Noise Characteristics Improvements for a New Generation of Variable Capacity Compressor using Linear Motor Technology

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2014 Purdue Conferences
Compressor Engineering
Refrigeration and Air Conditioning
High Performance Buildings
Stewart Center, Purdue University | July 14 - 17, 2014

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AGENDA

- Variable Speed Compressor
- Variable Capacity Linear Driven Compressor
- Transient starting noise
- Noise levels variation with cooling capacity
- Conclusions

Variable Speed Compressor

Current *state of art* compressor

Variable Speed Compressor

Concept

HIGH EFFICIENCY

FRESH FOOD AND FAST COOLING

RELIABLE

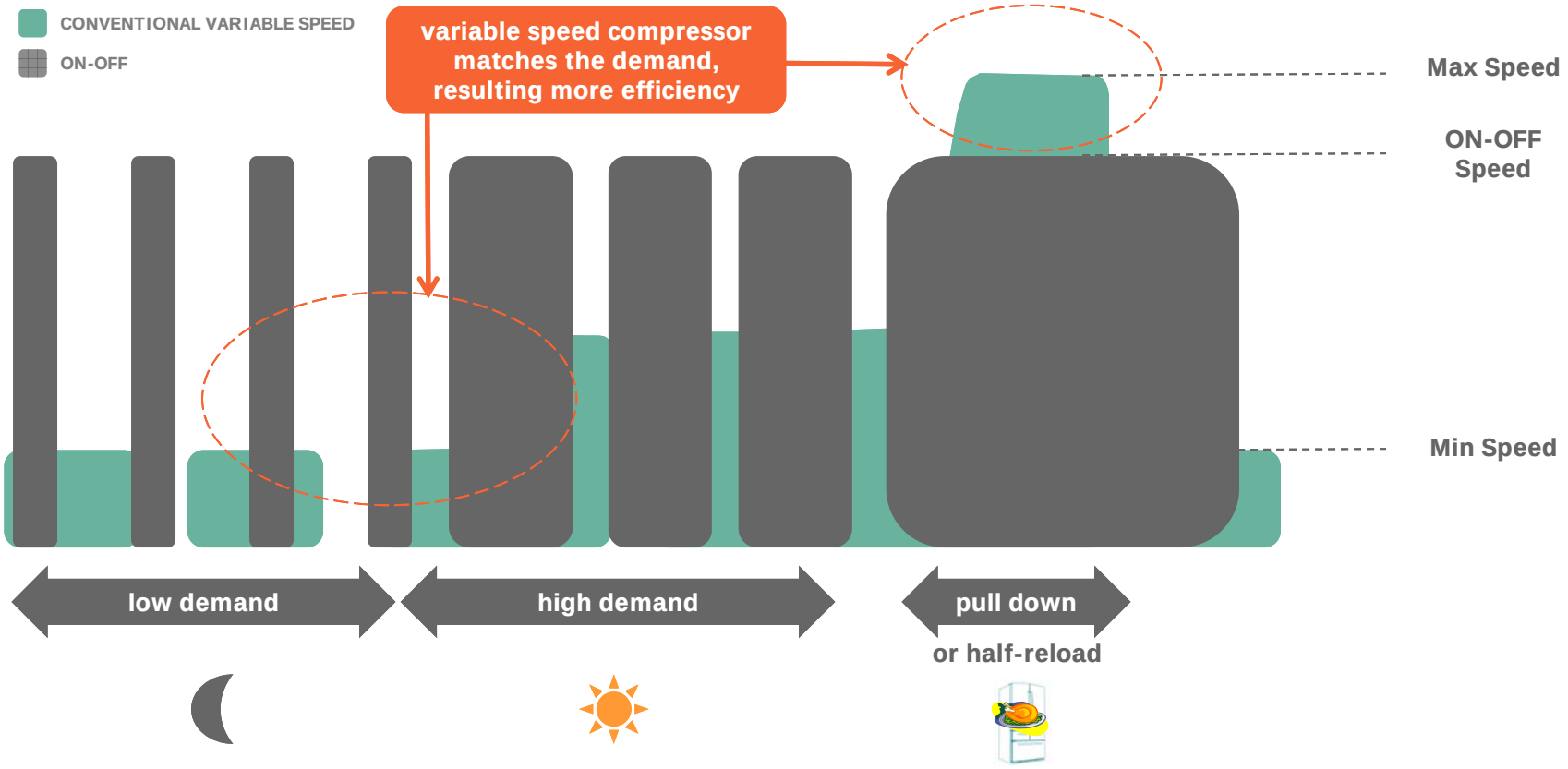
LOW NOISE AND VIBRATION

Compressor

Inverter

Variable Speed Compressor

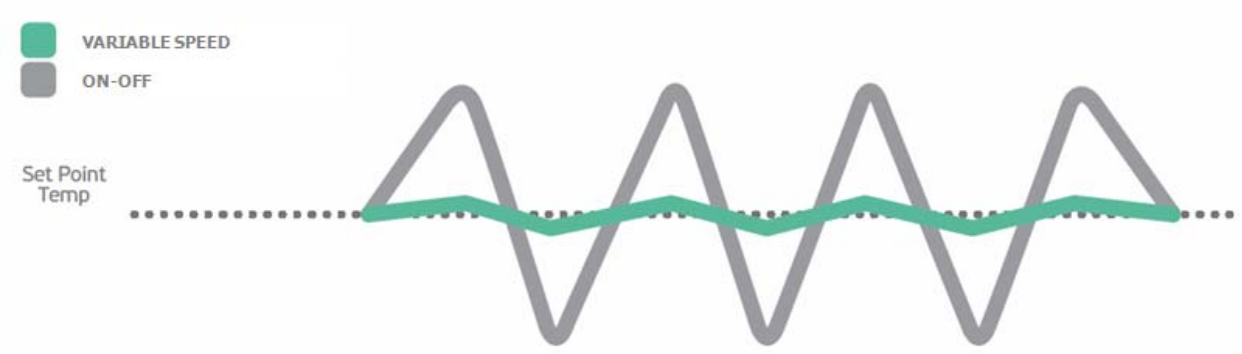
Concept



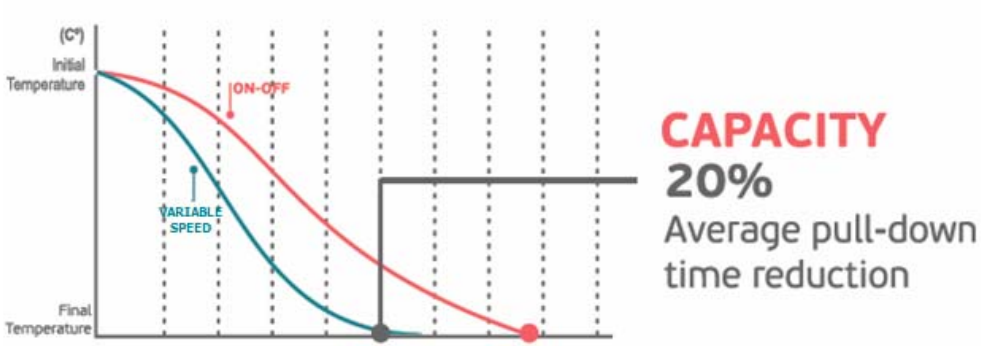
Variable Speed Compressor

Better temperature control

Variable speed compressors have better control on thermal fluctuations.



Fast cooling

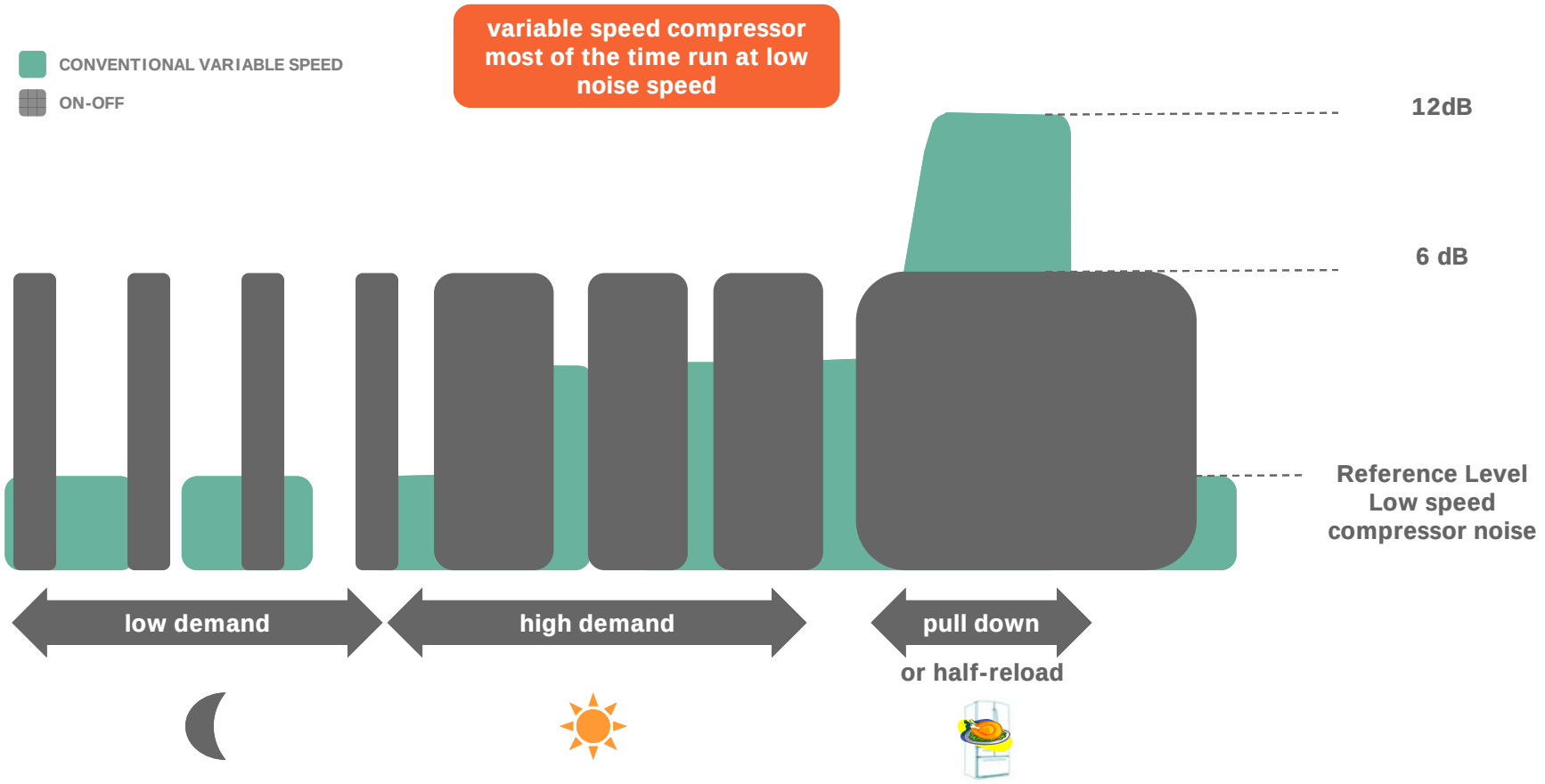


CAPACITY
20%
Average pull-down time reduction

Variable speed compressors can work at higher speeds resulting in increased capacity and pull-down time reduction.

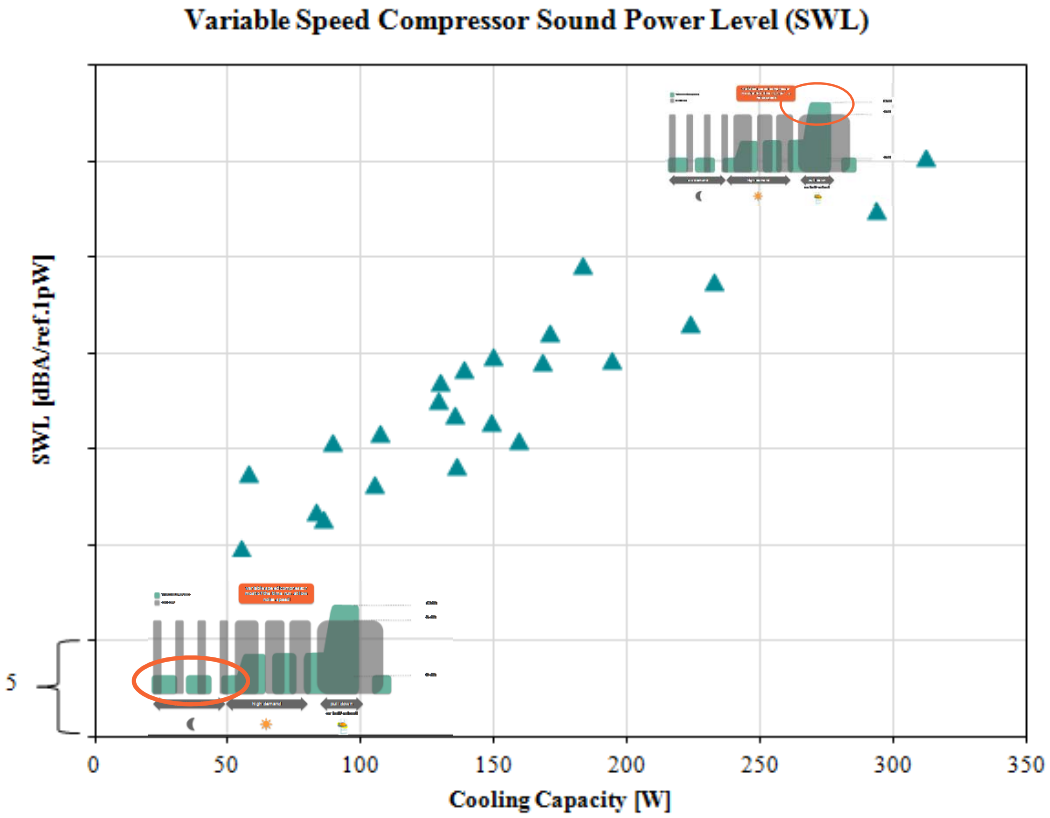
Variable Speed Compressor

NOISE



Variable Speed Compressor

NOISE

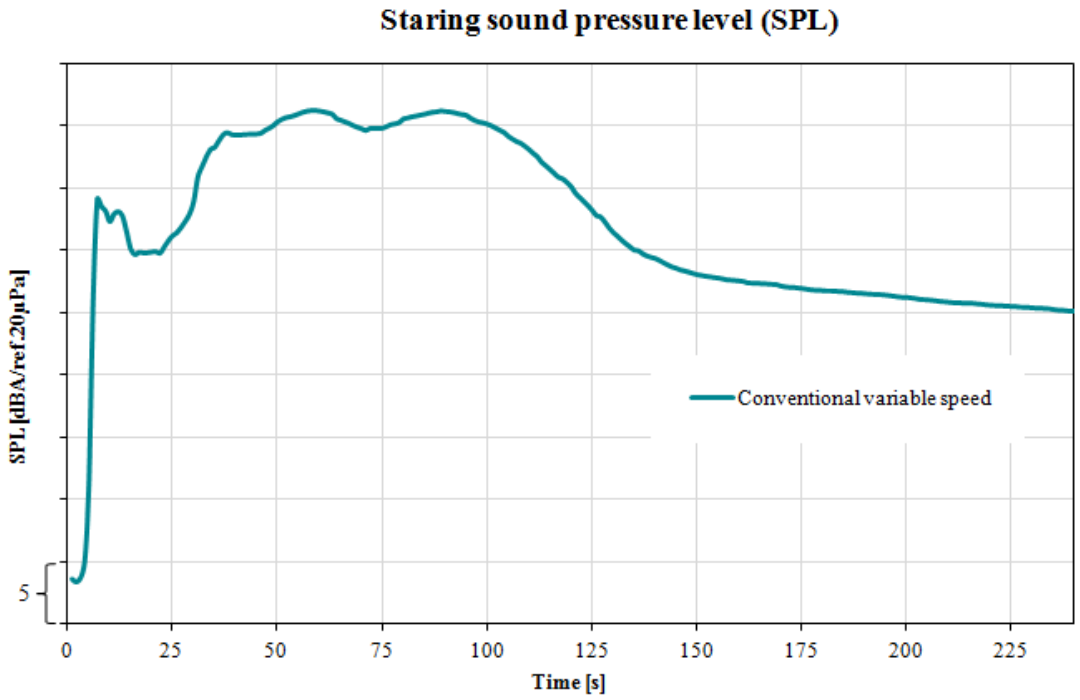


From smaller variable speed compressors at lowest speed to largest compressors at maximum speed, up to 20dB in noise levels variation.

Different variable speed compressor families are plotted in this figure.

Variable Speed Compressor

STARTING NOISE



Compressor starting strategy have features to protect the bearings and to increase the compressor efficiency.

Those features, associated with pressure transients generate this kind of starting noise.

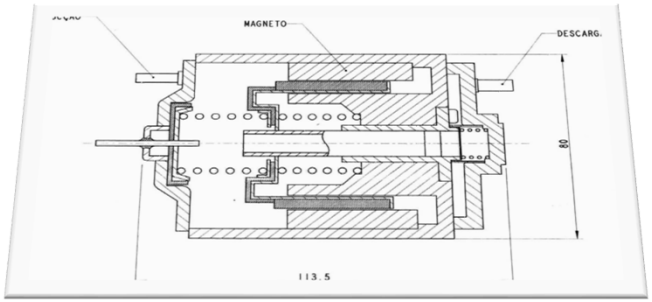
Variable Capacity Linear Driven Compressor

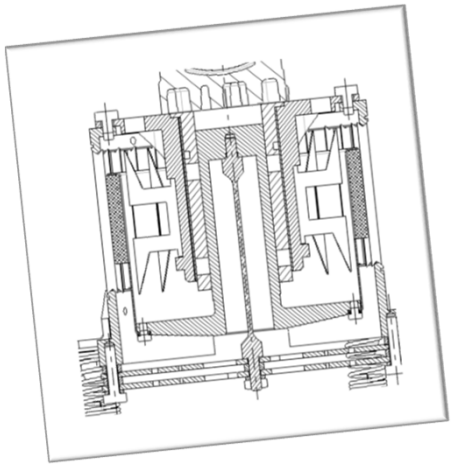
Newest *state of art* compressor

Variable Capacity Linear Driven Compressor

HISTORY

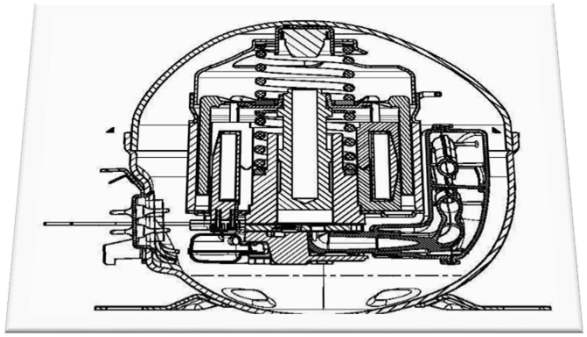
Sawafuji
1957



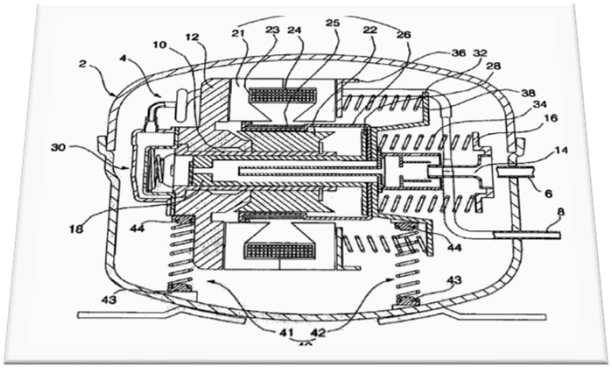


SunPower
1994

Embraco
2004

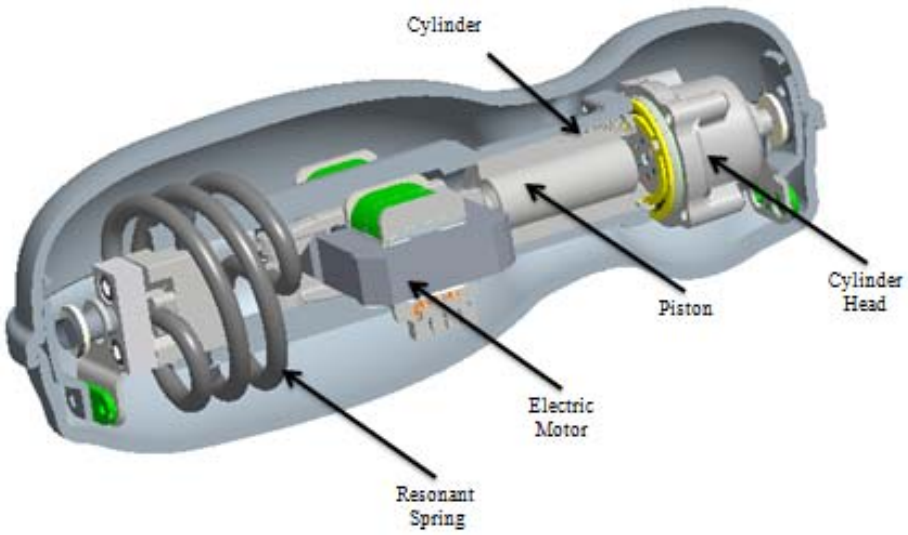


LG
1999



Variable Capacity Linear Driven Compressor

CONCEPT



Electronic device supply **power** modulated at the resonant frequency of the mass / spring system

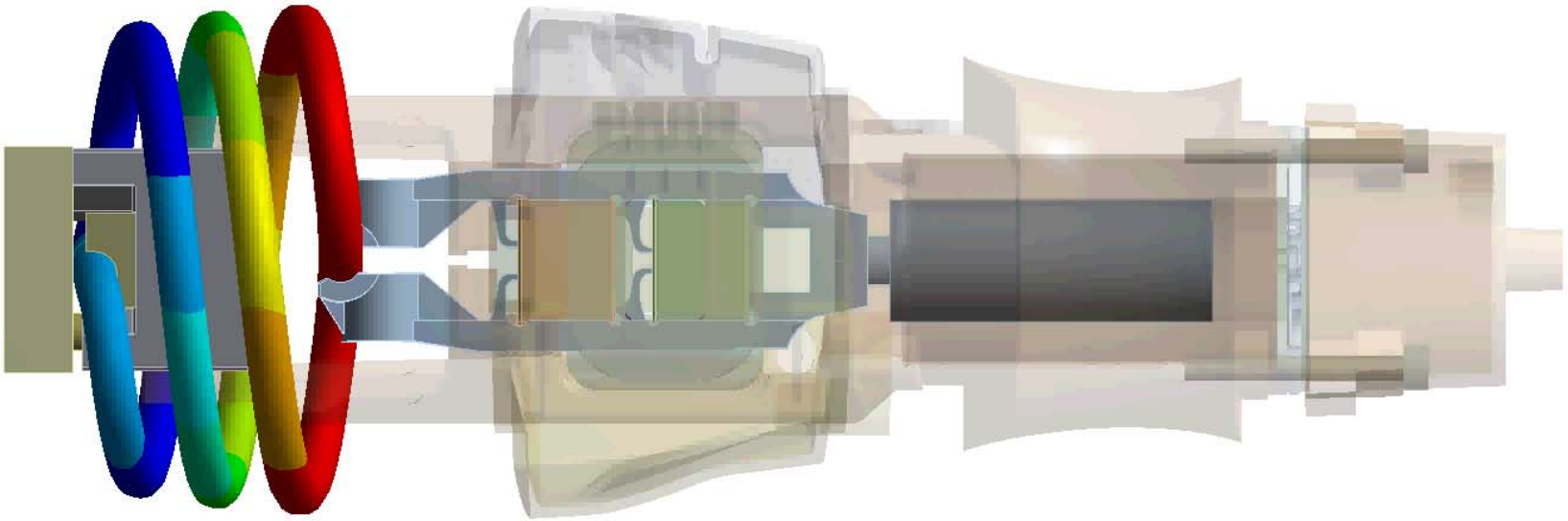
"F**ixed structure**" (electric motor, cylinder, cylinder head, spring support and shell),

Resonant spring

Moving components (piston, magnets and their support).

Variable Capacity Linear Driven Compressor

CONCEPT



Variable Capacity Linear Driven Compressor

COMPARISON

Characteristic	Linear Variable Capacity	Conventional Variable Speed
Type of motion	Reciprocating	Reciprocating
Type of capacity control	By compressor power	By motor speed
Type of motor	Linear	Rotating
Number of bearings	1	5
Oil	Oil free (piston coating + gas bearing) Environment friendly	According to gas type and compressor model.
Start ability	Starts at any pressure difference	Can start with low pressure difference
Stalling	Reduces stroke/capacity Does not stall	Stalls
Installation	Special care with absence of oil and other residues	Normal
Weight	5.2kg	6.75kg (Mini)

Transient Starting Noise

Smoothed compressor starting noise.

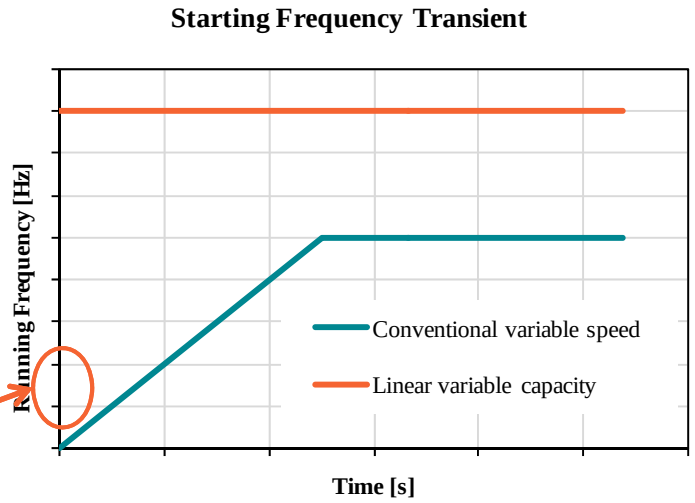
Transient Starting Noise

CONCEPT

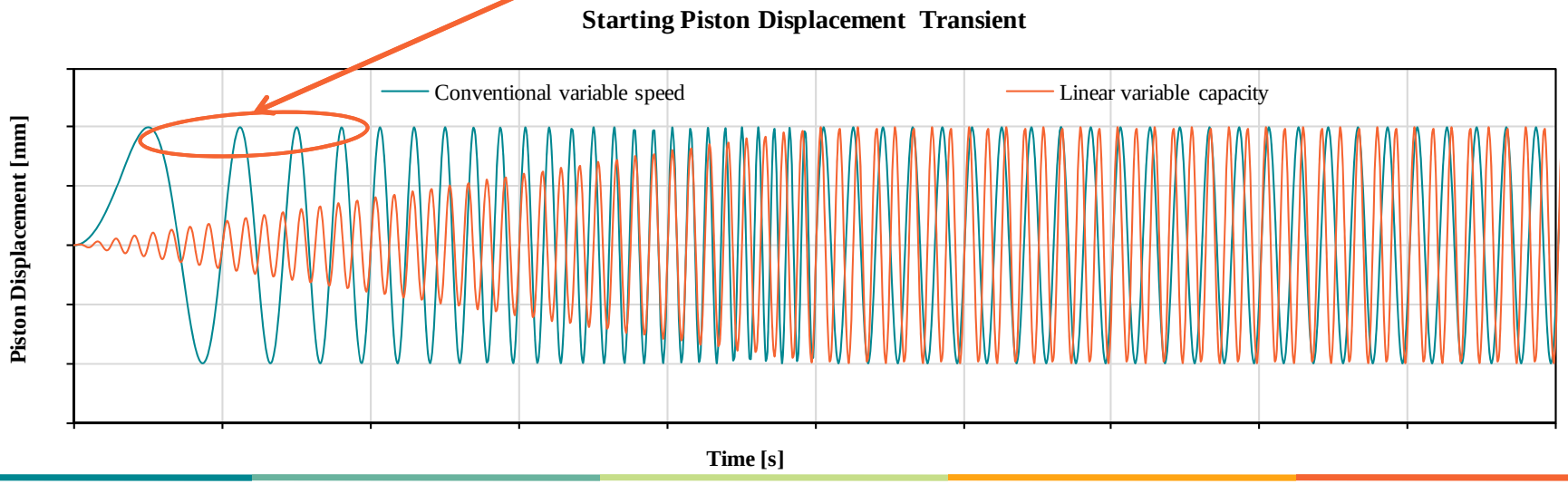
The concept of variable capacity linear motor driven compressor allows it to start smoothly with small piston displacements.

At each cycle the piston displacement increases a small proportion until it reaches the maximum stroke according a desirable cooling capacity.

That behavior creates a soft and constant starting noise without peaks and run-up, or acceleration noise.

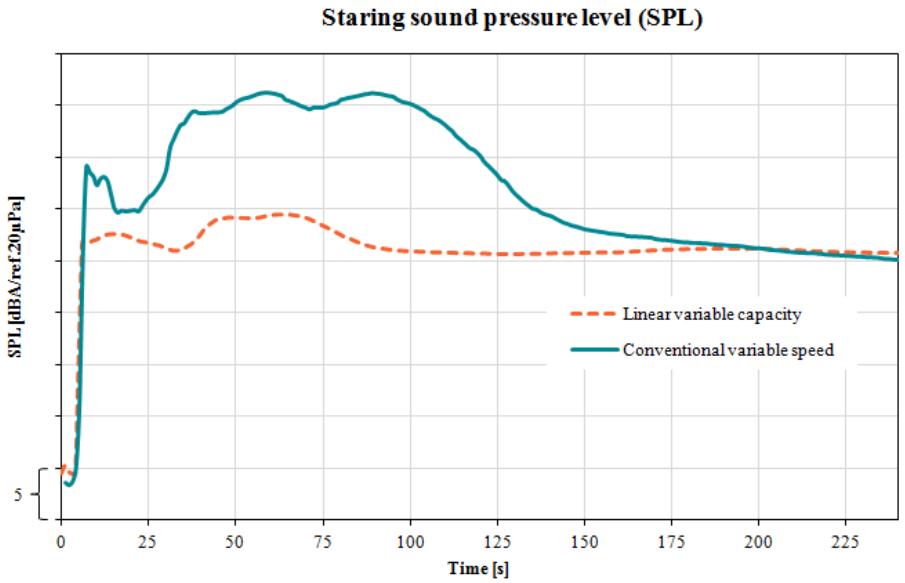


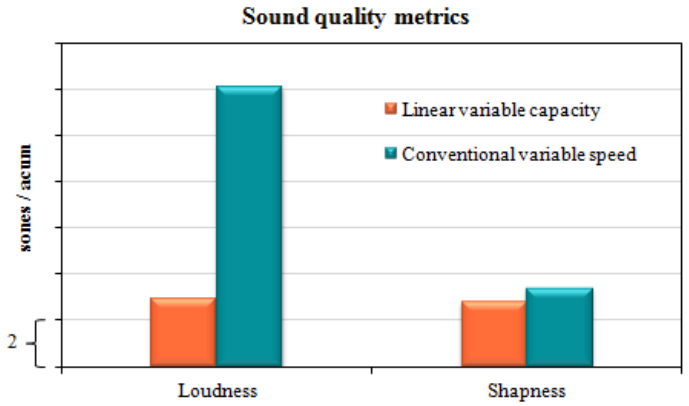
Assembly resonances region

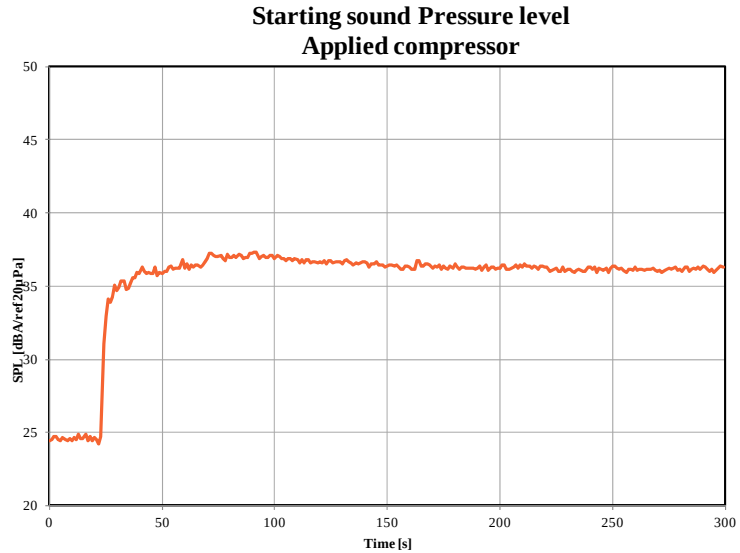


Transient Starting Noise

Sound pressure level vs. time



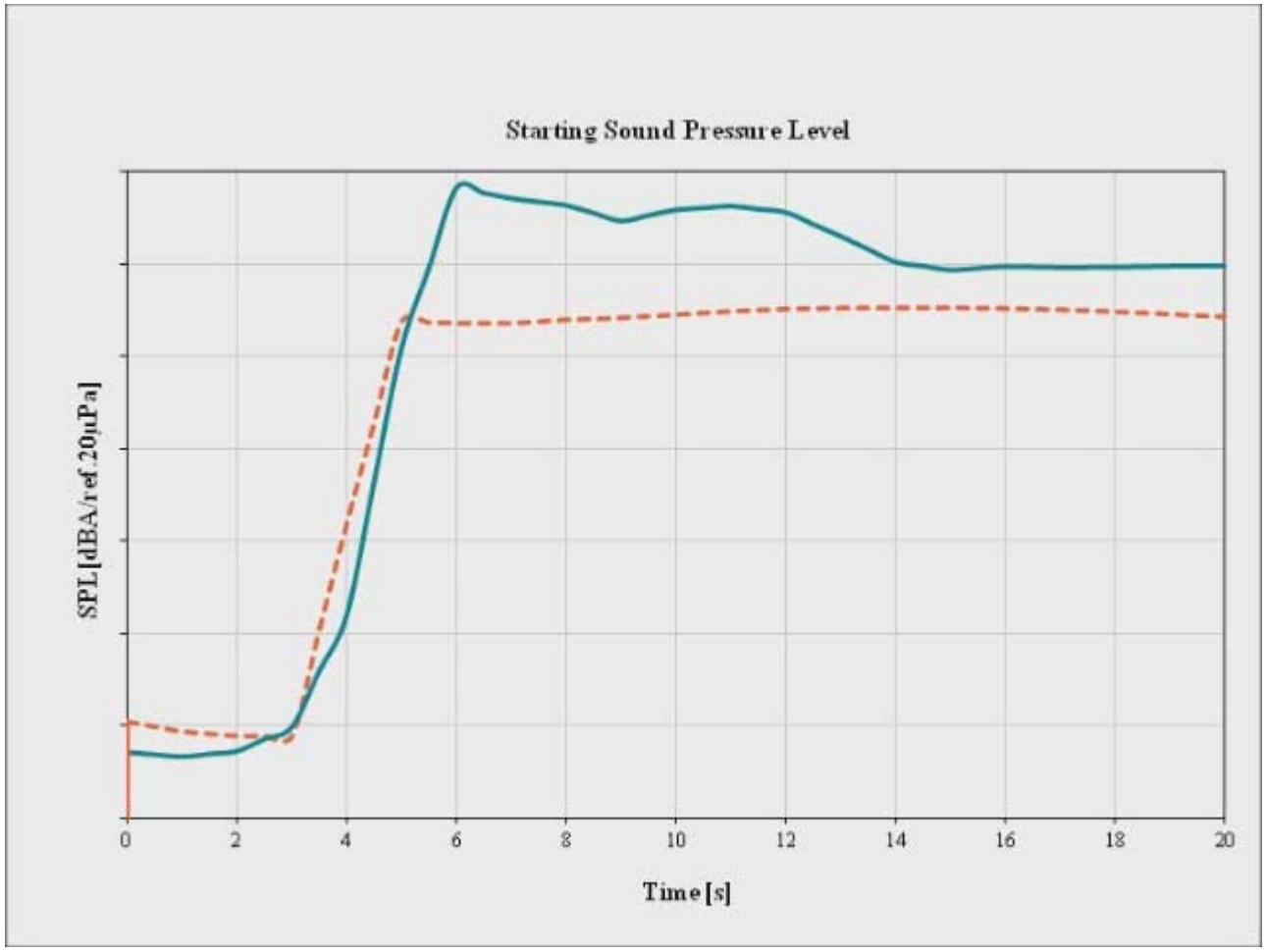




The concept of variable capacity linear motor driven compressor allows it to start smoothly with small piston displacements.

Transient Starting Noise

We can hear it...

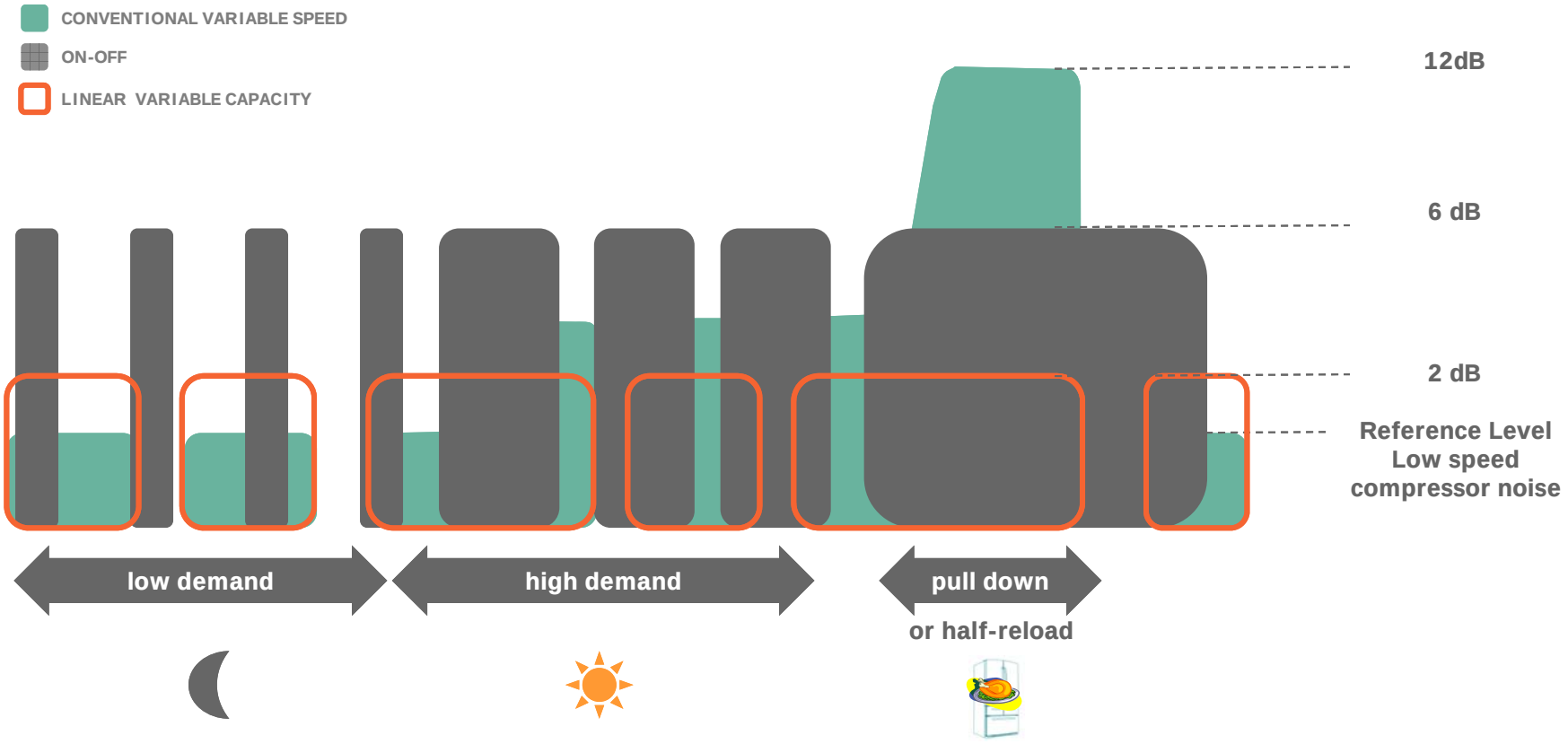


Noise Variation with cooling Capacity

Current *state of art* compressor

Noise variation with cooling Capacity

NOISE CYCLE



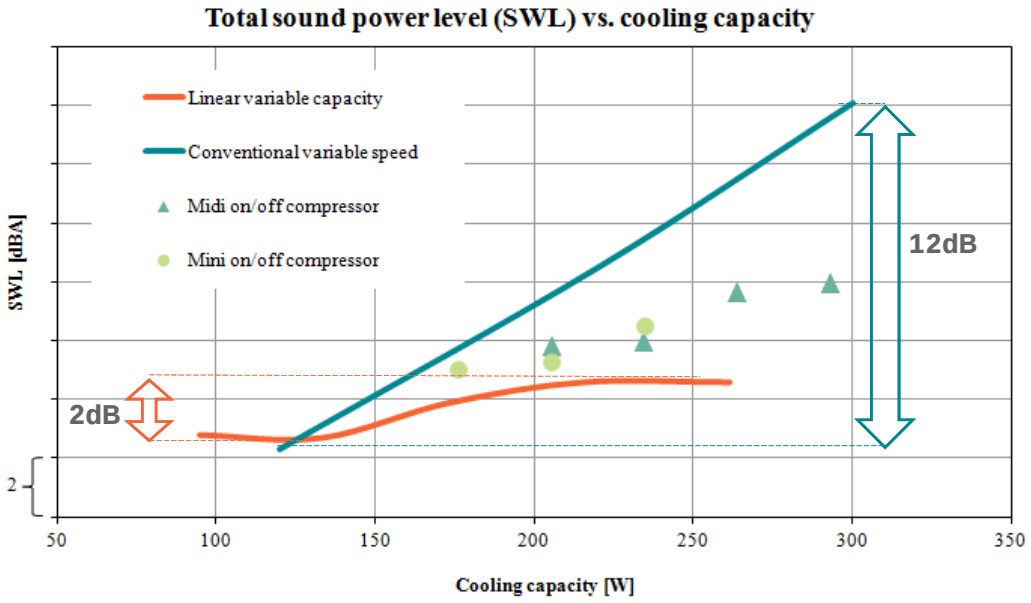
Noise variation with cooling Capacity

STEADY STATE NOISE

Sound power level results for a variable capacity liner motor driven compressor for different cooling capacities.

Less than 2dB louder when the cooling capacity is increased from minimum capacity (100W) to maximum capacity (250W).

For conventional variable speed compressor this range is at least 12dB.



Conclusions

Variable speed compressors have improved acoustic performance over on/off compressors.

Variable capacity linear motors driven have a **superior** acoustic performance over variable speed compressors.

The main advantages are:

- Lower starting noise transient
- Constant noise over capacity range

Thank you !

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