FUJIMOTO
Providing the Best

14.9 Ultra-High Strength Socket Head Cap Bolt

- Excellent delayed fracture resistance
- Outstanding durability
- Compact design
- Loosening prevention by enhanced tightening force

FUJIMOTO SANGYO CO.,LTD.

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COMPANY PROFILE

FUJIMOTO SANGYO CO.,LTD. is a trading company specializing in fasteners with a history of over 70 years. We provide optimal solutions as professionals in the field of fasteners, metal processing, and inventory management solutions.

We constantly provide value to our consumers by thorough quality control, accommodating diverse needs through local and foreign subsidiaries, and maintaining high procurement capabilities.

Our Logistics Center is based in the Wholesale Industrial Park in Higashi Osaka City, which is at an accessible distance from an international airport (Kansai) and harbors (Osaka and Kobe).

PRODUCT SUMMARY

The 14.9 Ultra–high strength hex cap bolt (hereinafter referred as "14.9 hex cap bolt") is a high-strength fixing solution developed by a collaboration with leading Japanese manufacturers who are known for their high-end technological capabilities. This hex cap bolt uses a high-strength steel[*1] with excellent delayed fracture resistance enabling it to have a tensile strength of 1,400 N/mm^2 and elongation of more than 9%[*2] . By incorporating the "MJ Threads" [*3] used in the aerospace industry, fatigue resistance is further improved.

Ultra-high strength, tightening force due to ultra-high strength, and prevention of loosening due to improved thread tolerance will solve the maintenance issues.

14.9 hex cap bolt's extended durability is assured by Delta Protekt coating[*4] which has passed over 1,000 hours of salt spray testing.

1 Refer to p.4 for detailed information on the material.
2 Refer to p.7 for 14.9 hex cap bolt specifications
3 Refer to p.8 for details on MJ Threads.
4 Refer to p.10 for detailed Delta Protekt coating information.

Material: KNDS4 (high-strength steel for bolts, manufactured by Kobe Steel, Ltd.)

Strength class	14.9
Tensile strength	1400N/mm^2
Yield strength	1,260N/mm^2
Proof load	1,120N/mm^2
Elongation	9% min
Hardness	HRC 44~50
Dimensional specification	JIS B 1176 (excluding fillet radius)
Thread standard	ISO5855-1 MJ Thread (aerospace)
Screw thread tolerance	4g6g (ISO5855-1)
Surface treatment	Black oxide coating / Delta Protekt

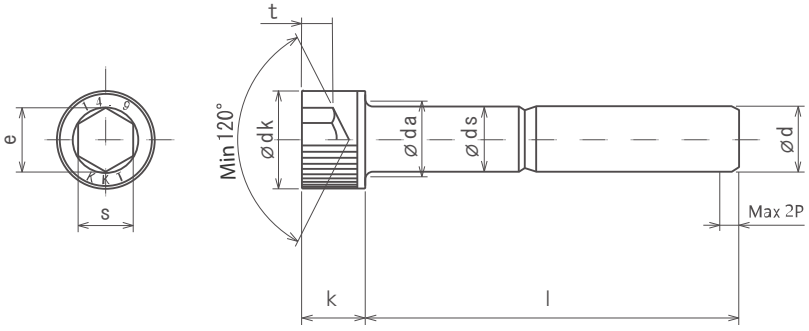
Inventory Range Table

	5	6	8	10	12	15	16	18	20	22	25	30	35	40	45	50	55	60	65	70	75	80	90	100	110	120	130	140	150
M3	●	●	●	●	●	●	●	●	●	●	○	○																	
M4	●	●	●	●	●	●	●	●	●	●	●	○	○																
M5		●	●	●	●	●	●	●	●	●	●	○	○	○	○	○													
M6				● ●	● ●	● ●	● ●		● ●		● ●	● ●	○	○	○	○													
M8					●	● ●	● ●		● ●		● ●	● ●	● ●	○ ○	○ ○	○ ○	○	○	○	○									
M10						● ●	● ●		● ●		● ●	● ●	● ●	● ●	○ ○	○ ○	○	○	○	○	○	○	○	○					
M12									●		● ●	● ●	● ●	● ●	● ●	● ●	○	○	○	○	○	○	○	○	○	○			
M16												●	●	●	●	●	●	●	○	○	○	○	○	○	○	○	○	○	○

● Fully threaded bolts with Black Oxide coating, ○ Half threaded bolts with Black Oxide coating

● Fully threaded bolts with Delta Protekt coating, ○ Half threaded bolts with Delta Protekt coating

Diagram



Dimensions

Nominal diameter (d)	Pitch (P)	dk		da	ds		e	k		s			t
		Max	Min	Max	Max	Min	Min	Max	Min	Dia meter	Max	Min	Min
M3	0.5	5.68	5.32	3.6	3.00	2.86	2.873	3.00	2.86	2.5	2.56	2.52	1.3
M4	0.7	7.22	6.78	4.7	4.00	3.82	3.443	4.00	3.82	3	3.08	3.02	2.0
M5	0.8	8.72	8.28	5.7	5.00	4.82	4.583	5.00	4.82	4	4.095	4.020	2.5
M6	1.0	10.22	9.78	6.8	6.00	5.82	5.723	6.00	5.70	5	5.095	5.020	3.0
M8	1.25	13.27	12.73	9.2	8.00	7.78	6.863	8.00	7.64	6	6.095	6.020	4.0
M10	1.5	16.27	15.73	11.2	10.00	9.78	9.149	10.00	9.64	8	8.115	8.025	5.0
M12	1.75	18.27	17.73	14.2	12.00	11.73	11.429	12.00	11.57	10	10.115	10.025	6.0
M16	2.0	24.33	23.67	18.2	16.00	15.73	15.996	16.00	15.57	14	14.142	14.032	8.0

KNDS4: HIGH-STRENGTH BOLT STEEL

KNDS4 is a high-strength steel for bolts with "Excellent delayed fracture resistance", which has undergone both delayed fracture tests: the underwater test and the acid atmospheric test.

This material is specially designed for bolts used in automotive applications such as racing applications, differentials, and engine cylinder heads. It has also been proven that KNDS4 steel can be used in 12-15T class high-strength bolts.

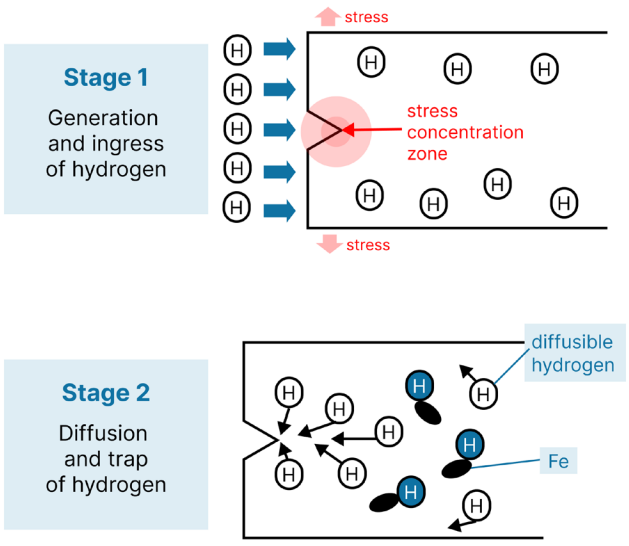
By refining grain size, reducing impurity elements, and precipitating fine carbonitrides (hydrogen trap sites), we make it possible to improve the bolt's strength and delayed fracture resistance.

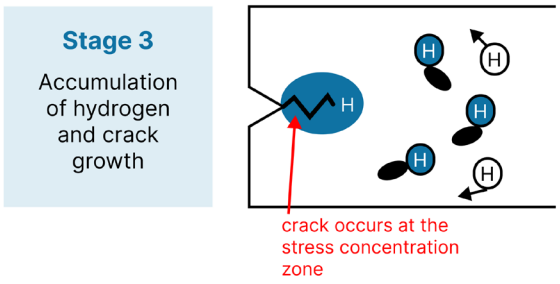
What is Hydrogen Embrittlement?

Hydrogen embrittlement occurs when a metal becomes brittle because of the absorption and diffusion of hydrogen within the material.

The degree of embrittlement depends on the amount of hydrogen absorbed, microstructure of the material, and stress applied to the material.

▼ Hydrogen embrittlement example





What is the design concept of KNDS4 whose aim is to improve delayed fracture resistance?

1. Reducing the hydrogen ingress
2. Increasing hydrogen trap sites
3. Improving the threshold of diffusible hydrogen content

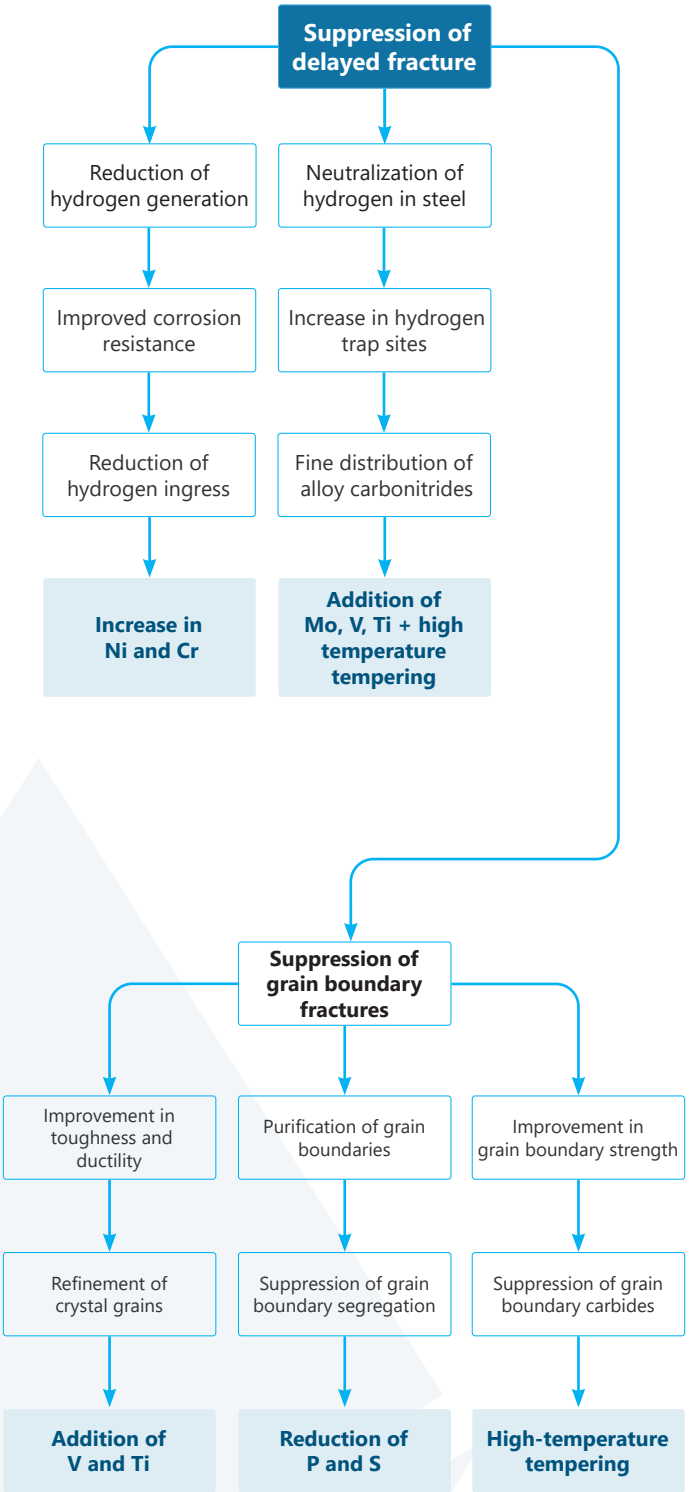
to enhance the delayed fracture resistance.

▼ Comparison of Chemical Composition between SCM440 and KNDS4 with Recommended Strengths of 1,000-1,200 N/mm² and 1,300-1,400 N/mm² / (%)

	C	Si	Mn	P	S	Ni	Cr	Mo	Ti	V
SCM440	0.41	0.20	0.72	0.013	0.010	-	1.01	0.18	-	-
KNDS4	0.42	0.06	0.53	0.007	0.004	0.54	1.00	0.97	0.05	0.07
							Reduction		Addition	

To improve delay fracture resistance and make high tensile strength possible, KNDS4 steel has a reduction in Si, Mn, P, S and an increase in Ni, Mo, Ti, V.

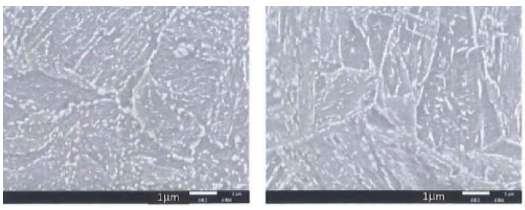
▼ Improved Delayed Fracture Resistance



Quenching and Tempering Characteristics

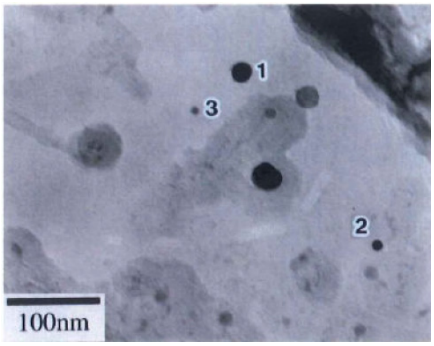
We let KNDS4 undergo high-temperature tempering to enhance its grain boundary strength. In addition, it is tempered at high temperatures to precipitate the composite carbides of Mo, Ti, and V. Therefore, a higher strength can be obtained over SCM440.

▼ Grain Boundaries: In KNDS4, film-like carbides at grain boundaries are reduced

Steel grade	SCM440	KNDS4
Strength	12T	14T
Micro structure		

Comparison of grain boundary carbides (SEM image)

▼ Fine Precipitates: Many ultrafine composite carbides that can serve as hydrogen trap sites are precipitated



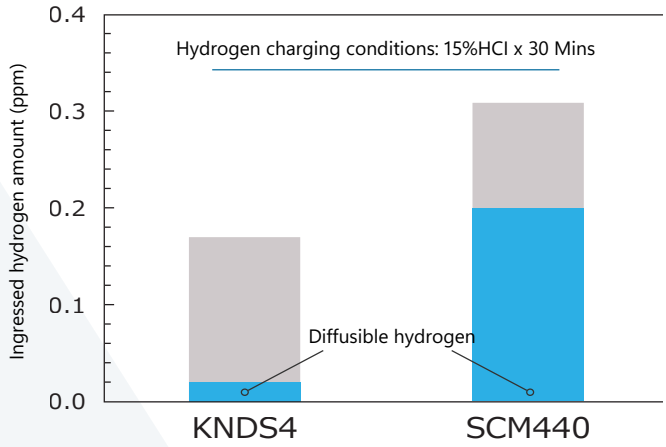
Fine Precipitates of KNDS4 (TEM image)
<Mo-Ti-V composite carbides>
(1:25nm, 2:15nm, 3:10nm)

The Amounts of Hydrogen Ingressed and Hydrogen Diffused on KNDS4 and SCM440

The graphs below indicate the measurement results of hydrogen ingressed and hydrogen diffused hydrogen amounts of KNDS4 and SCM440. When hydrogen is charged under the same conditions, KNDS4 steel shows a lower amount of hydrogen ingress than SCM440.

Furthermore, KNDS4 steel has more trapped hydrogen than SCM440 and a lower amount of diffusible hydrogen (higher amounts will result in delayed fracture).

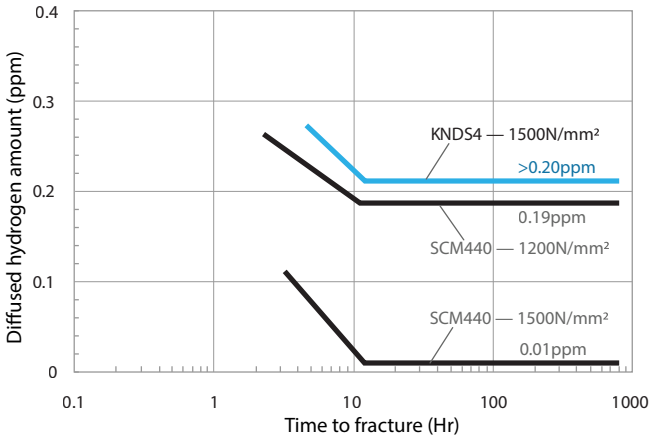
▼ The Amounts of Hydrogen Ingressed and Hydrogen Diffused



※Hydrogen measurement conditions:
Amount of hydrogen ingressed: 800°C x 1hr to heat extract
Amount of hydrogen diffused: 100°C x 1hr to heat extract

※Diffusible hydrogen:
The hydrogen present in the steel is believed to be the cause of delayed fracture.

▼ Diffusible Hydrogen Thresholds of KNDS4 and SCM440



Diffusible hydrogen threshold of KNDS4 and SCM440:

- KNDS4 (TS: 1,500N/mm^2 class)
- SCM440 (TS: 1,200N/mm^2 class)

Since the KNDS4's diffusible hydrogen threshold is higher, it shows excellent delayed fracture resistance.

SPECIFICATIONS OF THE 14.9 HEX CAP BOLT

14.9 hex cap bolt has demonstrated remarkable strength, durability, reusability, and corrosion resistance during the performance test.

This bolt addresses the loosening issue with a high tightening force and a MJ-4g6g screw thread tolerance. Furthermore, the improvement in tightening force enables designers to size down the product and achieve a more compact design. The improved surface hardness also reduces the seizing on the thread and seating surface while minimizing surface degradation due to repeated use.

Below is a comparison of specifications with bolts of different strengths.

▼ Comparison Table for High-Strength Bolts

Strength grade	Tensile strength (N/mm^2)	0.2% Yield strength (N/mm^2)	Guaranteed load (N/mm^2)	Elongation (%)
8.8	800	640	580	12
10.9	1,000	900	830	9
12.9	1,200	1,080	970	8
14.9	**1,400**	**1,260**	**1,120**	**9**

▼ Comparison of Minimum Tensile Load, Guaranteed Load, Tightening Force, and Torque (reference values)

	Effective cross-sectional area	Minimum tensile load (kN)			Guaranteed load (kN)			Tightening force (kN)			Torque (Nm)		
	(mm^2)	10.9	12.9	**14.9**	10.9	12.9	**14.9**	10.9	12.9	**14.9**	10.9	12.9	**14.9**
M3	5.03	5.2	6.1	**7.0**	4.2	4.9	**5.6**	3.3	3.9	**4.4**	1.7	2.0	**2.2**
M4	8.78	9.1	10.7	**12.3**	7.3	8.6	**9.8**	5.8	6.8	**7.7**	3.9	4.6	**5.2**
M5	14.2	14.8	17.3	**19.9**	11.8	13.9	**15.9**	9.3	10.9	**12.5**	7.9	9.3	**10.6**
M6	20.1	20.9	24.5	**28.1**	16.7	19.5	**22.5**	13.2	15.5	**17.7**	13.5	15.8	**18.1**
M8	36.6	38.1	44.6	**51.2**	30.4	35.5	**41.0**	24.1	28.2	**32.3**	32.8	38.4	**43.9**
M10	58.0	60.3	70.8	**81.2**	48.1	56.3	**65.0**	38.2	44.7	**51.2**	64.9	76.0	**87.0**
M12	84.3	87.7	103.0	**118.0**	70.0	81.8	**94.4**	55.5	64.9	**74.4**	113.2	132.4	**151.8**
M16	157.0	163.0	192.0	**220.0**	130.0	152.0	**176.0**	103.3	120.9	**138.5**	281.0	328.8	**376.7**

During tightening, the axial force and torque should be set accordingly.

※Above values are for reference only. Refer to JIS B1083, etc., for the proper tightening torque.

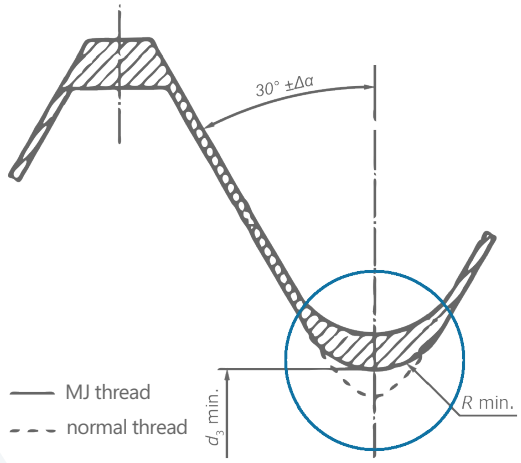
※The torque (T) is calculated as T = KdF, where K=torque coefficient (0.17), d=nominal diameter, F= yield load x 70%.

MJ THREADS FOR IMPROVED FATIGUE RESISTANCE

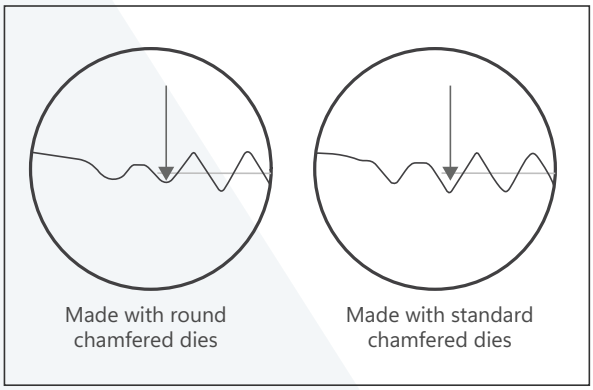
MJ threads is an “aerospace metric thread” commonly used in aircraft, rockets, and space stations.

The MJ threads standard is specified in ISO 5855, with a larger minor diameter and strict pitch diameter tolerance compared to standard metric threads.

▼ MJ Thread Standard



▼ Rounding of the Incomplete Screw Thread



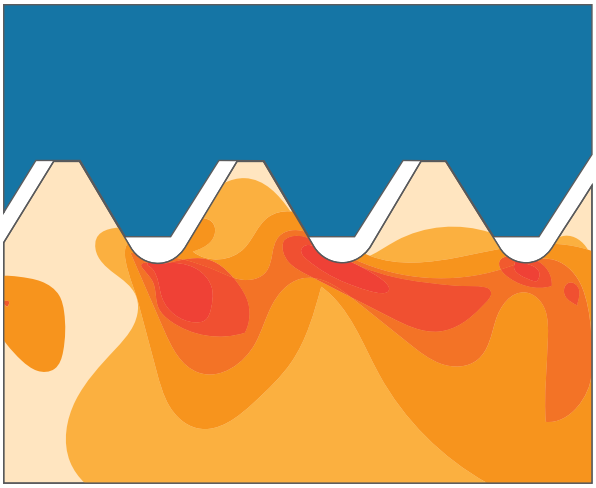
The load on the stress-concentration area was reduced by rounding the root of the incomplete thread.

What is Screw Fatigue?

Fatigue is the occurrence and spread of cracks in a material due to repeated loading. When fatigue cracks occur, they gradually spread within each load cycle.

Sharp cuts in the minor diameter of the external thread initiate fractures that create stress points which eventually cause external thread failure.

▼ Thread Stress Points Under Repeated Loading

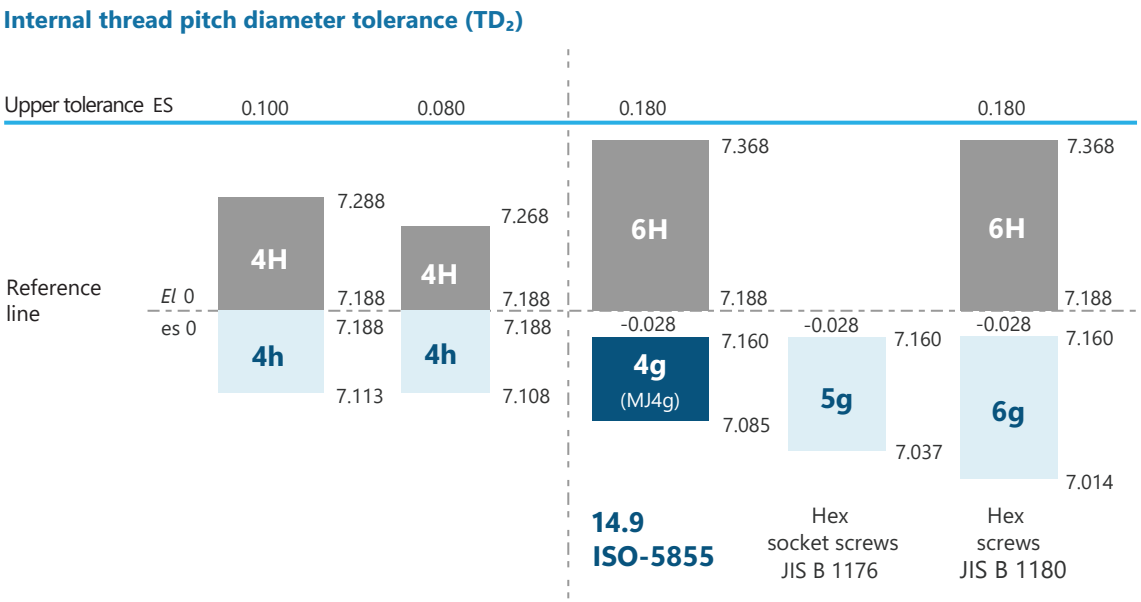


In the fatigue test with constant average stress of σm=0.7σ0.2 (conforming to JIS B 1081), 14.9 ultra-high strength hex cap bolt exhibited the same fatigue limit as the standard-strength 12.9 hex cap bolt.

Compared to 12.9 hex cap bolts, 14.9 hex cap bolts have sufficient fatigue strength even under heavier load conditions and provide a higher tightening force to the fastened body.

In other words, it is possible to improve fatigue resistance for both the screw itself and the screw assembly.

▼ Conceptual Diagram of the Screw Thread Tolerance System (example: M8 x 1.25P)



External thread pitch diameter tolerance (Td_2)

Tolerance position	(es)	0	0	-0.028	-0.028	-0.028
Lower tolerance	ei	-0.075	-0.080	-0.075	-0.123	-0.146

▼ Allowable Dimensions and Tolerances of MJ-4g6g Tolerance Class Conforming to (ISO 5855-1)

Nominal diameter	Pitch	Major diameter 6g		Pitch diameter 4g		Minor diameter MJ4g		Root radius MJ4g	
	(P)	Max	Min	Max	Min	Max	Min	Max	Min
M3	0.5	2.980	2.874	2.655	2.607	2.403	2.324	0.090	0.075
M4	0.7	3.978	3.838	3.523	3.467	3.170	3.071	0.126	0.105
M5	0.8	4.976	4.826	4.456	4.396	4.052	3.944	0.144	0.120
M6	1.0	5.974	5.794	5.324	5.253	4.819	4.687	0.180	0.150
M8	1.25	7.972	7.760	7.160	7.085	6.529	6.378	0.226	0.188
M10	1.5	9.968	9.732	8.994	8.909	8.236	8.060	0.271	0.225
M12	1.75	11.966	11.701	10.829	10.734	9.945	9.744	0.316	0.263
M16	2.0	15.962	15.682	14.663	14.563	13.653	13.431	0.361	0.300

※The MJ standard has a larger root radius than the general standards and this product has a 4g6g tolerance class. Using it under strict tolerance conditions on the internal thread will require checking the dimensional tolerances of the application environment or performing a trial-fitting test beforehand.

(There will be no complications if the internal thread side conforms to JIS general standards)

▼ Usage in High-Temperature Environments

As shown in the table below, 14.9 hex cap bolts maintain excellent mechanical properties in high-temperature environments.

Temperature	300°C	400°C	500°C
14.9	**90%**	**83%**	**64%**
12.9	75%	-	-
10.9	75%	-	-

0.2% yield strength at high-temperature environment.

> *※ The value in the table indicates the ratio to 0.2% yield strength at room temperature.*
>
> *※ Data is for reference only. Usage in a 500°C environment is not recommended.*

Continuous high-temperature conditions could lead to stress relaxation which should be taken into serious consideration.

For example, if the product is held at 300°C for 100 hours, the initial tightening force may decrease by 25% or more due to a decrease in the yield point.

Therefore, when used in high-temperature environments, it is essential to take the necessary precautions to verify the actual operating environment.

DELTA PROTEKT COATING

Surface-treated Delta Protekt 14.9 hex cap bolts can be considered an ideal fastening solution for applications under extreme weather conditions.

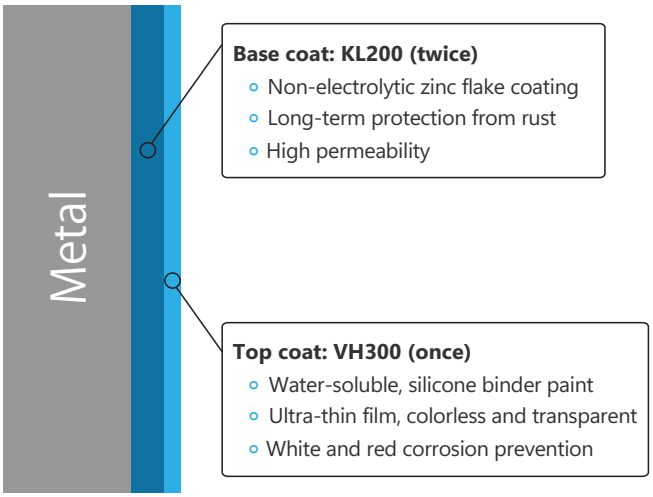
The Delta-Protekt coating applied to this product comprises two layers: the base coat (KL100) applied 2 times, and the top coat (VH300) applied 1 time.

The base coat of the Delta Protekt is composed of a "paint" made of many small zinc flakes. It demonstrates a high cathodic sacrificial corrosion protection due to the sacrificial action of the base metal zinc.

In addition, the top coat complements the properties of the base coat and enhances its overall chemical resistance or physical properties.

Furthermore, shot blasting method is used as the pre-treatment instead of the standard acid-washing method. Since no hydrogen is formed during the coating process, the risk of hydrogen-induced stress corrosion cracking is eliminated.

▼ Delta Protekt Configuration



▼ Salt Spray Test Results : Base Metal, Hexavalent Bright Chromate and Delta Protekt + Top Coat

	0hr	24hr	240hr	480hr	720hr	960hr	1200hr	1440hr	1680hr	1920hr	2160hr
Base metal											
Hexavalent bright chromate											
Delta Protekt + Top coat											

※This product successfully cleared the salt spray testing over 1,000 hours along with a tensile strength of 1,400 N/mm^2, which demonstrated a higher corrosion resistance through cathodic sacrificial corrosion protection.

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