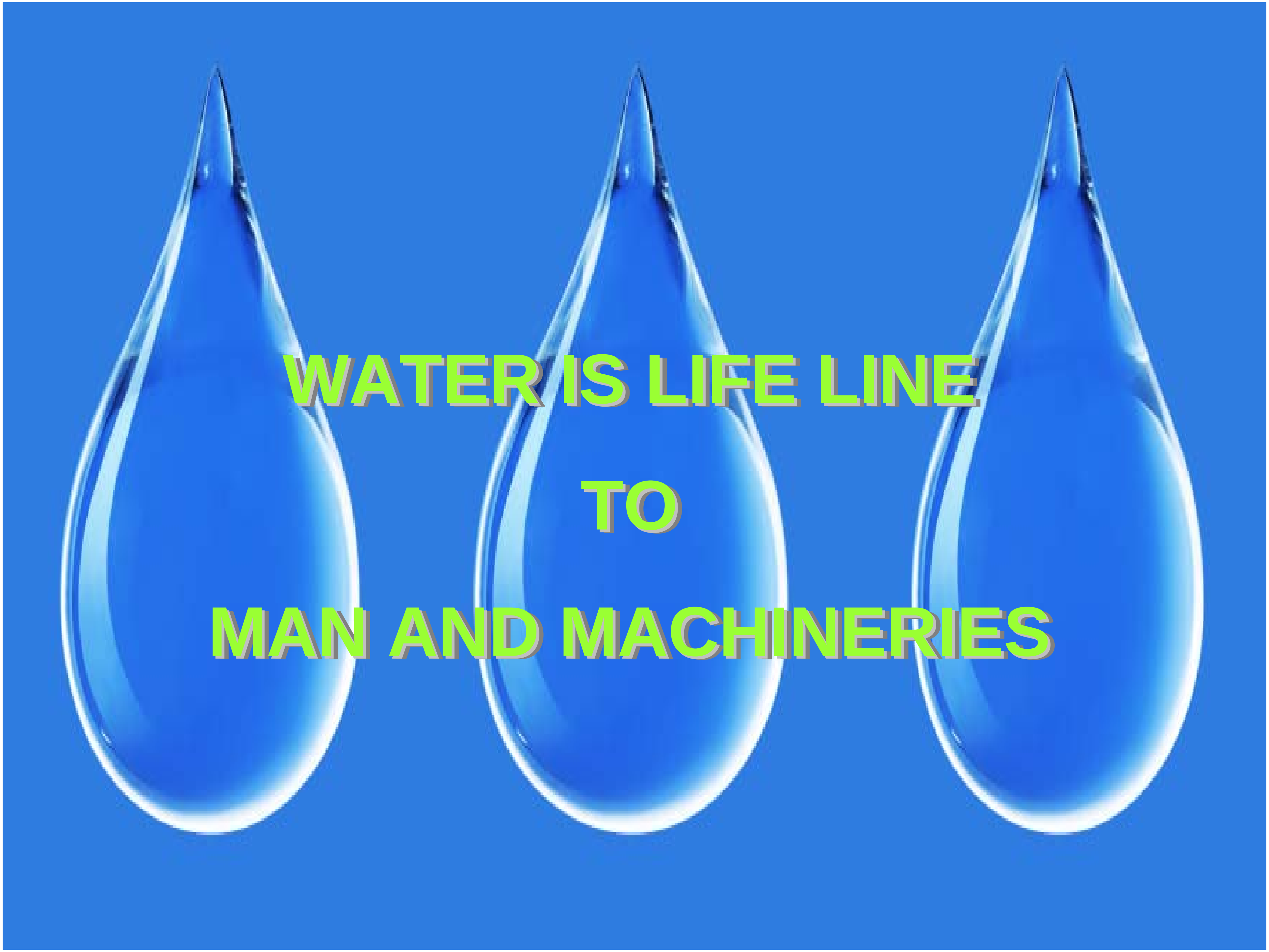

WATER IS LIFE LINE
TO
MAN AND MACHINERIES

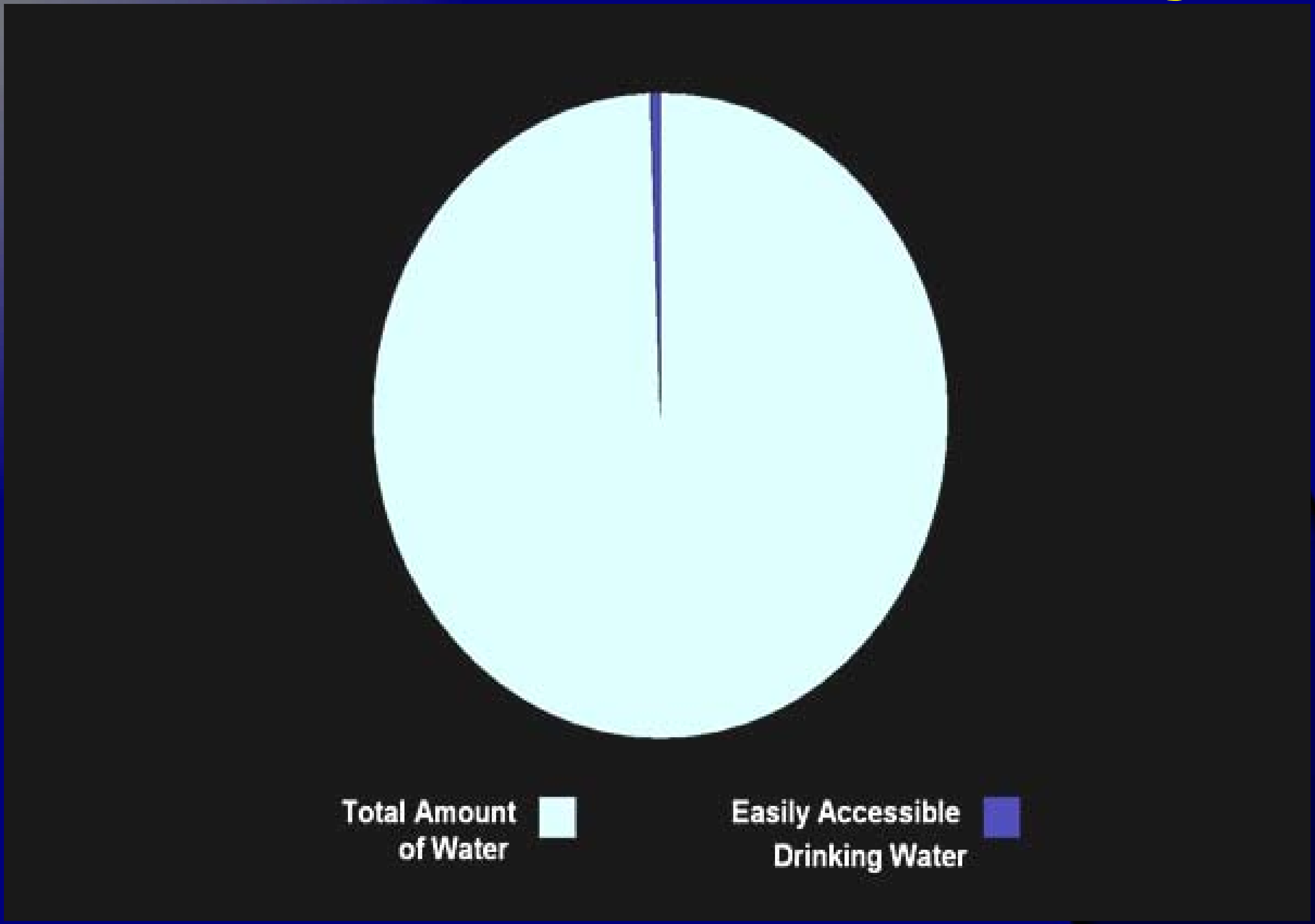
Water – as utility

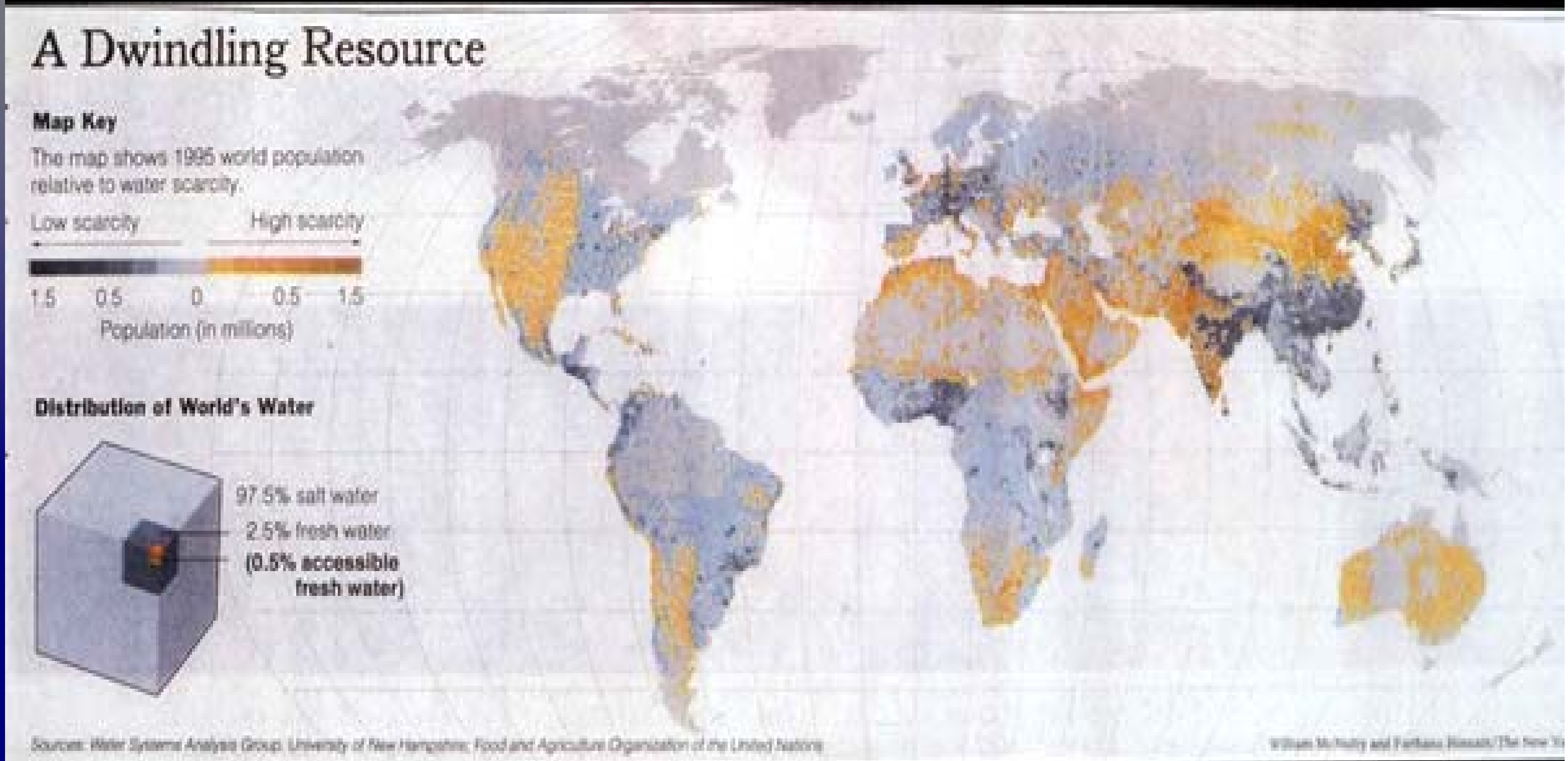
- A major use of water in industry is the transfer of heat and the production of steam.
- There is extensive use of cooling water in almost every manufacturing process, in commercial air conditioning, and even a substantial percentage in domestic air conditioning.
- Water is used in the passive sense for potable and for fire control purposes.
- Fossil and nuclear fuel steam plants are encountered in the heating and power generating fields.

Water is a key component

- Water is a key component in determining the quality of our lives.
- Today, we are concerned about the quality of the water we drink.
- Although water covers more than 70% of the Earth, only 1% of the Earth's water is available as a source of drinking.
- Yet, our society continues to contaminate this precious resource.

Water- a valuable rarity




A Dwindling Resource
Map Key
The map shows 1995 world population relative to water scarcity.
Low scarcity
High scarcity
1.5
0.5
0
0.5
1.5
Population (in millions)
Distribution of World's Water
97.5% salt water
2.5% fresh water
(0.5% accessible fresh water)
Sources: Water Systems Analysis Group, University of New Hampshire; Food and Agriculture Organization of the United Nations

Water - a key factor in industrial production

Water is a utility of primary importance for industry. For example, you need:

- 140 to 200 of water to produce 1 kWh of electricity;
- 5 to 15 liters of water to wash a microchip;
- ~ 8,000 liters of water to build a car;
- 11,000 liters of water to produce 1 metric ton of steel;
- 4 to 8 liters of water to produce 1 liter of beer.

Water management therefore has a notable impact on the **Financial Performance** of the company and its development.

Water - a key factor in industrial production

- Most industrial production processes need cooling water to operate efficiently and safely.
- Refineries, steel mills, petrochemical manufacturing plants, electric utilities and paper mills all rely heavily on equipment or processes that require efficient temperature control.
- Cooling water systems control these temperatures by transferring heat from hot process fluids into cooling water.
- As this happens, the cooling water itself gets hot; before it can be used again it must either be cooled or replaced by a fresh supply of cool water.

Water - a key factor in industrial production

- This makeup water contains dissolved minerals, suspended solids, debris, bacteria and other impurities.
- As the water continues to circulate throughout the system, other contaminants begin to concentrate.
- As the temperature rises, cooling equipment efficiency is threatened and a total plant shutdown can result.

Efficient Cooling Water Management

- Efficient cooling water management is critical to the operation of plant.

Under inadequate control, the cooling water system can present significant difficulty to the plant in

- Loss of production capacity,
- Increased cost of cleaning and protective chemicals,
- Increased energy
- Maintenance costs, and
- Reduction in service life.

Efficient Cooling Water Management

- Cooling water treatment technology has undergone a series of profound changes over the years.
- New chemicals have been developed that make possible new methods of chemical treatment.
- Environmental regulations now require strict control of the composition and quantity of cooling tower blow down discharged to receiving streams.

Efficient Cooling Water Management

States pollution control board regulations require

- Chemical and petrochemical plants to know the chemicals they use and discharge,
- To control carefully the water pollution and
- Safety aspects of working with these chemicals.

Types of Cooling Water Systems

Cooling water systems are either nonevaporative or evaporative

- Nonevaporative systems include once-through cooling and closed loop systems.
- Evaporative cooling systems include
  - ✓ Open recirculating systems in which heat rejection is accomplished in cooling towers,
  - ✓ Evaporative condensers,
  - ✓ Spray ponds or
  - ✓ Cooling lakes.

Needs of Success to CWT

Successful cooling water treatment programme must control

Corrosion, Scale, Fouling, and Microbiological Activities

All these problems are Interrelated

No one problem can be isolated from the others.

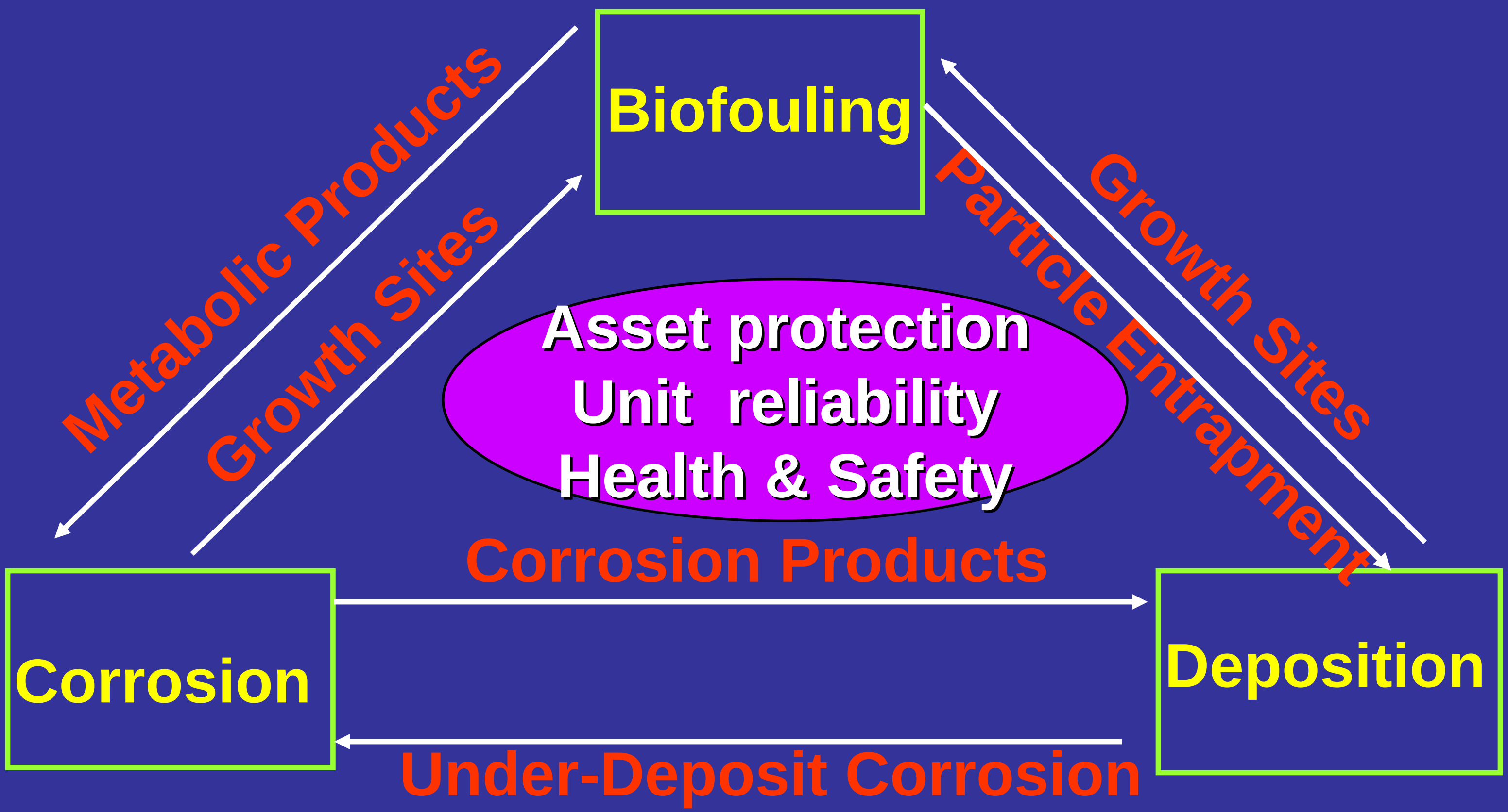
Integrated Problems to Control

- ✓**Scaling** occurs more rapidly in a corroding system
- ✓**Microbiologically induced corrosion** is a potentially-serious problem in almost all cooling system

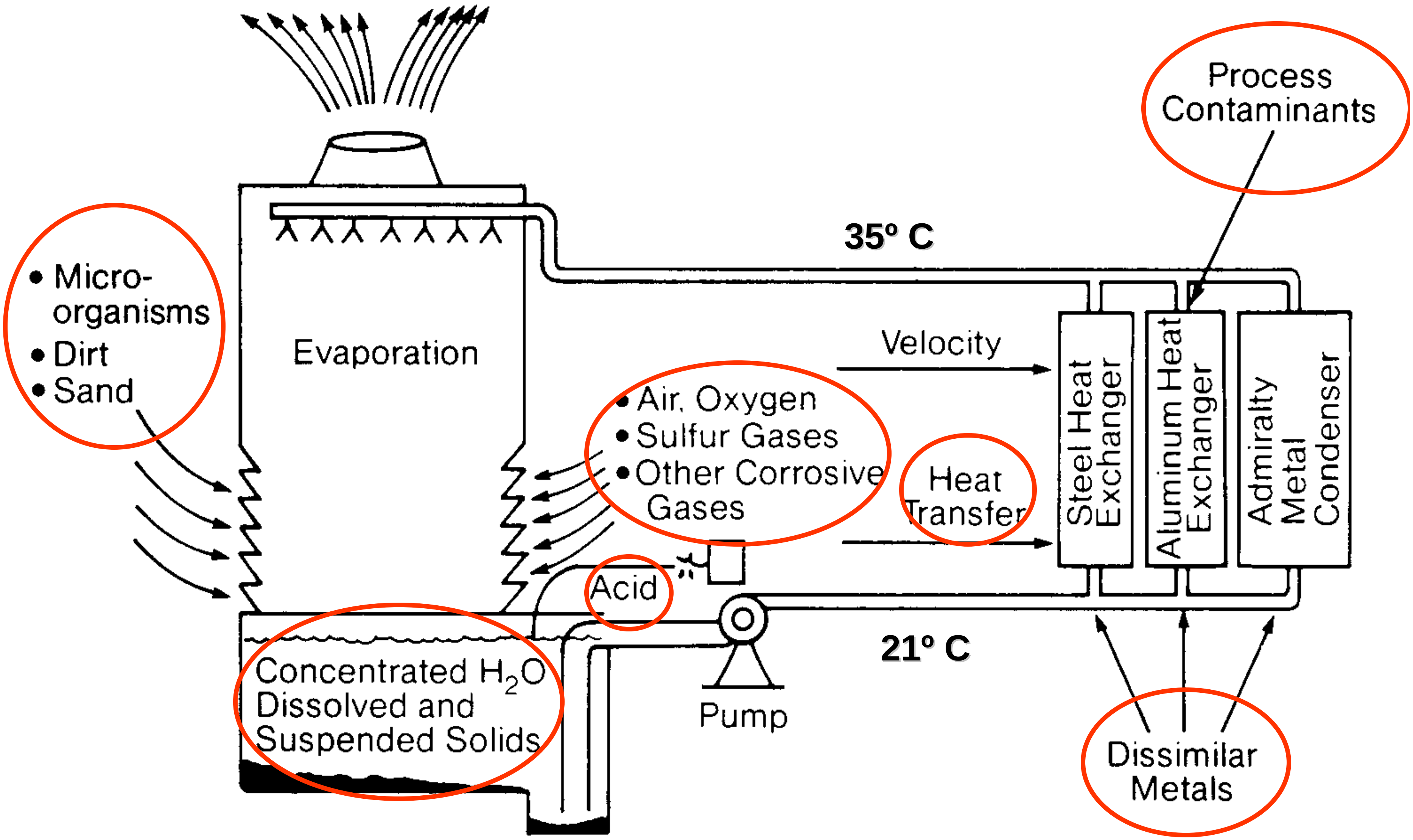
and

- ✓**Under deposit corrosion** can lead to rapid failure of otherwise unattacked metal

Water Treatment Concerns



Corrosive Factors in Cooling Tower Systems



WATER CHEMISTRY CONTROL

Based on many hundreds of surveys, it is observed that operational control of cooling water treatment programs is often neglected and that it is the

single most common cause of

WATER MANAGEMENT PROGRAMME FAILURE.

The best possible combination of corrosion, scale, and deposition control chemicals, with effective biocides, is completely worthless if not *consistently* and *correctly* applied to the cooling water.

Water - an Excellent Polar Solvent

Water, while an excellent transporter of heat and quite inexpensive, is also an excellent polar solvent which will dissolve in more, or less time just about all known materials.

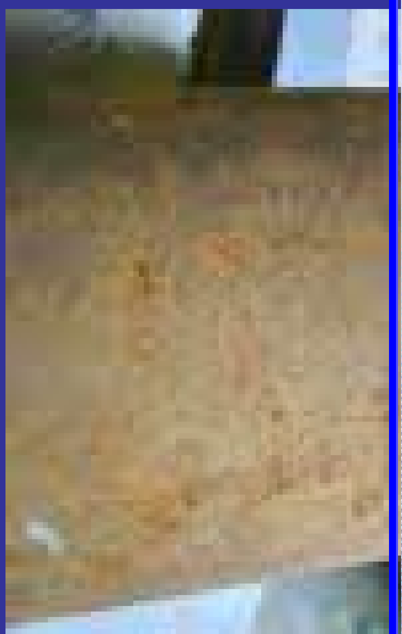
Given this fact, the chemistry of all cooling water treatment programs must begin by addressing

CORROSION

is basically an electrochemical oxidation process which results in destruction of the metals from which most cooling systems are constructed.

Iron Oxide Deposits

PRO ION



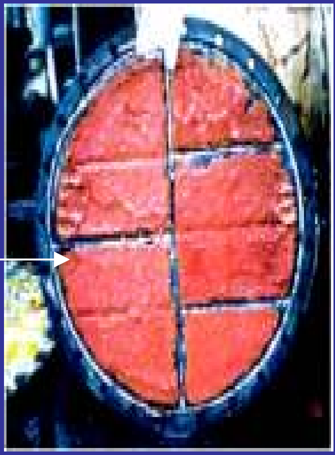
Iron Oxide Deposits, if not removed, can propagate

⇓⇓

Under deposit corrosion

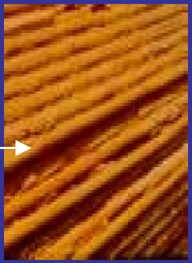
Restrict water flow

Cause blockages



Provide habitat for microbial species

Impede heat transfer



Leading to Microbiologically Influenced Corrosion

Primary Rule for Good Corrosion Control

- Keep the metal surface clean.
- Good design to avoid crevices and low flow areas,
- Good operating practices to maintain control limits and Velocities,

and

Judicious use of

- Corrosion & Scale inhibitors,
- Biocides, and
- Dispersants……

are all-important factors in keeping corrosion rates on steel within acceptable limits.

Corrosion Inhibition

Conductivity and Alkalinity

Water chemistry has profound effects upon corrosion rates. High conductivity waters are generally corrosive. Conductivity is measure of the dissolved ionic solids in the water, and increasing conductivity means that more corrosion current can flow.

It is not usually possible to control the conductivity in cooling water system, except by changing cycles of concentration.

Conductivity is always one important factor considered in selecting corrosion inhibitor programmes.

Corrosion Monitoring

The effectiveness of the corrosion inhibitor portion of a cooling water treatment program should be monitored by regular use of corrosion monitoring techniques to determine actual corrosion rates within the cooling water system.

While electronic corrosion rate meters have been developed to the point where they are often fairly accurate and quite valuable

Corrosion Rate

A good cooling water treatment programme should be able to reduce corrosion rates to the following generally accepted average levels reported as mil/yr:

Mild Steel	Aluminum	Copper Alloys	Zinc
1 to 2	1 to 2	0.1 to 0.2	2 to 4

Corrosion Inhibitor Chemistry

Chemical	Comments
Chromate	Excellent steel corrosion inhibitor, the standard against which all others are compared, banned by the United States Environmental Protection Agency for environmental reasons
Zinc	Good supplemental inhibitor at 0.5 to 2 mg/l level, some environmental restrictions, can cause scale if improperly applied
Molybdate	Non-toxic chromate replacement, often used as tracer, controls pitting corrosion control at 4 to 8 mg/l, primary inhibitor for steel at 8 to 12 mg/l, higher levels, 35 to 250 mg/l in closed loop and severe environments, very costly material, some environmental restrictions
Polysilicate	Excellent steel and aluminum inhibitor at 6 to 12 mg/l, not commonly used due to formulation difficulty

Corrosion Inhibitor Chemistry

Chemical	Comments
Azoles	Three specific azole compounds, MBT, BZT, and TTZ, which are excellent yellow metal inhibitor compounds at the 2 to 8 mg/l level
Nitrate	Specific corrosion inhibitor for aluminum in closed loop treatments at 10 to 20 mg/l
Ortho phosphate	Good steel inhibitor at 4 to 12 mg/l, needs a minimum of 50 mg/l calcium present with a pH above 7.5 to be effective
Poly phosphate	Good steel and yellow metal inhibitor at 4 to 12 mg/l, needs a minimum of 50 mg/l calcium present with a pH above 7.5 to be effective

Corrosion Inhibitor Chemistry

Chemical	Comments
Phosphonates	Includes AMP, HEDP, and PBCT, which are commonly used as scale control compounds. Fair steel corrosion inhibitors when operated with pH values above 7.5 and more than 50 mg/l calcium present
Nitrite	Excellent steel corrosion inhibitor at 500 to 700 mg/l, commonly used only in closed loops due to high level needed, attack by micro-organisms, and reaction with oxygen

Corrosion Inhibitor Chemistry

Most successful cooling water treatment programmes utilize several chemical inhibitors blended into one product to take advantage of a synergistic effect where the net reduction in corrosion from use of the mixture is greater than the sum obtained from individual components.

For example, adding 2 mg/l of zinc to a phosphonate product at 10 mg/l reduced the corrosion rate on mild steel from 2.2 mils/yr to 0.9 mils/yr.

Corrosion Inhibitor Chemistry

Substantial increase in effectiveness, almost all successful cooling water programmes use several corrosion inhibitors blended together such as:

- ✓Molybdate-silicate-azolepolydiol,
- ✓Phosphonate-phosphate-azole,
- ✓Zinc-phosphonate-azole.

The exact inhibitor chemistry must be determined by the water treatment programme supplier following an evaluation of makeup water chemistry, system construction materials, and operating conditions.

Scale

Deposition of scale is a chemical process that results when the concentration of dissolved salts in the cooling water exceeds their solubility limits and precipitates form on surfaces in contact with the water.

The most common scale formers, calcium salts, exhibit reverse solubility in that they become less soluble as the temperature of the water increases.

This property causes scale formation in the most sensitive area, the heat transfer surfaces of production equipment.

Scale

Since the thermal conductivity of scale is substantially less than metal, heat removal is reduced.

In extreme cases, enough material precipitates to physically block the cooling water passages, resulting in the affected equipment being removed from operation for either chemical (acid) or mechanical cleaning.

Factors Affecting The Scale Formation

The principal factors affecting the formation of scales in a cooling water system are:

1. Calcium content of the recirculating water
2. Alkalinity of the recirculating water
3. pH

   (Higher the pH, lower is the solubility of $CaCO_3$)
4. Temperature of recirculating water
5. TDS

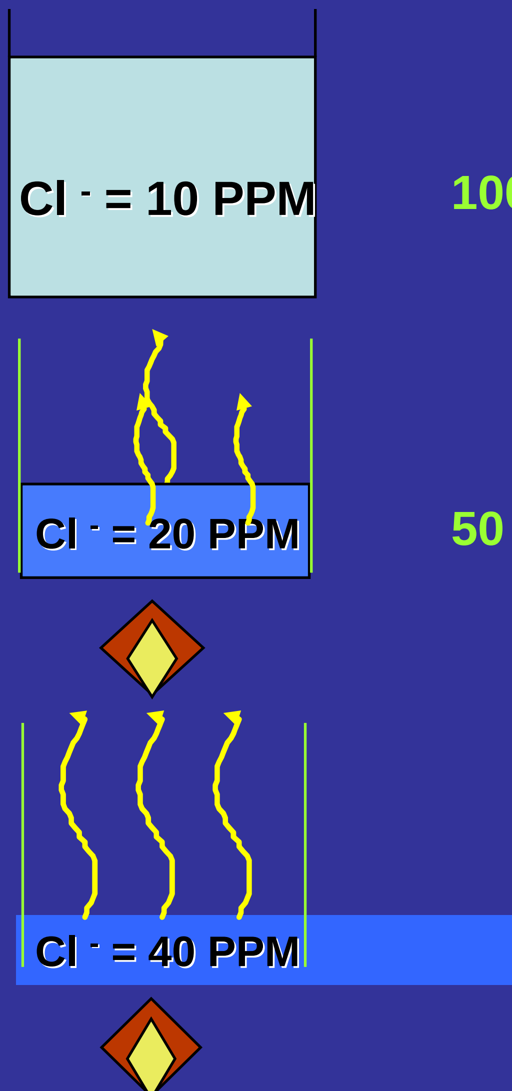
Scale Control

Scale can be controlled or eliminated by application of one or more proven techniques. Typical measures taken to control scale are:

- Controlling cycles at a set level
- Chemical scale inhibitor treatment
- pH adjustment by acid addition
- Softening of cooling water system makeup

Cycles are best controlled by installation of a high quality system for automatic blow-down based on conductivity or metered makeup.

Cycles of Concentration

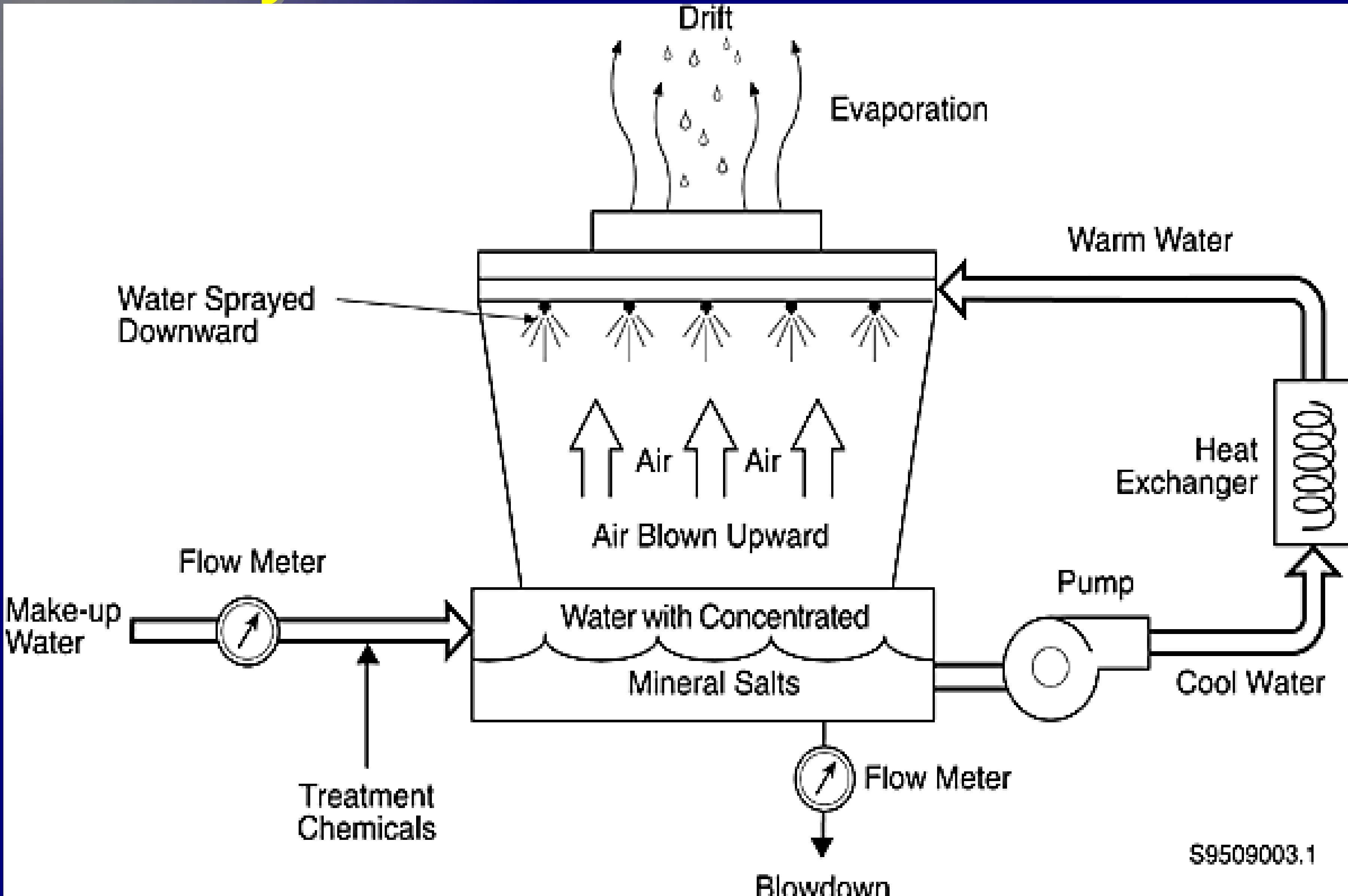


100 ml Makeup Water

50 ml 2 Cycles of Concentration

25 ml 4 Cycles of Concentration

Cycles of Concentration



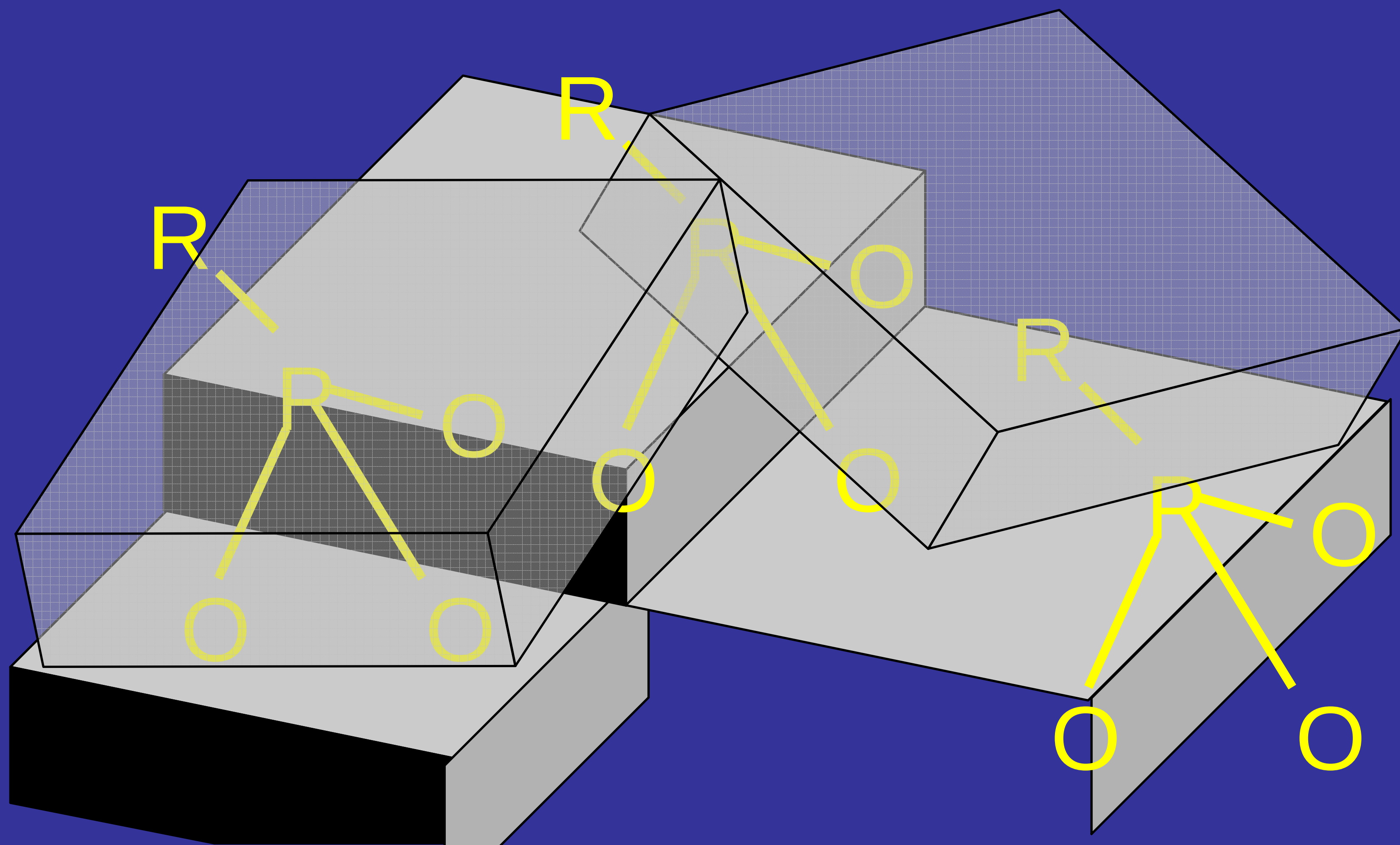
Chemical Scale Inhibitors

Chemical scale inhibitors function by either

(A) Selective adsorption on growing scale crystals, converting the crystal structure into a non-scaling type which does not form a hard scale, or

(B) Through chemical reactions with the scale forming ions, converting them into non-scale forming materials.

Crystal Modification



Chemical Scale Inhibitors

Chemical	Comments
Polyacrylate	Commonly used polymer, cost effective for calcium scale at 5 to 15 mg/l
Polymethacrylate	Less common polymer for calcium scale at 5 to 15 mg/l
Polymaleic	Very effective polymer for calcium scales at 10 to 25 mg/l, higher cost
Phosphonates	All three common phosphonates are excellent calcium scale inhibitors at levels from 2 to 20 mg/l
Chelants	Both EDTA and NTA, as well as citric acid and gluconate, have seen some limited use for calcium scale control at levels from 5 to 100 mg/l

Chemical Scale Inhibitors

Chemical	Comments
Copolymers	These products commonly incorporate two active groups, such as a sulfonate and acrylate, to provide superior performance to a single group compound at use levels at 5 to 20 mg/l, higher cost
Terpolymers	Like the co-polymers, only incorporate three active groups to give yet better performance under severe conditions at use levels of 5 to 20 mg/l, costly
Polyphosphates	Fairly good calcium scale control under mild conditions, can revert andcontribute to calcium phosphate scale

Deposition

Deposition is a general term for all the things that can cause problems in a cooling water system that are NOT due to scale, corrosion, or biological activity.

Such deposition can result from scrubbing of airborne material from the ambient air by the cooling tower, process contamination of cooling water by such things as leaking oil coolers, and suspended material in the makeup water.

Deposition

Deposition affects process operations much like scale, the deposits act as a thermal insulator to decrease heat transfer efficiency in production equipment.

Deposition can also cause physical blockage of cooling water passages and increase corrosion rates by blocking corrosion inhibitor access to the base metal, i.e., under deposit corrosion.

Deposition Control

Measures taken to control deposition depend on the cause of the problem.

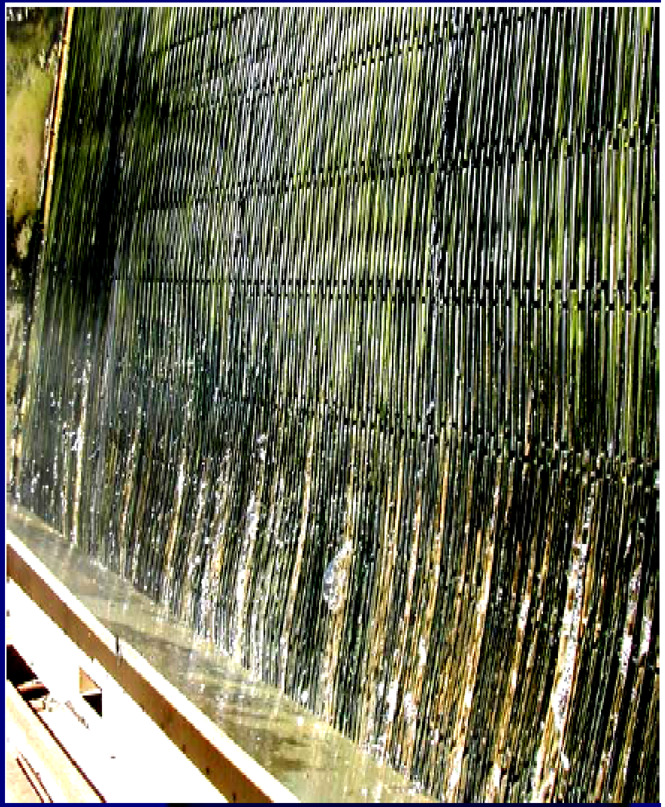
Process contamination problems are best corrected by elimination of the process leakage,

Most suspended solids deposition can be controlled by addition of dispersant/surfactant chemicals like **POLYACRYLATE, POLYMETHACRYLATE, POLYMALEIC, POLYSTYRENE, COPOLYMERS etc.** to the cooling water.

These materials function by charge neutralization of the suspended particles and emulsifying binding agents, breaking up existing deposits and preventing agglomeration of the particles to form new deposits.

Bio Fouling

- Microbiological growth within a cooling water system, if not controlled, can result in formation of biological fouling layers (biofilm) on all surfaces in contact with the cooling water.
- This biofilm affects process operation much like the scale and deposition.
- Biofilm usually results in a substantial corrosion rate increase due to formation of anaerobic areas under the fouling layer.
- This creates galvanic couple corrosion and forms metabolic by-products such as hydrogen sulfide, attack the base metals.



Biocide Chemistry

Control of biological fouling is to periodically dose the cooling system with a biocide to kill as many of the organisms present as possible.

The **dose makes the poison:** a biocide does not work unless a **critical dosage is reached and maintained** for a set time period.

The critical dosage point and time required for effective microbiological control varies substantially with the specific biocide in use and the overall condition of the cooling water system.

The most commonly used biocides can be separated into two major classes, oxidizing and non-oxidizing.

Cost of Biocides

The cost for oxidizing and non-oxidizing biocides varies substantially on a product basis, with actual use cost complicated by

- ✓The widely varying strengths (% actives) and
- ✓Dosages of the various products,

making cost comparisons difficult.

Supplier Selection

Our discussion so far provides the cooling water users with the basics for proper cooling water treatment.

The actual chemistry of the programme is in the hands of the supplier selected by the CW Treatment Management.

It is thus important that a knowledgeable supplier be selected who can provide appropriate

Control systems and

Chemistry tailored to the facility cooling systems and

Specific makeup water quality.

A Prudent Approach

The following are some comments on the selection of a water management program supplier.

The supplier selected should be in the water management business and deal on a routine, direct basis with various commercial facilities and industrial manufacturing plants.

There are many firms in the market, in particular sanitation firms, product distributors, and HVAC contractors that deal in such things as floor cleaners, solvents, oils, HVAC equipment/maintenance, or water softeners,

would also be happy to sell a few drums of cooling water treatment "Brand X" to anyone.

A Prudent Approach

Frequently these non-water management firms, while in some cases being quite large, have a

- Very limited product line,
- No expertise in actual water treatment chemistry,
- Little or no control system expertise, and
- No analytical laboratory support

for resolution of any cooling water treatment problems which appear.

A Prudent Approach

While there are many successful companies which utilize "toll blenders," experience indicates that product quality cannot be adequately controlled with outside product manufacture.

The very large water treatment firms have also been touting ISO 9001:2000 certification as a "quality indicator".

However, all the ISO 9000 process means is that they have a quality assurance and control program for manufacture and delivery of their chemical products:

IT HAS NO IMPACT ON THE QUALITY OF THE ACTUAL WATER MANAGEMENT PROGRAMME.

ISO programmes are generally fairly costly and ***Add Little Or Nothing,*** to indicate the potential for success of a proposed water management programme.

“the chemicals are all the same” ??

Comments that "the chemicals are all the same" are obviously incorrect to anyone who has some knowledge of the water treatment field.

A product that would provide excellent results with a hard, alkaline makeup will provide nothing but high corrosion rates and early system failure if used with a soft, low alkalinity water.

Water Treatment Chemist !!

Proper selection of the specific chemistry and product formulation to be used in any cooling water system should be under the supervision of an experienced water treatment chemist.

The **Association of Water Technologies (**AWT) "Certified Water Technologist (CWT)" & **NACE INTERNATIONAL** programme, open to anyone in the water treatment industry, is the one means of establishing the needed expertise in this field**.**

Environmental Concerns

Expertise in environmental regulations and water conservation

is also becoming a major consideration in selection of a water management programme supplier.

The supplier should have the capability to consider:

- The effect of environmental regulations on the specific chemistry to be used, and
- Provide any information needed by the regulatory authorities for discharge of blowdown.

Water Conservation

- From a standpoint of water conservation, the supplier should have specific in-depth knowledge of blowdown reduction and zero discharge technologies.
- This is a specialized area and few suppliers have yet developed the expertise, equipment, and chemistries needed to provide cost effective programme.
- The best means of obtaining a firm with expertise in this field is to note any technical presentations made by the firm and references as to completed projects.
- Experience is the best means to ensure quality work in this new and rapidly evolving part of the water treatment field.

Points to Ponder…

- Poor cooling water treatment management increases facility costs via destruction of expensive equipment, damage to the facility, increased costs for water and sewerage, and increased energy use and cost.
- Selection of a <u>cooling water management program</u> and <u>supplier</u> based on some knowledge of the chemistry and controls needed will
  - Increase the probability of obtaining reliable equipment cooling with maximum heat transfer efficiency at the lowest total cost.

Points to Ponder…

- Those facilities that devote sufficient time and resources to this vital area will be rewarded by lowered costs and more reliable operation.

- Knowledge of the field will also enable the buyer to separate counterfeit products from valid technologies and guard against the problems that can result from use of such something for nothing products.


Let us preserve water for the future generation