DOT-TSC-RSPA-86-5

An Examination of Outside Forces Damage to Natural Gas Pipelines and Damage Prevention

Paul K. Zebe

Transportation Systems Center
Cambridge MA 02142

July 1987
Final Report

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

US.Department of Transportation
Research and Special Programs Administration

Office of Hazardous Materials Transportation
Policy Development and Information Systems Division
Washington DC 20590

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

NOTICE

The United States Government does not endorse products of manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT-TSC-RSPA-86-5		

4. Title and Subtitle	5. Report Dote
AN EXAMINATION OF OUTSIDE FORCES DAMAGE TO NATURAL GAS PIPELINES AND DAMAGE PREVENTION	July 1987
	6. Performing Organization Code: DTS-42
7. Author's): Paul K. Zebe	8. Performing Organization Report No.: DOT-TSC-RSPA-86-5
9. Performing Organization Name and Address: U.S. Department of Transportation, Research and Special Programs Administration, Transportation Systems Center, Cambridge MA 02142	10. Work Unit No. (TRAIS): RS630/P6855
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address: U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Materials Transportation, Policy Development and Information Systems Division, Washington DC 20590	13. Type of Report and Period Covered: Final Report, Jan 1980 - Dec 1982
	14. Sponsoring Agency Code: DHM-60

16. Abstract

This report looks at the problem of damage to underground facilities caused by excavation and related activities and the efforts that have been made in recent years to limit and control it through laws, regulations, and damage prevention programs, such as one-call systems. The emphasis and focus of the study is on outside forces damage to U.S. natural gas pipelines, whose safe performance is the regulatory responsibility of the U.S. Department of Transportation. Outside forces damage is the most important cause of U.S. gas pipeline accidents.

To help develop a better understanding of outside forces damage and the impact of damage prevention programs on it, a statistical regression model of the level of outside forces incidents faced by gas distribution system operators participating in one-call systems, the most important type of damage prevention program in operation in the U.S., was specified and estimated. Variables in the estimated regression model included construction levels, state damage prevention law requirements, population levels, gas system pipeline mileage, gas system size, number of underground operators in one-call systems, one-call request times, calls made to one-call systems per system telephone operator, and one-call system advertising levels.

17. Key Words	18. Distribution Statement
he-Call System, Damage Prevention, Excavation Damage, Damage Prevention Program, Gas Distribution, Underground Utilities, Outside Forces Damage, Construction, Contractor,	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD. VIRGINIA 22161

19. Security Clarrif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	194	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

This report, prepared by the Economic Analysis Division of the Transportation Systems Center, U.S. Department of Transportation, examines the problem of excavation damage to buried facilities as it pertains to gas pipelines and the solutions that have been developed to limit and control it. The basic purpose of the report is to develop and present insights into the damage prevention process that can be used by government and industry to improve their damage prevention efforts.

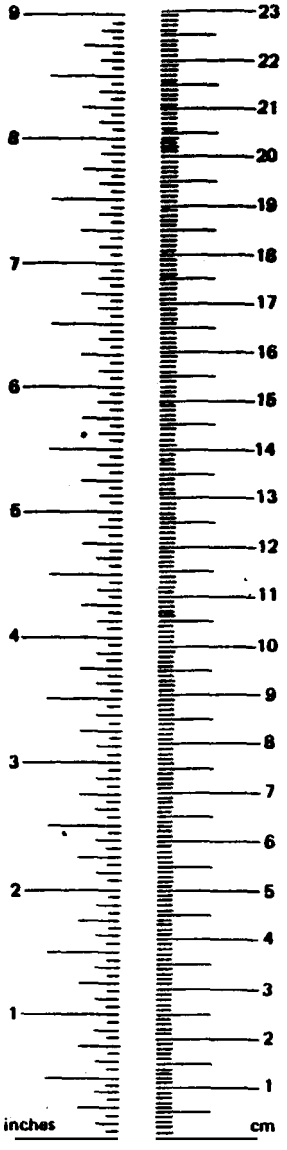
Numerous people cooperated in the researching and preparation of this report. The author would like to thank them all again for their assistance.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	6	milliliters	ml
Tbsp	tablespoons	16	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286, Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10286.



Approximate Conversions *from* Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0 M	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
in	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
tu	hectares (10,000 m^2)	2.6	acres	
		MASS (weight)		
a	grams	0.036	ounces	oz
kg	kilograms	2.2	pounds	10
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	21	pints	pt
I	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic foot	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

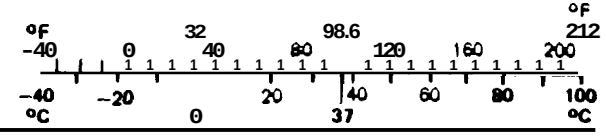


TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

This report examines outside forces damage to underground facilities and the efforts that have been made by industry and government to limit and control it through laws, regulations, and damage prevention programs, particularly one-call systems. The focus of the report is on outside forces damage to U.S. natural gas pipelines, whose safe performance is the regulatory responsibility of the U.S. Department of Transportation (U.S. DOT). To help develop a more complete understanding of outside forces damage and damage prevention, a statistical model of the level of outside forces incidents experienced by gas distribution system operators participating in one-call systems was specified and estimated.

Much plant and equipment in the U.S. is located Underground. Most, if not all, is vulnerable to outside forces damage. Outside forces incidents can have serious consequences. They can result, in addition to damage to underground facilities, in damage to excavating equipment, loss of product or service, environmental damage, third-party property damage, injuries, and/or death. Outside forces damage is the leading cause of serious gas pipeline accidents (those requiring reporting to the U.S. DOT) in the U.S. Between 1975 and 1984, inclusive, about 63 percent of all incidents reported to the U.S. DOT were the result of outside forces damage.

Excavation is the single most important cause of outside forces damage to underground facilities. Outside forces damage can also result from such things as earthquakes, land subsidence, vandalism, and freak occurrences. A significant proportion of the excavation damage that occurs is caused by underground operators and their contractors.

Excavation damage occurs for a number of reasons. Some occurs because excavators did not determine if underground plant underlies their excavation site. Other excavation damage occurs because of inaccurate or inadequate marking and staking of underground facilities at excavation sites. Additional reasons for excavation damage include (1) equipment operator carelessness, (2) equipment operator incompetence, (3) equipment operator malice, (4) unavoidable problems and mistakes, (5) equipment problems, and (6) poor operating procedures.

Because of the potentially serious nature of outside forces damage, outside forces damage prevention is an important concern of both industry and government. The primary focus of damage prevention efforts, as might be expected, has been on excavation damage. Today, many, if not most, underground operators have programs in operation designed to help prevent excavation damage.

Three basic types of damage prevention programs exist. The simplest is the informal program, which is primarily an ad hoc arrangement between individuals in various organizations who undertake to keep each other informed about excavation activity. Informal programs can be expected to have only a very limited impact on excavation damage. A second type of damage prevention program is the single company program. A company with this type of program has become formally involved in the promotion

of damage prevention. The primary weakness of this type of program is that it covers just one underground operator. The third type of damage prevention program is the multi-company program. In this type of program, a number of underground operators formally band together and coordinate at least some of their damage prevention activities. This type of program is generally the most successful of the three in limiting and controlling excavation damage.

The most important type of multi-company damage prevention program is undoubtedly the one-call system. A one-call system is

> ...a communication system established by two or more utilities, governmental agencies or other operators of underground facilities to provide one telephone number for excavating contractors and the general public to call for notification of their intent to use equipment for excavating, tunneling, demolition or any other similar work. [It]...provides the participating members an opportunity to identify and locate. their underground facilities.

The first one-call system, the UTILITY COORDINATING COMMITTEE of Rochester, New York, was founded in 1964. Since then, the number of one-call systems in operation has increased considerably. As of 1984-85, there were 98 one-call systems in operation in the U.S. One-call systems could be found in all but six U.S. states. Thirty states had statewide one-call coverage in 1984-85, provided by either single or multiple systems; fourteen states had more limited coverage.

One-call systems are either in-house, member-owned-and-operated, or contractor operations. Most systems today are either in-house or contractor operations; member-owned-and-operated operations are fairly new.

One-call systems appear to be fairly successful in reducing excavation damage to underground facilities. A 1978 American Public Works Association survey found that most one-call participants observed a reduction in damages following the start of their system participation. Some observed reductions of as much as 60 or 70 percent. In addition, gas pipeline operators participating in one-call systems have reported that the systems can help reduce damages by between 24 and 67 percent.

A number of legislative and regulatory efforts have been made to promote damage prevention. These efforts have been made by all levels of government, from local to Federal. At the state level, as of 1985, 31 states and the District of Columbia had enacted laws aimed at the promotion of excavation safety and damage prevention.

Federal damage prevention regulations have been issued by both the Occupational Safety and Health Administation and the U.S. DOT. The U.S. DOT's regulations, which went into effect in April 1983, establish minimum requirements for damage prevention programs that must be set up by gas distribution, transmission, and gathering system operators

for their operations in Class 4 and some Class 3 locations. While participation in a one-call system is not mandated, pipeline operators are explicitly permitted by the regulations to use the services of a one-call system to meet any of the requirements of the regulations.

The U.S. DOT's damage prevention program regulations emphasize what might be called the "one-call process" for gas pipeline damage prevention, since they mandate the development of a damage prevention program with many of the more important attributes and characteristics of a one-call system. To develop insights into the operation of the one-call process, a statistical model of the level of outside forces incidents experienced by gas distribution system operators participating in one-call systems was developed.

The statistical model used was a regression model. To provide a more flexible functional form for the model and to bring the distribution of the regression residuals closer to normality, the dependent and non-dummy independent variables of the model were transformed using the Box-Cox Transformation. The model was estimated using gas system and one-call data for 1980, 1981, and 1982. The sample used consisted of 363 observations on gas distribution systems operating in 26 states and participating in 41 one-call systems (and system "overlaps"). The dependent variable of the model was the number of outside forces incidents occurring to a gas distribution system operator during a year. Twenty-three independent variables, excluding the constant term, are explicitly included in the estimated model. These variables can be broken into five categories: exposure variables, state damage prevention law variables, gas company variables, one-call system variables, and year variables. The performance of the model proved to be quite good.

The statistical modelling of gas distribution system incident levels yielded a number of significant findings. Key among them are

- The level of incidents is affected by both the level of construction and by the amount of pipeline mileage: as mileage or construction increases, so do incident levels.

- The existence of a state damage prevention law decreases the level of incidents, all other things equal; however, state requirements that underground operators respond to all excavation notices and participate in one-call systems do not appear to provide any incremental improvement in safety beyond that provided by the existence of the basic state damage prevention law.

- Government owned/operated gas distribution systems have neither higher nor lower incident levels than non-government gas distribution systerns.

- Neither in-house nor contract one-call operations are superior to the other in performance.

- The level of advertising and promotion (in real terms) engaged in by one-call systems has a positive impact on incident levels: the higher the advertising budget, the lower the incident levels (a one percent increase in one-call system advertising expenditures

can be expected to result in an approximately .2 percent decrease in member gas distribution system incident levels).

- Neither a one-call system's request time (the time requested between notification and the start of excavation) nor its average number of incoming calls per telephone operator significantly affect the level of gas distribution system incidents.

- The type of coverage provided by a one-call system affects the level of gas distribution system incidents; the best performance, all other things equal, is found in non-statewide systems operating in states with no areas uncovered by a one-call system, while the worst performance is found in non-statewide systems operating in states with areas uncovered by a one-call system.

From these findings, it would appear that the easiest and most effective way in which one-call systems could help reduce the incident levels of their gas distribution system members (and, presumably, of the rest of their membership, as well) would be to increase their advertising. Improvements, it appears, could also be had by expanding the coverage of non-statewide one-call systems until the states in which they operate are completely covered by one-call service. In addition, improvements might also result if statewide one-call systems could make their activities more responsive to local needs and conditions. The lack of significant impact on incident levels of the type of one-call operation (in-house or contract), request time, and the average number of incoming calls per system telephone operator would seem to imply that one-call operators have considerable latitude in choosing the operational parameters of their systems.

1. INTRODUCTION

Today, much essential plant and equipment in the U.S. is located underground. These facilities, which range from telephone and television cables to sewer, water, and electric lines to subway tunnels to petroleum and natural gas pipelines, are all, vulnerable to damage by outside forces. Undoubtedly the single most important cause of outside forces damage to underground facilities, in terms of both numbers and severity of accidents, is excavation.[1]

As part of its ongoing effort to improve the safety of the natural gas pipeline system in the U.S., the U.S. Department of Transportation (U.S. DOT), in recent years, has devoted considerable attention to reducing outside forces damage, particularly excavation damage (or dig-ins), to gas pipelines. In compliance with the requirements of the Natural Gas Pipeline Safety Act of 1968[2] (NGPSA), as amended, on April 1, 1982, the U.S. DOT issued a final rule requiring all operators of gas pipelines in Class 3 and 4 locations (with minor exceptions) to have or participate in an outside force damage prevention program (DPP).[3] This final rule became effective on April 1, 1983. The rule sets forth the criteria of the minimum safety standards that must be met by the required gas pipeline damage prevention programs. These criteria are based, in large part, on the operational procedures of the more successful "one-call" systems in the U.S.[4] A one-call system is basically

> ...a communication system established by two or more utilities, governmental agencies or other operators of underground facilities to provide one telephone number for excavating contractors and the general public to call for notification

---

[1] See Courtney, Kalkbrenner, and Yie, especially Chapters 1 and 2.

[2] 49 U.S.C. 1671 et. seq.

[3] FEDERAL REGISTER, Vol. 47, No. 63, April 1, 1982, pp. 13818-13825. The complete text of the final rule is included in this report in Appendix A.

[4] FEDERAL REGISTER, April 1, 1982, p. 13819.

> of their intent to use equipment for excavating, tunneling, demolition or any other similar work. [It]...provides the participating members an opportunity to identify and locate their underground facilities.[5]

The effectiveness of the outside forces damage prevention programs is of considerable interest to the U.S. DOT.[6] Information on effectiveness, along with information on program operation, could be used by gas pipeline operators to identify and institute program changes that could increase program effectiveness and thereby enhance pipeline safety. Evaluation of the effectiveness of the damage prevention programs is extremely difficult, however, because of the relatively complex nature of the processes involved.

The purpose of this study is to develop insights into the effectiveness of damage prevention programs that can be used in the assessment and enhancement of program performance. This is accomplished, basically, by determining the relationship between outside forces damage and some of the more important factors that may influence it, including some directly relating to the damage prevention program itself.

The approach taken for this effort was to detail and examine the nature of outside forces damage and the efforts that have been made to contain it and then to use the information to specify and statistically estimate a firm-level model for a subset of the gas distribution system operators participating in one-call systems between 1980 and 1982, inclusive. The gas distribution systems included in the sample were those that operated in a state where all one-call systems in operation during the sample period supplied starting dates for the gas distribution system members. To provide a flexible functional form for the estimated model and to handle certain statistical problems that were indicated by the data, the model that was estimated for this study was specified using the Box-Cox Transformation.[7]

---

[5] "One-Call Systems Directory, 1984-85," p. 3.

[6] FEDERAL REGISTER, April 1, 1982, p. 13824.

[7] See Box and Cox.

2. OUTSIDE FORCES DAMAGE AND GAS PIPELINES

Outside forces damage is a problem for all operators of underground facilities. In addition to damage to underground plant and equipment, it can result in loss of product or service, damage to the environment, third-party property damage, injuries, or even death.[8] It can be a particularly serious problem for gas pipelines, since, due to the nature of the product being transported, the risks of death, injury, or substantial property damage are generally higher for gas pipeline operators than for most other operators of underground facilities.[9]

Outside forces damage is the most important cause of gas pipeline accidents occurring in the U.S. As Table 1 illustrates, there are more serious incidents resulting from outside forces damage than from all other sources, combined.[10] In no year of the ten included in Table 1 did the percentage of serious incidents caused by outside forces fall below 55 percent; in most years between 1975 and 1984, it was in excess of 60 percent. Though outside forces damage is the cause of the majority of the serious gas pipeline incidents, it is not the cause of the majority of gas pipeline leaks (which will be a consequence not only of the serious incidents reportable to the U.S. DOT, but also of less serious incidents, as well). Based on the repaired leaks information contained in the annual reports submitted to the U.S. DOT by gas transmission, gathering, and distribution system operators, less than half of the total number of pipeline leaks that occur are attributable to outside forces damage.[11]

---

[8] Courtney, Kalkbrenner, and Yie, p. 97.

[9] Courtney, Kalkbrenner, and Yie, pp. 93, 98.

[10] The information in Table 1 came from the individual accident reports that gas distribution system operators with more than 100,000 customers and gas transmission and gathering system operators must file with the U.S. DOT when the consequences of an incident are especially serious. Included among the consequences requiring a report to be filed are death, injury requiring hospitalization, gas ignition, and property damage of $5000 or more. For more on the incident report filing requirements, see 49 CFR Section 191.9 and Section 191.15.

[11] U.S. DOT, "Hazardous Materials Information System," computerized databases.

TABLE 1. **OUTSIDE FORCE DAMAGE TO GAS PIPELINES**

Year	Number of Reportable Incidents* Caused by Outside Forces	Total Number of Reportable Incidents	Outside Force Percent of Total
1975	981	1373	71.4
1976	878	1579	55.6
1977	1168	1996	58.5
1978	1343	2088	64.3
1979	1346	1970	68.3
1980	1361	1996	68.2
1981	1043	1623	64.3
1982	1042	1711	60.9
1983	974	1580	61.6
1984	584	1002	58.2
Average, 1975-84	1072	1692	63.4

*A reportable incident is one requiring notice to the U.S. DOT under 49 CFR Parts 191.9 or 191.15.

Sources of data: U.S. DOT, ANNUAL REPORT ON PIPELINE SAFETY for 1980, 1981, 1982, 1983, and 1984. The data for 1975-1979 were obtained from the ANNUAL REPORT for 1980.

The most important cause of outside forces damage is excavation and related earthmoving activities.[12] Other causes of outside forces damage to underground plant and equipment include natural forces, such as earthquakes and land subsidence, vandalism, and freak occurrences.[13] It is interesting to note that one of the groups causing significant unintentional excavation damage is utilities that operate underground facilities, and their contractors.[14]

Reasons for excavation damage vary. Some damage is a consequence of the excavator not determining what exists belowground at the excavation site.[15] Underground operators tend to identify this as the major reason for excavation damage.[16] An extreme example of this behavior is exhibited by contractors who use a "rip and pay" approach to excavation. These excavators appear to find it more cost effective to dig without checking first. They are not willing to wait for the local operators of underground facilities to determine what underlies the dig site, because this would idle their equipment and idle equipment costs.[17] Sometimes utilities pressure their contractors to get work done on schedules that do not take into consideration the need to locate underground facilities, and accidents result.[18] Many others who fail to find out about subsurface facilities have not considered the possibility that there might be facilities beneath them or mistakenly believe that they know what lies underground and, therefore, see no point in contacting any local subsurface facilities operators.[19]

---

[12] Bartol and Nichols, p 6-18; U.S. DOT, "Hazardous Materials Information System," computerized databases; Courtney, Kalkbrenner, and Yie, pp. 7-9; Walker, p. 27.

[13] NTSB, p. 5; U.S. DOT, "Hazardous Materials Information System," computerized databases.

[14] Courtney, Kalkbrenner, and Yie, p. 9.

[15] Courtney, Kalkbrenner, and Yie, p. 145.

[16] Hendrick, p. 21.

[17] Submission to Docket No. PS-59 by Mountain Fuel Supply Company, Feb. 11, 1980, p. 2; Courtney, Kalkbrenner, and Yie, pp. 92, 164.

[18] General discussion, 10th Annual One-Call Symposium.

[19] Hendrick, p. 21.

Some problem may exist in certain cases in identifying all the possible underground operators who should be contacted. Unfortunately, when one is left out, an accident can result.

Another reason for excavation damage is inaccurate or inadequate marking or staking of underground facilities by the locators sent out to excavation sites by underground operators.[20] Often, locators have imperfect information with which to work. System maps, for instance, may not be complete. In addition, subsurface facilities may be difficult to correlate with surface landmarks. Consequently, marking or staking may be inexact and, because of this, an accident may occur. Excavation contractors believe poor locating is one of the major reasons for dig-ins.[21]

Undoubtedly, some incidents can be attributed to confusion about which underground systems have been marked or staked and which have not. As the American Public Works Association's Uniform Color Code and National Marking Standards[22] continue to gain increased acceptance among operators of underground facilities, it can be expected that this confusion will diminish, as will errors arising from it that result in excavation damage.

Some excavation damage occurs even when all underground operators have been notified and marking or staking have been both accurate and adequate. Among the reasons this happens are (1) equipment operator carelessness, (2) equipment operator incompetence, (3) equipment operator malice, (4) unavoidable problems and mistakes, (5) equipment problems, and (6) poor operating procedures.[23] Equipment operators often cite the last of these, poor operating procedures, as a major reason for dig-ins. These poor procedures appear to arise out of the contractor's need to get the excavation work being performed done as quickly as possible.[24]

---

[20] NTSB, p. 6.

[21] Courtney, Kalkbrenner, and Yie, p. 162.

[22] For more on these, see America1 Public Works Association, "Uniform Marking and Staking of Underground Utilities."

[23] Courtney, Kalkbrenner, and Yie, p. 74.

[24] Courtney, Kalkbrenner, and Yie, p. 164.

3. DAMAGE PREVENTION

Because of the serious nature of outside forces damage, outside forces damage prevention has, in relatively recent years, become an important concern of gas pipeline operators (and other underground operators). The primary focus, as might be expected, has been on controlling excavation damage. Some of the impetus for damage prevention has been supplied by federal, state, and local regulations. Much, however, has been supplied by industry,[25] undoubtedly spurred, at least in part, by a desire to minimize service interruptions and repair outlays.

3.1 DAMAGE PREVENTION PROGRAMS

Throughout much of U.S. history, excavation damage was essentially treated as an unavoidable price of progress.[26] With the increase in excavation damage attending the intensive building activities of the 1950's, 1960's and 1970's (and the concurrent installation of considerable underground plant and equipment),[27] there came a change in attitude. The former view of excavation damage was no longer acceptable. Something, it was felt, needed to be done to control damage to underground facilities. Industry's answer to the problem of excavation damage was the development and institution of damage prevention programs. Efforts were underway in industry to develop these programs by the early 1960's. By the mid-1970's, many, if not most, operators of underground facilities had damage prevention programs of one sort or another in operation.[28]

There are three basic types of damage prevention program: informal, single company, and multi-company.[29] The most simple of these, as probably would be expected, is the informal program. This type of program consists,

---

[25] Walker, p. 27.

[26] Courtney, Kalkbrenner, and Yie, p. 12.

[27] "One-Call Systems Directory, 1984-85," p. 3.

[28] Courtney, Kalkbrenner, and Yie, p. 153.

[29] Courtney, Kalkbrenner, and Yie, pp. 17-18.

primarily, of informal arrangements between individuals at various organizations, including utilities with underground facilities, excavation contractors, and local governmental agencies involved with the issuing of permits, who undertake to keep each other, or themselves, apprised of excavation activity. The individuals involved in these informal arrangements may include, among others, utility field supervisors and foremen, utility safety administrators, contractor staff, and local governmental officials. Informal programs have, generally, been found to have a very limited impact on excavation damage.[30]

In a single company program, a firm operating underground facilities becomes, as a whole, actively and formally involved in damage prevention. The activities and actions that a company can take are varied. One of the most important, of course, is locating its facilities upon demand. Other activities and actions that a company might undertake include participation in meetings with local contractors and advertising its locating service. Underground operators can have some success in preventing excavation damage using a single company program. However, the success will be limited, primarily, it appears, by the lack of coordination with other underground operators.[31]

In the multi-company program, the third type of damage prevention program, a number of underground operators formally band together and coordinate at least some of their damage prevention activities. One important example of a multi-company program is the one-call system. Among the activities that may be coordinated in a multi-company program are meetings with local contractors, damage control seminars, advertising, and locating. In addition, one-call systems will have a common telephone number for excavation notifications.[32]

---

[30] Courtney, Kalkbrenner, and Yie, pp. 17, 143.

[31] Courtney, Kalkbrenner, and Yie, pp. 17, 143.

[32] Courtney, Kalkbrenner, and Yie, pp. 18, 143-151; NTSB, 1973, pp. 7-10; General discussion, 9th and 10th Annual One-Call Symposiums.

3.2 ONE-CALL SYSTEMS

Undoubtedly, the most important type of multi-company damage prevention program is the one-call system. The first one-call system, the UTILITY COORDINATING COMMITTEE, was founded in 1964 by a group of concerned utilities to provide one-call service in the Rochester area in the state of New York.[33] Since then, the number of one-call systems has increased considerably. As of 1984-85, in the U.S. there were 98 different one-call systems operating in a total of 44 states (there were 99 systems if the UTILITY COORDINATING COMMITTEE, which has merged many of its functions with the UNDERGROUND FACILITIES PROTECTION ORGANIZATION,[34] which also operates in New York, is included). In addition, one-call, systems also operate in the Canadian province of Alberta, the Republic of China (Taiwan), and Scotland.[35]

Many one-call systems are local in nature. They, like the TO BEGIN system, which operates in Springfield, Missouri, may cover a single city or county in a state. Others, like the CALL BEFORE YOU DIG system of Connecticut, cover much or all of a state. A number of systems operate in more than one state. Some are fairly local in nature. Others provide extensive coverage. The DIG SAFE system, as an example of the latter, provides coverage for the states of Massachusetts, Rhode Island, New Hampshire, Vermont, and Maine.[36]

Considerable growth in one-call coverage has occurred in recent years in the U.S., as Figure 1 illustrates. Not only has the number of states with one-call systems been increasing, but, as can be seen in Figure 1,

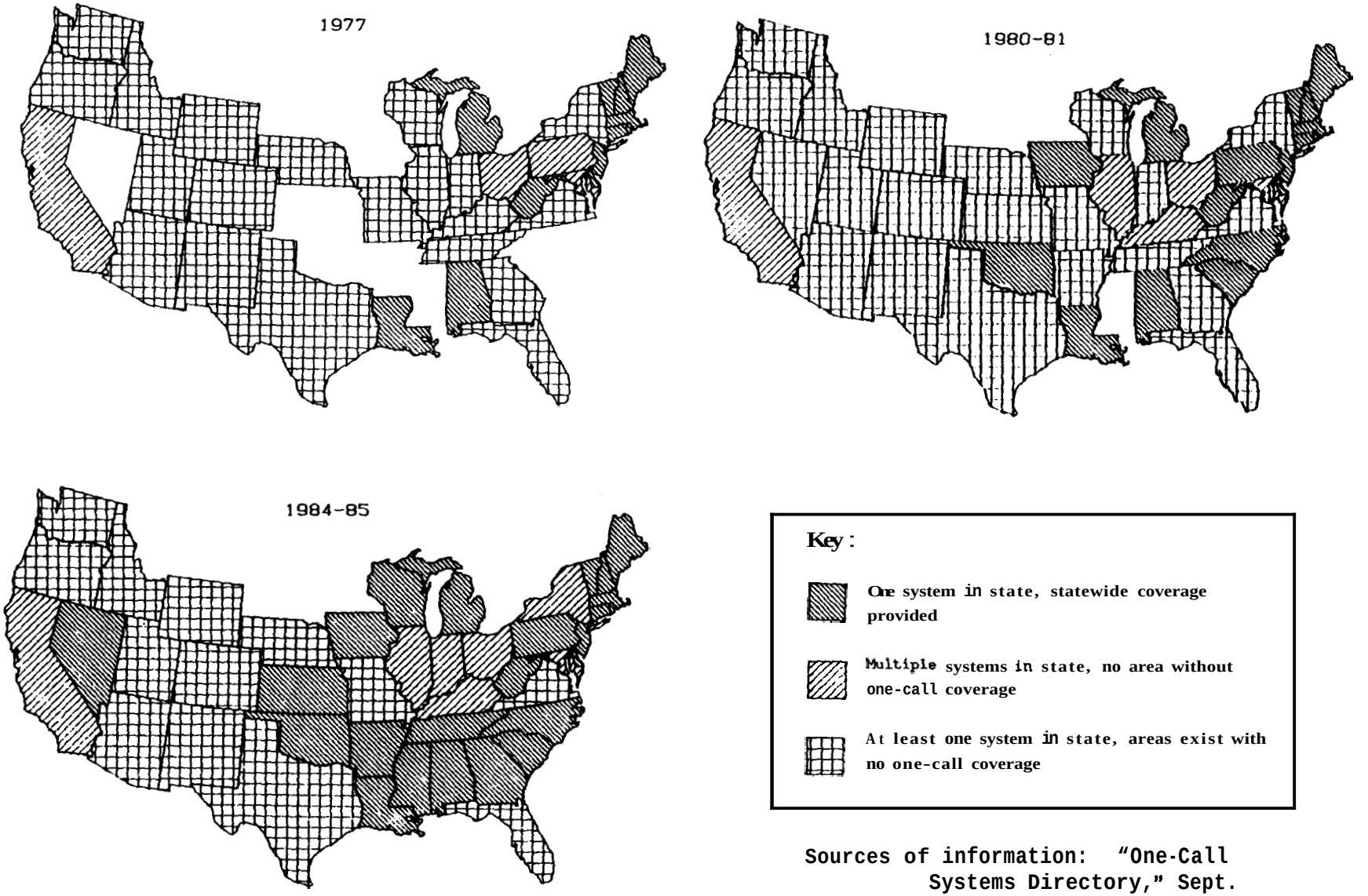
---

[33] Presentation by R. Taliento, Rochester Gas and Electric at Workshop 85, "Organization and Administration of Your One-Call System," at the 10th Annual One-Call Systems and Damage Prevention Symposium, April 1984; M. Hoyal, p. 2-3.

[34] Presentation by R. Taliento at the 10th Annual One-Call Symposium.

[35] One-Call Systems Directory, 1984-85." A copy of this can be found in Appendix C.

[36] See the "One-Call Directory, 1984-85."



Sources of information: "One-Call Systems Directory," Sept. 1977, 1980-81, and 1984-85; Contacts with various one-call systems.

FIGURE 1. U.S. STATES WITH ONE-CALL SYSTEMS

the coverage within the states has been expanding as well. In 1977, 12 states had statewide coverage provided by one one-call system, and another four had statewide coverage through multiple systems. By 1984-85, there were 23 states with statewide coverage by a single one-call system and seven states with statewide coverage through multiple systems.

U.S. one-call systems have a wide variety of participants. Included among them may be gas distribution, transmission, and gathering system operators; petroleum pipeline operators; sewer and water system operators; communications carriers (such as telephone and cable TV operators); and electric utilities. Excavators and contractors who operate in the one-call region may also be formally associated with the one-call system.[37] Participation rarely includes every potential member.[38] However, as many potential participants as possible should be brought into a system's membership in order to maximize its effectiveness.[39]

There is some indication that certain underground operators should be targeted for membership in one-call systems. Municipal water and sewer system operators are one example. Their pipe often lies below most other underground facilities and, as a consequence, accessing it can involve digging around and underneath the other facilities. Problems, of course, can result. Having these operators participating in one-call systems, it is felt, will increase the incidence of excavation notices by excavators intending to work on underground facilities connected with these systems and, as a result, decrease the likelihood that excavation damage will occur.[40]

A one-call system can be an in-house, member-owned-and-operated, or contractor operation. Member-owned-and-operated systems seem to be relatively new. Most systems appear to be either in-house or contractor

---

[37] Communications with selected one-call systems.

[38] Odegaard, p. 1; Courtney, Kalkbrenner, and Yie, p. 21.

[39] Courtney, Kalkbrenner, and Yie, p. 146.

[40] Courtney, Kalkbrenner, and Yie, pp. 88, 92-93.

operations.[41] In an in-house operation, one member of the system undertakes to provide the one-call service using its own personnel and facilities. The other members of the system help fund its operation, as well as work with the operating member in managing the system. The first U.S. one-Call system, the UTILITY COORDINATING COMMITTEE, began as an in-house system (with Rochester Gas and Electric as the operating utility) and remained so for many years. A problem with this type of system is that the operating utility is sometimes stuck with a disproportionate share of the system's operating costs.[42] In a contractor operation, the membership selects a management team, which, in turn, hires a contractor to handle the day-to-day operations of the system.[43] In some cases, the contractor hired is an answering service.[44] A member-owned-and-operated system differs from a contractor operated system in that, instead of hiring a contractor, the management team directly hires the people who will perform the day-to-day operations of the one-call system. In some circumstances, this can result in a cost savings.[45]

The basic one-call notification process is relatively straightforward. The process is initiated when a person calls the central office of a one-call system to report an impending excavation.[46] Problems can arise at this point if the caller cannot get through to the one-call center within a reasonable length of time, because, for example, of an insufficient number of telephone lines or operators. When this happens, the excavator

---

[41] "One-Call Systems Directory, 1984-85," pp. 7-17, 20-30.

[42] Presentation for H. Burke, DOTTIE, at Workshop #6, "Your One-Call Organization...," 9th Annual One-Call Symposium; Presentation by R. Taliento, Rochester Gas and Electric Company, at Workshop #5, "Organization and Administration of Your One-Call System," 10th Annual One-Call Symposium.

[43] J. Kelly, Jr., "DIG SAFE SYSTEM, INC. -- A Not For Profit Corporation," Paper Presented at Workshop #6, "Your One-Call Organization...," 9th Annual One-Call Symposium; J. Hill, "Oklahoma One-Call System, Inc.," Paper Presented at Workshop #6, 9th Annual One-Call Symposium; various industry sources.

[44] Communications with selected one-call systems.

[45] Presentation by M. Hoyal, USA-SOUTH, at Workshop #5, "Organization and Administration of Your One-Call System," 10th Annual One-Call Symposium.

[46] Odegaard, p. 1.

may decide to forego notification altogether, and, as a consequence, excavation damage may occur. Though it must undoubtedly occur upon occasion, just how frequently this situation occurs is not clear.

When a caller reaches a one-call system operator, the operator asks the caller for pertinent information about the proposed excavation. Included among the information requested from the caller will be the exact location of the excavation and how the excavator can be contacted. The caller will often be told during the call which underground operators will be contacted by the one-call system. It will be the responsibility of the excavator to identify and call any underground operators who may have facilities at the excavation site and who are not participants in the one-call system.[47]

After obtaining the information that it needs, a one-call system contacts its members about the impending excavation by telephone or teletype.[48] In many systems, the list of contacted members is limited to those who, in some way, can be identified as possibly operating in the area of the proposed excavation. This screening can, among other ways, be by political subdivision, by street, by subdivision and street, or by special map grid reference. The information used in the screening is obtained by a one-call system from its membership.[49]

Using the information obtained by the one-call system about the impending excavation, the contacted members determine, from their own records and knowledge of their systems, if their facilities are near the excavation site. If they are, the firms will send out locators to the site to mark and stake the location of their facilities.[50] Usually, this will occur within 48 hours of the notification about the dig. In a few

---

[47] Odegaard, p. 1-2; Hendrick, p. 22; Courtney, Kalkbrenner, and Yie, p. 149.

[48] Hendrick, p. 22; General discussion, 9th and 10th Annual One-Call Symposiums.

[49] Keesee, pp. 4-7; Rieben, p. 1; Chisholm, pp 2-6.

[50] Odegaard, p. 2.

areas, underground operators will have 72 hours to locate their facilities, and in a few others, they will only have 24 hours.[51] Emergencies are usually handled on a case-by-case basis. If the underground operators have no facilities at the excavation site, in some cases they will notify the excavator of this fact; in many cases they will not. Liability concerns and the extra labor that would be required and the extra costs that would be incurred if everyone giving notice of excavation were contacted are probably the most important reasons for not notifying excavators when no facilities are endangered by a proposed excavation.[52]

To help one-call systems function successfully, the American Public Works Association (APWA), which has been actively involved in the effort to reduce excavation damage for a number of years,[53] has established a set of "minimum standards" for one-call systems. These standards are

1. One telephone number should be provided for excavators to use to notify participating utilities within a predetermined area of planned excavation work.

2. The service should be provided during normal working hours, Monday through Friday.

3. Off-hours calls should reach a recording which explains emergency procedures.

4. All telephone calls should be mechanically voice-recorded.

5. The system should identify for the caller those utilities which will be notified for them.

6. The system should provide a permanent file number for each request.

---

[51] "One-Call Systems Directory, 1984-85," pp. 7-17, 20-30.

[52] Courtney, Kalkbrenner, and Yie, pp. 146, 149-150; Selected industry sources.

[53] Courtney, Kalkbrenner, and Yie, p. 18.

7. The system should provide, for a statutory period, a printed copy of all location requests which can easily be retrieved through use of the file number.

8. The system should provide a timely method of notifying the affected utilities. This method is to be determined by each individual system.

9. The system should provide periodic administrative reports as required by the participating utilities.

10. The system should document contractor education programs on an ongoing basis.[54]

These recommended minimum standards are fairly basic. Most one-call systems in operation today probably meet or exceed these standards. Many, if not most, systems, for example, have extensive contacts with area excavators, and engage in very extensive advertising campaigns to let contractors and the public know about their service, as well as the dangers of digging blind.[55]

While data on their performance are relatively sparse, what exists does indicate that one-call systems are successful in reducing excavation damage. A 1978 survey of one-call systems by the American Public Works Association found that 31 percent of the survey respondents had observed a 20 to 30 percent reduction in damages since beginning operation, 19 percent of the respondents had observed a 40 percent reduction in damages, 38 percent of the respondents had observed a 60 to 70 percent reduction in damages, and 12 percent of the respondents reported that they had no data on the extent to which damages had been reduced. It is interesting to note that more than half of the respondents to the APWA survey reported that 50 percent or more of the incidents that had been observed happened to excavators who had not bothered to report their intention to excavate to the one-call center.[56]

---

[54] APWA, "One-Call System Manual," p. 1. A copy of the "One-Call System Manual" can be found in Appendix B. This document, prepared as part of the APWA's ongoing effort to promote damage prevention, provides recommendations and pointers on organizing and operating a one-call system.

[55] Contacts with selected one-call systems.

[56] Odegaard, pp. 5-6.

Gas pipelines have evidently been some of the beneficiaries of the improvements that one-call participation have brought about. Gas pipeline operators who have participated in one-call systems have reported that the systems can help reduce damages by between 24 and 67 percent.[57]

3.3 LEGISLATIVE AND REGULATORY EFFORTS TO PROMOTE DAMAGE PREVENTION

Various states, as well as localities, have enacted laws and issued regulations relating to the prevention of excavation and related damage. In addition, Federal damage prevention regulations have been issued by the Occupational Safety and Health Administration and the U.S. DOT. The basic underlying purpose of these laws and regulations has been, of course, the promotion of excavation safety and damage prevention.

As of 1985, thirty-one states in the U.S., and the District of Columbia, had enacted damage prevention legislation (included in this total is North Carolina, whose law will not go into effect until sometime in 1986). In one additional state, Illinois, the Illinois Commerce Commission, a state regulatory authority, has issued regulations relating to damage prevention under the authority of its basic legislative mandate.[58] A similar situation currently exists in North Carolina.[59]

Selected aspects of the various state damage prevention laws and regulations can be found in Table 2. As can be seen in this table, there is some variation in the laws and regulations that the states (and the District of Columbia) have adopted. Some of the provisions listed in Table 2 are found in the damage prevention laws and regulations of most of the states. For example, more than 90 percent require excavators to notify utilities in advance of excavation. Similarly, over 80 percent of the states require excavators to determine the location of underground

---

[57] U.S. DOT, "Damage Prevention Program: Cost/Benefit Impact Analysis," p. 7.

[58] See Illinois Commerce Commission, General Order 185, Revised.

[59] Telephone conversation with staff at the North Carolina Utilities Commission.

TABLE 2. SELECTED ASPECTS OF STATE DAMAGE PREVENTION LAWS[a]

	Law Requires Excavator to			Law Requires Utility to				
	Determine Location of Underground Gas Plant	Notify Utility In Advance of Excavation	Notify Utility of Damage to Underground Plant	Encourage Excavator to Give Advance Notice to Utility	Respond To All Excavation Notices	Mark Location of Underground Plant Upon Request	Belong to One-Call System[b]	Year in Which Law Became Effective
California	Yes	Yes	Yes	No	No	Yes	Yes	1983-84
Colorado	Yes	Yes	Yes	No	No	Yes	No	1981
Connecticut	Yes	Yes	Yes	Yes	No	Yes	Yes	1977
Delaware	No	No	No	No	Yes	No	No	1979
D.C.	Yes	Yes	Yes	Yes	Yes	No	Yes	1980
Florida'	Yes	Yes	No	No	Yes	Yes	No	1977
Georgia'	Yes	Yes	No	Yes	Yes	Yes	No	1975
Illinois	No	No	No	No	No	No	Yes[e]	--
Louisiana[d]	No	Yes	No	No	No	No	No	c. 1977
Maine	Yes	Yes	No	No	No	Yes	No	c. 1971
Maryland	Yes	Yes	Yes	Yes	Yes	Yes	No	1974
Massachusetts	Yes	Yes	No	No	No	No	Yes	1980
Michigan	Yes	Yes	Yes	Yes	No	Yes	Yes	1975
Missouri	Yes	Yes	Yes	Yes	No	Yes	No	1976
Montana	Yes	Yes	Yes	Yes	Yes	Yes	No	1971
New Hampshire	No	Yes	Yes	No	No	Yes	Yes	1983
New Jersey'	Yes	Yes	Yes	Yes	No	Yes	No	1964
New Mexico	Yes	Yes	Yes	No	No	Yes	No	c. 1973
New York	Yes	Yes	Yes	No	No	Yes	No	1975
North Carolina	Yes	Yes	Yes	Yes	No	Yes	Yes[f]	1986
North Dakota	Yes	Yes	No	No	No	Yes	No	1973
Ohio	Yes	Yes	Yes	Yes	No	Yes	No	1982
Oklahoma	No	Yes	Yes	No	Yes	Yes	No	1982
Pennsylvania	Yes	Yes	Yes	Yes	Yes	Yes	No	1975

TABLE 2. **SELECTED ASPECTS OF STATE DAMAGE PREVENTION LAWS**[a] (CONTINUED)

	Law Requires Excavator to			Law Requires Utility to				
	Determine Location of Underground Gas Plant	Notify Utility In Advance of Excavation	Notify Utility of Damage to Underground Plant	Encourage Excavator to Give Advance Notice to Utility	Respond To All Excavation Notices	Mark Location of Underground Plant Upon Request	Belong to One-Call System[b]	Year in Which Law Became Effective
Rhode Island	Yes	No	Yes	Yes	No	No	No	c. 1984
South Carolina	Yes	Yes	Yes	Yes	No	Yes	No	1978
South Dakota	Yes	Yes	Yes	Yes	No	Yes	No	1977
Tennessee	Yes	Yes	Yes	Yes	No	Yes	No	c. 1978
Utah	Yes	Yes	Yes	Yes	No	Yes	Yes	1977
Virginia	No	Yes	Yes	No	Yes	Yes	No	1980
Washington	Yes	Yes	No	Yes	No	Yes	No	c. 1984
Wisconsin	Yes	Yes	Yes	No	No	Yes	No	c. 1977
Wyoming	Yes	Yes	Yes	Yes'	No	Yes	Yes	1978

Sources: National Association of Regulatory Utility Commissioners, **1982** ANNUAL REPORT ON UTILITY AND CARRIER REGULATION, Table **49,** p. **584; APWA/ULCC,** "One-Call Systems Directory, **1984-85,"** pp. **32-35;** the legal codes of various of the states; telephone conversations with staff at the public service commissions of Alabama, Kentucky, Montana, and North Carolina.

[a]The states of Alabama, Alaska, Arizona, Arkansas, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Mississippi, Nebraska, Nevada, Oregon, Texas, Vermont, and West Virginia have no damage prevention laws. The Illinois Commerce Commission does have regulations relating to damage prevention.

[b]**May** be required only if there is a one-call system covering the utility's area of operation.

[c]Applies only to gas pipelines.

[d]**Applies** only to work performed for "public entities."

[e]Required by the Illinois Commerce Commission for utilities under its jurisdiction beginning in **1976.**

[f]**Required** for gas pipelines by the North Carolina Utilities Commission beginning in **1981.**

gas facilities. Likewise, over 80 percent have laws that require utilities to mark the location of underground plant and equipment upon request. Around 72 percent require excavators to notify utilities of damage to underground plant. Other damage prevention provisions are found in the laws and regulations of fewer states. Only about 54 percent of the states require utilities to encourage excavators to give advance notice of excavation, while approximately 30 percent require utilities to belong to a one-call system and only 27 percent require that utilities respond to all excavation notices.

The penalties for noncompliance with damage prevention laws vary from state to state. In general, .they do not appear to be particularly onerous. In most states, the laws stipulate fines of $1000 or less per incident.[60] The extent to which the legal penalties for excavation damage are imposed is not clear, though it, like the penalties themselves, probably varies from state to state.

Enforcement of the state damage prevention laws has been somewhat spotty. The record of enforcement varies, as might be expected, from state to state.[61] Some laws, or at least provisions of the laws, are not enforced. For example, industry sources in Utah and Wyoming indicate that the provisions in the damage prevention laws of these states requiring utilities with underground plant to become members of the states' one-call systems (of which there are nine in Wyoming and one in Utah[62]) are not enforced, and, as a consequence, many utilities who should be part of a one-call system are not.

The first Federal regulations having to do with the prevention of excavation damage were issued by the Occupational Safety and Health Administration (OSHA). OSHA's regulations, which are presented in Table 3,

---

[60] "One-Call Systems Directory, 1984-85," pp. 32-35; the legal codes of various states.

[61] Courtney, Kalkbrenner, and Yie, p. 119.

[62] "One-Call Systems Directory, 1984-85," pp. 25, 28-30.

TABLE 3. OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION REGULATIONS RELATING TO DAMAGE PREVENTION

Excavation[a]
Prior to opening an excavation, effort shall be made to determine whether underground installations; i.e., sewer, telephone, water, fuel, electric lines, etc., will be encountered, and if so, where such underground installations are located. When the excavation approaches the estimated location of such an installation, the exact location shall be determined and when it is uncovered, proper supports shall be provided for the existing installation. Utility companies shall be contacted and advised of proposed work prior to the start of actual excavation.
Demolition[b]
All electric, gas, water, steam, sewer, and other service lines shall be shut off, capped, or otherwise controlled, outside the building line before demolition work is started. In each case, any utility company which is involved shall be notified in advance.
Blasting'
Blasting operations in the proximity of overhead power lines, communications lines, utility services, or other services and structures shall not be carried on until the operators and/or owners have been notified and measures for safe control have been taken.

[a]29 CFR 1926.651(a)

[b]29 CFR 1926.850(c)

[c]29 CFR 1926.900(o)

require that, prior to excavation, demolition, or blasting, the utilities that may be affected must be notified of the impending action. These regulations, it should be noted, apply only to employers over which OSHA has jurisdiction. Consequently, the regulations do not apply to all who might excavate. OSHA's damage prevention regulations have not, it appears, been particularly well enforced.[63] For this reason, among others, these regulations have probably had little direct impact on the incidence of excavation damage to underground facilities.

In April 1983, new Federal regulations concerned with damage prevention went into effect. These new regulations were issued by the U.S. DOT, which has been concerned for a number of years about the prevention of excavation damage. The regulations (see Table 4) establish minimum requirements for damage prevention programs that must be set up by gas distribution, and transmission and gathering system operators for their operations in Class 4 and some Class 3 locations.[64] As part of its damage prevention, the regulations require a pipeline operator to (1) maintain an up-to-date list of the excavators who generally operate in the area of the pipeline, (2) provide the public and the excavators who generally operate in the area of the pipeline with information about the operator's damage prevention program and the procedure for notifying the operator of impending excavation, (3) receive and record excavation notices, (4) provide those notifying the operator of proposed excavation with information on whether the company has any underground facilities in the area and how the company will mark them if there are, (5) provide temporary marking of any underground facilities operated by the pipeline company at an excavation site, and (6) inspect any pipe at an excavation site that could be damaged by excavation. Pipeline operators are explicitly permitted by the regulations to use the services of a one-call system to meet any of the requirements of the regulations. Examining the list of requirements, it is obvious that many could and, in fact, would be taken care of by the one-call systems operating in the U.S. today. Of course, pipeline operators choosing to participate in

---

[63] Courtney, Kalkbrenner, and Yie, pp. 119, 196.

[64] For definitions of Class 3 and 4 locations, see 49 CFR 192.5(d), (e), (f)(1), and f(2).

TABLE 4. **U.S. DOT DAMAGE PREVENTION PROGRAM REGULATIONS**

Damage Prevention Program -- 49 CFR 192.614

(a) Except for pipelines listed in paragraph (c) of this section, each operator of a buried pipeline shall carry out in accordance with this section a written program to prevent damage to that pipeline by excavation activities. For the purpose of this section, "excavation activities" include excavation, blasting, boring, tunneling, backfilling, the removal of above ground structures by either explosive or mechanical means, and other earth moving operations. An operator may perform any of the duties required by paragraph (b) of this section through participation in a public service program, such as a "one-call" system, but such participation does not relieve the operator of responsibility for compliance with this section.

(b) The damage prevention program required by paragraph (a) of this section must, at a minimum:

(1) Include the identity, on a current basis, of persons who normally engage in excavation activities in the area in which the pipeline is located.

(2) Provide for notification of the public in the vicinity of the pipeline and actual notification of the persons identified in paragraph (b)(1) of the following as often a needed to make them aware of the damage prevention program:

(i) The program's existence and purpose; and

(ii) How to learn the location of underground pipelines before excavation activities are begun.

(3) Provide a means of receiving and recording notification of planned excavation activities.

(4) Provide for actual notification of persons who give notice of their intent to excavate of whether there are buried pipelines in the area of excavation activity and, if so, the type of temporary marking to be provided and how to identify the markings.

(5) Provide for temporary marking of buried pipelines in the area of excavation activity before, as far as practical, the activity begins.

(6) Provide as follows for inspection of pipelines that an operator has reason to believe could be damaged by excavation activities:

(i) The inspection must be done as frequently as necessary during and after the activities to verify the integrity of the pipeline; and

(ii) In the case of blasting, any inspection must include leakage surveys.

(c) A damage prevention program under this section is not required for the following pipelines:

(1) Pipelines in a Class 1 or 2 location.

(2) Pipelines in a Class 3 location defined by Section 192.5 (d)(2) that are marked in accordance with Section 192.707.

(3) Pipelines to which access is physically controlled by the operator.

(4) Pipelines that are part of a petroleum gas system subject to Section 192.11 or part of a distribution system operated by a person in connection with that person's leasing of real property or by a condominium or cooperative association.

a one-call system must still take care of any requirements not met by participation in the one-call system. Gas system operators, it should be noted, are not required to use the services of a one-call system.[65]

[65] For more on these regulations, see Appendix A.