Sour Service

Vincent Flores – IADC Webinar
Sour Service Environment

- **What is Sour Service?**
  - Sour Service: Well containing H₂S
  - Origin: H₂S comes from decomposition of organic material.

- **Consequences?**
  - HSE Risk & Environmental Impact concerns: hazardous to human health, living organisms and environment.
  - NPT & OPEX:
    - Loss of DP and/or BHA due to Sulfide Stress Cracking (SSC)
    - Fishing job required in case of failure
    - Non Productive Time in case of loss of well control
Risks Associated to Sour Service

Risks on standard API grades (= non Sour Service grade):

- **Sulfide Stress Cracking**
  - Unpredictable brittle failure
  - Fishing costs
  - Non-productive time for drilling contractors

- **Failure example on 5” DP, S-135 API grade**
Drilling Challenges

Catastrophic Failure

- **Failure mechanism:** Sulfide Stress Cracking (SSC)

  Low pH Water
  High $\text{H}_2\text{S}$ \(\Rightarrow\) Corrosion
  \(\downarrow\)
  H Charging
  Low temperature
  Applied load

- **Escalation factors:**
  - When Yield strength \(\uparrow\)
  - Grade $\text{H}_2\text{S}$ resistance \(\downarrow\)
  - SSC phenomenon occurrence
  - Failure risks \(\uparrow\)
NACE Testing Methods

NACE TM 0177 (2005) defines 4 testing methods

- Method A is the most used for drilling products
- Solution A is the most used environment (Severe Sour environment)

Acceptance Criteria:

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<th>PASS</th>
<th>FAIL</th>
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NACE A
NACE “Tensile Test” under uniaxial tensile load.
- Failure/no failure test
- Test duration: 720h
NACE Testing Method A

NACE Test A: Laboratory Procedure

Environmental Testing Chamber

Application of tensile load = % SMYS

Example of samples under testing process

Source: Vallourec Research Center
NACE Material Recommendations: NACE MR0175
- 4 domains of susceptibility to $\text{H}_2\text{S}$
- pH and partial pressure of $\text{H}_2\text{S}$ as major parameters
  - Partial pressure = %$\text{H}_2\text{S}$ x total pressure

Domain 0: Non Sour Service
Domain 1: Mild Sour Service
Domain 2: Intermediate Sour Service
Domain 3: Severe Sour Service

$\text{H}_2\text{S}$ partial pressure (bar)
$\text{pH}$

NACE Solution A conditions

0.003 bar
Material Selection for H₂S resistant Drill Pipe

- **International standards:**
  - No guideline in API 5DP & ISO11961
  - Not included in the scope of the NACE MR0175 / ISO15156

- **Industry initiatives:**
  - Manufacturers: developing a variety of proprietary grades using NACE TM0177 testing since the 90’s
  - VNIIGAS qualification for Gazprom in Russia (*Vallourec passed in 2009 and produced its order for Burgas-Gazprom in 2010*)

- **A decade of IRP Drill Pipe use:**
  - Worldwide supply: from one manufacturer in 2004 to > 5 in 2014
  - Originated in Canada but used in several parts of the world, mainly: Russia, Middle East, China and Brazil
  - Successful switch from API to IRP products with safe operations
Evolution of the drilling environments & new frontiers

- **Pushing towards harsher drilling environments:**
  - Due to increase of domestic gas demand, fields with higher and higher \( \text{H}_2\text{S} \) content are being explored and developed
  - Managed Pressure Drilling & Underbalanced Drilling increase the risk of Drill Pipe exposure to fluids coming from the formation
  - HSE concerns is a first priority
  - Integrity of the entire Drill Pipe should now be considered

- **New frontiers:**
  - Highly sour fields (higher \( \text{H}_2\text{S} \) content). Example: Shah-24%, Bab-35% (UAE), SRAK-38% (KSA), Kurdistan-36% (Iraq)
  - HPHT conditions increasing the \( \text{H}_2\text{S} \) partial pressure → SSC risk

- **Technological challenges:**
  - SSC resistance in norms consider the pipe body and tool joint separately and ignore the weld zone and upsets
  - The weld zone and upsets have metallurgical heterogeneities and often high hardness points, potentially detrimental to SSC
  - Even IRP 1.8 specification does not cover these areas
Sour Service Grades

- **Sour Service steel = material with resistance to H₂S**

- **Key processes control:**
  - **Steelmaking:**
    - Supreme cleanliness
    - Dedicated steel chemistries
  - **Heat treatment:**
    - Homogeneous and fine microstructure
    - Specific heat treatments (double Q & T)
  - **Welding:**
    - Controlled hardness
    - Dedicated tempering

Sour Service Grades = Specific Chemistry + Specific Heat Treatment
Conclusion

- **Sour Service supplier of choice**
  - Vertical integration of Vallourec mills
  - In-house R&D expertise and NACE testing facilities
  - Proven manufacturer of IRP 1.8 compliant products
  - Manufacturer of Sour Service BHA
  - Reliable quality products through more than 2,000,000 ft of Sour Service products used worldwide since 2007 without any failure!

- **Sour Service technical leader**
  - On board of NACE committee and contributing to IRP & ISO standards
  - Yearly publications in international conferences
  - Industry recognized expertise in specialized workshops and technical conferences
  - Four new grades developed since the past 2 years, to address new frontiers and the extension of the drilling envelope