LNG Safety Research: FEM3A Model Development

Quarterly Report
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ABSTRACT

During this reporting period, kickoff and planning meetings were held. Subcontracted experimental and modeling tasks were defined. Efforts to address the numerical stability problems that hamper FEM3A's applicability to low wind speed, stable atmospheric conditions were initiated. A detailed review of FEM3A code and its execution, required for development of an accessible user interface, was also begun. A one-day workshop on LNG safety models has been scheduled for September 2004.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The goals of this project are to develop a national focal point for LNG safety research and technical dissemination and to develop the FEM3A dispersion model for application to general scenarios involving dispersion problems with obstacle and terrain features of realistic complexity.

During this reporting period, the objectives and scope of the project and its constituent tasks were discussed at a project kickoff meeting in Morgantown. Details of the subcontracted experimental and modeling tasks were further defined at a separate meeting at the University of Arkansas.

Researchers at the university have begun to modify the turbulence closure model used in FEM3A to insure numerical stability during simulation of low-wind-speed, stable atmospheric conditions. The university's wind tunnel is being prepared for upcoming experimental studies.

GTI has begun a detailed review of the FEM3A code and its execution that will provide guidance during development of an accessible user interface. Plans were made for a one-day workshop on LNG safety models that will be held at the end of September and will provide an introduction to currently available and pending software tools.

EXPERIMENTAL

Although no experimental studies were performed during this quarter, equipment modifications and repairs needed for the University of Arkansas' wind-tunnel experimental program have been initiated. Experimental work is expected to begin in the next quarter.

RESULTS AND DISCUSSION

A kickoff meeting held in Morgantown on June 4, 2004 was attended by representatives of GTI, researchers affiliated with University of Arkansas (subcontractor to GTI), and members of the NETL staff. Discussions are summarized in the Appendix at the end of this report.

Researchers from GTI and University of Arkansas met in Fayetteville on June 29, 2004. Following a tour of the university's wind tunnel facility, participants discussed the experimental and modeling studies that will be performed at the university. Although the interdependence of these studies makes full definition of the test matrix impossible, an initial test point consisting of measurements for a tank/dike/rough surface scenario was defined. Subsequent points will be selected to support improvement of the turbulence closure model, which is expected to be completed by the end of CY 2004. The improved model is expected to be applicable both immediately downstream of a tank/dike obstacle and further downstream. It is likely that this modeling task will require additional tank/dike/rough surface measurements with a focus on the area immediately downstream of the tank and dike to allow identification of a transition zone.

Simulation studies have been started. The numerical stability problems associated with low wind speed, stable atmospheric conditions are being addressed in a methodical way, with potential sources of numerical instability being introduced sequentially. In the first quarter, coding of three cases was started:
- base case: neutral atmosphere, no obstacles, no gas release
- base case with LNG release added; this case examines the effect of the introduction of dense gas into the boundary layer
- base case with stable atmosphere

As noted above, modifications to the university's wind tunnel are underway.

Mike Du of GTI, who will develop a user interface for FEM3A, remained at the university following the planning meeting and worked with Tom Spicer to develop a better understanding of mechanics of running the model. After gaining a thorough understanding of the model's operation and developing a "FEM3A user profile," he will be able to determine a reasonable level of "user friendliness" and a plan to develop an interface that attains that level.

Planning is underway for a one-day workshop on LNG safety models to be held in conjunction with the GTI *Fundamentals of Baseload LNG* course, which is scheduled for September 20-23. Workshop presenters will include:
- Representative of U.S. DOT Office of Pipeline Safety, "Federal Requirements for Siting LNG Plants"
- Rodney Anderson, NETL, "DOE's Research Programs in LNG Safety"
- Liese Dallbauman, GTI, "GTI's Research Programs in LNG Safety"
- Irwin Prader, Trinity Consultants, "DEGADIS and LNGFIRE Models: Description, Demonstration, and Examples"

- Jerry Havens and Tom Spicer, University of Arkansas, "The FEM3A Model: Description of Technical Capabilities and Computing Resource Requirements"

At the request of Rodney Anderson, Jerry Havens has informed the Office of Pipeline Security (OPS) of the planned changes in the FEM3A model. OPS has confirmed its interest in this effort and proposed dates for a meeting.

GTI has defined a broad spectrum of dissemination options. These options range from maintaining a closely held model, available only to the university and GTI, to providing the FEM3A code at a cost low enough to allow virtually unlimited access. Benefits and drawbacks associated with the various options will be identified and a draft dissemination plan will be provided to NETL during the next quarter. Neither of the extreme cases is realistic and it is anticipated that the selected plan will fall between the two.

CONCLUSION

The work done during this reporting period establishes the framework for the technical work that follows. During the next quarter, GTI will develop an FEM3A user profile (e.g. degree of technical knowledge, computing skills, …), which will define the interface requirements, and present a one-day introductory workshop on LNG safety models. The University of Arkansas will begin experimental studies and continue modeling work that addresses numerical stability problems associated with low wind speed, stable atmospheric conditions.

APPENDIX: Summary of June 4, 2004 Kickoff Meeting

A kickoff meeting for DE-FG26-04NT42030 (LNG Safety Research: FEM3A Model Development) was held on June 4 at NETL's Morgantown site. Attendees included K. Perry and L. Dallbauman of GTI, T. Spicer and J. Havens of the University of Arkansas (UA), and G. Sames, B. Tomer, R. Anderson, W. Rogers, and E. D. Hucakaby of NETL. Several other members of the NETL staff were also present, representing work in simulation and homeland security.

Following introductions by G. Sames, K. Perry presented information on GTI's LNG experience and L. Dallbauman provided a description of the contract objectives, scope of work, tasks, and budget. Because the contracted scope of work focuses entirely on the enhancement of the FEM3A model, four additions to the scope of work were proposed:

- provide potential users with accurate description of FEM3A requirements and capabilities
- develop a user-friendly interface
- determine the optimum point of use
- define roles for model development and support

These items were included in the original project budgeting and will not affect the contract budget.

There was a good deal of discussion regarding the dissemination of the FEM3A model. The complexity of the model will prevent users from simply installing and running it; if it is to be widely distributed, some sort of support mechanism will be required. The form this mechanism will take remains to be defined; licensing the software and providing a consulting service were among the approaches that were discussed. E. D. Huckaby, who has begun using FEM3A, pointed out that training will be a critical component of any dissemination plan.

R. Anderson expressed support for GTI's plan to hold a half-day workshop on LNG safety modeling in conjunction with the Fundamentals of Baseload LNG workshop scheduled to be held in Houston September 20-23.

T. Spicer described UA's wind tunnel facility and its role in FEM3A development and validation. He also discussed the enhanced capabilities of the model that will result from the planned worked; specifically, the addition of an advanced turbulence closure model will allow the model to more realistically describe dispersion in scenarios with realistic obstacle and terrain features.

E. D. Huckaby described related work being done at NETL. He has successfully applied FEM3A to the two of the data sets provided in GRI-03/0104 (*Evaluation of Mitigation Methods for Accidental LNG Releases. The FEM3A Model: Continuing Wind Tunnel*

Verification). The NETL simulation group has also applied FLUENT to the same data and is in the process of comparing FEM3A and FLUENT simulation results.

Two action items were assigned:

- GTI is to provide NETL with a draft dissemination plan within two months
- J. Havens is to inform the Office of Pipeline Safety of the planned changes in the model