HIGH-POWER LASER CUTTING

THE POWER OF LIGHT
Laser Flame Cutting of Mild Steel

![Graph showing cutting speed vs laser power for different thicknesses of mild steel using CO₂ Slab Laser and Fiber Laser. The graph illustrates the relationship between laser power and cutting speed for 1 mm, 2 mm, 4 mm, and 6 mm thick materials.]
Laser Flame Cutting of Mild Steel

Cutting of mild steel (up to 6 mm) with O₂ cutting gas:

- Cutting speed limited by combustion process
- Saturation of cutting speed for higher laser power
- Comparable cutting speeds for CO₂ Slab and fiber laser
- Cost effective cut with adapted laser power
- Cutting with nitrogen/air can be faster and more cost efficient

Please note:

All application data in this book reflect trials performed in the application lab at ROFIN-SINAR Laser GmbH, Hamburg/Germany. Installations using customer specific system technology and parts preparation might lead to different results. Therefore the given data cannot be guaranteed.
Laser Flame Cutting of Mild Steel

![Graph showing cutting speed vs laser power for different thicknesses of steel using CO₂ Slab Laser and Fiber Laser.](image)
Laser Flame Cutting of Mild Steel

Cutting of mild steel (8-25 mm) with $O_2$ cutting gas:

- Increase of cutting speed with higher laser power
- Comparable cutting speeds for $CO_2$ Slab and fiber laser
- Edge quality better with $CO_2$ Slab laser
High-Speed Cutting of 1 mm Stainless Steel

![Graph showing cutting speed versus laser power for Fiber Laser and CO₂ Slab Laser.]

- **Fiber Laser**
- **CO₂ Slab Laser**
High-Speed Cutting of 1 mm Stainless Steel

- CO\textsubscript{2} Slab laser using so called laser generated plasma cut
- Fiber laser cuts two times faster
- Process stability better with fiber laser
- Linear increase of cutting speed with laser power
Cutting of 4 mm Stainless Steel

![Graph showing cutting speed vs laser power for Fiber Laser and CO₂ Slab Laser.](image)

- **Fiber Laser**
- **CO₂ Slab Laser**
Cutting of 4 mm Stainless Steel

- Cutting speed increases linearly with laser power
- Fiber laser cuts approx. two times faster
- Edge quality better with CO$_2$ Slab laser
- Cutting speed exceeds CO$_2$ laser flame cutting speed at 3 kW fiber laser power
Cutting of 4 and 8 mm Stainless Steel

The graph compares the cutting speeds of different laser types at varying powers for 4mm and 8mm stainless steel. The graph shows:

- **Fiber Laser**
- **CO₂ Slab Laser**

Cutting speed is measured in meters per minute (m/min) on the y-axis, and laser power in kilowatts (kW) on the x-axis. The graph indicates that both Fiber Laser and CO₂ Slab Laser have higher cutting speeds with increased laser power.
Cutting of 4 and 8 mm Stainless Steel

- Cutting speed increases linearly with laser power
- Fiber laser cuts faster
- Edge quality slightly better with CO$_2$ Slab laser
# ROFIN Fiber Lasers

Standard version with separate housing for fiber handling

## Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>FL x50</th>
<th>FL x75</th>
<th>FL 010</th>
<th>FL 015</th>
<th>FL 020</th>
<th>FL 030</th>
<th>FL 040</th>
<th>FL 060</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Power</td>
<td>500 W</td>
<td>750 W</td>
<td>1000 W</td>
<td>1500 W</td>
<td>2000 W</td>
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<td>4000 W</td>
<td>6000 W</td>
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<tr>
<td>Available Fiber Optics</td>
<td>50-1000 µm</td>
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<td></td>
</tr>
<tr>
<td>Beam Quality</td>
<td>3-4 mm x mrad (using a 100 µm fiber)</td>
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<tr>
<td>Cabinet Characteristics</td>
<td>up to 4 process fibers&lt;br&gt;Multi-mode lasers using fiber-fiber-switch (FFS)&lt;br&gt;Handheld controller terminal (option)&lt;br&gt;Design with feet (standard) or casters (option)&lt;br&gt;Integrated scanner control for up to 2 scanners&lt;br&gt;IO interfaces, fieldbus interface (option)</td>
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</table>

ROFIN Fiber Lasers

Standard version with separate housing for fiber handling
# ROFIN Fiber Lasers

Compact version for easy integration

<table>
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<tr>
<th>Model</th>
<th>FL x50 C</th>
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<td>1500 W</td>
<td>2000 W</td>
<td>3000 W</td>
<td>4000 W</td>
<td>6000 W</td>
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<tr>
<td>Available Fiber Optics</td>
<td>20 µm 50 µm</td>
<td>50 µm 100 µm</td>
<td>100 µm (50 µm opt.)</td>
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</tr>
<tr>
<td>Beam Quality</td>
<td>0,4 mm x mrad (using a 20 µm fiber)</td>
<td>≤ 2,5 mm x mrad (using a 50 µm fiber)</td>
<td>3-4 mm x mrad (using a 100 µm fiber)</td>
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</tr>
<tr>
<td>Cabinet Characteristics</td>
<td>Standard interface</td>
<td>Fieldbus interface optional</td>
<td>Standard fiber length: Multi-mode: 15 m (other lengths on request) Single-mode: 8 m</td>
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</tbody>
</table>
FIBER LASERS – YOUR BENEFIT

- All fiber technology – robust, reliable, efficient
- High wall plug efficiency of more than 30 %
- Wide range of beam qualities adapted to your needs from single-mode to multi-mode (0.4 mm x mrad to 40 mm x mrad)
- Flexibility by using fast switching and beam splitting with up to 4 fiber outputs in multi-mode
- No general maintenance, just inspections in after sales service
- Fast analog input enables the shortest cutting times
- Back reflection handling:
  - High tolerance against process back reflection
  - Safe protection of the laser against damage
- Interface: Rofin Control Unit (RCU)
  - Compatible to all other MACRO products
  - Rofin Remote Service available as an option
# ROFIN CO₂ Slab Lasers

<table>
<thead>
<tr>
<th>Model</th>
<th>DC 010</th>
<th>DC 015</th>
<th>DC 020</th>
<th>DC 025</th>
<th>DC 030</th>
<th>DC 035</th>
<th>DC 040</th>
<th>DC 050</th>
<th>DC 060</th>
<th>DC 080*</th>
</tr>
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<tbody>
<tr>
<td>Output Power</td>
<td>1000 W</td>
<td>1500 W</td>
<td>2000 W</td>
<td>2500 W</td>
<td>3000 W</td>
<td>3500 W</td>
<td>4000 W</td>
<td>5000 W</td>
<td>6000 W</td>
<td>8000 W</td>
</tr>
<tr>
<td>Beam Quality</td>
<td>$M^2 = 1.05$</td>
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<tr>
<td>Pulse Frequency</td>
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</tr>
</tbody>
</table>

Cabinet Characteristics

- Head/cabinet combination – with wall mountable, space-saving control cabinet and optional touch panel on the control cabinet for easy operation.
- Compact version – laser head and control cabinet in one compact unit

*revised version available in 2015
CO$_2$ SLAB LASERS – YOUR BENEFIT

- A proven principle built to the highest industrial standards
- High beam quality of $M^2 = 1.05$ for best application results
- Low maintenance due to the absence of consumables
- Low service costs thanks to the robust design
- No gas recirculation due to diffusion cooling (no gas flow)
- Reduced gas consumption due to 7 days gas exchange intervals
- Minimal energy consumption while in standby
- New cabinet design: 45% smaller footprint due to wall mountability (standard)
- Interface: Rofin Control Unit (RCU)
  - Compatible to all other MACRO products
  - Rofin Remote Service available as an option
HIGH-POWER LASER WELDING

THE POWER OF LIGHT
Process Efficiency in Laser Welding

- DC 060 weld mild steel f 300
- FL 040 weld mild steel 200µm 1:1
Process Efficiency in Laser Welding

- The 4 kW fiber laser FL 040 achieves the penetration of a 6 kW fundamental mode DC 060 CO$_2$ Slab laser.

- Above approx. 6 mm material thicknesses, the higher power of the CO$_2$ laser gains an advantage.

Please note:

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Process Efficiency in Laser Welding

- **DC 060 weld mild steel f 300**
- **FL 060 weld mild steel 200µm**

Graph showing the relationship between speed [m/min] and thickness/penetration [mm].
Process Efficiency in Laser Welding

- Comparing 6 kW fiber laser FL 060 and 6 kW CO₂ Slab laser DC 060, the fiber laser can weld faster due to increased process efficiency.
Seam Shaping with Fiber Lasers

Speed [m/min] vs. Thickness/Penetration [mm]

- FL 040 weld mild steel 100µm
- FL 040 weld mild steel 200µm 1:1
- FL 040 weld mild steel 400µm
- FL 040 weld mild steel 600µm
An easy exchange of the fiber size allows the adjustment of the focus size adapted to the required specification (example at 5 m/min and 4 kW):
Seam Shaping with CO$_2$ Slab Laser

- DC 045 weld mild steel f 200
- DC 045 weld mild steel f 300
- DC 045 weld mild steel f 500

Graph showing the relationship between speed (m/min) and thickness/penetration (mm) for different welding conditions.
Seam Shaping with CO\textsubscript{2} Slab Laser

- Seam shaping by selection of spot size using different focal lengths with Gauss mode CO\textsubscript{2} Slab laser
- Larger spot size causes lower penetration and a wider weld
CO$_2$ Laser DC 080 – Gauss & Donut Mode

![Graph showing the relationship between speed (m/min) and thickness/penetration (mm) for DC 080 Donut weld mild steel f 300 and DC 080 weld mild steel f 300.]
**CO$_2$ Laser DC 080 – Gauss & Donut Mode**

Beam shaping by selection of beam quality:

**Gauss Mode:**
Highest possible beam quality ($M^2 \approx 1$) for narrow welds and high welding speeds.

**Donut Mode:**
Higher order mode ($M^2 \approx 2.2$) with donut-shaped intensity for wider welds and higher tolerances.
CO$_2$ Slab Laser – Power Scaling

- DC 025 weld mild steel f 200
- DC 040 weld mild steel f 300
- DC 060 weld mild steel f 300
- DC 080 weld mild steel f 300
# Laser Welding: Comparison of Technologies

<table>
<thead>
<tr>
<th>Feature</th>
<th>CO₂ Slab Laser</th>
<th>Fiber Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Weld Penetration</td>
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<tr>
<td>Welding Speed</td>
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<td>Seam Shaping</td>
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<td>fiber size and focal length</td>
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<td>Process Gas</td>
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<td>Safety Requirements</td>
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</table>
ROFIN Welding Systems

Systems for Tube and Scanner Welding

ROFIN Profile Welding System (PWS) for welding of tubes and profiles. Operation with either fiber or CO$_2$ lasers

ROFIN Scanner Welding System (SWS) for welding of complex shaped 3D components. Operation with ROFIN fiber lasers
ROFIN Fiber Lasers

Standard version with separate housing for fiber handling

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### ROFIN Fiber Lasers

**Compact version for easy integration**

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</tr>
<tr>
<td>Available Fiber Optics</td>
<td>20 µm</td>
<td>50 µm</td>
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<td>100 µm</td>
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FIBER LASERS – YOUR BENEFIT

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- Wide range of beam qualities adapted to your needs from single-mode to multi-mode (0.4 mm x mrad to 40 mm x mrad)
- Flexibility by using fast switching and beam splitting with up to 4 fiber outputs in multi-mode
- No general maintenance, just inspections in after sales service
- Fast analog input enables the shortest cutting times
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  - High tolerance against process back reflection
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# CO₂ Slab Lasers

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<tr>
<td><strong>Pulse Frequency</strong></td>
<td>CW or 2 - 5000 Hz</td>
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<td></td>
<td></td>
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<td></td>
<td>CW or 2 - 100 Hz</td>
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</tbody>
</table>
| **Cabinet Characteristics** | | | | | | | | | | The lasers of the DC Series are available in two configurations:  
- **Head/cabinet combination** – with wall mountable, space-saving control cabinet and optional touch panel on the control cabinet for easy operation.  
- **Compact version** – laser head and control cabinet in one compact unit  
*revised version available in 2015
CO$_2$ SLAB LASERS – YOUR BENEFIT

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