoff across the seat to prevent gas leak to the flare and hydrate formation due to high pressure drop across the valve.

The Vector™ velocity control, high friction trim (figure 5) is the perfect solution to the noise and hydrate formation problems associated with this application. KOSO reviews the valve selection and the outlet piping and will address noise related issues in the piping by offering flow profiling through a plate or in-line diffuser.

Amine Letdown Level Control Valve

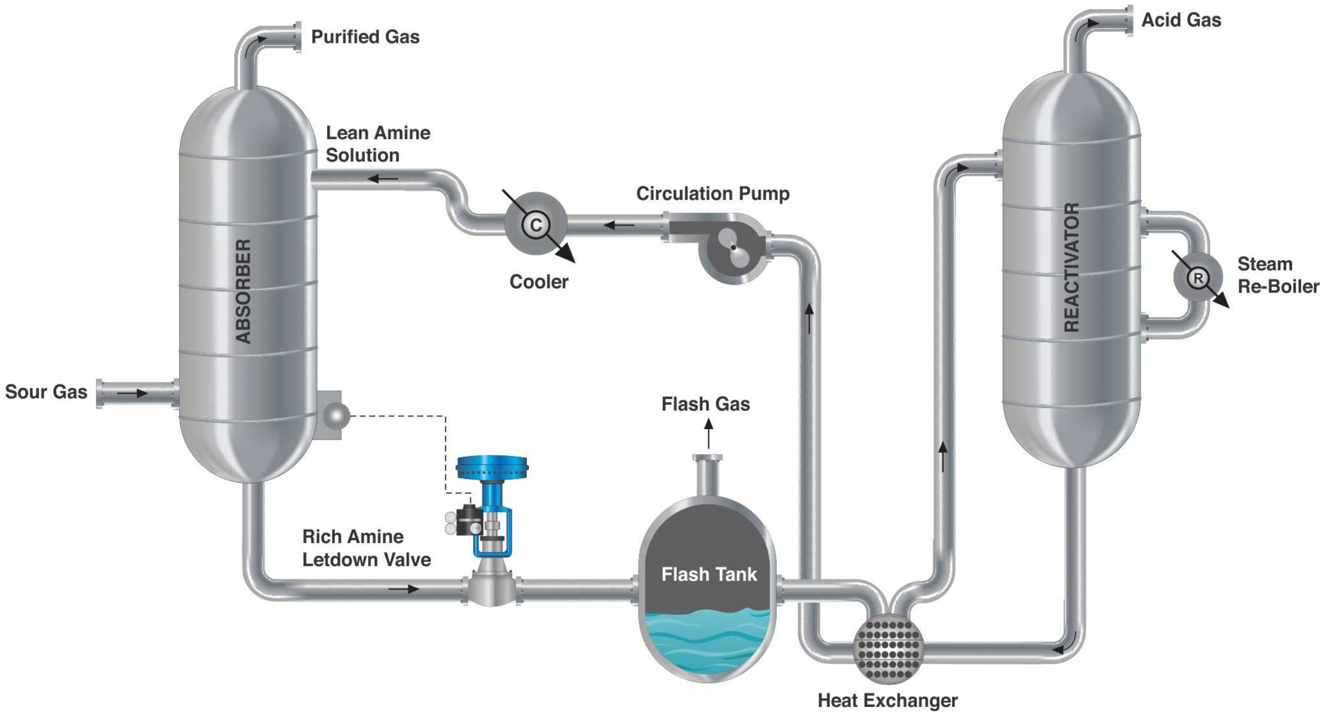


Figure 6: Typical representation of Rich Amine letdown and Lean Amine regeneration process

Amine Letdown is the process of flashing off the acid contaminants from the Rich Amine in a re-generative cycle and recirculates the Lean Amine to continue the acid gas removal process (figure 6).

The Amine solution extracts the acid gas (H2S) from the production stream at high pressure in the absorber tower. The rich amine with entrained gases is sent to a flash tank through the bottom of the absorber. The dissolved gases are outgassed in the flash tank before the rich amine is sent to the regenerative reactor.

The inherent problems with this service are excess vibration and valve stem breakage, flashing induced erosion of the trim parts, uncontrolled velocity through the valve trim and H2S related corrosion

Due to the challenges highlighted above, Vector™ is the natural choice. The combination of stainless steel valve bodies and Duplex trim can offer reliability and longer life for the valve.

Compressor Anti-Surge Control Valve

Compressor anti-surge control valve is used to prevent a damaging surge condition that can occur when the amount of gas flowing through the compressor is insufficient for the speed of compressor and the rotating blades lose their forward thrust, causing reversal of the shaft. Surge event can happen when the downstream demand is reduced. This usually occurs during start-up, shutdown, in emergency or reduced throughput operations.

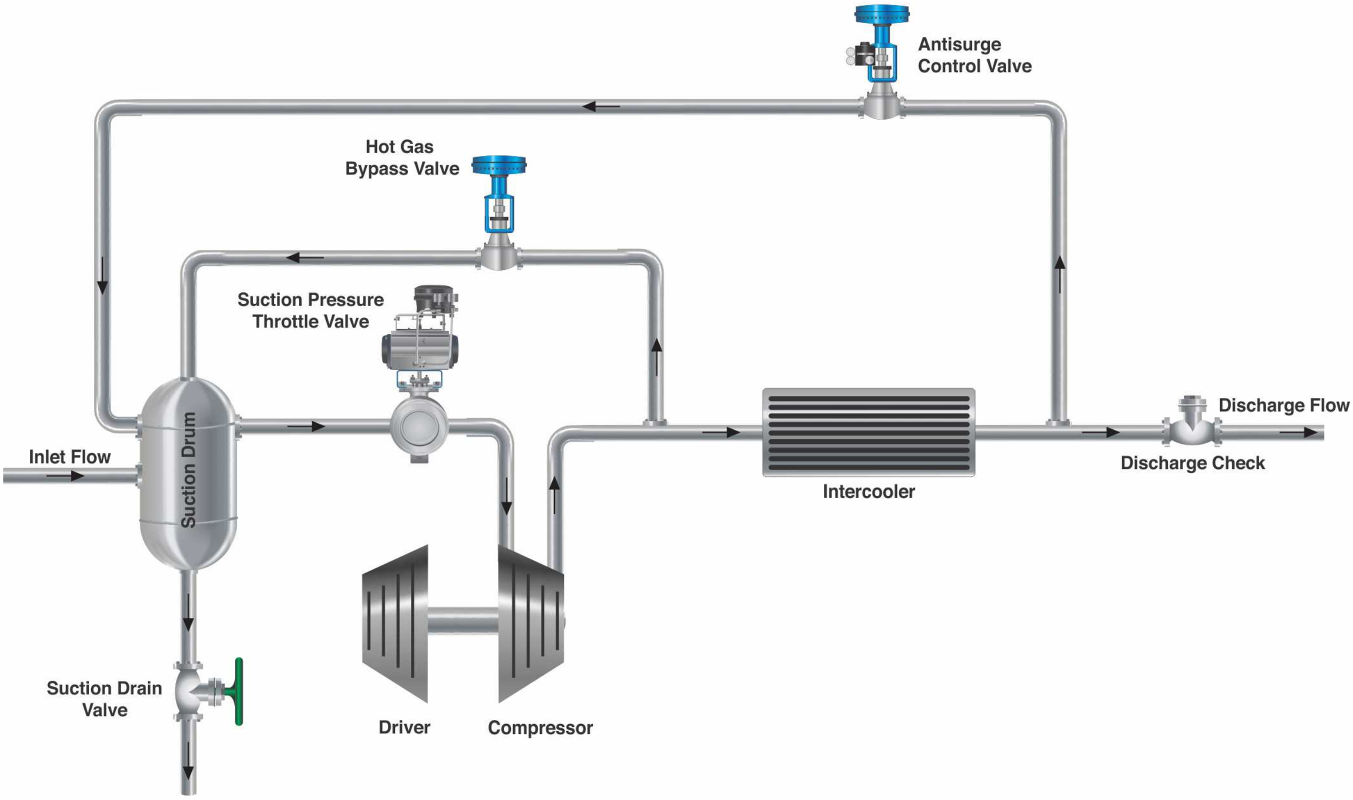


Figure 7: Typical representation of Anti-Surge, Hot Gas Bypass and Suction Pressure Control

The KOSO solution for Anti-Surge is offered in compliance with the needs of the compressor. The opening time is typically 2 seconds or less to keep the required flow through the compressor to prevent a surge. Typical capacity range is 1.8 to 2.2 times the calculated Cv. Figure 8 shows a Vector™ trim which provides precise control while providing excess capacity to protect the compressor. The fluid velocity control through the Vector™ trim can prevent damaging vibration and keep the noise level within the allowable limits. Proper selection of the actuator will ensure tight shutoff against seat leakage. Properly selected and tuned accessories will provide fast operation and precise control.

Figure 8: Normal and Over Capacity Throttle ranges for Vector™ trim

Hot Gas Bypass valve

When the system design requires large flow, the Hot Gas Bypass valve is employed for an extra protection. Hot Gas Bypass valve operates during emergency trips or shutdown. The challenges and solution are similar to the Anti-Surge valve except the on-off function.

Suction Pressure Throttle valve

During plant start-up, the suction throttle valve is kept closed to build sufficient back-pressure in the suction drum. To prevent the variations at the compressor inlet due to variations in gas flow into the suction drum, the suction throttle valve is employed to regulate the pressure to the compressor. This is typically a butterfly valve that is placed in the suction piping of the compressor. As pressure in the suction drum increases, the valve will close slightly and maintain a constant pressure to the compressor.

Koso has a wide range of Butterfly valves (figure 9) that can cater to various flow capacities and body material to suit the process requirements.

Figure 9: Series 710E High Performance Butterfly valve

Propane Desuperheater

In subcritical and transcritical processes (figure 10), the refrigerant vapor is compressed to cool down the natural gas. In subcritical process, the refrigerant vapor (A) at a pressure of P1 and temperature of T1 is compressed to the pressure of P2 and T2 (B). The compressed vapor is then desuperheated to the dew point (C), condensed to the bubble point (D) and subcooled to produce subcooled liquid (E). The subcooled liquid is then flashed to the original pressure P1 (F) and vaporized to complete the cycle and return to the vapor phase (A). During steps (B) through (E), the process rejects heat to ambient air or cooling water. During steps (F) through (A), the process provides cooling duty to the process stream.

In transcritical process, the cycle diagram looks similar; however, the heat rejection steps (B) through (E) occur above the critical point.

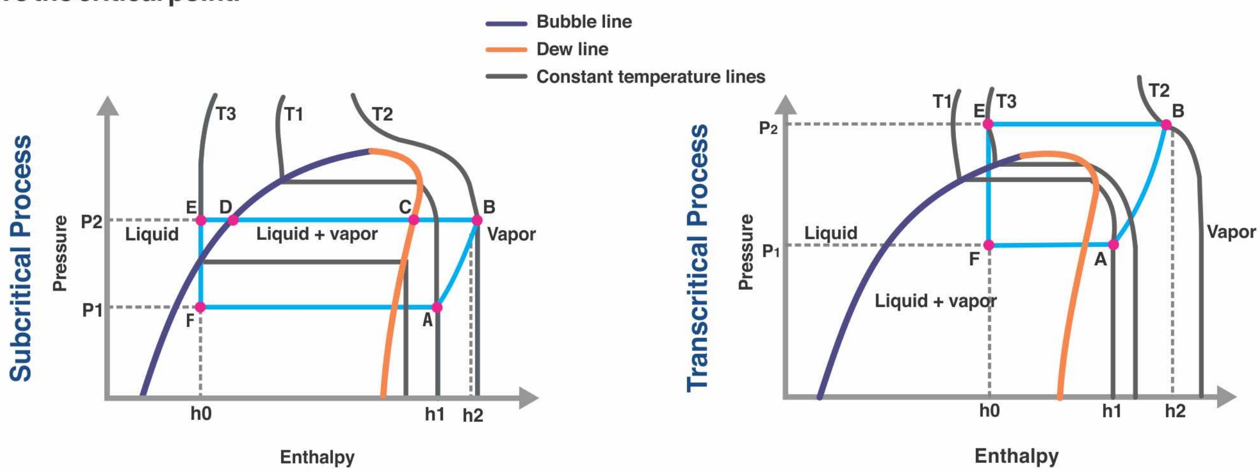


Figure 10: Pressure-Enthalpy diagram of Propane Precooling

Series T42 (figure 11) and 1-4442 (figure 12) pipeline desuperheaters produce finely atomized spray coolant through a series of propriety flat pattern spray jets, opening of which is controlled by an integral plug and stem through the top mounted actuator. A liner can be provided as demanded by the process in order to provide proper coolant evaporation and efficient desuperheating.

Figure 11:
Series T42 Desuperheater

Figure 12:
Series 1-4442 Desuperheater

KOSO also makes an insertion type probe style desuperheater (Series DPS), which has variable geometry spring loaded nozzles (figure 13). This ensures atomization of less than 250μ for the spray coolant so that the vaporization is efficient and fast in order to achieve the set point temperature at the outlet.

Figure 13 : Variable Geometry
Spring Loaded Nozzles

Joule Thomson (JT) Control Valve

The Natural Gas is cooled and liquefied in the Main Cryogenic Heat Exchanger (MCHE) through heat exchange against evaporating refrigerant flowing countercurrently on the shell side. The Mixed Refrigerant (MR) circulates in a closed-loop refrigeration cycle, which includes expansion in JT valves or equivalent devices. In some cases, the JT valve replaces the Turboexpander, and in some other cases, it works in parallel.

This valve may see high vibration and noise due to the large pressure ratio across the valve. Vector™ trim (figure 14) addresses both of these issues.

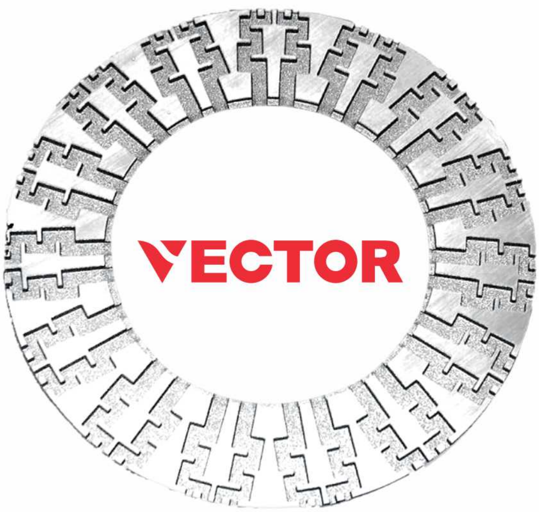
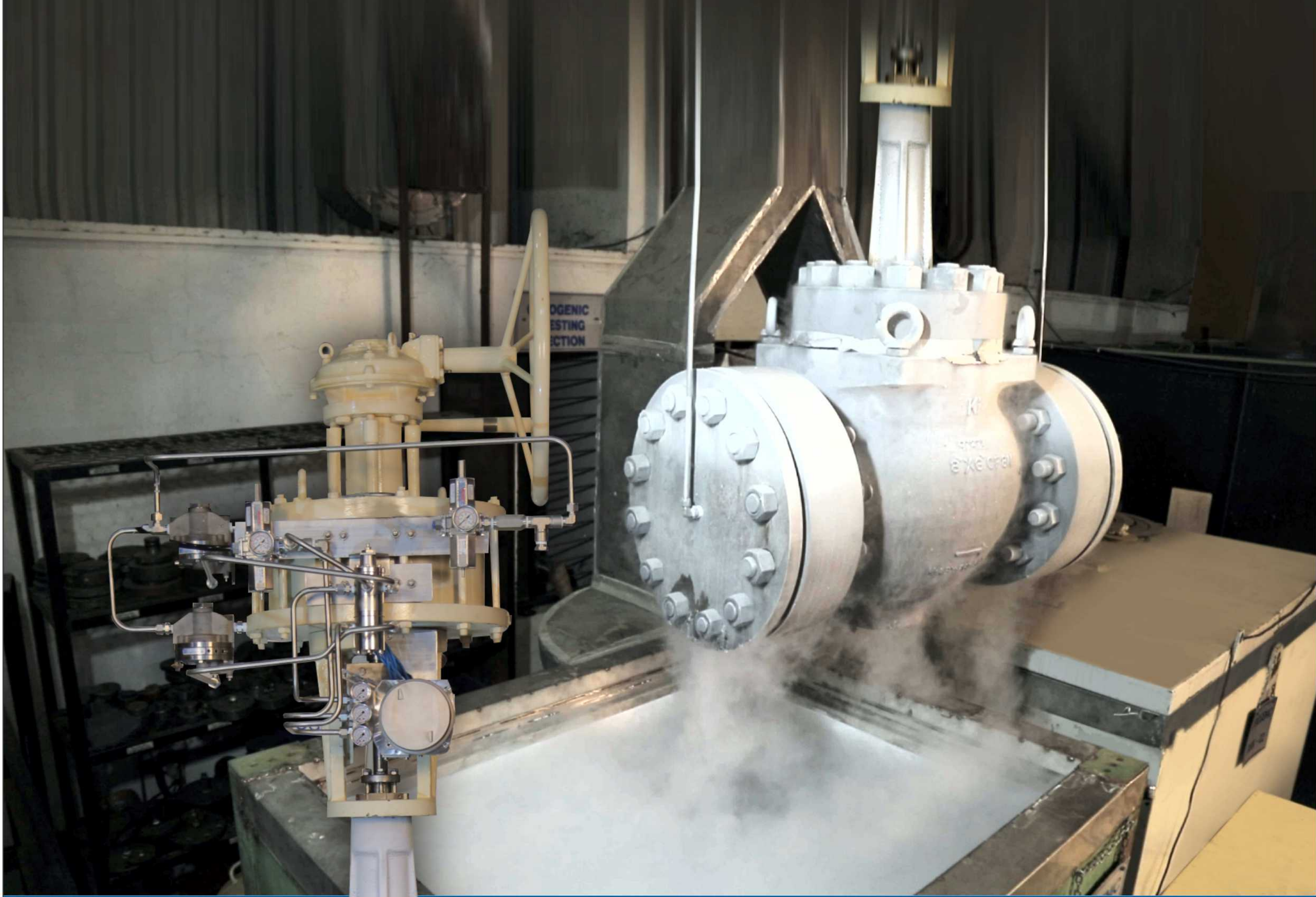


Figure 14: Disk Stack of high friction
velocity control Vector™ trim

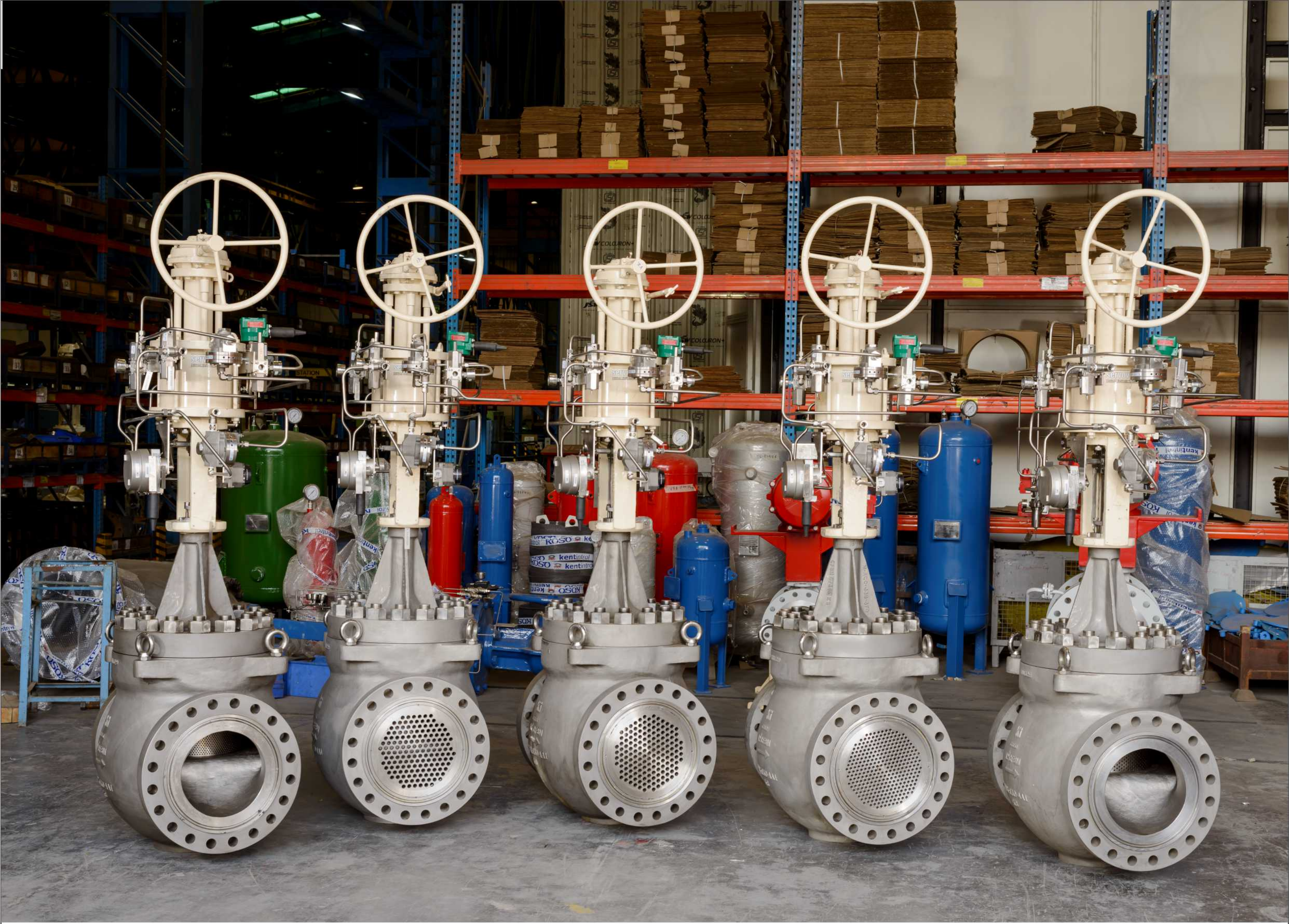
Quality Assurance and Testing

Koso's state of the art manufacturing locations worldwide have unique capability for engineering and testing of valves for LNG applications. Below are typical quality tests the control valves will undergo against the customer specifications.

- **Hydrostatic Shell test as per ASME B16.34, API 6D**
- **Seat Leakage test as per ANSI/FCI 70-2, API 598**
- **Fugitive Emission test as per ISO 15848, SHELL MESC SPE 77/300**
- **Cryogenic test as per BS 6364, SHELL MESC SPE 77/200**
- **Vacuum Pressure Test**



VECTOR



For technical queries

+81-3-5202-4100
www.koso.co.jp/en

+91-253-240-8811
www.koso.co.in

KOSO

Head Office
1-16-7, Nihombashi, Chuo-ku,
Tokyo, 103-0027, Japan

KOSO INDIA PRIVATE LIMITED

Registered Office & Factory 1
H-33 & 34, MIDC, Ambad, Nashik-422010,
India

Factory 2
J-1 & J-2, MIDC, Ambad, Nashik-422010,
India

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