

## Expandable Alloy



### Expandable Alloy → Alloy 27

#### Glass sealed and controlled expansion alloys

\*Alloy 27, ASTM F-256, UNS K92801, (Fe-28Cr), Chinese 4J28

Note:

Glass Sealing "27" Alloy, it's glass-to-metal sealing and iron-chromium alloy. Nominally 28 % chromium, in strip, bar, wire, and rod forms intended primarily for sealing to glass in electronic applications. UNS K92801 should only be considered for use at service temperatures below 300°C. The alloy is prone to sigma phase formation at temperatures close to 620°C, and exhibits brittle mechanical behavior after prolonged exposures at temperatures close to 475°C.

Grade and Chemical Composition (see Table 1)

Table 1 Grade and Chemical Composition

Grade	Chemical Composition (%)								Cr	Fe
	C	P	S	Mn	Si	Ni	N	≤		
4J28	0.12	0.02	0.02	1.00	0.70	0.50	0.20		27.0~29.0	Balance

Notes:

1、 Under condition that the average coefficient of the linear expansion meets the requirements of the standard, the content of chromium is allowed to deviate from the stated range.

2、 The shape and dimensions of the alloys are in compliance with GB/T14985.

Physical Property (see Table2 & Table 3)

Table 2 Coefficient of Linear Expansion

Grade	Heat Treatment of the Samples	Average Coefficient of Linear Expansion
		20~530°C
4J28	Heat to 1100±20°C, hold for 15min., cool to room temperature in the air.	10.8~11.4

Note: The hardness of the annealed strip should be no more than 170. Hardness inspection is not required when the thickness of the strip is less than 0.2mm.

Table 4 Coefficient of Linear Expansion

Grade	Average Coefficient of Linear Expansion $\bar{\alpha}/(10^{-6}/K)$							
	20~200 °C	20~300 °C	20~400°C	20~450°C	20~500°C	20~600°C	20~700°C	20~800°C
4J28	10.0	10.5	10.8	-	11.1	11.2	11.6	11.6

**Usage:** It is applied to seal the equipment of the electric component with the soft glass.

**Specification:** Sheet/Plate, Bar/Rod/Wire/Coil,Capillary/Pipe/Tube

**Size Range:**

\*Sheet---Thickness 0.1mm~3.5mm, width: ≤300mm,Condition: cold rolled, bright, bright

annealed \*Plate---Thickness 3.5mm~40.0mm,width: ≤300mm,Condition: cold rolled, hot rolled,

annealed \*Round Wire---Dia 0.1mm~Dia 5.0mm,Condition: cold drawn, bright, bright annealed

\*Flat Wire---Dia 0.5mm~Dia 5.0mm,length: ≤1000mm,Condition:flat rolled, bright annealed \*Bar-

--Dia 5.0mm~Dia 8.0mm,length: ≤2000mm,Condition:cold drawn,bright, bright annealed

Dia 8.0mm~Dia 32.0mm,length: ≤2500mm,Condition:hot rolled,bright, bright annealed

Dia 32.0mm~Dia 180.0mm,length: ≤1300mm,Condition:hot forging,peeled, turned, hot treated \*Capillary---

OD 8.0mm~1.0mm,ID 0.1mm~8.0mm,length: ≤2500mm,Condition: cold drawn, bright, bright annealed \*Pipe---

OD 120mm~8.0mm,ID 8.0mm~129mm,length: ≤4000mm,Condition: cold drawn, bright, bright annealed

Note: we could do any other products with specified technical standard, say,

ASTM,SAE,DIN,S.E.W.,JIS,ISO,IEC,NF,BS,ГОСТ.PLS contact us for more information:



**Expandable Alloy** → Alloy 42 & 48 & 52

\*Alloy 42, ASTM F30, UNS K94100, (Fe-42Ni), Chinese 4J42

\*Alloy 52, ASTM F30, UNS K95050, (Fe-50Ni), Chinese 4J50

\*Sealmet HC-4, alloy 426, ASTM F31, UNS K94760, (Fe-42Ni-6Cr), Chinese 4J6

Contrast :

Grade	Relative Grade					
	Russia	U.S.A.	U.K.	Japan	France	Germany
4J6	H42 X 6	42Ni-6Cr Carpenter426 Sylvania4 Sealmet 4	-	NRS-1 YEF-426 SNC	ASV(426) Ni42Cr6	Vacovit426 (NiCr426)
4J47	47HX	-	-	-	461	-
4J49	49HXP	Carpenter 456	-	-	FeNi46Cr5	Vacovit 465 Vacovit 485
4J42	42H	Glass Sealing 42 Uniseal 42	Nilo42	YEF42 NSD	N42	Vacodil 42 Nilo42
4J45	46H	Niromet 46 Ferrovac 46 Ni	Nilo45		Fe-Ni42	Vacodil 46
4J50	50H	FeNi50	Nilo51	NS-1	N50	Vacovit 500
4J52	52H 50H-BI	Glass Sealing 52 Niloy 52	-	N52	N52	Vacovit 520 FeNi52
4J54	-	-	-	-	N54	Vacovit 540 FeNi54

Grade & Chemical Composition (see Table 1)

Table 1 Grade & Chemical Composition

Grade	Grade & Chemical Composition(%)										
	C	P	S	Mn	Si	B	Al	Co	Ni	Cr	Fe
	≤										
4J6	0.05	0.020	0.020	0.25	0.30		0.20		41.5~42.5	5.50~6.30	Balance
4J47	0.05	0.020	0.020	0.40	0.30				46.8~47.8	0.80~1.40	Balance
4J49	0.05	0.020	0.020	0.40	0.30	0.02			46.0~48.0	5.00~6.00	Balance
4J42	0.05	0.020	0.020	0.80	0.30		0.10	1.0	41.5~42.5		Balance
4J45	0.05	0.020	0.020	0.80	0.30		0.10		44.5~45.5		Balance
4J50	0.05	0.020	0.020	0.80	0.30		0.10		49.0~50.5		Balance
4J52	0.05	0.020	0.020	0.60	0.30		-		51.5~52.5		Balance
4J54	0.05	0.020	0.020	0.60	0.30		-	-	53.5~54.5		Balance

Notes:

1、 Under condition that the average coefficient of the linear expansion meets the requirements of the standard, the content of nickel and cobalt are allowed to deviate from the stated range.

2、 The shape and dimensions of the alloys are in compliance with YB/T5235.

Mechanical Property (see Table 2 & Table

3) Table 2 Tensile Strength of Alloy Strips

Code	Status	Tensile Strength $\delta_b$ /MPa
R	Annealed	<590
L	Unannealed	>820

Table 3 Hardness of Deep-drawn Strips

Deep-Stamping	Thickness/mm	Hardness/HV
Fe-Ni-Cr		≤190

Fe-Ni	>2.5	≤190
	≤2.5	≤165

Physical Property (See Table 4 & Table 5)

Table 4 Heat Treatment & Coefficient of Linear Expansion

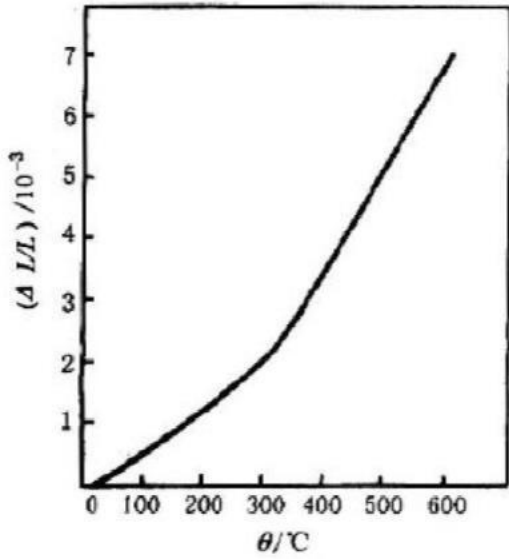
Grade	Heat Treatment System of the Samples	Average Coefficient of Linear Expansion		
		20-300°C	20~400°C	20-450°C
4J6	To be heat treated at a temperature of 1130±20°C in the hydrogen, hold for 15 min., cool to 200°C at a rate less than 5°C/min	7.6~8.3	9.5~10.2	
4J47			8.1~8.7	
4J49		8.6~9.3	9.4~10.1	
4J42	To be heat treated at a temperature of 900±20°C in the hydrogen, hold for 1h, cool at a rate less than 5°C/min to 200°C	4.0~5.0		6.5~7.5
4J45		6.5~7.2	6.5~7.2	
4J50		9.2~10.0	9.2~9.9	
4J52	To be heat treated at a temperature of 850±20°C in the hydrogen, hold for 1h, cool at a rate less than 300°C/H to 400°C	9.8~11.0	9.8~11.0	
4J54		10.2~11.4	10.2~11.4	

Table 5 Typical Expansion Coefficient

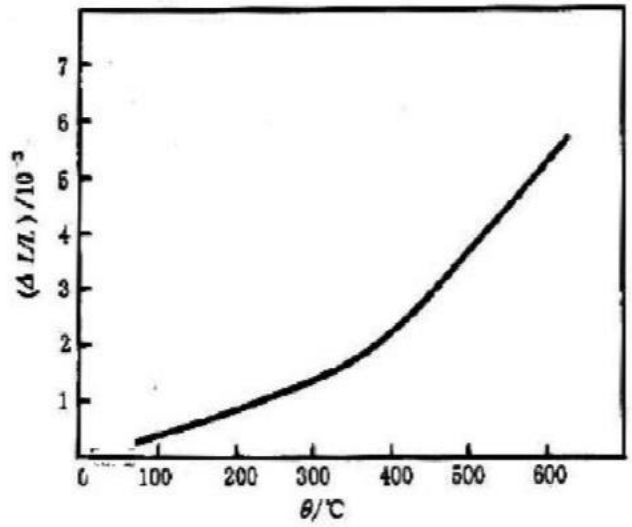
Grade	Average Coefficient of Linear Expansion $\bar{\alpha}/(10^{-6}/K)$						
	20~100°C	20~200°C	20~300°C	20~400°C	20~450°C	20~500°C	20~600°C
4J6	6.8	7.0	7.7	9.7		11.1	12.2
4J47	8.1	8.6	8.3	8.3		9.1	10.0
4J49	9.0	9.0	8.9	9.6		10.9	11.8
4J42	5.6	4.9	4.8	5.9	6.9	7.8	9.2
4J45	7.5	7.5	7.1	7.2	7.1	8.3	9.5
4J50	9.8	9.8	9.5	9.4		9.7	10.6
4J52	10.3	10.4	10.2	10.3	10.3	10.3	10.8
4J54	10.7	12.7	10.7	10.8	10.3	10.8	11.2

Note: The data in the table are for reference only.

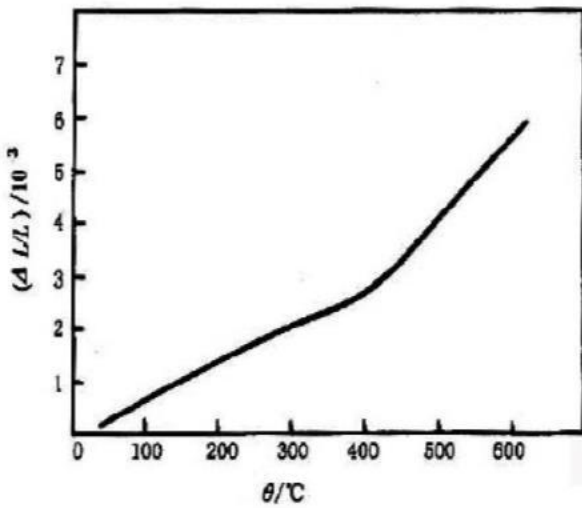
**Usage:** It is applied to soft glass-to-metal and ceramic-to-metal seals in electronic component.



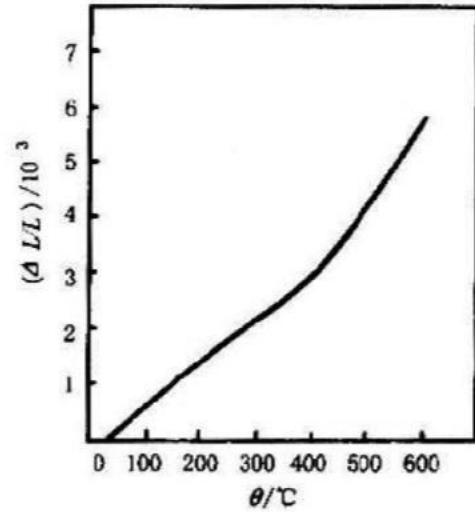
Dilatometer Curve of 4J6 [2]



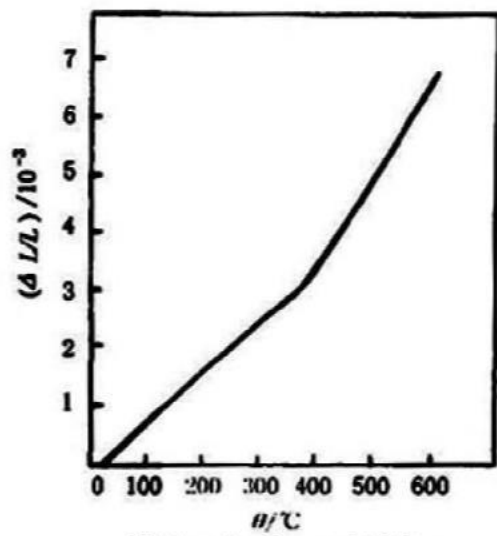
Dilatometer Curve of 4J42



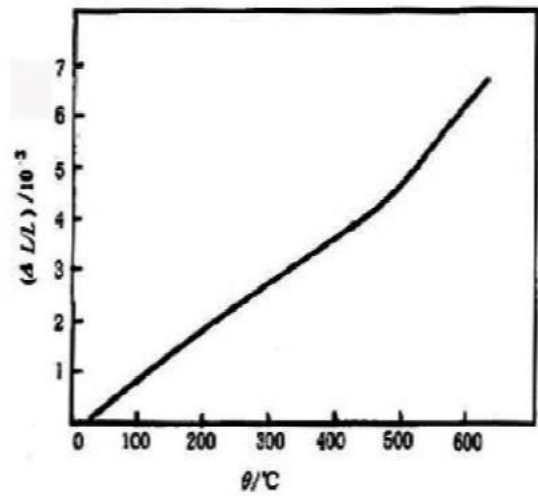
Dilatometer Curve of 4J45 [2]



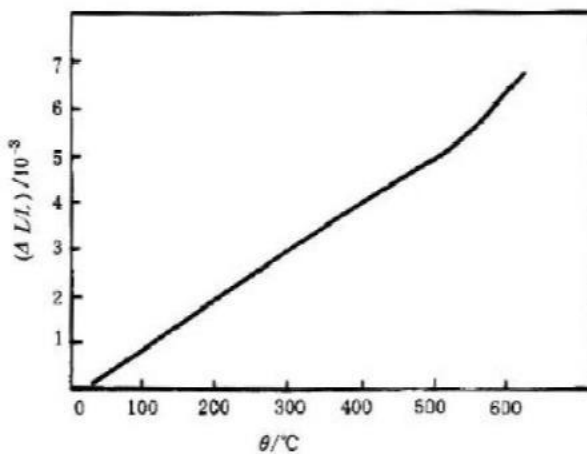
Dilatometer Curve of 4J47[2]



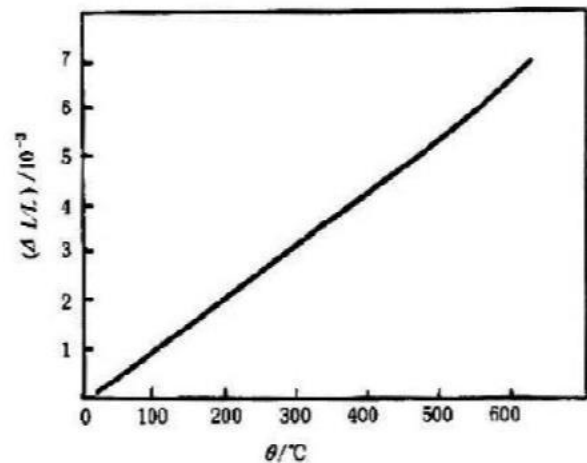
Dilatometer Curve of 4J49 [2]



Dilatometer Curve of 4J50 [2]



Dilatometer Curve of 4J52 [2]



Dilatometer Curve of 4J54 [2]

**Specification:** Sheet/Plate, Bar/Rod/Wire/Coil,Capillary/Pipe/Tube

**Size Range:**

\*Sheet---Thickness 0.1mm~3.5mm, width:≤300mm,Condition: cold rolled, bright, bright

annealed \*Plate---Thickness 3.5mm~40.0mm,width:≤300mm,Condition: cold rolled, hot rolled,

annealed \*Round Wire---Dia 0.1mm~Dia 5.0mm,Condition: cold drawn, bright, bright annealed

\*Flat Wire---Dia 0.5mm~Dia 5.0mm,length:≤1000mm,Condition:flat rolled, bright annealed \*Bar---

Dia 5.0mm~Dia 8.0mm,length:≤2000mm,Condition:cold drawn,bright, bright annealed

Dia 8.0mm~Dia 32.0mm,length:≤2500mm,Condition:hot rolled,bright, bright annealed

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Dia 32.0mm~Dia 180.0mm,length:≤1300mm,Condition:hot forging,peeled, turned, hot treated \*Capillary--  
-OD 8.0mm~1.0mm,ID 0.1mm~8.0mm,length:≤2500mm,Condition: cold drawn, bright, bright annealed \*Pipe---  
OD 120mm~8.0mm,ID 8.0mm~129mm,length:≤4000mm,Condition: cold drawn, bright, bright annealed

Note: We could do any other products with specified technical standard, say,

ASTM,SAE,DIN,S.E.W.,JIS,ISO,IEC,NF,BS,ГОСТ.PLS contact us for more information:





**Expandable Alloy → Alloy 46**

\*Alloy 46, UNS K94600, (Fe-46Ni), Chinese 4J46

Grade & Chemical Composition (see Table 1)

Table 1 Grade & Chemical Composition

Grade	Chemical Composition (%)								
	C	P	S	Mn	Si	Ni+Co+Cu	Co	Cu	Fe
	≤								
4J46	0.05	0.020	0.020	0.40	0.30	45.0~46.0	5.0~6.0	3.0~4.0	Balance

Notes:

- Under condition that the average coefficient of the linear expansion meets the requirements of the standard, the content of nickel, cobalt and copper are allowed to deviate from the stated range.
- The shape and dimensions of the alloys are in compliance with GB/T14985.

Physical Property (see Table 2)

Table 2 coefficient of linear expansion

Grade	Heat treatment of samples	Average coefficient of linear expansion		
		20~300°C	20~400°C	20~500°C
4J46	Heat to 850~900°C in a protective atmosphere or in vacuum condition, hold for 1 hour, and then cool to 300°C at a rate less than 300°C/h	5.5~6.5	5.6~6.6	7.0~8.0

Notes:

1. The Vickers hardness of the annealed strip (sheet) should be no more than 170.
2. For the unannealed strip (sheet) delivered, after heat treat at 900°C, and then hold for 30 min, the Vickers hardness should be no more than 170.

Typical Property (see table 3—table 6)

Table 3 coefficient of linear expansion

Grade	Average coefficient of linear expansion in different temperature, $\bar{\alpha}/(10^{-6}/K)$					
	20~100°C	20~200°C	20~300°C	20~400°C	20~500°C	20~600°C
4J46	6.8	6.5	6.4	6.4	7.9	9.3

Table 4 Mechanical Property

Grade	Heat treatment temperature, °C	Tensile strength, sb/MPa	Tensile stretch, $\delta$ (%)	Vickers hardness	Grain size
4J46	750	527.5	34.8	137.4	7
	850	510	35.4	134.6	6
	950	483.5	36.7	128.1	6~5
	1050	466.5	34.3	125.6	5~4

Table 5 Magnetic Property

Grade	magnetic induction		remanent magnetic induction/ Br/T	coercivity	maxmum permeability
	B10/T	B100/T			
4J46	1.58	1.61	0.31	2.96	55.5

Table 6 Other Propertise of the Alloy

Grade	modulus of elasticity	Resistivity	thermal conductivity200°C/[W/(m•K)]	Density/(g/cm3)
4J46	137500	0.54	20.1	8.18

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**Usage:** This alloy has a constant average linear expansion coefficient at the range of 20 °C to 500 °C. It is mainly used with 95% aluminum oxide ceramic to form air tight seal in vacuum electronics.

**Specification:** Sheet/Plate, Bar/Rod/Wire/Coil,Capillary/Pipe/Tube

**Size Range:**

\*Sheet---Thickness 0.1mm~3.5mm, width: ≤300mm,Condition: cold rolled, bright, bright

annealed \*Plate---Thickness 3.5mm~40.0mm,width: ≤300mm,Condition: cold rolled, hot rolled,

annealed \*Round Wire---Dia 0.1mm~Dia 5.0mm,Condition: cold drawn, bright, bright annealed

\*Flat Wire---Dia 0.5mm~Dia 5.0mm,length: ≤1000mm,Condition:flat rolled, bright annealed \*Bar-

--Dia 5.0mm~Dia 8.0mm,length: ≤2000mm,Condition:cold drawn,bright, bright annealed

Dia 8.0mm~Dia 32.0mm,length: ≤2500mm,Condition:hot rolled,bright, bright annealed

Dia 32.0mm~Dia 180.0mm,length: ≤1300mm,Condition:hot forging,peeled, turned, hot treated \*Capillary---

OD 8.0mm~1.0mm,ID 0.1mm~8.0mm,length: ≤2500mm,Condition: cold drawn, bright, bright annealed \*Pipe---

OD 120mm~8.0mm,ID 8.0mm~129mm,length: ≤4000mm,Condition: cold drawn, bright, bright annealed

Note: We could do any other products with specified technical standard, say,

ASTM,SAE,DIN,S.E.W.,JIS,ISO,IEC,NF,BS,ГОСТ.PLS contact us for more information:



**Expandable Alloy**→Ceramvar Alloy

**4J33、4J34 (YB/T5234-1993)**

**\*Ceramvar alloy, ASTM F1466, (Fe-Ni27-Co25), Chinese 4J33/4J34**

Cross Reference:

Grade	Russia	U.S.A.	Japan	Germany
4J33	33Hk (Ni33Co17)	-	KV-4 (Ni33Co17)	-
4J34	31HK (Ni31Co20) 24HK (Ni25Co18)	Ceramvar (Ni27Co25)	-	Vacon20 (Ni28Co20)

Grade & Chemical Composition (See Table 1)

Table 1 Grade & Chemical Composition

Notes:

1. Under condition that the average coefficient of the linear expansion meets the requirements of the standard, the content of nickel and cobalt are allowed to deviate from the stated range.

2. The shape and dimensions of the alloys are in compliance with GB/T14985.

Mechanical Properties (See Table 2—Table4)

Table 2 Tensile Strength (for wires)

Symbol	State	Tensile Strength
R	Annealed	<585
1	Unannealed	>860

Table 3 Tensile Strength (for Strips)

Symbol	State	Tensile Strength/MPa
R	Annealed	<570
l	Unannealed	>700

Table 4 Hardness of Deep Stamping Strips

State	Thickness	Hardness HV
Deep-Stamping	>2.5	≤170
	≤2.5	≤165

Physical Property (see Table 5 & Table 6)

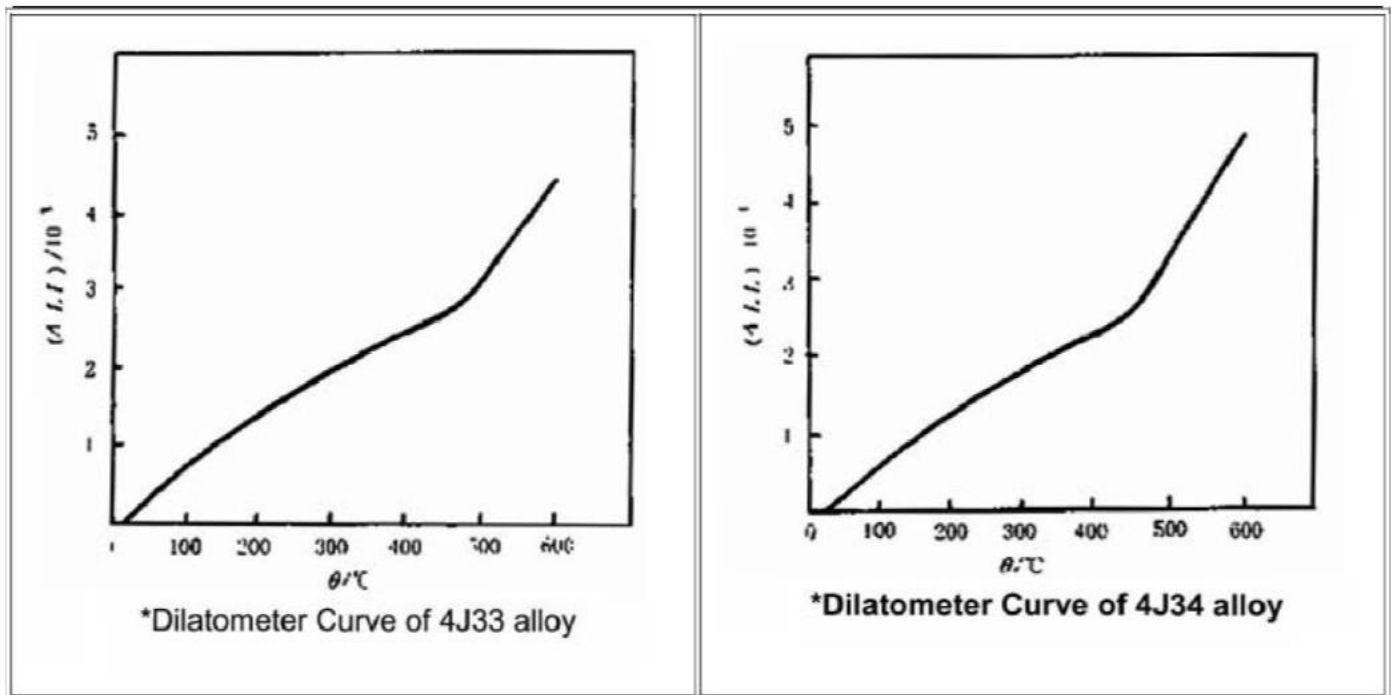
Table5 Linear Expansion Coefficient

Grade	Heat treatment of the samples	Mean Coefficient of Linear Expansion $\bar{\alpha}/(10^{-6}/K)$			
		20~300°C	20~400°C	20~500°C	20~600°C
4J33	Heat to 900±20°C in the protective atmosphere or in vacuum condition, hold for 1 hour, cooled to 200°C at a rate less than 5°C/h, and take out from the furnace.		6.0~6.8	6.6~7.4	
4J34			6.3~7.1		7.8~8.5

Table 6 Typical Coefficient of Linear Expansion

Grade	Mean Coefficient of Linear Expansion at Different Temperature $\bar{\alpha}/(10^{-6}/K)$				
	20~200°C	20.300°C	20~400°C	20~500°C	20~600°C
4J33	7.1	6.5	6.3	7.1	8.5
4J34	7.5	6.9	6.6	6.9	8.3

Note: The values in the tables are for reference only.



**Specification:** Sheet/Plate, Bar/Rod/Wire/Coil,Capillary/Pipe/Tube

**Size Range:**

\*Sheet---Thickness 0.1mm~3.5mm, width:≤300mm,Condition: cold rolled, bright, bright

annealed \*Plate---Thickness 3.5mm~40.0mm,width:≤300mm,Condition: cold rolled, hot rolled,

annealed \*Round Wire---Dia 0.1mm~Dia 5.0mm,Condition: cold drawn, bright, bright annealed

\*Flat Wire---Dia 0.5mm~Dia 5.0mm,length:≤1000mm,Condition:flat rolled, bright annealed \*Bar-

--Dia 5.0mm~Dia 8.0mm,length:≤2000mm,Condition:cold drawn,bright, bright annealed

Dia 8.0mm~Dia 32.0mm,length:≤3000mm,Condition:hot rolled,bright, bright annealed

Dia 32.0mm~Dia 180.0mm,length:≤1300mm,Condition:hot forging,peeled, turned, hot treated \*Capillary---

OD 8.0mm~1.0mm,ID 0.1mm~8.0mm,length:≤2500mm,Condition: cold drawn, bright, bright annealed \*Pipe---

OD 120mm~8.0mm,ID 8.0mm~129mm,length:≤4000mm,Condition: cold drawn, bright, bright annealed

Note: we could do any other products with specified technical standard, say, ASTM,SAE,DIN,S.E.W.,JIS,ISO,IEC,NF,BS,ГОСТ.PLS



**Expandable Alloy → Invar Alloy**

\*Invar alloy, ASTM F1684, UNS k93600 (FeNi36), Chinese 4J36

Note:

A Nickel-Iron, low expansion alloy containing 36% Nickel. It maintains nearly constant dimensions over the range of normal atmospheric temperatures and has a low coefficient of expansion from cryogenic temperatures to about +500°C. Invar 36 also retains good strength and toughness at cryogenic temperatures. Applications include standards of length, thermostat rods, laser components and tanks and piping for the storage and transportation of liquefied gasses.

Relative Grade:

Grade	Russia	U.S.A.	Japan	France	Germany	U.K.
4J32	32HK Д 32HK-ВН	Super-Invar Super Nilvar	SI	Invar Superieur	-	-
4J36	36H 36H-ВН	Invar Nilvar Unipsan36	Cactus LE	Invar Standard Fe-Ni36 -	Vacodil36 Nilos36 -	Invar Nilo36 36Ni
4J38	-	38NiFM Simonds38-7FM	-	-	-	-

Grade & Chemical Composition (see Table 1)

Table 1 Grade & Chemical Composition

Grade	Chemical Composition (%)									
	C	Si	P	S	Cu	Se	Mn	Ni	Co	Fe
	≤									
4J32	0.05	0.20	0.020	0.020	0.40~0.80		0.20~0.60	31.5~33.0	3.20~4.20	Balance

4J36	0.05	0.30	0.020	0.020			0.20~0.60	35.0~37.0		Balance
4J38	0.05	0.20	0.020	0.020	-	0.10~0.25	0.80	35.0~37.0	-	Balance
4J40	0.05	0.15	0.020	0.020	-	-	≤0.25	32.4~33.4	7.00~8.00	Balance

Notes:

1、 Under condition that the average coefficient of the linear expansion meets the requirements of the standard, the content of nickel and cobalt are allowed to deviate from the stated range.

2、 The shape and dimensions of the alloys are in compliance with GB/T14985.

Physical Property (see Table 2 –Table 3)

Table 2 Coefficient of Linear Expansion

Grade	Heat Treatment of the Samples	Mean Coefficient of Linear Expansion	
		20~100°C	20~300°C
4J32	To heat the semi-finished products samples to 840±10°C, hold for 1hour, and quench in the water. Machine the samples to finished samples. And heat at 315±10°C for 1h, furnace or air cool.	≤1.0	
4J36		≤1.5	
4J38			
4J40			≤2.0

Table 3 Typical Expansion Coefficient

Grade	Mean Coefficient of Linear Expansion					
	20~50°C	20~100°C	20~200°C	20~300°C	20~400°C	20~500°C
4J32	0.7	0.8	1.4	4.3	7.2	9.3
4J36	0.6	0.8	2.0	5.1	8.0	10.0
4J40	1.4	1.3	1.2	1.7	4.5	

Note: The data in the tables are just for reference.

**Usage:** Grade 4J32 and 4J36 are suitable for environmental temperature, make dimensional precision parts for instrumentation. 4J38 are used for easy to cut alloys. 4J40 are used for parts that require low expansion at high temperatures.



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**Specification:** Sheet/Plate, Bar/Rod/Wire/Coil,Capillary/Pipe/Tube

**Size Range:**

\*Sheet---Thickness 0.1mm~3.5mm, width: ≤300mm,Condition: cold rolled, bright, bright

annealed \*Plate---Thickness 3.5mm~40.0mm,width: ≤300mm,Condition: cold rolled, hot rolled,

annealed \*Round Wire---Dia 0.1mm~Dia 5.0mm,Condition: cold drawn, bright, bright annealed

\*Flat Wire---Dia 0.5mm~Dia 5.0mm,length: ≤1000mm,Condition:flat rolled, bright annealed \*Bar-

--Dia 5.0mm~Dia 8.0mm,length: ≤2000mm,Condition:cold drawn,bright, bright annealed

Dia 8.0mm~Dia 32.0mm,length: ≤3000mm,Condition:hot rolled,bright, bright annealed

Dia 32.0mm~Dia 180.0mm,length: ≤1300mm,Condition:hot forging,peeled, turned, hot treated \*Capillary---

OD 8.0mm~1.0mm,ID 0.1mm~8.0mm,length: ≤2500mm,Condition: cold drawn, bright, bright annealed Pipe---OD

120mm~8.0mm,ID 8.0mm~129mm,length: ≤4000mm,Condition: cold drawn, bright, bright annealed

\*Note:

We could do any other products with specified technical standard, say,

ASTM,SAE,DIN,S.E.W.,JIS,ISO,IEC,NF,BS,ГОСТ.PLS contact us for more information:



**Expandable Alloy → Kovar Alloy**

**Glass sealed and controlled expansion alloys**

\*kovar alloy, ASTM F15, Nilo-K, UNS K94610 (FeNi29Co17), Chinese 4J29

\* Specifications: ASTM F15; DIN 17745; S.E.W. 385; Werkstoff Nr. 1.3981; AFNOR NF A54-301

Note:

A Nickel-Iron-Cobalt, controlled expansion alloy containing 29% Nickel. It's coefficient of expansion (which decreases with rising temperature to the inflection point), matches the expansion rate of borosilicate glasses and alumina ceramics. Applications include glass to metal seals in applications requiring high reliability or resistance to thermal shock, ie. high-power transmitting valves, transistor leads and heaters and photography flash bulbs.

Similar Grades:

Russia	U.S.A.	U.K.	Japan	France	Germany
29HK	Kovar	Nilo K	KV-1	Dilver P0	Vacon 12
29HK-BI	Rodar Techallony Glasseal 29-17	Teleseal	KV-2 KV-3	Dilver P1	Silver 48

Grade & Chemical Composition (see Table 1)

Table 1 Grade & Chemical Composition

Grade	Chemical Composition (%)										
	C	P	S	Mn	Si	Cu	Cr	Mo	Ni	Co	Fe
	≤										
4J29	0.03	0.020	0.020	0.5	0.30	0.20	0.20	0.20	28.5~29.5	16.8~17.8	Balance
4J44	0.03	0.020	0.020	0.5	0.30	0.20	0.20	0.20	34.2~35.2	8.50~9.50	Balance

Notes:

1. The content of Al, Mg, Zr and Ti should be no more than 0.10%, the total content should be no more than 0.20%. Otherwise, the supplier's PO and/or contract shall indicate clearly.
2. Under condition that the average coefficient of the linear expansion meets the requirements of the standard, the content of nickel and cobalt are allowed to deviate from the stated range.
3. The shape and dimensions of the alloys are in compliance with GB/T14985.

Mechanical Property (see table 2-table 4)

Table 2 Tensile Strength of Wire

Symbol	Status	Tensile Strength/MPa
R	Annealed	<585
1/4 I	1/4 hard	585~725
1/2 I	1/2 hard	655~795
3/4 I	3/4 hard	725~860
I	unannealed	>860

Table 3 Tensile Strength Strip

Symbol	Status	Tensile Strength/MPa
R	annealed	<570
1/4 I	1/4 unannealed	520~630
1/2 I	1/2 unannealed	590~700
3/4 I	3/4 unannealed	600~770
I	unannealed	>700

Table 4 Hardness of Deep Stamping Strips

State	Thickness	Hardness,Hv
Deep Stamping	>2.5	≤170
	≤2.5	≤165

Physical Property (see Table 5 & Table 6)

Table 5 Coefficient of Linear Expansion

Grade	Heat Treatment of the Samples	Average Coefficient of Linear Expansion		
		20~300°C	20~400°C	20~450°C
4J29	Heat to temperature of 900±20°C in the hydrogen, hold for 1h; re-heat to 1100±20°C, hold for 15 min.; cooled to 200°C at a rate less than 5°C/min		4.6~5.2	5.1~5.5 <sup>①</sup>
4J44		4.3~5.1	4.6~5.2	

①Upper limit is 5.6 for transistors.

Table 6 Typical Coefficient of Linear Expansion

Grade	Average Coefficient of Linear Expansion							
	20~ 200°C	20~300°C	20~400°C	20~450°C	20~500°C	20~600°C	20~700°C	20~800°C
4J29	5.9	5.3	5.1	5.3	6.2	7.8	9.2	10.2
4J44	4.9	4.6	4.9	5.9	6.8	8.7		

Note: The values in the table are for reference only.

**Usage:** It is applied to hard glass-to-metal seals.

### Applications

Kovar alloy has been used for making hermetic seals with the harder Pyrex glasses and ceramic materials.

This alloy has found wide application in power tubes, microwave tubes, transistors and diodes. In intergrated circuits, it has been used for the flat pack and the dual-in-line package.

### Physical Properties

Specific gravity..... 8.36

Curie temperature

Density

°F..... 815

lb/cu in.....	0.302	°C.....	435
kg/cu m.....	8359	Melting Point	
Thermal conductivity		°F.....	2640
Btu-in/ft <sup>2</sup> /hr/°F.....	120	°C.....	1450
W/m-K.....	17.3	Modulus of elasticity	
Electrical resistivity		psi x 10(6).....	20
ohm-cir mil/ft.....	294	MPa x 10(3) .....	138
microhm-mm.....	490		

### Preparation for Sealing

All degreased, fabricated Kovar alloy parts should be degassed and annealed in a wet hydrogen atmosphere. Atmosphere is to be made moist by bubbling the hydrogen through water at room temperature. Care must be taken to prevent surface carbon pickup. Furnace should have a cooling chamber provided with the same atmosphere.

Heating should be conducted within the 1540/2010°F temperature range. Time at temperature should be approximately two hours for lowest temperature to 20 minutes for the highest temperature. Parts should then be transferred to the cooling zone and held until below 570°F, then removed.

An oxide film on the metallic part is preferred for metal-to-hard glass sealing. The best oxide film is thin and tightly adhering. The film can be produced by heating the parts to 1200/1290°F in regular ambient atmosphere for a time sufficient to form a dark gray to slight brown oxide.

### Workability

#### Forging

The principal precaution to observe in forging is to heat quickly and avoid soaking in the furnace. Long soaking may result in a checked surface due to absorption of sulfur from the furnace atmosphere and/or oxide penetration. A forging temperature of 2000/2150°F is preferred.

#### Coolant

It is important to control heat build up, the major cause of warpage. A suggested coolant would be Cool Tool. Cool Tool contains fatty esters to reduce friction in the cutting zone and a refrigerant to remove the heat generated by friction between the cutting tool and work place.

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## **Tooling**

T-15 Alloy, such as Vasco Supreme-manufactured by Vanadium Alloys Company. M-3 Type 2, such as Van Cut Type 2-manufactured by Vanadium Alloys Company. Congo manufactured by Braeburn.

For machining with carbide tools, a K-6 manufactured by Kennemetal, Firthie HA manufactured by Firth Sterling, or #370 Carboloy could be used, or a K2S manufactured by Kennemetal, or Firthie T-04 manufactured by Firth Sterling would be satisfactory. One thing of prime importance is that all feathered or wire edges should be removed from the tools. They should be kept in excellent condition by repeated inspection.

## **Turning**

If steel cutting tools are used, try a feed of approximately .010" to .012" per revolution and a speed as high as 35/FPM could probably be attained. Some of the angels on the cutting tools would be as follows:

- End cutting edge angle -Approximately 7°
- Nose radius -Approximately .005"
- Side cutting edge angle -Approximately 15°
- Back rake -Approximately 8°
- Side rake -Approximately 8°

When cutting off high speed tools are better than carbide tools, and a feed of approximately .001" per revolution should be used. The cutting tools should have a front clearance of about 7° and a fairly big tip--larger than 25° would be helpful.

## **Drilling**

When drilling a 3/16" diameter hole, a speed of about 40/FPM could possibly be used, and the feed should be about .002" to .0025" per revolution, for a 1/2" hole, approximately the same speed could be used with a feed of about .004" to .005" per revolution. The drills should be as short as possible, and it is desirable to make a thin web at the point by conventional methods. By conventional methods, we mean do not notch or make a crank shaft grinding. It is suggested that heavy web type drills with nitrided or electrolyzed surfaces be used. The hole, of course, should be cleaned frequently in order to remove the chips, which will gall, and also for cooling. The drill should be ground to an included point angle of 118° to 120°

## Reaming

Reaming speeds should be half the drill speed, but the feed should be about three times the drill speed. It is suggested that the margin on the land should be about .005" to .010", and that the chamfer should be .005" to .010" and the chamfer angle about 30°. The tools should be as short as possible, and have a slight face rake of about 5° to 8°.

## Tapping

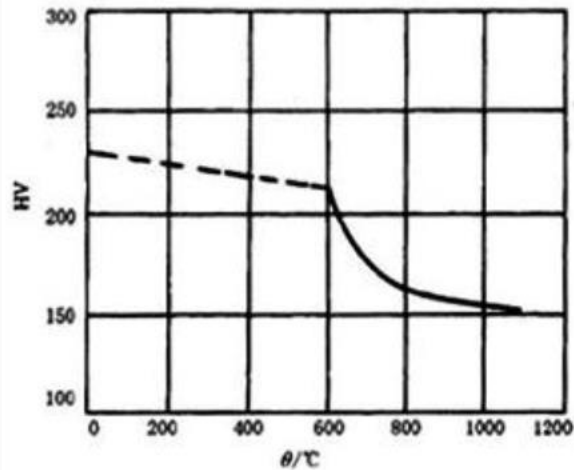
In tapping, a tap drill slightly larger than the standard drill recommended for conventional threads should be used, because the metal will probably flow into the cut. It is suggested that on automatic machines, a two or three fluted tapping tool should be used. For taps below 3/16", the two fluted would be best. Grind the face hook angle to 8° to 10°, and the tap should have a .003" to .005" chamfered edge. If possible, if binding occurs in the hole in tapping, the width of the land may be too great, and it is suggested that the width of the heel be ground down. Again, it is suggested that nitrided or electrolyzed tools be used. Speed should be about 20/FPM.

High Speed Tool*				
Turning And Forming	Cut-Off Tool	1/16"	SFM	65
			FEED	.0010
		1/8"	SFM	67
			FEED	.0012
		1/4"	SFM	69
			FEED	.0016
	Tool Width	1/2"	SFM	67
			FEED	.0012
1"		SFM	63	
		FEED	.0010	
	1-1/2"	SFM	63	
		FEED	.0009	
Drilling	Drill Dia.	3/8"	SFM	43
			FEED	.0030
		3/4"	SFM	45
			FEED	.0036
Reaming	Under 1/2"		SFM	57
			FEED	.003
	Over 1/2"		SFM	57
			FEED	.0045
Threading	T.P.I	3-7½	SFM	8
		8-15	SFM	10

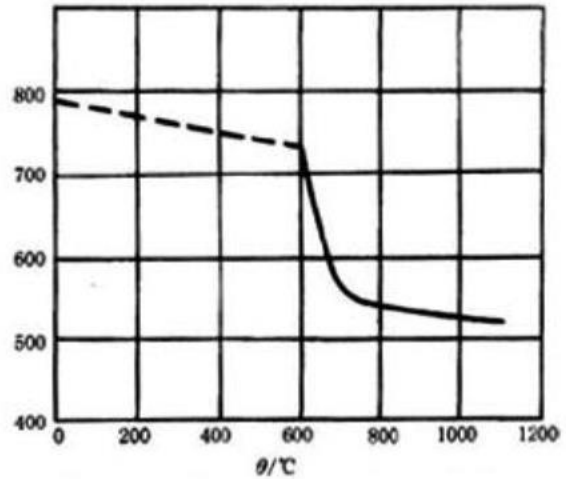
	Over 16	SFM	16	
Tapping	T.P.I	3-7½	SFM	6
		8-15	SFM	7
	Over 25	16-24	SFM	11
			SFM	16
Milling		SFM	35-70	
		FEED	.002-.005	
Broaching		SFM	8-12	
		FEED	.001-.005	
Turning Single Point & Box Tools	High Speed Tools	SFM	60-65	
		FEED	.0029-.0043	
	Carbide Tools	SFM	160-215	
		FEED	.025-.080	

- When using carbide tools, surface speed feet/minute (SFM) can be increased between 2 and 3 times over the high speed suggestions. Feeds can be increased between 50 and 100%.
- Note: Figures used for all metal removal operations covered are average. On certain work, the nature of the part may require adjustment of speeds and feeds. Each job has to be developed for best production results with optimum tool life. Speeds or feeds should be increased or decreased in small steps.
- The information and data presented herein are typical or average values and are not a guarantee of maximum or minimum values. Applications specifically suggested for material described herein are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes.





**The hardness of Sheets (have 50% cold-distortion) which have annealed (1h) at Different temperature**



**The tensile strength of Sheet (have 50% cold-distortion) which have annealed (1h) at Different temperature**

**Specification:** Sheet/Plate, Bar/Rod/Wire/Coil,Capillary/Pipe/Tube

**Size Range:**

\*Sheet---thickness 0.1mm~3.5mm, width:≤300mm,Condition: cold rolled, bright, bright

annealed \*Plate---thickness 3.5mm~40.0mm,width:≤300mm,Condition: cold rolled, hot rolled,

annealed \*Round Wire---Dia 0.1mm~Dia 5.0mm,Condition: cold drawn, bright, bright annealed

\*Flat Wire---Dia 0.5mm~Dia 5.0mm,length:≤1000mm,Condition:flat rolled, bright annealed \*Bar-

--Dia 5.0mm~Dia 8.0mm,length:≤2000mm,Condition:cold drawn,bright, bright annealed

Dia 8.0mm~Dia 32.0mm,length:≤2500mm,Condition:hot rolled,bright, bright annealed

Dia 32.0mm~Dia 180.0mm,length:≤1300mm,Condition:hot forging,peeled, turned, hot treated \*Capillary---

OD 8.0mm~1.0mm,ID 0.1mm~8.0mm,length:≤2500mm,Condition: cold drawn, bright, bright annealed \*Pipe---

OD 120mm~8.0mm,ID 8.0mm~129mm,length:≤4000mm,Condition: cold drawn, bright, bright annealed

Note: We could do any other products with specified technical standard, say,

ASTM,SAE,DIN,S.E.W.,JIS,ISO,IEC,NF,BS,ГОСТ.PLS contact us for more information:



**Elastic Alloy** → Axle-centre alloy

**Shock-proof & Wear Resistant axle-centre alloy (YB/T5243-1993)**

Relative Grade: 40XНЮ-ВН, ЭП793 Russia

Grade and Chemical Composition (see Table1)

Table1 Grade and Chemical Composition

Grade	Chemical Composition (%)									
	C	P	S	Mn	Si	Fe	Cr	Al	Ce <sup>①</sup>	Ni
	≤									
3J40	0.03	0.010	0.010	0.10	0.20	0.50	39.0~41.0	3.30~3.50	0.10~0.2	Balance

①Based on addition

Mechanical Property (see Table 2)

Table 2 Mechanical Property

Statue	Vickers Hardness/ HV		Commended Heat Treatment		Bend Test
	I	II	III		
Cold Drawing	450~510				Bend 90 degrees. No cracks and broken on the outside of the bending
Cold Drawn & Aging	780~830	>830~880	>880	480~540°C Keep warm for 5h	

Note: 1、 The default hardness classification of the alloy wire in cold drawing & aging status is class II.