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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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In reply refer to: P-97-14 through -24

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A gas explosion on November 21, 1996, in the Rio Piedras shopping district of San Juan, Puerto Rico, resulted in 33 fatalities and 69 injuries. This accident, one of the deadliest in pipeline history, made 1996 a record year for pipeline fatalities. The San Juan accident accounted for more fatalities than occurred the entire previous year, and it vividly illustrates the tragic potential of a single excavation-damaged pipe.

The National Transportation Safety Board determined that the probable cause of the propane gas explosion, fueled by an excavation-caused gas leak, in the basement of the Humberto Vidal, Inc., office building was the failure of San Juan Gas Company, Inc., to oversee its employees' actions to ensure timely identification and correction of unsafe conditions and strict adherence to operating practices; and to provide adequate training to employees.[1] Also contributing to the explosion was the failure of the Research and Special Programs Administration/Office of Pipeline Safety to effectively oversee the pipeline safety program in Puerto Rico; the failure of the Puerto Rico Public Service Commission to require San Juan Gas Company, Inc., to correct identified safety deficiencies; and the failure of Enron Corporation to adequately oversee the operation of San Juan Gas Company, Inc. Contributing to the loss of life was the failure of San Juan Gas Company, Inc., to adequately inform citizens and businesses of the dangers of propane gas and the safety steps to take when a gas leak is suspected or detected.

The Safety Board has long been concerned about the number of excavation-caused pipeline accidents. In response to six serious pipeline accidents during 1993 and 1994 that were caused by excavation damage and to foster improvements in State excavation damage prevention programs, the Safety Board and the Research and Special Programs Administration (RSPA)

[1] National Transportation Safety Board. 1997. San Juan Gas Company, Inc./Enron Corp. Propane Gas Explosion in San Juan, Puerto Rico, on November 21, 1996. Pipeline Accident Report NTSB/PAR-97/01. Washington, DC.

jointly sponsored a workshop in September 1994.[2] This workshop brought together about 400 representatives from pipeline operators, excavators, trade associations, and local, State, and Federal government agencies to identify and recommend ways to improve prevention programs.

The Safety Board recently completed a safety study that analyzed the findings of the 1994 workshop, discussed industry and government actions undertaken since the workshop, and formalized recommendations aimed at further advancing improvements in excavation damage prevention programs.[3] Safety issues discussed in the study include the essential elements of an effective State excavation damage prevention program, including employee qualifications and training; the reliability of locating equipment to determine the depth of buried facilities; the accuracy of information regarding buried facilities, including mapping; and system measures, reporting requirements, and data collection.

The Safety Board acknowledges that considerable progress has been made by RSPA and the industry in the area of improving excavation damage prevention programs since the Board's 1994 workshop and most likely because of it. The workshop provided a valuable forum to discuss how government and industry can work together to improve excavation damage prevention programs. The Safety Board believes that by continuing to focus attention on this important safety issue, the number of excavation-caused accidents to the Nation's underground facilities will ultimately decrease. Therefore, the Safety Board believes that RSPA should conduct at regular intervals, joint government and industry workshops on excavation damage prevention that highlight specific safety issues, such as full participation, enforcement, good marking practices, the importance of mapping, and emergency response planning.

State Excavation Damage Prevention Programs

Specific progress has been made to improve the effectiveness of State excavation damage prevention programs, including efforts to standardize marking symbols, to develop a uniform notification ticket, to develop guidelines for excavation practices and procedures, and to develop minimum standards for training programs. Also, the importance of mandatory participation has been advocated by industry as well as government, yet many entities are granted exemptions to participation in State excavation damage prevention programs. Although many elements of an effective State excavation damage prevention program have been identified, the Safety Board is concerned that these elements have not been uniformly implemented. Some States have realized the benefit of swift, effective sanctions through the administrative process, yet many States are lacking effective enforcement programs. The practices and activities of one-call notification centers have been identified, but these practices have also not been uniformly implemented. The Safety Board concludes that although considerable progress has been made to improve State

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[2] National Transportation Safety Board. 1994. Proceedings of the Excavation Damage Prevention Workshop. NTSB/RP-95/01. Washington, DC.

[3] National Transportation Safety Board. 1997. Protecting Public Safety Through Excavation Damage Prevention. Safety Study NTSB/SS-97/01. Washington, DC.

excavation damage prevention programs, additional efforts are needed to uniformly develop and implement programs that are most effective.

In 1996, RSPA established a joint government/industry Damage Prevention Quality Action Team. Participants include the American Petroleum Institute, the American Gas Association, the American Public Gas Association, the Interstate Natural Gas Association of America, One-Call Systems International of the American Public Works Association (APWA), the National Telecommunications Damage Prevention Council, the National Association of Regulatory Utility Commissioners, the Associated Electrical and Gas Insurance Services, the National Association of Pipeline Safety Representatives, and industry participants. As stated in its charter, "the purpose of that team is to assess the status of current excavation damage prevention efforts and their effectiveness, and to identify additional efforts that would lead to reduction of excavation damage." However, rather than assessing the status of damage prevention efforts, the group set as its goal to "conduct a national pipeline awareness campaign." As of June 1997, the team had developed and distributed surveys to assess the awareness of one-call systems. Because the critical elements of an effective excavation damage prevention program have not been uniformly implemented at the State level, the Safety Board believes there is a need to review and evaluate existing damage prevention programs and to highlight deficiencies in existing programs so that corrective action can be taken. The Safety Board supports current legislative interest in provisions for a review of existing excavation damage prevention programs but does not believe there is a need to await Congressional action before such an evaluation is undertaken. The Damage Prevention Quality Team appears to be an appropriate mechanism for accomplishing a detailed evaluation of existing programs. Therefore, the Safety Board believes that RSPA, in conjunction with the APWA, should initiate and periodically conduct detailed and comprehensive reviews and evaluations of existing State excavation damage prevention programs and recommend changes and improvements, where warranted, such as full participation, administrative enforcement of the program, pre-marking requirements, and training requirements for all personnel involved in excavation activity.

Employee Qualifications and Training

Training to prevent excavation damage to the underground infrastructure is not limited to the pipeline industry and operating personnel: locators need training in locating techniques, equipment technology, and marking procedures; excavators need training to fully participate in the notification process and to understand locator marking symbols; one-call operators need training to efficiently and effectively transmit information between excavators and underground system operators; and the general public needs to be aware of the one-call notification process when they dig for private projects. In addition, anyone working to operate underground systems or whose work requires underground digging needs to be trained in emergency response procedures. This diversity of training needs presents a real challenge to both system regulators and the industry.

Excavators need to be trained and educated about safe work conditions, good excavation practices, relevant State laws, and one-call procedures. In this context, the excavator is not only

the backhoe operator at the construction site, but also the project manager, the scheduler, company officials—anyone connected to excavation work. In an effort to ensure that excavators are aware of their responsibilities to protect underground facilities, some States have licensing requirements that assess professional knowledge. For example, Florida law (in Section 556.104 of the Florida Statutes) requires contractors who work near buried facilities to be licensed, a process that involves passing a written examination. Excavators should fully understand the one-call notification process: the meaning of facility markings, requirements for hand digging near underground facilities, notification responsibilities when the scope of work changes, and emergency response procedures. Many one-call centers offer outreach training programs designed for excavators. Some one-call center personnel have met with local union organizations and industry associations to explain the notification process and State damage prevention laws.

Because marking the position of an underground line is a safety-critical job, training is necessary to ensure that locators are well prepared to perform this function. The National Utility Locating Contractors Association (NULCA) has defined a set of minimum standards for its members to adopt as part of their training programs.[4] The program includes 118 hours of structured training in the topics of system design, construction standards, equipment techniques, recognition of line type, locating theory, and safety procedures. In addition to recommending the use of written tests, the program recommends field training and annual re-testing.

The NULCA has also developed guidelines for excavation practices and procedures for damage prevention. These guidelines, which were revised in September 1997, incorporate Occupational Safety and Health Administration (OSHA) requirements and identify best practices applicable to excavation work. Use of the guidelines is voluntary, but NULCA's brochure explains that legislation in most States requires contractors who plan to excavate to notify the appropriate one-call center and non-member facility owners before the job begins. The guidelines address pre-planning and job site activities for both large and small projects. Instructions for handling damage, along with a construction facility damage report form, are also included. The Safety Board has commended NULCA's efforts in promulgating good practices among its members and the excavation community.

Participants at the Safety Board's workshop recommended that excavator associations work in conjunction with operators of buried facilities and one-call notification centers to provide buried-facility damage-prevention training as part of their safety training programs. The participants acknowledged that the Associated General Contractors of America and many contractor organizations are very safety conscious and have produced several videotapes about safety issues. Few of these education efforts, however, include testing. The current negotiated regulation process at RSPA has addressed the issue of training verification and testing, but the scope of that work is limited to only oil and gas operators subject to Federal regulations.

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[4] National Utility Locating Contractors Association. 1996. Locator Training Standards & Practices. Spooner, WI.

Federal training requirements for the transport of hazardous liquids are stated in 49 CFR 195.403. These are general requirements that do not specifically discuss excavation activities, and there are no comparable general training requirements for gas operator employees. RSPA has a joint industry and government working group that periodically meets to develop proposed requirements for employee qualification and training.

In 1987, RSPA first issued a notice of proposed rulemaking (NPRM) to improve the competency of operator personnel and to set minimum training and testing standards for employees of pipeline operators. A notice issued in October 1991 stated that a second proposal, based on comments received earlier, would be forthcoming. By 1993, RSPA still had not acted to implement any employee qualification and testing standards, and the Safety Board urged that this issue become a priority in the regulatory agenda. Ten years after its original NPRM in 1987, RSPA has entered into negotiated rulemaking through the Negotiated Rulemaking Advisory Committee on Pipeline Personnel Qualifications. That committee completed its fourth meeting in August 1997. It has prepared three drafts of a proposed operator qualification regulation for committee consideration. The committee has not reached consensus and is still considering draft regulatory language. Action on this issue is long overdue. The Safety Board concludes that employee qualification and training is an integral component of an effective excavation damage prevention program, and industry has recognized the need for employee training but has not implemented training uniformly. Inadequate employee training was highlighted in the Safety Board's report of the San Juan accident. In that report, the Safety Board recommended (P-97-7) that RSPA complete a final rule on operator employee qualification, training, and testing standards within 1 year. The Safety Board further stated in that recommendation that the final rule should require operators to test employees on the safety procedures they are expected to follow and to demonstrate that they can correctly perform the work.

Because RSPA's rulemaking would cover only those employees of oil and gas operators subject to Federal regulations, additional efforts are needed by industry to provide training materials to those employees not covered by the regulations. The One-Call Systems International (OCSI) Training Committee of the APWA develops educational materials for use by notification center employees, facility owners, and excavators and thus would appear to be the appropriate organization to accomplish this goal. Therefore, the Safety Board is recommending that the APWA review existing training programs and materials related to excavation damage prevention and develop guidelines and materials for distribution to one-call notification centers.

Reliability of Locating Equipment to Determine Depth

The only certain method of determining facility depth is to expose the pipe, conduit, or cable through hand digging or through vacuum excavation. Southwestern Bell's use of vacuum excavation to expose and document exact facility locations is credited with decreasing cable damages by 50 percent in Texas during 1996.[5] This method positively identifies both the horizontal and vertical location of the pipe at a specific site. But certainty about the line's

[5] Underspace Bulletin 3(7): 2. April 1997. Spooner, WI: Center for Subsurface Strategic Action (CSSA).

position is inversely related to its distance from the test hole. Depth depends on how the line was installed and on the changes in surface grade caused by erosion or construction since installation.

For selected models of locating equipment, manufacturers claim that the units can accurately determine depth.[6] Accurate depth measurements are a highly desirable attribute of locating equipment. Based on equipment manufacturers' claims, States have begun to consider adding requirements for depth location information to their damage prevention legislation. Wyoming's Underground Facilities Notification Act of 1996 requires construction project owners to furnish information on the nature, location, and elevation of underground facilities.[7] Minnesota is considering a similar requirement.

Remote locating devices that measure depth are susceptible to calibration problems, antenna misalignment, and electronic fields that are combined from more than one surface conductor.[8] The capability for accurate depth measurement may exist under ideal situations, but given field conditions, depth measures may lack a high rate of reliability. Participants in the 1994 damage prevention workshop concluded that remote sensing methods should not be used for determining facility depth location. More recently, at the 1997 One-Call Systems and damage prevention symposium, a session on depth perception concluded that remote locator equipment was available that could provide elevation readings but not with a degree of accuracy that warrants placing the liability with the locating service.[9]

The capability of locator equipment needs to be incorporated into damage prevention practices. The Safety Board concludes that more research and testing is needed to determine the accuracy of depth detection by remote locating equipment. Therefore, the Safety Board believes that RSPA should sponsor independent testing of locator equipment performance under a variety of field conditions. Further, the Board believes that as a result of the testing, RSPA should develop uniform certification criteria of locator equipment. Finally, once locator equipment performance has been evaluated and defined by certification criteria, RSPA should review State requirements for location accuracy and hand-dig tolerance zones to determine that they can be accomplished with commercially available technology.

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[6] According to advertisements for the Sure-Lock locator by Heath Consultants, that equipment provides a continuous depth reading. Other equipment manufacturers, Fisher TW-770 and Metrotech 9800, advertise a pushbutton feature for digital display of depth.

[7] "Wyoming's Unique One-Call Legislation." Constructor, November 1996:17.

[8] Anspach, J.H. 1994. Locating and Evaluating the Conditions of Underground Utilities. In: RETROFIT '94. Washington, DC: National Science Foundation. Sponsored by: Stanford University and the National Science Foundation.

[9] "Depth Perception" session at the 22[d] annual One-Call Systems and Damage Prevention Symposium, April 20-23, 1997, New York City. Panel participants at the moderated session represented equipment manufacturers and underground locator services.

Mapping

Maps are important to many aspects of excavation damage prevention. Rather than using a standard, common mapping system, current damage prevention programs use many different maps. An excavator usually uses a city road map to identify to the one-call center the intended area of construction activity. The one-call center refers to its coverage map (grid system coded with database information) to identify which facility owners should be notified to mark their underground facilities. Locators use a combination of utility maps to direct their field work.

Engineers and project designers are forced to use a variety of data sources from both public and private organizations to determine the structure and location of the underground facility network. Land use and zoning maps, tax assessor maps, easement descriptions, highway and transportation network maps, quadrangle and topographic maps of the U.S. Geologic Survey, construction permit drawings, construction plans, and aerial photographs are also used to help define the location. As the following example illustrates, map quality can vary. Excavation to install telephone cable on the University of New Haven campus in Connecticut in August 1996 hit a gas main, but the gas did not ignite. The gas crew searched for 33 minutes to find the correct shut-off valve. The director of facilities for the university said the gas line was not marked on maps of the campus.[10]

Facility records maintained by the utility owners or pipeline operators are the most widely used sources of information about the underground infrastructure. As a result of the Pipeline Safety Act of 1992, OPS requires operators to identify facilities in environmentally sensitive areas and in densely populated areas, but there is no requirement for system operators to maintain a comprehensive system map of their underground facilities, though most do maintain this information to facilitate their business operations. Different utility services use different types of maps; they vary in scale, accuracy, resolution, standard notation, and data format. System records developed prior to the widespread use of computer technology most likely exist as architectural and engineering diagrams. For some systems, these diagrams have been electronically imaged so that they are easier to reference, update, and store. Digitized versions of early maps do not always reflect the uncertainty of information that may have been inherent on the hand-drafted version. Structural references and landmarks that define the relative locations of underground facilities also change over time and may not be reflected on maps.

Many system maps lack documentation of abandoned facilities. Abandoned facilities result when the use of segments of the underground system are discontinued, or when replaced lines run in new locations, or when entire systems are upgraded. Without accurate records of abandoned facilities, excavators run the risk of mistaking the abandoned line for an active one, thereby increasing the likelihood of hitting the active line. Several States have recognized the need to require facility operators to map abandoned lines; for example, Arizona requires that any line abandoned after December 1988 be mapped.

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[10] Underground Focus 10(6): 17. September/October 1996.

In addition to documenting the location of a facility, utility map records may also contain information on the age of the facility, type and dimensions of the material, history of leakage and maintenance, status of cathodic protection, soil content, and activity related to pending construction. However, the quality of this information varies widely. Participants at the 1994 damage prevention workshop recommended that when excavation revealed errors in mapping, operators should be required to update system maps.

Recent utility records often exist as geographical information systems in a variety of computerized software packages and electronic data storage formats. The Mapping Requirements and Standards task group of the American Gas Association's Distribution Engineering Committee surveyed member companies in 1995 about mapping requirements and practices. Of the 27 companies that responded, 12 used computer-based mapping systems, 12 others were planning to automate their mapping systems, and 3 reported that they had no plan to automate mapping records.[11]

Many automated mapping programs are not compatible, and it is difficult to merge system records developed over the years by different departments and companies. Additionally, computerized diagrams may be associated with large databases that contain entry errors that are difficult to identify. Inconsistencies between data dictionaries—similar information labeled differently in different databases—require considerable effort to correct once identified. More importantly, these differences may lead to an unknown error if they are not resolved. A good quality printed image of an electronic map can disguise the poor level of information used to generate the image.

One-call systems are beginning to use global positioning system (GPS) receivers and mapping programs.[12] Arizona Blue Stake One-Call and Ohio Utility Protection Service are working to develop positionally accurate, map-driven software to support their notification systems. California's USA North One Call ticket locations can be displayed as GPS coordinates.[13] Excavators, locators, and utility operators can use GPS information to identify field locations (longitude and latitude coordinates), and they can use this information to navigate to the sites. With the added capability of differential GPS, objects can be located to an accuracy of better than 1 meter (1.1 yards). This degree of accuracy makes differential GPS appropriate for many aspects of mapping underground facilities. The Tennessee One-Call System is considering the feasibility of installing differential GPS antennas across the State to provide location accuracy.

Most commercial maps are based on topographically integrated geographic encoding and referencing (TIGER) files from the U.S. Census Bureau. These files often contain positional inaccuracies that can be problematic when integrated with GPS latitude and longitude

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[11] Place, J.C. 1996. "Gas Utility Mapping: What's Needed, What's Used." Gas Industries, January: 21–22.

[12] Vista One Call Mapping Program by Kuhagen, Inc., is compatible with California's USA North One Call System and has been accepted for use by the State fire marshal as a method for digitizing pipeline mapping.

[13] "One-Calls Eye New Mapping." Underground Focus 10(2): 6. Symposium Edition 1996.

coordinates. For example, many, if not most, existing underground systems are not documented by GPS coordinates. Consequently, a facility owner working on a line may want to update the positional record of that line to include the coordinates. Using a GPS receiver, the facility owner acquires the line's position and then references a TIGER-based map for that area to verify aboveground landmarks. The map can indicate that those coordinates are on the south side of the highway, yet the locator might actually be standing above the underground facility on the north side of the highway.

In 1994, the Federal Geographic Data Committee recommended a plan for the Nation's spatial data infrastructure, and Congress mandated governmental response to the plan.[14] The OPS subsequently formed a joint government/industry team to start a national pipeline mapping system. The team's 1996 report, "Strategies for Creating a National Pipeline Mapping System," made several recommendations: (1) develop, promote, and aggressively communicate pipeline data standards that are consistent with the standards of the Federal Geographic Data Committee; (2) formalize a partnership with industry, and Federal and State agencies; (3) develop a partnership with One-Call Systems International to reach a better understanding of one-call system data needs and gather support for using geographically referenced data; and (4) create a distributed mapping system with centralized quality control and decentralized access capabilities.

There are many different facility mapping systems in use by one-call systems and facility owners. Those with GPS positional accuracy lack information on landmarks and developed structures, and maps that accurately reflect current structural improvements often lack positional accuracy. The Safety Board concludes that underground facility mapping must consider the amount of detail and the accuracy of information necessary for effective use. The Safety Board recognizes RSPA's efforts in creating strategies for a national pipeline mapping system and for its current Mapping Implementation Quality Action Team. The Board believes RSPA should develop mapping standards for a common mapping system, with a goal to actively promote its widespread use.

System Measures, Reporting Requirements, and Data Collection

Few performance-based measures are available and useful for assessing excavation damage prevention programs. Those measures that are maintained are specific to selected States or are maintained by individual companies for a specific underground system. Data concerning underground damage for all types of systems are needed (1) to determine if changes to State damage prevention programs are effective in decreasing underground facility damage; (2) to assess the benefit of different practices followed by one-call notification centers; (3) to identify the risks of different field practices used by facility operators, locators, and excavators; (4) to allow facility operators to evaluate their company's excavation damage prevention programs;

[14] The Federal Office of Management and Budget (OMB), under the directive of OMB Circular A16, created the Federal Geographic Data Committee, which is chaired by the Secretary of the Interior. The 1994 Plan for the National Spatial Data Infrastructure was issued in March 1994.

(5) to assess the needs and benefits of training; and (6) to perform risk assessment for the purposes of business, insurance, and public policy decisions.

Risk Exposure.—A critical component of excavation damage data is the total number of excavations that present a chance for damage. These data, however, are not available. The number of excavations presented in this report are industry estimates; they did not result from a national data collection system. To quantify the number of accidents in relation to how many could have occurred, it is necessary to determine some frequency of exposure. In the context of excavation damage, exposure can be measured by the number of excavations. This measure can be approximated by the number of locate tickets issued by one-call centers, although that number will capture only those excavations that were reported to one-call centers.

One-call centers offer the best opportunity for the industry as a whole to determine the rate of excavation damage. The OCSI delegate committee is developing a process to standardize and collect one-call center information from its members. To be useful, the information will need to be qualified by reporting criteria. Categories will need to be clearly defined: what is an excavation activity, what constitutes a facility hit, how is the level of damage categorized, what caused the damage?

Many facility operators, particularly companies that transport gas and hazardous liquids, investigate and record "line hits" in terms of damages per thousand locate requests. But because of proprietary interests, these numbers are rarely compiled across companies. The Gas Research Institute's (GRI) 1995 study made an effort to determine risk exposure for the gas industry.[15] The study surveyed 65 local distribution companies and 35 transmission companies regarding line hits. Less than half (41percent) of the companies responded, and several major gas-producing States were poorly represented (only one respondent from Texas and one from Oklahoma). The GRI estimate was determined by extrapolation and may be subject to a large degree of error because the data sample was not representative. Based on survey responses, however, GRI calculated an approximate magnitude of risk. For those companies that responded, a total of 25,123 hits to gas lines were recorded in 1993; from that, the GRI estimated total U.S. pipeline hits in 1993 to be 104,128. For a rate of exposure, this number can be compared to pipeline miles: for 1993, *Gas Facts* reported 1,778,600 miles of gas transmission, main, and service line, which calculates to a risk exposure rate of 58 hits per 1,000 line miles.[16]

Because the risk of excavation damage is associated with digging activity rather than system size, "hits per digs" is a useful measure of risk exposure. For the same year that GRI

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[15] Doctor, R.H.; Dunker, N.A.; Santee, N.M. 1995. Third-Party Damage Prevention Systems. GRI-95/0316. Final report, contract 5094–810–2870. Chicago, IL: Gas Research Institute. 67 p., plus appendixes.

[16] Calculated as total hits (104,128) ÷ miles of gas line (1,778,600) = 0.0585 hits per mile or 58.5 hits per 1,000 miles. Note: Different categories of gas lines were added together. Transmission lines have a substantially lower rate than other gas systems: survey respondents reported 201 hits per 36,042 line miles, for a rate of 5.5 hits per 1,000 miles. However, GRI survey numbers account for only 10 percent of the U.S. gas transmission system. If the number of transmission system hits per 1,000 miles is separated from the U.S. total, the rate for local distribution companies increases to 71 hits per 1,000 miles.

conducted its survey, one-call systems collectively received more than an estimated 20 million calls from excavators. (These calls generated 300 million work-site notifications for participating members to mark many different types of underground systems.) Using GRI's estimate of hits, the risk exposure rate for 1993 was 5 hits per 1,000 notifications to dig.[17] A comprehensive measure of hits per digs tracked over time can be a useful indicator of how well excavation damage prevention programs are performing. Because the measure is expressed as a rate rather than simply a number of hits, it can be used to compare years in which there were different levels of construction activity. The measure can also be used to compare geographic locations or utility systems of different size. Industry is beginning to use such measures of performance; for example, measures of hits per locates have been incorporated into contractual agreements between utilities and their locator services.[18]

The Safety Board is encouraged that attempts are being made to calculate risk exposure data. Without this information, evaluations on the effectiveness of State damage prevention programs cannot be adequately performed. The Safety Board is concerned, however, that these isolated attempts to calculate exposure data are neither standardized nor centrally reported. A "utility" in one State may be defined differently for another State, resulting in inconsistent measures of damage.

If all digging activity were recorded through one-call systems, notification ticket volume would be a useful measure of risk exposure. The Safety Board recognizes that not all excavators currently use one-call notifications systems and that there are 84 separate one-call systems operating in the United States collecting different information in different formats. The Safety Board concludes that the one-call notification centers may be the most appropriate organizations to collect risk exposure data on frequency of digging and data on accidents. To standardize how and what information should be collected, the Safety Board believes that RSPA, in conjunction with the APWA, should develop a plan for collecting excavation damage exposure data and then work with the one-call systems to implement the plan to ensure that excavation damage exposure data are being consistently collected. The universal damage report form developed by Alberta One-Call could be considered by the OCSI. Finally, the Safety Board believes that RSPA and the APWA should use the excavation damage exposure data in the periodic assessments of the effectiveness of State excavation damage prevention programs described in other safety recommendations in this letter.

Accident Reporting Requirements of RSPA.—RSPA receives accident reports on only a small portion of the underground infrastructure, not as a result of failure to report on the part of industry, but because RSPA's oversight responsibilities are limited to only a portion of the gas and hazardous liquids systems, and of that subset, accident reports are required only when reporting thresholds are exceeded. Nonetheless, RSPA's database is important because there are

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[17] Calculated as total hits (104,128) ÷ excavation notifications (20,000,000) = 0.0052 per notification or 5.2 per 1,000 notifications.

[18] Northern Illinois Gas incorporated a performance incentive based on hits per locates into its most recent locator service contract with Kelly Cable Corporation.

few sources for national accident measures and because RSPA's experience in collecting pipeline accident data can be useful for designing future databases on excavation damage.

According to the GRI study of damage prevention, gas transmission and distribution systems accident reports by RSPA account for less than 1 percent of the occurrences of underground pipeline damage.[19] Although numerous accidents and incidents do not meet the above reporting criteria and, consequently, are not recorded by RSPA, the Safety Board is concerned that many accidents that should be reported are not being reported because the cost of damage is underestimated. For example, a recent university study determined that a gas line rupture, originally reported to cost $15,000, cost substantially more.[20] Survey responses from businesses, homeowners, and emergency response units determined that the cost of the accident, not including the cost of lost gas or legal fees associated with ongoing litigation, was over $300,000. Because of the $50,000 reporting threshold, this accident, based on the original damage estimate, was not required to be reported to RSPA.

Although a determination by the operator that an incident costs less than $50,000 alleviates the operator of the requirement to report the incident to RSPA and may be a factor in the under-reporting of accidents, estimating property damage can be difficult and very subjective. The incident reports filed by operators ask for estimated property damage; however, little guidance is provided to operators on all costs that should be included to ensure accurate reporting. Dollar amounts are generally assumed to represent product loss, facility damage incurred by the operator and others, and the environmental cleanup cost; however, the exclusion of any one of these costs could reduce the estimated damage to below the reporting threshold. As a result, the accident would not be reported to RSPA. The Safety Board concludes that facility operators are provided little guidance for estimating property damage resulting from an accident, and subjective estimates of damage below the reporting threshold may account for some accidents not being reported to RSPA when they should have been. Therefore, the Safety Board believes that RSPA should develop and distribute to pipeline operators written guidance to improve the accuracy of information for reportable accidents, including parameters for estimating property damage resulting from an accident.

Definitions of Accident Cause.—The accident report form for hazardous liquid pipelines offers seven categories of cause.[21] For accidents reported between 1986 and 1995, three categories (corrosion, outside force damage, and other) accounted for 78 percent of the reported

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[19] Doctor, R.H.; Dunker, N.A.; Santee, N.M. 1995. Third-Party Damage Prevention Systems. GRI-95/0316. Final report, contract 5094–810–2870. Chicago, IL: Gas Research Institute. 67 p., plus appendixes.

[20] North Carolina State University, Construction Automation & Robotics Laboratory. 1996. Assessment of the Cost of Underground Utility Damages. Raleigh, NC. 17 p., plus appendixes. The study was also the subject of the following article: Carver, C. 1996. "Real Costs of Utility Damages Researched by NCSU." Underground Focus 10(6): 28. September/October.

[21] DOT Form 7000-1, Part D: (1) corrosion, (2) failed weld, (3) incorrect operation by operator personnel, (4) failed pipe, (5) outside force damage, (6) malfunction of control or relief equipment, (7) other—specify. Category 7 includes cases involving excavation damage, such as backhoe dug into line, and category 5 (outside force damage) includes vandalism and lightning strikes. Excavation damage is not separately categorized.

accidents. For 1996, RSPA data indicated that "outside force damage" was the leading cause of accidents (damage by outside force is primarily, though not exclusively, the category in which excavation damage is placed). The second leading cause for that year was "other." The Safety Board has previously expressed concern that the definition of accident cause is imprecise and that distinctions between categories of cause are vague. For example, in the data for hazardous liquid pipeline accidents, pipeline accidents resulting from similar events (as described by text explanations) are categorized differently. Accidents described as "lightning strike," "vandalism," "drilled into pipe," and "bullet hole" appear in both the "outside force damage" and "other" categories. Because excavation damage is not separately categorized, Safety Board staff conducted a systematic review of the accidents reported to RSPA for the years 1991 through 1996 to determine the number of excavation-related accidents. The review indicated no trend toward a long-term decrease in excavation-related accidents.

Numerous accident records in the databases for distribution, transmission, and hazardous liquids systems show $0.00 for accident costs.[22] This is particularly disturbing because in one case, a damage cost of $0.00 was reported for an accident that injured 12 persons (a distribution system accident, July 1996 in Brooklyn, New York). A review of text comments associated with the accident records indicated that most excavation damage accidents were classified in the database as "outside force damage." However, there were many additional accidents classified as "outside force damage" that were not excavation-caused and several incidents of excavation damage were mis-categorized as "other," "corrosion," "accidentally caused by operator," or "construction/operating error."

Based on this review and previous analysis of RSPA data, the Safety Board concludes that deficiencies in RSPA accident data, particularly with respect to the cause of accidents and a record of whether those involved in pipeline accidents participated in excavation damage prevention programs, precludes effective analyses of accident trends and evaluations of operator performance. Although RSPA and the industry consider excavation damage to be one of the leading causes of pipeline accidents, excavation damage is not specifically indicated on RSPA's accident form as a separate data element. A more useful analysis of accident data could also be performed if information were available on the primary, secondary, and contributing causes. The Safety Board has found through years of accident investigations that accidents are rarely the result of one event, but rather the consequence of a sequence or combination of events. Categories based on purpose of the excavation (building construction, road grading, utility maintenance); type of equipment involved (backhoe, grader, road vehicle); excavator (facility owner employee, contract employee, landowner, general public); and locator (facility owner or contract support) could provide meaningful information with which analyses of accident trends and evaluations of operator performance could be conducted.

[22] Accidents with $0.00 damage are included in the database because they meet one of the other criteria for reporting. For 1996, the three databases show 76 accidents with $0.00 damage costs.

The Safety Board has addressed deficiencies in RSPA's accident data on several previous occasions. Most recently, in a 1996 special investigation report, the Safety Board evaluated RSPA's collection and analysis of accident data for petroleum product pipelines.[23] In that report, the Board concluded that RSPA's failure to fully implement the Safety Board's original 1978 safety recommendations to evaluate and analyze its accident data reporting needs has hampered RSPA's oversight of pipeline safety. Consequently, the Safety Board recommended that RSPA

> Develop within 1 year and implement within 2 years a comprehensive plan for the collection and use of gas and hazardous liquid pipeline accident data that details the type and extent of data to be collected, to provide the Research and Special Programs Administration with the capability to perform methodologically sound accident trend analyses and evaluations of pipeline operator performance using normalized accident data. (P-96-1)

RSPA indicated that it agreed with the Board's recommendation and was working with the pipeline industry to determine the value of industry's data to RSPA.[24] Industry and RSPA have conducted workshops to review data issues and, as recommended by the Safety Board, RSPA has obtained database information from the Federal Energy Regulatory Commission for analysis. The Safety Board believes that given the large percentage of accidents that are caused by excavation damage and the emphasis in recent years by industry to address and respond to these types of accidents, RSPA should, as part of its comprehensive plan for the collection and use of gas and hazardous liquid data, revise the cause categories on its accident report forms to eliminate overlapping and confusing categories and to clearly list excavation damage as one of the data elements, and consider developing categories that address the purpose of the excavation.

Therefore, the National Transportation Safety Board recommends that the Research and Special Programs Administration:

> Conduct at regular intervals joint government and industry workshops on excavation damage prevention that highlight specific safety issues, such as full participation, enforcement, good marking practices, the importance of mapping, and emergency response planning. (P-97-14)

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[23] National Transportation Safety Board. 1996. Evaluation of Accident Data and Federal Oversight of Petroleum Product Pipelines. Pipeline Special Investigation Report NTSB/SIR-96/02. Washington, DC. 67 p. The special investigation was prompted by the ruptures of two petroleum product pipelines operated by the same company. Both ruptures occurred within a 15-month period.

[24] Correspondence dated August 7, 1996, from the RSPA Administrator. On January 2, 1997, the Safety Board classified Safety Recommendation P-96-1 "Open—Acceptable Response" based on RSPA's response and pending a further progress report.

Initiate and periodically conduct, in conjunction with the American Public Works Association, detailed and comprehensive reviews and evaluations of existing State excavation damage prevention programs and recommend changes and improvements, where warranted, such as full participation, administrative enforcement of the program, pre-marking requirements, and training requirements for all personnel involved in excavation activity. (P-97-15)

Sponsor independent testing of locator equipment performance under a variety of field conditions. (P-97-16)

As a result of the testing outlined in Safety Recommendation P-97-16, develop uniform certification criteria of locator equipment. (P-97-17)

Once locator equipment performance has been evaluated and defined by certification criteria as outlined in Safety Recommendation P-97-17, review State requirements for location accuracy and hand-dig tolerance zones to determine that they can be accomplished with commercially available technology. (P-97-18)

Develop mapping standards for a common mapping system, with a goal to actively promote its widespread use. (P-97-19)

Develop and distribute to pipeline operators written guidance to improve the accuracy of information for reportable accidents, including parameters for estimating property damage resulting from an accident. (P-97-20)

As part of the comprehensive plan for the collection and use of gas and hazardous liquid data, revise the cause categories on the accident report forms to eliminate overlapping and confusing categories and to clearly list excavation damage as one of the data elements, and consider developing categories that address the purpose of the excavation. (P-97-21)

In conjunction with the American Public Works Association, develop a plan for collecting excavation damage exposure data. (P-97-22)

Work with the one-call systems to implement the plan outlined in Safety Recommendation P-97-22 to ensure that excavation damage exposure data are being consistently collected. (P-97-23)

Use the excavation damage exposure data outlined in Safety Recommendation P-97-22 in the periodic assessments of the effectiveness of State excavation damage prevention programs described in Safety Recommendation P-97-15. (P-97-24)

As a result of this safety study, the Safety Board also issued safety recommendations to the American Public Works Association, the Federal Highway Administration, the Association of American Railroads, the American Short Line Railroad Association, the American Society of Civil Engineers, and the Associated General Contractors of America.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: ~~Jim Hall~~
Chairman