



aperam  
made for life

ELECTRICAL STEELS  
Grain Oriented (GO)  
Non-Oriented (NGO)





Aperam Bioenergia runs an eucalyptus forestry asset in Vale do Jequitinhonha, state of Minas Gerais, and produces renewable energy within the principles of sustainability, having as goal to meet demands for charcoal from Aperam South America in the town of Timóteo.



# Aperam South America

Aperam South America is the sole integrated producer of flat stainless and electrical steels in Latin America, in addition to holding an advanced technology for production of alloyed carbon steels.

Having more than 70% participation in the domestic market, the company also exports its products to more than 50 countries, and has an installed capacity capable of producing 900 thousand tons of molten steel per year. Aperam South America is a leading-edge company when it comes to technology, and it keeps an advanced research centre.

## Electrical Steels

Aperam produces Grain Oriented (GO) and Non-Oriented (NGO) electrical steel grades. Aperam's electrical steels feature high magnetic properties and they are supplied to large global manufacturers of electrical equipment.

Aperam is present in the generation, transmission, distribution and use of electric energy, right from the NGO grades with very low magnetic loss used in hydro-generators, through the GO grades used in power and distribution transformers, to the electrical steels used in a large variety of electrical equipment, such as compressors for refrigerators and electric motors.

With energy efficiency becoming an increasingly more important issue in the modern world, Aperam's electrical steels contribute significantly to the global reduction towards energy consumption and greenhouse gases.

## Aperam Bioenergia

With headquarters in the city of Belo Horizonte, the company is dedicated to the production of wood and charcoal to be used in steelmaking, by means of 76 thousand hectares of renewable eucalyptus forests found throughout the state of Minas Gerais.

The company runs a forestry asset of 126 thousand hectares, with 20% of this area being an ecological sanctuary, in addition to an area of permanent conservation. The company currently has a production capacity of 1.4 million m<sup>3</sup> of wood and charcoal.



# Grain Oriented electrical steels

## Increased efficiency and economy

GO electrical steel was developed to achieve low magnetic losses and increased magnetic permeability, required for attaining higher equipment efficiency and energy saving.

Main applications: Manufacturing of transformer cores, power reactors, hydro-generators and turbo-generators.

Main characteristics: Excellent magnetic properties in the rolling direction.

## Guaranteed Characteristics

The limit values for magnetic losses refer to fully processed products, tested after stress relief annealing, in samples cut following the rolling direction.

The user shall specify one magnetic induction and frequency, for the guarantee of the maximum core loss.

When not specified, the guaranteed core loss value will be supplied based on 1.5T and 60Hz.

This steel is supplied with ASTM C-5 coating.

Guaranteed Characteristics												
Grade		Thickness (mm)	Maximum Core Loss at (w/kg)				Minimum Magnetic Induction at (T)			Assumed Density (g/cm <sup>3</sup> )	Minimum Lamination Factor (%)	Minimum Bending Index
Reference	Aperam		1,5 T		1,7 T		800 A/m	2500 A/m	10000 A/m			
			50 Hz	60 Hz	50 Hz	60 Hz						
M108-23	E003-9	0.23	0.73	0.95	1.08	1.40	1.78	1.87	1.97	7.65	94.5	2
M117-23	E003-9	0.23	0.75	0.99	1.17	1.54						
M112-27	E004-7	0.27	0.80	1.05	1.12	1.46						
M125-27	E004-7	0.27	0.85	1.12	1.24	1.63						
M130-30	E005-4	0.30	0.88	1.15	1.30	1.71						
M140-30	E005-4	0.30	0.92	1.21	1.40	1.83						
M150-35	E006-2	0.35	1.05	1.38	1.50	1.97						
											95.5	
											96.0	

Aperam's Grain Oriented Electrical Steel can be supplied following the main International Standards or according to customer's specification. The supply in special conditions may be provided upon previous request.





### Typical Characteristics

Grade		Thickness (mm)	Core Loss at (W/kg)				Magnetic Induction at (T)		
Reference	Aperam		1.5 T		1.7 T		800 A/m	2500 A/m	10000 A/m
			50 Hz	60 Hz	50 Hz	60 Hz			
M108-23	E003-9	0.224	0.70	0.91	1.01	1.31	1.86	1.93	1.98
M117-23	E003-9	0.224	0.72	0.94	1.07	1.38	1.85	1.93	1.97
M112-27	E004-7	0.263	0.77	1.01	1.09	1.42	1.85	1.93	1.97
M125-27	E004-7	0.263	0.79	1.04	1.14	1.47	1.85	1.93	1.97
M130-30	E005-4	0.293	0.83	1.10	1.17	1.54	1.84	1.93	1.97
M140-30	E005-4	0.293	0.86	1.14	1.23	1.61	1.84	1.93	1.97
M150-35	E006-2	0.342	0.94	1.25	1.30	1.73	1.84	1.93	1.97

### International Standards

APERAM		ASTM A876M		JIS 2553-2000		DIN EN 10107		IEC 60404-8-7	
Grade	W/kg	Grade	W/kg	Grade	W/kg	Grade	W/kg	Grade	W/kg
M108-23	1.08	23H070	1.17	23G110	1.10	M110-23S	1.10	M110-23S 5	1.10
M117-23	1.17	23H070	1.17	23G110	1.10	M120-23S	1.20	M120-23S 5	1.20
M112-27	1.12	27H074	1.24	27G120	1.20	M120-27S	1.20	M120-27S 5	1.20
M125-27	1.24	27H074	1.24	27G130	1.30	M130-27S	1.30	M130-27S 5	1.30
M130-30	1.30	30H083	1.39	30G130	1.30	M130-30S	1.30	M130-30S 5	1.30
M140-30	1.40	30H083	1.39	30G140	1.40	M140-30S	1.40	M140-30S 5	1.40
M150-35	1.50	35H094	1.57	35G155	1.55	M150-35S	1.50	M150-35S 5	1.50

Core losses at 1.7T / 50 Hz.

## C-5 Coating

It is a phosphate-based inorganic coating applied on top of a magnesium silicate layer (ASTM C-2) present on the steel surface. This coating has good electrical resistivity and withstands stress relief annealing treatment.

Guaranteed Value			
Coating	Valor Garantido		Typical Value
	Maximum Average (A) *	Maximum per Reading (A) **	Average (A)
C-5	0.200	0.500	0.085

\* Average value of ten measurements (5 in the upper side and 5 in the lower side), Guaranteed values after October 20<sup>th</sup> 2012.

\*\* Maximum value of one measurement.

## Mechanical Properties

Mechanical Properties								
Yield Strength (MPa)		Tensile Strength (MPa)		Elongation (%)		Bending Index		Hardness (HV5)
L	T	L	T	L	T	L	T	
323	337	356	392	17	33	20	8	172

The typical values shown above are for information only, and cannot be used as specification. "L" and "T" correspond to samples cut longitudinally and transversally to the rolling direction.

## Standard Dimensions

All coils are supplied with a standard internal diameter of 610mm, with the possibility of being supplied also with 508 mm upon previous request. The standard internal diameter for strips is 508 mm.

In both cases the diameter tolerance is -10 / +20 mm.

Standard Dimensions						
Thickness (mm)	Lamination Factor (%)		Thickness (mm)	Tolerance (mm)	Width (mm)	Tolerance (mm)
	Guaranteed	Typical				
0.23	94.5	97.41	0.23	+/- 0.025	30 ≤ L ≤ 150	-0 / +0.3
0.27	95.0	97.44	0.27	+/- 0.030	150 < L ≤ 500	-0 / +0.5
0.30	95.5	97.41	0.30	+/- 0.030	500 < L ≤ 1020	-0 / +1.0
0.35	96.0	97.50	0.35	+/- 0.030		





# Non-Oriented Electrical Steels

## Increased efficiency and more economy in your daily life

Fully processed NGO (Non-Oriented) steel has its magnetic properties fully developed. It exhibits an excellent magnetic permeability value and low magnetic losses, with the possibility of being supplied with an isolating coating.

Main applications: generator cores, electric motors, electricity meters and hermetic compressors for refrigerators and freezers as well as a vast array of other electrical equipment.

Main characteristic: good magnetic properties in any given direction.

Applications	Non-Oriented Electrical Steel											
	E100	E105	E110	E115	E125	E137	E145	E157	E170	E185	E230	E233
Hydrogenerators / Turbogenerators	*	*	*	*	*	*	*					
Transformers for Electrical / Electronic Industry							*	*	*	*	*	*
Transformers for Welding Machines									*	*	*	*
Voltage Transformers									*	*	*	*
Power Reactors / Magnetic Amplifiers		*	*	*	*							
DC and AC Large Scale Motors		*	*	*	*	*	*	*	*			*
DC and AC Medium Scale Motors									*	*	*	*
DC and AC Small Scale Motors									*	*	*	*
Electricity Meters						*	*	*				
Ballasts									*	*	*	*
Hermetic Compressors							*	*	*	*	*	*

## Guaranteed Characteristics

The limit values for magnetic losses refer to fully processed products, tested as cut, without stress relief annealing introduced by cutting, with 50% of samples cut following the rolling direction and 50% cut in the crosswise direction.

The user shall specify one magnetic induction and frequency, for the guarantee of the maximum core loss. When not specified, the guaranteed magnetic loss value will be supplied based on 1.0T and 50Hz.

Guaranteed Characteristics															
Grade		Thickness (mm)	Minimum Magnetic Induction at (W/kg)				Minimum Magnetic Induction at (T)			Assumed Density (g/cm <sup>3</sup> )	Min. Lamination Factor (%)	Min. Bending Index			
Reference	Aperam		1.0 T		1.5 T		2500 A/m	5000 A/m	10000 A/m						
			50 Hz	60 Hz	50 Hz	60 Hz									
<i>P800-100A</i> (1)	E233	1.00	3.60	4.55	8.00	10.00	1.64	1.73	1.84	7.75	98.0	5			
<i>P450-65A</i> (1)	E233	0.65	1.95	2.35	4.25	5.40	1.64	1.73	1.84	7.75	97.0	10			
M600-65A	E230		2.60	3.25	6.00	7.70	1.60	1.70	1.80						
M470-65A	E185		2.00	2.50	4.70	6.00									
M450-65A	E170		1.95	2.35	4.25	5.40									
M400-65A	E157		1.70	2.15	3.95	5.00									
<i>M530-54A</i>	E230	0.54	2.30	2.91	5.30	6.66				1.59	1.69	1.79	7.75	97.0	10
<i>P400-50A</i> (1)	E233	0.50	1.70	2.15	3.68	4.66	1.64	1.73	1.83	7.75	97.0	10			
M530-50A	E230		2.30	2.91	5.30	6.66	1.59	1.69	1.79						
M470-50A	E185		1.85	2.34	4.10	5.19									
M400-50A	E170		1.70	2.15	3.68	4.66									
M370-50A	E157		1.57	2.00	3.42	4.33									
M350-50A	E145		1.45	1.84	3.33	4.22									
M330-50A	E137		1.37	1.74	3.14	3.98									
M310-50A	E125		1.25	1.58	3.05	3.85									
M290-50A	E115		1.15	1.45	2.90	3.65									
M270-50A	E110		1.10	1.40	2.70	3.45									
M250-50A	E105		1.05	1.35	2.50	3.20									
<i>M230-50A</i>	E100		1.00	1.30	2.30	2.95									
M330-35A	E170		0.35	1.30	1.70	3.30							4.12	1.56	1.66
M300-35A	E157	1.20		1.50	3.00	3.74									
M290-35A	E145	1.15		1.45	2.90	3.50									
M270-35A	E137	1.10		1.40	2.70	3.36									
M250-35A	E125	1.00		1.25	2.50	3.14									
M235-35A	E115	0.95		1.20	2.35	2.90									
M210-35A	E110	0.90		1.15	2.10	2.65									
<i>M195-35A</i>	E100	0.90		1.15	1.95	2.60									

(1) High magnetic permeability steels. Note that the other steels exhibit guaranteed magnetic induction values higher than those from International Standards.  
P.S.: Grades in italic do not exist in International Standards yet.



## Typical Characteristics

Grade		Thickness (mm)	Core Loss (W/kg)				Magnetic Induction at (T)					
Reference	Aperam		1.0 T		1.5 T		2500 A/m	5000 A/m	10000 A/m			
			50 Hz	60 Hz	50 Hz	60 Hz						
<i>P800-100A</i> (1)	E233	1.00	2.90	3.90	6.25	8.45	1.67	1.75	1.86			
<i>P450-65A</i> (1)	E233	0.65	1.73	2.26	3.74	4.92	1.62	1.74	1.82			
M600-65A	E230		1.83	2.35	3.97	5.16						
M470-65A	E185		1.76	2.27	3.84	5.01						
M450-65A	E170		1.69	2.20	3.70	4.85						
M400-65A	E157		1.61	2.09	3.57	4.70						
<i>M530-54A</i>	E230		0.54	1.53	1.95	3.31				4.27	1.62	1.72
<i>P400-50A</i> (1)	E233	0.50	1.41	1.81	3.08	3.97	1.62	1.72	1.82			
M530-50A	E230		1.53	1.95	3.31	4.27						
M470-50A	E185		1.46	1.88	3.19	4.10						
M400-50A	E170		1.42	1.83	3.10	4.00						
M370-50A	E157		1.38	1.77	3.02	3.90						
M350-50A	E145		1.33	1.72	2.94	3.82						
M330-50A	E137		1.24	1.60	2.77	3.58						
M310-50A	E125		1.11	1.42	2.54	3.28						
M290-50A	E115		1.08	1.38	2.48	3.21						
M270-50A	E110		1.04	1.34	2.42	3.13						
M250-50A	E105		1.00	1.28	2.35	3.05						
<i>M230-50A</i>	E100		0.93	1.20	2.25	2.91				1.59	1.69	1.81
M330-35A	E170		1.23	1.53	2.72	3.41				1.60	1.70	1.80
M300-35A	E157		1.16	1.46	2.59	3.26						
M290-35A	E145	1.10	1.39	2.49	3.15							
M270-35A	E137	1.04	1.31	2.37	2.99	1.59	1.70	1.79				
M250-35A	E125	0.98	1.23	2.25	2.83							
M235-35A	E115	0.93	1.17	2.14	2.69							
<i>M210-35A</i>	E110	0.84	1.08	2.05	2.60							
<i>M195-35A</i>	E100	0.82	1.04	1.93	2.46							
									1.62	1.72	1.79	

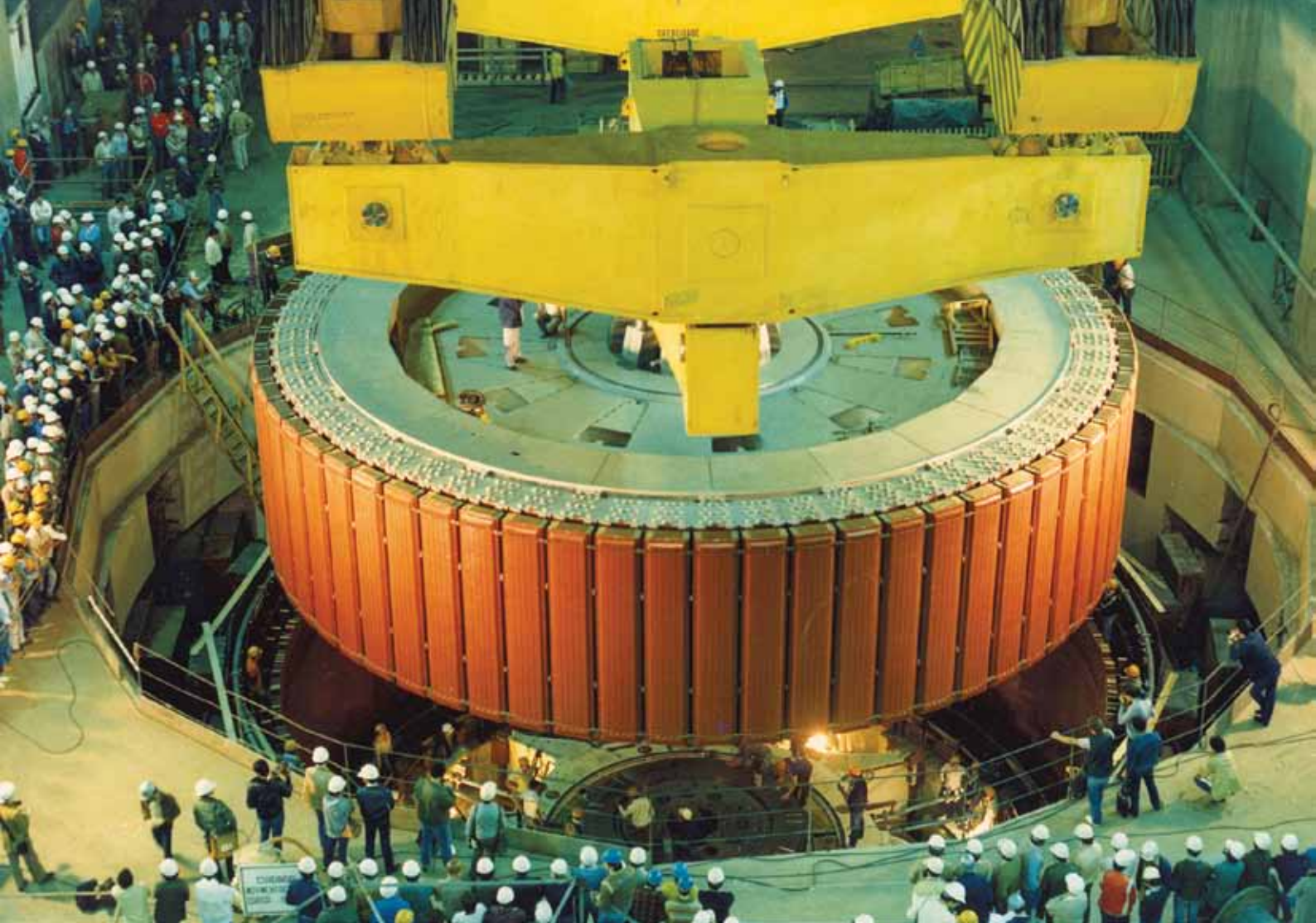
(1) High permeability grades.

## Yield Strength

Aperam Grade	Yield Strength (MPa)		Tensile Strength (MPa)		Elongation (%)		Bending Index	Hardness (HV5)	Lamination Factor (%)
	L	T	L	T	L	T			
E233	300	304	420	425	31	31	20	147	98.0
E230	311	315	433	438	30	30	20	154	98.0
E185	311	315	433	438	30	30	20	148	98.0
E170	300	304	420	425	31	31	20	147	98.0
E157	300	304	420	425	31	31	20	147	98.0
E145	300	304	420	425	31	31	20	147	98.0
E137	354	379	463	473	23	24	4	183	97.9
E125	354	379	463	473	23	24	4	183	97.9
E115	354	379	463	473	23	24	4	183	97.9
E110	354	379	463	473	23	24	4	183	97.9
E105	354	379	463	473	23	24	4	183	97.9
E100	354	379	463	473	23	24	4	183	97.9

Thickness = 0.50 mm. "L" and "T" correspond to samples cut longitudinally and transversally to the rolling direction. The values above indicated are for reference only, and cannot be used as specification.







## International Standards

Grade		Thickness (mm)	ABNT NM71 (2000)		former AISI	ASTM A677 (2007)		JIS 2552 (2000)		IEC 60404-8-4 (1998)		DIN EN 10106 (2007)		
Reference	Aperam		Grade	(W/kg)	Grade	Grade	(W/kg)	Grade	(W/kg)	Grade	(W/kg)	Grade	(W/kg)	
P470-65A (1)	E233	0.65	-	-	-	-	-	-	-	-	-	-	-	
M600-65A	E230		65F 770M	6.10	-	64F 320	5.57	-	-	M600-65A 5	5.30	M600-65A	5.30	
M470-65A	E185		65F 600M	4.70	-	64F 275	4.79	-	-	M470-65A 5	4.70	M470-65A	4.70	
M450-65A	E170		65F 540M	4.25	-	64F 250	4.35	-	-	-	-	-	-	
M400-65A	E157		65F 500M	3.95	-	64F 225	3.92	-	-	M400-65A 5	4.00	M400-65A	4.00	
M530-54A	E230	0.54	-	-	-	-	-	-	-	-	-	-	-	
P400-50A (1)	E233	0.50	-	-	-	-	-	-	-	-	-	-	-	
M530-50A	E230		50F 684M	5.40	M-45	47F 280	4.87	-	-	M530-50A 5	5.30	M530-50A	5.30	
M470-50A	E185		50F 570M	4.50	-	47F 240	4.18	50A470	4.70	M470-50A 5	4.70	M470-50A	4.70	
M400-50A	E170		50F 519M	4.10	M-43	47F 210	3.65	50A400	4.00	M400-50A 5	4.00	M400-50A	4.00	
M370-50A	E157		50F 466M	3.68	M-36	47F 200	3.48	-	-	-	-	-	-	
M350-50A	E145		50F 433M	3.42	M-27	47F 190	3.31	50A350	3.50	M350-50A 5	3.50	M350-50A	3.50	
M330-50A	E137		50F 422M	3.33	M-22	47F 180	3.13	-	-	M330-50A 5	3.30	M330-50A	3.30	
M310-50A	E125		50F 385M	3.05	M-19	-	-	50A310	3.10	M310-50A 5	3.10	M310-50A	3.10	
M290-50A	E115		50F 370M	2.90	M-15	47F 165	2.87	50A290	2.90	M290-50A 5	2.90	M290-50A	2.90	
M270-50A	E110		-	-	-	-	-	50A270	2.70	M270-50A 5	2.70	M270-50A	2.70	
M250-50A	E105		-	-	-	-	-	50A250	2.50	M250-50A 5	2.50	M250-50A	2.50	
M230-50A	E100		-	-	-	-	-	50A230	2.30	-	-	-	-	
M330-35A	E170		0.35	35F 420M	3.32	M-36	36F 195	3.39	35A360	3.60	M330-35A 5	3.30	M330-35A	3.30
M300-35A	E157			35F 395M	3.11	M-27	36F 175	3.04	35A300	3.00	M300-35A 5	3.00	M300-35A	3.00
M290-35A	E145	35F 371M		2.93	M-22	36F 165	2.87	-	-	M290-35A 5	2.90	M290-35A	2.90	
M270-35A	E137	35F 349M		2.75	M-19	36F 155	2.70	35A270	2.70	M270-35A 5	2.70	M270-35A	2.70	
M250-35A	E125	35F 320M		2.53	M-15	36F 145	2.52	35A250	2.50	M250-35A 5	2.50	M250-35A	2.50	
M235-35A	E115	-		-	-	-	-	35A230	2.30	M235-35A 5	2.35	M235-35A	2.35	
M210-35A	E110	-		-	-	-	-	35A210	2.10	-	-	-	-	
M195-35A	E100	-		-	-	-	-	-	-	-	-	-	-	

Note: Core losses at 1.5T / 50 Hz. ASTM A677: thicknesses 0.36 / 0.47 / 0.64 mm.

Core loss values from Standard ASTM A677 converted to 1.5T/50Hz following conversion formula (w17/60 x 0,79)

# Coating

Electrical steels are usually coated in order to minimize occurrence of eddy currents in the core of electrical machines and to reduce energy consumption.

Coating		Characteristics
Aperam	ASTM A976	
C-0	C-0	Uncoated steel, which can contain a very thin stable oxide layer. The electrical resistivity is not guaranteed at the surface. This coating withstands burn-off (up to approximately 540 °C) and stress relief annealing (up to approximately 850 °C) treatments.
C-4	C-4	Inorganic coating formed by the phosphatization of the steel surface. This type of coating is used in applications which require moderate levels of insulation resistance. This coating withstands burn-off (up to approximately 540 °C) and stress relief annealing (up to approximately 850 °C) treatments. It also improves punchability when compared to uncoated steel.
C-6	C-5	Hybrid organic/inorganic coating that is applied to the surface. It is used for applications that require high insulation resistance at the surface and good punchability. The coating withstands burn-off (up to approximately 540 °C) and stress relief annealing (up to approximately 850 °C) treatments.
C-3	C-6	Organic-based coating with addition of inorganic fillers to increase the insulating ability of the coating. It is used for applications that require higher insulation resistance at the surface and good punchability. The coating withstands burn-off treatments (up to approximately 540 °C), but does not withstand stress relief annealing.

The composition of the coating determines most of its properties. The organic composition emphasizes resistivity and drawability, and the inorganic composition emphasizes thermal resistance and weldability.

Coating		Guaranteed Values - Franklin Test		Typical Value	Thickness (per side)
Aperam	ASTM A976	Max. Average * (A)	Max. Per Reading ** (A)	Average (A)	Typical (µm)
C-4	C-4	0.700	0.800	0.500	0.6
C-6	C-5	0.400	0.600	0.150	2.5
C-3	C-6	0.300	0.500	0.100	3.5

\* Average value of ten measurements (five in the upper side and five in the lower side).

\*\* Maximum value of one measurement



Standard Dimensions	
Thickness (mm)	Tolerance (mm)
1.00	+/- 0.05
0.65	+/- 0.05
0.54	+/- 0.04
0.50	+/- 0.04
0.35	+/- 0.03

Standard Dimensions		
Edge	Width (mm)	Tolerance (mm)
Aparada	$30 \leq L \leq 150$	- 0 / + 0.3
	$150 < L \leq 500$	- 0 / + 0.5
	$500 < L \leq 1060$	- 0 / + 1.5
Não Aparada	1010	+/- 10
	1020	- 15 / + 10
	1080	+/- 10

The 0.47 mm thickness product may be supplied upon request. The E230 and E185 steels can be supplied in 1080 mm. Note: For the E100 to E137 steels the maximum width is 1040 mm (trimmed edge).

## Packaging - GO / NGO

Domestic Market	Spacers for strips
	With or without pallet
	Edge protection
	Transparent polyethylene film
	Steel or polyester ribbon
	Vertical / horizontal axis
Overseas Market	Spacers for strips
	Pallet
	Orvic paper (corrosion inhibitor)
	Edge protection
	Transparent polyethylene film
	Wrapper in coated steel or plastic
	Steel ribbon
Vertical axis	

## Aperam South America

### Aperam South America

Av. Carandaí 1.115 – 23º andar  
30130-915 – Belo Horizonte – MG – Brazil  
Tel.: 55 (31) 3235-4200 – Fax: 55 (31) 3235-4294

### Steelworks

Praça 1º de Maio, 9 – Centro  
35180-018 – Timóteo – MG – Brasil  
Tel.: 55 (31) 3849-7000 – Fax: 55 (31) 3848-4699

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