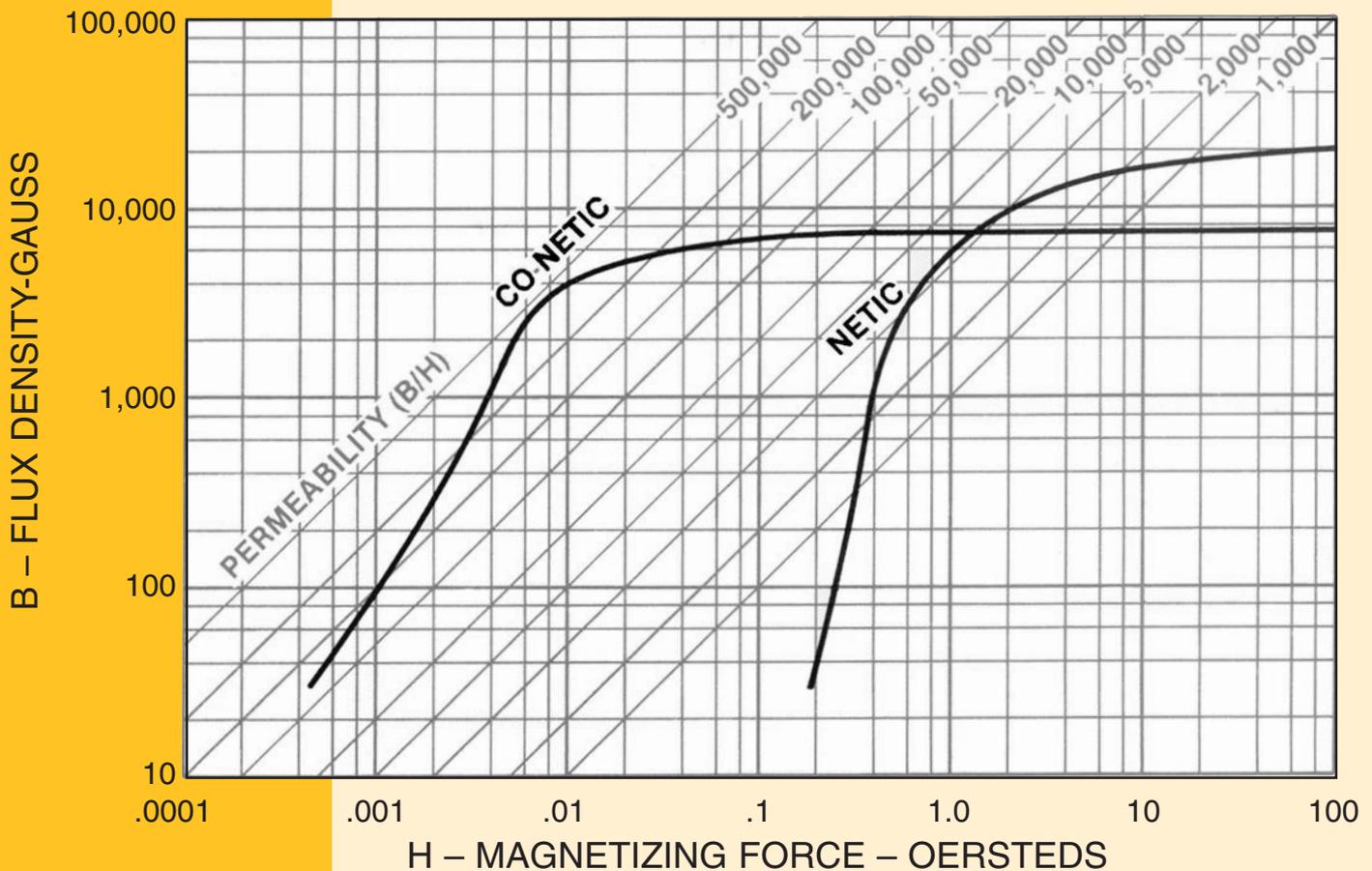


MAGNETIC SHIELD CORPORATION

CO-NETIC[®] & *NETIC*[®]

MAGNETIC SHIELDING ALLOYS

D.C. PERMEABILITY – CO-NETIC AA & NETIC S3-6



**MAGNETIC SHIELD
CORPORATION**
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Magnetic Shielding

*APPLICATION AND
MATERIAL GUIDE*

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MAGNETIC INTERFERENCE PROBLEMS AND SOLUTIONS

Magnetic interference can cause major problems in the design and operation of electrical and electronic equipment. Instruments, control systems, data processing equipment and communications networks frequently show aberrations whose sources may not be readily recognized, but which are due to magnetic interference created by components within the system or by adjacent sources such as transformers, switching equipment or power transmission lines.

Properly designed magnetic shielding diverts the magnetic field, economically providing essential protection for sensitive installations.

MAGNETIC SHIELD CORPORATION: SPECIALISTS IN MAGNETIC INTERFERENCE ELIMINATION

For over fifty years Magnetic Shield Corporation has specialized in solving problems of magnetic interference, becoming the recognized leader in this field. Our engineers concentrate on problems relating to magnetism. We provide professional consultation on problems of magnetic interference without cost or obligation, and are usually able to solve such problems promptly and economically. Frequently our facilities and experience provide "ready-made" solutions, saving time and money for companies whose technical personnel have broader responsibilities.

Our NETIC® and CO-NETIC® alloys, presented in this guide, are proprietary materials which have been useful in many demanding applications. Many users explore the effects of magnetic shielding through use of our Magnetic Shielding Lab Kit, quickly prototyping solutions to magnetic interference problems. (See brochure LK-3.)

We offer a variety of services, including custom fabrication of parts to customers' specifications or drawings – as well as materials and products ranging from laboratory instruments to magnetically shielded rooms. Descriptive literature is listed on the back cover of this guide.

COVER: B-H permeability characteristic curve for CO-NETIC AA and NETIC S3-6 alloys. Example: At a flux density (induction) of 600 Gauss in CO-NETIC AA, B/H (or μ) is approximately 200,000.

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CATALOG: MG-7B

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SHIELD MATERIAL SELECTION GUIDE

NETIC or CO-NETIC?

CO-NETIC and NETIC are proprietary alloys, developed by Magnetic Shield Corporation specifically to provide effective magnetic shielding. Both are available in either foil or sheet form in a convenient range of thicknesses. The permeability graph on the cover of this brochure illustrates the unique properties of each material.

In fields of low intensity, CO-NETIC AA is used in order to utilize its high initial permeability and corresponding high attenuation characteristics. In fields of high intensity, NETIC S3-6 is preferred because of its high magnetic saturation characteristics. In some applications, combinations of the two materials may be useful, with NETIC material always placed closer to the source of magnetic interference.

FOIL or SHEET?

Foils, supplied in thicknesses ranging from .002 to .010 inches (0.051 to 0.254 mm) provide effective shielding with minimum fabrication, avoiding expensive tooling and extended deliveries. Thus foil becomes the preferred material for many production, prototype and laboratory evaluation projects. Typical applications include shielding field-sensitive components, printed circuit boards, instruments, signal leads and power cables.

Sheet materials, supplied in thicknesses ranging from .014 to .062 inches (0.356 to 1.58 mm) provide additional shielding. Typical uses include applications which require production tooling. Our exclusive Perfection Annealed sheet is ready for use as a magnetic shield without further annealing (see page 5).

Physical and Magnetic Data on Shielding Alloys

	CO-NETIC AA PERFECTION ANNEALED	CO-NETIC AA STRESS ANNEALED*	CO-NETIC B STRESS ANNEALED*	NETIC S3-6 STRESS ANNEALED*
Specific Gravity	8.74	8.74	8.18	7.86
Coefficient of Expansion, per °C x 10 ⁻⁶	12.6	12.6	8.3	13.7
Tensile Strength, PSI x 10 ³	64	85	80	42
Yield Strength, PSI x 10 ³	18.5	33	27	27
Modulus of Elasticity, PSI x 10 ⁶	25	30	24	30
Hardness, Rockwell B	50 Ref.	70 Ref.	68 Ref.	50 Ref.
Elongation in 2 inches	27%	32%	32%	38%
Melting Point	2650°F 1454°C	2650°F 1454°C	2600°F 1427°C	2790°F 1532°C
Thermal Conductivity (cal/sec/cm ² /cm/°c) at 20°	.138	.138	.037	.118
Electrical Resistivity Micro-ohm-centimeters	55	55	48	11
Saturation Induction (Gauss)	8,000	After required annealing is done, magnetic properties are same as those for Perfection Annealed sheet.	15,000*	21,400
Initial Permeability	30,000		8,000*	200
Permeability at 40 B	75,000		12,000*	300
Permeability at 200 B	135,000		30,000*	500
Maximum Permeability	450,000		150,000*	4,000
Induction at μ max.	3,000		7,000*	8,000
Coercive Force Hc, Oersteds	.015		.05	1.0
Curie Temp.	850°F 454°C	850°F 454°C	840°F 449°C	1420°F 770°C
Minimum Operating Temp.	4°K	4°K	4°K	4°K

Note: Magnetic data is for sheet material measured in a D.C. field.

*Stress annealed material must be annealed after fabrication for optimum magnetic shielding properties.

FABRICATION & FINISHING

CO-NETIC & NETIC

Blanking & Stamping

Stress annealed CO-NETIC and NETIC lend themselves to conventional stamping operations. Normal procedures are used, except that die clearance must be held to a minimum in processing CO-NETIC. Normal die clearances are utilized in stamping NETIC.

Forming

CO-NETIC and NETIC are easily formed, using either conventional or urethane tooling. Because of the stress annealed condition, springback is at a minimum.

Drawing and Spinning

Stress annealed CO-NETIC and NETIC can be spun, drawn or Hydroformed. For complex configurations and close tolerances, Hydroforming has proved highly advantageous. This process offers the further advantage of low tool cost and uniformity of gauge. For long runs, conventional tooling is preferred because of lower piece part costs. Some parts may require intermediate anneal.

NOTE: Both CO-NETIC and NETIC, with respect to stamping and fabricating operations, have counterparts in more conventional materials. CO-NETIC exhibits physical properties which are similar in many respects to those of the 300 series stainless steels. Correspondingly, physical properties of NETIC are similar to those of low carbon cold rolled steel.

Welding

Heliarc welding provides the ideal means for welding seams and joints in the fabrication of magnetic shields. Heliarc welding maintains continuity of the magnetic circuit and ordinarily provides fusion without use of filler rod. If filler material is required, use strips of the parent material.

In many applications, spot welding provides an economical alternative to heliarc welding. To provide continuity of the magnetic circuit, spot welds should be closely spaced.

Annealing/NETIC

For optimum magnetic properties, NETIC material should be annealed at 1550°F. (843°C). Time and temperature considerations are less critical than in the annealing of CO-NETIC.

Low cost reducing type furnace atmospheres are adequate for the annealing of NETIC. If cracked natural or manufactured gas is used, it should be strongly reducing and have a low dew point. With all atmospheres, parts should be cooled sufficiently in the furnace to avoid any oxidation upon removal.

Annealing/CO-NETIC

To obtain optimum magnetic properties of CO-NETIC Stress Annealed material, annealing following fabrication is essential.

A batch furnace permitting careful control of annealing temperature and cooling rate provides optimum magnetic properties. A continuous furnace with careful control of heating and cooling rates is an acceptable alternative.

Furnace atmosphere is critical. Optimum properties are obtained in a pure, dry hydrogen atmosphere. Dissociated ammonia provides good results in continuous furnaces, as does a vacuum atmosphere in batch operations. Optimum magnetic properties of CO-NETIC materials are obtained by annealing at a temperature of 2050°F. (1121°C) for a period of four hours. Cooling is at the rate of 400°F (Approx. 222°C) per hour until a temperature of 1100°F. (600°C) is reached, after which the cooling rate can be accelerated. Parts can be exposed to normal atmosphere at 600°F (315°C).

To avoid excessive distortion of light gauge shields, an annealing temperature of 1950°F (1065°C) will provide acceptable magnetic properties. Correspondingly, magnetic tests may disclose that an accelerated cooling rate can be adopted without adverse effect.

Painting/NETIC

Over extended periods, NETIC material is subject to oxidation. To provide surface protection, the following procedures are recommended:

- (1) Clean parts thoroughly using vapor degreasing, hot alkaline solution, or solvent bath.
- (2) Prepare surface by phosphatizing, where specified.
- (3) Apply zinc chromate primer.
- (4) Apply finish coat of baked enamel, epoxy or other paints as specified.

A light oxide which may appear on NETIC is easily removed by conventional pickling or sandblasting procedures.

Finishing/CO-NETIC

CO-NETIC AA, because of its high nickel content, is highly corrosion resistant. Following annealing in hydrogen atmosphere, the material exhibits a clean and bright surface condition. As a consequence, CO-NETIC is frequently used as annealed, without further finishing operations. If required for cosmetic purposes, CO-NETIC readily accepts conventional surface finishes.

Plating

Cleaning of parts for plating is similar to that used for ferrous materials. Both CO-NETIC and NETIC respond to conventional cleaning methods. With proper surface preparation, CO-NETIC and NETIC provide excellent plated finishes using commercial plating procedures.

MECHANICAL DESIGN AND SPECIFICATION

CO-NETIC & NETIC FABRICATIONS

Temporary tooling is frequently used to fabricate magnetic shields. While reducing costs, this practice requires that print tolerances be no closer than required by design considerations.

Flat Blanks

Shear tolerance of $\pm 0.015''$. Corner details, in order of least cost, are square, chamfered and rounded.

Burrs

Shearing, blanking or perforating burrs are reduced through use of minimum clearance tooling. Standard deburring methods are applicable.

Bend Radius

In short run work, complex shapes are formed on temporary tooling. Relatively sharp corners, with an inside radius of up to twice metal thickness, are preferred. With Perfection Annealed sheet, particularly in the heavier gauges, minimum inside radius of three times material thickness is required to avoid work hardening and fracture.

Angles

Bends of 90 degrees that are not joined to another member have no support during anneal and may distort. A ± 5 degree tolerance should be specified for bends that will be supported in assembly. Alternatively, the drawing can specify bends to be restrained at inspection.

Concentricity

Small cylinders, to 3" diameter, should usually be specified for no less than $.015''$ T.I.R. Larger cylinders, and particularly cylinders with a low material thickness to diameter ratio, will show distortion because of annealing and movement in shipping.

Dimensions following Anneal

The full anneal process, essential for optimum magnetic properties, results in some distortion of fabricated parts as stresses are relieved. Some sizing of parts may be required. Because magnetic shields are in a dead soft condition following anneal, the shields will ordinarily conform to a more rigid part in assembly.

ANNEAL

In specifying CO-NETIC AA alloy, it is essential to specify either Stress Annealed or Perfection Annealed.

Stress Annealed sheets are forming temper and are commonly used for fabrication. To provide maximum magnetic shielding properties, the shields require annealing after fabrication. Annealing approximately doubles the attenuation in db or squares the attenuation ratio.

Perfection Annealed sheets may be fabricated into shields that require no further annealing if severe forming or heliarc welding is avoided. Perfection Annealed sheets have a large open grain structure that does not lend itself to severe stamping, drawing, spinning or Hydroforming operations. Because a rolled cylinder of small diameter is severely work hardened, Perfection Annealed sheets should not be used in their fabrication.

Perfection Annealed foil, because of its thin cross section, can be rolled to cylindrical shape with minimal loss of magnetic shielding properties.

FABRICATED SHIELDS

Magnetic Shield Corporation can produce complete magnetic shields, working to your drawings and specifications, or producing custom drawings and specifications to meet your requirements. A full range of design and manufacturing services is available from this single source.

PROCUREMENT AND SOURCING

The following information should appear on drawings and purchase orders:

Material: CO-NETIC or NETIC
(as applicable)
Source: Magnetic Shield Corporation
Part Number: (see pages 6 and 7)

NOTE: Certifications to Military, Aerospace, industrial and OEM specifications available.

CO-NETIC & NETIC FOIL

Foil may provide effective shielding with minimum fabrication, avoiding expensive tooling and extended production time.

Examples: Prototype and laboratory evaluation projects and production applications such as shielding field-sensitive components, printed circuit boards, instruments, signal leads and power cables.

CO-NETIC AA FOIL

Perfection Annealed—Part Numbers

Thickness		Width		Foil Only	Foil with PST
Inches	mm	Inches	mm		
.002	0,051	4	101,6	CF002-4	CFT002-4
.004	0,102	4	101,6	CF004-4	CFT004-4
.004	0,102	15	381,0	CF004-15	CFT004-15
.006	0,152	4	101,6	CF006-4	CFT006-4
.006	0,152	15	381,0	CF006-15	CFT006-15
.010	0,254	4	101,6	CF010-4	CFT010-4
.010	0,254	15	381,0	CF010-15	CFT010-15

NETIC S3-6 FOIL

Perfection Annealed—Part Numbers

Thickness		Width		Foil Only	Foil with PST
Inches	mm	Inches	mm		
.004	0,102	4	101,6	NF004-4	NFT004-4
.004	0,102	15	381,0	NF004-15	NFT004-15

Ordering CO-NETIC and NETIC Foil

- Ordering** – Specify part number and quantity in linear feet
Description: CO-NETIC AA Foil or NETIC S3-6 Foil
Thickness, width of coil.
- Annealing** – All foil has been Perfection Annealed for maximum Attenuation and acceptable surface appearance.
- Lengths** – Standard coils of 25, 50 and 100 linear feet
Other coil lengths also available. Priced per linear foot.
- Shipment** – Standard widths shipped immediately from stock.
- PST Backing** – All sizes available with double-faced Pressure Sensitive Tape and release coated liner. Temperature range 32°F. to 140°F. (0°C to 60°C). Specify with P.S.T. backing. Shipment within one week of receipt of order. Specification No. UU-T-91E, Type II Grade B. Other backings available (contact factory).
- Slitting** – Foils can be slit to a minimum width of 1/4" (6,350mm), with or without backing. Foil width tolerance ± 0.010 " (0,254 mm), with backing ± 0.015 " (0,381mm). Shipment within one week of receipt of order.
- Thickness** – Foil tolerance is $\pm 10\%$ of thickness.



CO-NETIC & NETIC SHEET

The sheet form of these materials is preferred in areas of high magnetic force, where greater alloy thickness is necessary, or where substantial production tooling investment is justified.

Examples: Power supplies, CRTs, photomultiplier tubes, disk drives, test chambers, and many electronic assemblies utilize cans, cylinders, boxes and enclosures fabricated from flat sheet by heliarc or spot welding.

CO-NETIC AA ALLOY

Perfection Annealed[▲] Sheet-Part Numbers

Thickness		Width		Standard Lengths—Inches (mm)		
Inches	mm	Inches	mm	14" (356mm)	29" (737mm)	59" (1499mm)
0.014	0,36	30	762	CP014-30-14	CP014-30-29	CP014-30-59
0.020	0,51	30	762	CP020-30-14	CP020-30-29	CP020-30-59
0.025	0,64	30	762	CP025-30-14	CP025-30-29	CP025-30-59
0.030	0,76	30	762	CP030-30-14	CP030-30-29	CP030-30-59
0.040	1,02	30	762	CP040-30-14	CP040-30-29	CP040-30-59
0.050	1,27	30	762	CP050-30-14	CP050-30-29	CP050-30-59
0.062	1,58	30	762	CP062-30-14	CP062-30-29	CP062-30-59

Stress Annealed⁺ Sheet-Part Numbers

Thickness		Width*		Standard Lengths—Inches (mm)			
Inches	mm	Inches	mm	15" (381mm)	30" (762mm)	60" (1524mm)	120" (3048mm)
0.014	0,36	30	762	CS014-30-15	CS014-30-30	CS014-30-60	CS014-30-120
0.020	0,51	30	762	CS020-30-15	CS020-30-30	CS020-30-60	CS020-30-120
0.025	0,64	30	762	CS025-30-15	CS025-30-30	CS025-30-60	CS025-30-120
0.030	0,76	30	762	CS030-30-15	CS030-30-30	CS030-30-60	CS030-30-120
0.040	1,02	30	762	CS040-30-15	CS040-30-30	CS040-30-60	CS040-30-120
0.050	1,27	30	762	CS050-30-15	CS050-30-30	CS050-30-60	CS050-30-120
0.062	1,58	30	762	CS062-30-15	CS062-30-30	CS062-30-60	CS062-30-120

* Note: 0.014 through 0.062 thicknesses also available in 24" inch wide sheets—consult factory

CO-NETIC B ALLOY

Stress Annealed⁺ Sheet-Part Numbers

Thickness		Width		Standard Lengths—Inches (mm)			
Inches	mm	Inches	mm	15" (381mm)	30" (762mm)	60" (1524mm)	120" (3048mm)
0.025	0,64	9	228	CBS025-9-15	CBS025-9-30	CBS025-9-60	CBS025-9-120

NETIC S3-6 ALLOY

Stress Annealed⁺ Sheet-Part Numbers

Thickness		Width		Standard Lengths—Inches (mm)			
Inches	mm	Inches	mm	15" (381mm)	30" (762mm)	60" (1524mm)	120" (3048mm)
0.014	0,36	30	762	NS014-30-15	NS014-30-30	NS014-30-60	NS014-30-120
0.020	0,51	30	762	NS020-30-15	NS020-30-30	NS020-30-60	NS020-30-120
0.025	0,64	30	762	NS025-30-15	NS025-30-30	NS025-30-60	NS025-30-120
0.030	0,76	30	762	NS030-30-15	NS030-30-30	NS030-30-60	NS030-30-120
0.050	1,27	30	762	NS050-30-15	NS050-30-30	NS050-30-60	NS050-30-120
0.062	1,58	30	762	NS062-30-15	NS062-30-30	NS062-30-60	NS062-30-120
0.095	2,41	30	762	NS095-30-15	NS095-30-30	NS095-30-60	NS095-30-120

▲ Fully hydrogen annealed. No further annealing necessary if drawing and heliarc welding are avoided (Not suitable for deep draw, spinning or hydroform fabrication).

+ Stress annealed for ease of fabrication. Must be final hydrogen annealed for maximum attenuation.

Ordering CO-NETIC and NETIC Sheet

Specify: Part number
CO-NETIC or NETIC
Anneal: Stress or Perfection
Thickness, width and length
Number of sheets

Shipment: All sheets shipped immediately from stock.

**For
Additional
Information. . .**



**Contact the factory or your
area sales representative.
Professional consultation
available without charge.**

Other Literature Available

CATALOG	DESCRIPTION
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CV-1	Cryogenic and Vacuum Magnetic Shields
EP-4	A.C. Magnetic Field Evaluator Probe
HC-1	Helmholtz Coil Assembly
LK-4	Lab Kit
MS-1	Product Selection Guide
PM-6	Magnetic Shields, Photomultiplier Tubes
RE-2	Magnetic Shield Room and Enclosures
SC-1	Shielding Slide Chart Calculator
WC-3	Wire, Cable, Conduit and Sleeving
ZG-2	Zero Gauss Chamber

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