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Abstract Cover Sheet

Paper Title **Identifying and Mitigating Flow-Induced Vibration in Recycle Loop Gas Piping at a Centrifugal Compressor Station**

Author(s) & Title(s)
Eugene (Buddy) L. Broerman, III –– Senior Research Engineer (SwRI)
Jason T. Gatewood –– Research Engineer (SwRI)
James T. O'Grady –– Engineer (SwRI)
Russell F. Troy, P.E. –– Project Engineer – Compressor Stations (Spectra Energy)
Charles L. Rand, Jr., P.E. –– President (RSH Engineering)
Gary T. Stroud, P.E. –– Project Manager (RSH Engineering)

(main contact listed first – all the below information is for that person)

Presenter(s)* Eugene (Buddy) and Jason

Company Southwest Research Institute (SwRI)

Address 6220 Culebra Road

City/State/ZIP/Country San Antonio TX 78238-5166

Telephone 210-522-2555 e-mail ebroerman@swri.org

Has this paper been presented or published previously? Yes – The paper was presented at the IPC 2010, which was held the week prior to the GMC 2010.

Unique, new, or useful information presented by the paper.

1. A case study is presented that includes field data associated with a vibration problem, analyses, system modifications, and the observed vibration improvement.

2. Lessons learned are presented, including brief description of cost benefit of performing an upfront analysis.

3. The paper presents pulsation and vibration data as a function of recycle loop valve position.

Abstract for

Identifying and Mitigating Flow-Induced Vibration in Recycle Loop Gas Piping at a Centrifugal Compressor Station

Centrifugal compressors are often used in pipeline compression applications where high flow rates are required. Under certain operating conditions, high flow rates past branched connections in the piping system can result in vortex shedding at the strouhal frequency. Significant excitation energy is generated if the stouhal frequency matches the acoustic resonance frequency of the piping side branch. This excitation energy can lead to undesirable piping vibration. Further coupling of the excitation energy with a mechanical natural frequency of the piping system will lead to increasingly undesirable vibration. During the commissioning of the Southeast Supply Header's Lucedale Compressor Station, unsafe vibration levels were observed in the recycle gas piping near the surge control valves during certain operating conditions. An on-site analysis was conducted to measure the amplitude and frequency of the compressor piping vibration over a range of operating conditions. The on-site analysis provided evidence of flow-induced vibration in the recycle gas piping. An acoustic and mechanical response analysis of the piping system was conducted to verify the conclusions of the on-site analysis and determine the necessary piping modification needed to eliminate the flow-induced vibration. The acoustic analysis determined that vortex shedding frequencies were coincident with acoustic resonance frequencies of the fast stop valve side branch. The acoustic excitation was eliminated by modifying the branch connection length and flow path through the connecting tee. The mechanical response analysis was conducted to ensure that piping modifications were implemented in a manner that resulted in an acceptably supported piping system. Piping modifications were implemented and the flow-induced vibration was eliminated allowing safe operation throughout the desired operating range. The lessons learned from this study were applied to other centrifugal compressor stations that were in the design phase. This paper will discuss the background of the station installation, field study (including data), acoustic and mechanical analyses (including data), implementation of the recommendations and lessons learned.

Biography for Eugene "Buddy" Broerman:
Eugene Broerman (nickname – Buddy) graduated with a Bachelor of Science in Mechanical Engineering and a minor in Computer Science in 2001 from Texas A&M University – Kingsville. Buddy then began working at Southwest Research Institute in the Machinery Piping Design Section of the Fluids Engineering Department where he is currently a Senior Research Engineer. Buddy has experience in the fields of acoustics, vibrations, compressor performance, and piping design. He has performed the acoustic design/study of complex piping systems with the aid of the GMRC Compressor System Analog, the GMRC Interactive Pulsation and Performance Simulation (IPPS) digital acoustic design tool, and SwRI's proprietary digital acoustic design tool (TAPS). He has also performed mechanical and thermal analyses of complex piping systems with the aid of ANSYS (finite element [FE] software) and Caesar II. These analyses have been performed on existing and new installations of compressor and pump systems. His experience also includes various field studies regarding compressor pulsation, vibration, and performance issues. From 2004 to the present Buddy has been a principal contributor in the GMRC funded research and development of advanced pulsation control system prototypes. This research has, to date, produced multiple prototypes that have been successful in significantly reducing reciprocating compressor system pulsations. Commercialization of several of the successful prototype concepts is currently in the works. **MEMBERSHIPS:** American Society of Mechanical Engineers (ASME), Tau Beta Pi (Engineering Honor Society), Pi Tau Sigma (Mechanical Engineering Honor Society).

Biography for Jason Gatewood:
Mr. Gatewood is a Research Engineer in the Fluid Machinery Systems Section at Southwest Research Institute. Mr. Gatewood graduated from the University of Florida with a B.S. in Materials Science and Engineering (2003) and has also completed courses towards an M.S. in Mechanical and Aerospace Engineering from the University of Florida with a concentration in Thermal and Fluid Sciences. As a field engineer at SwRI, Mr. Gatewood has performed vibration and pulsation studies on many centrifugal and reciprocating compressors for the gas processing and transportation industries. Mr. Gatewood has considerable experience helping operating companies identify and mitigate the sources of vibration and performance degradation in gas and liquid handling machinery and the associated piping systems. Prior to coming to SwRI, Mr. Gatewood was an engineer at Trow Engineering Consultants, Inc. where he provided engineering support for large diameter pipeline construction and permitting. Mr. Gatewood is an active member of the ASME and an active volunteer in the community, where he has assisted with United Way campaigns and volunteered for the American Red Cross.