

Specification for piping vibration/fatigue assessment

For plant or facility piping systems, including small bore connections (SBC).

Scope

Piping Vibration Integrity Assessment (Energy Institute)

The supplier shall perform a Piping Vibration Integrity Assessment based on the Energy Institute (EI) Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework, 2nd Ed., 2008 (known as AVIFF guidelines). The likelihood of failure (LOF) for the main line piping (and SBC, if required) will be calculated for screening purposes.

The scope of the Main Line Analysis includes:

- Flow-induced Turbulence (FIT) Study of main lines with flow (gas and liquid systems)
- Mechanical excitation evaluation (gas and liquid systems)
- Reciprocating pump and compressor pulsation evaluation (gas and liquid systems)
- Centrifugal compressor pulsation evaluation (rotating stall, gas systems only)
- Flow-induced Excitation (FIE, also called Flow-induced Vibration (FIV)) Pulsation Study at dead legs (gas systems only)
- Acoustic-induced Excitation (AIE, also called Acoustic-induced Vibration (AIV)) Study (gas systems only)
- Surge/momentum changes due to Valve Operation Study (gas and liquid systems)
- Cavitation and flashing evaluation (liquid systems only)

An SBC LOF Assessment will be required. This involves assessing each individual SBC on the main line based on key geometric and location information.

Methodology

Depending on the main line LOF (and the ability to make changes to meet the AVIFF guideline), additional EI-specified analysis services will be provided, including:

- Structural Finite Element Analysis (FEA)

This analysis predicts the dynamic response of structures, including piping systems and components. This may include free vibrations (natural frequencies and mode shapes), steady state forced vibrations, and transient forced vibrations. The modelling may be low frequency, which looks at modes of the main pipework and structure, or high frequency, which looks at the shell modes of large diameter pipe

- Acoustic FEA

This analysis predicts the dynamic response of fluid in a piping system and volumes. Similarly to structural FEA, the free and forced vibrations can be calculated at low and high frequencies

- Transient Flow (Surge) Analysis

This analysis predicts the dynamic pressures and forces generated in a piping system caused by a transient event like a sudden valve closure

Depending on the SBC LOF (and the ability to make changes to meet the AVIFF guideline), a detailed FEA of the SBC will be provided, which includes:

- Calculating the mechanical natural frequency (MNF) of an SBC and if necessary, providing recommendations to avoid coincidence with significant expected excitation frequencies
- Calculating the allowable vibration for a given SBC configuration to avoid fatigue failure

Additional assessments

The following additional analyses may be required:

- A Dynamic Transient Study for centrifugal compressor surge control system
- A Dynamic Surge/Water Hammer Analysis to determine transient forces and loads
- Piping Flexibility (Thermal) Study to calculate the stress, loads, and deflection due to pressure, temperature and weight

- Shell Transverse Acoustical Analysis on piping near centrifugal equipment to predict coincidence of the pipe shell modes and transverse acoustic modes excited by vane passing frequency
- Pulsation and Vibration Study on reciprocating compressor installation as per API 618, 5th Edition (2007)
- Pulsation and Vibration Study on reciprocating pump installation as per API 674 3rd Edition (2010)
- Field Vibration Assessments confirming actual risk on site

Qualifications

The supplier must be an established design engineer company with at least 10 years of experience providing Pulsation Analysis for compressors and pumps, Mechanical Forced Response Analysis, FEA, FIV/FIT/AIV Analysis, Shell Mode Analysis, Centrifugal Surge Analysis, water hammer, and other transient analysis studies. The supplier must also have dedicated and trained field analysts who have over 10 years of conducting troubleshooting on piping vibration, including FIV, FIT, AIV, water hammer, SBC audits, integrity investigations, pulsation measurements, and foundation/skid dynamics.

Required information

- Piping isometrics showing pipe diameters, thickness, flange rating, and support locations
- Process line lists showing fluid properties and flow rates
- Process flow diagrams
- Equipment and valve vendor data

Deliverables

- Piping Integrity Assessment report based on the EI AVIFF guidelines
- Recommendations for main line modifications including pipe clamp recommendations, flow and operation recommendations. If modifications cannot be made, then recommendations for further specialised analysis
- Recommendations for SBC modifications including bracing and relocation. If modifications cannot be made, then recommendations for further specialized analysis