Bumax is Bufab's registered trademark, known as the strongest stainless steel fastener in the world.
Bumax is manufactured in Bufab's own plants in Sweden and meets the requirements of high demanding customers when it comes to quality, corrosion resistance, high strength, fatigue strength, traceability and heat resistance. We deliver safety and reliability.

Some of the products in the Bumax family are completely unique that cannot be found anywhere else on the market. All products have full traceability (3.1 certificates available for each item) and are sourced solely from premium European stainless steel manufacturers according to rigid specifications.

INTRODUCTION to Bumax 88 and Bumax 109

Bumax 88 and Bumax 109 are premium A4 fastener products in the Bumax family. It is known as a very consistent product that offers higher yield strength, lower amount of inclusions and tighter tolerances in chemical composition compared to standard A4 fasteners. As a result, Bumax 88 and Bumax 109 offers superior mechanical properties and fatigue resistance, better corrosion resistance in most environments and very low magnetic permeability. For our customers it means unmatched reliability and life expectancy in the harshest environments.
Bumax 88 and Bumax 109 are made of the same material but due to a special manufacturing process, Bumax 109 offers higher strength and is the strongest A4 fastener on the market. Fasteners in the Bumax 88 class have strength properties that correspond to 8.8 carbon steel fasteners and Bumax 109 with 10.9 carbon steel.

APPLICATIONS

Bumax 88/109 are used in demanding applications in industries like oil and gas, pulp and paper, marine, petrochemical, energy and many other industries where standard A4 fasteners simply cannot do the job. Our products are used for water jets, particle accelerators, sub-sea equipment, pumps, valves, wind turbines, high-pressure equipment, nuclear plants, submarines and many more.

CHEMICAL COMPOSITION and standards

A4 standard as it is defined in ISO 3506 have a very wide tolerance range and superficial demands regarding trace element content. There are an extensive number of steel standards that falls inside the A4 definition and each standard has its own characteristic. The most common standards are listed in table1.
A4 bolts, nuts and washers are typical commodity products that can be purchased off the shelf in most hardware stores. A4 grades are globally produced in vast numbers and under high price pressure. Most fastener producers are therefore using the cheapest steel material available, as long as it fulfils the definition of A4 according to ISO 3506. Using steel that contain as low amount as possible of expensive elements such as Molybdenum (Mo), Nickel (Ni) and Chromium (Cr) and also the cheapest metallurgical process that gives a high trace element content and high inclusion/slag density. Nevertheless standard A4 is good enough for a wide range of non-critical applications.
For high demand applications, where low Life Cycle Cost is essential and where a failure can lead to large economic losses or even personal injuries, it is essential to use premium fasteners. You might not see the difference between a premium material and a commodity A4 just by naked-eye inspection or a tensile test. However it is a huge difference when the products are compared in real conditions or by thorough corrosion and fatigue laboratory testing. Bumax 88/109 is made of premium 316L high Molybdenum steel grade with much higher demands in regards of chemical composition. The difference between standard A4 and Bumax 88/109 fasteners consists primarily in that the Bumax properties starts where standard fasteners end or ended long ago. This means that a Bumax fastener is always better, stronger and more corrosion resistant than standard A4 fasteners.

Table 1. Stainless steel standard designation

GRADES	EN ISO 3506[1)]	EN	ASTM
Standard A4 fastener	A4	1.4401, 1.4404	316
Bumax 88/109	A4	1.4432, 1.4436, 1.4435	316L high Mo

[1)] EN ISO 3506: Mechanical properties of corrosion-resistant stainless steel fasteners

The special characteristics of the Bumax 88/109 composition is the low carbon content, enhanced molybdenum content and much tighter tolerance in regards of trace element and other unwanted elements such as slags and inclusions. The difference in chemical composition between Bumax 88/109 and standard A4 can be seen in table 2.
Carbon (C) should be kept as low as possible as it reduces the risk of chromium carbide precipitations and intergranular corrosion. High carbon content also has a negative effect on the ductility. Bumax 88 has a max carbon content of 0.03% and can therefore be designated as 316L.
Phosphorous (P) and Sulphur (S) are elements that reduce ductility and corrosion resistance and should be kept as low as possible.
Molybdenum (Mo) is the alloying element that has the strongest positive effect on corrosion resistance. Bumax 88´s enhanced molybdenum content is the main reason to its superior corrosion resistance compared to standard A4.
Copper (Cu) is an alloying element that improves cold heading productivity but has mainly negative effect on fastener properties. Copper reduces strength and hot working properties, which may affect surface properties and risk of copper rich phases that reduces corrosion resistance and ductility.

Table 2. Difference in chemical composition between standard A4 and Bumax 88/109

Steel grade	Chemical composition, weight-%							
	C	Si	P	S	Cr	Mo	Ni	Cu
A4 standard	max 0.08[1)]	max 1	max 0.045	max 0.03	16-18.5	2 - 3	10 - 15	max 4
Bumax 88/109	max 0.03	max 0.8	max 0.04	max 0.015	min 16.5	min 2.5	min 11	max 0.6

[1)] At the discretion of the manufacturer, the carbon content may be higher up to 0.12%

CORROSION RESISTANCE

BUMAX 88/109 offers better corrosion resistance than standard A4 due to higher molybdenum content, lower carbon content, smooth surface properties and rigid control of trace elements and inclusions. The Pitting Resistance Equivalent number, PRE[1)] is based on a well-known formula and gives a good indication of the pitting and crevice corrosion resistance as a function of the alloying content. The higher PRE number, the more resistant is the steel against pitting corrosion in seawater and chloride induced corrosion.

Table 3. Typical Pitting Resistance Equivalent

Steel grade	ASTM	Cr (%)	Mo (%)	N (%)	PRE[1)]
A4 standard	316	17	2.1	0.04	25
Bumax 88/109	316L high Mo	17	2.7	0.04	27

[1)] PRE = %Cr + 3.3x%Mo + 16x%N

As can be seen in table 3, it is a difference in PRE value between the two grades due to fact that Bumax 88/109 guarantees a molybdenum value of 2.5 to 3.0% and standard A4 only guarantees a minimum content of 2.0%. This higher PRE in combination with the above mentioned parameters gives better corrosion resistance which has been proved by numerous laboratory tests and even more important, experience from real cases. A particularly interesting field test has been performed by the stainless steel company Outokumpu together with Swedish Corrosion Institute at SwereaKIMAB and can be found in Outokumpu Corrosion Handbook. Test specimen has been exposed to conditions along roads and bridges at coastal locations in Sweden for a period of five years. The black dot in the table 4 indicates pitting corrosion after five year exposure.

Table 4. Outokumpu corrosion test, black dot indicates corrosion after five year exposure

Grade	EN	ISO 3506	Bumax grade	Borås	Gothen-burg	Öresund, bridge road	Öresund, under bridge	Öland	Höga kusten	Svartnora
304L	1.4307	A2		●	●	●	●	●	●	
316L	1.4404	A4		●	●		●	●	●	
316L high Mo	1.4432	A4	Bumax 88/109				●			

MECHANICAL PROPERTIES

Fasteners in the Bumax 88 class have strength properties that correspond to 8.8 carbon steel fasteners and Bumax 109 with 10.9 carbon steel. As can be seen in the table 5, it is only the method of measuring and stating the elongation that differs. The difference consists primarily in that all testing of stainless steel must take place on finished product according ISO 3506, while testing of carbon steel which many times are hardened is usually carried out on test pieces according to ISO 898.
That gives Bumax 88 and Bumax 109 the unique possibility to substitute 8.8 and 10.9 carbon steel.

Table 5. Minimum strength and elongation

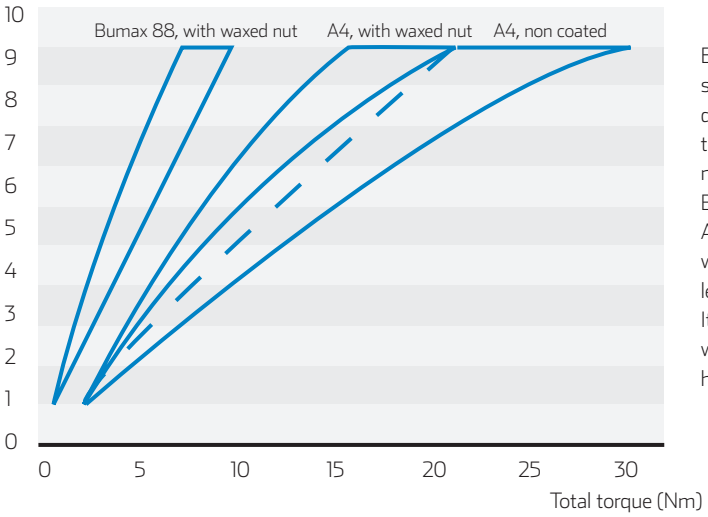
Product	Dimension, mm	Tensile strength R_m, min		Yield strength $R_{p0.2}$, min		Elongation, min mm	Testing standard
		MPa	psi	MPa	psi		
Bumax 109	M3-M20	1000	145 000	900	130 500	0.2 d	ISO 3506
Bumax 88	M3-M36	800	116 000	640	92 800	0.3 d	ISO 3506
Bumax 88 (PED)[1)]	M6-M30	800	116 000	640	98 200	0.4 d	ISO 3506
A4-80		800	116 000	600	87 000	0.3 d	ISO 3506
A4-70		700	101 500	450	65 200	0.4 d	ISO 3506
8.8 carbon steel		800	116 000	640	92 800	12 %	ISO 898
10.9 carbon steel		1000	145 000	900	13 500	9 %	ISO 898

[1)] Higher elongation demands in order to fulfill PED requirements

Preload is needed to keep the jointed part together and function correctly for long periods of time, resisting both static and dynamic loads. The combined stresses in the joint should normally not exceed the yield strength of the fastener. A guideline is to use a preload that is 65% of the yield load, however it can vary between 50 to 80% in practical use.

Yield load = As x $Rp_{0.2}$ As = nominal stress area (mm^2)
$Rp_{0.2}$ = yield strength (MPa)

Tightening torque is needed to achieve the necessary preload. Recommended tightening torque is calculated by the well-known Kellerman/ Klein formula and depends on parameters such as friction, preload, thread diameter, screw type and tightening procedure. The recommendations for Bumax are based on a targeted preload of about 65-70% of the yield load and a friction coefficient of 0.14-0.16, which can only be obtained by a burr-free surface and using high quality lubrication. Recommended preload and tightening torque data can be found at www.bumax.se



Empirical tests show that Bumax 88 has lower friction and more stable against galling than standard A4 fasteners. Fig1 shows a diagram where the real clamp load has been measured in relation to the torque on M6 ISO 4017 bolts and ISO 4032 nuts. Bumax 88/109 nuts are always waxed with our special tailor made wax suitable for Bumax products, with a friction coefficient of approximately 0.08. As comparison, standard A4 bolts and nuts have been tested, non-waxed fasteners as well as waxed nuts. The result show that much less torque is needed on Bumax 88 to obtain the needed clamp load. It is also noticeable that load values are more stable with less spread which is a result of an excellent wax that is working together with a hard rolled smooth thread and tight tolerances.

Fig1. Torque/clamp load diagram based on laboratory tests carried out on ISO 4017 bolts, ISO 4032 nuts and ISO 7089 washers of dimension M6.

FATIGUE RESISTANCE

Fatigue fracture occurs when a fastener is subjected to repeat cyclic loading. Even maximum stresses below the materials yield point can lead to the formation of microscopic cracks that eventually lead to a failure. The starting point of a fatigue fracture is often stress concentration in inclusions, slags or surface defects. Bumax 88 material has superior fatigue resistance compared to commodity fasteners. High quality raw material made with the best metallurgical processes together with good surface properties and high strength guarantees excellent fatigue resistance. Fatigue testing has been performed on Bumax 88 and competitor A4-80 material at an external laboratory up to 10 million cycles. Table 6shows testing result from longitudinal fatigue loading on M6x50 ISO 4017 bolts, wöhler curve (S-N curve) can be received on request. The bolts were pre-stressed to 400 MPa, which is the stress obtained on a typical preloading of M6 class 80 bolts. The main reasons for the outstanding fatigue resistance on Bumax 88 are higher yield strength, lower inclusion content and better surface properties compared to standard A4.

Table 6. Cycles before fracture at various stress levels. Test stopped at 10 million cycles.

Stress, MPa	Cycles before fracture	
	Bumax 88	A4-80
400±50	10 million	10 million
400±50	10 million	1.4 million
400±55	10 million	0.4 million
400±55	10 million	0.4 million
400±60	4.2 million	0.5 million
400±60	5.6 million	0.3 million

MAGNETIC PERMEABILITY

Relative magnetic permeability refers to a material's ability to attract and conduct magnetic lines of flux. The more conductive a material is to magnetic fields, the higher its permeability. Austenite is a non-magnetic phase and austenitic stainless steel has in general very low magnetic permeability. Bumax 88 and Bumax 109 has more rigid control regarding chemical elements, delta-ferrite and inclusions compared to a typical A4 fasteners, which means less variation from batch to batch and in most cases also lower magnetic permeability. Bumax 88 and 109 fasteners are used in advanced applications that demands very low magnetic permeability such as nuclear reactors, fusion reactors or particle accelerators.

Table 7. Typical Magnetic Permeability based on measurements on M5 screws

Grade	Relative magnetic permeability at 20ºC
Bumax 88	1.006
Bumax 109	1.007

Values in the table are the typical relative magnetic permeability at 20ºC based on measurements on M5 screws analyzed in a LakeShore Vibrating sample magnetometer at Sandvik R&D. The data should be used as guidance only. Magnetic permeability is difficult to measure and can vary depending on the quality of the measurement instruments, dimension, delivery form and degree of cold work.

QUALITY AND ENVIRONMENT

The majority of our fasteners are cold forged in our own facilities in Sweden where cold forged stainless fasteners have been made since 1926. Cold forging gives a superior product with increased strength and improved fatigue resistance. Raw material is sourced from premium suppliers in Europe with rigid specifications regarding chemical composition with low content of trace elements as well as low inclusion and slag content. All our products are delivered with full traceability and 3.1 certificate. Bumax 88 can also be delivered with a certificate that ensures that our fasteners fulfils the requirements according to the European Union's pressure equipment directive (PED97/23) as well as with CE marking as structural bolt according to EN 15048. Our facilities are approved according ISO 9001, 14001 and ISO/TS 16949.

STOCK

BUMAX 88 products are stocked in a wide range from M3 to M36 and the most common types of screws, nuts and washers. We also stock a range of UNC-threaded products. Contact your local Bumax salesman or visit www.bumax.se for more information.

SERVICE

The BUMAX 88 and BUMAX 109 products are manufactured in our own factories and we can therefore keep a very high service level on these products. Thanks to our own manufacturing, we can offer sizes other than those presented in our stock range enabling us to produce "special" products according to each customer needs. We can produce products having even higher strength than the ones presented in this brochure. In these cases, it is the limitations on the steel itself deciding how far we can reach in terms of strength and other properties. We are continuously working on improving the properties of our products.

Marking

The Bumax 88/109 fasteners held in stock consisting of hexagon head screws, hexagon socket screws, nuts and washers are normally marked in accordance with the figure on the right[1)]

[1)] Dimension <M5 do not contain some of the marking due to space restrictions.

Packing

Our products are packed in high quality sturdy boxes and are marked according to a colour coded system. We guarantee full traceability for all our products in unbroken boxes. On our labels all data for full traceability is given.