Armstrong®

APPLICATION GUIDELINES

TRAPS FOR SOUR GAS SERVICE

What is "sour gas"?

In the oil and gas industry, "sour gas" refers to natural gas that is contaminated with hydrogen sulfide (H_2S or "sulfide"). "Sour crude," similarly, is crude oil that contains hydrogen sulfide. These are naturally occurring conditions, but definitely not desirable. Aside from the environmental pollution problems with "high-sulfur" fuels, there are some serious corrosion problems that can affect many materials.

Liquid drainers (drain traps) and strainers are the most common Armstrong products ordered for sour gas service. A few other products are sometimes specified, notably inverted bucket air traps. An inquiry may be accompanied by an extensive specification of H_2S concentrations; there may be a line indicating "Sour Gas Service;" or may only be the note "NACE." This is a reference to Standard MR0175-93 published by the National Association of Corrosion Engineers (NACE).

What is the problem?

H_2S under pressure permeates into the crystalline structure of the metal and strains the structure of the crystal. This reduces its ability to deform in a ductile manner. The net effect is to make the material **brittle.** In the presence of external stresses due to applied pressure or loads, or internal stresses due to cold working or welding, parts may fail by cracking without any warning. This process is called Sulfide Stress Cracking (SSC).

SSC is affected by many parameters, including:

- Composition, strength, heat treatment, and microstructure of the material;
- Hydrogen ion concentration (pH) of the environment;
- Hydrogen sulfide concentration and total pressure;
- Total tensile stress;
- Time and temperature.

Choice of products and their limitations.

Inverted bucket traps (primarily for air trap service) should be selected from the Series 300 traps. The bucket and mechanism (except valve and seat) will be annealed to eliminate the locked-in stresses from the stamping operations. The valve and seat will be made from Type 316 stainless, without additional heat treatment. Cast iron bucket weights are permitted, since they are not stressed in tension. Special bolting is required only if the sour environment is also outside the trap.

Strainers should be selected from the cast carbon steel series for the fewest problems in application. The screens for all strainers will be annealed to eliminate locked-in stresses in the wire or perforated stock. Unless the sour environment is also outside the strainer, bolted retainers do not require special bolting and the standard operating pressures may be used.

Low alloy steel strainers (Grade WC6) may be used in screwed connections without any special heat treat. Versions with welded-on flanges must be annealed, as this alloy tends to harden very easily during the rapid cooling that occurs after welding.

Socketweld strainers in low alloy steel (Grades WC6 and F22) will not be furnished for sour gas service, as we have no way of ensuring that the required post-weld heat treat will be performed in the field.

Float traps*,* in general, require careful analysis of each application in order to obtain the best possible solution for each case. The critical factor for these traps is that the float must be annealed, which will **reduce its maximum working pressure (MWP) by up to 50%.** This may or may not affect the operating pressure of the trap. In many cases, it is necessary to use alternate floats in order to get a workable design. Also, the mechanism will be annealed, and the valve and seat will be made of Type 316 stainless (or Type 17-4Ph for Series HLS traps). The counterbalance spring in HLS traps will be Inconel X-750 alloy.

Table 2-1 lists the maximum working pressures at 100°F (38°C) of annealed floats for various traps. The allowable working pressure of the trap is the smallest of:

- the float working pressure, derated for high temperature if necessary,
- the mechanism operating pressure, or
- the vessel allowable pressure.

The last two pressures are normally available from Handbook 402 “Draining Compressed Air and Other Gases”. However, if a sour external environment is involved (Class I or II bolting—see section entitled, “Special Considerations for Bolts” on bolting considerations), it would be advisable to check with Armstrong Engineering on vessel ratings. Note especially that elevated temperatures will further reduce the float working pressure.

Table 2-1. Working Pressures at 100°F (38°C) of Annealed Floats

Trap Model	Float MWP, psig (bar)	Float (listed for reference only)
11-LD	225 (15.5)	B3337/A5856 (11-LD float)
11-LD/AV	400 (28)	B3773/A5848 (11-AV float)
12-LD/AV/DG	300 (21) (est.)	A9077
13-LD/AV/DG	550 (38)	B3131/A5378B
32-LD/AV/DG	350 (24)	B3316/A5441
33-LD/AV/DG	550 (38)	B3131/A5378B
36-LD/AV/DG	550 (38)	A10484/A5434E
2313/2413-HLS	1100 (76)	A4089B
2315/2415-HLS	1200 (83)	A5077
2316/2416-HLS	1250 (86)	A8828

The Series 2400 HLS traps in screwed or flanged connections must be annealed after welding on the side connection, as the F22 alloy steel tends to harden very easily during the rapid cooling that occurs after welding. These will not be furnished in socketweld, as we have no way of ensuring that the required post-weld heat treat will be performed in the field.

Traps NOT Suitable for "Sour" Service

Model 71-A snap-action liquid drainer is not suited for sour gas service, because the high-temper spring is inherently susceptible to SSC.

Thermodynamic traps are not suited because of the hardened internal parts.

Thermostatic traps and F&T traps are not suited because the bellows is inherently subject to SSC, being thin, severely cold-worked, and highly stressed.

Special Considerations for Bolts

Since the bolts on various products may have widely varying degrees of exposure to the sour environment, NACE Standard MR0175-93 defines three different classes of bolting based on this exposure. Bolting that is exposed to the sour environment must be either a Class I or Class II material.

- **Class I** bolting is made from any material accepted (by NACE Standard) for use in sour environments, subject to the appropriate heat treat and hardness limits.
- **Class II** bolting is a sub-set of Class I, and includes only bolts per ASTM A193, Grade B7M, and nuts per ASTM A194, grade 2HM. Note that these materials have only 80% of the tensile strength of the "standard" B7 and 2H materials. This may reduce the maximum allowable vessel pressure in some cases.
- **Class III** designates bolting that is not directly exposed to the sour environment, and that is freely open to a non-contaminated atmosphere**.** This can include any appropriate bolting material, including the common ASTM A193, Grade B7.

Please note that these are **not** quality grades, so don't specify Class I to get a "better" material. The standard grades of bolting are stronger, less expensive, and more readily available.

Ordering and Inquiry Data

Sour gas applications add several complicating factors to the selection process. **In addition** to the usual specification of model number, connection size and type, and required capacity, we can better handle inquiries if we know:

- Design pressure and temperature requirements.
- Data on the H_2S concentration if there is any question about the environment.
- Location of the sour environment (internal only or also external).
- For float traps, the actual specific gravity of the fluid to be drained.

Engineering Considerations Relating to Sour Gas Environments and Required Material Modifications

Exposure Limits
Standard MR0175-93 published by the National Association of Corrosion Engineers defines a complex function of H_2S pressures and concentrations which determines whether the sour environment will cause SSC. To greatly simplify matters, if the partial pressure of H_2S does not exceed 0.05 psia (0.34 kPa abs), or the total pressure does not exceed 65 psia (4.5 bar_a), sulfide stress cracking will not be a problem. Partial pressure of the H_2S is determined by multiplying the mole fraction of H_2S in the gas by the total pressure. Mole fraction = mol% / 100.
For example, if a system operating at 1000 psia is contaminated by 0.01 mol% of H_2S, the partial pressure of the H_2S is (0.01/100) x 1000, or 0.10 psia. This would fall within the SSC-susceptible region.
Consult the factory if there is any question whether the environment will cause SSC.

Material Selection and Modification to Prevent SSC
The first step in preventing SSC failures is the choice of an appropriate material, or conversely, avoiding those that are not allowed. The second step is limiting the hardness of the material to a relatively low value (which varies for different classes of materials). For Armstrong products, the significant limitations for materials exposed to the sour environment are as follows:

- Forged or cast carbon and low-alloy steels containing less than 1% nickel are permitted, with a maximum hardness of R_C 22. The heat treatment, in general, must include annealing or normalizing. If welding is involved, the hardness limit applies to all parts of the weld and the heat affected zone.
- Austenitic stainless steels (Types 304, 304L, 316, 316L) in both wrought and cast forms are permitted with a maximum hardness of R_C 22 in the annealed condition and "free of cold work designed to enhance their mechanical properties."
- Type 17-4Ph precipitation hardening stainless is permitted when heat treated to condition H-1150-M (double age-hardened at 1150^{o}F), resulting in a hardness of R_C 33 maximum.

The following materials are not permitted (i.e., they are not on the NACE approved list), or are specifically prohibited:

- Free-machining steels, including Type 303 stainless.
- Cast iron for pressure containing parts.
- Type 440 stainless steel, in any of its variant forms.
- Brass and bronze.
- Electroplating and plastic coatings are not accepted to prevent SSC.

Conclusion

Selecting traps and strainers for operation in sour gas applications does require more than normal care, and sometimes requires a selection of non-standard parts. Observation of the basic principles outlined in this guideline will do much to avoid errors in trap selection. If in doubt, consult Armstrong for design or selection assistance at the earliest opportunity.

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