Sour Gas

Hydrogen sulfide is considered corrosive, toxic, and lethal. As such, Ariel has specific recommendations as to the materials and compressor configuration options when compressing gas that contains H_2S. Hydrogen Sulfide (H_2S) can embrittle high strength, high hardness carbon steels, and most martensitic stainless steels (for a full and specific list of material compatibility with H_2S refer to NACE MR-0175, ISO-15156).

Ariel's equipment configuration recommendations for sour gas service are based upon field experience and the NACE guidelines for the protection of the equipment.

It is the End Users responsibility to be aware of the level of H_2S present, and to take all necessary precautions for the protection of personnel from harmful leakages of gas to the atmosphere.

Selection Recommendations / Requirements for Sour Gas Service

Several considerations should be made when selecting compressors in sour gas service. As the gas is both corrosive and toxic, special safety requirements are necessary for the maintenance of the equipment. It may be suitable to provide a more conservative selection to lengthen the time between maintenance. This would include operating at slower piston speeds and allowing for lower discharge temperatures.

The toxic and lethal nature of the gas dictates the use of an appropriate purge and vent system to ensure the gas leakage at the packing case and distance pieces is not vented to the atmosphere. Please refer to the Packager Standards Section 8 Packing and Distance Piece Vent Systems for this topic..

With higher percentages of H_2S in the gas stream, a review of the phase envelope and dew point of the gas constituents (not including water vapor) is recommended. At higher levels of H_2S and higher pressures, the interstage cooling can easily reach the dew point for the H_2S in the gas stream. Most often, condensation of the H_2S is to be avoided.

Sour Gas service, Level 1, can be applied with non-lubricated cylinder construction. NACE SS Valves will be required along with the requirements and recommendations of Sour Level 1 trim below.

Recommendations / Requirements for Sour Gas Service:

	100 ppm to 2% H_2S **Sour Level 1**	**> 2% H_2S** **Sour Level 2**
Distance Piece Arrangement (Requirement)	S2C / L2C / Single with purge wiper	L2C (Recommend)
Piston Rod Material (Requirement)	Stainless Steel	Stainless Steel
Purge Packing (Requirement)	Purged	Purged
Flushing Lube	N/A	Flushing Lube on Stage 1 (Recommend)
Stainless Steel Valves	Standard Valves	Stainless Steel
Forged Steel (-VS) Cylinders (Requirement)	Use lower strength 22Rc cylinder bodies, or stainless bodies even as low as 5-10 ppm of H_2S content	

Optional Equipment:

- Cylinder Bolting Material
- Cylinder Body Material
- Lubrication Tubing and Fitting Materials
- Separate Lube Supply

Distance Pieces Arrangement

A two compartment distance piece, or a long single distance piece with wiper seal purge are required for sour gas service. These configurations offer the ability to create a purge and vent system which segregates the crankcase and operator atmosphere from the packing leakage.

Long two compartment distance piece, "L2C", is recommended above 2% H_2S content as this provides better containment of the gas leakage. S2C distance piece and long single compartment distance piece with purged wiper seal can be used above 2% H_2S content, but do not offer the same level of protection and flexibility for the vent / purge system design.

Two compartment distance pieces are available for all units except for the JGM:N:P:Q and KBE frames.

The long single compartment distance piece with wiper purge is available on the KBE:K:T, KBU:Z and KBB:V frames.

Refer to Packager Standards Section 8 Packing and Distance Piece Vent Systems for notes on a purge system for sour gas.

Piston Rod Material

Ariel standard piston rod material is 4100 series carbon steel heat treated for strength. These are not suitable for sour gas service as defined by NACE MR-0175. For sour gas service with 100 ppm and greater H_2S content stainless steel piston rods are required. Ariel stainless steel piston rod material is 17-4PH in the double H1150 condition, UNS S17400, (per NACE MR-0175), Rc 33 maximum, chromium-nitrided in the packing travel area for a surface hardness of 2500 Vickers. The chromium nitride process has a length limitation due to manufacturing constraints. Longer stainless steel piston rods will be tungsten carbide coated.

Purge Packing

Ariel requires the use of "Purge packing" for sour gas services with 100 ppm and greater H_2S content. The purpose of purge gas is to block and contain hazardous, toxic, flammable or corrosive gases, and to prevent such from entering the compressor frame where damage to the running gear, or personnel safety hazards can occur. The purge gas must be sweet natural gas or an inert gas, such as nitrogen. Purge packing refers to a packing case modified to accept an external purge pressure 15 to 20 psi above the primary packing vent/drain pressure with no more than 5 psi external system back pressure. Refer to Ariel's recommendations in Packager Standards Section 8 Packing and Distance Piece Vent Systems for a purge system for sour gas. See also "Packing Leakage".

When the purged packing option is selected on a long two compartment distance piece, the intermediate and wiper seal sets will be configured for purge along with the pressure packing case. When the purge packing option is selected on a long single compartment for the KBE:K:T, KBU:Z or KBB:V frames, the wiper seal will be configured for purge along with the pressure packing case.

Flushing Lube

Ariel recommends the use of cylinder flushing lube for first stage cylinders for sour gas services with 2% and greater H_2S content. An atomizer for flushing lube injection can be constructed of tubing inserted into the gas stream at the suction pulsation cylinder nozzle with the end opened with a diagonal cut. The Packager would provide the lube lines from the end of the guide to the suction pulsation vessels cylinder nozzle. Flushing lube lines will be tubed to the end of the crosshead guide from the distribution block. Flushing oil is used to ensure corrosion protection for the suction valves, both the valve bodies and springs. Flushing oil is available as an

option on all units. If the first stage flushing recommendation for Sour Level 2 is not taken, provisions for flushing on the pulsation vessel nozzle are recommended.

Some cylinders have two nozzles at the suction (dual nozzle and peanut flange). Flushing lube for these two nozzle cylinders is configured for one flushing lube point per cylinder. This is sufficient, considering the flushing lube connection is in the suction pulsation vessel nozzle. If a client wants to apply flushing to both pulsation vessel nozzles, the packager can install a pipe tee to split the single line provided.

Stainless Steel Valves

Ariel standard valve body material is 400 series stainless steel and 1040 carbon steel. These are not suitable for sour gas applications per NACE-MR0175. Ariel recommends the use of NACE compliant stainless steel valves for sour gas services with 2% and greater H_2S content.Stainless steel valves generally consist of:

- Seats and guards: 17-4PH - H1150
- Plates: Nylon, MT or PEEK. 17-7PH or 15-7PH if metallic plates
- Coil springs: Nimonic 90
- Spring plates: stainless steel (equivalent to 420)

It could be prudent to start up a unit with standard valves and replace those with the stainless steel valves after any start up problems have been solved and piping debris has passed through the unit.

NACE Stainless Steel valves are required for Sour Level 1 service in non-lubricated cylinder construction.

Optional Equipment for Sour Gas Service

Cylinder bolting

Standard cylinder bolting for sweet and sour gas services consists of Grade 8 valve cap, head end head, crank end head and packing case cap screws. Cylinder bolts are outside the gas containment and not considered "wetted".Ariel provides an option to replace these bolts with 17-4PH stainless steel bolts for the valve caps, head end head, crank end head and packing case bolting.The 17-4PH fasteners for the heads and packing case are bolts. The 17-4PH fasteners for the valve caps are studs.

Cylinder Body Materials

Standard cylinder body materials are:

- ASTM A278 Grade 40 gray iron
- ASTM A536 Ductile iron 80-55-06
- ASTM A395 Ductile iron 60-40-18
- AISI 4340 Forged steel
- ASTM A668 Class J forged steel

Forged Steel Cylinder Body Materials

Attention must be paid to forged steel cylinder selections for hydrogen sulfide content. The NACE MR-0175 Stress Cracking Region will be used to determine how much H_2S is allowed for AISI 4340 cylinder bodies.Most Ariel forged steel cylinder bodies are manufactured from AISI 4340 high strength carbon steel.This material is not suitable for H_2S content, even as low as 5 to 10 ppm. When even small amounts of H_2S is present, forged steel cylinders will need to be either softened to 22 RC or manufactured of 17-4PH Stainless steel.This will impact most Ariel double acting forged steel cylinders.

Double acting forged steel cylinders that are not suitable for sour gas service, will be flagged in red in the performance software when H_2S is entered into the gas analysis. Most forged steel tandem cylinder arrangements are suitable for H_2S content due to the controlled hardness of 22 RC maximum.

Lube Tubing

Ariel standard cylinder and frame oil system is 304 / 304L stainless steel tubing with zinc plated carbon steel fittings. An option is available to use 316 / 316L stainless steel tubing and 316 stainless steel fittings. This would encompass the frame and cylinder tubing and fittings on a unit. A separate option is available for upgrading welded frame oil piping from carbon steel to 316L stainless steel, both on the pump suction and downstream of the filter on larger units. Fittings and plugs outside the frame and cylinder oil flow are not included in these stainless steel options.

Separate Lube Supply

Provision is made on all units to use a separate oil source for the cylinder bores and packing cases. Ariel standard is to tube from the main frame oil header to the inlet of the cylinder lubricator pumps. The packager can remove this tube, plug the connection at the main frame oil header and connect the separate supply to the inlet of the lubricator pumps. Sour gas services typically require a special lubricant through this separate lube supply. Refer to Section 6 of the Packager Standards for lubrication recommendations.