Free Span Assessment of Pipelines & Risers

Free Span Assessment

In-service pipelines could potentially suffer from fatigue damage (FLS) and local buckling failure (ULS) due to the free spans.

Pipeline vibration due to vortex shedding (in-line and cross-flow VIV) and direct wave actions causes accumulative fatigue in a free span. Pipeline static bending, vortex induced vibration, direct wave and current effects and trawl gear interaction are the main contributors of a local buckling failure in a free span.

Z-Subsea possesses comprehensive experience in assessment of free spans of in-service pipelines. Z-Subsea's approach is in full in compliance with "DNV-RP-F105 – Free Spanning Pipelines" recommended practice.

Allowable free span length need to fulfill the integrity of the pipeline against fatigue damage, local buckling failure and trawl gear interaction.

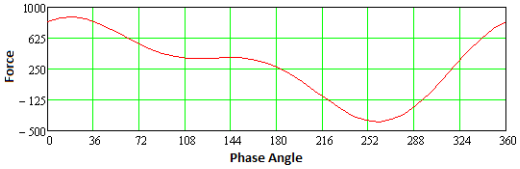
Pipeline Single Or Multi-Span VIV

To calculate allowable free span length against fatigue damage, Z-Subsea employs following levels of assessment:

Screening

This method is a simplified method and provides a very conservative allowable free span length based on a fatigue life in excess of 50 years based on DNV-RP-F105. In this method, the VIV in in-line and cross-flow directions is avoided.

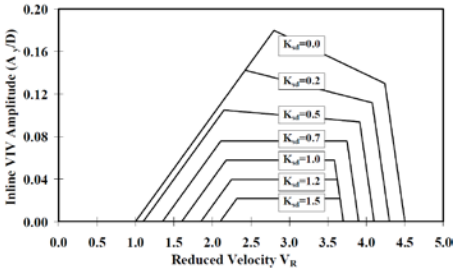
Z-Subsea has detailed in-house calculation sheets to address maximum allowable length of pipeline or riser span under design conditions.



Calculation Sheets for Screening Method

Response Model

This approach evaluates the pipeline span fatigue damage in each seastate independently. Water particle kinematics at pipeline level are established for each cell of scatter diagram, DNV-RP-F105 response model is utilized to calculate the vibration amplitude and frequency, appropriate S-N carves are applied to calculated the fatigue damage of that specific seastate and then the total fatigue damage over the expected time is obtained. This approach is yet conservative however, provides more realistic results compared to screening level assessment.

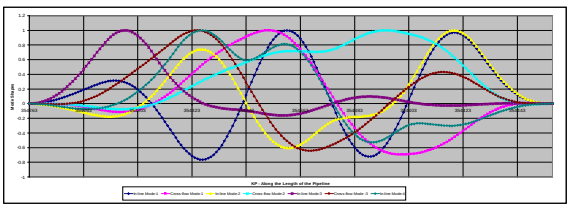


Response Model for VIV Amplitude (XF)

This approach utilizes the conservative approximations in calculation of free span fundamental natural frequency, unit diameter stress amplitude and etc.

Finite Element Assessment

"Screening" and "Approximated Fatigue Damage Assessment" levels cannot be utilized for situations where effective axial force is more than half the Euler buckling force of the pipeline because the frequency calculation approximation of the code loses its accuracy. Also it cannot be used when there is interacting spans or in case of several vibration modes may be excited simultaneously in the same direction (in-line or cross-flow).



Pipeline Multi-Span Multi-Mode VIV

For such cases and also if allowable free span length need to be pushed to the maximum possible limits, a "Detailed Finite Element Assessment" need to be performed.

Free Span Assessment of Pipelines & Risers

Finite Element Analysis extraction of natural frequencies of pipeline can take into account:

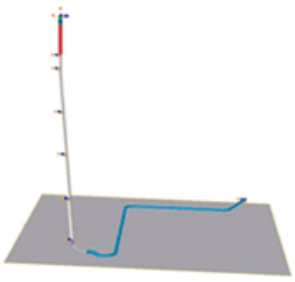
- boundary conditions
- interacting spans
- multi-mode in single span
- soil properties
- effective axial force
- span feed-in
- seabed features on pipeline route

Z-Subsea utilises advance modelling for situations where spanning requires FE analysis. The FE assessment is performed considering:

- In-place model of pipeline and spans based on seabed features along the route
- Single pipe, pipe-in-pipe, or piggybacked pipelines can be modelled
- Pressure and temperature profiles
- Extraction of In-line as well as Cross-flow mode shapes and frequencies
- The nonlinear effects of pipeline deformation, pressure, and temperature on natural frequencies

Advanced in-house calculation sheets are utilised to calculate the fatigue life of the spans.

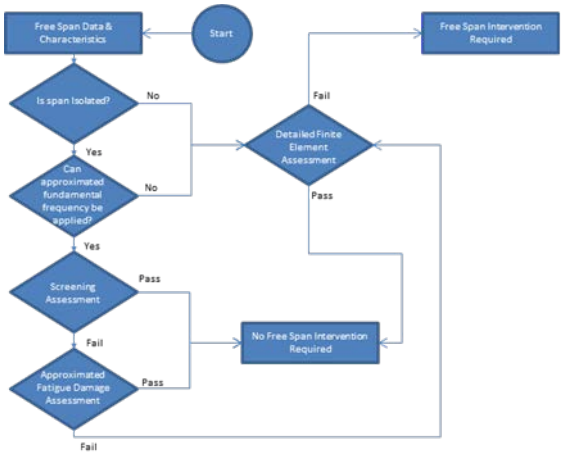
It is noted that these approaches can be also used for span calculations of platform rigid risers with spans between the riser guides with some considerations.



Jacket Rigid Riser Free Span VIV Assessment

Z-Subsea approach for free span assessment is shown in the following flow chart taking into account:

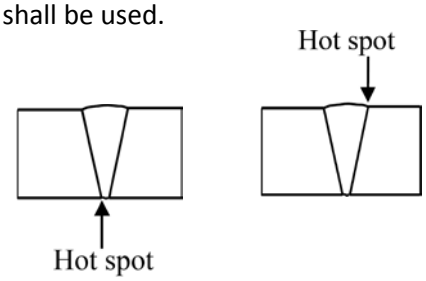
- Maximum allowable span length to avoid VIV if possible
- Assessing VIV fatigue damage of pipeline/riser welds if VIV occurs
- Local buckling or stress check at critical points
- Intervention methods if the above criteria fail



Z-Subsea Free-Span Assessment Methodology

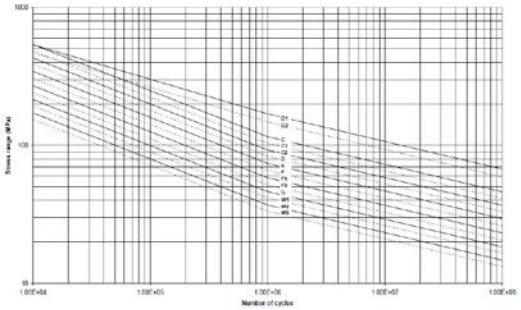
S-N Curves

To calculate the fatigue damage of pipeline spans it is conservatively assumed to have welds in most critical locations. Depending on crack initiation location (root or toe), appropriate S-N curve shall be used.



Weld Hot Spot Location For Fatigue Check

The application of S-N curve also depends on the type of the pipeline internal (sour service, clad, etc.) and external (cathodic protection, corrosion coating, etc.) condition for each of which there is appropriate S-N curve.



Typical S-N Curve