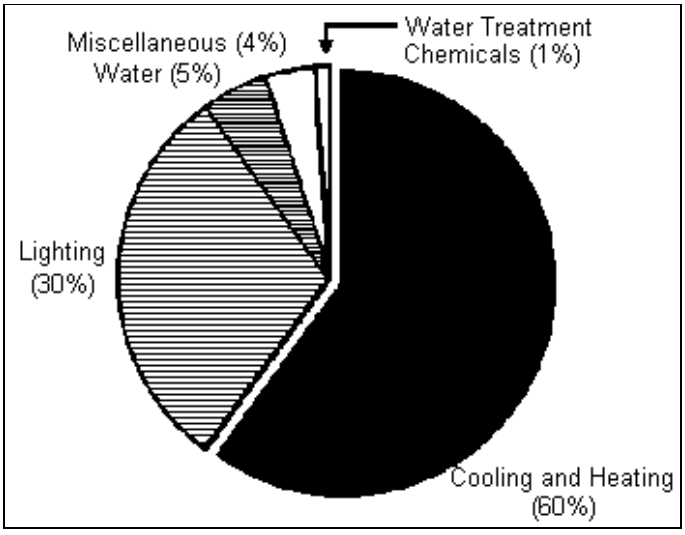
The Cost of Improper Water Treatment

There's More to Water Treatment than Treating Water

It's easy to underestimate the implications of your water treatment program, whether you manage it in-house or rely on an outside water treatment supplier.

That's because the effects of water treatment go well beyond maintaining satisfactory performance in HVAC systems. Water treatment has a profound impact on utility costs, maintenance costs, equipment life, worker safety, regulatory compliance, and more.

This chart reflects the percentages of the average facility's utility budget spent on lighting, water, cooling and heating, water treatment chemicals, and other miscellaneous expenses. It's clear that expenditures for water treatment are only a very small portion of the total cost — but proper water treatment can produce far-reaching improvements in other cost areas.



Typical utility budget percentages.

Energy Costs in Air Conditioning Operation

Both economy and function are critical to the operation of an air conditioning system. Economy is important for all of the obvious reasons. Function is also important, because an unexpected shutdown, especially during the hottest summer months, could cripple your operations—and cause severe financial losses.

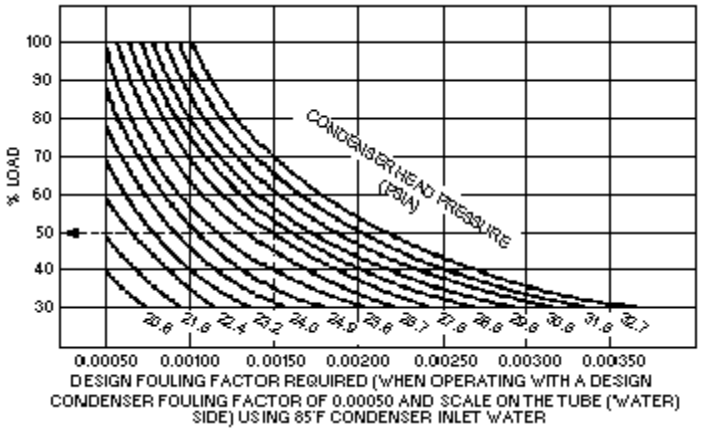
A sound water treatment program can help achieve both of these critical air conditioning objectives, keeping your system running reliably and minimizing your operating costs. It will also help avoid unbudgeted capital expenditures resulting from premature equipment failure.

Improving Air Conditioning System Efficiency

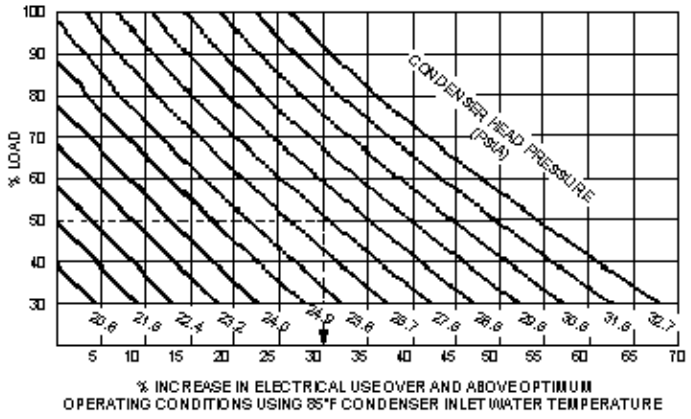
A well-designed water treatment program that reduces fouling, scaling, and corrosion can have dramatic effects on system performance.

Most of the energy consumed by the typical air conditioning system is used to operate the compressor, so an improvement in compressor efficiency should yield substantial cost reductions. The compressor is designed to produce a given pressure rise for a given load, and a greater-than-specified pressure rise can cause an inability to meet cooling load demand, or even cause an emergency shutdown. Moreover, higher discharge (head) pressure increases power consumption.

Why does high head pressure occur? Often because of fouling or scale formation in the condenser tubes. Since fouling and scale resist heat transfer, the compressor must increase the condensing pressure and its associated temperature. This increase in temperature difference between the refrigerant and the cooling water is needed to force the required transfer of heat. The increased energy consumption depends on the type of compressor used, the actual operating head pressure, and the percentage of full load at which the system is running.



Effect of water-side scale in a condenser (with a design fouling factor of 0.0005 using refrigerant 11 with centrifugal compressors) on the heat transfer ability of that condenser.

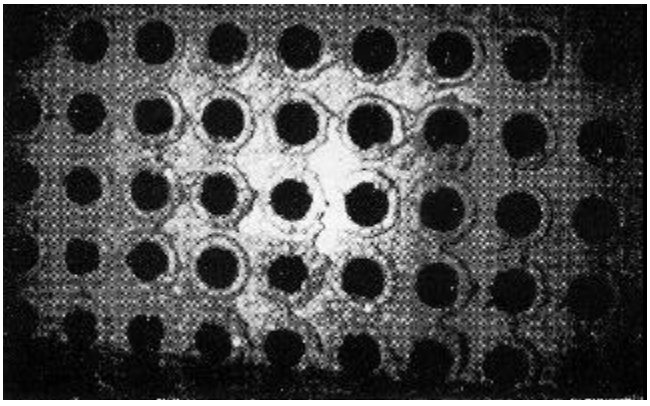


Effect of increased condenser head pressure (psia) on power consumption (kWh) using refrigerant 11 with centrifugal compressors.

To see the magnitude of the costs associated with high head pressure and other water-related efficiency factors, it's useful to consider a typical commercial air conditioning system with these specifications:

- Site = 1.2-million sq.-ft. commercial building
- Capacity = 3,000 tons, removing 36 million Btu/hr.
- Energy efficiency at full load = 0.65 kW/ton
- Full load energy requirement = 3,000 x .65 = 1,950 kW
- Energy cost = $0.10/kWh
- Operating cost = 1,950 x .10 = $195/hr.
- Actual average seasonal load = 50%
- Actual average energy efficiency = 0.7 kW/ton
- Actual energy requirement = 3,000 x 0.7 x 0.5= 1,050 kW
- Actual operating cost = 1,050 x .10 = $ 105/hr
- Operating hours/year = 3,200
- Actual annual energy requirement = 3,200 x 1,050 = 3.36 million kWh
- Actual annual energy cost = 3,360,000 kWh x .10 = $336,000

With improper water treatment, fouling and scale in the condenser can increase head pressure by 6% to 8% at 50% load, increasing energy consumption by 10%—an additional $10.50 per hour ($105 x 0.1) or $33,600 per year.

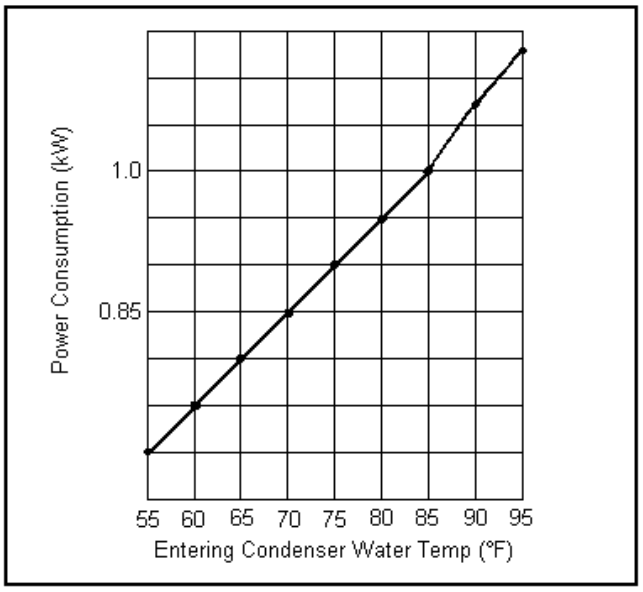


A fouled condenser can result in increased head pressure and wasted energy.

In evaporators, fouling and scale will also reduce efficiency and increase costs. Fouled evaporator tubes can cause a drop in refrigerant evaporating pressure and temperature, which in turn reduces the density of the refrigerant. Consequently, the compressor must pump more gas to a higher pressure to remove the same amount of heat from the chilled water. The compressor works harder and needs more energy.

In our typical building, fouling or scale that lowers the evaporating temperature only 2°F— from 40° to 38°F—can result in a 3% increase in chiller operating costs. That's an hourly penalty of $3.15 (105 x .03), or an additional annual expense of $10,080.00 ($3.15 x 3,200).

Cooling tower efficiency also suffers from improper water treatment. Neglected accumulations of microbiological growth—slime, algae, and bacteria—cause an increase in the water temperature leaving the cooling tower, increasing energy costs because the compressor must work harder.



Improved cooling tower operation allows compressor power requirements to be drastically reduced.

If our typical cooling tower is designed to deliver water to the condenser at 85°F, microbiological fouling could raise that temperature to 90°F and increase power consumption by about 5%. That could cost an additional $5.25 per hour (105 x .05), or $16,800.00 per year (3,200 x 5.25).

Altogether then, control of fouling, scale, and microbiological growth in the cooling water system can result in total potential savings of more than $60,000.00 per year.

Heat Transfer Unit	Evaporator	Condenser	Cooling Tower	Total
Problem	Scaled tubes	Scaled tubes	Bio. fouling	
Consequence	2° lower evap. temp.	6-8 psi higher cond. pr.	5° warmer cond. water	
Penalty $/hr.	$3.15	$10.50	$5.25	$18.90
% of Chiller Running Cost	3%	10%	5%	18%

Savings provided by effective water treatment:

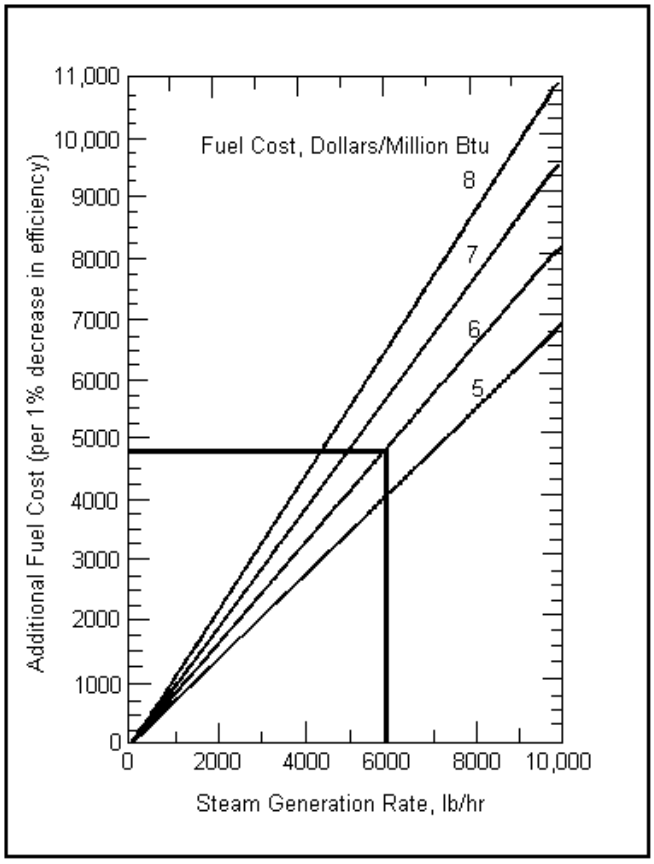
Three 1,000-ton chillers, with $105/hr. running cost.

(Excludes pumping and air moving costs.)

It's clear from these examples that a good water treatment program can help reduce air conditioning operating costs. A complete evaluation of your air conditioning system by a water treatment specialist can reveal potential problem areas.

Energy Costs in Boiler Operation

To see the cost of inefficient boiler operation, consider this graph.



It plots steam generation rate (in lbs/hr) against annual fuel costs (in dollars), and shows the additional fuel costs caused by a 1% decrease in boiler efficiency. At $6 per million Btu and a steam generation rate of 6,000 lbs/hr, reducing boiler efficiency by 1% increases annual fuel costs by $4,800.

It's clear, then, that even a small loss of boiler efficiency can result in substantial increases in fuel consumption and reduced plant profitability.

Five Factors to Monitor for Boiler Efficiency

Five vital factors can result in serious energy and fuel losses in boilers:

- Unnecessary water loss from the boiler;
- Reduced heat transfer because of deposits;
- Loss of steam and condensate through leaks in piping, valves, and fittings;
- Increased makeup water costs (and possibly sewer costs);
- Improper or incomplete combustion.

Minimizing these factors is well within the ability of qualified water treatment specialists. To see how these factors work together to reduce boiler efficiency, let's consider one boiler in detail.

Here are the facts about the boiler in question:

- Steam production = 300,000 lbs/day x 1,184.6 Btu/lb. = 355.38 million Btu/day
- Boiler operating pressure = 75 psig
- Boiler efficiency = 80%
- Fuel source = Natural gas at $4.50/ 1,000 cu. ft. and 1,000 Btu/cu. ft.
- Condensate return = 80% at 200°F
- Current blowdown rate = 10%
- Operating season = 150 days/year
- Water cost/1000 gal. = $1.20

Boiler blowdown is, very simply, a loss of water already heated—which means a loss of both energy and water. Reducing blowdown from 10% to 5% by improved water treatment will reduce energy and water costs as follows:

Energy (natural gas):

5,658 cu. ft. /day: $25.46/day

848,685 cu. ft./year: $3,819.00/year

Water:

2,104 gal. H_2O/day: $2.52/day

315,537 gal. H_2O/year: $378.72/year

Reducing blowdown by 5% saves $4,197.87 per year in this instance.

Let's go another step through the process of further improving this boiler's efficiency by returning more condensate.

First, increasing the percentage of steam recovered as condensate from 80% to 92% will save gas at the rate of

6,075 cu. ft./day: $27.34/day

911,250 cu. ft./year: $4,100.63/year

As a result, feedwater cycles will increase from 20 to 50—reducing boiler blowdown rate from 5% to 2%. The quantity of makeup water to the boiler(s) will be reduced by

5,471 gal. H_2O/day: $6.57/day
820,653 gal. H_2O/day: $984.78/year

The total savings realized from this change equals $5,085.41 per year.

Reclaiming heat otherwise lost from blowdown water by the addition of a blowdown flash tank and heat exchanger results in energy savings as follows (assuming the same boiler plant as in the earlier example):

300,000 lbs. steam/day
75 psig steam
150 days/year
2.0% blowdown
10 psig flash steam
534 lbs. flash steam/day

The blowdown water is flashed from 75 psig to 10 psig steam; the steam goes to the deaerating heater and the blowdown from the flash tank goes through a heat exchanger to preheat the boiler makeup water from 65 to 135°F.

Heat reclaimed as 10 psig flash steam:
601,575 Btu/day
Heat reclaimed by heating the makeup water:
866,241 Btu/day

Total Energy Savings:
1,834 cu. ft. gas/day = $8.25/day
275,215 cu. ft. gas/year = $1,237.95/year

The Role of Water Treatment

Your water treatment program can go a long way toward achieving this kind of energy savings.

Blowdown, for example, required to control the concentration of impurities in boiler water, can be substantially reduced by improving the quality of your feedwater and using effective dispersants.

Scale formation is a chief enemy of fuel-to-steam efficiency, and can be reduced and maintained at a low level by appropriate water treatment. Consider this example:

A 500 hp boiler producing steam at a rate of 16.74 million Btu/hour at 75% efficiency, and operating for 8,000 hours/year, requires an energy input of

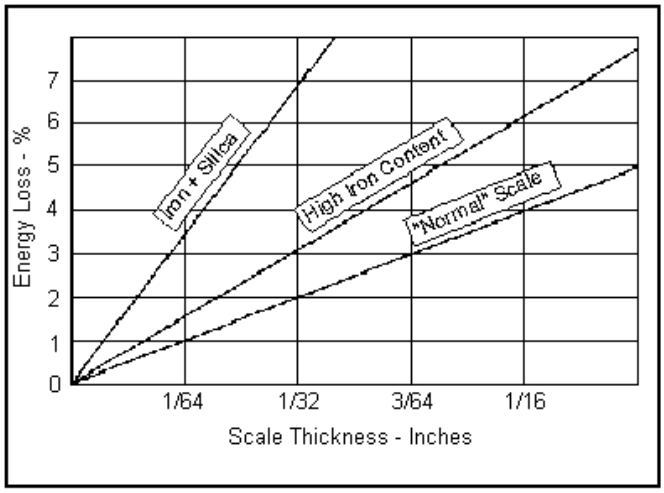
16.74 million Btu/hr x 8,000 hrs/yr. x 0.75 = 100,440 million Btu/yr

If scale 1 /32" thick forms on the tubes, depending on the composition, expect an energy loss of 2% to 7%.

Annual energy loss at 2% = 100,440 million Btu
x 0.02 = 2,009 million Btu/year

If the gas in use has a heating value of 1,000 Btu/cu. ft. and costs $4.50/ 1,000 cu. ft., removing that scale and preventing new deposits results in yearly cost savings of

2,009 million Btu/year x 1 cu. ft./1,000 Btu
x $4.50/1,000 cu. ft. = $9,040/year



Energy loss resulting from scale deposits.

Both scale and sludge can decrease boiler efficiency, and a good water treatment program must control both. The American Society of Mechanical Engineers has established maximum allowable levels of boiler water impurities shown in this table.

Boiler steam pressure, psig	Total dissolved solids, ppm.	Total alkalinity, ppm.	Total hardness, ppm.
O to 300	3500	700	0.30
301 to 450	3000	600	0.30
451 to 600	2500	500	0.20
601 to 750	2000	400	0.20
751 to 900	1500	300	0.10
901 to 1000	1250	250	0.05

ASME limits for boiler water impurities.

Armed with this information, and following a complete water analysis of your system, your water treatment specialist will be able to establish a treatment program for your boiler plant.

It's important to know that while boiler water and feedwater have the same concentration of impurities before the boiler is fired, concentration in boiler water increases rapidly as the boiler water is evaporated into steam. The "concentration factor" is the number of times your boiler water can be evaporated before reaching the maximum permissible concentration. That number is called “cycles of concentration.” Blowdown removes “cycled” water and replaces it with fresh water.

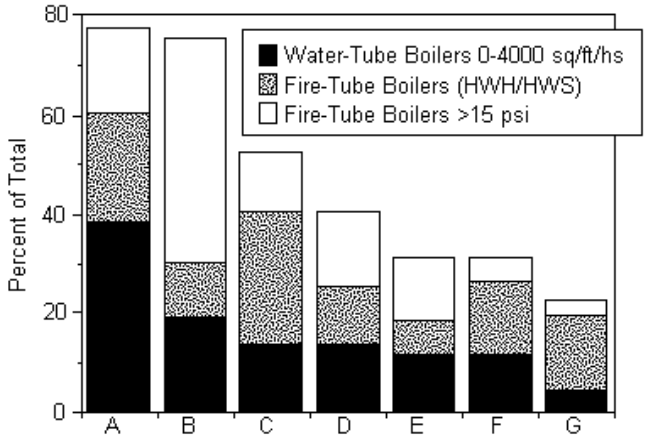
By improving and monitoring the quality of your feedwater—and by increasing your boiler cycles—a sound water treatment program can go a long way toward reducing operating costs and increasing plant profitability.

Protecting Your Capital Equipment

The Hartford Steam Boiler Inspection and Insurance Company has analyzed 2,462 boiler accidents, and determined that on average 23% of all boiler failures studied occurred as a result of poor water treatment.

In boilers with up to 4,000 square feet of heating surface, 36% of failures had to do with such problems as scale and sediment. Another 8% were the result of corrosion and erosion.

Similar percentages held across the entire range of boilers analyzed, as reflected in this table.



Key to Causes:	
A - Boiler water trouble	D - Personnel
B - Mechanical/electrical failure	E - Corrosion/erosion
C - External causes	F - Installation/design deficiencies
	G - Defective materials

Primary causes of failure, by boiler type.

When corrosion attacks metal components of the boiler or air conditioning system, it not only weakens the metal itself but produces an insulating effect that can cause overheating and eventual breaks and failure. The buildup of corrosion products decreases heat transfer ability and reduces system efficiency.

The cost of an ongoing water treatment program to reduce scale, corrosion, and fouling is small compared with the energy costs caused by lack of treatment or incorrect treatment.

The Costs of Compliance

This section might be more appropriately called “The Costs of Noncompliance.” After all. even though meeting the myriad local, state, and Federal regulations governing the treatment and disposal of water in your facility can be expensive. not meeting them can cost even more.

For example, failure to comply with Section 313 of the Superfund Amendments and Reauthorization Act of 1986 (SARA), the right-to-know portion of the Emergency Planning and Right-To-Know law that requires companies to supply a Chemical Release Inventory Form. carries a penalty of $25,000 per day.

Moreover, the penalty increases to $75,000 per day per violation (plus liability for individual civil and criminal penalties) for deliberate falsification.

And that covers only one set of Federal regulations. As you know, you must comply not only with a battery of Federal regulations, but with a variety of state and local requirements as well. Those regulations change frequently, and keeping up with them is difficult. But not keeping up with them can spell disaster.

(According to recent regulatory changes, your task of managing and reporting the use of chemicals in the workplace is a big one indeed. It can, in fact, include everything from photocopier toner solution to window-washing sprays. And your responsibility includes identifying all qualifying materials, establishing policies for their safe and proper handling, and training employees on their safe use.)

The task of tracking your use of hazardous chemicals in water treatment doesn't rest entirely with you. Your water treatment specialist must help by supplying a Material Safety Data Sheet (MSDS) for each toxic chemical used in your water treatment program. The MSDS is required by OSHA Hazard Communications Standard (29 CFR 1910.1200), which requires all chemical manufacturers, blenders, importers, and distributors to evaluate each chemical they supply to determine if it is hazardous (that is, a flammable, a corrosive, an oxidizer, a carcinogen, a combustible, or an irritant), and then to provide support and documentation by means of product labels, MSDS, training, and access to records.

Thus the MSDS is your main source of information when you file compliance reports and apply for permits.

Ideally, your water treatment supplier should go beyond the essentials dictated by law, and help you with reporting, permit applications, and emergency cleanup and disposal of spilled chemicals. Most water treatment companies, however, fall short in this area. BetzDearborn customers, on the other hand, are served by a Regulatory Affairs Group staffed by over 70 full-time professionals whose job is to stay abreast of changing legislation and touch with the various

local, state, and Federal agencies whose regulations you need to follow. We keep on top of new legislation even before it takes effect.

Our Regulatory Affairs Group supports the local BetzDearborn representative, supplying him with the information he needs to help you comply. In addition, a 24 - hour hotline (800-877-1940) is your source for emergency help in cleaning up and disposing of accidental spilled BetzDearborn chemicals.

Water Treatment An Investment not an Expense

The dollars you spend on water treatment must be considered in the same way you'd consider any other investment: in terms of the return achieved against money spent.

Buying water treatment services on the “lowest qualified bidder” or “lowest price per pound” basis is often not only misleading, but in fact dangerous. As preposterous as it may seem, per pound bidding is sometimes an opportunity for unscrupulous vendors to dilute their chemicals; their per-pound price is low, but the customer ends up buying far greater quantities to get the required results.

Effectiveness itself is in question, too, because some low-end vendors are likely to keep their prices attractive by minimizing the analysis and services they provide as part of their treatment package.

When you evaluate water treatment proposals, make sure that you keep the big picture in mind. Be sure that your supplier has in-house laboratory facilities that specialize in industrial and commercial water treatment, and doesn't rely on outside labs of uncertain quality and experience.

Make sure that your water treatment program will be preceded by thorough testing and analysis of your particular system's condition and needs. A sound water treatment program must also include periodic follow-up testing to ensure that your system is getting the treatment it needs as time goes by, along with preventive maintenance recommendations to keep it running efficiently.

Also be sure that you'll get written water treatment reports on a regular schedule, to be certain that the program is producing the positive results you're paying for.

Last, look for a performance guarantee. (BetzDearborn's is simple: Our water treatment program will perform as specified or we'll provide the chemicals and the manpower to correct the problem. Free.)