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CORROSION IN GEOTHERMAL WELLS AND INSTALLATIONS

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ABSTRACT

The selection of materials for the construction of geothermal wells and steam/brine installations is one of the factors of importance in the original design of geothermal power plants for the expected long service life of 30-60 years. There are localized problems of corrosion found in most geothermal installations, but the overall picture is a bright one. Thus, for example, the most common material selected for pipes and vessels in contact with the geothermal fluids is simply mild steel. The pipes form a protective coating of iron sulphide and perhaps a thin crust of scaling and are thus protected on the inside. The most common instances of casing corrosion are found in the few wells that have low pH fluids (<pH 4.5) originating from the reservoir, especially when coupled with erosion from the fast moving fluids. This is for example the case where superheated steam from a vapour zone producing HCl is corrosive. This has been overcome by caustic injection through a capillary tube deep into the well and by selecting corrosion resistant casing near surface and stainless steel cladding inside the wellhead. The steel may over time become brittle due to H_2S og H_2 cracking but a way to avoid that is to select “soft” or mild-steel grades. The well casings are produced under the American Petroleum Institute standard API Spec 5CT or ISO 11960 e.g. of API grade K-55 or L-80 and for seamless and welded pipes in surface installations under European Standards EN 10216-2 and EN 10028-2. The corrosive environment may only be present during shut-down or stand-by when the wells cool down or when oxygen is allowed to enter equipment without drying out all water. Outside corrosion (rust) from a moist environment where oxygen has access is, however, a problem if the metal is not protected by sheeting or is not hot enough to stay dry. The best way to avoid many of the corrosion problems is to keep the wells and pipelines hot and dry at all times. The wells should thus have a “bleed” of steam when shut-in for long periods and for pipelines to be kept hot. A drain in the floor of the well cellar and a roof is required to keep the casing dry on the outside. All steam and 2 phase pipelines are made off mild steel right up to the turbine. They are not corroded by the hot condensate that is always present at the bottom of the steam pipes. The cold (<~120°C) steam condensate in and after the turbine condenser or heat exchangers, however, is corrosive due to the low pH of the acidic gases absorbed by the water. This requires the selection of stainless steel and also for the gas extraction system and pipes transporting the non-condensable gases. Stainless steel requires special attention due to the problems of stress corrosion cracking (SSC) when the following three criteria are met: a) temperature above 55°C, b) presence of moisture with salt (chloride, Cl^-), c) presence of oxygen (O_2). If any one (1) of these (a-c) is not met, the stainless steel may resist. Stainless steel expansion bellows on pipelines and other equipment thus needs proper insulation to stay dry,

or they will be susceptible to cracking. Sometimes fibreglass pipes or other corrosion resistant materials such as plastics are selected instead of stainless but that depends on the temperature. The pipes with corrosive fluids tend to be not very long as when the condensate is mixed again with the brine the pH is elevated high enough again to be transported by a long steel pipeline back to the reinjection well. Most valve bodies are made from steel and purchased with a "stainless steel trim", usually SS 316, that is to say the spindle and valve seats are from stainless steel (sometimes with Stellite hardfacing on the sealing surfaces). In high salt environments a duplex steel valve spindle may work better.