Planning and Designing for Safety by Spike Cover

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It is a fact of life that all devices fail eventually. If we don't anticipate those failures, it is another fact of life that when failures occur, they will probably happen at the most inopportune moments. So how can we foil Mr. Murphy and his law?

Several things can be done:

- Performing routine inspections and maintenance precludes many failures. We all do this (or hopefully we all do) on our cars and pray that it's done on the airplanes.
- Estimating the life of a critical component and replacing it prior to failure
- Designing the system so that if a component fails, it's not catastrophic but rather fails to a "safe" mode.
- Having redundant systems so that a single failure does not cause a catastrophic failure.

Let's look at an example:

Suppose you have a flexible PVC tank that you use for a quarantine tank. We know that eventually all these tanks will leak or rupture. So if you routinely inspect the tank for leaks and patch those leaks, that should help to preclude the little leaks turning into big leaks and the potential resulting loss of the tank's inhabitants. Further, if you shield the tank from sunlight, the plastic will have a longer life.

Now suppose you contact the manufacturer of your PVC quarantine tank and are told that the average tank will last 10 years with some shading from the sun, but only 5 years in full sun, and up to 15 years if completely shaded. Now you have some idea of the life expectancy of your tank. If you have it partially shaded and at about 8 or 9 years, it's starting to show some significant leakage, you probably want to start thinking about replacing it.

But let's say you want to get the full life out of the tank, that is, you want to run it until it's no longer serviceable. What are your options? You could

- Just run it without any thought as to what will happen when it fails. Try to think of a way that when it fails, you don't lose all the fish that are in the tank at the time.
- Try to build in alarms that alert you to water loss so that you could take corrective action.
- Have sensors that detect a problem and turn on systems to correct or compensate for the problem

Let’s consider some general ways that the various options previously discussed might be accomplished. You could

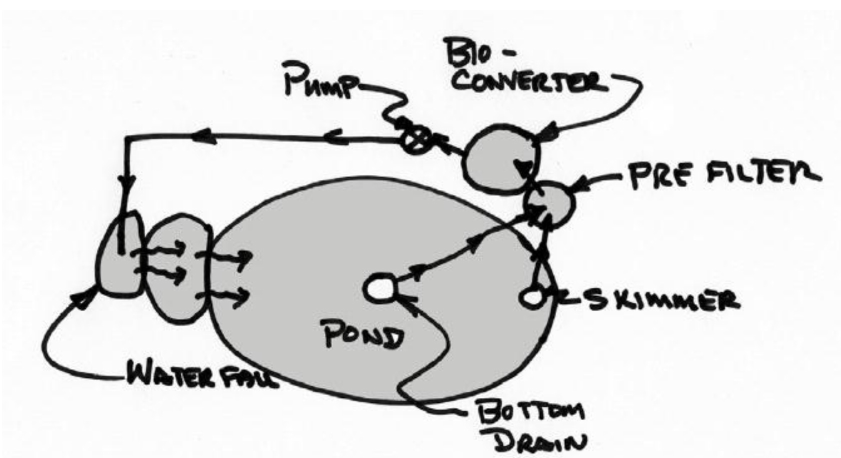
- Add another watertight container in which to sit the tank so that if the tank failed, all the water would not drain away but rather be kept to sustain the fish.
- Bury the tank half way in the ground and put a liner in the hole to contain part of the water in the event of a large leak.
- Add an alarm to the system so that if the tank sprung a leak, the low water level would trigger an alarm alerting you to the failure.
- Add an auto-fill valve to the tank with a serious flow restrictor (so that only a small flow of water would occur). That way if only a minor leak occurred, the auto-fill valve would replenish the lost water. (You’d have to make sure that system didn’t poison your fish with chlorine, chloramine), and so forth.

Hopefully you get the idea. (Creativity is a big help here.)

If you look at your system as a whole and look at each place where a serious or catastrophic failure might occur, you can then start to plan for such eventualities.

Let’s look at a typical system, if there is such an animal, and go through the most likely major failure modes and what might be done to plan for them.

In the following simple system, water flows from the pond under gravity to the prefilter, into the bio-converter, and then it is pumped back into the pond by way of a waterfall.



This system works when

- It has adequate water.
- The electricity is on.
- The water is unimpeded in its path.
- The prefilter is functioning correctly.
- The bio-converter is functioning correctly.
- The pump is working correctly.

- It has no major leaks

With each of these criteria, we can assign one or more failure modes; this is how and where the system is most likely to have a problem.

If we take each potential failure mode, examine its most likely cause or causes and provide for either compensation, a backup or an alarm, we will be much less likely to have a catastrophic event. By the way, commercial airplanes do this, that is, critical systems have redundancy so that if one system fails another is there to do the job without skipping a beat (or crashing the airplane).

Another thing to consider is that one failure could cause multiple problems, each of which could be a catastrophe in itself. For example: a power failure would cause electric water pumps to stop, which could cause

- Ammonia to build up to toxic levels in the pond.
- Oxygen in the pond could be used and not replenished such that the fish were oxygen starved.
- The bioconverter could be without oxygenated water for long enough that the aerobic bacteria could die.

All of these problems could be solved simultaneously by the timely use of an alternative power supply. Here are some ways to bring that solution to bear on the problem:

- Use a gasoline-powered generator with access to the circuits that run the pond pumps. An elegant and expensive version makes this switch automatically.
- Use an inverter off a DC (like a battery) source that is large enough to run the pumps. These can run off a car battery with long extension cords. If the power outage is anticipated to be quite a while, you may want to leave the car running so that the alternator keeps the battery charged.
- Run a cord from the neighbor’s power if you’re off line and they aren’t.

But what if you didn’t have access to an alternative power supply? Let’s examine what could be done with each of the problems.

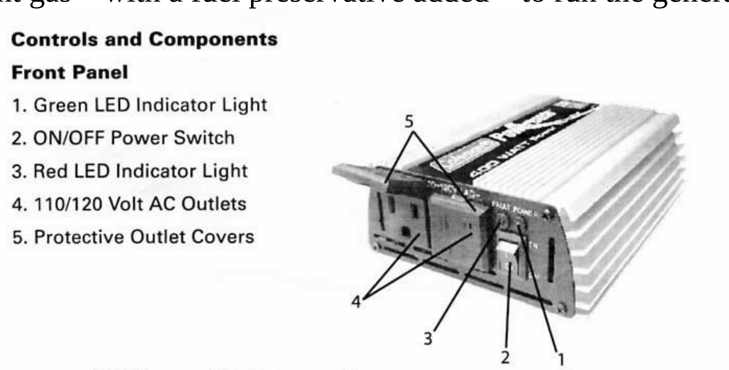
- Stop feeding the fish. Fish that are not eating produce much less ammonia. Fish can survive for weeks without eating at any time of the year.
- Use AmQuel, ChlorAm-X, or a similar ammonia binding product to render the excess ammonia in the water non-toxic, or
- Perform water changes to help rid the pond water of excess ammonia.
- Use a battery-powered air pump to circulate and aerate the water. In a pinch, almost anything that would stir the water would help aerate it, for example, a broom.
- If you have a battery back-up power supply for your computer, use this to provide small amounts of power that could run air pumps and maybe small water pumps in an emergency. (Most units do say not to run motors off them.)

- If possible, drain the bioconverter but keep it moist. The bacteria in a mature filter can live for weeks if they are kept moist and have a supply of oxygen. Draining the water from the bioconverter while keeping the media covered to prevent dehydration evaporation could provide those conditions, that is, damp media immersed in air.

OK, hopefully you get the idea that you need to think where your system could fail and of ways to either preclude that or to be ready to compensate for the failure before it becomes a disaster.

Here are some things you may wish to consider:

- Have at least one spare pump on hand for every system you have.
- Connect your pumps with unions, the pump-end of which can be UNSCREWED and put into the new pump. Trust me, you don’t want to be sawing and gluing in an emergency (and probably in the rain). Like Vicki Vaughan says, "Ask me how I know this." <groan>
- Keep enough ammonia binder, such as AmQuel, ChlorAm-X or Ultimate, on hand to do a complete water change in your systems.
- Keep dechlorinator on hand to dechlorinate a complete water change for your system. If your bioconverters are running and you need only to do small water changes, you can even fill with chloraminated water and just use dechlor to break the chlorine-ammonia bond and lock up the chlorine. The bioconverter will "eat" the ammonia and not poison your fish if it’s not too much ammonia too fast.
- Provide a way to drain your bioconverter if the power goes out—better that this be automatic and even if it takes four hours to drain, your bioconverter will not die in that time.
- Have nets and tubs on hand in case you need to remove some or all of the fish.
- Have an emergency water container that could be set up to temporarily house all your fish if need be.
- Have a gas-powered generator and a way to connect it to your pond pumps plus sufficient gas—with a fuel preservative added—to run the generator for a day or more.



400 watt inverter - example

- Keep a large or small DC-to-AC inverter plus extension cords to reach from the power supply to where the power will be needed.

- Have air pumps, tubing, and air-stones to keep water aerated in an emergency.
- Have tools, pipe, fittings, and glue available for plastic plumbing repairs.
- Purchase low water alarms. Places like Aquatic Eco-Systems in Florida sell them.
- Make a power failure alarm. Use a normally open relay and a battery-operated smoke alarm (the noise making part). These things are meant to wake you out of a sound sleep. This is another Norm Meck idea.
- Plug an old fashioned analog clock into the circuits for your pond. Then if the power goes off when you're gone, you can tell how long it's been off on your return (unless it's been off for more than 12 hours—ask the neighbors as someone will know). This is another Norm Meck idea.
- Have oxygen, bags, and boxes on hand so that the koi could be transferred to these temporarily or to another pond in case of a long-term power outage. Thanks to Steve Childers for this one.

Another good way to compensate for potential problems is to avoid them. Here are some things to consider avoiding:

- Avoid auto-fill valves when you have chlorine or chloramine in the water running through it. If you get a serious leak somewhere in the system, you can poison your fish before you know it. This has happened to some unfortunate hobbyists' ponds, and beautiful fish have died.
- Avoid leaving the water running unattended when you're doing water changes. If you do this often, eventually you WILL forget it and that can and does kill fish if you have chlorine or chloramine in your water. You can purchase a hose water timer that automatically limits the time the water is on from places like the Home Depot for about $20.

Hose Timer - Example

- Avoid leaving an inexperienced person to feed your fish while you are away. This can be a disaster. Unless you're going to be gone for over two weeks, just don't feed them or use an auto-feeder that's been proven reliable before you leave.
- Don't go away without designating someone on whom the "pond watcher" can call if things go South or just don't look right. When things get out of whack, you DON'T want someone inexperienced trying to "help." Leave them a couple of good phone numbers of folks with whom you have checked and confirmed they will be available in your absence.

Now that we have the principles, let's see how to implement a "fail safe" design. First, make a schematic of your system, which is a simple picture of all the components that are part of your system and that might cause a problem. Next make a list of how potential problems might occur and how these failures might be avoided or compensated for. Then choose the failures that are most likely and the ones that can cause a disaster, and choose practical ways to preclude or compensate for those eventualities. Then do it!

Good luck and if you need any help, give me a call. Spike Cover, Mission Viejo, California,9 a.m. to 9 p.m. (Pacific time): (949) 855-2371.