SERVICEMAN'S LOG

Carbon based failures are all too common

Not all faults in equipment are hardware or software based but are instead due to carbon-based failures or CBFs, as in carbon-based life forms. Unfortunately, CBFs can really waste your time.

Items Covered This Month

- Carbon-based failures
- The mosquito that died happy
- Is it electrical or fuel?
- Faulty air-conditioning controller

My first story this month comes from T. M. of St Agnes, SA and concerns faults in biomedical equipment. Here's the story in his own words . . .

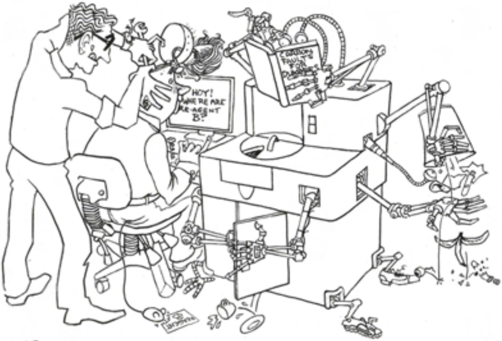
For the last 19 years, I have worked as a Biomedical Engineering Technician for one of the largest pathology providers in Australia. For most of that time, I have worked in a team that looks after all our regional labs. These can range from quite large labs with several hundred staff to small labs at country hospitals with only four or so staff members.

As with most modern equipment, the majority of problems are not strictly electronics related. Most of the gear in this industry is built in the USA, Europe or Japan by large corporations with huge design budgets. Failures in the medical industry can sometimes literally be a life or death situation and so the design and construction of such equipment is to a very high standard.

Certainly, the companies involved are not interested is sacrificing component quality just to save a few dollars.

As a result, most of our equipment is quite reliable. Even so, I have a team of seven guys who work hard at fixing the analysers that the supplier's sales reps tell us (at the time of purchase) should never break down.

One morning, I received a call from a Lab Manager complaining that his main chemistry analyser was reporting an error along the lines of "Can't find reagent B". Chemistry analysers usually have one or more thin probes attached to robotic arms that pick up samples or reagents and place them into a small cuvette (or tube), where a chemical reaction takes place. Light is then shone through the cuvette and the absorbance of the light at different wavelengths is measured.



REPAIRING A CHEMISTRY ANALYSER'S CARBON-BASED FAILURE

By measuring the absolute figure, rate of change or a peak value, the analyser can determine the amount of a certain chemical that was originally present in the sample. The results mean something to our medical fraternity but usually don't mean much to the engineering staff, especially as the chemical name is usually shortened to a code such as "T4" or "Dig" etc.

The volumes of both the sample and the reagent are kept very small for each test. Apart from anything else, keeping reagent volumes to a minimum is a cost-saving exercise as the number of tests each machine does in a week can run into the thousands.

Normally, a liquid-level sense circuit is incorporated on the probe, allowing the probe to draw a reagent or sample from the top of the fluid. This is done to minimise "wetting" of the outside of the probe, thus reducing carry over and contamination. The liquid level sensing is usually achieved by monitoring the capacitance of the probe and looking for a step change as it touches the surface.

Anyway, back to the "Can't find reagent B" problem. Initially, I spent a few hours on the phone with the Lab Manager, going through various things to check . . . "Have you changed the reagent pack? Is it empty? Has the signal wire broken from the probe? Take the probe out and ensure that there is no corrosion at the mounting sleeve (this isn't unheard of and will insulate the signal back from the probe). Is the reagent bottle properly earthed? Have there been any spills, resulting in dried conductive salt deposits interfering with the level sense signal?"

After exhausting all these and other ideas without result, there was nothing for it but to make the 3-hour trip to the lab with my tools and spares to check out the problem with the robot arm. When I arrived about mid-afternoon, I immediately looked into the reagent B bottle and saw that it was nearly empty. As a result, I asked the lab manager to get me a new bottle of reagent, after which the analyser worked perfectly, much to the mixed emotions of the lab manager.

In fact, he was very red-faced. He had, after all, spent half a day trying to fix an analyser that was reporting that it couldn't find a reagent that wasn't there. Much to his embarrassment, the fault had been fixed less than a minute after my arrival and that was without opening the tool box!

His excuse was that he thought one of his night-staff had changed the reagent while trying to fix the "fault" and he hadn't rechecked it – this despite the fact that I had asked him to do this at the start of the phone call.

This type of fault is what we tactfully call a CBF or "Carbon Based Failure" (as in, carbon-based life forms). The operators don't like getting service reports with "Operator Error" written on them!

The mosquito that died happy

Another "Carbon Based Failure" occurred one Sunday when I got a call from one of our large metropolitan labs, the operator complaining that one of their major chemistry analysers had stopped working. According to him, there were no lights, buzzes, whirrs or any other signs of life. It was just "dead"!

"So much for my nice relaxing Sunday afternoon", I thought as I headed off to the lab with my tools to investigate. However, it didn't take long to get an inkling of what the problem might be because as I was walking into the lab, I noticed that most of the lights were off. What's more, as soon as I got there, someone said "Thank heavens you're here because you can check that box under the bench as well. It's been beeping and driving us all crazy but at least it's stopped for now".

The "box" he was referring to was the 6kVA UPS (uninterruptible power supply). The beeping noise it had been making was simply a warning that it was running on batteries, as the power had failed. The beeps had then stopped when the batteries went flat, thus resulting in the power to the analyser dropping out.

It always amazes me how the addition of a UPS is the apparent answer to all problems. We normally install them to keep equipment operational during the time it takes for a back-up

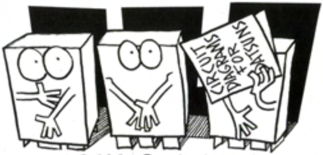
THE MOZZY THAT DIED HAPPY...

generator to kick in if the mains power fails. Even though the generators start up in a few seconds, computer systems only take a split second to shut down and the analysers "go down" with them, thereby losing any work that may be in progress.

In many of our hospitals, the load on the generators is normally heading towards full capacity. In this particular case, a decision was made not to put the second major analyser on emergency power for this very reason. Instead, the UPS was rated to allow enough time for the "main" analyser to finish the work that had already been loaded onto it, after which the operator could then do a controlled shut-down.

My next call was to service a blood gas analyser that wouldn't give any results. "The electronics must have failed as I have put in a new sensor. You need to come quickly!", was the plea from the operator.

In operation, blood gas analysers take a whole blood sample and meas-



...A STEEL PANEL BEHIND IT WAS MOVED TO EXPOSE A FURTHER 3 RELAYS

ure the pH and the amount of oxygen and carbon dioxide being carried by the blood. Usually, the labs want them fixed as soon as possible, as the results are clinically important to the medical staff. What's more, the samples normally can't be sent between sites as they have a very short shelf life. Apparently, atmospheric gases can contaminate the sample and make the readings invalid.

When I arrived, I quickly determined that the blood wasn't being presented to the electrodes. The reason for this was a blockage in one of the fine tubes between where the syringe is presented and the electrode housing. This is not that uncommon as the syringes that are used for collecting the sample have a chemical in them that is meant to mix with the blood to stop it from clotting.

Basically, the nurse is required to roll the syringe a few times after taking a sample to thoroughly mix the blood. Failing to do this will cause some of the blood to clot and this can subsequently be injected into the analyser, causing blockages.

I muttered something under my breath along the lines of "when will the @#$%^& staff learn to mix their samples"? and proceeded to pull the analyser apart to clean out the tubing. But it wasn't a clot – instead, I was surprised to find a mosquito corpse stuck in the main sample path! The mosquito must have thought it had found an absolute feast, only to be sucked up into the machine to a messy end.

My next story come from P. W. of Hope Valley in SA. Here it is . . .

Is it electrical or fuel?

My son has a 1991 Nissan Nomad van (8-seater) which developed an annoying intermittent engine problem. The engine (petrol/carburettor) would start and run for some time but then would stop without any warning and sometimes in the most inconvenient and dangerous road locations. And when it stopped, it would initially refuse to restart.

After a few minutes, it would then generally start again and operate normally until the next episode.

On one occasion, on the way to the repair garage, the vehicle broke down at a T-intersection. Unfortunately, the direction of travel was uphill and a 50-seat passenger bus pulled up behind, followed by numerous other cars. There was only one direction to go and that was to push the van uphill and to the side of the road, to allow the bus and other vehicles to drive around us. Even the bus driver helped to push.

The intermittent problem was very frustrating as it was possible to drive for some days without incident. Even an extended test drive by the repair shop mechanic failed to re-create the problem.

Under these conditions, diagnosis is very difficult and so I adopted the elimination method of fault finding. To begin, I talked to the experts, with the consensus being that it was either the ignition system electrics or the fuel system. It also seemed that it might be temperature related.

The ignition system was the most likely suspect, because the engine always stopped suddenly without any warning. If it were a fuel problem, some surging of the engine would normally be expected prior to stopping.

Unfortunately, this vehicle has a twin spark system (two plugs per cylinder) and an electronic distributor. The repair mechanic suggested that a replacement distributor may be difficult to source and would be expensive. Considering the age of the van, a replacement might be uneconomical, leaving us with little choice but to scrap the vehicle.

With that in mind, I decided to come up with a scheme to cheaply test the ignition system. I had an old ignition timing light in my workshop and after a good rummage around, I located it and connected it to the van's battery and number one spark lead. My theory was that if the problem was lack of spark, I just needed to wait until the engine stopped and then crank the engine with the timing light hooked up. If the timing lamp flashed, then the ignition system was working and could be eliminated as the cause of the problem.

Conversely, if there were no flashes, the ignition system would need to be checked out.

It was not long before the engine stopped and I tried the timing light. Bright flashes were immediately visible when the engine was cranked, thus eliminating the ignition system as the culprit.

Electric fuel pump

The next thing to look at was the fuel system. The van has an electric fuel pump in the fuel tank, so the main possibilities included a faulty fuel pump, a faulty fuel pump relay, a faulty electrical connection or fuse, a blocked fuel filter or a faulty carburettor or carburettor float valve. An electrical circuit diagram of the fuel system layout would have been useful but checking the Internet and two large local libraries drew a blank.

The expert advice was that I should wait until the van stopped and then check to see whether there was fuel visible in the sight glass on the side of the carburettor. If fuel were not visible, then it would be a fuel delivery problem. Conversely, if the fuel was visible, then the problem would be a sticky float valve or blockage in the carburettor.

Any person who has owned or worked on a van with the engine under and between the front seats knows that it is almost impossible to find the carburettor, let alone see an obscure sight glass on the side. I looked and looked and even removed some side panel covers and crawled underneath but to no avail. The sight glass remained "unsighted".

At this time, I consulted the repair mechanic and we decided that the first item to replace would be the fuel filter, followed by the fuel pump. The process would be to change the filter first and then test the pump delivery pressure. He also had some good news on the fuel pump if it needed replacement – it was currently being offered by his supplier at a special stock run-out price.

Anyway, the filter was replaced and the pump delivery pressure checked. This was found to be erratic, pointing to a problem with the pump itself. It was replaced and thinking that we had finally cracked the problem, we drove off towards home.

You've guessed it – just 2km down the road, the engine stopped again.

We eventually got home and parked the van in the driveway. It sat there until the following Saturday afternoon, at which point I gathered my tools together and resolved to solve the problem once and for all.

The first port of call was the connector closest to the fuel tank. This connector routes the +12V and ground supply leads to the fuel pump and also handles the wiring from the fuel-tank level sender.

After switching on the ignition, I identified each connection and checked the +12V supply to the pump circuit. This voltage initially wavered somewhat but then remained steady. This seemed odd so I plugged the connector in and listened for the sound of the pump. It ran OK so I switched the ignition off to think about where to go next. If the voltage was varying, then there was a poor connection somewhere, most likely in the fuel pump relay.

Tracking down the fuel pump relay

So where was the fuel pump relay located? Looking under the dash, I found a cluster of four relays plus a further two relays near the steering column. None were labelled to indicate their function but because the fuel pump only runs when the ignition is on, I decided to listen to the relays when the key was turned. That way, I could narrow down the likely suspects.

I removed the relays that clicked and then checked each one in turn using a multimeter and a 12V supply from the van battery. They all tested OK so I replaced them and tried the ignition again. This time, there was no noise from the fuel pump at all, so it wasn't running.

I tried turning the ignition off and on a number of times and eventually got the fuel pump working – well, for most of the time. I was on the right track but where was the fuel pump relay? I again removed the previous clicking relays and then listened carefully as I operated the ignition key. Eventually, I was able to detect a faint clicking sound somewhere near the glove compartment.

In the end, I concluded that the sound was coming from behind the glove box. The glove box was quickly removed and then a steel panel behind it was moved to expose a further three relays. I then identified the fuel pump relay by matching one of its colour-coded leads to the +12V lead going to the fuel pump connector.

At this time I thought that a screwdriver "tap test" might be useful to confirm the problem, my thinking being that the relay contacts were probably at the end

~SO I REPLACED IT WITH A MONOLITHIC TYPE

of their useful life. And so, with the ignition on, I carefully tapped the relay while listening for the sound of the fuel pump. The fuel pump responded immediately when the relay was tapped, the pump noise varying in pitch and often stopping and starting. The culprit had finally been nailed.

Having identified the cause of the problem, it was time to fix it. The relay was unplugged from the harness and the circuit board and plug contacts removed from the plastic case after some careful prising with a flat-blade screwdriver. A quick examination revealed that the circuit board held a small 9V relay plus two transistors and a handful of resistors.

Everything looked OK on the component side of the board, so I turned it over to check the track side. And that's when I spied a dark circle around one of the solder pads on one of the relay pins. A good solder joint should be shiny and bright but this joint had a dark circle between the centre of the pin and the outside of the pad.

In short, it was a typical dry joint problem and it affected the pin that supplies +12V to the fuel pump.

Clearly, the amount of solder applied to this pin had been marginal. It had lasted 19 years but after repeated thermal cycling and vibration, had now become intermittent.

It took no more than a minute to resolder this connection and all the other connections on the board for good measure. The relay was then reinstalled and a long test drive confirmed that the problem had finally been solved. What a relief!

However, this incident shows just how difficult and costly an intermittent fault can be to diagnose. There were times when we thought that the only reasonable outcome would be to scrap the vehicle and I wonder whether other people have faced similar problems with this particular model.

On the other hand, it's quite possible that a visit to the local Nissan dealer would have quickly solved the problem. Perhaps, in their repair knowledge base, they have a solution for this type of intermittent fault that reads "Replace the fuel pump relay behind the glove compartment (left-hand relay)".

Air-conditioning controller

The final story this month comes from R. G. of Cooloola Cove, Qld and concerns a faulty air-conditioner controller . . .

Recently, my wife observed that the temperature controller on our air-conditioner was showing a blank screen. Because it was the middle of summer, I decided I'd better take a look at it straight away.

I initially thought that the batteries were probably flat and that I would have it fixed in no time. However, when I removed the cover, I found a lot of corrosion on one of the terminals, so I cleaned it up and installed some fresh batteries. Much to my surprise, this didn't fix the problem so I unclipped the unit off the wall and took it down to the workshop.

The unit is manufactured by Arlec and controls a through-the-wall air conditioner. It has some nice features that I would lose with an ordinary thermostat. The problem is that, in view of their age, these units are probably no longer available, so I was going to have to repair it.

Having placed it on the workbench, I removed the circuit board and checked for more corrosion. There was some dust and dirt but all seemed to be OK. I gave it a good clean just to make sure and replaced the wire attached to the corroded terminal. I then put it back together, inserted the batteries and the screen came on at full brightness.

Thinking that that would be the end of the matter, I clipped it back on the wall but the screen went blank again less than an hour later.

Back in the workshop, I pulled it apart to check out the elastomeric strip that connects the LCD screen to the circuit board. The contacts looked OK but I gave them a good clean anyway and reassembled the unit. I then installed the batteries and once again the screen came on at full brilliance, so I clipped it back on to the wall.

This time, it lasted no more than 30 minutes before going blank again. It was time for a bit of a think.

One thing I had noticed was that the unit had become quite warm while I was working on it, due to a 50W QH 50mm reflector lamp that I was using for illumination. Thinking that the fault might be heat sensitive, I used the lamp to warm the controller while I watched the screen. Sure enough, it quickly came good but when I let it cool down, the screen went blank again.

Next, I tried heating up individual components one at a time by touching their leads with a soldering iron for a few seconds. This made no difference and I was beginning to suspect the main IC which is under a blob of black epoxy. However, I wasn't going to give up easily, so I tested all the transistors and replaced the two electrolytic capacitors. I then reassembled the unit but only had a very faint screen.

I then tried the heat test on the ceramic capacitors and when I tested C4, the screen went blank. This had me puzzled because heating things up used to make the screen come on. Now it was making things worse.

To make sure that C4 was the culprit I sprayed it with freezer spray and the screen reappeared but only faintly. I then removed C4 only to find that it did not have any markings. I tested it in my capacitance meter and this gave a value of 100nF which I considered reasonable considering its physical size.

I didn't have a ceramic type of that value so I replaced it with a monolithic type. And that finally fixed the problem because the display has been at full brilliance ever since. **SC**