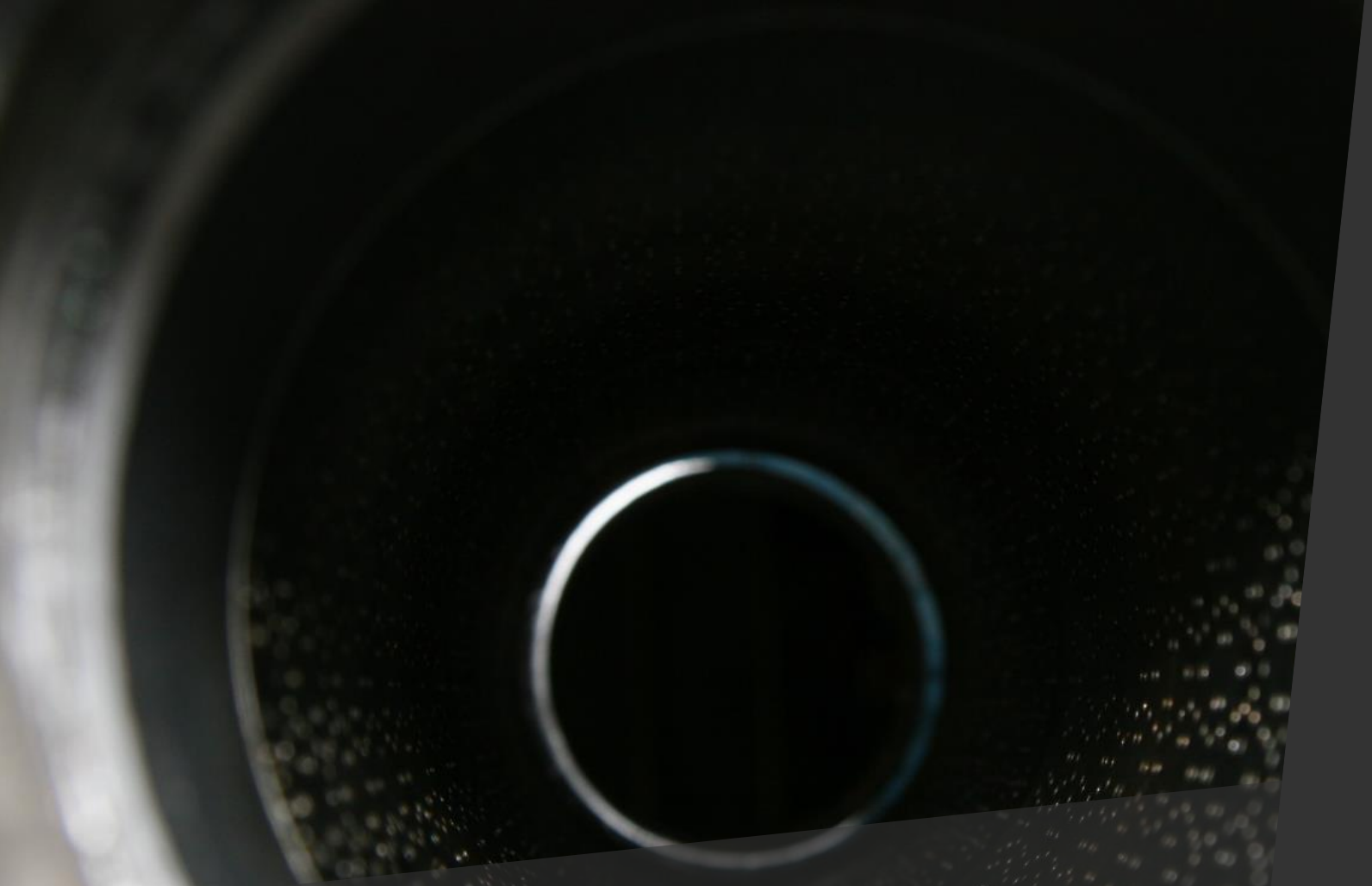

Qualification of Duct Resonator Array for Noise Reduction in Offshore Installations

Sandra Rodiño Palacios – Statoil ASA

Noise in Offshore Installations

Excessive noise can compromise worker's **Health and Safety**

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Our context on the Norwegian Continental Shelf

- ✓ High focus to reduce noise exposure
- ✓ Use of technical barriers, attenuate sound emissions from the source
- ✓ Target turbo-machinery, a major contributor to total noise exposure
- ✓ Provide our projects with flexible and efficient solutions, in terms of sound attenuation, space usage, maintenance, life-cycle, etc.

History of D-R Array in Statoil

2000	Development of D-R™ duct resonator array by Dresser-Rand, a centrifugal compressor noise reduction device
2002	Statoil qualifies D-R array for use **inside compressors**; satisfactorily implemented since
After 2007	Statoil learns the array can be applied as a **spool piece** so-called pipe array. Advantages: no compressor disassembling or internal modification, attenuation irrespective of size/type of compressor
2011	A new qualification process starts; laboratory acoustic measurements are made
2012	**Pipe array** is qualified and been recommended for use

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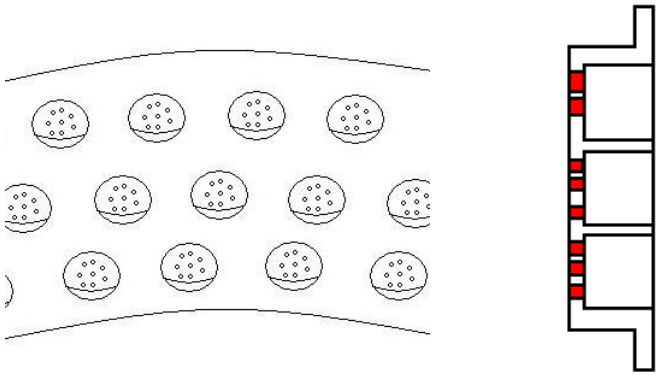
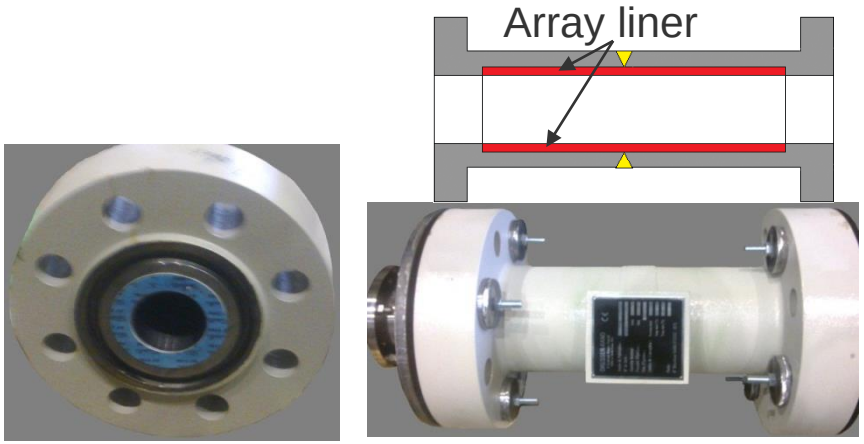
Pipe Array Design

One-piece solid steel tube with acoustic chambers connected to the flow path by a series of perforations



Inserted on a spool piece and applied to the inlet/discharge pipe



Typically delivered with a **4-diameter** effective **length**

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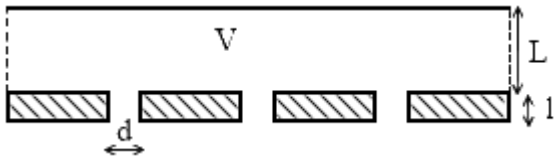
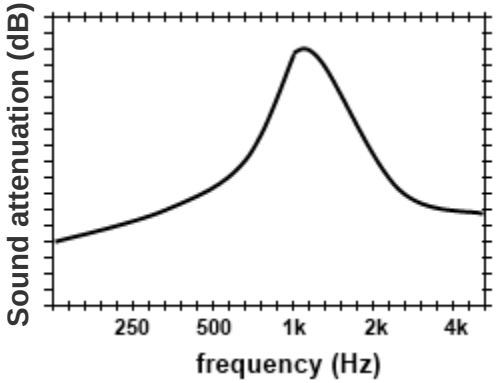
How it works

- Based on Helmholtz's resonance theory, air resonance in a cavity
- At the resonance frequency, f_0, energy loss occurs due to friction and viscosity
- The insert of the array changes the impedance of the pipe wall from acoustically rigid to absorptive



$$f_0 = \frac{c}{2\pi}\sqrt{\frac{P}{L(l+\delta)}}$$



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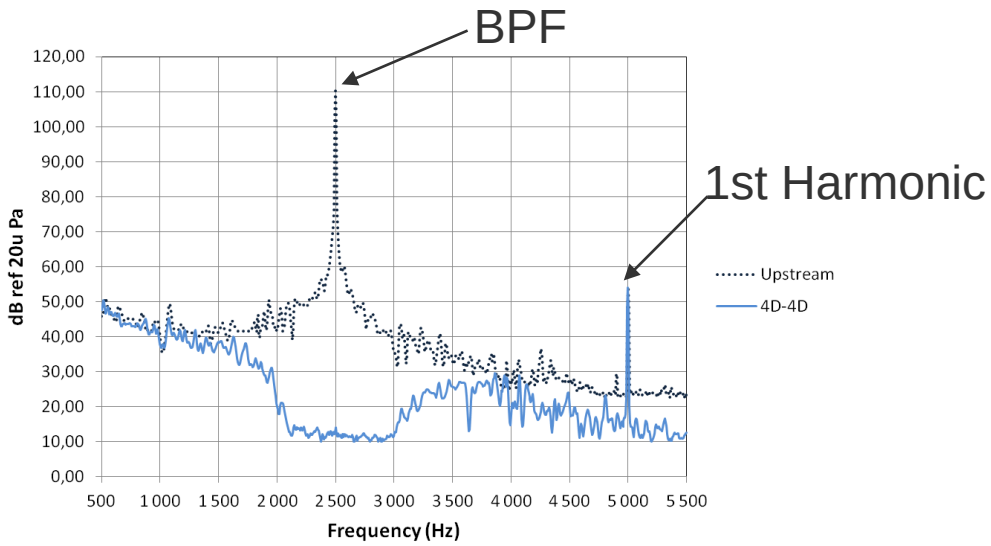
Pipe Array Frequency Response

- Perforations are designed and tuned to reduce the noise at the Blade Passing Frequency of the compressor
- According to manufacturer the overall noise attenuation is 10dBA (or 90% sound power reduction), 4-D length

Example of compressor tonal noise spectrum with (solid) and without (dotted) pipe array of 8-diameter length



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Qualification Process

Evaluate the technology performance

i.e. identify operational consequences and manage risk

Verify the acoustic performance

Laboratory acoustic measurements

Investigate further its characteristics and possibilities for implementation

Accommodate practical conditions in offshore installations

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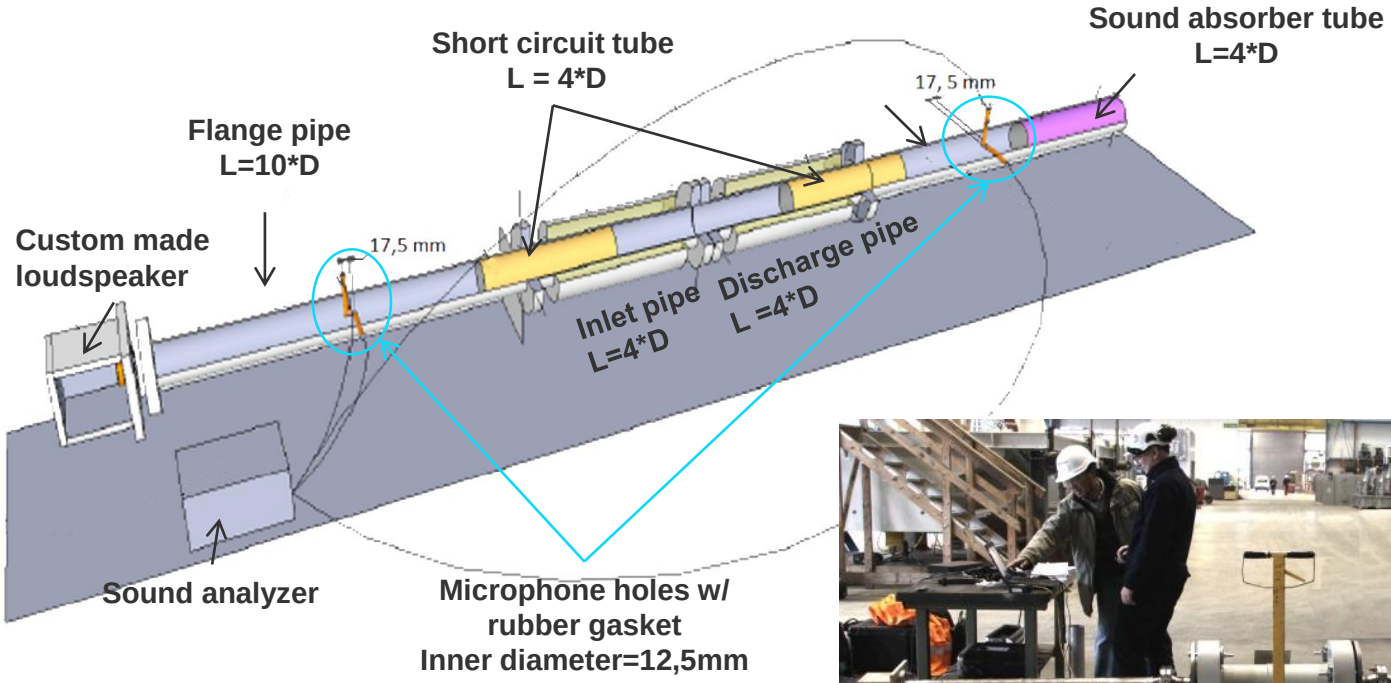
Acoustic Measurements

Sound insertion loss (dB) = difference in sound pressure level measured before and after the resonator



Broadband noise source

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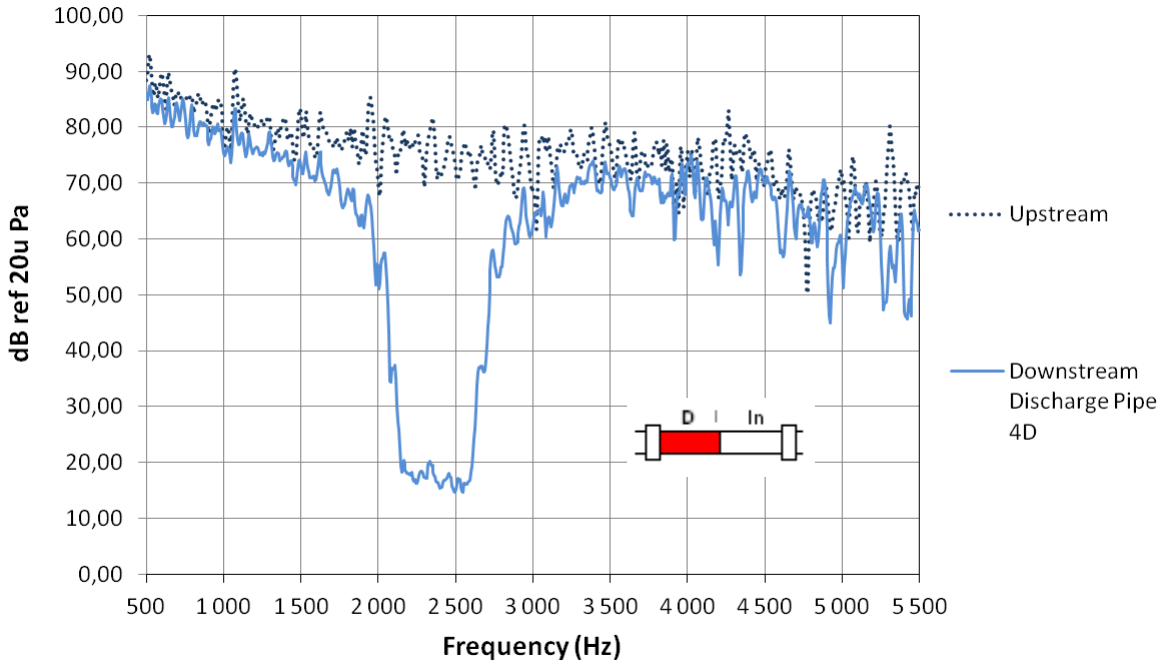
Results – Verification of Attenuation

- Sound attenuation ~14-18dB (4D) at BPF range (2-3kHz)
- At least 7-8 dB overall attenuation (82-85% sound power reduction) – average in octave bands –



Upstream = signal before array
Downstream = signal after array

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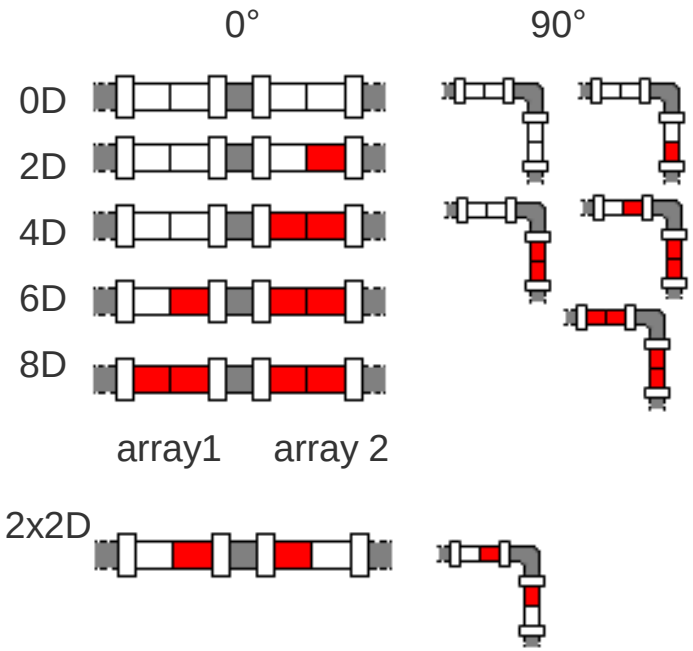
Study of Various Array Configurations

- ✓ Correlation between effective length and insertion loss
- ✓ Effect of applying spool pipe in-series or with 90° bend
- ✓ Effect of dividing a 4D pipe array into 2 spool, 2D each



Active area of array

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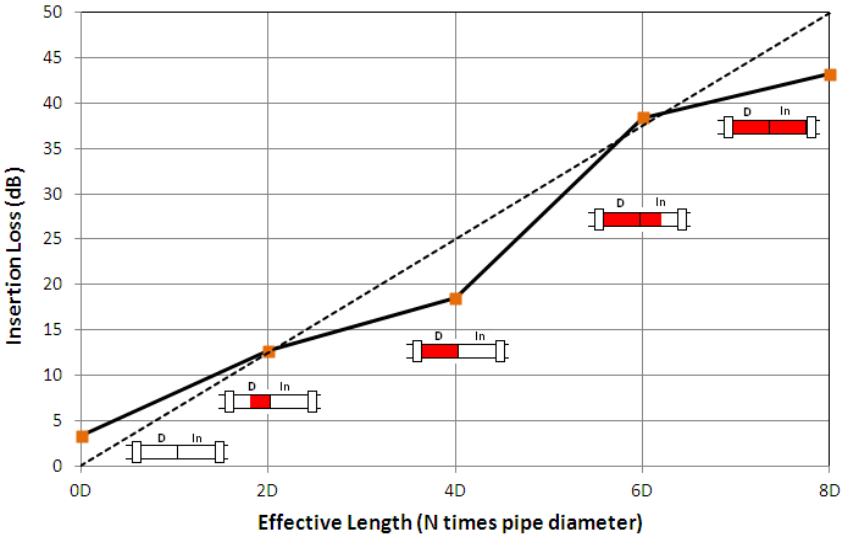
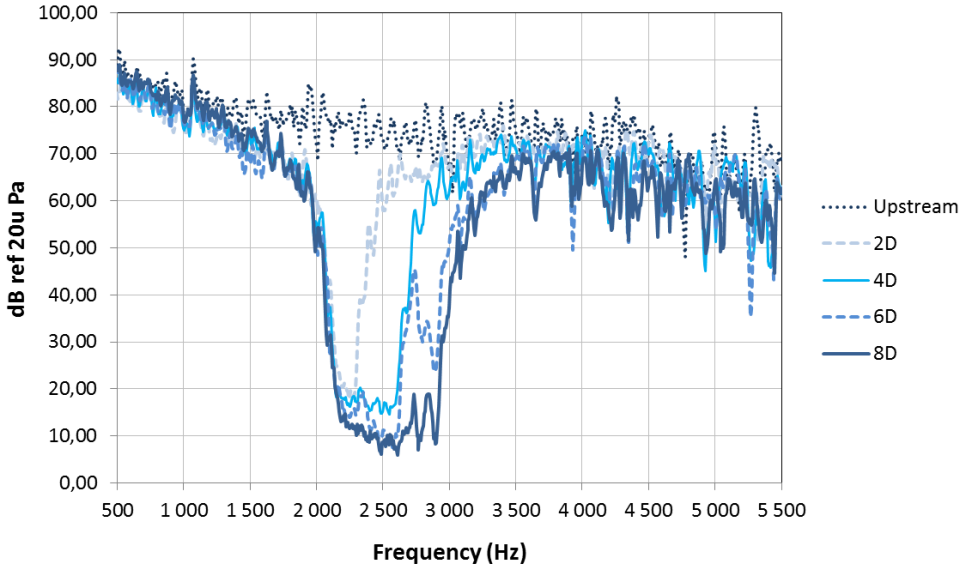
Results – Flexible Length

- Approximately linear correlation between effective area of array and resulting sound attenuation
- The arrays are tuned in the longitudinal direction!





Active area of array

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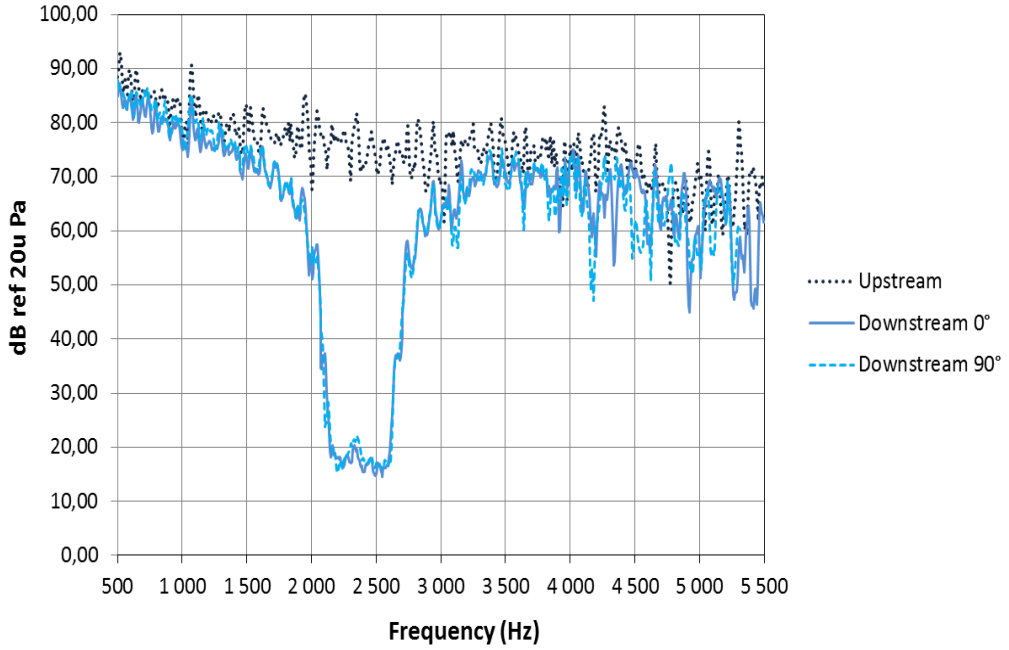
Results – Flexible Setup

- Performance is not diminished by angle of separation between pipes → allows significant flexibility of configuration
- Pipe array is most effective when placed as close to the source as possible!



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Mechanical and Process Assessment

- Design and manufacturing of PDRA reviewed and approved by Statoil piping and material technology specialists
- Gas flow measurements done by DR confirm no pressure drop cause by the presence of the PDRA
- Documented positive effect on pipe vibration
- Means to avoid liquid accumulation:
  - 16% of lower circumference not perforated
  - Drain capability
- No negative impact including corrosion or liquid accumulation of PDRAs in operation reported from other DR customers

Conclusion & Way Forward

- ✓ Significant reduction of the noise level at design frequency
- ✓ Potential flexibility of implementation which can facilitate its use in projects with challenging layouts
- ✓ Compliance with our goals by qualifying and recommending PDRA technology to efficiently reduce noise exposure
- ✓ Positive collaboration between manufacturers and industry to find best fit of technical solutions to installation demands
- ✓ Identified potential for other uses in machinery/applications with distinctive tonal components, e.g. HPU

There's never been a better time for good ideas

Thank you!

Questions?

Thanks to:

DRESSER-RAND & LIFETEC AS

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