DOT/MTB/OPSO-77/12

EFFECTIVENESS OF PROGRAMS FOR PREVENTION OF DAMAGE TO PIPELINES BY OUTSIDE FORCES

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16. Abstract

This investigation was conducted to determine the status of programs for prevention of damage to underground facilities of utilities, pipelines and other underground line systems. The study was centered on outside force/outside party damage during excavation near the underground facilities. Data concerning underground damage were analyzed; these data were obtained from OPSO, utilities, other line operators, one-call systems, and State agencies. The data analysis shows that there are wide variations in the effectiveness of damage prevention programs across the country. Many laws or regulations reviewed encourage the formation of one-call systems. In some one-call systems all of the utilities, private and municipal, are members, in others only private utilities are members. All organizations responsible for underground facilities need to work together on mutual damage prevention efforts to be effective. The one-call systems are a logical outgrowth of individual utility efforts to reduce outside party damage. When many utilities join together and advertise a single phone number to receive excavator calls, a one-call system exists. A number of conclusions and recommendations for improvement of underground damage prevention programs are presented.

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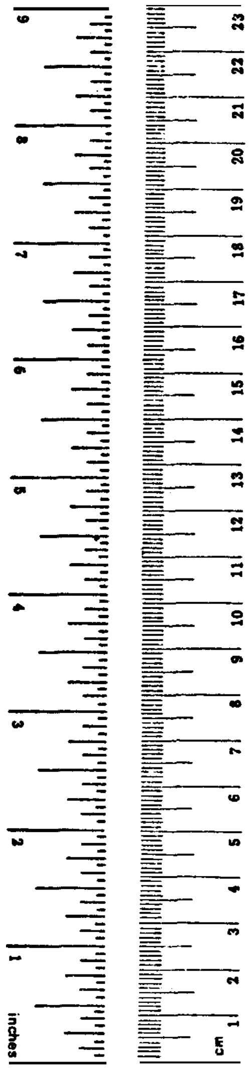
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

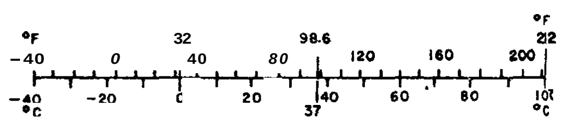
Symbol	When You Know	Multiply by	To Fill	Symbol
		LENGTH		
in	inches	25	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	09	meters	m
mi	miles	16	kilometers	km
		AREA		
in'	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi'	square miles	26	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	5	milliliters	ml
Tbsp	tablespoons	15	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 321	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
an	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in'
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)	2.5		
		MASS (weight)		
g	grams	0.035	ounces	ox
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	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



EXECUTIVE SUMMARY

The major purpose of this investigation was to determine the efficacy of programs for the prevention of damage to underground facilities of public and private utilities and other underground line operators.

Program Objectives

Five specific program objectives were: to determine the effectiveness of laws and regulations, to review existing damage reduction programs, to analyze underground outside force damage data of both governmental and private origin, to assess research and development efforts, and to develop recommendations for actions to reduce outside party damage by excavators.

Analysis of Underground Damage Data

The major portion of the data was supplied by Office of Pipeline Safety Operations **(OPSO)** of the Department of Transportation and both the reportable leaks and repaired leaks data were analyzed by the Institute of Gas Technology. **OPSO** supplied leak and accident data for both gas and liquid pipelines. Other data were obtained from: the State regulatory agencies (e.g., Illinois Commerce Commission), the Bell System, a number of gas utilities, one-call system centers and a lesser amount of data concerning electric utility data. The OPSO annually compiled gas data covered the 6-year period (1970-1975). Over the 6-year period there was an initial increase in damage then a decrease that correlates to some extent with the annual construction activity patterns.

Significant differences were shown to exist among various States for the outside force damage rate. The development of more effective damage prevention programs should have a significant effect in those States where there is a congruence of construction activity and extensive underground distribution and transmission systems. The data describing the costs of damage to underground lines is neither easily available, nor is the confidence limit on the cost per damage incident high.

Effects of Laws and Regulations

The effects of State and local regulations are quite different from area to area. This is true for localities even within a particular State. In some older cities, e.g., Chicago, Newark, a combination of local government action and voluntary efforts on the part of utilities result in quite low outside party damage rates.

Coordinated Damage Prevention Programs

The voluntary damage prevention programs range from a single utility working to reduce damage to its own underground facilities to the establishment of the well organized one-call system where many owners of underground facilities join together to reduce outside party damage. The Underground Facilities Protective Organization (UFPO) has been successful enough in Onandaga County New York since 1968 that 23 more New York counties will join during 1977.

Research and Development

The main research areas that need to be advanced for damage reduction are: further development of underground pipeline location equipment; depth of pipeline location equipment must be made more accurate and discriminating; marking systems need improvement; further development of computer assisted mapping; and refine excavation control equipment which can sense the proximity of an underground line and quickly stop the excavation equipment.

Federal/State Agencies Role

In this pluralistic society there are many organizations with some activity in damage prevention programs. The two most important agencies on the Federal level are the OPSO and National Transportation Safety Board (NTSB); in each of the States there is a utility regulatory agency such as the Commerce Commission involved in pipeline safety; and there are voluntary and mandated one-call systems.

Utility/Contractor Cooperation Essential

An important conclusion of the study is that all of the underground facilities must cooperate to have a really effective damage reduction program. The private utilities alone cannot do the job. The one-call system is an important part of an effective damage prevention program.

Recommendations

Recommendations developed which are particularly pertinent include; outside force damage and construction rates correlate so construction managers should stress damage prevention in early planning to eliminate future damage incidents; it is important to monitor interutility cooperation; continuing education programs are essential to keep contractors aware of the need to call be-fare digging; further,,the educational techniques should be improved; the use of a one-call system covering all underground facilities could lead to the development of more advanced locating crews and these should be evaluated as a possible cost-saving development; and it is recommended that penalties should be used to curb the willfully negligent excavator or underground line operator.

PREFACE

This is the final report on IIT Research Institute (IITRI) project J6392, "Effectiveness of Programs for Prevention of Damage to Pipelines by Outside Forces". The work was accomplished under Contract DOT-OS-60521 by LITRI for the Office of Pipeline Safety Operations (OPSO). This evaluation of damage reduction programs covered the period from September 1976 to April 1977.

The Institute of Gas Technology was the major subcontractor. Mr. John Shelton supplied consultation on one-call systems. Melvin Judah was the DOT Contracting Officer's Technical Representative for this project.

Respectfully submitted,
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Assistance was obtained from a wide variety of sources. The private and public utilities supplied data and discussions. The state regulatory agencies and various private associations were also helpful. Thank you to all who contributed.

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1. INTRODUCTION

There are two aspects of damage to underground pipelines and other underground facilities. One view is essentially an economic conception of efficiency, availability of the service or transported material, and the various costs associated with damage. The second view of damaged underground facilities can be much more grim. Figure 1.1 dramatically presents this other face (Ref. 1). Figure 1.2 depicts the outside party damage that caused the accident (Ref. 1). Note that there were nine fatalities and *14* other injuries. An important part of this report will deal with the economic and operating service aspects associated with damage prevention programs but the public safety, sudden death and injury elements of damage incidents cannot be ignored.

Since 1974, the Office of Pipeline Safety Operations (OPSO) of the Department of Transportation (DOT) has conducted a series of studies on the safety of gas distribution systems in the United States. This report presents the findings of a project with IIT Research Institute (IITRI) and the Institute of Gas Technology (IGT) contracted in September 1976 by OPSO to study and evaluate the effectiveness of programs for the prevention of damage to pipelines by outside parties. The specific objectives of this project are to:

- analyze features of and determine the effectiveness of the various state laws and local ordinances that have been enacted to prevent the damage to pipelines and underground utilities, and relate to OPSO proposed model statutes;
- review other pipeline and utility damage control programs instituted by state and local governments, industry, councils of utilities and contractors, and others for solving the problem;
- analyze OPSO leak, failure and accident data and other existing damage records of gas and liquid pipelines and other underground utility systems to determine the problem status;

Figure 1.1 Fire at Accident Site (Los Angeles Gasoline Fire Due to Outside Party Damage)

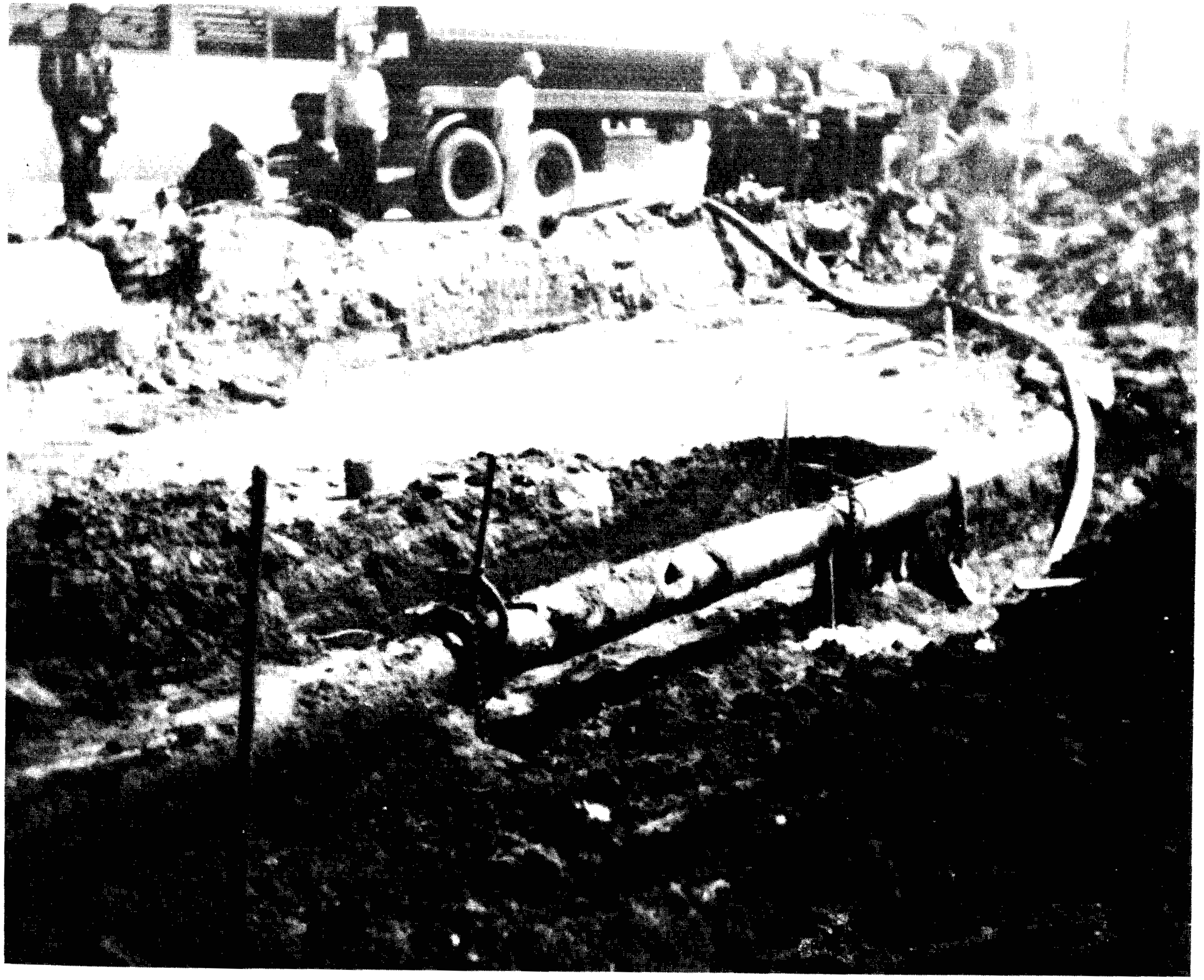

Figure 1.2 Punctured 8-inch Products Pipeline

- assess the research and development efforts that have been carried out or are being proposed on the technology, equipment, and instrumentation related to solving the pipeline damage problems, and review marking regulations and practices;
- recommend actions for reducing the occurrence of pipeline damage by outside parties.

To accomplish these objectives, the following pertinent subjects were analyzed in this program:

- status of outside force damage to pipeline and other underground utility systems;
- pertinent background factors of pipeline damage;
- interactions of underground utility systems;
- communications among parties involved in damage to underground utility systems;
- approaches to improve interutility communication;
- pipeline locating and marking techniques, procedures, and equipment;
- approaches to improve the safety of excavation techniques and equipment;
- approaches to reduce human carelessness in earth-moving endeavors.

This report presents the findings from each of these tasks.

1.1 Damage to Underground Utilities

This section is a review of the present array of underground facilities and a discussion of damage statistics. As this section develops, a number of terms will be introduced that have specific definitions. The terms and their definitions include:

- reportable leak - a leak in a natural gas line that must be reported to OPSO by telephone and on DOT form 7100.1 (distribution systems with 100,000 or more customers); DOT form 7100.2 (leaks in natural gas transmission and gathering systems); DOT form 7000.1 (accidents on liquid pipeline systems);
- repaired leaks - are all leaks that occur on the distribution, transmission and gathering lines which are summarized and reported annually;

- outside force damages - leaks which are caused by outside forces acting on a pipeline. Causes may be natural ones such as frost heaving induced pipe loading; floods washing out pipeline supports; landslides; or damage to a pipeline by excavation machines, the most common of which is the backhoe;
- outside party damages - are a subset of outside force damages; the damages caused by excavators or posthole diggers are outside party damages. (Third party damage is a term that often is incorrectly used as a synonym for outside party damage; third party damage implies a nonutility related cause of the damage);
- incident - another term for a leak resulting from corrosion, outside force damage, material failure; "incident" generally used in gas line reports is interchangeable with "accident" generally used for liquid pipeline reports.

1.1.1 Extent of Underground Facilities – Density of underground facilities range from a cheek to jowl proximity in city subterranean crossings to the isolated right-of-way of a transcontinental pipeline. Table 1.1 presents the extent of the various utility underground lines. The depth of burial is from a few inches to approximately 12 feet. In some cases there are regulations that specify the minimum burial distance while in other cases the frostline is the determining factor.

The national economy, or possibly some more specific influence, controls the amount of construction activity underground. The pipelines must be replaced or installation of new lines is required. Old abandoned systems must, in some cases, be removed. New buildings, either residential or commercial, are erected; new highways are built; old roadways are rebuilt; fences are installed. All of these activities may cause an impact on an existing underground facility. Construction materials cover the gamut from fire clay pipes for sewage to cast iron and steel for liquids and gas; copper and plastic for gas; and metal and plastic sheathed wire conductors for telephone, television cable, and electric utility lines.

TABLE 1.1 ACTIVE UNDERGROUND UTILITY SYSTEMS IN THE UNITED STATES

Type of Utility System	Miles of Systems in Service
1. Gas Pipelines[1]	
Gas Transmission and Gathering Systems	267,000
Gas Distribution Mains	766,500
Gas Distribution Services[2]	368,000
2. Petroleum Pipelines[3]	
Crude Trunk Lines	76,300
Product Trunk Lines	76,900
Gathering Lines	69,300
3. Electrical Cables	
Underground and Submarine Transmission[4]	2,740
Distribution Cables	Not Applicable
4. Water Distribution Systems	
Distribution Mains[5]	220,000
Distribution Services	Not Applicable
5. Telephone Cables[6]	
Duct	503,000
Trench	74,300
6. Sewer Pipe[7]	500,000

1. OPSO Annual Reports for Calender Year 1975
2. Estimated from OPSO data by assuming the average length of a service to be 50 feet in length.
3. Crude-Oil and Refined-Products Pipeline Mileage in the United States, Bureau of Mines, January 1, 1974.
4. U.S. Federal Power Commission News Release, February 26, 1976 (69KV or higher).
5. Operating Data of Water Utilities, American Water Works Assocation, 1970,
6. AT&T Data only.
7. Estimated by U.S. Department of Commerce.

Since all of these pipelines must coexist underground, each of them may be jeopardized when any of the others is being exposed, particularly when excavation machines are used. The larger the ditch, the bigger the machine and hence the greater jeopardy to parallel or crossing pipelines. These pipelines and utility systems include:

- Gas transmission and gathering systems
- Gas distribution mains and services

- Crude oil and petroleum product pipelines (gathering and trunk lines)
- Chemical pipelines
- Electrical transmission and distribution cables
- Telephone trunk and service cables
- Water distribution mains and services
- Other communication cables
- Sewers and drain pipes
- Other pipes and conduits

The location of utility systems in reference to street curbs and the burial depth of these systems can vary from city to city or within a city. The separate ownership of underground utility systems in a given city complicates the communications and coordination of construction and maintenance activities among the system operators, private contractors, and municipal departments. This situation can be reflected by the fact that the electrical power cables for illuminating streets in a city can be the property of a local power company or several municipal departments.

1.1.2 Damage to Pipelines — Pipelines are installed underground partially for the protection offered by the surrounding soil. Unfortunately some types of soil have characteristics that are hostile to metallic components of the utility systems and cause them to corrode. In addition, the soil surrounding the underground utility systems is not always without disturbance from internal or external forces. A disturbance can result in the imposition of a damaging force, or loss of support and protection, to the utility system and cause failure in a system component. The results of damaging soil disturbance on utility systems are commonly referred to as "damage by outside forces". Examples of "natural" outside forces damage are earthquakes, lightning, and flood washout or other loss of soil support plus frost heaves.

Excavation is the most important controllable cause of outside force damages. If a pipeline is damaged by an excavator who is not directly employed by the utility or a contractor hired by the utility, the damage is defined as outside party damage. Utility spokesmen are inclined to separate damages caused by their own personnel from damages caused by contractors that they hire.

Any type of earth removal can pose a threat to an underground pipeline. A plastic pipe can be cut by a shovel. Large mechanical equipment such as a backhoe can damage a *42* inch diameter pipeline. The maintenance of existing underground pipeline systems requires the use of mechanical excavation equipment. Usually the installation of a new or replacement pipeline requires the use of excavation equipment. The use of excavation machinery poses a threat to the system; and, the degree of threat is probably proportional to the size and depth of the trench and to the frequency of excavation activities. The safety of the various underground facilities cannot be isolated; one system's earthmoving activities can endanger the safety of another underground utility system.

Also there are earthmoving activities not related to the operation of underground utility systems. These activities are carried out by people who generally do not have knowledge of the precise location of existing underground systems, and therefore pose a greater threat to the safety of existing systems. Resulting damages to underground pipelines and utility systems by these activities are referred to as outside party damages in this study. This term, however, is not clearly defined as to whether it includes the contractors hired by utility system operators. In addition, one utility system operator can pose a threat to the safety of other utility systems if there is inadequate coordination and communication among system operators.

Another serious problem is the danger to which the pipeline or utility line is exposed once the protection of the soil is removed. The longer the pipeline is in an open ditch the greater the likelihood that it may be damaged.

Common equipment used for excavating soil in this country includes power tools capable of generating forces sufficiently high to damage metallic pipelines. These include backhoes, graders, trenchers, borers, and augers that are powered by engines, compressed fluid, or electricity. They generally do not provide the operators with "delicate feel" regarding the level of force being applied. Operation of this equipment depends primarily on the operator's visual observation which is hampered insofar as the safety of underground utility systems is concerned, by the cover of soil. As a result, earthmoving power equipment has been the major cause of damage to underground utility systems. Underground pipelines have been severed, fractured, bent, or gouged by power equipment. The seriousness of this problem has been recognized and efforts have been directed toward the reduction of this type of damage. The purpose of this program is to evaluate the effectiveness of existing damage prevention efforts and to determine what additional efforts are necessary.

1.1.3 Underground Pipeline Damage Statistics - There is a wide range of damage statistics on underground facilities. American Telephone and Telegraph Company (AT&T) compiled quite extensive and accurate statistics. They are almost unique in this respect. Other utilities do not collect as much data and often do not use the data very effectively. Some utilities require that their personnel report on each accident (or hit). These reported data are, in some cases, not collated, and are left as raw data in the accident report file. The data are available but to be useful, must be retrieved.

Another facet of the data problem is that of many utilities sharing a common underground zone. The utilities cause the most damage because they must repeatedly excavate for maintenance, service installation, and repair of malfunctions. Some utilities have a policy of repairing without billing. This practice is economically worthwhile when each of the utilities causes approximately the same amount of damage. They save themselves the billing expense; however, data collection is less complete.

1.2 Reportable Leaks

Because of the hazardous nature of escaping natural gas, the seriousness of gas pipeline failures depends on whether uncontrolled gas is released into the surroundings and whether the released gas poses a threat to the public. According to Part 191, Title 49, Code of Federal Regulations, the operators of the United States gas distribution systems and transmission and field gathering pipeline systems are required to report to OPSO the occurrence of any serious leaks in the pipeline systems. Under this law, a leak is considered serious enough to require reporting to OPSO if one or more of these conditions apply:

- Caused a death or a personal injury that required hospitalization
- Required taking any segment of gas pipeline out of service
- Resulted in the gas igniting
- Caused estimated damage to the property of the operator, the property of others, or both, estimated to be $5000 or more
- Was significant enough, in the judgement of the operator, to require reporting even though it did not meet the prior conditions
- Because of its location, it required immediate repair and other emergency action to protect the public, such as evacuation of a building, blocking off of an area, or rerouting of traffic.

Each operator of a gas transmission or gathering system and each operator of a gas distribution system serving more than 100,000 customers is required to report all such serious leaks by filing the appropriate forms with OPSO. These serious leaks in gas pipeline systems are customarily called "reportable leaks" and the information pertaining to these leaks is entered into a computer data bank by OPSO.

According to the definition of a reportable leak, damage to a gas pipeline can become reportable only if the gas contained in the pipeline is released into the surroundings because of failure of the pipeline or its components, and the uncontrolled release of gas is severe enough to result in certain affects and actions which impact on safety to employees and the public. A rupture in a transmission pipeline may not become a reportable leak if it occurred in an unpopulated area and it did not result in ignition of the released gas, while a small corrosion pit on a gas distribution system could become a reportable leak if the gas released by the pit caused serious consequences. For the same reason, severe damage to pipe, such as bending of the pipe, is not reportable as long as the pipe or component did not leak.

Whether a pipeline leak is serious enough to be reportable often is determined largely by the location of the pipeline and the pipeline components that are likely to fail, and, to a lesser extent, by the material of construction of the pipeline components. Some reportable leak incidents involved fatalities, injuries and substantial loss of property and have been investigated thoroughly by the staff of the National Transportation Safety Board (NTSB). Findings of such investigations have been presented in special NTSB case reports.

Title 49, Part 195 requires that operators of systems (pipelines) used to transport hazardous liquids must report on ".... failure in a pipeline system subject to this part in which there is a release of the commodity transported ....". DOT Form 7000-1 must be filed within 15 days after discovery of the accident. If 50 barrels of liquid leaks out because of one accident, a leak report must be filed.

Besides the reportable leaks, there are numerous other leaks occurring on natural gas and liquid pipeline systems that require attention and remedial actions on the part of pipeline operators even though they do not qualify to be reportable. A significant reduction in the number of these less serious leaks or damages will result in substantial savings in the pipeline operating costs. This program is concerned with both the reportable and nonreportable cases of pipeline damage.

1.2.1 Utility Damage Statistics – The outside party damage (or variously dig-ups, dig-ins, hits) in a one-call group of utilities is shown in Figure **1.3.** This particular set of data is interesting because the third party damage is compared for two cases. The curves linking the squares and triangles depict data where a dig-up occurred in spite of a location request (LR) through the one-call system, and data for dig-ups where no LR was made. Before an excavator is ready to dig he notifies the utilities by calling the Underground Facilities Protection Organization (UFPO) one-call system. The **UFPO** then transmits the excavator notification to the utilities as a LR or utilfty pipeline or cable marking request. Note that for several years there were approximately as many hits, or dig-ups whether a LR had been made or not. Note the hump in the two curves during the period 1972 to 1974.

Figure 1.4 presents damage data for the AT&T system. Again note the maxima in the total system and nonpressurized system data. Pressurized means that the telephone lines inside of the sheath are also enclosed in a tube which is pressurized with nitrogen or dry compressed air. Possibly the low damage rate per 100 sheath miles is due to the expense and careful maintenance for such systems.

In Figure 1.5 the general shape of the curve is quite similar to the third party damage curves that are shown in Figures 1.3 and *1.4.* **It** should be expected that construction activity, particularly housing and utility construction, would have a significant effect on outside party damage, i.e., the greater the excavation activity the greater the chance of dig-up.

1.3 Damage Control Programs

Prior to emphasis on pipeline damage prevention by many industrial and government bodies the damage to pipelines by outside forces or parties had been accepted by the pipeline operators and the public as the risk that had to be taken. In most parts

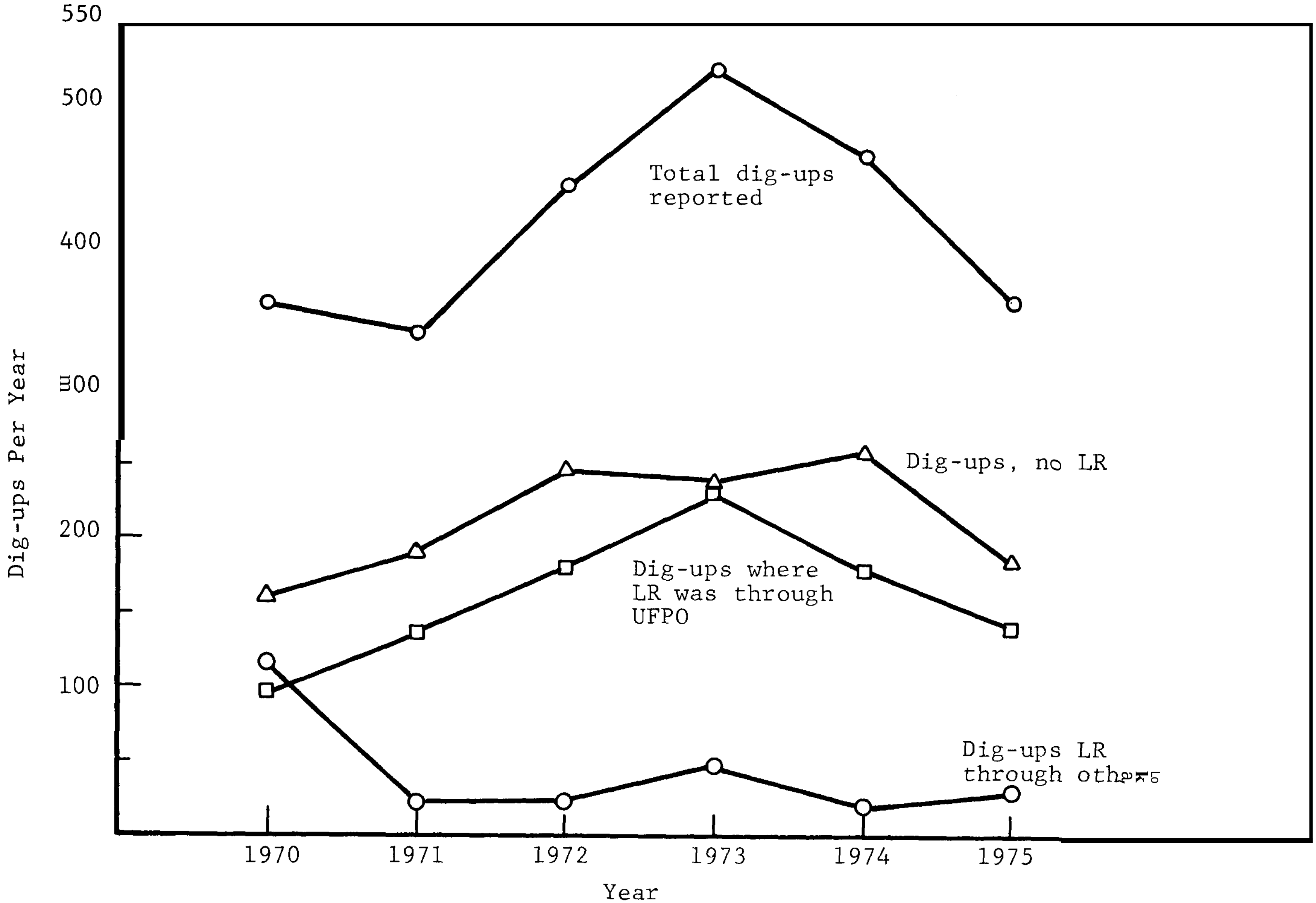

Figure 1.3 Outside Party Damage; Dig-ups per Year Related to Location Requests

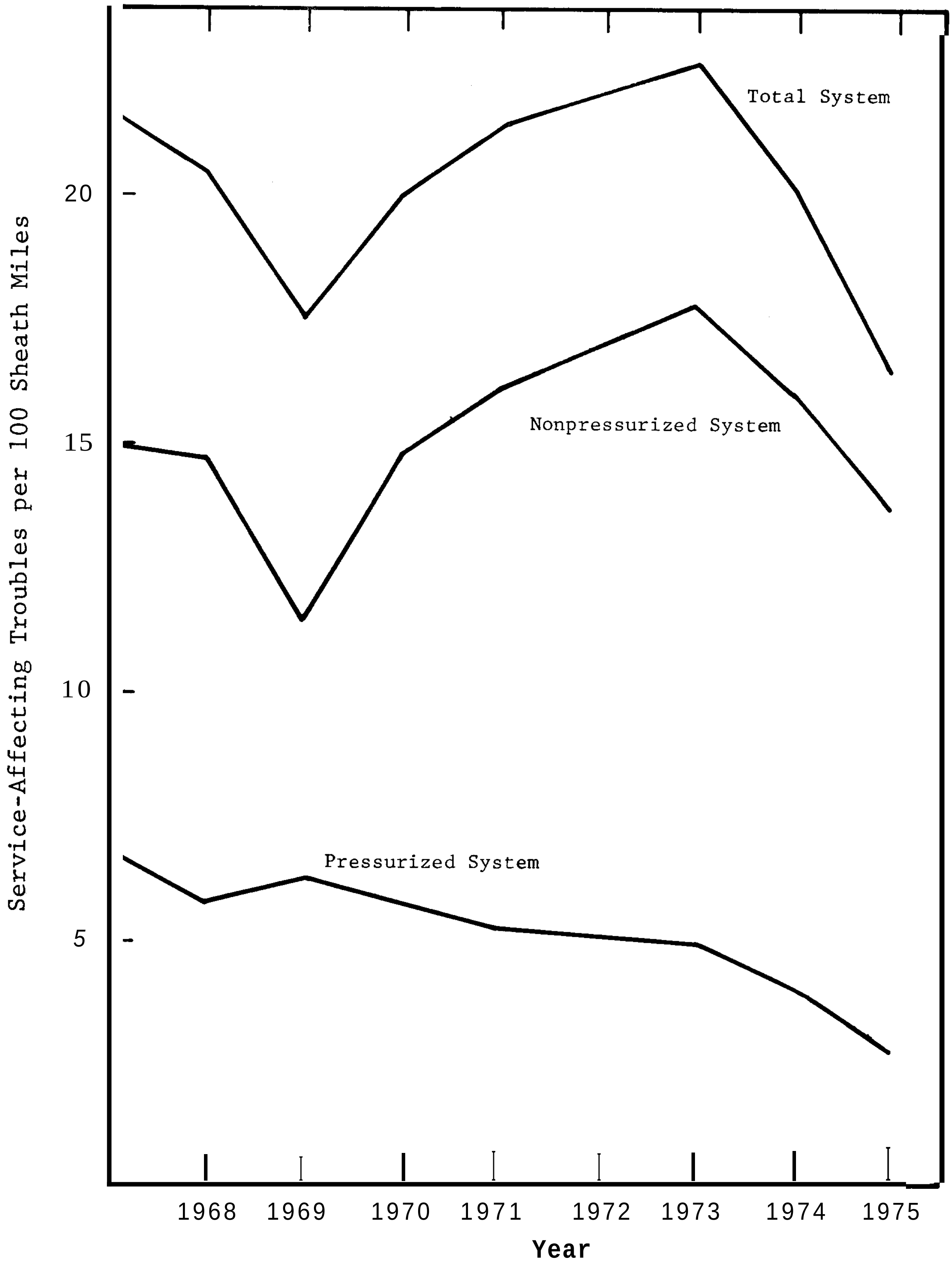

Figure 1.4 Damage Incidents to AT&T Underground Facilities

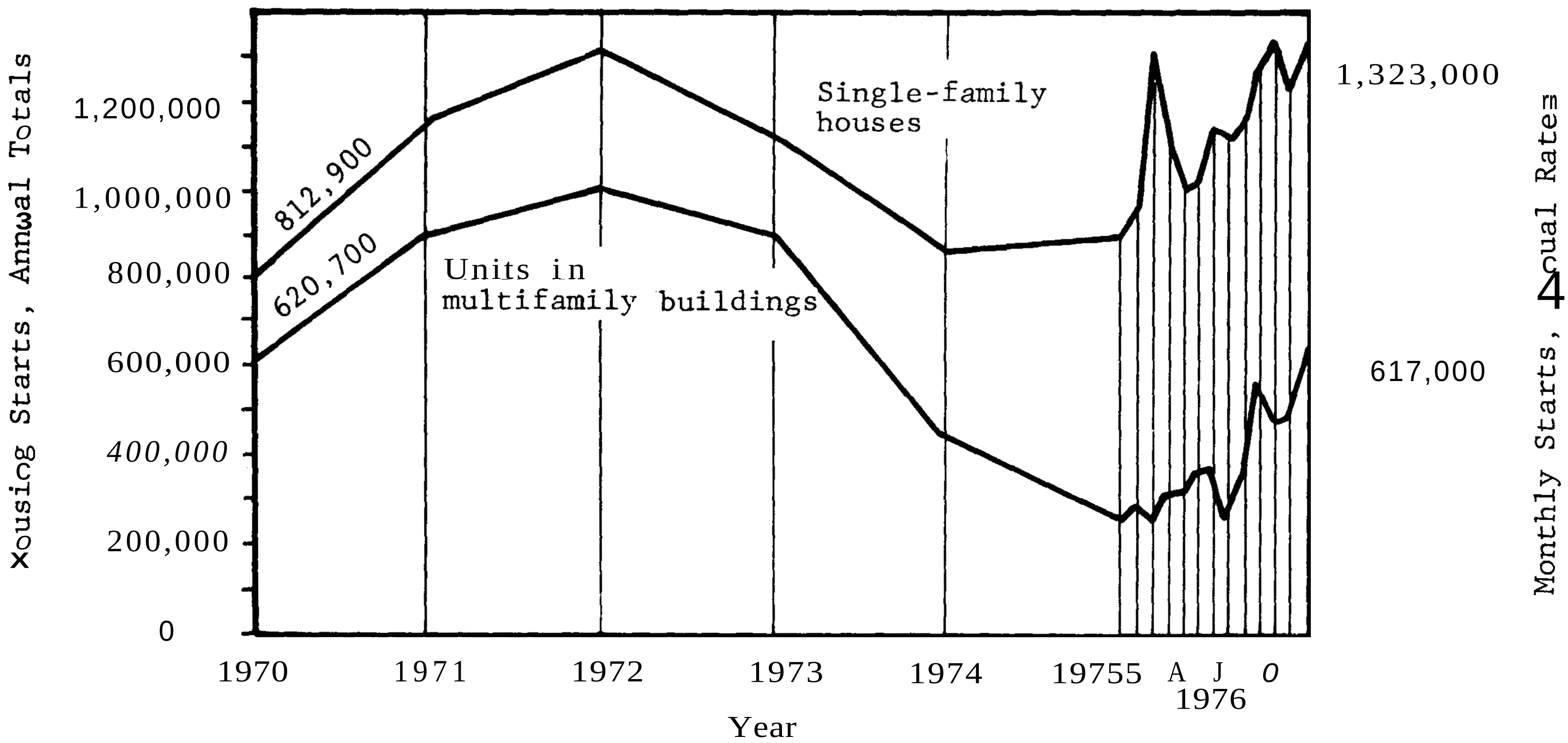

Figure 1.5 Residential Building Starts

Source: U.S. Department of Commerce,
Construction Review

of this country, formal programs for the prevention of pipeline damage were nonexistent. The informal liaison among officials of underground utility system operators was the extent of damage prevention programs. Many pipeline operators did not even bother to keep a record on the damages that occurred. The sophistication of this liaison varies unevenly among utility system operators and varies from city to city or county to county.

As urged by OPSO and NTSB (Ref. 2) and the increased awareness of public safety on the part of utility system operators in recent years, various actions have been taken to combat the damage problem. The rising cost of damage repair could also have been an important factor. As a result, more company programs have been established to treat the damage problem as one of the major areas of utility system operation; damage recordkeeping techniques and procedures have been improved. The importance of communications and coordination among utility system operators received greater attention, and as a result, voluntary associations have been set up to facilitate the communications. Furthermore, the necessity of communication between outside contractors and utility system operators has also been recognized and concrete programs have been established in many areas to promote this communication. An example of this effort is the so-called one-call program in which a single telephone call from an outside contractor will inform a number of utility system operators of the impending contractor action so that precautions, such as establishing the precise location of underground utility systems, could be taken in advance.

It has also been recognized that some pressure from the state or local governments may be helpful to make these programs work more effectively. Consequently, laws or regulations have been enacted or are being proposed, in various jurisdictions to make it unlawful for anyone to dig or excavate without notifying utility system operators in advance. Failure to do so may result in fines or other forms of penalty.

1.3.1 Informal Liaison — Probably the weakest response occurs when conscientious individuals informally look for a way to reduce outside party damage without using an organized approach. It has been used (to the author's knowledge) in Oklahoma, Nebraska, and California. A midlevel manager in one utility can arrange with his counterparts in other utilities, or with the permit desk of the local governmental agency, to notify or to be notified when significant excavation is going to occur. The manager can then apprise the excavator of underground pipeline locations. This type of liaison is better than none, but only slightly better.

1.3.2 Single Company Programs — A company policy of working to reduce underground facilities damage alone can be somewhat effective. The appropriate manager, usually of distribution, can develop contacts with the other utilities and major independent excavators so that he can be informed before excavation. Thus a means of being prepared, particularly for major excavations, can be developed. Having the prior knowledge of excavation, a utility has the option of informing the excavator of the utility underground location.

The claims manager can use damage claims as a disciplinary weapon with private contractors. He can, and in some cases does, develop a rapport with the insurance agencies who cover the excavators. Hypthetically at least, the insurance premiums can be used to discipline the excavators. The utility can exercise its option to join the excavator's trade associations. The company can become acquainted with the excavators and meet with them at business dinners. Also the company can continue an active public relations program with excavators.

In California, Illinois, and other states, governmental agencies notify utilities months in advance of their construction plans. This action permits utilities to monitor where construction might threaten their underground facilities. In some cases redesign can minimize dig-in troubles. This action is not unique to California. The state highway agencies are actively studying ways to enhance this type of contact (Ref. 3).

1.3.3 Voluntary Associations — There are a number of associations which are active in underground damage prevention programs. Each of the different types of utilities usually has its own trade association such as American Gas Association (AGA) for the natural gas utilities, Interstate Natural Gas Association of America (INGAA) for the natural gas pipeline systems, and American Petroleum Institute (API) for the liquid petroleum companies while American Public Works Association (APWA) provides an umbrella organization for pipelines, municipalities and utilities who work or interact with the various public works such as sewer, water supply, and roadway installations. Most of the associations reflect their members' desires and coordinate their activities.

The telephone company and the gas company are somewhat unique insofar as underground damage is concerned. Usually any outside party hit causes service interruption to more than one telephone or gas customer. Immediate and continuing pressure is exerted on the telephone or gas company to restore service. Any outside party hit on a gas line that causes a gas leak becomes a clear and present danger. If the odorant is detected the gas company is quickly notified. If the odorant is not detected a serious accident can result. Necessarily, the telephone utilities and the gas utilities are faced with immediate and continuing pressure from the general public. Both of these utilities have been in the forefront of those concerned with damage to underground facilities.

Prior to the 1970's there was little in the way of formal voluntary associations. The UFPO became operative in central New York State during 1965. Other one-call systems followed and attention was focused by the 1972 NTSB symposium and report and the OPSO model statute. The various utilities and groups looking for a central body with which to affiliate, found APWA. The APWA Utility Location and Coordination Council is the home of the most active of the voluntary associations for the reduction of damage to underground facilities.

1.3.4 Government Regulations and Industry Standards - When APWA or OPSO attempt to write a model statute applying nationally, they face a challenging task. There has been, is now and will be a hodge-podge of regulations and standards according to which underground facilities are installed and maintained. Where there are 50 sovereign states and many, often competing, utilities a duplication of controls is likely.

By late 1976, 15 states had enacted some sort of legislation concerning damage reduction €or underground pipelines. Also, 69 percent of the states have in operation one-call systems. Of the states that have one-call systems, 43 percent have statewide coverage while the remaining 57 percent have localized coverage. Within a state there are, at times multiple one-call systems operating. For example, in the state of Washington, there are 19 one-call systems organized to cover separate localized areas. There are, however, areas which are not covered. Of the 15 (43 percent) statewide coverage one-call systems, 12 have a statewide one-number system while the remaining three have two or more numbers in the state.

Enforcement of the laws is spotty. The state regulatory agencies in some cases direct the utilities to develop damage reduction programs. Illinois utilities are in the process of developing a statewide one-call system at the request of the Illinois Commerce Commission (ICC). From the point of view of damage reduction, it is unfortunate that the municipal gas utilities are not under the control of the ICC.

A number of the federal agencies are involved in damage reduction programs. The Occupational Safety and Health Administration (OSHA) has regulations that require notification to utilities by excavators. A great deal of moral support for development of one-call systems is supplied by the NTSB. Model statutes have been presented to the various states in 1972, 1974, and 1977 by the OPSO. The fact that these statutes exist and might be enacted has spurred the drive by the private sector to develop damage reduction programs emphasizing the one-call system.

1.3.5 Efficacy of Damage Reduction Programs – It is difficult **if** not impossible to correlate damage reduction, or increase with any single cause or effect, such as the number **of** units of some particular article of production. The production rate of gas meters might correlate with gas utility construction but obviously not with the electric or telephone utilities. If the cost of damage repairs was used as a criterion the erosion of the dollar by inflation would have to be considered. For example, if inflationary effects are not considered a successful damage reduction program could appear to be failing.

Assume that the annual number of excavations is constant for 5 years, and that the number of dig-ins is reduced by 3 percent each year. Further assume that an inflation rate of 6 percent holds for that 5-year period. Then the annual number of dig-ups after 5 years is $D_n = (1.0 - 0.03)^n \; D = 0.86D$ where D is the original number per year, and the annual cost per dig-up is

$$C_n = (1.0 + 0.06)^n \; C = (1.06)^5 \; C = 1.34C$$

The ratio of the cost per year after 5 years **is**

$$\frac{C_n D_n}{CD} = \frac{1.34C \times 0.86D}{CD} = 1.15$$

or a real decrease of 14 percent looks by money count only as a 15 percent increase.

The amount of construction that is near utilities must be considered. If a metropolitan area is divided into two parts, the old built-up central city and the growing suburbs, the damage rates are much different. The central city damage statistics are usually quite low. The suburban areas as building occurs show high annual damage rates. Then as space between the suburbs is filled in with further building the damage rates increase again. Finally the near-in suburbs are completely built-up and the construction necessarily ceases and the damage rates subside. In fact most of the construction activity impinges on utility underground systems. The installation of a new freeway commonly requires permanent or temporary movement of underground pipelines. Widening of roads affects utilities. Flood control normally affects underground facilities because the flood control sewer pipe normally goes in the road right-of-way under all of the other utilities.

The preceding paragraph is not meant to imply that the only successful damage reduction program is time. All of the available data show that damage in the form of hits by outside parties can be reduced by action on the part of individual utilities or groups of utilities. Probably the most important missing element is that of groups of utilities working together.

Very few of the one-call systems encompass all of the underground pipeline operators in their areas. Fewer have full cooperation by all of the utilities and contractors in their areas. If all of the utilities and contractors would treat dig-ins as a common problem to be solved by their mutual efforts, the task of damage reduction by outside forces would be greatly simplified.