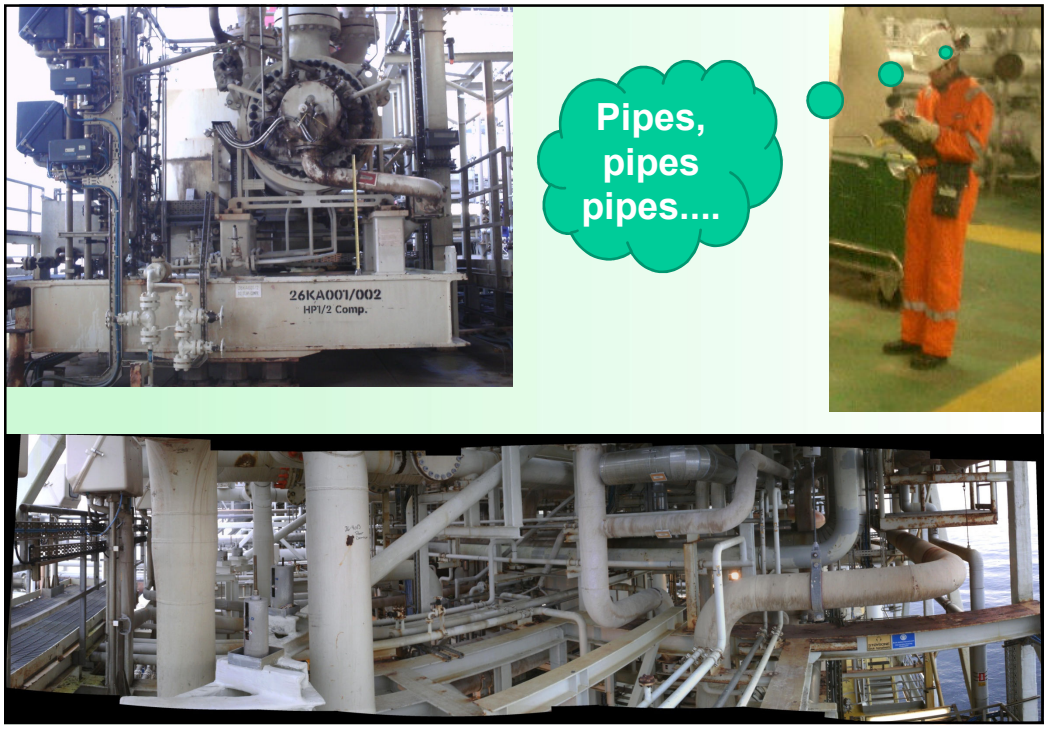
Do We Understand Gas Compressor Pipe Noise?

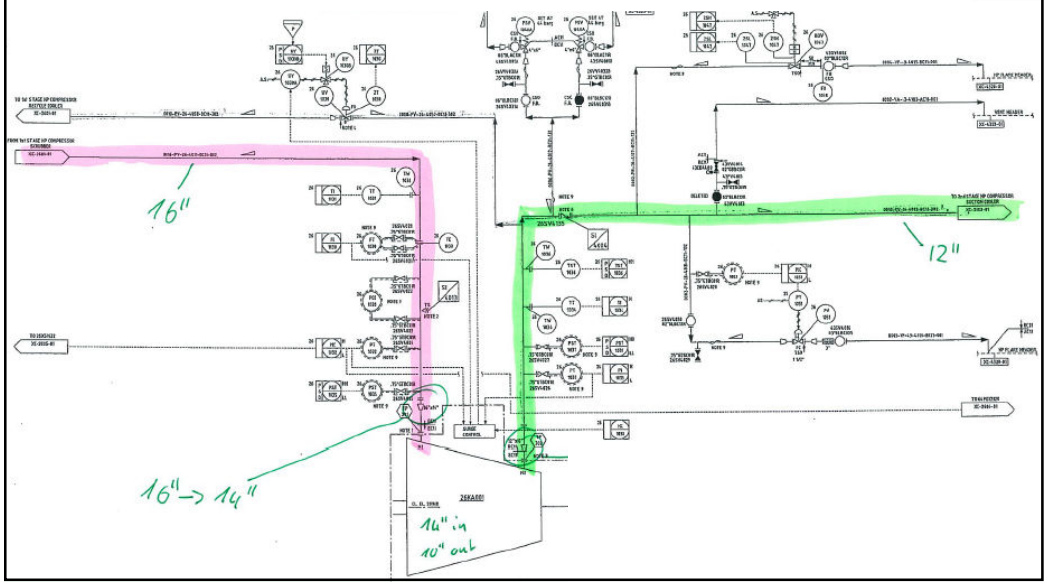
Frank Lemstad, Sinus as

Main topics

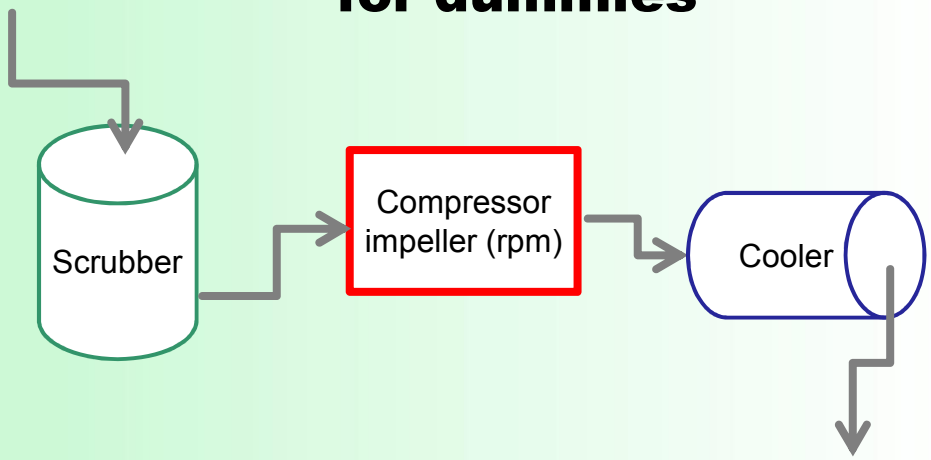
- System overview – why this noise problem?
- Results from measurements of bare pipes
- Prediction method – time for a change?
- Design strategy – recommendations



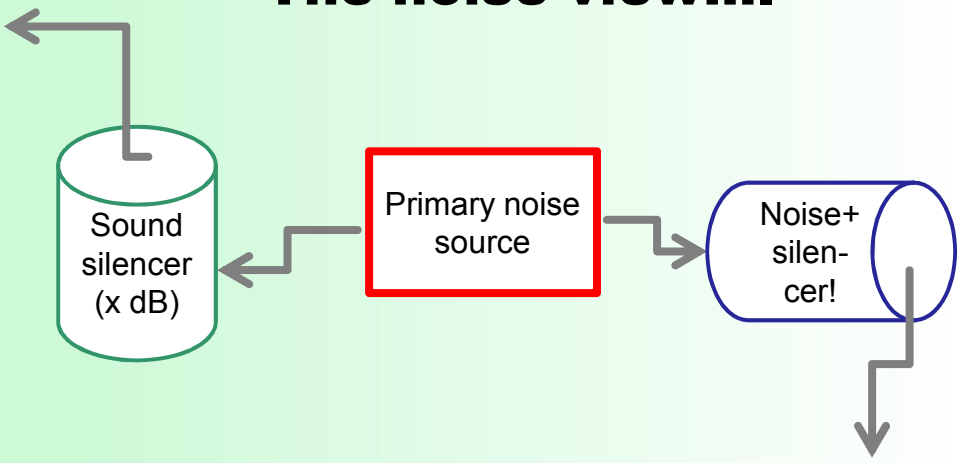
Process system overview!?

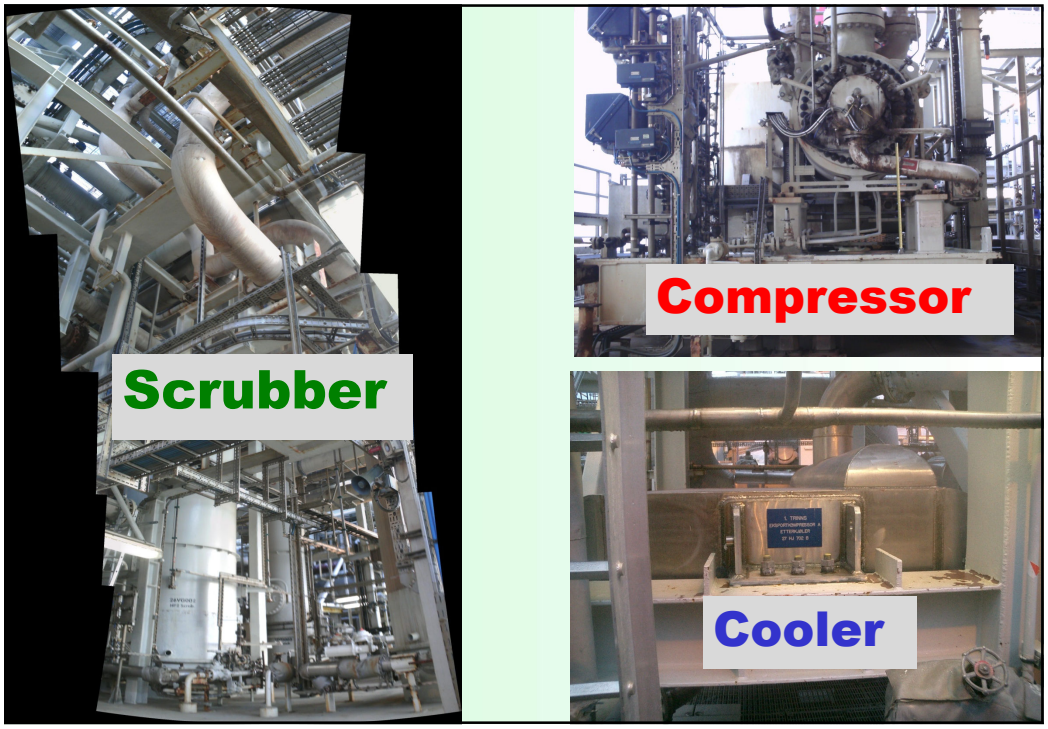


Process system overview for dummies



The noise view....





Case study : Noise emission from bare pipes

1. All insulation removed due to corrosion issues
2. Overall moderate noise increase only
3. Question: How much insulation do we ***really*** need to reapply?

What we ***really*** need...

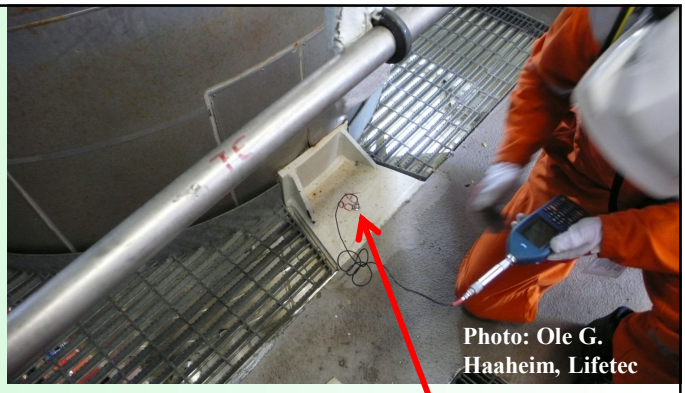
Noise increase

Area	Noise level in dB, no insulation	Noise increase, dB
Scrubber area 1	82 – 90	0 - 1
Scrubber area 2	87 – 95	2 – 3
After cooler area	88 – 99	3 – 8
Aux area	78 - 83	1 – 2

Scope

1. Determine sound intensity for all sections
2. Rank order sound emissions from each line
3. Provide recommendations for new pipe insulation

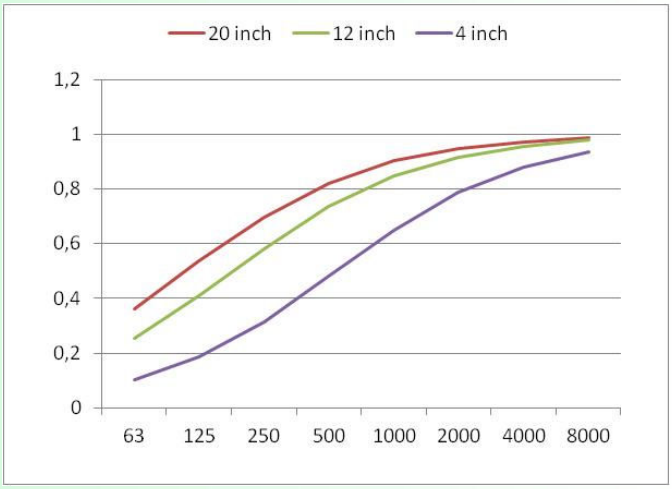
To do...

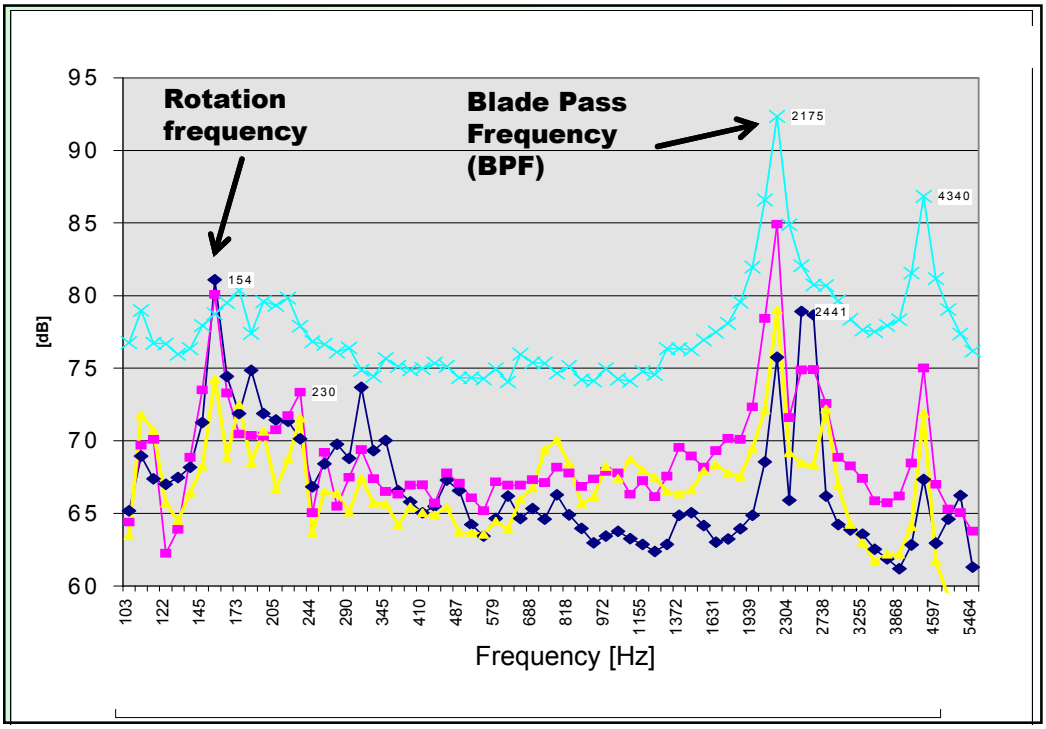


1. **Measure** surface vibrations
2. **Estimate** sound intensity
3. **Calculate** total sound power

From vibrations to sound...

The
Radiation
Factor





Results 1 – LP system

Pipe section	Pipe diameter	Sound Power level per m, dB
Stage 1 - IN	24”	96
Stage 1 - OUT	12” 16”	95 91
Stage 2 – IN	14”	84
Stage 2 – OUT	10”	84
Stage 3 – IN	8”	?
Stage 3 – OUT	6”	77

Results 2 – HP system

Pipe section	Pipe diameter	Sound Power level per m, dB
Stage 1 - IN	16”	95
Stage 1 - OUT	12”	104
Stage 2 – IN	16”	100
Stage 2 – OUT	12”	91
Stage 3 – IN	8”	92
Stage 3 – OUT	8” ?	81

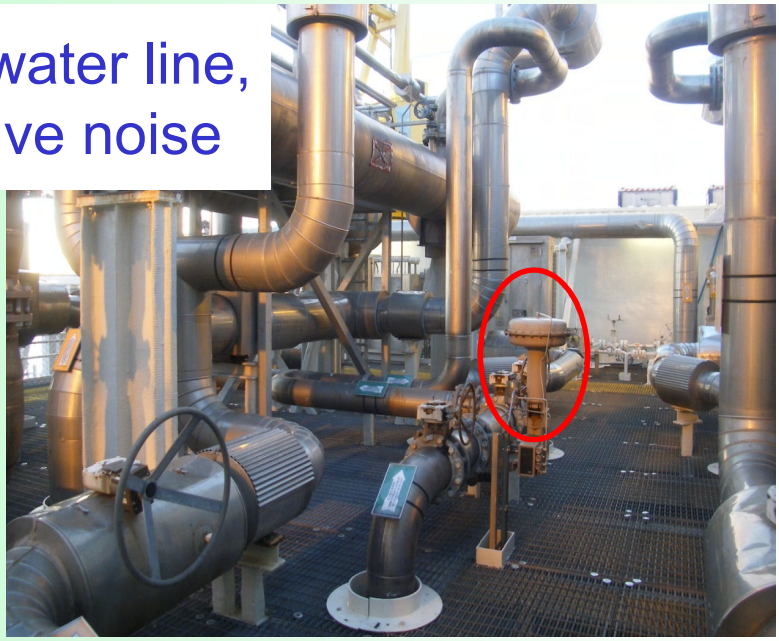
.... and more spaghetti...

...aux pipe lines with varying noise emission

May be:

- Blind piping to PSV
- Recirculation lines
- Cooler medium pipes

Sea water line, valve noise

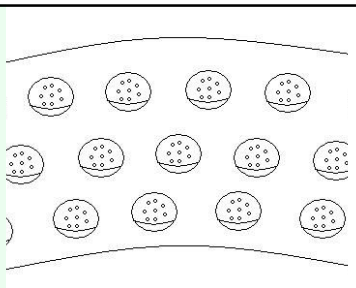


Total SWL and pipe insulation

Total pipe length ≈ 600 m

Alt	Status of insulation	Total Sound Power Level, dB	Reduction, dB
0	None	122	
1	100 m	117	-5
2	200 m	113	-9
3	300 m	106	-16

What if....
a **silencer** or six?

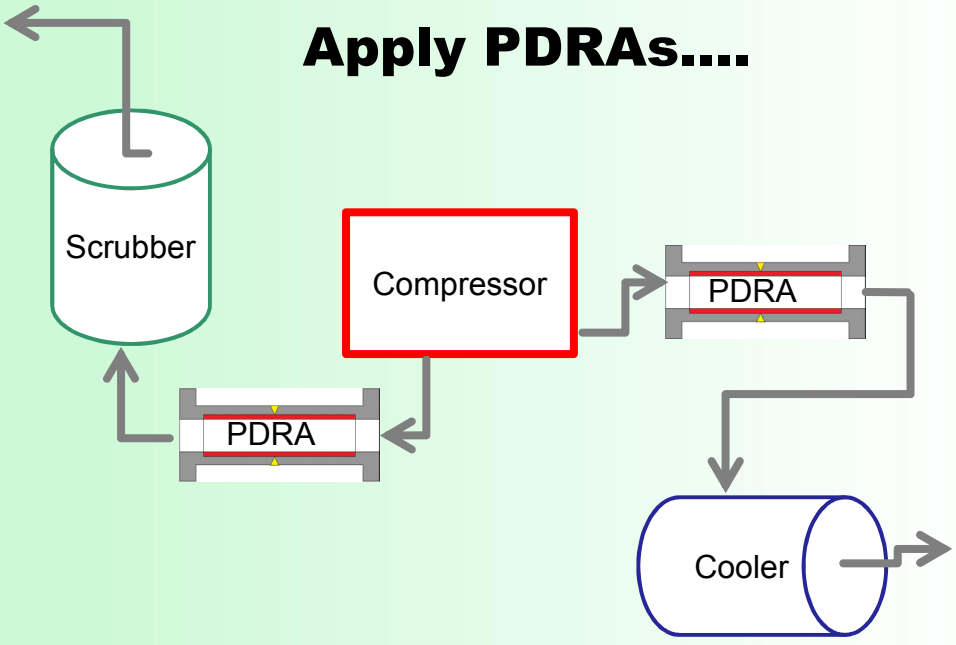


Old system, PDRA not an option at time of design!

BUT AS AN EXAMPLE:

- Assume 10 dB reduction of silencer (PDRA)
- Apply to inlet and outlet of LP1 and HP1/HP2

Apply PDRAs....



PDRA alternative

Guesstimate…

Alt	Status of insulation	Total SWL, dB	Reduction, dB
2	17% of total	117	-5
PDRA	10% of total	114	- 8
3	33% of total	113	-9

Main conclusions from study

1. Half of original pipe insulation a waste (?)
2. Highest noise emission from first stage
3. Recommend to reapply 30-50% of insulation
4. PDRA may significantly reduce insulation need

Predicting pipe noise emission...

Noise inside

- Transmission loss

= Noise outside

Transmission loss effects...

1. Coincidence
2. Strouhal number dependent vortex shedding phenomena
3. Strouhal number independent cavity resonances
4. Boundary layer turbulence
5. Propagating plane waves
6. Flow separation and increased turbulence at discontinuities
7. Mechanical excitation

- M.P. Norton, 1989

Transmission loss effects...

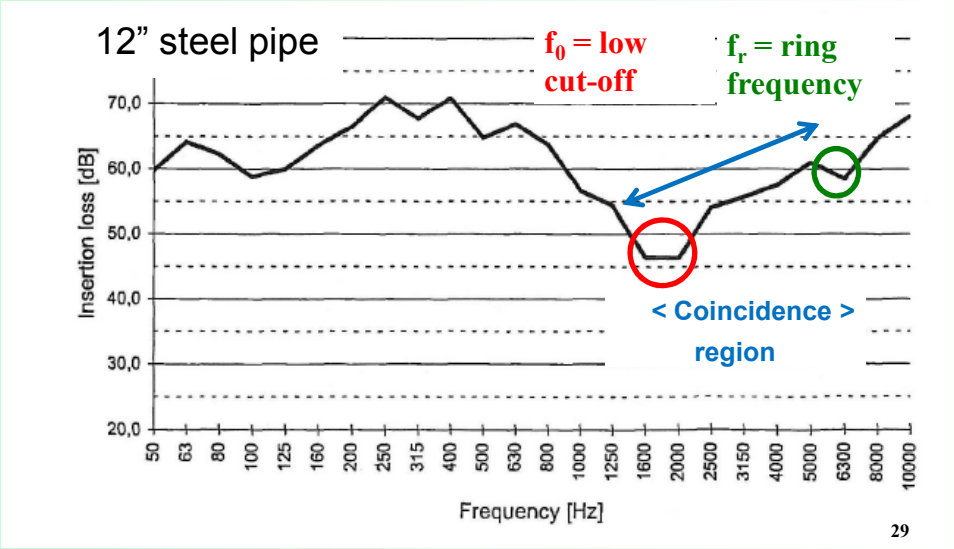
1. Coincidence

Transmission loss at coincidence?

There are no explicit mathematical relationships for the parametric dependence on coincidence – predicted results are qualitative and have to be obtained from an experimental data bank.

- M.P. Norton: Fundamentals of noise and vibration analysis for engineers, Cambridge University Press, 1989, pp.434-472

Transmission loss measured



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Transmission loss (coincidence)

Depends on:

- Pipe diameter
- Pipe thickness
- Sound velocity in pipe material
- Sound velocity in gas
- Internal Pressure

What is the effect of pipe dimensions?

Method 1

Minimum TL ∞ thickness^2 / diameter^2

Method 2

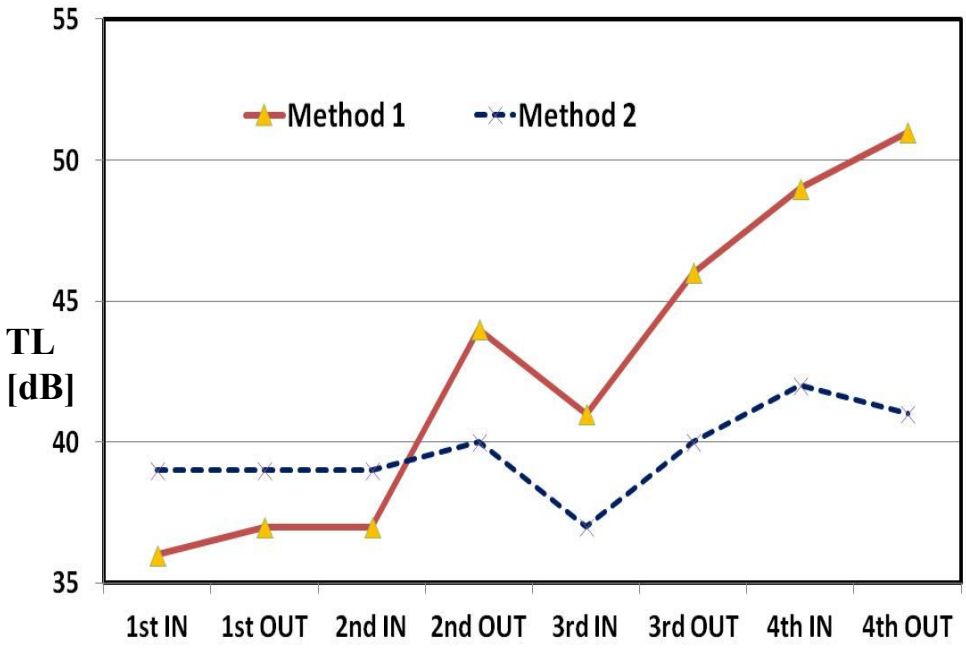
Minimum TL ∞ thickness / diameter

Case study comparing Method 1 and 2 - calculations

Method	Double thickness	Halve diameter
1	+ 6 dB	+ 6 dB
2	+ 3 dB	+ 3 dB

4-stage compressor system

Stage	Pipe Thickness (mm)	Pipe Diameter (") In / Out
1	8 -10	30 / 24
2	10 – 13	24 / 16
3	13 – 17	20 / 16
4	17 – 21	12 / 12



Verdict

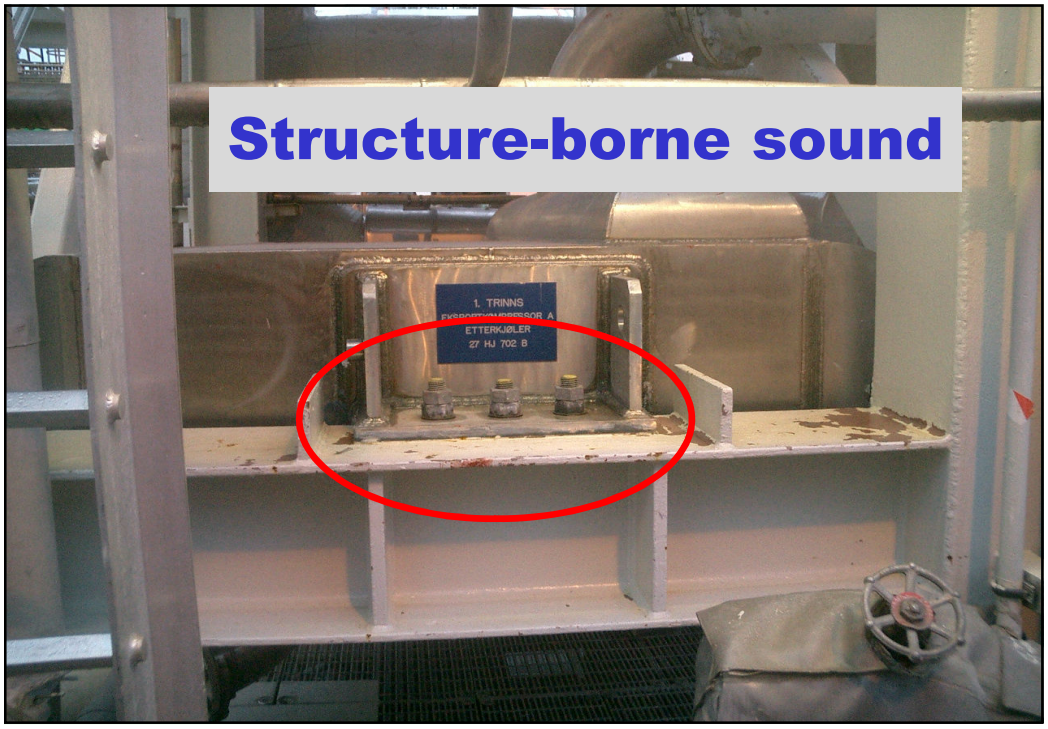
- Method 1 more in line with empirical data (?)
- Method 2 gives conservative values for higher stages

-> If correct, potential for less acoustical insulation on smaller / thicker pipes

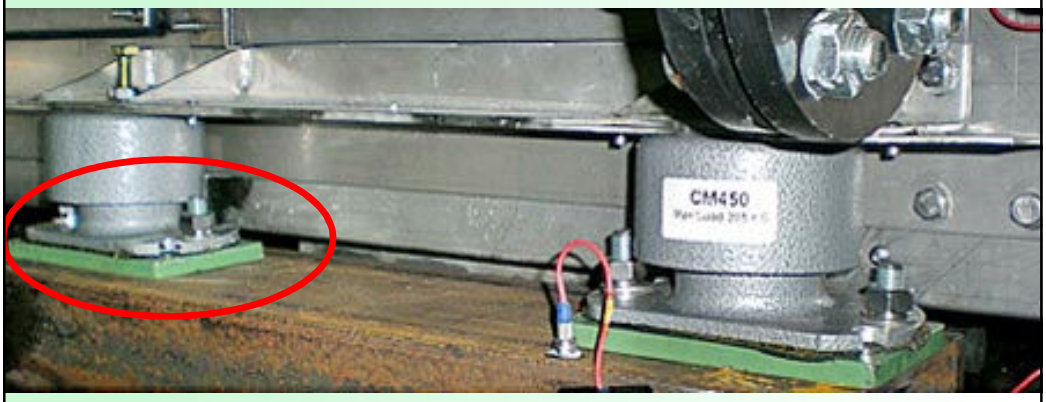
...and the methods are

Method	Reference
1	Norton (1989)
2	Concawe report 87/92 (1987)

Method 2 recommended in Norsok S-002 (2004)!



Elastic thin sheet pads: Avoids structure-borne noise



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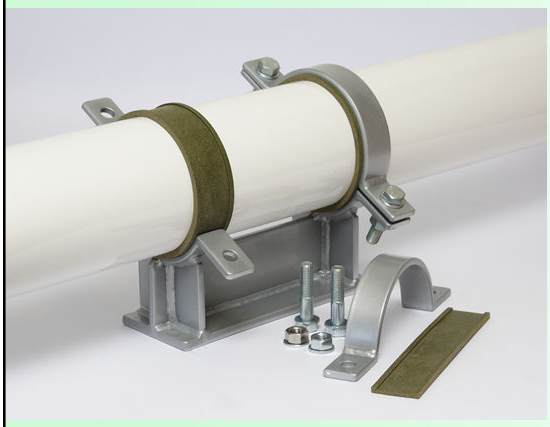
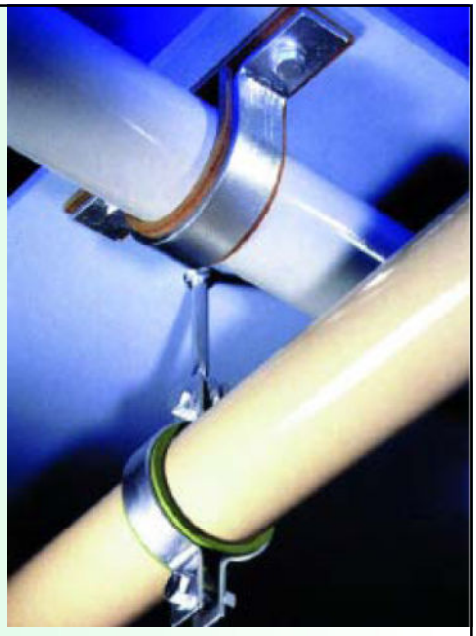
Thin sheet elastic pipe supports





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Soft Anti-Vibration Mount

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New designs – what shall we do?

Norsok S-002 :

- Area noise limit **85 dB** **(if tonal, 80 dB)**
- - Installation of **low-noise** equipment shall be the primary noise control measure
- - For piping systems, selection of **low-noise** valves and other components with **low-noise** properties shall be given priority.

Methods to combat pipe noise

	Method	Effect / comments
1	Silencer (P)DRA	Global effect, takes away pure-tone, ≈10 dB reduction (+5 dB for pure tone?). Durable.
2	Elastic supports	Needed for large systems, but not for ”small”? Thin sheet sufficient for noise abatement. Not costly. Long-life.
3	Pipe insulation	Local effect, 15-30 dB reduction. Corrosion issues. Need to remove and reapply. High life-time cost.
4	Low-noise valves	Reduces insulation needs. Low-noise valves may be more prone to clogging.

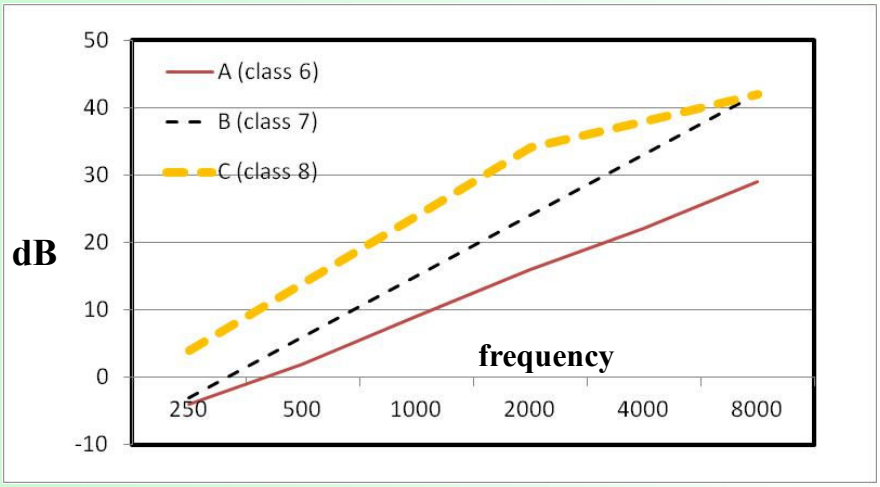
Possible strategy

1. Apply silencer on all compressor stages. Removes annoying tonal character.
2. Use vibration isolation (thin sheet) on main pipes + after coolers
3. Evaluate various pipe insulation scenarios using more accurate method(s)
4. Apply insulation on lines that ”obviously” need it

Possible strategy cont.

5. Set aside space to insulate later, following measurements (potential class to be identified)
6. Use low-noise valves (or be prepared to insulate cooling pipes)
7. Perform realistic life-time costs

What insulation class....?



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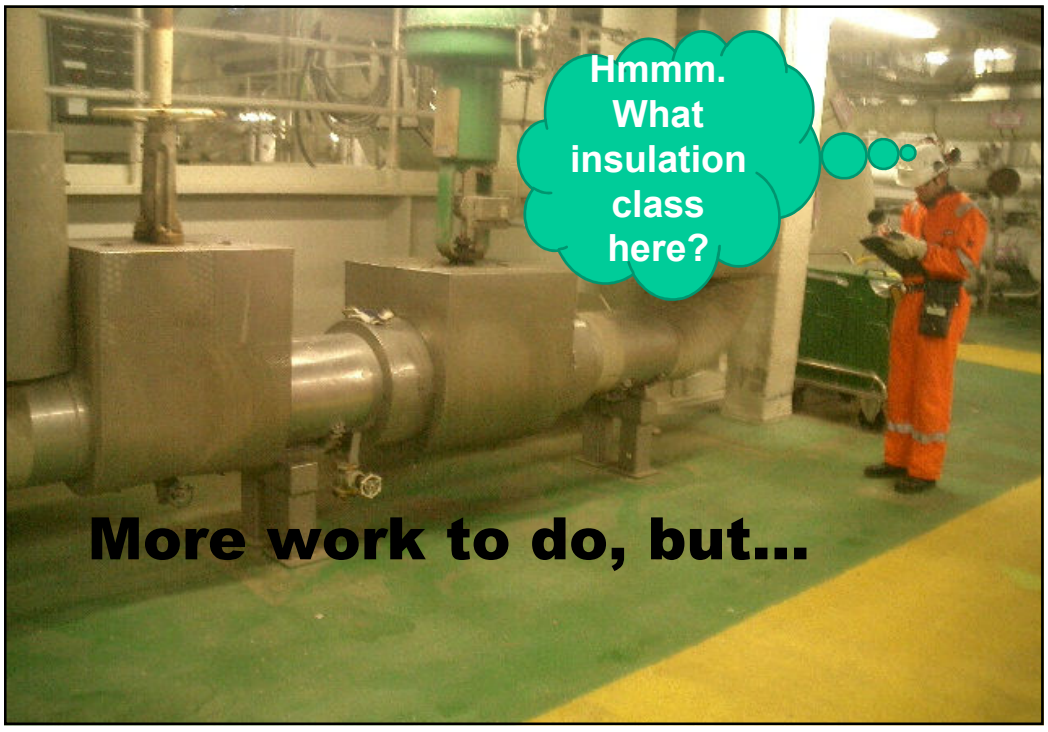


..this is the end, for now!
Special thanks to:
• Tilman Eichler, Sinus
• Mike Newman, Lifetec
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