Earthing lug design for the Alfa Laval Gasketed Plate Heat Exchangers

In applications involving the flow of low conductivity liquids, great care must be taken to avoid static electricity build-up and discharges. As the Gasketed Plate Heat Exchanger (GPHE) line-up offered by Alfa Laval is used in these scenarios, the heat exchanger has to be grounded using an earthing lug. But to be able to make a motivated choice of design to use for the earthing lug, it is necessary to understand how these charges accumulate and why.

Alfa Laval and the GPHE
One of Alfa Laval's primary areas of business is the development and manufacturing of heat exchangers for companies operating in a wide variety of industries. The point of a heat exchanger is to transfer heat energy between two liquids without allowing the two to mix. In the GPHE which is studied in this project, the two fluids are separated by several plates, forming a sandwich structure with the two liquids in alternating layers. It is also through these plates that the heat energy is transferred.

As these heat exchangers are used in industry sectors where liquids with a very low electrical conductivity is used, the need for an earthing lug is necessary to provide a dissipation path in the eventuality that electrical charges accumulate through a process commonly refereed as static electricity build - up. An earthing lug is essentially a component attached to the object of interest which allows one to easily connect a grounding cable.

Figure 1: Render of the M6 GPHE.

Static electricity
Static electricity is the result of an imbalance within the atoms that make up all matter. An atom consists of an equal amount positive protons and negative electrons. If electrons are removed or added to the atom, the normally neutrally charged atom becomes either positively or negatively charged. As more atoms become unbalanced, the material as a whole becomes "charged". This imbalance can be created through three mechanisms: Induction charging, Corona charging and Contact charging. A special case of contact charging is the Flow electrification phenomenon which involves a liquid and a solid.

Flow electrification
Flow electrification is basically a physiochemical reaction where ions in the liquid reacts with ions or molecules in the solid to create an Electrical Double Layer (EDL). The EDL is formed in the interface between the two materials and

is polarised, leaving the solid and liquid oppositely charged i this area. While the charge accumulation in the solid can be eliminated through an earthing lug (Grounding), the liquid upon leaving the area of contact will still retain its charge and will not be influenced by the earthing lug.

Three factors found to increase the charge accumulation is the liquid temperature, flow velocity and conductivity. Increasing the temperature and velocity increases the charge accumulation in both phases while increasing the conductivity increases to a point, then decreases it drastically.

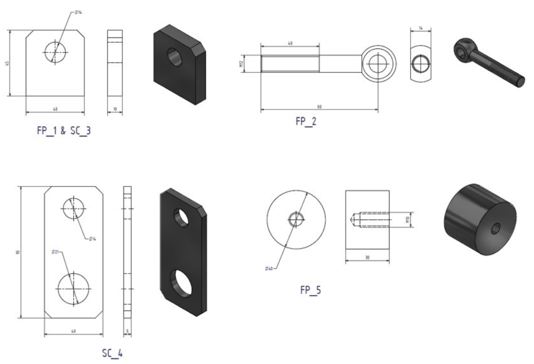

Figure 2: Earthing lug designs

Earthing lug evaluation
When evaluating thee five available designs, see Fig.2 (one of the four is used in two ways), five criterion's were used: Durability, Mounting, Replaceability, Cost and Test results. While evaluating a design based on the first four criterion's is subjective or based on information provided by Alfa Laval, the fifth criterion, test results, was based on the results obtained when measuring the resistance from the heat plates of the GPHE + the design + a ground cable used.

To accurately measure the resistance, four wire measuring was used, a method that is suited for measuring low resistances. Based on each designs performance against each criterion, an accumulated score was calculated using a selection matrix to determine the best alternative in an objective and systematic way.

Conclusion
After evaluating the five designs, it was determined that the optimal design is a carbon steel plate attached to the GPHE through a bolt which is already a part of the GPHE, see Fig3. This design is easy to attach and easy to remove/replace if the need arises. In addition to determining the best design, another important discovery was made.

The blue epoxy paint covering the two thick plates in Fig.1 proved to act as an insulator for three of the designs tested, isolating them from the heat plates. Since they are isolated, they are essentially useless to solve the problem at hand, something which was reflected in the test results. To leave no stones un-turned, paint was scraped in two areas, eliminating the isolating effect of the paint. While this made the three designs usable, other factors still weighed them down, making them unfavourable.

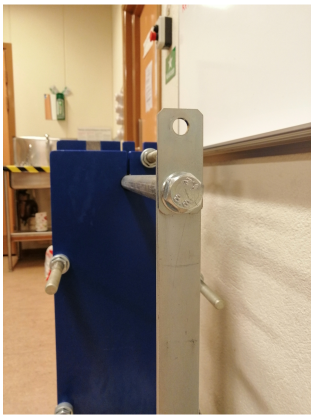

Figure 3: Chosen design based on evaluation process.

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