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September 2, 2003

VIA FEDERAL EXPRESS

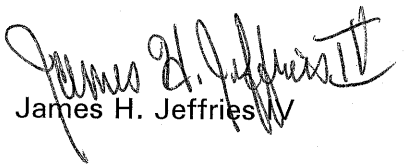
Honorable Deborah Taylor Tate
Chairman
Tennessee Regulatory Authority
460 James Roberson Parkway
Nashville, Tennessee 37243-0505

Re: Docket No. 03-00313

Dear Chairman Tate:

I have enclosed an original and fourteen copies of the Rebuttal Testimony of Ronald B. Edelstein on behalf of Nashville Gas Company, a Division of Piedmont Natural Gas Company, Inc. Please accept the attached for filing and return one "file-stamped" copy to me.

Very truly yours,



James H. Jeffries IV

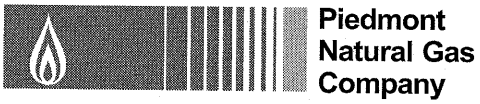
JHJ:bo
Enclosures
cc: All Parties of Record
Dale Grimes

Before The
Tennessee Regulatory Authority
Docket No. 03-00313

In the Matter of

Application of Nashville Gas Company,	)
A Division of Piedmont Natural Gas	)
Company, Inc., for an Adjustment of its	)
Rates and Charges, the Approval of	)
Revised Tariffs and the Approval of	)
Revised Service Regulations	)

Rebuttal Testimony of Ronald B. Edelstein
On Behalf Of
Nashville Gas Company,
A Division of
Piedmont Natural Gas Company, Inc.



Q. Please state your name and business address.

A. My name is Ronald Edelstein. My business address is 1700 South Mount Prospect Road, Chicago, Illinois 60018.

Q. By whom and in what capacity are you employed?

A. I am employed by the Gas Technology Institute (GTI) as Director, State Regulatory Programs

Q. Please describe your educational background and professional experience.

A. I graduated from the University of Florida with a BS in Aerospace Engineering (1969), Rensselaer Polytechnic Institute (RPI) with an MS in Engineering Science: Solid Mechanics (1972), and another MS from RPI in Engineering Science: Environmental Science & Technology (1977). I began my employment with Pratt & Whitney, working as a structural engineer on gas turbines for 8 years, then Planning Research Company as an engineering consultant to DOE for three years, then the Solar Energy Research Institute as an R&D planner for three years, then the Gas Research Institute ("GRI"), now Gas Technology Institute ("GTI"), for 20 years, first as an R&D planner, then strategic planner, then Director of Planning, then Director of Sales, and now Director, State Regulatory Programs.

Q. Have you ever testified before any regulatory commission?

A. Yes. I have testified before the Massachusetts Department of Telecommunications and Energy on behalf of KeySpan Energy on July 11, 2003. I have also submitted written testimony for ONEOK and Atmos Energy in Kansas.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to describe the benefits that Tennessee consumers receive from GTI and its gas consumer benefits research and development (R&D)

program, to delineate specific projects that Piedmont Natural Gas Company ("Company") is requesting funding for, and to request that the Tennessee Regulatory Authority ("Authority") authorize the Company to collect a surcharge from its customers to fund gas consumer benefits R&D.

Q. What is "gas consumer benefits R&D"?

A. This is a specific type of R&D, in which the applicable technologies result in benefits that primarily accrue to gas consumers.

Q. What is the GTI?

A. Natural gas local distribution companies ("LDC's") and pipeline companies, in agreement with the Federal Energy Regulatory Commission ("FERC"), formed GRI in 1977 in the midst of natural gas curtailments and a predicted gas supply shortage. GRI managed R&D projects on natural gas supply, operations, and end use for over 20 years. GTI was merged with the Institute of Gas Technology, the premier gas industry R&D laboratory, in 2000, and the combined entity renamed GTI. GTI now both manages R&D projects and operates as a performing laboratory.

Q. In short, what were the results of these efforts?

A. Since its formation in 1977, GTI has performed R&D on projects that have resulted in over 400 products, processes, and techniques reaching the marketplace. These technologies have benefited gas consumers by lowering the price of natural gas at the wellhead, lowering operating and maintenance (O&M) costs of gas pipelines and LDC's, and offering the consumer safer, increased-efficiency end-use equipment. Overall benefit-cost ratios for gas consumers have ranged between 8-1 and 10-1 over the 26 years of operation of GRI, now GTI. For instance, our latest consumer benefits paper, submitted to FERC in June of 2003 (and attached), documents benefit-cost ratios from the last five years of our R&D program at 8-1.

Q. What were the most notable R&D results that GTI has achieved?

A. In gas supply, our development of technologies for reducing the technical risk of exploration, drilling, and completion of unconventional natural gas and tight gas sands has produced significant results for Tennessee and the nation. For instance U.S. coalbed methane production increased from less than 50 billion cubic feet (Bcf) per year in 1982 to over 1,400 Bcf/yr by 2002, contributing to the "gas bubble" and the supply surplus that existed through the 1980's and into the 1990's. In transmission R&D, development of enhanced nondestructive evaluation sensors and tools have increased the safety of our natural gas pipeline system. In distribution R&D, development of accelerated life testing for plastic gas mains, directional drilling tools, and methane detectors have both lowered the cost of installation and O&M on gas distribution systems and enhanced the safety of these systems. In end use, GTI's development of the pulse combustion 96% fully condensing gas furnace led other manufacturers to developing high-efficiency furnaces, so that today over 25% of the furnaces sold in the U.S. are over 90% efficient. Similar development of increased-efficiency equipment has occurred in the commercial and industrial sectors. Enhanced consumer safety was achieved through development of venting system guidelines for mid-efficiency furnaces, CO monitor testing, flammable vapor studies, and indoor air quality testing.

Q. What R&D issues and challenges remain for GTI and the gas consumer?

A. I believe there are substantial remaining issues for gas supply, delivery, and use that have major impacts on gas consumers, dollarized benefits, environmental benefits, and safety benefits. There are many vital reasons for continuing the work GTI has begun:

- Advanced laser-based drilling and fracturing technologies are in the basic research stage and require a substantial amount of funding to carry them forward.
- Totally new sources of natural gas supply may be required to ensure domestic gas supply security. A vast supply resource may be in natural gas hydrates but DOE's basic research has not yet lowered the technical unknowns and risks to permit even exploratory production.
- Substantial research is needed to enhance the confidence in current nondestructive evaluation (NDE) techniques used to inspect natural gas pipelines. A substantial portion of the national pipeline system is not "piggable"; that is, valves, bends, turns, reduced-diameter pipe sections, or other obstructions prohibit internal inspection by moving a mechanical device, or "pig", through the pipe. Further, current NDE tools and technologies can detect pipe wall thinning and circumferential flaws but other types of flaws, such as stress corrosion cracking and axial flaws, are very difficult to detect. Only additional R&D can ameliorate these and other issues such as pipeline coatings lifetime determination and microbiologically influenced corrosion.
- Despite 20 years of research, we are still unable to reliably locate buried plastic pipe under all types of soil and moisture conditions. Tracer wire laid above the pipe is helpful but, since it can corrode or break, locating plastic pipe by tracer wire is not always reliable.
- The guided horizontal boring tools described earlier are guidable from point to point as well as steerable; however, they still cannot "see" in front of themselves underground. The ability to locate sewer pipes, utilities and other obstacles is still an important and unresolved safety issue.

- Infrastructure Security is at the forefront of national attention following the events of 9/11. R&D in this area is still uncharted; yet the "cyber" and physical security of our natural gas infrastructure is critical to gas consumers and the national interests.
- Environmental issues surrounding old manufactured gas plant sites will cost millions of dollars to clean up. Environmental research, beginning with the determination of environmentally acceptable endpoints ("how clean is clean?"), is still required to minimize environmental compliance costs and yet still answer regulatory concerns..
- End-use programs that are under development but which will not be able to proceed without continued funding include a low-cost, fully condensing residential water heater which is over 92% efficient, a residential heating-only absorption-based gas heat pump with a heating COP of 1.4, and an industrial super-boiler with efficiencies over 96% currently being funded by DOE as a laboratory sub-scale pilot project.
- A low-cost residential/commercial fuel cell is still not on the horizon. The private sector and DOE are developing a host of technologies for distributed generation, including larger fuel cells, reciprocating engines, and microturbines. However, their successful integration into the gas distribution system and electric grid is still not assured, emissions and costs (compared to central station generation and electric T&D system upgrades) need to be analyzed, and their impact on the reliability of the gas and electric infrastructure has not yet been documented.

Q. What type of projects is the Company considering funding?

A. The Company is considering funding projects for (1) reducing the cost and enhancing the safety of gas LDC operations and (2) increased-efficiency, enhanced safety end-use equipment.

Q. What specific projects in gas operations could the Company consider funding if the Authority approves recovery in this case?

A. The Company could consider funding GTI's Operations Technology Development ("OTD") Program, which includes the following projects:

Operations Technology Development Program

- **Pipe and Leak Location Project**

Underground Facility Pinpointing: The purpose of this project is to provide an independent, comparative, technical evaluation of existing facility locating tools that are currently available, and to develop enhancements or engineering modifications to the most promising tools, if needed, to provide optimal performance in locating buried natural gas lines. GTI will test and evaluate existing locating tools in a side-by-side companion under simulated field conditions such as pipes at multiple depths, various soil conditions, pavement types, and in the presence of electrical conductivities. One of the goals is to determine which tools perform best under the testing scenarios. A second goal is to improve the performance of the tools as needed to maximize their effectiveness and reduce costs for gas operations. A main focus of this project is support for expanded use of keyhole and micro-excavation procedures. For keyhole and micro-excavation produces to be successfully used, buried utilities have to be precisely located. Current locating technology does not provide the level of accuracy and reliability needed.

Miniature Methane/Ethane Detector for Leak Surveys: Previous gas-industry-sponsored work has resulted in the development of optical methods of finding gas leaks by detecting methane and, more recently, ethane. The presence of ethane in gas leak positively confirms that the leak is related to natural gas, and not "swamp gas" or other sources of methane. This confirmation eliminates the cost of gas sampling and analysis, minimizes multi-party discussions and time for the gas industry, thus reducing the cost of operations. However, detection of very low levels of ethane in natural gas leaks is very challenging. Initial experiments conducted with the previously developed Proof-of-Concept (POC) system for ethane have demonstrated the viability of detection of ethane content in natural gas plumes under realistic leak conditions. The proof-of-concept tests were successful in detection of ethane presence in low concentration (30 ppm methane) natural gas plumes. The best sensitivity of these tests showed the detection capability of ethane to 200 ppb. These Concept Evaluation Unit tests used an optical modulator for ethane detection which was too large to be integrated into a Portable Methane Detector (PMD) being developed under a separate project.

It was decided that the first step towards a practical ethane instrument would be to develop a miniaturized ethane modulator, the main component of the PMD. This miniaturized Ethane/Methane Detector (EMD) project is now coming to a successful conclusion. Although the work is not yet fully complete, an ethane capable modulator (approximately one cubic inch in size) has been developed. Thermal testing under controlled, laboratory conditions showed that ethane detection would be much more difficult (approximately three times more demanding than methane only detection). Preliminary tests have shown that the miniature EMD modulator is capable of operating at or near the same sensitivity level as the much larger unit used in the concept evaluation tests.

The next logical step in the EMD development is to miniaturize other components of ethane detection and integrate the ethane system into the PMD unit. The specific tasks for the proposed project are: (1) Receiver Design and Prototyping, (2) Methane Filtering, (3) Software Development, (4) Display Options and Integration with PMD and Testing, and (5) Prepare Final Report.

Magnetically Detectable Polyethylene (PE) Pipe: While magnetically detectable PE pipe has been in development for over fifteen years, additional work needs to be performed for successful completion of the program. GTI is offering three new initiatives regarding the development of "Mag Pipe" including the developing 8200 Series Mag Pipe, lowering the costs of Mag Pipe through additional research into enhancing its performance characteristics and developing a universal locator with Mag Pipe technology. These three projects will assist in the successful implementation of Mag Pipe into local distribution systems.

The focus of the proposed research is to mitigate third-party pipeline damage at the earliest stages through the development and commercialization of innovative locatable magnetic plastic pipe and a Universal Locator to locate various underground gas distribution pipelines. Today, more than 90 percent of gas distribution pipe being installed is PE pipe using a copper tracer wire or an electronic marker for locating the underground pipe. However, these methods are susceptible to breakage or corrosion, rendering the buried plastic material undetectable. Due to its locatability, Mag Pipe substantially reduces its risk of third party damage and provides LDC's a solution to this problem.

The objectives for this project are: (1) Development and approval of 8200 Series Mag Pipe (includes a pilot program for implementation into a utility's distribution system). 8200 Series mag pipe is Performance Pipe's 8100 Series PE compounded with

strontium ferrite particles, (2) Performance enhancements of Mag Pipe to lower the costs associated with the technology. GTI will perform research to improve the performance characteristics of Mag Pipe and lower the costs of the product. Reducing the costs associated with Mag Pipe technology is needed to ensure that distribution companies will immediately and broadly purchase, adapt and implement Mag Pipe technology in their distribution systems, and (3) Universal locating tool that can locate all types of buried gas facilities. GTI will work with current locating tool manufacturers on the implementation of the technology required to locate Mag Pipe into one, universal tool.

Program Status/Related Efforts: Mag Pipe has already been a proven technology with the development of both medium-density (2406) and high-density (3408) PE gas-grade resins. This program will provide additional development and better performance testing of Mag Pipe while lowering the associated costs of using it. This OTD project will allow the industry to take full advantage of the attributes associated with magnetically detectable polyethylene pipe.

Hand-Held Acoustic System for Plastic Pipe Location: Past GTI-sponsored research has successfully demonstrated that active pulsed-echo sonic technology can detect and locate small-diameter pipes, including PE pipes, to the depth of 5 feet in a laboratory environment. In addition, attenuation measurement data sets collected by a third party from soils around the United States were applied to the current system to perform mathematical analysis on the applicability of the system. This analysis showed that a laboratory-grade acoustic system has a potential for detecting 1.5 and 4-inch diameter pipes at a depth of 3 ft for 50% and 100% of soils in the United States, respectively.

In this project, the laboratory-grade pulse-echo pipe location system will be designed

into a hand-held system for application to buried pipe detection. The system will include data acquisition and processing boards powered by a battery, transducer and receiver arrays in a cane-like setup, and data display system. The system will be tested with participating utilities for detecting buried pipes, 1 to 6 inches in diameter at depths from 6 inches to 10 feet. The data collected at each location will require less than two minutes and the analyzed data will be displayed to the system operator.

The following tasks are included in the project: (1) Planning Meetings. GTI and its subcontractor will meet with industry representatives and present the initial work plan for the proposed effort. This plan will define pipe sizes to be detected, soil conditions, and system approach and cost. The plan will also determine the field evaluation site(s) and test time frame. (2) Design Electrical and Electronic System. Under this task, electrical and electronic components will be designed, tested and built. The power requirement for the system will be defined and appropriate battery needs will be procured. (3) Develop System Software. The objectives of this task are to develop the data acquisition system, signal processing, and user interface. The past knowledge of interactions of various acoustic waves and methods to avoid interactions of these acoustic waves will be used to improve data analysis packages. (4) Design Transmit-Receive Set. As indicated before, the project calls for a miniaturization of the current hardware for the hand-held pipe detection system application. In this task, two pairs of sensors, each consisting of two receivers and a transmitter, will be designed and build. These pairs of sensors will be integrated into a cane-like structure for hand-held application. (5) Integrate System. The electrical and electronic system, transmit-receive set, and software for data analysis will be integrated. Two sets of identical systems will be manufactured. The system weight, size, and cost will be determined, (6) System Evaluations. The complete system will be evaluated for its ability to detect buried pipes. This task will confirm the system's

capabilities and field evaluation needs. Based on these initial evaluations, the system will be improved, if required. The final system will be tested in the field at two locations with the participating utilities, and (7) Final Report.

Remote Laser Leak Surveys: Current leak surveys of natural gas distribution systems involve use of "flame packs" and the mobile Optical Methane Detector (OMD). Both of these leak location technologies require that the detector be brought in contact with the gas leakage plume, a very labor-intensive effort. The Laser Line-scan Camera (LLC) technology being developed under the on-going GTI-manager, utility-sponsored project with Laser Imaging Systems, Inc. (LIS) and AVISYS, Inc. allows "stand-off" inspection of both mains and service lines out to distances of 30 meters from a moving vehicle. The initial results of the on-going project are very encouraging. However, the detection limit, inspection speed, operator interface and packaging of the system will require further evaluations/improvements to make the LLC an attractive alternative to the current leak survey practices.

The primary objective of the proposed project is to evaluate/improve the detection limit and inspection speed of the LLC, and to make the system more user-friendly. This will be accomplished by conducting additional testing in laboratory, in field, and upgrading various components of the current LLC design.

In the current, on-going project, a prototype LLC was designed and built. This system used two semi-conductor lasers, one at a wavelength strongly absorbed by methane and the other at a wavelength for which the gas is essentially transparent. These two lasers are scanned across the field-of-view of a 32-element detector array that is projected from a turret atop a van.

The line scan field-of-view of the detector array is displayed on a conventional video image of the area being inspected. The operator controls the direction of the LLC field-of-view. When the line scan passes over an area on the surface where there is methane gas, an upward deflection of the line occurs. The higher the gas concentration, the higher is the line-scan deflection. By orienting the viewing direction of the LLC to maximize the line scan deflection, the operator is able to pinpoint the location of the leakage plume.

The specific technical issues to be resolved in the proposed project are: (1) Evaluation of detection limit and improvements: Studies involving the effect of laser pulse width and signal processing sample rates on the leak detection limit will be conducted. Improvements to the detection limit will be implemented, (2) Range limitations: Various designs of the collection optics will be investigated to increase the detection range of the LLC system, (3) Establish maximum survey speed: Trade-offs between line-scan frequency and detection sensitivity will be performed to determine the maximum survey speed for the LLC, (4) Packaging/operator interface improvements: Special attention will be directed towards reducing the size and power requirements of the LLC system. The system package will be hardened for routine field application, and the operator interface will be simplified.

Integration of Electromagnetic and Acoustic Obstacle Detection Systems for Utility Construction Operations: This project focuses on integrating the drill-head mounted electromagnetic (EM) obstacle detection sensors under development at Maurer Technology, Inc. (MTI) with the surface deployed acoustic sensors being developed by Folsom Research, Inc. (FRI). The objective of these projects is to provide real-time detection of underground utilities during horizontal directional drilling (HDD) operations

during installation of pipes. The current technology development research is funded by GTI with cofunding from several utilities. Together, these technologies have the potential to prevent striking and damaging buried utilities during creation of the pilot hole or during back reaming operations. The warning and detection circuitry would be electronically tied to the drill string rotation and forward advance controls so the drill string can be automatically stopped before a strike can occur. By combining these two technologies into a single, integrated display it would be possible to successfully detect buried, energized cables, as well as steel, plastic, clay and concrete pipes.

The specific objectives of this project will be to: (1) Improve the noise generation capability for acoustic technology, (2) Design a wireless radio link between the matrix of acoustic sensors and their processor to simplify field operation, (3) Reduce the size of the EM electronics and sensors mounted in the jet head for use in smaller utility directional drilling rigs (4) Integrate the data acquisition, processing and display of the acoustic and EM sensors, (5) Work with leading drill rig manufacturers to incorporate automatic stoppage of drill string rotation and advance when obstacles are detected within a few feet of the boring head, and (6) Conduct field trials of the integrated obstacle detection system in support of commercialization.

Product Development of an Obstacle Detection System Using Ground Penetrating Radar (GPR): Currently there are no commercial instruments available to sense the presence of obstacles in the vicinity of a horizontal directional drilling (HDD) bore used for installation of pipes. In the on-going project with Vermeer Manufacturing Company under the sponsorship of GTI, a new advanced GPR system, mounted on the drill head of an HDD, that is capable of detecting obstacles in the proximity of the bore is being developed. It is expected that this initial on-going project will provide a pre-production system suitable for only one size HDD machine. This new GPR offers a step forward in

the detection of obstacles in the HDD operations. However, this system will require further enhancements to be suitable as a commercially acceptable product from it current pre-production status.

The objective of the proposed work is to produce a fully commercial version of the drill head mounted GPR applying the results of the past developments. The program plan will address the tasks of (1) additional field testing to determine optimal hardware configuration, (2) further ruggedize the downhole components, (3) investigate optimal means of data transmission from the antenna to the surface, (4) continue software and data presentation development, and (5) address issues of integrating the GPR with HDD controls.

- **Pipe Materials, Repair, and Rehabilitation Project**

Alternatives to Squeeze-Off in Stopping Gas Flow in Plastic Pipe: Gas pipes have been manufactured from plastic materials since the 1960's. Over 600,000 miles of plastic pipe are in use in the U.S. for gas mains and gas services. One concern with these materials is resistance to slow crack growth, especially for older plastic materials. Slow crack growth can initiate internally through rock impingement, by inclusions, or by the effects of squeeze-off. Once initiated, slow crack growth proceeds through the pipe material leading to premature failure and gas leakage.

Squeeze-off is commonly used to stop the flow of gas in plastic gas pipes. The use of squeeze-off can initiate the development of slow-crack growth, leading to the premature failure of the pipe.

This project will develop an alternative to the squeeze-off technique which will permit the stopping of gas flow in a plastic pipe without damaging the pipe or initiating slow

crack growth, thus extending the useful life of plastic pipes presently in use. This will create significant operating and maintenance cost savings for gas utilities.

The objectives of this project are to: (1) Evaluate technologies, techniques, tools or equipment that have the potential to stop gas flow in a plastic pipe without squeezing or deforming the pipe, (2) Select the technology(s) with the greatest potential and perform laboratory and field experimental to determine its performances in stopping gas flow, (3) Perform plastic materials test on samples of pipe on which this technology has been used to determine its effect on the material performance characteristics of the pipe, (4) If necessary, modify the technology to make it suitable for gas operations field use.

Service-Applied Main Stopper: This project focuses on lowering the costs associated with emergency gas shut-off due to third-party damage, through the development of an innovative tool and method of use. Current field practices to isolate the damaged section of pipe involve multiple excavations to set stopping or squeeze-off equipment as well as multiple customer shut-offs. The Service Applied Main Stopper (SAMS) project objectives are to: (1) Develop technology and the necessary tools that will utilize existing customer service lines and meter sets to isolate pipe ruptures and stop the flow of gas, (2) Reduce costs by minimizing excavations through the use of the SAMS "no-dig" technology, and (3) Decrease the isolation area, which will reduce customer outages and impact due to third-party main damage

Service lines allow safe entry to the gas main. By inserting a stopping device through the customer's meter valve, crews can isolate the damaged section between neighboring customer service lines and stop the flow of gas.

Developing this technology will resolve two major issues: (1.) the costs associated with third-party damage repairs and (2.) the ability to isolate and stop a ruptured gas main.

The costs involved with third-party damages are high due to the labor associated with the number of excavations required to isolate the damaged area. Addressing the ruptured main, without having to make any excavations, would allow crews to decrease the time required to stop the blowing gas, decrease total repair allocations and substantially minimize the costs in restoration of pavement and landscaping. All of this will be performed remotely, at the customer's meter, which also increases crew safety. Under many circumstances, the ideal location to isolate a damaged section of main cannot be utilized due to a number of complications (other existing utility lines, pavement issues, etc.); however, this device does not discriminate against surrounding factors because the existing service line acts as a safe conduit to the main.

Reducing Utility Installation Costs Using Joint Trenching: This project focuses on reducing pipe installation costs by providing information on common utility placement that will assist a utility in determining the potential benefits, addressing typical challenges, working with partnering utilities, and expanding or implementing its use. Many gas, electric, cable, telecommunication, and water utilities are aggressively considering options for reducing costs and improving customer relations. Common utility placement can be a near-term solution for single or combination utilities. GTI will develop a database of tools, equipment, practices and procedures a utility needs to confidently promote and implement joint trenching within their company, with other utilities, installation contractors, and property developers. GTI will provide a complete look at common utility placement practices, providing analysis from both a technical and economic point of view. The objectives of this project are to: (1) Determine the feasibility of initiating or increasing the use of joint trench installations (Technical & Economic), (2) Provide a comprehensive report on joint trench practices and highlight benefits &

limitations, and (3) Examine local conditions and the local and state regulatory environment to develop joint trench implementation or expansion plans for two sites. Collaborative participants will help establish and prioritize criteria for assessing feasibility of performing joint trench installations. Participants will also help develop the survey for soliciting the level of interest, concerns, and expectations on behalf of potential trench partners. Participants will help select two sites for implementing the plans developed in this project to increase the level of joint trench use to benefit the utility. In addition to the economic benefits, common utility placement can also offer improved safety, customer satisfaction, and better business relationships among installation partners and municipalities.

Evaluation of Pipe Repair Products: Gas utilities across the nation continue to search for new and improved technologies that will allow them to more efficiently repair leaking gas mains, services and fittings. Several new technologies have recently been identified as having good potential for effectively making these repairs. This project will support the testing and field demonstrations of these new technologies. The technologies to be evaluated are: (1) MW Polymers Polyform – A two-part engineered polymer that can be used to seal leaks in low and medium pressure situations. Polyform can be applied to any size pipe, and can be used on irregular shaped fittings. Polyform is used by Transco, in the United Kingdom, but has seen limited use in the U.S.; (2) MW Polymers Ecoseal – An epoxy-type material used to seal cast iron joints. This material is used in the United Kingdom, but has seen very limited use in the U.S.; and (3) Syntho-Glass – A resin coated fiberglass cloth repair and maintenance system designed to be universally applicable to all utility pipes. Syntho-Glass has not yet been used in the natural gas industry.

GTI is proposing to conduct laboratory testing to establish the short term, and the long term performance characteristics of these materials. GTI will also coordinate field trials of the materials, with member companies. The field trials will demonstrate the effectiveness of the process for each material, and will help determine the long-term performance of each material.

Enhanced Service Line Replacement and Splitting System: During 2002, GTI and TT Technologies developed a system to replace old plastic pipe service lines with today's polyethylene pipe. The project utilized pipe splitting technology to simultaneously slice the existing service line while pulling in a new service behind the splitter. The project proved successful in splitting and replacing service lines as small as ½ inch CTS up to 100 feet in length. However, there were some shortcomings that this OTD project will address. Some of the more difficult obstacles include electrofusion and compression type repair fittings that may be encountered in the field. GTI and TT Technologies have discussed techniques to overcome these repair fittings.

GTI will again partner with TT Technologies to lead the development of a service pipe splitting system that will satisfactorily split ½ inch through 2 inch gas service lines. Not only will the project focus on typical service line replacements, but also on utilizing the system and administering the tool through a small hole or opening in pavement, accommodating desirable "keyhole" technology. The new pipe splitting system will be field-tested at GTI's facility. GTI and TT Technologies will coordinate and provide a demonstration with personnel from participating companies to display the capabilities of the newly designed splitting system. GTI will prepare a written report on the results of the newly designed system including a cost-benefit analysis.

The objectives of this project are to: (1) Develop a small Grundomat™ that will provide a pneumatic hammer to assist the splitter head through repair fittings, (2) Develop a new

winch system for the cable that pulls the splitter and replacement pipe. The winch will be able to be used either in or above the excavation, (3) Perform laboratory and field evaluations of the service pipe splitting system's performance, including various splitter head designs, at opening existing small diameter pipe while pulling in a new replacement pipe, and (4) Create savings between 15% and 25% compared to typical service replacement while substantially reducing the risk of damaging existing utilities around the service line.

- **Excavation and Site Restoration**

Safety and Performance Evaluation of Flowable Fill around Buried Pipe: Utility companies and municipalities face continuous challenges over the quality and durability of pavement restoration practices. Their goal of achieving high quality and long-lasting repair has resulted in various requirements regarding the selection of backfill material and compaction control specifications. One of the backfill materials that is regularly required by several municipalities and used by utility companies is the 'Controlled Low-Strength Material', commonly known as 'Flowable Fill'. This material has the advantage of providing a fast setup time while insuring uniform density and adequate pavement support.

However, several issues regarding the use of this material in trench backfill around utility pipes still need to be addressed. These issues are mainly related to structural performance of the buried pipes, effect of flowable fill on pipe corrosion, gas leak migration and detection through the flowable fill "cap", and the difficulty of re-excavation for repair. These issues will be investigated in long-term tests in full-road size paved sections.

The significance of these issues is that they directly relate to the performance and safety of the utility system in certain applications and pipe types. These issues have not yet been thoroughly investigated and they need to be evaluated through proper laboratory testing and performance monitoring programs in the field.

The objective of the proposed research is to perform a comprehensive evaluation of pipe-flowable fill interaction and the significance, if any, of these issues on the safety and performance of the system. Such evaluation will help utility companies, municipalities, and highway agencies in identifying the parameters that influence pipe safety and in making educated decisions about the use of flowable fill material with certain pipe types and performance requirements.

One-Step Pavement Application for Utility Cut Restoration: For most utility companies, the conventional process of pavement reinstatement is to close the hole with a temporary patch and return later to make a permanent repair using hot mix asphalt. While effective, this process can lead to extended road-closure times and interim return trips to the site for patch repairs when the temporary patch has settled or has been rutted by traffic.

This project focuses on lowering of the lifecycle costs associated with returning to the site to remove the temporary patch and replace it with a permanent patch. The objective of this project is to determine the best materials and processes available to complete a permanent patch on a road opening in a one-step pavement application.

One-step pavement processes have already been applied by some utilities and are considered as one of the "best practices" utilities use for reducing restoration expenses. In this project, researchers will: (1) Evaluate the performance of available one-step paving materials and assess their construction requirements based on their

effectiveness as one-step permanent pavement material, (2) Perform field tests on the most effective material and process in order to monitor the long-term performance in various loading and environmental conditions, and (3) Establish recommendations for material selection, application procedures, and associated costs.

Alternative Methods for Pavement Cutting: Most of the current pavement restoration procedures utilize jackhammers, pavement saws, and backhoes for cutting and moving the asphalt and concrete layers. These methods are noisy, restricted to daylight operations, produce a risk of injury, and cause damage to adjacent uncut pavement.

This proposal focuses on evaluating alternatives to these methods with the objectives of eliminating the current drawbacks of the existing methods and presenting improvements in efficiency and cost effectiveness. The proposed work consists of two phases: (1) Evaluate several alternative technologies. Various types of new and existing methods for pavement cutting will be evaluated in this phase. These technologies will include Laser-cutting devices, thermal cutting methods, microwave devices, water jets, and the latest developments in mechanical cutters such as pavement breakers and diamond saws. These methods have varying degrees of efficiency and operating costs. The work of phase one will define the parameters associated with the costs and development needs of these technologies. It will also include laboratory evaluation and specification development for the most promising technology; and (2) Acquire, design and implement engineering modifications to produce a prototype of the selected method, which meets the specifications and requirements of Phase One. Coordinate field tests with the participating utilities for evaluating the performance of the device.

Micro-Excavation System Applications: This project is part of the overall Micro-Excavation Systems Program to develop equipment, tools, sensors, materials, and procedures to access, examine and maintain buried pipe through two, 2" diameter

excavations. The initial project, to develop a method of excavating a cylindrical space around a pipe is already underway with funding from SMP. In this proposed OTD project, devices to determine the condition of the pipe and pipe coating will be developed.

The objectives of this project are to:

- Develop a prototype articulating device to hold sensors, tools and light sources, and to successfully deliver them through a 2" opening down to a buried pipe.
- Evaluate prototype sensors to examine a section of pipe through a micro-excavation opening to inspect for corrosion, coating conditions and wall thinning.
- Evaluate the effects of creating small voids around the pipe during micro-excavation, and to determine methods to sufficiently backfill and compact micro-excavation openings.
- Evaluate existing anaerobic sealing tools and procedures for use in micro-excavations.
- Develop methods to install anodes on pipes through micro-excavations.
- Evaluate methods to abandon gas services through micro-excavations

- **Pipeline Integrity Management**

Reduce Repair and Incident Costs through Ultrasonic Inspection: Magnetic Flux Leakage (MFL) pigs measure wall loss in a gas pipeline, but not the remaining wall thickness that determines remaining strength. They also have a precision limited to 10% of the wall thickness, and cannot find Stress Corrosion Cracking. The 10% limit means extra digs are required to ensure that all severe corrosion has been found. It also means that this inspection technique offers little ability to monitor corrosion growth rates

to determine where corrosion mitigation is effective and where it needs to be improved. Measuring wall loss means that the pipeline operator must base repairs on the minimum expected wall thickness rather than the actual measured amount of remaining metal in the pipe wall. Ultrasonic inspection can find cracks and measures the remaining wall thickness with a precision of a few percent but, currently, requires putting a liquid couplant in a gas pipeline. Transducers specialized for inspection in high pressure gas, as well as specialized inspection methods, can eliminate the need for a liquid couplant bringing the advantages of ultrasonic inspection to gas pipelines. Thus a delivery vehicle can be designed that readily bypasses pipeline obstructions. It could be propelled through an unpiggable pipeline by very flexible pig cups or by one of the robots being developed for use in unpiggable pipelines by DOE and NYGAS.

The technical objectives of this program are

- Develop ultrasonic transducers that work with high pressure gas as the couplant;
- Develop methods for inspecting pipes for corrosion using these Gas Coupled Ultrasonic transducers;
- Develop methods for inspecting for cracks using Gas Coupled Ultrasonic inspection.

Reduce Mandated Inspection Costs through Field-Eddy-Current Inspection of Unpiggable Lines: The Office of Pipeline Safety has introduced rules that require inspection of pipelines and distribution mains in high consequence areas by pigging inspection, hydrostatic testing, or direct assessment. Of these three choices, pigging costs the least while provide the most information on the condition of a pipeline. Unfortunately, most pipelines and high-pressure distribution mains cannot be inspected with current pigging technologies because of diameter changes, short-radius elbows and miter bends, offsets, reduced port valves and plug valves, and limited access to the

pipeline. An examination of technologies that could inspect these unpiggable pipelines quickly leads to the conclusion that the Remote Field Eddy Current (RFEC) technique offers the potential to inspect unpiggable pipelines. The technique should provide inspection precision comparable to that of magnetic flux leakage, but does not require sensor contact with the inside wall of the pipe, which means it can be made much smaller than the pipeline diameter. The RFEC technique is in commercial use for inspecting everything from boiler tubes to the reinforcing in 12' diameter water mains, but needs to be adapted to unpiggable pipeline use.

The technical objectives of the program are

- Prove the feasibility of inspecting unpiggable pipelines by Remote Field Eddy Current inspection;
- Develop a detailed plan for taking the project to the prototype stage and commercialization
- Build a prototype and test it in an unpiggable pipeline
- Transfer the technology to a manufacturer and a pipeline inspection company.

Detection of Unauthorized Construction Equipment in Pipeline Rights of Way: The goal of this project is to develop a system to detect when construction equipment encroaches into a pipeline right-of-way and alert the pipeline operating company before damage occurs. An optical fiber laid along the pipeline is used as the sensor. Periodic pulses of light interrogate the status of the fiber. Disturbances to the fiber, caused by vibration or earth movement due to the presence of heavy equipment, are detected and analyzed to identify equipment in the pipeline right-of-way. The pipeline company would be alerted when encroachment is present, permitting immediate corrective action. The

proposed system will provide real-time policing of pipelines 24 hours a day, seven days a week.

The objectives of this project:

- Develop custom hardware that can create, collect, and analyze the light signals.
- Demonstrate that the system is sensitive enough to detect encroachments.
- Develop techniques that will discriminate among benign and potentially hazardous encroachments.

Reducing Riser/Meter Set Corrosion: This project focuses on the lowering of lifecycle costs associated with the constant rehabilitation of natural gas risers and meter sets through the development of a simple, cost-effective, and more permanent method to clean, prepare, and coat atmospherically exposed risers and meter sets. Many of the current rehabilitation coating methods offer only temporary protection from corrosion. As a result, the meter sets, and adjacent risers, continue to corrode at an accelerated rate leading to "call backs" for additional coating/rehabilitation or complete piping replacement at a significant overall cost and with customer-service interruptions. The objectives of this project are to develop cost-effective tools, procedures and methods to:

- Properly clean and remove surface contamination, deteriorated coating, and corrosion products.
- Provide adequate surface preparation to enhance long-term coating adhesion.
- Coat the meter/riser sets with a properly specified high-quality, long-lasting corrosion protection system.

Inspection Platforms for Unpiggable Lines: In response to a number of significant pipeline incidents in recent years, the federal government has imposed new

requirements on gas transmission pipeline operators to assess the condition of their facilities. One of the methods used to examine a transmission pipeline is in-line inspection (ILI), also known as "smart pigging." Many transmission pipelines are designed to accommodate pigs. Similar requirements are expected within the next few years for LDC-owned transmission pipelines. Unfortunately, the majority of LDC-owned transmission lines contain short radius bends, plug valves and other obstacles that render them unpiggable with traditional pigging devices.

In July 2001, the New York State Gas Group, through its NYSEARCH Committee, issued a Request for Proposal to develop a device that could internally inspect LDC-owned transmission pipelines. The following system requirements were identified:

- 12" to 24" diameter; up to 0/5" wall thickness
- Five mile run length
- Self-powered
- Operate in gas flow velocities of 25 feet per second to 150 feet per second
- Able to negotiate plug valves, mitered bends, compound 90 degree bends, and diameter reductions of at least two sizes
- Detect defects resulting from both internal and external corrosion through the use of MFL sensors
- Minimize the number of hot taps
- Minimize extent of excavations needed for launching

In 2002, NYSEARCH and the Southern California Gas Company conducted a preliminary investigation into the feasibility of developing integrated locomotor/sensor robotic system for the inspection of presently unpiggable LDC-owned pipelines.

NYSEARCH identified two proposals for funding, from Foster-Miller/PII and Automatika/Maurer Engineering. Each of these teams produced preliminary designs. Additional funding is required to further develop the systems.

This project will cofund a Phase II effort to develop and test the following:

- Foster-Miller/PII System
  - Locomotor and inspection sensor application
  - Performance testing
- Automatika/Maurer Engineering System
  - Test critical technologies
  - Wireless
  - Locomotor
  - In-pipe battery recharge
  - Inspections sensor application

Camera for Inspecting Large-Diameter Gas Mains in a Live Environment: The objective of this project is to develop and field test a camera system for inspecting "live" (while gas is flowing) large diameter (12- to 4-inch) cast-iron mains in gas distribution systems. The safety and reliability of the natural gas infrastructure can be enhanced with increased use of cameras for inspecting gas mains. The use of cameras would be beneficial to both cast iron and steel mains, but the initial emphasis of this project will be on cast iron mains. The camera will assist in determining the internal condition of cast iron mains and joints. The system will assist in locating joints for repair using other methods. The development of this new technology will also reduce the cost of pipe lining operations by providing an effective inspection method. In the future, the

technology will also be used for steel mains inspection, with particular emphasis on integrity management for short sections of unpiggable pipelines.

GTI has supported the development of a system to inspect small-diameter (4-inch) pipe and non-destructive evaluation (NDE) sensors for detecting flaws in 12-inch diameter cast iron mains. The proposed project will extend the "live" mains inspection capability to 24-inch diameter pipes, thus addressing needs of all segments of LDCs. The proposed project will utilize the push-rod concept for sending the inspection camera into gas pipelines. A preferred design for the camera inspection head, centralizer, and internal movement assembly will be identified. Various collapsible centralizer designs suitable from 12-inch to 24-inch diameters will be identified and an appropriate design will be selected. The camera travel is generally limited to the coiled tubing design, expected bends to be negotiated, and pipeline friction. Several methods (e.g., push only vs. push with rolling) will be evaluated so that the goal of 1,000 ft travel distance, in either direction of entrance to the pipeline, can be met. The camera system will also be designed with an appropriate centralizer mechanism. The complete system will be fabricated, evaluated in the laboratory environment, and tested at three utility sites. The specific tasks for the proposed project are:

- Evaluate Camera/Centralizer Designs
- Detailed Design and Fabrication of Color Camera System
- Design and Fabricate Entry Fittings for Cast-Iron Mains
- Evaluate the System in the Laboratory and Extensively in Field with Participating Utilities
- Conduct Benefits Analysis
- Obtain System Certification

- Prepare Final Report

Global Positioning System (GPS) for O&M and Direct Assessment Tracking Database: This project focuses on the use of advanced Global Positioning Systems (GPS) and Global Information Systems (GIS) technologies to create real-time, accurate information regarding buried gas facilities, and the tracking of inspection, repair and maintenance data to ensure the production of reliable maps and to reduce operating costs. Currently, most of these databases are generated manually in the field during routine surveys and repairs. The data is manually transferred to the utility databases and tagged on maps referenced to specific known objects above ground. This manual method of data collection and transfer is labor-intensive and frequently inaccurate because referenced objects may be moved, changed or obliterated during construction.

Much of the individual technology required to accomplish the objectives of this project exist, but has not been developed into a single operating package, with the required support software. This project will focus on use of advanced technology such as differential GPS and GIS to generate and record accurate data automatically during survey, repair and/or construction activities. The system will allow utility operators to determine exact locations of past inspection surveys, and repair and emergency access points for critical components. The objectives of this project are to:

- Determine and define the cost, time and accuracy trade-offs with the use of standard GPS, real-time differential GPS, and inverted (post-processed) GPS technologies to generate highly accurate spatial references for survey, repair and maintenance data.

- Develop software to include tracking of survey, repair and maintenance operations.

- Conduct field evaluations, with assistance from gas utilities, with the GPS systems identified above.
- Define scenarios for potential commercialization.

- **Operations Infrastructure Support**

Develop a CD-Based Learning Module to Educate Fire and Police on Natural Gas Emergencies: This project will concentrate on the design, development and delivery of a comprehensive new education program for use by gas companies to educate Fire and Police Professionals on issues relating to natural gas emergencies. The education materials will be developed and presented in a CD-ROM format, and will be intended for use by Fire, Police and other First Responder Professionals either in a classroom environment, or as a self-teaching tool. There will be self-test questions so that the users can check their progress. The topics covered in the education program will be determined by the participants, but will be expected to include:

- Natural gas basics
- Distribution system description and operation
- Transmission system description and operation
- System devices; piping, meters and regulators
- Gas leaks (both inside and outside of structures)
- Leaks resulting from fires
- Unusual problems
- Distribution and transmission system emergencies
- Natural disasters

- Third-party damage
- Terrorism
- Working with the local gas distribution company
- Working with local, state and federal emergency agencies
- Additional resources

Q. What end-use technologies could the Company consider funding?

A. The Company could consider the following end-use technologies if the Authority approves R&D recovery:

- **Residential Technologies**

Combination Residential Space/Water Heater: GTI is seeking to assess the performance via field testing of an optimized condensing water heater in combination space/ water heater applications. The system will eliminate the need for a space heater, using the water heater for both water and space heating.

The U.S. DOE and GTI are currently cofunding technology development of the condensing water heater. The high-efficiency, condensing water heater uses porcelain coating on both sides of the heat exchanger to avoid corrosion and keep manufacturing costs down (by avoiding the use of stainless steel). It has an extremely high Energy Factor of 0.77 and a heat exchanger efficiency of over 90%. However, field testing and system design in a real-world environment is critical to minimizing the technical risk on this project

Condensing water heaters have Energy Factors approaching the high .70's, however; often, the increased cost in production and installation outweighs the cost saved from energy. Producing condensing water heaters that are efficient and more cost effective would greatly benefit the consumer, manufacturer and nation. The cost

of a condensing water heater can be reduced (possibly by as much as 30%) by coating a standard heat exchanger with porcelain. Presently condensing heat exchangers use stainless steel.

In Phase 1, the existing furnace and water heater are replaced with a power vent water heater combination heating system. Baseline data is gathered on the performance and energy consumption of the power vent combo system until April 2004. At that time Phase 2 will commence and a high-efficiency, optimized, condensing water heater will replace the power vent water heater. The performance and energy consumption of the condensing water heater will be closely monitored for a 12-month period.

The field test will validate superior operational performance and comfort as well as any economic benefits associated with the utilization of a low-cost condensing water heater for space and water heat in various climates throughout North America. In addition, the field test will validate to the utility and homeowner the value of combination systems in new and retrofit heating applications.

Heating-Only Residential Heat Pump: This R&D will further the development of the Ambien heating-only gas heat pump, which offers heating efficiencies of 120-140%. Prototype design and field testing in real-world environments will be part of this effort.

Low-Cost Residential Gas-Fired Desiccant Dehumidification System: This R&D will continue development and field testing of a residential desiccant dehumidification system which can considerably lower home energy-use requirements in the South. New technology has been developed, which uses natural gas, to reduce and control the humidity level in a home or business. This technology, called desiccant

dehumidification, utilizes a natural gas burner to regenerate a desiccant wheel providing control over an indoor space up to 3000 square feet.

In addition to improving the indoor air quality and possibly providing health benefits (maintaining average relative humidity (RH) within the ASHRAE-prescribed comfort/health range), it is believed that these residential/light commercial desiccant units may reduce the peak energy consumption in a residence or small business by removing the humidity and providing a high degree of comfort at 72+ degrees Fahrenheit.

The purpose of this project is to evaluate a desiccant dehumidification technology in the residential and light commercial market of the southern U.S. The intent is to determine the effectiveness of the technology in varying degrees of humidity levels and it's effectiveness under different construction practices. It is believed that by controlling the moisture levels, peak energy consumption will be reduced due to the reduced load on the traditional vapor compression air conditioners and the higher level of comfort associated with lower humidity levels. GTI will install and monitor desiccant dehumidifiers and report on the affect they have on the home or buildings overall energy efficiency and consumption.

Q. What do you have to say in conclusion?

A. Over the past twenty-five years, gas consumers have realized billions of dollars of benefits from GTI's R&D. Our overall consumer benefit-to-cost ratio is 8/1, including all R&D costs and benefits from commercialized products and services. Based on our over twenty-five-year track record of maintaining benefit-cost ratios of over 8/1, I believe that in the future GTI can sustain this benefit cost ratio for Tennessee gas consumers.

The Authority and other public utility commissions, and the guidance of LDCs and others (such as consumer advocates and environmental groups), will ensure the selection of specific R&D projects that are appropriate to and offer benefits for Tennessee gas consumers.

Continuation of GTI's R&D programs is absolutely critical for the continued distribution and use of natural gas as a current and future environmentally benign, domestically produced energy source for Tennessee and for the United States.

Q. Does this conclude your testimony?

A. Yes.

VERIFICATION

STATE OF ILLINOIS

COUNTY OF COOKE

Ronald B. Edelstein, being duly sworn upon his/her oath, deposes and states that he/she is Director, State Regulatory Programs for the Gas Technology Institute; that he has read and is familiar with the foregoing Direct Testimony filed herewith; and that the statements made therein are true to the best of his/her knowledge, information, and belief.

RONALD B. EDELSTEIN

Subscribed and sworn to before me this 25th day of August 2003.

Harriet V. Heidelmeier
NOTARY PUBLIC

"OFFICIAL SEAL"
HARRIET V. HEIDELMEIER
Notary Public, State of Illinois
My Commission Expires 6/30/07

My appointment Expires:

June 30, 2007