Improving the consideration of biofouling in the standards of the offshore industry

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Summary

• Regulatory state of the art
  o International standards
  o Certification bodies

• Current practice in Bureau Veritas
  o Design
  o Monitoring and cleaning

• Tracks for improvement
NORSOK N-003: Actions and action effects

- First information about marine growth found in an offshore standard (1999)
- “A surface coat on marine structures caused by plants, animals and bacteria”
- Marine growth may influence:
  - Hydrodynamic actions
  - Weight
  - Hydrodynamic additional mass
  - Hydrodynamic instability
- If marine growth exceeds the documented values, cleaning may be omitted if new analysis shows that the structure has sufficient strength
 Thickness values of marine growth are provided for the Norwegian and North seas:

- The thickness of marine growth may be assumed to increase linearly over 2 years after installation.
- Roughness height may be taken as 20mm below +2m.
- Specific weight of marine growth in air may be set to 13kN/m$^3$.

The water depth refers to mean water level.
ISO 19901: Petroleum and natural gas industries – Specific requirements for offshore structures

Part 1: Metocean design and operating considerations

API-RP-2MET: Derivation of metocean design and operating conditions

- “Living organisms attached to an offshore structure”
- The importance of site specific study to establish marine growth profile is highlighted
- Increased dimensions and increased drag coefficient shall be considered to take into account the effect of marine growth
- Distinction is made between “smooth” and “rough” circular components / “soft” and “hard” marine growth
Typical values of marine growth are provided for different locations:

- **Reference to NORSOK values is made for areas Offshore Norway**

- **UK area:**

- **Other locations:**
  - Caspian Sea: densities of 10 to 12kg/m³ have been observed

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**Table:**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Africa</td>
<td>300</td>
</tr>
<tr>
<td>California</td>
<td>200</td>
</tr>
<tr>
<td>Gulf of Mexico</td>
<td>60</td>
</tr>
<tr>
<td>South-East Asia</td>
<td>500</td>
</tr>
</tbody>
</table>

| Splash zone      | 300            |
| 0m to 20m        | 100            |
| 20m to 50m       | 100            |
Regulatory state of the art – International standards

ISO / API

- Marine growth may have a detrimental effect on fatigue life of structures
- Marine growth can interfere with corrosion and corrosion protection systems
- Information about marine growth removal is provided (waterblasting, sandblasting)
- Scheme for the definition of surface roughness is shown:
  - Roughness value: $e > 10^{-3}$

ISO 19902: Petroleum and natural gas industries – Fixed steel offshore structures

API-RP-2A-WSD: Planning, designing and constructing fixed offshore platforms – Working stress design
Regulatory state of the art – International standards

ISO / API

ISO 19902: Petroleum and natural gas industries – Fixed steel offshore structures

API-RP-2SIM: Structural integrity management of fixed offshore structures

- ISO: Information about marine growth recording is provided
- API: Marine growth removal should be sufficient to enable the platform to meet assessment criteria
- Marine growth to be:
  - Observed during level II inspections
  - Measured during level III inspections
  - Removed during level IV inspections, if deemed necessary

<table>
<thead>
<tr>
<th>Exposure level</th>
<th>Level I inspection</th>
<th>Level II inspection</th>
<th>Level III inspection</th>
<th>Level IV inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Annual</td>
<td>3 years</td>
<td>5 years</td>
<td>Determined from level III inspection results</td>
</tr>
<tr>
<td>L2</td>
<td>Annual</td>
<td>5 years</td>
<td>10 years</td>
<td>Determined from level III inspection results</td>
</tr>
<tr>
<td>L3</td>
<td>Annual</td>
<td>5 years</td>
<td>not required</td>
<td>not required</td>
</tr>
</tbody>
</table>
ISO 19904-1: Petroleum and natural gas industries – Monohulls, semi-submersibles and SPARs

ISO 19905-1 and 2: Petroleum and natural gas industries – Site specific assessment of mobile offshore units – Jack-ups

- “Surface growth on offshore structures, caused by plants, animals and bacteria”
- Additional information related to marine growth cleaning is provided (anti-fouling, ROV cleaning...)
- Specific gravity of 1.0 to 1.4 is given
- Typical value of 12.5mm marine growth thickness is given
- Typical value of surface roughness implied by marine growth on tubulars are shown: 0.005 to 0.05m
ISO 19905-1 and 2: Petroleum and natural gas industries – Site specific assessment of mobile offshore units – Jack-ups

Information for evaluating drag coefficient including marine growth is provided for tubulars:

\[
C_{D_i} = C_{D_0} + C_{D_1} \left( \frac{W}{D_i} - C_{D_0} \right) \sin^2 \left( \frac{(\theta - 20^\circ) \theta}{9} \right)
\]

where

\( D_i = D + 2t_{mu} \)

\( t_{mu} \) is the marine growth thickness;

\( \theta \) is the angle in degrees; see Figure A.7.3-3;

\( C_{D_0} \) is the drag coefficient for a tubular with appropriate roughness

\[
C_{D_0} = \begin{cases} 
18 & ; \quad W/D_i < 1.2 \\
14 + \frac{1}{3}(W/D_i) & ; \quad 1.2 < W/D_i < 18 \\
2.0 & ; \quad W/D_i \geq 18
\end{cases}
\]
### Regulatory state of the art – Certification bodies

<table>
<thead>
<tr>
<th>Certification Body</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bureau Veritas</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR445: Rules for Offshore Units</td>
<td>Amount of allowable marine growth to be integrated in the operating manual</td>
</tr>
<tr>
<td>NR493: Rules for the Classification of mooring systems for permanent offshore units</td>
<td>Marine growth on upper part of mooring lines to be cleaned during Class Renewal Survey</td>
</tr>
</tbody>
</table>
NI624: Risk-based Integrity Management of Offshore Jacket Structures

- Marine growth considered as a risk factor for jacket structure
- References to API-RP-2SIM and ISO19902 for inspection methods
- Marine growth is to be measured and removed in order to reduce risk
- A marine growth average thickness and profile are to be provided
- Marine growth is to be considered for structural assessment by increasing cross-sectional area, mass and drag coefficients of submerged part of the structure
- History of measurement of marine growth profile is to be provided in the scope of fatigue analysis
Regulatory state of the art – Certification bodies

NI572: Guidance Note for the Classification and Certification of Floating Offshore Wind Turbines

- Marine growth is to be considered for determining:
  - the corrosion rates
  - the hydrodynamic loads
  - the natural frequencies of the support structure
  - the dynamic loadings on the structure

- Marine growth is to be characterized by site-specific data of thickness and density in function of water depth

NI432: Guidance Note for the Certification of fibre ropes for Deepwater mooring

- Upper part of fibre rope is to be kept 100m below surface to avoid the development of hard marine growth inside the rope

- The filter installed on the rope for particle ingress protection is expected to have a beneficial effect with respect to hard marine growth development

Bureau Veritas

FEM S&T Tribune 2020 – Improving the consideration of biofouling in the standards of the offshore industry
Regulatory state of the art – Certification bodies

DNV GL

- Site specific marine growth thickness profile to be determined
- The impact of marine growth on cross-sectional area and drag coefficients of slender structures is to be considered
- Marine growth is to be considered for determining:
  - the corrosion rates
  - the hydrodynamic loads
  - the natural frequencies of the support structure
  - the dynamic loadings on the structure

DNV-GL-RP-C205 – Environmental conditions and environmental loads

DNV-GL-ST0437 - Loads and site conditions for wind turbines
Regulatory state of the art – Certification bodies

DNV-GL-RP-C205 – Environmental conditions and environmental loads

DNV-GL-ST0437 - Loads and site conditions for wind turbines

- Values of marine growth surface roughness (0.005 to 0.05m) and density (1325kg/m3) are given
- For site specific thickness and density values, reference is made to NORSOK and ISO19901-1
- Typical thickness values for some additional locations are provided:
  - Southern North Sea: 150mm between sea level and LAT -10m
  - Baltic Sea: 100mm below -2m MSL
Formula for approximating the variation of drag coefficient on circular cylinders due to marine growth is provided:

\[ C_D = C_{D0}(\Delta) \cdot \psi(K_c) \]

- For smooth surfaces, \( \Delta < 10^{-4} \):
  \[ C_{D0}(\Delta) = 0.65 \]
- For rough surfaces, \( \Delta > 10^{-2} \):
  \[ C_{D0}(\Delta) = 1.05 \]
- For intermediate roughness, \( 10^{-4} < \Delta < 10^{-2} \):
  \[ C_{D0}(\Delta) = \left( \frac{29 + 4 \cdot \log_{10}(\Delta)}{20} \right) \]

\[ \psi(K_c) = \begin{cases} 
  C_\pi + 0.10(K_c - 12) & 2 \leq K_c < 12 \\
  C_\pi - 1.00 & 0.75 \leq K_c < 2 \\
  C_\pi - 1.00 - 2.00(K_c - 0.75) & K_c \leq 0.75 
\end{cases} \]

where:
- Non-dimensional roughness: \( \Delta = k/D \)
- Keulegan-Carpenter number: \( K_c = \frac{v_m T}{D} \)
- \( C_\pi = 1.50 - 0.024 \cdot (12/C_{D0} - 10) \)
Formulae for calculating the mass, submerged weight and increase on drag coefficient due to marine growth are provided:

\[
M_{growth} = \frac{3}{4} \left[ D_{nom} + 2 \Delta T_{growth} \right] \left( D_{nom}^2 - D_{nom}^2 \right) \rho_{growth} \cdot \mu \ (kg/m)
\]

\[
W_{growth} = M_{growth} \left[ 1 - \rho_{seawater} \right] \left( 9.81 \right) \left( 1000 \right) \ (kN/m)
\]

\[
C_{D_{growth}} = \frac{D_{nom} + 2 \cdot \Delta T_{growth}}{D_{nom}}
\]

\[
C_0 = \begin{cases} 
2.6 & \text{stud chain; 2.4 with respect to chain diameter} \\
1.8 & \text{stranded rope; 1.6} \\
2.0 & \text{spiral rope without sheathing; 1.2} \\
2.0 & \text{spiral rope with sheathing; 1.2} 
\end{cases}
\]
Regulatory state of the art – International standards

RECAP

- Influence of marine growth to be considered in design calculations in terms of:
  - Increase in hydrodynamic diameter, mass and buoyancy
  - Variation of the hydrodynamic drag coefficient as a function of roughness

- Marine growth may influence corrosion and corrosion protection

- Important to obtain site-specific marine growth profile

- Typical values for density, surface roughness as well as site specific values of thickness and formula for approximating drag coefficient can be found in the standards

- Marine growth to be recorded / measured
Common practices at Bureau Veritas - Design

- No certification process including biofouling
- Information about biofouling is received as an input data from our client
- We consider biofouling in our independent design analyses (extreme and fatigue loads on submerged structures and mooring lines)
Common practices at Bureau Veritas – Monitoring and cleaning

- For offshore units under BV Class, biofouling shall be monitored (divers and/or ROVs)
- In case excessive marine growth values are measured:
  - New design calculations can prove the safety of design with additional amount of marine growth
  - Marine growth to be removed from structure
Common practices at Bureau Veritas – Monitoring and cleaning

- Inspection and cleaning performed by:
  - Divers
  - ROVs

- Cleaning methods:
  - Mechanical cleaning
  - High pressure water cleaning
  - Cavitation blasting
  - Polymeric blade
Tracks for improvement

- Require for documented site-specific information and refer to NORSOK and ISO19901-1 for typical marine growth thickness profile of several geographical sites

- Require the installation of marine growth prevention devices
Tracks for improvement

- Fibre rope for anchoring lines: penetration of “hard” species between rope cover and rope core

- Size of eggs?
- Particle ingress protection?
- Rope damage?