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Triboelectric Charge Generation

with regard to

Partially and Fully Fluoronated Lined Pipe

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(Written on April 15, 2004 in preparation for a discussion that took place in response to an issue on lined pipe corrosion)

Abstract

There is a heightened degree of concern with both currently operating facilities and future facility design with regard to Internal and External Triboelectric Charge Generation and Accumulation (static electricity) as it relates to Lined Pipe. This paper will address those concerns, on a non-specific basis, while attempting to suggest some possible corrective actions/solutions to both installed systems as well as possible inclusions to a Company's pipe specifications for future installations.

Clarification

Internal and external charge accumulation, known as static electricity, or more technically known, as triboelectric charge accumulation, is the result of charge generation unable to dissipate. If the charge generation is allowed to dissipate to ground then there is no problem. However, if the charge generation cannot dissipate and is allowed to accumulate, it now becomes a potential problem by creating an Electrostatic Discharge (ESD). With regard to thermoplastic lined pipe there are two issues to be considered: External Charge Accumulation (ECA) and Internal Charge Accumulation (ICA).

External Charge Accumulation

ECA is a concern with lined pipe due to the potential loss in spool-to-spool continuity. The concern is not due to the liner, but is instead due to other factors related to lined pipe. This potential loss of integral continuity is the result of the prime paint coat that is applied by the manufacture. When pipe spools, lined or un-lined, are joined by flanges using non-metallic gaskets the only thing that completes the Spool-to-spool continuity is the bolting.

Pipe generally does not come with a prime coat of paint, however lined pipe does. Since flange bolts are used to complete continuity from spool to spool the installer has to make certain, when installing lined pipe, that the bolts, at least one of the four or more bolts, has penetrated the primer and made contact with bare metal. This was achieved in the past by using star washers on at least one flange bolt while assuming possible bare metal contact with the other bolts allowing the washers, as they were tightened, to scrape away the prime coat so that contact was made with the bare metal of the flange. With improved prime coat material this is no longer an assurance.

If continuity from spool to spool is not achieved any charge generation resulting from an internal or an external source cannot readily dissipate to ground. The voltage in triboelectric charge generation will build until it is strong enough to jump to the closest grounded object creating an undesired spark of electricity in doing this (Electrostatic Discharge).

Internal Charge Accumulation

ICA, with regard to pipe, is unique to thermoplastic lined pipe and solid thermoplastic pipe. Without being impregnated with a conductive material, thermoplastics are not good conductors of electricity. PTFE (Polytetrafluoroethylene), as an example, used as a pipe liner, has a high ($>10^{16}$ Ohms/Square), resistivity factor. This is a relatively high resistance to conductivity. Which means that any charge created internally to the pipe cannot readily be conducted away to ground by way of the PTFE liner. Instead the charge will be allowed to build until it exceeds its total dielectric strength and burns a pinhole in the liner to the internal metal wall of the casement pipe. It isn't charge generation itself that is the problem, it's the charge accumulation. When the rate of charge generation is greater than the rate of charge relaxation (the ability of material to conduct away the generated charge), charge accumulation occurs.

The dielectric strength of PTFE is 450 to 500 volts/mil. This means that for every 0.001" of PTFE liner 450 volts of triboelectric charge will be required to penetrate the liner. For a 2" pipeline with a 0.130" thick liner this translates into 58500 volts of triboelectric charge to burn through the liner thickness.

When this occurs two additional problems (time bombs) are created: 1. Corrosive fluid is now corroding the metal pipe wall, which at some point, depending on rate of corrosion, will fail locally causing fluid to leak to the environment, and 2. The initial charge that burned through the liner is now charging the outer metal pipe, which, if continuity has not been achieved for the outer pipe will simply continue to build until, at some point, it will have accumulated enough energy to jump to the closest grounding point causing a spark.

Corrective Action

External Charge Generation

Aside from no paint or a conductive prime paint, the current ready-made solution to the external continuity problem is the addition of stud bolts located in close proximity to flanges on both pipe spools and fittings (see Fig. 1 below). These studs can be applied at the factory or in the field. At each flange joint a grounding strap (jumper) is then attached and affixed with a nut to the stud on one spool, extended over the flange joint and attached to a stud on the connecting spool completing continuity throughout the chain of connecting spools and fittings.

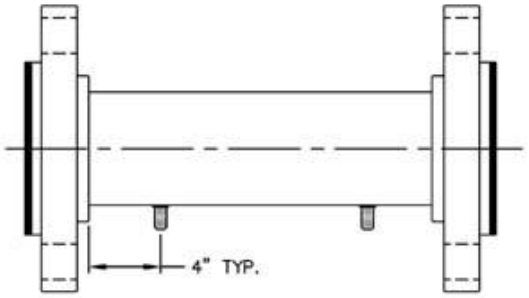

Figure 1 – Grounding Lug Location

Another method of creating continuity at flange joints, as suggested by this paper, while being less obtrusive and more integral is described as follows and represented in Fig. 2:

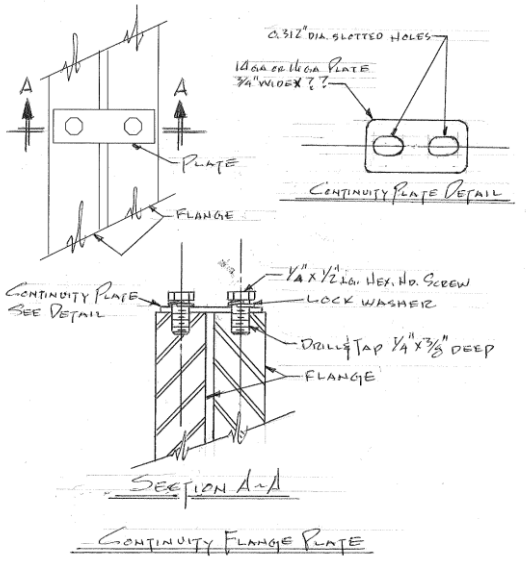

Figure 2 – Continuity Flange Plate

Referring to Fig. 2 flanges would be purchased pre-drilled and tapped in the center of the outer edge of the flange between the backside of the flange and the face side of the flange. The drilled and tapped hole in each flange will need to be centered between boltholes so that they line up after the flange bolts are installed. The tapped hole is 1/4" dia. x 3/8" deep.

After a flange set is installed and fully bolted the Continuity Plate (Fig. 2) can be installed using two 1/4" x1/2" long hex head screws and two lock washers. The Continuity Plate has two 0.312" slotted boltholes allowing for misalignment and movement.

The entire continuity plate assembly is relatively simple to install, unobtrusive and establishes integral contact throughout the pipeline.

Internal Charge Generation

One of the first options in preventing Internal Charge Accumulation is by minimizing charge generation. This can be done by adjusting the flow velocity relative to the liquid's conductivity. To minimize design impact, cost and even schedule impact on a project this needs to be evaluated early in the project due to the possibility of line size increase.

To retard charge generation by reducing flow velocities British Standard (BS) suggests the following in Table 1 per BS 5958:

TABLE 1 - RECOMMENDED VELOCITIES

Liquid Conductivity	BS 5958 Recommended Flow Velocity
Greater than 1000 pS/m	No restriction
50 – 1000 pS/m	Less than 7 m/s
Less than 50 pS/m	Less than 1 m/s

pS/m (picosiemens/meter)

The entire continuity plate assembly is relatively simple to install, unobtrusive and establishes integral contact with the pipeline.

If velocity reduction is not an option, or further safeguards against charge accumulation are warranted then a mechanical solution to provide a path to ground for Internal Charge Generation may be called for.

One method for conducting charge accumulation from the interior of the pipe to ground is indicated in Figures 3 & 4. What is shown is an orifice plate made of conductive (static dissipative) material that is compatible with the fluid service. The orifice itself is off center to the OD of the plate. With the ID of the orifice plate tangent to the invert of the pipe it allows the piping to drain in horizontal runs.

The tab portion of the plate extends beyond the flange OD. On the tab is a bolt hole for attaching the modified Continuity Flange Plate. The plate is designed to come in contact with the interior surface of the liner wall as well as protrude into the flowing fluid providing a conduit for internally generated charge. Continuity is achieved by attaching the plate to the flange OD that is in contact with the piping, which is, in turn, grounded through equipment.

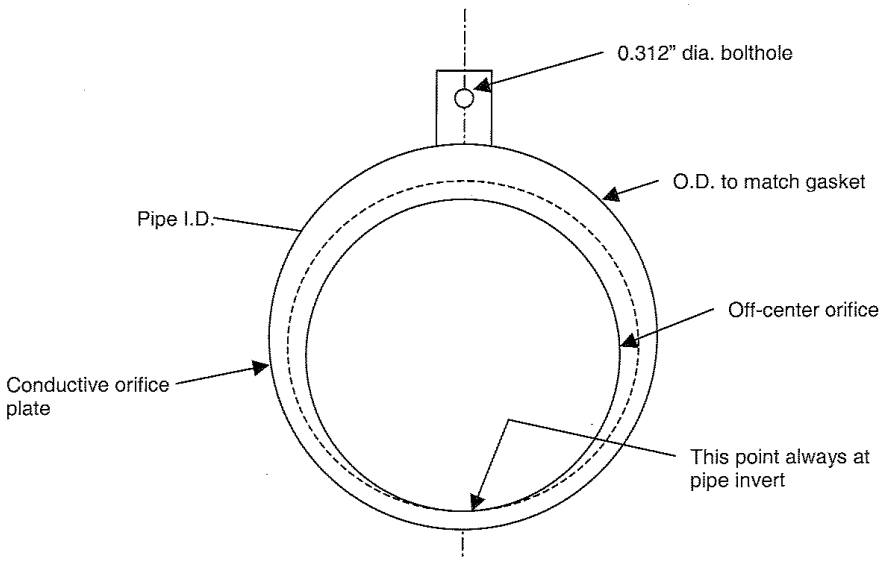

Figure 3 – Conductive Orifice Plate

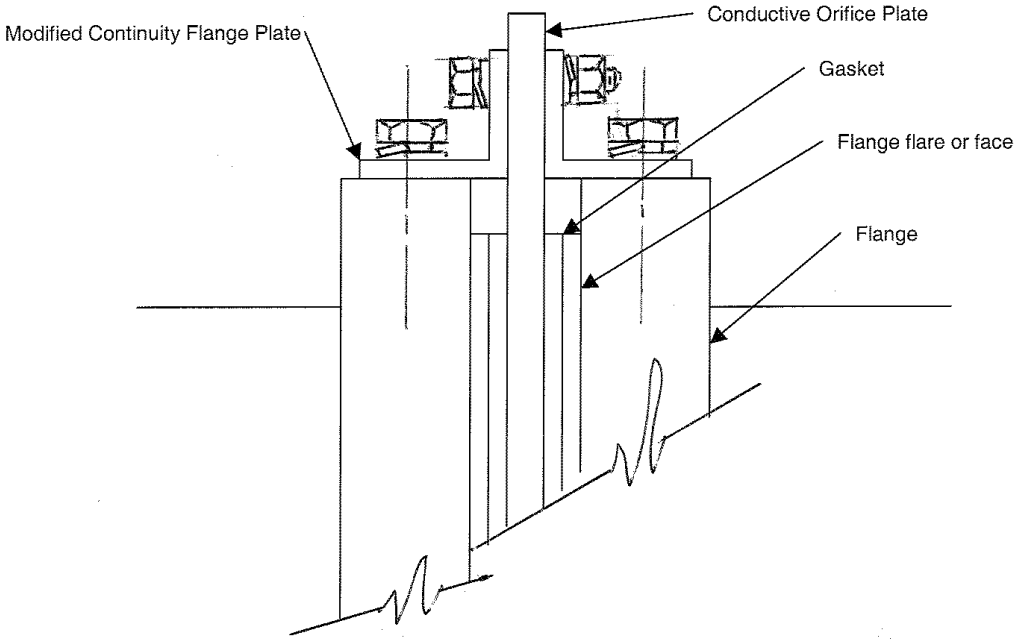

Figure 4 – Conductive Orifice Plate Assembly

Conclusion and Recommendations

It is difficult to pre-determine, in a lab environment, what fluid services and systems will be candidates for charge accumulation prevention and Electrostatic Discharge protection. The simplest and most conservative

answer to that is to assume that all services and systems are susceptible. In saying that, we then have to declare that the pipe specifications need to reflect a global resolution that will affect all installations.

With regard to External Charge Accumulation, the recommendation for future installations with the least impact would be to specify pipe with no prime coat, or a prime coat using a conductive paint, available from some of the manufacturers. The un-primed pipe would be painted the same as the unlined carbon steel pipe… after installation. This would provide spool-to-spool external continuity, the same as unlined pipe.

For existing installations either the studs or the continuity plate installation would work. It can also be suggested that the continuity plates can be tacked on rather than drilling and tapping each flange. This will require grinding out the weld on at least one flange for removal. If that poses no problem then it is a simpler method.

For dissipating internal charge generation the orifice plate, as shown in Figures 3 & 4, is the only recommendation.

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