SOME CONSIDERATIONS FOR EM COOLING SYSTEMS

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Introduction:

For numerous reasons a closed-circuit water cooling system is the preferred option for providing cooling water to the electron microscope. Cooling water is required by the electron microscope to cool the diffusion pumps and to keep the electronics' and column temperature stable.

A closed-circuit water cooling system is essential if the local water supply has a high chloride concentration, has floating particles, is acidic, has a water temperature that fluctuates and is uncontrollable. This potentially leads to specimen drift problems in the TEM, and/or has a water temperature that is very cold. This potentially leads to condensation problems or diffusion pumps not functioning properly in the TEM.

Closed-circuit cooling systems have many advantages which include providing significantly better control of the cooling water temperature through "heat-producing" equipment and are less susceptible to biological fouling (from slime and algae) and to the build up of scale deposits. Because of the small water "top-up" requirements, control of potential problems is greatly simplified.

In many areas closed systems are required by local by-laws because open systems (i.e., connected to town supply) are extremely wasteful of water.

It is usually recommended that closed systems should be filled with distilled water to eliminate the formation of scale deposits in the water lines. Conditions in the closed system can be favourable for the growth of algal or bacterial slime, however this is prevented by adding a biocide to the water, and by the occasional replacement of the water.

Algal growth can also be retarded by excluding light from the system, such as by keeping the reservoir tightly covered, and by using opaque tubing for cooling water lines. A filter should be installed on the water line to the microscope to collect any algae that do grow in the reservoir, thus preventing the algae from entering the cooling lines. This filter must be cleaned or replaced periodically.

Another point to consider is that the use of different metals in a water circuit can give rise to electrolytic corrosion. This is potentially serious, as part of the water conducting pipework inside the electron microscope could fail.

My problem:

With the installation of our new TEM (Philips CM100), I decided it was time to review the additives we had been using in our closed-circuit water cooling systems. We have two systems, one for cooling our Akashi 002A TEM and the other system for cooling a Philips 410LS TEM and a Philips CM100 TEM. Both systems ran different additives; this was a historical situation.

My first aim was to find out more about the need for additives in the TEM cooling system and my second aim was to settle on one additive that I could use in both of our TEM cooling systems.

There are a number of factors to be considered when choosing such an additive:

1) The anti-corrosion function; over the years I had heard a few horror stories about the inside of TEM lens coils "rusting' away due to the fact that no precautions had been been taken against corrosion.

2) The anti-microbial requirement; stopping bugs growing in the system and clogging up filters and small water lines.

3) The additive should not be depleted too quickly nor require the regular replacement of all the water in the cooling system and the additive activity must be replenishable. Each of our two reservoir tanks hold 160 litres of water and I didn't want to frequently replace these volumes.

To start off, I decided to seek advice from the Microscopy listserver. It is here I found the widest range of opinions.

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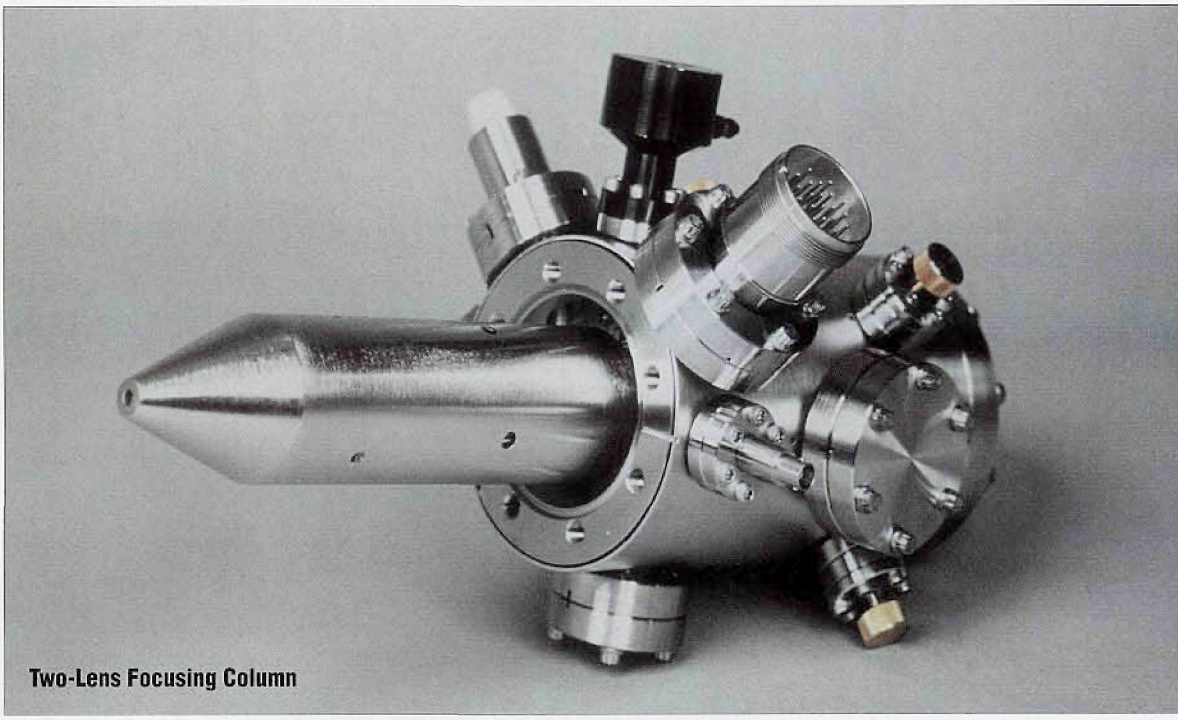
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Next I consulted some water experts. Interestingly it turned out that those who could advise me about keeping bugs out of the system could not give me much advice about corrosion and vice versa.

Our Solution:

Through BDH I had discussions with Coalite Chemicals, the supplier of a wide range of biocides.

They recommended a product called Phylatol. Phylatol is an aidehyde biocide, has a pH of 7.0 and contains no metal ions. It is a broad spectrum biocide with the same activity as Panacide M but with a neutral pH. They also indicated that the pH of the water containing Phylatol could be adjusted up slightly if desired. I had indicated that I would like to use a pH of 7.5 to 8 and would like to adjust the pH with Sodium Bicarbonate.

We are going to use Phylatol at a concentration of 0.2% and make it up in filtered tap water.

We will buffer the Phylatol to pH 8.00 with Sodium Bicarbonate. This requires only a very small amount of Sodium Bicarbonate, approximately 0.3 gram in 2 litres of water.

Some other interesting points:

The dimensions of the water channels within the electron microscope are often quite small. It is very important to exclude fibrous or particulate matter from these pipes both during assembly of the water lines and during cleaning of the reservoir tanks.

In addition to the filter at the reservoir, wire or plastic gauze filters are usually included in the water circuit of the electron microscope. These filters also require occasional cleaning.

We have had personal experience with the frustration of insufficient water flow only to eventually find a lump of plumbers hemp (or something similar) lodged in a lens coil cooling line restricting the flow.

Ideally the materials to construct a closed circuit cooling system should have smooth surfaces to resist being colonized by microorganisms. Bacteria tend to grow on a solid surface but they cannot lodge onto a surface while a brisk flow of water is maintained. It is advisable to avoid areas of 'stagnant' water, where possible, in the reservoir. Bringing the return into the tank in such a way that promotes a swirling motion is one way of doing this.

It is believed that the lid of the reservoir tank can be a good habitat for bacteria. It is constantly wet but has no flow to prevent growth. To counter this, some of the return water should be directed at the lid, keeping it scoured. Also, a small UV lamp should be located in the air space at the top of the tank to inhibit microbial growth.

Storage tanks should be smooth walled inside with a conical or dished bottom so that water can be drained completely at the time of water replacement.

Pumps with a small number of large vanes should be avoided and instead use a pump with a large number of small vanes, an Archimedes screw type pump being the best. This is to reduce pulsations in the water line which could potentially lead to specimen movement in the TEM.

The pump should be able to deliver a greater pressure than required as pressure drops off quickly In small lines. It is a good idea to use large lines right up to the EM.

To help eliminate pulsations it is suggested that a coil of copper pipe (with several coils) be located beside the pump and a long run of plastic tubing rather than metal pipe be used to the microscope. If the problem is very serious, a rubber diaphragm system with air above the diaphragm to compress will help. If using copper tubing at all, to prevent earth loops it must not connect to the microscope.

Right angle bends in the plumbing should be avoided as these can also set up turbulence in the water which can lead to specimen movement problems.

One last but very important aspect to consider is maintaining the correct pressure to the various pathways inside the microscope. This aspect will be the subject of my next investigation.

This is a summary of a larger report that outlines the information I was able to obtain and the conclusions I drew. If anyone would like a copy of the full document then contact me at the above email address. ■

References:

Further information about closed-circuit water cooling systems and cooling systems on the EM can be obtained from the following books:

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Jackson, P.A. and G.S. Soit. Water for the Electronics Industry. Technical Bulletin No. 33. DewPlan Designs for Effluent and Water Treatment Reprints available from: DEWPLAN (WT), Beechwood Hall, Kingsmead Road, High Wycombe, Bucks HP11 1LA, England.

Phylatol supplier: Coalite Chemicals, Coalite Chemicals Division, P.O. Box 152, Buttermilk Lane, Bolsover, Chesterfield, Derbyshire S44 6AZ, England. Fax: 0044 01246 240309