ABOVE: *Chlorine that leaked from a train wreck in Graniteville, S.C., combined with moisture in the air to form acids that corrosively ate away at metal and other surfaces in the Avondale Mills textile plant near the accident scene. Damage included chlorine-induced pitting and general corrosion. On the lower inset photo, blisters (circled in pink) were the result of chlorine-induced electrical failures of boiler control systems. Much of the mill's equipment was beyond repair.*

PHOTOS COURTESY OF LISA DETTER-HOSKIN

Chlorine's Casualties and Counsel

Nation's worst chlorine gas leak wreaked havoc, but research reveals lessons learned.

BY JANE M. SANDERS

The United States' worst-ever chlorine gas leak killed nine people and injured 250. Eighteen months later — despite efforts to clean and restore the textile mill affected by the leak — 4,000 people lost their jobs, and a longtime, family-owned textile company went out of business.

Perhaps the only good thing to come out of the disaster is that, if such an accident occurs again, authorities will have better guidelines for first responders and cleanup crews. These guidelines will be the product of about two years of testing and research by scientists and engineers at the Georgia Tech Research Institute (GTRI) and the Georgia Institute of Technology.

GTRI scientists and engineers from Georgia Tech's National Electric Energy Testing, Research and Applications Center (NEETRAC) first became involved in cleanup efforts within a few days after the train wreck that caused the leak on Jan. 6, 2005 in the small town of Graniteville, S.C. South Carolina Electric & Gas needed advice, as well as analysis of components from its heavily damaged power substations that served Graniteville and the large, local textile facility owned by Avondale Mills. The 70 to 80 tons of chlorine gas that leaked from the wrecked train corroded equipment in the substations, which eventually had to be rebuilt.

Because of the magnitude of the disaster, emergency response activities delayed cleanup crews' access to the substations and textile mill. It was 17 days after the accident before clean up began at Avondale, which, by early February 2005, had contracted with GTRI to do materials testing and assessment of restoration efforts.

"Basically, you had items sitting in an acid bottle for days," says Lisa Detter-Hoskin, a GTRI senior research scientist who led the research. "Chlorine combined with moisture in the air to form acids that corrosively ate away at surfaces and moved inward like a cancer in the human body. Much of the mill's equipment was beyond repair due to the severity of the chlorine attack."

Early in the research, it became apparent that the far-reaching effects of the chlorine accident on Avondale would require a variety of expertise from GTRI, Georgia Tech and elsewhere. So Avondale's law firm, King & Spalding in Atlanta, hired Detter-Hoskin as a consultant to coordinate environmental and materials-related testing and find appropriate experts. Detter-Hoskin, group leader of the GTRI Materials Analysis Center, also performed materials analysis and corrosion testing on behalf of Avondale and provided technical consultation for chemical cleanup and restoration.

Detter-Hoskin compiled all of the research and recommendations into a report for Avondale. That report is now the basis for a white paper Detter-Hoskin is writing for the U.S. Department of Homeland Security. She will explain the relationship between acid concentration, exposure effects and possible degrees of material damage. She also will document the cleaning protocols most

PHOTO BY GARY MEEK

ABOVE: *Senior research scientist Lisa-Detter Hoskin, foreground, director of the GTRI Materials Anaysis Center, performed materials analysis and corrosion testing on equipment parts damaged by acids that formed when chlorine combined with moisture in the air at the Avondale Mills textile plant in Graniteville, S.C.*

effective to decontaminate and restore an area affected by a chlorine spill. Detter-Hoskin believes that paper will ultimately become a handbook for first responders, disaster cleanup companies and the chemical industry.

"Chlorine and other highly reactive chemicals are of great concern because they're shipped daily by rail, barge and truck," Detter-Hoskin says. "There have been some spills in U.S. history, but until Graniteville, they were mostly small, and little damage was done. So there was very little public information on how to best serve Avondale Mills in this accident."

Now, GTRI and Georgia Tech have a unique database of information resulting from 18 months of testing and assessment of samples from Avondale's Graniteville facilities. This information may be able to help in the event of another accident, or even a terrorist attack, Detter-Hoskin says.

Detter-Hoskin is reviewing the details of and gleaning the lessons learned from the Graniteville disaster. Numerous factors contributed to the wide-ranging impact of the chlorine leak, she says. For one, the weather in Graniteville at the time of the accident was warm and humid, and there was no breeze that might have dispersed the gas.

"The gas had plenty of moisture to react with, in addition to particulates in the air," Detter-Hoskin explains. "Chlorine will react with almost anything to transform it into more reactive chlorine derivatives. So, dust, lint and dirt in the mill all became chlorinated."

Another factor negatively affecting cleanup was the delay in getting initial access to the mill and the ineffective cleanup process that was implemented, Detter-Hoskin says.

Norfolk Southern was in charge of the initial cleanup efforts at Avondale. According to Detter-Hoskin, their cleaning protocols lacked ongoing environmental abatement, such as that used in lead paint or asbestos remediation. This allowed chlorinated dirt and lint to be redistributed onto cleaned surfaces. Also, limited mechanical or abrasive steps were used to pre-clean material surfaces, and they did not perform any deep chemical cleaning with strong acids or bases.

"The phosphate-based restoration process was selected because it is environmentally friendly, safer for workers and commonly employed after chlorine chemical fires," Detter-Hoskins says. "But these chlorine fires do not cause the extreme deep-metal pitting damage observed at Avondale Mills. The phosphate cleaning methods do not aggressively get into metal layers to clean the chlorine acidic salts deep within pits. The process they used actually encapsulated a lot of chlorine debris. In the long run, that exacerbated cleanup attempts."

Detter-Hoskin recommended implementing two alternative rigorous cleaning methods approved by the American Society for Testing and Materials and the Society for Protective Coatings. These processes would have required skilled workers and costly hazardous acidic waste disposal. But by May 2006, when Avondale Mills settled with its insurance company, damage to equipment in the mill was beyond repair, Detter-Hoskin says. Two months later the company went out of business.

Avondale has a federal lawsuit pending against Norfolk Southern and the three workers who left open the manual switch, leading to the train wreck. That case will be tried in federal court in Aiken, S.C., but it may be many years before it's resolved, Detter-Hoskin says. She will serve as a lead scientific expert for Avondale in the trial.

@ Read more at:
gtresearchnews.gatech.edu/reshor/rh-f06/chlorine.html

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BELOW: *Senior research scientist Lisa Detter-Hoskin, foreground, inspects the results of chlorine decontamination and restoration efforts to a corroded stainless steel tank used to hold hydrogen peroxide.*

PHOTO COURTESY OF LISA DETTER-HOSKIN