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CONCEALED PIPING INTEGRITY ASSESSMENT WITHIN UKRAINIAN NPPS LTO JUSTIFICATION

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Introduction

According to “European Nuclear Safety Regulator's Group ENSREG .1st Topical Peer Review Report «Ageing Management». October 2018” (Ageing Management Programme) on concealed pipework have not yet proven to be effective, as they have only recently been introduced. With respect to long-term operation (LTO) two problems arise for effective ageing management. The first one is linked with buried or underground location of concealed piping and general inaccessibility for inspection using conventional techniques as result. So, the decision about future safe operation must be justified based on inspection in accessible locations and indirect non-destructive testing. The second issue relates to strength assessment of multibranch concealed piping as methods and requirements for calculation of buried and underground piping are not well-developed and verified in comparison with techniques for main equipment of NPP.

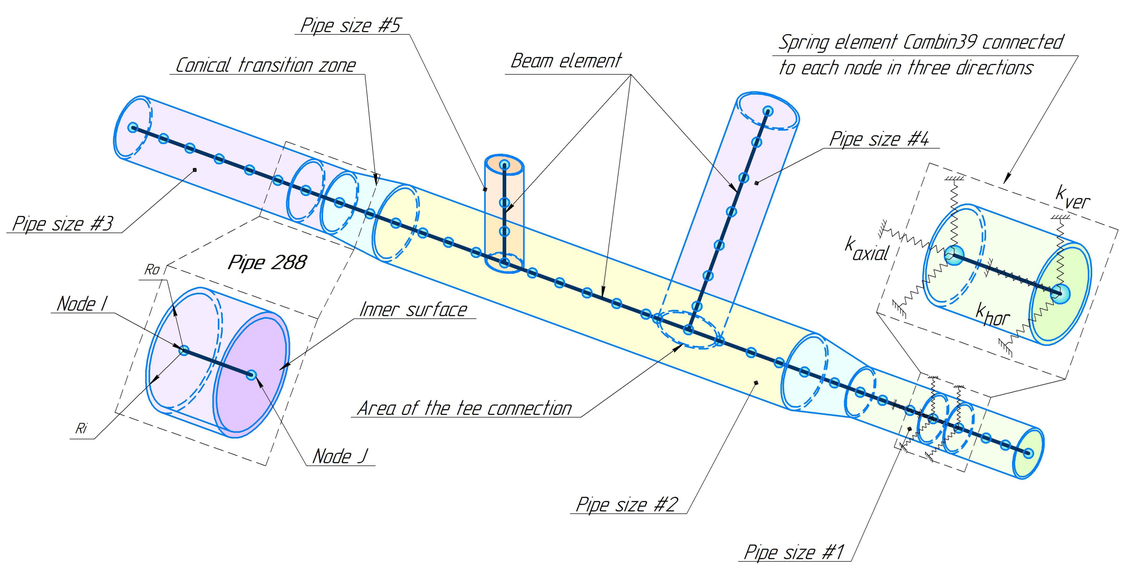
The main aim of the project is to present recent experience regarding concealed piping LTO justification for Ukrainian NPPs. The work included non-destructive techniques as well as numerical modelling of concealed piping for different types of strength assessment.

Non-destructive Testing (NDT)

Basic testing methods:
base metal and welds inspection in accessible places (visual, ultrasonic etc.); hardness testing; coating quality testing; adhesion; internal inspection; out-of-roundness measurement; wall thickness measurement.
Additional testing methods:
measurement of soil electrical resistivity; measurement of DC and AC stray currents to assess the electro-corrosive activity of the environment; magnetometry diagnostics; acoustic-emission diagnostics.

Numerical modelling for strength assessment

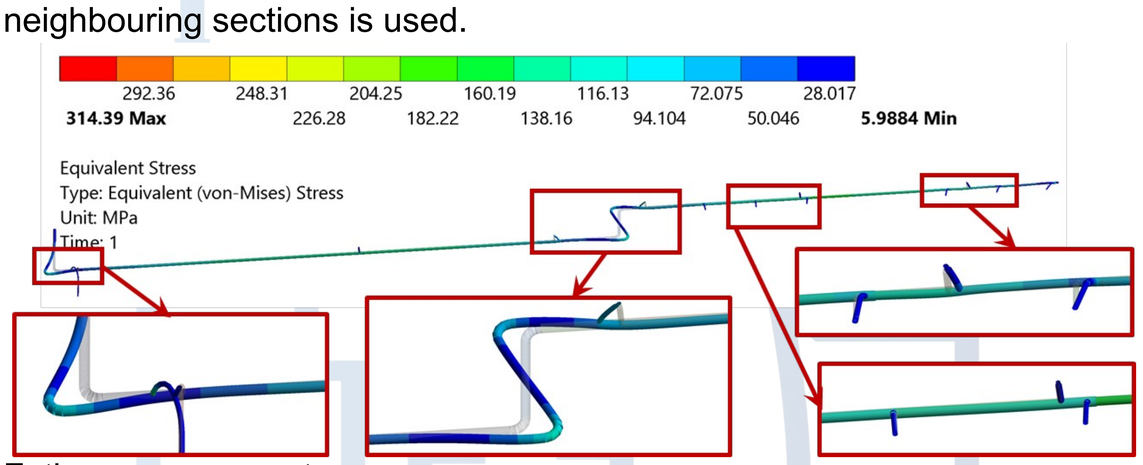
Pipe-soil interaction model



Non-linear springs in all three directions in the model for multibranch concealed piping system are used

Static analysis

Piping system design preliminary analysis has been performed to determine the pipeline sections for separate calculations. Overlapping between neighbouring sections is used.

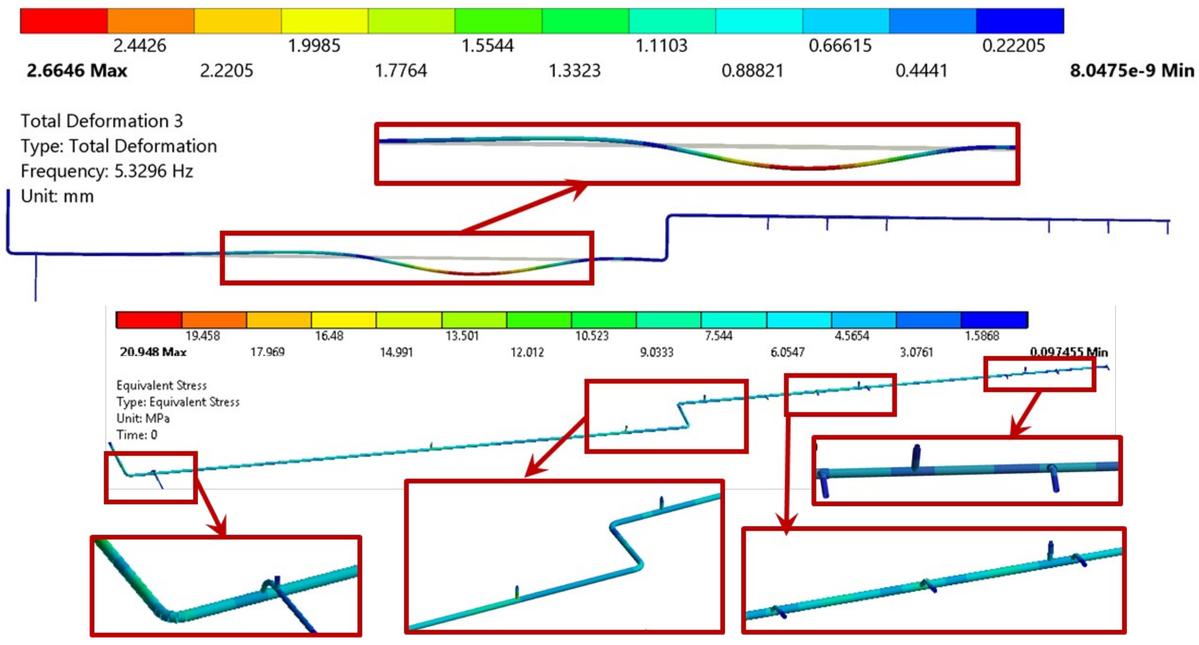


Fatigue assessment

The number of load cycles for concealed piping is not regulated as a rule. During almost the entire period of operation, the piping is under normal operation conditions. Possible cycles of loading includes technical inspection every 8 years if draining for internal testing is used, seasonal water level changing, hydraulic testing.

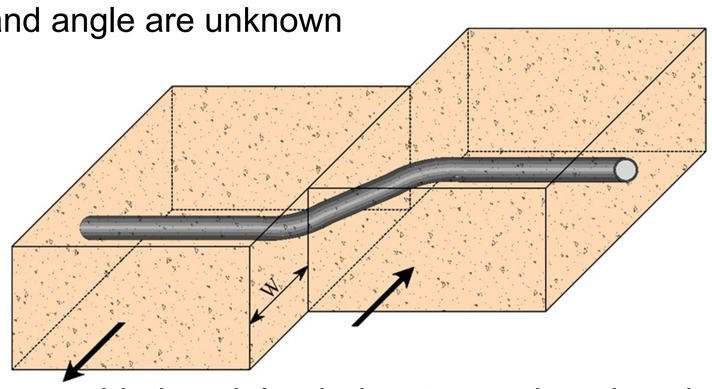
Seismic analysis

Conventional oscillation under seismic influence



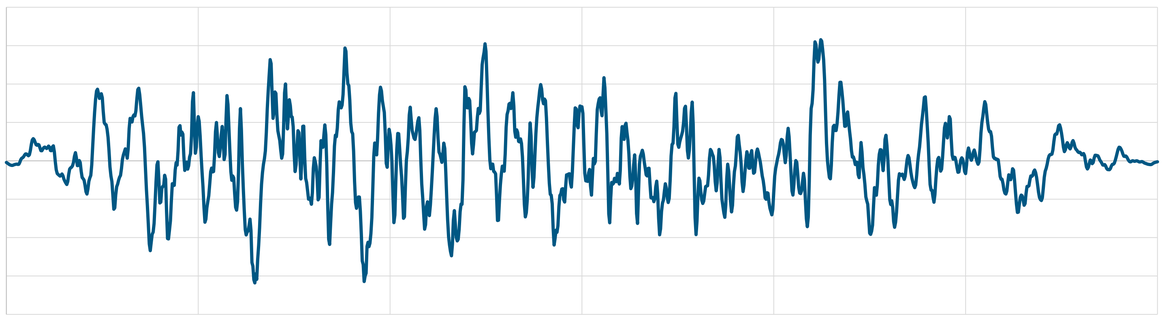
Permanent ground-induced load

Schematic of a pipeline crossing a strike slip fault at a crossing angle. The value of *W* and angle are unknown

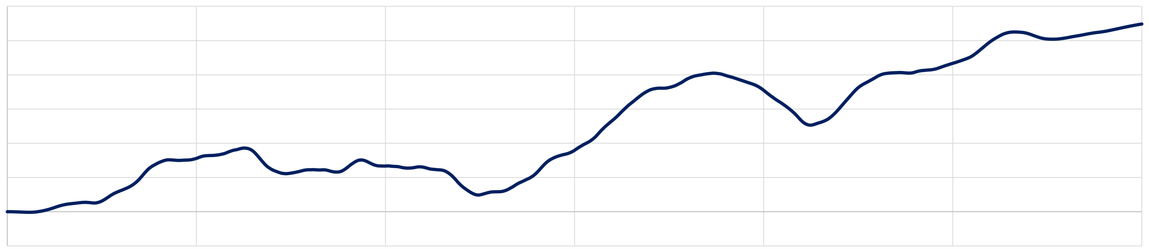


Permanent ground-induced load due to earthquakes is one of the main calculation issues for integrity assessment of the buried piping. The problem is the absence of a methodology on how to obtain the correct value of permanent ground displacement after seismic influence, depending on its magnitude.

Acceleration (X, Y, Z)



Displacement (X, Y, Z)



Values of permanent ground displacements at the end of oscillation process are used in stress calculation by geometrically nonlinear numerical procedure for pipe-soil interaction

Conclusion

The first challenge in LTO justifications arises from the general inaccessibility of concealed piping systems for NDT using conventional techniques, as well as the inability to conduct continuous monitoring of their structural integrity during operation. The second challenge pertains to seismic analysis, which involves two primary types of loading: (1) permanent ground-induced displacement due to seismic events and (2) common oscillatory effects. Given the lack of a standardized methodology for accurately determining permanent ground displacement following seismic activity seismic accelerograms as input data for final soil displacement determination after earthquake are used.