CHAPTER 7

ANALYSIS OF PROGRAM OPTIONS

7.1 INTRODUCTION

7.1.1 Gas Pipeline Safety

In accordance with the requirements contained in the Natural Gas Pipeline Safety Act of 1968, the Department of Transportation was chartered by Congress to ensure safety in the transportation of natural gas. The Secretary has delegated this mission to the Office of Pipeline Safety Regulation and the Office of Operations and Enforcement of the Materials Transportation Bureau, Research and Special Programs Administration. The Associate Director for Operations & Enforcement (OE) operates his program for gas pipeline safety through regional offices which, in turn, operate through state agencies.

For natural gas, most of the technical effort required under the program has been done by the gas utilities, since they have a substantial capability for inspection of gas facilities, leak detection, repair, and protection against deterioration. In fact, with respect to transportation of natural gas in transmission and distribution lines, meeting the objectives of the legislation is based on the technical and administrative capacity of utilities to carry out the main burden of the effort required to bring gas transportation into conformance with the Federal safety regulations. The gas pipeline safety effort has generally operated well and has achieved most of the goals in developing a system of regular inspection and repair and in installing protection systems to halt deterioration of gas pipeline facilities.

7.1.2 "Master Meter" Systems

Master meter systems, small gas distribution systems which operate beyond utility systems, include the following:

- gas distribution systems within trailer parks which take the gas from the utility's meter to the individual coaches
- distribution systems in university complexes which distribute gas beyond the utility meter
- similar systems for hospital complexes
- garden apartment gas lines
- housing development lines
- duplex supply lines

Yard lines, which serve single family homes via customer owned buried/exterior piping are not included in this list, though they pose a similar potential for hazard.

To date, the program for gas transportation safety has not dealt with this class of distribution system in a systematic way, although their existence and the potential for safety hazard has been recognized by the Congress, by DOT, and by the Public Service Commissions. These systems are within the OPS charter because the gas is transported for resale or reuse by the person owning the distribution system. A good example is a trailer park or housing development that purchases gas from a utility at a commercial rate and then redistributes it to clients and charges for the gas through rent. However, many other systems which are physically in the same class - that is consist of underground lines carrying gas from the utility meter to buildings - are not within the formal DOT charter because there is no resale of the gas. In terms of safety, these systems present similar hazards.

Many master meter systems installed after 1971 are not in conformance with the present gas pipeline safety regulations, and have not been maintained to meet the regulation standards. In addition, many installed before 1971 were not installed in accordance with acceptable industry standards and, hence, have failed to meet local building code requirements or local commercial practice in cases where codes did not exist. The systems have in many cases, not been routinely checked for physical condition or for leaks, and they have not been protected against deterioration. They often are 5 to 15 years old, subject to deterioration, and present an unknown hazard.

The owners and operators of many master meter systems are often not aware of the Federal regulations regarding gas pipeline safety and many would be hard pressed technically and financially to achieve full compliance with them.

7.2 MASTER METER SYSTEM INVESTIGATION

7.2.1 Summary of Approach

The first step in this investigation was to develop "Use scenarios", which were projections of reasonable combinations of findings of the investigation and of program options which would be possible should these findings become reality. These scenarios were for the purpose of focusing the following management interchange on the most pertinent data.

For maximum efficiency, the second step was to conduct a management interchange at the utility level to determine what data are presently available at the utilities on the master meter system population, and to get access to pertinent portions of that data.

The last step was to conduct statistical and other analyses of the data to extrapolate to the best national, regional, and state estimates of the total system population, to derive information on the status and the history of master meter systems, and to estimate the composition of the master meter systems' population.

7.2.2 Summary of Investigation

This report was a preliminary investigation conducted for the Office of Operations and Enforcement to determine the nature and degree of hazard nationwide in master meter systems and to discuss the impact of potential OPS action with respect to their safety.

Specifically, the first effort was to get a good basis for estimating the national population of master meter systems. Other "yard line" systems were excluded from consideration by DOT's charter.

The second effort was to begin the process of gaining insight into:

- the distribution of the systems nationally,
- the uses of the systems,
- the status of their inspection and repair,
- the roles of the Public Service Commissions and utilities with respect to safety in "Master Meter" systems,
- the awareness of the owners and operators of master meter systems of the potential for safety hazard and of the requirements for conformity to the national safety regulations, and
- the physical characteristics of typical systems.

The third effort was to begin the development of the basis for analyzing possible specific program action with respect to master meter systems through the formulation of "Use Scenarios".

The fourth effort was to obtain expert judgement from personnel in the DOT Regions, the Public Service Commissions, and the utilities to conduct a small sample of direct interviews with master meter system operators to gain insight into the degree of hazard, the safety status of the systems, and the ability of master meter system operators to meet national safety standards.

The fifth element of the investigation was an interchange at the master meter system level to determine the characteristics of master meter systems and the awareness and capabilities of master meter system owners and operators with respect to gas safety regulations and procedures.

The sixth was an analysis of the total master meter interchange data to begin in-depth understanding of the situation and capability of master meter system owners and operators to routinely inspect and maintain their own systems.

All of the above elements served as the building blocks necessary to establish candidate program options for master meter safety. These options, which were refinements of the "Use Scenarios" developed initially, are discussed in Section 7.3 which follows.

7.3 DISCUSSION OF MASTER METER SYSTEM SAFETY PROGRAM OPTIONS

1. The data indicated that separate recognition of master meter systems in the gas pipeline safety regulations and, possibly, law may be appropriate. For instance:
   - the nature and degree of safety hazard in master meter systems is different than that in large utility gas pipeline facilities,
   - the technical expertise and administrative capacity to ensure a safety program are not available to master meter system operators as they are to the utilities,
   - communication with master meter system owners and operators will be much more difficult than it is with utilities.

Any safety program treating master meter systems should also recognize the existence of the "yard line" population.

2. It is probably reasonable for any master meter system gas safety program to follow the basic pattern of the program which has been carried out for utilities in particulars such as these:

- the federal role should be to establish inspection requirements,
- the burden for maintenance, repair, and protection should rest with master meter system owners and operators,
- to the degree possible, state participation should provide the primary inspection mechanism.

3. Because there are wide variations in the degree of potential hazard offered by master meter systems, stratification of the requirements for action by master meter systems owners by degree of public hazard of the systems may be indicated. A possible stratification of systems is offered:

CLASS I - relatively large systems, such as trailer parks and shopping centers, that operate near heavily populated areas and which run near buildings or other enclosures where, in the event of a pipeline problem, leaking gas may be entrapped.

CLASS II - systems which feed gas to multiple users, but that do not have large populations of people near them or which do not have substantial potential for gas entrapment.

CLASS III - small isolated systems in remote areas, primarily.

To implement such a stratified system it would be necessary to conduct research and analysis to identify and quantify the parameters defining each class.

For the Class I master meter systems:

A. It may be necessary to aggressively identify each specific system and communicate with the owners and operators with respect to their responsibilities.

B. It might be appropriate to establish requirements for immediate leak surveys and repair in cases where hazard is detected.

C. Protection, using cathodic techniques, is required, but this requirement might be extended beyond the period for protection now specified in the regulations for utility systems.

D. Action might be taken with public service commissions and utilities to conduct the necessary inspection and maintenance of master meter systems using utility capability wherever possible. Appropriate compensation to the utilities would be part of this action.

With respect to the Class II systems:

A. It may be required to establish communications of the requirements for gas pipeline safety to owners and operators, and education with respect to the procedures.

B. Less frequent periodic inspection of these systems may be appropriate.

C. It might be appropriate to urge Class II owners and operators to install corrosion protection.

D. These systems might be inspected and maintained using utility capabilities, with compensation.

For Class III Systems:

A. Communications and awareness outreach efforts with respect to the problems associated with master meter systems, including provision to owners and operators of information on procedures for maintaining gas safety, may be appropriate action for Class III systems.

B. To implement a program with provisions such as these, it would be necessary to identify and communicate with each of the master meter system operators in the country and, to this end, development of the information and outreach mechanisms would be required.

C. Development of the planning, management, inspection, and certification capabilities for orderly inspection and certification of master meter systems on a national basis may involve a specific DOT program effort.

CHAPTER 8

SUMMARY AND RECOMMENDATIONS

8.1 SUMMARY OF FINDINGS

This section assimilates the key findings that the study effort determined, from the survey of utility companies, regarding the size and distribution of the master meter system population nationwide. Observations from the analysis of returned master meter instruments are presented at the end of the Appendix. As indicated earlier, these observations were made on the basis of a small sample of returned instruments from master meter owners and operators. Since this sample did not truly reflect the actual geographic distribution of systems nationwide nor the mix of system types, the results could not be used to project accurately the characteristics of the master meter population and, hence, are not included below.

8.1.1 <u>Characteristics of Utility Company Responses</u>

1. Nationally, the average utility company serves 30,000 customers. The typical company in the study sample was larger, serving an average of 54,000 customers each.
2. 79% of the utility companies responding felt that the study definition of master meter systems was adequate for completing the form, although the heretofore recognized industry definition

also includes those multiple user systems without buried or exterior pipelines.

3. 43% of the utility companies responding own fewer than 100 miles of gas pipeline, while only 3% own over 5000 miles of pipeline. The average distribution system contained 800 miles of pipeline.
4. Nearly 2/3 of the nation's gas utility companies are expected to serve at least one master meter customer, with the average from the study sample being approximately 60 master meter systems.
5. Nearly 5/6 of the utility companies sampled do not maintain the pipeline system beyond the meter. A multitude of other metering configurations, depending on the property line, exist for other companies.
6. 27% of responding gas utilities perform leak surveys on master meter systems on request and 24% perform these surveys on an annual basis. Nearly 50%, however, do not perform leak surveys on master meter systems.
7. 76% of responding gas utilities indicated no knowledge of any master meter leaks in their distribution system. Nearly half the responding utility companies reported fewer than 50 leaks on their pipeline system in 1978, although over one third reported more than 200 leaks.
8. 10% of responding gas utilities negotiate contracts with master meter owners to maintain their distribution system, and 26% of the remaining companies would be

interested in maintaining/inspecting these systems at some future time.

9. Nearly 1200 utility companies did not respond or provided responses with "data not available" due primarily to the structure of their data base which does not distinguish between multiple user systems with and without buried/exterior pipeline.

8.1.2 Size and Distribution of Master Meter Population

1. Based on responses from 344 of 1526 utility companies nationwide, the study predicted that there is currently almost 81,000 master meter systems in operation across the country which possess buried or exterior piping downstream of the meter.
2. Due to the nature of sampling from a population, the interval of estimate for the master meter population is 65,000 to 102,000, with 95% confidence.
3. The concentration of these Master Meter systems is primarily in the Southwest (-46,500) and Western (-20,700) regions of the country. Nearly two-thirds of these systems can be expected to be found in Texas (-39,400) and California (-12,900) alone.
4. The number and concentration of master meter systems in the Eastern, Central and Southern regions is small (-14,000 total) compared to the Western and Southwest regions, with an estimate ranging from0.3 to 0.8 master meter systems per 1,000 gas accounts. Concentration in the Western and Southwest regions is 2.1 and 8.4 master meter systems per 1,000 gas accounts, respectively..

5. The Public Service Commissions have, in general, a very good qualitative understanding of the nature of the master meter system safety situation. Some states and utilities are moving with the PSCs toward utility takover either of the safety maintenance of the systems or toward utility ownership of the systems. The State of Michigan, for example, has enacted legislation requiring utility companies to develop maintenance and operation agreements with master meter system owners. In fact, in some instances, when new construction was in process at the time legislation was enacted, some utilities were required to assume ownership of the full system.

6. In general, the Master Meter System population is no longer growing, since there is an awareness that some owners are not in a position to maintain them or to conform to acceptable safety levels. In some situations, master meter systems are being replaced with individual meters at each outlet.[1]

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[1] SASC was aware that another factor contributing to the banning of new master meter systems and conversion of existing systems is energy conservation. However, this factor was outside the scope of the study effort.

8.2 RECOMMENDATIONS FOR FULL INFORMATION EXCHANGE SPECIFICATIONS

The initial Phase I effort represents a first order estimate of the magnitude of the safety problem associated with master meter gas systems. A slice of the population of gas utilities and master meter systems was sampled to gain preliminary insight into the size and characteristics of the nation's master meter systems. In addition, cause/effect relationships were established, wherever the data indicated the presence of these relationships.

As discussed in Chapter 5, only a small percentage of the nation's gas utilities responded with meaningful data. The major contributing reason for the low response was identified as the difficulty that many utilities had in discerning between those multiple user systems (commonly referred to as master meter systems by the gas industry) who do possess buried/exterior piping downstream of the master meter and those systems without the buried/exterior piping. From a safety standpoint, the latter group of systems is not of interest since the corrosion tendencies are not nearly as likely inside the building as they are underground or outside.

This problem of data base structure cannot easily be resolved without significant amounts of time and money on the part of utilities. SASC proposes that the Phase II effort address this problem directly.

As a result of these exchanges, however, three major observations can still be made. They are:

- the size of the nation's master meter population has been established within broad limits (60,000 to 100,000 systems),

- many master meter systems are not routinely maintained, repaired, protected, and inspected, as are utility systems.
- the mechanisms to reach compliance with Federal requirements are not available to master meter system owners as they are to utility owned systems,

What has <u>not</u> been established, however, is the <u>degree of safety hazard present</u>. Therefore, SASC proposes three alternative work plans for the Phase II Full Survey that are geared to the perception of the safety hazard in master meter systems and to the desire for accurate identification of the characteristics of those systems. The first alternative is the most comprehensive of the three. The remaining two represent reduced cost/effort options available if the perceived degree of hazard and desired accuracy is less than the maximum.

8.2.1 <u>Work Plan Alternative A</u>

For this effort, SASC proposes that a <u>complete</u> information exchange with the mation's gas utilities he, conducted. However, to ensure maximum timely response, the questionnaire should be refined significantly. Inquiries regarding the number of master meter systems should be made for the total number of multiple user systems. If utilities can identify those systems which possess the buried/ exterior pipe feature, then they should be encouraged to do so. Since the Phase I effort indicates that utility companies can readily identify their total number of multiple user systems, but not readily identify the subset of master meter systems desired by the study, the response to the refined exchange instrument will be significantly greater.

Following the utility exchange, an unrefined mailing list of all multiple user systems will be generated. Obviously, this list will be impure since it will contain many systems that are not of interest because they lack the buried/exterior pipe feature. Therefore, a simplified master meter operator exchange will take place with the complete list.

Using ADP generated mailing labels for rapid turnaround, a letter will be sent to the complete "impure" list of multiple user systems. This letter will be brief and inquire as to the following:

- Showing a drawing of the ''pure" master meter system along with a definition, determine if the particular multiple user system does in fact possess buried/ exterior piping downstream of the meter characteristic of the ''pure" master meter system.
- Determine what type of master meter system is present at the site (e.g. apartments, housing authorities, shopping centers, etc.)
- Identify if the billing name/address is the owner or manager of the site; if it is the manager, identify the name/address of property owner.

Any lack of response to these two questionnaires will be followed up through contacts with State Public Service Commissions and other local officials. However, because of the simplified structure of both questionnaires, especially regarding the need for utility companies to identify only their multiple user systems, the response problem of Phase I should not occur.

Responses from the 1st Multiple User exchange will thus establish the data base of ''pure" master meter systems. Having done this, a 2nd exchange with ''pure" master meter systems will occur. This exchange will be a much more in-depth analysis. Furthermore, it will be done from a scientifically designed sample that is reflective of the geographic/type of master meter mix present in the population. The questionnaire, a refinement of the Phase I exchange with master meter operators, will focus more accurately on the true degree of safety hazards present in the nation's master meter population.

In support of this phase, a sample of the ''pure" master meter systems will also be studied through physical "on site" inspections. These inspections will include leak surveys of the property, identification of potential or existing safety hazards, and proposed remedies. To accomplish this phase, it will be necessary to employ qualified leak survey consultants.

Alternative A represents the approach taken if it is perceived that the safety hazard present is severe.

8.2.2 Work Plan Alternative B

This alternative is selected if the perceived degree of hazard is not as great. The work plan is identical to that of Alternative A except that no physical "on-site" inspections and leak surveys are performed. The gas utility exchange and two iterations of surveys of master meter operators are the same as described for Alternative A.

8.2.3 Work Plan Alternative C

This represents the low cost/low safety hazard option. For this alternative, the primary output is the complete mailing list of names and addresses of the "pure" master meter operators. Since the degree of safety hazard perceived is extremely low, then the 2nd master meter exchange and physical "on-site" inspections are not conducted in this alternative. The gas utility and 1st master meter exchanges are performed to provide the "pure" mailing list of names and addresses.

8.2.4 Summary of Recommendations

All three alternatives presented will provide DOT with the population of "pure" master meter systems nationwide and the mailing list of names/addresses to be used for Phase III in communicating strategies to the master meter systems. Where the three alternatives differ is in the level of in-depth analysis of individual master meter system safety hazards. Depending on the level of hazard, the appropriate Phase II alternative can be determined, ranging from the low hazard Alternative C to the severe safety hazard Alternative A.

Table 8-1 presents the estimated funding/level of effort required for each alternative discussed.

TABLE 8-1

ESTIMATED BUDGETS FOR PHASE II ALTERNATIVES

Alternative Description	Estimated Contract Length	Man-Years	Cost
A - COMPLETE SAMPLING OF UTILITIES PLUS 2 iterations of sampling on master meter owners, on-site leak survey of systems, mailing list of names/addresses of master meters	18 mos	12	$700,000
B - COMPLETE SAMPLING OF UTILITIES PLUS 2 iterations of sampling on master meter owners, mailing list of names/addresses of master meters	18 mos	9	550,000
C - COMPLETE SAMPLING OF UTILITIES PLUS 1st exchange with master meter owners, mailing list of names/addresses of master meters	12 mos	6	360,000

APPENDIX - ANALYSIS OF MASTER METER SURVEY DATA

BACKGROUND

The gas utility companies and the DOT Regional Chiefs working cooperatively with the respective state gas pipeline officials provided the Project with almost 5000[1] names and addresses of known master meter owners/operators through-out the country. In December, the design of the instrument was finalized, arrangements were made with the Riverdale U.S. Post Office for receiving guaranteed postage paid "self-mailers," and SASC proceeded with the mail-out effort. Instruments were sent to all states with the exception of Connecticut, Maine, Vermont, New Jersey, and Hawaii where master meter systems may exist, but were not known to the Project.

A.1 MASTER METER OPERATOR DATA

The design of the instrument was similar to the first page of the Utility Company instrument providing elements to be filled out identifying the name of the company, owner, responsible persons, etc. In this case, SASC requested that one form be filled out for each property with the statement:

"PLEASE COMPLETE ONE FORM FOR EACH SITE OWNED/MANAGED WHICH IS MASTERED METERED"

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[1] A little over 4200 were mailed from the middle of December 1978 through the middle of February 1979. Mailing ceased when it was determined that the Project schedule would not permit further data collection.

placed at the top of the first page. The **SASC** Control Numbers also contained an alpha prefix for the state abbreviations and Table **A-1** show the frequencies of returned instruments by state. In addition to those states not having master meters (or not known to the Project), Colorado, Delaware, Iowa, Idaho, Kansas, Louisiana, Massachusetts, Nebraska, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Texas, Washington, and West Virginia master meter operators did not respond to the survey. Hence, unlike the responses from utility companies, the sample of master meter instruments showed wider gaps in geographic representativeness.

All names and addresses of master meter operators are in this data base[2] in addition to the response data.

A.2 INTRODUCTION AND DEFINITION

SASC's original definition of master meter system was slightly modified on this instrument to clarify the word "exterior'?. " . . . and possessing <u>exterior</u> pipelines", was replaced with ". . . having pipelines downstream of the meter which may be buried or exposed outside of the building." It is not known if this improvement in the definition helped in clarifying the intent

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2 **SASC** entered the full name and address of each master meter operator for each record in this data base, and succeeded in instructing SPSS to print the information in mailing label format.

```
STATE     STATE LOCATED IN

   CODE
          I
     1,   **  (      1)
          I  AK
          I
          I
     2.   ******************************  (      31)
          I  AL
          I
          I
     3.   ........................  (      24)
          I  AR
          I
          I
     4.   ***********  (      11)
          I  AZ
          I
          I
     5.   *******************  (      19)
          I  CA
          I
          I
     8.   ***  (      2)
          I  DC
          I
          I
    10.   *****  (      4)
          I  FL
          I
          I
    11.   *******************  (      19)
          I  GA
          I
          I
    15.   ************************  (      24)
          I  IL
          I
          I
    16.   ***************************  (      27)
          I  IN
          I
          I
    18.   ***********************************  (      35)
          I  KY
          I
```

TABLE A-1

(page 1 of 3)

```
    I
21. ***** (      4)
    I  MD
    I
    I
23, **** (      3)
    I  MI
    I
    I
24. *** (      2)
    I  MN
    I
    I
25. ** (      1)
    I  no
    I
    I
26. ********** (      9)
    I  MS
    I
    I
27. ************ (      11)
    I  MT
    I
    I
28. ****************************** (      28)
    I  NC
    I
    I
29. *********** (      10)
    I  ND
    I
    I
31, ** (      1)
    I  NH
    I
    I
33. *************** (      14)
    I  an
    I
    I
34, ******* (      6)
    I  NV
    I
    I
35. *** (      2)
    I  NY
    I
```

TABLE A-1
(page 2 of 3)

```
        I
   41.  **************  (      13)
        I  SC
        I
        I
   42,  **************  (      13)
        I  SD
        I
        I
   43.  *********************  (      20)
        I  TN
        I
        I
   45.  *********  (      8)
        I  UT
        I
        I
   46.  ************************  (      23)
        I  VA
        I
        I
   49,  *****  (      4)
        I  WI
        I
        I
   51.  ***  (      2)
        I  WY
        I
        I.........I.........I.........I.........I.........I
        0        10        20        30        40        50
        FREQUENCY
```

VALID CASES 371 MISSING CASES 3

TABLE A-1
(page 3 of 3)

of the Project, since those who indicated that the definition did not describe their system in the space provided, left the rest of the instrument blank or did not bother to return it.

In addition to the above, SASC classified each returned instrument in accordance with the 1972 edition of the Standard Industrial Classification Codes (SIC) (see Exhibit A-1) so that retrieval by nature of business would be possible. Each SIC category shown in the Exhibit represents a master metered type of business that responded. SASC allowed space following the four character SIC code in the computer record format for 3 additional numeric characters, to provide for in-depth retrieval in the future. In this way, a "finer tuning" classification would be possible when required.

The distribution of returned instruments by SIC codes maybe seen in Table A-2, which shows a predominance of returned instruments from Apartment Buildings/Housing Authorities (6513) and Mobile Home Parks (6515).

A. 3 PROPERTY PIPELINE DATA

The first elements requested from the respondents dealt with their knowledge of the site that they owned or managed (Question III A). Table A-3 shows a wide range of property sizes represented in the data.

A. How many buildings/lots do you own/manage at this site that are served by natural gas?

[ ][ ][ ][ ] NO. OF BUILDINGS/LOTS

(17-20)

EXHIBIT A-1

STANDARD INDUSTRIAL CLASSIFICATION CODES

0821	NURSERIES, FOREST AND SEED GATHERINGS
3295	MINERALS AND EARTHS, GROUND OR OTHERWISE TREATED
3334	ALUMINUM, PRIMARY PRODUCTION OF
3728	AIRCRAFT PARTS AND AUXILIARY EQUIPMENT, NOT ELSEWHERE CLASSIFIED
3999	MANUFACTURING INDUSTRIES NOT ELSEWHERE CLASSIFIED
4582	AIRPORTS AND FLYING FIELDS
4932	GAS AND OTHER SERVICES COMBINED
6513	OPERATORS OF APARTMENT BUILDINGS
6515	OPERATORS OF RESIDENTIAL MOBILE HOME SITES
6531	REAL ESTATE AGENTS AND MANAGERS
7011	HOTELS, TOURIST COURTS, MOTELS
7349	DWELLINGS AND OTHER BUILDING, NOT ELSEWHERE CLASSIFIED
7996	AMUSEMENT PARKS
7999	AMUSEMENT AND RECREATION SERYICES, NOT ELSEWHERE CLASSIFIED
8059	NURSING AND PERSONAL CARE FACILITIES, NOT ELSEWHERE CLASSIFIED
8062	HOSPITALS, GENERAL MEDICAL AND SURGICAL
8211	SCHOOLS, ELEMENTARY AND SECONDARY
8221	COLLEGES, UNIVERSITIES AND PROFESSIONAL SCHOOLS
8411	MUSEUMS AND ART GALLERIES
8421	SCHOOLS, VOCATIONAL
8661	RELIGIOUS ORGANIZATIONS

```
SIC       STANDARD INDUSTRIAL CLASSIFICATION

   CODE
          I
    821.  *  (      1)
          I
          I
          I
   3295.  *  (      1)
          I
          I
          I
   3334.  *  (      1)
          I
          I
          I
   3728.  *  (      1)
          I
          I
          I
   3999.  *  (      2)
          I
          I
          I
   4582.  *  (      2)
          I
          I
          I
   4932.  *  (      2)
          I
          I
          I
   6513.  ***************************  (    251)
          I
          I
          I
   6515.  ********  (     65)
          I
          I
          I
   6531.  **  (      3
          I
          I
          I
   7011.  **  (      7)
          I
          I
```

TABLE A-2
(page 1 of 2)

```
        I
 7349.  *  (      1)
        I
        I
        I
 7391.  *  (      1)
        I
        I
        I
 7996,  *  (      1)
        I
        I
        I
 8059.  *  (      1)
        I
        I
        I
 6362.  *  (      3)
        I
        I
        I
 8211.  ** (      6)
        I
        I
        I
 8221.  ** (     12)
        I
        I
        I
 8411,  *  (      1)
        I
        I
        I
 8421.  *  (      2)
        I
        I
        I
 8661,  *  (      2)
        I
        I
        I.........I.........I.........I.........I.........I
        0        100       200       300       400       500
        FREQUENCY
```

VALID CASES 371 HISSING CASES 3

TABLE A-2
(page 2 of 2)

BLDGSOWN HOW MANY BUILDINGS OR LOTS

```
      CODE
             I
        1.   ***********  (      41)
             I   1-5
             I
             I
        2.   *************  (      47)
             I   6-13
             I
             I
        3.   ............................     (      111)
             I   11-25
             I
             I
        4,   ****************  (      61)
             I   26-53
             I
             I
        5,   *************  (      46)
             I   51-100
             I
             I
        6.   *************  (      49)
             I   101-HIGHEST
             I
             I
     9999.   *****  (      16)
(MISSING)    I   ELANK
             I
             I.........Io.........I.........I.........I.........I
             3         43         83        123       163       233
             FREQUENCY
```

VALID CASES 355 HISSING CASES 16

TABLE A-3

It is obvious that those reporting high values of building/lots were reporting mobile home rental spaces.

It was also of interest to this study to determine the age of master metered properties and, more specifically, the age of the gas distribution systems. Results of Questions III B and III C are shown in Tables A-4 and A-5, which are displayed as frequency tables for convenience.

B. This property was developed (began operation) in:

☐☐☐☐ YEAR

(21-24)

C. **The** Master Meter System was insta led in:

☐☐☐☐ YEAh

(25-28)

Property developed dates run from **1867** to **1979** with 15% **of** those responding having been built in **1950** or earlier. System installed dates go from 1910 to the current year with **9%** having been installed in **1950** or earlier.

D. **The** Master Meter system was installed by:

☐ 1. Owner's maintenance crew

☐ 2. Local plumbing contractor

☐ 3. Developer

☐ 4. utility company

☐ 5. Gas pipeline contractor

☐ 6. Unknown

(29)

DEVELPIN PROPERTY WAS DEVELOPED IN

CODE	FREQ	ADJ PCT	CUB PCT	CODE	FREQ	AD3 PCT	CUM PCT	CODE	PREQ	ADJ PCT	CUM PCT
1667.	1	3	0	1942.	6	2	11	1962,	11	3	46
1878.	2	1	1	1944,	1	3	12	1963.	13	4	53
1880.	1	3	1	1945.	2	1	12	1964.	12	3	53
1887..	1	3	1	1946,	1	3	12	1965,	19	5	59
1893.	1	3	2	1948.	2	1	13	1966,	9	3	61
1900.	1	3	2	1949,	3	1	14	1967.	8	2	63
1901.	1	3	2	1950.	6	2	15	1968.	19	5	69
1907.	1	3	3	1951.	3	1	16	1969,	16	5	73
1910.	1	3	3	1952.	27	8	24	1970.	19	5	79
1925.	1	3	3	1953.	13	4	28	1971.	22	6	85
1927.	1	3	3	1954.	10	3	33	1972.	24	7	92
1932.	1	3	4	1955.	6	2	32	1973.	11	3	95
1934.	1	3	4	1956,	1	3	32	1974.	12	3	98
1935.	1	3	4	1957.	1	3	33	1975.	3	1	99
1937,	3	1	5	1958.	13	3	35	1976,	2	1	99
1939.	3	1	6	1959.	13	3	38	1977,	1	3	133
1943,	4	1	7	1960.	12	3	42	1979..	1	3	133
1941	9	3	13	1961.	5	1	43				

M I S S I N G   D A T A

CODE	PREQ	CODE	FREQ	CODE	PREQ
9999,	16				

TABLE A-4

INSTIN SYSTEM WAS INSTALLED IN

CODE	PREQ	ADJ PCT	CUM PCT	CODE	PREQ	ADJ PCT	CUM PCT	CODE	PREQ	ADJ PCT	CUM PCT
1910.	1	3	3	1953.	8	2	19	1967.	7	2	57
1933,	2	1	1	1954,	13	3	22	1968..	18	5	62
1937.	1	3	1	1955.	5	1	23	1969.	22	6	68
1939.	2	1	2	1957.	2	1	24	1970.	16	5	73
1940.	3	1	3	1958.	8	2	26	1971.	24	7	80
1941.	5	1	4	1959.	13	3	29	1972,	25	7	07
1942.	6	2	6	1960.	14	4	33	1973.	10	3	93
1945.	2	1	6	1961,	5	1	34	1974.	15	4	94
1946.	1	3	7	1962..	11	3	37	1975,	9	3	97
1949.	3	1	7	1963..	16	5	42	1976.	7	2	99
1950.	6	2	9	1964	11	3	45	1977.	2	1	99
1951.	4	1	13	1965,	20	6	51	1978.	2	1	133
1952.	22	6	17	1966.	15	4	55	1979.	1	3	133

MISSING DATA

CODE	FHEQ	CODE	FREQ	CODE	PREQ
9999.	23				

TABLE A-5

A significant number of respondents to III D felt that it was important to answer more than one of the electives in spite of the instructions. In view of this, SASC felt that multiple answers were valid data points and re-created category 6, into "More than one of the above" in place of "Unknown". During the manual overview of each instrument prior to data entry, SASC made the appropriate selection when multiple answers occurred. This was an acceptable decision since even though some non-responses (blanks) were present, there were no cases of "Unknown" in the data. Table A-6 shows that over one third of the master metered installations were accomplished by utility companies.

Questions III E and III F requested information from respondents

E. The predominant type of pipeline materials used in your distribution system is:

- ☐ 1. steel
- ☐ 2. Copper
- ☐ 3. Aluminum
- ☐ 4. Plastic
- ☐ 5. Unknown
- ☐ 6. other, explain: ______________________

(30)

to test their awareness of the materials used in their pipeline and the corrosion protection technique used. Tables A-7 and A-8

```
INSTBY     SYSTEM WAS INSTALLED BY

      CODE
                 I
       1,        ***  (       9)
                 I  OWNERS MAINTENANCE C
                 I
                 I
       2.        ************ (       44)
                 I  LOCAL PLUMBING CONTR
                 I
                 I
       3,        *********************** (       88)
                 I  DEVELOPER
                 I
                 I
       4,        ********************************* (       122)
                 I  UTILITY COHPANY
                 I
                 I
       5.        ************ (       44)
                 I  GAS PIPELXNE CONTRAC
                 I
                 I
       6.        **************** (       58)
                 I  MORE THAN ONE OF THE
                 I
                 I
       9.        ***  (       6)
   (HISSING)     I  BLANK
                 I
                 I.........I.........I.........I.........I.........I
                 3         43        83        123       163       233
                 FREQUENCY

VALID CASES      365        HISSING CASES      6
```

TABLE A-6

```
PIPEMAT   TYPE OF PIPELINE HATERIALS

     CODE
         I
      1. ****************************** (    301)
         I  STEEL
         I
         I
      2. * (      1)
         I  COPPER
         I
         I
      4. ***** (     37)
         I  PLASTIC
         I
         I
      5. ** (     12)
         I  UNKNOWN
         I
         I
      6. ** (      9)
         I  OTHER
         I
         I
      9. ** (     11)
(MISSING) I  BLANK
         I
         I.........I.........I.........I.........I.........I
         0        100       200       300       400       500
         FREQUENCY

VALID CASES      363       HISSING CASES     11
```

TABLE A-7

CORRPROT CORROSION PROTECTION TECHNIQUE

```
     CO CE
          I
       1. ************************ (    222)
          I   CATHODIC PROTECTION
          I
          I
       2. ***  (     24)
          I   VINYL COATED OR WRAP
          I
          I
       3. ****** (     54)
          I   COATED AND WRAPPED
          I
          I
       4  **  (      9)
          I   GALVANIZED
          I
          I
       5. ***  (     24)
          I   NONE
          I
          I
       6. **** (     28)
          I   UNKNOWN
          I
          I
       9. **  (     10)
 (HISSING) I  ELANK
          I
          I.........I.........I.........I.........I.........I
          3        100       233       333       400       533
          FREQUENCY
```

VALID CASES 361 MISSING CASES 13

TABLE A-8

show that **84%** of the respondents' systems are steel and that 62%

F. The principal corrosion protection technique used is:

- [ ] 1. Cathodic protection
- [ ] 2. Viny1 coated/wrapped
- [ ] 3. Coated and wrapped
- [ ] 4. Galvanized
- [ ] 5. None
- [ ] 6. Unknown

(31)

are cathodically protected. Here again, since the utility survey indicated that **39%** were cathodically protected, the sample of master meter instruments does not reflect completely the systems identified by utilities. In fact, the sample of master meter instruments is weighted more towards those systems which have implemented protection techniques.

A.4 MANAGEMENT DATA

One of the difficulties facing any pipeline repair crew is attempting to locate buried pipe without a map or "as built" drawings of the system. Question IV B was designed to determine if master meter owners in general have these site plans. Table **A-9** shows that out of those reponding, 14% indicated that they

MAP MAP OR DRAWING OF SYSTEH

```
     CODE
          I
       1. ******************************** (     334)
          I  YES
          I
          I
       2. ****** (     49)
          I  NO
          I
          I
       9. ***  (     18)
(KISSING) I  BLANK
          I
          I.........I.........I.........I.........I.........I
          0        100       200       300       400       500
          FREQUENCY
```

VALID CASES 353 MISSING CASES 16

TABLE A-9

do not have this material (quite likely in older systems). Coupled with this line of questioning, Question IV C produced

B. Do you have a map or drawing of your pipeline distribution system?

☐ 1. YES (32) ☐ 2. NO

C. Please indicate the footage of pipelines in your natural gas distribution system:

☐☐☐☐☐ ft. (34-38)

a 72% response in respondents knowing (or estimating) the footage of their distribution systems. Table A-10 shows that 35% of the respondents own or manage approximately a mile or more of pipeline. In Question IV D, the Project needed to know if master meter

D. Do you have a maintenance and operation plan of your gas distribution system in effect with either a utility company or consultant firm?

☐ 1. YES (39) ☐ 2. NO

owners/operators are concerned sufficiently about the potential safety hazards of their natural gas systems to employ pipeline safety professionals on a regular basis. Table A-11 shows that less than half responded that they do have an M/O agreement in effect. The next question in this sequence requested information

```
FOOTAGE    FOOTAGE OF PIPELINES

     CODE
          I
       1. ********* (    31)
          I  LOWEST-500
          I
          I
       2. ******* (    22)
          I  501-1000
          I
          I
       3. ******************************* (    120)
          I  1001-5000
          I
          I
       4. ************ (    42)
          I  5001-10000
          I
          I
       5. ************** (    53)
          I  10001-100000
          I
          I
  999999. *********** ************* * (    103)
(MISSING) I  BLANK
          I
          I.........I.........I.........I.........I.........I
          0        40        80        120       160       200
          FREQUENCY

VALID CASES     268       MISSING CASES    103
```

TABLE A-10

MAINOPS MAINTENANCE AND OPERATION PLAN

```
     CODE
          I
       1. ****************  (    149)
          I  YES
          I
          I
       2. ********************  (    203)
          I  NO
          I
          I
       9. ***  (    19)
(MISSING) I  BLANK
          I
          I.........I.........I.........I.........I.........I
          0        100       200       300       400       500
          FREQUENCY
```

VALID CASES 352 HISSING CASES 19

TABLE A-11

E. Would you or your staff be able to safely restore service after an unexpected stoppage?

☐ 1. YES

☐ 2. NO, Explain: ______________________

(40)

on the owner's/operator s ability (or their maintenance crew) to safely restore service after an interruption. Table A-12 shows that 81% of the respondents do have this capability. Question IV F, a similar type of question, requested information on the respondent's ability to safely interrupt service, if needed. Of those responding, 83% indicated (Table A-13) that they do have this capability, which parallels the results of Question IV E quite closely.

F. Would you or your staff be able to perform an emergency shutdown and pressure reduction in any section of your gas distribution system?

☐ 1. YES

☐ 2. NO, Explain: ______________________

(41)

The next series of questions requested information dealing with the most recent years that the owners had their gas distribution systems

G. Year of last gas distribution system inspection:

☐☐☐☐ YEAR

(42-45)

H. Year of last gas distribution system leak survey:

☐☐☐☐ YEAR

(46-49)

SAFREST SAFELY RESTORE SERVICE

```
     CODE
          I
       1. ****************************** (    286)
          I  YES
          I
          I
       2. ******** (    69)
          I  NO
          I
          I
       9. *** (    16)
(MISSING) I  BLANK
          I
          I.........I.........I.........I.........I.........I
          0        100       200       300       400       500
          FREQUENCY
```

VALID CASES 355 HISSING CASES 16

TABLE A-12

EMEBSHUT EHERGENCP SHUTDOWN

```
     CODE
         I
      1. ******************************** (    297)
         I  YES
         I
         I
      2. ******* (     6J)
         I  NO
         I
         I
      9. ** (    14)
(MISSING) I  BLANK
         I
         I.........I.........I.........I.........I.........I
         J        1JJ       2JJ       3JJ       4JJ       5JJ
         FREQUENCY
```

VALID CASES 357 MISSING CASES 14

TABLE A-13

either inspected or surveyed for leaks. The SPSS was instructed to process this data to count an entry as "Yes" or a blank as "No". The results can be seen in Tables **A-14** and **A-15,** where **85%** of the inspection response and **84%** of the leak survey response were "Yes". The range of dates resulting from both of these questions was **1962-1979,** indicating there are some systems that have not been inspected/surveyed for as long as 17 years. In addition, 15%of the systems have not been inspected since installation. These questions were followed by Question IV I which was also processed as a "Yes" for leaks identified and "No" for none indicated. Table **A-16** shows that **40%** of the respondents did have leaks confirmed by Leak Survey. Question

I. ... which resulted in identifying:

☐☐ NO. OF LEAKS
(50-51)

IV J was developed to determine what types of leaks master meter systems were experiencing and what action they were taking. Table **A-17** shows that **19%** took no action (non–hazardous leaks), **54%**

J. If the answer to (I) indicated that leaks were found, the action taken by you-was:

☐ 1. None, leaks were not hazardous

☐ 2. Arranged for repairs within a reasonable time

☐ 3. Immediate repairs were necessary and performed.

(52)

INSPECT LAST SYSTEM INSPECTION

```
COCE
        I
   1.   ****************************** (    314)
        I   YES
        I
        I
        *******
   2,           (      57)
        I   NO
        I
        I.........I.........I.........I.........I.........I
        0        100       200       300       400       500
        FREQUENCY
```

VALID CASES 371 HISSING CASES 3

TABLE A-14

SURVEY LAST SYSTEH LEAK SURVEY

```
CODE
     I
  1. ******************************** (    310)
     I  YES
     I
     I
  2. ******* (    61)
     I  NO
     I
     I.........I.........I.........I.........I.........I
     0        100       200       300       400       500
     FREQUENCY
```

VALID CASES 371 MISSING CASES 3

TABLE A-15

LEAKS NUMBER OF LEAKS

```
CODE
        I
  1.    **************** (    147)
        I    YES
        I
        I
  2.    *********************** (    224)
        I    NO
        I
        I.........I.........I.........I.........I.........I
        3        133       233       333       433       533
        FREQUENCY
```

VALID CASES 371 HISSING CASES 3

TABLE A-16

```
ACTION     ACTION TAKEN


    CODE
           I
       1.  ********** (      36)
           I  NONE
           I
           I
       2.  **************************** (     105)
           I  REPAIRED WITHIN A RE
           I
           I
       3,  ************** (     52)
           I  IMMEDIATE REPAIRS WE
           I
           I
       9.  ************************************************ (     178)
(MISSING)  I  BLANK
           I
           I.........I.........I.........I.........I.........I
           3        43        63       123       163       233
           FREQUENCY

VALID CASES     193       MISSING CASES    176
```

TABLE A-17

were repaired within a reasonable time, and 27% were hazardous and repaired immediately.

The response to Question IV K ranged from names of utility companies to local, state and Federal Agencies (generally Housing Authorities).

K. Who regulates gas pipeline safety for master meter systems in your area?

____

____

____

Leak repairs were also of interest to the Project and Question IV L

L. Who repairs the leaks in your master meter system?

- ☐ 1. Owner's maintenance crew
- ☐ 2. Local plumbing contractor
- ☐ 3. Developer
- ☐ 4. Utility company
- ☐ 5. Gas pipeline contractor
- ☐ 6. Other, explain: ________________

(53)

____

____

data (Table A-18) revealed that 28% of the respondents' crews make their own repairs and *30%* depend upon the utility companies. An additional 23% depend upon local contractors. Since 66 respondents, or 19%, elected more than one category, 6. was changed to "more than one of the above" which is shown on the table.

```
REPAIRS   WHO REPAIRS THE LEAKS

     CODE
          I
      1.  **************************** (    101)
          I  CWNERS MAINTENANCE C
          I
          I
      2.  ***************** (    62)
          I  LOCAL PLUMBING CONTR
          I
          I
      3.  * (      1)
          I  DEVELOPER
          I
          I
      4.  ***************************** (    105)
          I  UTILITY COMPANY
          I
          I
      5.  ****** (     20)
          I  GAS PIPELINE CONTRAC
          I
          I
      6.  ****************** (     66)
          I  MORE THAN CNE OF TXE
          I
          I
      9.  ***** (     16)
(MISSING) I  BLANK
          I
          I.........I.........I.........I.........I.........I
          0        40        80       120       160       200
          FREQUENCY

VALID CASES     355      MISSING CASES     16
```

TABLE A-18

Recognizing that many master meter owners would prefer to not own and manage their gas distribution systems, Questions IV M and IV N results (Tables A-19 and A-20) showed that 76% of the

M. Would your company be interested in having the utility company that serves you natural gas assume the full safety responsibility of your distribution system?

☐ 1. YES

☐ 2. NO, Explain: ______________________

(54)

N. If answer to (M) was YES, it would be preferable to:

☐ 1. Negotiate the ownership of your entire system.

☐ 2. Develop a maintenance and operation agreement for your system, which would be renewable periodically with no change of ownership.

☐ 3. Contract with them on an "as needed" basis, only.

☐ 4. Inspect and maintain your system independently of the utility company.

(55)

respondents wanted to be relieved of the safety responsibility of their systems. Of those wishing to be relieved, 50% of the respondents to Question IV N would prefer to negotiate the ownership of their system, 42% would be amenable to a renewable M/O agreement/contractual "as needed" basis, and 8% would prefer to continue to maintain their own systems independently of the utility company.

ASSUME ASSOHE THE SAFETY RESPONSIBILITY

```
     CODE
          I
       1. ***************************** (    268)
          I  YES
          I
          I
       2. ********* (    83)
          I  NO
          I
          I
       9. *** (    2))
(MISSING) I  BLANK
          I
          I.........I.........I.........I.........I.........I
          )        1))       2))       3))       4))       5))
          FREQUENCY
```

VALID CASES 351 HISSING CASES 20

TABLE A-19

PREFER IF PES IT WOULD BE PREFERABLE TO

```
      COCE
           I
        1. ********************************** (    132)
           I  NEGOTIATE THE OWNERS
           I
           I
        2. ************* (     47)
           I  DEVELOP AN MO AGREEM
           I
           I
        3. ***************** (     62)
           I  CONTRACT WITH THEM
           I
           I
        4. ****** (     20)
           I  HAINTAIN INDEPENDENT
           I
           I
        9. ***************************** (    110)
 (MISSING) I  ELANK
           I
           I.........I.........I.........I.........I.........I
           3        43        80       123       163       233
           FREQUENCY
```

VALID CASES 261 MISSING CASES 113

TABLE A-20

Question IV O provided "scanty" data since most of the master meter owners/operators did not know how to compute un-accounted for gas, or those that did respond were inconsistent in their understanding of the terms. This data was abandoned as contributing very little to this study.

O. What has been the history of the percentaae (%) of unaccounted natural gas in your system for (please answer all items):

	☐☐ %	1.	1978
	☐☐ %	2.	1977
(56-57)	☐☐ %	3.	1976

Respondents provided cost figures in response to Question IV P,

P. What has been the approximate average annual cost to your company for inspecting and maintaining your natural gas distribution system for the last 3-5 years?

☐☐☐☐☐☐ DOLLARS
(59-64)

which was grouped as "$100 or less" and "More than $100" intervals. Slightly more than one quarter of those responding indicated that they were spending less than $100 per year on the maintenance of their systems (Table A-21).

ANNCOST AVERAGE ANNUAL COST

```
     CODE
          I
       1. ******************* (     72)
          I  100 OR LESS
          I
          I
       2. **************************************************** (    199)
          I  MORE THAN 100
          I
          I
  999999. ************************** (    100)
(MISSING) I  BLANK
          I
          I.........I.........I.........I.........I.........I
          0        40        80       120       160       200
          FREQUENCY
```

VALID CASES 271 MISSING CASES 133

TABLE A-21

The master meter consumption data (Table A-22), grouped by intervals of 1,000 Mcf, showed approximately one half were using 8,000 Mcf or more per year of natural gas, which implies apartment complexes of 60 or more units each.

Q. **What was the consumption of natural gas for your system in 1978?**

☐☐☐☐☐ **Mcf (thousand cubic feet)**

(66-70)

The last question was especially important to the Project and the

R. **Are you aware of federal inspection requirements governing master meter distribution systems?**

☐ 1. YES ☐ 2. NO

(71)

data shows, in Table A-23, that 75% of the respondents were aware of federal inspection requirements.

A. 5 CONTINGENCY ANALYSIS

By extending the descriptive statistics, the study investigated the presence of certain cause/effect relationships in the responses of master meter operators. These cause/effect relationships can be established through the use of a statistical technique known as contingency analysis. Examples of potential cause/effect

```
CONSUMPT  CONSUMPTION OF GAS

      CODE
           I
        1. ********** (      37)
           I   1-1000
           I
           I
        2. ****** (      18)
           I   1001-2000
           I
           I
        3. ****** (      20)
           I   2001-3000
           I
           I
        4. **** (      10)
           I   3001-4000
           I
           I
        5. ***** (      17)
           I   4001-5000
           I
           I
        6. **** (      12)
           I   5001-6000
           I
           I
        7. ** (       4)
           I   6001-7000
           I
           I
        8. *** (       6)
           I   7001-8000
           I
           I
        9. ************************ ******** *(     129)
           I   8001-HIGHEST
           I
           I
  999999.. ******************************** (     118)
 (MISSING) I   BLANK
           I
           I.........I.........I.........I.........I.........I
           0        40        80       120       160       200
           FREQUENCY

VALID CASES     253      MISSING CASES    118
```

TABLE A-22

FEDINSP AWARE OF INSPECTION REQUIREMENTS

```
     CODE
          I
       1. **************************** (   267)
          I   YES
          I
          I
       2. ********** (     89)
          I   NO
          I
          I
       9. *** (     15)
(MISSING) I   BLANK
          I
          I.........I.........I.........I.........I.........I
          0        100       200       300       400       500
          FREQUENCY
```

VALID CASES 356 MISSING CASES 15

TABLE **A-23**

relationships examined are the following: (1) Did type of corrosion prevention affect the likelihood of leaks? **(2)** Did knowledge of Federal inspection requirements reduce the likelihood of leaks? (3) Was the likelihood of leaks affected by who installed the systems? These and other questions were studied via the contingency analysis approach.

Before presenting the results of the analysis, a brief description of the concept of contingency tables is presented. Those wishing to pursue the topic further may refer to a variety of statistics texts.

A.5.1 Methodology of Contingency Tables

Quite often, one is interested in determining how responses to one question will affect responses to another question. For example, is the fraction of people who exercise less likely to be overweight than the fraction of people who do not exercise. These two questions, posed as 1.) Do you exercise? and **2.)** Are you overweight? might have been posed to 200 people. Four possible combinations of answers exist: a) Exercise, not overweight: b) Exercise, overweight: c) Don't exercise, not overweight; and d) Don't exercise, overweiqht. Results of posing these two questions might take the form as presented in Table **A-24.**

TABLE A-24

EXAMPLE OF CONTINGENCY TABLE

SHOWING EFFECT OF EXERCISE ON OBESITY - SAMPLE OF 200 PEOPLE

COUNT / TOTAL PERCENT		ARE YOU OVERWEIGHT? YES	NO	ROW TOTAL
DO YOU EXERCISE?	YES	24 12.0%	66 33.0%	90 45.0%
	NO	96 48.0%	14 7.0%	110 55.0%
COLUMN TOTAL		120 60.0%	80 40.0%	200 100.0%

As can be seen by the table, 24 out of 90 people who exercise are overweight, whereas 96 out of 110 who do not exercise are overweight. Clearly, the fraction who exercise are less likely to be overweight than those who do not exercise at all. Statistically, this can be tested through the use of a statistic known as χ^2 (read chi-square). This statistic compares the observed frequency in each of the four cells in Table A-24 to the expected frequency as follows:

$$\chi^2 = \sum_{i=1}^{2} \sum_{j=1}^{2} \frac{(f_{\text{observed}_{ij}} - f_{\text{expected}_{ij}})^2}{f_{\text{expected}_{ij}}} \qquad (1)$$

The expected frequency is the number of observations in each cell expected if the attributes of exercise and overweight are independent of each other. Computation of expected frequency for each cell is simply the row total for that cell multiplied by the column total for that cell divided by the total number of observations in all 4 cells. In this example, the four observed cell frequencies were 24, 66, 96 and 14. The expected frequencies corresponding to these are:

$$\frac{(90)\ (120)}{200} = 54, \quad \frac{(90)\ (80)}{200} = 36,$$

$$\frac{(110)\ (120)}{200} = 66, \quad \frac{(110)\ (80)}{200} = 44.$$

Hence, if level of exercise and obesity are independent of each other, the fraction of people who exercise that are overweight should be no different than the fraction of people who do not exercise who are overweight. For this example, the χ^2 value is:

$$\chi^2 = \frac{(24-54)^2}{54} + \frac{(66-36)^2}{36} + \frac{(96-66)^2}{66} + \frac{(14-44)^2}{44} = 75.76 \qquad (2)$$

The value of **75.76** can be compared to a reference level and a significance can be assigned. In general, the larger the value of χ^2, the smaller the significance level. In this example, the significance would be essentially 0.000. This indicates that if these two characteristics, exercise and obesity, are truly independent of each other, then there would be almost zero chance of obtaining a sample of data as divergent as that obtained. Therefore, we would conclude that these two characteristics are related to each other and thus, reject the hypothesis of independence. In general the smaller the significance level, the stronger is the relationship between the two variables, i.e., less likely that the results occurred due to chance.

One additional factor to know is the degrees of freedom. This number is simply the product of one less than the number of rows and one less than the number of columns ((R-1).(C-1) where R = number of rows, C = number of columns). The larger the number of degrees of freedom means the larger the χ^2 value required to reject the notion of independence. In this example, both questions are of the yes/no variety indicating that the number of degrees of freedom is simply (2-1)•(2-1) or 1. Many of the questions studied will have different degrees of freedom.

A.5.2 Leaks/Safety Considerations Vs. Potential Cause/Effect Variables

This subsection addresses what impact certain variables had on the likelihood of gas leaks. Included in this discussion are variables such as geography, type of master meter installation, age of system and type of protection.

- What Effect Did Geographic Location Have on Leak History?

Table **A-25** shows the contingency table for leak history versus geographic location. As can be seen from the table, master meter systems in the Southern and Southwest region had a significantly higher incidence of leaks as compared to the other three regions. Approximately half of thesystemsin those two regions have had a recent history of leaks while less than 40% in the East, 308 in the Central and less than **25%** in the West experienced leaks. These differences can be considered significant as shown by the χ^2 value of 25.03.

This observation, however, can be explained by other factors such as age, type of system, etc. The higher leak incidence in the South and Southwest does not mean that these two regions are

TABLE A-25 - EFFECT OF GEOGRAPHIC LOCATION ON

GAS PIPELINE LEAKS IN MASTER METER DISTRIBUTION SYSTEMS

DOT REGIONS	COUNT TOTAL PERCENT	YES	NO	ROW TOTAL
	EASTERN	12 3.2%	20 5.4%	32 8.6%
	SOUTHERN	79 21.3%	80 21.6%	159 42.9%
	CENTRAL	18 4.9%	43 11.6%	61 16.5%
	SOUTHWEST	21 5.6%	17 4.6%	38 10.2%
	WEST	17 4.6%	64 17.2%	81 21.8%
	COLUMN TOTAL	147 39.6%	224 60.4%	371 100.0%

χ^2 = 25.03 Degrees Freedom = 4 Significance = <.001

inherently more susceptible to leaks, but simply that within the sample of systems examined, these two regions showed a higher rate of leaks.

- What Effect Did Leak History Have on Willingness for Utility Takeover of Pipeline System?

Intuitively, it was felt that those operators who had a history of gas leaks were far more likely to desire the utility companies to take over their pipeline system than those without a leak history. As seen by Table **A-26**, however, this was not the case: 112 out of **142**, or **79%** of the operators with a leak history desired the takeover **as** compared to **156** out of **209**, or **75%** of those without a leak history who desired takeover. The χ^2 value of **.62** and significance of .43 indicated that although a slight difference between expected and observed frequencies occurred, it was not large enough to conclude that this leak history caused the desire for utility takeover.

(Note that for 2x2 contingency tables, the SPSS system computes a modified "corrected" chi-square value which is slightly different from that shown in equation (1).)

In otherwords, master meter operators want to be relieved of the burden of safety responsibility, regardless of past experiences, good or bad. The fear of safety hazard alone, together with the

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* * * * * * * * * * * * * * * * * * * *   C R O S S T A B U L A T I O N   O F   * * * * * * * * * * * * * * * * * * *
    LEAKS     NUMBER OF LEAKS                                  BY  ASSUME     ASSUME THE SAFETY RESPONSIBILITY
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  PAGE 1 OF 1

                     ASSUME
             COUNT  I
             TOT PCT IYES        NO          ROW
                    I                        TOTAL
                    I       1.I       2.I
LEAKS        --------I--------I--------I
                 1.  I   112  I    30  I   142
  YES                I  31.9  I   8.5  I  40.5
                    -I--------I--------I
                 2.  I   156  I    53  I   209
  NO                 I  44.4  I  15.1  I  59.5
                    -I--------I--------I
             COLUMN     268        83      351
              TOTAL    76.4      23.6    100.0
```

CORRECTED CHI SQUARE = 0.62074 WITH 1 DEGREE OF FREEDOM SIGNIFICANCE = 0.4308
PHI = 0.04888
CONTINGENCY COEFFICIENT = 0.04883
LAMBDA (ASYMMETRIC) = 0.0 WITH LEAKS DEPENDENT. = 0.0 WITH ASSUME DEPENDENT.
LAMBDA (SYMMETRIC) = 0.0
OUCERTAINTX QEPPICIENT (ASYMMETRIC) = 0.00179 PITE LEAKS DEPENDENT. = 0.00220 WITH ASSUME DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.00197

NUMBER OF MISSING OBSERVATIONS = 20

TABLE A-26

lack of knowledge of pipeline safety in many instances, creates this situation.

- <u>What Effect Did Knowledge of Federal Inspection Requirements Have on Leak History?</u>

This investigation resulted in a complete reversal of what had been anticipated. It was felt that those operators with knowledge of Federal inspection requirements had a lower incidence of leaks than those unknowledgeable about the inspection requirements. As Table A-27 shows, however, those systems whose operators were knowledgeable about inspection requirements had a far greater incidence (136 out of 267 or 51%) of leaks than those operators unknowledgeable about the requirements (10 out of 89 or 11%). This result indicated, with extremely high confidence, that 1) a majority of those operators who had leaks became aware of inspection requirements <u>after</u> the leaks occurred and 2) those operators who did not have knowledge of inspection requirements lack the knowledge primarily because they have not had leaks. Only after the presence of leaks did the operators attempt to educate themselves about Federal inspection requirements. Until that time, it appeared that concern about these requirements was low.

- <u>What Effect Did Type of Master Meter System Have on Leak History?</u>

Using the SIC Codes as defined in Exhibit A-1, the impact of type of master meter system on leak history was examined..

```
* * * * * * * * * * * * * * * * * * *   C R O S S T A B U L A T I O N   O F   * * * * * * * * * * * * * * * * * * *
   LEAKS     NUMBER OF LEAKS                                          BY  FEDINSP    [illegible] OF INSPECTION REQUIREMENTS
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  PAGE 1 OF 1

                   FEDINSP
            COUNT  I
          TOT PCT  IYES      NO        ROW
                   I                   TOTAL
                   I     1.I      2.I
LEAKS     ---------I--------I--------I
              1.   I   136  I    10  I   146
  YES              I  38.2  I   2.8  I  41.0
                  -I--------I--------I
              2.   I   131  I    79  I   210
  NO               I  36.8  I  22.2  I  59.0
                  -I--------I--------I
           COLUMN     267       89       356
            TOTAL    75.0     25.0     100.0

CORRECTED CHI SQUARE =    41.86230     WITH 1 DEGREE OF FREEDOM   SIGNIFICANCE =  0.0000
PHI =    0.38951
CONTINGENCY COEFFICIENT =    0.32994
LAMBDA (ASYMMETRIC) =  0.03425 WITH LEAKS     DEPENDENT.          =  0.0      WITH FEDINSP  DEPENDENT.
LAMBDA (SYMMETRIC) =  0.02128
UNCERTAINTY COEFFICIENT (ASYMMETRIC) =  0.10240 WITH LEAKS     DEPENDENT.          =  0.12326 WITH FEDINSP  DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) =  0.11187

NUMBER OF MISSING OBSERVATIONS =        15
```

TABLE A-27

Unfortunately, the sample of master meter data did not provide sufficient numbers within each SIC code category beyond **6513** (Housing Authorities) and **6515** (Mobile Home Sites). However, as compared to all other categories taken together, two observations can be made regarding Apartment Building/Housing Authorities and Mobile Home Sites. First, as shown in Table A-28, **112** out of **251**, or **45% of** category **6513** had a leak history compared to **20** out of **55**, or **36%** of all other categories excluding Housing Authorities and Mobile Home Sites. Second, and more interesting, is that only **15** out of **65**, or **23%** of the Mobile Home Sites had a leak history. The other categories had too small a sample to make inferences individually and thus could only be addressed collectively.

- <u>What Effect Did Age Have on Leak History?</u>

Table A-29 shows that pipeline system age did affect the incidence of leaks, as anticipated. However, the effect of age was more pronounced for relatively new systems. Systems less than **5** years old showed a **22%** incidence **of** leaks. Systems **5-15** years old showed a 40% incidence of leaks. Beyond **15** years of age, however, the incidence of leaks was **43%**, not significantly greater than the **5-15** year group.

* * * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * * * * * * * * * * * * * * * *
SIC STANDARD INDUSTRIAL CLASSIFICATION BY LEAKS NUMBER OF LEAKS
* PAGE 2 OF 2

SIC	COUNT / TOT PCT	LEAKS YES 1.	NO 2.	ROW TOTAL
821.	COUNT	0	1	1
	TOT PCT	0.0	0.3	0.3
3295.	COUNT	1	0	1
	TOT PCT	0.3	0.0	0.3
3334.	COUNT	1	0	1
	TOT PCT	0.3	0.0	0.3
3728.	COUNT	1	0	1
	TOT PCT	0.3	0.0	0.3
3999.	COUNT	0	2	2
	TOT PCT	0.0	0.5	0.5
4582.	COUNT	2	0	2
	TOT PCT	0.5	0.0	0.5
4932.	COUNT	2	0	2
	TOT PCT	0.5	0.0	0.5
6513.	COUNT	112	139	251
	TOT PCT	30.2	37.5	67.7
6515.	COUNT	15	50	65
	TOT PCT	4.0	13.5	17.5
6531.	COUNT	3	5	8
	TOT PCT	0.8	1.3	2.2
7011.	COUNT	0	7	7
	TOT PCT	0.0	1.9	1.9
7349.	COUNT	1	0	1
	TOT PCT	0.3	0.0	0.3
7391.	COUNT	0	1	1
	TOT PCT	0.0	0.3	0.3
7996.	COUNT	0	1	1
	TOT PCT	0.0	0.3	0.3
8059.	COUNT	0	1	1
	TOT PCT	0.0	0.3	0.3
8062.	COUNT	2	1	3
	TOT PCT	0.5	0.3	0.8
8211.	COUNT	1	5	6
	TOT PCT	0.3	1.3	1.6
8221.	COUNT	5	7	12
	TOT PCT	1.3	1.9	3.2
8411.	COUNT	1	0	1
	TOT PCT	0.3	0.0	0.3
8421.	COUNT	0	2	2
	TOT PCT	0.0	0.5	0.5
8661.	COUNT	0	2	2
	TOT PCT	0.0	0.5	0.5
COLUMN TOTAL		147	224	371
		39.6	60.4	100.0

CHI SQUARE = 37.20522 WITH 23 DEGREES OF FREEDOM SIGNIFICANCE = 0.0111
CRAMER'S V = 0.31668
CONTINGENCY COEFFICIENT = 0.30190
LAMBDA (ASYMMETRIC) = 0.0 WITH SIC DEPENDENT. = 3.36833 WITH LEAKS DEPENDENT.
LAMBDA (SYMMETRIC) = 0.03745
UNCERTAINTY COEFFICIENT (ASYMMETRIC) = 0-05139 WITH SIC DEPENDENT. = 0.09399 WITH LEAKS DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.06645

TABLE A-28

CAMERA READY COPY
FILE NN (CRBATIOB DATE = 06/12/79) DISTRIBUTED INSTRUMENT

* * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * * * * * * * * * * * * * * * *
INSTIN SYSTEM WAS INSTALLED IN BY LEAKS NUMBER OF LEAKS
* PAGE 1 OF 1

INSTIN	LEAKS COUNT TOT PCT	YES 1.	NO 2.	ROW TOTAL
15 IRS OR OLDER	1.	63 17.9	84 23.9	147 41.9
5-15 IRS OLD	2.	68 19.4	133 28.5	168 47.9
LESS THAN 5 YRS	3.	8 2.3	28 8.0	36 10.3
	COLUMN TOTAL	139 39.6	212 60.4	351 100.0

CAI SQUARE = 5.25116 WITH 2 DEGREES OF FREEDOM SIGNIPICANCE = 0.0724
CRAMER'S V = 0.12231
CONTINGENCY COEFFICIENT = 0.12141
LAMBDA (ASYMMETRIC) = 0.0 WITH INSTIB DEPENDENT. = 0.0 UITB LEAKS DEPENDENT.
LAMBDA (SYMMETRIC) = 0.0
UNCERTAINTY COEFFICIENT (ASYMMETRIC) = 0.00842 WITH INSTIN DEPENDENT. = 0.01192 WITH LEAKS DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.00987

NUMBER OF EISSING OBSEEVATIONS = 23

TABLE A-29

This phenomena indicated that the older systems (15 years or greater) were repaired, so as to reduce the risk of leaks to the level of systems 5-15 years old. However, the repairs never returned the system to "like new" status.

- <u>What Effect Did Installer of System Have on Leak History?</u>

Table A-30 shows that installer of the system had an impact on the incidence of leaks, but at the .12 level of significance. This was strong enough to perceive differences but not strong enough to completely reject independence of leak history and installer of system. From the table, it can be seen that those systems installed by developers possessed a higher incidence of leaks than those installed by utility companies or even local plumbing contractors. Systems installed by gas pipeline contractors also had a lower leak incidence than developer installed systems. No meaningful observations could be made from the little data for owners' maintenance crew nor for the line item pertaining to multiple installers of the system.

- <u>What Effect Did Type of Corrosion Protection Have on Leak History?</u>

This'question also resulted in a reversal of what had been anticipated. It was expected that systems with little or no corrosion protection would have had a significantly higher incidence of leaks than cathodically protected systems. Table A-31 shows

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FILE NE (CREATION DATE = 06/12/79) DISTRIBUTED INSTRUMENT

* * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * * * * * * * * * * * * * * * *
INSTBY SYSTEM WAS INSTALLED BY BY LEAKS NUMBER OF LEAKS
* PAGE 1 OF 1

INSTBY (COUNT / TOT PCT)	LEAKS: YES 1.	NO 2.	ROW TOTAL
1. OWNERS MAINTENAN	3	6	9
	0.8	1.6	2.5
2. LOCAL PLUMBING C	14	30	44
	3.8	8.[illegible]	12.1
3. DEVELOPER	42	46	88
	11.5	12.6	24.1
4. UTILITY COMPANY	40	82	122
	11.0	22.5	33.4
5. GAS PIPELINE CON	18	26	44
	4.9	7.1	12.1
6. MORE THAN ONE OF	29	29	58
	7.9	7.9	15.9
COLUMN TOTAL	146	219	365
	40.0	60.0	100.0

CHI SQUARE = 8.65995 WITH 5 DEGREES OF FREEDOM SIGNIFICANCE = 0.1234
CRAMER'S V = 0.15403
CONTINGENCY COEFFICIENT = 0.15224
LAMBDA (ASYMMETRIC) = 0.00823 WITH INSTBY DEPENDENT. = 0.0 WITH LEAKS DEPENDENT.
LAMBDA (SYMMETRIC) = 0.00514
UNCERTAINTY COEFFICIENT (ASYMMETRIC) = 0.00742 WITH INSTBY DEPENDENT. = 0.01766 WITH LEAKS DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.01045

NUMBER OF MISSING OBSERVATIONS = 6

TABLE A-30

CAMERA READY COPY
FILE MM (CREATION DATE = 06/12/79) DISTRIBUTED INSTRUMENT

* * * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * * * * * * * * * * * * * * * *
CORRPROT CORROSION PROTECTION TECHNIQUE BY LEAKS NUMBER OF LEAKS
* PAGE 1 OF 1

CORRPROT (COUNT / TOT PCT)	LEAKS: YES 1.	NO 2.	ROW TOTAL
1. CATHODIC PROTECT	110 30.5	112 31.0	222 61.5
2. VINYL COATED OR	10 2.8	14 3.9	24 6.6
3. COATED AND WRAPP	15 4.2	39 10.8	54 15.0
4. GALVANIZED	1 0.3	8 2.2	9 2.5
5. NONE	8 2.2	16 4.4	24 6.6
6. UNKNOWN	3 0.8	25 6.9	28 7.8
COLUMN TOTAL	147 40.7	214 59.3	361 100.0

CHI SQUARE = 25.18363 WITH 5 DEGREES OF FREEDOM SIGNIFICANCE = 0.333:
CRAMER'S V = 0.26411
CONTINGENCY COEFFICIENT = 0.25535
LAMBDA (ASYMMETRIC) = 0.0 WITH CORRPROT DEPENDENT. = 0.0 WITH LEAKS DEPENDENT.
LAMBDA (SYMMETRIC) = 0.0
UNCERTAINTY COEFFICIENT (ASYMMETRIC) = 0.03131 WITH CORRPROT DEPENDENT. = 5.39717 WITH LEAKS DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.04046

NUMBER OF MISSING OBSERVATIONS = 10

TABLE A-33

that type of protection did significantly affect likelihood of leaks. However, it also shows that nearly half (110 out of 222) of those systemswith cathodic protection had a history of leaks while only one third (8 out of 24) of those systems with no protection had a history of leaks. This of course did not imply that cathodic protection <u>caused</u> leaks. What it did indicate was that following a leak, operators ~~then~~ installed protection (e.g., coatings, plastic pipe, cathodic protection). If no leak had occurred, however, why implement protection? This appeared to be the logic of the operators in the sample and thus indicated that only by experiencing the leaks were any steps ever taken to protect previously unprotected piping.

Another indication of this is shown in Table A-32. Here it can be seen that type of protection in master meter systems was affected by age. The significance level of 0.0002 was reflected by the fact that systems 15 years or older tend to be cathodically protected to a greater extent than new systems. Almost 65% of systems 5 years or older were cathodically protected while fewer than 50% of newer systems were protected in this manner. In addition, the absence of any protection was less pronounced the older the system. This also points out that as the system got older, leaks occurred, and ultimately protection was implemented.

(CREATION DATE = 06/12/79) DISTRIBUTED INSTRUMENT

* * * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * * * * * * * * * * * * * * * *
INSTIN SYSTEM WAS INSTALLED IN BY CORRPROT CORROSION PROTECTION TECHNIQUE
* PAGE 1 OF 1

INSTIN (COUNT / TOT PCT)	CORRPROT: CATHODIC PROTECTED 1.	VINYL COATED OR 2.	COATED AND WRAPPED 3.	GALVANIZED 4.	NONE 5.	UNKNOWN 6.	ROW TOTAL
1. 15 YRS OR OLDER	92 26.9	2 0.6	31 9.1	3 0.9	11 3.2	7 2.0	146 42.7
2. 5-15 YRS OLD	106 31.0	19 5.6	17 5.0	3 0.9	9 2.6	8 2.3	162 47.4
3. LESS THAN 5 YRS	16 4.7	2 0.6	4 1.2	1 0.3	4 1.2	7 2.0	34 9.9
COLUMN TOTAL	214 62.6	23 6.7	52 15.2	7 2.0	24 7.0	22 6.4	342 100.0

CHI SQUARE = 33.50070 WITH 10 DEGREES OF FREEDOM SIGNIFICANCE = 0.0002
CRAMER'S V = 0.22131
CONTINGENCY COEFFICIENT = 0.29869
LAMBDA (ASYMMETRIC) = 0.08889 WITH INSTIN DEPENDENT. = 0.0 WITH CORRPROT DEPENDENT.
LAMBDA (SYMMETRIC) = 0.05195
UNCERTAINTY COEFFICIENT (ASYMMETRIC) = 0.04865 WITH INSTIN DEPENDENT. = 0.03826 WITH CORRPROT DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.04283

NUMBER OF MISSING OBSERVATIONS = 29

TABLE A-32

- Other Investigations

A number of other cross tabulations of responses were done as part of the analysis. Table A-33 shows that 197 out of 274, or 72% of those operators who could safely restore service following a shutdown desired the utility company in their area to takeover their distribution system. However, 62 out of 67, or 93% of those operators who could not restore service desired the utility company takeover. Both groups of operators indicated an unwillingness to continue bearing the responsibility for their systems, but the operators who could not restore service were even more desirous of the utility company takeover.

An interesting note is that it was not the cost of repairs which caused the operators to want this takeover. Table A-24 shows that 56 out of 71, or 79% of those operators expending less than $100 per year for repairs to their pipeline system wanted the utility company to take over the system. On the other hand, only 145 out of 197, or 74%, of those operators who spent more than $100 per year for repairs wanted the utility to takeover. This departure could be attributed to sampling deviations and indicated only that it was safety considerations, not cost considerations, that were causing master meter operators to desire the utility company takeover of their distribution systems.

CAMERA READY COPY
FILE   MM   (CREATION DATE = 06/12/79)   DISTRIBUTED INSTRUMENT

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* * * * * * * * * * * * * * * * * * *   C R O S S T A B U L A T I O N   O F   * * * * * * * * * * * * * * * * * *
   SAFREST   SAFELY RESTORE SERVICE                            BY  ASSUMP    ASSUME THE SAFETY RESPONSIBILITY
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  PAGE  1 OF  1

                      ASSUMP
              COUNT   I
            TOT PCT   IYES         NO          ROW
                      I                        TOTAL
                      I       1.I       2.I
SAFREST      ---------I---------I---------I
                 1.   I   197   I    77   I    274
  YES                 I  57.8   I  22.6   I   80.4
                     -I---------I---------I
                 2.   I    62   I     5   I     67
  NO                  I  18.2   I   1.5   I   19.6
                     -I---------I---------I
             COLUMN       259        82        341
              TOTAL      76.0      24.0      100.0

CORRECTED CHI SQUARE =     11.45175      WITH 1 DEGREE OF FREEDOM    SIGNIFICANCE =  0.0007
PHI =      0.19189
CONTINGENCY COEFFICIENT =      0.18845
LAMBDA (ASYMMETRIC) =  0.0      WITH SAFREST  DEPENDENT.           =  0.0     WITH ASSUMP   DEPENDENT.
LAMBDA (SYMMETRIC)  =  0.0
UNCERTAINTY COEFFICIENT (ASYMMETRIC) =  0.04483 WITH SAFREST  DEPENDENT.          =  0.04032 WITH ASSUME   DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) =  0.04246

NUMBER OF MISSING OBSERVATIONS =      30
```

TABLE A-[illegible]

* * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * * * * * * * * * * * * * * *
ASSUME ASSUME THE SAFETY RESPONSIBILITY BY ANNCOST AVERAGE ANNUAL COST
* PAGE 1 OF 1

ASSUME	COUNT / TOT PCT	ANNCOST: 100 OR LESS (1.)	MORE THAN 100 (2.)	ROW TOTAL
YES	1.	56	145	201
		20.9	54.1	75.0
NO	2.	15	52	67
		5.6	19.4	25.0
	COLUMN TOTAL	71	197	268
		26.5	73.5	100.0

CORRECTED CHI SQUARE = 0.51739 WITH 1 DEGREE OF FREEDOM SIGNIFICANCE = 0.4720
PHI = 0.05370
CONTINGENCY COEFFICIENT = 0.05362
LAMBDA (ASYMMETRIC) = 0.0 WITH ASSUME DEPENDENT. = 0.0 WITH ANNCOST DEPENDENT.
LAMBDA (SYMMETRIC) = 0.0
UNCERTAINTY COEFFICIENT (ASYMMETRIC) = 0.00263 WITH ASSUME DEPENDENT. = 0.00256 WITH ANNCOST DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.00259

NUMBER OF MISSING OBSERVATIONS = 103

TABLE A-34

The two final contingency tables shown provide further indications as to how simple lack of knowledge about inspection requirements has contributed to the safety problems in master meter systems. Table A-35 shows that 254 out of 267, or 95%, of operators who were aware of inspection requirements have in fact had a recent inspection. Only 52 out of 89, or 58% of operators unaware of inspection requirements have had a recent inspection. The χ^2 value of 71.5 indicates this as extremely significant (low significance level).

Similarly, Table A-36 shows that 247 out of 267, or 93%, of operators aware of Federal inspection requirements have had a leak survey while only 53 out of 89 or 60%, of those unaware of inspection requirements had a recent leak survey. This data is also extremely significant in pointing out that knowledge by master meter operators of these requirements contributed greatly to the actual implementation of periodic systems inspections and leak surveys.

A.6 SUMMARY

As indicated in Chapter 6, extrapolating the results of the analysis of returned master meter survey instruments could generate inaccuracies regarding the characteristics of master meter systems nationwide. Despite this, however, the observations which follow do serve as indicators about the master meter population.

* * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * * * * * * * * * * * * * * * *
INSPECT LAST SYSTEM INSPECTION BY FEDINSP AWARE OF INSPECTION REQUIREMENTS
* PAGE 1 OF 1

INSPECT	FEDINSP COUNT / TOT PCT	YES 1.	NO 2.	ROW TOTAL
YES	1.	254	52	306
		71.3	14.6	86.0
NO	2.	13	37	50
		3.7	10.4	14.0
	COLUMN TOTAL	267	89	356
		75.0	25.0	100.0

CORRECTED CHI SQUARE = 71.47914 WITH 1 DEGREE OF FREEDOM SIGNIFICANCE = 0.0000
PHI = 0.45722
CONTINGENCY COEFFICIENT = 0.41597
LAMBDA (ASYMMETRIC) = 0.0 WITH INSPECT DEPENDENT. = 0.26966 WITH FEDINSP DEPENDENT.
LAMBDA (SYMMETRIC) = 0.17266
UNCERTAINTY COEFFICIENT (ASYMMETRIC) = 0.22200 WITH INSPECT DEPENDENT. = 0.16019 WITH FEDINSP DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.18610

NUMBER OF MISSING OBSERVATIONS = 15

TABLE A-25

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CAMERA READY COPY
FILE  MM        (CREATION DATE = 06/12/79)    DISTRIBUTED INSTRUMENT

* * * * * * * * * * * * * * * * * * *   C R O S S T A B U L A T I O N   O F   * * * * * * * * * * * * * * * * * * *
   SURVEY    LAST SYSTEM LEAK SURVEY                           BY  FEDINSP   AWARE OF INSPECTION REQUIREMENTS
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  PAGE  1 OF  1

                         FEDINSP
                COUNT  I
              TOT PCT  IYES      NO         ROW
                       I                    TOTAL
                       I      1.I      2.I
SURVEY        ---------I--------I--------I
                   1.  I   247  I   53  I   300
  YES                  I  69.4  I  14.9 I  84.3
                      -I--------I--------I
                   2.  I    20  I   36  I    56
  NO                   I   5.6  I  10.1 I  15.7
                      -I--------I--------I
              COLUMN      267       89      356
               TOTAL      75.0     25.0    100.0

CORRECTED CHI SQUARE =    52.24152      WITH 1 DEGREE OF FREEDOM   SIGNIFICANCE =  0.0000
PHI =    0.39198
CONTINGENCY COEFFICIENT =    0.36495
LAMBDA (ASYMMETRIC) =  0.0    WITH SURVEY   DEPENDENT.          =  0.17978 WITH FEDINSP  DEPENDENT.
LAMBDA (SYMMETRIC) =  0.11034
UNCERTAINTY COEFFICIENT (ASYMMETRIC) =  0.15364 WITH SURVEY   DEPENDENT.          =  0.11890 WITH FEDINSP  DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) =  0.13406

NUMBER OF MISSING OBSERVATIONS =      15
```

TABLE A-36

A.6.1 Characteristics of Master Meter Systems

1. From the responses tabulated, 67% of the master meter systems nationally are residential apartment buildings/housing authorities, 18% are mobile home parks, 3% are colleges/universities and 2% are commercial hotels, tourist courts, and motels. The remaining 10% include shopping centers, hospital complexes, industrial and other commercial etablishments.

2. The typical master meter system serves between 10 and 25 buildings/lots each.

3. The average master meter system is approximately 16 years old, with 9% of all systems installed before 1950 and 36% of all systems installed after 1968.

4. Only one third of the sample of master meter systems were installed by utility companies, with nearly 40% installed by developers, local plumbing contractors, or owners' maintenance crews.

5. The primary material used in master meter systems was steel (84% of systems). Plastic was used in another 10% of the systems sampled.

6. Slightly over 60% of the master meter systems sampled use cathodic protection as the primary corrosion protection technique. Fewer than 7% of the systems have no protection whatsoever.

7. Nearly **80%** of the master meter owners/operators responding own 1000 feet or more of buried piping in their distribution system.

8. 80% of the sampled master meter systems can safely restore service following an emergency shutdown and **83%** can perform this shutdown.

9. **40%** of the sampled master meter systems reported leaks after the most recent survey. In 27% of the cases, the leaks were deemed hazardous and repaired immediately.

10. Fifty percent of master meter systems in the Southern and Southwest regions have experienced leaks as compared to 27% of those systems in the Eastern, Central and Western Regions.

11. Repairs of leaks were done by utility companies in 30% of the cases and by gas pipeline/local plumbing contractors, and owners' maintenance crews in over half the cases.

12. Three fourths of the master meter owners are aware of Federal inspection requirements.

13. 76% of the master meter owners sampled desire the utility company which serves them to assume the safety responsibility of their pipeline system and nearly half of these want the utility to ultimately take over the ownership of the system.

A.6.2 Causative Factors Affecting Safety Problems in Master Meter Systems

After additional analysis of the data received, on-site observations conducted, and expert jugement available, a number of observations surfaced regarding master meter systems and safety issues associated with these systems. These included the following:

1. The desire of master meter system owners for utility company takeover of the safety responsibility for their pipeline system was not related to any previous leak history or repair costs associated with these leaks. Rather, it was driven by the safety hazards associated with owner maintained pipeline systems.

2. Master metered apartments/housing authorities had a higher incidence of leaks and mobile home parks had a lower incidence of leaks than the rest of the master meter population. This, however, could be attributed to greater and lesser frequency of inspections/leak surveys.

3. Newer systems had a significantly lower incidence of leaks than systems 5 - 15 years of age. Systems 15 years or older, however, did not have a significantly higher incidence of leaks than the 5 - 15 year group, due primarily to implementation of corrosion protection techniques <u>after</u> discovery of leaks.

4. Those master metered systems installed by developers had a significantly higher incidence of leaks than systems installed by utility companies and local plumbing contractors.

5. Cathodic protection for many master metered systems tended to be implemented <u>after</u> discovery of leaks rather than as a preventative against leaks.

6. Knowledge of Federal inspection requirements also tended to be acquired only <u>after</u> discovery of leaks.

7. A primary inspection mechanism for master meter systems wasoperator detection and gas utility response to calls from operators who smelled gas or utility inspection when new clients took over old systems.

8. Plaster meter system operators and owners were often unaware of the degree of hazard in their systems, of the condition or design of the system, or of the nature of the existing gas pipeline safety regulations and their responsibilities in meeting these regulations.

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