Southwest Research Institute

PREDICTING VORTEX-SHEDDING INDUCED PULSATION AMPLITUDES IN PIPING SYSTEMS

INCREASED CUSTOMER DEMAND

Shale gas ramp-up has significantly increased U.S. natural gas production

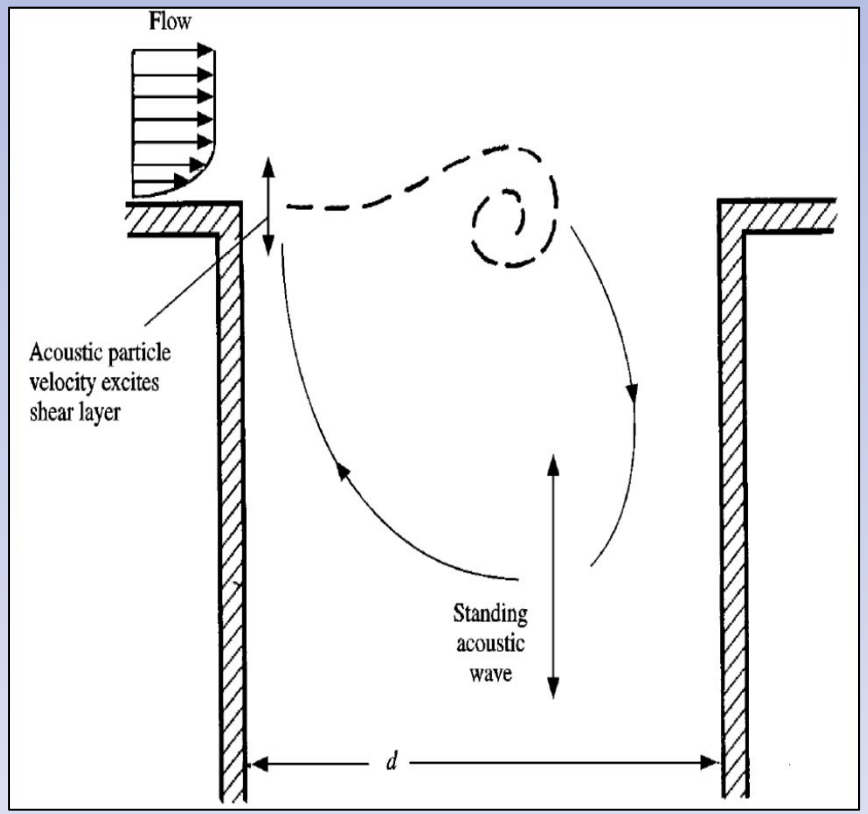
Geographic locations of new production has changed, resulting in changes and additions to the gas pipeline grid

Centrifugal compressors are increasingly becoming the pipeline compressor of choice, higher gas flows in metering areas and hubs

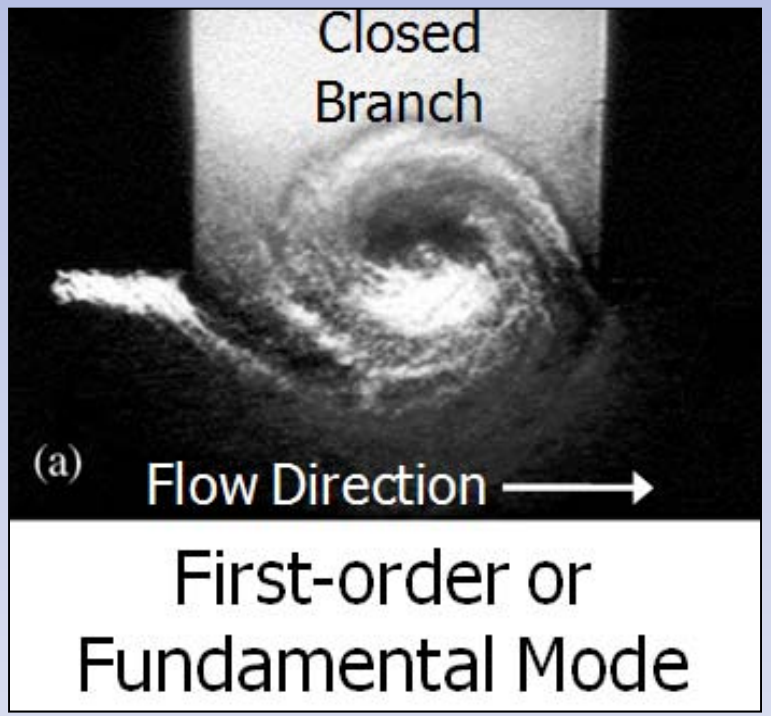
Result – an increase in pulsation control analysis requests for new compressor installations, meter stations, and hubs

VORTEX SHEDDING

Vortex shedding is the primary source of low-frequency pulsations in centrifugal compressor piping systems.



Feedback mechanism of flow-excited acoustic resonances at closed side-branches (Ziada & Shine, 1999)



Side-branch Pulsation in Water (S. Dequand, et al.)

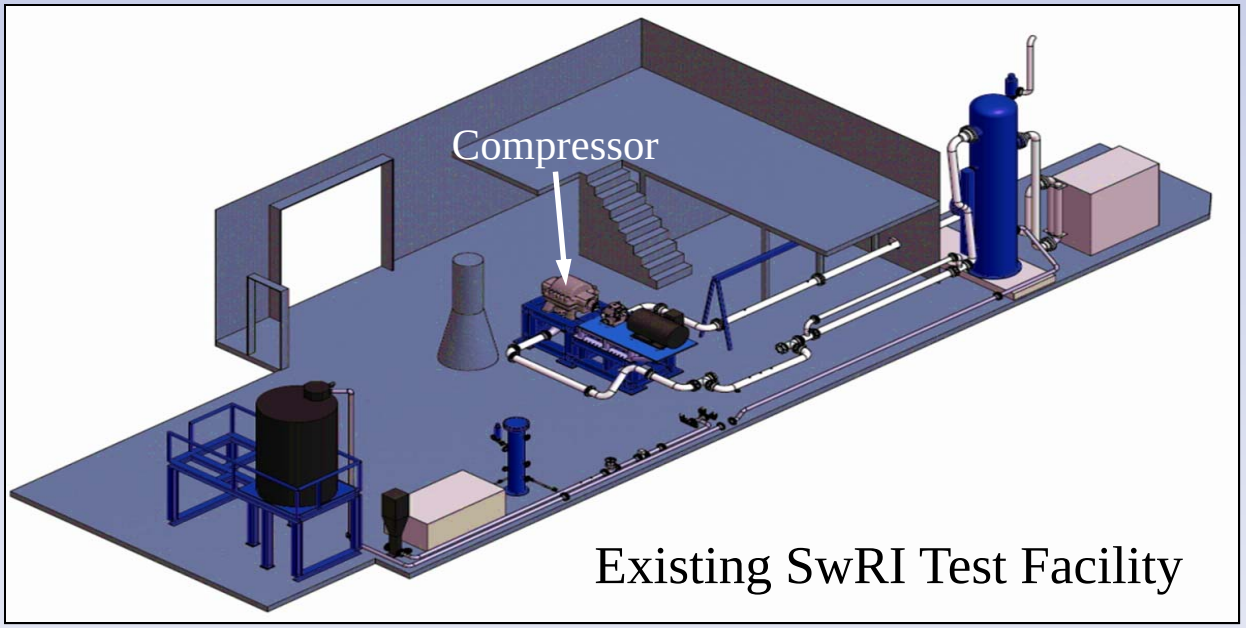
CURRENT ANALYTIC TECHNIQUE

Vortex Shedding Screening Analysis

- Frequency avoidance method: a separation margin is maintained between the calculated Strouhal shedding frequency and the predicted acoustic natural frequencies.
- Cannot currently predict pulsation amplitudes when frequencies coincide to determine if amplitudes are acceptable.
- Results in reduced operating flexibility and costly piping changes to avoid frequency coincidence.
- Clients have requested amplitude predictions at frequency coincidence to determine if pipe clamps would suffice.

EXPERIMENTAL TESTING (INITIAL)

- Utilize an existing test air flow loop equipped with a 750 HP centrifugal compressor, instrumentation, and data acquisition system. Air flow at 775 acfm at 250 psi.
- Used various side-branch configurations and main pipe diameters
- Record pressure histories at various points in the flow loop and side branch to obtain pulsation amplitudes and Strouhal numbers of excitation to provide foundation for response surfaces.



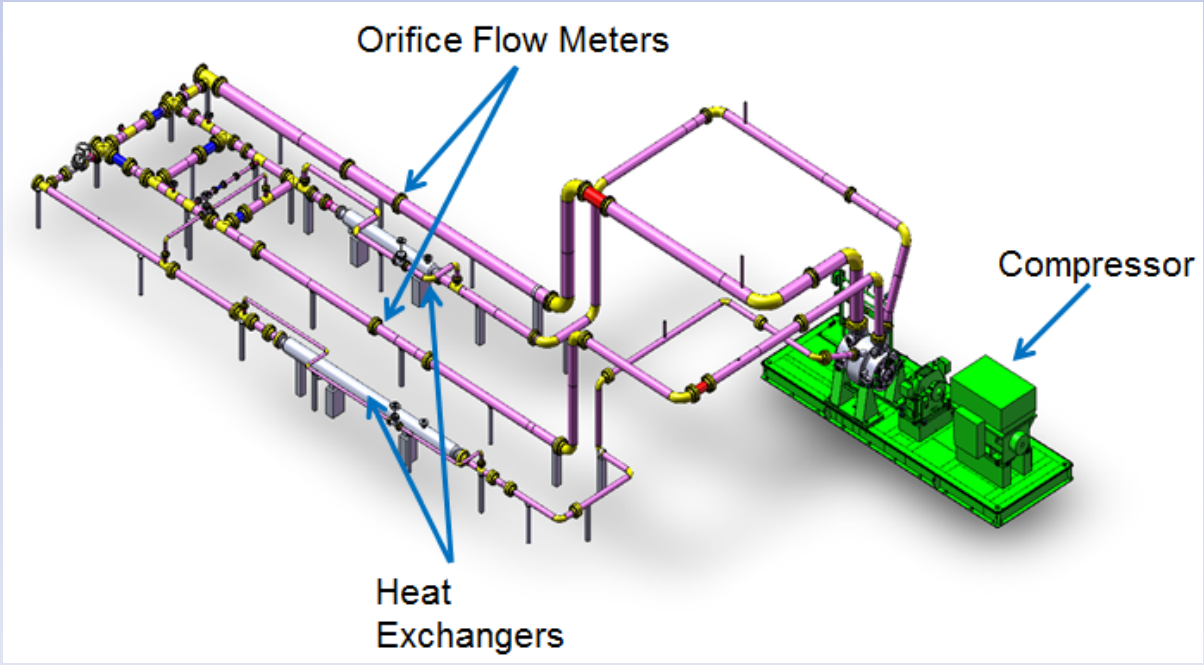
Existing SwRI Test Facility

EXPERIMENTAL TESTING (MRF)

- Additional testing with various branch configurations performed at SwRI's Metering Research Facility with a 1300 HPcompressor.
- Transmission grade natural gas with a flow rate of 1,550 acfm at 700 psi.

EXPERIMENTAL TESTING (TURBO LAB)

- Additional testing with various branch configurations will be performed at SwRI's new CO_2 compression loop with a 3,000 HP, 6-stage compressor.
- Gas flow velocities from 30 ft/s to well over 120 ft/s.



BENEFITS TO SWRI'S CLIENTS

- Clients would have available an additional analysis option that is not offered by any other engineering company to determine if the use of pipe clamps would suffice when acoustic coincidences occur.
  - It would be cheaper to perform an analysis than increase tee and piping size or make other piping changes.
  - In the normal rush to complete projects, piping is often already installed by the time the pulsation control analyses are complete, so proposed changes (other than the addition of pipe supports) are too difficult / costly to make.
  - Changing gas composition or re-staging of compressor units at existing installations, where piping changes are difficult, can create pulsation problems that might be mitigated by the use of pipe clamps when coincidences are predicted.

Questions?