RECIPROCATING PUMP
Selection Guide for Pulsation Studies

Pump Pulsation Study Options

There are three different approaches (scope) for a pulsation analysis. The following guidelines are used to select the appropriate scope of work for a new reciprocating (or plunger) pump installation. For more information on pump pulsations, see the comments below.

Design Approach 1 (DA1)
No pulsation study, good engineering judgment

- **Non-critical application (no significant impact if unit fails)**
- **Experience with similar units indicates the likelihood of successful operation**

Design Approach 2 (DA2)
Digital pulsation study, valve dynamics, basic mechanical review of piping system (*)

- **Important application, or**
- **Speed above 200 RPM or variable speed applications, or**
- **Multiple units are online,**
- **Variable operating conditions, or**
- **Higher power applications (above 50 kW)**

*** A Design Approach 2 analysis should be performed if any of the above design factors are required.**

Design Approach 3 (DA3)
DA2 and Mechanical Analysis of the Piping System (**)

- **Critical application – requiring very high reliability, or**
- **Offshore operations (platforms, FPSOs), or**
- **Elevated piping.**

**** Any of these factors require more detailed mechanical analysis of the piping system.**

Note DA3 is an additional level of analysis not outlined in API 674.

Vibration Problems with Reciprocating Pumps

These pumps create dynamic pressure pulsations that interact with the piping system to create acoustical resonances and cause the following problems:

- High pressure pulsation induced forces in piping may cause excessive vibration and piping failures,
- High pressure pulsation at the relief valves may lead to pressures exceeding the opening pressure setting of the relief valve, and
- Pressure pulsation may result in pressures inside the pump chambers, at the suction valves, inside the suction manifold, and in the piping dropping low enough to cause bubbles of gas to form (cavitation).

To avoid these problems, a pulsation study is performed on the pump and piping system. The need for a pulsation analysis is based on a number of factors, including:

- Pump speed, type of fluid, and size (power),
- Number of pumps and plungers, and
- Maintenance/operational considerations such as remoteness of the location, reliability requirements, economics, spared units, piping layout, etc.

Pulsation Study Scope

API Standard 674 (June 1995) defines the pulsation and vibration control requirements for a positive displacement (plunger) pump. An additional level of analysis (DA3) is recommended for more complex applications.

Design Approach 1 (DA1) – Good Engineering Practice

- Does not require a pulsation (acoustical) study
- Design based on good piping layout and support principles, adequate Net Positive Suction Head available (NPSHA)

Design Approach 2 (DA2) – Pulsation Analysis per API 674

- Proven acoustical analysis software required. The analysis should be based on a Time Domain (TD) solver to ensure sufficient accuracy. Older software programs based on "Frequency Domain" solver shall not be employed.
- Evaluate acoustics of the entire pumping system and predict pulsations and shaking forces throughout the system versus guidelines. Evaluate pulsation control solutions and recommend a design that is practical for the application.
- Provide the minimum suction pressure required to prevent cavitation based on the pulsation amplitudes.
- Mechanical review of the piping system to evaluate pipe runs and support details (clamp design and spacing).
- Review the pump skid design and make recommendations for adding beams or local stiffness.
- Review small diameter branch connections (for example: instrument connections, level gauges) and make recommendations for support or layout changes to minimize failures. Recommendations are based on past experience and best practices.

Recommended Option: It is recommended to evaluate and, if necessary, adjust the pump's valve dynamics once operational. The information necessary to complete a Valve Dynamic Analysis (VDA) is often not available during the package design stage. A field test has been found to be much more accurate than attempting to model the valve behavior.

Design Approach 3 – DA2 above plus a Mechanical Analysis

- Pulsation and mechanical review (per DA2)
- Prepare a Finite Element Analysis (FEA) of the piping system. Calculate mechanical natural frequencies (MNFs) and recommend changes to ensure the MNFs are 20% above the plunger passing frequency.
- The report shall include a summary of calculated MNFs vs. order of run speed as well as mode shape plots.
- Approved FEA software shall be used for the analysis. The software shall have capabilities to simulate structures using 3D solid and shell elements. Approved software packages include ANSYS, Nastran, and Cosmos.
- Piping FEA software, such as CAESAR II, AutoPIPE and other similar software programs shall not be approved for this application.