

SECTION 5

NGO STEEL GRADES PRODUCED BY NLMK

STANDARD GRADES UNDER EN 10106 AND GOST 33212

| Grade EN 10106 GOST 33212 | Nominal thickness, mm | Values* | Specific magnetic losses, $P_{1.5/50}$, W/kg, max | Anisotropy of specific magnetic losses, $\Delta P_{1.5/50}$, %, max | Magnetic induction | | |
|---------------------------------|--------------------------|--------------------|---|---|------------------------|--------------------------|---------------------------|
| | | | | | B_{2500} , T, min | B_{5000} , T, min** | B_{10000} , T, min** |
| M250-35A | 0.35 | EN 10106 | 2.50 | ±17 | 1.49 | 1.60 | 1.70 |
| D250-35A | | GOST 33212 | 2.50 | ±17 | 1.49 | - | - |
| | | typical properties | 2.45 | 11 | 1.54 | 1.64 | 1.76 |
| M270-35A | 0.35 | EN 10106 | 2.70 | ±17 | 1.49 | 1.60 | 1.70 |
| D270-35A | | GOST 33212 | 2.70 | ±17 | 1.49 | - | - |
| | | typical properties | 2.62 | 10 | 1.54 | 1.63 | 1.75 |
| M250-50A | 0.50 | EN 10106 | 2.50 | ±17 | 1.49 | 1.60 | 1.70 |
| D250-50A | | GOST 33212 | 2.50 | ±17 | 1.49 | - | - |
| | | typical properties | 2.46 | 11 | 1.56 | 1.65 | 1.77 |
| M270-50A | 0.50 | EN 10106 | 2.70 | ±17 | 1.49 | 1.60 | 1.70 |
| D270-50A | | GOST 33212 | 2.70 | ±17 | 1.49 | - | - |
| | | typical properties | 2.58 | 11 | 1.55 | 1.64 | 1.77 |
| M290-50A | 0.50 | EN 10106 | 2.90 | ±17 | 1.49 | 1.60 | 1.70 |
| D290-50A | | GOST 33212 | 2.90 | ±17 | 1.49 | - | - |
| | | typical properties | 2.75 | 10 | 1.54 | 1.63 | 1.75 |
| M310-50A | 0.50 | EN 10106 | 3.10 | ±14 | 1.49 | 1.60 | 1.70 |
| D310-50A | | GOST 33212 | 3.10 | ±14 | 1.49 | - | - |
| | | typical properties | 2.99 | 9 | 1.52 | 1.62 | 1.75 |
| M330-50A | 0.50 | EN 10106 | 3.30 | ±14 | 1.49 | 1.60 | 1.70 |
| D330-50A | | GOST 33212 | 3.30 | ±14 | 1.49 | - | - |
| | | typical properties | 3.17 | 9 | 1.52 | 1.61 | 1.74 |
| M350-50A | 0.50 | EN 10106 | 3.50 | ±12 | 1.50 | 1.60 | 1.70 |
| D350-50A | | GOST 33212 | 3.50 | ±14 | 1.50 | - | - |
| | | typical properties | 2.98 | 9 | 1.52 | 1.62 | 1.75 |
| M400-50A | 0.50 | EN 10106 | 4.00 | ±12 | 1.53 | 1.63 | 1.73 |
| D400-50A | | GOST 33212 | 4.00 | ±12 | 1.53 | - | - |
| | | typical properties | 3.60 | 9 | 1.58 | 1.67 | 1.79 |
| M470-50A | 0.50 | EN 10106 | 4.70 | ±10 | 1.54 | 1.64 | 1.74 |
| D470-50A | | GOST 33212 | 4.70 | ±10 | 1.54 | - | - |
| | | typical properties | 4.14 | 5 | 1.63 | 1.72 | 1.83 |
| M530-50A | 0.50 | EN 10106 | 5.30 | ±10 | 1.56 | 1.65 | 1.75 |
| D530-50A | | GOST 33212 | 5.30 | ±10 | 1.56 | - | - |
| | | typical properties | 4.92 | 5 | 1.63 | 1.72 | 1.83 |
| M600-50A | 0.50 | EN 10106 | 6.00 | ±10 | 1.57 | 1.66 | 1.76 |
| D600-50A | | GOST 33212 | 6.00 | ±10 | 1.57 | - | - |
| | | typical properties | 4.00 | 6 | 1.62 | 1.71 | 1.82 |
| M700-50A | 0.50 | EN 10106 | 7.00 | ±10 | 1.60 | 1.69 | 1.77 |
| D700-50A | | GOST 33212 | 7.00 | ±10 | 1.60 | - | - |
| | | typical properties | 5.39 | 4 | 1.67 | 1.75 | 1.86 |
| M800-50A | 0.50 | EN 10106 | 8.00 | ±10 | 1.60 | 1.70 | 1.78 |
| D800-50A | | GOST 33212 | 8.00 | ±10 | 1.60 | - | - |
| | | typical properties | 5.40 | 4 | 1.67 | 1.75 | 1.86 |
| M940-50A | 0.50 | EN 10106 | 9.40 | ±8 | 1.62 | 1.72 | 1.81 |
| D940-50A | | GOST 33212 | 9.40 | ±8 | 1.62 | - | - |
| | | typical properties | 5.21 | 4 | 1.66 | 1.74 | 1.85 |

* Parameters under EN and GOST are guaranteed values

** Not specified under GOST 33212

STANDARD GRADES UNDER EN 10106 AND GOST 33212

| Grade EN 10106 GOST 33212 | Nominal thickness, mm | Values* | Specific magnetic losses, $P_{1,5/50}$, W/kg, max | Anisotropy of specific magnetic losses, $\Delta P_{1,5/50}$, %, max | Magnetic induction | | |
|---------------------------------|--------------------------|--------------------|---|---|------------------------|--------------------------|---------------------------|
| | | | | | B_{2500} , T, min | B_{5000} , T, min** | B_{10000} , T, min** |
| M400-65A | 0.65 | EN 10106 | 4.00 | ± 14 | 1.52 | 1.62 | 1.72 |
| D400-65A | | GOST 33212 | 4.00 | ± 14 | 1.52 | - | - |
| | | typical properties | 3.29 | 8 | 1.56 | 1.66 | 1.78 |
| M470-65A | 0.65 | EN 10106 | 4.70 | ± 12 | 1.53 | 1.63 | 1.73 |
| D470-65A | | GOST 33212 | 4.70 | ± 12 | 1.53 | - | - |
| | | typical properties | 3.85 | 9 | 1.61 | 1.70 | 1.81 |
| M530-65A | 0.65 | EN 10106 | 5.30 | ± 12 | 1.54 | 1.64 | 1.74 |
| D530-65A | | GOST 33212 | 5.30 | ± 12 | 1.54 | - | - |
| | | typical properties | 4.77 | 4 | 1.62 | 1.71 | 1.82 |

HIGH-PERMEABILITY GRADES UNDER GOST 33212

Used in electric motors with high torque and power generators with stricter requirements to size.
The desired properties are achieved through improved magnetic induction.

| Grade | Nominal thickness, mm | Values* | Specific magnetic losses, $P_{1,5/50}$, W/kg, max | Anisotropy of specific magnetic losses, $\Delta P_{1,5/50}$, %, max | Magnetic induction | | |
|-----------|--------------------------|--------------------|---|---|------------------------|--------------------------|---------------------------|
| | | | | | B_{2500} , T, min | B_{5000} , T, min** | B_{10000} , T, min** |
| D310-50AP | 0.50 | GOST 33212 | 3.10 | ± 14 | 1.55 | - | - |
| | | typical properties | 2.84 | 10 | 1.59 | 1.69 | 1.81 |
| D330-50AP | 0.50 | GOST 33212 | 3.30 | ± 14 | 1.55 | - | - |
| | | typical properties | 3.05 | 9 | 1.61 | 1.70 | 1.81 |
| D350-50AP | 0.50 | GOST 33212 | 3.50 | ± 12 | 1.59 | - | - |
| | | typical properties | 3.07 | 10 | 1.61 | 1.70 | 1.81 |
| D400-50AP | 0.50 | GOST 33212 | 4.00 | ± 12 | 1.61 | - | - |
| | | typical properties | 3.39 | 9 | 1.62 | 1.71 | 1.82 |

HIGH-FREQUENCY GRADES UNDER EN 10303

Used in EV motors that operate at or above 400 Hz. The steel is purposefully designed to achieve optimal losses at those specific frequencies.

| Grade | Nominal thickness, mm | Values* | Specific magnetic losses, $P_{1,0/400}$, W/kg, max | Magnetic induction | | | Yield strength, σ_T , N/mm ² |
|-------------|--------------------------|--------------------|--|------------------------|------------------------|-------------------------|--|
| | | | | B_{2500} , T, min | B_{5000} , T, min | B_{10000} , T, min | |
| N025-14**** | 0.25 | guaranteed | 13.0 | 1.55 | 1.65 | 1.77 | 400 |
| | | typical properties | 12.7 | 1.56 | 1.66 | 1.78 | 410 |
| N025-14 | 0.25 | EN 10303 | 14.0 | 1.48 | 1.59 | 1.69 | 390 |
| | | typical properties | 13.7 | 1.52 | 1.62 | 1.72 | 410 |
| N027-15*** | 0.27 | guaranteed | 15.0 | 1.55 | 1.65 | 1.76 | 370 |
| | | typical properties | 14.5 | 1.56 | 1.66 | 1.77 | 410 |
| N027-15 | 0.27 | EN 10303 | 15.0 | 1.48 | 1.59 | 1.69 | 370 |
| | | typical properties | 14.5 | 1.54 | 1.63 | 1.75 | 410 |
| N030-16*** | 0.30 | guaranteed | 16.0 | 1.55 | 1.65 | 1.76 | 420 |
| | | typical properties | 15.5 | 1.57 | 1.66 | 1.77 | 410 |
| N030-19 | 0.30 | EN 10303 | 19.0 | 1.49 | 1.60 | 1.70 | 320 |
| | | typical properties | 16.0 | 1.54 | 1.64 | 1.75 | 410 |
| N035-19**** | 0.35 | guaranteed | 17.5 | 1.55 | 1.65 | 1.75 | 400 |
| | | typical properties | 17.0 | 1.57 | 1.66 | 1.76 | 410 |
| N035-19 | 0.35 | EN 10303 | 19.0 | 1.49 | 1.60 | 1.70 | 370 |
| | | typical properties | 17.2 | 1.54 | 1.64 | 1.75 | 410 |

* Parameters under EN and GOST are guaranteed values

** Not specified under GOST 33212

*** Advanced induction grades

****Advanced induction and lower loss grades

GUARANTEED PROPERTIES UNDER GOST 21427

| Nominal thickness, mm | Grade | Specific magnetic losses, $P_{1,5/50}$, W/kg, max | Magnetic induction, B_{5000} , T, min | Anisotropy of specific magnetic losses, $\Delta P_{1,5/50}$, %, max | Anisotropy of magnetic induction, ΔB_{5000} , T, max | Stacking factor*, min | Bends, min |
|-----------------------|-------|--|---|--|--|-----------------------|------------|
| 0.35 | 2413 | 2.5 | 1.50 | ±18 | 0.16 | 0.95 | 2 |
| | 2412 | 2.7 | 1.50 | ±18 | 0.16 | 0.95 | 2 |
| | 2411 | 3.0 | 1.50 | ±18 | 0.16 | 0.95 | 2 |
| 0.50 | 2414 | 2.7 | 1.49 | ±18 | 0.16 | 0.96 (0.95) | 1 |
| | 2413 | 2.9 | 1.50 | ±18 | 0.16 | 0.96 (0.95) | 1 |
| | 2412 | 3.1 | 1.50 | ±18 | 0.16 | 0.96 (0.95) | 1 |
| | 2411 | 3.6 | 1.49 | ±18 | 0.16 | 0.96 (0.95) | 1 |
| | 2312 | 3.8 | 1.58 | ±14 | 0.16 | 0.96 (0.95) | 2 |
| | 2216 | 4.0 | 1.60 | ±12 | 0.13 | 0.96 (0.95) | 3 |
| | 2215 | 4.5 | 1.64 | ±12 | 0.13 | 0.96 (0.95) | 3 |
| | 2214 | 4.8 | 1.62 | ±12 | 0.13 | 0.96 (0.95) | 3 |
| | 2213 | 5.0 | 1.65 | ±12 | 0.13 | 0.96 (0.95) | 3 |
| | 2212 | 5.0 | 1.60 | ±12 | 0.13 | 0.96 (0.95) | 3 |
| | 2211 | 5.5 | 1.56 | ±12 | 0.13 | 0.96 (0.95) | 3 |
| 0.50 | 2112 | 6.0 | 1.62 | ±12 | 0.13 | 0.96 (0.95) | - |
| | 2111 | 7.0 | 1.60 | ±12 | 0.13 | 0.96 (0.95) | - |
| | 2013 | 6.5 | 1.65 | ±10 | 0.13 | 0.96 (0.95) | - |
| | 2012 | 7.0 | 1.62 | ±10 | 0.13 | 0.96 (0.95) | - |
| | 2011 | 8.0 | 1.60 | ±10 | 0.13 | 0.96 (0.95) | - |

* For coated steel: Group A (Group B)

GUARANTEED MECHANICAL PROPERTIES UNDER GOST 21427

| Grade | Ultimate tensile strength, σ_B , N/mm ² | Relative elongation, δ_4 , % | Hardness, HV ₅ |
|-----------|---|-------------------------------------|---------------------------|
| 2411-2414 | 370-600 | 15-30 | 140-210 |
| 2312 | 330-470 | 20-35 | 120-160 |
| 2216-2211 | 300-450 | 20-35 | 120-145 |
| 2111-2112 | 300-450 | 20-35 | 110-145 |
| 2011-2013 | 290-490 | 15-35 | 120-160 |

TYPICAL MAGNETIC AND MECHANICAL PROPERTIES UNDER GOST 21427

| Nominal thickness, mm | Grade | Specific magnetic losses, $P_{1,0/50}$, W/kg | Specific magnetic losses, $P_{1,5/50}$, W/kg | Anisotropy of specific magnetic losses, $\Delta P_{1,5/50}$, % | Magnetic induction, B_{2500} , t | Magnetic induction, B_{5000} , t | Magnetic induction, B_{10000} , t | Yield strength, σ_r , N/mm ² | Ultimate tensile strength, σ_B , N/mm ² | Relative elongation, δ_4 , % | Hardness, HV ₅ |
|-----------------------|-------|---|---|---|------------------------------------|------------------------------------|-------------------------------------|--|---|-------------------------------------|---------------------------|
| 0.35 | 2412 | 0.97 | 2.29 | 9 | 1.54 | 1.64 | 1.76 | 403 | 516 | 16 | 200 |
| 0.50 | 2412 | 1.24 | 2.97 | 8 | 1.52 | 1.61 | 1.74 | 390 | 514 | 20 | 203 |
| | 2411 | 1.3 | 3.04 | 8 | 1.52 | 1.61 | 1.74 | 384 | 506 | 19 | 201 |
| | 2312 | 1.59 | 3.66 | 8 | 1.6 | 1.69 | 1.81 | 246 | 407 | 29 | 137 |
| | 2212 | 1.83 | 4.11 | 6 | 1.63 | 1.71 | 1.82 | 226 | 390 | 31 | 127 |
| | 2112 | 2.13 | 4.73 | 4 | 1.65 | 1.73 | 1.85 | 274 | 404 | 30 | 127 |
| | 2012 | 2.58 | 5.61 | 4 | 1.64 | 1.7 | 1.855 | 283 | 404 | 31 | 128 |

ALIGNMENT OF FULLY PROCESSED NGO STEELS ACROSS DIFFERENT STANDARDS

| Nominal thickness, mm | Europe | | | | Russia | | | | | | USA | | India | | |
|-----------------------|----------|----------------------------|-----------------------|-----------------------|------------|----------------------------|-----------------------|------------|----------------------------|-----------------------|-----------|----------------------------|--------|----------------------------|-----------------------|
| | EN 10106 | | | | GOST 33212 | | | GOST 21427 | | | ASTM A677 | | IS 648 | | |
| | Grade | P _{1,5/50} , W/kg | B ₂₅₀₀ , T | B ₅₀₀₀ , T | Grade | P _{1,5/50} , W/kg | B ₂₅₀₀ , T | Grade | P _{1,5/50} , W/kg | B ₂₅₀₀ , T | Grade | P _{1,5/50} , W/kg | Grade | P _{1,5/50} , W/kg | B ₂₅₀₀ , T |
| 0.35 | M250-35A | 2.50 | 1.49 | 1.60 | Д250-35A | 2.50 | 1.49 | 2413 | 2.50 | 1.50 | 36F145 | 2.53 | 35C250 | 2.50 | 1.49 |
| | M270-35A | 2.70 | 1.49 | 1.60 | Д270-35A | 2.70 | 1.49 | 2412 | 2.70 | 1.50 | 36F155 | 2.70 | 35C270 | 2.70 | 1.49 |
| | - | - | - | - | - | - | - | - | - | - | 36F165 | 2.88 | - | - | - |
| | - | - | - | - | - | - | - | - | - | - | 36F175 | 3.05 | - | - | - |
| | M330-35A | 3.30 | 1.49 | 1.60 | Д330-35A | 3.30 | 1.49 | - | - | - | 36F185 | 3.22 | 35C330 | 3.30 | 1.49 |
| | - | - | - | - | - | - | - | - | - | - | - | - | 35C360 | 3.60 | 1.49 |
| 0.50 | M250-50A | 2.50 | 1.49 | 1.60 | Д250-50A | 2.50 | 1.49 | - | - | - | - | - | 50C250 | 2.50 | 1.49 |
| | M270-50A | 2.70 | 1.49 | 1.60 | Д270-50A | 2.70 | 1.49 | 2414 | 2.70 | 1.49 | - | - | 50C270 | 2.70 | 1.49 |
| | M290-50A | 2.90 | 1.49 | 1.60 | Д290-50A | 2.90 | 1.49 | 2413 | 2.90 | 1.50 | 47F165 | 2.88 | 50C290 | 2.90 | 1.49 |
| | M310-50A | 3.10 | 1.49 | 1.60 | Д310-50A | 3.10 | 1.49 | 2412 | 3.10 | 1.50 | - | - | 50C310 | 3.10 | 1.49 |
| | - | - | - | - | - | - | - | - | - | - | 47F180 | 3.14 | - | - | - |
| | M330-50A | 3.30 | 1.49 | 1.60 | Д330-50A | 3.30 | 1.49 | - | - | - | 47F190 | 3.31 | 50C330 | 3.30 | 1.49 |
| | M350-50A | 3.50 | 1.50 | 1.60 | Д350-50A | 3.50 | 1.50 | - | - | - | 47F200 | 3.48 | 50C350 | 3.50 | 1.50 |
| | - | - | - | - | - | - | - | 2411 | 3.60 | 1.49 | 47F210 | 3.66 | - | - | - |
| | - | - | - | - | - | - | - | 2312 | 3.80 | 1.58 | - | - | - | - | - |
| | M400-50A | 4.00 | 1.53 | 1.63 | Д400-50A | 4.00 | 1.53 | 2216 | 4.00 | 1.60 | 47F240 | 4.18 | 50C400 | 4.00 | 1.53 |
| | - | - | - | - | - | - | - | 2215 | 4.50 | 1.64 | - | - | - | - | - |
| | M470-50A | 4.70 | 1.54 | 1.64 | Д470-50A | 4.70 | 1.54 | - | - | - | - | - | 50C470 | 4.70 | 1.54 |
| | - | - | - | - | - | - | - | 2214 | 4.80 | 1.62 | 47F280 | 4.87 | - | - | - |
| | - | - | - | - | - | - | - | 2213 | 5.00 | 1.65 | - | - | - | - | - |
| | - | - | - | - | - | - | - | 2212 | 5.00 | 1.60 | - | - | - | - | - |
| | M530-50A | 5.30 | 1.56 | 1.65 | Д530-50A | 5.30 | 1.56 | - | - | - | - | - | 50C530 | 5.30 | 1.56 |
| | - | - | - | - | - | - | - | 2211 | 5.50 | 1.56 | - | - | - | - | - |
| | M600-50A | 6.00 | 1.57 | 1.66 | Д600-50A | 6.00 | 1.57 | 2112 | 6.00 | 1.62 | - | - | 50C600 | 6.00 | 1.57 |
| | M700-50A | 7.00 | 1.60 | 1.69 | Д700-50A | 7.00 | 1.60 | 2111 | 7.00 | 1.60 | 47F400 | 6.97 | 50C700 | 7.00 | 1.60 |
| | - | - | - | - | - | - | - | 2013 | 6.50 | 1.65 | - | - | - | - | - |
| | - | - | - | - | - | - | - | 2012 | 7.00 | 1.62 | - | - | - | - | - |
| M800-50A | 8.00 | 1.60 | 1.70 | Д800-50A | 8.00 | 1.60 | 2011 | 8.00 | 1.60 | 47F450 | 7.84 | 50C800 | 8.00 | 1.60 | |
| - | - | - | - | - | - | - | - | - | - | - | - | 50C900 | 9.00 | 1.61 | |
| M940-50A | 9.40 | 1.62 | 1.72 | Д940-50A | 9.40 | 1.62 | - | - | - | - | - | - | - | - | |
| - | - | - | - | - | - | - | - | - | - | - | - | 50C1000 | 10.00 | 1.62 | |
| 0.65 | M400-65A | 4.00 | 1.52 | 1.62 | Д400-65A | 4.00 | 1.52 | - | - | - | 64F235 | 4.09 | 65C400 | 4.00 | 1.52 |
| | M470-65A | 4.70 | 1.53 | 1.63 | Д470-65A | 4.70 | 1.53 | - | - | - | - | - | 65C470 | 4.70 | 1.53 |
| | M530-65A | 5.30 | 1.54 | 1.64 | Д530-65A | 5.30 | 1.54 | - | - | - | - | - | 65C530 | 5.30 | 1.54 |