AIChE Meeting

Rubber lining for phosphoric acid plants

Rubber material made by HAW
Applications for phosphoric acid plants
Experiences, References

Clearwater, FL

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Introduction

Rubber lining is used for the protection of carbon steel equipment in the world’s chemical industry. Even though a lot of experience has been made with this corrosion protection, the quality and lifetime of commercialized products vary dramatically, which is unknown for other technical products. The aim is to show the difference of the fully adapted HAW rubber material and other products known as ‘rubber lining’.

The experience of the users of rubber linings is sometimes dominated by damages and all kinds of failures and the most feasible way of handling them. This leads to an unjustified opinion of the quality and maintenance cost of rubber lined equipment. Let me introduce to you the rubber lining systems developed by HAW over the last decades that provides a reliable corrosion protection.

The life expectancy for rubber lining systems of HAW for phosphoric acid installations is a minimum of at least 10 - 15 years, for some installations even longer. Our rubber sheets used have a standard thickness of 5/32 inch.

Maroc Phosphore I in Safi (Nissan - process), Morocco was installed between 1974 to 1976. The rubber lining surface executed by HAW was 700,000 ft² and is running since then still with the first lining. Please find more details at the attached reference list.

The reason for the durability of HAW rubber lining systems is, that we have investigated the whole product as a high tech corrosion protection system and not just as black rubber. There are two major elements of a rubber lining system, that either work perfectly together or they don’t work at all:

- The rubber material
- The bonding of the rubber to the steel surface.

Rubber material made by HAW

The quality and lifetime of the HAW rubber lining has been achieved by a profound study of the rubber behavior during production in our shop, during application on site and - of course - during operation. What are the reasons for this success in phosphoric acid installations in the world?

Rubber is a organic material based on macroscopic polymeric molecules that form a three dimensional network by an interlacing process known as vulcanization. The two categories of rubber are:

- Hard rubber (ebonite)
  
  hard material with a high elastic modulus (high cross linking of the polymer) and very good diffusion resistance.

- Soft rubber
  
  soft material, that can be reversibly deformed up to some 100% of it’s length without being destroyed. Outstanding corrosion resistance.
The raw material for rubber production are long polymers chains, that are unvulcanized and have a chemically weak double carbon - bond, e.g. butyl rubber

\[
\left(\text{CH}_2 - \text{C} - \text{CH}_2 - \text{C} - x \text{CH}_2 - \text{C} = \text{CH} - \text{CH}_2\right)_n
\]

The production know-how of HAW is to treat the raw material in a way, that (mainly) two things happen:

- The double bond is saturated with sulfur to attain chemical resistance
- The polymeric chains vulcanize among themselves.

\[
\left(\text{CH}_2 - \text{C} - \text{CH}_2 - \text{C} - x \text{CH}_2 - \text{C} - \text{S} - \text{C} - \text{CH}_2 - \text{CH}_2\right)_n
\]

If this is done properly during production, the result is a three dimensional interlaced (vulcanized) rubber material which results in a chemically resistant material suitable for a long lasting corrosion protection.

This process is influenced by many parameters such as:

- temperature during mixing process
- composition of the raw material
- concentration and nature of additives
The two main reasons for failures in producing a high quality rubber are:

- the very narrow permissible tolerances of the process parameters due to various cross-interference’s
- the underestimation of this circumstance.

It has been a long journey of research and development from the beginning of HAW rubber production in the early years of our century towards the deep understanding of the behavior of rubber mixtures we have nowadays. The result are production procedures that allow HAW to produce a high quality rubber material with excellent chemical and mechanical properties at a constant quality level.

**Bonding the rubber material to steel**

Next to the production technology of the rubber material itself, the application of the rubber on the steel is the decisive step. We have developed a bonding system that has the same chemical principles as the rubber itself:

> The HAW bonding system bonds the rubber CHEMICALLY to the steel.  
> It is not just a glue that works by adhesive force.

This technology results in a bonding force that is by far superior to classical glue systems. But the most remarkable feature is not even the high bonding force, but the fact that

- the HAW system is neither attacked by temperature nor by liquid absorption.

**Applications for phosphoric acid plants**

HAW linings have many years of experience in rubber lining of equipment for phosphoric acid plants. The equipment lined includes ore attack tanks, vacuum evaporators, crystallizers, digesters, storage tanks, piping systems and valves.

The materials used are:
**Hard rubber VULCOFERRAN 2194**

Graphite filled hard rubber used for evaporators due to

- better diffusion resistance than soft rubber
- temperature resistance up to more than 220°F

The vulcanization temperature of hard rubber is about 210°F. If this is not feasible a self vulcanizing soft rubber is used for these applications.

**Soft rubber VULCOFERRAN 2206**

Soft bromobutyl rubber used for storage tanks, digesters and crystallizers. This kind of rubber is vulcanized at about 120°F. The diffusion resistance of the unvulcanized rubber is comparable to the finished product. The energy for the vulcanization can therefor be supplied by the phosphoric acid.

**Use of defoamers**

In general, defoamers can attack the rubber material chemically. For our HAW material we recommend

- **ANTISPUMIN NPK** by Stockhausen, Germany

This product can be used without any restrictions. Please contact HAW before using other defoamers. Many defoamers are tested within HAW and the test results are available on request.

**CONCLUSION**

There are many companies that have not invested in R&D and consequently do not have the necessary knowledge or experience needed to produce a high tech product for a long lasting corrosion protection in hazardous conditions in the chemical process industry.

Certainly, it is not necessary for every ft² to be rubber lined to have rubber lining system that represents the technologically leading corrosion protection attainable on the market. Therefore every degree of quality is justified. But when evaluating the best technical and economical solution for the corrosion protection of key components for a large installations such as a phosphoric acid plant, reliability is a must.

For these key components the rubber lining system manufactured and applied by HAW with lifetimes between 10 to 20 years is the right choice.
Reference list of rubber lined equipment for phosphoric acid plants

- Maroc Phosphore I Safi, Morocco, 1974 - 1976
  Total rubber lining surface 700,000ft²

- Techmashimport, Moscow, Soviet Union, 1979 - 1981
  Total rubber lining surface 170,000ft²
  14 storage tanks in 7 different locations in the Soviet Union

- Maroc Phosphore II Safi, Morocco, 1979 - 1981
  Total rubber lining surface 300,000ft²

- Alkaim Fertilizer, Alkaim, Iraq 1980 - 1983
  Total rubber lining surface 1,100,000ft²

- Jordan Phosphate Aqaba, Jordan 1980 - 1982
  Total rubber lining surface 450,000ft²

- Philphos, Isabel / Leyte, Philippines 1983 - 1984
  Total rubber lining surface 320,000ft²

- Jordan Phosphate Mines Co. Aqaba, Jordan
  Total rubber lining surface 180,000ft²
  Rehabilitation of the acid plant and related facilities

- BAG FAS Bandırma Gubre Fab. A.S. Turkey
  Total rubber lining surface 12,000ft²
  Rehabilitation of the acid plant and related facilities

- BAG FAS Bandırma Gubre Fab. A.S. Turkey
  Total rubber lining surface 15,000ft²
  Phase II Extension of concentration unit and installation of gas scrubbing unit

- Windwill, Netherlands
  Total rubber lining surface 50,000ft²

- Police, Poland
  Total rubber lining surface 30,000ft²

- CFB Budenheim, Germany
  Total rubber lining surface 50,000ft²

- Fosfory Gdańsk, Poland
  Total rubber lining surface 15,000ft²

- Haifa Chemicals, Israel
  Total rubber lining surface 10,000ft²