Analysis and testing of the relaxation in Vetresit screws in a generator end winding

Energiforsk seminar Vibrations in nuclear applications
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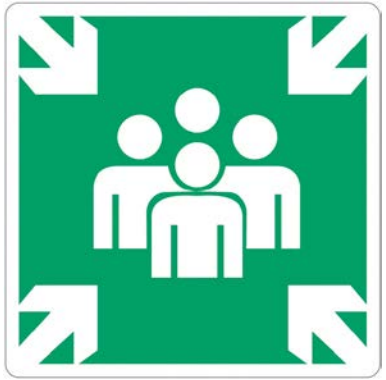
Säkerheten främst

Vänligen notera var närmaste nödutgångar, brandsläckare, samlingsplats och hjärtstartare finns



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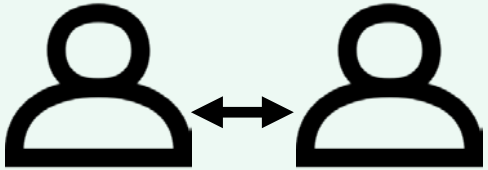
Prevent the spread

- protect yourself and others



Keep a distance

Cough and sneeze in the bend of the arm

Wash your hands

Stay at home if you are feeling sick

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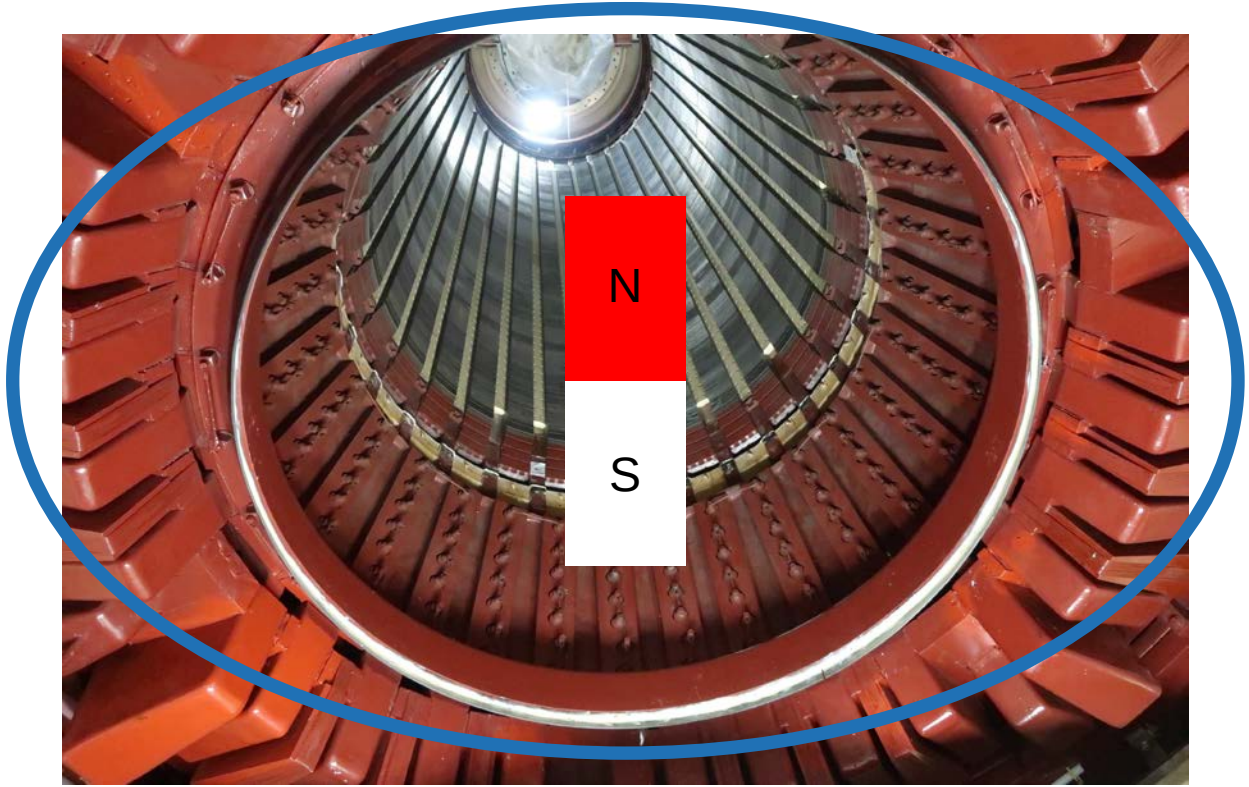
Generator

Stator A2

- 680 MVA x 0.9
- 21.5 kV

End winding exciter end



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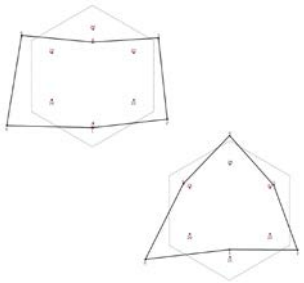
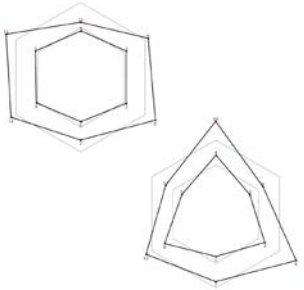
Result from impact tests on the end windings



- Drive end (DE)

Mode	SAT 2000	2021	Remaining stiffness
4-node	81 Hz	65 Hz	64 %
6-node	139 Hz	104 Hz	56 %



- None drive end (NDE)

Mode	SAT 2000	2021	Remaining stiffness
4-node	76 Hz	49 Hz	41 %
6-node	121 Hz	90 Hz	56 %

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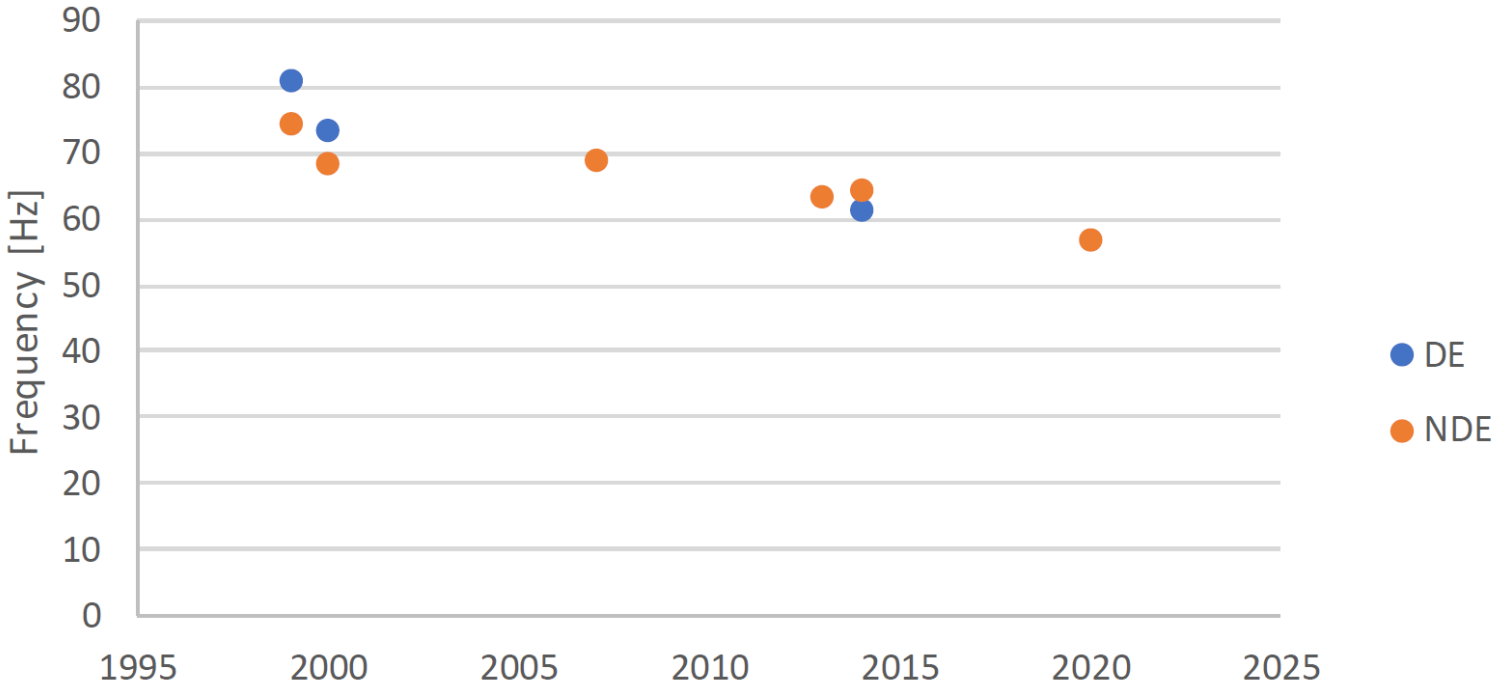
4-node mode - Long term trend for Stator Ab1



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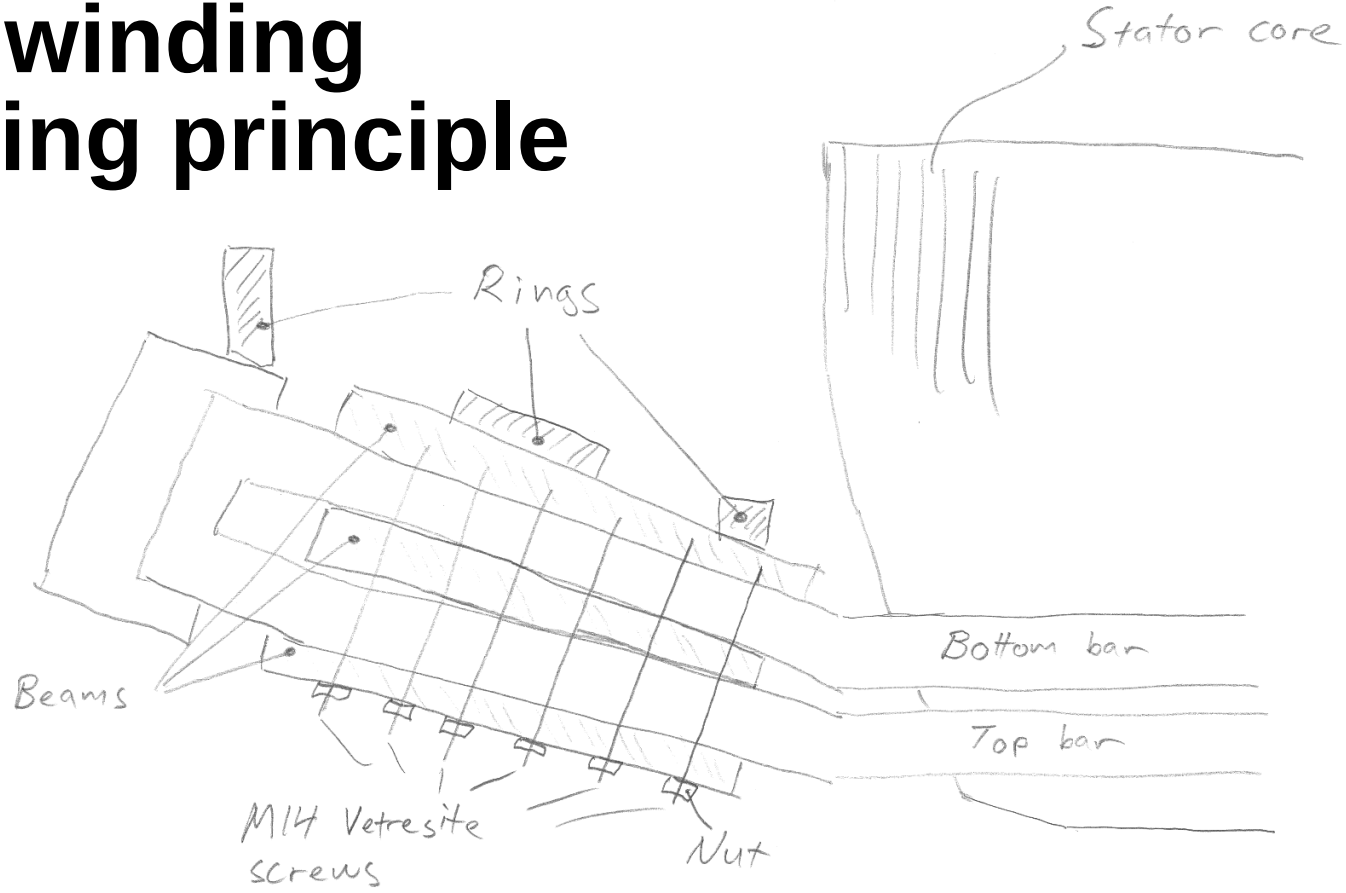
End winding bracing principle



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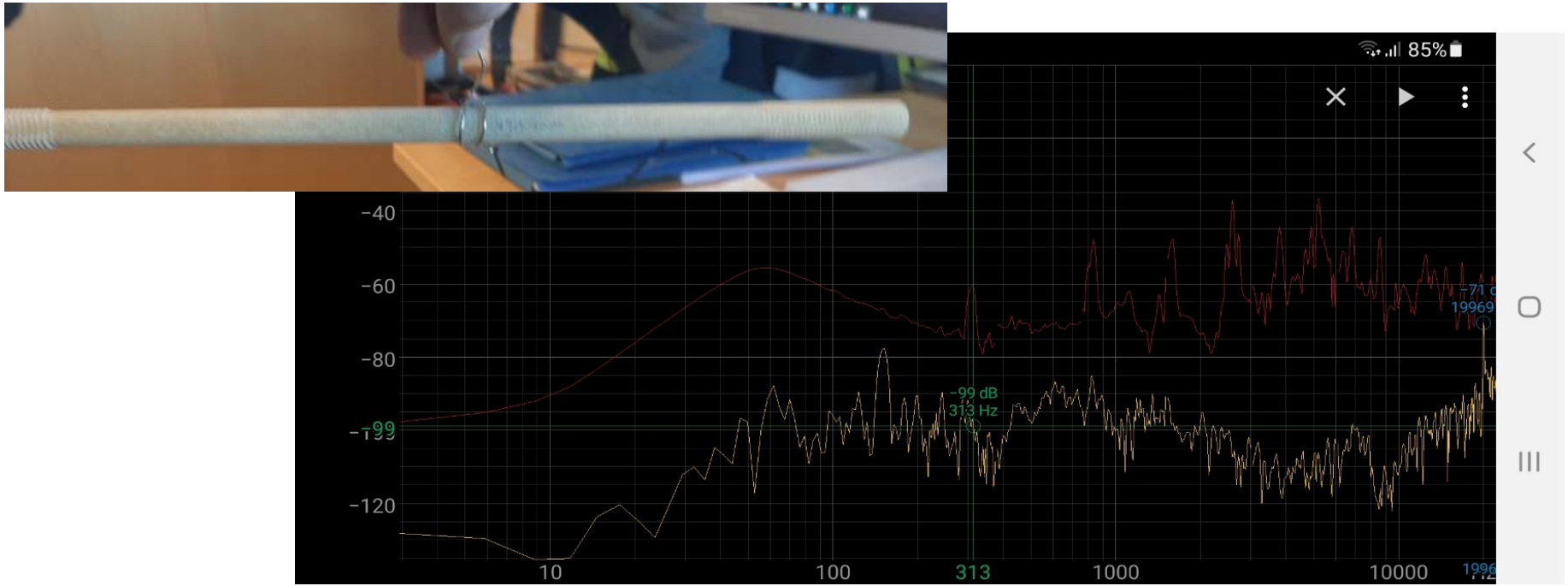
”Impact test” test on a free-free Vetresit screw – Sound pressure measured by an Android phone with Spectroid 1.1.1



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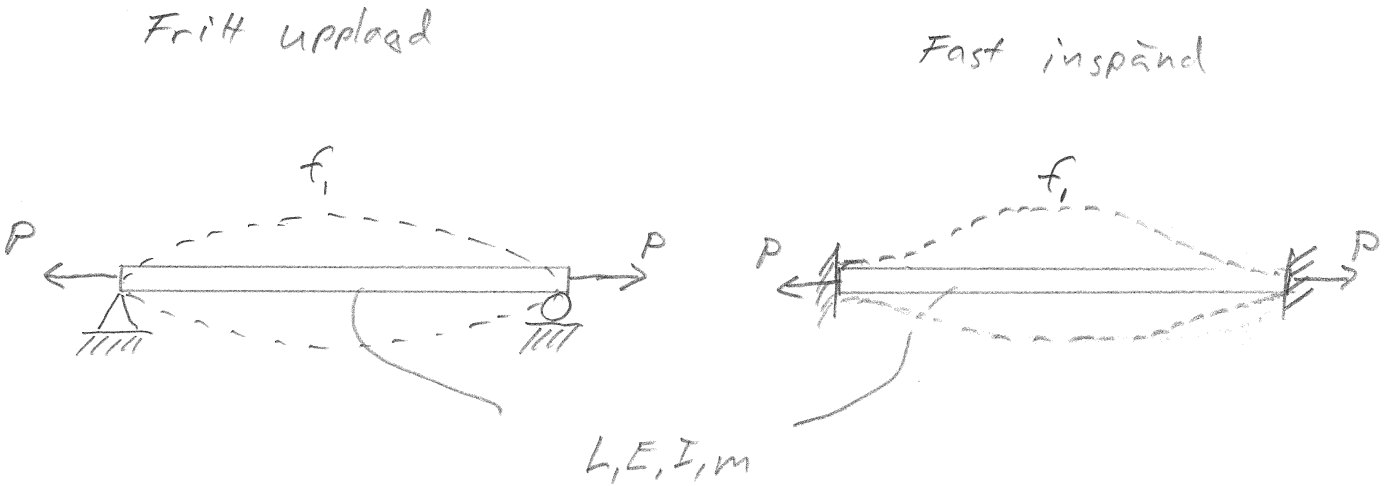
1st natural frequency for a pre-stressed beam

P – [N]
L – [m]
E – [Pa]
I – [m^4]
m – [kg/m]



$$f_1 = \frac{\pi}{2L^2}\left(1 + \frac{PL^2}{EI\pi^2}\right)^{1/2}\left(\frac{EI}{m}\right)^{1/2}$$

$$f_1 = \frac{4.73^2}{2\pi L^2}\left(1 + \frac{PL^2}{4EI\pi^2}\right)^{1/2}\left(\frac{EI}{m}\right)^{1/2}$$

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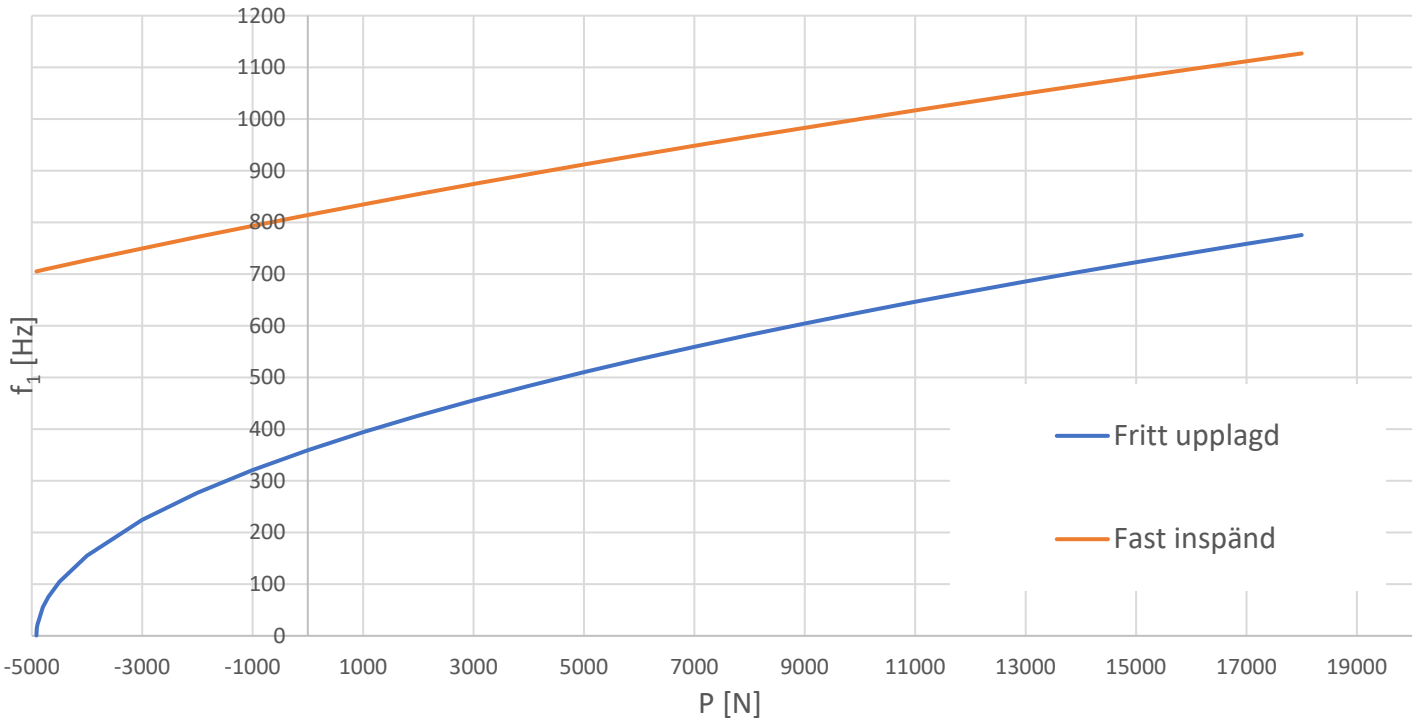
Analytical results for a pre-stressed M14 Vetresit screw



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Test setup

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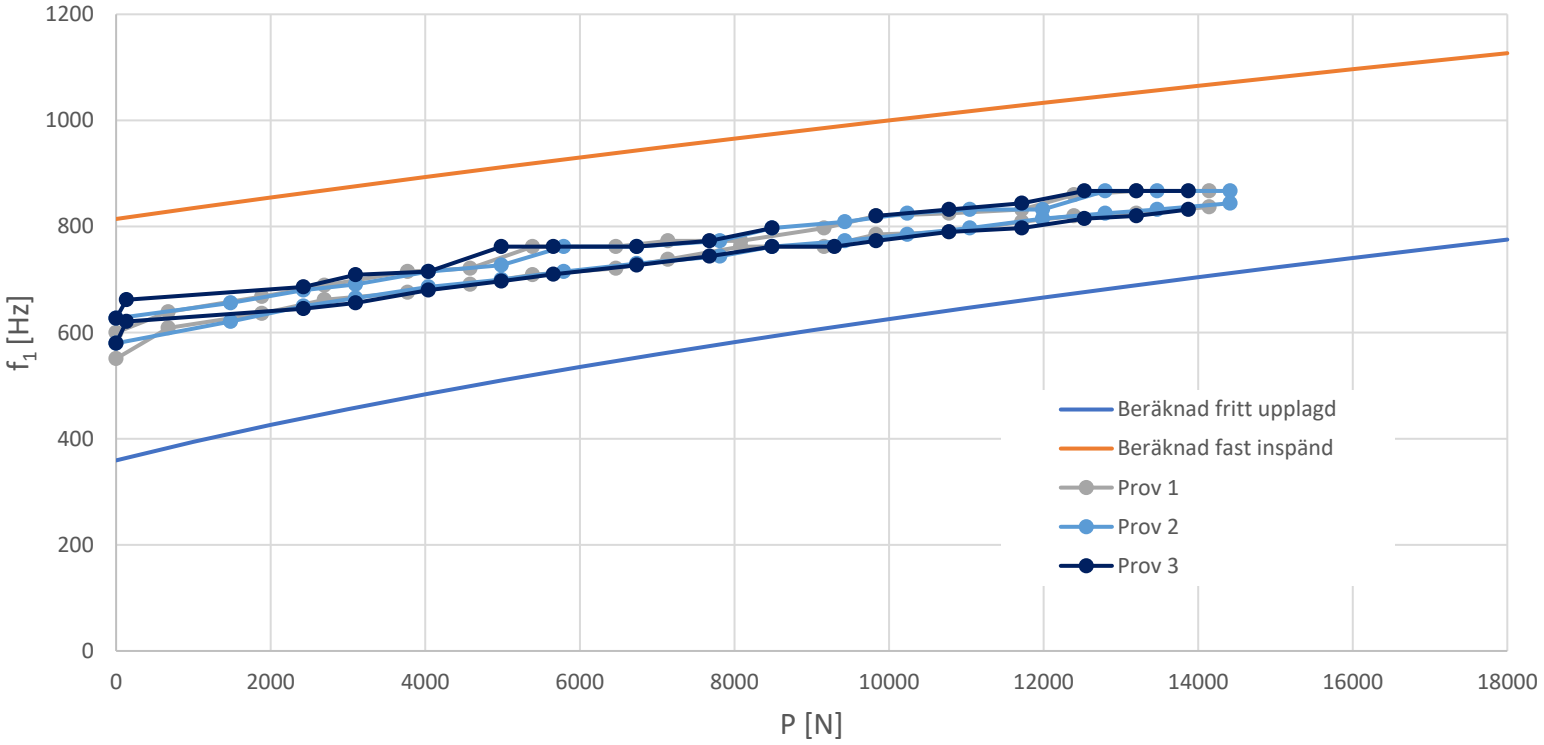
Test results



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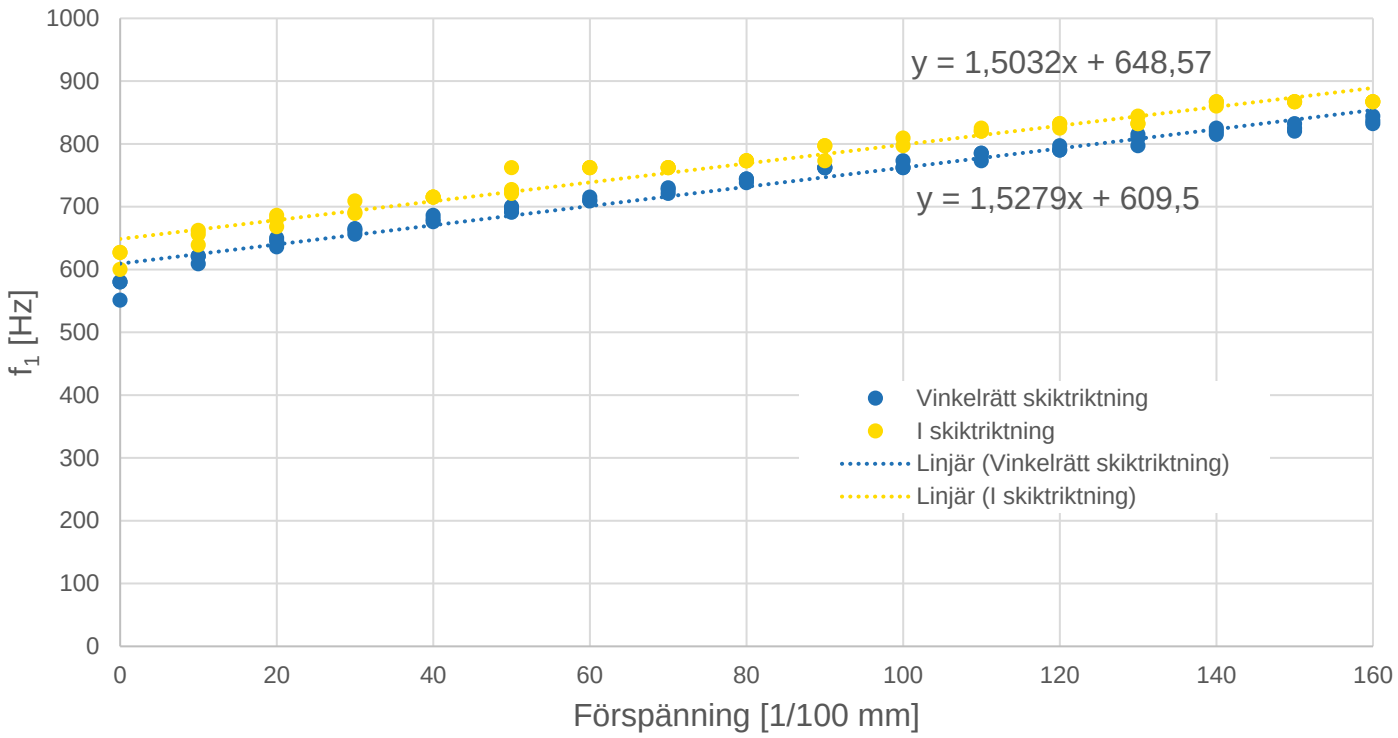
Linear curve fit to the test results



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Results for Vetresit scews in stator A2

Slot	Measured f_1 [Hz]	Calculated pre stress			
		Perpendicular laminate direction		In laminate direction	
		[1/100 mm]	[%]	[1/100 mm]	[%]
1	750	92	66	67	48
2	686	50	36	25	18
3	686	50	36	25	18
4	686	50	36	25	18
5	686	50	36	25	18
6	656	30	22	5	4
7	656	30	22	5	4
8	691	53	38	28	20
9	691	53	38	28	20
10	691	53	38	28	20
11	697	57	41	32	23
12	709	65	47	40	29
13	709	65	47	40	29
14	809	131	93	107	76
15	709	65	47	40	29
16	615	4	3	-22	-16
17	744	88	63	63	45
18	662	34	25	9	6
19	797	123	88	99	71
20	715	69	49	44	32
21	686	50	36	25	18
22	744	88	63	63	45
23	762	100	71	75	54
24	790	118	84	94	67
25	780	112	80	87	62
26	700	59	42	34	24
27	785	115	82	91	65
28	686	50	36	25	18
29	727	77	55	52	37
30	662	34	25	9	6
		Average	**48**		**30**

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Conclusions

- The test indicates that tested Vetresit screws have lost ~ 50% of their pre-tension after 20 years of operation.
- We do need to check the remaining pre-tension on more screws during the repair work to set the long term maintenance planning for the other units.
- All Vetresit screws to be replaced during the repair work.
- Using the mobile phone with the installed FFT-analyser was a very quick solution to get results ”good enough” in this case.

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