# THE TREATMENT OF LEGIONELLA BACTERIA WITH MAGNETO HYDRODYNAMICS

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**INTRODUCTION**

*Legionnaires disease made its first reported appearance in the United States 13 years ago when 34 delegates to a convention in Philadelphia died from a pneumonia type infection.*

*Since that time medical authorities around the world have come to realise the major Public Health Problem that the Legionella bacteria poses.*

*The disease is contracted by the inhalation of droplets of water infected with the bacteria which then progresses to the development of pneumonia.*

*Authorities have recognised that Legionella species are commonly present in potable water at low levels, and when this water is placed into a system which fosters their growth and provides a means of atomisation then the potential for disease outbreaks is ever present. Since the bacteria can be present in the water supply then it becomes self evident a considerable vigilance is required along with a technically competent control system which must be applied to equipment or locations where the bacteria will grow.*

**GENERAL LOCATIONS OF INFECTION**

Essentially any fresh water storage or transport piping can become infected with the bacteria and then become a source of infection themselves. However the atomisation of the water for inhalation is a major critical factor. The types of water systems where this can take place include water cooled air conditioning systems, spa baths and showers. It is an unfortunate fact that most large air conditioning systems use water cooling for their operation and this must therefore take place in locations with high occupancy of transit populations. Any negligence or lack of diligence in control of bacteria levels in the cooling water system has the potential to produce a sudden appearance of cases of *Legionella* infection.

All engineers and maintenance supervisors therefore have weighty responsibility to manage their water cooling system in a proper manner.

**CRITICAL ASPECTS OF *LEGIONELLA* CONTROL**

There are some important technical considerations which must be recognised and allowed for in the management of cooling towers or else treatment is likely to fail.

(a) The cooling tower make up water is likely to be regularly infected with *Legionella* bacteria. This means that introduction of *Legionella* bacteria into the system is inevitable and randomly distributed in time and intensity.
(b) Cooling tower water will become contaminated with material from the air it uses for cooling. This means that nutrients can be introduced to the tower which acts as a food source for algae, slime and bacteria.
(c) Cooling tower water uses evaporation as its cooling mechanism. Therefore salts in solution can exceed their solubility and produce scale on all immersed or wetted surfaces.
(d) Bacterial colonies can grow both within and under scale, algal growths, slime and sludge, thereby acting as a separate and continuing infection source to the introduction of colonies in make up water.
(e) Chemical treatments with biocides are ineffective against bacterial cells that they cannot come in contact with. Therefore colonies within scale, algae and sludge will propagate and maintain a continuous infection within the tower.

The above facts mean that cooling towers represent ongoing management problem. A system must be introduced which accounts for the above facts and prevents *Legionella* blooms.

**NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL GUIDELINES**

The guidelines produced by the Council recognise the above complication and therefore require the adoption of certain procedures.

1. Regular maintenance cleaning of equipment is required to control algae, scale and slime build-up.
2. A biocidal treatment must be applied to the waters contained within the tower.
3. A major cleaning out of growth of scale and algae is required on a twice yearly basis (in some states quarterly cleansing is required).
4. A regular monitoring procedure should be introduced to verify that the treatment is effective.

The guidelines include much more detail than the above and address other issues such as design, siting, acceptable treatments and testing programmes. However, the recommendation can be reduced to the principles of cleaning, disinfecting and monitoring.

**MAGNETO HYDRODYNAMIC TREATMENT**

Turbomag fluids treatment equipment has been used for some years, both in Australia and overseas, for the control of scale and algal growths in cooling towers and their circulating cooling systems. They performed the task of cleaning, and maintaining in a clean state, all the wetted surfaces within the cooling tower and the external cooling system. The development of equipment having the capability of killing bacteria, including *Legionella,* has been the subject of an intense research program in Australia over the past twelve months.

This has resulted in the development of the Turbocide unit as a total water control treatment system, for scale and slime control together with algal and bacterial (including *Legionella)* control, in cooling water systems.

**RESEARCH AND DEVELOPMENT**

The evaluation was planned with three major aspects in mind. The first was to demonstrate under controlled laboratory conditions that *Legionella* bacteria and other important species such as *Naeglaria* and *Acanthamaoeba* were killed by MHD treatment. During these evaluations the Turbocide unit evolved. The second was to show cooling tower case histories of bacterial counts with time under normal working conditions. The third was to carry out a survey of towers already under treatment by taking a random sample and testing the water for the presence and number of *Legionella* bacteria in the water.

These three programmes were each intended to demonstrate key issues which were:-

(a) The killing capability

(b) The ability to withstand the ongoing and inevitable bacterial challenges.

(c) The statistical result in the field which would show infection rates below the population average and control of infection at 'no risk' levels when challenged. When considering the "no risk' level we have been guided by public health authorities that Legionella counts of less than 100 per mil are considered safe.

**LABORATORY EVALUATION OF MHD**

The equipment used was a 45 litre cylindrical stainless steel tank which was fitted with a lower outlet and upper inlet through which water was circulated to an external unit. The outlet from the tank was fitted to a Grundfos circulation pump, gate valve and Turbomag W75 unit equipped with the modification required for it to perform as a Turbocide unit.

The outlet of the Turbomag was then connected to the tank inlet. A sampling point was also fitted to the tank.

The procedure which was adopted was to fill the tank with town water and circulate the water through the system for 5 minutes without the Turbomag power supply on. A culture of the bacteria under study was then inoculated into the tank and again circulated for 5 minutes without power supply to the Turbomag. A sample of water was taken for analysis as the initial pre-treatment level of infection.

Continuous circulation was then commenced, the Turbomag turned on, and equipment allowed to circulate the tank water at a rate of 30 litres/minute through the Turbomag unit. Samples were taken periodically and analysed for the inoculated bacteria.

Several tests were carried out as follows:-

(1) Inoculation with *Naeglaria* (to assess the killing potential).

(2) Inoculation with *Acanthamoeba* (to assess the killing potential).

(3) Inoculation with *Legionella rubrilucens* (to assess the killing potential).

(4) Inoculation with *Legionella rubrilucens* (to assess the killing potential).

(5) Inoculation with *Legionella rubrilucens* (to assess the effect of recirculating with faulty impeller)

(6) Inoculation with *Legionella rubrilucens* (to assess the effect of preventing recirculating through the Turbomag)

(7) Inoculation with *Legionella pneumophila* (to assess the killing potential).

Note.

A. In test (5) the system was operational with the magnetic field applied but the rotating impeller was jammed and unable to rotate.

B. In test (6) the magnetic field was applied but the gate valve was closed to prevent flow through the Turbomag.

The results of the above tests are presented in Table 1 below.

***TABLE 1***

**Microbiological Analysis Results for the Turbocide Treatment of Bacteria**

| Test No. | Inoculum | Time | Colony forming units |
|---|---|---|---|
| 1 | Naeglaria | Zero | Positive |
| | | 5 days | Negative |
| 2 | Acanthamoeba | Zero | Positive |
| | | 5 days | Negative |
| 3 | L. Rubrilucens | Zero | 30 |
| | | 4 days | Nil |
| | | 6 days | Nil |
| 4 | L. Rubrilucens | Zero | 70 |
| | | 1 days | 20 |
| | | 2 days | Nil |
| | | 5 days | Nil |
| 5 | L. Rubrilucens | Zero | 150 |
| | | 2 days | 110 |
| | | 5 days | 3 |
| 6 | L. Rubrilucens | Zero | 300 |
| | | 1 days | 240 |
| | | 2 days | 130 |
| | | 3 days | 200 |
| | | 5 days | 590 |
| 7 | L. Pneumophila | Zero | 900 |
| | | 6 hours | 300 |
| | | 1 days | Nil |
| | | 2 days | Nil |

The results in Table 1 show in tests 3, 4 and 7 that *Legionella* (including *pneumophila)* are killed by the MHD treatment. However it was deemed appropriate to show that circulation without the Turbocide correctly operational or with the water not passing through the unit did not produce a killing effect, i.e. tests 5 and 6.

**AUSTRALIA WIDE SURVEY**

Cooling towers under Turbocide treatment are located in all states of Australia. The scope of the survey was to test for the presence of *Legionella* in all towers and to test a few of the towers for Total Bacterial count. It is recognised that a large percentage (50% in the NH & MRC guidelines) of cooling towers are colonised by *Legionella* bacteria in scale, slime, algae and sludge deposits or growths. These are not disinfected by chemicals unless the material protecting the colonies is first removed prior to biocidal treatment. Therefore it was considered that a large deviation from the published statistics is conclusive evidence of both the cleaning/ descaling power of the Turbocide treatment as well as the capability of the unit to *kill Legionella.*

The results of the survey are detailed below in Table 11. Samples were collected in clean sterilised bottles in accordance with standard industry practice as advised by the analyst and were either delivered immediately to the analyst or refrigerated to prevent bacterial growth before analysis

***TABLE 11***

| | |
|---|---|
| Australia Wide Survey of Cooling Towers Under Turbocide treatment | 33 |
| Number of Cooling Towers Tested | 29 |
| Number of Cooling Towers Infected with *Legionella* | 3[a] |
| Number of Cooling Towers containing greater than 100 colony forming units per millilitre | 0 |
| Percentage of Towers infected with Legionella | 10% |
| Percentage of Towers considered a health risk | 0% |
| Number of Towers tested for Total Bacterial Count | 10[b] |

Note

a. The results for *Legionella* infected towers were:- 4 cfu/ml, 23 cfu/ml, 20 cfu/ml.

b. The Total Bacterial Counts on towers tested were:- $2x10^2$ cfu/ml, $6.7x10^2$ cfu/ml, $3x10^2$ cfu/ml, $6.7x10^2$ cfulml, $4.5x10^2$ cfulml, $2x10^2$ cfu/ml, $3x10^2$ cfulml, $1.3x10^2$ cfu/ml, $4.7x10^2$ cfulml, $1.8X10^2$ cfu/ml.

Average Value $9x10^2$ cfu/ml. Range 130--4700 cfu/ml. Sample testing was carried out by independent laboratories in each state.

Balance of 19 cooling towers were only tested for Legionella.

It is self evident from the above results that the Turbocide treatment is providing protection for the cooling towers and systems. Only one tower had biocides added to the cooling water and this tower had only been on Turbocide treatment for 5 days and was also infected with *Legionella* at a rate of 500 cfu/ml, i.e. chemical treatment had not prevented infection or eliminated the *Legionella* from *the* cooling system.

**COOLING TOWER CASE HISTORY**

An important factor in the acceptance of a water treatment system must be its ability to perform its ongoing task reliably and efficiently over long periods under all forms of challenge. This must be proven to be successful over extended periods of time. The owner/operator of a cooling system must have confidence in the system. We therefore quote the following case histories.

**CASE 1**

This is detailed in Table lll and is for two cooling towers used for air conditioning on a major hotel. One was an older cooling tower which had operated on chemical treatment for several years. The other tower was newly commissioned and treated from the commissioning date. The older tower has a history of being free of *Legionella infections* under chemical treatment and has routinely operated with Total Bacterial Counts (TC) in the range of $10^4$--$10^5$ cfu/ml.

It is readily apparent that under Turbocide treatment the exclusion of *Legionella has* continued while the Total Bacterial Counts had been dramatically reduced to the range of $10^1$ -- $10^2$ cfu/ml. This case history is therefore one which shows a steady trouble-free operation which has improved with the introduction of Turbocide treatment.

**TABLE III**
**HOTEL COOLING TOWERS**

| Date | Bacterial Count | | Yeast | | Fungi | | Legionella | |
|---|---|---|---|---|---|---|---|---|
| | New Tower | Old Tower | New Tower | Old Tower | New Tower | Old Tower | New Tower | Old Tower |
| 6/7 | | $10^4$ | | Trace | | 0 | | |
| 14/7 | | $10^4$ | | Trace | | 0 | | |
| 22/7 | | $10^3$ | | 0 | | 0 | | |
| 29/7 | | $10^3$ | | 0 | | 0 | | |
| 3/8 | | $10^3$ | | 0 | | 0 | | |
| **CHEMICAL TREATMENT SUSPENDED** | | | | | | | | |
| 8/8 | | $10^3$ | | 0 | | 0 | | |
| 15/8 | $10^3$ | $10^3$ | 0 | 0 | 0 | 0 | 0 | 0 |
| 22/8 | $10^3$ | $10^3$ | 0 | 0 | 0 | 0 | | |
| 29/8 | $10^2$ | $10^2$ | 0 | 0 | 0 | 0 | | |
| 7/9 | $10^2$ | $10^2$ | 0 | 0 | 0 | 0 | | |
| 14/9 | $10^2$ | $10^2$ | 0 | 0 | 0 | 0 | | |
| 21/9 | $10^2$ | $10^2$ | 0 | 0 | 0 | 0 | 0 | 0 |
| 28/9 | $10^2$ | $10^2$ | 0 | 0 | 0 | 0 | | |
| 3/10 | $10^1$ | $10^1$ | 0 | 0 | 0 | 0 | | |
| 7/10 | $10^1$ | $10^1$ | 0 | 0 | 0 | 0 | | |

Note where results are not quoted, no testing took place.

**CASE 11**

The second case is detailed in Table IV and is located in a city where Legionella infections and mortalities have occurred. The source of Legionella infections is the water added to the cooling systems. It is therefore self evident that this city, like most others, occasionally supplies water contaminated with Legionella bacteria to the plant. Therefore within the case history as detailed in Table IV is a factor which means that the cooling towers are regularly challenged with *Legionella* bacteria.

Another factor associated with the cooling towers is the background treatment, and age of the towers. The towers have operated for approximately fifteen years with continuous biocidal treatment but without scale control chemicals. *Legionella* infections did occur during chemical treatment and scale growth and algal growth also occurred.

Since commencement of the Turbomag treatment the scale which has grown during the early operation of the towers has been steadily removed from the towers and its associated plumbing system. Also algal and slime growths have been eliminated. The bacterial profiles of the water have been monitored and are reported in Table IV.

The system is a bank of 3 cooling towers at a freezer works treated from one common Turbocide treated water source. The Turbocide was installed several months prior to the following analyses being carried out.

Readings obtained were from all three sumps.

***TABLE IV***
**FREEZING PLANT COOLING TOWER**

| Date | T.P.C. | L. Pneumophila |
|---|---|---|
| 7/8/89 | Not tested | 20 cfu/ml |
| 25/8/89 | $4.5 \times 10^4$ | Nil |
| 14/9/89 | $1.4 \times 10^4$ | Nil |
| 3/10/89 | $1.4 \times 10^4$ | Nil |
| 20/10/89 | $2.1 \times 10^4$ | Nil |

**CASE III**

The third case involves a cooling tower within a large mineral processing plant. The problems this cooling tower experiences involve excessive scaling due to water quality as well as the usual algal and bacterial problems. Scaled surfaces are regularly cleaned physically despite the use of antiscaling chemicals and biocides. Dosage of chemicals was carefully controlled as cooling system scaling or general failure produce massive downtime or loss of production, costs. The cooling tower had therefore been treated for some years prior to the installation of the Turbocide unit. The results of bacterial testing were as detailed in Table V.

***TABLE V***
**MINING PLANT COOLING TOWER BACTERIAL ANALYSIS (TURBOCIDE INSTALLED 21/6/89)**

| Date | T.P.C. | L. Species |
|---|---|---|
| 26/6 | $1.6 \times 10^4$ cfu/ml | 500 cfu/ml L. Pneu |
| 31/6 | ---- | Nil |
| 1/8 | $9 \times 10^3$ cfu/ml | 100 cfu/ml not Pneu |
| 7/8 | $<1 \times 10^4$ cfu/ml | Nil |
| 13/10 | $1 \times 10^3$ cfu/ml | 100 cfu/ml L. Pneu |
| 9/11 | $2.5 \times 10^4$ cfu/ml | Nil |

This is again a location where *Legionella* species are commonly found in the water supply to the tower. There has been regular challenges to the treatment, none of which have resulted in a bloom over the first 5 months of installation.

**DISCUSSION AND CONCLUSION**

This evaluation of the Turbocide system of cooling tower treatment was designed to examine the problem of *Legionella* control in three ways. All three approaches were deemed necessary to rigorously establish the success of the technology as the techniques used are soundly based but are complementary. It is our belief that the total weight of evidence is critical. Other technologies have demonstrated killing potential which does not translate into field case histories.

However a single case history is not enough. Statistical significance in the field is essential. Therefore a large enough sample population is required for comparison to accepted field results

As a result of this study we have demonstrated four critical aspects of *Legionella* control:

(a) The ability to kill *Legionella* bacteria.
(b) The ability to withstand close scrutiny in an individual case history.
(c) The ability to produce a significant variation from accepted Australian cooling tower infection rates.
(d) The ability to meet NH & MRC Guidelines for cleanliness without a stop and physically clean regimen.

The weight of evidence is now available to prove the effectiveness of the Turbocide treatment in *Legionella* and other bacterial controls. It has the unique feature of being able to clean and disinfect during operation and uses no environmentally unacceptable or corrosive chemicals.

**Corrosion Control**

Electromagnetic water treatment has been known to produce a passivation of mild steel surfaces. This effect can be prevented by three main factors. The first is pH levels less than 7, the second is high TDS levels (we prefer less than 3000 ppm) and the third is galvanic corrosion caused by differential metals in contact or plating of copper metal onto mild steel surfaces.

None *of* the cooling towers in this study are using corrosion inhibitors or alkaline chemical addition. However it is not possible to guarantee that this will not be needed in future installations.

**Multiple Tower Treatment**

It is not necessary to have one Turbocide unit installed on each cooling tower or condenser. It is possible to treat four or more towers with one unit so long as the installation instructions are adhered to.

Turbocide treatment of cooling systems represents a total treatment package that is cost effective, easily managed, maintained and monitored. Future users can also proceed with confidence that the system has stood the test of time and been proven eminently suitable for the task.

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Note:-

Dynamag Pty Ltd is a private company incorporated in Victoria. The Author is based in the Perth office. Further information about the unit and technology can be obtained from Dynamag Pty Ltd, Victoria Park, W.A., Phone (09) 4702738, Fax (09) 4702393, or Hawthorn, Victoria, Phone (03) 8119915, Fax(03)8133979.

The company would also like to make known that it has applied for patent protection to cover the above application of Magno Hydro Dynamics in the control of bacterial growth in water systems.