

Macalloy

BAR & CABLE SYSTEMS

Macalloy AB WindForce
**Foundation Anchor Solutions
for Wind Turbines**



ETA-07/0046

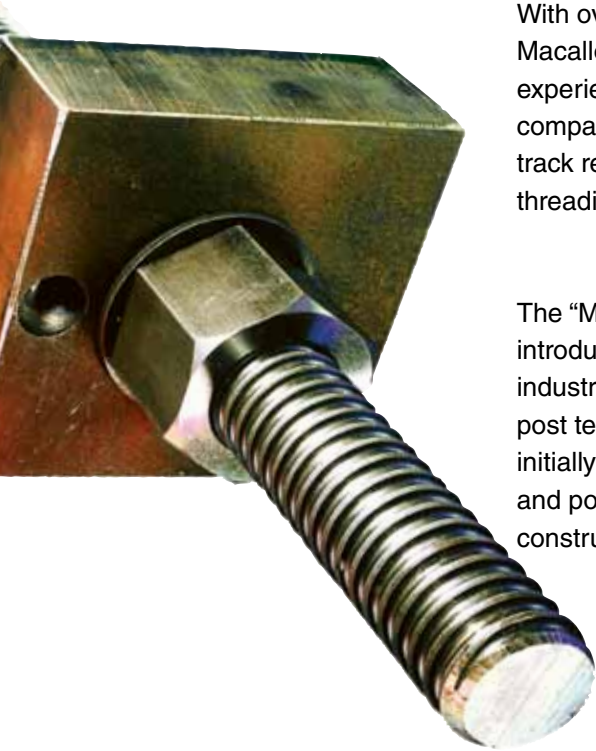


EXPERIENCE

INNOVATION

QUALITY

Introduction



Introduction

With over 60 years of history, Macalloy are the most experienced bar threading company in the UK with a proven track record at the forefront of bar threading technology.

The benefits of using the Macalloy bar have been widely recognised across the construction industry and it is now used extensively in many different structural applications.

The "Macalloy Bar" was first introduced to the construction industry in 1948 as the worlds first post tensioning bar, developed initially for use in pre-stressed and post tensioned concrete construction.

Europe's only Grout-less PT Bar system for Wind Turbine Foundations

Macalloy manufactured the Worlds First Post-Tensioning Bar system in 1948. We are currently the only European manufacturer of an end-threaded Post tensioning Bar system for use in Wind Turbine Foundations.

This allows us to compliment the properties of the bar, with a corrosion-protected system using Denso tape.

This is a 3 stage process of Denso Paste primer, Denso tape and PVC tape. The Denso materials are semi-solid which allows for movement between the un-bonded length of the bar, and the concrete foundation.

The frictional effects during tensioning are negligible which means.....No more Grout.

Our Denso system is actually a cheaper alternative to a duct-sleeve and grout application, and it also greatly reduces the installation process, offering a cost saving to Developers and Contractors, and a unique selling point for any Turbine Manufacturer.



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Strength

Table 1: Mechanical Properties

Grade	Nominal ultimate tensile strength N/mm ²	Nominal 0.1% proof stress N/mm ²	Minimum elongation %	Approximate modulus of elasticity kN/mm ²
Macalloy 1030 25-40mm	1030	835	6	170*
Macalloy 1030 50-75mm	1030	835	6	205
Macalloy S1030	1030	835	10	185

*Secant Modulus of Elasticity in range 5 - 70% UTS

The mechanical properties of the Macalloy 1030 bars can be found in Table 1.

Bars are supplied with a range of fittings including, nuts, washers,

plates and couplers. Spherical nuts and washers are also available to accommodate up to 3 degrees of rotation. All fittings are designed to exceed the failing load of the threaded bars.

The specified characteristic failing load and 0.1% proof load for the Macalloy 1030 bar are given in Table 2.

Table 2: Characteristic Loads

Nominal Bar Dia.	mm	20**	25	26.5*	32	36*	40	50	75*
0.1% Proof Load	kN	262	410	460	670	850	1050	1639	3495
Falling Load	kN	323	506	569	828	1049	1295	2022	4311
Nominal Bar Weight	(kg/m)	2.53	4.09	4.58	6.63	8.35	10.3	15.72	33.0

*Available in Carbon steel only

** Available in Stainless steel only

Rolled Threads and Fatigue

All the Macalloy 1030 bars have the unique Macalloy rolled thread rather than a cut thread, offering a distinct advantage with regard to fatigue performance.

In rolling a thread the grain structure of the material is aligned with the peaks and troughs of the thread, providing a smooth running thread form. As the threading operation is effectively a cold working operation, it results in a local increase in the tensile properties to the surface of the bar.

With a cut thread the grain structure is removed creating dislocations within the material and potential areas of crack propagation.

It has been proved via testing that a rolled thread, with its smooth thread form and increased strength, results in improved fatigue performance.

Macalloy threaded assemblies have a fatigue resistance in excess of two million cycles of loading over a tensile stress range of 80N/mm². As part of the approval, regular tests are carried out on the bars. Contact Macalloy's Technical Department for further information.

Relaxation

The requirements laid down in BS4486 for the loss of stress due to relaxation in a bar loaded to 70% of its characteristic failure load, after 1000 hours at room

temperature, is 3.5% maximum. Macalloy carries out tests in its own test house along with independent audit tests, the results of which show the bars comfortably achieve results below 3.0%.

Lock Off Losses

The 'lock off' losses exhibited with the Macalloy 1030 bar are typically 0.5mm if the load is cycled and locked off several times. This can be reduced even further if a torque is applied to the nut after the final load cycle.

Approved GL Renewables System

Macalloy manufactured the Worlds first Post-Tensioning bar system in 1948. The system has been specified and used in Civil Engineering ever since.

Our 1030 system has held an ETA for several years, and following recent growth in our Wind Division, Macalloy is proud to obtain it's certification from GL Renewables for our system.

This Certification approves the Macalloy system for use in Wind Turbine foundations.

For further information, please contact:

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Approved GL Renewables System

Macalloy operates a quality assurance system complying with the provisions of BS EN ISO 9001:2008. The Macalloy AB WindForce bars are independently approved to the requirements of BS4486.

Up to 40mm, the system also holds the ETAG 13. We also hold various National approvals such as German Zulassung and French National standards.



Worlds No 1



Our 1030 system is used in different foundation types for a number of the top 10 Turbine manufacturers in the World, but the Macalloy AB WindForce currently holds up more Vestas Turbines than any other.

Vestas are the No 1 Turbine Manufacturer in the World and have held that position for years. They embrace innovative systems like the Macalloy AB WindForce, which has already been used in 48 Vestas V90 Turbines in the last 12 months.

Up to 50% less Bar than current Anchor bolt methods

The Properties of the Macalloy AB WindForce allow for much greater loads to be put into the bars than current methods.

On the tables opposite, we have compared the operational loads which can be put into both 8.8 and 10.9 bolts alongside the AB WindForce

Also highlighted is a sample spec of 8.8 bolts and Macalloy's alternative of either less bars or a thinner diameter, which offer a more cost-effective solution.

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Table 3: Bolt Comparison

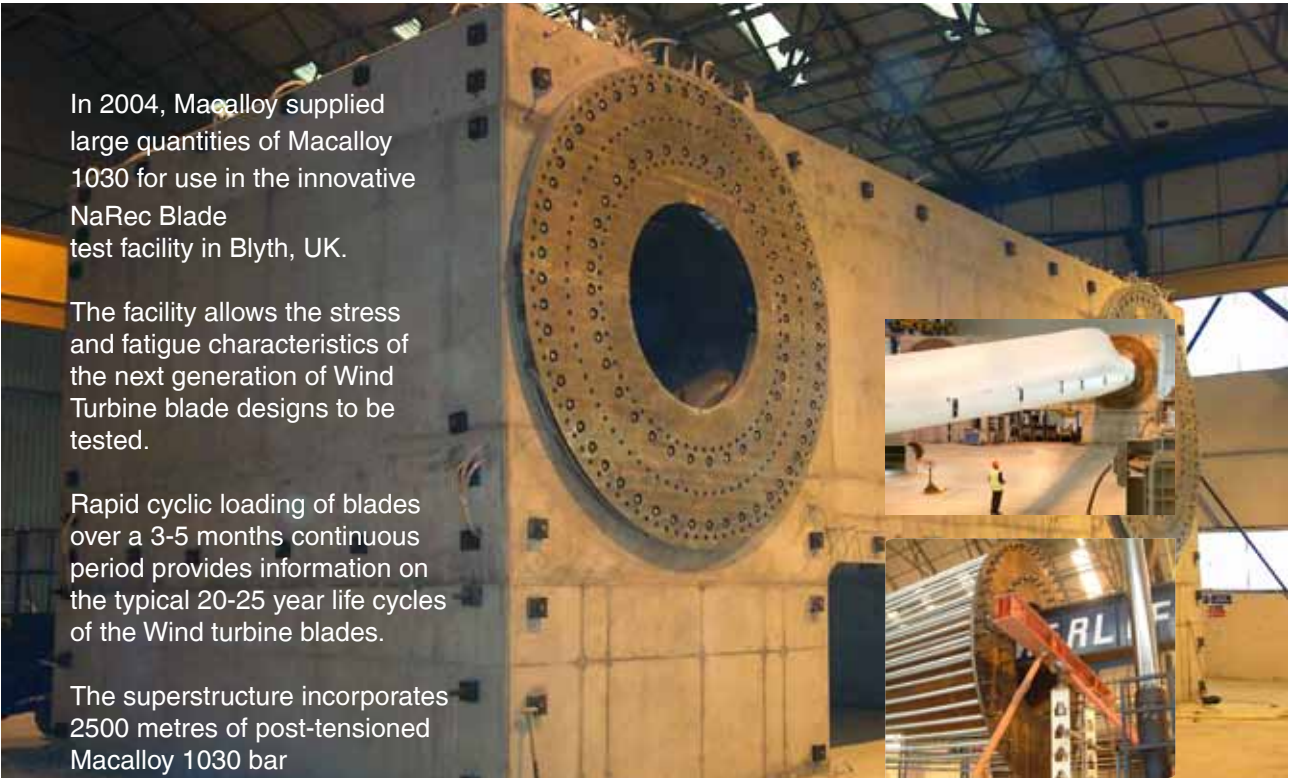
Thread Size	Grade 8.8 Bolts		Grade 10.9 Bolts		Macalloy 1030	
	Stressing capacity kN	Ultimate load capacity kN	Stressing capacity kN	Ultimate load capacity kN	Stressing capacity kN	Ultimate load capacity kN
M20	101.7	203.4	152.9	254.8	227.1	324.5
M22	125.7	251.5	189.1	315.1		
M24	146.5	293.0	220.3	367.1	354.0	505.7
M27	190.5	381.0	286.4	477.4	398.0	568.6
M30	232.8	465.6	350.1	583.4		
M33	288.0	576.0	433.1	721.8	579.7	828.1
M36	339.1	678.1	509.8	849.7	734.0	1048.5
M39	405.0	810.1	609.0	1015.0		
M42	464.8	929.6	698.9	1164.8	906.3	1294.7
M45	539.5	1079.0	811.2	1352.0		
M48	610.1	1220.1	917.3	1528.8		
M52	730.4	1460.8	1098.2	1830.4	1415.3	2021.9
M56	842.5	1684.9	1266.7	2111.2		
M64	1112.2	2224.4	1672.3	2787.2		
M72	1415.3	2830.6	2128.0	3546.7		
M76	1584.6	3169.2	2382.6	3971.0	3017.4	4310.6

Table 4: Bolt Comparison

	Thread	Quantity	Stressing capacity (kN)	Total compressive load (kN)
8.8 bolt	M36	160	339.1	54,256
Macalloy equivalent 1	36mm	74	734	54,316
Macalloy equivalent 2	26.5mm	160	398	63,680

Projects

Macalloy – Supplying the future of Wind Turbines – BLYTH BLADE TEST FACILITY



In 2004, Macalloy supplied large quantities of Macalloy 1030 for use in the innovative NaRec Blade test facility in Blyth, UK.

The facility allows the stress and fatigue characteristics of the next generation of Wind Turbine blade designs to be tested.

Rapid cyclic loading of blades over a 3-5 months continuous period provides information on the typical 20-25 year life cycles of the Wind turbine blades.

The superstructure incorporates 2500 metres of post-tensioned Macalloy 1030 bar

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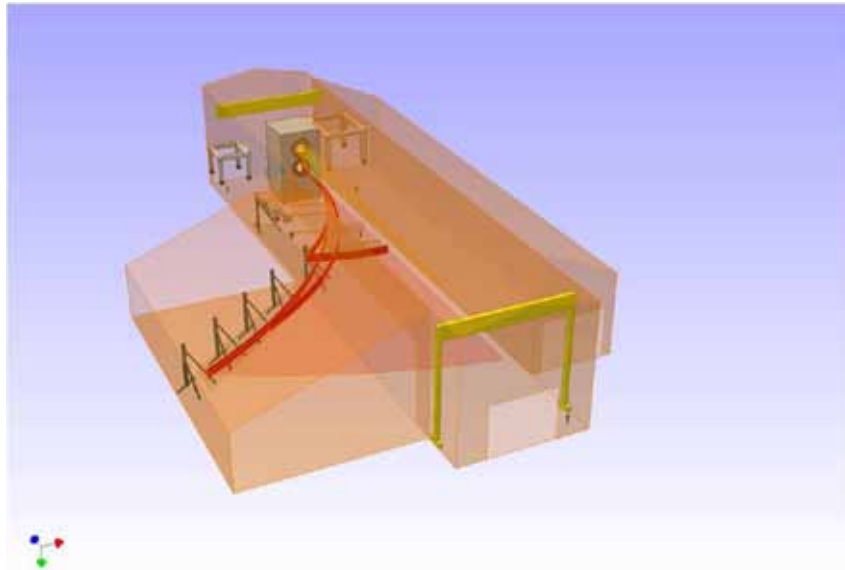
BT2

Following the success of Narec's first Blade test facility in 2004, a new £15million facility is under construction to test up to 100m Wind Turbine blades.

This will allow Narec to build on its World-leading fatigue testing technology.

Macalloy 1030 has once again been specified heavily throughout the structure by Arup, the Engineering firm tasked with the design of the structures.

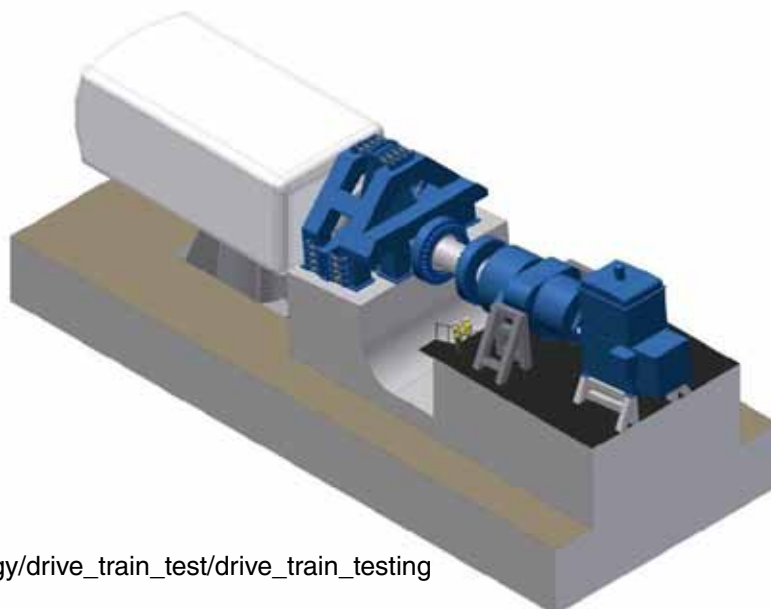
For more information, please visit:
www.narec.co.uk/sectors/wind_energy/blade_test



Project Nautilus

In addition to BT2, NaRec are also constructing the World's largest open-access Offshore wind turbine drive train test rig for machines up to 12MW, the future of the Offshore Wind Energy market.

"Fujin", along with its Rotary test-rig counterpart "Nautilus", will be constructed during summer 2011 and will both feature large amounts of Macalloy 1030 in the foundations.



For further information, please visit:
www.narec.co.uk/sectors/wind_energy/drive_train_test/drive_train_testing

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Idhult – Sweden

The Idhult project comprised of eight Vestas 2.0 MW turbines, to be delivered during the autumn of 2010.

The turbines are intended for the Idhult wind farm in Mönsterås municipality, which has received a permit and has thus begun construction.

The eight turbines, with an aggregate output of 16 MW, and used Macalloy AB WindForce as PT foundation bolts.



Sodra Karra – Blekhem

12 Vestas Turbines in total supplied in early 2011, once again using the Macalloy AB WindForce in place of the inferior and more expensive 8.8/10.9 bolt system.

This project is based on a new Vestas foundation design which increases the height of the towers giving increased output and performance.

Macalloy AB WindForce was chosen for the properties and benefits of the system.

Why Choose Macalloy?

Only Anchor bar system to hold a GL Renewables certification

60+ years of Manufacturing the bar for use in Civil Engineering Groundwork projects

More space to work with for the rest of the foundation - Ease of work on-site

Significantly less Installation time (€€€ reduced cost on contractor time)

EIA Approved Post-Tensioning system

Up to 50% less bars (€€€ reduced cost on Material and transportation)

Only EU Manufacturer of a PT bar with de-bonded length (allows for Denso tape)

Denso tape removes requirement for Grouting into a duct (€€€ reduction on cost)

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Wind Farm Applications

Uljabuouda - Sweden

The wind farm at Uljabuouda consists of a total of 10 3MW wind turbines, with a total annual production of 80 GWh. The turbines will supply electricity to more than 3000 homes.

Macalloy 40mm bars were installed as part of the foundation system. 136 bars at approximately 2.6 m long

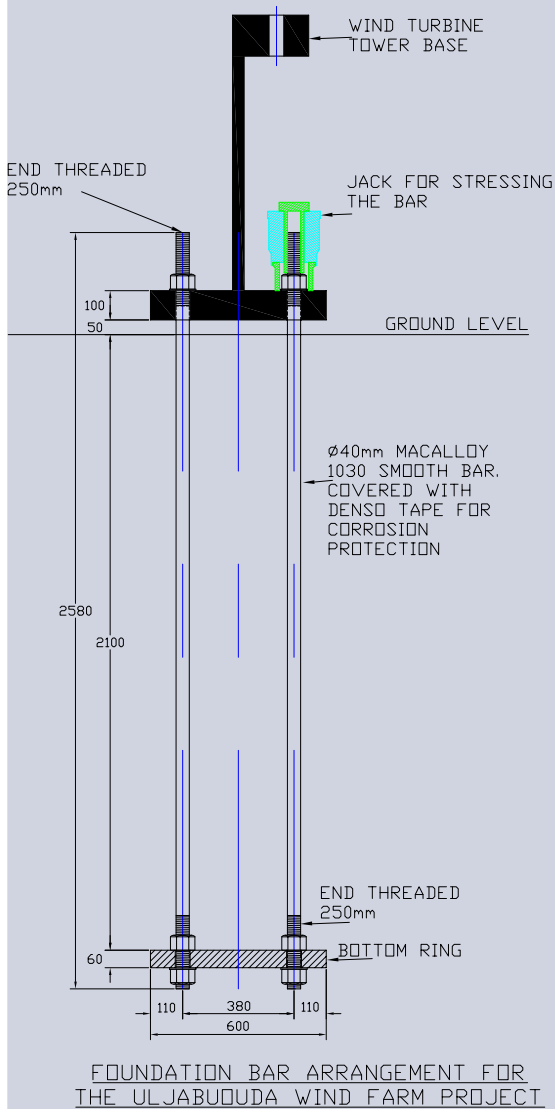
were supplied to each wind turbine, using Denso/ PVC tape for corrosion protection.

The first four wind turbines are expected to begin operations in the autumn of 2009 and the remaining six in the summer of 2010.

The bars serve a dual purpose, not

only do they provide a means of stressing the concrete foundations but also they act as the holding down bolts for the base of the wind turbine tower.

Uljabuouda - Sweden



This publication provides the technical details currently used by Macalloy in the manufacture of its components.

The company reserves the right to amend technical details as and where necessary in line with its policy of continuous development.

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