Log P-316J

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National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: January 6, 1998

In reply refer to: P-97-37 and -38

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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 excavation damage prevention program; accuracy of information regarding buried facilities; and system measures, reporting requirements, and data collection.

With respect to the accuracy of information regarding buried facilities, the Safety Board examined current underground detection technologies, directional boring/trenchless technology, mapping systems, and the use of subsurface utility engineering (SUE). The discussion in this letter is limited to the directional boring/trenchless technology and the use of SUE.

Directional Boring/Trenchless Technology

Excavation work is frequently for the purpose of installing additional facilities. General practices require digging an open trench from the surface down to the installation depth. However, trenchless technology offers a different method for installing underground facilities. Directional boring "snakes" a new line that follows a drill bit horizontally through the subsurface. This method is particularly advantageous for traversing below waterways, ecologically sensitive wet lands, or major traffic arteries. But there are practical limits to the depth that lines are installed. Eventually, additional depth becomes infeasible because of the cost of the extended line runs, geologic changes at lower stratum, or practical concerns for future maintenance. New lines must then go through the areas that have had line laid by directional boring.

Differences in soil density, rock formations, and variable torque on the drilling head often result in a directional line that does not run along a straight route. Drilling heads can be deflected by hard rock or unknown underground objects. The operational accuracy of directional boring depends on the accuracy of sensors located on the drill bit and the drilling unit's resolution and correlation to a common base map. Though they do not involve sensors, similar problems can be found with the use of pneumatic drills and mechanical augers.

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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-97/00. Washington, DC.

Directional boring is not always sensitive to line hits; it is possible for a boring equipment operator to hit a facility without being aware of the hit. The drill bits, designed to go through rock, experience little change in resistance when going through plastic pipe or cable. This sets up a situation for hitting a gas line without knowing it; migrating gas can then collect, creating conditions for an explosion. The Safety Board recently investigated an accident involving directional boring in Indianapolis, Indiana.[4] The explosion resulted in one fatality, one injury, and extensive damage to a residential subdivision.

Over the past year, the trade literature has documented several accidents, not investigated by the Safety Board, that resulted from horizontal directional boring. For example:

- In Seattle, directional boring caused a gas explosion that destroyed a home;
- A major traffic artery in northern New York State was closed for several days to determine if a water main break resulting from directional boring had seriously weakened the roadbed; and
- Two people were hospitalized in Overland Park, Kansas, when a gas explosion, caused by directional boring, destroyed four homes.[5]

Equipment manufacturers have tried to address the problem of recording the position of lines installed by directional boring. Sensors, generally magnetic guidance-type sensors attached to the drill bit, record location information for mapping the line. The relative position of the drill bit is plotted on a real-time display at the drilling operator's control position.[6] Stored as an electronic data file, this information can be archived in facility data records. Conceptually, this accounts for "recording the course of a new line." Associated issues, however, can affect the accuracy of information gathered in this manner. First, accuracy depends on sensor calibration. Operators must know how to check for and correct calibration error. Second, the drill's sensor may know where it is in relation to some global positioning system (GPS) coordinates, but it may not know its location in relation to ground surface. Depth of line, an important fact, is dependent on accurately orienting the drilling activity on a topographic survey map. The accuracy of the topographic map is, in turn, affected by erosion and grade changes over time.

The Safety Board concludes that facility maps should have a standard depiction for underground facilities that were installed using directional boring techniques. The Safety Board believes that the American Public Works Association (APWA) should work in conjunction with the American Society of Civil Engineers (ASCE) to develop standards for map depiction of underground facilities that were installed using directional boring techniques.

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[4] NTSB accident DCA97FP005; the accident occurred on July 21, 1997.

[5] (a) Underground Focus 10(6): 16–19; 22–23. September/October 1996. (b) Underground Focus 10(7): 18–19. November/December 1996.

[6] Configuration of the Mole Map System developed by McLaughlin Boring Systems.

Subsurface Utility Engineering

Subsurface utility engineering (SUE) is a process for identifying, verifying, and documenting underground facilities. Depending on the information available and the technologies employed to verify facility locations, a level of the quality of information can be associated with underground facilities. These levels indicate the degree of uncertainty associated with the information; level A is the most reliable and level D the least reliable. This categorization is a direct result of the source of information and the technologies used to verify the information.

A comprehensive map and automated computer diagram of a construction site is developed as a SUE product; it depicts co-registered information for all utilities in that area. The SUE process identifies all utilities during a single coordinated effort. In this way, information known about one facility can beneficially affect the mapping of other utilities, and unknown facilities are more likely to be documented. By signing the SUE product, a professional engineer warrants the maps against errors and omissions and assumes liability for the accuracy of the information.

The Federal Highway Administration (FHWA) considers SUE an integral part of preliminary engineering work on highway projects receiving Federal aid. It has the potential to reduce facility conflicts, relocation costs, construction delays, and redesign work. In 1984, the State of Virginia began a SUE program, called the Utility Designation and Locating Program, and determined that there were substantial cost savings. A highway project in the city of Richmond used SUE work costing $93,553 to avoid an estimated $731,425 worth of expenses to move utilities had the highway projects not been designed to avoid conflict with underground facilities. Virginia's estimate of cost savings, just in terms of avoiding utility relocations, was $4 saved for each dollar spent. Additionally, Virginia credits the process with reducing design time by 20 percent.[7] The utility coordinator for Maryland's State Highway Administration estimates a savings of $18 for each dollar spent. Florida DOT found that it saved $3 in contract construction delay claims for each dollar spent on SUE. Variations in these estimates reflect different cost assumptions, geographic conditions, and system configurations. Twenty-six highway agencies have used SUE at some level on some projects;[8] FHWA estimates a nationwide savings of $100 million a year as a result of SUE.[9]

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[7] U.S. Department of Transportation, Federal Highway Administration. 1995. Subsurface Utility Engineering Handbook. FHWA-PD-96-004 (p. I–14). Washington, DC. November.

[8] According to the FHWA, Maryland, Pennsylvania, Delaware, North Carolina, and Arizona use SUE on an extensive basis.

[9] U.S. Department of Transportation, Federal Highway Administration. 1995. Subsurface Utility Engineering Handbook. FHWA-PD-96-004 (p. I–29). Washington, DC. November.

Compiling comprehensive information on underground facilities can be expensive and labor intensive. Small contractors generally do not have the resources or expertise available to accomplish SUE on a regular basis; consequently, SUE is generally used on large construction projects such as those typical of highway development.

Architects, engineers, and contractors should have ready access to information on the location of underground facilities to plan construction activities. The advantage of this information was recognized at the 1994 damage prevention workshop. The Safety Board concludes that providing construction planners with information on the location of underground facilities, referred to as "planning locates," can reduce conflicts between construction activities and existing underground facilities. The Safety Board is recommending, therefore, that the APWA encourage one-call notification centers to work with their members to provide facility location information for the purpose of construction planning.

The Standards Committee of the ASCE is developing standards for depicting underground facilities on construction drawings. The Board thus believes that the APWA and the ASCE should address the accuracy of information that depicts subsurface facility locations on construction drawings.

Therefore, the National Transportation Safety Board recommends that the American Society of Civil Engineers:

> Develop standards, in conjunction with the American Public Works Association, for map depiction of underground facilities that were installed using directional boring techniques. (P-97-37)
>
> Address, in conjunction with the American Public Works Association, the accuracy of information that depicts subsurface facility locations on construction drawings. (P-97-38)

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

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility ". . . to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any actions taken as a result of its safety recommendations and would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations P-97-37 and -38 in your reply.

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

By: Jim Hall
Chairman