General Electric
Cathode Ray Tube Dept.
Syracuse, N.Y.

DIFFUSION OF HYDROGEN THROUGH STEEL[1]

A steel vessel, well degassed, evacuated and tightly sealed, can become filled with gaseous hydrogen by any of the following methods:

1. By having gaseous hydrogen on the outside. This penetration from a hydrogen atmosphere can occur at room temperature. It is speeded up by (a) high temperature, (b) thin wall steel, (c) high hydrogen pressure and (d) active steel surface.

2. By corrosion of the steel in water. Whenever corrosion of steel occurs in water, hydrogen is liberated according to the reaction $Fe + H_2O = FeO + H_2$. A portion of the liberated hydrogen dissolves in the steel and may diffuse through it.

3. By acid pickling the steel. The pickling operation results in the formation of much hydrogen at the steel surface and the hydrogen is in a very active form.. By the rate with which this hydrogen penetrates the steel it appears the same as though the hydrogen were at a high pressure around the outside of the vessel. Acid pickling sends hydrogen through steel much faster than either of the first two methods.

4. By electrolysis. This fourth method of forcing hydrogen through steel can also be very rapid. It can occur whenever the vessel is in an electrically conducting solution and becomes negative with respect to some other electrode in the solution. The result is active hydrogen released at the steel surface, which penetrates almost as rapidly as in the case of acid pickling.

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[1] Summarized from the work of Dr. F.J. Norton, Research Lab. by J.L. Zehner.

METHODS OF PREVENTING THE PENETRATION OF HYDROGEN INTO VACUUM TUBES

Vacuum tubes having envelopes of glass, copper, stainless steel or the normal combinations of these are practically immune from hydrogen penetration.

Vacuum tubes having envelopes of carbon steel may be safely operated in ordinary living-space atmospheres if they are protected from rusting by almost any one of the common finishes. However, finishes containing sodium silicate or other hygroscopic material must be avoided.

If it is desired to operate carbon steel tubes in water, hydrogen penetration can be prevented by adding sufficient anhydrous sodium chromate to make a 0.5% solution (by weight) if ordinary tap water is used or a 0.1% solution if pure water is used. This results in the formation of a protective chromate film over the surface of the steel, which prevents corrosion. This, of course, requires a closed system for the water cooling so the proper chromate concentration can be maintained.

JL Zehner
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