NEW WILFRED E. BAKER RESEARCH TEST FACILITY OPENS

by Jim Wesevich and Mike Lowak

Construction is almost complete on the new Wilfred E. Baker Research Test Facility and its opening is slated for January 2008. The 160-acre site includes our new 9,800 sq ft high-bay test building, several outdoor test pads, and a hardened test cell. The facility is located 45 minutes southeast of our San Antonio office and two and a half hours west of Houston between St. Hedwig and La Vernia along the Cibolo Creek.

This new facility is designed to accommodate our expanded testing capabilities and consolidates our shock tube and blast testing programs into a single facility that is relatively close to our San Antonio headquarters. Shock tube testing can now be conducted year round and is less dependent on weather conditions, since test equipment is housed inside the high-bay. The main test building was designed for a 120 MPH hurricane wind load due to anticipated test conditions. The building includes a control room to operate the shock tube, a second control room to operate outdoor test programs, and a client meeting room. The BakerRisk shock tube and test equipment have been refurbished and relocated into the high-bay, which is equipped with a 10-ton travelling crane beam for safe installation of test specimens and to support one-off indoor testing and accident reconstruction efforts.

(continued on page 2)

FLAMMABILITY LIMIT TESTING

by Massimiliano Kolbe

BakerRisk's testing capabilities have recently been expanded to include flammability limit testing for elevated initial temperatures and pressures. Flammability limits are the mixture proportions of fuel and oxidizer (e.g., air) that can be ignited and support flame propagation. Accurate knowledge of these limits is critical to ensure safe process control.

There are two flammability limits: the lower, or lean, flammability limit (LFL) and the upper, or rich, flammability limit (UFL). A mixture is flammable when the fuel concentration is between the LFL and UFL. The flammability limits are functions of temperature, pressure and the concentration of inert species (e.g., water vapor, carbon dioxide, etc.).

(continued on page 3)
Large roll-up doors located in the high-bay will vent blast pressure during shock tube tests and allow truck entry into the building for direct offloading of prefabricated test specimens and equipment.

Shock tube testing includes blast test programs for windows and other building components that provide performance validation for test specimens and analytical modeling verification. BakerRisk’s shock tube apparatus consists of two major sections, a driver section and an expansion section. Blast pressures are generated when a rupture diaphragm, placed between the two sections, fails due to pressure in the driver section. A shock wave then travels down the expansion section and loads the test specimen at the end of the expansion section.

The shock tube has an 8-foot square target area in its normal configuration, and can be configured to deliver a variety of blast load pressure and impulse combinations with a maximum possible peak blast pressure of 45 psi with a maximum impulse greater than 1,000 psi-msec. The 8-ft target area can be expanded to a 10-ft square area to accommodate larger test specimens.

Installation of Shock Tube at New Test Facility

One of the test pads at our new facility will be used to support BakerRisk’s ongoing joint industry testing program on the hazards associated with high pressure equipment. The 2008 high pressure JIP is focused on the hazards created by fitting failures on pneumatically charged equipment. Another of the test pads will support vapor cloud and dust explosion testing programs being carried out for both BakerRisk’s Explosion Research Cooperative joint industry program and our own internal research programs. The hardened test cell will support a continuing series of smaller scale explosion, flammability and reactivity testing programs carried out in support of BakerRisk’s clients.

For more information on our expanded testing capabilities at our new test facility, please contact Mike Lowak at (210) 824-5960 or via email at MLowak@BakerRisk.com.®

(continued from page 1 - Wilfred E. Baker Research Test Facility)
(continued from page 1 – Flammability Limit Testing)

The flammability limit testing apparatus and procedures developed by BakerRisk are based on the ASTM 918 standard for flammability limit testing at elevated temperature and pressure. The test apparatus consists of a stainless steel cylindrical vessel with an inner diameter of approximately 4 inches and an internal volume just over 4 liters. The vessel is equipped with multiple ports for instrumentation and piping access.

The ignition system utilizes a fuse wire (10-mm length of No. 40 tinned copper wire) connected across a terminal set powered by a 500VA/115V transformer. The vessel is equipped with external heaters to control its temperature and internal heaters to facilitate the evaporation of liquid fuels.

A typical test begins by heating the vessel to the desired test temperature and evacuating it using a vacuum pump. Liquid components to be added are measured in glass syringes and then injected into the evacuated vessel through a septum. The combination of the vessel thermal inertia and internal heaters ensures rapid evaporation, and the resulting pressure rise is monitored to verify the desired partial pressure is achieved. Gas components are fed directly into the vessel through multipoint orifices, with the desired component concentration being achieved via control of the associated pressure rise. The individual components are injected separately, with a waiting period of approximately 5 minutes following each component addition to allow the system temperature to return to the desired test value and to ensure good mixing. After all components have been added, a wait time of approximately 10 minutes is used to allow the system to stabilize. The resulting mixture is considered to be flammable at the test temperature and pressure if the final to initial pressure ratio exceeds 7% after activation of the ignition system (i.e., a pressure rise of more than 1 psig for an initial system pressure of 14 psia).

Typically, our tests are performed under conditions where no literature data are available, or for multi-component mixtures, some containing inert species. Initial temperature and pressure testing conditions have ranged from 20 °C to 200 °C and 14.7 psia to 200 psia.

Please contact Max Kolbe at (210) 824-5960 or via email at MKolbe@BakerRisk.com if you would like additional information on BakerRisk’s capabilities for determining flammability limits.

Massimiliano (Max) Kolbe is a Project Consultant in the Blast Effects Section at BakerRisk.

**BakerRisk Visits South China Univ. of Technology**

Dr. Yin Mao, a Principal Engineer at BakerRisk, was recently invited to speak at a technical seminar held at the South China University of Technology. Dr. Mao’s presentation included a discussion of conventional vs. blast resistant building design and mitigation of hazards resulting from industrial explosion accidents.

The seminar was well received and generated great interest from the audience of professors, engineers, and students. The South China University of Technology is one of the top engineering schools in China. It has close ties with industries and professional societies in China, and is well known as a pioneer of many engineering solutions, providing a wide variety of technical consultations to the Chinese industrial community.
UNITY EFFORTS BY LNG SCIENTIFIC COMMUNITY

by John L. Woodward, Ph.D.

The world-wide community of scientists specializing in aspects of Liquefied Natural Gas (LNG) safety has cooperated in the completion of three major consensus-building efforts:

1) The U.S. Government Accountability Office (GAO) assembled a panel of 19 LNG experts who edited a set of statements on LNG safety and voted their degree of agreement with the final statements.

2) A special issue of the Journal of Hazardous Materials (JHM) dedicated to technical LNG safety issues was published.

3) The Center for LNG (CLNG) invited experts to a panel discussion in Washington, DC in June 2007. The Mary K O’Connor Center at Texas A&M University is summarizing the discussion points in a white paper.

Each of these efforts also contributed toward a consensus of priorities on research needs in this field. The growing consensus correlates well with BakerRisk’s research plans and proposals for a Joint Industry Project highlighting LNG Safety Issues. The driving force for these activities is to address public concerns pertaining to the siting of new LNG import terminals. According to the GAO report, 32 applications for the construction of new LNG Terminals have been filed with the Federal Energy Regulatory Commission (FERC) and the U.S. Maritime Administration/Coast Guard (USMA/USCG). Of these, 11 have been approved by FERC and two have been approved by the USMA/USCG. Extreme positions by a very few LNG safety experts have fueled public concern and resulted in some applications for LNG terminals being held up or even withdrawn.

GAO Expert Panel Survey

The GAO proposed a set of 27 statements and asked each expert to vote on his level of agreement with each statement. The subjects addressed ranged widely over such issues as LNG hazards (e.g., fire, explosion, asphyxiation, cryogenic burn, rapid phase transition, cascade events, etc.) and future research needs. An example outcome is the response histogram in Figure 1 below. The statement corresponding to Figure 1 was, “The Sandia report concluded that the most significant impacts to public safety exist within 500 meters of a spill, with much lower impacts at distances beyond 1,600 meters even for very large spills.” The balanced distribution of responses indicates generally good consensus, but with considerable remaining uncertainty on this point.

On the issue of priorities for needed LNG research, the GAO panel of experts produced the following ranking:

<table>
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<tr>
<th>Rank</th>
<th>Research Area</th>
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<tbody>
<tr>
<td>1</td>
<td>Large fire phenomena</td>
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<tr>
<td>2</td>
<td>Cascading failure of LNG carrier</td>
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<tr>
<td>3</td>
<td>Large-scale spill testing on water</td>
</tr>
<tr>
<td>4</td>
<td>Large-scale fire testing</td>
</tr>
<tr>
<td>5</td>
<td>Comprehensive modeling: interaction of physical processes</td>
</tr>
<tr>
<td>9</td>
<td>Effect of sea water coming in as LNG flows out</td>
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These priorities coincide well with the tests proposed in BakerRisk’s JIP proposal for LNG.

Figure 1. Example Histogram of Responses to GAO Statement on LNG

(continued on page 5)
Special Issue of Journal of Hazardous Materials (JHM)

William Lehr of the National Oceanographic and Atmospheric Agency (NOAA) invited LNG experts to contribute to a special issue of the JHM on LNG safety issues. The papers ranged widely, with such topics as: summaries of LNG experimental data; lessons learned from LNG research; a review of LNG fire test data and models; keys to modeling LNG spill spread and evaporation; application of computational fluid dynamics (CFD) to LNG spills; the potential for BLEVE of an LNG carrier tank; and the influence of ice formation.

More than one paper addressed the subject of spreading of a burning pool of LNG on the sea. This was also the subject of a BakerRisk paper “Coupling Dynamic Blow Down and Pool Evaporation Model for LNG” concerning the development of a fully dynamic pool spread model for burning and non-burning pools of LNG. In this model, an option in our SafeSite3G® modeling suite, the discharge rate, decreasing in time as the tank level drops, directly affects the pool spread rate.

Figure 2 is an example of the results of this dynamic model. The radius of a circular (or similarly for a semi-circular pool) expands until the average thickness of the leading edge of the pool decreases enough that the leading edge totally evaporates. Then the pool radius retreats. The maximum radius reached exceeds the radius predicted for a steady-state constant initial discharge rate because of the momentum of the spreading pool. The model for a burning LNG pool follows the same curve as predicted for a non-burning LNG pool, except that the decreasing portion of the pool spread curve occurs earlier than for a non-burning pool. Interestingly, this model predicts a larger maximum pool radius for a 3-meter diameter hole in the inner hull of an LNG carrier than for a 5-meter hole. This is because the level inside the LNG carrier drops faster for a 5-meter hole, affecting the LNG pool thickness that is the driving force for pool spread.

CLNG Conference Discussion Topics

At the Washington DC CLNG conference, papers were presented at each of four sessions. The session topics were: 1) LNG Release from a Ship (Source rate), 2) Pool Spread Description, 3) Pool Fire Description, and 4) Radiant Heat.

A lively discussion occurred in each session, particularly concerning new and controversial areas. For example, the penetration of an LNG spill into water is postulated to strongly increase the initial LNG evaporation rate beyond that previously considered. Previous LNG spill tests have been constructed with spill plates just under the water surface to specifically limit penetration.

Representatives of Sandia Laboratories and the National Institute of Standards Technology (NIST) discussed fire test data and CFD model predictions for fires. The largest LNG spill test, conducted by a consortium at Gaz de France’s Montoir test facility in 1988, was examined in some detail. A new fire model based on this test purportedly produces shorter radiant heat contours than were previously predicted. This sparked a discussion that the new model requires thorough vetting before it can be accepted. The same can be said for a number of issues discussed at the CLNG conference, so the white paper is likely to elicit considerable discussion.※

John Woodward is a Senior Principal Consultant with a Ph.D. and a B.E.S. in Chemical Engineering and a B.S. in Chemistry.
**NEW FACES AT BAKER RISK**

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hala Daher</td>
<td>Process Safety Group</td>
<td>Joined the Structures Group. She received her B.S. in Chemical Engineering at Wayne State University in Detroit, MI. Hala is located in our Houston office.</td>
</tr>
<tr>
<td>Jay Idriss</td>
<td>Structures Group</td>
<td>Joined the Structures Group. He is a Master’s level Civil/Structural engineer with 2 years experience performing threat analysis of potential damage caused by weapons to selected targets, evaluating the design and construction of underground blast hardened structures, and working with explosive demolition safety and techniques. Jay is located in our San Antonio office.</td>
</tr>
<tr>
<td>Akansha Khandelwal</td>
<td>Structures Group</td>
<td>Joined the Structures Group. She completed her master’s degree in Structural Engineering at The University of Texas in Austin. Akansha is located in our San Antonio office.</td>
</tr>
<tr>
<td>Scott Schiller</td>
<td>Process Safety Group</td>
<td>Joined the Process Safety Group. He has over 27 years of industry experience as an engineer in Process Safety performing qualitative and quantitative risk analysis, establishing loss and prevention programs, inspecting pipe and pressure vessel equipment as well as performing accident and incident investigations. Scott is also accomplished in procedural writing and public speaking. Scott is located in Bartlesville, Oklahoma.</td>
</tr>
<tr>
<td>Hongfang Zhang</td>
<td>Blast Effects Group</td>
<td>Joined the Blast Effects Group. She completed her D. Sc. in Mechanical and Aerospace Engineering specializing in Thermal-Fluid Science and Energy Systems at George Washington University in Washington DC. She also has her BS in Civil and Environmental Engineering and is located in our San Antonio office.</td>
</tr>
<tr>
<td>Hala Daher</td>
<td>Process Safety Group</td>
<td>She received her B.S. in Chemical Engineering at Wayne State University in Detroit, MI. Hala is located in our Houston office.</td>
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**BLAST RESISTANT STRUCTURAL DESIGN COURSE**

The 2008 structural design course will be taught by BakerRisk during the week of March 3-7, 2008 in San Antonio, Texas. This course acquaints practicing engineers with procedures used in the analysis and design of structures subjected to loads from accidental and terrorist explosions. Explosion effects from vapor clouds and high explosives will also be addressed.

To register for the course, visit us online at http://www.bakerrisk.com/Courses-Training or contact BakerRiskTraining@BakerRisk.com. For details, contact Judy Nesloney at BakerRisk: (210) 824-5960.

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**May 2008 Course**

*“Introduction to Consequence Modeling”*

Topics include toxic, fire, and blast load predictive methods and the response of structures to blast loads.

Course will be held at BakerRisk’s Canada office.

For more info, contact BakerRiskTraining@BakerRisk.com
CAREER OPPORTUNITIES WITH BAKER RISK

<table>
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<tr>
<th>Job Title / Description</th>
<th>Locations</th>
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</table>
| **Structural Engineer (Senior Level)** | San Antonio, Texas  
Toronto, Ontario |
Qualifications: Expertise in analysis and design of protective structures to resist the effects of blast wave and fragment/debris impact loading; inspection of damaged structures and associated engineering failure analysis.  
Education: BS or MS in Civil/Structural Engineering with 8+ years direct experience. |

| Blast Effects Engineer (Senior Level) | San Antonio, Texas  
Toronto, Ontario |
Qualifications: Expertise required in the evaluation of flammability and explosion related phenomena; prediction of blast and fragment loads; conducting explosion tests; and preparation of technical proposals, reports and presentations of findings.  
Education: BS in Mechanical, Aerospace, or Mining Engineering (MS or Ph.D. preferred) with 5+ years direct experience. |

| Process Safety Engineer (Intermediate Level) | Houston, Texas  
Chicago, Illinois |
Education: BS or MS in Mechanical or Chemical Engineering with 2+ years direct experience. |

| Fire Protection Engineer | Any |
Qualifications: Experienced in managing and executing loss prevention projects and activities.  
Education: BS or MS with 3+ years experience in Fire Protection Mechanical or Chemical Engineering. |

| Materials Engineer | San Antonio, Texas |
Qualifications: Experience performing life and fitness-for-service assessments, risk evaluations, participating in on-site incident investigations, initiating promotional activities, overseeing and performing laboratory testing, and conducting R&D.  
Education: BS, MS or Ph.D. with 5+ years experience in metallurgical or mechanical engineering with a materials emphasis. |

| Software Development Engineer | Houston, Texas |
Qualifications: Experienced with developing mathematical models and GUIs, maintaining and debugging existing code, and developing new code.  
Education: BS in Chemical Engineering, Computer Science, or equivalent (Master’s or Ph.D. preferred). |

BakerRisk offers a highly competitive compensation and benefit plan that includes medical/dental, life, STD/LTD insurance, Section 125 plan, a generous retirement program, and substantial performance bonus plan.

Send your resume to:
Human Resources - BakerRisk
3330 Oakwell Court, Suite 100  San Antonio, TX 78218-3024
Resumes@BakerRisk.com
About BakerRisk
Baker Engineering and Risk Consultants, Inc. is one of the world’s leading explosion analysis, structural design, and risk engineering companies. BakerRisk provides comprehensive consulting, engineering, laboratory and range testing services to government agencies and private companies who are involved with dangerous, highly hazardous, reactive, or explosive materials.

Our Mission:
To provide integrated engineering, research, and risk assessment to aid our clients in managing hazards associated with explosive, flammable, reactive and toxic materials.

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289.288.0100

UK Office
(+44) 1244 893 178

BakerRisk Calendar of Events
Look for BakerRisk at these upcoming events:

April 6-9, 2008
AIChe Global Conference on Process Safety
New Orleans, Louisiana

May 7-8, 2008
NPRA National Safety Conference
The Woodlands, Texas

For subscription inquiries, address changes or additional information about BakerRisk, please send your request to BakerRisk_News@BakerRisk.com