

---

---

# INDUSTRY STANDARDS

---

---

## 1 Standardization of Threaded Fastener for Automobiles: Reestablishing the JASO Hexagon Bolts with Flange Standard

The screw thread parts of an automobile are responsible for helping to ensure the durability and reliability of the basic vehicle functions: driving, turning, and stopping. In addition, the design of the fastening locations for a variety of different pieces of on-vehicle equipment have to address various issues, such as the development of high performance parts, the use of high-strength materials, increasing use of common parts, reducing the cost of materials, and axial tension stabilization.

The ISO standards that concern fasteners are handled by TC1 (Screw threads) and TC2 (Fasteners). There are five SC and two WG working on these standards within those committees, and they continue to issue many common standards and part standards. The Japan Research Institute for Screw Threads and Fasteners is the group that drafts the standards concerning fasteners for the JIS (Japanese Industrial Standards) and currently more than 140 such standards, including some unique to Japan, have been issued as JIS B based on the concept of harmonizing them with existing international standards. New ISO standards, such as tightening test methods, have also been created from proposals submitted by Japan.

When it comes to the standardization of mechanical component parts in Japan, the Component Subcommittee of the Standards Committee is in charge of 36 JASO F standards and four JIS D standards. They conduct periodic reviews based upon surveys of the technological progress that is being made and the state of actual operations. They not only try to maintain and improve the value of using these standards, but also to expand the opportunities to apply these standards. Fourteen of the standards for which they are responsible concern the

screws used on automobiles. The Component Subcommittee is also in charge of the permanent Bolt and Nut Subcommittee meeting, which includes the participation of 22 automobile manufacturers and screw thread part suppliers, as well as of the Japan Research Institute for Screw Threads and Fasteners. This meeting works to keep the standards as up-to-date as possible and in line with how the parts are actually being used.

Most of the screw related standards at Japanese automobile manufacturers are created and put into practice based on the JIS and JASO standard systems. For example, the standards at automobile manufacturers have already switched over to include the most advanced content, such as the property class system that emphasizes the yield point of bolts already been adopted by ISO standards, and the new screw thread tolerance system.

However, even as efforts such as these to promote harmonization with international standards are making progress, some part specifications in the ISO and JIS standards are still not in alignment. One example of this is the principal shape and dimensions of certain screws, such as the width across flats of bolts and nuts with hexagon head (driven portions) and the pitch of self-tapping screws. Figure 1 shows one of these examples, a flanged hex bolt. This part accounts for 90% of the automotive bolts used in Japan and every year over 6.5 billion of these bolts are produced in the automobile industry.

The JASO flanged hex bolt standard helps ensure high quality and economic efficiency while also contributing to efforts to reduce the size and weight of automo-

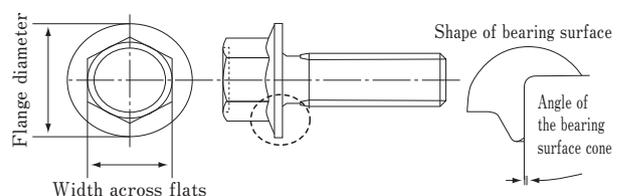


Fig. 1 Shape of the Hexagon Bolts with Flange

biles. Therefore, this article introduces the efforts made to reestablish the JASO flanged hex bolt standard over a period of three years, including everything from the standardization survey conducted on an international scale to the discussions held by the technical review subcommittee.

## 2 History of the Flanged Hex Bolt Standard: From the Old JASO Standard to JIS and from the Main Text of JIS to the Annex

The first standard in Japan covering the flanged hex bolt was JASO F 6820, established in 1969. However, it was then abolished in 1977 when the JIS B 1189 standard was established (the automotive and electronics industries participated in the drafting process). The bolt was then covered by ISO standards when ISO 15071 and ISO 15072 were established in 1999. Discussions held that same year about revising the JIS standard led to the decision that the JIS standards concerning fasteners should be harmonized with the international standards. Consequently, the main text in the JIS would contain the ISO specifications for the fasteners, which were different from the principal dimensions of the fasteners in the Japanese standard, and the Japanese specifications would be placed in the Annex with a plan to abolish these at a later date. However, the discussions about JIS revisions held in 2014 revealed that many parts using the dimensions in the Annex were still being distributed and used. Therefore, it was decided that the Annex will continue to be used for the time being and “because it will be abolished in the future, it should be OK to keep it for now so long as it is not used for any newly designed equipment or parts”.

The automotive industry in Japan has settled on the following. One, the flanged hex bolts with a small width across flats common to all the bolts and nuts listed in the JIS Annex are useful for reducing the size and weight of automobiles, and should therefore become the standard specifications for the automotive industry. Two, over 90% of the bolts are flanged parts, so a standard that makes new designs possible is necessary. And three, it is not possible to revise and modernize the JIS Annex that is planned to be abolished in the future, so a new JASO standard that reflects the latest technologies shall be established for bolts in FY 2015 and for nuts in FY 2017. The automotive industry in Japan, in cooperation with

Table 1 Width Across Flats of Bolts and Nuts in Japan and Western Nations

Region	Company name	Part	Relevant standard	Nominal diameter of screw thread (mm)						
				5	6	8	10	12	14	16
Japan	A ~ K	BOLT	JIS Annex	8	10	12	14	17	19	22
		NUT								
	L	BOLT	ISO revised	7	8	10	13	16	18	21
			DIN (H)	—	10	13	16	18	21	24
		NUT	DIN	—	10	13	16	18	21	24
M	BOLT	ISO	7	8	10	13	15	18	21	
	NUT	ISO	8	10	13	15	18	21	24	
U.S.	A	BOLT	DIN (H)	8	10	13	16	18	21	24
			DIN	—						
	B	BOLT	ISO	7	8	10	13	15	18	21
		NUT	ISO	8	10	13	15	18	21	24
Europe	A	BOLT	DIN (H)	8	10	13	16	18	21	24
		NUT	?							
	B,C	BOLT	DIN (H)	8	10	13	16	18	21	24
		NUT	DIN							
	D	BOLT	ISO	—	8	10	13	15	18	21
			DIN (H)	—	10	13	16	18	21	24
	E	NUT	?							
		BOLT	DIN (H)	8	10	13	15	18	21	24
	NUT	revised	8	10	13	15	18	—	—	

the Japan Research Institute for Screw Threads and Fasteners, has decided to continue to support the proposal of the scheme described above on an international level.

## 3 Standardization Survey: Benchmarking Auto Parts in Japan and Western Nations

All the Japanese auto manufacturers and seven overseas automobile manufacturers that utilize hexagon bolts with flange were surveyed in an effort to establish a new standard. The survey looked at the shape and dimensions of the bolt head, as well as overseas standards and technical papers.

Basically, the shape of the bolt head at all of the Japanese automobile manufacturers was the shape found in the old JASO standard and in the JIS Annex, with only a few exceptions. If the bolts are classified according to a detailed breakdown of their dimensions, almost all of the companies employed a specific value and 19 types of bolts with a nominal diameter of 10 mm (including one company with two sets of specifications) were in circulation.

At the overseas automobile manufacturers in the Western nations, almost all of the companies were em-

**Table 2 Bolt Shapes and Weights (Nominal Diameter of 10 mm)**

		ISO/JIS	New JASO F126		DIN : Heavy
Width across flats	Bolt	13	14		16
	(Nut)	15			
Flange diameter		Standard ( $\phi 20.8$ )	Standard ( $\phi 20.8$ )	Large ( $\phi 22.3$ )	Large ( $\phi 22.3$ )
Head weight (g)		13.2	14.1	15.0	18.4
Weight ratio		94%	100%	107%	131%
		88%	94%	100%	123%
External appearance of bolt head					

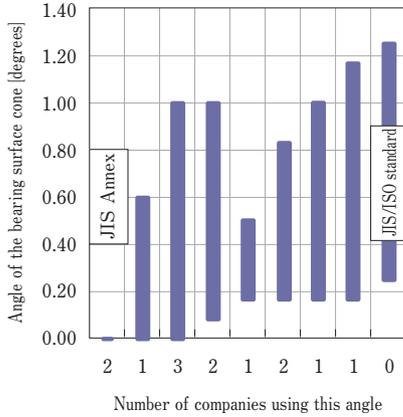


Fig. 2 Cone Angles Used by Each Japanese Manufacturer

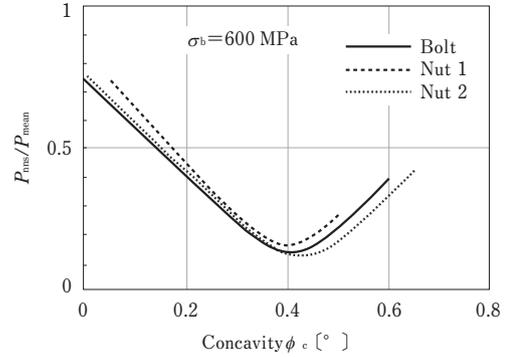


Fig. 3 Deviation of Cone Angle and Bearing Surface Pressure<sup>(1)</sup>

ploying bolts with a width across flats and flange diameter whose specifications differed from those in the ISO standards, again, with some exceptions. The following describes the main bolt head shapes and dimensions found in the survey results.

### 3.1. Width across flat

Table 1 shows the current state of affairs with regard to the width across flats of the bolts and nuts being used at Japanese automobile manufacturers and overseas manufacturers in Western nations. The eleven Japanese automobile manufacturers surveyed employed a common series of bolts and nuts with a small width across flats (14 mm for a nominal diameter of 10 mm) that was the same as in the old JASO standard and in the JIS Annex.

Two of the manufacturers amongst the seven Western companies employed ISO standard (Small series, JIS main text) bolts and nuts that had different specifications for their width across flats (13 mm and 15 mm respectively for a nominal diameter of 10 mm). Only one manufacturer in the U.S. employed this set of specifications exclusively.

Six of the manufacturers amongst the seven Western companies employed a common width across flats for

both bolts and nuts, DIN EN 1665 (Heavy series: Bolts) and DIN EN 1661 (Nuts), in which the width was 16 mm for a nominal diameter of 10 mm.

There are many locations where bolts and nuts are used during automobile assembly work (especially on the chassis) and there are even cases where the fastening and driven parts are different on the same piece of equipment due, for example, to the layout. Consequently, the automobile industry is suggesting that a common socket size be determined and made an international requirement from the standpoints of work efficiency and improving quality, including preventing damage to the driven portions when the wrong socket is used. At the same time, some of the manufacturers in Western nations use a combination of DIN and ISO bolts. They would like to use the lighter ISO standard bolts as a fastener for internal threads that were tapped into the engine body and other locations.

Table 2 shows a comparison of the different bolt shapes and bolt head weights (calculated values) for bolts with a nominal diameter of 10 mm. The bolts by themselves are lightest under the ISO/JIS main text specifications, but when it comes to the bolt and nut sets with a common width across flats, the specifications in the old JASO and JIS Annex are the lightest and smallest in

size. Consequently, it was decided to use this small size series for the width across flats of the new JASO flanged hex bolt.

### 3.2. Flange diameter

The flanged hex bolt has a larger bearing surface area than a regular hexagon head bolt. Consequently, bearing surface pressure decreases, and the equivalent diameter of friction of the larger bearing surface results in an increase in the resistance to rotational loosening.

The Japanese automobile manufacturers also added some original specifications were to the old JASO standard, as well as the JIS main text and Annex specifications resulting in five types of dimensions being employed. Similarly, standardization was promoted at the manufacturers in the Western nations, so just two main types of dimensions for the width across flats, ISO (Small) and DIN (Heavy), were employed.

The bearing surface pressure of the design is strongly related to the level of axial force used, the material from which the parts being fastened are made, and whether the bolt is used with or without a flat washer. Therefore, a fact-finding survey was carried out to determine the current trends in bolt strengthening and the tightening methods employed on softer aluminum parts. The survey indicated that bolts with a property class of 10.9 or more accounted for approximately half of the bolts being used. In addition, it also confirmed that aluminum parts are being used to reduce the weight of equipment, and that the bearing surfaces of these parts are increasingly being fastened directly to certain portions without using a washer and tightened to just below the yield axial force value defined in JIS B 1083 using a bolt coated with a low- $\mu$  friction coefficient stabilizer. Next, a detailed technical investigation was carried out to determine the optimal bearing surface diameter.

### 3.3 Angle of the bearing surface cone

Usually, the bearing surface of a flanged hex bolt is given a slightly conical shape along the outer periphery. This design is intentional and provides a uniform distribution of bearing surface pressure at the time of tightening because the tensile force from the shank gets applied to the flange portion and causes elastic deformation to occur.

Figure 2 shows the current values of the stipulated angles of each Japanese manufacturer.

In Japan a maximum angle of 1 degree or less is very common and stipulated at each manufacturer. However,

this angle is smaller than the  $0.75 \pm 0.5$  degrees stipulated by ISO and in the JIS main text and used by three of the Western automobile companies. Various research conducted on this topic(1)(2)(3), and Figure 3 shows the research results(3) of Okada et al. on the impact of this angle. In their research, bolts possessing various different cone angles were tightened until the threaded portion stress reached 600 MPa and then FEM stress analysis was used to find the bearing surface pressure distribution. The results indicated that the coefficient of variation in the average calculated surface pressure of the bearing surface reached its minimum when the angle of the cone was approximately 0.4 degrees. Therefore, an angle of 0.75 degrees is considered excessive. Furthermore, the uniform distribution of the flange bearing surface pressure is also affected by more factors than just the cone angle. These factors include the angle of the upper surface of the flange, the flange thickness, and the width across flats. Consequently, a technical investigation to help determine the optimal shape of the flange portion was carried out to reduce non-rotational looseness, suppress rotational loosening, and stabilize the tightening characteristics.

## 4 Investigation by the Technical Review Subcommittee

The standardization survey revealed that all of the automobile manufacturers are using flanged hex bolts with heads that have modified shapes based on the various standards. The technical review subcommittee taking a closer look at these flanged hex bolts is made up of six automobile manufacturers and six external thread manufacturers. This subcommittee met a total of seven times during the course of this investigation and made full use of the FEM stress analysis technique and other methods. Their goal was to identify the optimal shape for the head of this flanged hex bolt while also keeping in mind the need to maintain compliance with the ISO standards. The optimal hex bolt identified by the subcommittee would have the following properties: the bolt and nut would both have a common width across flats, the bolt would possess moderate rigidity and bearing surface area, the bearing surface pressure distribution would be uniform, the bolt would have stable tightening characteristics and finally, the shape of the bolt head would be relatively easy to form through cold forging. The following sections describe the main results of this investigation.

#### 4.1. Flange diameter and bearing surface pressure

Figure 4 shows the relationship between the tightening torque and the bearing surface pressure of two different bolts when they were tightened to four different levels of the overall friction coefficient. The two bolts are M10 × 1.25 with the flange diameters stipulated in the ISO standard and the DIN standard (Heavy). One bolt had a strength classification of 8.8, while the other was 10.9. The friction coefficient of the thread face and the bearing surface are assumed to be the same and the yield-point axial tension of the bolts was calculated using the full cross-section yield conditions.

If the surface pressure limit of cast aluminum is assumed to be 250 MPa, then among bolts with a flange diameter in line with the ISO and JIS main text standards (Fig. 4(a)), the bolts in the 8.8 strength class will not exceed their surface pressure limit, even in a high lubrication state (where  $\mu=0.1$ ). However, if these same bolts continue to be tightened up to near the yield point of the 10.9 strength class bolts, then the surface pressure becomes excessive and non-rotational looseness occurs due to the increasing amount of bearing surface depression. The flange diameters of the bolts under the old JASO standard and JIS Annex are even smaller, so it is presumed that their specifications were designed mainly for use with bolts in the 8.8 strength class. Consequently, there were cases where some manufacturers decided that it was necessary to also use a large, rigid, flat washer in combination with the bearing surface diameter when tightening cast aluminum bolts. However, both cost and quality issues, such as variation in the axial tension due to simultaneous bolt and washer rotation, arose.

In contrast, the automobile manufacturers in the Western nations often used bolts with the flange diameters stipulated in the DIN standard (Heavy) (Fig. 4(b)). In this case, even when bolts in the 10.9 strength class were lubricated and then tightened to the axial force just below their yield point, they remained within the surface pressure limit. This meant that the axial force of the bolt was maximized and also made miniaturization possible.

Next, an investigation was carried out to determine what equipment and economic issues may be involved if automobile manufacturers tried to produce flanged hex bolts with a small width across flats, a large bearing surface diameter equivalent to that found in the DIN standard (Heavy), and formed via cold forging using the upset manufacturing method. According to the responses

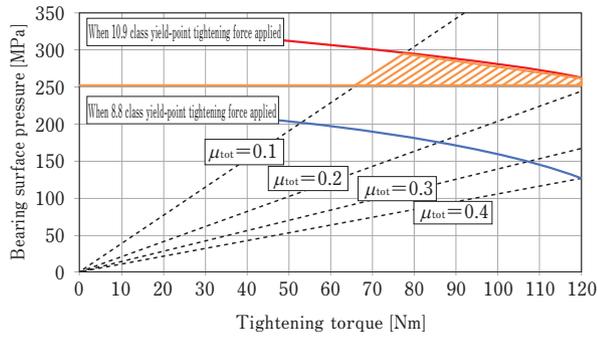
from Japanese fastener manufacturers, this would not present any particular problem, except for some nominal diameter bolts that would require multistage forging.

The results described above suggest that a cast aluminum bearing surface on a strength class 10.9 bolt can be lubricated and tightened directly. Therefore, a bolt with a large flange whose bearing surface area was enlarged by approximately 16% was selected as the strength class 10.9 bolt.

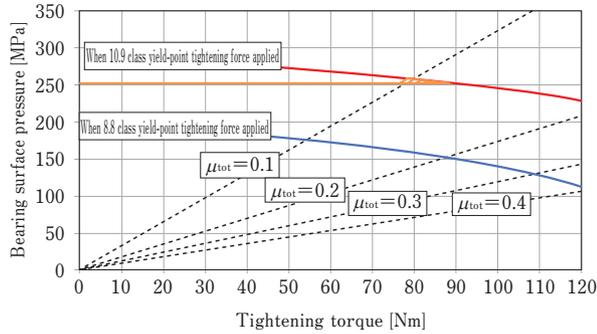
#### 4.2. Impact of the bolt head shape on the bearing surface pressure distribution: application of quality engineering method to FEM stress analysis

The advantage of using flanged hex bolts is their ability to uniformly distribute a low bearing surface pressure. The shape of the bolt head in this case consists of factors such as the width across flats, the head height, the flange thickness, the angle of the upper surface of the flange, and the cone angle of the bearing surface. The impact of this bolt head shape on the uniform distribution of the bearing surface pressure was subjected to FEM stress analysis using an 8-factor L18 orthogonal array and then evaluated with quality engineering techniques. For the purposes of this analysis the nominal diameter was 10 mm and the tightening force was set to three levels that were equivalent to 80% of the yield point/proof stress of property class 4.8, 8.8, 10.9. The FEM stress analysis was conducted with the cooperation of the Iwata Bolt Co., Ltd., and the analysis using quality engineering techniques was carried out with the cooperation of a committee member from Saga Tekkohsho Co., Ltd.

Table 3 shows the factorial arrangement of the L18 orthogonal array based on the various standards. Figure 5 shows the FEM model and an example calculation of the bearing surface pressure distribution in the radial direction. The graph in this figure compares the bearing surface location to the bearing surface pressure distribution and shows an example where a high surface pressure is only distributed in the vicinity of the outer periphery. The data shown in the graph confirms that the axial force of a strength class 4.8 bolt only applies a surface pressure load to a portion of the outermost periphery of the flange. Quality engineering techniques were then used to conduct an analysis of the bolt head shape to determine how much of an influence each of the eight shape factors has and to draw closer to a more uniform distribution of the surface pressure.



(a) JIS/ISO Standard (Small) Bearing Surface M10x1.25  $\phi$ 20.8



(b) DIN Standard (Heavy) Bearing Surface M10x1.25  $\phi$ 22.3

Fig. 4 Relationship between the Bearing Surface Pressure and Tightening Torque for Bearing Surfaces under the ISO Standard and the DIN Standard (Heavy)

Figure 6(a) shows the signal-to-noise ratio (SN ratio) of the zero-is-best response in decibels (dB) for the eight shape factors of the bolt head. In this case the difference between the surface pressure value at each location when the axial force is applied and the average calculated surface pressure value when the pressure is uniformly distributed was considered to be noise. This figure indicates that the closer that the value of dB gets to 0 (zero), the smaller that the difference between it and the uniform calculated value becomes. However, the wider the difference becomes, the larger the degree of influence of that factor also becomes. The results shown in Fig. 6 indicate that factors such as the width across flats, the bearing surface diameter, and the angle of the upper surface of the flange have a comparatively large influence, while other factors, such as the height of the bolt head, have a smaller influence.

Next, the width across flats was set to 14 mm (the standard fixed value) and flanged hex bolts with the standard bearing surface (flange diameter) obtained from the design examination of the bearing surface pressure were compared to the bolts with the two types of large flange diameters. The cone angle of the bearing surface is related to the flange rigidity, so this factor along with

Table 3 The Factors and Levels of the L<sub>18</sub> Orthogonal Array

Factors		Level 1	Level 2	Level 3	
A	Diameter of bolt body	mm	$\phi$ 9.1	$\phi$ 10	—
B	Cone angle of bearing surface	°	0	0.4	0.9
C	Width across flats	mm	13	14	16
D	Height of bolt head	mm	8	9	10
E	Effective bearing surface diameter (dw)	mm	17.5	19	20.5
F	Flange thickness	mm	1.2	1.5	1.8
G	Angle of flange upper surface	°	15	22.5	30
H	Material of fastened portion		SS400	FCD450	ADC12

the angle of the upper surface of the flange and two other factors were chosen for another FEM stress analysis using a 4-factor L<sub>9</sub> orthogonal array, and the SN ratio was once again used to evaluate the degree of influence of these factors on the uniform distribution of the bearing surface pressure.

Figures 6(b) and 6(c) show the results of that analysis and evaluation. The results indicate that the cone angle of the bearing surface had the largest influence regardless of the flange diameter. Consequently, it was determined that an angle of approximately 0.5 degrees is optimal and that the angle stipulated in the JIS and ISO standards is excessively large. In addition, where the width across flats is 16 mm, the restriction of the width across flats is large and the influence of the cone angle tends to be larger than when the width across flats is 14 mm.

As a result of this analysis and evaluation, it was decided that the cone angle of the bearing surface that shall be applied to bolts in the 8.8 and 10.9 strength classes is  $0.5^\circ \pm 0.4^\circ$  ( $\pm 3\sigma$ ) in consideration of the process capabilities at the manufacturers. Furthermore, this value is nearly equivalent to that obtained in the aforementioned verification results reported by Okada et al.

## 5 Outline of the Content in the New JASO F 126 Standard

The analysis described above was used to determine many of the specifications of the new hexagon bolts with flange, and the other required specifications were determined based on harmonization with existing international standards, actual usage conditions at Japanese manufacturers, and the latest trends in technology, and other factors.

### 5.1 Pitch of screw thread

In a survey of Japanese automobile manufacturers to

determine the kinds of fasteners they actually used, many of the respondents stated they only used fine pitch thread that have larger tensile stress area of thread than coarse thread. However, for parts with an internal thread made from a softer, light alloy, a coarse thread made it possible to shorten the length of the thread engagement. Consequently, in consideration of the weight reduction benefits to be gained from using light alloy parts and in an effort to promote harmonization with international standards, the same coarse thread as in the JIS and ISO standards was selected for the new hexagon bolts with flange.

### **5.2. Property class**

Very few manufacturers use screws with property class 9.8, which is scheduled to be abolished from the JIS and ISO standards in the future. Therefore, in an effort to promote greater use of common parts, two types, property class 8.8 and 10.9, were applied as new hexagon bolts with flange. Furthermore, based on the results of the bearing surface pressure calculations, the bolts with a large flange diameter will only be available in property class 10.9.

### **5.3. Type of bolt body**

The bolt body was set to a bolt with pitch a diameter body only (including full thread bolts). JIS B 1189 adopts bolts with a pitch diameter body that possessed a nominal diameter shank with a  $1d$  equivalent length beneath the bolt head. However, as a result of the manufacturer's survey, we adopted lighter specifications than those in JIS standard by rolling blank diameter for the all bolt bodies and by simplifying the forging process. Nominal diameter bolts are useful to inhibit rotational loosening in environments where perpendicular input to the bolt shank is severe, so it was decided that they would be used as exclusive parts with a shank shape designed to handle the conditions in those locations.

### **5.4. Diagonal distance of the width across corner**

The tolerance of the width across corner ( $e$ ) is slightly different between the JIS Annex and in the JIS/ISO standards. The method in the JIS Annex was adopted for the inspection gauge dimensions of the bolt head effective height, therefore it was decided to adopt that value for dimensional tolerance. The inspection method may later be changed to the two-gauge method in the main text of the JIS and ISO standards in consideration of harmonization with international standards.

### **5.5. Flange head diameter (standard bearing surface) & fillet transition diameter**

The standard flange diameter ( $d_c$  and  $d_w$ ) is not only related to the bearing surface pressure, but also has effects on the space, tightening characteristics, and ease of cold forging. Therefore, it is difficult to set an absolute standard for this value and the value in the JIS/ISO standards, which approximates current circumstances at the manufacturers, was adopted in pursuit of harmonization with international standards. The fillet transition diameter was also set to a value that harmonizes it with international standards, as has usually been done in the past.

### **5.6. Angle of flange upper surface, flange thickness, and roundness of hexagonal base**

These factors are related to the deformation rigidity of the flange and also influence the uniform distribution of the bearing surface pressure according to the FEM stress analysis, so appropriate values have been chosen. The angle of the upper surface was changed to the narrower tolerance stipulated in the JIS/ISO standards, and the flange thickness and base roundness values were set to be in harmony with the values in the international standards.

### **5.7. Height of bolt**

Half of the Japanese automobile manufacturers that use hexagon bolts with flange with a small width across flats, do not change the effective head height that possesses a torque transmission function. A head height of  $0.95d$ , which is lower than the head height of  $1.0d$  stipulated in the JIS Annex, is used as part of the weight reduction specifications, including on bolts in the property class 10.9, when the nominal diameter of the bolt is 8 mm or larger. An examination using the mathematical formulas in JIS B 1021 showed that setting the height to  $0.95d$  results in a better agreement, so the effective head height will not be changed and it was decided to slightly lower the height of the bolt head.

### **5.8. Minimum nominal length**

The minimum nominal length of the hexagon bolts with flange should be longer than approximate  $1.5d$  specified in JIS F101 (hexagon bolts) because this bolt is used with hexagon nuts with flange with  $1d$  height which is higher than hex nut. However, if this length is increased to  $2d$  as stipulated in the JIS/ISO standards, then it will become difficult to use it with the thin and lightweight fastened members made from high-strength steel sheets.

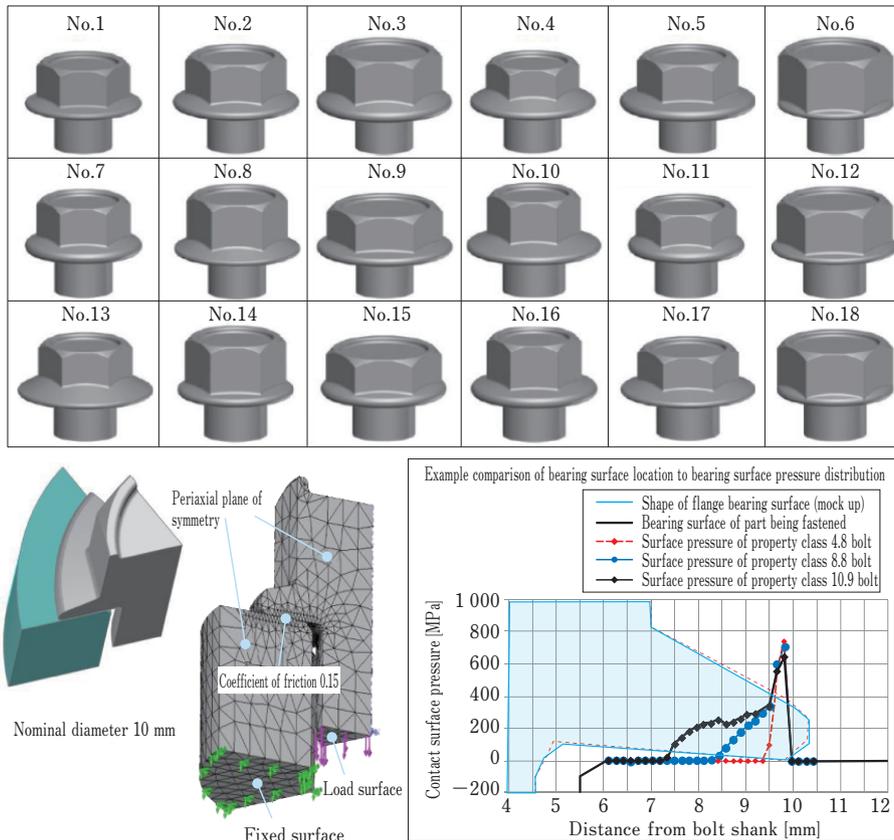
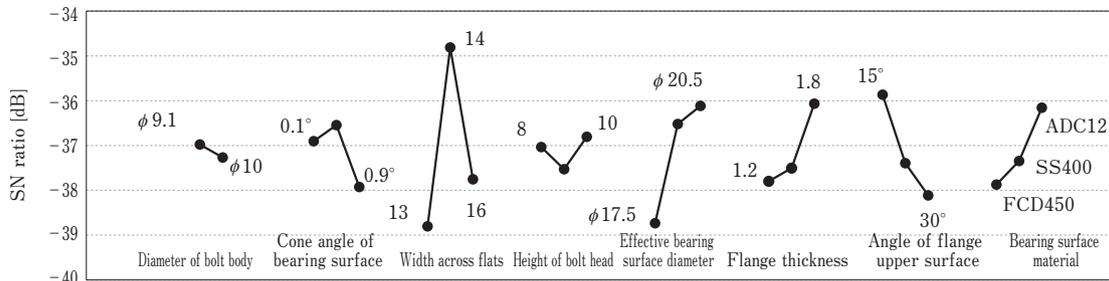
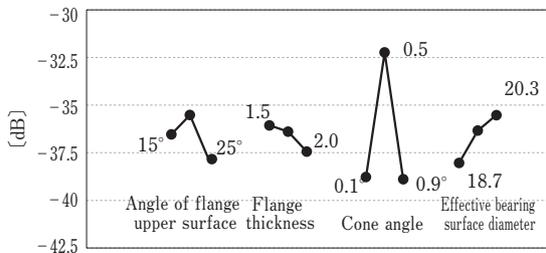


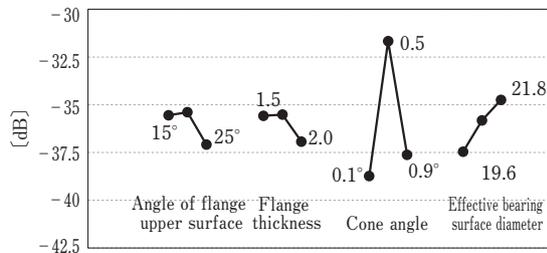
Fig. 5 FEM Stress Analysis Model and Bearing Surface Pressure Distribution Graph



(a) SN Ratios of each Factor in the  $L_{18}$  Orthogonal Array



(b) SN Ratios of each Factor on a Standard Bearing Surface and Width Across Flats of 14 mm



(c) SN Ratios of each Factor on a Large Bearing Surface and Width Across Flats of 14 mm

Fig. 6 Influence of the Bolt Head Shape Factors on the Uniform Bearing Surface Pressure Distribution

At present, optimal value for the minimum length is still unclear, so we adopted the values specified in JIS Annex and JASO F101 which many manufactures are using.

#### 5.9. Geometric tolerance

At the present time the directive regarding the geometric tolerance in the JASO screw thread part standards refers to old JIS standards, so there is no single interpretation of this directive and no internationality either. In the future, revising this directive will become an important task. At this time, under the presumption that it is not always necessary to use a function gage, the content currently being measured by the manufacturers shall be expressed using the indication method based on the latest JIS, and the possible specified values were set to be harmonized with the international standard values.

#### 5.10. Annex

Two specifications of the width across flats, which differs from those specified in main text of this standard and which used by some Japanese automobile manufactures, described below are specified as Annex.

The small series specifications make it possible to achieve even further levels of weight reduction, such as when engine dress-up parts are fastened in place without using nuts in combination with the bolt head shape specified in the main text of the JIS standard.

The heavy series specifications are the DIN EN 1165 specifications with a large width across flats common to both the bolts and nuts adopted by many automobile manufacturers in Western nations. This width across flats is a common set of specifications for both hexagon bolts and nuts with flange in the main text of the JIS standards as well.

## 6 Future Issues to be Considered for International Proposals

The use of a common width across flats for all general bolts and nuts used in the automobile industry around the world was identified as a distinctive characteristic,

and efforts were made, in the form of JASO F126, to re-establish a standard for hexagon bolts with flange that would incorporate the latest research results to realize a bolt that was both small in size and lightweight. In the near future, based on the tenth long-term plan, a new JASO standard for hexagon nuts with flange with similar specifications is also scheduled to be established in FY 2017.

The width across flats of the bolt in the main text of the current JIS standard is smaller than that in the new JASO standard. Consequently, if the width across flats of the bolt is made the same as that of the nut, the width across flats of the nut would be thinned down from 15 mm to 13 mm for a nominal diameter of 10 mm. This means that there would be a strong possibility that the shear strength of the screw thread ridge would not be realized and so verification testing will need to be carried out in the future.

This particular issue has been promoted in conjunction with the other international proposals being made by the Japan Research Institute for Screw Threads and Fasteners. In fact this issue was also raised during discussions with the Chairman of TC2 during his visit to Japan in the fall of 2015.

Moving forward it is hoped that a set of hexagon bolts and nuts with flange that are small in size, lightweight, possess stable levels of quality, and are economic to manufacture will be realized, and efforts to support the proposal of such standards at the international level will continue.

#### References

- (1) Proceedings of Materials & Mechanics Division, JSME, Vol. A, pp. 149-150 (1995)
- (2) Morozumi et al., Transaction of JSME (A), Vol. 76, No. 772, pp. 77-85 (2010)
- (3) Okada et al., Journal of Japan Society for Design Engineering, Vol. 40, No. 1, pp. 42-47 (2005)