

KOBELCO

Kobelco Abrasion-Resistant steel

**New
K-TEN
ARseries**

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KOBE STEEL, LTD.

In response to recent customer's need, KOBELCO has improved its Abrasion-Resistant steel.

We categorize our products into Standard type, Low temperature toughness type, Excellent weldability type depending on their properties, making it easier to understand.

Kobelco Abrasion-resistant steel (K-TEN AR) series has been extensively applied in construction and industrial machinery for numerous years. In response to recent customers' need for the plate's formability and hardness uniformity in thickness direction, we have renewed our abrasion-resistant steel lineup. The new lineup and typical properties are introduced as follows.

■ Kobelco Abrasion-Resistant steel (K-TEN AR) series

Lineup/Thickness range/Specification (May.2015 *1)

Classification	Code	Thickness* ¹ (mm)	Brinell Hardness (HBW) * ²	Charpy test* ³	
				Temp. (°C)	Absorbedenergy (J)
Standard type	K-TEN AR400A	9 ≤ t ≤ 50	360~440	—	—
Low temp. toughness type	K-TEN AR400LT	9 ≤ t ≤ 50	360~440	-40	≥ Ave.27
	K-TEN AR400LT-HC	9 ≤ t ≤ 40	360~440* ⁵	-40	≥ Ave.27
Excellent weldability type* ⁴	K-TEN AR320WA	20 ≤ t ≤ 80	300~* ⁴	—	—
	K-TEN AR360WA	6 ≤ t ≤ 50	340~380* ⁴	—	—

*1 Please contact Kobe steel for the latest information including the thickness range and specification not listed in this table.

*2 Results of brinell hardness test is average of 3 points on surface.
Test specimen is prepared by removing decarburized layer (around 1mm).

*3 Charpy test specimen is JIS Z 2242 V-notch transverse to rolling direction. Results is data of 3 specimens and test is performed for steel over 12mm in thickness.

*4 Non-uniform hardness in thickness direction is a characteristic of excellent weldability type.

*5 Hardness at the core of the plate is superior.
(Guarantee of brinell hardness values at the center of thickness is for additional charge.)

■ Chemical composition characteristics are as below.

① Standard type/400A,

② Low temp. toughness type : Alloy contents can be decreased by special heat treatment.

③ Excellent weldability type : Alloy contents are restricted at the same level as that of general TS490N/mm² steel, while maintaining the surface hardness.

Chemical composition of each product *¹ (mass%)

Classification	Code	C	Si	Mn	P	S	Elements	Ceq* ¹
Standard type	AR400A	≤ 0.18	0.10 ~ 0.70	≤ 1.50	≤ 0.020	≤ 0.010	*2	≤ 0.64
Low temp. toughness type	AR400LT	≤ 0.18	0.10 ~ 0.70	≤ 1.50	≤ 0.020	≤ 0.010	*2	≤ 0.64
	AR400LT-HC	≤ 0.18	0.10 ~ 0.70	≤ 1.50	≤ 0.020	≤ 0.010	*2	≤ 0.64
Excellent weldability type	AR320WA	≤ 0.18	≤ 0.55	≤ 1.60	≤ 0.025	≤ 0.015	—	≤ 0.44
	AR360WA	≤ 0.19						

*1 $Ceq = C + Mn/6 + (Cu + Ni) / 15 + (Cr + Mo + V) / 5$

*2 In addition elements may be used.

In response to users' requirement, we categorize our products by formability and by the following three properties, depending on application.

Typical properties/ ① Standard type (K-TEN AR400A)

○ Hardness uniformity in thickness direction is obtained by special heat treatment.

Chemical composition & Mechanical properties

Thickness (mm)	Chemical composition (mass%)							Brinell hardness (HBW) Surface
	C	Si	Mn	P	S	Elements	Ceq	
20	0.14	0.36	1.18	0.006	0.001	Cr and others	0.44	423
50	0.15	0.35	1.20	0.005	0.001	Cr and others	0.61	406
Spec.	≤0.18	≤0.55	≤1.60	≤0.025	≤0.015	※ 1	≤0.64	360~440

※ 1 In addition elements may be used.

Typical properties/ ② Low temp. toughness type (K-TEN AR400LT)

○ Toughness at -40°C are ensured by optimal chemical composition and more advanced special heat treatment.

○ Hardness uniformity in thickness direction is also obtained.

Chemical composition

Thickness (mm)	Chemical composition (mass%)							
	C	Si	Mn	P	S	Elements	P _{CM} *1	Ceq
20	0.14	0.36	1.18	0.006	0.001	Cr and others	0.25	0.43
50	0.15	0.36	1.20	0.005	0.001	Cr and others	0.27	0.61
Spec.	≤0.18	0.10~0.70	≤1.50	≤0.020	≤0.010	※ 2	—	≤0.64

※ 1 $P_{CM} = C + Si/30 + Mn/20 + Cu/20 + Ni/60 + Cr/20 + Mo/15 + V/15 + B$

※ 2 In addition elements may be used.

Mechanical properties

Thickness (mm)	Brinell hardness (HBW)		Impact test			Tensile test (Reference test)				
	Surface	t/2 (Reference)	Test position	Test direction	vE-40 (J) Ave	Test position	Test direction	YP (MPa)	TS (MPa)	EL (%)
12	404	402	t/4	C	(41) Reference	Full thickness	C	1040	1310	16
16	403	384			50			1020	1312	18
20	404	383			50			1023	1294	22
30	426	404			55			951	1336	16
40	423	409			60			1018	1315	17
50	421	391	57	967	1287	17				
Spec.	360 - 440		t/4	C	≥27	—	—	—	—	—

※ 1 Test conditions (thickness under 12mm): Indenter size 5mm, Load 750kgf

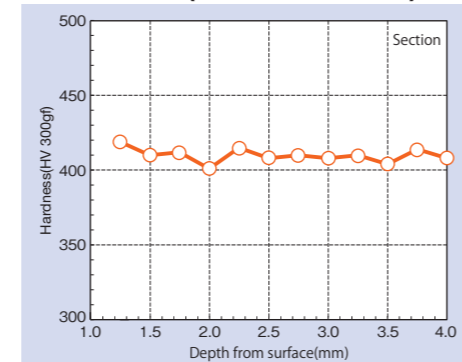
Bending properties

Thickness (mm)	Bend test (Reference test) n=2						
	TP Width (mm)	Test position	Test direction	Bend angle(°)	Inside radius R*1		
					1t	2t	3t
20	120	Full thickness	L	180	×	○	○

※ 1 t: Thickness of test specimen

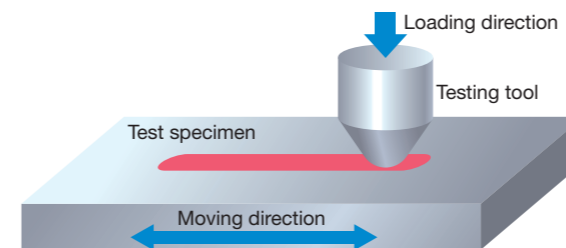


Typical data of hardness distribution near surface (Thickness:20mm)



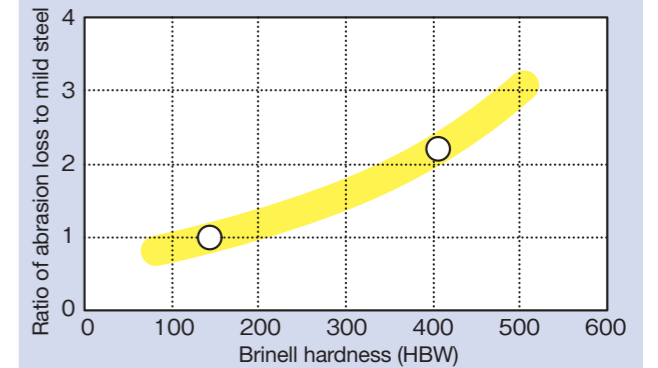
Typical properties/ ② Low temp. toughness type (K-TEN AR400LT)

○ The results of tests evaluating the abrasion property (Both way slide type frictional wear testing) show that the abrasion property is improved 2 times higher than that of general steel (SS400).



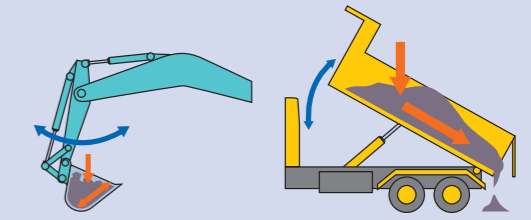
Test condition

Testing tools : Alumina (φ10mm)
Load : 70N
Strokes : 20mm
Sliding speed : 150mm/s
Test time : 30min
Test Number : N3



Both way slide type frictional wear testing

The tests modeling shovel or back of truck that receives the frequent and linear sliding from earth and sand.



Typical properties/ ③ Excellent weldability type (K-TEN AR360WA)

○ By restricting alloy contents, we can make abrasion-resistant steel weld as easily as 50kg-class tensile strength steel, while maintaining the surface hardness.

⚠ Non-uniform hardness in thickness direction is a characteristic of this type.

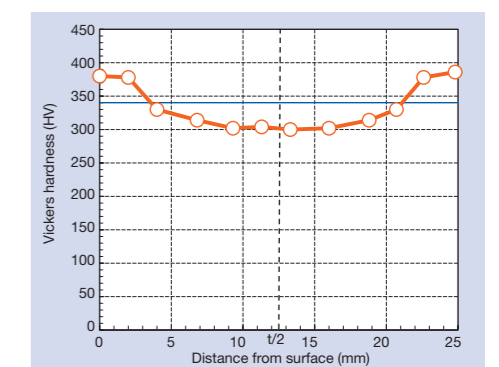
Chemical composition (mass%)

	C	Si	Mn	P	S	P _{CM}	Ceq
Example	0.16	0.33	1.36	0.017	0.005	0.24	0.41
Spec.	≤0.19	≤0.55	≤1.60	≤0.025	≤0.015	—	≤0.44

Mechanical properties

Thickness (mm)	Brinell hardness (HBW)		Tensile test (Reference test)*1			
	Surface	t/2 (Reference)	Test position	Test direction	TS (MPa)	EL (%)
25	366	300	Full thickness	C	1087	25
Spec.	340 - 380		—	—	—	—

※ 1 JIS Z2241 No.5 Tension test specimens (G.L.=50mm, W=25mm)



Welding method/Welding consumables

1. Welding method

SMAW or MAG are mainly applied. For SMAW, low-hydrogen type electrodes are recommended in consideration of crack resistance because of its high strength and hardness.

2. Welding consumables

(Welding between abrasion resistance steel)

There are two ways to select welding consumables depending on the properties required for the welding metal.

1) Focus on the weldability :

Choose from the following welding consumables for 400-780MPa class high tensile strength steel.

Recommended welding consumables

Classification	Pre-heating	400MPa class		490MPa class		570MPa class		690MPa class		780MPa class		
		SMAW	GMAW	SMAW	GMAW	SMAW	GMAW	SMAW	GMAW	SMAW	GMAW	
Standard type	New	≥100°C ≥150°C	LB-47	MG-50	LB-52	MG-50	LB-62	MG-60	LB-106	MG-70	LB-116	MG-80
	Conventional		LB-47A	SE-50T MG-S50	LB-M52	SE-50T MG-S50	LB-62UL	MG-S63B		MG-S70	LB-80UL	MG-S80
Low temp. toughness type	50 - 150°C		LB-52NS	MG-S50LT	LB-52NS	MG-S50LT	LB-62L	—	LB-Y75	—	LB-88LT	MG-S88A
Excellent weldability type	—		LB-47 LB-47A	MG-50 SE-50T MG-S50	LB-52 LB-M52	MG-50 SE-50T MG-S50	LB-62 LB-62UL	MG-60 MG-S63B	LB-106	MG-70 MG-S70	LB-116 LB-80UL	MG-80 MG-S80

2) Focus on the abrasion resistance of weld metal :

Please contact Kobe steel for further information.

(Welding between abrasion-resistant steel and general steel (ex. SS400))

Generally, welding consumables suitable for the base metal with lower strength and more strict welding procedure regarding cold cracking resistance should be applied.

For example, in the case of welding with SS400, low-hydrogen type electrodes are applied considering the weldability of the abrasion-resistant steel.

3. Pre-heating

Pre-heating is needed except for thin steel plate or small restraint case.

Pre-heating over 200°C cannot be applied due to decrease of hardness and toughness.

Caution/Cutting

1. Shear cutting

- Hardening and embrittlement occur by plastic deformation in shear area.
There are many irregularities on fracture surface, as well as burrs at the bottom of the fracture surface.
- When bending sheared steel having high hardness or tested with small bending radius ratio (r/t), please make sure that the corner of the fracture surface is deburred and rounded with a grinder.

2. Gas cutting

- Due to rapid heating and cooling in gas cut area, residual stress and strain deformation is generated by expansion and contraction, and at the same time, hardening occurs Heat affected zone is 3-4mm wide on the surface closer to the torch, while 1-2mm wide on the opposite surface. Degree of hardening is affected by cutting condition, plate chemical composition (especially Carbon equivalent) and thickness.
- Grinding corner of cut surface is needed to prevent cracks during bending.
- When steel with high carbon equivalent and heavy thickness is cut under the condition of low room temperature, pre-heating or post-heating is needed to prevent micro-cracks on the cut surface.

Caution/Bending

1. Cold bending

- Average bending strain on outside surface is calculated by following equation.

$$\epsilon t = 1 / (1 + 2r/t) \times 100 \approx t/2r \times 100(\%) \quad (t: \text{thickness}, r: \text{bending radius})$$

This shows that bending cracks are easily generated with increasing thickness and decreasing bending radius.

- Bending cracks are affected by plate strength, bending direction, bending angle, plate width, end surface condition and surface condition.

2. Hot bending

- Do not apply hot forming to the abrasion-resistant steel, because it was specially heat treated.

Reference/Handling of conventional products

Besides new types of steel, we also sell conventional products.

Please contact Kobe steel for further information.

Conventional lineup

Conventional Classification	Code	Brinell hardness (HBW)	Further responses (mm)
Carbon steel type	K-TEN AR320C	320 - 360	$6 \leq t \leq 75$
	K-TEN AR360C	360 - 400	$6 \leq t \leq 75$
	K-TEN AR400C	400 - 440	$6 \leq t \leq 60$
	K-TEN AR500C	470 - 530	$6 \leq t \leq 50$
Alloy steel type	K-TEN AR320	300 - 340	$6 \leq t \leq 65$
	K-TEN AR340	320 - 360	$6 \leq t \leq 65$
	K-TEN AR360	340 - 380	$6 \leq t \leq 65$
	K-TEN AR400	380 - 420	$6 \leq t \leq 50$
Excellent weldability type	K-TEN AR320W	320 - 360	$6 \leq t \leq 50$
	K-TEN AR340W	340 - 380	$6 \leq t \leq 50$