

BUMAX® is Bufab's registered trademark, known as the strongest stainless steel fastener in the world.

BUMAX® is manufactured in Sweden and meets the highest customer demands in terms of quality, corrosion resistance, high strength, fatigue strength, traceability and heat resistance. We deliver safety and reliability.

Some of the products in the BUMAX® range are completely unique and cannot be found elsewhere on the market. All our products have full traceability (3.1 or 3.2 certificates available for each item upon request) with raw materials only sourced from premium European stainless steel manufacturers according to our rigid specifications.

INTRODUCING BUMAX® DUPLEX GRADES

Duplex Stainless Steel, also known as Ferrite-Austenitic Stainless Steel, is a family of stainless steel that has a two-phase microstructure containing Ferrite and Austenite.

Figure 1 shows the austenitic grains embedded in a ferritic phase. It is important that the mix of ferritic and austenitic phase is roughly 50/50 as an excessive proportion of either structure can lead to reduced corrosion resistance and poor mechanical properties. Duplex stainless steel offers many beneficial properties.

BUMAX® duplex grades include two main products, BUMAX® DX 129 (Duplex) and BUMAX® SDX 109 (Super Duplex). Both products are produced through cold working.

BUMAX is accredited according to Norsok M-650, Norsok M-630

MDS D60 and listed as an approved manufacturer on EQUINOR TR2000. More product information can be found in our BUMAX® SDX Norsok datasheet.

BUMAX® duplex grades can be used at service temperatures between -50 to 300°C

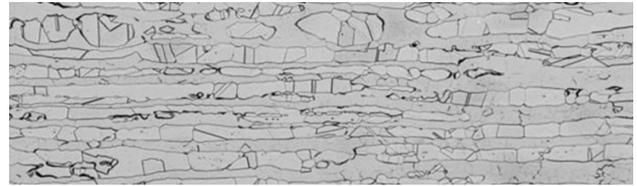


Figure 1: Duplex stainless steels have a two-phase microstructure of austenite and ferrite grains.

APPLICATIONS

BUMAX® Duplex grades are suitable for applications that require:

- Excellent corrosion resistance.
- High strength, strength class 10.9 to 12.9.
- Low relaxation.
- Excellent fatigue resistance.
- Excellent ductility and super high strength.

Even at very high strength levels, such as 10.9 or 12.9, BUMAX® Duplex fasteners offer equally good or better elongation than A4-80.

BUMAX® Duplex fasteners are used in many demanding applications that require better corrosion resistance and mechanical properties than 12.9 alloy steel/carbon steel fasteners, A4 (316L) or BUMAX® 88/109.

Duplex stainless steel fasteners are widely used for critical applications that demand a combination of excellent corrosion resistance and high strength. The material ensures very high strength, even in annealed condition, and is a material that is difficult to cold form. Therefore, almost all Duplex fasteners until now have either been machined or hot forged. Cold headed duplex stainless steel high-strength fasteners have a wide variety of critical applications that demand a long service life and high strength, combined with corrosion resistance – for example off-shore applications with a lifespan of 50 years.

High alloyed Duplex grades such as BUMAX® SDX 109 are primarily used in the oil/gas, chemical, and pulp and paper industries, and subsea or other applications in highly corrosive environments. BUMAX® DX 129 is developing as a preferred high performance alternative to traditional 12.9 coated (and even non-coated) alloy steel fasteners, where excellent mechanical

properties and/or a level of corrosion resistance is required.

BUMAX® DX 129 has proven to be an excellent substitute for 12.9 alloy steel as it is not subject to the same challenges that coated 12.9 fasteners are well-known for, such as risk of hydrogen embrittlement, poor ductility, as well as many of the associated quality and performance issues inherent with the use of a secondary protective coating. The total lifecycle costs can be much lower using BUMAX® DX 129 or SDX 109 by reducing or eliminating future maintenance, downtime and replacement costs, which can often far outweigh the initial higher cost of the fastener.

Examples of BUMAX® DX 129 and BUMAX® SDX 109 fastener applications include:

Robotics – a leading supplier of industrial robots experienced corrosion problems with their coated 12.9 fasteners. BUMAX® DX 129 have provided corrosion resistance without compromising on the necessary strength.

Sub-sea filters – BUMAX® SDX 109 were used for a seawater filter for filtering cooling water for a nuclear plant. The design requires high-strength fasteners that can be submerged in seawater for at least 30 years.

Sub-sea cable protection – BUMAX® SDX 109 have been selected for sub-sea cable protection systems due to their unique combination of high-strength and excellent corrosion resistance.

Electric bicycles – a leading manufacturer of high-performance e-bikes uses BUMAX® DX 129 fasteners to attach the motor to the bike frame. Alloy steel 12.9 fasteners were previously used, which had corrosion problems.





CHEMICAL COMPOSITION & PHYSICAL PROPERTIES

Nominal wt%

| GRADES | EN | UNS | ISO 3506 | Cr | Ni | Mo | W | N | PRE ¹⁾ |
|------------------------------------|------------------|-------------------|----------|----------|--------|----------|------|--------------|-------------------|
| BUMAX® DX 129 | 1.4462 | S32205/ S31803 | D6 | 22 | 5 | 3.2 | | 0.18 | >34 |
| BUMAX® SDX 109 | 1.4410 | S32750 | D8 | 25 | 7 | 4 | | 0.30 | >40 |
| BUMAX® SDX NORSOK ²⁾ | 1.4410 1.4501 | S32750 S32760 | D8 | 25 25 | 7 7 | 4 3.5 | 0.75 | 0.30 0.25 | >40 |

¹⁾ PRE (Pitting resistance Equivalent) = %Cr + 3.3x%Mo + 16x%N

²⁾ BUMAX® is accredited according to NORSOK M-650, NORSOK M-630 MDS D60. More product information can be found in the BUMAX® SDX NORSOK datasheet.

Other duplex grades such as Lean Duplex BUMAX® LDX can be offered on request. Ferrite-austenitic microstructure is magnetic and has a lower constant of thermal expansion compared to an austenitic stainless steel, which can offer design advantages and is beneficial for bolted joints at elevated temperatures.

Constant of thermal expansion, mean values in temperature ranges (x10⁻⁶) per °C

| GRADES | 20 to 100°C | 20 to 200°C | 20 to 300°C |
|----------------|-------------|-------------|-------------|
| BUMAX® DX, SDX | 13.0 | 13.5 | 14.0 |
| A4 (316L) | 16.5 | 17.5 | 18.0 |

Constant of thermal expansion, mean values in temperature ranges (x10⁻⁶) per °F

| GRADES | 70 to 200°F | 70 to 400°F | 70 to 600°F |
|----------------|-------------|-------------|-------------|
| BUMAX® DX, SDX | 7.0 | 7.5 | 8.0 |
| A4 (316L) | 9.5 | 9.5 | 10.0 |



MECHANICAL PROPERTIES

BUMAX® Duplex grades achieve their high strength from cold working such as cold heading and thread rolling. BUMAX® Duplex grades can be provided in different strength classes depending on customer requirements, dimension and fastener type. Dimension range and mechanical properties of BUMAX® Duplex grades are presented in the table below.

BUMAX® DX 129, SDX 109 and SDX NORSOK are standard BUMAX® products that are always in stock. Visit the BUMAX® website for more

information. Other strength classes according to table below can be produced on request.

BUMAX® can also offer bar turned Super Duplex fasteners with complex geometry and dimensions larger than M30. Machined Super Duplex grades have lower strength and can be offered in strength class 80 or according to specific standards such as NORSOK and NACE MR0175/ISO 15156.

| GRADES | Production capability | Stock range | Tensile strength Rm, min MPa ksi | Yield strength Rp _{0.2} , min MPa ksi | Elongation, min |
|---------------------------------|-----------------------------|-----------------------|--|--|--------------------|
| BUMAX® DX 129 | M3 – M24 0.125" - 0.875" | M6 to M16 | 1200 174 | 1080 156 | 0.3 d |
| BUMAX® SDX 109 | M3 – M24 0.125" - 0.875" | M6 to M16 | 1000 145 | 900 130 | 0.3 d |
| BUMAX® DX 109 | M3 – M24 0.125" - 0.875" | Produced upon request | 1000 145 | 900 130 | 0.3 d |
| BUMAX® SDX 129 | M3 – M24 0.125" - 0.875" | Produced upon request | 1200 174 | 1080 156 | 0.3 d |
| BUMAX® SDX NORSOK ¹⁾ | Up to M36 (1.1/2") | Produced upon request | 750 108 | 550 79 | 16% |
| BUMAX® SDX 80 ²⁾ | M3 – M42 0.125" – 1.5" | Produced upon request | 800 116 | 600 87 | 16% |

¹⁾ BUMAX® are accredited according to NORSOK M-650, NORSOK M-630 MDS D60. More product information can be found in BUMAX® SDX NORSOK datasheet.

²⁾ Machined fasteners suitable for designs or dimension that can not be cold headed. Contact BUMAX for more information

The data shown in the table are represented for the majority of BUMAX® duplex fasteners. May be subjected to alterations depending on design and length.



FATIGUE RESISTANCE

Fatigue fracture occurs when a fastener is subjected to repeated cyclic loading. Even maximum stresses below the material's yield point can lead to the formation of microscopic cracks that eventually result in failure. The starting point of a fatigue fracture is often a stress concentration in inclusions, slags or surface defects.

BUMAX® DX 109, and SDX 109 exhibit extraordinary fatigue resistance, far better than any standard austenitic fastener such as A2 and A4. The reasons for that are:

- High strength fasteners
- Favourable compressive stresses due to thread rolling
- Excellent ductility and elongation
- Superior material quality- low amount of inclusion
- Dual phase that prevents crack propagation

BUMAX® is one of only a few fastener companies that has conducted testing to compare the mechanical performance of duplex stainless grades with austenitic stainless and high strength 12.9 alloy steel. The fatigue resistance properties of strain hardened duplex fasteners have been compared with austenitic stainless steel and high strength 12.9 alloy steel fasteners at 3rd party laboratories.

Diagram 1 shows the Wöhler curve (S-N curve) of BUMAX® DX 109, BUMAX® 88 and competitor A4-80 products tested at a third-party laboratory up to 10 million cycles. All bolts were M6x50 ISO 4017 and pre-loaded to 8 kN (400 MPa) and subjected to longitudinal cyclic loadings at a frequency of approximately 160 Hz. The test stopped after 10 million cycles (run-out), unless the bolt had broken before.

The second fatigue test was carried out at a third-party laboratory to evaluate the difference in fatigue resistance between alloy steel 12.9 and BUMAX® DX 129.

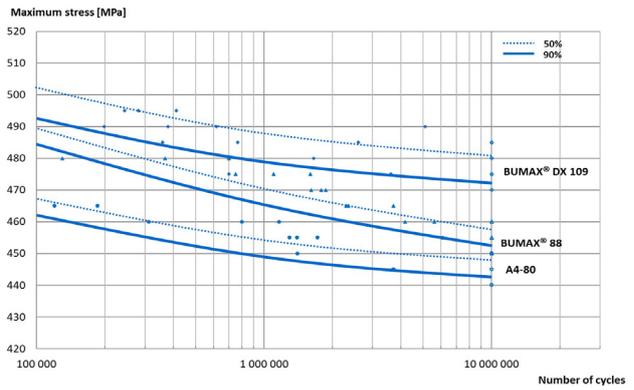


Diagram 1: Wöhler curve (S-N curve) at 50 and 90% certainty against failure

The M8x50 ISO 4762 screws were assembled with nuts and pre-loaded to 28 kN (770 MPa) and subjected to very high applied dynamic stresses up to 308 MPa. The test was carried out at a frequency of approximately 66-69 Hz. The below table shows the mechanical properties of the tested bolts and highlights considerably higher ductility of BUMAX® DX 129, compared with that of 12.9 carbon steel. There is a significant difference in elongation after breakage between 12.9 carbon steel and BUMAX® DX 129.

Total 16 bolts were tested. The average number of cycles before breakage was 34 000 on 12.9 with which should be compared with an average of over 46 000 cycles for BUMAX® DX 129. The outcome of this very intense test showed a 36% longer lifetime for BUMAX® DX 129.

| PRODUCTS | Tensile strength (MPa) | Yield strength (MPa) | Elongation (mm) |
|---------------|------------------------|----------------------|-----------------|
| 12.9 | 1320 | 1266 | 2,44 |
| BUMAX® DX 129 | 1244 | 1199 | 4,07 |

Table: Mechanical properties of the fatigue tested ISO 4762 M8x50, BUMAX® DX129

CORROSION RESISTANCE

Duplex stainless steel offers very good resistance to general and pitting corrosion due to its high PRE number. Duplex is also well known to possess excellent stress corrosion (SCC) resistance in chloride environments, even in its high strength strain hardened condition. As a result, BUMAX® DX and BUMAX® SDX fasteners have long been used in the most demanding corrosive marine environments.

Duplex stainless steel consists of Lean Duplex, Duplex, Super Duplex and the latest addition Hyper Duplex. All these duplex grades have similar mechanical and physical properties, with the main difference being the PRE value and corrosion resistance.

Lean Duplex has the lowest PRE value comparable with A4 (316), whereas the Hyper Duplex has a corrosion resistance that can only be matched by the most advanced nickel base and Ni-Cr-Mo super alloys.

BUMAX® Duplex grades exhibit great corrosion resistance, ranging from BUMAX® DX, which has much better corrosion resistance than A4 (316), to BUMAX® SDX, which can substitute very expensive Super Austenitic or even nickel base alloys or titanium in some applications.

The Pitting Resistance Equivalent number, PRE 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 the PRE number, the more resistant the steel against pitting corrosion is in seawater and chloride induced corrosion.

Figure 2 shows the typical PRE number of BUMAX® products in comparison

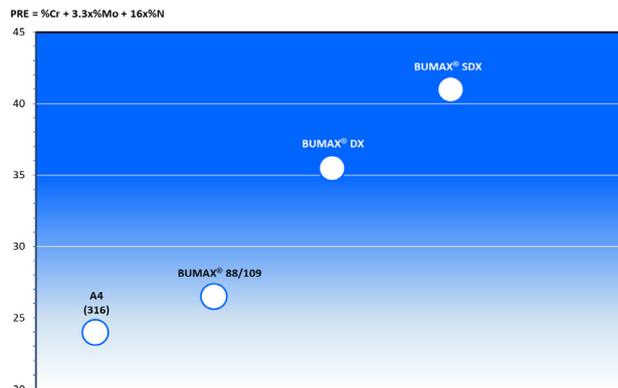


Figure 2: Typical PRE number of different grades. Products in the blue field are recommended for seawater applications.

with a common A4 (316) grade. Corrosion resistance in saltwater depends on several parameters such as salt concentration, temperature, location and design. Engineers often consider PRE min 34 to be seawater resistant and this requirement can often be found in marine fastener specifications. PRE min 40 is typically specified for the most critical bolted joints, which can be found in the petrochemical and offshore oil and gas industry.

The blue color in Figure 2 indicates if the product is suitable for seawater applications.

Laboratory corrosion test results in a chloride bearing environment can be found in Figure 3. The above data is taken from test results conducted on the material grades used for the manufacture of BUMAX® DX 129 and SDX 109 products. The temperature is defined as maximum temperature the specimen can resist without any sign of corrosion.

- Critical pitting temperatures (CPT) at 1% Sodium Chloride and at a potentiostatic determination of +300 mV SCE.
- CPT ASTM G48 in 6% FeCl₃ for 72 hours. Note that A4 (316) is not able to resist this aggressive chemical solution even in room temperature.
- Stress Corrosion Cracking test in 1% Sodium Chloride on cold worked stainless steel. Testing time 1000 hours at an applied stress equal to yield strength.

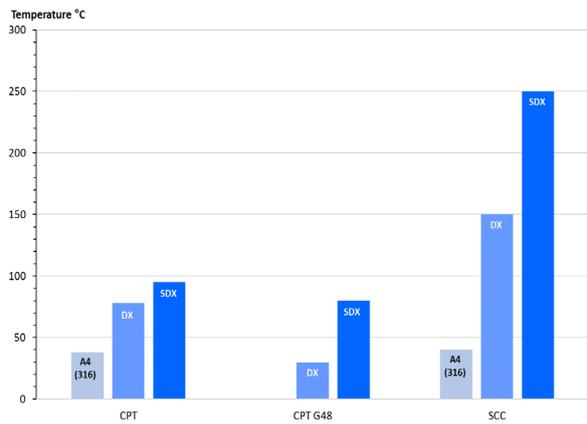


Figure 3: Laboratory corrosion specimen testing results.

PRODUCT OFFERING

BUMAX® DX 129 and BUMAX® SDX 109 are stock products. Find information about the BUMAX stock range at www.bumax-fasteners.com or contact the BUMAX Sales team.

All BUMAX® duplex fasteners are as standard coated with our tailor-made wax to guarantee low and consistent friction to minimize the risk of galling. Recommended preload and tightening torque data can be found at www.bumax-fasteners.com.

BUMAX® duplex fasteners are manufactured at the BUMAX production facilities located in Åshammar, Sweden. Our own production facility enables us to produce small quantity prototype orders and other 'special' products according to specific customer needs while maintaining a very high level of service. We continuously work to improve the properties of our products.

Contact the BUMAX sales team and let us know how we can help you.



MARKING

All BUMAX® duplex fasteners are marked with BUMAX® brand, steel grade and strength class. Fasteners of M5 or smaller are not marked due to space restriction

We can also provide individual marking according to special customer requests.

PACKING

Our products are packed in high quality sturdy boxes and are marked according to a color-coded system. We guarantee full traceability for all our products in sealed boxes. Our boxes are labelled with product data,

material and manufacturing batch reference numbers for full traceability, high-strength and excellent corrosion resistance.

Disclaimer: The information contained in this data sheet is for guidance only and summarizes Bufab best knowledge and is considered accurate as of the version date. Since the use of BUMAX® products is not within the control of Bufab, the user has the obligation to determine the suitability of the product for its intended application and assumes all risk and liability for its safe use.