LEAFLET Cooling Water Additives

Lasers have become an indispensable part of industrial material processing. However, they still have a relatively low efficiency of between > 5% and < 50%, depending on the technology. The resulting power loss in the form of heat must be cooled down. For power ratings of up to approx. 50W, this can still be achieved using air cooling measures with appropriate heat sinks and fans.

However, from about 100W laser power at the latest, water cooling must be used as a much more efficient heat transfer. And that is where the dilemma begins.

1. "WATER", a broad term.

1.1. Clean Tap-water / Tap water

in Central European regions is sometimes clean drinking water with varying concentrations of salts and minerals. Chlorine is often added to kill pathogens in the water that can cause illness in humans.
However, this type of water is usually suitable for cooling laser cooling circuits, provided a few basic rules are observed (see 5.2. Standard additives).

1.2. Contaminated Tap-water / Tap water

can, however, also be heavily polluted in many regions of the world and contaminated with a wide variety of pathogens. It is not uncommon for water to come out of water towers or storage tanks in factories whose water is used over and over again without being purified in the meantime.
This type of water must be cleaned of suspended solids with appropriate filters before it is used as cooling water. In addition, it is mandatory to use biocides to prevent the growth of fungi and algae.

1.3. Deionized / Demineralized / Distilled Water

This treated form of water contains no or hardly any mineral ions or pathogens and can be described as highly unsaturated. That is, it is aggressive when it encounters soft metals and supports electrochemical series with appropriate metal combinations.

The difference between demineralized or deionized water and distilled water is that demineralization / deionization removes salts and minerals but not pathogens and other microorganisms. However, distilled water is not required for laser cooling.

The advantage of demineralized water is the low conductivity in the water, measured in µS/cm. Only the free mineral substances in the water cause current conduction.
The more mineral substances there are in the water, the greater the conductance and the lower the electrical resistance.

2. When do you need demineralized water?

Laser manufacturers often build their own coolers into their high-power lasers, which can cool and temper both the laser itself and the connected optics. In such a case, the environment of the cooler is made of stainless steel, including its heat exchanger.
Connected optics such as collimators and fixed optics are often also made of stainless steel. Stainless steel does not bond in any way, even when in contact with demineralized water.
No oxidation occurs.

In such a cooling circuit there is often a conductance of < 10µS. If an additive were present, the conductance would quickly rise to 1000µS and more.

Some laser manufacturers measure the conductance in the cooling water and, if a certain value is exceeded, issue an alarm that causes the laser to shut down or block operation. These alarm thresholds vary, but are often exceeded even with a small amount of additive.

Now one would like to think that in such a circuit, if it is also designed to be protected from light, no additive is needed at all. This was the hope of many laser manufacturers, who had to be proven wrong in practice.
After a certain time, germ formation, the growth of fungal cultures or even algae always occurs, mainly caused by residual microorganisms in the demineralized water.

3. Measures for cleaning polluted water:

Pore filters should have a maximum pore size of 100µm.
If the cooling water on the house side shows strong proportions of microorganisms, activated carbon block filters should be used. Monobloc activated carbon filters can very reliably remove heavy metals, pesticides, drug residues, chlorine and many other organic substances from the water, but leave all dissolved minerals (including lime) in the water.
Therefore, the conductance should not change as a result, but the final filtered water should be many times cleaner.

	If demineralized or deionized water is not expressly specified for a laser system by the laser manufacturer, clean tap water plus the use of a porous filter + suitable additive is always preferable. An equal mixture of tap water and demineralized water can also be a useful alternative to increase cleanliness.

4. What are additives?

Additives are substances added to the cooling water that can usually have 3 different effects.

4.1. Antifreeze effect:

Some additives always contain a certain amount of antifreeze (e.g. polypropylene glycols), which provide important services especially during transport and storage of laser systems, because the cooling circuits usually cannot be blown completely free of water.

4.2. Biocides:

Biocides prevent germ, fungal and algae growth, but should be renewed at least annually.

	All piping and tubing of cooling water circuits must be impermeable to light. Sunlight promotes the growth of germs, fungi and algae!

4.3. Inhibitors:

Inhibitors are additives to prevent corrosion.

Both when using tap water and, to a much greater extent, when using demineralized water, corrosion in the form of pitting corrosion can occur after different points in time if 2 soft metals such as aluminum and copper are in the same cooling circuit. A conductive connection is created via the medium of water, which enables an exchange of ions when there is a corresponding electrochemical series between the metals.

Practical example:
Recirculating chillers are often used for laser cooling that have copper-brazed heat exchangers. Without corrosion protection in the cooling water, aluminum ions are released from the cooling channels of the deflection units (pitting corrosion). These migrate to the copper of the plate heat exchangers and settle there. The result is a reduction in cooling capacity and even damage to the plate heat exchangers of the cooler.

Chiller recommendation:

	If an external recirculating chiller is needed for a laser system, the customer should not be afraid to invest in a recirculating chiller with a nickel-brazed plate heat exchanger in the interest of long, repair-free operation of the system. Many manufacturers of recirculating chillers for laser systems offer these. This increases the reliability of all aluminum cooling circuits.

Avoid soft metals in cooling circuits:

	Only materials should be used for the external cooling circuit where corrosion will not occur. Aluminum, zinc, mild steel and materials made of cast iron, copper or even brass are unsuitable. Stainless steel is particularly suitable as transition pieces (fittings), but nickel and PVC are also suitable.

5. Which additives we recommend:

5.1. Food industry:

In the food industry, only additives that do not lead to any health hazards when residues come into contact with the end product are permissible if the machine is designed as intended. Such an end product can be a packaging film for a food product.

If this is the case, so-called polypropylene glycols must be used, which have different advantages but also disadvantages.

We recommend at this point the product of the company Dow Chemicals "Dowcal N".

Advantages of polypropylene glycols:

- Harmless with regard to possible contamination and the resulting potential health hazard.
- Frost protection is largely given. When transporting or storing a machine, the cooling circuit can be flushed with pure Dowcal N to prevent damage from frost.
- At a standard dosage of approx. 33% in the cooling water, sufficient protection against germ, fungus and algae growth as well as corrosion is provided.

Disadvantages of polypropylene glycols:

- Lubricating liquid with reduced viscosity compared to water.
- High proportion of the additive in the cooling water (approx. 33%). Therefore large containers in purchase.
- Strong increase of the conductance in the cooling water (typically 3 mS)
- Heat transfer is reduced by approx. 10%, therefore the cooling capacity of a recirculating chiller must be designed approx. 10% higher.
- Recirculating chillers which are to be operated with polypropylene glycol must have suitable seals in their pumps.

5.2. Standard additives

	As a general rule, additives must contain at least one biocide component and also one corrosion protection component, regardless of the type of cooling water.

Inhibitors are needed to prevent corrosion in cooling circuits.

Our recommended product from NALCO is TRAC105A_B.

This additive can be purchased as an extract for percentage admixture into the cooling water. Such concentrates are usually declared as dangerous goods, which entails appropriate measures during transport and goods reception.
At the same time, TRAC105A_B acts as a biocide.

	These highly concentrated additives are added to the cooling water in only small quantities and have a corrosive effect on skin contact. Gloves and eye protection must be worn.

Alternatively, a ready-mix is offered, a so-called "Pre-Mix".

Our recommended product from NALCO is the Pre-Mix CCL105, based on TRAC105A_B.

Advantages of TRAC105A_B, CCL105:

- TRAC105A_B and CCL105 are suitable for cooling circuits where stainless steel, non-ferrous metals and aluminum are used. It is also possible to use carbon steel in the cooling circuit with this additive.
- This additive has a very low conductivity and also has the property of being biologically stabilizing.
- As a pre-mix, CCL105 is not classified as a hazardous material.

5.3. Other NALCO products with different applications:

Inhibitor Nalco 73199:
Nalco 73199 is suitable for cooling circuits using stainless steel, non-ferrous metals and aluminum, but not suitable when carbon steel is used. Nalco 73199 is used as a concentrate for percentage admixture in cooling water.
As a concentrate, it is declared as a hazardous material, which entails appropriate measures during transport and in the goods receiving department.

Nalco 73199 has a low nutrient content, which is advantageous in a cooling water circuit.

Biocides Nalco 7330 and 77352NA:
Both biocides are based on the same raw material. Nalco 7330 is approved in most European countries. Nalco 77352NA is approved in the USA and is also produced in the USA. In Asia, Nalco 7330 is mostly used.

Nalco 7330 and 77352NA are used as concentrates for percentage blending. They are therefore declared as dangerous goods, which entails appropriate measures during transport and in the goods receiving department.

5.4. Other instructions when using inhibitors and biocides from NALCO:

- It is important that a pH value between 6.5 and 8.5 is set in the cooling circuit.
- The cooling water should have the lowest possible nutrient content.
- As a maintenance measure, it is recommended to carry out measurements of conductivity and microbiology at regular intervals.
- An annual replacement of the cooling water is recommended.

6. Customer wants to use own additive or supplier

It happens again and again that customers ask us if they can use a certain additive.

	RAYLASE is not in a position to judge whether an additive from a different manufacturer can be used than the additives recommended by us from the manufacturers NALCO and Dow Chemicals. We do not have the necessary knowledge of the chemical substances in the additives for this.

6.1. Assistance to the customer:

The following points should be discussed by the customer with his desired additive manufacturer:

Materials in the cooling circuit:

1. Cooling circuit of RAYLASE deflection unit made of aluminum or stainless steel?
2. Optical components such as collimators and sensor adapters, material of the cooling circuit?
3. Laser used, material of the cooling circuit?
4. External recirculating chiller:
   - Pipes cooling circuit (not refrigeration circuit) made of PVC, stainless steel, copper or other material?
   - Plate heat exchanger made of stainless steel or other material?
   - Brazing of the individual plates of the heat exchanger with copper or nickel?
5. External material of piping or tubing between recirculating chiller, laser, deflection units and other optical components, transition and manifold pieces?

If this material mix is known, the additive manufacturer can assess whether and which of his additives can be used.

IMPORTANT!
As a rule, the additive must always contain both a component for corrosion protection (inhibitor) and a component against germ formation, fungal and algae growth (biocide).
Only if no electrochemical series can arise due to the different substances in the cooling circuit (e.g. stainless steel, nickel, PVC pipe in the cooler, fabric hose to the laser and deflection unit, aluminum heat sink in the optics circuit) can an inhibitor be dispensed with.