Schrems

How to get Maximum Lifetime of Trotec CO_2 Lasertubes

Most oft he following information is based on general technical knowledge and valid for ALL RF-excited sealed-off CO2 lasers – not depending on the laser source manufacturer or on the system where the laser source is embedded.

1 CO_2 Laser basics

A CO_2 laser has carbon dioxide (CO_2) as active medium. Energy transfer into the laser active medium (denominated as "pumping") is done electrically via antennas (for all Trotec CO2 lasers) which emit at a frequency from about 40MHz to 90Mhz. The efficiency (RF power in to laser power out) of a pulsed CO_2 laser is about 10% - 15%. That means that the emitted power from the antennas can exceed 1kW to get 100W laser output power. The RF pumping leads to a (high-pressure) gas-discharge in the gas-reservoir of the laser. Gas-discharge is also a process in a fluorescent lamp.
High quality lenses for CO_2 lasers are made of Zincselenide. CO_2-mirrors are made of aluminum, silver, copper, gold (reflectivity: 99% - 99,5%) OR dielectric (reflectivity up to 99,9%).

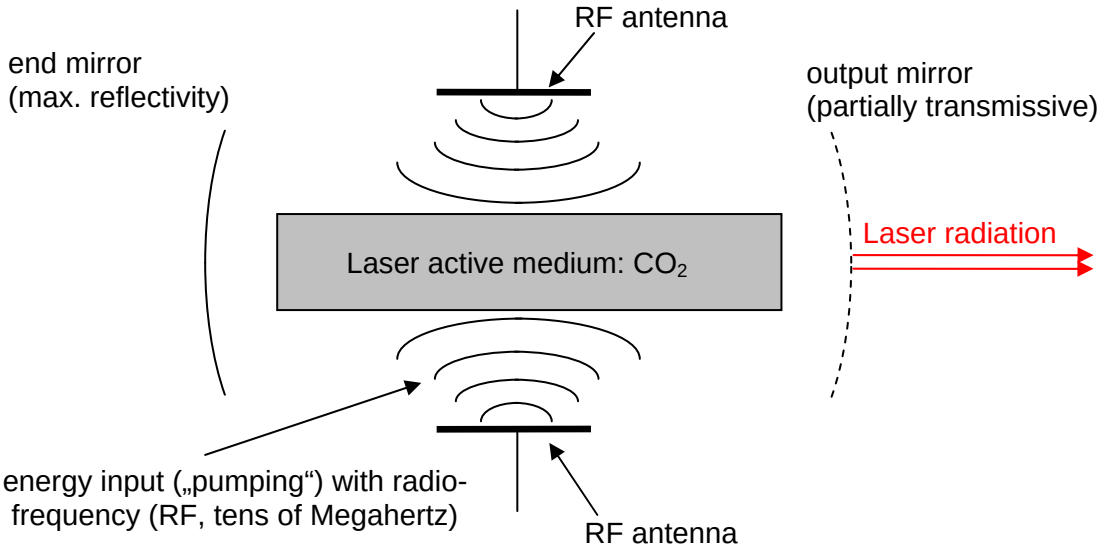

Fig. 1: schematic drawing of a sealed-off CO_2 laser

2 Components of a CO_2 laser

A CO_2 laser consists of the laser resonator (see Fig. 1), power electronics and control electronics. The laser resonator components are the gas reservoir (which contains the laser active medium), the end-mirror and the output mirror. The power electronics drive the antennas which emit at least 100 Watts (for a 12W laser tube) at a frequency of tens of Megahertz. Control electronics switch, modify and / or monitor electrical signals like interlock, tickle pulses, 5-second-delay, status LEDs and others.

3 Ageing effects: operating hours, storage hours, ambient temperature

A CO_2 laser ages due to 3 factors:

1. **increasing lifetime (even without operation)**
2. **operating hours**
3. **ambient temperature**

1. The gas reservoir has a lower gas pressure compared to atmospheric pressure. Although sealings are very hermetic, **air diffuses over time into the gas reservoir** and contaminates the laser active medium. This leads to loss of power over time (typical very few percent per year).

2. The laser source also ages due to operation since **waste heat** leads to high temperatures on the RF driver power electronics. **Semiconductors** (in transistors, diodes, … of the power electronics) **age exponentially with increased temperature**. As a rule of thumb: An increase of 10°C in a semiconductor halves life-time.
Heating and cooling of the complete gas reservoir can lead also to increased leakage rates through the sealings. That means that air comes at higher rates into the gas reservoir. Waste heat increases with increased emitted power, duty cycle and repetition rate (often denominated as “frequency”).

3. ambient temperature too low or too high
3a. High ambient temperature: The waste heat of the laser yields in a temperature increase in the complete laser source. The higher the ambient temperature the higher is the peak temperature which leads to fast ageing of the laser tube. Air-cooled tubes: The higher the nominal power of the tube the more critical is the ambient temperature. Most aircooled tubes have a derating, i.e. output power lowers typically 0,5% - 1,5% per degree Celsius above a certain temperature level (e.g. t-series laser: 22°C (!)). Water cooled tubes should be operated below 30°C in any case to prevent condensation.
Although the ambient temperature is in the desired range the lasertube can overheat if **air circulation** is inhibited. **Cooling fans should have at least 0,5m free distance**. The rear side of 45W laser models should have 0,3m distance to the next wall since air take-in occurs via the rear side. If the laser is very close to the wall then the fans lose efficiency. The laser must not be placed close to a heat source because then the laser is insufficiently cooled with already warm air. Room temperature could be optimum 22°C but if the laser is close to a heater then the air intake volume (i.e. locally) will be clearly above those 22°C.
All air-cooled Trotec lasers emit the waste heat upwards. Cooling slits must not be covered and a free distance of 1m upwards must be established. The stream of waste-heat air must not be inhibited by a fan which blows air from top to bottom (i.e. AGAINST the air flow direction of the cooling fan).

3b. Low ambient temperature: If ambient temperature is too low then the ignition of the gas-discharge can take quite long. This means that the power electronics has to handle very high currents over relatively long times. This causes additional wear to the power electronics. Partially this behavior is similar to a fluorescent tube which also shows starting problems at low temperatures. When a laser is powered on in a cool room then the poor ignition behavior of the cool gas can lead to missing first lines in a job (the axis system moves but there was no laser emission). Applying high levels of RF power into a gas reservoir of a CO2 laser which has NOT ignited yet, leads also to backreflection which yields in additional wear of electronics.

Low air pressure: Air cooling efficiency DECREASES with decreasing pressure of the surrounding air. Therefore **all air-cooled lasers should be operated below certain heights** (above sea level). High power lasers above those limits should be watercooled.

Laser Power [W]	Max. Height for operation (above sea-level)
12; 25; 30	2500m / 8200ft
45	2000m / 6600ft
60; 80; 100	1500m / 5000ft

Generally any job which is done at high power and high duty cycle (e.g. cutting jobs) leads to strong warming of the tube. If during such a job the laser emission stops and can only be restarted by switching off the laser, waiting for at least some minutes and then restart, then you already operate the tube in a temperature regime which will lower laser life expectancy seriously.

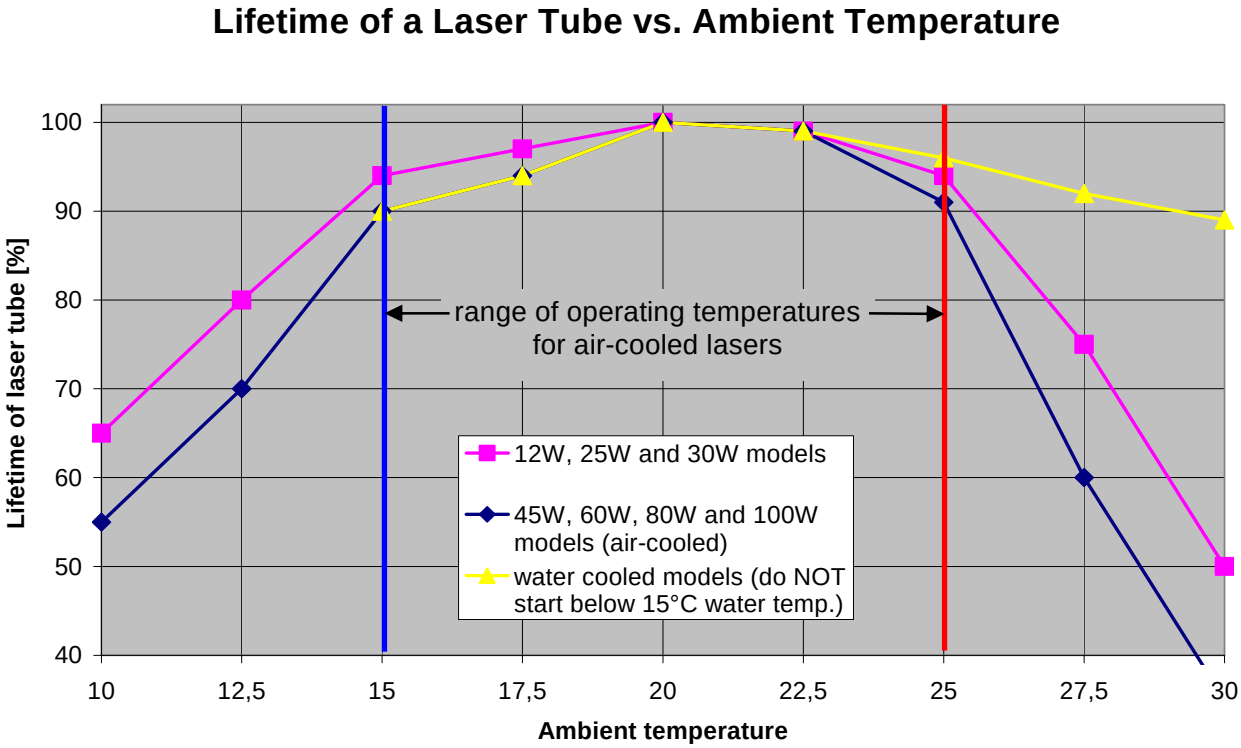

Fig. 2 Lifetime of a CO_2 lasertube vs. ambient temperature, water cooled tubes do not start at water temperatures below 15°C, condensation must be prevented in water cooled tubes

4 Conclusion

- ***Operate your air-cooled CO_2 laser system at around 20°C and below 1500m (5000 ft) above sea-level for 60W or stronger lasers, below 2000m (6600 ft) for 45W lasers and below 2500m (8200 ft) for air-cooled lasers up to incl. 30W.***
- ***Temperatures above 25°C reduce lifetime significantly!***
- ***Too low temperatures (below 15°C) are as destructive as too high temperatures!***
- ***Ensure that cooling fans have enough in-take volume and enough space so that the fans can transport away waste heat effectively.***
- ***Water cooled systems can only be started above 15°C water temperature. Condensation must be prevented under any circumstances.***
- ***Any laser which has 60W or more and which should be placed above 1500m (5000 ft) above sea-level should be water-cooled.***
- ***12W, 25W and 30W lasers are very robust and relatively tolerant by means of ambient conditions. Air cooled lasers at higher powers suffer SIGNIFICANTLY when they are operated outside the above specifications.***