

Corrosion And Corrosion Protection of Water Wells

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ABSTRACT

During routine maintenance inspection of some of the water wells owned/operated by San Francisco Public Utilities Commission, severe corrosion was observed on the pump columns and on the stainless-steel pump shafts. Due to a phenomenon known as ennoblement of stainless steel the potential of stainless steel in water can become positive, in the range of +300 mV (CSE) which can result in serious galvanic corrosion of the pump column. Casing-to-water potential profiles of the wells were conducted. Our results showed that this ennoblement was occurring in eight out of 13 of the well locations. Ennoblement can cause galvanic corrosion of the pump column if it is electrically connected to the stainless steel casing. Cathodic protection of the pump column and the well casing was considered a feasible option to mitigate galvanic corrosion as well as MIC. Cathodic protection (CP) has subsequently been installed on some of the wells. The corrosion analysis, design considerations and results of the CP survey are included in this paper.

INTRODUCTION

The subject wells are part of a project by San Francisco Public Utilities Commission (SFPUC) to develop a groundwater supply in the South Westside Basin of San Francisco for use during drought conditions for Daly City, San Bruno, and the South San Francisco District. The project includes construction of 13 groundwater wells with a total capacity of 7.2 million gallons per day (mgd). During routine maintenance inspection of two of the wells in Daly City, severe corrosion was observed on the pump columns and on the stainless steel pump shaft. A study was subsequently conducted to determine the cause(s) of the corrosion found on the pump columns

and on one stainless steel casing and based on these findings to determine appropriate remedial action to mitigate this on-going corrosion problem. Investigations were conducted to determine how pervasive these corrosion problems are on other wells owned and operated by SFPUC as a part of this drought year groundwater supply project. Casing-to-water electrical potential profiles of the wells were conducted to determine if the stainless-steel casings are being ennobled which could be contributory to the corrosion problem. Tests were also conducted to determine the degree of electrical continuity between the casings and pump columns to establish if galvanic corrosion is contributing to the accelerated corrosion occurring to the pump column and casing. Better understanding these complex issues provided information necessary to the development of a road map to remediating these corrosion problems



Figure 1: General Project Location Plan

STRUCTURE DESCRIPTION

A typical well is constructed as shown below in Figure 2. The stainless-steel (Alloy 304) well casing has a typical ID of 12-16 inches (304.8-406.4mm). The wall thickness is typically 0.375-inches (9.53mm). The carbon steel pump column typically has a nominal diameter of 6-inches (152.4mm) and a wall thickness of 0.280 inches (7.11mm). The pump column has an external and internal fusion bonded epoxy (FBE) coating. The total well depth is typically around 600 feet (182.88 meter) in total depth. The water chloride level is typically around 95 mg/Liter and the water pH around 7.93. The water resistivity is commonly 1184 ohm-cm indicating corrosive water. Wells with submersible motors have a 3-conductor submersible cable that runs outside the pump column from top of the well to the pump motor at the bottom; whereas the wells with above-grade motors have a pump shaft which is made from 416 stainless steel with a rod diameter of 1.69" (42.9mm). This information, while specific to a particular well, is fairly representative of all wells in the project.

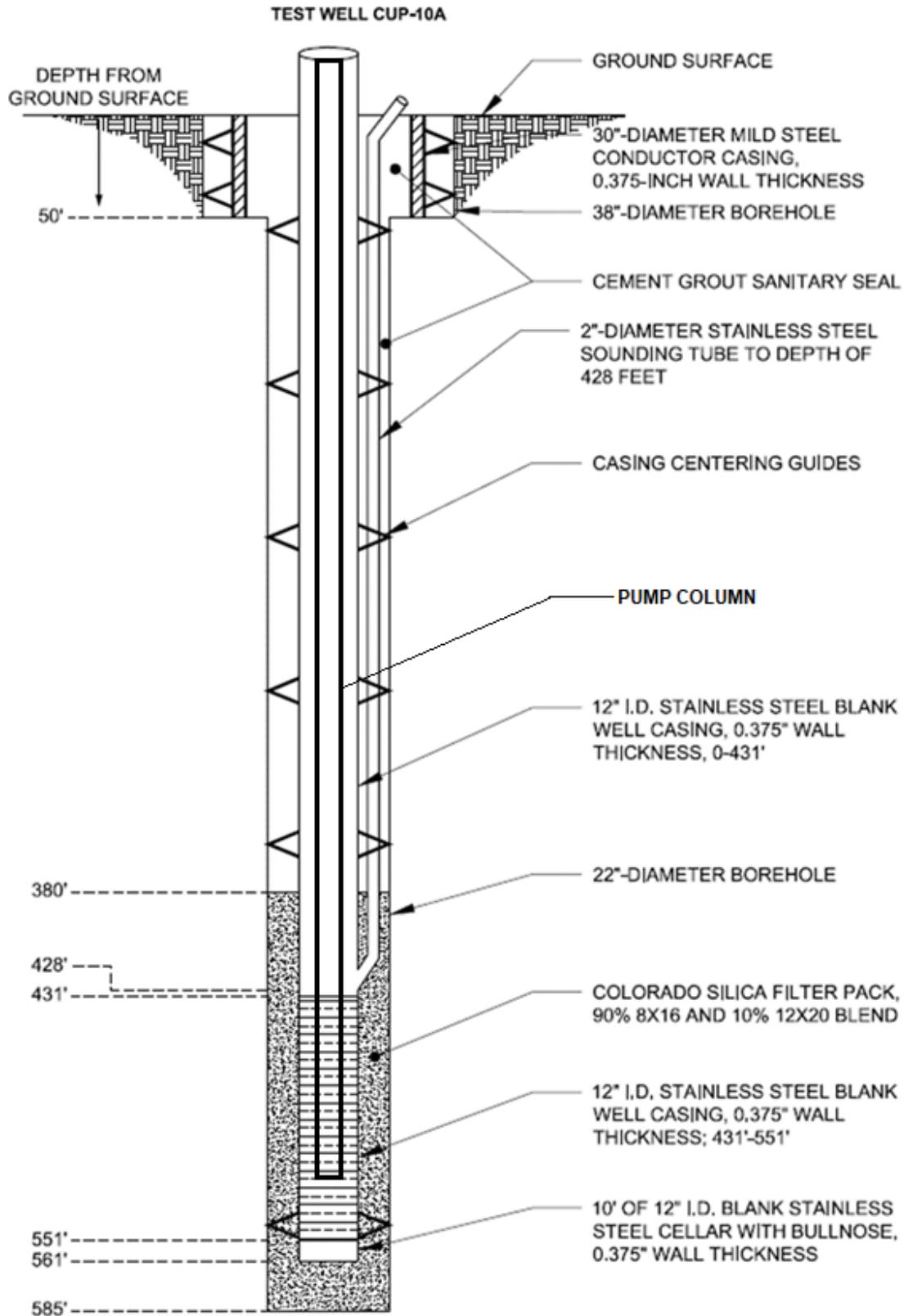


Figure 2: Typical Well Construction

EXPERIMENTAL PROCEDURE

Visual Inspection

Visual inspections of the pump column and the pump shaft were conducted at two of the well locations.

Severe external localized corrosion was observed on the pump column with several through-wall penetrations at the threaded areas of the pipe. The corrosion was located where there was coating damaged (i.e. holidays), most probably a result of tool damage as well as at the threaded section of the pipe. Attempts were made to repair coating damage during pump installation but apparently the coating repairs were not very successful. Moderate corrosion was also observed on the pipe internal diameter (ID) of the pump column. This appears to be due to coating failure and exposure to corrosive waters. However, the corrosion may have been exacerbated by the galvanic effect between the stainless steel shaft which runs inside the pump column in wells with above grade motors, and the coated carbon steel pump column ID. Galvanic corrosion cells will always find the weak spots in the coating to initiate and accelerate corrosion damage. These weak areas could result from coating holidays that originate at the factory where the coating is applied to coating damage that occurs during transit and installation.

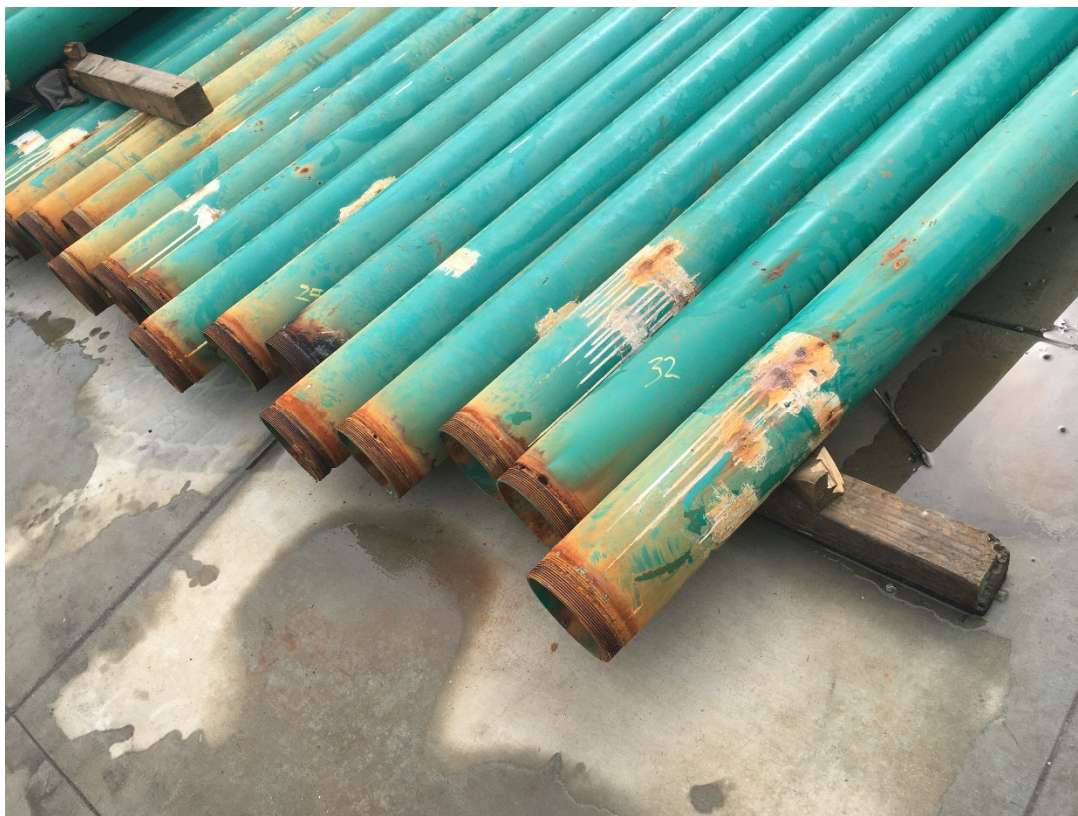


Figure 3 – Corrosion on Pipe Outer Diameter (OD) at Threaded Areas and at Coating Defects Due to Possible Tool Damage