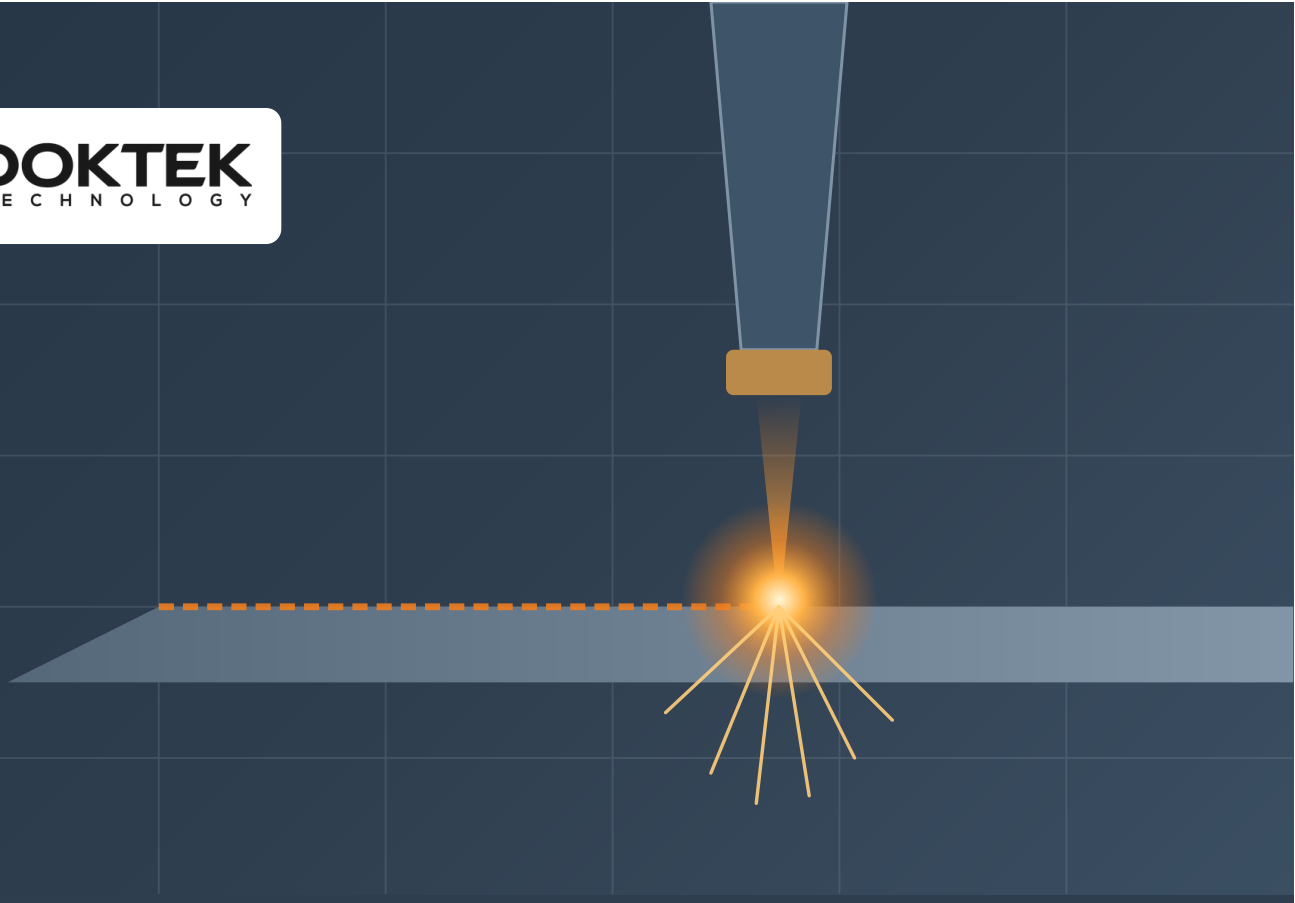


OPERATOR AND USER HANDBOOK

Fiber Laser Cutting Guide

Gas selection, power and speed tables, focus and nozzle adjustment, maintenance, safety and "what to do if it will not cut" — from 1 kW to 30 kW.

1 – 30 kW · Raycus · Max · IPG · Reci

Mild steel · Stainless steel · Galvanised steel · Aluminium · Brass · Copper

English · EN

19
chapters and appendices

6
materials

12
power tables, 1 – 30 kW

Step-by-step
troubleshooting

DOKTEK Technology
Akçeşme Mah. 2017 Sok. No: 15/A, 20020 Merkezefendi / Denizli
Salih Akkaya: +90 542 525 11 59 · İbrahim Küçükoğul: +90 530 891 44 04
info@doktek.com · doktek.com

Version 1.0
November 2026 · EN

Contents

Page numbers refer to the body after the cover.

00 How to use this guide 3
- 0.1 Who is this guide for, and where should you start? 3
- 0.2 Symbols and boxes 4
- 0.3 Responsibility and version 4
- 0.4 Where do parameter tables come from? 5

01 Safety 6
- 1.1 Class 4 laser and reflections 6
- 1.2 Fire, fumes and dust 8
- 1.3 Gases and compressed air 9
- 1.4 Electricity, motion and LOTO during maintenance 10
- 1.5 Authorization, PPE and daily safety checks 11

02 Know your machine 13
- 2.1 System overview 13
- 2.2 Component functions and operator checks 15
- 2.3 Inside the cutting head 16
- 2.4 Manual-focus and autofocus heads 17
- 2.5 Chiller: two circuits, temperature and condensation 18
- 2.6 Bed, pallets and auxiliary systems 19

03 Start-up, homing, calibration and shutdown 20
- 3.1 Safe start-up sequence 20
- 3.2 Homing: establishing the machine reference 21
- 3.3 Capacitive height calibration 22
- 3.4 Initial setup sequence and nozzle centering 23
- 3.5 Dry run and frame check 24
- 3.6 Shutdown, frost protection and restart after an extended stop 25

04 Workflow from drawing to cutting 27
- 4.1 Plan the whole job 27
- 4.2 DXF / DWG preparation 28
- 4.3 Import, layers and parameters 29
- 4.4 Lead-ins and lead-outs 30
- 4.5 Kerf compensation and micro joints 31
- 4.6 Cutting sequence, sheet placement and edge finding 33
- 4.7 Simulation, starting and resuming 34
- 4.8 Part removal, first-part inspection and records 35

05 Nesting 36
- 5.1 Nesting objectives and terms 36
- 5.2 Automatic and manual nesting 36
- 5.3 Part spacing, edge margin and direction 37
- 5.4 Common line and part-in-part 38
- 5.5 Cutting sequence and good nesting 38
- 5.6 Recording and reusing remnants 39
- 5.7 Skeleton cutting and yield calculation 39
- 5.8 Nesting software and final checks 40

06 Cutting techniques 41
- 6.1 Selecting lead-ins and lead-outs 41
- 6.2 Micro joints and bridges 41
- 6.3 Corner processing and power–speed curves 42
- 6.4 Small holes 42
- 6.5 Flycut 43
- 6.6 Leapfrog 44
- 6.7 Pre-piercing, cooling points and sequence 44
- 6.8 Introducing a new technique 45
- 6.9 Brief note on tube cutting 45

07 Gas selection 46
- 7.1 How do oxygen, nitrogen and air work? 46
- 7.2 Purity and compressed air preparation 46
- 7.3 Selecting the gas supply 47
- 7.4 Gas selection by material 49
- 7.5 Gas delay and line purging 49
- 7.6 Assessing gas costs 50
- 7.7 Shift-start checks 50

08 Power selection 52
- 8.1 Power, thickness and speed 52
- 8.2 Reading the maximum thickness summary 52
- 8.3 Thin sheet power and machine dynamics 53
- 8.4 O_2 on thick mild steel and beam characteristics 53
- 8.5 Power selection checklist 54
- 8.6 Working with 12–30 kW 54

09 Cutting parameter tables 56
- 9.0 How to read the tables 56
- 9.1 1 kW (1000 W) 58
- 9.2 1.5 kW (1500 W) 60
- 9.3 2 kW (2000 W) 62
- 9.4 3 kW (3000 W) 64
- 9.5 4 kW (4000 W) 66
- 9.6 6 kW (6000 W) 68
- 9.7 8 kW (8000 W) ★ 71
- 9.8 10 kW (10000 W) ★ 74
- 9.9 12 kW (12000 W) 77
- 9.10 15 kW (15000 W) 80
- 9.11 20 kW (20000 W) ★ 83
- 9.12 30 kW (30000 W) 86

10 Material-specific notes 88
- 10.1 Mild steel: S235 and S355 88

10.2 Stainless steel: 304, 316 and protective film 88
10.3 Galvanised steel: account for zinc coating 89
10.4 Aluminium: surface oxide and dross 89
10.5 Brass and copper: back-reflection 90
10.6 Coated and painted sheet 90

11 Focus, nozzle and height 92
11.1 Focus signs: + / 0 / – 92
11.2 Performing a focus test 92
11.3 Autofocus and lens focal length 93
11.4 Nozzle type and diameter 94
11.5 Centering with a tape test 94
11.6 Nozzle height and capacitive sensing 95
11.7 Distinguishing deviations and keeping records 96

12 Piercing 97
12.1 Selecting a piercing method 97
12.2 Height, time, frequency and duty cycle 98
12.3 Thick-plate spatter and pre-piercing 98
12.4 Transition from piercing to cutting 99
12.5 Piercing troubleshooting table 99
12.6 Recording a piercing recipe 100

13 Cut quality and defect diagnosis 101
13.1 Quality checklist 101
13.2 Dross and edge defects — diagnostic table 103
13.3 Single-parameter rule and step sizes 104
13.4 Defect photo examples 106

14 Laser sources 107
14.1 What does the laser source do? 107
14.2 Power, core diameter and beam quality 107
14.3 Raycus, Maxphotonics (Max), IPG and Reci 109
14.4 Single-module and multi-module construction 109
14.5 Transferring parameters to another source 110
14.6 Environment and source maintenance 110
14.7 Power measurement and performance monitoring 111
14.8 Source records for warranty and service 111

15 Software guides 112
15.1 Common workflow and terms 112
15.2 CypCut 114
15.3 CypOne 116
15.4 CypNest and HypCut 117
15.5 Raytools XC3000 series 118
15.6 Ermaksan Fibermak 119
15.7 Durma HD-FL — Siemens 120
15.8 Other software and CAM-to-machine file flow 121

16 Maintenance 123
16.1 Maintenance plan and responsibilities 123
16.2 Nozzle replacement 124
16.3 Ceramic ring replacement 124
16.4 Protective window inspection, cleaning and replacement 125
16.5 Focusing/collimating lenses and post-maintenance verification 126
16.6 Chiller maintenance 127
16.7 Gas and air line maintenance 128
16.8 Mechanical maintenance: rails, racks, belts and bed 129
16.9 Fume extraction and electrical cabinet 130

17 Troubleshooting 131
17.0 Symptom index 131
17.1 Not cutting / not penetrating material 132
17.2 Not piercing 133
17.3 Head collision / height sensor warning 133
17.4 Protective window rapidly dirties / burns 134
17.5 Parts lift / tip 135
17.6 Dimensional error / shape shift 135
17.7 Laser source alarms 136
17.8 Chiller alarms 137
17.9 Gas pressure alarms 137

90 Appendices 139
Appendix A — Machine-side quick reference card 139
Appendix B — Daily check form: 7-day week 140
Appendix C — Parameter change form 141
Appendix D — Glossary: guide terms and English equivalents 142
Appendix E — Information required for service 145
Appendix F — References 145

00

How to use this guide

Use this guide at the machine to prepare it safely, take a job from drawing to finished part and carry out the right trial.

0.1 Who is this guide for, and where should you start?

This book is for customers who purchase a fiber laser cutting machine from DOKTEK and for trained operators. The site manager, maintenance team and quality inspector can use the same checks. If you are a first-time operator, do not start cutting simply by opening the parameter table. Read the safety instructions, machine components and start-up sequence first.

Your need	Reading path	Expected result
Initial training / new operator	01 → 02 → 03 → 04; then supervised practice	Learn the emergency stop, working limits and safe start-up.
New material / new thickness	07 → 08 → 09 → 10 → 11 → 12	Verify the gas, recipe and piercing method.
Part quality has deteriorated	13; then 11, 12 and 17	Move from the visible defect to a controlled trial.
Start / end of shift	Check forms in 03, 16 and 90	Prepare the machine in the same sequence and record its condition.
The software looks different	15 and your machine's software manual	Find the same function in your version.

The large number at the start of a chapter identifies the main topic. The contents list both chapters and subsections. Page numbering starts at 1 after the cover. A link takes you to the relevant subsection; in a printed copy, find its number in the contents.

> **Read these three types of information together**
>
> **Description** explains what the component does. **Procedure** gives the working sequence. **Warning** boxes identify conditions that require you to stop the operation. The “Why?” paragraph explains which fault the check prevents.

Before using a table value, identify your machine's laser source power, fiber core, head model and optics ratio. Do not guess the specifications of a component whose label you cannot read. Use the commissioning record or information from DOKTEK service.

The dashed areas in this book are placeholders for photos or screenshots to be added from a DOKTEK machine. SVG diagrams explain functions; they are not dimensioned manufacturing drawings of the actual product. Screen layouts and menu names may vary by version.

0.2 Symbols and boxes

Symbol	Meaning	What should you do?
★	Value derived or interpolated by DOKTEK	Do not treat it as a manufacturer's measurement; verify it with a test cut.
◆	Manufacturer's trial value	Do not use it as a series production recipe.
◯ S	Single-layer nozzle	Check both diameter and head compatibility.
D	Double-layer nozzle	Do not assume it is equivalent to S, even with the same diameter.
+ / − / 0	Focus: above the surface / inside the material / at the top surface	Compare the software's sign convention with the manufacturer's definition.
O_2	Orange: oxygen	Keep oil and grease out of the oxygen line.
N_2	Blue: nitrogen	Remember the asphyxiation risk in enclosed spaces.
Air	Gray: compressed air	Verify a dry, oil-free, filtered supply.

Gas colors make this book easier to read; they are not cylinder colors, piping standards or hose connection codes. Identify the gas on site by its label and installation documentation. Color alone is not sufficient for identification.

Warning

Identifies a condition that could cause injury, fire or machine damage. Eliminate the hazard first.

Tip

Helps you carry out the correct task more consistently. It does not replace a safety check.

Information

Explains differences in equipment, terminology or practice. Where several methods are valid, it tells you which manual to consult.

0.3 Responsibility and version

Values are for reference; your machine manufacturer's table and DOKTEK service recommendations take priority. Results may change with material batches, gas quality, optics condition, software and mechanical settings. A parameter table does not replace safety training, a site risk assessment or authorized maintenance instructions.

Version 1.0 · English · November 2026. In the copy used at each machine, record the serial number, control system and person responsible for local recipes. Save successful settings with the date and material details; do not overwrite the master recipe with uncontrolled changes.

0.4 Where do parameter tables come from?

Distinguish two approaches. In the closed OEM library model, TRUMPF supplies machine-tested laser technology tables (LTT) and guided optimisation. The table in Amada AP100 help is read-only reference data; editing requires special access. The source does not explain whether users can overwrite TRUMPF tables. In the open library model, CypCut lets you edit layer parameters and save them in a material library; Raytools XC3000 provides import/export in a material → thickness tree.

Read each table's basis together: publisher and document date, laser source model/power, fibre core diameter, head model, and focal lengths of the collimating and focusing optics. Material, gas purity/pressure and nozzle belong to the same set of conditions. Do not assume equivalence when information is missing; confirm it with the manufacturer. Equal power does not mean equal optics.

Raycus lists the following standard output cores. They do not describe every Raycus model or the hardware behind every table in this guide; use the installed model's documentation.

Power	Core diameter in the Raycus note
≤1 kW	25 µm
1.5 / 2 / 3 kW	50 µm
4–20 kW	100 µm
30 kW	200 µm; 150 µm option

Keep the manufacturers' "reference only" qualification. Bodor says to adjust values to actual cutting results; CypCut notes that parameters can differ with the laser source and gas configuration. A table is not a production guarantee for your machine.

Save recipes tested on your own machine as separate records in your own material library. Keep material/thickness, gas, head/optics and nozzle details with the results. Preserve the starting table; confirm that conditions match before reusing a successful setting. Menu names may vary by version.

TRUMPF LTT · Amada AP100 · CypCut V6.5 · Raytools XC3000 · Raycus · Bodor

01

Safety

Manage laser, motion, electrical, gas and hot metal hazards together. Do not start production if the safeguards are not working.

1.1 Class 4 laser and reflections

The cutting source presents a Class 4 laser hazard. The near-infrared beam of industrial fiber cutting systems, at approximately 1064–1080 nm, is invisible. The visible red aiming light is not the cutting beam itself. Seeing no brightness does not mean that no beam is present. The direct beam, mirror-like reflections and hazardous scattering can severely damage eyes or skin.

Under IEC 60825-1, a validated machine with an interlocked enclosure may be Class 1 during normal use; the laser source inside is Class 4. Opening the enclosure or servicing changes the access conditions. Do not check for the beam by looking at the cutting area, nozzle or reflecting surface.

Distinguish enclosures from curtains

ISO 11553-1:2020 addresses laser radiation safety in laser processing machines; this standard series replaced EN 12626. Use IEC 60825-4:2022 as the basis for laser guards enclosing the processing zone. EN 12254 curtains are limited in scope to a maximum mean power of 100 W or 30 J per pulse; do not use them as the primary protection on a kW cutting machine. ISO 11553-1:2020 does not cover other hazards such as fumes and fire; address these separately in the workplace risk assessment.



Schematic illustration. Actual reflection direction and intensity may change during cutting.

Eye and skin protection

Optical density (OD) alone is insufficient. Use laser eyewear marked to EN 207:2017. The marking identifies wavelength, operating mode and LB protection level; D 1064 nm LB6 is an example product marking for continuous wave (D), not a selection recommendation for every machine. Have the laser safety officer confirm the LB level for the actual wavelength, operating mode and exposure assessment. Do not treat general tinted glasses, welding helmets or sunglasses as equivalent. Inspect eyewear for scratches, cracks, dirt and fit.

Do not replace the enclosure viewing window with ordinary glass or plastic. Suitable wavelength protection, the frame and seal integrity are all required. Report damage, darkening or unreadable markings to the responsible person. Open-beam servicing is restricted to the authorized team's designated area.

Doors and interlocks

Do not bypass doors, service covers, pallet area guards or safety interlocks. Do not defeat an interlock with a key, magnet, tape or software intervention. Stop the machine if an interlock fails and notify authorized service.

Why? The human eye cannot react quickly enough to avoid an invisible beam. Engineering safeguards take priority over personal protective equipment.

1.2 Fire, fumes and dust

Address hazardous fume emissions in the risk assessment using EN 1093 and ISO 14123-1/-2, and extraction equipment separation-efficiency testing using ISO 21904-2:2020; use the references in Annex F.

The laser produces hot metal, sparks and slag. Keep oily sheet, unknown coatings, cardboard, packaging and cleaning cloths away from the cutting area. Check beneath the bed and in the slag bin according to the shift plan. Accumulated fine metal, oil and dust can remain hot for a long time; smouldering may continue after work ends.

Do not collect aluminium dust or other combustible metal dust with a general workshop vacuum cleaner. The extraction and filter system must suit the fire and explosion risks of the material being cut. When changing materials, follow the filter manufacturer's instructions for mixed metal dust and spark management. Use wet dust collection only with a suitable design and the manufacturer's instructions.

Source	Risk	Control
Oil, coating, protective film	Flames, heavy fumes, unknown decomposition products	Verify the material safety information and the film's suitability for laser cutting.
Galvanised steel / zinc	Zinc oxide fumes; metal fume fever	Use filtered extraction at source; do not inhale the fumes.
Stainless steel	Hazardous metal compounds, including chromium VI, may form	Provide suitable extraction, filtration and exposure assessment.
Copper and its alloys	Metal fumes and alloying elements	Know the material composition; do not rely on general ventilation.
Hot slag and filters	Delayed fire	Prevent accumulation; follow the cooling and waste management procedure.

Initial response to fire

Purpose: Protect people and prevent the incident from spreading. **Requirements:** The site's fire plan, a clear escape route and a suitable extinguisher.

1. Stop cutting and press the emergency stop if there is danger. Warn people nearby.
2. If safe, isolate gas/energy supplies at the safe point specified in the site plan; do not enter the hazardous area.
3. Raise the fire alarm. Evacuate if you are not trained or the escape route is unsafe.
4. Only a trained person may tackle an incipient fire with a suitable extinguisher.

> **Select the extinguisher class for the material**
>
> Combustible metal fires require a suitable Class D agent; not every D agent suits every metal. Suitability differs for oil/flammable liquids, solid materials and electrical equipment. Provide labeled equipment according to the site's risk assessment. Do not apply water or a general-purpose extinguisher indiscriminately to a metal fire.

Why? Opening a door can increase oxygen and spread fumes into the workplace. Cutting with failed extraction allows fumes inside the enclosure to reach workers.

If you experience throat irritation, headache, fever-like symptoms or heavy fume exposure, stop work, move to a clean area and follow the site's emergency medical procedure. Do not dismiss symptoms as something you will “get used to”.

1.3 Gases and compressed air

O_2 is not flammable, but intensifies combustion. Oil, grease and incompatible materials in contact with oxygen create ignition and severe fire/explosion risks. Keep oil off oxygen regulators, valves, connections and your gloves. Lubricating an oxygen line or cleaning a part with oxygen is prohibited.

N_2 is odorless; a leak can reduce oxygen in an enclosed or low-lying area. Do not rely on breathing to detect it. Ventilation and, where needed, oxygen monitoring for nitrogen storage/supply areas must be provided according to the site's assessment. Do not enter a suspect area unprotected to rescue a colleague; call emergency assistance.

Check point	Action
Cylinder	Keep upright with suitable restraints. Use a suitable trolley and valve protection when moving it. Do not roll the cylinder or lift it by the regulator.
Regulator	Use a maintained regulator suitable for the gas type and supply pressure. Do not force an incompatible connection with an adapter.
Hose / pipe	Look for cuts, burns, swelling, abrasion and loose connections. Do not tighten nuts under pressure.
Leak test	Use a leak detection product suitable for the gas or an approved method. Do not search with a flame or your hand.
Valve	Open slowly in the manufacturer's sequence; do not stand in front of the regulator. Do not force a stuck valve.
Air	Check the compressor, dryer and filter together. Do not exceed the gas/air line's permitted pressure.

Working on a gas line

Purpose: Open the connection with stored energy released. **Requirements:** Authorization, correct gas equipment and the site's gas isolation plan.

1. Stop cutting. Disable laser emission and park safely.
2. Close the relevant supply valve; prevent unauthorized reopening.
3. Safely relieve line pressure at the designated vent point. Verify zero on the gauge and confirm that pressure does not build up again.
4. Fit suitable equipment. On completion, admit gas in a controlled manner and carry out the approved leak check.

> **Do not clean with pressurised gas**
>
> Do not direct air/gas at your body, clothing or another person. Compressed air ejects particles, injures skin and makes dust airborne. Release residual pressure before opening a line.

Why? Closing the valve does not release the energy stored in the hose. An oxygen-incompatible material can turn a small leak into a serious incident.

1.4 Electricity, motion and LOTO during maintenance

Only authorized personnel may open electrical cabinets, laser sources, servo drives and compressors. Capacitors may retain energy even with the main switch off. A qualified electrical person must verify absence of voltage by suitable measurement and wait the manufacturer's discharge time. Operators must not bridge fuses or troubleshoot inside the cabinet.

Protective earthing is essential for machine safety. Contact between sheet and bed affects capacitive measurement; this contact does not replace the electrical installation's protective earthing. Stop the machine and notify the responsible person if earthing is loose, cables are damaged, you smell burning or feel an electric shock.

The gantry, Z axis, pallet changer and hydraulic/pneumatic mechanisms present crushing and trapping points. Do not reach inside the guarded boundary. Keep everyone out from under pallets. Use suitable lifting equipment for heavy sheets and skeletons; do not use the cutting bed as a platform for carrying people.

Lockout–tagout: LOTO

Purpose: Prevent unexpected start-up and release of stored energy during maintenance. **Requirements:** A site-specific energy isolation plan, authorized maintenance personnel, personal locks/tags and verification tools.

1. Define the task. Identify laser, electrical, gas, pneumatic/hydraulic, gravity and hot surface energy sources; notify those affected.
2. Stop the machine in the normal sequence. Isolate the relevant energy sources at their actual isolation points.
3. Apply personal locks and tags. For group maintenance, follow the site's group LOTO method.
4. Release pressure; secure moving parts or parts that could fall with safe mechanical supports. Allow hot parts to cool.
5. Verify the de-energised state using the authorized method. If a controlled start attempt is required, confirm that the area is safe; then return the control to off.
6. Complete maintenance. Remove tools and supports in the specified sequence, refit guards and clear people from the area.
7. Remove locks only under the defined authority and procedure. Restore energy in a controlled manner and verify safeguards.

> **An emergency stop is not energy isolation**
>
> An emergency stop stops motion/hazardous operations; it is not a main energy isolator or a personal lock. A software indication of “beam off” alone is also insufficient for maintenance. Do not remove another person's lock without following the specified procedure.

Why? An alarm reset, remote command or automatic cycle can initiate unexpected motion. Verifying a de-energised state requires more than pressing a button.

1.5 Authorization, PPE and daily safety checks

Only trained, authorized operators may use the machine. Training must cover normal cutting, gas changes, alarm response, emergency stops, the fire plan and prohibited service interventions. New operators must carry out their first work under supervision. Keep visitors in the marked safe area.

PPE	Selection / use	Limitation
Eye protection	Suitable impact eyewear for part removal/deburring; EN 207-marked laser eyewear with the appropriate wavelength, operating mode and LB level for authorised work with laser access; OD alone is insufficient	These protections are not interchangeable; do not run production with the enclosure open.
Cut-resistant gloves	Suitable rating for handling sheets and skeletons; additional heat resistance for hot parts	Does not permit approaching moving mechanisms.
Safety footwear	Toe and sole protection; slip resistance suitable for the floor	Does not replace safe lifting of heavy sheets.
Work clothing	Suitable clothing covering the body; no loose sleeves, jewelry or dangling items	Follow the risk assessment for sparks and hot metal.
Hearing protection	According to measured noise and the workplace plan	Work arrangements must allow warnings to be heard.
Respiratory protection	With exposure assessment, suitable filters/mask, fit testing and training	Do not continue cutting to compensate for failed extraction.

Daily safety check

Purpose: Start the shift with working safeguards. **Requirements:** Shift form, authorization and the manufacturer's safety test method.

1. Clear escape routes, extinguisher access and working boundaries. Look for combustible deposits and uncooled slag beneath the bed.
2. Visually inspect doors, the viewing window, interlocks and the pallet area. Perform functional tests only by the manufacturer's method, without generating a beam and under safe conditions.
3. Check access to emergency stops. Follow the manufacturer's plan for testing and restarting; do not test safeguards by cutting.
4. Check extraction/filters, chiller, gas and air lines. Record leaks, alarms and broken connections.
5. Confirm that nobody is around the machine, no maintenance lock is fitted and no unresolved work remains from the previous shift.
6. Sign the check. Report defects to the responsible person; do not start cutting until hazardous non-conformities are resolved.

> **After an emergency stop**
>
> Check people and the cause of the hazard first. Turning and resetting the emergency stop does not authorise restarting. Inspect head/sheet positions, axis references, the pallet and the remaining program; complete the necessary homing and calibration.

Why? A signed check is meaningful only if it records a check actually performed. Habitually resetting recurring safety faults conceals the hazard.

Apply safety measures together with the machine's safety instructions, site risk assessment, gas supplier information and authorized service procedures.

Legislation and conformity

Regulation (EU) 2023/1230 on machinery applies to machines placed on the EU market from 20 January 2027. In Türkiye, the Machinery Safety Regulation was published in the Official Gazette of 16 October 2026, No. 33402; most provisions take effect on 20 January 2027. Confirm the applicable requirements with the manufacturer/competent body according to your machine's placing-on-the-market date and modification history.

Under the Turkish regulation, digital instructions must be printable or downloadable and remain online for at least 10 years. A short paper version must be supplied free of charge within one month of the user's request. Increasing power or changing the guarding may count as a substantial modification. This box is not a legal conformity determination; confirm instruction delivery and conformity assessment after modification with the manufacturer/competent body.

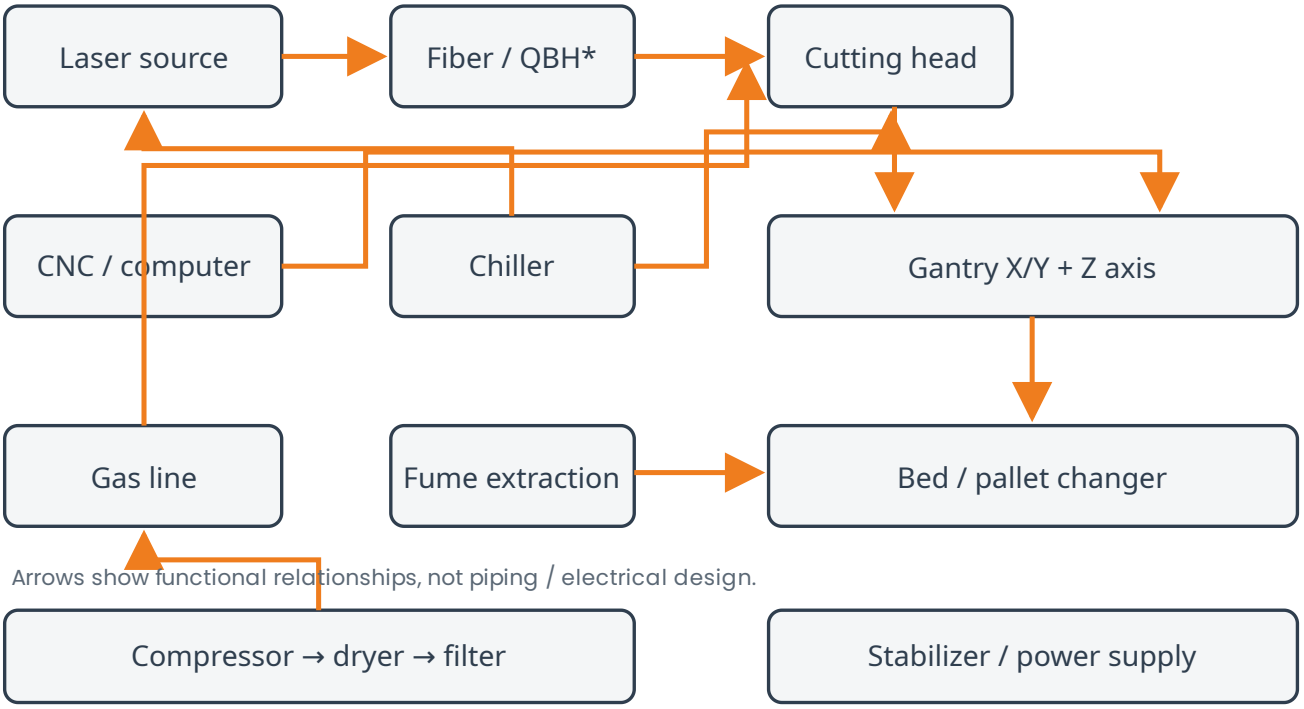
02

Know your machine

Cutting involves more than one device. Beam, motion, cooling, gas and extraction must all work correctly at the same time.

2.1 System overview

The laser source generates light; the delivery fiber carries it to the cutting head. The head focuses the beam and directs assist gas to the cutting area. The gantry X/Y axes follow the drawing path. The Z axis controls the distance between nozzle and sheet surface. The control system coordinates this motion, the beam, gas and piercing timing.



*QBH is a common fiber connection type; the actual machine may use a different connector. Operators must not work on the connector.

Boxes shown in sequence in the diagram are not necessarily physically arranged in that order. The chiller cools the source and head; the gas line connects to the head; extraction removes fumes from beneath the bed. A stabilizer, if fitted, regulates the electrical supply. The compressor may serve the machine's pneumatic functions as well as air cutting; consult the manufacturer's diagram.

Prepare a machine identification card

Record the machine model/serial number, laser source brand/power, head model, control system version, chiller model and gas supply type. Machines that look identical may have different sources or heads.



Overview of the DOKTEK machine, cutting head and control computer.

2.2 Component functions and operator checks

Component	Function	What does the operator check?
Laser source	Generates the cutting beam; manages emission permission and alarms.	Ready status, alarms, cooling conditions; do not open the housing.
Delivery fiber / QBH	Carries the beam to the head.	External crushing, excessive bending or tension; do not disconnect.
Cutting head	Provides collimation/focusing, protective optics and gas flow.	Alarms, focus, window/nozzle condition, gas tightness.
Gantry X/Y	Follows the contour in the horizontal plane.	Clear path, unusual noise, motion alarms.
Z axis / capacitive sensor	Monitors nozzle height and follows the sheet.	Calibration, ceramic/nozzle, sheet contact and collision marks.
Bed / support slats	Supports the sheet; beam and melt pass below.	Slag deposits, bent slats, risk of small parts tipping.
Pallet changer	Exchanges the loading and cutting beds.	Locks, position, clear area and load distribution.
CNC / computer	Converts the drawing into motion and process commands.	Correct file, dimensions, layers, origin, parameters and alarms.
Chiller	Keeps source/head temperatures within the required range.	Level, temperature, flow/alarms and leaks; correct coolant.
Gas line	Supplies assist gas at suitable pressure and flow.	Gas type, supply level, leaks, dynamic pressure.
Fume extraction / filter	Collects cutting fumes at source.	Suction, filter/alarms, spark and dust management.
Compressor / dryer / filter	Supplies air at the required pressure and quality.	Condensate drainage, dryer and filter condition.
Stabilizer / supply	Keeps electrical input within machine requirements.	Alarms and supply status; measurement/repair is for authorized personnel.

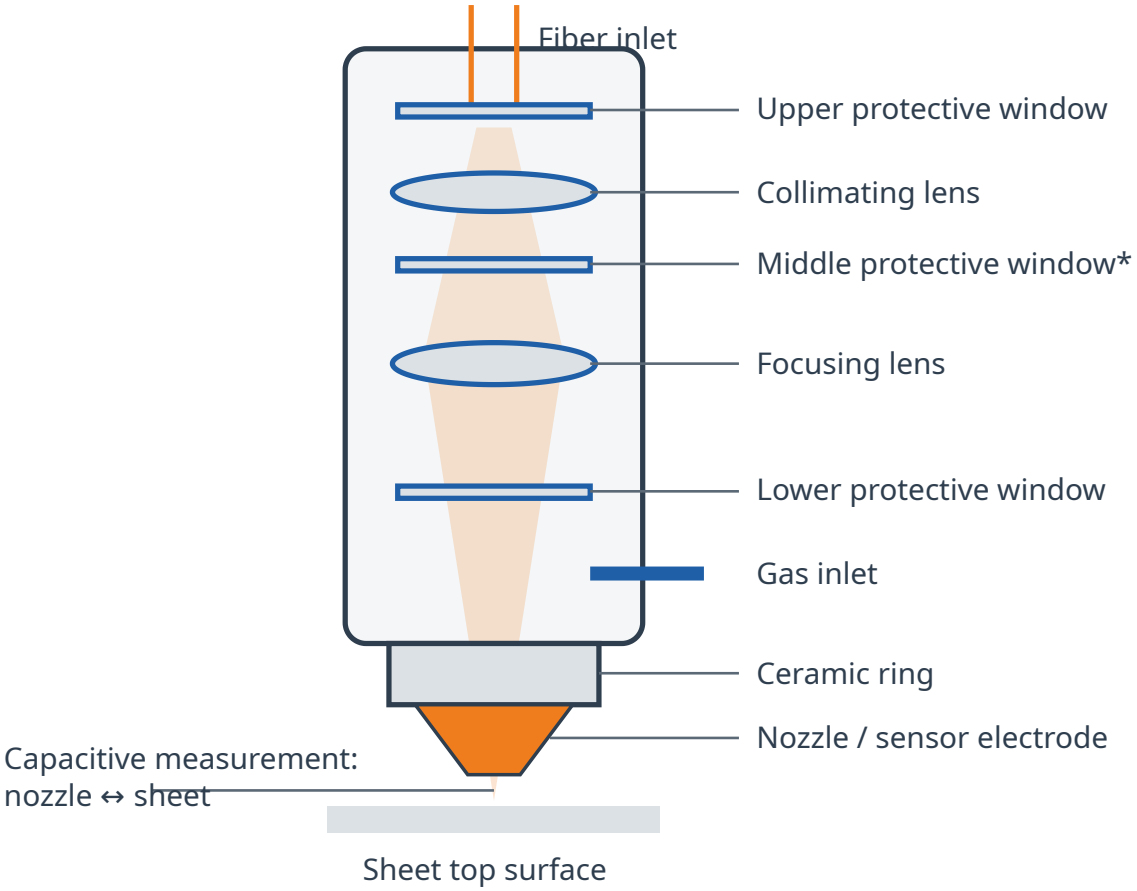
Do not attribute an alarm to a single component. A source “not ready” warning may result from chiller conditions; a height error from poor sheet contact; a gas pressure drop from inadequate line flow. Record the symptom, when it began and any accompanying alarms.

✓ Read the label; do not guess

The laser source brand is not the head brand. The optics ratio describes the focal lengths of the collimating/focusing lenses; fiber core is a separate specification. Use these details separately when matching a parameter table.

2.3 Inside the cutting head

The cutting head concentrates the beam into a small spot and supplies gas coaxially to the sheet surface. The drawing below is a functional cross-section. The number, position and names of upper/middle/lower protective windows vary by model; some heads do not have three separate windows. Do not order parts based on this drawing.



*Schematic model. Component layout and service access are determined by the manual for your head.

The collimating lens conditions the beam emerging from the fiber. **The focusing lens** concentrates the beam in the cutting area. **The protective window** protects expensive optics from dust and spatter; if dirty, it can absorb the beam and heat up. Do not continue using a scratched or burnt window.

The ceramic ring provides electrical insulation at the nozzle connection and mechanical protection depending on the model. Cracked or loose ceramic can destabilize height control. **The nozzle** shapes the gas flow; it is also the capacitive sensing electrode. A dented tip, burrs or incorrect tightening impair both flow and measurement.

Opening the optical path is a service task

Do not remove upper lenses or the fiber connection for routine checks. Access protective windows only within your training and the manufacturer's procedure, with energy in a safe state and in a clean environment.

2.4 Manual-focus and autofocus heads

This guide describes the physical focus position relative to the top sheet surface: + above it, – inside the material. However, the Raytools head/CypCut control arrangements behind the tables reference focus to the nozzle tip; Raytools tape dotting sets zero at that tip. With this sign convention, **surface-relative focus ≈ controller value + nozzle height**. Controller 0 with a 1 mm gap puts focus ≈1 mm above the sheet; controller -1 mm with a 1 mm gap puts it at the surface. Verify your controller's reference and signs in its manual. Do not interchange nozzle height and internal optical focus adjustment.

Raytools BM115 · Friendess CypCutPro

Feature	Manual focus	Autofocus
Adjustment	Uses the manufacturer's ring/scale mechanism.	A motor moves internal optics to the recipe value.
Material change	The operator checks and records the setting.	The layer or process recipe may call for a different focus.
Reference	Verify the scale and focus zero.	Verify the motor reference, software sign convention and mechanical zero.
Possible faults	Wrong scale, loose lock, misreading	Wrong recipe, lost reference, motion/alarm problem
Shared requirements	Correct nozzle, centered beam, sound ceramic, clean window and capacitive calibration	

Preparing the focus system for the job

Purpose: Apply the table's focus value using the correct mechanism. **Requirements:** Head model, head manual and approved recipe.

1. Identify manual focus or autofocus from the head model. Do not decide by appearance.
2. For manual focus, put the laser in a safe state; use the adjustment scale by the manufacturer's method and check the lock.
3. For autofocus, check ready/reference status and the commanded value. Do not force operation with an active alarm.
4. Verify the sign convention. This book uses + above and – inside; if the software definition differs, use the manufacturer's conversion.
5. Verify cutting on a suitable test coupon; save the setting in the recipe.

Focus zero and capacitive zero are different

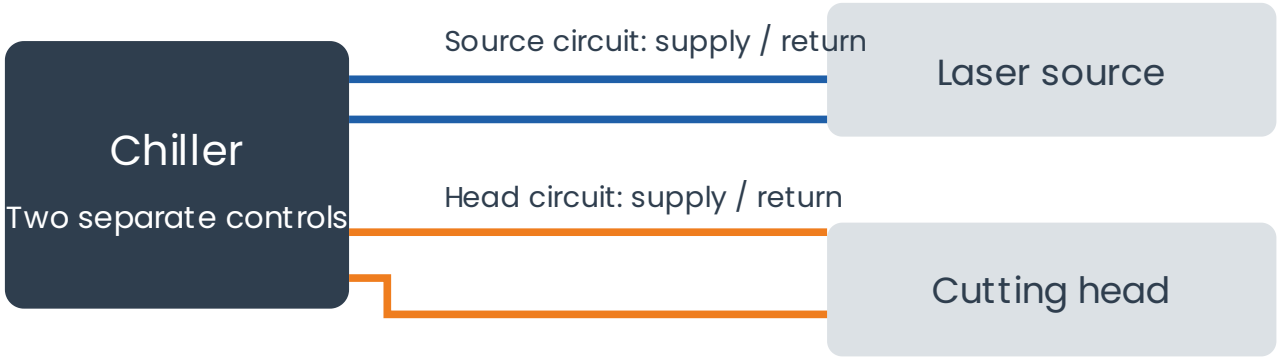
Capacitive calibration learns the nozzle–sheet distance relationship. It does not automatically correct optical focus zero. Smooth sheet following does not prove that optical focus is correct.

Why? Incorrect focus changes energy distribution and kerf. Incorrect nozzle height affects gas entry into the kerf and collision risk.

Photo to be added from a DOKTEK machine — **manual focus scale and autofocus head model label; energy in a safe state**

2.5 Chiller: two circuits, temperature and condensation

The chiller cools the laser source and the relevant parts of the cutting head. Many systems have separate source and head circuits. Circuit temperatures, flow rates and coolant requirements need not be identical. Follow hose labels; do not interchange source and head circuits.



Circuits are schematic. Shared or separate tank designs vary by manufacturer.

Dew point is the temperature at which moisture in the air starts condensing on a surface. Condensation may form if cooling water or the head surface falls below the ambient dew point. Avoid excessively cold settings, especially in hot, humid workshops. Assess the manufacturer's permitted operating range together with ambient temperature and humidity.

This book does not specify a universal chiller temperature. Use a setting permitted jointly by the source, head and chiller manufacturers. Do not lower the coolant setting arbitrarily just to increase cooling. Do not start cutting if condensation is present on the head, even if the chiller shows ready.

Cooling check at shift start

Purpose: Ensure stable, leak-free cooling before emission. **Requirements:** Manufacturer's level/temperature requirements, correct coolant and check form.

1. With the machine in a safe state, check the level, hoses, connections and floor.
2. Switch on the chiller; wait for the circuits to reach their settings and for flow to stabilize.
3. Verify no alarms, no supply/return leaks and no moisture around the head/fiber.
4. Record the values. Do not reset a flow or temperature alarm and force cutting; eliminate its cause.

Do not mix unsuitable fluids

The manufacturer specifies water quality, additives and replacement intervals. Do not add automotive antifreeze or unknown chemicals. For frost protection and extended shutdown, follow section 3.6 in sequence.

Why? Incorrect fluid can cause corrosion and blockages. Insufficient flow and condensation can damage optics or electrical equipment.

2.6 Bed, pallets and auxiliary systems

Bed slats support the sheet; gaps let the beam, gas and melt pass downwards. Slag-filled or bent slats do not hold the sheet flat. A small part that tips after cutting may remain in the head's path. Sheet surface irregularities cannot always be corrected by height control.

The pallet changer reduces preparation time by exchanging the cutting pallet and loading pallet. Motion areas, pallet locks and access guards vary by machine. Seeing a position sensor or a screen indication alone does not confirm that the area is clear of people.

Preparing for a pallet change

Purpose: Change the sheet and pallet without collision. **Requirements:** Manufacturer's pallet sequence, authorized operator and suitable lifting equipment.

1. Finish cutting or stop safely by the manufacturer's method; move the head and gantry to the defined pallet change position.
2. Confirm that nobody is on the loading or cutting side. Keep tools/skeletons out from under the bed and the pallet passage.
3. Check that the sheet does not project beyond limits, tipped parts are removed and the load is positioned correctly.
4. Close guards; issue the change command in the manufacturer's sequence. Do not enter the area during motion.
5. Verify the pallet's final position and lock status. Check the work origin/edge finding for the new sheet.

> **Do not push a stuck pallet**
>
> Do not try to complete movement by hand, with a forklift or by entering the guarded area. Stop, put energy in a safe state and initiate authorized maintenance.

Why? Pallet movement before the head reaches a safe position can cause a collision between head, sheet and gantry. An uncertain pallet position can also invalidate work coordinates.

Consider air and extraction together

Alongside compressor capacity, the dryer, filters, receiver and piping determine cutting pressure/flow. Idle pressure may drop during cutting. A water separator alone may not ensure dry air; check the dryer and drainage. A blocked extraction filter or closed zone damper spreads cutting fumes inside the enclosure.

Check pressure loss, dryer selection and the ISO 8573-1 class triplet in the air-cutting infrastructure box in section 7.2.

Photo to be added from a DOKTEK machine — **pallet safety area, chiller circuit labels and compressor–dryer–filter sequence**

03

Start-up, homing, calibration and shutdown

Follow the same sequence every shift. If your machine's commissioning instructions specify a different sequence, the manufacturer's sequence takes priority.

3.1 Safe start-up sequence

Purpose: Start the source with cooling and auxiliary systems ready. **Requirements:** Machine with daily safety checks completed, sufficient gas/air, suitable coolant and an authorized operator.

1. **Stabilizer / main switch:** Check the working area. Do not start work if a maintenance lock is fitted. Switch on the stabilizer, if fitted, then the machine's main supply in the manufacturer's sequence.
2. **Chiller:** Check the level and look for leaks. Start the chiller; wait for source and head circuits to reach the manufacturer's required temperature and flow conditions.
3. **Compressor and gas:** Prepare the dryer/filter and extraction. Open the correct gas supply and machine valves in the defined sequence. Stop for leaks or unsuitable pressure.
4. **Laser source switch:** Switch on the source with cooling ready. Switching on and permitting cutting emission are separate actions; keep the beam disabled until needed for the operation.
5. **CNC / computer:** Start the control system. Read start-up warnings; do not launch an automatic job left from the previous shift.
6. **Software:** Open the correct machine configuration and job file. Check connection, axis and safety status.
7. **Servo enable:** Confirm the area is clear. Enable motion by the manufacturer's method. Stop for unexpected motion or alarms.
8. **Homing:** Follow section 3.2 to carry out homing.
9. **Calibration:** Check nozzle, ceramic and centering. Complete the required capacitive calibration and the manufacturer's other start-up checks.

Do not emit a beam before the system is ready

Do not attempt cutting if cooling, gas, extraction, safeguards or axis references are unsuitable. Do not accept a recurring alarm as “normal at start-up”.

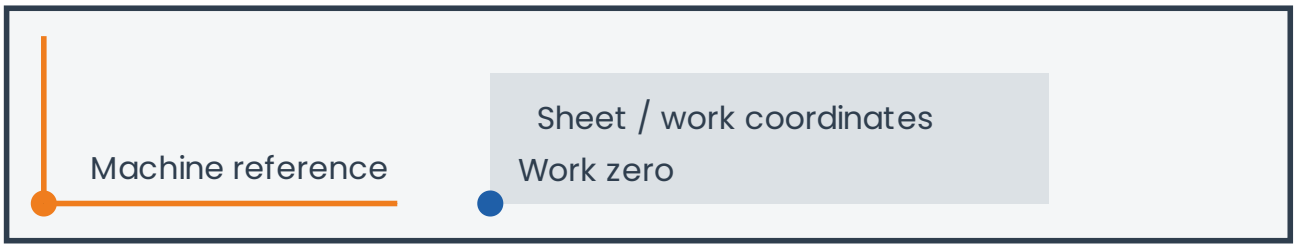
Why? Open cutting software does not mean auxiliary systems are ready. Following the same sequence reveals incomplete preparation early.

Condition for proceeding	Check
Source ready	Cooling conditions correct; no unexplained source alarm.
Motion ready	Area clear, servo status correct, homing complete.
Process ready	Correct gas, extraction, safeguards and approved recipe selected.

This is a general operator workflow. Contactor, switch and software menu names may vary by machine/version.

3.2 Homing: establishing the machine reference

Homing re-establishes absolute machine axis positions using reference/origin sensors and the control system's position information. Workpiece zero is different. Selecting a sheet corner as work zero does not establish an axis reference.



Homing references the axes; work zero positions the program on the sheet.

Verify the two coordinate systems separately. Arrow directions are illustrative only.

Software limits, safe travel and pallet positions depend on correct referencing. With a lost reference, displayed distance may not represent actual mechanical distance. Homing is one element of collision protection; alone it does not guarantee obstacle detection or a safe area.

When?	Additional check
At every start-up	Verify the manufacturer's homing-complete indication.
After an emergency stop	Eliminate the stop cause first; restore references as required.
After a servo / encoder alarm	Eliminate the alarm cause; do not assume position is reliable.
After a collision	Have the nozzle, ceramic, head mounting and axes checked.
After mechanical work	Wait for authorized maintenance to verify references and limits.

Purpose: Link travel limits to correct machine coordinates. **Requirements:** Sound axis system, clear travel path and manufacturer's homing sequence.

1. Clear the bed and gantry path. Check for raised sheet, tipped parts, tools and clamps.
2. Raise the Z axis safely by the manufacturer's method. Do not move a head horizontally over sheet if its position is unknown.
3. Close guards; issue the homing command. Axis sequence and reference direction vary by manufacturer; do not guess manually.
4. Watch motion from a safe position. Stop for wrong direction, obstruction, unusual noise or limit alarms.
5. Verify completion. Check work zero and pallet position separately.

What happens if it is omitted?

Incorrect software limits, movement beyond the sheet, incorrect pallet positions and collision risks may result. Do not operate an axis that cannot home by bypassing limit or sensor protection.

Why? Work coordinates align correctly only with reliable machine coordinates. Alarm reset does not prove physical reference accuracy.

3.3 Capacitive height calibration

The capacitive sensor monitors distance using the electrical relationship between nozzle and sheet. In height controllers such as BCS100, calibration learns this relationship. It differs from optical focus adjustment and X/Y homing.

Reassess calibration after nozzle/ceramic replacement, collision inspection, significant material or temperature changes, and when height drifts. Obtain daily frequency and acceptance criteria from the head/height controller manufacturer. Do not try to correct cracked ceramic or a loose nozzle through calibration.

Purpose: Ensure stable sheet following at the correct nozzle distance. **Requirements:** Sound, clean nozzle/ceramic; flat, clean sheet with good electrical contact to the bed; correctly referenced machine and manufacturer's instructions.

1. Disable cutting emission. Check correct nozzle/ceramic installation and sound cables/connections.
2. Place clean sheet flat on suitable supports. If rust, oil, slag, thick coating or film affects measurement, use the manufacturer's suitable calibration method.
3. Position the head above a flat sheet area away from edges and holes. No gap or small part liable to tip may lie beneath it.
4. Run the height controller's calibration command. Menu names vary by version; most versions have a separate sensor/capacitance calibration function.
5. Watch the automatic approach. Stop for unexpected contact, continuous vibration or abnormal descent.
6. Inspect the result curve and manufacturer's quality/consistency indication. It must be smooth and repeatable; do not accept interruptions, sudden jumps or failure warnings.
7. Perform the manufacturer's safe height check. Verify stable following on different flat sheet areas without nozzle rubbing; record the result.

> **If calibration fails**
>
> First check sheet electrical contact, nozzle cleanliness, ceramic, sensor cable and environmental stability. Do not save an incorrect curve or continue production by “raising the head a little”.

Why? Incorrect measurement can bring the head too close or too far away. Cutting gas is affected and collision risk increases.

Screenshot to be added from a DOKTEK machine — **successful calibration curve and version information in BCS100 or the installed height controller**

3.4 Initial setup sequence and nozzle centering

Initial setup: authorized service task

Purpose: Base motion and following settings on reliable mechanical conditions. **Requirements:** Authorized commissioning personnel, machine-specific FSCUT/BCS100 manuals and correct version/configuration.

1. Service personnel must verify mechanical assembly and electrical connections; check servo direction, encoders, limits and reference sensors.
2. They must complete initial servo calibration/tuning by the authorized method. Operators must not change gains or motor parameters for trials.
3. They must verify homing and machine coordinates in the manufacturer's sequence.
4. They must complete capacitive calibration with a sound nozzle and suitable sheet.
5. They must perform the automatic tuning required by the BCS100/FSCUT version under safe conditions; verify following and motion.

> **The sequence may vary by version**
>
> "Servo tuning → homing + capacitive calibration → automatic tuning" is the general dependency sequence. Consult the installed FSCUT/BCS100 manual for exact commands and prerequisites. This paragraph is not a commissioning service instruction.

Why? Automatic tuning with incorrect mechanics or sensor conditions can retain an incorrect result.

Nozzle centering: tape test

Purpose: Verify beam passage through the nozzle bore center using the manufacturer's approved test method. **Requirements:** Task-specific training, head manufacturer's approved test material and low-energy centering procedure; working enclosure/interlocks.

1. Put emission in a safe state; park the head at the approved test position. Check nozzle, ceramic and correct tightening.
2. Place manufacturer-recommended tape/test material beneath the nozzle. Beam generation must be impossible during placement.
3. Confirm the area is clear and close the enclosure. Apply only the manufacturer's short, low-energy test pulse; do not choose power/duration arbitrarily.
4. Put emission in a safe state again before removing the tape. Assess the hole center relative to the nozzle imprint.
5. If offset, make small centering adjustments permitted by the head manual; repeat safe placement–enclosed test–safe removal at every check.
6. Once centering is stable, remove all test material; verify no nozzle residue. Complete required height calibration.

> **No firing with doors open**
>
> Do not fire while looking under the nozzle. Do not bypass interlocks. Stop and contact service for irregular/large burns, persistent center drift or reaching adjustment limits.

Why? Misalignment unbalances gas flow and may cause one-sided dross and nozzle heating. The test does not authorise open-beam work.

3.5 Dry run and frame check

A frame check traces the job's outer boundary on the sheet. A dry run follows the program path without a beam. Simulation checks paths/sequences on the computer. They answer different questions: “is the program correct?”, “does the job fit the sheet?”, “is the actual travel path clear?”



Check safeguards and the motion area at every step.

If the job file or work zero changes, reassess previous verification.

Purpose: Find placement and motion errors before the first beam. **Requirements:** Homed/calibrated machine, secured sheet, correct file and test mode with emission verified disabled.

1. Check actual program dimensions, sheet size and work zero. Complete edge finding/angle correction if required.
2. In simulation, examine inner contour sequence, lead-ins, micro joints, pierce points and rapid moves.
3. Raise the head to the manufacturer's safe height. Assess obstacles, curved sheet edges and clamps.
4. Run the frame function without a beam; check the entire job stays within sheet and safe travel limits.
5. Perform a dry run at a safe test speed. Gas/following functions may behave differently in some versions; separately verify emission is off.
6. Correct any file/origin error and repeat the relevant check. If successful, prepare the first test coupon for cutting.

! A dry run still involves motion

Gantry, Z and pallet hazards remain with the beam off. Do not reach into the enclosure or motion area. Do not proceed to cutting if actual and expected paths differ.

Why? Simulation cannot see sheet warping or tools on the bed. A frame check alone does not prove all internal moves are safe.

Screenshot to be added from a DOKTEK machine — **job boundary, work zero and beam-off test indication in the installed software**

3.6 Shutdown, frost protection and restart after an extended stop

Normal shutdown

Purpose: Bring the job and auxiliary systems to a controlled state. **Requirements:** Job records, manufacturer's shutdown sequence and suitable area for hot parts.

1. Finish cutting or end the program with a safe stop. Check hot parts and slag; follow extraction requirements after cutting.
2. Disable laser emission. Move head and gantry to the manufacturer's park position; leave the pallet safe.
3. Record job/recipe changes, alarms and unfinished work. Close the software and shut down the CNC/computer correctly.
4. Switch off the laser source in the manufacturer's sequence. If the chiller must continue running briefly after source shutdown, **consult the manufacturer's manual**; do not invent a fixed duration.
5. Shut off gas supplies and compressor/auxiliary systems according to the site plan. Safely relieve line pressure where required.
6. Switch off the chiller, then the machine's main supply/stabilizer in the defined sequence. Manage any supply needed for cooling, frost protection or extraction according to the manufacturer.
7. Check surroundings; verify no smouldering, leaks or unresolved work. Hand over the shift form.

> **! An emergency stop is a separate situation**
>
> In danger, do not try to finish normal shutdown; apply the emergency stop and site emergency plan. Normal shutdown does not replace maintenance LOTO.

Why? Abruptly cutting control computer power can lose job records. Stopping cooling too early while the source is running can damage equipment.

Winter / frost protection

Purpose: Prevent water freezing in an idle system. **Requirements:** Winter procedure jointly approved for the source, head and chiller.

1. Assess minimum ambient temperature and power failure risk.
2. Select manufacturer-recommended room heating, circulation, suitable fluid or draining; do not add incompatible antifreeze.
3. If draining is required, use the authorized method covering internal source/head pockets. Do not blow through with uncontrolled compressed air.
4. Label the measures taken. Do not start the source until refilling and air removal are complete.

> **! Do not start if freezing is suspected**
>
> Do not run the source to thaw ice. Have authorized personnel check for cracks, leaks and lost flow.

Why? Fluid may remain in internal channels even if external hoses appear empty.

Restart after an extended stop

Purpose: Restore reliable system condition. **Requirements:** Shutdown record and maintenance plan.

1. Check fluid, hoses, filters, gas lines, mechanics and electrical equipment externally; remove storage protections according to the manufacturer.
2. Prepare cooling circuits; verify no leaks, condensation or alarms.
3. Carry out normal start-up, homing, centering and required capacitive calibration. Return to production after a dry run and test coupon.

The old recipe alone is insufficient

Material, gas and optics conditions may have changed. Do not start series production before measuring the first part.

Why? Moisture, contamination and leaks can develop during a stop; previous successful work does not rule these out.

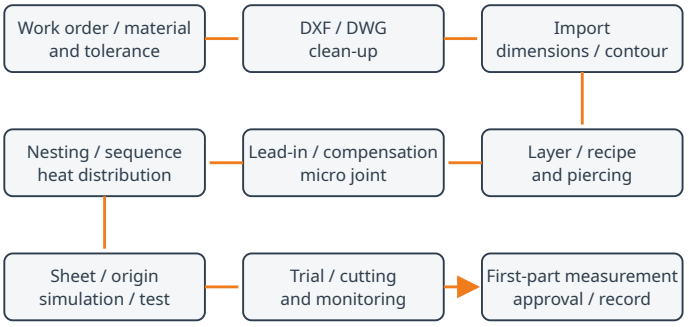
04

Workflow from drawing to cutting

Clean the drawing first, then generate the cutting path. Separately verify on the machine any shape that looks correct on screen.

4.1 Plan the whole job

A cutting job is more than a DXF file. Material, actual thickness, quantity, dimensional tolerance, edge requirements and subsequent operations determine the recipe. A painted part may need different edges from a part to be welded. Do not resolve unclear work orders by experimenting during cutting; clarify them with the responsible person.



A correction can affect later steps. Repeat path checks if scale, contours or nesting change.

Before starting	Information to record
Technical drawing	Revision, critical dimensions, tolerances and edge requirements
Material	Type/grade, thickness, batch, coating/film, surface condition
Machine / recipe	Source, head, gas and approved parameter ID
Plan	Quantity, nesting, part orientation, lifting and skeleton handling

Allow for the first part

Do not start a new job by cutting the whole sheet. Plan a test coupon or first part for dimensional and edge checks. Save the file and recipe revisions together.

4.2 DXF / DWG preparation

The drawing file must contain one consistent representation of the geometry to be cut. Dimension lines, invisible duplicates and open ends can create extra paths or unwanted piercing. Use geometry checks as well as visual zooming.

Preparation	Action	Check
Units / scale	Prepare the drawing in mm at actual size.	Measure a known outer dimension and hole diameter.
Single line	Define each cutting edge once.	Ensure line thickness does not create a separate closed contour.
Closed contour	Close part and hole boundaries.	Find endpoints and small open gaps.
Duplicate / overlapping lines	Remove duplicate geometry and coincident segments.	Check contour counts and repeated passes in simulation.
Text	Convert text to be cut into contours.	Assess bridges needed to retain letter centers.
Spline	Convert to arcs/lines at the tolerance required by the controller.	Check for excessive short segments, corners and dimensional deviations.
Small gaps	Join endpoints with an approved joining tolerance.	Do not accidentally close a genuine design gap.
Auxiliary objects	Remove dimensions, hatching, borders and notes from cutting geometry.	Ensure no unexpected layers/contours remain after import.

Drawing clean-up procedure

Purpose: Create unique, closed contours for the machine to process. **Requirements:** Approved drawing, CAD file and backup copy.

1. Verify the file revision; open a working copy. Check units and a known dimension.
2. Separate non-cutting objects. Convert blocks/objects to a format supported by the control software.
3. Remove duplicate lines. Find open contours; close them according to the actual design.
4. Convert text and splines. Check that small arcs and letter centers remain.
5. Save in a suitable DXF/DWG version, reopen and measure.

! Automatic correction can change the design

Do not increase joining/smoothing tolerance simply to remove all warnings. A small opening may be a functional slot. Have critical shape changes approved by the drawing owner.

Why? Duplicate lines reheat the same area; open contours may cause incorrect inside/outside classification or incomplete parts.

4.3 Import, layers and parameters

A file opening correctly after import does not mean it is ready for cutting. Recheck dimensions, part counts, inner/outer contour relationships and layer functions. Screen color does not identify physical gas; in most software it only indicates a process layer.

Purpose: Assign the correct operation and recipe to every contour. **Requirements:** Clean file, work order, material details and a recipe selected/approved using section 9.0.

1. Import the file into the control software. Menu names may vary by version; most versions provide separate import and geometry checking functions.
2. Measure overall width/height and a known hole. Verify part counts and rotation/mirroring.
3. Inspect closed/open and inner contours. Every drawing object must have a defined purpose.
4. Assign cutting, marking or other supported operations to separate layers. Do not use an unsupported function simply because a layer color exists.
5. Assign correct material, gas, pressure, nozzle, height, focus, power and speed together to each cutting layer. Check the piercing recipe separately.
6. Verify that non-cutting auxiliary layers are excluded from processing. Review the layer list and contour counts.
7. Save under a new job name/revision. Do not make uncontrolled changes to the master recipe with trial settings.

> **Check machine limits and units**
>
> Software may display power in W or percent and speed in different units. Match the table's W and m/min to the screen units; convert and verify before applying. Do not change authorized machine configuration.

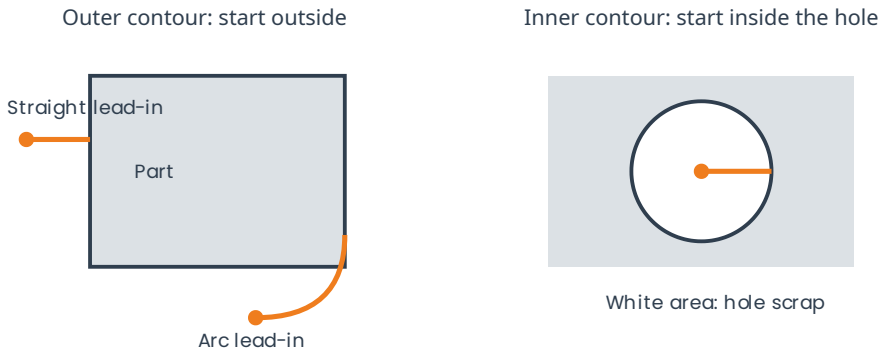
Why? Moving the same geometry to another layer can change gas, piercing and motion conditions as well as color.

Final check	Question
Geometry	Correct revision; correct overall dimensions and holes?
Layer	Is every object's operation clear; are auxiliary lines disabled?
Recipe	Are gas and all row values used together; is piercing suitable?
Record	Can the job file and parameter revision be traced?

Screenshot to be added from a DOKTEK machine — **imported part, dimensional check and process layers**

4.4 Lead-ins and lead-outs

A lead-in is the approach from the pierce point to the actual contour. A lead-out is the departure at the contour end in a supported workflow. Most of the lead-in stays on the scrap side to prevent piercing marks and unstable start-up from damaging the part edge.



Orange lines show example lead-ins; determine actual length/radius by test cutting. Drawing not to scale.

Choice	When to consider it	What to check
Straight lead-in	With sufficient scrap space and a suitable joining point	No notch/corner mark where it joins the contour
Arc lead-in	When a smoother change of direction is needed	Arc must not cross another part or a narrow hole boundary
Thick plate	When piercing and transition to stable cutting need more room	Start outside the finished part, within sufficient scrap
Small inner contour	With limited lead-in space	Pierce crater must not reach the dimensioned surface
Near a corner	When specifically required by design/subsequent operations	Deceleration, heat build-up and edge joining marks

Positioning the lead-in

Purpose: Keep piercing and acceleration marks on the scrap side. **Requirements:** Part with recognized inner/outer contours and a suitable piercing recipe.

1. Identify finished part and scrap sides. Approach outer contours from outside and inner contours from within the hole.
2. Choose a joining point that is not dimensionally or visually critical. Do not start at a sharp corner by default.
3. Choose straight/arc form and length for material, thickness and available space; do not use a universal fixed length.
4. In simulation, check that the pierce mark, lead-in and any lead-out do not reach adjacent parts.
5. Inspect the joining mark on the first part; correct one variable if needed and record it.

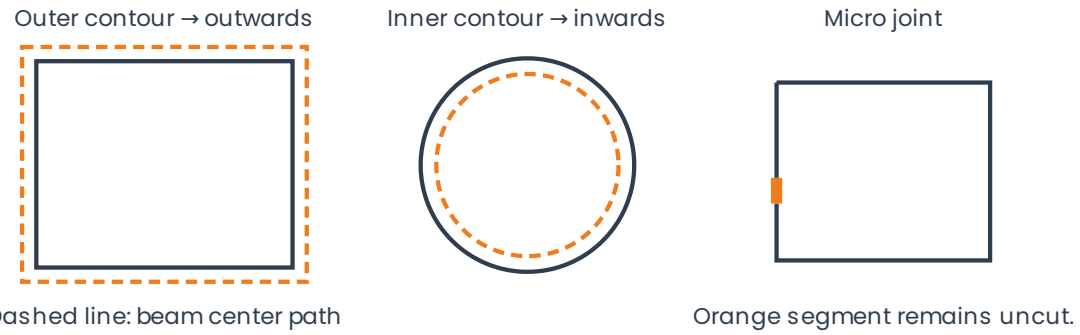
! A longer lead-in is not always better

In tight nesting, a lead-in may cut another part. An unnecessarily long lead-out may reheat a released part. If a corner start is necessary, verify the method by trial.

Why? Piercing is not yet stable cutting. Moving the start away from the finished edge reduces crater and notch risks.

4.5 Kerf compensation and micro joints

Kerf is the width of the channel removed by the beam. Compensation shifts the beam center path towards scrap to retain finished dimensions. For outer contours the path moves outwards; for inner contours it moves inwards towards the hole center. Do not enlarge CAD dimensions and also apply software compensation.



Compensation is exaggerated in the diagram. Determine the actual kerf by measuring a test part.

Verifying compensation

Purpose: Bring part and hole dimensions closer to the technical drawing. **Requirements:** Measuring instrument, clean test part and compensation applied in one place only.

1. Check nominal CAD dimensions and whether compensation has already been applied.
2. Verify inside/outside classification; select the correct compensation direction.
3. Cut the test part, allow it to cool and measure on surfaces unaffected by dross.
4. Compare outer and hole dimensions separately. Change only compensation in a controlled manner; measure again.

> **! Do not mask geometry faults with compensation**
>
> Oval holes, taper or dimensions varying by direction may involve more than compensation error. Check nozzle centering, mechanics and the recipe.

Why? Reversed compensation can shrink the outer part while enlarging the hole. Double compensation shifts dimensions twice.

Planning micro joints

Micro joints retain a part in the skeleton with small uncut sections. They reduce small-part tipping, lifting and head collisions. Choose joint width/count for material, thickness, shape, support and subsequent separation; this book gives no single size.

Purpose: Keep parts stable until cutting is complete. **Requirements:** Nesting, part removal plan and permitted surface area.

1. Identify parts liable to tip or fall.
2. Place joints away from critical dimensions, holes, visible surfaces and sharp corners.
3. Determine size/count by trial; avoid weak joints and unnecessarily high separation loads.
4. Check in simulation and on the first part that joints actually remain uncut.

Do not pull parts free

Use suitable separation/deburring methods without bending thin parts. Skeletons can move unexpectedly under attached part loads.

Why? Joints can improve cutting safety; poor placement can impair dimensions or appearance.

4.6 Cutting sequence, sheet placement and edge finding

The general sequence is inside out: holes and small inner contours first, then the part exterior. Cutting the exterior first loosens the part; position or support may be lost during inner contour cutting. Small-to-large sequencing also helps on many jobs; assess the whole nest for heat, narrow bridges and tipping risk.

Cutting adjacent small parts consecutively concentrates heat. Spread the sequence across different areas; watch for sheet lifting/warping. Reducing rapid travel is not the only aim. Use common line cutting or flycut only with suitable software/machine functions and a verified recipe; for details see section 06.

Decision	Check
Inside out	Does the part become free before inner contours are complete?
Small to large	Does a small part tip early and obstruct a later path?
Heat distribution	Is consecutive piercing/cutting concentrated in a narrow area?
Support	Will the cut part rest on slats; are micro joints needed?
Non-cutting travel	Does the head cross tipped parts or a raised skeleton?

Edge finding and sheet angle correction

Purpose: Align the program with actual sheet boundaries and angle. **Requirements:** Homed/calibrated machine, flat sheet placement and a software-supported edge finding method.

1. Place the sheet with suitable support; check securing and surface condition. Do not try to correct tilted, loose or buckled sheet in software.
2. Verify machine coordinates and work zero selection. Do not assume the previous sheet's origin is correct.
3. Run the manufacturer's edge finding function. Keep holes, broken edges and clamps out of the measurement path.
4. Compare the calculated sheet angle and boundary with expected placement. Reject reversed directions or unexpected angles.
5. Update the nest; verify by frame check that the whole job fits within the sheet.

Edge finding is not homing

Correcting sheet angle does not correct an incorrect machine reference. Recheck travel limits after changing sheet, pallet or work zero.

Why? A small angular difference can move the far corner of the job beyond the sheet. A software transformation is reliable only with correct measurement.

Screenshot to be added from a DOKTEK machine — **sheet edge measurement, detected angle and job placement within actual sheet boundaries**

4.7 Simulation, starting and resuming

Starting the cut

Purpose: Begin a controlled first cut of the verified job. **Requirements:** Approved file/recipe, suitable sheet, safeguards, gas, cooling and extraction.

1. Review sequence, pierces, lead-ins/outs, compensation and micro joints one final time in simulation.
2. Complete frame checks and beam-off dry runs following section 3.5 in sequence.
3. Verify that enclosure and pallet areas are clear/closed. Check correct gas selection, dynamic supply and extraction readiness.
4. Start cutting by the manufacturer's method. Watch the first pierce and edge only through an approved viewing window/camera.
5. Stop for abnormal upward sparks, persistent failure to cut through, fume accumulation, collision or alarms. Do not worsen a defect by continuing.
6. Remove the first part when safe; perform the section 4.8 check. Do not proceed to series production without approval.

> **! Do not intervene in the cutting area**
>
> Do not press parts down, retrieve tipped parts or clear the head path during operation. Stop as required and establish safe access.

Why? The first contours reveal wrong gas or work zero early. Material and time losses increase as the program progresses.

Pausing and breakpoint resume

Breakpoint resume returns to a recorded point in the cutting program. The gas/piercing/motion states retained by the controller vary by version. Pause, emergency stop and power failure are different recovery conditions.

Purpose: Resume remaining work from a safe position and correct contour. **Requirements:** Unchanged sheet/part position, known stop cause and the software's resume procedure.

1. Identify and eliminate the stop cause. If collision or reference loss is suspected, first complete mechanical checks, homing and required calibration.
2. Verify that sheet, pallet and parts have not moved. Check the job file, work zero, angle and layer settings.
3. Review the saved resume point and cut/uncut paths. Select return/re-piercing distance by the manufacturer's method.
4. Keep the head's return path clear. Verify that re-piercing will not damage finished edges or land on a released part.
5. Close guards, start with the manufacturer's resume command and watch the first rejoining point.

> **! Do not guess a resume position without a record**
>
> A shifted sheet or lost reference is not corrected by a screen marker. Without an authorized repositioning method, stop and replan the job.

Why? Restarting a contour a few steps earlier is not always safe; it may recut an already released part.

4.8 Part removal, first-part inspection and records

Removing parts and skeleton safely

Purpose: Unload hot, sharp or unstable material in a controlled manner. **Requirements:** Stop/access permission, suitable PPE, lifting equipment and a part stacking area.

1. Verify cutting is complete, the beam is safe and head/gantry are parked. Do not approach before pallet movement ends.
2. Assess cooling of parts and slag. No visible red glow does not mean cold.
3. Inspect micro joints and uncut areas. Do not force parts free; use the defined separation method.
4. Prevent small parts falling between slats and skeletons folding closed. Follow the appropriate lifting/handling plan for heavy parts.
5. Lift the skeleton evenly; check sharp edges and parts caught beneath. Clean the bed during a safe stop.

! Do not stand on the skeleton

Cut narrow bridges may break under weight. Do not reach under the bed for parts; use appropriate access and energy isolation methods.

Why? Cutting changes sheet handling stiffness. A large skeleton can fold and create a cutting edge with little movement.

Approving the first part

Purpose: Verify dimensions and edge quality before series production. **Requirements:** Technical drawing, calibrated measuring instrument, cooled part and record form.

1. Verify correct part/revision and material. Assess dross or temperature differences affecting measurement.
2. Measure critical outer dimensions, holes, hole positions and corners if required. Use drawing tolerances.
3. Inspect upper/lower edges, dross, taper, striations, burns, discoloration and lead-in marks.
4. Classify the defect; use section 13 for a single-variable trial. Use the same measurement conditions each time.
5. Record the approved result by the responsible person's method; only then continue series production.

! Do not increase speed at the expense of quality

A part dropping free is not sufficient acceptance. Meet edge requirements for welding, painting or assembly too.

Why? Without assessing dimensions and edges together, a dimensionally correct but unusable part may be produced.

Record field	Contents
Job / material	Drawing revision, file name, batch, type, thickness and surface
Recipe	Gas, pressure, nozzle, height, focus, power, speed and piercing settings
Result	Dimensions, edge/dross, trial change and photo
Traceability	Machine, operator, date, parameter revision and approval

The preparation workflow has been assessed alongside the FSCUT family's general processing approach and Linde cutting check topics. The actual software version and machine manufacturer's instructions govern.

05

Nesting

Nesting arranges ordered parts on a sheet in a layout that can be cut. Use material efficiently; include heat, non-cutting travel and part separation labor in your assessment.

5.1 Nesting objectives and terms

Nesting is more than filling gaps. It aims to obtain more sound parts from one sheet, reduce waste, pierce counts and cutting time. Parts that are hard to remove, tip or distort with heat cancel material savings. Assess accepted parts and total labor.

Term	Meaning	Operator check
Sheet / plate	Starting material for nesting.	Verify material type, thickness, actual dimensions and surface.
Part	Closed outer contour and any inner contours to be produced.	Check quantity, revision and holes.
Part spacing	Gap between adjacent parts.	Allow room for lead-ins and thermal effects.
Edge margin	Distance from the sheet boundary to the nearest part.	Account for wavy edges, clamping areas and supports.
Rotation angle	Permitted part orientations in the nest.	Preserve grain, brushed finish and film direction requirements.
Common line	Cutting a shared boundary between two parts once.	Verify dimensional compensation and shared edge sequence.
Part-in-part	Placing another part in a large part's discarded opening.	Cut the nested part before releasing its supporting opening.
Skeleton	Connected sheet framework remaining after part removal.	Check that it will not break apart during lifting and unloading.
Remnant	Usable material retained for a later job.	Record shape, direction, thickness and stock ID.

Kerf relates to kerf compensation; it is not part spacing. Check whether the software measures spacing from nominal lines or compensated cutting paths. Do not apply compensation twice in the same file.

5.2 Automatic and manual nesting

Automatic nesting quickly tries many part arrangements. Wrong quantities, rotation angles, sheet sizes, spacing or margins quickly produce a wrong result. Manual nesting helps with single-part jobs, irregular remnants and surfaces with direction requirements. Manually adjusting an automatic result suits many jobs.

Purpose: Prepare a safely cuttable nest that meets production requirements.

Requirements: Approved drawing, part list, sheet dimensions, material details and a machine-compatible cutting recipe.

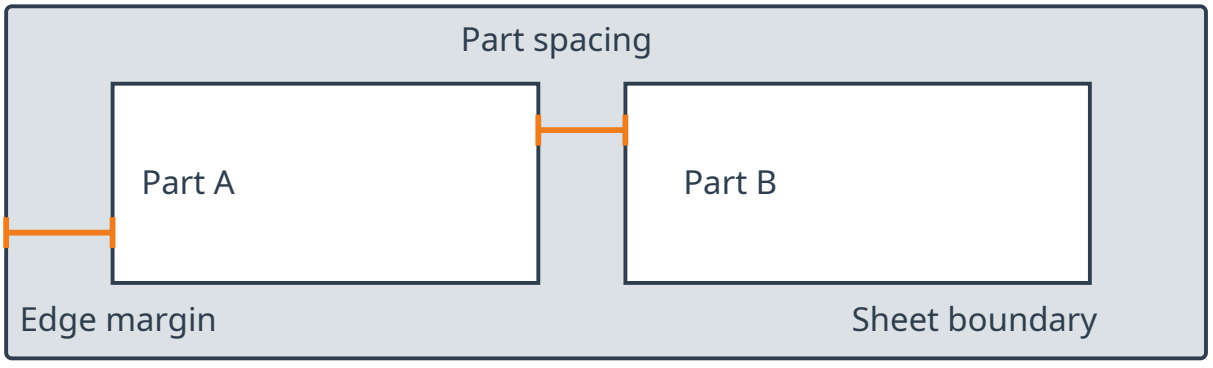
1. Complete open-contour and overlapping-line checks; use section 4 for the workflow.
2. Define actual sheet boundaries. Exclude defective, bent or clamping areas.
3. Assign correct quantities and permitted rotation angles to every part. Lock parts that must not be mirrored.
4. Place large parts and those with mandatory orientations first. Try small parts in remaining areas.
5. Run automatic nesting or move parts manually. Inspect lead-ins, common lines and nested parts.
6. Watch cutting sequence and non-cutting travel in simulation. Compare net part quantity with the order.

> **Warning**
> Do not remove direction locks, edge margins or safe spacing to improve percentage yield. Verify that apparently empty simulation areas are not occupied by clamps on the actual machine.

Why? A nesting error affects the whole sheet. Even if the first part is sound, support and heat conditions change for later parts.

5.3 Part spacing, edge margin and direction

As a starting point, generally consider spacing at least equal to sheet thickness; 1–3 mm is a common planning range for thin sheet. These are neither cutting recipes nor minimum limits for every job. Lead-ins, pierce craters, heat build-up and part support may require wider gaps. Do not directly use thin-sheet spacing for thick plate.



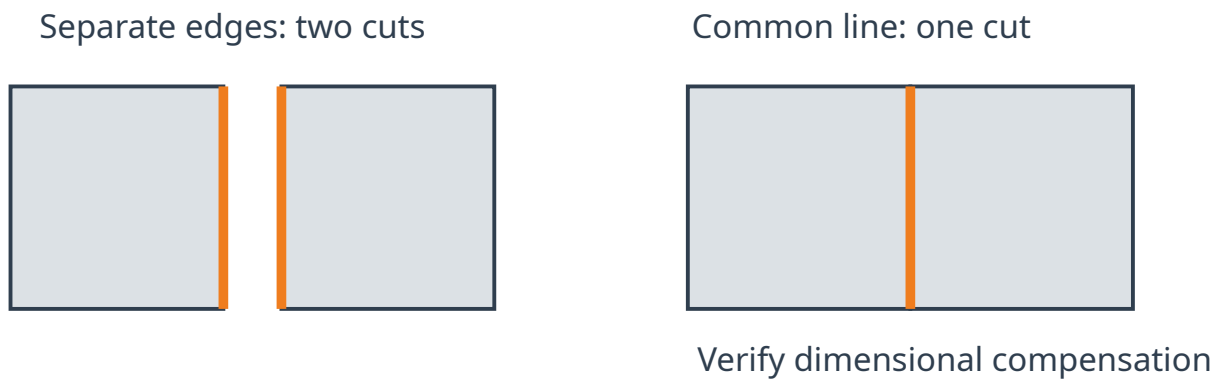
Schematic dimensions. Define spacing and edge margin separately.

Allow room for piercing and lead-ins at the sheet edge. Do not treat an unevenly cut edge as a usable boundary. Instead of assigning a fixed edge margin, check actual edge condition, head path and machine working area.

Preserve brushed finish direction on stainless steel, required rolling direction on parts to be bent, and appearance direction on decorative or filmed sheet. Restrict rotation angles to drawing requirements. Mirroring differs from rotation.

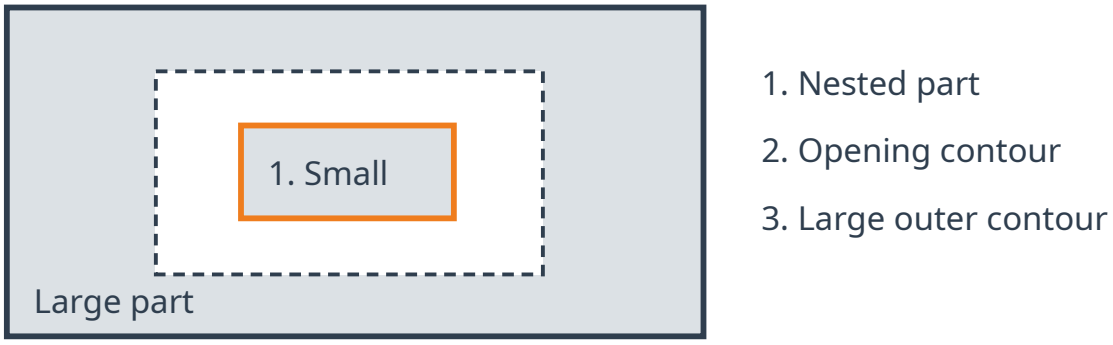
5.4 Common line and part-in-part

Common line cutting can reduce path length and pierce count on thin sheet. Do not simply overlap two independent lines; use the software's common line function. Shared line compensation must suit both parts' dimensions. Measure a sample first for tight tolerances.



Orange lines indicate cut edges. Consecutive adjacent cuts on thick plate concentrate heat.

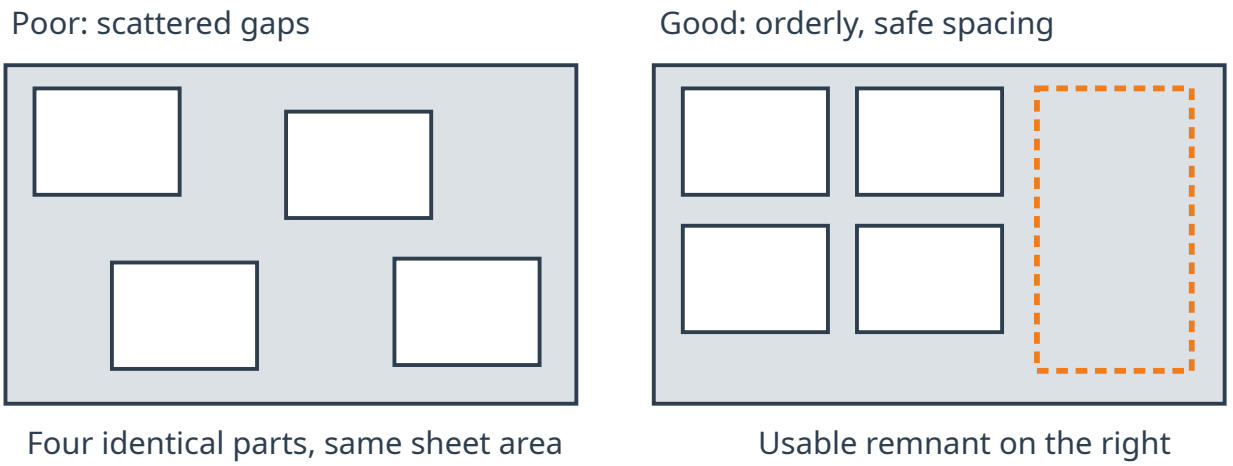
Repeated heating of shared edges, corner burning and dimensional changes become greater risks on thick plate. Compare nesting gains with cut quality and separation labor. Do not use the same common line arrangement for every material.



Once the opening is cut and drops out, its nested part cannot be cut. Ensure the small part is supported on the slats too.

5.5 Cutting sequence and good nesting

Generally cut inner holes before outer contours. Distribute cuts across the sheet rather than repeatedly heating adjacent areas. Do not release long, narrow parts early. To prevent small parts falling through the slats or lifting, consider the micro joints in section 6.2.



Equal part areas give the same immediate yield; the shape of the remaining area affects savings on later jobs. The diagram does not show cutting sequence.

The shortest non-cutting path is not always safest. Do not move the head over released parts. The leapfrog motion in section 6.6 does not make a raised part in the path safe. Assess remaining skeleton integrity until cutting ends.

5.6 Recording and reusing remnants

Purpose: Store usable remnants as stock items with known material and boundaries.

Requirements: Remnant stock system or form, measuring tool, durable stock label and safe handling equipment.

1. After cutting, allow the sheet to cool. Separate usable material from sharp, weak skeletons.
2. Record material grade, thickness, batch and direction requirements. Do not identify stainless steel grade by appearance.
3. Measure remnant boundaries; record cut-outs and defects. A rectangular bounding-box measurement is insufficient.
4. Use the same ID on the physical label and software stock record. Add storage location.
5. When reloading, verify direction, reference, supports and capacitive height sensing. Check boundaries with the laser off.

> **Warning**
>
> Do not use a small or bent remnant simply because it fits on the machine. Do not cut material that rocks or lacks support along the head's travel.

Why? Wrong material identity compromises the next order; wrong boundaries can cause piercing over a void and head collisions.

5.7 Skeleton cutting and yield calculation

Scrap cuts divide the remaining skeleton into manageable pieces. Keep division lines away from finished parts and retained remnants. Check support and cutting sequence in software; do not divide in a sequence that collapses the skeleton early. Remove heavy skeletons with suitable lifting equipment. Do not pull sheet by hand while the machine operates.

> **Warning**
> Skeletons can be hot, sharp and unstable. Stop motion, put the laser in a safe state and follow the unloading procedure. Account for springing strips, falling parts and collapse during lifting.

Area yield (%) = total net area of accepted parts ÷ sheet area used × 100. Subtract holes from net part area if they leave no material in the product. Waste, kerf and unused area are included in the denominator.

Calculation example: For a 1,000 × 2,000 mm sheet, sheet area is 2,000,000 mm². If total accepted net part area after subtracting holes is 1,500,000 mm², yield is 1,500,000 ÷ 2,000,000 × 100 = **75%**. Do not treat all the remaining 25% as scrap; record usable remnants separately. These numbers illustrate area calculation only.

If software uses outer contour area, its displayed percentage may exceed net yield. Compare using the same definition. Include pierce count, total cutting path, estimated time and separation labor alongside material yield.

5.8 Nesting software and final checks

Software	Use	Before sending the job
Nesting within CypCut	Basic nesting alongside cutting preparation; functions depend on version and license.	Verify available automatic nesting and common line options.
CypNest	Separate paid nesting software/add-on; automatic nesting and common line preparation.	Verify licensing and file compatibility with the CypCut version.
Lantek	Sheet nesting and cutting programming solutions.	Verify the output converter for your machine.
SigmaNEST	Part grouping, nesting and production preparation.	Verify cutting technology and controller compatibility.
ProNest	Nesting solution usable with suitable configurations on many machines, including Durma.	Brand support alone is insufficient; verify the postprocessor for the model and controller.

Menu names may vary by version; most versions place nesting, rotation and spacing settings in job preparation tools. Brands and licenses do not all offer the same options. Prepare output with a machine-compatible postprocessor: a configuration that converts the job into a program the controller understands.

- Are part quantity, revision, direction and material correct?
- Are lead-ins in free areas; are inner contours and common lines correctly sequenced?
- Have tipping risk and final skeleton condition been checked?
- Are remnant records and unloading methods ready?

Basis: Nesting and software scope follows the work brief. Verify spacing recommendations with sample cuts; for cutting recipes use section 9.

06

Cutting techniques

The same recipe gives different results with different lead-ins and cutting sequences. Keep the part stable first; then reduce piercing, non-cutting travel and corner times. Verify a new technique on a sample before applying it to a whole sheet.

6.1 Selecting lead-ins and lead-outs

A lead-in moves piercing away from the finished edge and brings the beam onto the contour. A lead-out manages the transition at contour completion. For drawing-to-program preparation see section 4; here, select the type for the part shape.

Type	Suitable situation	Check point
Straight lead-in	Simple contours with ample scrap space.	Abrupt joining marks and distance from the pierce crater.
Arc lead-in	Parts requiring smoother joining to the finished edge.	Arc stays within scrap; no interference with adjacent parts or narrow holes.
Tangential lead-in	Edges needing entry aligned with the contour direction.	Tangent extension must not enter the product or create excess heat.
Short lead-in	Inner openings with limited space.	Complete piercing; crater must not reach the dimensioned surface.
No / short lead-out	Jobs where the part becomes free when the contour closes.	No uncut point or re-burnt notch at the finish.
Arc or tangential lead-out	Contours where the finish mark can be moved into scrap.	Lead-out must not follow a released part or cut an adjacent contour.

For outer contours, the lead-in generally stays outside the part; for inner contours, inside the discarded hole. Inspect pierce and contour joining points separately. Keep lead-ins away from tight corners, functional dimensioned surfaces and micro joints. Thick plate may need more space for craters and spatter.

Assess lead-in length and speed separately from main cutting. Excess length increases time and heat; an overly short lead-in reaches the product before cutting stabilizes. Obtain numerical recipes from section 9 and the machine's lead-in/piercing table.

6.2 Micro joints and bridges

Micro joints retain a part in the skeleton by leaving a small contour section uncut. Use them on small, long narrow parts or parts between support lines. They prevent falling and lifting into the head path. Joint marks on visible edges require later cleaning.

Depending on software, a bridge may mean a supporting connection between parts or a path joining contours. Do not rely on its name alone; use simulation to see where material remains and where cutting occurs. Do not treat bridges and micro joints as the same function.

Decision	Starting approach	Sample acceptance criterion
Joint size	Choose machine/software recommendations for thickness, material strength and part weight.	Part must not lift during cutting or bend during separation.
Number of joints	Retain long, unstable parts at several suitable points.	Gas jets and final cutting must not break the joints.
Position	Prefer accessible straight edges without dimensional or appearance requirements.	Joint marks must not damage functional surfaces.
Ease of separation	Find the smallest safe retention by sample testing.	Separate cooled parts with suitable tools without tearing edges.

Do not use one fixed joint width for every material. Overly thin joints break early; overly thick joints increase separation labor. Check support positions too: joints cannot always compensate for missing support.

Warning

Do not break joints by hand while the machine operates. Put the laser in a safe state for unloading, allow parts to cool and use tools with suitable gloves. Direct breaking forces away from your face and other people.

6.3 Corner processing and power–speed curves

If power remains constant as the head slows at a corner, energy per unit length increases. Oxygen's exothermic effect can also burn corners. If sharp corners burn, holes enlarge or dimensions are lost, examine more than straight-line speed.

A power–speed curve regulates power as speed falls. Frequency curves and pulse settings may be separate functions on systems providing them. Menu names vary by version; most versions offer corner power and speed-dependent power in layer or technology settings. Stay within the source's permitted operating range.

A corner loop can extend the path into scrap for a smoother sharp turn. Verify that it does not enter adjacent parts or impair required dimensions. For cooling functions, check that the laser is off during stationary pauses and gas behavior matches the recipe. Waiting with the laser on increases heat.

- Verify nozzle, gas and surface conditions first.
- If straight edges are good, inspect corner power and motion behavior.
- Change only the curve and recut the same corner.
- Apply rounding only if the technical drawing permits; do not change tolerances.

6.4 Small holes

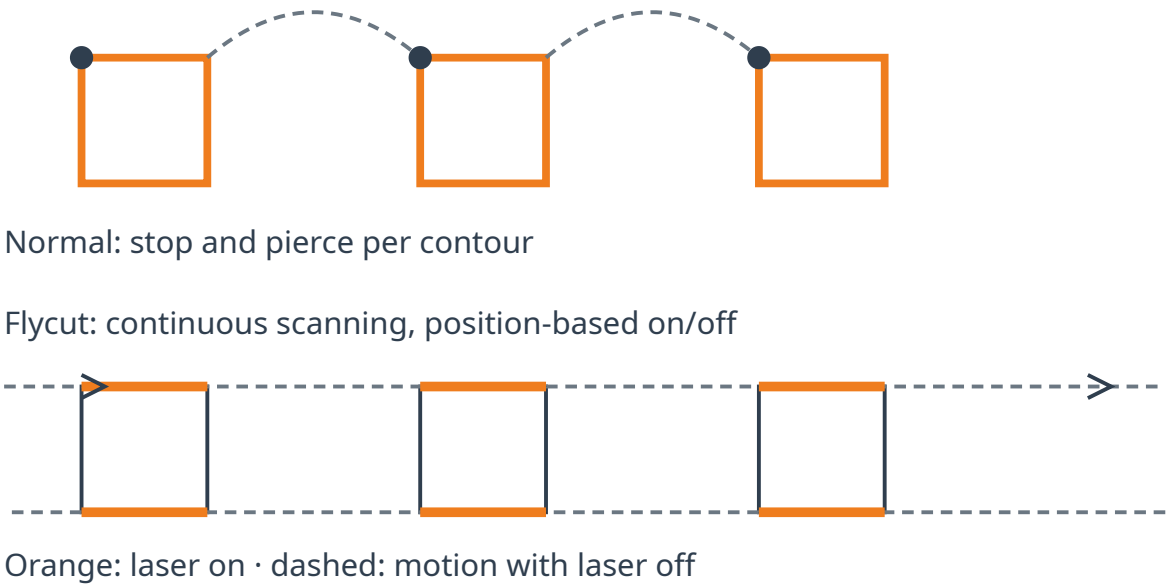
When hole diameter is approximately equal to or smaller than sheet thickness, smooth, square, correctly sized holes become harder to achieve. This ratio is not a capacity guarantee. Pierce craters, short travel distances, gas exit and corner energy build-up act together.

Pulsed mode and suitable low speed may form part of approved small-hole technology. Excessively reducing speed alone can burn and enlarge holes; assess power, frequency and duty cycle together with the relevant technology. Measure bore diameter at top and bottom. Record ovality and taper separately.

If there is no room for a lead-in, do not force piercing onto the dimensioned surface. Consider drawing-permitted alternative manufacturing methods; pilot holes for later drilling require technical approval. Operators must not enlarge drawing diameters at their own discretion.

6.5 Flycut

Flycut switches the laser on and off at suitable positions without stopping head motion across regular arrays of holes and rectangles. Suitable thin-sheet applications omit a separate stop and piercing dwell at each feature. Piercing must complete reliably during motion; the need to penetrate the sheet remains.



Path principle diagram. Only horizontal scans are shown below; other scans completing the rectangles are omitted.

Removing stops can save substantial time on thin sheet with many regular openings. Do not assume a percentage saving; compare total cycles for the same job. Include sheet loading, edge cleaning and defective-hole correction time.

Condition	Check	Risk if unmet
Regular array	Do pitch, direction and openings suit the technique?	On/off points shift; contours remain incomplete.
Thin, flat sheet	Is stable piercing possible during motion?	Uncut starts and adhesion underneath.
Machine dynamics	Do the controller, source triggering and axes support the function?	Position and dimensional errors.
Verified piercing	Are holes fully open, including the first and last rows?	Repeated errors spread across the whole sheet.

Do not force this technique onto randomly positioned holes, thick plate or unsupported machine programs. Measure the first array; inspect start/finish marks and dross. Monitor the effect of moving-pierce spatter on the protective window.

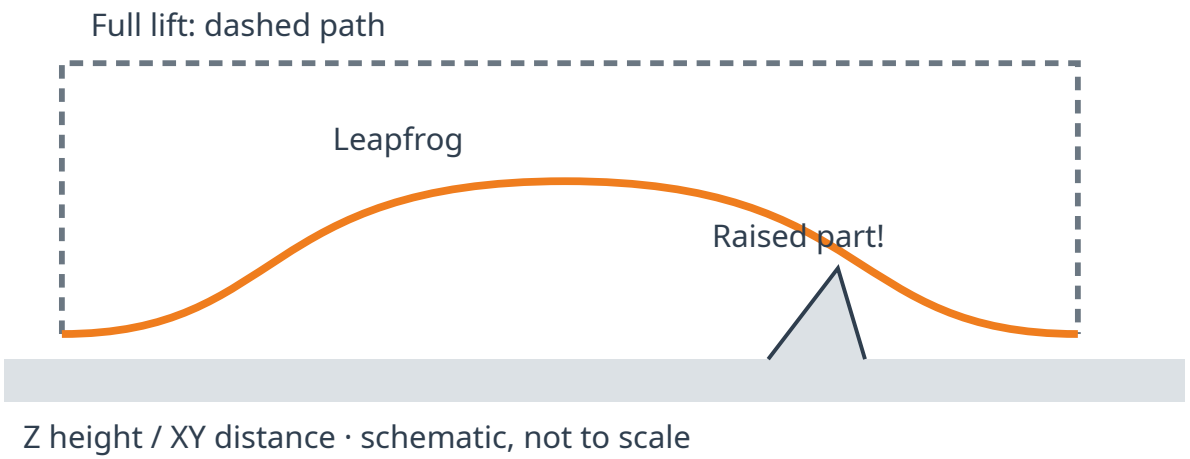
Distinguish similar-looking motions

Process	When does the laser operate?	Main benefit
Normal contour cutting	Follows the contour after piercing and lead-in; off during travel to the next contour.	Flexible paths for free-form parts.
Flycut	Switches on/off by position during continuous scanning.	Eliminates stops and piercing dwell per contour in suitable arrays.
Leapfrog	Off during non-cutting travel between contours.	Reduces lift–travel–lower time during non-cutting moves.
Pre-piercing	At separate pierce points first; along cutting paths in a later pass.	Manages piercing and contour cutting separately.

Having these functions available does not mean enabling them all on one job. First obtain an accepted part by the normal method. Then assess a supported technique by its effect on total job time and quality.

6.6 Leapfrog

Leapfrog combines Z-axis raising and lowering with XY travel in a curved motion, instead of lifting to full height and lowering at every move. This reduces non-cutting travel time. Actual profiles and permitted heights depend on the controller and machine dynamics.



A low travel path can collide with a raised part. The spatial motion principle is shown, not a time profile.

Prepare micro joints, safe cutting sequence and travel routes together. Avoid crossing released parts, especially after the final outer contour. Do not prioritize speed gains on wavy sheet or unsupported remnants. Simulation does not always model parts tipping.

6.7 Pre-piercing, cooling points and sequence

Pre-piercing opens designated pierce points first, then returns to cut contours. On thick plate, it helps manage piercing spatter and heat load separately. It may increase non-cutting travel, gas use and total time. Do not confuse pre-piercing with flycut; pre-piercing uses separate piercing cycles.

If a pre-pierced point shifts, the second pass reaches solid material instead of the hole. Do not move the sheet between passes; retain references. Check that slag, meaning accumulated solidified melt, does not remain in the head's following path after piercing. For piercing details see section 12.

Use cooling points or dwells only through the controller's approved function. Laser-off and gas-on/off behavior is defined by the recipe. Moving to another region is often preferable to cutting an adjacent contour while the sheet is hot.

- Adapt the sequence of inner contours → supported small parts → large outer contours to the job.
- Do not concentrate heat at one corner; distribute it among parts.
- Watch common line and micro joint sequence separately.
- Check how the remaining skeleton and remnants will behave at the final outer cut.

6.8 Introducing a new technique

Purpose: Verify time savings while retaining part quality.

Requirements: Approved baseline recipe, same-material sample, measuring tool and trial record.

1. Cut a sample by the baseline method. Record dimensions, edges, pierce count and cycle time.
2. Enable only one technique. Check software support and simulation.
3. Check boundaries with the laser off. Watch the first small group from behind the machine's closed guards.
4. Measure cooled parts; compare upper/lower edges, corners and lead-in marks.
5. Return to the baseline method if there is collision risk, uncut points or quality loss. Save suitable results as a revision-controlled recipe.

> **Warning**
> Do not open doors to watch motion or disable interlocks. Safely stop the automatic cycle if samples show lifting or collision signs.

Why? A short program time alone is not success. Total time and labor per accepted part must fall.

6.9 Brief note on tube cutting

This guide covers flat sheet. Rotary axes, chucks, tube supports and beam passage to the rear wall create different risks in tube cutting. Separate software such as TubesT and machine-compatible tube cutting technology may be needed. Do not directly transfer flat-sheet nests and recipes to tubes.

Basis: Technical scope follows the work brief; diagnostic approach follows the local Linde “Laser cutting advice” document. Cutting recipes are in section 9; verify software functions in the installed version.

07

Gas selection

Assist gas removes molten metal from the kerf and affects edge chemistry. Do not select gas by price alone; assess material, edge requirements, available pressure and subsequent operations together.

7.1 How do oxygen, nitrogen and air work?

Gas	Cutting mechanism and edge	General arrangement
O_2 Oxygen	Oxidation is exothermic; the chemical reaction adds heat. Leaves an oxide layer on mild steel edges.	Generally low pressure, double-layer nozzle (D), positive focus.
N_2 Nitrogen	The laser supplies most energy; nitrogen ejects melt. Suitable purity gives a bright, oxide-free edge.	Generally high pressure, single-layer nozzle (S), negative focus.
Air Dry compressed air	A nitrogen/oxygen mixture. Can be economical and fast on thin–medium sheet; edges may be slightly dark with some dross.	Requires a suitable compressor, dryer, filters and approved air recipe.

O_2: A typical low-pressure range for mild steel is 0.5–1.5 bar. Common O_2 rows in the local Maxphotonics table show 0.6–0.9 bar. Do not use these as universal settings; take all values for the selected row from section 9. The special O_2 process for copper is outside this low-pressure generalization.

Remove the oxide layer before painting and welding according to job requirements. Painting directly over an oxidised edge may affect adhesion. Increasing oxygen does not cure every defect; excessive pressure can burn corners and damage fine details.

N_2: The general high-pressure range is described as 8–25 bar; the local Maxphotonics table specifies 20 bar in many N_2 rows. Do not treat this range as equipment capacity. Regulator, line and head limits apply together with the machine recipe. High flow generally means greater consumption than O_2 cutting.

Air: Can offer cycle and gas cost advantages on suitable thin–medium sheet jobs. Do not assume thickness limits are independent of power. Oxygen in air prevents the same oxide-free edge as nitrogen. Obtain sample acceptance for appearance and subsequent operations.

> **Distinguish ranges from recipes**
>
> General pressure ranges here describe gas families. Operator settings come from the material–thickness–power row in section 9 and the machine's approved table. Take nozzle and focus from the same row.

7.2 Purity and compressed air preparation

Target O_2 purity of at least 99.95% (3.5). For N_2, use at least 99.995%; target 5.0 (99.999%) for quality work requiring oxide-free/bright edges. Also check the moisture and hydrocarbon limits in the Raytools BM115 specification: H_2O < 5 ppm, HC < 1 ppm. Assess the gas supply certificate and line contamination together; follow any stricter machine/head manufacturer requirement.

Oxygen and moisture contamination in nitrogen can cause oxidation and discolouration at the cut edge; **hydrocarbons** can damage optics. Total purity alone does not guarantee colourless edges on every job.

Supply dry, oil-free compressed air. A typical preparation chain is **compressor → suitable dryer → 1 µm prefilter → 0.01 µm fine/coalescing filter → machine**. Arrange the receiver, drains and filters according to the compressor manufacturer's design. These two filter ratings alone do not remove all oil vapor or moisture; obtain required air quality from the machine manufacturer. ISO 8573-1:2010 specifies air quality as a particles.water.oil class triplet; BEKO recommends class 1 or 2 for particles and oil, but confirm the complete triplet required for your machine with the manufacturer/head supplier.

- Check dryer operation and condensate drainage.
- Monitor filter maintenance and pressure loss; blocked filters reduce flow despite high compressor pressure.
- Stop air cutting if oil or water carries over; do not restart until the cause is eliminated.
- Oil/water reaching the head can deposit on the protective window, causing window burning and optical damage.

! Warning

Do not use oil or grease in oxygen lines. Select equipment for the relevant gas. Do not loosen pressurised connections; isolate the line and verify it is depressurised for maintenance. Ventilate enclosed areas where nitrogen may accumulate.

Purity targets: Linde and Messer; H_2O/HC limits: Raytools BM115; air classes: ISO 8573-1 and BEKO. Source links are in Appendix F.

i Air-cutting infrastructure

Write the ISO 8573-1 class triplet in particle.water.oil order. The BEKO recommendation above covers particles/oil; confirm the full triplet, including the water class, with the machine/head supplier.

Saidesi/GWK vendor guides describe a 16 bar compressor as a common choice at ≥3 kW and report total losses of 1.5–3 bar through the dryer, filters, regulator and piping. The research obtained these figures from search summaries; losses vary between installations. Check pressure during cutting flow at the machine inlet and at a manufacturer-permitted measuring point on the nozzle side; 16 bar is not a nozzle setting.

Dryer recommendations differ: the vendor summaries in the research mention desiccant drying to about -40 °C pressure dew point and refrigerated drying at 3–5 °C; the attribution of each recommendation to a particular vendor was not verified. Select the dryer with the supplier for the required water class and peak flow. **DOKTEK rule — no primary source:** Monitor and record pressure dew point; if the acceptance limit is exceeded or the protective window fogs, stop air cutting and check the dryer, drains and filters.

ISO 8573-1 · BEKO · Saidesi 16 bar · Saidesi 2026 · GWK

7.3 Selecting the gas supply

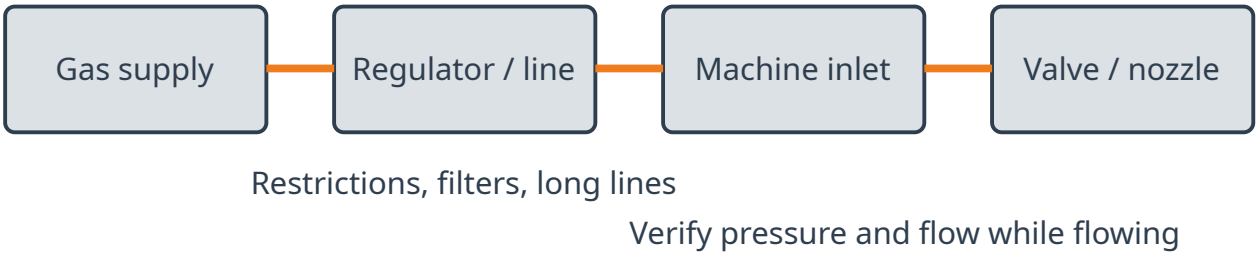
Supply	Investment	Operation	Purity	Pressure and flow
Single cylinder	Generally low initial investment; requires regulator and safe connections.	Practical for low use; frequent changes and logistics costs.	Depends on purchased gas grade and connection cleanliness.	Limited by regulator capacity and cylinder contents; shorter duration at high N_2 flow.

Supply	Investment	Operation	Purity	Pressure and flow
Cylinder bundle	More space and manifold arrangements than a single cylinder.	Less frequent changes; transport and rental terms matter.	Certified gas; distribution line cleanliness must be maintained.	Longer supply duration; lines and regulators must still suit required flow.
Liquid tank	Tank, vaporiser and site infrastructure; depends on supply contract.	An option for sustained high consumption; account for losses and logistics.	Defined by supply grade; stable supply with a suitable system.	Vaporization capacity and outlet pressure must meet continuous demand.
N_2 generator	High initial investment; compressor, treatment and possibly booster required.	Electricity, maintenance and filter costs; economics depend on operating hours.	Available flow changes with target purity; verify by measurement.	Storage/boosting may be needed for cutting pressure; check peak demand.
Air compressor	Investment in compressor, dryer and filters suitable for pressure and flow.	Electricity, maintenance and air treatment costs.	Air composition remains; drying and filtration determine quality.	Compressor nameplate is insufficient; verify values at the machine inlet during cutting.

Investment levels are relative assessments, not prices or payback periods. Compare quotations using monthly consumption, shifts, site conditions and supply contracts. Without peak flow capacity, even a full tank and high static pressure do not ensure good cutting.

Do not simply ask for “laser gas”. Specify purity, working pressure, continuous and peak flow, and number of simultaneous machines. Record whether pressure was measured at the cylinder outlet or machine inlet, and whether gas was flowing for cutting.

Distinguish supply pressure from the cutting point



High pressure at one point does not prove adequate flow downstream. This is not a gas installation design.

If pressure is normal before cutting but low during cutting, investigate supply capacity. Regulator flow, valve opening, hose bore, blocked filters and simultaneous demand may contribute. Do not exceed system pressure limits to compensate for inadequate flow. Leave line changes to authorized gas installation personnel.

If gas analysis is correct at the supply outlet but edges discolor, assess mixing in shared lines, valves and connections. Do not blame only the gas supplier or cutting recipe; record whether samples deteriorate only at job start or throughout.

7.4 Gas selection by material

Material	O_2	N_2	Air
Mild steel	**Recommended:** where oxidised edges are acceptable, especially thick plate.	**Suitable:** appropriate thin sheet with oxide-free edge requirements; assess power and consumption.	**Suitable:** verified thin–medium sheet recipe and accepted edges.
Stainless steel	**Not recommended:** impairs oxide-free edge and surface requirements.	**Recommended:** with sufficient purity for oxide-free edges.	**Suitable:** if discoloration/oxide and subsequent cleaning are acceptable.
Galvanised steel	**Not preferred:** GWEIKE allows an O_2 option at ≥3 mm after sample validation; assess zinc reactions and fumes.	**Recommended:** with suitable fume extraction and recipe.	**Suitable:** with dry, oil-free air and sample approval.
Aluminium	**Not recommended:** not the standard approach in this guide.	**Recommended:** after verifying source and head compatibility.	**Suitable:** if sample edges and dross are accepted.
Brass	**Not recommended:** not provided here as a standard recipe.	**Recommended:** in a system with verified back-reflection compatibility.	**Suitable:** only with an explicitly manufacturer-approved recipe.
Copper	**Source dependent:** BWT specifies high-pressure O_2 for pure copper, only on suitable approved systems.	**Source dependent:** Boss Laser calls N_2 the normal choice; verify the machine-specific recipe.	**Not recommended:** do not assume a general air recipe in this guide.

"Suitable" does not mean it works at every thickness and power. Even the recommended gas does not remove machine material-compatibility requirements. For brass and copper, follow the back-reflection warnings in section 10.5. If section 9 has no relevant row, do not copy another material's settings.

Copper sources disagree: Chinese laser-source maker BWT specifies high-pressure O_2, while Western supplier Boss Laser calls N_2 the normal choice. A compilation published under the IPG name also includes N_2/air examples; it is not a primary IPG gas recipe. Do not treat gases as equivalent; obtain copper approval and a complete recipe from your source/head manufacturer.

BWT's precautions for ≥10 kW copper/aluminum: use full-power continuous wave (CW) only on a suitable system; select the smallest nozzle that works and reduce series speed to ≈80% of the successful sample speed. Keep nozzle cooling gas on continuously. These recommendations do not override machine limits; do not transfer high-pressure copper O_2 settings to mild steel.

GWEIKE · BWT

7.5 Gas delay and line purging

Gas delay allows the selected gas to reach the cutting point with stable flow before the laser starts. Long lines, gas changes and inadequate flow affect results. Air in nitrogen lines can particularly discolor initial parts.

Purpose: Start cutting with correct gas and stable flow.

Requirements: Approved gas line, regulator, suitable pressure gauge and machine gas test/purge function.

1. Verify correct gas connection and supply level. Record the gas grade.
2. Run the manufacturer's gas test with the laser off. Check machine inlet pressure during flow.
3. After a gas change, purge the shared line by the manufacturer's method. Displace air with process gas.
4. Cut a sample with approved gas delay. Compare edge color on initial and subsequent parts.
5. For a poor first part, inspect delay and line mixing. For persistent defects, also check purity, leaks and flow.

> **Warning**
> Purging here means passing gas through the machine's controlled outlet. Do not “bleed air” by loosening a pressurised connection. Manage gas discharge with adequate ventilation.

Why? Gauge pressure does not prove that gas reaches the nozzle at correct purity and sufficient flow.

7.6 Assessing gas costs

Gas cost = consumption × unit price. Use the same volume basis for consumption and price; do not directly compare standard volume with pressurised line volume. Include piercing, pre-flow, cutting, standby blowing and leakage in job costs.

Gas cost per part = total job gas cost ÷ accepted part quantity. With other conditions unchanged, larger nozzle diameter and higher pressure generally increase consumption. Do not assume a linear flow–pressure relationship to invent consumption figures; use flow measurement or supplier/nozzle data.

Air is not free: it incurs electricity, drying, filter and maintenance costs. Generators also need energy, purity checks and maintenance. Assess whether cheaper gas adds deburring or paint preparation work in total job cost.

Nozzle flow and nitrogen per metre

For the same gas, pressure and similar nozzle geometry, flow is approximately proportional to the square of the nozzle bore diameter: $Q \propto d^2$. Increasing diameter from 1.5 mm to 2.0 mm gives $(2.0 \div 1.5)^2 = 1.78 \approx 1.8$ times the flow. Do not treat this as a consumption rule based on laser power alone.

N_2 per metre (L/m) = nozzle flow (L/min) ÷ cutting speed (m/min). State the standard/normal volume basis of the flow and use the same basis for comparisons.

Calculation example — assumption: Assume a nozzle flow of 300 L/min and, for this calculation only, a cutting speed of 3 m/min: 300 L/min ÷ 3 m/min = 100 L/m = 0.10 m³/m. This is neither a cutting recipe nor a measured flow; it covers only gas-on time during cutting. Add piercing, pre-flow, standby flow and leakage separately to the job total.

Oxywise · Arcus

7.7 Shift-start checks

- Is the selected gas suitable for material and edge requirements?
- Are purity certification and gas level acceptable?
- Does pressure fall during flow; are filters or lines restricted?
- If using air, are dryer and drains working?

- Has the line been purged after changing gas?
- Do nozzle type, diameter, focus and height belong to the same recipe?
- Have first-sample edge color and dross been accepted?

Sources: Local Maxphotonics MFSC/MFMC cutting data; Linde “Laser cutting advice”; work brief and local v1 example for galvanised steel. Numerical cutting rows are provided together in section 9.

08

Power selection

Do not select laser power for a single thickest part. Regular materials, thickness distribution, required edges and shift workload all matter. Nameplate power may differ from recipe power.

8.1 Power, thickness and speed

In nitrogen fusion cutting, the laser supplies most energy for melting. As thickness increases, stable speed at the same power generally falls. Higher power with suitable optics and gas can increase speed or workable thickness. Do not assume two machines of equal power give identical results on every material.

Cutting speed depends on beam properties, focus, nozzle, gas flow, surface and machine motion. Total cycle time includes piercing, corner deceleration, non-cutting travel and loading. A table speed for one long straight line is not the average production speed of a part with small holes.

Do not compensate for a dirty protective window, inadequate gas or poor centering by changing power. Verify the system first; for diagnosis use section 13.1.

85% of the table's lower speed is the first-trial start (DOKTEK rule — no primary source); at ≥10 kW on thick or reflective material, use ≈80% of the sample-validated speed for series production. 85% starts the first trial from the table, whereas 80% provides production margin from a successful sample; do not apply both ratios successively to table speed. BWT's 80% advice directly covers ≥10 kW copper/aluminum; extending it to thick material is a DOKTEK rule — no primary source.

BWT

8.2 Reading the maximum thickness summary

This list does not guarantee capacity. "Production" is the greatest source thickness excluding ◆; "Trial" includes ◆. ★ indicates derived data.

Power	Mild steel		Stainless steel		Galvanized sheet		Aluminum		Brass		Copper	
	Production mm	Trial mm	Production mm	Trial mm	Production mm	Trial mm	Production mm	Trial mm	Production mm	Trial mm	Production mm	Trial mm
1 kW	12	12	6	6	6 ★	6 ★	3	3	3	3	—	—
1.5 kW	16	16	8	8	6 ★	6 ★	5	5	4	4	—	—
2 kW	20	20	8	8	6 ★	6 ★	6	6	4	4	—	—
3 kW	20	20	10	10	—	5	8	8	6	6	—	—
4 kW	22	25	12	16	6 ★	6 ★	10	12	8	8	4	4
6 kW	25	40	22	35	6 ★	6 ★	20	20	12	20	6	8
8 kW	25 ★	40 ★	22 ★	35 ★	6 ★	6 ★	20 ★	20 ★	12 ★	16 ★	6 ★	8 ★
10 kW	25 ★	40 ★	22 ★	35 ★	6 ★	6 ★	20 ★	20 ★	12 ★	16 ★	6 ★	8 ★
12 kW	35	40	30	40	6 ★	6 ★	40	40	16	16	10	10
15 kW	50	50	50	50	6 ★	6 ★	50	50	20	20	10	10
20 kW	50 ★	50 ★	30 ★	50 ★	6 ★	6 ★	30	60	20	20	10	12
30 kW	50	80	35	100	6 ★	6 ★	—	—	—	—	—	—

This area summarizes power–material thickness from section 9 data. **Maximum thickness** does not guarantee identical edge quality or speed in continuous production. Read material and gas together; missing data means neither zero nor unlimited capacity.

Purpose: Assess summary capacity alongside full recipes and actual production conditions.

Requirements: Automatic thickness summary, complete section 9 row, machine information and same-material sample.

1. First find source power and the correct material column.
2. For the summary thickness, go to section 9 for the complete row.
3. Read gas, power, nozzle, focus and height together. Verify optics and source conditions match your machine.
4. ★ indicates a DOKTEK-derived value; ◆ indicates a “trial value, not for series production”.
5. Measure piercing, cutting continuity and sample edge quality. Base production choices on accepted parts.

> **Warning**
>
> Do not make the summary's highest thickness your daily production target. Series work requires stable results across material batches, long contours, pierce counts and gas infrastructure. Do not treat trial-marked rows as production guarantees.

Why? The summary helps selection; gas, optics and piercing conditions that determine quality are in the full recipe.

8.3 Thin sheet power and machine dynamics

More power on thin sheet does not always increase production proportionally. Small parts and frequent corners prevent axes reaching high speed. Acceleration, controller path processing and laser on/off behavior then limit the cycle.

Higher power is not entirely unnecessary; it can help on long straights or suitable nitrogen cutting. But for exclusively thin, small parts, compare actual program cycles rather than higher nameplate power. Flycut and nesting improvements also affect time; see section 6.5.

Compare quotations using the same drawing, material, gas and quality acceptance. Record loading, piercing, cutting and unloading separately. Do not substitute maximum straight-line speed for total production time.

8.4 O_2 on thick mild steel and beam characteristics

Oxygen cutting gains additional heat from chemical reaction. Excess laser power on thick mild steel can widen the kerf and increase burning. Some recipes therefore use less than full source power. Reduced power in thick O_2 rows of the local Maxphotonics table must not be assumed to be a typo.

This reduction is not a formula for all thicknesses. Thinner O_2 rows may use high power with different nozzle/focus technology. Do not select speed or power alone; retain the entire row. High-power sources need not always run at full power on thick O_2 jobs.

Beam/output example	General tendency	Selection check
Single module with 50 µm output fiber	Suitable beam quality allows a small focus and high energy density; may benefit thin-sheet speed.	Measure actual cycle and fine-feature quality on a thin-sheet program.
Multiple modules with 100 µm output fiber	Wider processing region with suitable optics; may support stable thick-plate edges.	Verify piercing and long-cut continuity on thick plate.

Here, 50 and 100 µm describe output fiber core diameters, not direct focal spot diameters on sheet. Single/multiple modules do not correspond one-to-one with these diameters in every product. Collimating and focusing lenses, beam quality and head determine results. Do not generalize local Max table optics conditions to all product series.

8.5 Power selection checklist

- **Material mix:** Establish job proportions of mild steel, stainless steel, galvanised steel, aluminium, brass and copper. Verify reflective-material compatibility separately.
- **Thickness distribution:** Distinguish frequent thicknesses from rare thick jobs. Prioritize jobs consuming production hours.
- **Part shape:** Do long straights or small holes and corners dominate? Assess machine dynamics accordingly.
- **Shifts:** Record daily cycles, pierce counts and planned stops. Cutting one sample is not continuous shift capacity.
- **Gas:** Select O_2, N_2 or air for required quality. Check line pressure/flow capacity and gas cost.
- **Acceptance:** Compare top/bottom dimensions, dross, oxide and finishing time on the same drawing.

Record source model, head, optics, gas and sample recipe alongside source power in the decision. This allows later assessment of the same job under identical conditions.

Source: The local Maxphotonics MFSC/MFMC table requires power and optics conditions to be read together. The 50/100 µm comparison is general explanation from the work brief, not a product-specific capacity claim.

8.6 Working with 12–30 kW

Distinguish two O_2 recipe families

On thick mild steel, the positive-focus/reduced-power family may remain around 2 m/min; the negative-focus/full-power family uses different nozzle, height and pressure settings. GYC examples follow; the first two rows have different thicknesses and are not a direct speed-gain test. Focus numbers are source controller values; use section 11.1 for conversion to the surface. Do not copy a single value between families.

Source/thickness	Power · speed	O_2 · nozzle	Focus · height
GYC 12 kW / 10 mm, positive	7200 W · 2.2–2.4 m/min	0.6 bar · 1.2E	+8 mm · 0.8 mm
GYC 12 kW / 12 mm, negative	12000 W · 3–3.5 m/min	1.0 bar · 1.6SP	-10 mm · 1.5 mm
GYC 20 kW / 12 mm, negative	20000 W · 3.2–3.5 m/min	1.0 bar · 1.6SP	-10 mm · 1.5 mm

GYC

N_2 mixtures and high-power air cutting

The Fabricator reports that adding typically 1.5–5% O_2 to N_2 can supply reaction heat that helps eject melt through the bottom. The notes verify this only through a search excerpt; do not equate it with an oxide-free N_2 edge. Validate the mixture on a sample with gas-system and machine approval; do not directly transfer pure-gas settings.

IPG authors report ≈2 m/min for 16 mm mild steel with O_2 across 10–30 kW, versus >9 m/min with air at 30 kW. For dross-free air cutting of 20 mm mild steel, they report >16 bar at 15 kW and 10–12 bar at ≥20 kW. These results belong to the IPG test setup; they do not replace your machine's pressure, air-quality or head limits.

The Fabricator · IPG / Laser Focus World

Heating, height following and slat cleaning

Chuangxin's high-power thick-steel note highlights nozzle overheating. For ≥10 kW copper/aluminum, BWT describes the chain of nozzle heating → capacitive sensor drift → nozzle-gap change during continuous cutting; it recommends ≈80% of sample speed in production, continuous nozzle cooling gas and water cooling of the optics. Raytools BM115 specifies N_2 or filtered air below 1 bar for nozzle cooling and prohibits O_2. Do not generalize this head example to other models; follow your own head manual.

Remove slag regularly from the support slats; inspect support and openings. The Fabricator reports harder N_2 slag at high power that can increase cleaning work; the notes verify this claim only through a search excerpt. Set cleaning/replacement intervals from buildup in your own production.

Chuangxin / Laserfair · BWT · Raytools BM115 · The Fabricator

If quality deteriorates after a few minutes

Purpose: separate causes when a good cold sample deteriorates as cutting heats up. Required: last successful recipe, sample record, head manual and safe inspection state. The sequence below is a DOKTEK rule — no primary source; the heating/drift mechanism comes from BWT/Chuangxin.

1. Stop safely. Check nozzle heating symptoms, orifice and centering; verify continuous nozzle cooling gas and suitable head/optics water cooling.
2. Check nozzle/ceramic and capacitance calibration. With the laser off, compare actual and indicated height by an approved method; do not hide drift by changing the focus recipe.
3. Inspect the protective window, gas pressure/flow during delivery and slag on the slats. After correcting the fault, run a long trial on the same material.
4. At ≥10 kW on thick/reflective work, verify series stability at ≈80% of successful sample speed; extending this to thick material is a DOKTEK rule. Tune one variable only once equipment and thermal conditions are stable.

> **Caution**
>
> do not touch a hot nozzle or disable cooling or guards. Stop the trial if alarms, heavy spatter or incomplete cutting occur.

Why? Heat-induced nozzle-gap changes alter energy and gas action at the sheet with the same controller focus value; a good cold sample does not prove series stability.

09

Cutting parameter tables

Select power class, material, thickness and gas together. These tables help plan the first trial; the machine manufacturer's approved recipe takes priority.

9.0 How to read the tables

Each row is one cutting recipe. Enter pressure, nozzle, nozzle height, focus, power and speed together. Do not combine one row's speed with another row's nozzle or gas. Multiple gases or recipes at one thickness describe separate conditions. Power is the actual cutting power and may be below the table's nominal rating.

1. Check machine power and fiber core. Compare the head/optics in the conditions box with your equipment.
2. Find the actual sheet thickness under the material and gas. Do not add unlisted thicknesses.
3. Cut a test coupon at the starting speed: the lower manufacturer speed × 0.85, rounded for printing according to magnitude.
4. If edge, dimensions and dross are acceptable, raise speed in 5–10% steps. Max. speed shows the manufacturer range or a ★ interpolated value; it is not a guaranteed production speed.
5. If cutting is unstable, stop and check gas and optics. Change one variable per trial and record the result.

> **! ★ and ◆ have different meanings**
>
> ★ is derived by DOKTEK or calculated from adjacent power ratings. ◆ marks a trial, capacity limit or incomplete recipe reference; it is not for series production. Both may appear on one row. No mark does not guarantee production capacity.

Galvanized ★ rule: Up to 6 mm, use mild steel N_2/air speed at the same thickness × 0.85. If absent, use stainless steel N_2 speed × 0.95. Copy the other settings from that row; gas is shown as N_2/air. Do not add thicknesses without a source row. If the source uses only N_2, test air separately; do not assume equivalent results. These ratios are DOKTEK estimates, not published measurements. The 3 kW galvanized table is an exception: it uses the GWEIKE note's 1–2 mm N_2 and 3/5 mm O_2 rows. Nozzle/height are unspecified (—); these are incomplete ◆ references, not complete recipes. O_2 may burn zinc and the coating; manufacturer approval and a sample test are required.

Equipment differences: Core diameter, beam quality, optical ratio, head, gas flow and sheet quality affect results. Equal nominal W does not automatically mean an equal recipe across Raycus, Maxphotonics (Max), IPG or Reci sources. Verify optics and nozzle requirements for Raytools, Precitec, BOCI or Au3tech heads.

Focus: Physical position: + above the surface, – inside the material. Raytools/CypCut table values reference the nozzle tip: surface-relative focus ≈ controller value + nozzle height. 0 + 1 mm → ≈1 mm above the surface; -1 + 1 mm → at the surface. Verify your controller reference in its manual; section 11.1. Unsigned positive source values receive +. S is single-layer, D double-layer; diameters separated by "/" are alternatives.

Interpolation: For 8 and 10 kW use 6–12 kW; for 20 kW mild steel/stainless steel use 15–30 kW. Interpolate lower and upper speeds separately, linearly, only for common material/gas/thickness rows. Auxiliary settings come from the upper neighbor. W comes from the upper neighbor and is capped at target nominal power; this choice also carries ★. Do not interpolate ambiguous multiple recipes with the same key.

See data/veri_raporu.md for corrected blocks and row sources. The 12 kW, 6 mm brass row is now available at 9–11 m/min from the 100 µm source. The 6 kW aluminum block has been replaced by the 100 µm block; old rows annotated "2000/98" are unused. The 6 kW O_2 30–40 mm and stainless 25–35 mm rows are ◆ capacity limits.

85% of the table's lower speed is the first-trial start (DOKTEK rule — no primary source); at ≥10 kW on thick or reflective material, use ≈80% of the sample-validated speed for series production. 85% starts the first trial from the table, whereas 80% provides production margin from a successful sample; do not apply both ratios successively to table speed. BWT's 80% advice directly covers ≥10 kW copper/aluminum; extending it to thick material is a DOKTEK rule — no primary source.

BWT

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Bodor · GYC

9.1 1 kW (1000 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
Maxphotonics MFSC-1000 · 50 µm	Raytools · 100/125	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
1	N_2	20	S1.0	0.5	0 / -1	1000	**20**	24 – 26
2	O_2	0.6 – 0.9	D1.0	0.8	+4.5 / +5.5	1000	**6.8**	8 – 9
3	O_2	0.6 – 0.9	D1.0	0.8	+4.5 / +5.5	1000	**2.4**	2.8 – 3
4	O_2	0.6 – 0.9	D2.5	1.5	+2 / +3	1000	**1.9**	2.2 – 2.4
5	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1000	**1.3**	1.5 – 1.7
6	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1000	**1.0**	1.2 – 1.4
8	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1000	**0.85**	1 – 1.1
10	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1000	**0.64**	0.75 – 0.85
12	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1000	**0.51**	0.6 – 0.65
Stainless steel N_2; air where a source row exists.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	0 / -1	1000	**18**	21 – 23
2	N_2	20	S1.5 / S2.0	0.5	-1.5 / -2	1000	**5.5**	6.5 – 7
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	1000	**2.0**	2.3 – 2.5
4	N_2	20	S3.0	0.5	-3.5 / -4	1000	**0.68**	0.8 – 1
5	N_2	20	S3.5 / S4.0	0.5	-3.5 / -4	1000	**0.51**	0.6 – 0.7
6	N_2	20	S3.5 / S4.0	0.5	-5 / -5.5	1000	**0.43**	0.5 – 0.6
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	20	S1.0	0.5	0 / -1	1000	**17**	20 – 22
2 ★	N_2 / Air	20	S1.5 / S2.0	0.5	-1.5 / -2	1000	**5.2**	6.2 – 6.7
3 ★	N_2 / Air	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	1000	**1.9**	2.2 – 2.4
4 ★	N_2 / Air	20	S3.0	0.5	-3.5 / -4	1000	**0.65**	0.76 – 0.95
5 ★	N_2 / Air	20	S3.5 / S4.0	0.5	-3.5 / -4	1000	**0.48**	0.57 – 0.67
6 ★	N_2 / Air	20	S3.5 / S4.0	0.5	-5 / -5.5	1000	**0.40**	0.48 – 0.57
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	-0.5 / -1	1000	**16**	19 – 21
2	N_2	20	S1.5 / S2.0	0.5	-1 / -1.5	1000	**3.8**	4.5 – 5
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	1000	**1.5**	1.8 – 2
Brass Highly reflective.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	0 / -0.5	1000	**14**	16 – 18
2	N_2	20	S1.5 / S2.0	0.5	-1 / -1.5	1000	**2.6**	3 – 3.5
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2 / -2.5	1000	**0.94**	1.1 – 1.3

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated
◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: Maxphotonics MFSC/MFMC; https://www.forum.linuxcnc.org/media/kunena/attachments/22451/null.pdf; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

Copper: No source row; consult the manufacturer.

9.2 1.5 kW (1500 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
Maxphotonics MFSC-1500 · 50 µm	Raytools · 100/125	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
1	N_2	20	S1.0	0.5	0 / -1	1500	**29**	34 – 37
2	O_2	0.6 – 0.9	D1.0	0.8	+4.5 / +5.5	1500	**10**	12 – 14
3	O_2	0.6 – 0.9	D1.0	0.8	+4.5 / +5.5	1500	**2.5**	2.9 – 3.2
4	O_2	0.6 – 0.9	D1.0	0.8	+4.5 / +5.5	1500	**2.0**	2.4 – 2.6
5	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1500	**1.5**	1.8 – 2
6	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1500	**1.4**	1.6 – 1.8
8	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1500	**0.94**	1.1 – 1.3
10	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1500	**0.77**	0.9 – 1
12	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	1500	**0.68**	0.8 – 0.9
14	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	1500	**0.51**	0.6 – 0.7
16	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	1500	**0.43**	0.5 – 0.6
Stainless steel N_2; air where a source row exists.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	0 / -1	1500	**27**	32 – 35
2	N_2	20	S1.5 / S2.0	0.5	-1.5 / -2	1500	**7.7**	9 – 10
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	1500	**3.6**	4.2 – 4.5
4	N_2	20	S3.0	0.5	-3.5 / -4	1500	**1.8**	2.1 – 2.3
5	N_2	20	S3.5 / S4.0	0.5	-3.5 / -4	1500	**1.4**	1.6 – 1.8
6	N_2	20	S3.5 / S4.0	0.5	-5 / -5.5	1500	**0.85**	1 – 1.2
8	N_2	20	S4.0	0.5	-6 / -7	1500	**0.43**	0.5 – 0.6
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	20	S1.0	0.5	0 / -1	1500	**25**	29 – 31
2 ★	N_2 / Air	20	S1.5 / S2.0	0.5	-1.5 / -2	1500	**7.3**	8.6 – 9.5
3 ★	N_2 / Air	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	1500	**3.4**	4 – 4.3
4 ★	N_2 / Air	20	S3.0	0.5	-3.5 / -4	1500	**1.7**	2 – 2.2
5 ★	N_2 / Air	20	S3.5 / S4.0	0.5	-3.5 / -4	1500	**1.3**	1.5 – 1.7
6 ★	N_2 / Air	20	S3.5 / S4.0	0.5	-5 / -5.5	1500	**0.81**	0.95 – 1.1
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	-0.5 / -1	1500	**26**	30 – 32
2	N_2	20	S1.5 / S2.0	0.5	-1 / -1.5	1500	**6.8**	8 – 9
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	1500	**3.2**	3.8 – 4.2
4	N_2	20	S3.0	0.5	-3.5 / -4	1500	**1.7**	2 – 2.2
5	N_2	20	S3.5 / S4.0	0.5	-3.5 / -4	1500	**0.68**	0.8 – 1
Brass Highly reflective.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	0 / -0.5	1500	**21**	25 – 27

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
2	N_2	20	◯ S1.5 / S2.0	0.5	-1 / -1.5	1500	**6.0**	7 – 8
3	N_2	20	◯ S2.0 / S2.5 / S3.0	0.5	-2 / -2.5	1500	**2.3**	2.7 – 3
4	N_2	20	◯ S3.0	0.5	-3 / -3.5	1500	**1.3**	1.5 – 1.7

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: Maxphotonics MFSC/MFMC; https://www.forum.linuxcnc.org/media/kunena/attachments/22451/null.pdf; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

Copper: No source row; consult the manufacturer.

9.3 2 kW (2000 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
Maxphotonics MFMC-2000 · 50 µm	Raytools · 100/200	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
3	O_2	0.6 – 0.9	D1.0	0.8	+4.5 / +5.5	2000	**2.6**	3 – 3.2
6	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2000	**1.7**	2 – 2.2
8	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2000	**1.1**	1.3 – 1.5
10	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2000	**0.77**	0.9 – 1
12	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2000	**0.68**	0.8 – 0.9
14	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2000	**0.60**	0.7 – 0.8
16	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2000	**0.51**	0.6 – 0.7
18	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2000	**0.43**	0.5 – 0.6
20	O_2	0.6 – 0.9	D4.0	1.2 – 1.5	+2 / +3.5	2000	**0.34**	0.4 – 0.5
Stainless steel N_2; air where a source row exists.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	0 / -1	2000	**26**	30 – 32
2	N_2	20	S1.5 / S2.0	0.5	-1.5 / -2	2000	**8.5**	10 – 11
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	2000	**4.3**	5 – 6
4	N_2	20	S3.0	0.5	-3.5 / -4	2000	**2.6**	3 – 3.5
6	N_2	20	S3.5 / S4.0	0.5	-5 / -5.5	2000	**1.1**	1.3 – 1.5
8	N_2	20	S4.0	0.5	-6 / -7	2000	**0.43**	0.5 – 0.6
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	20	S1.0 / S1.2 / S1.5	0.5	0 / -1	2000	**24**	29 – 30
2 ★	N_2 / Air	20	S1.5 / S2.0	0.5	-1.5 / -2	2000	**8.1**	9.5 – 10
3 ★	N_2 / Air	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	2000	**4.0**	4.8 – 5.7
4 ★	N_2 / Air	20	S3.0	0.5	-3.5 / -4	2000	**2.4**	2.9 – 3.3
6 ★	N_2 / Air	20	S3.5 / S4.0	0.5	-5 / -5.5	2000	**1.0**	1.2 – 1.4
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	-0.5 / -1	2000	**15**	18 – 20
2	N_2	20	S1.5 / S2.0	0.5	-1 / -1.5	2000	**5.1**	6 – 7
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	2000	**2.6**	3 – 4
4	N_2	20	S3.0	0.5	-3.5 / -4	2000	**1.4**	1.6 – 1.9
6	N_2	20	S3.5 / S4.0	0.5	-5 / -5.5	2000	**0.43**	0.5 – 0.6
Brass Highly reflective.								
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2 / -2.5	2000	**2.4**	2.8 – 3.2
4	N_2	20	S3.0	0.5	-3 / -3.5	2000	**1.3**	1.5 – 1.7

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: Maxphotonics MFSC/MFMC; https://www.forum.linuxcnc.org/media/kunena/attachments/22451/null.pdf; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

Copper: No source row; consult the manufacturer.

9.4 3 kW (3000 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
Maxphotonics MFMC-3000 · 50 µm	Raytools · 100/200	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Additional manufacturer rows may use different heads/optics from the main Maxtable. Check the source note below.

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
3	O_2	0.6 – 0.9	D1.0	0.8	+4.5 / +5.5	3000	**3.0**	3.5 – 3.7
6	O_2	0.6 – 0.9	D1.2	0.8	+4.5 / +5.5	3000	**2.0**	2.3 – 2.5
8	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2200 – 2400	**1.5**	1.8 – 2
10	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2200 – 2400	**1.3**	1.5 – 1.7
12	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2200 – 2400	**1.0**	1.2 – 1.4
14	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2200 – 2400	**0.85**	1 – 1.1
16	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2200 – 2400	**0.72**	0.85 – 0.9
18	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2200 – 2400	**0.60**	0.7 – 0.75
20	O_2	0.6 – 0.9	D4.0	1.2 – 1.5	+2 / +3.5	2200 – 2400	**0.51**	0.6 – 0.65
1	N_2 / Air	10	S1.5	1	0	3000	**24**	28 – 35
2 ◆	N_2	12 – 16	S2.0	0.5	-1 / -1.5	3000	**24**	28
Stainless steel N_2; air where a source row exists.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	0 / -1	3000	**30**	35 – 37
2	N_2	20	S1.5 / S2.0	0.5	-1.5 / -2	3000	**11**	13 – 15
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	3000	**6.0**	7 – 8
4	N_2	20	S3.0	0.5	-3.5 / -4	3000	**3.8**	4.5 – 5.5
6	N_2	20	S3.5 / S4.0	0.5	-5 / -5.5	3000	**1.4**	1.7 – 1.9
8	N_2	20	S4.0	0.5	-6 / -7	3000	**0.68**	0.8 – 1
10	N_2	20	S4.0	0.5	-7.5 / -8.5	3000	**0.51**	0.6 – 0.7
Galvanized sheet GWEIKE 3 kW: N_2 at 1–2 mm; O_2 at 3 and 5 mm. Nozzle/height absent from source notes (—); ◆ reference, not for series production. O_2 may burn the coating; verify on a sample.								
1 ◆	N_2	14	—	—	-0.5	3000	**38**	45 – 55
2 ◆	N_2	16	—	—	-1	3000	**15**	18 – 24
3 ◆	O_2	0.8	—	—	+1.5	3000	**3.4**	4 – 5
5 ◆	O_2	0.6	—	—	+2.5	3000	**1.7**	2 – 3
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	-0.5 / -1	3000	**26**	30 – 33
2	N_2	20	S1.5 / S2.0	0.5	-1 / -1.5	3000	**8.5**	10 – 12
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	3000	**4.7**	5.5 – 5.9
4	N_2	20	S3.0	0.5	-3.5 / -4	3000	**2.4**	2.8 – 3.2
6	N_2	20	S3.5 / S4.0	0.5	-5 / -5.5	3000	**0.60**	0.7 – 0.8
8	N_2	20	S4.0	0.5	-6 / -7	3000	**0.43**	0.5 – 0.6

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Brass Highly reflective.								
3	N_2	20	◯ **S2.0 / S2.5 / S3.0**	0.5	-2 / -2.5	3000	**3.8**	4.5 – 5
4	N_2	20	◯ **S3.0**	0.5	-3 / -3.5	3000	**2.6**	3 – 3.5
6	N_2	20	◯ **S3.5 / S4.0**	0.5	-5 / -5.5	3000	**0.85**	1 – 1.2

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated ◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: Maxphotonics MFSC/MFMC: https://www.forum.linuxcnc.org/media/kunena/attachments/22451/null.pdf; GYC RFL-3000(50u): https://gyclaser.com/de/2024/03/07/fiber-laser-cutting-speed-chart/; KRRASS 3000W (2 mm ◆): https://www.krrass.com/3000w-fiber-laser-cutting-machine-cutting-parameters/; GWEIKE 3 kW galvanized steel (research note): https://www.gwklaser.com/how-to-cut-galvanized-sheet-metal.html; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

Copper: No source row; consult the manufacturer.

9.5 4 kW (4000 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
Maxphotonics MFMC-4000 · 50 µm	Raytools · 100/200	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Additional manufacturer rows may use different heads/optics from the main Maxtable. Check the source note below.

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
3	O_2	0.6 – 0.9	D1.0	0.8	+4.5 / +5.5	4000	**3.4**	4 – 4.3
6	O_2	0.6 – 0.9	D1.2	0.8	+4.5 / +5.5	4000	**2.1**	2.5 – 2.7
8	O_2	0.6 – 0.9	D1.2	0.6 – 0.8	+5.5 / +6	4000	**1.7**	2 – 2.3
10	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2200 – 2400	**1.5**	1.8 – 2
12	O_2	0.6 – 0.9	D3.0	1.5	+2 / +3	2200 – 2400	**1.3**	1.5 – 1.6
14	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2200 – 2400	**1.0**	1.2 – 1.4
16	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2200 – 2400	**0.85**	1 – 1.1
18	O_2	0.6 – 0.9	D4.0	1.5	+2 / +3	2200 – 2400	**0.77**	0.9 – 1
20	O_2	0.6 – 0.9	D4.0	1.2 – 1.5	+2 / +3.5	2200 – 2400	**0.55**	0.65 – 0.7
22	O_2	0.6 – 0.9	D4.0	1.2 – 1.5	+2 / +3.5	2200 – 2400	**0.47**	0.55 – 0.6
1	N_2 / Air	10	S2.0	0.6	0	4000	**34**	40 – 50
2	N_2 / Air	10	S2.0	0.6	-1	4000	**13**	15 – 20
3	N_2 / Air	10	S2.0	0.6	-1	4000	**8.5**	10 – 12
4	O_2	0.6	D1.0	0.6	+5	3000	**3.0**	3.5 – 4
5	O_2	0.6	D1.0	0.6	+5	3300	**2.6**	3 – 3.5
25 ◆	O_2	0.6	D5.0	1.5	+5	2600	**0.34**	0.4 – 0.5
Stainless steel N_2; air where a source row exists.								
1	N_2	20	S1.0 / S1.2 / S1.5	0.5	0 / -1	4000	**34**	40 – 43
2	N_2	20	S1.5 / S2.0	0.5	-1.5 / -2	4000	**16**	19 – 21
3	N_2	20	S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	4000	**9.4**	11 – 13
4	N_2	20	S3.0	0.5	-3.5 / -4	4000	**5.5**	6.5 – 7
6	N_2	20	S3.5 / S4.0	0.5	-5 / -5.5	4000	**1.9**	2.2 – 2.5
8	N_2	20	S4.0	0.5	-6 / -7	4000	**1.3**	1.5 – 1.7
10	N_2	20	S4.0	0.5	-7.5 / -8.5	4000	**0.68**	0.8 – 0.9
5	N_2	14	S3.0	0.5	-2	4000	**3.4**	4 – 5
12	N_2	18	S5.0	0.5	-5	4000	**0.60**	0.7 – 1
14 ◆	N_2	18	S5.0	0.5	-8	4000	**0.51**	0.6 – 0.8
16 ◆	N_2	20	S5.0	0.5	-8	4000	**0.26**	0.3 – 0.5
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	10	S2.0	0.6	0	4000	**29**	34 – 43
2 ★	N_2 / Air	10	S2.0	0.6	-1	4000	**11**	13 – 17
3 ★	N_2 / Air	10	S2.0	0.6	-1	4000	**7.2**	8.5 – 10
4 ★	N_2 / Air	20	S3.0	0.5	-3.5 / -4	4000	**5.2**	6.2 – 6.7
5 ★	N_2 / Air	14	S3.0	0.5	-2	4000	**3.2**	3.8 – 4.8
6 ★	N_2 / Air	20	S3.5 / S4.0	0.5	-5 / -5.5	4000	**1.8**	2.1 – 2.4

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	20	◯ S1.0 / S1.2 / S1.5	0.5	-0.5 / -1	4000	**30**	35 – 37
2	N_2	20	◯ S1.5 / S2.0	0.5	-1 / -1.5	4000	**13**	15 – 17
3	N_2	20	◯ S2.0 / S2.5 / S3.0	0.5	-2.5 / -3	4000	**5.5**	6.5 – 7
4	N_2	20	◯ S3.0	0.5	-3.5 / -4	4000	**3.8**	4.5 – 4.8
6	N_2	20	◯ S3.5 / S4.0	0.5	-5 / -5.5	4000	**1.7**	2 – 2.2
8	N_2	20	◯ S4.0	0.5	-6 / -7	4000	**0.85**	1 – 1.2
10	N_2	20	◯ S4.0	0.5	-7.5 / -8.5	4000	**0.43**	0.5 – 0.6
5	N_2	15	◯ S3.0	0.5	-3	4000	**2.6**	3 – 4
12 ◆	N_2	18	◯ S5.0	0.5	-5.5	4000	**0.51**	0.6 – 0.8
Brass Highly reflective.								
3	N_2	20	◯ S2.0 / S2.5 / S3.0	0.5	-2 / -2.5	4000	**5.5**	6.5 – 6.8
4	N_2	20	◯ S3.0	0.5	-3 / -3.5	4000	**3.8**	4.5 – 4.7
6	N_2	20	◯ S3.5 / S4.0	0.5	-5 / -5.5	4000	**1.1**	1.3 – 1.5
8	N_2	20	◯ S4.0	0.5	-6 / -7	4000	**0.60**	0.7 – 0.8
1	N_2	10	◯ S2.0	0.5	0	4000	**26**	30 – 35
2	N_2	10	◯ S2.0	0.5	-1	4000	**13**	15 – 20
5	N_2	13	◯ S3.5	0.5	-2.5	4000	**1.7**	2 – 3
Copper Use the source row's gas; highly reflective.								
1	O_2	10	◯ S3.0	0.5	-1	4000	**22**	26 – 30
2	O_2	12	◯ S3.0	0.5	-1	4000	**8.5**	10 – 13
3	O_2	12	◯ S3.0	0.5	-2	4000	**4.7**	5.5 – 6.5
4	O_2	14	◯ S3.5	0.5	-4	4000	**1.7**	2 – 3

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: Maxphotonics MFSC/MFMC; https://www.forum.linuxcnc.org/media/kunena/attachments/22451/null.pdf; manufacturer 4 kW table: https://www.bestsheetmetalmachine.com/4000w-laser-cutting-parameters/; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

Source note: recipes missing from the main Max table are retained in JSON with the note "Source: manufacturer 4 kW table".

9.6 6 kW (6000 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
KRRASS / BSM · mixed sources; follow each row's source · 50 / 100 µm; depends on material	Source page gives no specific model · Not specified for this source table	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
3	O_2	0.6	D1.0	0.6	+6.5	4000	**3.1**	3.6 – 4.5
4	O_2	0.6	D1.0	0.6	+6.5	4000	**3.0**	3.5 – 4
5	O_2	0.6	D1.0	0.6	+6	4000	**2.4**	2.8 – 3
6	O_2	0.6	D1.0	0.6	+6	4000	**2.2**	2.6 – 2.8
8	O_2	0.6	D1.2	0.6	+6	5000	**1.9**	2.2 – 2.6
10	O_2	0.6	D1.2	0.6	+7	6000	**1.7**	2 – 2.2
12	O_2	0.6	D1.2	0.6	+9	6000	**1.5**	1.8 – 2
14	O_2	0.5	D1.4	0.6	+12	6000	**1.2**	1.4 – 1.6
16	O_2	0.6	D1.4	0.3	+14	6000	**0.85**	1 – 1.3
18	O_2	0.6	S1.6	0.3	+14	6000	**0.68**	0.8 – 1.1
20	O_2	0.6	S1.6	0.3	+15	6000	**0.51**	0.6 – 1
22	O_2	0.65	S1.6	0.3	+15	2400	**0.47**	0.55 – 0.65
25	O_2	0.8	S1.7	0.3	+16	6000	**0.51**	0.6 – 0.8
30 ◆	O_2	0.8	S1.7	0.3	+18	6000	**0.34**	0.4 – 0.5
35 ◆	O_2	1	S1.7	0.3	+19	6000	**0.26**	0.3 – 0.4
40 ◆	O_2	1	S1.7	0.3	+19	6000	**0.17**	0.2 – 0.3
1	N_2 / Air	10	S2.0	0.6	0	6000	**51**	60 – 80
2	N_2 / Air	12	S2.0	0.5	-0.5	6000	**34**	40 – 45
3	N_2 / Air	14	S3.0	0.5	-1.5	6000	**20**	23 – 28
4	N_2 / Air	14	S3.0	0.5	-3	6000	**13**	15 – 20
5	N_2 / Air	16	S3.5	0.5	-3.5	6000	**8.5**	10 – 13
6	N_2 / Air	18	S3.5	0.5	-4	6000	**6.0**	7 – 9
Stainless steel N_2; air where a source row exists.								
12	N_2	18	S4.5	0.5	-8	6000	**1.3**	1.5 – 2
14	N_2	16	S4.5	0.5	-10	6000	**0.85**	1 – 1.3
16	N_2	18	S4.5	0.5	-11.5	6000	**0.68**	0.8 – 1
18	N_2	18	S5.0	0.5	-12.5	6000	**0.51**	0.6 – 0.7
20	N_2	18	S5.0	0.5	-13	6000	**0.43**	0.5 – 0.65
22	N_2	20	S6.0	0.5	-13	6000	**0.34**	0.4 – 0.5
25 ◆	N_2	25	S6.0	0.5	+6‡	6000	**0.13**	0.15 – 0.2
35 ◆	N_2	25	S6.0	0.5	+6‡	6000	**0.09**	0.1
1	N_2	10	S2.0	0.6	0	6000	**51**	60 – 80
2	N_2	12	S2.0	0.5	0	6000	**26**	30 – 35
3	N_2	12	S3.0	0.5	-0.5	6000	**17**	20 – 24
4	N_2	12	S3.0	0.5	-1	6000	**11**	13 – 16
5	N_2	14	S3.0	0.5	-1.5	6000	**7.7**	9 – 12
6	N_2	14	S4.0	0.5	-2	6000	**5.1**	6 – 8.5
8	N_2	16	S4.0	0.5	-4	6000	**2.6**	3 – 4.8
10	N_2	16	S4.5	0.5	-7.5	6000	**1.5**	1.8 – 2.5

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	10	◯ S2.0	0.6	0	6000	**43**	51 – 68
2 ★	N_2 / Air	12	◯ S2.0	0.5	-0.5	6000	**29**	34 – 38
3 ★	N_2 / Air	14	◯ S3.0	0.5	-1.5	6000	**17**	20 – 24
4 ★	N_2 / Air	14	◯ S3.0	0.5	-3	6000	**11**	13 – 17
5 ★	N_2 / Air	16	◯ S3.5	0.5	-3.5	6000	**7.2**	8.5 – 11
6 ★	N_2 / Air	18	◯ S3.5	0.5	-4	6000	**5.1**	6 – 7.7
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	10	◯ S2.0	0.6	0	6000	**47**	55 – 60
2	N_2	10	◯ S2.0	0.5	-0.5	6000	**21**	25 – 28
3	N_2	14	◯ S3.0	0.5	-1	6000	**12**	14 – 16
4	N_2	14	◯ S3.0	0.5	-1.5	6000	**8.5**	10 – 12
5	N_2	15	◯ S3.0	0.5	-2	6000	**5.1**	6 – 8
6	N_2	16	◯ S4.0	0.5	-2.5	6000	**3.0**	3.5 – 4
8	N_2	16	◯ S4.0	0.5	-2.5	6000	**2.1**	2.5 – 3
10	N_2	18	◯ S4.0	0.5	-3	6000	**1.7**	2 – 2.5
12	N_2	18	◯ S4.0	0.5	-4	6000	**0.85**	1 – 1.5
14	N_2	20	◯ S5.0	0.5	-5	6000	**0.77**	0.9 – 1.1
16	N_2	20	◯ S5.0	0.5	-7	6000	**0.68**	0.8 – 0.9
18	N_2	25	◯ S5.0	0.5	-9	6000	**0.60**	0.7 – 0.8
20	N_2	25	◯ S5.0	0.5	-10	6000	**0.43**	0.5 – 0.7
Brass Highly reflective.								
1	N_2	10	◯ S2.0	0.6	0	6000	**34**	40 – 50
2	N_2	12	◯ S2.0	0.5	-0.5	6000	**17**	20 – 25
3	N_2	12	◯ S3.0	0.5	-1	6000	**6.8**	8 – 10
4	N_2	14	◯ S3.0	0.5	-1.5	6000	**5.5**	6.5 – 7.5
5	N_2	14	◯ S4.0	0.5	-2	6000	**4.7**	5.5 – 6.5
6	N_2	16	◯ S4.0	0.5	-2	6000	**3.0**	3.5 – 4.5
8	N_2	16	◯ S4.0	0.5	-3	6000	**1.3**	1.5 – 1.8
10	N_2	16	◯ S4.0	0.5	-3	6000	**0.68**	0.8 – 1
12	N_2	18	◯ S5.0	0.5	-7	6000	**0.51**	0.6 – 0.7
16 ◆	N_2	20	◯ S5.0	0.5	-9	6000	**0.26**	0.3 – 0.4
20 ◆	N_2	20	◯ S5.0	0.5	-10	6000	**0.09**	0.1 – 0.2
Copper Use the source row's gas; highly reflective.								
1	O_2	10	◯ S3.0	0.5	-1	6000	**26**	30 – 35
2	O_2	10	◯ S3.0	0.5	-1	6000	**10**	12 – 15
3	O_2	12	◯ S3.0	0.5	-2	6000	**6.0**	7 – 9
4	O_2	12	◯ S3.5	0.5	-3	6000	**5.1**	6 – 7
5	O_2	13	◯ S4.5	0.5	-4	6000	**4.3**	5 – 6
6	O_2	14	◯ S5.0	0.5	-5	6000	**2.1**	2.5 – 3.5
8 ◆	O_2	14	◯ S5.0	0.3	-5	6000	**1.3**	1.5 – 2

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: KRRASS 6000W (O_2/thick stainless: 50 µm; mild steel N_2 and thin stainless: single-module 100 µm; Al: multi-module 100 µm); BSM12 brass/copper 6000 W; https://www.krrass.com/6000w-fiber-laser-cutting-machine-parameters/; https://www.bestsheetmetalmachine.com/12000w-laser-cutting-parameters/; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

9.7 8 kW (8000 W) ★

! Interpolated table

No complete published table was found for this power. Values are interpolated between adjacent power tables. Validate with test cuts.

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
★ 6–12 kW speed interpolation · 50 / 100 µm (according to adjacent source rows)	From the 12 kW row: Jiaqiang · 100/125 (12 kW)	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
8 ★	O_2	0.6	D1.2	0.6	+10	4000	**1.9**	2.2 – 2.6
10 ★	O_2	0.6	D1.2	0.6	+11	6000	**1.7**	2 – 2.2
12 ★	O_2	0.6	D1.2	0.6	+12	6000	**1.5**	1.8 – 2
14 ★	O_2	0.6	D1.4	0.6	+12	8000	**1.2**	1.5 – 1.7
16 ★	O_2	0.5	D1.4	0.5	+13	8000	**0.99**	1.2 – 1.4
18 ★	O_2	0.5	S1.5	0.5	+14	8000	**0.91**	1.1 – 1.3
20 ★	O_2	0.5	S1.5	0.5	+15	8000	**0.74**	0.87 – 1.2
22 ★	O_2	0.5	S1.5	0.5	+15	8000	**0.68**	0.8 – 0.93
25 ★	O_2	0.55	S1.5	0.5	+15	8000	**0.62**	0.73 – 0.93
30 ★◆	O_2	0.7	S1.7	0.5	+16	8000	**0.45**	0.53 – 0.67
35 ★◆	O_2	1.5	S1.7	0.5	+17	8000	**0.31**	0.37 – 0.5
40 ★◆	O_2	1.2	S1.7	0.5	+17	8000	**0.20**	0.23 – 0.33
1 ★	N_2 / Air	8	S2.0	0.5	0	8000	**51**	60 – 80
2 ★	N_2 / Air	8	S3.0	0.5	-0.5	8000	**35**	42 – 47
3 ★	N_2 / Air	8	S3.0	0.5	-1	8000	**22**	26 – 31
4 ★	N_2 / Air	8	S3.0	0.5	-1	8000	**15**	18 – 23
5 ★	N_2 / Air	8	S4.0	0.5	-2	8000	**11**	13 – 16
6 ★	N_2 / Air	8	S4.0	0.5	-2	8000	**8.5**	10 – 13
Stainless steel N_2; air where a source row exists.								
12 ★	N_2	18	S5.0	0.5	-3	8000	**2.6**	3 – 3.7
14 ★	N_2	18	S5.0	0.5	-5	8000	**1.7**	2 – 2.5
16 ★	N_2	20	S5.0	0.5	-6	8000	**1.2**	1.4 – 1.7
18 ★	N_2	20	S5.0	0.5	-10	8000	**0.79**	0.93 – 1.1
20 ★	N_2	20	S5.0	0.3	-11	8000	**0.68**	0.8 – 0.93
22 ★	N_2	20	S5.0	0.5	-12	8000	**0.57**	0.67 – 0.8
25 ★◆	N_2	20	S6.0	0.5	-13	8000	**0.31**	0.37 – 0.53
35 ★◆	N_2	25	S5.0	0.5	+7‡	8000	**0.11**	0.13 – 0.17
1 ★	N_2	10	S2.0	1	0	8000	**51**	60 – 77
2 ★	N_2	12	S2.0	0.5	0	8000	**27**	32 – 38
3 ★	N_2	13	S3.0	0.5	-0.5	8000	**20**	23 – 28
4 ★	N_2	12	S3.0	0.5	-1	8000	**13**	15 – 19
5 ★	N_2	12	S3.5	0.5	-1	8000	**9.4**	11 – 15
6 ★	N_2	12	S4.0	0.5	-1.5	8000	**6.8**	8 – 11
8 ★	N_2	13	S5.0	0.5	-3	8000	**4.3**	5 – 6.9

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
10 ★	N_2	14	◯ S5.0	0.5	-3	8000	**2.7**	3.2 – 4
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	8	◯ S2.0	0.5	0	8000	**43**	51 – 68
2 ★	N_2 / Air	8	◯ S3.0	0.5	-0.5	8000	**30**	35 – 40
3 ★	N_2 / Air	8	◯ S3.0	0.5	-1	8000	**19**	22 – 27
4 ★	N_2 / Air	8	◯ S3.0	0.5	-1	8000	**13**	15 – 19
5 ★	N_2 / Air	8	◯ S4.0	0.5	-2	8000	**9.6**	11 – 14
6 ★	N_2 / Air	8	◯ S4.0	0.5	-2	8000	**7.2**	8.5 – 11
Aluminum Highly reflective; verify source/head compatibility.								
1 ★	N_2	12	◯ S2.0	0.6	0	8000	**45**	53 – 60
2 ★	N_2	12	◯ S2.0	0.5	-1	8000	**24**	28 – 32
3 ★	N_2	12	◯ S2.0	0.5	-1	8000	**15**	18 – 21
4 ★	N_2	12	◯ S2.0	0.5	-2	8000	**11**	13 – 16
5 ★	N_2	14	◯ S2.5	0.5	-3	8000	**7.4**	8.7 – 11
6 ★	N_2	14	◯ S2.5	0.5	-4	8000	**4.8**	5.7 – 6.7
8 ★	N_2	14	◯ S2.5	0.5	-6	8000	**3.4**	4 – 4.7
10 ★	N_2	14	◯ S5.0	0.5	-7	8000	**2.6**	3 – 3.7
12 ★	N_2	16	◯ S5.0	0.5	-7	8000	**1.3**	1.5 – 2.2
14 ★	N_2	16	◯ S5.0	0.5	-8	8000	**0.99**	1.2 – 1.6
16 ★	N_2	16	◯ S5.0	0.5	-9	8000	**0.91**	1.1 – 1.3
18 ★	N_2	16	◯ S5.0	0.5	-10	8000	**0.74**	0.87 – 1
20 ★	N_2	16	◯ S5.0	0.3	-12	8000	**0.57**	0.67 – 0.9
Brass Highly reflective.								
1 ★	N_2	10	◯ S2.0	0.6	0	8000	**34**	40 – 50
2 ★	N_2	12	◯ S2.0	0.5	-1	8000	**20**	23 – 28
3 ★	N_2	12	◯ S3.0	0.5	-1	8000	**11**	13 – 15
4 ★	N_2	12	◯ S3.0	0.5	-2	8000	**8.5**	10 – 12
5 ★	N_2	14	◯ S3.5	0.5	-3	8000	**7.1**	8.3 – 9.7
6 ★	N_2	14	◯ S4.0	0.5	-3	8000	**4.5**	5.3 – 6.7
8 ★	N_2	14	◯ S4.5	0.5	-4	8000	**2.8**	3.3 – 3.9
10 ★	N_2	14	◯ S4.5	0.5	-5	8000	**1.7**	2 – 2.5
12 ★	N_2	14	◯ S4.5	0.5	-5	8000	**1.0**	1.2 – 1.5
16 ★◆	N_2	16	◯ S5.0	0.5	-11	8000	**0.40**	0.47 – 0.6
Copper Use the source row's gas; highly reflective.								
1 ★	O_2	10	◯ S3.0	0.6	-0.5	8000	**26**	30 – 35
2 ★	O_2	12	◯ S3.0	0.5	-1	8000	**12**	15 – 18
3 ★	O_2	13	◯ S3.0	0.5	-2	8000	**8.5**	10 – 13
4 ★	O_2	13	◯ S3.5	0.5	-3	8000	**6.2**	7.3 – 9
5 ★	O_2	13	◯ S4.5	0.5	-4.5	8000	**4.8**	5.7 – 7.3
6 ★	O_2	14	◯ S4.5	0.5	-5	8000	**2.7**	3.2 – 4.2
8 ★◆	O_2	16	◯ S4.5	0.5	-6	8000	**1.6**	1.8 – 2.3

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: KRRASS 6/12 kW + BSM12 6000 W; https://www.krrass.com/6000w-fiber-laser-cutting-machine-parameters/; https://www.krrass.com/12kw-fiber-laser-cutting-machine-cutting-parameters/; https://www.krrass.com/12000w-fiber-laser-cutting-machine-parameters/; https://www.bestsheetmetalmachine.com/12000w-laser-cutting-parameters/; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

★ Speed ranges are printed with at most two decimal places.

9.8 10 kW (10000 W) ★

! Interpolated table

No complete published table was found for this power. Values are interpolated between adjacent power tables. Validate with test cuts.

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
★ 6–12 kW speed interpolation · 50 / 100 µm (according to adjacent source rows)	From the 12 kW row: Jiaqiang · 100/125 (12 kW)	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
8 ★	O_2	0.6	D1.2	0.6	+10	4000	**1.9**	2.3 – 2.5
10 ★	O_2	0.6	D1.2	0.6	+11	6000	**1.7**	2 – 2.2
12 ★	O_2	0.6	D1.2	0.6	+12	6000	**1.5**	1.8 – 2
14 ★	O_2	0.6	D1.4	0.6	+12	8000	**1.3**	1.5 – 1.7
16 ★	O_2	0.5	D1.4	0.5	+13	8000	**1.1**	1.3 – 1.6
18 ★	O_2	0.5	S1.5	0.5	+14	10000	**1.1**	1.3 – 1.5
20 ★	O_2	0.5	S1.5	0.5	+15	10000	**0.96**	1.1 – 1.4
22 ★	O_2	0.5	S1.5	0.5	+15	10000	**0.89**	1.1 – 1.2
25 ★	O_2	0.55	S1.5	0.5	+15	10000	**0.74**	0.87 – 1.1
30 ★◆	O_2	0.7	S1.7	0.5	+16	10000	**0.57**	0.67 – 0.83
35 ★◆	O_2	1.5	S1.7	0.5	+17	10000	**0.37**	0.43 – 0.6
40 ★◆	O_2	1.2	S1.7	0.5	+17	10000	**0.23**	0.27 – 0.37
1 ★	N_2 / Air	8	S2.0	0.5	0	10000	**51**	60 – 80
2 ★	N_2 / Air	8	S3.0	0.5	-0.5	10000	**37**	43 – 48
3 ★	N_2 / Air	8	S3.0	0.5	-1	10000	**25**	29 – 35
4 ★	N_2 / Air	8	S3.0	0.5	-1	10000	**17**	20 – 25
5 ★	N_2 / Air	8	S4.0	0.5	-2	10000	**14**	17 – 20
6 ★	N_2 / Air	8	S4.0	0.5	-2	10000	**11**	13 – 16
Stainless steel N_2; air where a source row exists.								
12 ★	N_2	18	S5.0	0.5	-3	10000	**3.8**	4.5 – 5.3
14 ★	N_2	18	S5.0	0.5	-5	10000	**2.6**	3 – 3.8
16 ★	N_2	20	S5.0	0.5	-6	10000	**1.6**	1.9 – 2.3
18 ★	N_2	20	S5.0	0.5	-10	10000	**1.1**	1.3 – 1.6
20 ★	N_2	20	S5.0	0.3	-11	10000	**0.94**	1.1 – 1.2
22 ★	N_2	20	S5.0	0.5	-12	10000	**0.79**	0.93 – 1.1
25 ★◆	N_2	20	S6.0	0.5	-13	10000	**0.50**	0.58 – 0.87
35 ★◆	N_2	25	S5.0	0.5	+7‡	10000	**0.14**	0.17 – 0.23
1 ★	N_2	10	S2.0	1	0	10000	**51**	60 – 73
2 ★	N_2	12	S2.0	0.5	0	10000	**28**	33 – 42
3 ★	N_2	13	S3.0	0.5	-0.5	10000	**23**	27 – 31
4 ★	N_2	12	S3.0	0.5	-1	10000	**15**	18 – 23
5 ★	N_2	12	S3.5	0.5	-1	10000	**11**	13 – 17
6 ★	N_2	12	S4.0	0.5	-1.5	10000	**8.5**	10 – 13
8 ★	N_2	13	S5.0	0.5	-3	10000	**6.0**	7 – 8.9

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
10 ★	N_2	14	S5.0	0.5	-3	10000	**3.9**	4.6 – 5.5
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	8	S2.0	0.5	0	10000	**43**	51 – 68
2 ★	N_2 / Air	8	S3.0	0.5	-0.5	10000	**31**	37 – 41
3 ★	N_2 / Air	8	S3.0	0.5	-1	10000	**21**	25 – 29
4 ★	N_2 / Air	8	S3.0	0.5	-1	10000	**15**	17 – 22
5 ★	N_2 / Air	8	S4.0	0.5	-2	10000	**12**	14 – 17
6 ★	N_2 / Air	8	S4.0	0.5	-2	10000	**9.4**	11 – 14
Aluminum Highly reflective; verify source/head compatibility.								
1 ★	N_2	12	S2.0	0.6	0	10000	**44**	52 – 60
2 ★	N_2	12	S2.0	0.5	-1	10000	**27**	32 – 36
3 ★	N_2	12	S2.0	0.5	-1	10000	**18**	21 – 25
4 ★	N_2	12	S2.0	0.5	-2	10000	**13**	15 – 19
5 ★	N_2	14	S2.5	0.5	-3	10000	**9.6**	11 – 14
6 ★	N_2	14	S2.5	0.5	-4	10000	**6.7**	7.8 – 9.3
8 ★	N_2	14	S2.5	0.5	-6	10000	**4.7**	5.5 – 6.3
10 ★	N_2	14	S5.0	0.5	-7	10000	**3.4**	4 – 4.8
12 ★	N_2	16	S5.0	0.5	-7	10000	**1.8**	2.1 – 2.8
14 ★	N_2	16	S5.0	0.5	-8	10000	**1.2**	1.4 – 2
16 ★	N_2	16	S5.0	0.5	-9	10000	**1.1**	1.3 – 1.6
18 ★	N_2	16	S5.0	0.5	-10	10000	**0.88**	1 – 1.3
20 ★	N_2	16	S5.0	0.3	-12	10000	**0.71**	0.83 – 1.1
Brass Highly reflective.								
1 ★	N_2	10	S2.0	0.6	0	10000	**34**	40 – 50
2 ★	N_2	12	S2.0	0.5	-1	10000	**23**	27 – 32
3 ★	N_2	12	S3.0	0.5	-1	10000	**15**	17 – 20
4 ★	N_2	12	S3.0	0.5	-2	10000	**11**	14 – 16
5 ★	N_2	14	S3.5	0.5	-3	10000	**9.5**	11 – 13
6 ★	N_2	14	S4.0	0.5	-3	10000	**6.1**	7.2 – 8.8
8 ★	N_2	14	S4.5	0.5	-4	10000	**4.4**	5.2 – 5.9
10 ★	N_2	14	S4.5	0.5	-5	10000	**2.8**	3.3 – 4
12 ★	N_2	14	S4.5	0.5	-5	10000	**1.5**	1.8 – 2.2
16 ★◆	N_2	16	S5.0	0.5	-11	10000	**0.54**	0.63 – 0.8
Copper Use the source row's gas; highly reflective.								
1 ★	O_2	10	S3.0	0.6	-0.5	10000	**26**	30 – 35
2 ★	O_2	12	S3.0	0.5	-1	10000	**15**	17 – 22
3 ★	O_2	13	S3.0	0.5	-2	10000	**11**	13 – 16
4 ★	O_2	13	S3.5	0.5	-3	10000	**7.4**	8.7 – 11
5 ★	O_2	13	S4.5	0.5	-4.5	10000	**5.4**	6.3 – 8.7
6 ★	O_2	14	S4.5	0.5	-5	10000	**3.3**	3.8 – 4.8
8 ★◆	O_2	16	S4.5	0.5	-6	10000	**1.8**	2.2 – 2.7

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: KRRASS 6/12 kW + BSM12 6000 W; https://www.krrass.com/6000w-fiber-laser-cutting-machine-parameters/; https://www.krrass.com/12kw-fiber-laser-cutting-machine-cutting-parameters/; https://www.krrass.com/12000w-fiber-laser-cutting-machine-parameters/; https://www.bestsheetmetalmachine.com/12000w-laser-cutting-parameters/; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

★ Speed ranges are printed with at most two decimal places.

9.9 12 kW (12000 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
KRRASS · mixed sources; follow each row's source · 50 / 100 µm; depends on material	Jiaqiang (source name) · 100/125	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
1	N_2 / Air	8	S2.0	0.5	0	12000	**51**	60 – 80
2	N_2 / Air	8	S3.0	0.5	-0.5	12000	**38**	45 – 50
3	N_2 / Air	8	S3.0	0.5	-1	12000	**27**	32 – 38
4	N_2 / Air	8	S3.0	0.5	-1	12000	**20**	23 – 28
5	N_2 / Air	8	S4.0	0.5	-2	12000	**17**	20 – 23
6	N_2 / Air	8	S4.0	0.5	-2	12000	**14**	16 – 20
8	N_2 / Air	8	S5.0	0.5	-3	12000	**8.5**	10 – 13
10	N_2 / Air	10	S5.0	0.5	-3	12000	**4.7**	5.5 – 7.5
12	N_2 / Air	16	S5.0	0.5	-3	12000	**3.4**	4 – 5.5
8	O_2	0.6	D1.2	0.6	+10	4000	**2.0**	2.3 – 2.5
10	O_2	0.6	D1.2	0.6	+11	6000	**1.7**	2 – 2.2
12	O_2	0.6	D1.2	0.6	+12	6000	**1.5**	1.8 – 2
14	O_2	0.6	D1.4	0.6	+12	8000	**1.4**	1.6 – 1.8
16	O_2	0.5	D1.4	0.5	+13	8000	**1.3**	1.5 – 1.7
18	O_2	0.5	S1.5	0.5	+14	10000	**1.4**	1.6 – 1.7
20	O_2	0.5	S1.5	0.5	+15	12000	**1.2**	1.4 – 1.6
22	O_2	0.5	S1.5	0.5	+15	12000	**1.1**	1.3 – 1.5
25	O_2	0.55	S1.5	0.5	+15	12000	**0.85**	1 – 1.2
30	O_2	0.7	S1.7	0.5	+16	12000	**0.68**	0.8 – 1
35	O_2	1.5	S1.7	0.5	+17	12000	**0.43**	0.5 – 0.7
40 ◆	O_2	1.2	S1.7	0.5	+17	12000	**0.26**	0.3 – 0.4
Stainless steel N_2; air where a source row exists.								
12	N_2	18	S5.0	0.5	-3	12000	**5.1**	6 – 7
14	N_2	18	S5.0	0.5	-5	12000	**3.4**	4 – 5
16	N_2	20	S5.0	0.5	-6	12000	**2.1**	2.5 – 3
18	N_2	20	S5.0	0.5	-10	12000	**1.4**	1.6 – 2
20	N_2	20	S5.0	0.3	-11	12000	**1.2**	1.4 – 1.5
22	N_2	20	S5.0	0.5	-12	12000	**1.0**	1.2 – 1.4
25	N_2	20	S6.0	0.5	-13	12000	**0.68**	0.8 – 1.2
30	N_2	25	S5.0	0.5	+7‡	12000	**0.26**	0.3 – 0.4
35 ◆	N_2	25	S5.0	0.5	+7‡	12000	**0.17**	0.2 – 0.3
40 ◆	N_2	25	S5.0	0.5	+7‡	12000	**0.09**	0.1 – 0.15
1	N_2	10	S2.0	1	0	12000	**51**	60 – 70
2	N_2	12	S2.0	0.5	0	12000	**30**	35 – 45
3	N_2	13	S3.0	0.5	-0.5	12000	**26**	30 – 35
4	N_2	12	S3.0	0.5	-1	12000	**17**	20 – 26
5	N_2	12	S3.5	0.5	-1	12000	**13**	15 – 20
6	N_2	12	S4.0	0.5	-1.5	12000	**10**	12 – 15
8	N_2	13	S5.0	0.5	-3	12000	**7.7**	9 – 11

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
10	N_2	14	S5.0	0.5	-3	12000	**5.1**	6 – 7
1	Air	10	S2.0	1	0	12000	**51**	60 – 70
2	Air	12	S2.0	0.5	0	12000	**30**	35 – 45
3	Air	13	S3.0	0.5	-0.5	12000	**26**	30 – 35
4	Air	12	S3.0	0.5	-1	12000	**17**	20 – 26
5	Air	12	S3.5	0.5	-1	12000	**13**	15 – 20
6	Air	12	S4.0	0.5	-1.5	12000	**10**	12 – 15
8	Air	13	S5.0	0.5	-3	12000	**7.7**	9 – 11
10	Air	14	S5.0	0.5	-3	12000	**6.0**	7 – 8
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	8	S2.0	0.5	0	12000	**43**	51 – 68
2 ★	N_2 / Air	8	S3.0	0.5	-0.5	12000	**33**	38 – 43
3 ★	N_2 / Air	8	S3.0	0.5	-1	12000	**23**	27 – 32
4 ★	N_2 / Air	8	S3.0	0.5	-1	12000	**17**	20 – 24
5 ★	N_2 / Air	8	S4.0	0.5	-2	12000	**14**	17 – 20
6 ★	N_2 / Air	8	S4.0	0.5	-2	12000	**12**	14 – 17
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	12	S2.0	0.6	0	12000	**43**	50 – 60
2	N_2	12	S2.0	0.5	-1	12000	**30**	35 – 40
3	N_2	12	S2.0	0.5	-1	12000	**21**	25 – 30
4	N_2	12	S2.0	0.5	-2	12000	**15**	18 – 23
5	N_2	14	S2.5	0.5	-3	12000	**12**	14 – 17
6	N_2	14	S2.5	0.5	-4	12000	**8.5**	10 – 12
8	N_2	14	S2.5	0.5	-6	12000	**6.0**	7 – 8
10	N_2	14	S5.0	0.5	-7	12000	**4.3**	5 – 6
12	N_2	16	S5.0	0.5	-7	12000	**2.2**	2.6 – 3.5
14	N_2	16	S5.0	0.5	-8	12000	**1.4**	1.7 – 2.5
16	N_2	16	S5.0	0.5	-9	12000	**1.4**	1.6 – 2
18	N_2	16	S5.0	0.5	-10	12000	**1.0**	1.2 – 1.5
20	N_2	16	S5.0	0.3	-12	12000	**0.85**	1 – 1.3
25	N_2	25	S5.0	0.5	-13	12000	**0.51**	0.6 – 0.8
30	N_2	25	S5.0	0.5	+7‡	12000	**0.26**	0.3 – 0.4
40	N_2	25	S5.0	0.5	+8‡	12000	**0.17**	0.2 – 0.3
Brass Highly reflective.								
1	N_2	10	S2.0	0.6	0	12000	**34**	40 – 50
2	N_2	12	S2.0	0.5	-1	12000	**26**	30 – 35
3	N_2	12	S3.0	0.5	-1	12000	**19**	22 – 25
4	N_2	12	S3.0	0.5	-2	12000	**14**	17 – 20
5	N_2	14	S3.5	0.5	-3	12000	**12**	14 – 16
6	N_2	14	S4.0	0.5	-3	12000	**7.7**	9 – 11
8	N_2	14	S4.5	0.5	-4	12000	**6.0**	7 – 8
10	N_2	14	S4.5	0.5	-5	12000	**3.8**	4.5 – 5.5
12	N_2	14	S4.5	0.5	-5	12000	**2.0**	2.4 – 3
14	N_2	16	S5.0	0.5	-8	12000	**1.2**	1.4 – 2
16	N_2	16	S5.0	0.5	-11	12000	**0.68**	0.8 – 1

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Copper Use the source row's gas; highly reflective.								
1	O_2	10	◯ **S3.0**	0.6	-0.5	12000	**26**	30 – 35
2	O_2	12	◯ **S3.0**	0.5	-1	12000	**17**	20 – 25
3	O_2	13	◯ **S3.0**	0.5	-2	12000	**14**	16 – 20
4	O_2	13	◯ **S3.5**	0.5	-3	12000	**8.5**	10 – 13
5	O_2	13	◯ **S4.5**	0.5	-4.5	12000	**6.0**	7 – 10
6	O_2	14	◯ **S4.5**	0.5	-5	12000	**3.8**	4.5 – 5.5
8	O_2	16	◯ **S4.5**	0.5	-6	12000	**2.1**	2.5 – 3
10	O_2	18	◯ **S4.5**	0.5	-8	12000	**0.85**	1 – 1.5

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: KRRASS 12 kW (mild steel/thick stainless: 50 µm; Al/brass/copper/thin stainless: 100 µm); https://www.krrass.com/12kw-fiber-laser-cutting-machine-cutting-parameters/; https://www.krrass.com/12000w-fiber-laser-cutting-machine-parameters/; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

9.10 15 kW (15000 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
MAX/Raycus/IPG · multi-module · 100 µm	Jiaqiang (source name) · 100/125	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
1	N_2 / Air	10	S2.0	1	0	15000	**51**	60 – 80
2	N_2 / Air	10	S2.0	0.5	0	15000	**43**	50 – 60
3	N_2 / Air	12	S3.0	0.5	0	15000	**26**	30 – 33
4	N_2 / Air	12	S3.0	0.5	0	15000	**20**	23 – 26
5	N_2 / Air	12	S3.5	0.5	0	15000	**17**	20 – 22
6	N_2 / Air	12	S3.5	0.5	0	15000	**14**	17 – 19
8	N_2 / Air	12	S4.0	0.5	-1	15000	**9.4**	11 – 12
10	N_2 / Air	13	S4.0	0.5	-1	15000	**6.0**	7 – 8
12	N_2 / Air	13	S4.5	0.5	-2	15000	**4.3**	5 – 6
14	N_2 / Air	15	S4.5	0.5	-6	15000	**3.4**	4 – 4.5
16	N_2 / Air	16	S5.0	0.5	-8	15000	**2.6**	3 – 3.5
10	O_2	0.6	D1.2	0.5	+8	6000	**1.7**	2 – 2.3
12	O_2	0.6	D1.2	0.5	+8	7500	**1.5**	1.8 – 2.1
14	O_2	0.6	D1.4	0.5	+9	8500	**1.4**	1.7 – 1.9
16	O_2	0.6	D1.4	0.5	+10	9500	**1.4**	1.6 – 1.7
20	O_2	0.6	D1.6	0.5	+12	15000	**1.2**	1.4 – 1.6
22	O_2	0.7	D1.6	0.5	+12	15000	**1.0**	1.2 – 1.4
25	O_2	0.7	S1.4	0.3	+13	15000	**0.85**	1 – 1.2
30	O_2	0.9	S1.6	0.3	+12	15000	**0.34**	0.4 – 1
40	O_2	1.3	S1.8	0.3	+13	15000	**0.17**	0.2 – 0.3
50	O_2	1.5	S1.8	0.3	+13	15000	**0.09**	0.1 – 0.2
Stainless steel N_2; air where a source row exists.								
1	N_2	10	S2.0	1	0	15000	**51**	60 – 80
2	N_2	12	S2.0	0.5	0	15000	**34**	40 – 50
3	N_2	13	S3.5	0.5	0	15000	**29**	34 – 38
4	N_2	12	S3.5	0.5	-1	15000	**20**	23 – 30
5	N_2	13	S4.0	0.5	-1	15000	**15**	18 – 23
6	N_2	13	S4.5	0.5	-2	15000	**14**	16 – 19
8	N_2	13	S5.0	0.5	-3	15000	**8.5**	10 – 12
10	N_2	14	S5.0	0.5	-4	15000	**6.8**	8 – 10
12	N_2	15	S5.0	0.5	-5	15000	**5.1**	6 – 7
14	N_2	15	S5.0	0.5	-7	15000	**3.0**	3.5 – 4.5
16	N_2	16	S5.0	0.5	-8	15000	**2.1**	2.5 – 3.5
18	N_2	18	S5.0	0.5	-9	15000	**1.5**	1.8 – 2.3
20	N_2	20	S5.0	0.5	-11	15000	**1.3**	1.5 – 2
25	N_2	25	S5.0	0.5	-13	15000	**0.77**	0.9 – 1.2
30	N_2	25	S5.0	0.5	-16	15000	**0.26**	0.3 – 0.4
40	N_2	25	S5.0	0.5	+8‡	15000	**0.13**	0.15 – 0.2
50	N_2	25	S5.0	0.5	+9‡	15000	**0.09**	0.1 – 0.15

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
1	Air	10	S3.0	1	-1	15000	**51**	60 – 80
2	Air	12	S3.0	0.5	-1	15000	**34**	40 – 60
3	Air	13	S3.5	0.5	-1	15000	**26**	30 – 35
4	Air	14	S3.5	0.5	-2	15000	**21**	25 – 28
5	Air	16	S4.0	0.5	-4	15000	**19**	22 – 25
6	Air	16	S4.5	0.5	-4	15000	**15**	18 – 20
8	Air	16	S4.5	0.5	-4	15000	**8.5**	10 – 12
10	Air	16	S4.5	0.5	-5	15000	**6.8**	8 – 9
12	Air	18	S4.5	0.5	-6	15000	**5.1**	6 – 7
14	Air	18	S5.0	0.5	-8	15000	**3.4**	4 – 4.2
16	Air	20	S5.0	0.5	-10	15000	**2.1**	2.5 – 3
18	Air	20	S5.0	0.5	-10	15000	**1.7**	2 – 2.3
20	Air	25	S5.0	0.5	-15	15000	**1.5**	1.8 – 2
25	Air	25	S6.0	0.5	-19	15000	**1.0**	1.2 – 1.4
30	Air	25	S6.0	0.5	-21	15000	**0.68**	0.8 – 1
35	Air	25	S6.0	0.5	-24	15000	**0.34**	0.4 – 0.6
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
1 ★	N_2 / Air	10	S2.0	1	0	15000	**43**	51 – 68
2 ★	N_2 / Air	10	S2.0	0.5	0	15000	**36**	43 – 51
3 ★	N_2 / Air	12	S3.0	0.5	0	15000	**22**	26 – 28
4 ★	N_2 / Air	12	S3.0	0.5	0	15000	**17**	20 – 22
5 ★	N_2 / Air	12	S3.5	0.5	0	15000	**14**	17 – 19
6 ★	N_2 / Air	12	S3.5	0.5	0	15000	**12**	14 – 16
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	10	S3.0	0.6	0	15000	**51**	60 – 70
2	N_2	12	S3.0	0.5	-1	15000	**34**	40 – 50
3	N_2	14	S3.0	0.5	-1	15000	**29**	34 – 40
4	N_2	14	S3.5	0.5	-2	15000	**18**	21 – 26
5	N_2	14	S3.5	0.5	-3	15000	**14**	16 – 20
6	N_2	14	S4.0	0.5	-4	15000	**11**	13 – 15
8	N_2	16	S4.0	0.5	-6	15000	**7.7**	9 – 11
10	N_2	16	S4.5	0.5	-7	15000	**5.1**	6 – 8
12	N_2	16	S4.5	0.5	-9	15000	**2.1**	2.5 – 4
14	N_2	16	S5.0	0.5	-9	15000	**1.7**	2 – 3
16	N_2	18	S5.0	0.5	-10	15000	**1.3**	1.5 – 2
18	N_2	18	S5.0	0.5	-11	15000	**1.1**	1.3 – 1.8
20	N_2	20	S5.0	0.3	-13	15000	**0.68**	0.8 – 1.3
25	N_2	25	S5.0	0.5	-14	15000	**0.43**	0.5 – 0.7
30	N_2	25	S5.0	0.5	-17	15000	**0.34**	0.4 – 0.5
40	N_2	25	S5.0	0.5	+8‡	15000	**0.17**	0.2 – 0.3
50	N_2	25	S5.0	0.5	+9‡	15000	**0.09**	0.1 – 0.2
Brass Highly reflective.								
1	N_2	12	S2.0	1	0	15000	**43**	50 – 60
2	N_2	12	S2.0	0.5	-1	15000	**32**	38 – 42
3	N_2	12	S3.0	0.5	-1	15000	**21**	25 – 30
4	N_2	12	S3.5	0.5	-2	15000	**17**	20 – 24

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
5	N_2	14	S3.5	0.5	-3	15000	**15**	18 – 21
6	N_2	14	S4.0	0.5	-3	15000	**7.7**	9 – 11
8	N_2	14	S4.0	0.5	-4	15000	**6.0**	7 – 9
10	N_2	14	S4.5	0.5	-5	15000	**4.3**	5 – 6
12	N_2	14	S4.5	0.5	-5	15000	**2.6**	3 – 3.5
14	N_2	16	S4.5	0.5	-8	15000	**2.1**	2.5 – 3
16	N_2	18	S5.0	0.5	-11	15000	**1.1**	1.3 – 1.5
18	N_2	18	S5.0	0.5	-11	15000	**0.85**	1 – 1.2
20	N_2	18	S5.0	0.3	-12	15000	**0.51**	0.6 – 0.8
Copper Use the source row's gas; highly reflective.								
1	O_2	10	S2.0	0.6	-0.5	15000	**32**	38 – 42
2	O_2	10	S2.0	0.5	-1	15000	**24**	28 – 32
3	O_2	10	S3.0	0.5	-2	15000	**17**	20 – 24
4	O_2	12	S3.5	0.5	-3	15000	**12**	14 – 16
5	O_2	12	S3.5	0.5	-4.5	15000	**6.8**	8 – 10
6	O_2	13	S4.0	0.5	-5	15000	**5.1**	6 – 7
8	O_2	13	S4.0	0.5	-6	15000	**2.1**	2.5 – 3.5
10	O_2	14	S4.0	0.5	-8	15000	**1.3**	1.5 – 2

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: KRRASS 15000 W; thickness cross-check: BSM15; https://www.krrass.com/1500w-fiber-laser-cutting-machine-cutting-parameters/; https://www.bestsheetmetalmachine.com/15000w-laser-cutting-parameters/; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

9.11 20 kW (20000 W) ★

! Interpolated table

No complete published table was found for this power. Values are interpolated between adjacent power tables. Validate with test cuts.

20 kW aluminum, brass and copper rows are actual manufacturer 20000 W data, without ★. Mild steel and stainless steel use ★ interpolation.

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
★ 15–30 kW speed interpolation; Al/brass/copper: actual 20000 W · 100 µm (adjacent tables)	30 kW row; model not specified · Not specified in source	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
8 ★	N_2 / Air	10	S4.5	0.5	-1	20000	**12**	14 – 16
10 ★	N_2 / Air	10	S4.5	0.5	-2	20000	**8.2**	9.7 – 12
12 ★	N_2 / Air	12	S4.5	0.5	-3	20000	**5.7**	6.7 – 8.7
14 ★	N_2 / Air	14	S4.5	0.5	-3	20000	**4.8**	5.7 – 6.5
16 ★	N_2 / Air	14	S5.0	0.5	-4	20000	**4.0**	4.7 – 5.5
10 ★	O_2	0.6	D1.2	0.6	+8	6000	**1.8**	2.1 – 2.4
12 ★	O_2	0.6	D1.2	0.6	+9	6500	**1.6**	1.8 – 2.1
14 ★	O_2	0.6	D1.4	0.6	+10	8000	**1.5**	1.7 – 1.9
16 ★	O_2	0.6	D1.4	0.6	+11	8500	**1.4**	1.6 – 1.7
20 ★	O_2	0.5	S1.5	0.3	+12 / +13.5	11000	**1.2**	1.4 – 1.6
22 ★	O_2	0.5	S1.6	0.3	+12 / +13.5	12000	**1.0**	1.2 – 1.4
25 ★	O_2	0.5	S1.6	0.3	+13 / +14.5	12000	**0.92**	1.1 – 1.3
30 ★	O_2	0.8	S1.6	0.3	+13 / +14.5	17000	**0.54**	0.63 – 1.1
40 ★	O_2	1.2	S1.8	0.3	+14 / +15	20000	**0.37**	0.43 – 0.57
50 ★	O_2	1.3	S1.8	0.3	+15 / +16	20000	**0.17**	0.2 – 0.3
Stainless steel N_2; air where a source row exists.								
6 ★	N_2	8	S4.5	0.5	+1 / -2‡	20000	**18**	21 – 24
8 ★	N_2	8	S5.0	0.5	-1 / -2	20000	**13**	15 – 17
10 ★	N_2	8	S5.0	0.5	-1 / -3	20000	**10**	12 – 14
12 ★	N_2	10	S5.0	0.5	-1 / -5	20000	**7.7**	9 – 10
14 ★	N_2	14	S5.0	0.5	-3 / -5	20000	**4.8**	5.7 – 7
16 ★	N_2	14	S5.0	0.5	-4 / -5	20000	**3.8**	4.5 – 5.7
18 ★	N_2	16	S5.0	0.5	-5 / -6	20000	**2.7**	3.2 – 3.9
20 ★	N_2	20	S6.0	0.5	-5 / -6	20000	**2.3**	2.7 – 3.3
25 ★	N_2	20	S6.0	0.5	-6.5 / -7.5	20000	**1.4**	1.6 – 2.1
30 ★	N_2	25	S8.0	0.3	-9.5 / -10.5	20000	**0.74**	0.87 – 1.1
40 ★◆	N_2	25	S8.0	0.3	-15 / -16.5	20000	**0.34**	0.4 – 0.53
50 ★◆	N_2	25	S6.0	0.3	+8‡	20000	**0.11**	0.13 – 0.18
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
6 ★	N_2 / Air	8	S4.5	0.5	+1 / -2‡	20000	**17**	20 – 23
Aluminum Highly reflective; verify source/head compatibility.								
1	N_2	8	S3.0	0.5	0	20000	**51**	60 – 80

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
2	N_2	8	S3.0	0.5	0	20000	**43**	50 – 60
3	N_2	8	S3.0	0.5	-1	20000	**30**	35 – 45
4	N_2	8	S3.0	0.5	-1	20000	**26**	30 – 40
5	N_2	10	S4.5	0.5	-2	20000	**17**	20 – 25
6	N_2	10	S4.5	0.5	-2	20000	**13**	15 – 22
8	N_2	10	S5.0	0.5	-3	20000	**12**	14 – 20
10	N_2	10	S5.0	0.5	-3	20000	**6.8**	8 – 10
12	N_2	10	S5.0	0.5	-4	20000	**6.0**	7 – 8
14	N_2	12	S5.0	0.5	-5	20000	**3.4**	4 – 6
16	N_2	14	S5.0	0.5	-6	20000	**2.6**	3 – 4.5
18	N_2	14	S5.0	0.5	-6	20000	**2.0**	2.3 – 3
20	N_2	16	S5.0	0.5	-7	20000	**1.7**	2 – 2.3
25	N_2	18	S6.0	0.5	-8	20000	**0.85**	1 – 1.5
30	N_2	20	S6.0	0.5	-8	20000	**0.51**	0.6 – 0.8
40 ◆	N_2	25	S6.0	0.5	+8‡	20000	**0.26**	0.3 – 0.6
50 ◆	N_2	28	S6.0	0.5	+8‡	20000	**0.26**	0.3 – 0.4
60 ◆	N_2	28	S6.0	0.5	+8‡	20000	**0.17**	0.2 – 0.3
Brass Highly reflective.								
1	N_2	10	S3.0	0.5	0	20000	**43**	50 – 60
2	N_2	10	S3.5	0.5	0	20000	**30**	35 – 45
3	N_2	10	S3.5	0.5	0	20000	**24**	28 – 35
4	N_2	10	S3.5	0.5	-1	20000	**20**	23 – 28
5	N_2	12	S4.5	0.5	-1	20000	**13**	15 – 20
6	N_2	12	S4.5	0.5	-1.5	20000	**10**	12 – 15
8	N_2	12	S5.0	0.5	-2	20000	**6.8**	8 – 10
10	N_2	13	S5.0	0.5	-3	20000	**4.3**	5 – 7
12	N_2	14	S5.0	0.5	-3	20000	**3.0**	3.5 – 5.5
14	N_2	14	S5.0	0.5	-4	20000	**2.6**	3 – 4.5
16	N_2	14	S5.0	0.5	-5	20000	**1.7**	2 – 3
18	N_2	16	S5.0	0.5	-6	20000	**0.85**	1 – 1.5
20	N_2	18	S6.0	0.5	-6.5	20000	**0.60**	0.7 – 0.9
Copper Use the source row's gas; highly reflective.								
1	O_2	8	S3.0	0.5	0	20000	**26**	30 – 40
2	O_2	8	S3.0	0.5	0	20000	**19**	22 – 30
3	O_2	8	S3.5	0.5	0	20000	**17**	20 – 25
4	O_2	10	S3.5	0.5	-1	20000	**13**	15 – 18
5	O_2	10	S5.0	0.5	-1	20000	**10**	12 – 14
6	O_2	10	S5.0	0.5	-2	20000	**6.0**	7 – 9
8	O_2	10	S5.0	0.5	-3	20000	**3.8**	4.5 – 5.5
10	O_2	12	S5.0	0.5	-4	20000	**2.6**	3 – 3.5
12 ◆	O_2	14	S5.0	0.5	-5	20000	**1.7**	2 – 2.5

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: KRRASS 15 kW + bestsheetmetalmachine 30000W (including 20000 W rows); https://www.krrass.com/1500w-fiber-laser-cutting-machine-cutting-parameters/; https://www.bestsheetmetalmachine.com/30000w-laser-cutting-parameters/; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

★ Speed ranges are printed with at most two decimal places.

9.12 30 kW (30000 W)

SOURCE / CORE	HEAD / OPTICS	GAS PURITY	COMPRESSED AIR
30 kW class · multi-module · 100 µm	Model not specified in source · Not specified in source	O_2 ≥ 99.95% (3.5) · N_2 ≥ 99.995%; quality work: 5.0 (99.999%) · H_2O < 5 ppm · HC < 1 ppm	Dry, oil-free · 0.01 µm filter

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
Mild steel Follow gas and power for each row.								
8	N_2 / Air	10	S4.5	0.5	-1	30000	**17**	20 – 25
10	N_2 / Air	10	S4.5	0.5	-2	30000	**13**	15 – 20
12	N_2 / Air	12	S4.5	0.5	-3	30000	**8.5**	10 – 14
14	N_2 / Air	14	S4.5	0.5	-3	30000	**7.7**	9 – 10.5
16	N_2 / Air	14	S5.0	0.5	-4	30000	**6.8**	8 – 9.5
18	N_2 / Air	20	S5.0	0.5	-7	30000	**5.1**	6 – 7
20	N_2 / Air	25	S6.0	0.5	-10	30000	**3.4**	4 – 5
10	O_2	0.6	D1.2	0.6	+8	6000	**1.9**	2.2 – 2.5
12	O_2	0.6	D1.2	0.6	+9	6500	**1.6**	1.9 – 2.1
14	O_2	0.6	D1.4	0.6	+10	8000	**1.5**	1.8 – 1.9
16	O_2	0.6	D1.4	0.6	+11	8500	**1.4**	1.6 – 1.8
18	O_2	0.5	S1.5	0.3	+12 / +13	11000	**1.3**	1.5 – 1.7
20	O_2	0.5	S1.5	0.3	+12 / +13.5	11000	**1.3**	1.5 – 1.6
22	O_2	0.5	S1.6	0.3	+12 / +13.5	12000	**1.1**	1.3 – 1.5
25	O_2	0.5	S1.6	0.3	+13 / +14.5	12000	**1.1**	1.25 – 1.4
30	O_2	0.8	S1.6	0.3	+13 / +14.5	17000	**0.94**	1.1 – 1.3
35	O_2	1	S1.7	0.3	+13.8 / +14.5	17000	**0.94**	1.1 – 1.2
40	O_2	1.2	S1.8	0.3	+14 / +15	20000	**0.77**	0.9 – 1.1
45	O_2	1.2	S1.8	0.3	+15 / +16	28000	**0.60**	0.7 – 0.9
50	O_2	1.3	S1.8	0.3	+15 / +16	30000	**0.34**	0.4 – 0.5
60 ◆	O_2	1.6	S1.8	0.3	+16 / +17	30000	**0.17**	0.2 – 0.3
70 ◆	O_2	1.6	S1.8	0.3	+16 / +17	30000	**0.09**	0.1 – 0.2
80 ◆	O_2	1.6	S1.8	0.3	+16 / +17	30000	**0.09**	0.1 – 0.15
Stainless steel N_2; air where a source row exists.								
6	N_2	8	S4.5	0.5	+1 / -2‡	30000	**26**	30 – 35
8	N_2	8	S5.0	0.5	-1 / -2	30000	**21**	25 – 28
10	N_2	8	S5.0	0.5	-1 / -3	30000	**17**	20 – 22
12	N_2	10	S5.0	0.5	-1 / -5	30000	**13**	15 – 17
14	N_2	14	S5.0	0.5	-3 / -5	30000	**8.5**	10 – 12
16	N_2	14	S5.0	0.5	-4 / -5	30000	**7.2**	8.5 – 10
18	N_2	16	S5.0	0.5	-5 / -6	30000	**5.1**	6 – 7
20	N_2	20	S6.0	0.5	-5 / -6	30000	**4.3**	5 – 6
25	N_2	20	S6.0	0.5	-6.5 / -7.5	30000	**2.6**	3 – 4
30	N_2	25	S8.0	0.3	-9.5 / -10.5	30000	**1.7**	2 – 2.5
35	N_2	25	S8.0	0.3	-11 / -13	30000	**1.3**	1.5 – 1.8
40 ◆	N_2	25	S8.0	0.3	-15 / -16.5	30000	**0.77**	0.9 – 1.2
50 ◆	N_2	25	S6.0	0.3	+8‡	30000	**0.17**	0.2 – 0.25
60 ◆	N_2	25	S6.0	0.3	+9‡	30000	**0.13**	0.15 – 0.2
70 ◆	N_2	25	S8.0	0.3	+9‡	30000	**0.09**	0.1 – 0.15

Thickness mm	Gas	Pressure bar	Nozzle type · Ø mm	Height mm	Focus mm	Power W	Starting speed m/min	Max. speed m/min
80 ◆	N_2	25	◯ S8.0	0.3	+9‡	30000	**0.07**	0.08 – 0.12
90 ◆	N_2	25	◯ S8.0	0.3	+9‡	30000	**0.04**	0.05 – 0.1
100 ◆	N_2	25	◯ S8.0	0.3	+9‡	30000	**0.04**	0.05 – 0.08
Galvanized sheet ★ Mild steel N_2/air × 0.85; otherwise stainless steel N_2 × 0.95. Up to 6 mm.								
6 ★	N_2 / Air	8	◯ S4.5	0.5	+1 / -2‡	30000	**24**	29 – 33

S single-layer nozzle · D double-layer nozzle + / – controller value: verify the nozzle-tip reference ★ DOKTEK derived/interpolated

◆ trial; not for series production

‡ Positive focus: the source table gives it this way; Bodor/GYC describe negative or near-zero focus for N_2 — verify on the machine. The mark is added to N_2 and N_2/air rows when the first focus number is positive.

Data source: bestsheetmetalmachine 30000W; https://www.bestsheetmetalmachine.com/30000w-laser-cutting-parameters/; ★ DOKTEK derived/interpolated; ◆ Trial / capacity limit / incomplete recipe reference; not for series production.

Aluminum: Start with the 20 kW table; Brass: Start with the 20 kW table; Copper: Start with the 20 kW table.

10

Material-specific notes

Two sheets of equal thickness may behave differently. Record grade, surface, coating and batch. After changing material, do not send the old recipe straight to series production; verify a sample again.

10.1 Mild steel: S235 and S355

Do not record structural steels such as S235 and S355 simply as “mild steel”. Grade, surface condition and batch changes affect cutting. Surface and chemical composition changes can affect combustion stability in thick O_2 cutting. A recipe successful at the same thickness needs checking on another batch.

Inspect mill scale before accepting the plate. In the study by Yamane et al., thin (20–40 µm), strongly adherent scale with a smooth surface is associated with better cut quality; this can help O_2 cutting. Check consistency across the whole sheet. Not all scaled plate is defective; loose rust, sand and dirt can disrupt piercing, gas flow and capacitive tracking.

DOKTEK rule — no primary source: If scale is flaking or rust is present, retest with more conservative recipe conditions or reject the plate. There is no universal speed/pressure factor for “derating the recipe”. Prepare the surface by a suitable method; do not start production before sample acceptance. The finding by Yamane et al. is not a prescribed acceptance procedure.

Yamane et al. — QJJWS 41(2)

- Exclude deep scratches, flaking scale and heavily rusted areas from nesting.
- Measure bent sheet; verify reliable height sensor following.
- Specify oxide-edge preparation for painting or welding in the work order.
- If cutting is good in one area and poor elsewhere, check surface changes and heat build-up.

Source: Linde “Laser cutting advice” lists rust, paint, mill scale and deep scratches as factors affecting cut quality in its material condition section.

10.2 Stainless steel: 304, 316 and protective film

Identify 304 and 316 separately in stock and recipes. Use suitably pure N_2 for oxide-free edges. Do not attribute yellow/blue edges solely to focus; check gas purity, residual air in shared lines and start delay according to section 7.2.

Use N_2 purity of at least 99.995%; target 5.0 (99.999%) for oxide-free/bright edges. Verify H_2O < 5 ppm and HC < 1 ppm in the supply certificate; check gas and lines according to section 7.2.

For the single-sided film application in this guide, keep film on top. Use laser-compatible film; not all plastic films are suitable. Obtain manufacturer instructions for double-sided or different films. Mark direction and visible face before nesting.

Purpose: Open the film in a controlled manner to protect edges and surfaces.

Requirements: Film information, suitable extraction, manufacturer-approved film recipe and same-material sample.

1. Verify laser compatibility and film adhesion. Check lifted or torn areas.

2. Load film side up with correct visible-face direction.
3. If needed, use an approved pre-pass/film vaporization function. Do not treat this pass as the metal cutting recipe.
4. Cut the sample. Look for top-surface burns, film lifting, adhesive residue and bottom dross.
5. Record successful results with film type and sheet batch. Do not transfer a defective sample process to series work.

Warning

Do not vaporize unknown film with the laser. Extract film fumes effectively; do not cut without working extraction. Monitor film deposits and protective window contamination.

Why? Film and adhesive behave differently from metal. An incorrect pass can damage the surface and destabilize cutting starts.

10.3 Galvanised steel: account for zinc coating

Prefer N_2 or suitable dry oil-free air for galvanized sheet. **O_2 is not preferred; GWEIKE allows it at ≥3 mm after sample validation.** O_2 can intensify zinc reactions, coating burn, spatter and optical contamination. Maintain effective extraction; do not copy a mild-steel recipe to galvanized sheet.

Coating thickness and surface treatment changes can affect piercing, spatter and edges. Repeat samples when coating changes even at equal sheet thickness. Check protective windows on the first part and at shift start; increase frequency according to observed contamination. Open the window drawer only in a safe state and clean environment.

Zinc fumes and optical contamination

Zinc fumes are harmful and can cause metal fume fever. Do not cut without effective local extraction. Zinc spatter can rapidly contaminate protective windows. Smell or visible fumes alone are not safe-working criteria.

- Record coating and sheet batch in the work order.
- Verify extraction works in the cutting area.
- Assess film, paint or additional surface treatments separately.
- For bottom dross, first check recipe, nozzle and flow; trial one parameter.

Distinguish coating burning from failure to cut the base metal. An opened coating on top does not prove full penetration. Inspect sample undersides too.

Gas selection: GWEIKE galvanized guide. See chapter 9 for speed and complete recipes; incomplete references are not series-production recipes.

10.4 Aluminium: surface oxide and dross

Aluminium is reflective and conducts heat rapidly. Its oxide layer and base metal behave differently. Record alloy, surface and plate flatness. Verify aluminium compatibility with the source and head manufacturers.

N_2 is common for clean edges. Air is possible with a suitable recipe and accepted edges. Assess air-cut edge oxide and color for later welding or painting. Do not use the same recipe for every aluminium alloy.

Speed, focus and gas evacuation can jointly cause sticky bottom dross. First check the nozzle is sound and centered, and gas remains sufficient during flow. Inspect the protective window. Then follow section 13.3 for a single-parameter trial.

Measure after cooling. Bending of thin, long parts cannot be corrected solely by kerf compensation. Assess nesting, heat distribution and micro joints.

10.5 Brass and copper: back-reflection

Reflected beams from brass and copper can damage the laser source. Suitability depends on source type and model. Do not rely solely on brand or power labels; verify manufacturer approval for these materials with the installed source, optical connection and head.

> **! Back-reflection protection**
>
> Do not disable back-reflection protection or alarms. Do not trial brass/copper on an unverified system. Protection does not guarantee freedom from damage in all conditions. Stop by the manufacturer's procedure if cutting is unstable or protection trips.

Copper sources disagree: Chinese laser-source maker BWT specifies high-pressure O_2, while Western supplier Boss Laser calls N_2 the normal choice. A compilation published under the IPG name also includes N_2/air examples; it is not a primary IPG gas recipe. Do not treat gases as equivalent; obtain copper approval and a complete recipe from your source/head manufacturer.

The local Maxphotonics MFSC/MFMC text includes brass rows; do not derive numerical copper recipes from it. Do not transfer settings from brass to copper or copper to aluminium. Pay particular attention to stable cutting during initial piercing and transition.

Copper/brass surface cleanliness, coating and batch also affect results. Run required extraction; do not touch hot parts bare-handed. Do not compensate for protective window contamination by increasing power.

BWT's precautions for ≥10 kW copper/aluminum: use full-power continuous wave (CW) only on a suitable system; select the smallest nozzle that works and reduce series speed to ≈80% of the successful sample speed. Keep nozzle cooling gas on continuously. These recommendations do not override machine limits; do not transfer high-pressure copper O_2 settings to mild steel.

BWT

10.6 Coated and painted sheet

Paint, oil, film and metallic coatings change cutting starts and fumes. Identify coatings before production. Do not identify unknown coatings through test cutting; use supplier material information and the site's approved method.

Check	Work order information	Acceptance
Material and surface	Base metal grade, coating type, face and batch.	Must match the recipe.

Check	Work order information	Acceptance
Fumes and cleaning	Extraction requirements, residue removal method.	Approved method must be ready.
Visible face	Top/bottom orientation, film direction, permitted burn marks.	Sample must meet customer/job requirements.
Subsequent operation	Welding, bending, painting and edge preparation.	Cut edges must suit the operation.

Inspect sample top surface, bottom edge, holes and entry point separately. Do not record only “good result”; include gas, surface and acceptance criteria. For speed and other numerical settings use section 9; for defect diagnosis use section 13.

Accepting a new material batch

Purpose: Identify material-change effects before series cutting.

Requirements: Supplier material information, approved previous sample, production drawing and record form.

1. Compare the label with the order. Verify grade, thickness, coating and batch.
2. Inspect both faces; record rust, oil, blistering, film and flatness. Exclude defective areas from nesting.
3. Cut a sample with a straight edge, corner and hole using an approved material-specific recipe.
4. Compare the cooled sample with the previously accepted part. Assess edges and finishing needs as well as speed.
5. If acceptable, record acceptance with the batch. Otherwise, trial the recipe separately with one variable at a time.

> **Warning**
> Do not identify unlabelled remnants by appearance and use them in series work. Do not admit reflective materials to sample acceptance without verified source and head compatibility.

Why? Batch acceptance helps distinguish surface problems from machine or parameter faults. Good records preserve a starting point for repeat orders.

Photo to be added from a DOKTEK machine — **comparison of top surfaces and cut edges by material**

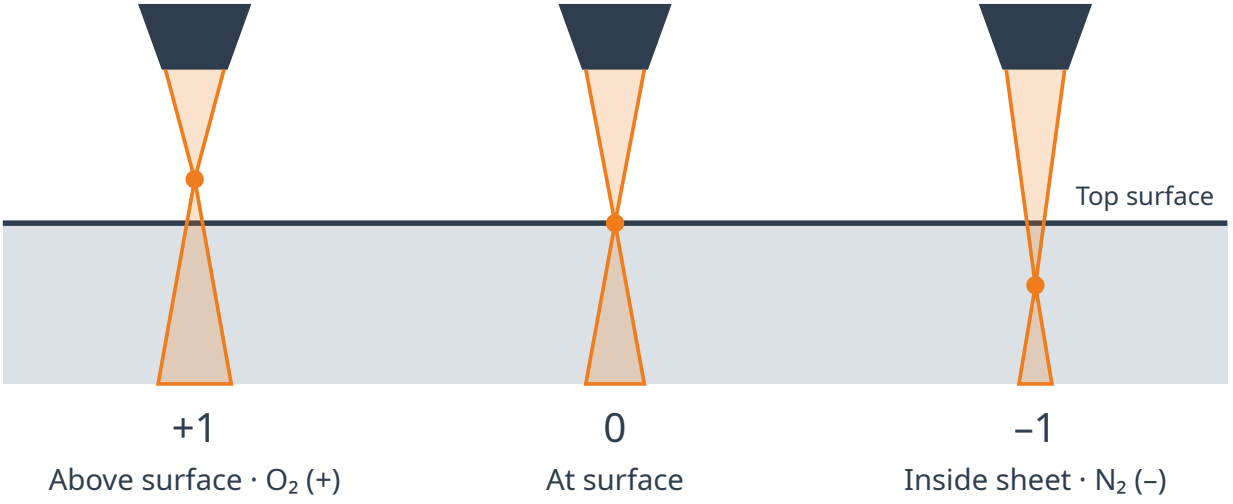
11

Focus, nozzle and height

Focus is the beam's focal position; nozzle height is the distance from nozzle tip to sheet surface. Check these separately. Correct focus cannot cure gas faults from a damaged or off-center nozzle.

11.1 Focus signs: + / 0 / –

This guide's physical position convention is **+ above the sheet, 0 at the surface, – inside the material**. The Raytools/CypCut controller values in chapter 9 instead reference zero to the nozzle tip; table zero does not directly mean the sheet surface. With the same +/– direction, **surface-relative focus ≈ controller value + nozzle height**: 0 + 1 mm → ≈1 mm above the surface; -1 + 1 mm → at the surface. Verify your machine's controller reference in its manual.



+1 / 0 / –1 indicate position signs only; the diagram is not to scale and gives no cutting recipe. Gas–focus pairing is a general approach.

Positive focus is common for O_2 cutting of mild steel; negative focus for N_2 cutting of stainless steel and aluminium. Air cutting may also use near-surface or negative focus depending on material. Do not infer focus from gas alone. Use the correct row in section 9.

Changing nozzle height changes the focus position relative to the sheet even if the controller focus value stays constant. Treat autofocus and Z following separately; do not confuse a mechanical scale with the calibrated controller focus value.

Raytools BM115 · Friendess CypCutPro

11.2 Performing a focus test

Purpose: Find optical zero at the nozzle tip, then verify the controller focus test and sign direction.

Required: Your head/controller manuals, approved test tape, a clean centered nozzle, flat 1 mm sheet, an authorized operator and a test record.

1. Record the head model and current reference. Check nozzle, ceramic ring and protective window in a safe state.
2. If the Raytools BM115 method applies to your machine, disable emission and attach textured tape to the nozzle tip. Remove your hands and close the enclosure; use only the manufacturer's test cycle.
3. At the Raytools test power of 80–100 W, change the focus scale in 0.5 mm steps to make separate dots. Disable emission before each tape change; this power is not a normal cutting recipe.
4. The scale position giving the smallest hole is optical zero: focus is at the nozzle tip. Set the reference only within your authorization and by the manufacturer's method; remove the tape.
5. Recalibrate capacitance after replacing the nozzle or ceramic. After homing, calibrate height over clean flat sheet in the manufacturer's sequence.
6. Use XC3000 Focus Test to cut five lines on the recommended 1 mm sheet. Its manual identifies the best line as zero focus; distinguish this controller test from tape zero at the nozzle tip and verify its reference definition.
7. Record sign direction, nozzle height and results. Return to the approved production recipe and cut a sample; the best production edge is not at zero focus for every material.

> **Caution**
>
> Even 80–100 W is hazardous laser radiation. Do not fire with an open enclosure or start normal cutting with tape attached. Use this method only if your own head manual approves it. If permanent reference adjustment exceeds your authorization, send the results to service.

Why? Tape dotting finds optical zero at the nozzle tip; capacitance calibration learns the nozzle-to-sheet gap. The five-line test checks focus in the controller; record the references of these three operations separately.

Raytools BM115 · Raytools XC3000

Photo: to be added from a DOKTEK machine — **Raytools tape holes and XC3000 five-line test, labeled with reference and height.**

11.3 Autofocus and lens focal length

An autofocus head moves internal optics to the recipe's focus position. This differs from the Z axis following the surface. Autofocus does not remove centering or height-check requirements after nozzle changes.

Initial reference, focus travel limits and alarm status depend on head model. Menu names vary by version; most versions include focus in the layer recipe. Do not force travel beyond head limits in software. Reverify references according to the manufacturer after optics changes.

125, 150 and 200 mm focal lengths are different optical arrangements. With other optical conditions unchanged, longer focal length changes spot size and depth of focus. Identical numerical focus on heads with different lenses therefore need not give identical cutting behavior.

This does not automatically change the +/– convention; physical references and suitable recipes change. Do not multiply a 125 mm lens focus by 200/125 to create a recipe. Collimating lenses and beam properties also matter. Compare local Max data's 100/125 and 100/200 optics ratios with your head.

11.4 Nozzle type and diameter

Nozzle	General use	Check
◯ **Single-layer nozzle (S)**	Common in fusion cutting with N_2 and air.	Outlet bore, surface and head compatibility.
◎ **Double-layer nozzle (D)**	Common for O_2 cutting of mild steel.	Sound internal section and correct type.
High-speed types	Manufacturer-specific flow and tip geometries.	Special recipe, height and centering requirements.

Greater thickness and required gas flow may need larger diameters. But do not apply “thick plate = always the largest nozzle”. Some high-power O_2 technologies use special small-bore nozzles. Select diameter from section 9 using the same recipe.

Larger diameters generally increase consumption; incorrect diameter may impair evacuation or flow pattern. S and D are not equivalent even at equal diameter. Do not confuse special high-speed nozzle markings with standard S/D labels; record manufacturer codes.

Nozzles have no universal calendar life. Collisions, spatter and surface damage shorten use. At shift start and when quality changes, inspect bore roundness, tip face and threads. Do not drill out dented bores; replace damaged nozzles. Afterwards check centering and capacitive calibration if needed.

11.5 Centering with a tape test

Purpose: Verify beam centering relative to the nozzle outlet bore.

Requirements: Head manufacturer's approved centering method, suitable test tape/target, defined test pulse and authorized operator.

1. Stop the job. Disable laser emission and move the head to its manufacturer-defined service position. Check correct installation, cleanliness and nozzle condition.
2. Place specified test tape on the nozzle opening. Remove your hand from the beam path and close guards.
3. Only in approved centering/test mode, apply the defined lowest suitable test pulse. Do not use a normal cutting command.
4. Disable emission again and verify safe status. Remove tape; inspect trace centering relative to the nozzle bore reference.
5. If offset, apply only manufacturer-permitted operator centering adjustments. Do not guess adjustment direction or screw count.
6. Repeat with fresh tape. Once centered, remove test material and cut a sample.

> **Warning**
>
> This test generates a beam. Do not cut normally with tape fitted, blow tape off with gas or pulse in an open enclosure. If tape testing is not approved, use the manufacturer's recommended enclosed centering system. Do not align optics without authorization.

Why? An off-center beam or damaged nozzle directs gas unevenly into the kerf. One-sided dross and direction-dependent quality may result.

11.6 Nozzle height and capacitive sensing

Typical nozzle height families are 0.3–1 mm for N_2 and 0.6–1.5 mm for O_2. These are neither control limits nor settings for every job. The local Max table often gives 0.5 mm for N_2; O_2 heights vary by recipe. Obtain the actual value from section 9.

Lower height changes gas interaction but may increase collision and spatter risks. Excess height may impair gas evacuation and quality. Do not assume the old height suits a changed nozzle type.

The capacitive sensor monitors height through electrical behavior between nozzle and sheet. Ceramic ring, nozzle connection, surface, earthing and sensor cable may affect results. Calibration is not cutting focus adjustment. Perform approved height calibration over suitable flat sheet; for the detailed start-up/calibration workflow see section 3.

Film, slopes, small remnants and approaching edges can change following behavior. If actual height differs from the display, do not hide the problem by changing speed or power. Move the head safely and investigate.

Verifying height deviation

Purpose: Distinguish surface following problems from focus recipe problems.

Requirements: Suitable flat sample, manufacturer's height-check method, permitted measuring tool and last successful recipe.

1. Stop cutting and disable emission. Safely check nozzle looseness, tip damage, ceramic ring and visible contamination.
2. Verify sample support and electrical contact. Do not calibrate on overhanging remnants.
3. Perform the manufacturer's capacitive calibration. Do not continue normal cutting if calibration fails.
4. Check following with the laser off by the approved method. Compare displayed height and actual distance only by a manufacturer-permitted safe measurement method.
5. If differences vary by position or edge proximity, examine sheet and sensing conditions. For persistent constant differences, contact authorized service for reference/setup checks.
6. Once following is verified, cut a baseline sample. If quality remains poor, investigate focus and gas separately.

> **Warning**
>
> Do not put hands or measuring tools under a moving head. Make motion safe for distance measurements too. Do not hide alarms by arbitrarily reducing sensor sensitivity or collision protection.

Why? Height errors change gas jet effects. Focus trials with unresolved following problems change several conditions in one trial.

11.7 Distinguishing deviations and keeping records

Symptom	Check first	Action
Poor quality in every direction	Protective window, recipe and focus zero.	Verify the system; then cut single-parameter samples.
Dross in one direction	Nozzle damage and centering.	Replace damaged nozzles; perform the approved centering test.
Fluctuating height	Ceramic ring, loose nozzle, sheet flatness and capacitive following.	Stop cutting; eliminate mechanical/sensing causes.
Poor quality after optics changes	Correct part, installation and reference.	Verify by authorized service/manufacturer procedure.

Record head model, lens focal length, nozzle type/diameter, focus zero date and cutting height. This distinguishes recipe changes from equipment changes.

Sources: Focus convention: local v1 example; optics and cutting heights: local Maxphotonics data; centering and nozzle effects: Linde “Laser cutting advice”. The installed head manufacturer's procedure takes priority for test details.

12

Piercing

Piercing lets the beam penetrate the sheet fully before contour cutting. A top-surface crater does not prove complete penetration. Check piercing and transition to cutting as separate stages.

12.1 Selecting a piercing method

Method	Operation	Suitability and limitations
Single pulse	An approved single energy application creates penetration.	Fast on suitable thin sheet. Can create large craters and spatter on thick plate.
Staged piercing	Power/pulses, gas, focus and height can change in 2–5 controlled stages; XC3000 and JCZ CutMaker support five levels.	Helps manage thick-plate spatter. Verify stages and transitions separately.
Flash / fast piercing	A short, optimized piercing cycle supported by the machine.	Depends on source, head and controller. Use only on specified materials/thicknesses.

“Fast” or “flash” does not describe the same cycle in every software package. Menu names vary by version; most versions select piercing technology in the layer recipe. Do not transfer thin-sheet single-pulse settings to thick plate. Multiple stages alone do not guarantee safe piercing.

Consider hole proximity, lead-in space and protective window condition alongside material and thickness. A large crater in a narrow opening may damage the finished edge. Correct pierce location in the nest first; see section 6.1.

What should you monitor in a staged cycle?

Stage	Purpose	Records and observations
Start	Establish a controlled piercing start at the surface.	Take starting height, gas and energy conditions from the machine table; record excessive upward spatter.
Progress	Complete penetration through the thickness.	Observe permitted stage duration and pulse conditions; do not force an incomplete hole by contour cutting.
Completion / transition	Remove melt and switch to cutting conditions.	Verify gas, focus and height change sequence; inspect this transition if cutting breaks at the lead-in.

This table describes functional stages; it does not imply three identically named controller stages. A two-stage recipe may combine functions. Not every stage needs more power or time; change direction depends on material and approved technology.

Record the failure stage. Heavy initial spatter and unnecessary hole enlargement after penetration are different problems. Merely extending total time hides the distinction and may add protective window load.

Friendess CypCutPro warns that incorrectly set Flash Piercing can easily damage the protective window. Use only a cycle approved for your machine; inspect the window after the sample.

Raytools XC3000 · JCZ CutMaker · Friendess CypCutPro

12.2 Height, time, frequency and duty cycle

Parameter	Meaning	Effect of incorrect setting
Piercing height	Nozzle–sheet distance during piercing.	Too close: spatter/collision; unsuitable distance: unstable piercing.
Piercing time	Time allocated to one stage or all piercing.	Too short: no penetration; too long: wide crater and unnecessary heat.
Frequency	Pulse repetitions per second in pulsed operation; unit Hz.	Changes energy distribution over time; source limits apply.
Duty cycle	Percentage of a pulse period for which the laser is on.	Changes average energy and spatter behavior; differs from peak power.
Piercing focus and gas	Separate position and gas behavior for the initial hole.	Affects hole width, melt exit and optical contamination.

Piercing and cutting heights need not match. Piercing focus and pressure may also differ from main cutting. Staged methods may change values between stages. Verify whether the controller shows time per stage or total time.

The following are source examples, not a universal Hz/duty range or ready-to-use machine recipes. Bodor omits thickness and power; GWEIKE covers 3 kW/22 mm mild steel. Do not guess missing conditions.

With constant peak power and similar pulse shape, duty cycle affects average energy; actual source behavior depends on control mode. Do not change frequency and duty cycle together and lose cause-and-effect information. Do not use pulse conditions outside source permissions.

Bodor three-level O_2 piercing example: level 3/2/1 heights 20/15/10 mm; peak power 70–100%; level 3 frequency 500–800 Hz, levels 1–2 100–300 Hz; duty 35–75%, increasing from level 3 to 1. Focus is 0…+2 at level 3 and -6…-2 at levels 1–2; O_2 ≈1 bar, level 3 dwell ≈100 ms. With no stated thickness or power, do not apply this directly.

GWEIKE 3 kW, 22 mm mild steel, three-stage O_2 example (high/medium/low): power 3000/3000/3000 W; duty 100/45/55%; frequency 200/150/150 Hz; nozzle height 12/8/4 mm; O_2 1.0/0.7/0.6 bar; focus 0/-4/-6; beam time 200/2500/3000 ms. A 200 ms gas purge follows each of the first two stages: total beam time ≈5.7 s plus ≈0.4 s purge.

IPG authors report piercing times for 16 mm stainless steel of >1 s at 6 kW, 0.5 s at 10 kW and 0.1 s at 20 kW. These test results illustrate power effects; they are not a complete piercing recipe.

Bodor · GWEIKE · IPG / Laser Focus World

12.3 Thick-plate spatter and pre-piercing

Melt may return upwards at piercing start. Heavy spatter on thick plate can rapidly contaminate nozzle tips and protective windows. More time or power does not always solve incomplete piercing; with wrong focus and poor gas evacuation it can enlarge craters.

Approved staged piercing can manage spatter. Keep pierce points away from finished edges. Nozzle spatter deposits disrupt the gas jet and worsen later pierces. Clean/replace according to the manufacturer; do not intervene by hand during cutting.

Pre-piercing opens holes in a separate pass before returning to contours. It may help heat distribution and technology management on the same sheet, but can increase non-cutting travel and gas use. Do not move sheet after pre-piercing; verify lead-ins reach the open points on the second pass.

> **Warning**
> Do not repeatedly pierce the same point with heavy upward spatter or persistent failure to penetrate. Stop safely and check recipe and optics. Hot craters and protruding slag may remain in the head path; do not clean during machine motion.

Dirty or burnt protective windows can impair piercing and cause more spatter. Do not sustain this cycle by increasing power. For window inspection and replacement, follow the maintenance methods in section 16.

12.4 Transition from piercing to cutting

Purpose: Move from a completed hole to a stable lead-in and cutting recipe.

Requirements: Machine piercing table, suitable section 9 cutting row, sample and trial record.

1. Check material, gas, nozzle and piercing method match. Verify pierce points are in scrap.
2. Start the cycle with approved gas pre-flow and piercing height.
3. Verify penetration by the manufacturer's monitoring method. If sensor detection exists, understand its limits; do not assume every machine has a sensor.
4. Apply cycle cooling/blowing and height transitions. Verify transition to cutting focus, pressure, power and height is complete.
5. Start lead-in motion; do not reach the finished edge before cutting stabilizes.
6. After cooling, inspect sample start and bottom edge. Do not continue series work without full penetration.

> **Warning**
> Do not open doors or enter the working area to look underneath. Observe only through closed guards and approved monitoring systems. Do not decide penetration is complete from top light or a crater alone.

Why? Horizontal motion before full piercing can drag melt upwards, causing start notches, incomplete cuts and optical contamination.

12.5 Piercing troubleshooting table

Symptoms are not definitive diagnoses. First check gas, nozzle, protective window and correct recipe; then apply section 13.3 and its single-parameter rule.

Symptom	Possible cause	Check and correction
No / incomplete penetration	Wrong material row; inadequate energy or time; wrong focus; gas/optics problem.	Verify equipment and recipe first. Check for incomplete staged cycles. Assess time/energy separately only within the approved table.
Large crater	Excess time/energy; unsuitable stage; pierce point near edge.	Move the point safely within scrap. Consider approved staged piercing. Check for unnecessary dwell after penetration.

Symptom	Possible cause	Check and correction
Heavy upward spatter	Wrong height/focus; unsuitable gas evacuation; dirty nozzle; incomplete piercing.	Stop; inspect nozzle and window. Restore piercing height, gas and stage sequence to the manufacturer's recipe.
Hole keeps enlarging	Energy continues after penetration; excessive time; repeated trials at a hot point.	Check piercing–cutting transition. Monitor sample timing; do not repeatedly force the same point.
Pierces, but cut breaks at lead-in	Incomplete transition to cutting conditions; short/wrong lead-in; gas delay or crater effects.	Verify piercing and main cutting recipes separately. Inspect lead-in position and transition motion.

12.6 Recording a piercing recipe

For every successful trial, record stage values with source/head details, material grade, thickness, gas, nozzle and piercing method. Define piercing time. Also record initial protective window condition and sample results.

One successful pierce is insufficient; check cold starts and heated areas during the job. Compare different regions on parts with many holes. Do not increase start notches, uncut points or cleaning labor while reducing piercing time.

Photo to be added from a DOKTEK machine — **comparison of pierce craters, spatter and transition marks**

Piercing examples: Bodor, GWEIKE and IPG authors; stage support: XC3000 and JCZ CutMaker; Flash Piercing window warning: Friendess CypCutPro. No piercing recipe is derived from the main cutting table.

13

Cut quality and defect diagnosis

Good cutting produces dimensionally correct, sufficiently square edges with acceptable roughness and suitability for subsequent operations. Record defects, verify equipment and change only one parameter at a time.

13.1 Quality checklist

Do not inspect only the top edge. Assess top/bottom dimensions, entry point, straight edge, corner and small hole separately. Take acceptance limits from the drawing or work order. This chapter specifies no universal numerical roughness or squareness tolerance.

ISO 9013:2017 (+Amd 1:2024) classifies cut faces by perpendicularity/angularity tolerance u and mean profile height Rz5 ranges. Its laser scope is 0.5–32 mm. Informative Annex A gives dimensional tolerance class 1 as typical for laser cutting; this is distinct from the u/Rz5 edge-quality ranges. Specify acceptance ranges in the drawing or work order. The limits below come from the 2017 edition's tables; a is cut thickness in mm. Measure brushed, oxide-free surfaces away from the piercing zone and the start and end of the cut.

Range	u upper limit (mm)	Rz5 upper limit (µm)
1	0.05 + 0.003a	10 + 0.6a
2	0.15 + 0.007a	40 + 0.8a
3	0.4 + 0.01a	70 + 1.2a
4	0.8 + 0.02a	110 + 1.8a
5	1.2 + 0.035a	—

ISO 9013 designation and measurement conditions

The designation is **ISO 9013-xyz**: x = u range, y = Rz5 range, z = dimensional tolerance class. One example: **ISO 9013-312** means u range 3, Rz5 range 1 and dimensional tolerance class 2. State the edge range and dimensional class separately.

Under the 2017 edition, measure Rz5 at 15 mm from the cut start in the direction of advance, at the location of the greatest expected cut-face roughness. Rz5 is the arithmetic mean of profile heights over five consecutive individual measuring lengths; 15 mm is not the profile measuring length. The upper and lower sheet reference faces must be even and clean.

The manufacturer specifies measuring points. If unspecified, take two groups of three u measurements spaced 20 mm apart and one Rz5 measurement per metre of cut; select locations where the highest values are expected. Below 2 mm thickness, measure Rz5 at half the thickness and agree the u method separately.

For u, exclude a band Δa at both the upper and lower edges: 0.1a for a ≤3 mm; 0.3 mm for 3<a≤6; 0.6 mm for 6<a≤10; 1 mm for 10<a≤20; 1.5 mm for 20<a≤32. Agree quality acceptance separately above 32 mm.

Informative Annex A notes that aluminium and its alloys can have Rz5 values approximately four times those given for steel. Do not treat steel roughness ranges as an automatic guarantee for aluminium.

For thickness-dependent limits, use **Laser Assistant → Quality calculator**.

ISO 9013:2017 §6, §9–10, Annex A

Feature	Good result	Check
Edge squareness	Difference between upper and lower contours meets job tolerance.	Compare top/bottom dimensions after cooling; record taper.
Roughness / striations	Uniform marks; no local gouges, excessive drag or interruptions.	Inspect straight edges, starts and corners separately.
Dross	No unacceptable adhesion or uncut connections at the bottom edge.	Distinguish thread-like, droplet and hard continuous dross.
Oxide and color	Suitable for selected gas and subsequent processing.	Do not confuse O_2 oxide on mild steel with unwanted N_2 discoloration on stainless steel.
Heat-affected zone	Burning and distortion meet job requirements.	Observe color marks and bending; do not verify required metallurgical acceptance visually alone.
Dimensions and integrity	Part, holes and corners match the drawing.	Use calibrated instruments; verify drawing revision.

Purpose: Establish a repeatable quality baseline before parameter trials.

Requirements: Approved drawing, baseline recipe, same-material sample, measuring tool and record form.

1. **Verify the job**
   A wrong material row invalidates correct settings.
   Check material, thickness, gas and drawing revision. Compare the baseline recipe with section 9 and the machine table.

2. **Inspect equipment**
   Dirt and misalignment resemble parameter faults.
   Safely inspect nozzle, ceramic ring, protective window and centering. If needed, follow section 11.5.

3. **Verify gas**
   Static pressure does not prove sufficient flow.
   Check gas type, purity, pressure during flow and start delay.

4. **Check references**
   Incorrect focus zero affects every recipe.
   Verify focus, nozzle height and capacitive following. Inspect sheet flatness.

5. **Measure the sample**
   One edge does not represent the whole part.
   Assess top/bottom dimensions, dross, corners and holes on the cooled sample. Record defect direction and position.

> **Warning**
>
> Put the laser in a safe state and follow manufacturer maintenance procedures when checking nozzles/windows. Do not reach into an operating machine. Do not pull incompletely cut samples free by hand.

Why? Setting trials are not repeatable while equipment or material problems remain; the real cause is concealed.

13.2 Dross and edge defects — diagnostic table

This table shows possible causes; each dross type has more than one potential cause. Actions within a cell are not a package to apply simultaneously. Complete preliminary checks, select the likeliest cause and follow section 13.3 with one variable at a time.

Symptom	Possible cause	Sequential checks / individual trials
O_2 **Oxygen cutting — mild steel**		
Hard, continuous bottom dross	High speed; low O_2 pressure or purity; focus too high.	Verify gas type, purity and flow. Try reducing speed by 10%. If ineffective, return to baseline; separately try increasing O_2 by 0.1 bar or lowering focus by 0.2 mm.
Burnt edge, wide kerf	High pressure; focus too high; excess energy; unsuitable surface.	Check surface and nozzle. In separate trials, reduce O_2 by 0.1 bar or lower focus by 0.2 mm. Change power only within approved limits.
Edge craters / gouges	High pressure; low speed; rust/dirt; local heat build-up.	Compare with a clean, cold sample. Try distributing adjacent cuts in the same nest. Change pressure or speed separately in parameter trials.
Corner burning	Power and reaction heat remain high as corner speed falls.	If straight edges are good, examine corner technology. Verify power–speed curve, corner loops or cooling separately; see section 6.3.
N_2 Air **Nitrogen / air cutting**		
Fine, thread-like bottom dross	Low speed; focus too high; low pressure; hot sheet.	Check gas flow and a cold sample first; then verify focus and, if necessary, test 0.2–0.5 mm more negative separately. Once flow/focus are verified, test +10% speed. Consider +1 bar N_2 only within allowed limits and in a separate trial; these numeric steps are DOKTEK rules.
Small droplet-shaped bottom dross	Focus too low; high speed; insufficient melt evacuation.	Check nozzle and gas. Separately raise focus 0.2–0.5 mm towards zero or reduce speed by 10%.
Dull, rough surface	Insufficient energy; focus too low; nozzle damage; dirty/damaged optics.	Safely check nozzle and protective window first. If equipment is sound, trial focus; assess power only within manufacturer limits.
Yellow / blue stainless steel edge	Insufficient N_2 purity; air mixing in the line; short gas delay; excess heat. Oxide may be expected with air cutting.	Check N_2 target and oxygen contamination. For poor first parts, purge in a controlled manner or assess delay separately. Investigate leaks and mixing; see section 7.2.

Symptom	Possible cause	Sequential checks / individual trials
Bright plasma, intermittent loss of cut	High speed; insufficient energy; focus too low; gas evacuation problem.	Stop if penetration is incomplete. Verify gas, nozzle and optics. Then reduce speed or raise focus in separate trials; do not exceed power limits.
Checks independent of gas		
Dross on one side only	Off-center, dented or malformed nozzle bore; beam/gas alignment problem.	Replace damaged nozzles and verify centering. If unresolved, contact authorized service for optical alignment. Do not compensate with speed.
Oval circles, distorted shapes	Drawing or motion settings; axis backlash; nozzle/optics problems; thermal distortion.	Verify drawing and cold dimensions. Record defect direction. After nozzle checks, leave mechanical/axis inspection to authorized service; do not attribute distortion solely to gas.
Striations lean sharply backwards	High speed; insufficient energy or gas evacuation; unsuitable focus.	Verify gas flow and optics. First try reducing speed by 10%. If ineffective, restore baseline and assess focus or nozzle/recipe suitability.
Regular waviness on straight edges	Vibration, unstable following or motion problems; surface changes.	Compare edges in different directions. Check height following and sheet support. Refer mechanical inspection to service if needed.
Tapered edge, different top/bottom dimensions	Unsuitable focus/optics; centering; nozzle height; cutting technology limits.	Record top/bottom dimensions. Verify correct lens and focus zero. Trial focus alone; do not try to correct both faces solely with compensation.
Similar dimensional deviation in every direction	Kerf compensation or its direction; wrong drawing scale; hot measurement.	Measure cooled parts. Check drawing scale, inner/outer contours and single compensation. Correct compensation after quality stabilizes.
Dimensions vary by direction	Axis/scaling or mechanical problems; thermal bending; direction-dependent quality.	Compare the same sample in different orientations. Check support and centering. Do not change permanent axis settings without authorization.

Adaptation: Local *ornek_tr.html* content 9.2 has been moved and expanded as 13.2. Read alongside Linde speed, nozzle, gas and material checks.

The Fabricator

13.3 Single-parameter rule and step sizes

DOKTEK rule — no primary source: The speed ±10%, focus ±0.2–0.5 mm, O_2 ±0.1 bar and N_2 ±1 bar steps here, including the same steps in section 13.2, are DOKTEK comparison suggestions. They are not manufacturer settings or safety limits. For stringy N_2 dross, check gas flow and focus before speed.

1 parameter Only one variable per trial	**Speed ±10%** Relative to the current value	**Focus ±0.2–0.5 mm** Relative to verified zero	**O_2 ±0.1 bar** N_2 ±1 bar	**Record** Result and return value

These are small comparison steps, not universal recipes or safety limits. Do not trial beyond permitted ranges. Do not automatically apply N_2 steps to air pressure; follow the air system's permitted recipe. No universal power, frequency or duty-cycle step is specified here.

Purpose: Identify which change affects the defect and make successful settings repeatable.

Requirements: Stable baseline recipe, same-batch sample, defect criterion, measuring tool and trial record.

1. Record the baseline recipe. Define defect location, direction, dross shape, top/bottom dimensions and gas.
2. Select the likeliest table cause. Correct equipment faults first without changing the recipe simultaneously.
3. Change one parameter by a suitable small step. Retain other conditions and sample geometry.
4. After cooling, compare against the same criteria. Record improvements, new values and side effects.
5. If worse, restore baseline. Change another parameter only in a new, separate trial.
6. Verify successful settings on other edges and holes; save recipe revision and material details.

> **Warning**
> Do not continue trials with uncut points, heavy upward spatter, lifting parts or head approach risks. Stop safely and eliminate the cause. Never exceed machine limits, even in small steps.

Why? Changing speed, focus and pressure together makes the cause of improvement unknown. You will have to solve the same problem again on the next batch.

Include at least material/batch, thickness, source/head, nozzle, gas, baseline recipe, single changed parameter, old/new values, defect result and acceptance decision. Label photo direction and upper/lower face.

How to interpret trial results

Result	Interpretation	Decision
Less dross, dimensions and corners unchanged	Trial appears positive.	Verify other edges/holes; record successful value.
Less dross, burnt corner	One defect improved, another acceptance condition failed.	Do not enter series production; restore baseline and assess the cause separately.
No change	Selected cause may not be relevant; trial conditions may also have changed.	Restore baseline. Check that material, temperature and equipment remained constant.
Improvement in one area only	Local surface, support or heat effects may exist.	Investigate nesting and material differences before changing the whole recipe.

For example, if dross remains only along one cutting direction, do not continue successive speed changes. Nozzle bore and centering may be stronger candidates. Conversely, with leaning striations and incomplete penetration in every direction, examine speed/energy balance alongside gas evacuation. Recording *where* the symptom occurs is more useful than merely writing “dross present”.

13.4 Defect photo examples

DOKTEK examples with identical lighting, scale and material labels will be added below. These areas currently contain no photos. Visual similarity alone is not a diagnosis; read the example's gas, material and sample recipe together.

Photo to be added from a DOKTEK machine — **good cut: square edge, uniform striations and accepted bottom edge**

Photo to be added from a DOKTEK machine — **defective cut: hard, continuous bottom dross**

Photo to be added from a DOKTEK machine — **defective cut: comparison of thread-like and droplet dross**

Photo to be added from a DOKTEK machine — **good/defective comparison: sound corner and corner burning**

Photo to be added from a DOKTEK machine — **good/defective comparison: striations and rough surface**

Photo to be added from a DOKTEK machine — **defective cut: tapered edge and stainless steel discoloration**

Add accepted parts to the example archive too. Do not photograph a defect from only one direction; show top surface, cut edge and bottom edge. Photos are more useful for later diagnosis with numerical settings recorded separately.

14

Laser sources

The laser source generates the beam; the cutting head focuses it on the sheet. Assess source, optics, gas and cooling together. Equal nominal power alone does not guarantee equal cutting results.

14.1 What does the laser source do?

The beam generated in a fiber laser source travels through the output fiber to the cutting head. Head optics condition and focus it. Nozzle gas helps remove melt from the cutting area. Source, head and gas line are separate components; a problem in one can resemble failure in another.

A source-ready display alone does not prove sufficient energy reaches the cutting point. Dirty protective windows, wrong focus, damaged nozzles or unsuitable gas conditions can also stop cutting. When cutting weakens, first follow section 17.1 checks in sequence.

Component	Function	Operator check
Laser source	Generates the process beam.	Ready status, operating hours, alarms and cooling information.
Output fiber and QBH connection	Carries the beam to the head. QBH is an optical connection type, not a power rating.	External damage or strain; do not intervene at the connection.
Cutting head	Focuses the beam; carries nozzle and height following.	Protective window, nozzle, ceramic ring and calibration.
Chiller	Provides source/head cooling conditions; circuit design varies by model.	Level, flow, alarms, hoses and condensation.

Photo to be added from a DOKTEK machine — **source label, external output fiber routing and cooling connections; covers closed**

Optical connections are a service task

Do not disconnect QBH, look inside it or force the fiber into bends. Safely stop the machine and notify service if contamination or damage is suspected. Permitted bending and handling conditions vary by model.

14.2 Power, core diameter and beam quality

Concept	Meaning	Use at work
Nominal power	Source nameplate power class. Not the same information as the software power percentage.	Record nameplate power and process setting separately. Do not definitively diagnose power loss from cut appearance without measuring output.
Fiber core diameter	Size of the beam-carrying fiber core; not directly equal to the focal spot on sheet.	Compare core diameters when transferring settings between sources. Remember head optics affect results.
BPP / beam quality	Beam parameter product describes focusing and divergence behavior.	Compare the value and measuring conditions in the manufacturer's technical document; do not generalise the product examples below to every brand.
CW	Continuous wave: continuous beam generation mode.	Check process compatibility with the source operating mode.
Pulsed operation	Delivers energy in pulses over time. Pulse duration, frequency and power relationships vary by source.	Do not infer source type from the software frequency field alone. Verify supported modes in manufacturer documentation.

BPP, core diameter and nominal power are different properties. Do not derive thickness, speed or quality limits from one value alone. For cutting values use section 9 tables and your machine's approved process record.

BPP = w_0 × θ = M^2 × λ/π. w_0 is the waist radius at the narrowest point of the beam; θ is the far-field divergence half-angle. The unit is mm·mrad. For an ideal Gaussian beam M^2 = 1; at λ = 1.07 µm, the diffraction limit is λ/π = 1.07 ÷ π ≈ 0.34 mm·mrad. This theoretical lower limit is not the measured BPP of the installed source.

Typical product example: with a 25 m fibre, Coherent Edge FL figures are 1.5 kW → 1.5 mm·mrad and 3 kW → 2.7 mm·mrad for a 50 µm core; ≥6 kW → <4 mm·mrad for a 100 µm core. The research saw these figures only in a search summary; confirm them in your model's technical document. ISO 11146-1 defines measurement methods for beam width, divergence and propagation ratio.

BPP · Coherent Edge FL · ISO 11146-1

14.3 Raycus, Maxphotonics (Max), IPG and Reci

This guide covers four laser source brands. Brand names do not form a quality ranking. Assess installed model, fiber design, power class, head compatibility and service support together. Connections, alarm screens and maintenance requirements may vary between series of the same brand.

Brand	General introduction	Verify on the machine
Raycus	Fiber laser source brand. Cutting behavior depends on installed model and the machine as a whole.	Full model, serial number, nominal power, core diameter and applicable manufacturer instructions.
Maxphotonics (Max)	Fiber laser source brand, also called “Max”.	Label series/model; whether similarly named tables use identical fiber and optics conditions.
IPG	Fiber laser source brand. Cutting parameters cannot be selected by brand alone.	Installed model output characteristics, cooling requirements and alarm/monitoring interface.
Reci	Fiber laser source brand. Verify compatibility and conditions of use in model documentation.	Power and fiber details, machine integration and service records.

Sources have their own alarm/monitoring interfaces. The machine screen may also display some information; fields depend on integration. For service reports, record full source alarm text as well as brief machine-screen descriptions. Do not enter manufacturer-restricted settings.

14.4 Single-module and multi-module construction

Construction	General tendency	When deciding
Single module	Often found with 50 µm cores; used for fast thin–medium sheet cutting.	Do not apply this tendency to every model. Read actual core diameter and source/head pairing from documentation.
Multiple modules	Found with cores of 100 µm and above; used for stable thick-plate processing.	Do not infer speed or quality solely from module count. Verify thick-plate processes by test cutting.

Module construction, power class and optics work together. Two sources with equal nominal power can differ in focus and piercing behavior. Do not reduce selection to “single” or “multiple”; consider material range, gas infrastructure, head equipment and service conditions together.

! Copper, brass and aluminium

These materials present back-reflection risks. Verify installed source/head suitability in manufacturer documentation. Do not merely reset a back-reflection alarm and repeat the process; follow section 17.7 in sequence.

14.5 Transferring parameters to another source

Purpose: Use previous settings as a controlled starting record and verify cutting on the new machine.

Requirements: Both source nameplates, core diameters, head/nozzle information, approved parameter record, suitable test sheet and Appendix C form.

1. Preserve the old file. Create a separate trial record under the new machine/source name.
2. Compare nominal power and core diameter. With equal power/core, treat settings only as a starting point. If different, return to the suitable model table or service-recommended starting process.
3. Compare material, actual thickness, coating, gas, nozzle type and head optics. Do not fill missing information with assumptions.
4. Check focus signs, units, speed interpretation in m/min and pressure in bar. Power and pulse field meanings may vary by software/source.
5. Perform frame checks and test cuts in a safe test area. Inspect piercing, full penetration, underside, dross and dimensions.
6. Change one parameter per trial. Record old/new values and results. Add successful results to production records after local approval.

> **Do not copy settings in bulk**
> Transferring cutting tables does not authorise copying servo, source communication or safety settings. Service manages machine-specific configuration.

Why? Even with identical power and core diameter, optics, gas flow and control behavior can change results. Trial records help recover reliable settings.

14.6 Environment and source maintenance

Monitor temperature and humidity around the source. Obtain limits from source and chiller documentation; do not use one temperature setting for all brands. Condensation can form when a cold surface falls below ambient dew point. Stop cutting if hoses or the head show condensation; do not restart until the cause is eliminated.

Purpose: Maintain source surroundings and external connections under manufacturer-specified conditions.

Requirements: Manufacturer checklist, ambient temperature/humidity records, clean dry cloth and maintenance form.

1. Put the machine in its manufacturer-defined maintenance state; do not open source covers. Check ventilation inlets are clear.
2. Remove external source dust by a suitable method. Do not direct compressed air or liquid into openings.
3. Look for hose leaks, crushing or looseness and external fiber route damage. Do not disconnect.
4. Check chiller level, flow, filters and alarms. Identify source/head circuits for the model; continue with section 16.6.
5. Record conditions and observations. Outside permitted limits, do not operate until manufacturer conditions are met.

> **Do not hide condensation with settings**
> Do not arbitrarily adjust the chiller to silence alarms. Assess ambient humidity, water settings and permitted equipment conditions together.

Why? Dust and unsuitable cooling can cause failures. Environmental records show conditions associated with recurring alarms.

14.7 Power measurement and performance monitoring

Plan periodic output power checks with service. Set intervals by workload, previous measurements and manufacturer recommendations. Requested software power is not measured optical power. Do not substitute cutting-speed changes for power measurement.

Purpose: Record service measurements from suitable power meters in a comparable form.

Requirements: Authorized/trained service, suitable source-compatible power meter with valid calibration, manufacturer measurement procedure and an enclosed safe measurement area.

1. Send the complaint and previous report to service. State protective window, gas and focus check results first.
2. Let service define measurement points. Do not combine source-output and post-head measurements under one heading.
3. Service must measure by the manufacturer's method. Operators must not set up open-beam trials or improvised measurement arrangements.
4. Report requested/measured power, measurement point, instrument ID, date and conditions. Have results assessed against model-specific acceptance criteria.

> **Do not bypass safeguards for measurement**
>
> Do not bridge door interlocks or measure exposed beams. Meter selection and beam path safety are service responsibilities.

Why? Comparable measurements help distinguish power loss from process problems. Results from different points or methods cannot be compared directly.

14.8 Source records for warranty and service

Record	Information	When?
Identification	Machine/source brand, full model, serial number, power and documented core diameter if available.	At delivery and source replacement.
Use	Displayed operating hours; counter definition, date and operator.	At planned maintenance and failure.
Alarm history	Full code/text, time, material, process stage, recurrence and screenshot.	Before resetting.
Environment and maintenance	Temperature/humidity, chiller status, water/filter work and service report.	At checks and after interventions.
Measurement and changes	Power report, replaced parts, old/new process records and approver.	At measurement, part or setting changes.

Warranty coverage and service terms vary by contract and model. This chapter makes no warranty duration or coverage commitment. Preserve labels; leave source cover opening and internal adjustments to authorized service. For reporting use Appendix E and its list.

15

Software guides

Verify software name and version on the machine screen. This chapter explains operation purposes and check sequences. Menu names, permissions, licenses and available functions vary with version and machine integration.

First-day rule

Run the first job with a trained person. Do not cut before verifying axis position, coordinates, units, material and process records. Learn emergency stop, normal pause and controlled stop from the machine manual.

15.1 Common workflow and terms

Opening a drawing does not make it ready for cutting. Verify geometry, toolpaths, process parameters and machine references/calibration separately. Locations below are general screen areas, not specific menu paths. A listed operation is not necessarily available in every software package.

Operation	Purpose	Typical software location
Homing / return to origin	Establishes the machine reference. Differs from workpiece zero.	Control panel or machine preparation area.
Capacitive calibration	Prepares nozzle–sheet distance sensing; requires suitable sheet and clean tooling.	Height controller or calibration area.
Edge finding	Helps determine sheet position/angle; support and methods vary.	Control panel or sheet positioning tools.
Frame	Helps check that job boundaries fit within the bed/sheet.	Control panel or job preparation tools.
Dry run	Tests toolpaths by moving without a beam; gas, height and motion behavior vary by model.	Control panel or test run area.
Start cutting	Runs the prepared job on the machine. Complete safety/process checks first.	Control panel or cycle management.
Pause	Temporarily suspends the job. Head and beam behavior during pauses depend on integration.	Control panel or cycle management.
Stop	Ends the cycle in a controlled manner; restart state varies by version.	Control panel or cycle management.
Resume from breakpoint	Resumes from a saved stop point under suitable conditions; verify starting point.	Control panel or interruption recovery area.
Layer parameters	Assign process settings such as cutting, piercing, gas and focus to geometry groups.	Layer/process settings.
Material/process library	Helps store verified material and thickness settings.	Material library or process settings.
Lead-in	Defines where and how the beam enters the part contour.	Geometry/toolpath tools or process settings.
Micro joint	Leaves small uncut connections to retain parts in the sheet.	Toolpath tools or part properties.
Kerf compensation	Compensates for cutting width effects on part dimensions.	Toolpath or layer/process settings.
Nesting	Arranges parts within usable sheet area.	Top menu/toolbar or separate CAM application.
Simulation	Previews cutting sequence and motion on screen; does not prove actual cut quality.	Toolpath tools or preview area.

Operation	Purpose	Typical software location
Job report	Records job, time and production information where supported.	Report/job management area; scope varies by license.

Preparing the first job

Purpose: Convert the file into a safe, repeatable machine job.

Requirements: Machine manual, approved parameters, suitable sheet/nozzle, working safeguards and ready gas/cooling/fume extraction.

1. Prepare the machine using section 3 and the manufacturer's start-up sequence. Open the software; check connected control system, license and alarms.
2. Clear the motion area. Perform required homing; verify position references.
3. Perform capacitive calibration on clean, secured sheet by the manufacturer's method. Do not repeat initial setup instead of daily operations.
4. Open the file. Inspect units, dimensions, open/duplicate lines, inner/outer contours, quantities and nesting.
5. Match each layer to suitable material, thickness and process. Check lead-ins, micro joints, compensation and cutting sequence.
6. Watch the entire simulated path. Check actual placement using manufacturer-defined frame checks and dry runs if needed. Verify the beam is off.
7. Close safeguards. Make a test cut; inspect full penetration, dimensions and edges. If acceptable, start production and monitor initial parts.

> **Frame checks also produce motion**
> The head may collide with raised parts or clamps. Frame checks and dry runs do not replace area checks; verify gas and beam states separately.

Why? Correct drawings can be cut incorrectly with wrong coordinates or layers. This sequence verifies file, process and machine state together.

Restarting after a pause

Purpose: Verify starting point and process state after interruption.

Requirements: Stop cause, job record, unchanged sheet position and machine resume procedure.

1. Record and eliminate the stop cause. Do not resume with persistent gas, chiller or safety alarms.
2. Check sheet, workpiece zero and machine reference are unchanged. Do not blindly return to the old point if sheet moved or position was lost.
3. Inspect the displayed start point and selected layer. Re-piercing or backing up on resume varies by version.
4. Perform required simulation/position checks. Resume under control once safeguards are established; watch the initial cut.

> **After an emergency stop**
> Releasing an emergency stop does not authorise automatic resume. Reverify area, references and fault clearance by the machine procedure.

Why? If sheet moved, the old stop point no longer corresponds to the correct physical location.

15.2 CypCut

CypCut is Friendess's flat-sheet cutting software. Friendess/FSCUT is stated to have been established in 2007. It combines cutting technology editing, nesting and process control. It works with FSCUT cards, such as FSCUT1000/2000, and the BCS100 capacitive height controller. Verify installed cards and supported functions on your machine separately.

Where is it used? On flat-sheet fiber laser machines configured with Friendess/FSCUT control infrastructure. Source or head brand alone does not identify CypCut.

First-day workflow

Purpose: Prepare a CypCut job with its connected FSCUT and height system.

Requirements: Software/card version details, machine training, approved file and parameter record.

1. Open the software. Check controller communication and alarms. A visible file does not mean the machine is ready.
2. Clear the motion area and home by the machine procedure. Check machine reference and workpiece zero separately.
3. Perform BCS100 initial setup with a trained person: **servo calibration → homing and capacitive calibration → automatic tuning**. Later use generally requires only capacitive calibration. Do not repeat servo tuning for daily checks.
4. Open the file; check units, contours, dimensions and nesting. Verify imported lines are assigned to the correct cutting layer.
5. Compare material, thickness, gas, nozzle, focus, cutting and piercing settings in the layer/process area against approved records.
6. Watch inner contour and lead-in sequence in simulation. Verify sheet fit with frame checks; dry-run with beam off if needed.
7. With safety, gas, chiller and extraction ready, cut a sample. If dimensions and penetration are correct, start the job; record file/parameter versions.

> **Warning**
> Do not confuse BCS100 service settings with cutting parameters. If calibration fails, do not force height and cut; check nozzle, ceramic ring and sheet.

Why? Height control and cutting process are separate checks. Readiness of one does not correct errors in the other.

File and parameter checks

For common lines, micro joints or special toolpaths, examine execution on the machine. Check layer mapping of externally nested jobs. Ensure compensation is not applied in both CAM and the machine.

When a job stops, record last point, active layer and stop cause. If sheet moved, do not return to production by resume alone. Menus and screen layouts vary by version.

Screenshot to be added from a DOKTEK machine — **CypCut: main screen; job and machine status**

Screenshot to be added from a DOKTEK machine — **CypCut: layer/parameter screen; material and units**

Screenshot to be added from a DOKTEK machine — **CypCut: calibration screen; control system identity**

15.3 CypOne

CypOne is economical flat-sheet software, especially for signage and thin sheet. It offers drawing processing, parameter settings, process customization, nesting, toolpath planning, simulation and cutting control. Operation requires a control card; without one it opens in demo mode.

Where is it used? On flat-sheet machines configured with CypOne and a compatible card. Demo screens do not verify all machine licenses, hardware and functions.

First-day workflow

Purpose: Prepare CypOne files for the actual machine configuration.

Requirements: Control card details, manufacturer procedure, approved material record and test sheet.

1. Open the application; verify demo mode or actual control card operation. If the card is unrecognised, check connection and permissions with the responsible person.
2. With machine ready and area clear, home in the manufacturer's sequence. Then perform capacitive calibration for the machine's height system.
3. Open the file. Inspect fine details, open lines, units and actual dimensions. Recheck quantities after drawing corrections.
4. Select layers and process settings. Do not treat thin-sheet settings from another machine as direct production values.
5. Check nesting, lead-ins and micro joints. Watch toolpath simulation; verify placement by machine frame checks.
6. Check gas, cooling, extraction and safeguards, then cut a sample. Approve results, start the job and record changed settings.

> **Warning**
> A file opening correctly in demo mode is not cutting approval on the actual machine. Verify card, height system and process mapping at the machine.

Why? Drawing preparation and physical machine preparation require different verification.

Points to watch

Record the version used to prepare demo files. Verify file format and function compatibility before transfer. Do not fill missing process fields by copying another version's screen. Use material and process records permitted by the installed system.

Screenshot to be added from a DOKTEK machine — **CypOne: main screen; job and machine status**

Screenshot to be added from a DOKTEK machine — **CypOne: layer/parameter screen; material and units**

Screenshot to be added from a DOKTEK machine — **CypOne: calibration screen; control system identity**

15.4 CypNest and HypCut

CypNest: separate nesting preparation

CypNest is Friendess's separate paid advanced nesting software. It offers common lines, automatic nesting and toolpath preparation. Sites producing compatible output may use a separate preparation computer; transfer formats vary by version.

Purpose: Verify nests before transfer to the target machine.

Requirements: License, suitable machine/output definition, part and sheet records.

1. Open the application; verify target machine, material, thickness and quantities.
2. Import parts. Check nesting, common lines, lead-ins and toolpaths.
3. Watch simulation; save and transfer suitable target-machine output.
4. **At the machine:** Open control software → home → perform capacitive calibration → open file → verify layer parameters → simulate/check frame → cut after trial and approval.

> **Warning**
> Homing and sensor calibration occur at the target machine; do not treat them as CypNest functions. Use common lines with an approved process.

Why? Verify machine process mapping as well as nesting.

Screenshot to be added from a DOKTEK machine — **CypNest main screen and nest**

Screenshot to be added from a DOKTEK machine — **CypNest process/output and layer mapping**

Screenshot to be added from a DOKTEK machine — **target machine calibration screen; not a CypNest function**

HypCut: high-power and bus-based control

HypCut is Friendess software used in high-power, bus-based systems. It appears on machines with compatible control hardware. Consult manufacturer documentation for functions, licensing and commissioning details.

Purpose: Verify the installed system's first job in the manufacturer's sequence.

Requirements: HypCut/machine documentation, training and approved process.

1. Open the application; check communication and alarms. Home in the manufacturer's sequence and calibrate the height system.
2. Open the file; verify layers and parameters. Complete simulation and frame checks.
3. With safeguards and auxiliary systems ready, cut a sample; approve results and begin production.

> **Warning**
> Do not change bus, drive or communication configuration as operator cutting settings.

Why? Software names do not verify machine integration.

Screenshot to be added from a DOKTEK machine — **HypCut main screen**

Screenshot to be added from a DOKTEK machine — **HypCut layer/parameter screen**

Screenshot to be added from a DOKTEK machine — **HypCut calibration screen**

15.5 Raytools XC3000 series

Raytools XC3000 series is a laser cutting motion control system. Software operates with a dongle; without it, simulator mode is available. Verify actual machine operation through installed hardware and dongle.

Where is it used? On laser cutting machines fitted with XC3000 series controllers. A Raytools cutting head alone does not prove the control system is XC3000.

First-day workflow

Purpose: Prepare jobs while distinguishing simulator and actual machine states.

Requirements: Hardware dongle, machine documentation, controller/head model details and approved process.

1. Open the application; check dongle detection and actual machine operating state. Do not treat simulator motion as physical axis verification.
2. With machine ready and area clear, home in the manufacturer's sequence. Perform capacitive calibration by the height system's own method.
3. Open the file; verify units, contours, quantities and sheet size. Match layers to suitable process records.
4. Check piercing, cutting, gas and focus settings. Verify nozzle and window condition suits the cutting head.
5. Watch simulation; frame-check actual sheet boundaries. Perform required dry runs with beam off.
6. With safeguards and auxiliary systems ready, cut a sample. If penetration and dimensions are correct, start the job; retain file and setting records.

> **Warning**
> Do not change safety settings to solve dongle or communication errors. Do not use simulator mode as production preparation approval.

Why? License state, machine connection and motion safety are separate checks.

Distinguish head from controller

Do not assume heads such as Raytools BM111 and BM06K have identical maintenance arrangements. BM111 has three protective windows: upper, middle and lower. Identify model and window location; replacing one does not prove the whole optical path is clean. For maintenance follow section 16.4 in sequence.

Screenshot to be added from a DOKTEK machine — **Raytools XC3000: main screen; job and machine status**

Screenshot to be added from a DOKTEK machine — **Raytools XC3000: layer/parameter screen; material and units**

Screenshot to be added from a DOKTEK machine — **Raytools XC3000: calibration screen; control system identity**

15.6 Ermaksan Fibermak

The Ermaksan Fibermak operator panel and software were developed by Ermaksan. The panel uses a simple workflow designed to reduce operator errors. Consult the installed machine's Ermaksan manual for HMI, CNC application and button definitions.

Where is it used? On Ermaksan Fibermak machines. Panel generation, software version and options vary by machine; do not expect another machine's screen to be identical.

First-day workflow

Purpose: Verify Fibermak jobs through the machine's own panel and CNC application.

Requirements: Machine-specific Ermaksan manual, operator training, approved file and process record.

1. Follow manufacturer start-up and open the operator interface. Check HMI/CNC state, safeguards and auxiliaries.
2. Clear the area. Complete reference return/homing by the machine manual; then perform specified height calibration.
3. Open the job file by a supported method. Verify units, sheet, part count, coordinates and contours.
4. Match layers or equivalent process groups to suitable material/thickness records. Screen field names may vary by installed version.
5. Perform available simulation and boundary/frame checks by the manual. Inspect lead-ins and parts liable to lift.
6. Cut a sample with safeguards closed. Approve results, start production and inspect initial parts.

> **Warning**
> Do not assign another software package's functions to physical panel buttons. Verify start, pause, stop and resume behavior in the Ermaksan manual.

Why? A simple panel does not remove process and reference checks.

Job handover

At shift change, state open job name, last-part status, process record and pause cause. Record full panel alarm text. Verify external CAM files use suitable machine output and correctly mapped processes.

Screenshot to be added from a DOKTEK machine — **Ermaksan Fibermak: main screen; job and machine status**

Screenshot to be added from a DOKTEK machine — **Ermaksan Fibermak: layer/parameter screen; material and units**

Screenshot to be added from a DOKTEK machine — **Ermaksan Fibermak: calibration screen; control system identity**

15.7 Durma HD-FL — Siemens

Durma HD-FL uses a 64-bit Siemens Sinumerik 840D sl CNC with integrated PC. External CAM/nesting software, such as Hypertherm ProNest, supports Durma machines. Verify installed model, CNC configuration and output definition separately.

Where is it used? This description concerns the Durma HD-FL configuration. Do not assume identical screens/cycles on other Durma models or other manufacturers' Siemens CNC machines.

First-day workflow

Purpose: Prepare CAM output for the Durma/Siemens machine cycle.

Requirements: Durma manual, CNC details, suitable postprocessor, approved program and process record.

1. Start the machine in the manufacturer's sequence; check CNC/operator interface readiness. Verify alarms and safety conditions.
2. Perform manufacturer reference return/homing. Complete height calibration by the machine procedure.
3. Transfer CAM output by a permitted method; select the correct program. Compare file format and program name with job records.
4. Check program material/thickness and process mapping. Layers may correspond to technology records or process groups; do not assume names.
5. Inspect toolpaths in simulation/preview. Follow manufacturer instructions for supported boundary/frame and dry-run checks.
6. With gas, cooling, extraction and safeguards ready, cut a sample. If dimensions and quality are acceptable, start the job; record program/process versions.

> **Warning**
> Do not directly run another Durma machine's program because the CNC name matches. Supported codes, cycles and safe moves vary by postprocessor and machine.

Why? CAM support does not mean every program runs unchanged on every machine.

Keep programs and process records together

Save job number, CAM version, machine output definition and process record together. If CAM applies compensation, check the CNC side separately. Follow site authorization and recording procedures for manual program changes.

Screenshot to be added from a DOKTEK machine — **Durma HD-FL / Siemens: main screen; job and machine status**

Screenshot to be added from a DOKTEK machine — **Durma HD-FL / Siemens: layer/parameter screen; material and units**

Screenshot to be added from a DOKTEK machine — **Durma HD-FL / Siemens: calibration screen; control system identity**

15.8 Other software and CAM-to-machine file flow

CutMaker — awaiting verification

This software section will be completed with screenshots from a DOKTEK machine.

This version does not verify CutMaker machine pairing, menus, functions or first-day steps. Do not apply specific sequences before recording the exact software name/version. Verification will document whether start-up, homing, calibration, file opening, layer parameters, simulation/frame checks and cutting transition occur in this software or on the machine panel.

Screenshot to be added from a DOKTEK machine — **CutMaker — function/location to be verified: main screen; job and machine status**

Screenshot to be added from a DOKTEK machine — **CutMaker — function/location to be verified: layer/parameter screen; material and units**

Screenshot to be added from a DOKTEK machine — **CutMaker — function/location to be verified: calibration screen; control system identity**

Lantek, SigmaNEST, ProNest and similar CAM software

Transfer of computer-aided manufacturing (CAM) jobs depends on version, license, machine support and suitable postprocessor. Lantek, SigmaNEST or ProNest names alone do not prove compatibility with the installed machine. Sites using compatible CAM output may prepare drawings/nests on a separate computer and control motion/cutting at the machine panel.

Purpose: Verify geometry and process information at the target machine without loss.

Requirements: Verified target-machine CAM output definition, job number, material/sheet record, transfer method and machine manual.

1. Open CAM; verify target machine and output definition. For Lantek, SigmaNEST or ProNest, verify the installed package specifically.
2. Import the drawing. Check units, dimensions, closed contours, quantity, sheet size and material. Prepare nesting and cutting sequence.
3. Inspect lead-ins, micro joints and kerf compensation. Decide where compensation is applied; do not repeat it in CAM and CNC.
4. Watch simulation; generate correct machine output. Record file name, revision and material/thickness; transfer by a permitted method.
5. **At the machine:** Open control software → home in manufacturer sequence → perform capacitive calibration → open file → verify layer/process mapping → simulate/check frame → approve test results and cut.
6. At job completion, record the process version actually used. Do not assume machine changes automatically update CAM files.

> **Warning**
> Do not ignore unknown-file or unsupported-command warnings. Do not try to make another machine's output compatible by changing its extension.

Why? Even if transferred geometry looks correct, process codes, compensation or coordinate interpretation may differ.

Screenshot to be added from a DOKTEK machine — **Installed Lantek / SigmaNEST / ProNest package: main screen; software name, target machine and nest**

Screenshot to be added from a DOKTEK machine — **Installed Lantek / SigmaNEST / ProNest package: process/output screen; machine layer mapping**

Screenshot to be added from a DOKTEK machine — **Installed Lantek / SigmaNEST / ProNest package: target machine calibration screen; not to be presented as a CAM function**

> **Job file handover check**
> Hand over job name/revision, target machine, sheet material/thickness, part quantity, output definition and process version together. Verify missing details with the job preparer instead of guessing.

16

Maintenance

Plan maintenance before failures occur. Do more than replace dirty or damaged parts; eliminate the contamination cause too. Intervals and methods vary by model, workload and manufacturer instructions.

Safe state before maintenance

Stop cutting; disable laser beam generation and park the head safely. Isolate, lock and tag electrical, motion and pressure energies required for the task by the manufacturer's method. Verify motion or beam generation cannot recur. Allow hot parts to cool. Do not bypass door interlocks as a maintenance method.

16.1 Maintenance plan and responsibilities

Times below are approximate active working times for planning; they exclude cooling, energy isolation, drying, access and service waiting. Follow shorter manufacturer intervals where specified. Increase checks for heavy dust, galvanised steel and aluminium work. Operators must work only within training and site authorization.

Interval	Task	Approximate time	Responsible person
Daily / shift start	Check nozzle, ceramic ring and protective windows with permitted access; follow relevant replacement procedures if needed.	10–15 min	Trained operator
Daily / shift start	Chiller level/flow/alarms, external leaks, condensation; gas and extraction readiness.	5–10 min	Operator
Daily / shift end	Bed and accessible slag cleaning; compressor drain status.	10–20 min	Trained operator
Weekly	Gas/air filters, dryer, drains and external leaks.	15–30 min	Maintenance personnel
Weekly	Visible rail/rack contamination, lubrication system and extraction inlets.	20–40 min	Maintenance personnel
Monthly	Chiller filter and air passages; extraction filter/duct condition; fan filters.	30–60 min	Maintenance personnel; cabinet work by qualified electrical personnel
Monthly	Pallets, bed slats, belts/racks and connections.	30–60 min	Maintenance personnel
Every 3 months	Compare water replacement needs, hoses, filters and environmental records with manufacturer plans.	45–90 min	Maintenance personnel / service
Every 3 months	Mechanical wear and lubrication plan; recurring calibration/dimensional errors.	45–90 min	Maintenance personnel / service
Yearly	General manufacturer-defined service; safety, electrical, mechanical and optics assessment; review power measurement plan.	According to service plan, generally on a shift timescale	Authorized service and site maintenance manager

Plan water changes by manufacturer recommendations, generally every few months. The 3-month row is not a fixed replacement interval for every machine. Set filter and lubrication intervals from manufacturer documentation too.

For every task, record date, operating hours, observations, parts/consumables and worker. Distinguish “checked” from “replaced”. For daily records use Appendix B form.

16.2 Nozzle replacement

Purpose: Replace damaged or blocked nozzles with the correct type.

Requirements: Head-compatible nozzle, clean gloves, suitable hand tools, clean cloth and manufacturer's centering procedure. Select single-layer (S) or double-layer (D) nozzles from the approved process.

1. Establish the safe maintenance state. Record fitted nozzle type and job; allow hot nozzles to cool.
2. Remove loose surrounding dirt without pushing it inside. Remove the nozzle by the model-specific method; do not strain the ceramic ring.
3. Inspect tip, bore and threads. For dents, ovality or adhered slag, follow permitted cleaning/replacement decisions. Do not repair by enlarging the bore.
4. Check the new nozzle's identity, cleanliness and threads. Fit by the manufacturer's method; avoid cross-threading and arbitrary tightening force.
5. Remove tools and consumables. Return to safe operation; under section 16.5 final checks, complete capacitive calibration and centering in manufacturer sequence.
6. Verify results by frame check and controlled test cut. Record replacement cause, type and date.

> **Warning**
> Do not improvise exposed-beam centering shots. If the enclosed, guarded manufacturer test requires training, use trained personnel.

Why? Nozzle bore and centering affect beam/gas alignment. Incorrect installation can also impair height following.

Photo to be added from a DOKTEK machine — **old/new nozzle, tip damage and correct nozzle label; beam off**

16.3 Ceramic ring replacement

Purpose: Replace cracked/damaged ceramic rings with suitable parts and verify height sensing.

Requirements: Head-compatible ceramic ring, clean gloves, manufacturer-suitable tools and assembly instructions.

1. Isolate beam, motion and required energies. Park the head safely; remove the nozzle following section 16.2 in sequence.
2. Inspect ceramic for cracks, breaks, burns and dirty contact surfaces. Report visible cable/connection damage to service.
3. Remove the ring by the manufacturer's method. Clean seating/contact surfaces by a permitted method; keep dirt out.
4. Fit the correct part in the proper orientation. Secure retainers/connections as instructed; do not twist or force ceramic.
5. Fit the suitable nozzle. Remove tools; safely complete capacitive calibration and centering.
6. Perform a low-risk position check and test cut. For persistent sensor warnings, follow section 17.3; do not force operation.

> **Warning**
> Do not use cracked rings repaired with adhesive or bridged by conductive material. Tightening method and force vary by model.

Why? The ceramic ring contributes to nozzle assembly insulation and position integrity. Cracks or loose connections can destabilize capacitive measurement.

Photo to be added from a DOKTEK machine — **ceramic ring crack, clean seat and correct installation orientation**

16.4 Protective window inspection, cleaning and replacement

Purpose: Identify protective window contamination/damage and act without contaminating the optical path.

Requirements: Clean gloves, dust-free surroundings, clean work surface, correct replacement window/seal, lens tissue and manufacturer-approved purity isopropyl alcohol. Verify coating and cleaning compatibility in head documentation.

1. Make the machine safe. Identify head model and window holder permitted to be opened. **BM111 has three protective windows: upper, middle and lower.** Do not assume the same arrangement in BM06K or another model.
2. Clean around the holder. Wear clean gloves; place windows only on the prepared clean surface. Minimise dust exposure while open.
3. Remove the cassette/holder by the manufacturer's method. Record window orientation, retainers and seals before dismantling. Do not touch optical surfaces with fingers.
4. Inspect against ambient light at an oblique angle; do not look into the beam path. Check spots, stains, cracks, scratches, burns and coating damage. Do not reuse burnt, cracked or permanently damaged windows.
5. For removable dirt only, use approved lens tissue and isopropyl alcohol. Wet tissue appropriately; wipe lightly in one direction without pressure. Use fresh tissue each pass; do not rub dry or reuse dirty surfaces.
6. Recheck in light for dryness and marks. Replace persistently stained windows rather than repeatedly rubbing the coating.
7. Fit the correct window in the correct orientation with a clean, suitable seal. Do not guess unclear orientation. Do not pinch seals; close the cassette by the manufacturer's method.
8. In a safe operating state, verify capacitive calibration and centering in manufacturer sequence. Test cut; if rapid contamination persists, investigate section 17.4 causes.
9. Record window position, part details, action and observations. Do not put used windows in new-window boxes.

> **Warning**
> Isopropyl alcohol is flammable; keep away from hot surfaces and ignition sources and provide ventilation. Do not pour solvent into the head. Do not use paper towels, ordinary cloths, oily air or scrapers. Do not open service-only window holders.

Why? Optical dirt absorbs the beam and can heat up. Incorrect orientation, dirty seals or open holders can rapidly damage new windows too.

Photo to be added from a DOKTEK machine — **ambient-light inspection, lens tissue cleaning, correct orientation and seal; labeled model and window position**

> **Record recurring window losses**
> Record which material and piercing operation preceded contamination. Increase checks after galvanised steel and aluminium work. Do not conceal dirty gas or excess spatter causes merely by replacing windows.

16.5 Focusing/collimating lenses and post-maintenance verification

Purpose: Leave internal optics work to authorized personnel and verify operation after external maintenance.

Requirements: Head model documentation, trained personnel/service, controlled clean conditions, approved calibration and centering methods.

1. Stop cutting if internal lens damage is suspected. Record external window checks and the job when symptoms began; prepare Appendix E service information.
2. Only specifically trained personnel or service may access focusing/collimating lenses. Do not open internal optical holders as operator cleaning.
3. Service must follow model-specific lens, seal and connection instructions. This section gives no internal lens removal, orientation or adjustment values.
4. After nozzle, ceramic or window work, verify all holders are closed and correct parts fitted. Remove tools, solvent and packaging.
5. Return to a safe operating state. Complete capacitive calibration and centering **in the manufacturer's specified sequence**; sequence may vary by method. Do not skip checks.
6. Use enclosed test equipment where required. Do not open guards for tape/firing centering tests.
7. If required, perform the section 11 focus test. Check frame, height following and test-cut penetration/dimensions/edges.
8. Record results on the maintenance form. Contact service before production if calibration will not hold or focus is not repeatable.

> **Warning**
> Do not look directly at laser beams or reflections. Do not compensate for internal optical misalignment with cutting parameters. Obtain service records and return-to-work approval.

Why? Internal optics position affects focusing. Even with new external parts, stable cutting needs verified height and centering.

Photo to be added from a DOKTEK machine — **enclosed head model, safe test arrangement and calibration result; internal optics documented by service**

16.6 Chiller maintenance

Purpose: Maintain suitable source/head cooling.

Requirements: Chiller/source documentation, specified water quality, clean filling container, suitable filter and maintenance form.

1. Record displayed temperature, flow and alarms. Identify source/head circuits from model documentation; do not assume identical settings.
2. Perform required stops and energy isolation. Check water level in the specified state and at the correct indicator. Investigate leaks if topping up is needed.
3. Use specified purified/deionized water; conductivity and additive requirements vary by model. Do not add tap water or arbitrary antifreeze/biocides. Do not mix fluids without approval.
4. Check hoses, connections and filters. Clean/replace filters by manufacturer methods without contaminating circuits. Follow pressure/draining instructions before opening water circuits.
5. Plan water changes **according to manufacturer recommendations, generally every few months**. Follow model-specific draining, circuit cleaning, filling and air removal.
6. Compare temperature settings with source/head instructions. Consider humidity and dew point; do not cut with condensation. Do not use one fixed temperature for every machine.
7. Restore energy safely. Verify level, tightness and flow through the manufacturer's check run. Do not run the laser before alarms clear and cooling stabilizes.
8. Record water/filter dates, fluid, settings, ambient conditions and observations.

> **Warning**
> Do not bypass flow alarms. Do not keep topping up and operating with persistent level loss. Do not open hot or pressurised circuits.

Why? Water quality, flow and ambient conditions jointly determine cooling. Unsuitable water or condensation may damage source/head.

Photo to be added from a DOKTEK machine — **level indicator, circuit labels, filter and condensation check points**

16.7 Gas and air line maintenance

Purpose: Deliver cutting gas at suitable pressure and cleanliness.

Requirements: Gas system documentation, compatible leak detection product, suitable filter element, dryer/compressor instructions and required PPE.

1. Verify gas type and machine line matching. Externally inspect cylinders/tanks and regulators; record alarms and pressures.
2. Isolate lines before filter/connection work. Safely relieve pressure by the manufacturer's method; do not loosen pressurised connections.
3. Look for water, oil and dirt in filter bowls/elements. Replace elements by manufacturer methods; do not fit incompatible filters. If oil is found, do not supply gas to optics until the cause is eliminated.
4. Check dryer ready/alarm state and manufacturer-defined drying indicator. Verify compressor drainage; follow model procedure for manual drains.
5. Inspect hoses for crushing, cracks and abrasion. After safe repressurization, test connections with suitable leak product; never use a flame.
6. Verify stable pressure during cutting flow using the permitted indicator. Do not approve lines from static regulator pressure alone.
7. Record gas type, filter/dryer work, drainage and leak results. If problems persist, follow section 17.9.

> **Warning**
> Do not oil or grease oxygen-contact parts. Do not tighten leaking connections under pressure. Leave regulators and safety-device repair to authorized personnel.

Why? Dirty/oily gas affects window life and quality. Line restrictions cause pressure drops during flow.

Photo to be added from a DOKTEK machine — **filter water/oil checks, dryer indicator, compressor drain and gas label**

16.8 Mechanical maintenance: rails, racks, belts and bed

Base axis positioning accuracy and repeatability acceptance on ISO 230-2:2014 (+Amd 1:2016) in the service report; do not use withdrawn VDI/DGQ 3441 as the acceptance standard. A cut part's dimensions alone do not constitute an axis positioning test.

Purpose: Keep motion systems clean and preserve bed support.

Requirements: Machine lubrication plan, suitable cleaning tools, specified oil/grease, slag tools and cut/heat protection.

1. Move axes and pallets to maintenance positions; safely isolate electrical and unexpected-motion energy. Allow hot slag to cool.
2. Inspect rails/racks for visible dirt, wear and damage. Remove chips/dust without damaging surfaces or pushing dirt into slides/seals.
3. Apply correct lubricant at planned points; check central lubrication reservoir, lines and warnings. Do not mix oils or apply excess arbitrarily.
4. If fitted, visually inspect belts for cracking, wear and looseness. Trained maintenance personnel must check tension by the manufacturer's method; do not adjust by feel.
5. Inspect pallets, slats and part supports. Remove slag with suitable tools; replace bent/worn slats by manufacturer plans. Check pallet locks and motion areas.
6. Remove tools/waste. With safeguards established, perform controlled motion tests; stop for unusual noise, sticking or position differences.
7. If dimensional/shape errors persist, follow section 17.6. Operators must not change servo gains, electronic compensation or rack adjustments.

> **Warning**
> Prevent unexpected motion before entering beds or approaching pallets. Slag can be sharp and hot. Keep cloths and hands away from moving rails/racks.

Why? Dirt and insufficient lubrication hinder motion. Poor bed support can bend sheets and increase part lifting.

Photo to be added from a DOKTEK machine — **rail/rack cleaning, lubrication point, belt check if fitted, and dirty/clean slats**

16.9 Fume extraction and electrical cabinet

Fume extraction system

In maintenance and supplier records, distinguish EN 1093 / ISO 14123 emission assessment from ISO 21904-2:2020 equipment separation-efficiency testing; a single filter cartridge is outside the scope of that equipment test, and citing it during maintenance does not by itself prove adequate on-site extraction (Annex F).

Purpose: Maintain suitable removal of cutting fumes.

Requirements: Extraction documentation, suitable filters, dust-compatible collection tools and specified protection.

1. Stop cutting. Make extraction safe by its shutdown/cleaning sequence; prevent unexpected fan operation during cleaning.
2. Inspect bed inlets and ducts for blockages, leaks and deposits. Do not enter ducts; leave inaccessible areas to trained teams.
3. Check filters using manufacturer indicators and maintenance plans. Clean/replace only by permitted methods; not all filters are washable.
4. Manage collected dust in suitable containers. Verify material-appropriate collection/cleaning, especially for aluminium; do not use household vacuums or uncontrolled compressed air.
5. Close covers/connections. Verify extraction by manufacturer methods; do not cut with insufficient extraction. Record the task.

> **! Fumes or signs of combustion**
>
> Do not restart if filters/ducts show abnormal heating, sparks or fumes; follow the site fire/emergency plan. Do not blow dust into the surroundings.

Why? Blocked filters/ducts leave fumes in the workplace. Unsuitable cleaning can make dust airborne again.

Photo to be added from a DOKTEK machine — **extraction inlet, duct access, filter indicator and safe dust collection point**

Electrical cabinet

Purpose: Safely check cabinet dust and cooling conditions.

Requirements: Electrical maintenance authorization, manufacturer waiting/isolation instructions, suitable fan filter and electrical-equipment-compatible cleaning tools.

1. Operators must observe only closed-cabinet external air inlets, fan filters and alarms. Refer work requiring opening to qualified electrical personnel.
2. Authorized personnel must isolate, lock and tag energy. After the manufacturer's waiting time, verify absence of voltage by a suitable method.
3. Clean/replace fan filters as instructed. Only authorized personnel may remove internal dust by suitable methods; keep air blasts, solvent and moisture off circuit boards.
4. Report burns, signs of loose connections, damaged cables and failed fans to service. Do not tighten terminals or take electrical measurements without authority.
5. Authorized personnel must close the cabinet and complete safe energisation and fan/cooling checks. Record findings and filter replacement.

> **! The main switch alone is not verification**
>
> Some circuits may retain energy or stored voltage. Only authorized personnel may work inside electrical cabinets or verify voltage.

Why? Blocked fan filters can raise cabinet temperature. Unauthorized cleaning risks electric shock or equipment damage.

Photo to be added from a DOKTEK machine — **closed cabinet fan filter and maintenance label; internal views only by authorized personnel**

17

Troubleshooting

Define the symptom first, then check in sequence. Change only one setting per trial. Stop cutting for damage, condensation, gas leaks or safety failures; do not restart until the cause is eliminated.

Distinguish checks from interventions

Screen information can be read with the machine closed. Before touching heads, optics, lines or mechanics, prevent beam generation and unexpected motion; isolate required energies by manufacturer methods. Do not open pressurised lines. Leave electrical/internal optics work to authorized personnel.

Time labels indicate approximate initial check times, excluding cooling, isolation, consumable changes and service waiting. "Service" task duration depends on the fault. Alarm meanings and reset methods vary by model/version.

17.0 Symptom index

Symptom	Look here first
Cut does not penetrate sheet	17.1 Not cutting
No initial hole	17.2 Not piercing
Head collision / height sensor warning	17.3 Height following
Protective window rapidly dirties / burns	17.4 Protective window
Parts lift / tip	17.5 Part support
Dimensional error / shape shift	17.6 Dimensions and motion
Laser source alarm	17.7 Source alarms
Chiller flow, temperature or level alarm	17.8 Chiller alarms
Gas pressure alarm / pressure drop during cutting	17.9 Gas pressure

For alarms, consult the relevant alarm section first. Do not try cutting parameters to solve source/chiller readiness problems. For dross and edge defects also use section 13 tables.

17.1 Not cutting / not penetrating material

Purpose: Distinguish optics, gas and process causes sequentially when the beam does not penetrate.

Requirements: Approved parameter record, actual material/thickness, clean consumables, machine documentation and Appendix C form.

One variable	Speed	Focus	Gas	Take notes
Only one setting per trial	Controlled trial within approved limits	Verify using section 11	Type, cleanliness and flowing pressure	Old/new values and results

1	**Protective window** Dirty, stained or burnt windows may absorb power.	Make the machine safe. With clean gloves in dust-free conditions, remove the permitted window and inspect against ambient light. For stains use section 16.4 cleaning; replace damaged or uncleanable windows. Check more often after galvanised steel/aluminium. FREQUENT CHECK POINT · 5–10 MIN
2	**Nozzle** Dented, blocked or off-center nozzles impair cutting.	Remove the nozzle; look for tip dents and adhered slag. Replace with a suitable part and center by the manufacturer's guarded method. The example tape test requires approved enclosed methods and training; do not test exposed beams. 5–10 MIN
3	**Focus** Wrong focus concentrates energy in the wrong region.	Compare focus with suitable process records. If uncertain, use the section 11 focus test. Report suspected loose lens holders to service; do not open internal optics. 5–15 MIN
4	**Speed** Speed may be too high for material/process.	Compare speed with approved records. Trial lower speed within permitted limits, changing only one variable. Record improved penetration; do not overwrite master process records without verification. 5–10 MIN
5	**Gas** Pressure drops, depleted supply or dirty gas may contribute.	Check gas type, cylinder/tank and regulator. Monitor flowing pressure on a safe gauge. Verify purity from supplier/manufacturer documents; air must be dry and oil-free. For filters/dryers/leaks follow section 16.7 in sequence. 5–10 MIN
6	**Nozzle height** Capacitive sensing may be incorrect or unstable.	Check water, oil, film and dirt on sheet. Have electrical contact safely verified. Calibrate capacitance by manufacturer methods; for persistent warnings follow section 17.3. 5–10 MIN
7	**Material** Thickness/coating may differ from expectations.	Safely measure thickness; check type, coating, film and rust. Select an approved record for actual material/thickness. Do not assume the next thickness's parameters automatically solve the problem. 2–5 MIN
8	**Power** Process power may be wrong or output reduced.	Compare power percentage and available pulse/frequency fields with approved records. If this job previously cut and external checks are clear, follow section 14.7 for service power measurement. SERVICE · DURATION VARIES
9	**Alarms and chiller** The source may be in protection mode.	Record full source alarm code/text. Compare chiller temperature, flow and level with model instructions; do not apply one temperature range to every source. Stop for condensation on heads/hoses. 2–5 MIN / SERVICE

Warning

Safely isolate beam and motion before touching the head. Do not continue test cuts with burnt windows, recurring alarms or condensation.

Why? The example page 12.1 sequence starts with windows/nozzles and progresses to power/cooling. It helps distinguish process problems from faults requiring service.

Final check: After checks, make a single-variable test cut. If penetration still fails, prepare Appendix E information and contact DOKTEK service.

17.2 Not piercing

Purpose: Identify why full penetration fails during piercing.

Requirements: Material/thickness record, approved piercing process, head documentation and clean test sheet.

1	**Distinguish the symptom** The initial hole and subsequent cutting are different stages.	Safely inspect the pierce point from above and below. Is there only a top crater, a hole with poor contour transition, or a source alarm? Record stage and screen state. 2–5 MIN
2	**Material and process** Wrong thickness or piercing record may be selected.	Check actual thickness, material, coating/film and active layer. Select approved piercing records. Do not substitute cutting settings for piercing. FREQUENT CHECK POINT 2–5 MIN
3	**Window and nozzle** Piercing spatter may affect optics/nozzle opening.	Isolate beam and motion; inspect window, nozzle and ceramic ring using section 16. Assess contamination causes before fitting new windows. 5–15 MIN
4	**Gas and height** Unsuitable gas or distance may prevent hole formation.	Compare gas, flowing pressure and piercing height with approved processes. Verify calibration. Do not arbitrarily lower the nozzle towards sheet to force penetration. 5–10 MIN
5	**Piercing stages** Time, power, focus or staged transitions may differ.	Compare staged fields, if present, only with approved model records. Change one setting per trial; follow section 12 processes. Do not increase time/power without control. 5–15 MIN
6	**Trials and service** Repeated failed piercing may damage optics.	Do not repeatedly test a damaged hole; choose a suitable fresh point. If approved processes fail, record source/chiller alarms for service. SERVICE · DURATION VARIES

> **Warning**
> Stop for severe spatter, abnormal flare or alarms. Do not try to remove parts before cutting is complete.

Why? Piercing may use different energy, gas and height. Cutting speed alone does not solve initial-hole problems.

Final check: Verify full piercing by the manufacturer's observation method; then test transition on a short contour and record results.

17.3 Head collision / height sensor warning

Purpose: Safely distinguish collision causes and unstable capacitive measurement.

Requirements: Head/height controller documentation, clean flat sheet, suitable nozzle/ceramic ring and maintenance record.

1	**Stop the collision** Continued motion may worsen damage.	Emergency-stop if dangerous. Do not move the head blindly up/down. Record incident position/alarm before safely isolating energy; request service if damage is suspected. IMMEDIATE · 1–2 MIN
2	**Sheet and path** Raised parts, bent sheet or obstacles may be present.	Check cut parts, clamps, slag and bed support. Remove obstacles with the head safe and motion disabled. Remove water/oil and dry sheet; handle film by an approved process. 5–10 MIN
3	**Nozzle and ceramic** Loose nozzles/cracked ceramic may affect measurement.	Inspect nozzle seating, ceramic ring and permitted connections. Replace damaged parts using section 16.2 and 16.3; do not improvise repairs. FREQUENT CHECK POINT 5–15 MIN

4	**Earthing and contact** Poor sheet contact may destabilize measurement.	Check for dirt/coating at sheet/bed contacts. Have authorized personnel electrically check protective earthing and sensor connections. Do not test with protective earth disconnected. 5–10 MIN / AUTHORIZED PERSON
5	**Calibration** Tooling may have changed or calibration expired.	After correcting damage/surface problems, calibrate on suitable sheet by manufacturer methods. Do not cut with failed calibration or change servo setup instead of daily calibration. 5–10 MIN
6	**Guarded motion test** Resetting the alarm alone does not prove resolution.	With area clear and safeguards established, run the manufacturer's beam-off height/frame test. If following remains unstable, call service for sensor cable, controller or mechanical checks. SERVICE · DURATION VARIES

Warning

Do not simply recalibrate after a collision and resume production; assess head, nozzle, ceramic and optical damage.

Why? Capacitive measurement depends on tooling, sheet surface and electrical contact together. Mechanical obstacles cause collisions even with correct calibration.

Final check: After stable following and correct frame motion are verified, cut a small sample; stop if alarms/collisions recur.

17.4 Protective window rapidly dirties / burns

Purpose: Find spatter, gas and assembly causes to protect replacement windows.

Requirements: Head model/window position, contamination photo, gas maintenance records and approved process.

1	**Remove damaged windows from use** Operating with burnt surfaces can extend damage.	Stop cutting. Inspect windows safely and cleanly using section 16.4. Replace burns, cracks or coating damage. Record the affected window. 5–15 MIN
2	**Height and nozzle** Wrong distance or gas flow may increase spatter.	Compare piercing/cutting heights with approved records. Verify nozzle damage, centering and capacitance calibration. More gas pressure is not a universal solution. 5–10 MIN
3	**Dirty / oily gas** Contaminated lines may dirty clean windows again.	Look for air-line water/oil, dirty filters and dryer alarms. Verify documented gas cleanliness. If oil is present, do not cut with a new window until the line problem is eliminated. FREQUENT CHECK POINT 5–15 MIN
4	**Piercing spatter** Problems may occur mainly at starts.	Record whether contamination begins after piercing. Compare stages, focus/height and gas transitions with approved processes; follow section 17.2. 5–15 MIN
5	**Material and coating** Galvanised steel/aluminium may need more checks.	Record material, coating and film. Check windows more often after these jobs. Verify adequate extraction and correct process. 2–5 MIN
6	**Orientation, seals and internal optics** Dirt may enter during opening, or seals may seat incorrectly.	Check window orientation and seals against model documentation. Do not mix BM111 upper/middle/lower windows. Refer suspected internal dirt/damage to service; do not open holders indiscriminately. SERVICE · DURATION VARIES

Warning

Do not hold hot/damaged windows bare-handed. Do not remove protective windows and cut without them.

Why? Rapid replacement-window failure may indicate contamination sources or process problems rather than consumable life; track causes in records.

Final check: After a short trial with a new/clean window, inspect again safely. If contamination persists, request service with photos/job records.

17.5 Parts lift / tip

Purpose: Reduce parts falling off supports and obstructing subsequent head travel.

Requirements: Nest/toolpath, bed support condition, micro joint plan and motion documentation.

1	**Make the area safe** Raised parts may collide with the head on the next move.	Stop the cycle; safely isolate beam/motion before removal. Do not pull parts from under an operating head. After collisions perform section 17.3 checks. IMMEDIATE · 1–2 MIN
2	**Bed support** Small parts may be unstable between slats.	Check slats, slag and sheet seating. Assess support after final cuts in the nest; correct support problems. 5–10 MIN
3	**Micro joints** Fully released parts may tip.	Plan micro joint positions/count for the part and approved process. Verify retention in simulated toolpaths. Record later separation and expected marks. 5–10 MIN
4	**Cutting sequence** Early-released parts may obstruct paths.	Inspect inner/outer contour and part sequence. Assess final release points alongside support and subsequent moves. Manage heat build-up using section 6 approaches too. 5–15 MIN
5	**Non-cutting travel and leapfrog** Low travel may collide with raised parts.	Verify leapfrog or suitable safe travel support in machine documentation. Heights/behavior vary by version. Do not substitute these functions for support/micro joints. 5–10 MIN

> **Warning**
> Do not continue over raised parts. Do not enter guessed heights or service parameters for motion safety.

Why? Plan support, release sequence and non-cutting travel together.

Final check: Watch updated simulation; check release/retention behavior in a safe trial.

17.6 Dimensional error / shape shift

Purpose: Distinguish file, compensation and mechanical motion errors.

Requirements: Drawing dimensions, suitable instruments, cooled sample, job/CAM records and maintenance history.

1	**Verify measurement** Temperature, dross or wrong references may affect dimensions.	Allow safe cooling. Assess dross and measurement reference; measure in several directions with suitable tools. Record constant overall offsets versus single-axis shifts. 5–10 MIN
2	**Units and geometry** Scale or drawing problems may exist.	Compare drawing dimensions, import units and machine preview. Verify correct revision/scale; do not compensate for wrong files with parameters. 2–5 MIN
3	**Kerf compensation** Wrong side or double compensation changes dimensions.	Check inside/outside compensation direction. Verify CAM and controller do not both apply it. Confirm process-specific compensation with a sample. 5–15 MIN

4	**Reference and sheet** Lost position or shifted sheet may displace shapes.	Verify homing/work zero by machine procedure. Check unchanged sheet position, supports and clamping. Do not blindly transfer resume points to new references. 5–10 MIN
5	**Belts and racks** Backlash, dirt or wear may affect motion.	After safe isolation, visually check dirt/wear. Leave belt tension, rack backlash and mechanical adjustment to trained maintenance/service; use section 16.8 for records. SERVICE · DURATION VARIES
6	**Servos and repeatability** Axis or drive problems may exist.	Record error direction, position and recurrence. Send servo/alarm text to service. Operators must not change gains, electronic gearing, axis scaling or error compensation. SERVICE · DURATION VARIES

Warning

Do not hide mechanical/servo faults by scaling drawings. Do not begin series production with unacceptable dimensions.

Why? Constant dimensional offsets and position-dependent shifts require different checks.

Final check: After suitable correction, trial inner/outer dimensions across both axes; verify tolerances against job drawings.

17.7 Laser source alarms

Purpose: Classify alarms with full records and safely refer to service.

Requirements: Source brand/model/serial, full alarm code/text, time/job records and source documentation.

1	**Capture the full record** Brief screen messages may be insufficient.	Stop cutting. Record full machine/source interface codes/text, time and process stage. Do not invent meanings for unknown codes; consult model documentation. 2–5 MIN
2	**Temperature category** Cooling or ambient conditions may contribute.	Check chiller alarms, water level, flow and external hoses. Record temperature/humidity and condensation. Obtain limits from manufacturer documentation; do not open source covers. 5–10 MIN
3	**Back-reflection category** May relate particularly to copper, brass and aluminium.	Do not repeatedly restart the process. Send material, piercing stage, head/nozzle and process details to service. Do not continue solely by changing power/focus before source/head compatibility is verified. SERVICE · DURATION VARIES
4	**Power category** Process or source output may need assessment.	Retain requested settings/job records. Safely check external optics; leave power measurement under section 14.7 to service. Exact causes depend on code/model documentation. SERVICE · DURATION VARIES
5	**Communication category** Controller–source communication may be interrupted.	Record which device is not ready and the last change. Report external cable damage. Do not open cabinets or alter communications/bus configuration. Power-cycle only if manufacturer-permitted. SERVICE · DURATION VARIES
6	**Restart decision** Reset does not prove the cause is eliminated.	Once causes are identified and eliminated, perform permitted reset/readiness checks. Do not cut with recurring or unknown alarms; prepare Appendix E records for service. 5–10 MIN / SERVICE

Warning

Do not bridge alarms/protection inputs. Do not repeatedly reset/power-cycle merely to clear the screen.

Why? The same general alarm category may have different causes and remedies across models.

Final check: With source/auxiliaries ready, make controlled trials under manufacturer/service instructions; stop on recurrence.

17.8 Chiller alarms

Purpose: Assess flow, temperature and level warnings without damaging the source.

Requirements: Chiller model documentation, source/head cooling requirements, alarm record and suitable water details.

1	**Stop cutting** The laser must not run before cooling is verified.	Record full alarm code/text, affected circuit and displayed values. Verify flow/temperature/level classification against manufacturer documentation. IMMEDIATE · 1–2 MIN
2	**Flow** Low level, crushed hoses or filter problems may exist.	Inspect closed-system external indicators, hose routes and leaks. Assess pumps/filters by maintenance procedures. Do not bypass flow switches or disconnect pressurised hoses. 5–10 MIN
3	**Temperature** Settings, ventilation or ambient conditions may contribute.	Compare manufacturer settings; check air inlets, filters and surroundings. Do not confuse source/head circuits. Stop for condensation; do not enter a universal fixed temperature. 5–10 MIN
4	**Level** Fluid loss or leaks may exist.	Read level in the manufacturer's specified running/stopped state. For permitted topping-up and leak checks use section 16.6. Do not dismiss recurring loss by refilling alone. 5–15 MIN
5	**Controlled return** Alarm disappearance alone is insufficient.	After maintenance, verify air removal, level, flow and tightness by manufacturer methods. Refer recurring pump, sensor or cooling-circuit assessment to service. SERVICE · DURATION VARIES

> **Warning**
> Do not cut with chiller protection disabled. Do not add unsuitable fluids or arbitrary additives.

Why? Incorrect fluid or condensation risks can exist even with apparently adequate flow and temperature.

Final check: With stable cooling, cleared alarms and source ready, return to trials in manufacturer sequence; record all values.

17.9 Gas pressure alarms

Purpose: Distinguish supply, regulator, line and process pressure problems.

Requirements: Gas type/line diagram, gauges, manufacturer limits, approved process and suitable leak test method.

1	**Verify gas and alarm** Wrong gas/layer may be selected.	Stop cutting; record the full alarm. Compare selected gas with cylinder/tank, line labels and active layer. Verify alarm threshold meanings from model documentation. 2–5 MIN
2	**Supply and regulator** Supply may be depleted, valves closed or regulator unsuitable.	Check cylinder/tank levels and permitted gauges. Only trained personnel may operate valves in the correct sequence. Check regulators within manufacturer limits; request service for freezing/damage. 5–10 MIN
3	**Flowing pressure** Static pressure may be normal but fall under demand.	With beam off and safeguards established, use the safe gas check cycle and permitted gauge. Have maintenance assess supply capacity, filters or restrictions if flowing pressure falls. 5–10 MIN
4	**Filters, hoses and leaks** Blockages, crushing or leakage may exist.	Visually check hoses/filters. Isolate/depressurise lines before intervention. Use suitable leak detection products, never flame. Follow Section 16.7 in sequence. 5–15 MIN

5	**Sensors and valves** Alarms may persist despite apparently correct pressure.	Record gauge differences, alarm timing and active gas. Leave sensor calibration, pressure switches, valves and wiring to authorized maintenance/service; do not lower alarm limits to operate. SERVICE · DURATION VARIES

Warning

For gas leaks, shut supply only if safe and follow the site emergency plan. Do not lubricate oxygen lines or arbitrarily increase pressure as a remedy.

Why? Line behavior under flow may differ from stationary pressure.

Final check: With no leaks, correct gas and suitable flowing pressure, make a controlled test cut. Send records to service if alarms recur.

90

Appendices

Keep the quick reference card beside the machine. Retain forms with job and maintenance records. Apply manufacturer operating and emergency instructions alongside these appendices.

Appendix A — Machine-side quick reference card

Machine / serial no: _____ **Authorized operator:** _____

Start-up and first cut

Purpose: Prepare the machine for its first job.
Requirements: Training, manufacturer start-up instructions, approved file/parameters.

1. Check the area and safeguards. Prepare gas, chiller and extraction in manufacturer start-up sequence.
2. Start the machine/control software. Verify auxiliary readiness and cleared alarms.
3. Home with the area clear. Perform capacitive calibration by the manufacturer's method.
4. Verify sheet and file. Check material, thickness, layers, gas, nozzle and focus records.
5. Simulate and frame-check. Test cut with safeguards closed; start production if dimensions/quality are acceptable.

Daily checks

- Nozzle sound/clean; ceramic ring free of cracks.
- Protective window inspected by a permitted method.
- Chiller level/flow/temperature correct; no leaks/condensation.
- Correct gas; filters/dryer and pressure suitable.
- Bed support, motion area and extraction suitable.
- Calibration, job file and process verified.
- Check results and non-conformities recorded in Appendix B.

Start-up varies by model; do not run the laser before the chiller is ready. Initial setup/servo tuning is not daily calibration.

8 most frequently consulted faults: initial action

Symptom	Initial action	Details
Not cutting	Stop; check window, nozzle and correct process record.	17.1
Not piercing	Do not pierce repeatedly; verify material/thickness and piercing record.	17.2
Head collision	Stop motion; safely inspect obstacles, nozzle, ceramic and surface.	17.3
Window dirties quickly	Do not use damaged windows; investigate gas water/oil and piercing spatter.	17.4
Parts lift	Stop cutting; inspect support, micro joints and cutting sequence.	17.5
Dimensional / shape error	Measure cooled parts; check units, compensation and references.	17.6
Source / chiller alarm	Stop cutting; record full code. Check flow, level and condensation.	17.7 / 17.8
Gas pressure alarm	Check gas type and supply; do not change alarm thresholds.	17.9

Emergency

Emergency-stop for collision, uncontrolled motion or imminent danger. Clear the area and notify the responsible person. For fire/gas leaks, follow the site emergency plan; isolate energy/supply if safe. Call 112 for injury or fire. Do not bypass safeguards; do not restart before the cause is eliminated and an authorized person approves return.

Warning: Safely isolate beam/motion before touching heads and pressure before line work. **Why?** Readiness checks and records reduce recurring errors.

Site emergency coordinator / extension: _____ **Service contact:** _____

Appendix B — Daily check form: 7-day week

Machine / serial no: _____ Week starting: ____ / ____ / ______ Shift: ______

In each cell enter **U** (acceptable), **D** (stop/non-conforming) or **G** (not applicable to this model). Explain G entries. Do not mark unperformed checks acceptable. Do not begin affected work until non-conformities are resolved; record actions below.

Check	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Date / day	_____	_____	_____	_____	_____	_____	_____
Operating hours indicator	_____	_____	_____	_____	_____	_____	_____
Safeguards and emergency stop: manufacturer check	_____	_____	_____	_____	_____	_____	_____
Nozzle: clean, sound, correct type	_____	_____	_____	_____	_____	_____	_____
Ceramic ring: no cracks / looseness	_____	_____	_____	_____	_____	_____	_____
Protective window: suitable, holder closed	_____	_____	_____	_____	_____	_____	_____
Chiller: level and flow correct	_____	_____	_____	_____	_____	_____	_____
Chiller: correct temperature, no condensation / leaks	_____	_____	_____	_____	_____	_____	_____
Gas: correct type and flowing pressure	_____	_____	_____	_____	_____	_____	_____
Air: filter / dryer / drains correct	_____	_____	_____	_____	_____	_____	_____
Bed / slats / motion area clean	_____	_____	_____	_____	_____	_____	_____
External rail / rack and lubrication check	_____	_____	_____	_____	_____	_____	_____
Extraction ready, no filter warning	_____	_____	_____	_____	_____	_____	_____
Calibration and nozzle centering correct	_____	_____	_____	_____	_____	_____	_____
File / material / layers verified	_____	_____	_____	_____	_____	_____	_____
First-part dimensions and cutting checks acceptable	_____	_____	_____	_____	_____	_____	_____
End-of-day cleaning and shutdown complete	_____	_____	_____	_____	_____	_____	_____
Operator name / initials	_____	_____	_____	_____	_____	_____	_____

Non-conformity / action record

Date	Observation and stop cause	Action / part	Restart authorized by / time
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Cabinet opening, internal optics and electrical measurements are outside daily operator checks. Report observations to authorized maintenance. Attach completed forms to maintenance records.

Appendix C — Parameter change form

Machine / serial no: _____ **Job / file / revision:** _____

Source model / power / core: _____ **Head / nozzle:** _____

Baseline process record / version: _____ **Gas type:** _____

Record one parameter per row. State material and thickness for every trial. Include units with old/new values: speed (m/min), pressure (bar), focus/height (mm); use software-defined units elsewhere. Stop trials for alarms or damage.

Date / time	Material	Thickness (mm)	Changed parameter	Old value / unit	New value / unit	Result	Operator
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Trial result and approval

Record full penetration, piercing, dross, lower/upper surfaces, dimensions and any alarms. Give photo/sample numbers. A single word such as “good” is insufficient.

Dimensions / acceptance criteria	_____
Photo / sample no	_____
Decision	Continue trials: ____ Approved for production: ____ Return to old setting: ____
Approved by / date	_____
New process record / version	_____

! Keep trial and production records separate

Do not overwrite master libraries with unapproved results. DOKTEK-derived values carry ★; “trial value, not for series production” rows carry ◆. These marks do not remove trial/approval requirements.

Appendix D — Glossary: guide terms and English equivalents

English equivalents help with screen and manufacturer documentation. A listed term does not mean the function is offered by every software package; names and scope vary by version/model.

Guide term	English equivalent	Brief explanation
Laser source	Laser source	Beam-generating unit.
Fiber laser	Fiber laser	Fiber-based laser source type.
Cutting head	Cutting head	Assembly focusing the beam in the processing area.
Output fiber	Delivery fiber	Carries the beam from source to head.
Fiber core diameter	Fiber core diameter	Diameter of the fiber's light-carrying core.
Nominal power	Rated power	Nameplate power class.
Power percentage	Power percentage	Relative power requested in the process.
Beam quality	Beam quality	Property relating to beam focusing behavior.
Beam parameter product	Beam parameter product (BPP)	Describes beam propagation and focusing.
Continuous wave	Continuous wave (CW)	Continuous beam generation mode.
Pulsed operation	Pulsed operation	Energy delivered in pulses.
Frequency	Frequency	Repetitions per unit time.
Pulse duration	Pulse duration	Time length of one pulse.
Duty cycle	Duty cycle	On-time as a proportion of the cycle.
Back-reflection	Back reflection	Light returning from the process towards the source.
QBH connection	QBH connector	Optical connection type at fiber output.
Collimation	Collimation	Conditioning beam propagation.
Collimating lens	Collimating lens	Beam-conditioning lens in the head optics.
Focus	Focus	Beam focal state or process setting.
Focusing lens	Focusing lens	Lens focusing the beam.
Focal point	Focal point	Region where the beam is focused.
Focus test	Focus test	Verification of suitable focus by testing.
Protective window	Protective window	Optical element protecting internal optics.
Coating	Coating	Layer on material or optical surfaces.
Nozzle	Nozzle	Component directing gas to the cutting area.
Single-layer nozzle (S)	Single-layer nozzle	Nozzle type with single-layer construction.
Double-layer nozzle (D)	Double-layer nozzle	Nozzle type with double-layer construction.
Ceramic ring	Ceramic ring	Ceramic component in the nozzle assembly.
Nozzle centering	Nozzle centering	Verifying nozzle/beam alignment.
Nozzle height	Nozzle standoff	Distance between nozzle and sheet.
Capacitive sensor	Capacitive sensor	Senses distance capacitively.
Capacitive calibration	Capacitive calibration	Calibration preparing height measurement.
Height following	Height following	Head following the sheet distance.
Return to origin / reference	Homing	Axes returning to the machine reference.
Machine coordinate	Machine coordinate	Position relative to the machine reference.
Workpiece zero	Workpiece zero	Starting reference defined for the job.
Edge finding	Edge finding	Determining sheet edge position.
Frame	Frame	Motion checking job boundaries.
Dry run	Dry run	Toolpath test without a beam.
Simulation	Simulation	Screen preview of toolpaths.
Cutting speed	Cutting speed	Speed of cutting motion; m/min.
Piercing	Pierce / piercing	Making a hole to start cutting.
Kerf	Kerf	Cut width opened by the beam.
Kerf compensation	Kerf compensation	Path correction for cutting width.
Lead-in	Lead-in	Entry path to the cutting contour.
Lead-out	Lead-out	Exit path at contour end.
Micro joint	Micro joint	Small uncut section retaining a part.
Common line	Common line	Cutting parts along a shared line.
Flycut	Flycut	Supported special high-speed cutting method.
Leapfrog	Leapfrog	Head lifting approach during travel.

Guide term	English equivalent	Brief explanation
Nesting	Nesting	Arranging parts within sheet area.
Toolpath	Toolpath	Processing path followed by the head.
Cutting sequence	Cut sequence	Order of contour and part processing.
Inner contour	Inner contour	Boundary of a hole/opening within a part.
Outer contour	Outer contour	Part's outer boundary.
Open contour	Open contour	Geometry with unjoined endpoints.
Duplicate line	Duplicate line	Repeated overlapping line.
Layer	Layer	Geometry group sharing a process.
Process parameter	Process parameter	Setting determining cutting/piercing behavior.
Material library	Material library	Material-specific setting records.
Pause	Pause	Temporarily suspending a job.
Stop	Stop	Ending the cycle.
Resume from breakpoint	Resume	Controlled continuation after interruption.
Job report	Job report	Production record for the job.
Computer-aided manufacturing	Computer-aided manufacturing (CAM)	Manufacturing job preparation approach.
Output converter	Postprocessor	Converts paths to target-machine output.
CNC	Computer numerical control	Computer numerical control system.
Human–machine interface	Human–machine interface (HMI)	Operator interaction screen.
Hardware key	Dongle	Physical key for licensing.
Data bus	Bus	Communication infrastructure between controllers.
Chiller	Chiller	Source/head cooling unit.
Flow	Flow	Movement of coolant or gas.
Water level	Water level	Tank water quantity indication.
Deionized water	Deionized water	Water with reduced ions.
Condensation	Condensation	Moisture liquefying on a cold surface.
Dew point	Dew point	Temperature at which condensation can begin.
Dryer	Dryer	Unit reducing line moisture.
Regulator	Regulator	Component regulating gas pressure.
Gas pressure	Gas pressure	Pressure in the gas line; bar.
Filter	Filter	Traps unwanted substances in flow.
Fume extraction	Fume extraction	System removing cutting fumes.
Bed slat	Support slat	Bed element supporting sheet and parts.
Pallet	Pallet	Bed assembly for carrying/exchanging sheet.
Rack	Rack	Toothed element transmitting linear motion.
Rail	Linear guide rail	Element guiding axis motion.
Belt tension	Belt tension	Manufacturer-specified belt tension.
Servo	Servo drive / servo system	Controlled axis drive system.
Dross	Dross / burr	Unwanted deposits remaining on cut edges.
Slag	Slag	Solidified process residue.
Mild steel	Mild steel sheet	The guide's term for carbon steel sheet.
Stainless steel	Stainless steel	Stainless steel material group.
Galvanised steel	Galvanised steel	Zinc-coated steel sheet.
Aluminium	Aluminium	Metal presenting back-reflection risk during cutting.
Brass	Brass	Copper-based alloy material group.
Copper	Copper	Metal presenting back-reflection risk during cutting.
Oxygen	Oxygen (O_2)	Cutting gas requiring process compatibility verification.
Nitrogen	Nitrogen (N_2)	Cutting gas requiring process compatibility verification.
Compressed air	Compressed air	Air that must be dry and oil-free.
Safety interlock	Safety interlock	Safeguard making hazardous operation conditional.
Emergency stop	Emergency stop	Stop function for imminent danger.
Serial number	Serial number	Equipment identification number.
Alarm history	Alarm history	Record of previous warnings.

Guide term	English equivalent	Brief explanation
Operating hours	Operating hours	Usage counter as defined by the interface.
Power meter	Laser power meter	Suitable instrument for optical power measurement.

Appendix E — Information required for service

Capture screens before resetting alarms. Complete these fields for service reports. Do not open guards or operate unsafely for photos. This form records information for service communication.

Information	Record
Contact	Company / contact person / phone: _____
Machine	Brand / model / serial no: _____
Laser source	Brand / model / serial no / power / core: _____
Cutting head	Brand / model / nozzle type / last window change: _____
Control and software	CNC/card / software name and version / height controller: _____
Chiller	Model / temperature / flow / level / ambient humidity and temperature: _____
Job and material	File / revision / material / thickness / coating: _____
Process	Gas / flowing pressure / speed / focus / piercing-cutting record: _____
Alarm	Full code and text / originating device / date-time / operating hours: _____
Symptom	When it began / stage / every job? / recurrence: _____
Last change	Part / water / filter / software / process change and date: _____
Checks performed	Steps followed / observations / old-new settings / results: _____
Machine status	Stopped? / energy isolated? / damage-leaks-condensation: _____

Images and records to attach

- Full alarm and parameter screen; exclude unnecessary personal/job-specific information from the frame.
- Sample upper and lower faces; mark dimensions and cutting direction where possible.
- Photos of nozzle, ceramic, window and relevant labels taken in a safe state.
- Job file/revision, Appendix B–C records and previous power/service reports if available.

> **Unknown model information**
>
> Do not guess unavailable information; write “unknown”. Do not open closed cabinets or source covers to read serial labels. Perform additional service-requested tests only with suitable training and manufacturer methods.

Appendix F — References

Relevant standards and legislation

- ISO 9013:2017 (+Amd 1:2024) — Defines cut-face u/Rz5 ranges and dimensional tolerance classes.
- IEC 60825-1 — Defines laser product classification and product safety requirements.
- IEC 60825-4:2022 — Addresses laser guards enclosing the processing zone.
- ISO 11553-1:2020 — Addresses laser radiation safety in laser processing machines; the series replaced EN 12626.
- EN 207:2017 — Defines wavelength, operating mode and LB protection markings for laser eyewear.
- EN 12254 — Covers screens and curtains for low-power laser workplaces; not primary protection for a kW machine.

- ISO 14175 — Classifies assist gases and mixtures, including those used for laser cutting.
- ISO 8573-1 — Defines compressed-air quality classes for particles, water and oil.
- ISO 11146-1 — Defines measurement methods for beam width, divergence and beam propagation ratio.
- (EU) 2023/1230 — Provides the EU machinery conformity and instruction framework applicable from 20 January 2027.
- Türkiye Machinery Safety Regulation — Regulates machinery conformity and instructions in Türkiye; Official Gazette 16 October 2026 / 33402.
- ISO 230-2:2014 (+Amd 1:2016) — Tests positioning accuracy and repeatability of numerically controlled axes by direct measurement.
- EN 1093 — Evaluates airborne hazardous-substance emissions from machinery; the link is to the reference in ISO 11553-1:2020 §4.1.
- ISO 14123 — Addresses risks from hazardous substances emitted by machinery (Parts 1–2); the link is to the reference in ISO 11553-1:2020 §4.1.
- ISO 21904-2:2020 — Defines testing and marking of separation efficiency for welding and allied-process fume equipment; not a single-cartridge test.

ISO 9013:2017/Amd 1:2024 · ISO 9013:2017 (u, Rz5) · Linde · Messer · Raytools BM115 · BEKO · EN 12626 · EN 207 / CE · ABB · Pilz

1. **Maxphotonics MFSC/MFMC cutting data**
   https://www.forum.linuxcnc.org/media/kunena/attachments/22451/null.pdf
   Local manufacturer PDF text: kaynak_veri/max_mfsc_500-6000W.txt. Main 1/1.5/2/3/4 kW data. Copied 500W footnotes checked against page headings.; Offline text: kaynak_veri/max_mfsc_500-6000W.txt; URL from brief_A.md, not opened online. Used in chapters 07, 08 and 11 for recipes, focus, nozzle, optics and reduced power in thick O_2 rows. Full rows are in chapter 9; this document supplies no copper piercing/cutting recipe.
2. **KRRASS 3000W cutting parameters**
   https://www.krrass.com/3000w-fiber-laser-cutting-machine-cutting-parameters/
   Local HTML. Only the missing 1–2 mm mild steel N_2 rows in the Max 3 kW table.
3. **KRRASS 6000W cutting parameters**
   https://www.krrass.com/6000w-fiber-laser-cutting-machine-parameters/
   Local HTML. The 50 µm single-module table was selected from three tables; lower neighbor for 8/10 kW interpolation.
4. **KRRASS 12 kW cutting parameters**
   https://www.krrass.com/12kw-fiber-laser-cutting-machine-cutting-parameters/
   Local krrass_12kW_50um.html; 50 µm, 100/125. Damaged 6 mm brass speed cell omitted and recorded in veri_raporu.md.
5. **KRRASS 15000W cutting parameters**
   https://www.krrass.com/1500w-fiber-laser-cutting-machine-cutting-parameters/
   URL label 1500W; content 15000 W and 100 µm multi-module. Alternative recipes with the same key retained.
6. **bestsheetmetalmachine 4000W cutting parameters**
   https://www.bestsheetmetalmachine.com/4000w-laser-cutting-parameters/
   Local HTML fills missing Max 4 kW rows. Verify these recipes' head/optics separately.
7. **bestsheetmetalmachine 30000W cutting parameters**
   https://www.bestsheetmetalmachine.com/30000w-laser-cutting-parameters/
   Local HTML. 30 kW mild steel/stainless steel; aluminum/brass/copper rows with 20000 W cutting power assigned to 20 kW. Proofing marks retained as ◆.
8. **Linde — Laser cutting advice**
   https://static.prd.echannel.linde.com/wcsstore/REN_Industrial_Gas_Store/Laser-cutting-advice-EN.pdf
   Local text. Diagnosis by speed, gas, nozzle, standoff, material and optics. CO_2-specific mirror/helium notes are not fiber-system instructions.; Offline text: kaynak_veri/linde_laser_cutting_advice.txt; URL from brief_A.md, not verified online. Used for gas purity, flow/pressure, centering, surface, dross and burning. 100 ppm and 0.1% mean O_2 contamination in N_2. CO_2 mirror, helium and polarization advice is not fiber-laser maintenance guidance.
9. **FSCUT1000S user manual**
   https://purelogic.ru/docs/termicheskaya_rezka/controller-FSCUT1000S_user_manual_en.pdf
   User-supplied reference; no full local copy, so page/menu quotations were not verified. Follow the actual controller/BCS100 version manual for homing, drawing and calibration.

10. **DOKTEK — Turkish sample guide v2, 9.2 dross diagnosis**
    ornek_tr.html

    Local project document. Content 9.2 moved to 13.2 and expanded with striations, taper and dimensional errors. One-variable trials retained; sample cutting speed tables not copied.; Control sequence and steps/pill structure used for 17.1; focus-test reference updated to chapter 11. Sample numeric cutting changes, gas purity and temperature ranges omitted; centering follows the manufacturer's protected test method.

11. **DOKTEK — Turkish sample guide v1, galvanizing and focus**
    ornek_tr_v1.html

    Local document. Zinc fume, protective-window contamination and no-O_2 warnings adapted to 10.3; +/0/– focus diagram to 11.1. Sample numerical speed/gas tables not transferred.

12. **DOKTEK — Work B brief and shared writing rules**
    brief_B.md

    Local scope document, used with KILAVUZ_YAZIM_KURALLARI.md. Covers nesting/software, techniques, gas purity/air preparation, 50/100 µm, general height and piercing frequency/duty. These are not approved machine recipes. Verify software version/license and postprocessor.

13. **Work C — verified information and chapter scope**
    brief_C.md

    User-supplied local verification summary for chapters 14–17 and appendices. No network or online manufacturer documents used. No menu paths, alarm codes or model capacities inferred.

14. **Maxphotonics MFSC-500–6000 W — local cutting data**
    kaynak_veri/max_mfsc_500-6000W.txt

    Local fiber core and optical conditions reviewed. Data is reference-only for different equipment/environments. No numerical cutting parameters copied here; use chapter 9.

15. **DOKTEK shared writing and technical rules — TR, Version 1.0**
    KILAVUZ_YAZIM_KURALLARI.md

    Local rules for Turkish terms, procedures, HTML fragments, chapter numbers and photo/screen placeholders. Maintenance times are planning estimates, not model-specific instructions.