A UTAH UTILITY ADDRESSES SEISMIC HAZARDS

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SUMMARY

In 1980, Mountain Fuel Supply Company began researching and correlating data to determine what types of piping damage could be expected for various intensities of earthquakes, referencing this work to the Modified Mercalli intensity scale. This, coupled with predicted magnitudes for future earthquakes, has enabled the Company to estimate how the piping system might respond under various situations.

This paper presents these findings, along with the various ways we are designing and operating our system to minimize the impact of a major earthquake.

INTRODUCTION

The State of Utah has long been recognized as an active seismic area, primarily due to the existence of the Wasatch Fault. This feature lays in a north-south direction for a distance of approximately 230 miles between Malad, Idaho and Gunnison, Utah (Figure I).

A predominant visual feature associated with this fault is the Wasatch Mountain Range, which rises immediately to the east. These mountains were formed through fault displacement.

Although the state's population is small (approximately 1.5 million people), approximately 80% of this population, along with most of the urban centers, are situated directly adjacent to the Wasatch Mountains and fault.

Mountain Fuel Supply Company is a diversified energy company, headquartered in Salt Lake City, Utah, and involved in the production, transmission, and distribution of natural gas in Utah and southwest Wyoming. Because of availability and favorable pricing, natural gas continues to be the preferred space and water heating fuel for the majority of residential and commercial customers within our service area. Within the state of Utah this equates to 6,200 miles of distribution pipe and approximately 341,300 service lines bringing gas to 393,800 customers.

In 1980, the Company began a study to identify three major points:

1) What is the maximum earthquake that is expected within our service area?

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2) How would an earthquake of given magnitude or intensity affect the gas distribution system?

3) What design practices does Mountain Fuel Supply currently have to minimize possible damage?

MAXIMUM EXPECTED EARTHQUAKE

Since the coming of the first permanent white settlers in 1847, the greatest earthquakes associated with the Wasatch Fault have been magnitude 5.5 (intensity VII) events, the most recent in 1914. Utah has, however, experienced earthquakes of up to magnitude 6.5 in historic times, although these apparently have not been associated with the Wasatch Fault. Seismologists feel that the maximum earthquake expected in the region could be magnitude 7.5 (Ref.1).

Estimating recurrence intervals is extremely difficult. Methods used by the experts have included extrapolating existing records of smaller magnitude events and more recently, trenching across the fault to measure actual fault movement.

Results have varied greatly. For example, five recent studies produced the following range of recurrence intervals for earthquakes of given Modified Mercalli Intensities: VII - 21 to 54 years; VIII - 41 to 667 years; IX - 50 to 667 years; X - 387 to 1266 years.

The fact that at least 6.5 magnitude earthquakes are possible along the Wasatch Fault has been confirmed by the trenching work. This has indicated a high probability of a 6.5 magnitude earthquake, somewhere along the Wasatch Fault, during the next 50 years (Ref. 2). Seismic gaps, identified by the University of Utah, between Brigham City and North Salt Lake; and from South Salt Lake to Provo, give additional concern for the safety of people, and protection of property within these areas.

EARTHQUAKE EFFECTS

Much has been written on the effects to structures due to damaging earthquakes. Significantly less, however, is recorded on damage to underground piping systems. This, perhaps, is partly due to the damage being less visually obvious and thus, only fully realized by the pipeline operators involved.

While considerable work has been done at the university level on theoretical design of piping systems subject to seismic effects, this has had limited application to real world conditions and thus, when we first asked the question of how an earthquake would affect our pipeline facilities, no immediate answers presented itself except for one report, published in 1978, which stated that a 7.5 magnitude earthquake on the Wasatch Fault might cause 380 breaks in the gas network (Ref. 3).

An extensive literature survey has, however, enabled us to find more of the answers. Pipe damage data from ten earthquakes, that occurred in various parts of the world, was obtained. These include damage to water systems, which we felt were relevant since the cast and ductile iron often used in these systems are analogous to the cast iron gas systems still in use in many areas.

The results were as follows:

For Modified Mercalli intensities of VI or less - roughly equivalent to Richter magnitude 5 and below - we probably would experience no failures within the gas system.

At intensity VII, and a magnitude in the 6 range, some cast iron damage might be anticipated, probably in the smaller pipe sizes or at cemented joints.

At intensity VIII, equivalent to approximately 6.5 magnitude, significant cast iron damage might occur, plus possible damage to outside metering equipment hit by falling brick veneer or weak masonry construction. Possibly some damage might occur in older, small diameter steel pipe. Within structures, damage caused by falling gas water heaters might be expected.

At intensity IX, at a magnitude around 7 to 7.5, we would anticipate some damage to our steel piping network, probably at points of ground cracking or faulting and damage to metering equipment due to falling masonry.

At intensities above IX, significant damage to steel pipelines is possible resulting in the system being placed out of service.

Appendix I lists the background data utilized.

CURRENT DESIGN AND OPERATING PRACTICES

While a realistic awareness of seismic risk and potential facility damage is imperative, even more important are the steps being taken to minimize that damage. We at Mountain Fuel Supply are taking a number of steps in that direction:

1) We have an active cast iron pipe retirement program. Cast iron, most of it installed during the first quarter of the 20th century, is acknowledged to be the most brittle of the various materials used in gas piping systems, and thus the most vulnerable to seismic related damage (Ref. 4). We currently have approximately 140 miles remaining within our system (2% of total system). Since 1977 we have been retiring an average of 11 miles per year and plan to continue at approximately this rate until all is removed from service.

2) Mountain Fuel Supply has 3728 miles of steel distribution mains (operating below 60 psig) plus 479 miles of high pressure feeder lines within Utah. While this material is extremely strong, the one drawback

of steel pipe is that it will corrode if not properly cathodically protected. This can lead to reduction in pipe wall thickness and strength and eventual leakage. In an earthquake, this can result in increased failure rates such as occurred during the 1976 Tangshan earthquake (Ref. 5).

We maintain a corrosion control department where nine members have the responsibility of monitoring pipelines for corrosion and either electrically protecting the facility or, if corrosion induced leakage is suspected, recommending replacement.

3) A significant decision was made approximately twelve years ago when we decided to utilize polyethylene pipe in our distribution system. We use this in all new distribution system installations of 1/2" through 6". Thirty-seven percent of our system is currently polyethylene. This type of plastic is very ductile and is the best material available to withstand deflections resulting from ground movement. Additionally, during construction we "rope" the pipe from one side of the trench to the other, to realize its ability to withstand longitudinal stress.

4) We maintain a very extensive valve system (over 550 valves within the Salt Lake area alone), which in case of emergency, could isolate our distribution system into areas containing approximately 5,000 customers. The location and details of these valves are maintained in emergency valve books, which are available to key personnel within the Company.

5) We maintain a redundant system, with many interconnections to more than one gas feed into a particular area.

6) We warehouse an ample supply of spare fittings and pipe. This is an imperative safety requirement in the gas industry.

7) We maintain continually updated maps which show, in detail, all of our subsurface piping. On copies of these we have attempted to locate all the known earthquake faults to aid us in placing emergency shutoff valves.

8) Much of our pressure reduction equipment is housed in above ground structures. In past years, these buildings were made of brick and stucco. Current design now calls for the use of steel buildings. Besides being economical in cost, they also provide superior shear strength. Since damage to pressure regulating equipment by falling masonry could seriously impair our ability to maintain or restore gas service after an earthquake, these new structures are an important part of our earthquake mitigation program.

9) We have attempted to inform the public, through talks to community groups and through a recent pamphlet, about the things Mountain Fuel is doing regarding earthquake mitigation and what they, as homeowners, can do to minimize hazards in their homes.

10) We maintain a written emergency plan dealing with our response to all types of emergencies. Employees are kept aware of their emergency responsibilities.

11) Finally, through attendance at engineering seminars, membership in appropriate technical societies and continual review of earthquake related literature, we attempt to glean as much knowledge as possible on how to make our piping system as seismically safe as possible.

In 1980, the American Society of Mechanical Engineers published a survey of 114 North American gas companies regarding the seismic resistance of buried gas pipelines. One of their conclusions was that...

> "Very few utilities, particularly in the Western United States, perceive that seismic risk is important enough to justify changes in the material, coupling and in backfill procedure for newly installed pipes; or even to replace some old cast iron pipes with welded steel and/or plastic-heat fusion pipes....There is no common course of action for upgrading the seismic performance of systems." (Ref. 4)

I am pleased that Mountain Fuel Supply Company does not fit this description. Our seismic safety philosophy continues to be that:

1) A certain seismic risk exists in our geographic area. That risk must be acknowledged.

2) As a major utility, we owe it both to our customers and to ourselves to take practical steps to design and operate our piping network with consideration of potential seismic activity and to continue to train our employees to react to all types of emergencies.

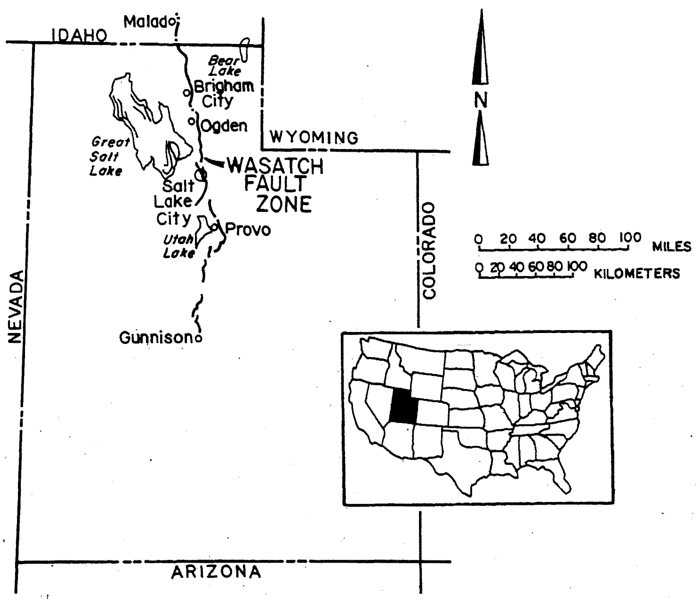

FIGURE I

APPENDIX I

Intensity	Magnitude	Comments
VI	5.9	No gas distribution problems. One house piping leak. Reference: Coyote Lake (Gilroy) California Earthquake - August 1979 (Ref. 6)
VI-VII	5.5-5.8	No gas distribution problems. Several minor house piping leaks. Some meter sets damaged when mobile homes shifted. Reference: Livermore Valley, California Earthquake - January 1980 (Ref. 7)
VII-VIII	--	Cast iron failure ratio of 1.69 failures/mile (Water Pipe), 1.08 Failures/Mile (Gas Pipe) Reference: Tokachi-Oki, Japan Earthquake - 1968 (Ref. 8)
VII-IX	7.3	Cement mortar jointed cast iron "severely damaged". All pipelines along or across rivers "severely damaged". Cast iron failure ratio of 0.13 - 1.29 failures/mile. Steel failure ratio (mostly weld cracks) of 0.50 failure/mile (20.87" diameter), 2.57 failures/mile (1.97" - 3.94" diameter). Reference: Haichen, China Earthquake - February 1975 (Ref. 5)
VII-XI	7.8	Cast iron failure rate of 0.29 - 16.09 failures/mile. "Old" wrapped steel with some corrosion, failure rate of 10.73 failures/mile (5.9" diameter). 21" steel pipeline damaged at three points in intensity VII area due to fault fissures and cracks. Reference: Tangshan, China Earthquake - July 1976 (Ref. 5 & 16)
VII-VIII	6.5	In city of El Centro, California - approximately 30 water main breaks - mostly in cast iron about 40 years old in 8" and smaller sizes. "Only Minimum" gas distribution damage. 500 customers without gas in Imperial Valley, California. Reference: Imperial Valley, California Earthquake - October 1979 (Ref. 9 & 10)
VIII	7.4	City gas service to 136,000 customers off for 4 weeks. Only 4 minor failures of steel pipes at flanges. Piping damage concentrated on alluvial soils. Failure Ratios: Welded steel: 0.03 Failures/Mile, Cast Iron: 0.02 - 0.06 Failures/Mile, Cast Iron Water Pipe: 0.07 Failures/Mile. Percentage of Service Lines Damaged: 0.08 - 0.38 (Depending on ground conditions). Reference: Miyagi-Oki, Japan Earthquake - June 1978 (Ref. 11)

Intensity	Magnitude	Comments
VIII	7.1	"Several large diameter water and gas mains fractured in low lying areas". Reference: Olympia, Washington Earthquake - April 1979 (Ref. 12)
VIII	6.3	1.56 cast iron water main breaks per mile - mostly in smaller sizes. Reference: Managua Earthquake - December 1972 (Ref. 8)
IX-X	6.6	0.67 gas line breaks per mile (various pipe sizes). This included 181 main breaks, 137 service breaks, 62 breaks at service to main connections. Utility service shut off in approximately 12 square mile area. 90 water main leaks, including 51 corrosion leaks, 8 broken welds, 5 cracks in cast iron. Reference: San Fernando Earthquake - February 1971 (Ref. 13, 14 & 15)

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