

Corrosion Issues in Sweet and Sour Oil & Gas Wells

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ABSTRACT

Material selection of oil and gas wells must be reliable, cost-effective, and meet corrosion resistance criteria during a well-operating lifecycle. During a well lifecycle, significant changes can occur in the fluids produced or the way wells are operated. Some anticipated and unanticipated changes can occur during design life, and material selection shall be adequate for primary and secondary exposures from design to final abandonment. Various well components such as Christmas tree, wellhead, production tubing, tubing hanger, downhole jewelry, elastomers, and surface casing are exposed to excursions during production/interventions. Any level of corrosion of these critical components is not acceptable, and the compromise of the integrity of these components could result in functional failure and incur production deferment and HSE consequences. Materials of these components are continuously exposed to corrosion risks due to reservoir souring, sand production, water breakthrough, acid stimulation, poor cementing, lack of cathodic protection etc., and directly impact the performance of well integrity barriers. This paper aims to share field experience of unexpected corrosion failures of various materials exposed to excursions during production, well interventions, acid stimulations, annulus fluid changes etc. A review of contributing factors in corrosion of materials in Oil and Gas wells were discussed.

Key words: External casing corrosion, production tubing, Christmas trees, subsurface, coiled tubing, wireline

INTRODUCTION

The unstable oil market demand in the petroleum industry, the oil financial crisis and the Covid-19 pandemic have pushed the Oil and Gas operators to look for optimized, cost effective and more reliable strategies of design and operation. Large part of CAPEX is invested in the well materials. Hence, materials of Oil and Gas wells should be selected to withstand both internal and external threats to ensure integrity and availability while maintaining on focus on affordability over the lifecycle.¹

The impact which results from wells material failure can be significant to an organization from safety, environmental, and business perspective. The calculated costs of deferment, well intervention and workovers, and reactive maintenance can reach to millions of dollars. Top quartile Oil and Gas operators should aim at taking learnings from premature and unscheduled failure to prevent it from reoccurring, by using continuous Improvement tools such as practical problem-solving (PPS), causal Learning, root Cause

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Investigation and, for the simplest investigations, five Why's.¹

The precise in-situ conditions either from the native reservoir fluids, or exposures due to well design and operation scenarios are shown in Figure 1, at the point of concern are often highly uncertain, not only at/near the time of the failure, but also during the preceding days, months or years, which present a significant challenge the understanding on the cause of the failure.

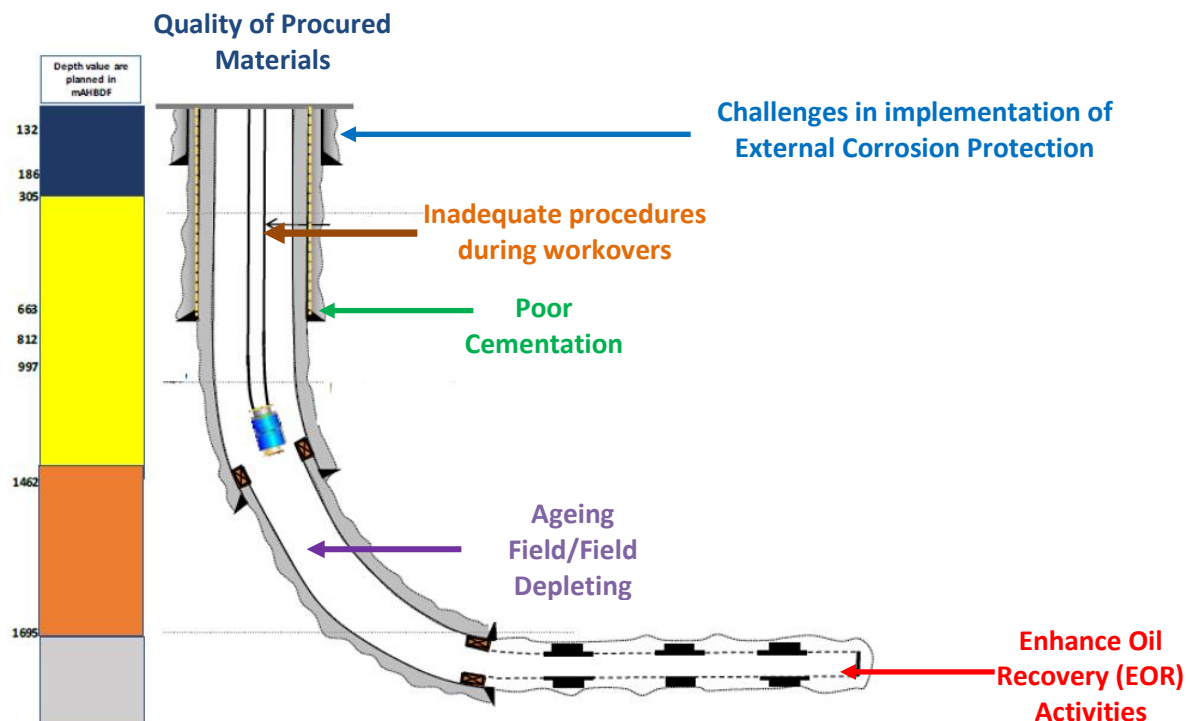


Figure 1: Factors affecting subsurface material performance

This paper addresses four different case studies of unexpected and premature well or intervention equipment failure as shown in Figure 2.

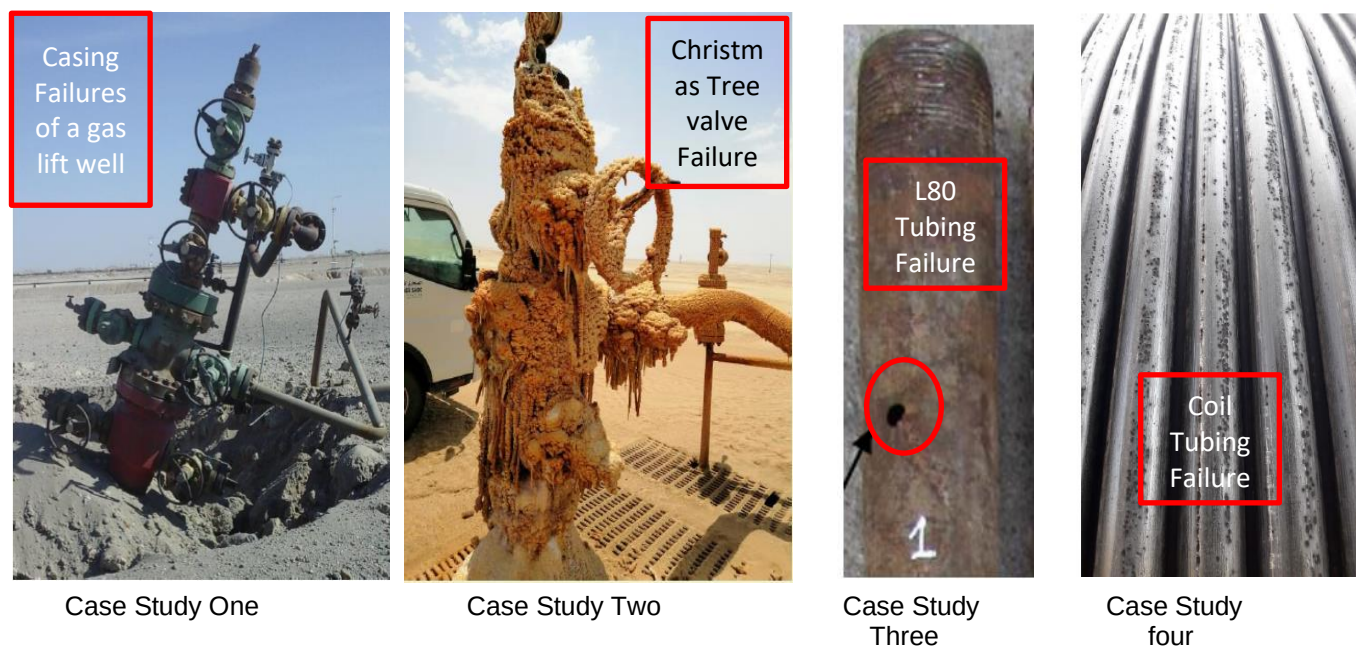


Figure 2: The four case studies of wells material failures

Case Study One: Casing Failure of a Gas Lift well

1.0 Background

Surface casings, while in principle not designed to withstand reservoir conditions, have a major structural role in well design. This casing string may also be one of the oldest string in a well along with the conductor, as tubing and production casings may be replaced with successive workovers or sidetracks, the surface casing will remain in place until well abandonment. A failure would be observed with dramatic event at site, such as well collapse as experienced in this case study, or collapse of a blowout preventer for example during well intervention, or may cause more challenging well abandonment operations due to inability to obtain an isolation. Surface casing failures therefore can lead to well major corrective activities of the affected well, but tend to have a knock-on doubt on the integrity of nearby wells, field or cluster. In the presented case study, Surface casing corrosion is typically observed within the first 50m depth of the well. It is caused by the aquifer contacting the external surface casing and difficulties to obtain good cementation to surface. In principle, this external threat can be mitigated by selecting an appropriate external corrosion barriers. However, many challenges are faced during the implementation of the external corrosion protection systems, shown in Figure 3.

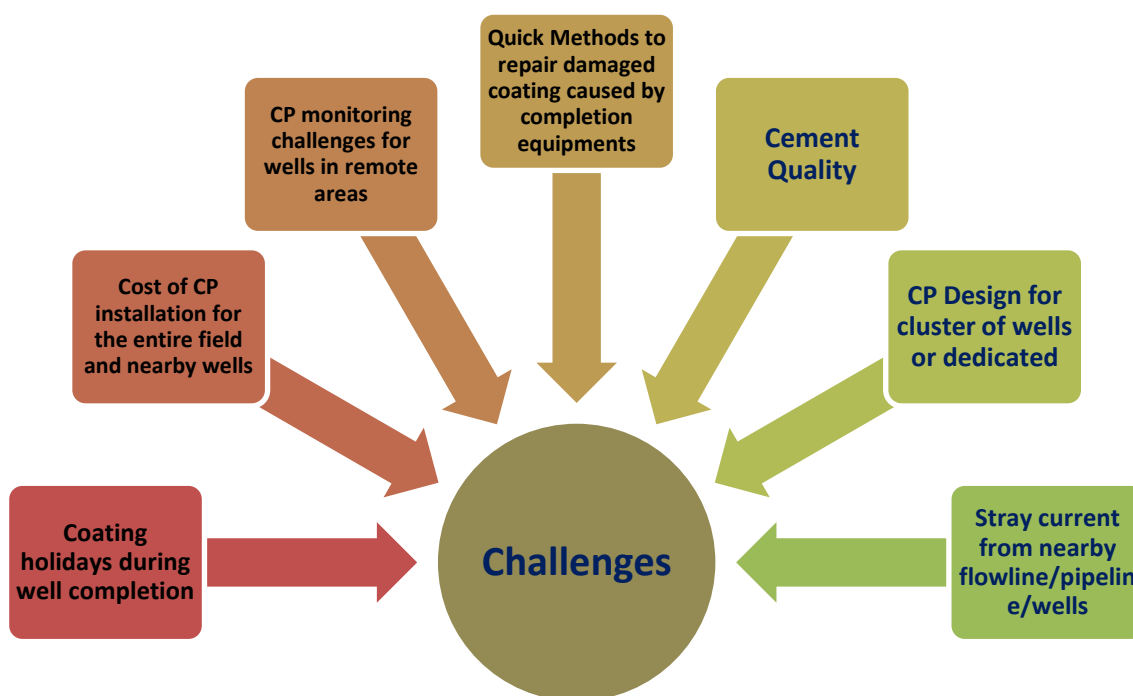


Figure 3 Design and Operational challenges for mitigating against shallow external casing corrosion

Coatings can in principle constitute a good mitigation against external corrosion, as long as holidays are not present. Yet, the nature of making up OCTG with grips, handling with elevators and running in hole, makes maintaining and guaranteeing coating integrity once in hole questionable. Such examples of coating damage observed on gripped pipes are presented in Figure 4.



Figure 4: Coating Damage observed in gripped pipe

Furthermore, cementation quality, both in terms of an intrinsic porosity perspective but also ability to obtain concentric and homogenous cement to the desired depth, is critical to minimize access and replenishment of any corrosive fluids to the casing.² This cement quality can therefore vary from well to well in the same field, creating disparity of surface casings corrosion in the same area. These effects are schematically represented in Figure 5 which show that the probability of experiencing corrosion on a coated casing, several factors need to line up:

- 1) Holiday on coated pipe
- 2) Linked cement pores
- 3) Poor cement pipe adhesion allowing water accessing pipe areas not directly near water ingress area

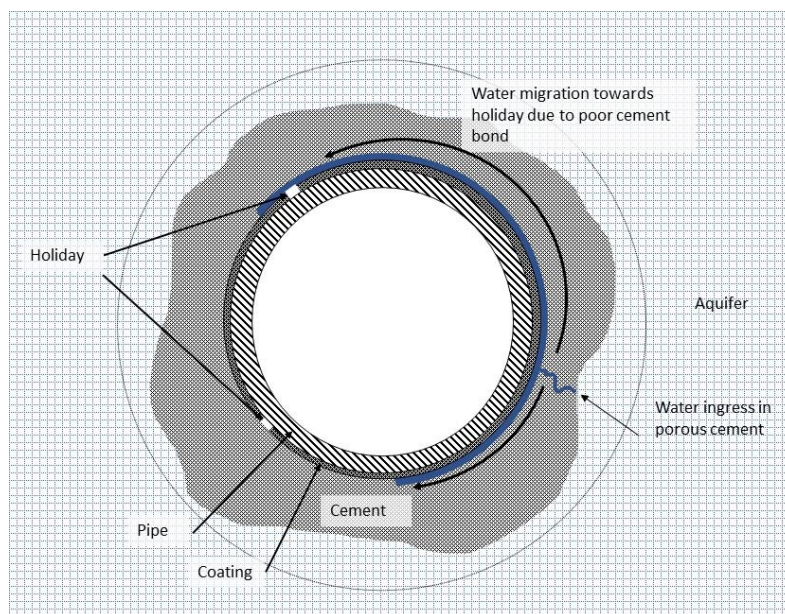


Figure 5: The probability of experiencing corrosion on a coated casing,

With regards to the present case study, the failed gas lift well was drilled and completed in 1996 with carbon steel K-55 surface and production casings. B-annulus failure was reported in 2005. Standard well design mandate to have 2 isolation barriers from the reservoir at any time. For gas life injected into the A annulus however, only one barrier exists as shown in the well schematics in Figure 6. No action was taken at the time of the failure since the main process safety barriers remained unaffected.