SIR Warren Rogers: King of Leak Detection By the Numbers

In an interview with Jaime Kammerzell, Dr. Warren Rogers discusses his early years as a United States Naval Aviator, his involvement in the Office of the Chief of Naval Operations and the US Naval War College, and his current career as president of Warren Rogers Associates, Inc.

Statistics reconcile the facts-

Dr. Warren F. Rogers is recognized as the leading authority on statistical inventory reconciliation (SIR) to detect leaking underground storage systems. How did this retired Navy Commander and former teacher at the prestigious Naval War College arrive at this position? The answer, plus some interesting comments on the future use of SIR, are found in this interview of Dr. Rogers.

Where were you born?
I was born in New York City, but my family moved to Ireland when I was an infant and I remained there until I was 21.

Why did you return to the United States?
When I applied for a passport at the American Embassy in Dublin, I was informed that a condition for getting the passport was that I enter one of the armed services—I was subject to the Korean War draft. I had the option of going to Paris and joining the Air Force there for a couple of years or returning to the United States, which I did, and entering the Navy. My original intent when I entered the Navy was to complete the shortest possible tour of duty, get out and get on with my life. But after I'd been in the Navy for awhile, I found I enjoyed it, particularly when I was given the opportunity to enter flight training. So I went to Pensacola, Florida and became an aviator. After an 18-month training program, I emerged with a set of Navy wings and I was sent to Chincoteague, Virginia, which was a Naval Air Station at that time, to join Patrol Squadron 24.

While I was in the Navy, I earned a Bachelors and Masters Degree in Operations Research at the Navy Postgraduate School and a Doctorate in Statistics from Stanford University. The Navy policy when you earn an advanced degree while on active duty requires that you serve a tour of duty practicing in the field in which you earned the degree. It's called a "pay-back tour." I was sent to the Center for Naval

Analysis which, like the Rand Corporation for the Air Force, is a private corporation which supplies analytical services to the Navy. Some years later, after I had retired from the Navy, I taught at the Naval War College in Newport, Rhode Island. When the Navy released me from federal government service, the Center for Naval Analysis retained me as a consultant and subsequently a vice president.

When did you retire from the Navy?

I retired from the Navy in 1973, after serving for 23 years. The Navy asked me to set up an academic department at the Naval War College. We agreed that I would retire and go to Newport as a civilian.

The Naval War College is a senior military college for, not just the Navy, but for all of the services. Typically, the rank of students is Captain US Navy, or Colonel US Army, Air Force or Marine Corps. These are senior officers who have been very successful in operational capacities. They come to Newport, Rhode Island for a year for a program which was divided into three parts. One section was Strategy, one was Naval Operations, and the one in which I was involved was Defense Economics. The Defense Economics program was designed to educate people in methods of scientific decision-making, in choosing where to put resources in terms of weapons procurement, people, support, and readiness—all of those things that an armed service has to buy every year. After the officers complete the program, they move out to more senior assignments, typically in Washington.

What was the most important lesson you learned in the Navy and at the Naval War College?

Well, in the Navy, I was flying airplanes, so the most important lesson I learned was how to stay alive. Towards the later part of my career in the Navy, I was very heavily involved in analytical reasoning in support of high level decision-making. When I was at the Center for Naval Analysis, still in the Navy, the then-president of the Center for Naval Analysis was Charles DeBona. He subsequently became president of the American Petroleum Institute. I had conducted statistical analyses directly for him while he was at the Center for Naval Analysis. When I resigned from the Naval War College and was free of government service, he asked me to become a consultant to the API.

Warren with daughter, Maureen, and son, Mike

What did you do for API?

I did a variety of different studies on different topics. The largest study, prior to getting involved in USTs, involved an analysis of the economic effect of changes in the law dealing with recovering oil from the outer continental shelf. That study became part of the Congressional Record.

What did you learn from that study?

A large number of amendments were being proposed to the existing legislation dealing with exploration and development on the outer continental shelf. We found that if those amendments had been passed, it would have extended the time from initial exploration to the point where oil was actually recovered, from a period of three-and-a-half to six-and-a-half or seven years. The net cost to the economy would have been in the range of $6 billion.

In 1978, while I was still working for the Center for Naval Analysis and the American Petroleum

Institute, the issue of underground storage tanks came up. At that time, the frequency of leaks that were occurring in unprotected steel tanks seemed to be increasing dramatically. No one had any good explanation for why that was happening. Most particularly, they didn't have any means of predicting when a tank would fail because of the various corrosion effects it was exposed to. So I was asked by the API in 1978 to conduct an analysis to determine if one could predict when tanks would fail. We were successful in developing a method for doing that in 1979.

On the completion of the work for the API, Chevron asked us to implement this procedure at all of their company owned locations. Chevron had decided, as had most of the major oil companies at this point, that they were going to remove all of their unprotected steel tanks and replace them with some alternative. The problem the major companies faced was the sheer magnitude of the undertaking. It was clear that such programs would take from seven to ten years to accomplish. A means of prioritizing was essential so that the sites which were most at risk would be addressed first and then those in descending order of risk. That's what our predictive method provided and that is how it was employed.

We performed this service for Chevron first, then Texaco, then Getty, then the Southland Corporation and various others over the years. We've been to more than 30,000 locations now performing this particular service.

An interesting issue arose in 1981. In the course of conducting analyses for the companies, we frequently observed leaking tanks being removed from the ground with obvious corrosion holes. Most often it was not immediately apparent when looking at the inventory data that the tank was leaking. In 1983, we were retained by Amoco to develop better means of analyzing the inventory data. The result of that research was what became known as Statistical Inventory Reconciliation Analysis (SIRA™).

Warren with grandson, Patrick

Please explain Statistical Inventory Reconciliation Analysis (SIRA™)

When we began our analysis of inventory data, inventory control was the only means of leak detection. Tank testing devices that were available in 1981 were often unreliable and subject to false alarm. The traditional methods of inventory control were subject, however, to systematic errors caused by industry practices of that time.

For example, it was not and is not the practice to meter fuel from a tank truck into the tank in the ground. Instead, a compartment on the tanker empties into the tank and one assumes 1) that all of the fuel went into the tank, and 2) it was the right volume. It is not unusual for a delivery to be off by 200 or 300 gallons.

When discussing this issue an important distinction must be made between activities that are undertaken for purely business reasons and activities which are required for leak detection. Typical deliveries can consist of 10,000 or so gallons so that an error of that magnitude in the delivered quantity is not considered significant, in view of the time savings involved. So, from a business standpoint, that is quite acceptable. From a leak-detection standpoint, though, it's crucial. If during the course of a month someone takes an over-delivery of 200 gallons, it will effectively cover up a leak of six gallons a day. The opposite side of the coin is, if someone takes an under-delivery of 200 gallons once during a 30-day period, it creates the false impression that there is a leak of six gallons a day where there isn't one.

One of the biggest problems in inventory analysis arises from the way in which we determine how much product is in the tank. We cannot directly measure the volume of product in a tank. We measure its height. Then we can use our knowledge of the geometry of the tank, if we know it, to convert that height to volume. In practice, however, we must rely on a conversion chart. The tank manufacturer supplies the chart but the chart he provides is not specific to any one tank. It's a generic chart. The dimensions of a tank may be off by as much as 10 percent from the nominal. As a result, the actual volume for a given height can be very different than the theoretical one in the chart. An automatic tank gauge also measures product height but relies on nominal dimensions to convert to volume.

Another source of error is inaccurately calibrated meters at the dispenser. This calibration is done by consumer affairs people, not by leak-detection people and they can be off. These are some of the problems we found when we first addressed this problem in 1983.

The process of statistical inventory analysis consists of identifying those errors, removing their effects from the data and then looking to see if underlying them there is a continuous loss of product that would be consistent with leakage. With statistical inventory analysis and reasonably careful record keeping, we can pick up leaks from manual data or automatic tank gauge data on the order of half a gallon a day.

Warren at Maureen's wedding

You have written several papers and articles, which one stands out most in your memory?
I wrote one, which became a chapter in a book published by ASTM called "Volumetric Leak Detection: A Systems Approach." I think it summarizes a lot of the thinking we had gone through in those years about how the whole process of leak-detection works. For sheer fun I enjoyed one titled, "Fear and Trembling in SIR Land " and published in Lust Line.

In your statistical findings, have any stirred up any controversy?
I did stir up something of a hornet's nest with the major article I mentioned published by ASTM. Various practitioners of other technologies did not want certain weaknesses in their methodologies exposed. They objected strenuously when the paper was submitted for publication. However, the ASTM editors decided they wanted it published anyway. In it, I advocated certain things. For example, I feel very strongly that precision tank test results should be subjected to an in-depth statistical analysis. That's never done and I don't think the people who practice this were kindly disposed towards that idea.

What are you currently doing?

We provide the SIRA™ system as an ongoing service to industry. We also have recently completed a very large number of corrosion analyses—the leak prediction work—because the EPA decided to accept that as a means of evaluating tanks for upgrade by cathodic protection. So before the 1998 deadline, we conducted a large number of corrosion analyses nationwide as a means of determining whether the tanks were suitable for upgrade or not.

We have developed and we are implementing in the field a fully automated inventory analysis system (US PATENT # 5757664). It is a means of continuous analysis of the inventory data with no interaction on the part of the operators. Basically, we have software that takes tank volume from an automatic tank gauge and the amount sold from the dispenser and feeds the information into a processor on-site. With this procedure, SIRA™ is carried out daily. It has many advantages. A major advantage, of course, is that the operator is no longer in the loop. He does not enter any data; it's all done automatically.

The system provides for extremely accurate leak detection and discriminates between tank and line leaks. Typical minimum detectable leaks (MDL) are of the order of .01 gallons per hour. In a controlled test conducted by Amoco, the system detected an induced .05 gallon per hour leak in less than 12 hours. It also discriminates between meter miscalibrations and line leaks.

Apart from leak detection, the system has the capability to perform many business applications. Among the most exciting is the ability to determine individual dispensing meter accuracies from the inventory data alone without on-site physical measurements (Patent pending). We have recently confirmed our ability to do this at an instrumented facility. Accuracy was determined to within plus or minus .75 cubic inches. The economic benefits realizable from this include continuous monitoring at high volume sites to avoid costly give-aways and avoidance of unnecessary calibrations.

Where do you see the petroleum industry going in the future?
Certainly I can't address the entire industry, but I see it going in two interesting directions right now. One is this movement toward automation—the wave of the future in fuel management and leak detection. Processing data will take place through a network rather than through proprietary devices and consoles on-site.

Secondly, what we're finding in the marketplace right now is an indication that leak detection is becoming a matter of secondary importance. In other words, people increasingly use our procedures for business applications.

When an operator has 30,000 gallons of storage capacity at his service station, he has potentially a substantial amount of money that's not drawing any interest. Therefore, there should be considerable incentive not to put more product into his tanks than he absolutely needs to satisfy demand.

On the other hand, if he runs out he can lose not only the sale of the product, he can also lose sales in his convenience store. With the data generated by the automated system there is the possibility of employing optimal inventory theory, a well-known body of mathematics that is applied in many other industries.

Once you have available the volume and kind of data we collect routinely with our system, all kinds of interesting business applications become possible. People who approach us these days are very interested in the business applications. Of course they also get leak detection along with the business application because it’s part of the system. So, this procedure that was initially developed entirely from a leak-detection standpoint has made leak detection applications secondary to the business applications.

Managing Editor of PE&T