

Failure of In-Service Stainless-Steel Chemical Storage Tanks Fasteners and Gaskets – A Case Study

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ABSTRACT

This paper demonstrates a case study associated with the improper installation of non stainless steel materials in chemical tanks against design specification, which explicitly called for the use of stainless steel fasteners and gaskets. An operating facility required the substitution of current chemicals with new ones, and as part of the management of change (MOC) process, the cleaning and inspection of the tanks were required. Internal visual inspection (IVI) of the tanks revealed severe corrosion of the tank internal fasteners, including fasteners supporting structural elements of the tank central periphery. Positive Material Identification (PMI) testing was conducted and concluded that chrome-manganese bolt nuts were used during construction stage which does not match with the design recommended material which is stainless steel ASTM Type 316 (S31600), ASTM A193 GR. B7 (a hardenable Cr-Mo steel) and ASTM A194 GR. 8M (S31600). The causal factors for the fasteners corrosion were determined to arise from galvanic corrosion from using dissimilar materials alongside very corrosive environment. Similarly, it was observed that all tanks manway suffered from localized and crevice corrosion due to the use of non-asbestos gasket instead of spiral wound metallic stainless steel Type 316 gasket as per design. Consequently, chemical incompatibility of the gasket led to flange surface crevice and localized corrosion.

Keywords: Fasteners, Integrity, IVI, materials, Positive Material Identification, Incompatible, Galvanic corrosion, localized corrosion

INTRODUCTION

The Joint Operation (J.O) Wafra Oilfield is in the west central part of the Kuwait-Saudi Arabia Neutral Zone. The Wafra oilfield produces light and heavy oil and export it to its various customers after processing. Upstream field consists of various Sub Centres where crude, oil and water being separated, and the separated crude transported to the main gathering centre for further processing in two different trains. The produced water being disposed/injected via water disposal & injection facilities after treatment.

The production fluid is normally treated with various oil field chemicals such as emulsion breaker, antifoam in order to meet export crude quality requirement while corrosion inhibitor, scale inhibitor and biocide chemicals being utilized for asset protection.

CHEMICAL STORAGE FACILITIES

The chemical storage facility is used to handle and store the production and integrity chemicals. The facility is equipped with storage tanks, unloading and loading stations, centrifugal pumps, Coriolis flow meter, Program control logic room, firefighting system, close drain system etc. The chemicals are analysed in the laboratory to assure quality before being unloaded into the storage tanks. Company laboratory personnel normally conduct chemical quality testing parameters such as Density, Viscosity, Specific gravity, pH, Chloride, FTIR fingerprint and verify with contractor QA/QC certificate for each batch chemical delivery. Also, physical properties such as colour, odour, solubility, appearance and flash point also checked. Once the quality meets company's requirement, then approval will be given for unloading into the respective chemical tank.

There are a total of ten storage tanks, consisting of eight internally coated carbon steel chemical storage tanks, which were constructed in the year of 2000 and two additional stainless steel storage tanks that were constructed in 2015 for the storage of corrosion inhibitors and scale inhibitors respectively. Experience from WJO has previously shown that coated carbon steel tanks were inadequate for the storage of corrosion and scale inhibitors due to widespread localized corrosion.

The facility serves various stakeholders and is operated by company personnel on daily basis. Robust preventive maintenance and corrective maintenance are also in place to ensure the equipment integrity in accordance with the company asset integrity policy. The capacity, size and material of construction of each tank are as shown below:

**Table 1:
Chemical Storage Tank Details**

Chemical Name	Tank No.	Capacity (USG)	Material of Construction
Demulsifier	1	20,000	Carbon steel with internal Coating
Corrosion Inhibitor(W)	2	15,000	Carbon steel with internal Coating
Corrosion Inhibitor(O)	3	6,000	Carbon steel with internal Coating
Defoamer	4	6,000	Carbon steel with internal Coating
Demulsifier	5	40,000	Carbon steel with internal Coating
Biocide	6	6,000	Carbon steel with internal Coating
Scale Inhibitor	7	6,000	Carbon steel with internal Coating
Standby	8	6,000	Carbon steel with internal Coating

Corrosion Inhibitor	9	25,000	Stainless Steel
Scale Inhibitor	10	25,000	Stainless Steel

CASE STUDY

The use of stainless steel materials, especially austenitic stainless steel such as 316 in chemical storage facilities is well proven due to their corrosion resistance for most chemicals. However, installation of improper materials against design specification usually makes facilities at vulnerable risk and could result in catastrophic failures of assets, increased maintenance activities and lost production. Consequently, robust quality assurance and control processes that ensure the design premise, including material composition, welding processes and other requirements are strictly complied with from fabrication, storage, construction and commissioning phases is mandatory. This fundamental concept is often not strictly enforced, not taken seriously and worse ignored, leading to either operational, integrity and/or safety consequences the operational stage of a plant and/or equipment. This paper discusses only the two tanks (T9 & T10) which were constructed in the year 2015 but not the rest of tanks. These two tanks were designed as per the API 650 code and the materials of construction are as follows:

Table 2:
Tank components and Material details

Tank Dimensions & Components	Material Details
Diameter	Dia. 5004mm x Ht. 5486 mm
Shell, Annular ring, Bottom plate, structural and roof material	SA 240Gr.316 L
Piping Material	ASTM A312 Gr. 304L.
Stud bolt nuts	ASTM A193Gr B8M/ASTM 194 Gr.8M

The construction contractor executed the project as per the contractual scope of work and supplied material requirement. While commissioning, stagewise walk through inspection were conducted by company's several departments such as Construction, Facility, Mechanical, Electrical, Instrument and end user to ensure the project scope requirement.

Performance acceptance test (PAT) was also conducted as per the commissioning. Once the facility was successfully commissioned, the operational scope was transferred from construction team to end user (operation) team.

Chemical Tank (T-9) is used to store corrosion inhibitor and the active ingredient of this chemical was quaternary ammonium salt with ammonium bisulfite (Oxygen scavenger). The pH of the chemical is in the range of 4.5-5.5. It is a water base chemical being used in the process specially in the upstream of water injection facility to mitigate corrosion and its problems. The chloride content of this chemical is around 20,000 ppm.

Chemical Tank (T-10) is used for storing scale inhibitor whose active ingredient was sodium salt of phosphono methylated diamine. The pH of the chemical is in the range of 4.2-4.8. It is a water base chemical used in the process to prevent scale deposition.