# On Pump Annular Seals Operating with Multiple-Phase Conditions: Measurements and Gas Injection to Increase Seal Centering Stiffness

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The lecture presents measurements of leakage and dynamic force coefficients for six distinct annular pressure seals operating with an air in oil mixture ranging from pure liquid to just air. The comprehensive test campaign reveals the salient characteristics of various annular pressure seal configurations, thus aiding to better design multiple-phase flow centrifugal pumps.

**Keywords (from 3 to 5 max):** annular seals, rotordynamics, two-phase flow

## 1. Introduction

In the subsea oil and gas industry, multiphase pumps enable a long distance tie back system and eliminate topside oil and gas separation stations. A persistent challenge to operate (vertical) centrifugal pumps handling (gas in liquid) mixtures is their poor reliability due to persistent sub synchronous vibrations. The mixture gas volume fraction (GVF), changing over the life of the well, affects the forced performance of leakage control components, namely seals, and which may lead to an increase in lateral and axial rotor vibrations. The lecture presents measurements of leakage and dynamic force coefficients for six annular seals operating with an air in oil mixture ranging from pure liquid to just air, see Figure 1. The seals have distinct clearances: one is a smooth surface with nominal clearance and a worn clearance twice larger, another has multiple lobes or waves, a third and fourth have step-wise clearances, and the fifth has a grooved surface. Tests with gas injection (GVF~0→0.6) in the oil stream demonstrate the seal recovers its dynamic stiffness, hence promoting rotor stability in large hydraulic pump/turbine systems. Air injection into a liquid stream causes a dramatic reduction in the mixture sound speed to make it highly compressible; hence the hardening of the seal centering stiffness [1]. Predictions of seal force coefficients derived from a two-phase bulk flow model agree with the test data.

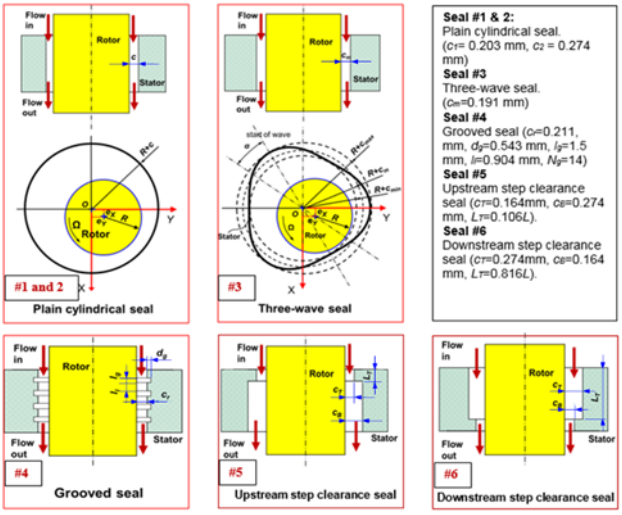

Figure 1: Schematic views of six test seals: plain, wavy, grooved and stepped configurations. Clearances exaggerated to illustrate the seal geometry.

## 2. References

[1] San Andrés, L, and Lu, L., 2018, "Leakage and Force Coefficients for Pump Annular Seals Operating with Air/Oil Mixtures: Measurements and Predictions and Air Injection to Increase Seal Dynamic Stiffness, " *Proc. of the 34th Pump Symposium,* The Turbomachinery Laboratory, Texas A&M University, Sept 18-20, Houston, TX, http://hdl.handle.net/1969.1/175007