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Erosion Management in the Oil and Gas Industry

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Foreword

Solid particle erosion and erosion corrosion has been a recognized threat to the Oil and Gas production Industry for many years. On recognition of this, substantial amount of research and technology has been developed to asses, monitor, predict and mitigate these degradation mechanisms. Testing, Inspection, monitoring and prediction modelling technologies are now available to Projects and Operations and they have overcome many of the limitations of the original guidelines on erosion and erosion corrosion addressed by Industry standards as API[(1)] 14E[1] and EEMUA[(2)] 194.[2] This document is conceived as an opportunity to gather the current Industry wisdom as an attempt to summarize some of the procedures and criteria already put in place by many contractors and operators using the above-mentioned technology areas.

This SP provides guidance on internal erosion and erosion-corrosion management. Guidance is given for erosion and erosion-corrosion threat assessment/prediction, barrier selection, monitoring, inspection, risk assessment and data management. This SP covers mainly sand caused erosion. However, the guidance in this document can be used for other solid particles.

This SP is applicable to tubular products, e.g., tubing, pipelines, flowlines, risers, valves, and piping systems.

Equipment with complex geometries like downhole valves, intelligent completion design, and sand screens are outside the scope of this document.

Drill cuttings injection and high concentration slurries transport are outside of the scope of this SP. In this document, a high concentration slurry is considered a liquid that contains greater than 2% by volume particles.

This standard was prepared by Task Group (TG) 245 on Oil and Gas Production, Erosion Management. TG 245 is administered by Specific Technology Group (STG) 35 on Pipelines, Tanks, and Well Casings. This standard is issued by NACE International under the auspices of STG 35.

In NACE standards, the terms ***shall, must, should,*** and ***may*** are used in accordance with the definitions of these terms in the NACE Publications Style Manual. The terms ***shall*** and ***must*** are used to state a requirement, and are considered mandatory. The term ***should*** is used to state something good and is recommended, but is not considered mandatory. The term ***may*** is used to state something considered optional.

(1) American Petroleum Institute (API), 1220 L St. NW, Washington, DC 20005-4070.
(2) The Engineering Equipment and Materials Users Association (EEMUA), Second Floor, 16 Black Friars Lane, London, EC4V 6EB.

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TABLES AND FIGURES

Section 1: General

1.1 Erosion is defined by NACE International as “The progressive loss of material from a solid surface resulting from mechanical interaction between that surface and a fluid, a multicomponent fluid, or solid particles carried with the fluid.”

1.1.1 Erosion has two main consequences for the Oil and Gas Industry:

1.1.1.1 Operating conditions can lead to erosion and damage to equipment and potentially loss of primary containment. These consequences can have an impact on safety, environment, and operations.

1.1.1.2 Production rate can be limited to avoid erosion. If these limits are set too low, the consequence is significant and unnecessary production loss or deferment.

1.1.2 Erosion problems are frequently caused by solids. These solids may come from the following sources:

- Unconsolidated reservoirs. The rate of sand produced from reservoir is influenced by the following factors:
  - Reservoir management
  - High drawdown from subsurface artificial lift systems: ESPs, PCPs, sucker rod pump (SRPs)
  - High drawdown due to well high flow rate in naturally produced wells.
  - High Flow rates
  - Sand/Proppant used in fracking operations
- Corrosion products such as $FeCO_3$, FeS, $Fe(OH)_2$. See section 4.1.3.8.
- Inorganic solids from scaling water with tendency of producing carbonate scales and/or others

1.1.3 Erosion problems are likely to continue in the future because of the following reasons:

- The requirement to maintain and increase production.
- The occurrence of multiphase flow (i.e. slugging in the transport of production fluids in both existing and new projects).
- Continued development of sand-production-prone reservoirs.

1.1.4 Many flow dependent wastage mechanisms are termed “erosion.” For produced fluids, there are three main mechanisms to be considered:

- Erosion by fluids through liquid droplet impact. This requires very high fluid velocities in gas-dominated multiphase flow.
- Erosion by non-corrosive fluid carrying solid particles. Also applicable to low corrosivity fluids overwhelmed by the mechanical action of the metal removed by the solid particle impingement.
- Erosion-corrosion by a corrosive medium containing solid particles. For conditions where both erosion and corrosion are recognized as important contributors to the total metal wastage. Erosion-corrosion can also happen at high velocity in presence of droplets.

1.1.5 High flow rates may enhance corrosion by increasing mass transport of corrosion products and reactants, but this is not to be confused with erosion-corrosion as no mechanical removal of material is involved.

1.1.6 There are cases when small content of solids, even below typical detection limits, may trigger erosion-corrosion as per mechanism described in the third bullet point in 1.1.4.

1.1.7 These definitions can easily be distinguished on paper by degradation mechanisms, but in real practice these mechanisms are often not absolute, and they may be distinguishable and defined by the significance of the contribution of either corrosion or erosion and the consequent mitigation method used to minimize the wastage. For example, an erosion-corrosion problem on carbon steel subject to nominally solid free corrosive production (per EEMUA 194 definition) might be effectively resolved using a corrosion resistant alloy (CRA), hence for practical purposes the damage mechanism is often classified as Corrosion.

1.1.8 Erosion and corrosion can be independent of each other, in which case the total wastage is the sum of the wastage produced by each mechanism in isolation, or synergistic, in which case the total wastage is greater than the sum of the independent processes of erosion and corrosion taken separately.

1.1.9 Erosion caused by cavitation occurs as result of the formation and collapse of bubbles at or near the surface which result in material removal. Cavitation is a threat in high velocity fluid flow with sudden changes in pressure.

Section 2: Terms and Definitions

For the purpose of this SP, the following terms and definitions apply:

Barrier: A design, construction or operational activity that manages threats due to erosion, preventing the threat from developing into an event.

Barrier monitoring: A measurement of the performance of a barrier.

Erosion: The progressive loss of material from a solid surface resulting from mechanical interaction between that surface and a fluid, a multicomponent fluid, or solid particles carried with the fluid.

Erosion-Corrosion: A conjoint action involving erosion and corrosion in the presence of a moving corrosive fluid or a material moving through the fluid, leading to accelerated loss of material.

Erosion rate: The time-rate of metal loss due to erosion. It is typically expressed in as penetration per unit time, e.g., (mm/year or mpy).

Likelihood: In common use, this is an estimate of the expected probability or frequency of occurrence of an event. Typically, descriptors are used rather than a number e.g. 'very likely' or 'likely to occur several times during the life of the equipment.'

Threat: A damage mechanism that results in the degradation of a component, circuit or system.

Threat (Credible): A credible threat is one that is expected to produce degradation in a system, circuit or component. Credible threats depend on the barriers that are in place.

Section 3: Erosion Management—Overview

Erosion is a potential safety risk to operations and can cause production deferrals and high repair costs.

Erosion management shall comprise these steps:

- Erosion threat assessment
- Identification, implementation and management of barriers for each erosion threat
- Monitoring of barrier effectiveness.
- Monitoring of erosion rates.
- Inspection program.
- Performance management.

The sections that follow describe the erosion management process.

Section 4: Erosion Threat Assessment

The first step in managing erosion in projects and operations shall be to assess the erosion threat. The flow chart in Figure 1 describes the process for evaluating the erosion threat and the procedure to quantify it. Instructions for use of the flow chart are described in the next sections. The titles of the sections correspond to the labels for each box in Figure 1.

4.1 Data collection

4.1.1 The first step for erosion threat assessment is to collect the necessary input data. The threat assessment will only be as good as the input data used, such that care needs to be taken to ensure their validity and accuracy. The data listed in Table 1 should be gathered to perform an effective erosion threat assessment. When it is not possible to obtain field specific data, the values should be estimated from other sources. Both subsurface and facility disciplines should be consulted to ensure that the most appropriate data relative to sand production and operating conditions are used.

4.1.2 The parts in bold in the table indicate those parameters that shall be used as minimum required inputs for erosion models.

4.1.3 Solid particles data