

Comparison of 47,5 % NiFe Alloy PERMENORM 5000 H2 (Vacuumschmelze GmbH & Co. KG) with “composition 3” alloy according to MIL-N-14411C (MR), (1977)

Vacuumschmelze’s most common “50% NiFe” alloy, PERMENORM 5000 H2, meets the “composition 3” alloy specifications with respect to magnetic properties, however features some (minor) deviations with respect to mechanical and structural properties. According to our best knowledge these differences can be tolerated for most applications. However individual approvals are required, or course. In order to support such approvals and the “decision making”, the following information compares PERMENORM 5000 H2 with the definitions given for “composition 3” material in MIL-N-14411C (MR), (1977).

“50” % NiFe alloys are used in form of strips or rods, e. g. for products like tape-wound cores or parts in magnet systems like e. g. relays. The main features are the magnetic properties like saturation flux density, permeability, coercivity and electrical resistance after magnetic annealing. Additionally typical mechanical properties are required and defined, either to machine the material or to ensure defined mechanical properties of parts in the application.

The (void) MIL specification N-14411C (MR) defines supplementary to minimum mechanical and magnetic properties, maximum values for “adders” and “impurities” in the composition, such like Carbon, Manganese, Silicon, Phosphorus, Sulphur and Chromium. The main reason to limit these ingredients is to ensure the required magnetic properties after annealing and to allow the use of these alloys from different suppliers for the same applications.

Both mechanical and magnetic properties do not only content from the composition, the amount of impurities and the annealing process but also from the production process itself, like e. g. the specific ovens used for the melting of the alloy, certain pre-treatments and processes to homogenize the melt. Consequently unavoidable variations in composition and in the processes will result in tolerances with respect to magnetic and mechanical properties.

Vacuumschmelze GmbH has decades of experience with the melting and processing of special magnetic alloys. The compositions/alloys are melted in a state of the art vacuum furnace to ensure the required purity of the alloy. The chemical composition is controlled as part of a strict quality control to ensure mechanical and especially specified magnetic properties (after suitable annealing treatment).

Remark: Occasionally customers ask for PERMEMORM 5000 H2 not in the intention to not use its magnetic properties but take advantage of the special thermal expansion coefficients of NiFe alloys. PERMENORM 5000 H2 is a magnetically optimized alloy. Minor experience only is available about the expansion behavior, especially the variations from batch to batch. Please contact us for more information.

Table I. Chemical composition of composition 3 vs PERMENORM 5000 H2, percent

	Carbon max	Manganese max	Silicon max	Phosphorus max	Sulfur max	Nickel	Iron
Comp. 3	0,035	0,8	0,5	0,02	0,008	47,0-50,0	Rem
PERMENORM 5000 H2	☑	☑	☑	☑	☑	47,5	Rem

PERMENORM 5000 H2 with 47,5 % Ni is in line with the Ni contents of composition 3. Maximum values for “impurities” or “refiners” like Carbon, Manganese, Silicon, Phosphorus, Sulphur or Chromium are respected. The consistency of the alloy is ensured by chemical analysis and the definition of the mechanic and mainly magnetic properties, which depend very sensitively from the composition.

After appropriate annealing to fulfill the magnetic specifications, PERMENORM 5000 H2 possesses a secondary recrystallized grain structure with large grains and no pronounced crystallographic and thus magnetic orientation. Thus PERMENORM 5000 H2 complies with the additional requirements “available in all forms. Random-oriented magnetic properties”.

3.1 Chemical composition, analysis

The supply of a chemical analysis (as requested in 3.1 of the standard) is basically possible, but is no standard and means additional costs. The main argument is that the composition is indirectly defined by the magnetic properties.

3.2 Mechanical properties, Table II Hardness

Table II defines a Rockwell B hardness of > 90 for cold rolled material, and < 75 for annealed material.

Table II mechanical hardness: composition 3 vs PERMENORM 5000 H2

	MIL-N-14411C (MR)	Corresponds with	PERMENORM 5000 H2
Temper	Hardness Rockwell B	Vickers HV	Vickers HV
As cold rolled	> 90	192	220 - 280
Annealed	< 75	137	90 -120

3.3 Magnetic properties

Table III DC magnetic properties: composition 3 vs PERMENORM 5000 H2

	Permeability, μ , minimum			μ , maximum	Coercive force
	B=100 Gauss	B=2500 Gauss	B=5000 Gauss		
MIL-N-14411C (MR) (Sheet, strip, bar, rod, wire)	7000	-	60000	60000	0,07 from B=10000 Gauss
PERMENORM 5000 H2 (Sheet, strip, bar, rod, wire)	7000	-	60000	60000	0,07

MIL-N-14411C (MR) defines minimum values of finished parts after an appropriate annealing under dry hydrogen. Values for “thin-strip” products (e. g. tape-wound cores) are typically higher, values of bigger parts/sheets or devices made from bigger parts/sheets can be lower depending on the size, mechanical stresses on the material, and possible compromises in the annealing conditions due to the shape/weight.

Table IV. AC (60 CPS) magnetic properties, sheet - strip: composition 3 vs PERMENORM 5000 H2

Thickness (inch)	Permeability, minimum value at x Gauss				
	B=40	B=200	B=2000	B=4000	B=6000
0,02	5700	9000	21 000	28 000	
0,014	7500	13 500	28 000	40 000	45 000
0,006	8000	14 500	38 000	52 000	65 000

Vacuumschmelze specifies minimum values for finished products like tape-wound cores (Magnetic Quality). To our best knowledge products/cores produced from PERMENORM 5000 H2 strip-material meet or exceed the MIL-N-14411C (MR) specifications after appropriate annealing. Please have in mind that these values are valid for closed magnetic shapes (magnetic circuits) with uniform cross section. Deviating shapes may strongly influence the possible permeability values (shearing).

3.4 Electrical properties (composition 3)

	Ohms circular mil/foot	$\Omega\text{mm}^2/\text{m}$
MIL-N-14411C (MR)	286 - 316	0,475 - 0,525
PERMENORM 5000 H2	271	0,45

PERMENORM 5000 H2 has a slightly lower electrical resistivity compared the MIL-N-14411C (MR) specification. To our best knowledge the difference is insignificant for most applications.

4 Quality assurance provisions

The material is typically delivered together with an EN 10204-2.2 certification confirming that the material is PERMENORM 5000 H2 as specified. Annealed parts can be delivered with ring samples on request (if the shape of the parts does not allow the direct measurement of magnetic properties).

Customized agreements are possible, especially for parts or annealed parts.

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