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# Risk Mitigation & Life Extension

Civil Inspections for in-service Wind Farms



## Risk Mitigation & Life Extension



- ⊕ **Mechanical Elasticity** is a property where an element is able to experiment reversible deformations when subjected to external forces and regain to their original shape when those forces are eliminated.
  
- ⊕ **A Wind Tower** is not a static elements, therefore:
  - ⊕ Two different **elasticity behaviors** are taking place in the tower base, where concrete and metal meet.
  
  - ⊕ Separate tower horizontal planes: Base, middle tower or nacelle, have different displacements and deformations tolerance structural performance, however all have been designed to be centered on the same **vertical axis**.

## Risk Mitigation & Life Extension

- ⊕ Having a structure under **constant stress** causes exponential side effects in the long term operation.
- ⊕ **Low cost** predictive & preventive inspections help to take better business decision **anticipating and planning** proper corrective or maintenance activities to:
  - ⊕ Improve unavailability **losses** due vibrations shutdowns.
  - ⊕ **Life extension** the wind tower after of amortization periods.
  - ⊕ or even prevent from **collapsing**.



## Tower Foundation Movement Measurements



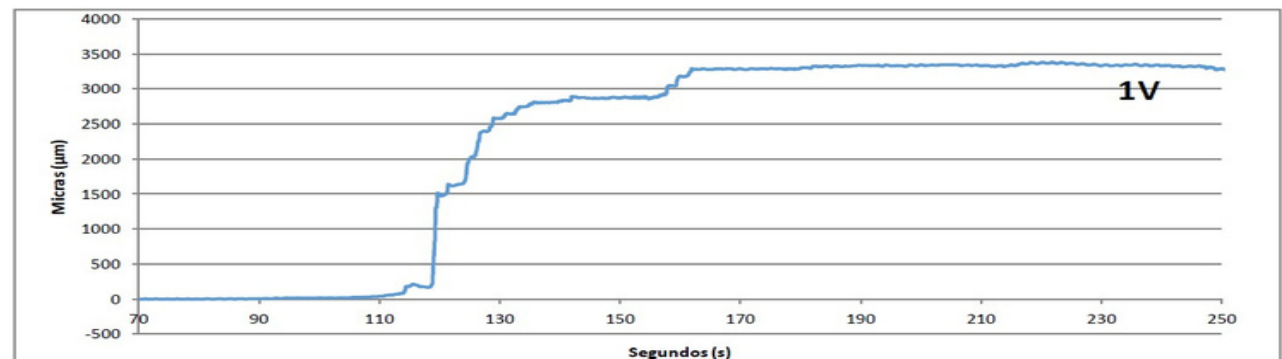
- ⊕ The dynamic forces in the base generate foundation micro cracks due the differences elasticity, no matter if grouting or anchor bolt.
- ⊕ Water leaks in combination with the vibration forces generate internal high pressure in those cracks which accelerate the process but also generates erosion, which increase the vibrations forces, which generates more cracking, which generates more erosion, which generates more vibrations, ... **It is an exponential phenomenon.**

⊕ After 5 or 10 years operation, it is high recommended to determinate foundation health

## Tower Foundation Movement Measurements

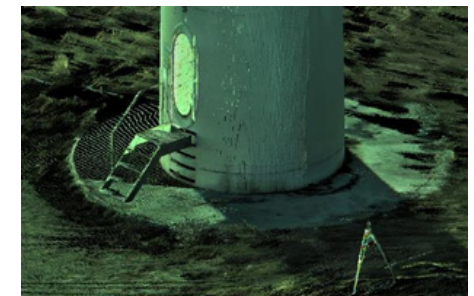


- ✓ Linear strain control sensors to measure vertical & horizontal movements at 4 points: Wind direction & perpendicular.
- ✓ Readings at normal operation and during the start-up.
- ✓ Reporting magnitudes of displacement to determinate the need of rehabilitation treatments periods.



## Wind tower Verticality & Horizontal Planes

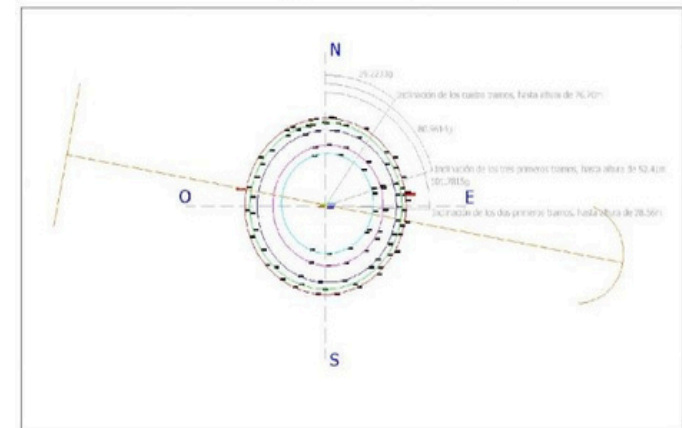
- ⊕ Verticality measurements are very useful:
  - ⊕ In aged tower deformation during long term standard operation, after 5 o 10 years.
  - ⊕ After suffer a big shock like a strong storm or a blade impact (real case).
- ⊕ All that can cause important deviations in the vertical axis reference over several tower planes and affecting foundation seating differential.
- ⊕ Becoming in an abnormal behavior of the tower, stressing the structure, generating extra vibrations and **causing un expected fails or amplified others** in the foundation, in the tower itself in the gear-box or on the alignment of the shaft.



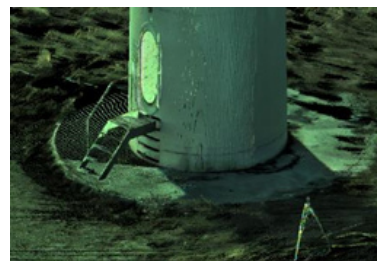
## Wind tower Verticality & Horizontal Planes

- ✓ Using a total station with several references points
- ✓ 100 readings per second measuring different horizontal planes: Bottom, middle & top
- ✓ Point cloud data processing to determinate flatness, inclination and verticality over the circumferences planes.

ACTA DE COMPROBACIÓN DE VERTICALIDAD DE UN AEROGENERADOR		Applus+					
INSTALACIÓN:	PARQUE EÓLICO	FECHA:	04/12/2019				
		Nº SERIE:	737470				
INSTRUMENTO:	LEICA TCPR1202 R300	FECHA CALIBRACIÓN:	07.05.2019				
<b>AEROGENERADOR A09 EN REPOSO</b>							
<b>P.E.</b>							
<b>PARÁMETROS DE MEDIDA:</b>							
HORA DE MEDICIÓN:	10:00-13:00						
VELOCIDAD MEDIA DEL VIENTO:	1.5 m/s						
AZIMUTAL DEL VIENTO:							
TEMPERATURA MEDIA:	48C						
<b>DESVIACIÓN VERTICAL</b>		<b>DESVIACIÓN HORIZONTAL:</b>					
ESTADO	ANGULAR (g)	EXCENTRICIDAD (m)	ANILLOS	TRAMOS (m)	DIÁMETRO (m)	DESNIVEL (mm)	ANGULAR (g)
EN REPOSO	0.0658	0.01	ANILLO 1	0.49	4.04	1.5	0.0233
	0.0716	0.03	ANILLO 2	11.10	3.81	3.0	0.0508
	0.0791	0.06	ANILLO 3	16.97	3.49	2.7	0.0487
	0.0791	0.06	ANILLO 4	23.85	2.77	1.1	0.0242
	0.0654	0.08	ANILLO 5	24.29	2.30	-	-
				ALTURA:		76.70	



- ⊕ Job can be done also by a Laser Scan to obtain the 3D point cloud, but the accuracy will not be the same. However could help to locate deformations.



## Risk Mitigation & Life Extension



⊕ Easy, Faster and cheaper test HELP:

⊕ To avoid unavailability losses

⊕ To life extension after the amortization period

⊕ To prevent from collapsing due aging

Less than 300€ per tower (\*\*)

(\*\*) In normal conditions 3 to 5 towers can be tested per day

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