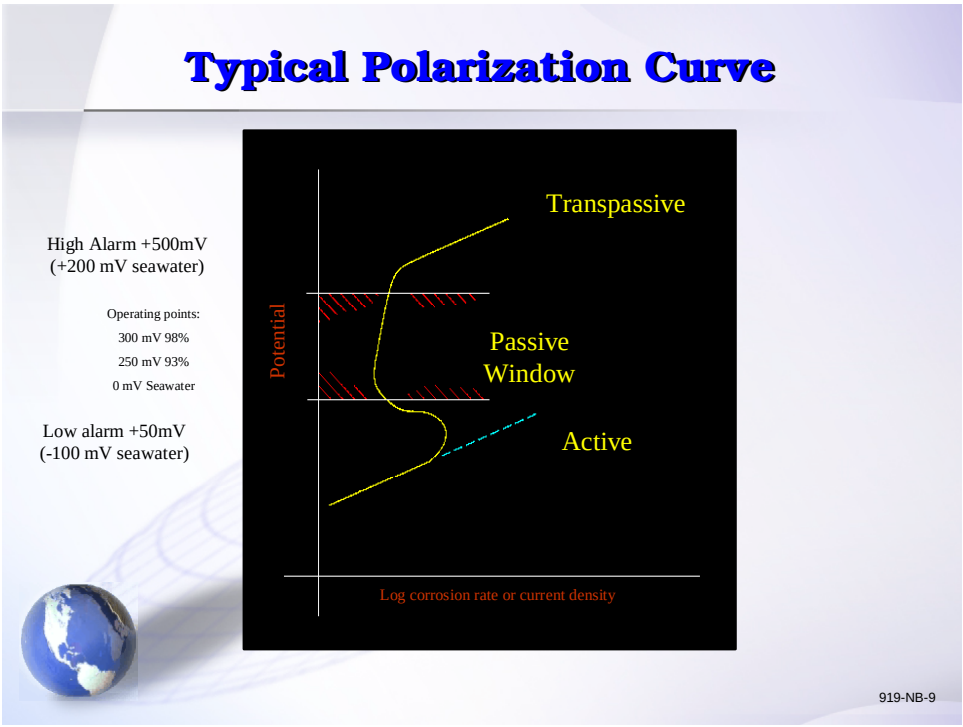
# ZeCor ™ Acid coolers – The Value proposition

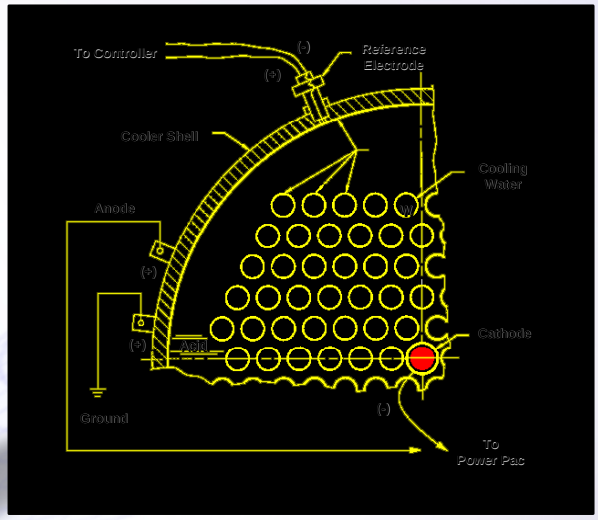
Anodically protected acid coolers have been the standard in our industry for almost 40 years. Anodic protection enabled the industry to make the move from cast iron coolers that presented a host of practical and economic challenges to a more robust and reliable technology. Anodic protection also stretched the traditional temperature limitations of the stainless steels used in this service. Today, one is hard pressed to find a modern day acid plant that does not operate shell & tube coolers; over 2000 such coolers are in service across the globe.

Anodic protection relies upon the formation of a passive film that is formed on all the wetted surfaces of the cooler. This passive film provides a high degree of corrosion resistance when operated within the guidelines of the system. When the system is operating at the optimum level, it is referred to as operating within the "Passive Window".



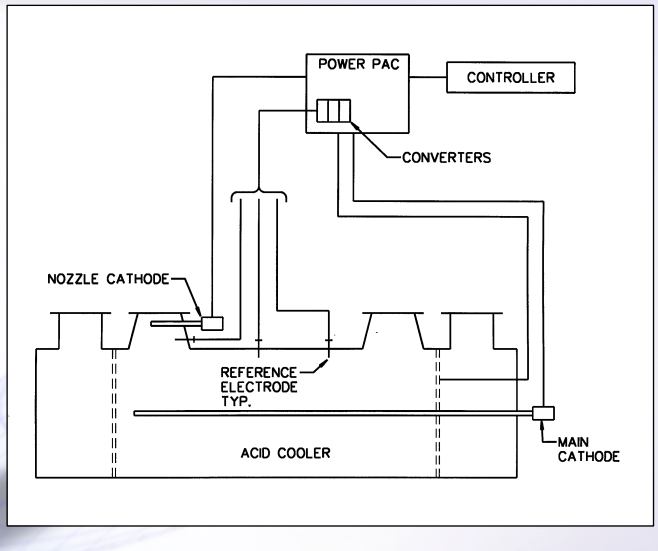

The anodic protection system consists of several reference electrodes, one of which is usually the controlling electrode. The system measures the potential of the wetted surfaces and feeds the information to the controller. The controller regulates the amount of current supplied by the power supply through the cathodes to maintain the system with the passive window.

# How Does Anodic Protection Work?






# Anodic Protection -Typical Configuration



## Limitations of Anodic protection in acid coolers

Anodic protection increases the temperature limitations of stainless steels in acid coolers. However, it is imperative that the anodic protection system be properly maintained and monitored at all times. Failure of the system can lead to catastrophic failure of the cooler if it is not functioning correctly. Minimum acid concentration limits are also to be closely monitored. Low acid concentrations below 90% should be avoided at all times.

Optimal thermal designs of anodically protected acid coolers are limited by the need to maintain acid side velocities low enough to preserve the passive film. Acid velocities that are too high (above 3.5 ft/s) can lead to an ineffective system quickly resulting in tube failures. Additionally, the need for cathodes in the tube field increases the size of the cooler.

Spare parts for the most critical components of the anodic protection system must be maintained on site. Although a small percentage of the capital cost of the cooler, it is an extra cost.

## The roadblocks for alloy coolers

The ideal acid cooler would provide optimum thermal performance, virtually no maintenance and a value proposition that is extremely competitive. One way to accomplish this is to use higher and more exotic alloys that

- have superior corrosion characteristics in the operating regime
- are not susceptible to erosion corrosion
- eliminate the need for operating the anodic protection system
- eliminate costly and time consuming annual inspections and maintenance

Over the years, there have been several alloys that have been tried and used with varying degrees of success. Although the performance of these alloys have been remarkable, the value proposition (when compared to that of an anodically protected cooler), has fallen well short of expectations. For very small applications (500 TPD), the high cost of the alloy is offset by the fixed cost of the anodic protection system (electronics, cathodes, electrodes etc.). However, on larger plants, the high cost of the alloys has lead to the capital cost of an alloy cooler into a range that has been as high as 250% of that of an anodically protected cooler.

The introduction of ZeCor™ has changed the paradigm for corrosion resistant materials. Local sourcing and control of the raw material coupled with a high volume demand for it’s performance has led to a value proposition that will change the way we look at the options available to the industry.

At the time of publication of this paper, code approval for ZeCor™ will be final. Several ZeCor™ coolers have been requested and we expect to ship and install 3-5 units in 2004.

**ZeCor™ coolers – optimizing the value proposition**

The chart below compares two designs for a mid sized cooler with

a) anodic protection and
b) ZeCor™ with no anodic protection

| | AP Cooler | ZeCor™ cooler |
|---|---|---|
| **Heat exchanged Btu/h** | 73,820,000 | 73,820,000 |
| **Acid flow (lb/h)** | 4,072 | 4,072 |
| **Heat transfer surface area ($ft^2$)** | 4415 | 3900 |
| **Cost ($)** | 260,000 | 310,000 |
| **Premium** | | 19% |

****Note: Costs do not include any surcharges, which are determined at time of order.**

In the example above, a simple "Present Value" analysis shows the true benefit of the ZeCor™ option:

Basis for analysis and results:

| | AP cooler | ZeCor™ cooler |
|---|---|---|
| **Life of cooler (years)** | 20 | 20 |
| **Estimated annual escalation/inflation** | 2% | 2% |
| **Discount rate** | 8% | 8% |
| **Initial capital cost ($)** | 270,000 | 310,000 |
| **Electrical installation costs ($)** | 3,500 | N/a |
| **Spare parts($)** | 3,500 | N/a |
| **Annual maint. Costs** | $2,500 | N/a |
| **Present value (PV, 20 years)** | **$436,645** | **$416,737** |

Similar comparisons have been made for coolers of various sizes and thermal requirements. These comparisons hold true for most conventional applications. BFW and heat recovery applications present other thermal challenges that may limit our ability to leverage the advantages of ZeCor™ in the context of initial capital cost. However, in most cases, the life cycle cost advantages of ZeCor™ do indeed hold true.

In another example, a BFW unit operated with the assistance of anodic protection is being replaced or re-tubed on average once every 5 years. In this case the PV analysis would be as follows:

| | **BFW AP cooler** | **BFW ZeCor™ cooler** |
|---|---|---|
| **Life of cooler (years)** | Retube every 5 years, replacement in full every 10 years | 10 |
| **Estimated annual escalation/inflation** | 2% | 2% |
| **Discount rate** | 8% | 8% |
| **Initial capital cost ($)** | 330,000 | 440,000 |
| **Retube cost ($, today)** | 150,000 | 0 |
| **Electrical installation costs ($)** | 3,500 | N/a |
| **Spare parts($)** | 3,500 | N/a |
| **Annual maint. Costs** | $2,500 | N/a |
| **Present value (PV, 20 years)** | **$698,000** | **$709,000** |

This example is worthy of further discussion as the basis for the calculation is very subjective. The analysis assumes that a retube will be required in year 5. It is very likely that a complete replacement may be the answer in year 5 instead. This event if true, would swing the advantage well to the side of the ZeCor™ cooler. There are other tangible but unpredictable events that should be taken into account such as:

- Failure of the anodic protection system
- Excessive corrosion
- Unanticipated downtime

**Summary:**

ZeCor™ coolers offer a viable and attractive alternative to anodically protected coolers. The examples above are offered to spur productive dialogue when considering new coolers for your plant.