It’s all about the right balance

With its leading experience in EDM, Mersen has developed a complete range of graphite grades aiming to answer to the widest range of electrode designs and workpiece materials.

The selection of the right graphite grades will depend on numerous factors. Mersen’s expertise will guide you to the proper conclusion. There are 4 key factors that will largely impact your selection.

**WEAR RESISTANCE (WR)**

Or how long will the electrode be able to maintain the level of details during the spark erosion process?

A good Wear Resistance control of your graphite electrode means fewer electrodes to do the same job, less time and decreased manufacturing cost.

Low graphite wear will determine the accuracy of the work. The material loss is more significant with coarse grain graphites since the amount of wear will be greater than with fine grain graphite at the same operating parameters.

**METAL REMOVAL RATE (MRR)**

Or how fast will the graphite electrode remove material during the spark erosion process?

Typically the larger the grain of the electrode graphite, the higher the Metal Removal Rate.

Typically, with each spark, a fine grain graphite grade will remove less metal on the work piece than a coarse grain graphite but will have a smoother surface finish.
GRAPHITE VS COPPER

**Easy to machine**
- It is much easier to fabricate an electrode out of graphite than copper.

**5 times lighter**
- Graphite has a low density so electrodes weigh less. This is a critical factor as electrodes become larger.

**Greater geometrical stability**
- Due to its low Coefficient of Thermal Expansion, graphite will not expand as much as copper, allowing it to maintain its critical dimensions.

**Metal Removal Rate is doubled**
- Graphite has a metal removal rate 2 times higher than copper with lower electrode wear.

**Much less Wear**
- Graphite does not melt but sublimes at 3,400° C, providing much greater wear resistance than the low melting point of copper.

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**SURFACE FINISH**

Or how smooth should your workpiece surface be?

Fine grain graphite grades will be the preferred choice to erode very fine and smooth surfaces up to 0.4 Ra(µm). The greatest advantages are when complicated cavities are involved. Such cavities are difficult, time consuming and therefore expensive to polish manually.

When a very high quality finish is needed, the operator follows a high-speed roughing cut with one or more finishing - skimming, to use EDM terminology - cuts. By taking multiple skimming passes, EDM finish quality can become almost mirror-like.

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**MACHINABILITY**

Or how easy the material can be machined into fine details with good finish?

Graphite grades are not equal when it comes to machining them into electrodes. Ultra-fine particle sizes are key to achieve a perfect accuracy of the electrode. Time to produce an electrode is highly related to:
- the grain size of the grade
- its strength along with the complexity of the electrode to be machined.
UNIVERSAL FINE GRAIN GRADE

For high metal removal rate with excellent performance ratio

YOUR BENEFITS:

- Production cycles shortened with high removal rate capacities
- Excellent machinability
- Best choice for medium surface finish
- Ellor® +18 recommended for die casting molds in aluminium

WEAR RESISTANCE: 3/5
METAL REMOVAL RATE: 5/5
SURFACE FINISH: 3/5
MACHINABILITY: 4/5
<table>
<thead>
<tr>
<th>GRAIN SIZE</th>
<th>HARDNESS SHORE</th>
<th>HARDNESS ROCKWELL</th>
<th>DENSITY</th>
<th>FLEXURAL STRENGTH</th>
<th>ELECTRICAL RESISTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>µm</td>
<td>inch</td>
<td></td>
<td>g/cm³</td>
<td>MPa</td>
<td>ohm.cm ohm.inch</td>
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<tr>
<td>12</td>
<td>0.0005</td>
<td>62</td>
<td>1,78</td>
<td>45</td>
<td>1370 0.00054</td>
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<tr>
<td>11</td>
<td>0.0005</td>
<td>65</td>
<td>1,81</td>
<td>52</td>
<td>1240 0.00049</td>
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</table>

**Ellor® +18**

**Ellor® +20**
UNIVERSAL SUPERFINE GRAIN GRADE

multi-skilled, multi-talented. You will love it.

YOUR BENEFITS:
- Good removal rate capabilities
- Superior strength and wear resistance characteristics for longer life time
- Easy to machine
- Excellent surface finish up to 1.6 Ra(µm)

Ellor® +25

WEAR RESISTANCE: 4/5
METAL REMOVAL RATE: 4.5/5
SURFACE FINISH: 4/5
MACHINABILITY: 4.5/5
ELECTRICAL RESISTIVITY
- ohm.inch: 0.00048
- µohm.cm: 1220

FLEXURAL STRENGTH
- Density: 114 lbs/ft³

HARDNESS
- ROCKWELL: 80 H
- SHORE: 65

GRAIN SIZE
- µm: 9
- inch: 0.0004

ELLOR® + 25 also exists in copper impregnated graphite grade for a higher electrical conductivity and improved performance.
EXCEPTIONAL SUPERFINE GRAIN GRADES for outstanding performances

Ellor® + 30
Ellor® + 40
Ellor® + 50

YOUR BENEFITS:

- Exceptional surface finish up to 0.56 Ra(µm)
- Outstanding strength and wear resistance to keep a high performance even with intricate designs
- Excellent Metal Removal Rate (MRR)
- Preferred grades from mobile phone manufacturers

WEAR RESISTANCE
METAL REMOVAL RATE
SURFACE FINISH
MACHINABILITY

4.7/5
4.5/5
4.7/5
4/5
<table>
<thead>
<tr>
<th>GRAIN SIZE</th>
<th>HARDNESS SHORE</th>
<th>HARDNESS ROCKWELL</th>
<th>DENSITY</th>
<th>FLEXURAL STRENGTH</th>
<th>ELECTRICAL RESISTIVITY</th>
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<tbody>
<tr>
<td>µm</td>
<td>inch</td>
<td></td>
<td>g/cm³</td>
<td>MPa</td>
<td>Ω·cm Ω·inch</td>
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<tr>
<td>Ellor® + 30</td>
<td>8</td>
<td>&lt;80</td>
<td>90 H</td>
<td>1.84</td>
<td>65 111</td>
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<td>1.86</td>
<td>76 11,000</td>
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</table>
THE PREMIUM ULTRAFINE GRAIN GRAPHITE

The star...call it Dark Star

YOUR BENEFITS:

- Exceptional surface finish up to 0.40 Ra(µm)
- Outstanding strength and wear resistance to keep a high performance even with intricate designs

WEAR RESISTANCE: 5/5
METAL REMOVAL RATE: 4.5/5
SURFACE FINISH: 5/5
MACHINABILITY: 5/5
<table>
<thead>
<tr>
<th>GRAIN SIZE</th>
<th>HARDNESS SHORE</th>
<th>HARDNESS ROCKWELL</th>
<th>DENSITY g/cm³</th>
<th>FLEXURAL STRENGTH MPa</th>
<th>ELECTRICAL RESISTIVITY ohm.cm ohm.inch</th>
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<tr>
<td>Ellor® + DS4</td>
<td>4 0.0002</td>
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<td>3,00 187</td>
<td>131 19,000</td>
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A COMPLETE OFFERING OF EDM GRADES TO COVER ALL YOUR NEEDS

<table>
<thead>
<tr>
<th></th>
<th>AVERAGE GRAIN SIZE</th>
<th>DENSITY</th>
<th>HARDNESS ROCKWELL</th>
<th>HARDNESS SHORE</th>
<th>FLEXURAL STRENGTH</th>
<th>ELECTRICAL RESISTIVITY</th>
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<tr>
<td></td>
<td>µm</td>
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<td>g/cm³</td>
<td>lbs/ft³</td>
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<td>psi</td>
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**RECOMMENDED GRADES**

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<th>GRADE</th>
<th>Ellor +18</th>
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<th>Ellor +25</th>
<th>Ellor +30</th>
<th>Ellor +40</th>
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</table>

**OPERATIONS**

**STEEL**

- Ellor +18
- Ellor +20
- Ellor +25
- Ellor +30
- Ellor +40
- Ellor +50
- Ellor +DS4

**MATERIAL TO BE MACHINED**

- REFRACTORY STEEL
- TITANIUM, MOLYBDENUM, COPPER
- TUNGSTEN, CARBIDE

**SURFACE FINISH ACHIEVABLE ON STEEL WITH ELLOR® GRAPHITE**

<table>
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<tr>
<th>FINISHING MODE</th>
<th>INTERMEDIATE</th>
<th>ROUGHING</th>
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<td>Ellor +DS4</td>
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<td>Ellor +50</td>
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<tr>
<td>Ellor +25</td>
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<td></td>
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<tr>
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<tr>
<td>Ellor +18</td>
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<th>VDI 3400</th>
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<th>18</th>
<th>21</th>
<th>24</th>
<th>27</th>
<th>30</th>
<th>33</th>
<th>36</th>
<th>39</th>
<th>42</th>
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</thead>
<tbody>
<tr>
<td>Ra[µm]</td>
<td>0.40</td>
<td>0.56</td>
<td>0.80</td>
<td>1.12</td>
<td>1.60</td>
<td>2.24</td>
<td>3.15</td>
<td>4.50</td>
<td>6.30</td>
<td>9.00</td>
<td>12.50</td>
<td>18.00</td>
</tr>
<tr>
<td>Ra[µinch]</td>
<td>16</td>
<td>22</td>
<td>31</td>
<td>44</td>
<td>63</td>
<td>88</td>
<td>124</td>
<td>177</td>
<td>248</td>
<td>354</td>
<td>492</td>
<td>709</td>
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</tbody>
</table>
READY TO CLAMP ELECTRODES

SQUARE BAR, ROUND BARS AND FOIL SHEETS

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OUR RECOMMENDATIONS TO GET THE MOST OF ELLOR® ELECTRODES

Good EDM results require not only the proper selection of EDM material, but also proper machine settings, such as peak current, on time, off time, gap size, electrode polarity and most importantly the flushing conditions.

TIPS FOR ERODING WITH GRAPHITE ELECTRODES

ROUGHING
- High discharge current causes high erosion and a rough surface

SIZING
- Low discharge current causes a low removal and a fine surface

SURFACE ROUGHNESS
- High discharge current causes high erosion and a rough surface
- Low discharge current causes a low removal and a fine surface
- Surfaces up to VDI 12 are possible, if given the right selection of graphite

CONTOUR AND DIMENSIONAL ACCURACY
- Is always given due to the low thermal expansion of graphite
- Graphite is thermally stable and distortion-free

TIME SAVING
- Through linking multiple electrodes

AVOID ARCING
- Improve pulse duration
- Lower downtime
- Increase set point
- Improve flushing conditions

ELECTRODE WEAR
- Decreases with increasing pulse duration and decreasing pulse break

EDM DIE SINKING PROCESS

CURRENT AND VOLTAGE SCHEMATIC VIEW

(t) pulse duration (S)
(to) pause duration (S)
(te) discharging duration (S)
(Ui) open circuit voltage (V)
(Ue) voltage discharge (V)
(ie) current (Amp)
(td) discharge delay time (S)

MACHINING RECOMMENDATION

<table>
<thead>
<tr>
<th>MACHINING</th>
<th>SPEED m/min</th>
<th>ADVANCE mm per revolution</th>
<th>DEPTH OF CUTTING in mm</th>
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<tbody>
<tr>
<td>MILLING</td>
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<tr>
<td>ROUGHING</td>
<td>800–1000</td>
<td>0,1–0,8</td>
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</tr>
<tr>
<td>FINISH</td>
<td>1000</td>
<td>&lt;0,09</td>
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</tr>
<tr>
<td>TURNING</td>
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<tr>
<td>ROUGHING</td>
<td>100–250</td>
<td>0,3–0,45</td>
<td>5–19</td>
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<td>0,06–0,15</td>
<td>0,1–0,5</td>
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<td>RECTIFICATION</td>
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<td>150–800</td>
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<td>300–400</td>
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