

EMAT BOLT AXIAL FORCE TESTING SYSTEM

ORIBOLT X

Measure the real preload of every bolt in service. Electromagnetic ultrasound, dual-wave method, no couplant, no polishing, 4 to 10 seconds per bolt.



ORIBOLT-X100: main unit, rugged terminal and EMAT probe on the bolt end

Absolute axial force

Direct measurement of the bolt preload in service, without measuring the bolt before installation.

No couplant, no polishing

Electromagnetic coupling instead of piezoelectric contact. No patch, simple operation, low cost.

Calibration-free

Enter the bolt size and start. Calibration parameters are determined automatically.

Loose, over-tightened and missed bolts are invisible until you measure them

Bolted flanges in wind turbines are tightened by torque. Under constant torque installation the axial force in the bolts is highly dispersed and difficult to control: the same torque gives a different preload depending on friction, lubrication, tools and method. A missed, under-tightened or over-tightened bolt looks exactly like a good one.

The torque routine

In normal annual maintenance the bolts are re-tightened with torque wrenches. This is time-consuming and labour-intensive, and it re-tightens bolts that were never loose.

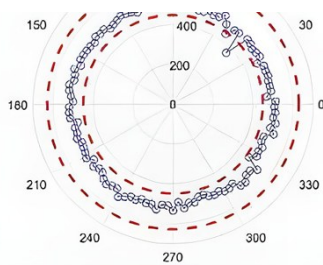
Re-tightening does not reveal a bolt whose preload is low because of insufficient lubrication, or a flange where every bolt was taken over the design value by a wrong process. Both were found in the field with ORIBOLT X (test cases, page 7).

What measurement gives you

The real axial force of each bolt, stored per bolt. Loose and broken bolts are identified quickly. Bolts that are not loose do not need re-tightening, so inspection replaces maintenance.

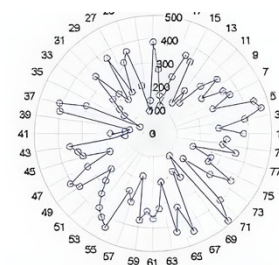
The distribution of a whole flange shows at a glance whether the installation met the design range or whether a region of the flange is low.

The same flange, two very different outcomes



Good axial force distribution

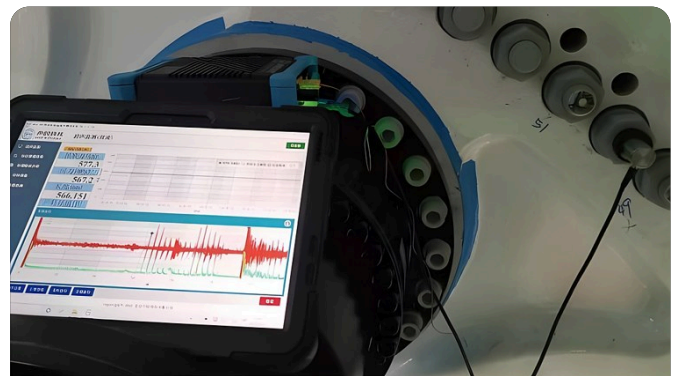
All bolts inside the design band (dashed lines). Mean 501.8 kN, 3 sigma 60.4 kN.



Poor axial force distribution

Bolts scattered far outside the design band. Mean 284.4 kN, 3 sigma 307.3 kN.

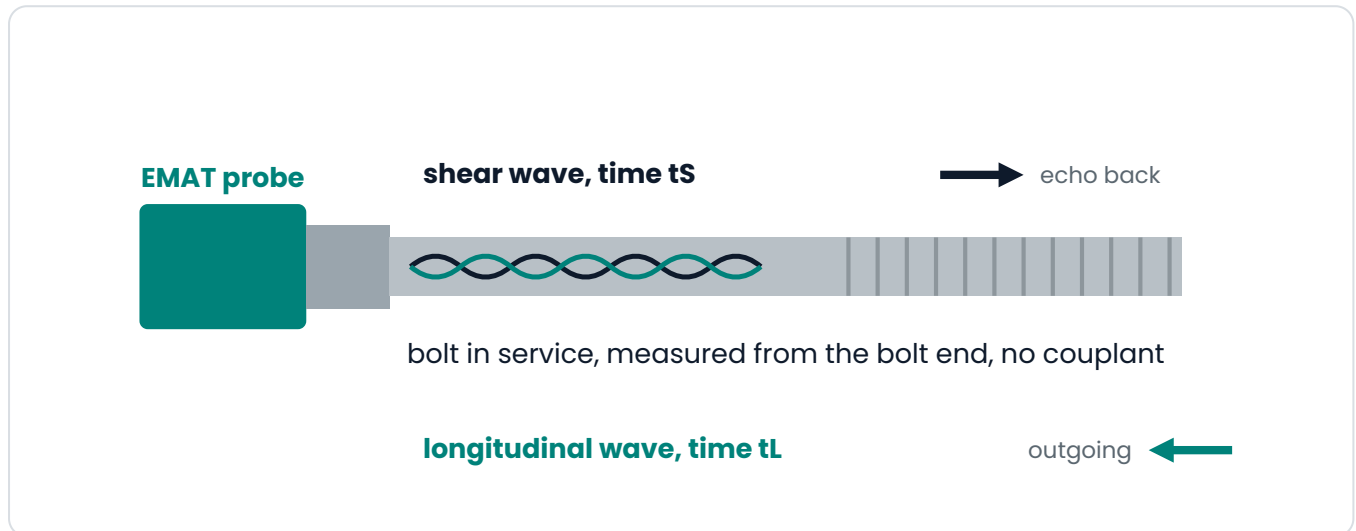
Radar charts: one point per bolt around the flange, radius = measured axial force in kN, dashed circles = design limits. Source: ORISONIC brochure.



Measuring hub and bearing ring bolts; the terminal shows the axial force and the ultrasonic waveform of each bolt.

How ORIBOLT X works

ORIBOLT X is based on an electromagnetic ultrasonic transducer (EMAT). The probe sits on the flat end of the bolt and generates two ultrasonic waves that travel along the bolt and return from the far end: a shear wave and a longitudinal wave. Their times of flight respond differently to the axial force. Comparing the two cancels the bolt length out of the calculation, so the system reads the absolute axial force of a bolt that is already installed, without a measurement of the unloaded bolt.



01 Direct measurement of the absolute value of the bolt axial force (preload).

04 The dual-wave method does not need to measure the initial state of the bolt.

02 Electromagnetic ultrasonic dual-wave method: unlike piezoelectric ultrasound it needs no polishing, no coupling and no patch. Simple operation, low cost.

05 Camera function and real-time data storage: the whole process can be traced.

03 Software for bolt calibration, measurement database and material library.

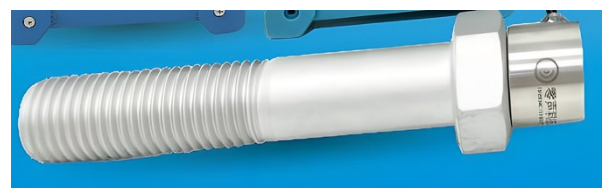
06 Contributed to drafting GB/T 43232-2023, Ultrasonic measurement method for axial stress of fasteners.

Calibration-free, quick and easy

From the bolt size information the exact calibration parameters are determined automatically. Enter the bolt size and start the axial force measurement directly. If there is no calibration data for a bolt type, it can be measured first and calibrated later.

Any flat bolt end

The bolt end must be flat. Hexagon socket heads, centre holes and raised stamp marks are accepted. EMAT probes come in several models to suit different bolts, and the material temperature is measured and compensated automatically.



EMAT probe on the bolt end

Technical parameters

Detection method	Electromagnetic ultrasound, single-wave and dual-wave methods, no couplant required
Bolt range	M8 and above (M8 to M72), length up to 6000 mm; longer lengths can be customised
Applicable bolt surfaces	Flat bolt end; hexagon socket, centre hole or raised stamp marks accepted
Axial force measurement accuracy	±1 % to 5 %
Efficiency	4 to 10 s per bolt
Measurement mode	Automatic, manual
Calibration-free function	Exact calibration parameters determined automatically from the bolt size information
Temperature compensation	Temperature sensor, automatic compensation
Probe type	Electromagnetic ultrasonic probes, multiple models for different bolts
Bolt temperature at the probe	Room temperature, or customised wide range (−200 to 600 °C)
Communication	WIFI or wired Ethernet; computer communication supported
Data storage	120 GB
Power supply	Replaceable lithium-ion battery
Operating temperature	−40 to 50 °C

Values from the ORISONIC ORIBOLT-X100 brochure and the ORIBOLT X series data sheet.

Participation in the standard

ORISONIC contributed to drafting GB/T 43232-2023, Ultrasonic measurement method for axial stress of fasteners.



SGS calibration certificate, ORIBOLT-X100, 2023

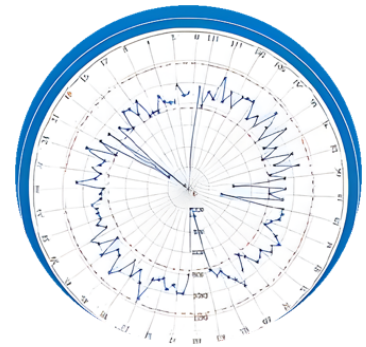
SGS-CSTC Standards Technical Services (Shanghai), force calibration at 100, 200, 300 and 400 kN, June 2023. Reported errors between 0.1 % and 1.4 %, within the ±2 % limit.

Software functions

Bolt axial force measurement and monitoring	Automatic measurement of the bolt axial force, automatic storage of the data, full traceability
Core algorithms	Automatically recognises the ultrasonic echo and calculates the time of flight
Calibration-free function	Exact calibration parameters determined automatically from the bolt size information
Quick and easy measurement	Enter the bolt size and start the axial force measurement directly
Automatic calibration results	Multiple bolts can be calibrated and the calibration factors are fitted automatically
Test before calibrate	If there is no calibration data for a bolt, it can be measured first and calibrated later
Automatic temperature compensation	The material temperature is measured and compensated automatically
Material library	Calibration database for different bolt grades, recalled at any time
Data storage and playback	Ultrasonic waveforms are stored automatically and can be replayed for later verification and traceability
Automatic reporting	One-click export of the bolt data as an Excel table, a radar chart and a statistical bar chart
Camera monitoring	Dual cameras capture the working conditions and the test personnel with one click, for review and site supervision



Measurement screen on the rugged terminal: axial force, temperature, bolt length and the live waveform



Axial force distribution radar chart of a complete flange, exported with one click

The value of measuring axial force

1. Bolt installation quality inspection

Verify the design

Check the axial force of every bolt after installation against the design requirement.

Find the outliers

Missed, under-tightened and over-tightened bolts, and regions of the flange with low axial force.

Assess the flange

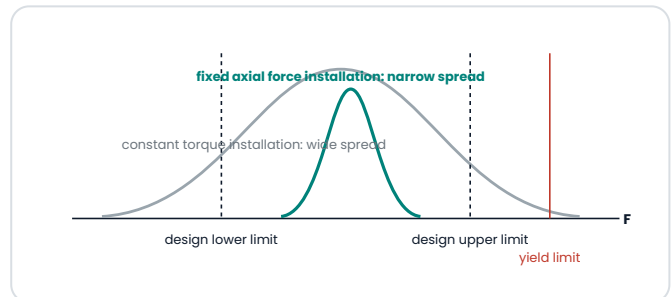
Mean and variance of the distribution, maximum to minimum ratio, dispersion, and the resulting leakage risk.

2. Inspection instead of maintenance

Under normal operation and maintenance the bolts are re-tightened every year with torque wrenches, which is time-consuming and labour-intensive. When the axial force is measured during the annual inspection, bolts that are not loose do not need to be re-tightened. Each measurement is stored per bolt, so the next inspection shows the trend.

3. Fixed axial force installation

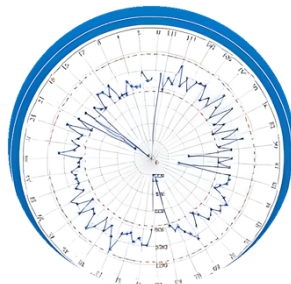
The axial force is measured during tightening. The dispersion of the bolt axial force can then be controlled within $\pm 10\%$, which solves the bolt tightening problem and gives a consistent axial force across the flange. This addresses loose bolts and flange leakage, improves bolt performance and reduces cost.



Schematic after the ORISONIC brochure: spread of the axial force under constant torque installation versus fixed axial force installation.



Field test



Axial force distribution radar chart



Broken bolt found by its waveform



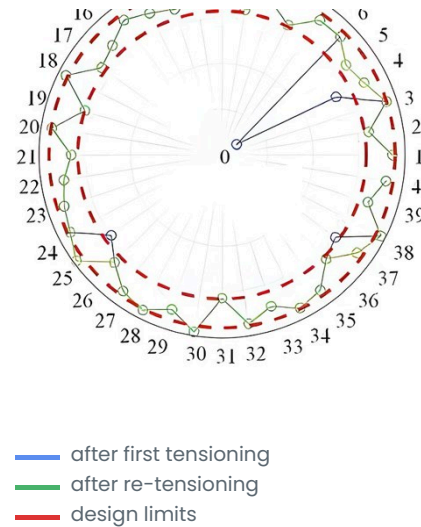
Wind farm measurement

Three test cases in wind power

Three findings from ORISONIC's wind power test cases, each with the radar chart of the flange: one point per bolt, radius = measured axial force, dashed circles = design limits.

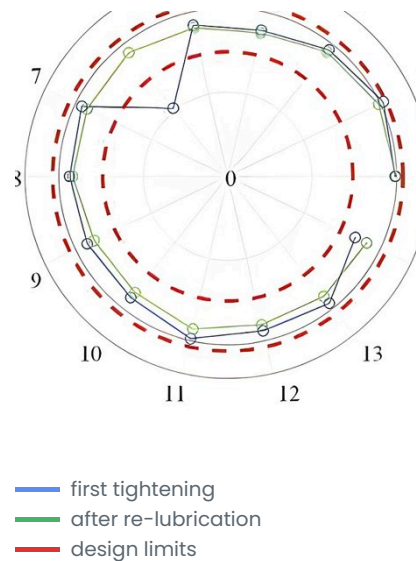
Case 1: four bolts below the design limit after tensioning

The flange was tightened by the tensioning method and the locking line drawn afterwards. Axial force acceptance found 4 bolts below the design lower limit, one of them seriously low, a risk for the operation of the unit. After re-tensioning the axial force was inside the design range. Bolt No. 5 showed movement of the anti-loosening line: it had not been fastened in place at first. Possible causes: abnormal bolt friction, abnormal tools, personnel negligence.



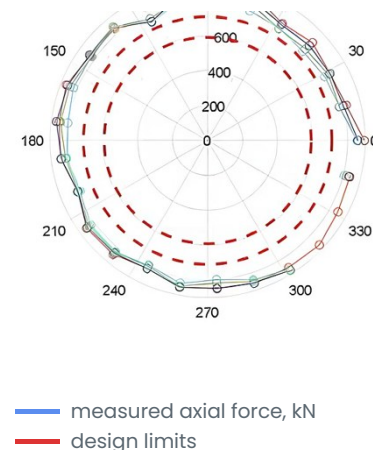
Case 2: low preload from insufficient lubrication

During construction by the torque method, a connecting bolt between the motor shaft and the inner ring of the gearbox was found with a seriously low preload. Measuring the axial force in the routine construction inspection showed the value far too small. The bolt was removed and the lubrication found insufficient. After sufficient lubrication and reinstallation the axial force reached the normal level.



Case 3: every bolt above the design value

During construction by the torque method all bolts exceeded the design value, probably because the wrong process was selected. The torque method has to control many factors: bolts, flanges, tools and method. A problem in one of them gives a large deviation that is not easy to find and threatens the safety of the equipment. Axial force measurement finds such installation problems in time.



Radar charts and case descriptions from the ORISONIC brochure.

Applications

Wind power

Factory quality inspection, wind farm bolt risk investigation, inspection instead of maintenance, long-term operation and maintenance, maintenance-free bolting.



Petroleum and petrochemical

Leakage detection on key flanges, axial force attenuation on high-temperature flanges, identification of bolts with insufficient axial force.



Nuclear power, hydrogen energy, heavy industry

Leak-proof flanges and bolts protected against breakage.



ORISONIC reference customers



Reference customers of ORISONIC Technology for the ORIBOLT system, as published by ORISONIC.



WindX UCP

Independent multi-brand wind services. ORIBOLT X audits, installation verification and inspection instead of maintenance for wind fleets.

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