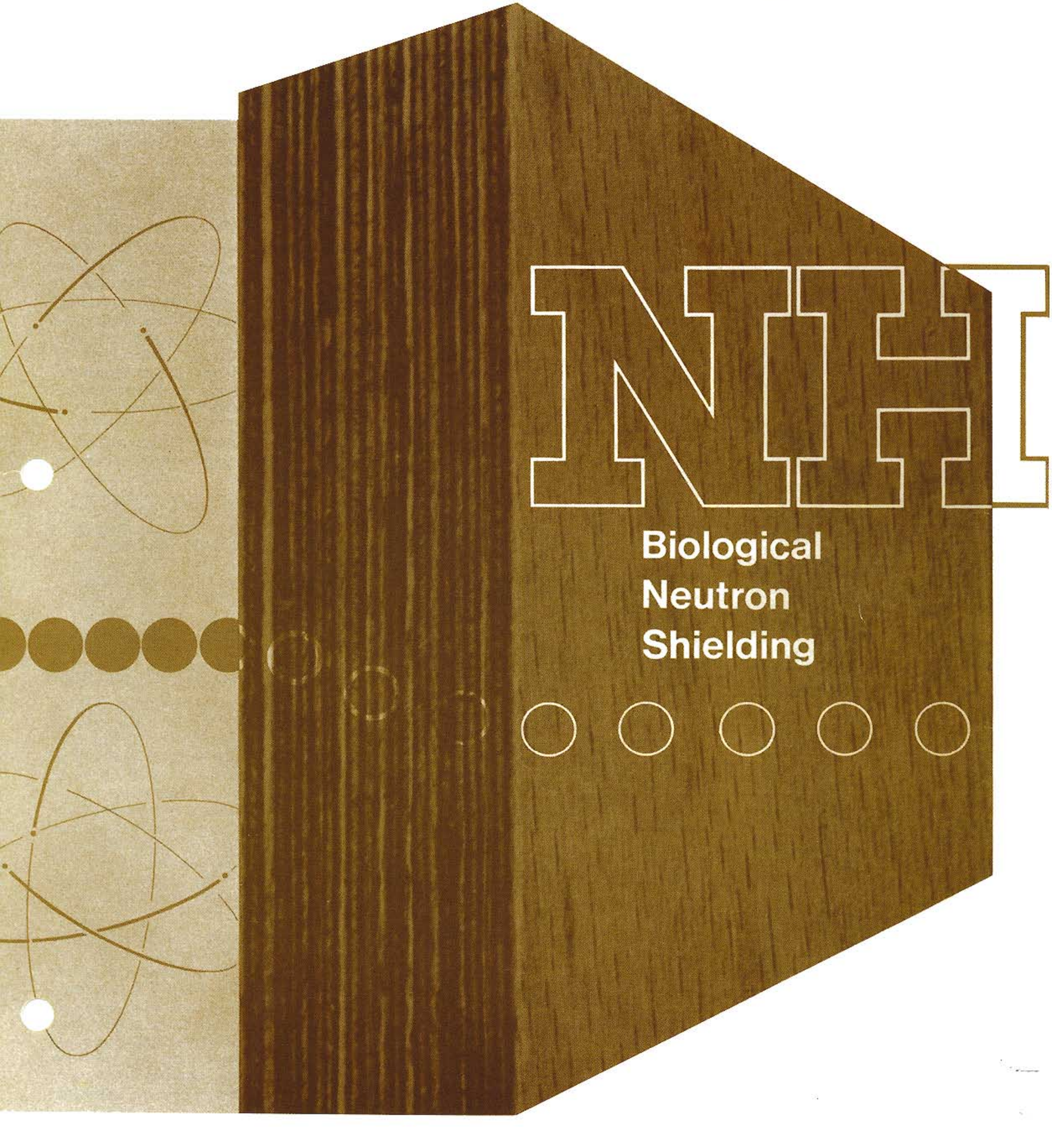
C-K COMPOSITES, INC.



NH

Biological Ne

WHAT IS INSULAM NH?

Insulam NH is a special grade of densified beechwood laminate with a hydrogen content of approximately 6%. The beechwood veneers are impregnated under vacuum with a modified phenolic resin and then densified through the application of heat and pressure. The densification required to produce Insulam NH provides increased hydrogen concentration per unit volume of material. The hydrogen content is in a combined form, being a part of the hydrocarbon molecules of both constituents.* Since the hydrogen is uniformly dispersed, the material is isotropic with respect to neutron shielding effectiveness.

Insulam NH is available in boards as pressed, or in fully machined components such as segmented shield plugs, doors or movable walls. Machining tolerances can easily be held to normal construction requirements.

Insulam NH biological neutron shielding material has been in use at nuclear power stations in the United States and abroad for several years.

*It is the presence of hydrogen atoms within a material which attenuates fast neutrons.

WHY USE INSULAM NH?

Ease of Handling

Increasingly stringent Atomic Energy Commission requirements have placed added emphasis on the structural integrity and portability of neutron shielding materials. Periodic inspection of Boiling Water Reactor (BWR) recirculating system pipe sections between reactor core and primary or sacrificial shield, as well as inspection of the drywells, the space between core and shield, have necessitated periodic removal of shielding. Shield removal is usually manual or manually-assisted, and thus shielding weight becomes significant. The heavier the shielding to be removed, the greater is the time required in removing it, and the shorter the exposure time remaining for the same personnel to do the actual inspecting; relief crews may be required. Even during shutdown for in-service inspection, low-level radiation continues to be emitted and exposure time for personnel is limited and must be carefully monitored. Insulam NH, in contrast to concrete, is relatively lightweight, allowing more rapid shield removal and, consequently, greater time for inspection by the same personnel. Increased removal speed also means decreased downtime.

Concrete Dusting

In addition to the weight problem, the use of concrete for shield plugs has another serious drawback. Concrete surfaces tend to dust and powder from exposure or from contact with another surface. This action by frequently moved concrete blocks releases radioactive microscopic particles which are easily inhaled, further reducing safe exposure time. Inhaled "hot" particles tend to produce maximum radiation tolerance levels much faster than does external exposure.

To control dusting and increase manageability of concrete used in removable shielding it is sometimes contained in block form within a tin or aluminum "can." These metals, however, are prone to denting and deformation. When such irregularities develop, the effectiveness of the shielding is compromised and a real danger of escaping radiation develops.

By the nature of its composition, Insulam NH does not exhibit dusting and, consequently, does not require any "canning" or encapsulating.

RADIATION RESISTANCE

Various tests have shown the degree to which Insulam NH retains its mechanical strength under radiation. For example:

1. After irradiation for 320 hours at a gamma dose rate of 2.0×10^6 R/hour and in a fast neutron (>1 Mev) flux of 1.3×10^9 n/cm²/second, Insulam NH specimens averaged 1700 psi flexural strength (range 1200 to 1900). This irradiation exposure is equal to 200,000 hours (23 yrs.) life in a BWR reactor.

2. At a dosage rate of 1×10^3 rads/hour, 40 years' exposure $= 3{,}504 \times 10^8$ rads.

RETAINED STRENGTH AFTER 40 YEARS

Elongation and impact
 33% of initial value

Tensile Strength
 47% of initial value

Modulus
 93% of initial value

EFFICIENCY

The efficiency of a material as a shield is indicated by its relaxation length. This measure of screening efficiency is defined as the thickness of the material required to reduce the neutron flux in the ratio of "e" (base of Naperian logarithm). Thus the shorter the relaxation length, the more efficient the material. The relaxation length of Insulam NH varies with neutron energy level and is 7.8 cm. at an energy level of 4 Mev.

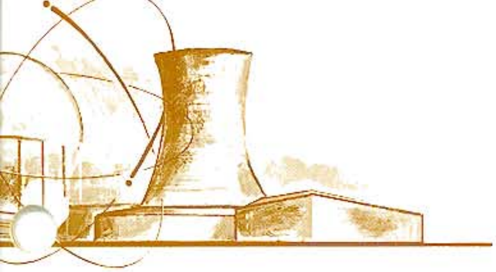
The amount of Insulam NH required for a specific application will depend on the spectrum of neutron energies and the degree of attenuation required. The table below shows the thickness of Insulam NH necessary to attenuate the flux by a factor of 10.

Neutron Energy	Thickness of Insulam NH
.05 Mev	1.18 inches
.10 Mev	1.32 inches
.50 Mev	1.70 inches
1.00 Mev	2.36 inches
1.50 Mev	3.55 inches
2.00 Mev	4.52 inches
3.00 Mev	5.96 inches
4.00 Mev	7.05 inches
5.00 Mev	7.90 inches
6.00 Mev	8.55 inches

EVALUATED TEMPERATURE

The recommended maximum operating temperature of Insulam NH is 105°C with intermittent increases to 150°C acceptable. Long exposure to temperatures above 150°C will result in degradation of mechanical properties. There will, however, be no loss of hydrogen unless the temperature is high enough to cause charring. Charring is a breakdown of the hydrocarbon molecule by heat in which hyrogen is driven off and carbon left as a residue.

In our experience, Insulam NH does not char; i.e., exhibit molecular breakdown, at temperatures below 150°C (302°F). Further, it has been our experience that when Insulam NH is subjected to excessive temperatures, molecular breakdown is a surface phenomenon only, with the interior of the material unaffected. The depth of degraded surface layer



tron Shielding

will of course, be dependent on the temperature and length of exposure, but the rate of progression is not a straight line function. At any given temperature the rate of propogation of the degraded surface decreases with time.

INSULAM IN EXPERIMENTAL FUSION APPARATUS

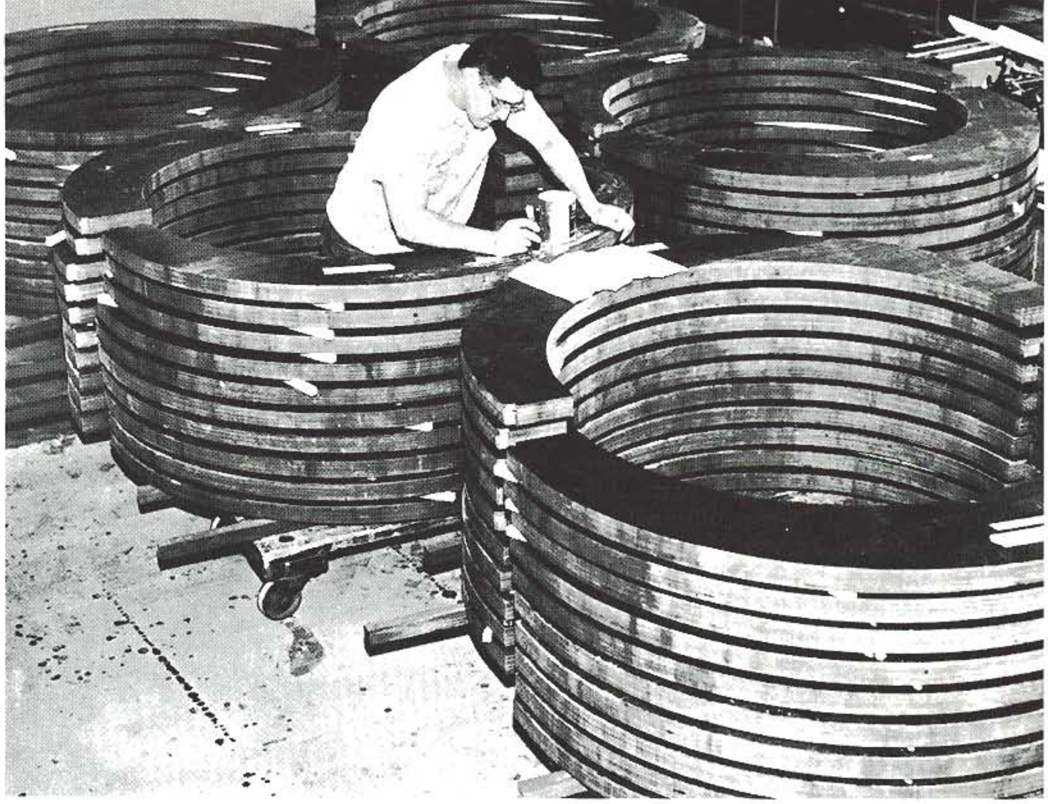
Insulam has been widely used in experimental thermonuclear fusion apparatus in the U.S.A. and abroad. Although parts may be subjected to a strong neutron flux during operation of this apparatus, the use of a non-metallic material is primarily necessary because of the heavy magnetic fields encountered. The unique mechanical and electrical properties of Insulam NH, plus its exceptional machinability, make it ideally suited for these applications.

GENERAL INFORMATION

Insulam NH is available in a number of grades and types in the form of sheets, rods, rings, continuously threaded rod, nuts, bolts and other fabricated components. Maximum available sizes vary according to type, but lengths up to 165″ and thicknesses to 4″ are available. However, there are virtually no limits to the size parts which can be fabricated. Additional technical information on the properties of Insulam NH will be sent on request. Our design engineers are available for consultation on specific problems.

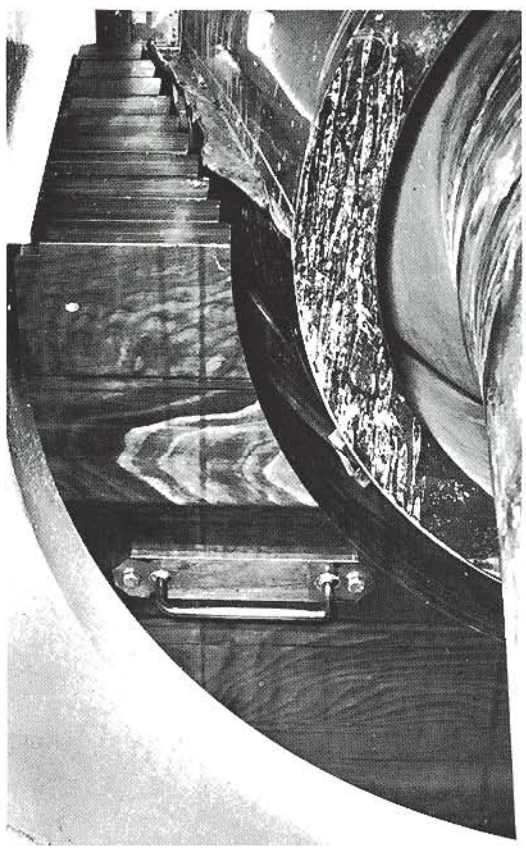
Insulam JN

For applications where neutron capture — not solely attenuation — is required, boronated Insulam JN is available. While maintaining a hydrogen content of approximately 6%, this material also contains 3% boron, uniformly dispersed throughout.

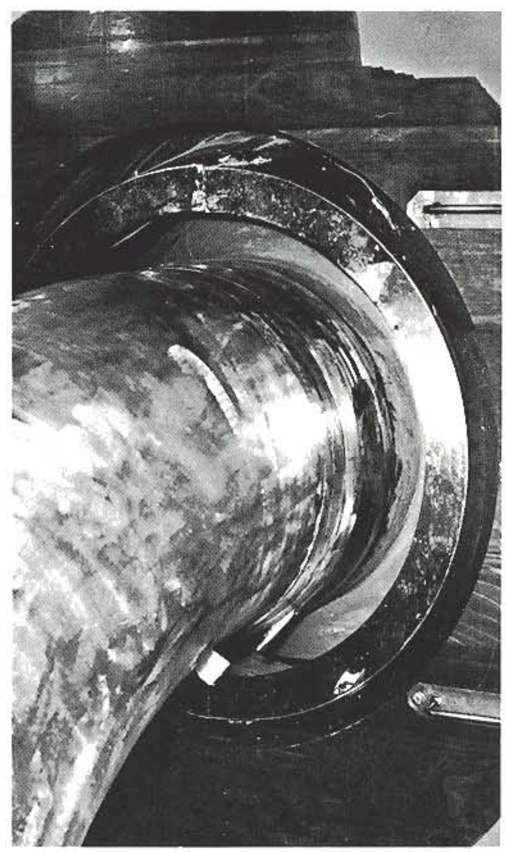


Removable Sacrificial Shield Plugs: Insulam NH may be machined into easily removable plugs which fit around recirculation nozzles, piping, instrumentation lines and other penetrations which pass through the primary shield. These plugs are easily lifted out for in-service inspection.

Insulam NH ring segments being stenciled with proper installation marks prior to shipment from the C-K plant.



View looking into the penetration with the top ring segments removed.



View from outside sacrificial shielding wall showing Insulam NH shielding in place at recirculation nozzle. Nine Mile Point Nuclear Station, Unit #1, Niagara Mohawk Power Corp., Oswego, New York.

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C-K COMPOSITES, INC

NH and JN PROPERTIES

CHEMICAL	Insulam NH	Insulam JN
Hydrogen	6%	6%
Boron	—	3%
Oxygen	52%	49%
Carbon	41%	38%
Sodium	—	1.8%
Chlorine	—	0.002%
Nitrogen	trace	trace
Other Minerals	trace	trace
PHYSICAL*		
Density, lbs/cu ft	81	84
Thermal Conductivity, cal/cm²/°c/sec/cm		
perpendicular to laminations	3.4×10^{-4}	3.4×10^{-4}
parallel to laminations	5.6×10^{-4}	5.6×10^{-4}
Operating Temperature,		
continuous	105°C	105°C
intermittent	150°C	150°C
MECHANICAL*		
Tensile strength, psi	15,000	15,000
Flexural strength, psi	18,000	18,000
Compressive strength, psi		
flatwise	30,000	30,000
endwise	22,000	14,000
Shear strength perpendicular to laminations, psi		
face	7,200	7,000
edge	3,500	3,500
Impact strength, Izod, ft lb/in of notch		
perpendicular to face	3.4	4
perpendicular to edge	1.6	2
Modulas of Elasticity, psi	2×10^{6}	1.5×10^{6}

**All data based on applicable ASTM test standards.*