Michigan Technological University has been awarded a contract from the US Department of Energy to establish a set of calibration procedures designed to provide information about tools used for the improvement of production of oil and gas from poorly-producing wells in the USA using sonic stimulation methodology. The project dates are January 2002 – December 2004.

OBJECTIVE OF PROJECT

The goal of this project is to establish the link between laboratory experiments and field demonstrations in the promising but poorly understood area of sonic oil stimulation. Scientific theories for the mechanism of sonic stimulation currently depend strongly on the levels of vibrational energy partitioned among the fluid and solid phases in subsurface formations, yet such levels are presently unknown. Laboratory simulations are limited in their ability to provide meaningful results without knowing what levels can be achieved in the field. Theoreticians are developing models that require knowledge of absolute levels of vibrational motion, yet those levels have not been scientifically determined or calculated.

Presently available sonic source tools have been designed with little or no results from hard field data, particularly regarding frequency and power levels. Sonic stimulation sources currently do not have standards. At the present time, efforts in improving source tools and/or their deployment in oil fields are proceeding without the benefit of a good physically based theoretical model. This project is designed to provide the linkage between field and theory, between field and laboratory, and between field demonstrations and the scientific method.

Michigan Technological University (MTU) will conduct experiments at a test site that provides ideal conditions for remote monitoring of the far-field displacements induced by sonic stimulation tools, under closely controlled and repeatable conditions. The test facility is extremely well characterized; the entire geological sequence at the site consists of high velocity formations, ensuring very efficient seismic wave propagation. This test site is intended to become a standard location at which any sonic source can be tested.

STATEMENT OF WORK

The proposed project is expected to require 36 months to complete. This project involves Dr. Wayne Pennington and Dr. Roger Turpening of MTU and Dr. Igor Beresnev of Iowa State University. Industry partners currently involved are Wave Energy Resources Inc. (Centralia, IL); Well Seismic Computing Services (Newport Beach, CA); and BakerAtlas (Houston, TX).

In close association with tool manufacturers, theoreticians, laboratory modelers, and others with an interest in sonic stimulation technologies, a set of experiment standards will be designed to provide information on the absolute levels of vibrational energy (frequency, displacement amplitudes, etc) created in the far field by sonic stimulation sources. These techniques will be employed at a test site that is known to be ideal for such purposes. The methodology and results of this test will be provided to the sonic-stimulation community and criticisms and suggestions will be sought, particularly at a meeting held for this purpose. The results will be incorporated into theoretical results contemporaneously.

The experimental field procedure will be modified, as necessary, to include all source types and deployment conditions (to the extent possible), and repeated. The resulting standard experiment and test site will be made available to the industry at large for calibration of additional source tools. Another set of standards will be developed to provide a scientific methodology to be applied during field demonstrations. Technology transfer is an integral part of all portions of the project.
TASKS TO BE PERFORMED

1) DESIGN EXPERIMENTAL TEST STANDARDS

The experimental standards will include deployment of the source tools and deployment of a set of borehole-based receivers and surface vibrators under similar conditions at the same site.

**DESIGN SOURCE DEPLOYMENT CONFIGURATION AND PROCEDURES (during 2002, to be revised 2003)**

Different sources require extremely different deployment methodologies. The two source tools used to guide the experiment will use simple wireline-conveyed power in one case, and tubing conveyed high-pressure water in the other case.

**DESIGN RECEIVER CONFIGURATION (during 2002, to be revised 2003)**

Receiver well will have multiple levels of clamped geophones and hydrophones if required by theoretical and laboratory models.

**CALIBRATE RECORDING SYSTEM (during 2002-2003)**

Obtain information to calibrate the recording system, from sensor to final recording media, expressing results in absolute units.

2) ACQUIRE INITIAL TEST DATA (during 2003)

The initial deployment will use two sources in the test wells, with the receiver array (calibrated) in the opposite well; then the geometry of the experiment will be reversed to confirm and ensure robustness.

3) INCORPORATE THEORETICAL AND LABORATORY CONSIDERATIONS AND FINDINGS (ongoing)

In the process of designing the original experiment, modifying it, and using the results, theoretical and laboratory constraints will be provided and evaluated. That is, if it turns out to be necessary to provide a certain piece of information in order to assist the theoretical modeling, then it will be incorporated in the experimental design.

4) SOLICITING INPUT AND FEEDBACK FROM THE SONIC STIMULATION COMMUNITY (ongoing)

There are several stages in this project in which input from the community at large will be sought. Informal input will be obtained prior to any of the design, but the primary input will be obtained during a workshop to be scheduled after the initial field testing (in 2003). The workshop participants will be requested to provide criticism and suggestions to ensure that the final standards are all inclusive and cover all existing and likely future tool types to the extent possible.

5) REVISED EXPERIMENT (FINAL CALIBRATION STANDARD) (during 2003-2004)

Considering the results of the initial experiment, the test for the final standard of calibration will be modified.

6) PROCESSING AND INTERPRETATION (during 2003-2004)

Recognize and identify components of signal received at monitor well. Develop 3D model of vibrational energy at receiver well.

7) SCIENTIFIC METHODOLOGY FOR FIELD DEMONSTRATIONS (ongoing)

Concurrent with development of the sonic source calibration, develop a set of guidelines for applying scientific methodology to field demonstrations involving fluid flow from producing wells. Thorough accounting of previous well performance, nearby well performance, and changes in field operational conditions during the experiment will be considered.

8) TECHNOLOGY TRANSFER (ongoing)

The workshop conducted midway through the project will provide one means of technology transfer; another meeting will be held at the end of the project to describe and distribute the results and final details of the calibration standards and the procedures for calibration. Publications of results and methodologies, together with presentations at professional meetings will constitute one primary avenue of technology transfer. In the final stages of the project and workshops, advice will be solicited on the continuation of the calibration efforts, the ability of the community to allow distribution of new results, and the mechanism for funding such ongoing calibrations that may be required.

**DELIVERABLES**

The primary deliverable will be a document with a set of scientific guidelines and operational standards, developed with broad community input and following the experiences gained and applicability to tool design and theoretical modeling, and the calibration results of two tools tested. The operational procedure will be fully documented, with a discussion of errors likely to be present, and the results of the tools tested. The procedure will be made available at the MTU site and with MTU expertise for other source tool manufacturers beyond the life of this project. (An interim report will also be published following the first workshop.)

For more information, contact Wayne D. Pennington (wayne@mtu.edu).
A web site, accessed through http://www.geo.mtu.edu/spot will contain updated information as the project progresses.