Ceramvar Fe-21

Brazing:

Readily joined to metallized ceramics with brazing alloys. In order to properly process ceramic-to-metal seals by brazing, consideration must be given to the following: (1) The components to be joined must be absolutely clean: (2) The joint must be designed to have a high mechanical strength prior to bonding. (3) If possible, the thermal expansion of the brazing alloy should be close to that of the metal and ceramic, (4) Brazing time and temperature must be accurately controlled, (5) Ceramvar should be in a strain-free condition to minimize the possibility of intergranular penetration, (6) Copper plating Ceramvar diminishes intergranular penetration. Gold-copper alloys are less prone to penetration than copper-silver alloys. (7) Avoid the use of fluxes for high vacuum applications because they have high vapor pressures, and leave harmful voids in the filler metal, (8) Components to be sealed should be heated uniformly to prevent excessive thermal stressing.

The iron-cobalt-nickel alloys are prone to penetration by silver and silver alloys. As a result, when brazing with silver-bearing alloys, it is suggested that the material be copper plated.

Pickling:

To remove heavy oxides, degrease in trichlorethylene, immerse in a solution containing 50g ferric ammonium sulphate, 125 cc H_2SO_4 (1.84 sp. gr.), 150 cc HCl (20° Be), 5cc H_3PO_4 (75%), 1cc HNO_3 (42° Be), 69 cc water at 82°C.

Cleaning:

Ceramvar parts must be thoroughly degreased, and all evidences of organic or carbonaceous matter removed, to produce a clean surface for subsequent brazing or plating. Possible cleaning solutions for removing all surface contamination and organic matter are:

1. Hydrogen peroxide method for cleaning electron tube parts. Immerse parts in deionized water, bring to a boil, add enough peroxide to make a 5% solution, boil 20-30 minures, rinse with tap water and then with deionized water, dry in air furnace, and store parts in glass containers previously cleaned by the hydrogen peroxide method.
2. Ultrasonic agitated aqueous detergent solutions.

Note: It has been observed that ceramics cleaned with trichlorethylene are left with an undesirable conductive coating.

General Characteristics:

Ceramvar is a metal for high alumina ceramic-to-metal sealing. Its expansion characteristics closely match those of high temperature alumina ceramics. The low thermal conductivity of Ceramvar, which approximated that of ceramics, minimizes thermal stresses during the rapid heating and cooling cycles.

Forms Available:

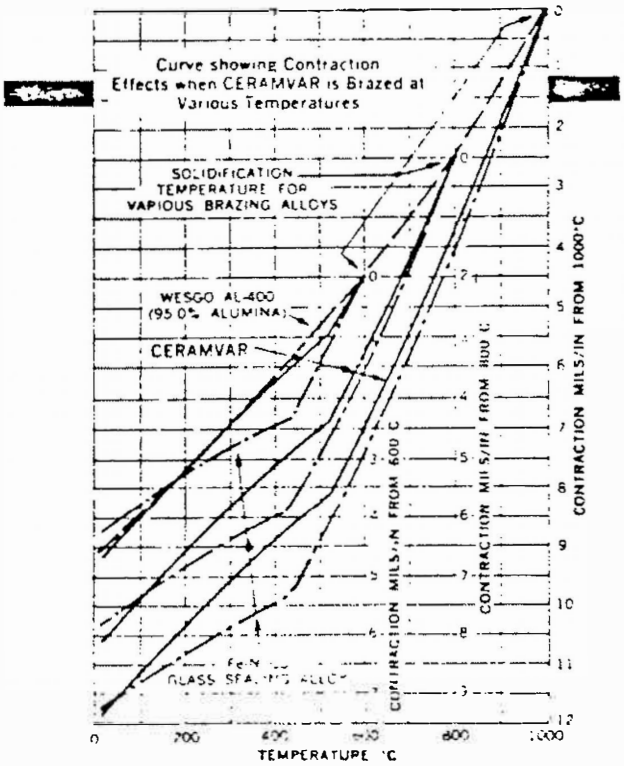
Wire and strip (air of vacuum melted).

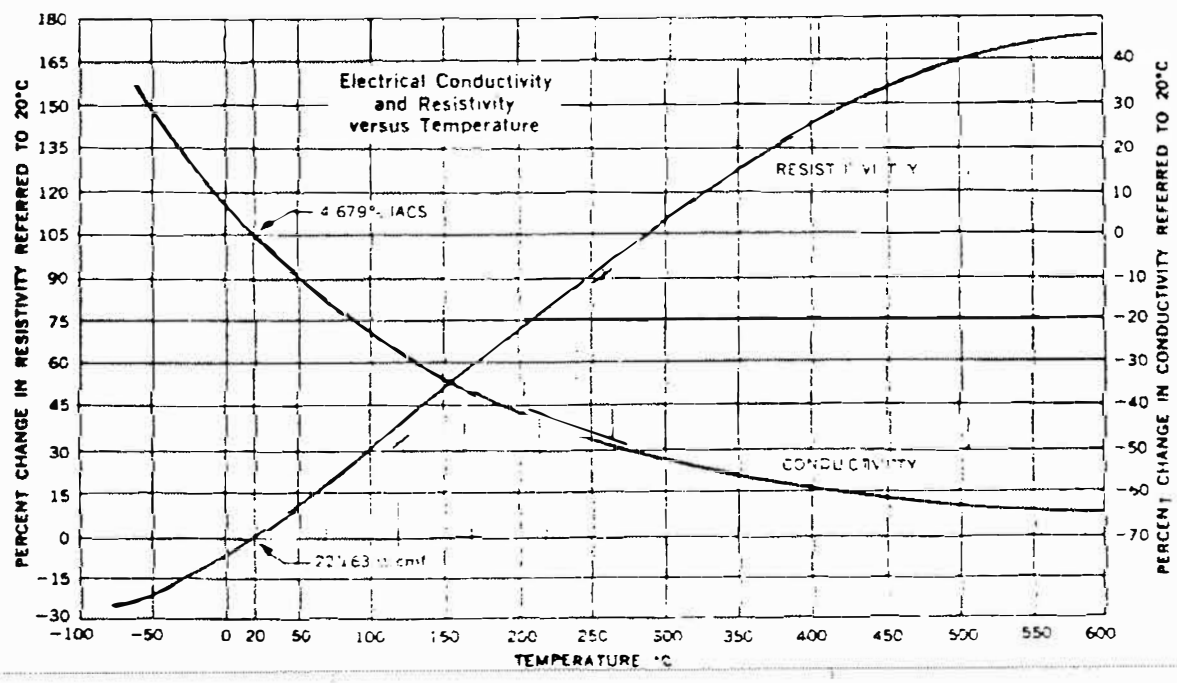
Applications:

Metal-to-ceramic seals.

Manufacturer:

Wilbur B. Driver Company
Newark, New Jersey





Alloy DIGEST

Filing Code: Fe-21
Iron Alloy

DECEMBER 1962

DATA ON WORLD WIDE METALS AND ALLOYS

CERAMVAR *

CERAMVAR*

(Ceramic-to-Metal Sealing Alloy)

Published by
Engineering Alloys Digest, Inc
Upper Montclair, New Jersey

CERAMVAR is an iron, nickel, cobalt alloy specially designed and suited for ceramic-to-metal sealing. It has expansion characteristics closely matching those of high temperature alumina ceramics.

* Pat. No. 2,960,402

Composition:

	Nominal
Iron	48
Nickel	27
Cobalt	25

Physical Constants: (at 20°C)

Specific gravity	8.17
Density, lb./cu.in.	0.295
Melting point, °F	2590
Thermal conductivity, cal/cm²/cm/sec/°C	
at 20°C	0.040
at 600°C	0.057
Electrical conductivity, % IACS	4.679
Electrical resistivity, microhm-cm	36.9
Modulus of elasticity, psi x 10^6	19.0
Modulus of rigidity, psi x 10^6	7.1
Curie temperature, °C	525-550
Specific heat, cal/g/°C (calculated)	0.112
Thermal coef. expansion/°C x 10^{-6} at 100°C	8.80
Transformation temperature, °C	below −80

PROPERTIES

Table 1 – SPECIFIC HEAT
(calculated)

Temperature °C	Specific Heat cal/g/°C
−100	0.095
0	0.111
20	0.112
100	0.119
200	0.125
300	0.131
400	0.136
500	0.141

Table 2 – AVERAGE THERMAL COEFFICIENT OF EXPANSION

Temperature °C	Coef. of Expansion/°C x 10^{-6} (from 20°C to temperature)
100	8.80
200	8.70
300	8.39
400	7.96
500	7.65
600	8.32
700	9.46
800	10.47
900	11.34
1000	12.12

Table 3 – TEMPERATURE COEFFICIENT OF RESISTANCE

Temperature °C	Temperature Coefficient, °C From 20°C to Temperature
−80	0.0030
0	0.0030
100	0.0038
200	0.0039
300	0.0039
400	0.0037
500	0.0034
600	0.0030

Machinability:

Machining Ceramvar can best be accomplished with tools of high speed steel, Stellite or cemented carbide having smaller cutting angles than normally used for steel. Speed is slower, and feed somewhat lighter, than for mild steel. In general, the machining properties of Ceramvar are similar to Monel alloy R-405.

Sulphurized oil is generally preferred and should be used as a cutting lubricant with high speed tool steels for boring, drilling, and tapping, provided it can be completely removed. Water soluble oils may be used for lathe work, and are preferred lubricants for Stellite or carbide tools.

Workability:

Ceramvar is normally supplied in the annealed condition with a fine grain suitable for deep drawing. In general, drawing techniques are similar to those used for mild steel. An annealing or stress-relieving treatment should be given between and after deep drawing operations. Stress-free metal is less susceptible to intergranular penetration by brazing alloys.

Drawing lubricants should be selected with care to eliminate the possibility of any residue remaining after a degreasing operation.

Fe-11 Therlo

steel. Electric arc and resistance welding are equally satisfactory. Arc welding should be done with a flux-coated electrode of either 18-8 or 25-12 chrome-nickel content.

Pickling:

To remove the oxide on Therlo from the sealing operation before soldering or brazing, pickle electrolytically in a 5-10% sulphuric acid containing 1% quinoline or 1% Rodine No. 110 as an inhibitor. The piece to be cleaned is used as one electrode with carbon or another part serving as the other electrode. The current should be 10-12 volts a-c, with approximately 10 amperes per square inch of surface to be cleaned. Normal acid pickling with a hydrochloric-nitric solution (10% by weight of each acid) for 2-5 minutes immersion at 160 deg. F. is sufficient to loosen the oxide and scale, which can then be wiped off with a cloth.

General Characteristics:

"Therlo" is an alloy which is primarily designed for making glass-to-metal seals with the so-called hard glass. The alloy has a thermal expansion similar to that of hard glass all the way from room temperature up to the annealing temperature of the glass. "Therlo" has a high resistance to amalgamation with mercury and exceptional resistance to high thermal shock. It is readily soft solderable with regular 60-40 lead, tin solder. It may also be copper brazed, electric arc welded or welded with an atomic hydrogen torch. "Therlo" is available in wire from 9/16" to .001" and strip in thicknesses as low as .0005" and widths as great as 12".

The Tensile Strength of "Therlo" Glass Seals is: 600 psi.

Recommendation for best results are as follows:

1. Metal surface should be smooth, bright, clean and free from defects.
2. Avoid sharp edges of the metal in contact with the glass.
3. The metal should not be subjected to successive heating in oxidizing, reducing or carbonaceous atmospheres.

The remarkable physical properties of this alloy make it ideal for any application demanding a vacuum-tight metal-to-glass joint to conduct power into a glass vessel or to insulate electrodes from metal-walled vessels.

Forms Available:

Strip and wire.

Applications:

Metal-to-glass seals, small rectifiers, grid-glow tubes, ignitrons, vacuum tight metal-to-glass seal.

Manufacturer:

Driver-Harris Company
Harrison, New Jersey

Alloy DIGEST

THERLO

DATA ON WORLD WIDE METALS AND ALLOYS

Filing Code: Fe-11
Iron Alloy

JULY 1956

Published by
Engineering Alloys Digest, Inc.
Upper Montclair, New Jersey

THERLO*

(Metal-to-Glass Sealing Alloy)

THERLO, also known as D-H Alloy No. 373, is an iron-nickel-cobalt alloy ideally suited for sealing to glass.

*Registered Trade-Mark of Driver-Harris Company

Composition:

Nickel	28.5-29.5
Cobalt	16.5-17.5
Manganese	0.30 max.
Iron	Remainder

Physical Constants:

Density, lb./cu.in.	0.302
Specific elec. resistance, microhms-cm	49
Specific elec. resistance, ohms/cmf	294
Thermal conductivity, watts/cm/°C. (approx.)	0.142
Modulus of elasticity, psi	20,000,000
Curie point, °C. (approx.)	435
Melting point, °C. (approx.)	1450

PROPERTIES

Table 1 — THERMAL EXPANSION (Average)

(After annealing in H_2 for 1 hr. at 900°C. or for 15 minutes at 1100°C.)

Temperature Range °C.	Thermal Expansion in./in./°C. (1 x 10^{-6})
30-200	4.33-5.30
30-300	4.41-5.17
30-400	4.54-5.08
30-450	5.03-5.37
30-500	5.71-6.21
30-600	7.89
30-700	9.31
30-800	10.39
30-900	11.47

Table 2 — MECHANICAL PROPERTIES

(0.030" thick sheet, tested parallel to the direction of rolling).

Tensile strength, psi	89700
Yield point, psi	50500
Proportional limit, psi	32300
Brinell hardness	200-250

Table 3 — MAGNETIC PERMEABILITY

Magnetic Permeability	Flex. Density (Gauss)
1000	500
2000	2000
3700	7000 (max. value)
2280	12000
213	17000

Heat Treatment:

Annealing may be done in temperatures from 1290-2000 deg. F. It is nearly softened when annealed at 1470 deg. F. for 30 minutes after considerably cold reduction. The time interval required varies with the size and shape of the charge, and annealing under 1650 deg. F. may be done in air if surface scale is removed by sand-blasting or pickling after annealing. Hydrogen annealing is preferable, however, to avoid oxidation.

Machinability:

Machines readily at slow speeds with standard high speed cutting tools. For fine finish work, the cut should be lubricated with lard oil. Single point turning tools of high speed steel should be ground to 6-8 deg. side rake, 8-12 deg. back rake, 5-8 deg. side clearance, 7-10 deg. front clearance, 10-15 deg. cutting-edge angle, and 10-15 deg. lead angle. Circular and straight cutoff blades have about 7-10 deg. back rake and 5-8 deg. side rake. Cutting tools should have a sharp smooth and keen cutting edge. Stone the cutting edge after normal grinding.

Workability:

Readily hot or cold worked. Work-hardens very rapidly on cold working. Therlo deep draws readily and in this respect is slightly better than mild steel. The recommended rule for deep drawing Therlo is 40% maximum reduction on the first draw, 25% maximum reduction on the first redraw (30% after reanneal), and 20% maximum reduction on the second and subsequent redraws (25% after reanneal). Spinning is not recommended since there is danger of fracturing the metal.

Weldability:

Readily soft-soldered, brazed or welded. Soft soldered with 60-40 lead-tin solder. Copper brazed to soft steel at 2000 deg. F. in a suitable atmosphere of hydrogen, and also to other non-ferrous metals. Excellent joints are made by atomic hydrogen welding Therlo to soft

Fe-6

PROPERTIES

Table 1 — MECHANICAL PROPERTIES

	Sheet (0.030")		Bar
	Typical	Annealed	Annealed
Tensile strength, psi	89700	75000	80000
Yield strength, psi	50500	—	—
Proportional limit, psi	32200	—	—
Elongation, % in 2"	—	25	30
Brinell hardness	200-250	140-160	156

(Tested parallel to the direction of rolling)

Table 2 — MAGNETIC PROPERTIES — LOSSES IN WATTS PER POUND

Thickness, in.	10 Kilogausses 60 cycles/sec	10 Kilogausses 840 cycles/sec	2 Kilogausses 5000 cycles/sec.	2 Kilogausses 10,000 cycles/sec.
0.010	1.05	23.4	16.6	41.0
0.030	1.51	—	—	—
0.050	2.77	—	—	—

Table 3 — MAGNETIC PROPERTIES

Magnetic Permeability	Flux Density (gausses)
1000	500
2000	2000
3700	7000 (max. value)
2280	12000
213	17000

Heat Treatment:

Annealing may be done in temperatures from 700-1100 deg. C. It is nearly softened when annealed at 800 deg. C. for 30 minutes after considerable cold reduction. The time interval required varies with the size and shape of the charge, and annealing under 900 deg. C. may be done in air if surface scale is removed by sand-blasting or pickling after annealing. Hydrogen annealing is preferable, however, to avoid oxidation.

Machinability:

Machines readily at slow speeds with standard high speed cutting tools. For fine finish work, the cut should be lubricated with lard oil. Single point turning tools of high speed steel should be ground to 6-8 deg. side rake, 8-12 deg. back rake, 5-8 deg. side clearance, 7-10 deg. front clearance, 10-15 deg. cutting-edge angle, and 10-15 deg. lead angle. Circular and straight cutoff blades have about 7-10 deg. back rake and 5-8 deg. side rake. Cutting tools should have a sharp, smooth and keen cutting edge. Stone the cutting edge after normal grinding.

Workability:

Readily hot or cold worked. Work-hardens very rapidly on cold working. Rodar deep draws readily and in this respect is slightly better than mild steel. The recommended rule for deep drawing Rodar is 40% maximum reduction on the first draw, 25% maximum reduction on the first redraw (30% after reanneal), and 20% maximum reduction on the second and subsequent redraws (25% after reanneal). Spinning of Rodar is not recommended since there is danger of fracturing the metal.

Weldability:

Readily soft-soldered, brazed or welded. Soft soldered with 60-40 lead-tin solder. Copper brazed to soft steel at 1100 deg. C. in a suitable atmosphere of hydrogen, and also to other non-ferrous metals. Excellent joints are made by atomic hydrogen welding Rodar to soft steel. Electric arc and resistance welding are equally satisfactory. Arc welding should be done with a flux-coated electrode of either 18-8 or 25-12 chrome-nickel content.

Pickling:

To remove the oxide on Rodar from the sealing operation before soldering or brazing, pickle electrolytically in a 5-10% sulphuric acid containing 1% quinoline or 1% Rodine No. 110 as an inhibitor. The piece to be cleaned is used as one electrode with carbon or another part serving as the other electrode. The current should be 10-12 volts a-c, with approximately 10 amperes per square inch of surface to be cleaned. Normal acid pickling with a hydrochloric-nitric solution (10% by weight of each acid) for 2-5 minutes immersion at 160 deg. F. is sufficient to loosen the oxide and scale, which can then be wiped off with a cloth.

General Characteristics:

Rodar has high resistance to amalgamation with mercury and withstands high thermal shock. The remarkable physical properties of this alloy make it ideal for any application demanding a vacuum-tight, metal-to-glass joint to conduct power into a glass vessel or to insulate electrodes from metal-walled vessels. The thermal expansion of Rodar is similar to that of hard clear glass from room temperature up to annealing temperature of glass. Similar to KOVAR "A".

Forms Available:

Bars, rods, wire, and strip.

Applications:

Small rectifiers, grid-blow tubes, ignitrons, metal-glass seals, vacuum tight metal-to-glass seals.

Manufacturer:

Wilbur B. Driver Company
Newark 4, New Jersey

Alloy DIGEST

Filing Code: Fe-6
Iron Alloy

MARCH, 1955

DATA ON WORLD WIDE METALS AND ALLOYS

Published by
Engineering Alloys Digest, Inc.
Upper Montclair, New Jersey

RODAR

RODAR*

(A Metal-to-Glass Sealing Alloy)

RODAR is a cobalt, nickel, iron alloy recommended for sealing into hard glass. Has similar expansion curve as glass, makes firm bond between metal and glass, is easy to machine and form, and has high resistance to thermal shock.

*Registered Trade-Name (555,349)

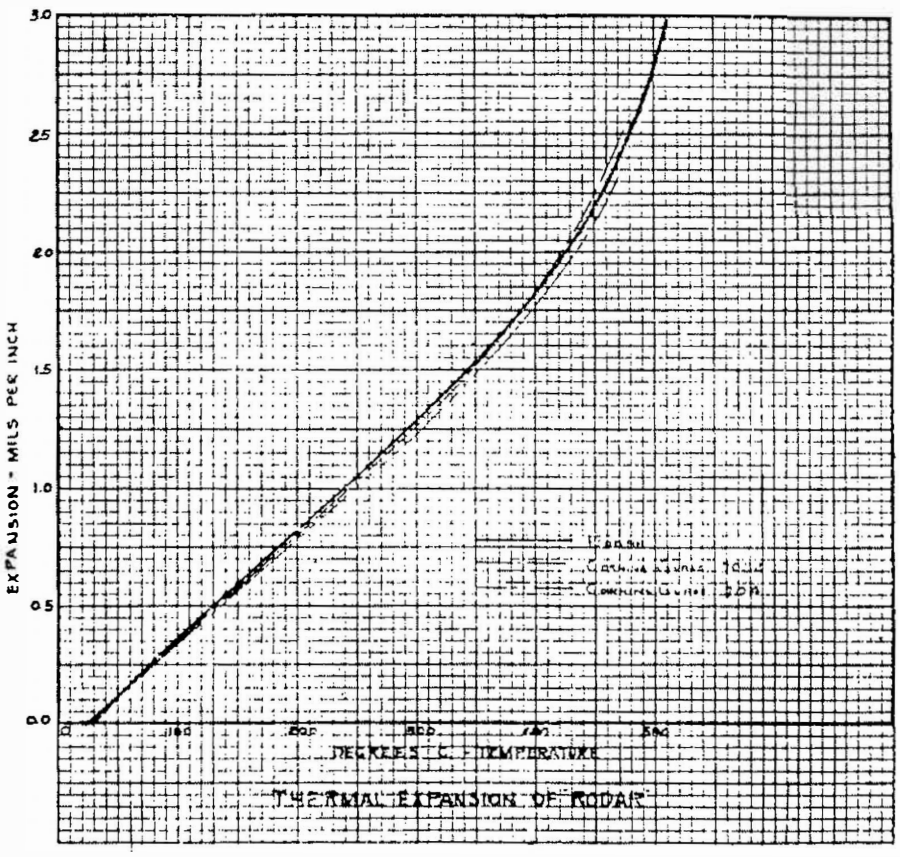
Composition:

	Nominal	Range
Nickel	29	28.70-29.20
Cobalt	17	17.30-17.80
Manganese	0.3	0.50 max
Silicon	—	0.20 max
Carbon	—	0.05 max
Iron	balance	balance

Physical Constants:

Density, lb/cu in.	0.302
Melting point, deg. C (approx.)	1450
Electrical resistance, microhm-cm,	49
ohms/cir mil ft.	294
Thermal conductivity, cal/cm/sec/deg C	0.046
Modulus of elasticity, psi	20,000,000
Curie point deg. C (approx.)	435
Mean thermal expansion (annealed) in in/deg C	
30-200 deg. C	4.33-5.30 x 10^{-6}
30-300 deg. C	4.41-5.17 x 10^{-6}
30-400 deg. C	4.54-5.08 x 10^{-6}
30-450 deg. C	5.03-5.37 x 10^{-6}
30-500 deg. C	5.71-6.21 x 10^{-6}

NOTE: As determined from cooling curves after annealing in hydrogen for one hour at 900°C and for 15 minutes at 1100°C.



THERMAL EXPANSION OF RODAR

Fe-3

Heat Treatment:

Annealing may be done in temperatures from 700-1100 deg. C. It is nearly softened when annealed at 800 deg. C for 30 minutes after considerable cold reduction. The time interval required varies with the size and shape of the charge, and annealing under 900 deg. C may be done in air if surface scale is removed by sand-blasting or pickling after annealing. Hydrogen annealing is preferable, however, to avoid oxidation.

Machinability:

Machines readily at slow speeds with standard high speed cutting tools. For fine finish work, the cut should be lubricated with lard oil. Single point turning tools of high speed steel should be ground to 6-8 deg. side rake, 8-12 deg. back rake, 5-8 deg. side clearance, 7-10 deg. front clearance, 10-15 deg. cutting-edge angle, and 10-15 deg. lead angle. Circular and straight cutoff blades have about 7-10 deg. back rake and 5-8 deg. side rake. Cutting tools should have a sharp, smooth and keen cutting edge. Stone the cutting edge after normal grinding.

Workability:

Readily hot or cold worked. Work-hardens very rapidly on cold working. Kovar deep draws readily and in this respect is slightly better than mild steel. The recommended rule for deep drawing Kovar is 40% maximum reduction on the first draw, 25% maximum reduction on the first redraw (30% after reanneal), and 20% maximum reduction on the second and subsequent redraws (25% after reanneal). Spinning of Kovar is not recommended since there is danger of fracturing the metal.

Weldability:

Readily soft-soldered, brazed or welded. Soft soldered with 60-40 lead-tin solder. Copper brazed to soft steel at 1100 deg. C in a suitable atmosphere of hydrogen, and also to other non-ferrous metals. Excellent joints are made by atomic hydrogen welding Kovar "A" to soft steel. Electric arc and resistance welding are equally satisfactory. Arc welding should be done with a flux-coated electrode of either 18-8 or 25-12 chrome-nickel content.

Pickling:

To remove the oxide on Kovar "A" from the sealing operation before soldering or brazing, pickle electrolytically in a 5-10% sulphuric acid containing 1% quinoline or 1% Rodine No. 110 as an inhibitor. The piece to be cleaned is used as one electrode with carbon or another part serving as the other electrode. The current should be 10-12 volts a-c, with approximately 10 amperes per square inch of surface to be cleaned. Normal acid pickling with a hydrochloric-nitric solution (10% by weight of each acid) for 2-5 minutes immersion at 160 deg. F is sufficient to loosen the oxide and scale, which can then be wiped off with a cloth.

General Characteristics:

Kovar "A" has high resistance to amalgamation with mercury and withstands high thermal shock. The remarkable physical properties of this alloy make it ideal for any application demanding a vacuum-tight, metal-to-glass joint to conduct power into a glass vessel or to insulate electrodes from metal-walled vessels. The thermal expansion of Kovar "A" is similar to that of hard clear glass from room temperature up to annealing temperature of glass.

Forms Available: AMS 7727/28 ; ASTM F-15 MIL ~ 23011

Sheet, wire, rod, tubing, and cup and eyelet formed parts.

Applications:

Small rectifiers, grid-glow tubes, ignitrons, metal-glass seals, vacuum tight metal-to-glass seals.

Manufacturer:

Westinghouse Electric Corporation

Pittsburgh, Pennsylvania

Stupakoff Ceramic & Manufacturing Co.

Latrobe, Pennsylvania

Alloy DIGEST — DATA ON WORLD WIDE METALS AND ALLOYS

Filing Code: Fe-3
Iron Alloy

OCTOBER 1953

Published by
Engineering Alloys Digest, Inc.
Upper Montclair, New Jersey

KOVAR "A"

also: Nicoseal (Carpenter)

KOVAR "A"

(A Metal-to-Glass Sealing Alloy)

KOVAR "A" is a cobalt, nickel, iron alloy recommended for sealing into hard glass. Has similar expansion curve as glass, makes firm bond between metal and glass, is easy to machine and form, and has high resistance to thermal shock.

Composition:	Nominal	Range
Nickel	29	28.70-29.20
Cobalt	17	17.30-17.80
Manganese	0.3	0.50 max.
Silicon	—	0.20 max.
Carbon	—	0.06 max.
Iron	balance	52.90-53.40

Physical Constants:

Density, lb./cu.in.	0.302
Melting point, Deg. C (approx.)	1450
Electrical resistance, microhm cm.	49
ohms/cir mil ft.	294
Thermal conductivity, cal./cm./sec./deg. C	0.0395
Modulus of elasticity, psi	20,000,000
Curie point deg. C (approx.)	435
Coef. thermal expansion (annealed) in/in/deg. C	
30-200 deg. C	4.33-5.30 x 10^{-6} = 2.40-2.94
30-500 deg. C	5.71-6.21 x 10^{-6} = 3.17-3.45

PROPERTIES

Mechanical Properties (0.030" sheet)

	Typical	Annealed
Tensile strength, psi	89700	75000
Yield strength, psi	50500	—
Proportional limit, psi	32200	—
Elongation, % in 2"	—	25
Brinell hardness	200-250	140-160

(Tested parallel to the direction of rolling)

MAGNETIC PROPERTIES—LOSSES IN WATTS PER POUND

Thickness, in.	10 Kilogausses 60 cycles/sec.	10 Kilogausses 840 cycles/sec.	2 Kilogausses 5000 cycles/sec.	2 Kilogausses 10,000 cycles/sec.
0.010	1.05	23.4	16.6	41.0
0.030	1.51	—	—	—
0.050	2.77	—	—	—

MAGNETIC PROPERTIES

Magnetic Permeability	Flux Density (gausses)
1000	500
2000	2000
3700	7000 (max. value)
2280	12000
213	17000

Alloy DIGEST

UNISEAL 29-17

Filing Code: Fe–45
Iron Alloy

NOVEMBER 1970

DATA ON WORLD WIDE METALS AND ALLOYS

Published by
Engineering Alloys Digest, Inc.
Upper Montclair, New Jersey

UNISEAL* 29 - 17

(Glass-to-metal sealing alloy)

UNISEAL 29-17 is a controlled expansion iron-base alloy containing nickel and cobalt. It is widely used for glass-to-metal seals with borosilicate glasses commonly employed in electronic power tube envelopes.

*Registered trademark

Composition:

Carbon	0.02 max.
Manganese	0.30 max.
Silicon	0.10 max.
Nickel	29.00 nom.
Cobalt	17.00 nom.
Iron	53.50 nom.

Physical Constants:

Density, lb/cu in.	0.302
Melting point, °F (approx.)	2650
Thermal conductivity, cal/sq cm/cm/sec/°C	0.04
Electrical resistivity, microhm-cm	49
Curie temperature, °F (approx.)	815
Modulus of elasticity, psi (tension)	20×10^6
For thermal expansion see Table 1	

PROPERTIES

Table 1 – MEAN COEFFICIENT OF LINEAR THERMAL EXPANSION
(Reduce ranges to meet all specifications)

Temperature Range °F	Thermal Expansion per °F	Temperature Range °C	Thermal Expansion per °C
86– 392	$2.41–2.94 \times 10^{-6}$	30-200	$4.33–5.30 \times 10^{-6}$
86– 572	$2.45–2.87 \times 10^{-6}$	30–300	$4.41–5.17 \times 10^{-6}$
86– 752	$2.52–2.82 \times 10^{-6}$	30–400	$4.54–5.08 \times 10^{-6}$
86– 842	$2.79–2.98 \times 10^{-6}$	30–450	$5.03–5.37 \times 10^{-6}$
86– 932	$3.17–3.45 \times 10^{-6}$	30–500	$5.71–6.21 \times 10^{-6}$
86–1112	4.38×10^{-6}	30–600	7.89×10^{-6}
86–1292	5.18×10^{-6}	30–700	9.31×10^{-6}
86–1472	5.77×10^{-6}	30-800	10.39×10^{-6}
86–1652	6.36×10^{-6}	30–900	11.47×10^{-6}

*Determined from cooling curves after annealing in hydrogen for one (1) hour at 900°C and 15 minutes at 1100°C. Material heat treated in this manner is not to show any transformation when cooled to –80°C for four (4) hours. This can be checked by metallographic examination or thermal expansion curves.

Table 2 – TYPICAL MECHANICAL PROPERTIES
(Annealed condition)

Tensile strength, psi	75000
Yield strength (0.2% offset), psi	50000
Elongation (2 in.), %	30
Reduction of area, %	65
Rockwell B Hardness	76

Flux Density	Treatment 1830°F (999°C) 30 min – FC Permeability	Treatment 2010°F (1099°C) 20 min – FC Permeability
500	1000	1900
1000	1400	3500
2000	2000	5800
5000	2300	10000
10000	3400	8200
12000	3000	5000

PREPARATION FOR SEALING:

It is recommended all degreased, fabricated Vacumet Nicoseal parts be degassed and annealed in a hydrogen atmosphere.

.tmosphere is to be made moist by bubbling the hydrogen ırough water at room temperature. Care must be taken to prevent surface carbon pickup. Furnace should have a cooling chamber provided with the same atmosphere.

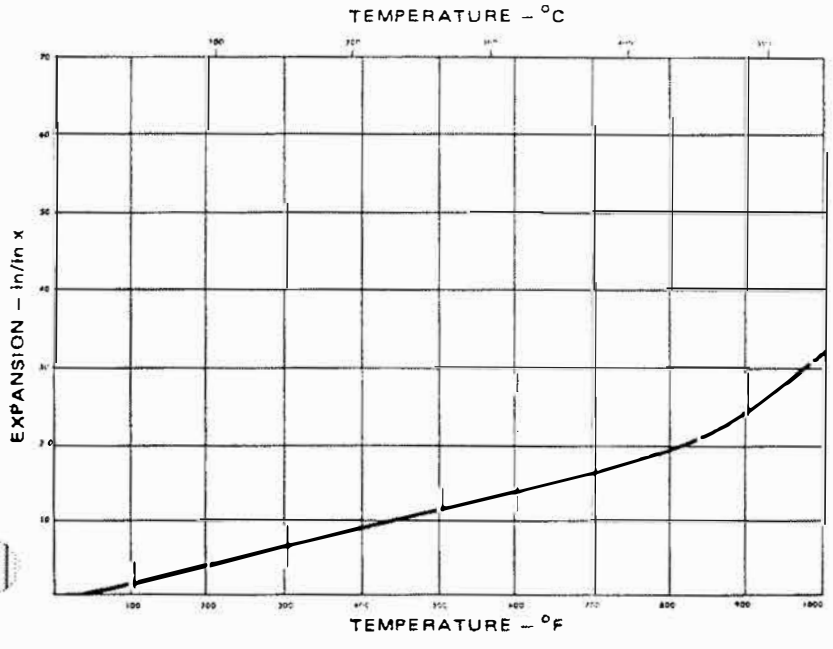
Heat treatment should be conducted within the temperature range of 1540/2010°F (838/1099°C). Time at temperature should be approximately two hours for lowest value to 20 minutes for the highest temperature. Parts are then to be transferred to the cooling zone until below 570°F (299°C) before removal.

An oxide film on the metallic part is recommended 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 (649/699°C) in regular ambient atmosphere at a time sufficient to form a dark gray to slight ·own oxide.

ORMS AVAILABLE:

.trip, cold rolled, annealed for forming or annealed for deep drawing. Photo-Etch quality available.
Wire, cold drawn or annealed
Bars, hot rolled, cold drawn and centerless ground
Billets for forging

Expansion Curve of Vacumet Nicoseal



CARTECH
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TECHNICAL DATA

CARPENTER VACUMET NICOSEAL

Glass and Ceramic Sealing Alloy

Type analysis:

Carbon	0.02% max.
Manganese	0.30%
Silicon	0.20%
Nickel	29.00%
Cobalt	17.00%
Iron	Balance

DESCRIPTION:

Carpenter Vacumet Nicoseal® is a vacuum-melted low-expansion alloy used for making hermetic seals with the harder Pyrex glasses and ceramic materials. It is an iron-nickel-cobalt alloy whose chemical composition is controlled within narrow limits to assure precise uniform thermal expansion properties. Vacumet Nicoseal is processed from ingot to finished size under the strictest quality control to provide uniform physical and mechanical properties and easier deep drawing, stamping and machining.

Vacumet Nicoseal is manufactured to meet requirements of ASTM Specification F 15-61T.

PHYSICAL CONSTANTS:

Specific gravity	8.36
Density – lb/in^3	0.302
Electrical resistivity	
ohm-cir mil/ft	294
microhm-cm	49
Thermal conductivity	
BTU/in/ft^2/hr/°F	120
kcal/m/hr/°C	14.9
Curie temperature	815°F (435°C)
Melting point	2640°F (1449°C)

THERMAL EXPANSION PROPERTIES:

The following are the average coefficient of expansion properties after annealing in hydrogen for one hour at 1650°F (899°C) and 15 minutes at 2010°F (1099°C) and cooled to room temperature within one hour. Sample heat treated in the above manner is not to show any transformation when cooled to -112°F (-80°C) for 4 hours. This is determined by means of metallographic examination.

Temperature		Coefficient	
77°F to	25°C to	in/in/°F x 10^{-6}	cm/cm/°C x 10^{-6}
212	100	3.25	5.86
392	200	2.89	5.20
572	300	2.85	5.13
662	350	2.72	4.89
752	400	2.81	5.06
842	450	2.92	5.25
932	500	3.41	6.15
1112	600	4.34	7.80
1292	700	5.06	9.12
1472	800	5.73	10.31
1652	900	6.25	11.26

MECHANICAL PROPERTIES:

Strip tested parallel to the direction of rolling

(Treatment – annealed 1830°F (999°C) – 30 min FC)

Yield point	
ksi	50
kg/mm^2	35
Tensile strength	
ksi	75
kg/mm^2	53
Elongation, %	30
Hardness, Rockwell B	68
Modulus of elasticity	
psi x 10^6	20
kg/cm^2 x 10^6	1.41

MAGNETIC PROPERTIES:

Vacumet Nicoseal will be magnetic at all temperatures below the Curie point. Magnetic properties will depend upon heat treatment; the lower the hardness, the higher the permeability values and lower hysteresis loss. Examples of permeability properties are:

For additional information and price of this alloy, please contact your nearest Carpenter Service Center.

Fe-16 Nilo-K

Heat Treatment:

a) If it is necessary to carry out an inter-stage anneal when producing components from Nilo 'K', then a heat treatment of 900°C. for one hour will be adequate. It is preferable that this annealing be done in dry hydrogen but if this is not available a neutral atmosphere may be used.

b) It is necessary for the material to be annealed and degassed before making a glass-to-metal seal. Heating up to at least 950°C. for about one hour in an atmosphere of wet hydrogen will serve both functions.

Machinability:

Machines readily at slow speeds with standard high speed cutting tools. For fine finish work, the cut should be lubricated with lard oil. Single point turning tools of high speed steel should be ground to 6-8 deg. side rake, 8-12 deg. back rake, 5-8 deg. side clearance, 7-10 deg. front clearance, 10-15 deg. cutting-edge angle, and 10-15 deg. lead angle. Circular and straight cutoff blades have about 7-10 deg. back and 5-8 deg. side rake. Cutting tools should have a sharp, smooth and keen cutting edge. Stone the cutting edge after normal grinding.

Workability:

Readily hot or cold worked. Work-hardens very rapidly on cold working. Nilo-K deep draws readily and in this respect is slightly better than mild steel. The recommended rule for deep drawing is 40% maximum reduction on the first draw, 25% maximum reduction on the first redraw (30% after reanneal), and 20% maximum reduction on the second and subsequent redraws (25% after reanneal). Spinning is practicable, but not easy and frequent anneals are necessary.

Weldability:

Readily soft-soldered, brazed or welded. Soft soldered with 60-40 lead-tin solder. Copper brazed to soft steel at 2000 deg. F. in a suitable atmosphere of hydrogen, and also to other non-ferrous metals. Excellent joints are made by atomic hydrogen welding Nilo-K to soft steel. Electric arc and resistance welding are equally satisfactory. Arc welding should be done with a flux-coated electrode of either 18-8 or 25-12 chrome-nickel content.

Pickling:

To remove the oxide from the sealing operation before soldering or brazing, pickle electrolytically in a 5-10% sulphuric acid containing 1% quinoline or 1% Rodine No. 110 as an inhibitor. The piece to be cleaned is used as one electrode with carbon or another part serving as the other electrode. The current should be 10-12 volts a-c, with approximately 10 amperes per square inch of surface to be cleaned. Normal acid pickling with a hydrochloric-nitric solution (10% by weight of each acid) for 2-5 minutes immersion at 160 deg. F. is sufficient to loosen the oxide and scale, which can then be wiped off with a cloth.

General Characteristics:

Nilo K matches very closely the expansion characteristics of medium hard glasses of borosilicate type, used for envelopes of special high power valves, such as transmitters and rectifiers, and for glass-to-metal seals on X-ray tubes and numerous electronic components. The mean coefficient expansion is approximately 5-6 millionths per °C. from 30-500°C. and the inflection point 450°C.

It has high resistance to amalgamation with mercury and withstands high thermal shock. The remarkable physical properties of this alloy make it ideal for any application demanding a vacuum-tight, metal-to-glass joint to conduct power into a glass vessel or to insulate electrodes from metal-walled vessels.

Forms Available:

Sheet, wire, rod, tubing.

Applications:

Small rectifiers, grid-glow tubes, ignitrons, metal-glass seals, vacuum tight metal-to-glass seals.

Manufacturer:

Henry Wiggin & Company Ltd.
Birmingham, England

Alloy DIGEST

Filing Code: Fe-16
Iron Alloy

AUGUST 1959

DATA ON WORLD WIDE METALS AND ALLOYS

Published by
Engineering Alloys Digest, Inc.
Upper Montclair, New Jersey

NILO-K

(AKA Kovar Radian etc)

NILO K

(Controlled Expansion Alloy)

NILO K has been developed specifically for the production of matched glass-to-metal seals when using hard, borosilicate glass.

Composition:

Nickel	29
Cobalt	17
Iron	Remainder

Physical Constants: (at 20°C.)

Specific gravity	8.20
Density, lb./cu. in.	0.296
Melting point, °F.	2640
Specific electrical resistance	
microhms/cm/cm²	44-50
ohms/cir. mil. ft.	265-301
Thermal conductivity, cal/cm²/cm/sec/°C.	0.046
Inflection point, °C. (approx.)	440

PROPERTIES

Table 1 -- TOTAL EXPANSION

Temperature, °C	Parts per thousand
25 - 50	0.20
25 - 100	0.41
25 - 150	0.67
25 - 200	0.93
25 - 250	1.15
25 - 300	1.38
25 - 400	1.84
25 - 500	2.95

Table 2 — MEAN LINEAR COEFFICIENT OF THERMAL EXPANSION OF ANNEALED MATERIAL

Temperature Range °C.	Coef./°C.
25 - 100	0.0000054
25 - 200	0.0000053
25 - 300	0.0000050
25 - 400	0.0000049
25 - 500	0.0000061

Table 3 — MECHANICAL PROPERTIES — (0.030" SHEET)

	Hard	Annealed
Tensile strength, psi	89700	75000
Yield strength, psi	50500	—
Proportional limit, psi	32200	—
Elongation, % in 2"	—	25
Brinell hardness	200 - 250	140 - 160

(Tested parallel to the direction of rolling)

this fact can be used to follow the transformation by electrical measurements.

Seal Fabrication. "Kovar" parts are available in a wide range of standard sizes from commercial suppliers so that machining operations are generally confined to cutting the part off to the length required. Spinning is not recommended as there is danger of fracturing the metal. Prior to seal-making, the machined parts must be carefully polished in the area where the seal is to be made, and edges should be free from burrs. The polishing treatment aims at the elimination of tool marks that could cause leaka the seal are After degre part must h firing in w about 30 m tion should few hours. duced on perature n atmospher oxidized s applicatio the techni "Kovar" h Data Bul Company. Pennsylva name Stup ing Comp distributo by the We More rece "Kovar" available t turers of 14.3. "Ko

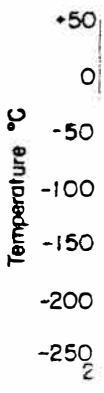


FIG. 14.32. temperature i After Herrma derer Verlag G

TABLE 14.10. Physical Characteristics of "Kovar"-type Alloys*

Nominal composition (Wt. percent):	Ni:29; Co:17; Fe:Bal.
Minor constituents (Max. Wt. percent):	Mn:0.50; Si:0.20; C:0.06; Al:0.10; Mg:0.10; Zr:0.10; Ti:0.10. (Al + Mg + Zr + Ti): 0.20
Density (g/cc):	8.36 8.20 (Nilo K)
(lb/cub.in.):	0.302 0.296 (Nilo K)
Annealed temper (Rockwell hardness):	B 82 (max.)
Cold-worked temper (Rockwell hardness):	B 100 (max.)
Approx. melting point (°C):	1450 (2640°F)
Heat of fusion (cal/g):	64
Vapor pressure (torr):	10^{-5} (1000°C)
Ar_3 point ($\gamma - \alpha$ phase transformation) (°C):	< −80; (see Fig. 14.32)
Thermal conductivity (cal/cm²/cm/sec/°C):	0.0395 (30°C); 0.0485 (300°C); 0.0585 (500°C)
Specific heat (cal/g/°C):	0.105 (0°C); 0.155 (300°C)
Curie point (°C):	435
Thermal expansion coeff. (cm/cm/°C × 10^{-7}):	46.0–52.0 (30–400°C)
(after annealing in hydrogen at 900°C for 1 hr. or at 1100°C for 15 min.) (see Fig. 14.4)	51.0–55.0 (30–450°C)

30–200	30–300	30–400	30–500	30–600	30–700	30–800	30–900	°C
55	51	49	62	79	93	104	115	

Electrical resistivity (Ohm-cm × 10^{-6}):

25	100	200	400	600	°C
49	62.7	80.4	107.3	116.6	

Magnetic Properties:

Flux density (Gauss):	500	2000	7000	12,000	17,000
Permeability (B/H):	1000	2000	3700	2280	213

Mechanical Properties: (Data obtained at a strain rate of 800 %/hr.)

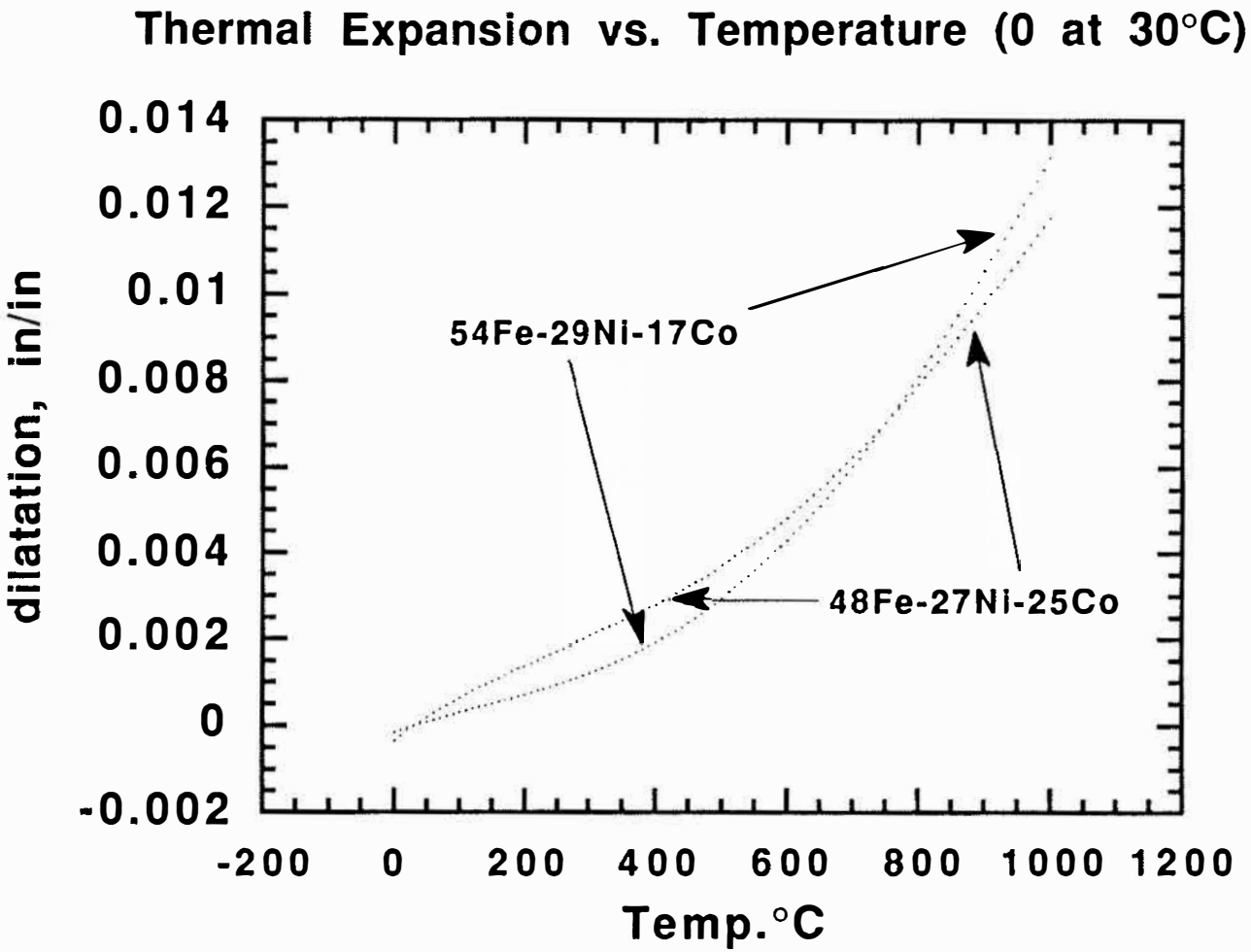
Temperature of test (°C)	Yield strength (0.5%) (psi × 10^3)	Ultimate strength (psi × 10^3)	Uniform elongation (%)	Total elongation (%)	Reduction of area (%)
21	59.5	77.5	16.78	35.4	69.0
213	39.0	58.5	18.59	32.08	73.2
308	32.5	54.5	22.12	34.79	65.2
400	30.0	50.0	20.90	36.33	74.0
500	26.5	42.0	21.69	33.96	71.0
600	23.5	36.0	19.45	28.40	35.0
738	21.5	25.0	6.87	18.23	25.0
790	17.1	19.0	5.21	14.65	21.6

*"Kovar" is a registered trademark of Westinghouse Electric Corporation; the alloy is fabricated and distributed by the Materials Manufacturing Division, Metals Plant, Blairsville, Pa. 15717. Most of the data presented are taken from their Technical Data Bulletin 52-460 (Mar. 8, 1965).

Other Tradenames and Suppliers:

"Therlo"	Driver Harris Company, Harrison, N.J.
"Rodar"	Wilbur B. Driver Company, Newark, N.J.
"Nicoseal"	The Carpenter Steel Company, Reading, Pa.
"Sealvac-A"	Vacuum Metals Corporation, Syracuse, N.Y.
"Nilo-K"	Henry Wiggin & Company Limited, Birmingham, England
"Dilver P"	Aciéries d'Imphy, Imphy (Nièvre), France
"Vacon"	Vakuumschmelze A.G., Hanau/Main, Germany

*Notis[12] that the de alloys shoul 1100°C for 1 for 30 min. sistently.



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