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# JAPANESE PRIVATE SECTOR EARTHQUAKE PROGRAMS AND THEIR APPLICABILITY IN THE UNITED STATES

## Volume II:

## Earthquake Emergency Preparedness



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This study focuses on the measures Japanese industries and businesses are implementing to reduce their earthquake risk. Japan's historic seismic activity is discussed as well as perception of earthquakes, prediction of earthquakes, and the public education program. Attention is directed to the regulations pertaining to disaster preparedness in Japan. Activities of the government of Shizuoka Prefecture are discussed, in particular the role this prefectural government plays in promoting earthquake hazard reduction among industries by providing financial incentives, and both planning and technical guidance. The organizational and engineering measures implemented at the Shizuoka General Hospital are discussed. This hospital, in the Tokai Region, was designed and built after the prediction of a major earthquake in the region. Earthquake damage incurred by the petroleum industry and measures taken by this industry to minimize damage in the future are discussed. Products developed by private industry specifically for earthquake hazard reduction are identified.

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# JAPANESE PRIVATE SECTOR EARTHQUAKE PROGRAMS AND THEIR APPLICABILITY IN THE UNITED STATES

## Volume II:

## Earthquake Emergency Preparedness of Japanese Industries

by

Dr. Guna Selvaduray

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## EXECUTIVE SUMMARY

Japan has one of the highest seismic activities among the nations in the world. It is also a very industrialized country and depends rather heavily on its industrial capability to maintain its economic well-being. The Japanese are therefore extremely concerned about the damage a major earthquake could inflict on their industries. Not only has Japan had several damaging earthquakes, but the occurrence of two future earthquakes has also been predicted, one for the Kanto (Tokyo) region and another for the Shizuoka region. Both of these regions are highly industrialized and heavily populated.

This study focuses on the measures Japanese industries and businesses are implementing to reduce their earthquake risk. Emphasis throughout this report is placed on measures that companies are taking ahead of time, especially in employee training and education, and reduction of nonstructural and secondary damage.

Section 1 of this report is meant to provide the reader with the necessary background information. In addition to Japan's historic seismic activity, other relevant topics, such as perception of vulnerability to earthquakes, prediction of earthquakes, the public education program, etc., are also discussed.

Section 2 is specifically devoted to the regulations that pertain to disaster preparedness in Japan. After a brief tracing of the historical evolution of disaster-related regulations, the Large-Scale Earthquake Countermeasures Act (LECA) of 1978 is discussed. LECA is specifically important in that it focuses attention on earthquake hazard reduction. Further, it identifies the Kanto and Tokai regions as being especially vulnerable and provides the legal framework for earthquake prediction and issuance of National Disaster Warnings by the Prime Minister. LECA and its forerunner, the Disaster Countermeasures Basic Act of 1961, together form the cornerstones of disaster-related regulations in Japan today.

Shizuoka Prefecture, located in the Tokai region, is an area where the prefectural government has been aggressively pursuing earthquake hazard reduction. Section 3 discusses the activities of this prefectural government in general, and the role it plays in promoting earthquake hazard reduction among industries in particular. The prefecture provides financial incentives, provides both planning and technical guidance, and also devotes considerable effort to creating an atmosphere that promotes emergency planning among industries.

Section 4 outlines typical corporate earthquake hazard reduction programs. Earthquake preparedness is typically divided into two categories - SOFT (from software) and HARD (from hardware). The first category consists typically of education, training, planning, securing of budget requirements, etc. The second category, HARD, pertains to engineering countermeasures for hazard reduction. The profile of a pharmaceutical company, covering both SOFT and HARD aspects, is presented. Examples of hazard reduction measures implemented at eight different companies are also presented in this section.

Shizuoka General Hospital is unique because it was designed and built after the prediction of a major earthquake in the Tokai Region. This hospital is also expected to be the medical nerve center after the Tokai earthquake. The organizational and engineering measures implemented at this hospital are discussed in Section 5.

The petroleum industry, which fuels the rest of Japan's industries, has incurred major damage in several earthquakes. Section 6 discusses the earthquake damage this industrial sector has incurred, and the measures this industry, as a whole, has taken to ensure that damage in future earthquakes will be minimized.

Another feature that is noteworthy in the Japanese earthquake preparedness realm is the extent to which private industry has developed products that are specifically intended for earthquake hazard reduction. These range from simple braces and latches for furniture to sophisticated base isolation systems for computer floors. Section 7 discusses those products identified as having been developed for this purpose. It should also be noted that all these products, with one exception, were developed solely by industry, at its own initiative and with its own funding.

This study, aimed at investigating Japanese corporate earthquake preparedness, was never intended to be a survey. The emphasis has been placed on studying what Japanese companies have developed in this area. The applicability of their technology in the United States is discussed in a separate report.

Though this study has focused on the private sector, both public and private sectors in Japan are working together so that future earthquakes can be rendered less harmful, regardless of magnitude and/or intensity. This is being achieved by implementing hazard reduction techniques ahead of time and by long-range planning.

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Kokubu Company
Toyokeizi
Tokyo National Museum
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## TABLE OF CONTENTS

## TABLE OF CONTENTS (continued)

## LIST OF FIGURES

## LIST OF TABLES

# Section 1
# EARTHQUAKE EMERGENCY PREPAREDNESS OF JAPANESE INDUSTRIES

This report on the Earthquake Emergency Preparedness of Japanese companies has been written with the specific intention of documenting and compiling advances made in this field in Japan. It is not intended to be a general survey of the status quo. Such surveys of average corporate preparedness would be would be useful, however, for gauging general levels of consciousness, and to the extent that such survey results are available, they have been included in this study. In discussing an issue such as this, it must also be borne in mind that the kinds of emergency preparedness measures taken by companies can be expected to be affected by sociological/geographical conditions as well as government regulations.

There are two factors that make Japan's earthquake preparedness programs unique, namely:

1. Japan expects to be able to predict the occurrence of major earthquakes in the Tokyo and Tokai regions.

2. The population is expected to take measures before the occurrence of the earthquake to mitigate its consequences.

## INTRODUCTION

The Kanto Plain of Japan has often been subjected to destructive earthquakes. Since 1600 A.D. 37 earthquakes with intensity of 5 or more on the JMA scale (9 or more on the Modified Mercalli scale) have hit the Tokyo area alone[1]. Table 1 lists all the major earthquakes that have occurred in Japan. The Great Kanto Earthquake, which occurred on September 1, 1923, is widely remembered as the most disastrous natural occurrence in modern times in Japan. The damage this earthquake caused is summarized in Table 2.

Of particular concern at present is the Great Tokai Earthquake, which has been predicted to occur in the Suruga Trough, an area that is approximately 200 km (320 miles) north-south and approximately 100 km (160 miles) east-west in dimensions, adjacent to Shizuoka Prefecture[2]. This earthquake is expected to be of at least intensity 5 on the Japan Meteorological Agency (JMA) scale; this is equivalent to an intensity of 8 on the Modified Mercalli (MMI) scale. Figure 1 shows a comparison of

TABLE 1
EARTHQUAKES THAT HAVE DAMAGED TOKYO
(compiled from the data after T. Usami, 1970)

| Date of Occurrence | Focus Long. (E) | Focus Lat. (N) | Magnitude | Intensity in Tokyo (JMA) | Degree of Damage* | Damage in Tokyo |
|---|---|---|---|---|---|---|
| June 26, 1615 | 139.7 | 35.7 | 6.4 | 6 | 3 | Many houses collapsed, many people killed and injured. Ground cracked. |
| Aug. 10, 1628 | - | - | 6.1 | 5 | 1 | Stone walls of Edo Castle crumbled. |
| Aug. 2, 1630 | - | - | 6.7 | 5 | 1 | Stone walls of Edo Castle crumbled. |
| Mar. 1, 1633 | 139.2 | 35.2 | 7.1 | 5 | 0 | |
| Mar. 12, 1635 | - | - | 6.1 | 5 | 1 | Walls of some houses collapsed. Most of stone lanterns at Zojoji Temple fell. |
| Dec. 6, 1643 | - | - | 6.2 | 5 | 1 | Roofs and walls of houses gave way. |
| June 16, 1647 | - | - | 6.4 | 5 | 2 | Stone walls and gates of Edo Castle collapsed. Many houses collapsed and quite a few people died. |
| Sept. 9, 1647 | - | - | - | 5 | 1 | Stone walls of Edo Castle crumbled. |
| June 12, 1648 | 139.2 | 35.2 | 7.1 | 5 | 1 | Roof tiles of many houses fell. |
| July 30, 1649 | 139.8 | 35.7 | 7.1 | 6 | 2 | Stone walls of Edo Castle damaged. Many houses collapsed and many people were crushed to death. |
| Sept. 1, 1649 | 139.7 | 35.5 | 6.4 | 5 | 1 | Some structures in Edo Castle were damaged. |
| June 18, 1683 | 139.7 | 36.8 | 7.3 | 5 | 1 | |
| Nov. 25, 1697 | 139.6 | 35.5 | 6.9 | 5 | 1 | Stone walls of Edo Castle crumbled. |
| Dec. 31, 1703 | 139.8 | 34.7 | 8.2 | 6 | 3 | Many houses collapsed and fires broke out. Many people were killed. Tsunami hit southern coast. |
| Oct. 21, 1706 | 139.8 | 35.6 | 6.6 | 5 | 1 | Stone walls of Edo Castle were damaged. |
| Oct. 28, 1707 | 135.9 | 33.2 | 8.4 | 5 | 0 | |
| May 14, 1746 | - | - | 6.9 | 5 | 1 | Some houses were damaged. |
| Aug. 23, 1782 | 139.2 | 35.2 | 7.3 | 5 | 2 | Some houses collapsed. Some people died. |
| Aug. 29, 1784 | 139.8 | 35.6 | 6.1 | 5 | 1 | Many houses tilted and roofs damaged. |
| Dec. 7, 1812 | 139.7 | 35.5 | 6.6 | 5 | 1 | Many houses collapsed. |
| Dec. 23, 1854 | 137.8 | 34.0 | 8.4 | 5 | 1 | Some houses were damaged. |
| Nov. 11, 1855 | 139.8 | 35.6 | 6.9 | 6 | 4 | More than 10,000 people were killed. Twenty thousand houses collapsed and burned. |

* Degree of Damage:
- 0: No damage
- 1: Slight damage: houses did not collapse, but were broken.
- 2: Light damage: many houses were damaged, but few of them collapsed.
- 3: Medium damage: considerable number of houses collapsed; some people killed and many injured.
- 4: Serious damage: catastrophic damage was caused.

TABLE 1 (contd)
EARTHQUAKES THAT HAVE DAMAGED TOKYO
(compiled from the data after T. Usami, 1976)

| Date of Occurrence | Focus Long. (E) | Focus Lat. (N) | Magnitude | Intensity in Tokyo (JMA) | Degree of Damage* | Damage in Tokyo |
|---|---|---|---|---|---|---|
| Nov. 4, 1856 | - | - | 6.6 | 5 | 1 | |
| Feb. 22, 1880 | 139.8 | 35.4 | 5.4 | 5 | 1 | |
| Oct. 15, 1884 | 139.8 | 35.7 | - | 5 | 1 | Brick walls of houses were cracked. |
| Feb. 18, 1889 | 139.7 | 35.4 | 5.7 | 5 | 1 | |
| June 3, 1892 | 139.8 | 35.7 | 6.2 | 5 | 1 | Twenty-nine houses were damaged. |
| June 20, 1894 | 139.8 | 35.7 | 7.0 | 6 | 3 | Twenty-four people were killed, 157 injured. Ninety houses collapsed and 5,000 damaged. |
| Oct. 7, 1894 | - | - | 7.0 | 5 | 2 | Roof tiles and walls of many houses were damaged. |
| Jan. 18, 1895 | 140.3 | 36.2 | 6.8 | 5 | 2 | One man was killed and 31 people were injured. |
| Feb. 24, 1906 | 139.8 | 35.5 | 6.7 | 5 | 2 | Roof tiles and walls of many houses were damaged. |
| Apr. 26, 1922 | 139.4 | 35.1 | 6.4 | 5 | 2 | Walls of 82 houses fell. |
| Sept. 1, 1923 | 139.3 | 35.2 | 7.9 | 6 | 4 | SEE TABLE 2 |
| Jan. 15, 1924 | 139.2 | 35.5 | 6.7 | 5 | 2 | Six people killed and 116 injured. One hundred three houses collapsed and 1,692 were partly damaged. |
| Aug. 3, 1926 | 139.5 | 35.3 | 6.2 | 5 | 1 | Gas pipes were broken. |
| July 17, 1929 | 139.1 | 35.5 | 6.1 | 5 | 1 | Telephone lines and water pipes were broken. Three fires broke out. |

* Degree of Damage:
0: No damage
1: Slight damage: houses did not collapse, but were broken.
2: Light damage: many houses were damaged, but few of them collapsed.
3: Medium damage: considerable number of houses collapsed; some people killed and many injured.
4: Serious damage: catastrophic damage was caused.

TABLE 2
DAMAGE CAUSED BY THE GREAT KANTO EARTHQUAKE OF 1923
(after Imperial Earthquake Investigation Committee, 1925)

| Prefecture (City) | CASUALTIES Died | Injured | Missing |
|---|---|---|---|
| Tokyo | 68,215 | 42,135 | 39,304 |
| (Tokyo City) | (59,065) | (15,674) | (1,055) |
| Kanagawa | 29,065 | 56,269 | 4,002 |
| (Yokohama City) | (23,440) | (42,053) | (3,183) |
| (Yokosuka City) | (540) | (982) | (125) |
| Chiba | 1,335 | 3,426 | 7 |
| Saitama | 316 | 497 | 95 |
| Yamanashi | 20 | 116 | |
| Shizuoka | 375 | 1,243 | 68 |
| Ibaraki | 5 | 40 | |
| Nagano | | | |
| Tochigi | | 3 | |
| Gunma | | 4 | |
| TOTAL | 99,331 | 103,733 | 43,476 |

| Prefecture (City) | Total Collapse | PROPERTY DAMAGE Half Collapse | Destroyed by Fire | Washed Away by Tsunami | Total (excluding half-collapsed) |
|---|---|---|---|---|---|
| Tokyo | 20,179 | 34,632 | 377,907 | | 398,086 |
| (Tokyo City) | (3,886) | (4,230) | (366,262) | | (370,148) |
| Kanagawa | 62,887 | 52,863 | 68,569 | 136 | 131,592 |
| (Yokohama City) | (11,615) | (7,992) | (58,981) | | (70,496) |
| (Yokosuka City) | (8,300) | (2,500) | (3,500) | | (11,800) |
| Chiba | 31,186 | 14,919 | 647 | 71 | 31,904 |
| Saitama | 9,268 | 7,577 | | | 9,268 |
| Yamanashi | 1,763 | 4,994 | | | 1,763 |
| Shizuoka | 2,298 | 10,219 | 5 | 661 | 2,964 |
| Ibaraki | 517 | 681 | | | 517 |
| Nagano | 45 | 176 | | | 45 |
| Tochigi | 16 | 2 | | | 16 |
| Gunma | 107 | 170 | | | 107 |
| TOTAL | 128,266 | 126,233 | 447,128 | 868 | 576,262 |

<table>
<tr><th>MMI<br>(Modified Mercalli<br>Intensity) Scale</th><th>JMA<br>(Japan Meteorological Agency)<br>Intensity Scale</th></tr>
<tr><td>I. Not felt.</td><td>0. Not felt.</td></tr>
<tr><td>II. Felt by persons at rest or on upper floors.</td><td rowspan="2">I. Felt only feebly.</td></tr>
<tr><td>III. Felt indoors, hanging objects swing.</td></tr>
<tr><td>IV. Hanging objects swing. Vibration like passing of heavy trucks.</td><td>II. Felt by most persons; slight shaking of windows and Shoji (Japanese latticed sliding doors).</td></tr>
<tr><td>V. Felt outdoors. Sleepers wakened. Liquids disturbed. Small unstable objects displaced or upset.</td><td>III. Some people are frightened; heavy rattling of windows and Shoji, swinging of hanging objects, sloshing of liquids.</td></tr>
<tr><td>VI. Felt by all. Knickknacks and books fall off shelves. Some cracking of plaster and unreinforced masonry walls.</td><td>IV. Overturning of unstable objects, spilling of liquids out of vessels.</td></tr>
<tr><td>VII. Difficult to stand. Some unreinforced masonry chimneys, parapets, and cornices fall.</td><td rowspan="2">V. Cracking of brick and plaster walls, overturning of stone lanterns and gravestones, damaged chimneys.</td></tr>
<tr><td>VIII. Unreinforced masonry buildings damaged, most buildings designed to resist earthquakes structurally undamaged.</td></tr>
<tr><td>IX. Major damage to most unreinforced masonry and many minimally earthquake resistant buildings.</td><td rowspan="2">VI. 1% to 3% of Japanese wooden houses severely damaged; soils effects such as liquefaction and large landslides.</td></tr>
<tr><td>X. Most non-resistant buildings heavily damaged or collapsed; some major damage to minimally earthquake resistant buildings, including collapse.</td></tr>
<tr><td>XI. Increasing intensity of ground motion (defined by soils failures such as slippage of railroad track beds).</td><td rowspan="2">VII. More than 30% of Japanese wooden houses severely damaged; soils effects such as large landslides and fissures.</td></tr>
<tr><td>XII. Increasing intensity of ground motion (defined by soils failures such as displacement of large rock masses).</td></tr>
</table>

Figure I. American and Japanese Intensity Scales.

Sources: Modified Mercalli Scale adapted and abbreviated from 1956 revised version by Richter; JMA Scale adapted and abbreviated from 1951 Kawasumi version, as revised by Japan Meteorological Agency; correlation of the scales from P.J. Barosh, "Use of Seismic Intensity Data to Predict the Effects of Earthquake and Underground Nuclear Explosions in Various Geologic Settings," U.S. Geological Survey Bulletin No. 1279, 1969.

the Modified Mercalli Intensity scale (MMI), more commonly used in the United States, and the Japan Meteorological Agency (JMA) scale used in Japan. In 1979, in view of the urgent situation, the national government designated the prefecture as an "Area of Intensive Earthquake Response"(3).

It has been predicted by Kawasumi(4) that there is a 99.94 per cent probability that earthquakes with magnitude of 5 (JMA) or more repeat in the Kanto Region at a cycle of 69 years, with a 13-year margin of error. If this theory were to be correct, the next major earthquake in Tokyo should occur anywhere between 1978 and 2004. The occurrence of the Tokai earthquake is also expected to have a strong effect on Tokyo, equivalent to intensity 5 (JMA).

Figure 2(5) shows the areas in Japan that have been identified as being particularly earthquake prone. Of the regions identified here, the Tokai and South Kanto regions fall under the jurisdiction of a special law since the occurrence of a future major earthquake in these regions has been predicted.

Japan, as a country, has been very aware of the dangers an earthquake can pose, and the consequences suffered during the 1923 Kanto Earthquake have not been forgotten. This disaster, in which approximately 100,000 people died, affected the Tokyo-Yokohama metropolitan area. Like the greatest earthquake disaster in the United States, namely the 1906 San Francisco earthquake, most of the destruction was caused by the ensuing fire. The number of casualties from the San Francisco earthquake was approximately 1,000, however. The fact that Japan has relatively recently (in the 20th century) experienced an earthquake with consequences a hundred times greater than the most disastrous U.S. earthquake is an important fact to keep in mind in comparing earthquake programs in the two countries.

Until the early 1960's construction of high-rise buildings was severely limited; the national height limit was 12 stories. The first skyscraper was the Kasumigaseki building completed in 1964. Since then several more skyscrapers have been built in Tokyo, but only after special seismic design review.

Another factor that has played a key role in Japanese disaster preparedness and planning is the methodical and goal-oriented manner in which the task has been attacked. This, of course, is in keeping with the general manner in which things are done in Japan. An equally important factor is the cooperation among the various government agencies, trade groups, and companies. This has been crucial in making the planning a success.

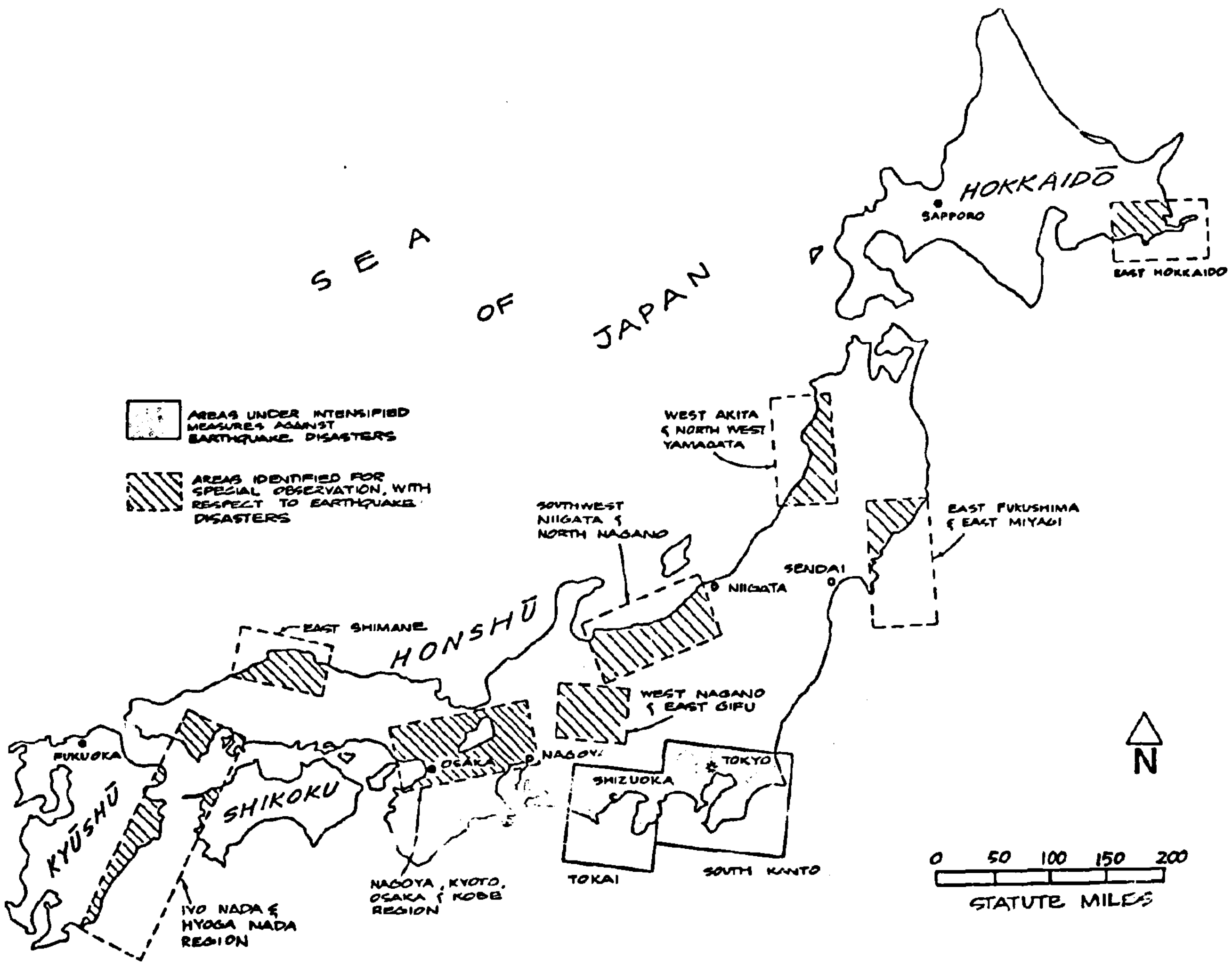



Figure 2. Areas in Japan Identified as Being Particularly Earthquake Prone.

PREDICTABILITY

The main factor that sets Japan's earthquake preparedness activities apart from most earthquake preparedness activities going on in the world is that the government expects to be able to predict the occurrence of an earthquake, especially in the Suruga Trough area. While the exact time of occurrence is unknown, sophisticated and extensive instrumentation is being used to detect abnormal behavior that could be interpreted as the forerunner of an imminent earthquake. Another unique factor that has been integrated into Japan's earthquake prediction activities is the elaborate message flow scenario from the time of detection of an abnormality until the Prime Minister issues a National Disaster Warning. Included in this message flow scenario are actions that various organizations, companies, and individuals will take in order to reduce the consequences of an earthquake before it actually occurs.

Figure 3 shows the different kinds of instruments that have been installed along the coastline stretching from southwest of Shizuoka to north of Tokyo. The information gathered by these instruments is fed on-line to the Japan Meteorological Agency head office in Tokyo, where it is monitored 24 hours a day. The detection of abnormalities in the information thus gathered can set off a chain of events that could lead to a National Disaster Warning, as shown in the same figure.

PERCEPTION OF VULNERABILITY

Japan's geography is quite different from the United States in that there is very little land suitable for industrial development. Historically, industrial development was concentrated in fewer than 20 major areas around the country. (The land area of Japan is 143,800 square miles, or 90% or the area of California, but its population of 105 million is more than four times that of California.) A major disaster in one area could have a major effect on the country as a whole. The Japanese national interest in local disasters is therefore more understandable.

Japan's livelihood depends almost entirely on its capability to maintain its industrial production; in this respect it has a very narrow economic base, unlike the United States, which has a very broad economic base that includes not only industrial production, but also the extraction of natural resources and agriculture. Industrial installations, such as factory buildings and plant equipment, are vulnerable to natural hazards, and Japan is rightfully concerned about maintaining its main source of income. Although major earthquakes are low probability events, in Japan they can have consequences severe enough to affect the economic stability of the entire country, much more so than any single earthquake's effect in the United States.

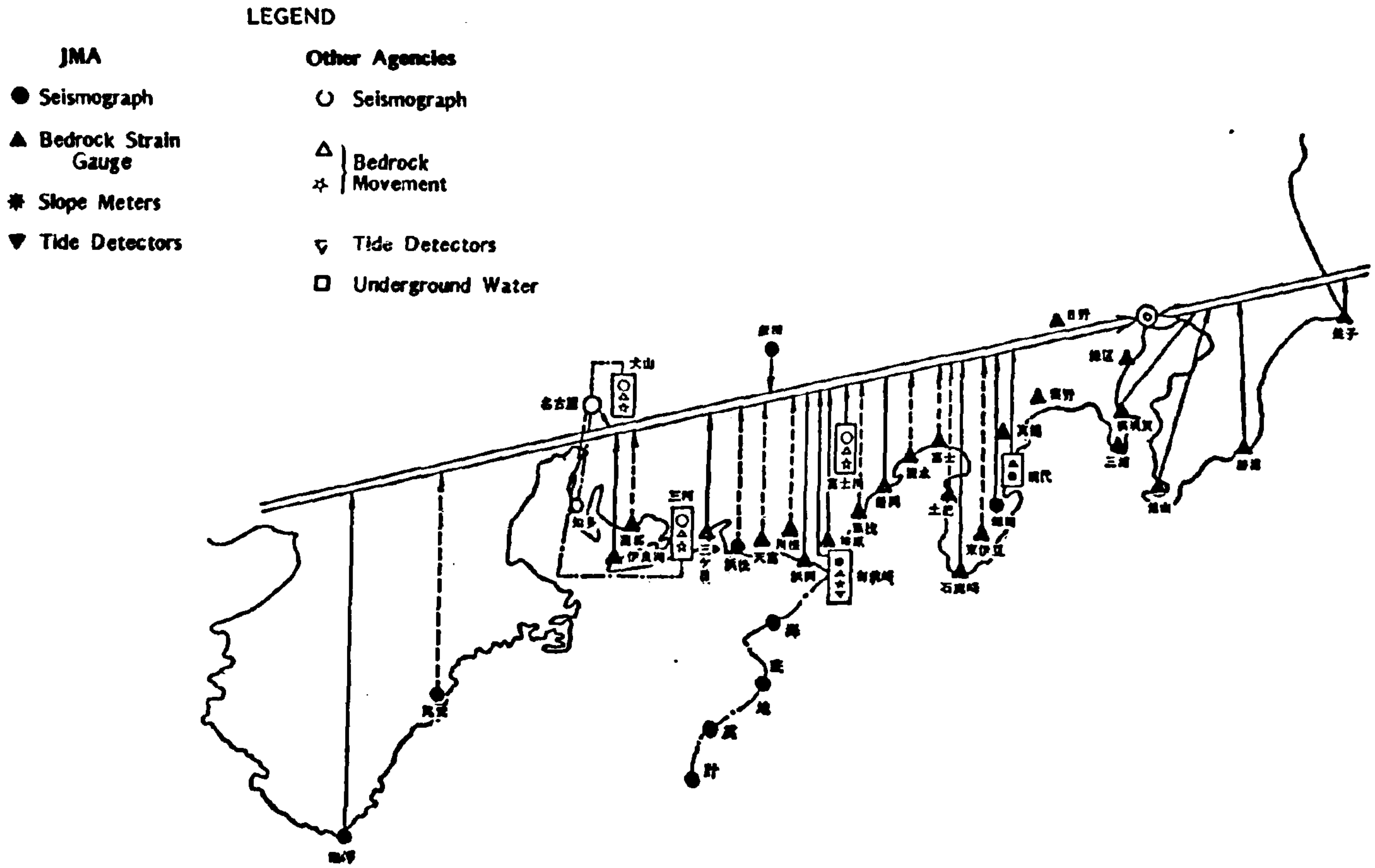



Figure 3. Map of Coastline of Kanto and Tokai Regions, Showing Instruments That Have Been Installed. Data are transmitted 24 hours a day by telemeter to JMA headquarters in Tokyo.

EMPHASIS ON SECONDARY EFFECTS

"Secondary effects" include earthquake-caused fires and hazardous materials spills, and damage from tsunamis, or seismic sea waves. In some cases, the Japanese use the term "secondary effect" as a translation for what would be called "nonstructural damage" in the United States.

Practically every article written by Japanese authors[6] on the Great Kanto Earthquake of 1923 stresses that a significant portion of the deaths were as a result of fires. The lesson learned from this incident has obviously not been forgotten. Most Japanese homes are still of wood construction, and the use of open flames is still prevalent. Gas, rather than electricity, is the main source of energy for cooking, and rupturing of gas lines would pose a major hazard.

More recent earthquakes have also reinforced this concern. The 1964 Niigata earthquake resulted in two major conflagrations at Showa Petroleum. One of these fires burned for two weeks before it was eventually extinguished. In 1978, when the Miyagi-ken-oki earthquake occurred, a major oil spill resulted in contamination of Sendai Port.

Tsunamis, or seismic sea waves, have also caused significant life loss in Japan, whereas only relatively localized areas of the west coast of the United States are especially subject to this hazard.

The extent to which secondary effects of earthquakes are being addressed in Japan is quite impressive. In the case of fire, a gradual changeover to fire-resistive construction is being implemented. The use of buildings as firewalls for refuge areas is probably an original conception of Japan, an example of this being the Shirahige project in Tokyo. The provision of underground water tanks at specific locations in Tokyo, for firefighting, in addition to potable water, is another example. (San Francisco has cisterns under its streets for this very purpose.) Notable in this effort is the extent to which government has taken a leading financial role; without the subsidies and cost-sharing schemes offered by local and central governments, the private building owner would not be able to afford the modifications.

Several special laws have also been passed to minimize possible damage. For instance, after the 1978 Miyagi-ken-oki earthquake, new laws requiring periodic detailed inspection of petroleum storage tanks for pitting and other forms of corrosion were passed. On the other hand, even when laws have not been passed, manufacturers have responded to the call of the government. For instance, at the request of the Tokyo Fire Department, manufacturers of unvented kerosene space heaters developed a new model with a built-in safety shutoff device, which would extinguish the heater when it was shaken. Today it is no longer possible to purchase kerosene space heaters without this feature, despite the fact that the law does not require it.

## PUBLIC EDUCATION

Invariably, when an earthquake occurs, it is the public that suffers the consequences, and hence, education of the public is an important aspect of disaster preparedness. Not only is it important that members of the public should know what actions to take before, during, and after an earthquake, but they should also act as a unified group rather than as individuals looking after only their own interests. In this respect, the public education programs underway in Japan are probably without comparison in the world. The booklets for the public are not only written in language easy for them to understand, but are also well illustrated. (See Figures 4 through 9.) The Shizuoka Prefectural Government has even published a booklet that contains a section on how homeowners can evaluate their houses for earthquake resistance (Figure 10). The importance in educating the public on appropriate actions to take when a disaster strikes is that it will greatly reduce panic-stricken behavior that can actually worsen the consequences. In view of the large concentrations of foreign residents (approximately 100,000 or 0.85% in the case of Tokyo) within their jurisdictions, several local governments have actually published similar booklets in English as well, as can be seen in Figures 8 and 9. The Tokyo Metropolitan Government has also produced an educational video tape for educating resident foreigners in earthquake preparedness.

In Shizuoka Prefecture, a wide range of publications is available from the Prefectural office. Of special interest is the large number of manuals for professional engineers. These are designed to aid them in inspection, evaluation, and retrofitting of buildings so they will be more earthquake resistant. Of the 18 staff members of the Earthquake Preparedness Division of the Shizuoka Prefectural Government, nine are architects or engineers. The prefectural office has also compiled 16 case studies of companies that are particularly well prepared for earthquake emergencies. This publication gives details on how the program was originated at each company, training programs for employees, details of structural and nonstructural upgrading, and organizational charts of emergency response teams. Such reference documents would be extremely valuable to other companies that are just embarking on earthquake emergency preparedness activities.




Figure 4. Urban Disaster Prevention - How to Prevent a Major Earthquake From Becoming a Major Disaster. Published by the Osaka City Government.

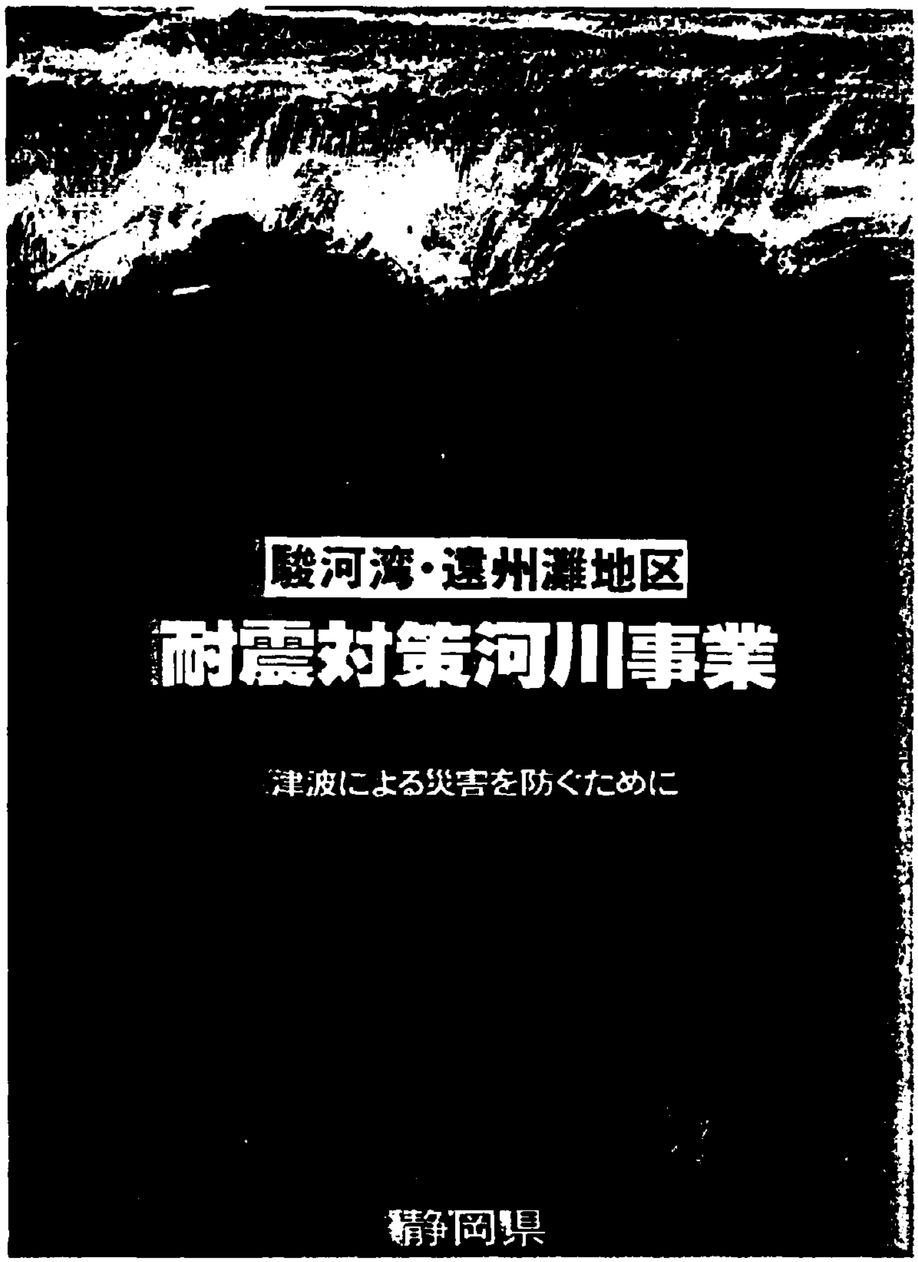



Figure 5. Prevention of Tsunami Disasters. Published by Shizuoka Prefectural Government.


Figure 6. Disaster Prevention Manual(for Earthquakes). Published by the Tokyo Fire Department.

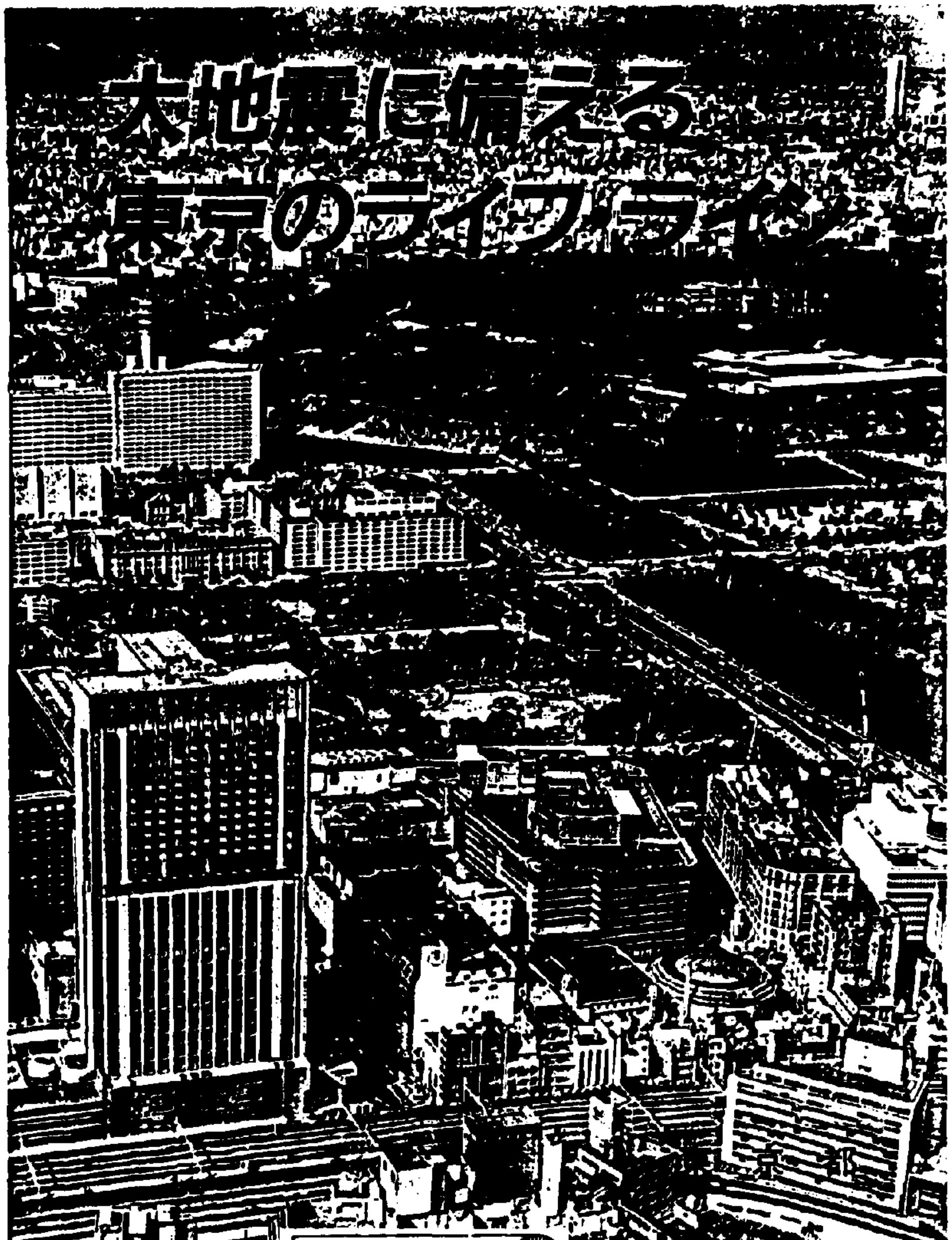





Figure 7. Tokyo Lifelines in the Event of a Major Earthquake. Published by the Tokyo Metropolitan Government.

**EARTHQUAKE DISASTER SERIES**
震災対策シリーズ

## WHAT TO DO IN CASE OF AN EARTHQUAKE

**– Some Pointers on How to Protect Yourself and Your Family –**

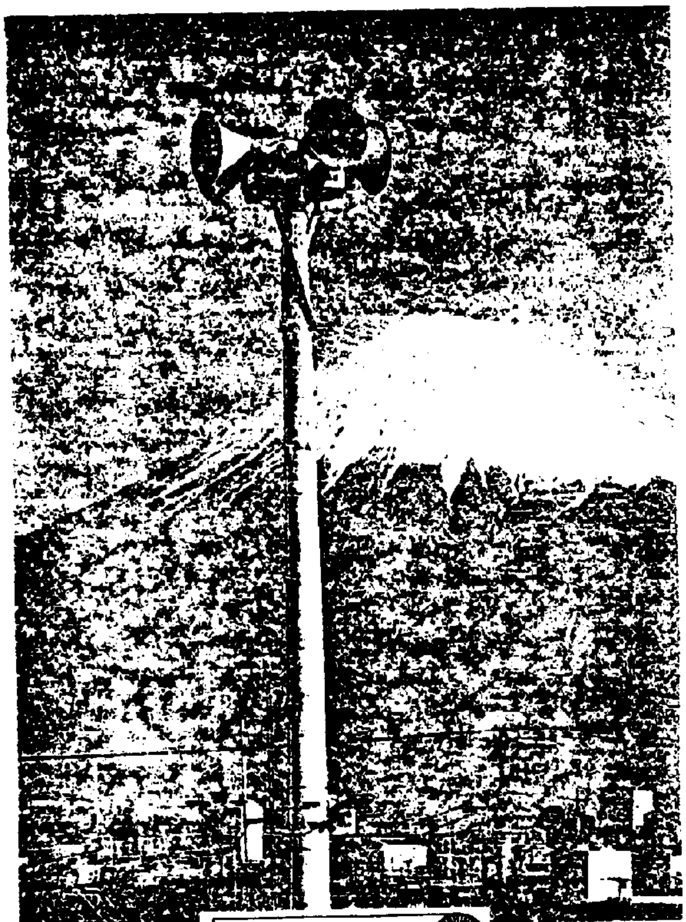
地震発生時にはどうすればよいのか

－ あなたとあなたの家族を保護する方法についての指針 －

| | | |
|---|---|---|
| **Planning** | : | **Planning Section, Disaster Prevention Division, Bureau of General Affairs, The Tokyo Metropolitan Government** |
| 企　画 | : | 東京都総務局災害対策部企画課 |
| **Production** | : | **Tokyo Metropolitan Motion Picture Corporation** |
| 制　作 | : | 東京都映画協会 |

Figure 8.

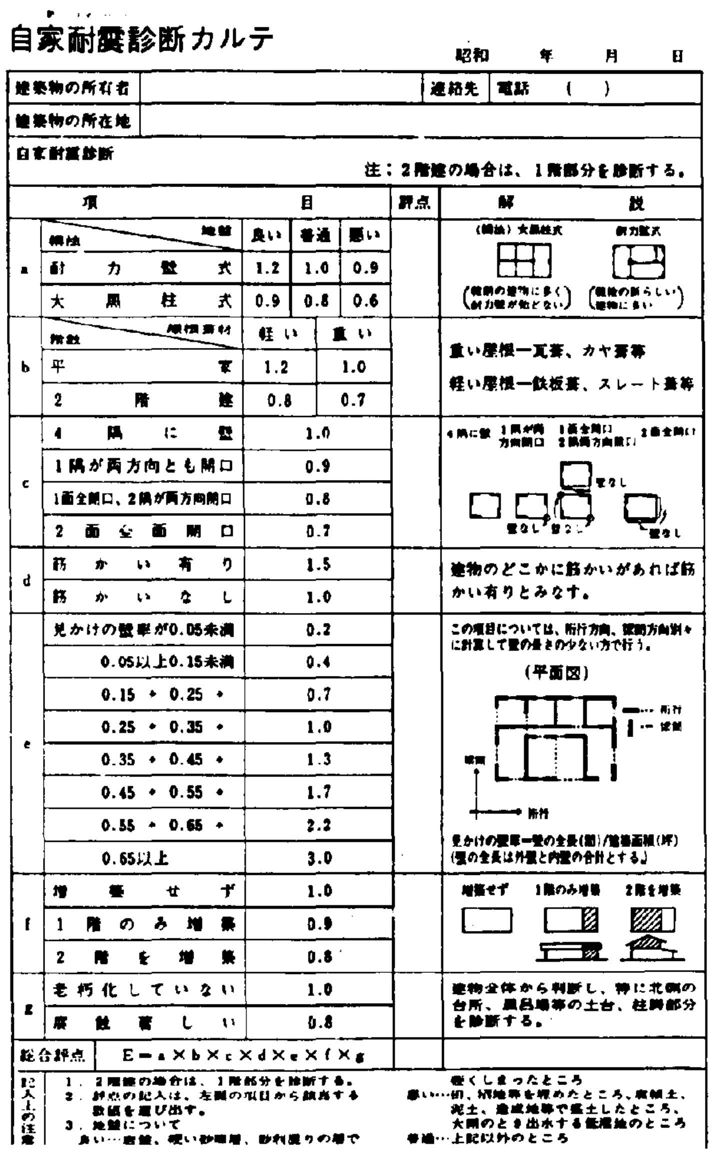
# EARTHQUAKE COUNTERMEASURES IN SHIZUOKA PREFECTURE





EARTHQUAKE PREPAREDNESS DIVISION
SHIZUOKA PREFECTURAL GOVERNMENT

Figure 9.



# 自家耐震診断カルテ

昭和　　年　　月　　日

| | | | |
|---|---|---|---|
| 建築物の所有者 | | 連絡先 | 電話　（　　） |
| 建築物の所在地 | | | |

自家耐震診断

注：2階建の場合は、1階部分を診断する。

| 項 | 目 | | | | 評点 | 解説 |
|---|---|---|---|---|---|---|
| a | 構法＼地盤 | 良い | 普通 | 悪い | | （軸組）大黒柱式　耐力壁式 |
| | 耐力壁式 | 1.2 | 1.0 | 0.9 | | （戦前の建物に多く耐力壁が少ない）（戦後の新らしい建物に多い） |
| | 大黒柱式 | 0.9 | 0.8 | 0.6 | | |
| b | 階数＼屋根葺材 | 軽い | 重い | | | 重い屋根一瓦葺、カヤ葺等 |
| | 平家 | 1.2 | 1.0 | | | 軽い屋根一鉄板葺、スレート葺等 |
| | 2階建 | 0.8 | 0.7 | | | |
| c | 4隅に壁 | 1.0 | | | | 4隅に壁　1隅が両方向開口　1面全開口 2隅両方向開口　2面全開口　壁なし |
| | 1隅が両方向とも開口 | 0.9 | | | | |
| | 1面全開口、2隅が両方向開口 | 0.8 | | | | |
| | 2面全面開口 | 0.7 | | | | |
| d | 筋かい有り | 1.5 | | | | 建物のどこかに筋かいがあれば筋かい有りとみなす。 |
| | 筋かいなし | 1.0 | | | | |
| e | 見かけの壁率が0.05未満 | 0.2 | | | | この項目については、桁行方向、梁間方向別々に計算して壁の量の少ない方で行う。 |
| | 0.05以上0.15未満 | 0.4 | | | | （平面図）桁行　梁間 |
| | 0.15 〃 0.25 〃 | 0.7 | | | | |
| | 0.25 〃 0.35 〃 | 1.0 | | | | |
| | 0.35 〃 0.45 〃 | 1.3 | | | | |
| | 0.45 〃 0.55 〃 | 1.7 | | | | |
| | 0.55 〃 0.65 〃 | 2.2 | | | | 見かけの壁率＝壁の全長（間）/建物面積（坪） |
| | 0.65以上 | 3.0 | | | | （壁の全長は外壁と内壁の合計とする。） |
| f | 増築せず | 1.0 | | | | 増築せず　1階のみ増築　2階を増築 |
| | 1階のみ増築 | 0.9 | | | | |
| | 2階を増築 | 0.8 | | | | |
| g | 老朽化していない | 1.0 | | | | 建物全体から判断し、特に北側の台所、風呂場等の土台、柱脚部分を診断する。 |
| | 腐蝕著しい | 0.8 | | | | |
| 総合評点 | E＝a×b×c×d×e×f×g | | | | | |

記入上の注意
1．2階建の場合は、1階部分を診断する。
2．評点の記入は、左欄の項目から該当する数値を選び出す。
3．地盤について
良い…岩盤、硬い砂礫層、砂利混りの層で硬くしまったところ
悪い…田、沼地等を埋めたところ、腐植土、泥土、造成地等で盛土したところ、大雨のとき出水する低湿地のところ
普通…上記以外のところ

Figure 10. Evaluation Form for the Individual Homeowner to Use. By Shizuoka Prefectural Government.

## GUIDANCE FOR EMERGENCY PREPAREDNESS PLANNING

Companies are required by law to have emergency action plans. In areas that have been identified as being particularly prone to earthquakes, such as the Kanto region, which surrounds Tokyo, and the Tokai region, which surrounds Shizuoka, they also have to file them with the fire department for approval. In the case of Shizuoka Prefecture, which would be the center of the expected Tokai earthquake, the Prefectural Office has published detailed guidelines on how these emergency plans are to be formulated and their scope; it also emphasizes that such plans should be detailed and specific rather than general and abstract.

The extra-regulatory guidance provided by public officials is quite impressive. These officials have obviously convinced several companies that the only real means available for reducing earthquake damage is to take preventive action prior to the occurrence of the earthquake. Though this is not required by law, the enthusiasm devoted to preventive measures is commendable. This can be achieved only by a concerted effort aimed at convincing industries and businesses that money spent on hazard reduction is really an investment in the company itself.

### Integration of Long Range and Short Range Planning

At all of the public agencies and private companies contacted, both long range and short range planning had been done, with the latter fitting into the former. One such example is the planning being undertaken to provide sufficient refuge space for disaster evacuees in Tokyo. The final goal is to provide refuge areas greater than 10 hectares (22.5 acres) each, with at least 1 square meter/person (10 sq ft/person), and a travel time of less than an hour. Beginning in 1971, detailed surveys were made, and refuge areas and refuge routes were set. Annual surveys are used to update not only the adequacy of the refuge areas available, but also utilities and other lifelines available. These refuge areas are predicated on the probability of earthquake-caused fires.

At the private companies visited, long range plans for structural and nonstructural upgrading were found, with annual goals established. While the total overall plan is ambitious and would require a significant financial outlay, the annual programs are small enough that they would be within a manageable range, both in terms of financial expenditure and personnel commitment. The annual plans fit into the framework of five-year plans. The fact that Japanese companies use five-year plans extensively for all of their planning makes it much easier to provide continuity of budgetary support for earthquake programs.

## Section 2
## THE REGULATORY FRAMEWORK

The main agency in Japan in charge of disaster preparedness activities is the National Land Agency. This agency has no direct parallel in the United States. It was established on June 26, 1974 with the object of promoting comprehensive national land administration. In addition to the Minister's Secretariat, it has six bureaus: the Planning and Coordination Bureau, the Land Bureau, the Water Resources Bureau, the Metropolitan Areas Development Bureau, the Regional Development Bureau, and the Disaster Prevention Bureau, which is the central administrative organization for disaster prevention.

In addition to the formulation of basic policies, this agency also coordinates various complementary measures such as the establishment of disaster prevention systems, promotion of disaster prevention projects, prompt and appropriate recovery measures, and promotion of science and technology concerning disaster prevention. As can be seen from Table 3, the NLA is also in charge of the Special Financial Support Act of 1962, which authorizes support from the national government to local governments in the event of disasters. With specific reference to earthquakes, the long-term objective is to build earthquake-resistant cities; the short-term objectives are:

1. Promotion of disaster prevention measures in urban areas.

2. Consolidation of disaster prevention systems and enhancement of consciousness of disaster prevention.

3. Promotion of earthquake prediction techniques.

The agency also coordinates the various measures taken by other agencies and organizations in order to enforce comprehensive earthquake countermeasures.

In the event of a major disaster, the agency identifies the extent of damage and coordinates various emergency measures, and if necessary, establishes the Headquarters for Major Disaster Control so appropriate measures may be taken promptly.

TABLE 3

COMPILATION OF JAPANESE LAWS PERTAINING TO DISASTERS

| NAME OF LEGISLATION | YEAR ENACTED | MINISTRY HAVING JURISDICTION | DISASTER RELATED FEATURES |
|---|---|---|---|
| The River Law | 1896 | Construction | Control over rivers to prevent flood disasters. |
| The Erosion Control Law | 1897 | Construction/ Transportation Agriculture, Forestry & Fisheries | Erosion control facilities, river improvements & erosion control works |
| Flood Prevention Association Law | 1908 | Construction | Establishment of flood prevention associations to carry out flood control projects |
| Disaster Security Law | 1947 | | Emergency relief measures by national government in collaboration with local governments |
| Law for Reduction/ Exemption of Taxes & Deferment of Tax Payment for Disaster Sufferers | 1947 | Health & Welfare | Financial accommodation for sufferers |
| Fire Service Law | 1948 | Fire Defense Agency | Damage reduction, emergency administration |
| Flood Fighting Law | 1949 | Construction | Flood control and prevention |
| Temporary Measures Law for Subsidizing Rehabilitation of Agri- cultural, Forestry & Fishing Facilities Damaged by Disasters | 1950 | Agriculture, Forestry & Fisheries | National government subsidy for recovery of farm lands, agricultural facilities, forestry & fishery facilities damaged by disasters |

TABLE 3 (contd)

COMPILATION OF JAPANESE LAWS PERTAINING TO DISASTERS

| NAME OF LEGISLATION | YEAR ENACTED | MINISTRY HAVING JURISDICTION | DISASTER RELATED FEATURES |
|---|---|---|---|
| The Forest Law | 1951 | Agriculture, Forestry & Fisheries | Conservation & nourishing of forests |
| Meteorological Service Law | 1952 | Meteorological Agency | Observation of typhoons, earthquakes, and systems of forecasting, warnings, & dissemination |
| Law on National Treasury's Share of National Disaster Relief Expenditure for Public School Facilities | 1953 | Education | Provides for National Treasury's expenditures for rehabilitation of public schools damaged by disasters |
| Self Defense Forces Law | 1954 | Defense Agency | Deployment of Defense Forces (military) during disasters. |
| Temporary Measure Law for Financing Farmers, Forestry Proprietors, and Fishermen Threatened by Natural Disasters | 1955 | Agriculture, Forestry & Fisheries | Stabilization of agriculture, forestry & fisheries damaged by disasters |
| The Seacoast Law | 1956 | Construction/ Transportation/ Agriculture, Forestry & Fisheries | Protection of seacoasts from tsunami, flood tide, etc., and seacoast conservation facilities and projects |

TABLE 3 (contd)

COMPILATION OF JAPANESE LAWS PERTAINING TO DISASTERS

| NAME OF LEGISLATION | YEAR ENACTED | MINISTRY HAVING JURISDICTION | DISASTER RELATED FEATURES |
|---|---|---|---|
| Landslide Prevention Law | 1958 | Construction/ Agriculture, Forestry, & Fisheries | Prevention & elimination of damage from landslides & collapsed coal-waste heaps |
| Forest Conservation & Flood Control Countermeasures Law | 1960 | Agriculture, Forestry & Fisheries | Implementation of forest conservation and flood control projects |
| Building Standards Law | 1961 | Construction | Minimum standards for planning and structural design including disaster prevention |
| Law for Control over Development of Housing Sites | 1961 | " | Control over housing site development; prevention of disasters from earth movement at housing sites |
| Disaster Countermeasures Basic Act | 1961 | National Land Agency/Fire Defense Agency | Adjustment of affairs of administrative organs concerned with disaster control |
| Act on Special Financial Support to Deal With Designated Disasters of Extreme Severity | 1962 | National Land Agency | Special support from national government to local governments in the case of extremely severe disasters |
| City Planning Law | 1968 | Construction | City planning, including disaster prevention |

TABLE 3 (contd)

COMPILATION OF JAPANESE LAWS PERTAINING TO DISASTERS

| NAME OF LEGISLATION | YEAR ENACTED | MINISTRY HAVING JURISDICTION | DISASTER RELATED FEATURES |
|---|---|---|---|
| Law for Prevention of Disasters Due to Col-of Steep Slopes | 1969 | Construction | Prevention of landslides; projects for relocation of dwellings |
| Law on Special Fiscal Measures for Promotion of Collective Home Relocation for Disaster Prevention | 1972 | National Land Agency | Special support from national government to local governments for collective home relocation projects in disaster areas |
| Law for Payment of Compensation & Livelihood Restoration Fund Loans for Disasters | 1973 | Health & Welfare | Payment of disaster condolence money, and loans from the Disaster Relief Fund |
| Law on National Treasury Charge for Disaster Rehabilitation of Public Civil Engineering Facilities | 1973 | Construction/ Transportation/ Agriculture, Forestry & Fisheries | Provides for the National Treasury's share in the expenditure for projects to rebuild or repair public civil engineering facilities from damage caused by disasters |
| Large Scale Earthquake Countermeasures Act | 1978 | National Land Agency | Special provisions and requirements for the Tokai and Kanto regions. |

TABLE 3 (contd)

COMPILATION OF JAPANESE LAWS PERTAINING TO DISASTERS

| NAME OF LEGISLATION | YEAR ENACTED | MINISTRY HAVING JURISDICTION | DISASTER RELATED FEATURES |
|---|---|---|---|
| National Police Law | | National Police Agency | Disaster guard, relief measures, etc. |
| Science & Technology Agency Establishment Law | | Science & Technology Agency | Consolidation of research on disaster prevention |
| Livelihood Protection Law | | Health & Welfare | Disaster recovery of social welfare facilities |
| Explosive Control Law | | International Trade & Industry | Prevention of disaster by explosives |
| High Pressure Gas Control Law | | " | Prevention of disaster by high pressure gas |
| Smaller Enterprise Finance Corporation Law | | Smaller Enterprise Agency | Financial accommodation for small business owners |
| Maritime Safety Agency Law | | Maritime Safety Agency | Protection of life and property at sea and salvage operation |
| Law on Disaster Prevention at Petrochemical Bases | | Fire Defense Agency | Prevention of disasters at petrochemical complexes |

HISTORY OF DISASTER-RELATED LEGISLATION

Laws pertaining to disasters first appeared in the Meiji era when the River Law (1896) and the Erosion Control Law (1897) were enacted to conserve the national land. (The Meiji Era began in 1868 with the "restoration of power" to the Meiji Emperor. It is also synonymous with the beginning of the modernization of Japan.) The immediate post World War II period witnessed the occurrence of typhoons (as hurricanes are called in Asia) and other disasters in quick succession, with great loss of life and property. These disasters prompted the enactment of the Disaster Security Law (1947), the Fire Service Law (1948) and the Flood Fighting Law (1949), all of which were aimed at streamlining emergency measures against disasters, especially preventive measures. In the same period, the Law Concerning National Treasury Share of Expenses for Rehabilitation of Damage to Public Civil Engineering Facilities Damaged by Disasters (1951), the Temporary Measures Law for Subsidizing the Rehabilitation of Agricultural, Forestry and Fishing Facilities Damaged by Disasters (1950), the Law Concerning National Treasury's Share of Natural Disaster Relief Expenditure for Public School Facilities (1953), and the Temporary Measure Law for Financing Farmers, Forestry Proprietors and Fishermen Threatened by Natural Disasters (1955) were enacted to streamline measures for recovery from disasters.

The severe damage inflicted by the Ise-wan typhoon in 1959 became a turning point. The necessity to establish comprehensive and systematic permanent measures for disaster prevention was keenly felt. In 1961 the Disaster Countermeasures Basic Law, which would form the keystone of measures against disaster, was enacted. In 1962, the Act Concerning Special Financial Support to Deal with Designated Disasters of Extreme Severity, which provided for a smooth execution of disaster recovery work and legitimate financial aid, was enacted.

In 1960, the Forest Conservation and Flood Control Emergency Countermeasures Law was enacted in order to step up the conservation of the nation's land, including forestry conservation and river improvement projects. Later, the Law for Payment of Compensation and Livelihood Restoration Fund Loans for Disasters (1973) was enacted to replenish the system of disaster relief to individuals. The Act on Special Measures for Active Volcanoes was also enacted. (While only the Mt. Lassen volcano has erupted in recent times in California, Japan has had several volcanic eruptions in the past century.) With an accidental effluence of crude oil from the Mizushima Refinery of the Mitsubishi Oil Company in 1974 as a turning point, the Petrochemical Plant Complexes Disaster Prevention, Protection, and Control Law (1975) was enacted. To prevent the occurrence and spread of maritime disasters, the Oceanic Pollution Prevention Law was amended into the Law for Prevention of

Sea Pollution and Maritime Accidents (1976) in an attempt to work out a system of disaster prevention that would conform to changes in the social environment. The above laws and other disaster related legislation are summarized in Table 3.

The Large-Scale Earthquake Countermeasures Act (1978) was enacted to link prediction immediately before an earthquake to disaster prevention measures. Inasmuch as the Disaster Countermeasures Basic Law of 1961 was the cornerstone for future regulatory developments, this law also has become the cornerstone for subsequent regulatory developments, especially with regard to the Tokyo and Shizuoka regions.

## EVOLUTION OF LARGE-SCALE EARTHQUAKE COUNTERMEASURES ACT

The Large-Scale Earthquake Countermeasures Act (LECA), which was introduced to the 84th Session of the Diet on April 6, 1978, and passed on June 7, 1978, was promulgated on June 15, 1978 as Law No. 73.

This Act is intended for the protection of life and property of the citizens against disaster due to large-scale earthquakes by intensifying earthquake disaster prevention arrangements such as the designation of areas under intensified measures against earthquake disaster, formulating earthquake disaster prevention plans and improving seismological observation systems, issuing earthquake warning statements when earthquakes can be predicted, establishing the headquarters for earthquake disaster prevention, implementing short-term prevention measures against earthquake disaster and improving other earthquake disaster prevention measures.(3)

In 1964 the Ministry of Education, in conjunction with university and government scientists established an "Earthquake Prediction Research Program." These are five-year programs, with the second and third programs having been begun in 1969 and 1974, respectively. The Fourth Earthquake Prediction Research Program began in 1979. In April 1969 the Ministry of Construction established an Earthquake Prediction Committee to serve both as a clearinghouse on earthquake related information and as a place where the information and data obtained can be evaluated.

The prediction, at the 1976 Seismological Institute of Japan meeting, that there was a high probability of a major earthquake occurring in the Tsuruga Bay region (southwest of Tokyo) was picked up by the news media and publicized. The Earthquake Prediction Committee at the Ministry of Construction came to the conclusion that although it was not possible at that time to predict an earthquake on a short-term basis, they should take concrete steps toward making this prediction possible.

This resulted not only in deploying more instruments, but also in a reevaluation of the Third Earthquake Prediction Research Program in December 1976. A Tokai Region Earthquake Assessment Council, to assess the data in the event abnormalities were observed, was formed in April 1977. The network of measuring instruments in the Tsuruga Bay vicinity was also increased, and organized so the measurements would be transmitted directly to the Meteorological Agency by telemeter. The network includes sea-floor micro-tremor monitoring equipment.

The establishment of the Assessment Council meant there was now a very high probability that earthquakes could be predicted. This put pressure on the organizations involved in Disaster Preparedness and Planning to be ready for the time when there is a prediction. The Large Cities Earthquake Disaster Countermeasures Committee was set up within the Central Disaster Prevention Council to take the lead in promoting consideration of countermeasures to be taken, not only by the various government agencies, but also by private industry and citizens. It also began the study of a public information transmittal system. Some of the major problems that faced this committee were:

1. Accuracy of predictions, given the level of technology available.

2. Accepting the existing accuracy (meaning that there could be false predictions), what would be an appropriate level of response?

3. Who assumes governmental and financial responsibility in the event of a false prediction?

4. Once a prediction is made, how should response be organized to ensure that countermeasures will be implemented as speedily as possible?

At the same time, the Earthquake Countermeasures Special Committee was also actively involved in acquiring the necessary budget for earthquake prediction and countermeasures. The committee drew up the proposed "Large-Scale Earthquake Prediction and Countermeasures Special Act" in November 1977. This proposal covered six salient points:

1. Establishment of a Large-Scale Earthquake Prediction Committee as a means of strengthening prediction reliability.

2. Designation of an "Area of Intensive Earthquake Response" (the Tokai Region), and formulation of a plan to collect and evaluate earthquake related information and data.

3. Establishment of an Earthquake Assessment Council, and reporting to the Prime Minister in the event of an imminent earthquake.

4. Disaster Warning from the Prime Minister.

5a. Obligation on the part of designated prefectures, cities, villages, and communities to formulate large-scale earthquake disaster countermeasures plans.

5b. Obligation on the part of all persons responsible for hazardous materials, and other public and private organizations, to implement earthquake disaster prevention plans once the warning is announced.

6. Subsidy for the activities involved in planning for, and implementing, large-scale earthquake countermeasures.

In December of 1977 the National Prefectural Governors' Council drew up a proposal entitled: "Special Emergency Countermeasures for a Large-Scale Earthquake." This proposal covered the following ten essential points:

1. Upgrading and unification of the Earthquake Prediction System.

2. Designation of an "Area of Intensive Earthquake Response" (The Tokai Region).

3. Centralization of measurements from the area of intensive earthquake response, constant monitoring of these measurements, and evaluation of imminency of earthquake occurrence.

4. Large-scale earthquake emergency declaration by the Prime Minister.

5. Establishment of an Earthquake Emergency Response Headquarters, and obligation on the part of all personnel related to emergency response to take necessary actions.

6. Emergency powers for the Prime Minister to despatch necessary personnel for disaster relief, transportation of emergency supplies, regulation of industrial operations, regulation of traffic, regulation of commodities transportation and distribution, price control, and moratoria.

7. Requirement that all prefectural, city, village, and community governments implement emergency procedures, and a clear declaration that compensation for losses suffered by citizens as a result of following emergency orders will not be paid.

8. Implementation of a 5-year plan to upgrade emergency response capability for large-scale earthquake disaster countermeasures. This plan includes distribution of personnel, distribution of disaster prevention equipment, availability of emergency transportation, disaster prevention activities in disaster areas, improving fire-resistivity of specified buildings, upgrading and improving refuge areas and access roads, improving water supply for firefighting, and improving wireless communication capability.

9. Assistance from the central government for emergency response activities and equipment, and for regional preparedness activities.

10. Monitoring of earthquake prediction activities by establishing a Central Earthquake Countermeasures Council.

The National Land Agency, in addition to keeping track of the above activities, had also been planning modifications to the existing Disaster Countermeasures Basic Law, which had been enacted in 1961. In the midst of these activities, on January 14, 1978 the Izu-Oshima earthquake (magnitude 7) occurred, with 25 deaths and several injuries. This brought home the realization that the necessary modifications to the existing laws had to be done rather speedily, and the speed at which modifications were made was increased greatly. The basic provisions for a new law were identified by February of the same year, and after going through the machinery of the government party (the Liberal Democratic Party), the government proposed the "Large-Scale Earthquake Countermeasures Act" to parliament in May 1978. After several debates in both the Senate and Parliament, this proposal became law on June 15, 1978.

The major significance of this law is that it is the first of its kind in the world. It seeks to reduce damage to life and property, as a result of a major earthquake, by combining earthquake prediction studies with disaster prevention activities. This law provides for preparation and improvement of disaster prevention measures before the fact, so that when an earthquake is predicted, using the emergency declaration as a signal, all related personnel can go into action at once, with the net result of reducing the disastrous effects of a large-scale earthquake.

## Section 3
## SHIZUOKA PREFECTURE: INDUSTRIAL EMERGENCY PREPAREDNESS AND THE PREFECTURAL GOVERNMENT

In Japan today Shizuoka Prefecture is a very special case. As has been pointed out earlier, the occurrence of a major earthquake along the Suruga Trough, off the Shizuoka coastline, has already been predicted in a long-term sense, and there is the expectation of a short-term prediction as well. This earthquake has been named the **Tokai Earthquake**, and is the first instance of naming an earthquake before its occurrence. The Large-Scale Earthquake Countermeasures Act (LECA) of 1978 basically put emphasis on the Tokai region and Kanto (Tokyo) region as being particularly earthquake prone, and called for national and local governments to act ahead of time. In 1979 another law, identifying the Tokai Region, where Shizuoka prefecture is located, as being under "intensified measures against earthquake disasters," was passed.[7] This law placed national attention on the region.

Shizuoka Prefecture is not only densely populated, but it also has a large concentration of industries, ranging from light manufacturing to heavy industry, such as petrochemical complexes. Slightly over three million people live in this prefecture.

The issue was important enough to prompt the previous governor, Mr. Yamamoto to use it as one of his campaign platforms when he was running for office in 1980. After he was elected to office, an Earthquake Disaster Countermeasures Division was established in the Prefectural Office. All prefectural offices have emergency countermeasures departments or divisions, and the subject of earthquakes normally falls within their jurisdiction. Shizuoka is unique in that it has a whole division devoted to the subject. As of summer 1985, this Division had 18 employees, half of whom were engineers and architects. This Division has several tasks, including:

- Upgrading and retrofitting existing public buildings, including hospitals and schools.

- Public education, including distribution of specially prepared brochures and pamphlets for private citizens, specialized publications for professionals such as engineers, and organizing and conducting training exercises.

- Providing guidance to companies so they can implement hazard reduction measures ahead of time.

This section will examine the role that Shizuoka Prefecture plays in encouraging and promoting earthquake hazard reduction and preparedness among its industries. Since 1975 all corporations employing 50 or more people have been required by law to have emergency preparedness plans. However, implementation of LECA in December 1978 made it obligatory for practically all organizations (with the exception of private households) not only to formulate disaster preparedness plans, but also to maintain them. In August 1979 all corporations employing 50 or more people were required to submit their emergency preparedness plans for approval within 6 months; 84% had complied by the end of June 1983. New companies must submit and obtain approval of their emergency preparedness plans before their business licenses are issued.

Though the prefecture now has a new governor, its policies regarding earthquake preparedness are not expected to change. Governor Yamamoto was defeated in the Liberal Democratic Party primaries, and therefore did not participate in the June 1986 gubernatorial elections.

SURVEYS

The prefecture has conducted two surveys so far in order to both assess the state of industrial emergency preparedness and also to find out the requirements of industry to improve emergency preparedness profiles.

The first survey of 1,100 companies employing 100 or more people (termed large companies) was conducted from December 1980 to January 1981.(8) Seven hundred and fifty-one companies (68.3%) responded. The second survey of companies having between 50 and 99 employees (termed medium-size companies) was conducted between January and February, 1982.(9) Of the 1,738 companies surveyed, 1,227 (70.6%) responded. The two surveys were essentially the same and consisted of questions in the following areas:

1. Characteristics of company: Type and scale of company, site conditions, hazards, number of employees, conditions of employment.

2. Disaster Countermeasures and Emergency Response Planning: Role of employees, reception and transmission of disaster warning, personnel responsible.

3. Earthquake Countermeasures: Implementation of countermeasures, detailed examples, improvement of disaster mitigation equipment, storage of

food supplies, medical response, and cooperative agreements with outside organizations.

4. Training and Education: Implementation of disaster drills and training programs.

5. Response to Emergency Warning: Evacuation & refuge, return of employees to their homes, effect on operations, coordination with labor unions.

Although the results have been tabulated in great detail, the salient features of the results of this survey are summarized in Table 4. As might be expected, the larger companies in general appear to be better prepared than the medium-sized companies. This is probably reflective of the greater economic resources available to the former.

The questionnaire also sought to identify the requirements (and desires) industries had in order to improve their earthquake emergency preparedness. Topping the list of "demands" was the requirement that there be some financial provision, in the form of tax incentives, subsidies, or some other form of preferential treatment, which would alleviate the cost involved in implementing countermeasures. Other major industry requests to the national and prefectural governments included:

1. Improving the speed, accuracy, and reliability of earthquake predictions and relay of information.
2. More comprehensive earthquake insurance.
3. More guidance from governmental agencies.
4. Applicability of workers' compensation to earthquake incurred injuries.
5. Improved public relations for disaster countermeasures, and implementation of education and training.

## FINANCIAL INCENTIVES

Although the prefectural government does not offer direct monetary aid or subsidies, it offers several economic incentives. Some of the economic incentives in effect at the present time are:

1. All equipment readily identifiable as improving the company's earthquake resistance, such as emergency shutoff valves, firefighting equipment, are tax deductible.

## TABLE 4
## RESULTS OF INDUSTRIAL EARTHQUAKE PREPAREDNESS SURVEYS CONDUCTED BY THE SHIZUOKA PREFECTURE

| | **Large Companies** 100 emp. | **Medium-Sized Companies** 50-99 emp. |
|---|---|---|
| 1. Time required to implement emergency response plans for earthquake prediction | | |
| - 1 hr | 21.7% | 69.1% |
| - 2 hr | 44.2% | 21.0% |
| - 5 hr | 2.7% | 0.9% |
| 2. Initiation of in-house earthquake countermeasures activities | | |
| - Begun | 75.4% | 56.0% |
| - Planned | 22.8% | 26.2% |
| 3. Earthquake analysis of facilities | | |
| - Completed | 23.3% | 18.7% |
| - Being done | 5.7% | 2.0% |
| - Planned | 48.9% | 27.8% |
| - Will not do | 20.5% | 48.5% |
| 4. Tie-down of equipment: | | |
| - Prevention of equipment overturning | 45.1% | 28.4% |
| - Prevention of equipment falling | 36.9% | 22.2% |
| - Fixing of tables | 5.4% | 3.8% |
| - Tie-down of lockers, etc. | 25.6% | 11.7% |
| 5. Installation of automatic shutoff valves: | | |
| - High pressure gas | 45.5% | 42.3% |
| - Propane | 29.8% | 29.8% |
| - Fuel oil | 30.2% | 32.9% |
| - Other hazardous materials | 28.3% | 25.5% |
| 6. Disaster drills | | |
| - Conducted | 75.9% | 61.2% |
| - Number of drills in 1980 | | |
| a. Once | 41.2% | 61.1% |
| b. Twice | 34.2% | 24.5% |
| c. Three times | 8.4% | 2.3% |
| 7. Decision regarding operations upon reception of earthquake warning | | |
| - Total halt | 79.8% | 65.6% |
| - Partial halt | 13.6% | 20.3% |
| - Will continue | 3.1% | 1.8% |
| - Undecided | 3.6% | 12.3% |
| 8. Refuge area | | |
| - Within facilities | 68.6% | 51.4% |
| - As designated by municipality | 22.8% | 45.7% |

2. Expenses incurred in preventing glass shattering and dispersion of fragments (by application of plastic film) are tax deductible.

3. Low interest loans to companies having 300 or fewer employees.

4. Accelerated depreciation of earthquake preparedness capital outlay permitted from 1983.

5. A 33% reduction in property tax applicable to equipment installed for improving earthquake resistance, preparedness, and countermeasures. This measure came into effect in 1982.

The prefectural government was also negotiating with the Ministry of Labor to include injuries incurred from earthquakes under workers' compensation programs. In 1985, however, the Ministry decided against this. (In California earthquake-related injuries are covered under workers' compensation.)

In addition to national and prefectural funds for promoting earthquake preparedness, Shizuoka Prefecture has instituted a 10% surtax to be levied on corporations and higher income bracket individuals as an additional source of income for its activities in this area. Shizuoka is the only prefecture to have this measure, which was introduced in 1979 for a five-year period. It has been extended for a further five-year period, from 1984 to 1989. The projected and actual incomes from this measure, for the years 1980 to 1983, are shown in Table 5.

TABLE 5
PROJECTED AND ACTUAL INCOME FROM 10% SURTAX[10]
Unit: Million Dollars

| Year | Projected million $ | Actual million $ |
|---|---|---|
| 1980 | 30.5 | 37 |
| 1981 | 40.5 | 37 |
| 1982 | 36.1 | 38.7 |
| 1983 | 36.5 | |

Note: Budget figures have been converted from Japanese yen to U.S. dollars, using 1984 exchange rates of Y235=$1. Using an average 1986 exchange range of Y160=$1 would change the above figures significantly.

In principle, the prefectural government keeps 50% of this revenue for its own expenditures for its various programs, and disburses the other 50% to cities, villages, and communities in the prefecture to aid them in their earthquake preparedness activities. Some of the specific activities for which these monies are earmarked include:

- Establishment of community disaster prevention centers
- Improving communications (wireless) systems
- Improving firefighting facilities
- Education of voluntary disaster prevention groups
- Earthquake resistance evaluation of public buildings

## GUIDANCE TO THE PRIVATE SECTOR

The prefectural governments are required by law to have complete plans for earthquake disaster preparedness and countermeasures. In keeping with this, the Shizuoka Prefectural Government has embarked on a program, unprecedented in magnitude, to educate the population on earthquake disaster preparedness.

One of the key areas being emphasized by the prefectural government is promotion of disaster preparedness and planning in industries. Although the prefectural government does not provide any direct subsidies to individual companies to aid them with the planning, the emphasis is on "creating an environment conducive to disaster preparedness planning," which includes technical support and the financial incentives described earlier. The prefectural government has also specified that because businesses and industries are places where there are normally large numbers of employees and guests, and because they also use a large variety of equipment and materials, they have the social responsibility to:

1. Protect the life safety of employees, guests, and customers.
2. Ensure that they do not become the source of secondary damage to their surroundings.
3. Protect their production equipment, thus minimizing the damaging effects of an earthquake on society.

The prefectural government's Earthquake Preparedness Division provides considerable guidance to companies for the formulation of disaster preparedness plans. A 50-page guidance booklet on the formulation of Earthquake Disaster Prevention and Emergency Response Plans published by the prefectural government in June 1980 outlines in detail who has to prepare disaster plans, where to submit these plans for approval, and in how many copies.[11] Chapter 2 of this booklet outlines the assumptions that should be used in planning and spells out typical warning times for earthquake predictions, expected earthquake characteristics, and conditions to be expected, such as shutting off of utilities (electricity, gas, water), discontinuation of transport facilities, and the communications media that would be available.

The booklet states that the plans formulated should not be abstract, but rather detailed plans of who is to do what, when, and how, and that all employees should not only be aware of the existence of such a plan, but also be familiar with it. Toward this end, the booklet outlines:

- How disaster information will be transmitted from the National Government headquarters
- How companies should organize themselves for earthquake disaster countermeasures and emergency response
- How evacuation is to be conducted
- The organization of emergency medical response
- Procedures for inspection of property and equipment for earthquake resistance
- What emergency supplies are to be stockpiled
- The planning and conducting of disaster drills (more than once a year)
- The types of education programs and information to be disseminated regarding earthquakes and countermeasures.

Special attention is paid to the fact that different organizations, such as hospitals, theaters, small companies, companies handling hazardous materials, or large companies, will have different requirements. This booklet outlines special measures different organizations should take, or provide for, based upon their occupational hazards. A detailed example of a disaster plan is also given as a model.

Another booklet published by the prefectural government, entitled "Organization of Independent Disaster Prevention Groups," explains in detail all aspects of earthquakes, including origin, consequences, the laws governing disasters, and countermeasures that can be taken.(12) An example of a disaster plan for a foundry is given, including aims, organizational structure, specific actions to be taken for structural inspection, improvement of fire protection facilities, handling of hazardous materials, materials to be stockpiled, evacuation routes and drills, and actual response activities and responsibilities.

A third publication by the prefectural Earthquake Countermeasures Division is a compilation of 16 case studies of industries that have complied with and implemented earthquake countermeasures.(13) In each case, a brief description of the company (location, number of employees, products) is followed by a description of its site conditions. The next section describes the development of emergency (earthquake) preparedness activities in the company, frequently quoting starting dates, the section or division in charge, and the establishing of objectives. Practical examples of the organizational structure (with organizational charts and flow charts) in each of the companies and the countermeasures taken (with photographs and sketches) are also given. The training and education programs undertaken by each of these companies are described next, with frequent reproductions of the actual materials used. Each case study is concluded with a section on how the company is coordinating its efforts with the immediate neighborhood, including the city government and residents. This is probably to be contrasted with the U.S. corporate structure where there is little, if any, interaction between companies and the neighborhood population.

Detailed examples of recommended preparations that businesses and industries should undertake, as outlined in the above publications and other government publications[(14)] include the following:

1. **Assessment of Facilities:** Evaluate site conditions (liquefaction potential, danger of tsunami, density of private residences in surroundings), storage of hazardous materials, necessity for rapid shutdown of equipment or machinery, organizational structure for emergency response, possibility of employees returning home.

2. **Upgrading of Facilities and Equipment:** Anchoring of machinery, equipment, and furniture. Inspection and upgrading of smokestacks, water towers, and concrete block walls. Protection of chemicals so they do not fall down. Prevention of glass shattering along evacuation routes. Installation of automatic extinguishing systems for equipment that uses open flames. Prevention of rupturing of pipe joints in fuel lines by use of flexible tubing. Installation of emergency shutoff valves for chemicals that could possibly leak.

3. **Emergency Preparedness:** Proper instruction of employees and their families by distribution of literature and holding tutorials and exercises. Prepare organized emergency response groups so the employees will behave as a cohesive group, and make sure that employees are familiar with this organization.

## SAFETY MEASURES FOR HAZARDOUS MATERIALS

All forms of hazardous materials are specifically targeted in Japan because they are recognized as being particularly prone to causing secondary damage. For example, a damaged oil storage tank has the potential to cause more damage because of spills and fires than would a damaged water storage tank. The prefecture has been active in paying special attention to this problem, and this section outlines some of the achievements in this area.

**City Gas (Natural Gas)**

Thirteen city gas companies distribute (pipe) gas to approximately 330,000 households in the prefecture. Earthquake countermeasures must be undertaken by these companies in order to minimize the fire risk. The following measures are being implemented by all gas companies since June 1981.

a. All companies have installed seismographs. When the detected acceleration exceeds 300 gal (equivalent of 6 on the JMA scale), the distribution system will be shut off at the storage tanks.*
b. Residual gas in the pipes will be released within 5 minutes. Emergency gas venting equipment has been installed for this purpose.
c. When a National Disaster Warning is issued, the distribution pressure is lowered to the lowest possible pressure.

**Propane Gas (Bottled Gas)**

Bottled gas is distributed in two forms. It is distributed in smaller bottles to individual homes. For businesses and high-rise flats, these bottles are installed in a centralized location, and the gas subsequently piped to individual users. There are approximately 740,000 households that use bottled gas. The gas companies that distribute bottled gas are implementing the following measures, with the aim of having 60% of the households properly protected by the end of 1985.

a. For individual homes: Install emergency shutoff valves immediately after the cylinder so there will be no escape of gas if the piping ruptures. There are two types of valves being installed. One type is triggered by excessive flow, so that if the piping ruptures, it will shut off automatically. The other type is designed to shut the cylinder off in the event the cylinder falls. This is done by means of a chain that is attached to the wall.
b. For centralized installations such as businesses and high-rise flats: For relatively small installations, the countermeasures taken are identical to those described for individual homes. For larger installations emergency shutoff valves that would be triggered by the earthquake's vibrations are installed.

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* A gal, or Galileo, is the metric unit of acceleration, and is one cm per second per second. Because 1 g, the earth's gravitational acceleration, is 980 gals, 300 gals is approximately 0.3 g, 400 gals is approximately 0.4 g, etc.

**Fuel Oil Tanks**

The types of damage that fuel oil tanks, and other similar tanks, could suffer during an earthquake include slipping, overturning, buckling, and overflow due to sloshing inside the tank. During an earthquake, buckling of the sides because of the forces exerted by the mass of the contents is considered to be the primary danger. Countermeasures to be considered for such tanks include:

a. Strengthening the sides of the tank.
b. Limiting the maximum storage.
c. Making sure that spills do not escape beyond the limits of the dikes.

In addition to the above, measures to prevent slipping of tanks and sloshing of the contents is also recommended.

**Storage of Pressurized Gas**

There are 500 locations within Shizuoka Prefecture where LPG, liquefied oxygen, and other highly pressurized gases are stored in quantity. Compared to fuel oil, storage tanks containing pressurized gas are normally smaller in volume, and have thicker walls. Thus, rupture of the tank itself in an earthquake is unlikely. Countermeasures to be implemented include strengthening of anchor bolts, prevention of overturning by strengthening the foundations, and installation of emergency shutoff valves, triggered by seismometers, at the outlet.

**Gas Stations**

Underground gasoline tanks at gas stations are fabricated from 6 mm mild steel plates. There have been no past incidents of spillage or fire from these installations during earthquakes. Points to pay special attention to in these facilities include destruction of the surrounding firewall, rupturing of underground pipes, and collapse of canopy over the gas station.

LIFELINES

**Water**

Individuals are to provide for a three-day supply of 3 liters per day. Neighborhood preparedness committees should have a group for water distribution, and also be prepered with filters, pumps, and tanks. Local governments should have a plan for emergency water distribution, equipment and materials necessary for repairing damaged water systems, water trucks for water distribution, tanks, filters, and emergency power generators. Reservoirs should have been evaluated for their earthquake resistance and upgraded. Emergency shutoff valves should be installed.

Local governments should be prepared to supply water to the public after it has exhausted its three-day supply, and for at least a week thereafter.

**Electricity**

Damage expected includes damage of insulators at generating stations and transformers, damage of underground cables and transmission towers due to earth movement, damage to transmission lines from fires and other secondary effects.

Utilities are to confirm that the design of hydro- and thermal power stations has included seismic design criteria. The nuclear power plant (Hamaoka) has been designed to withstand earthquakes more severe than Ansei and other major earthquakes. It is designed to shut down automatically at an acceleration of 150 gal. Design criteria for transformers should include dynamic loading, including resonance.

All power companies have emergency equipment--power generators, cables, transformers, and distributing equipment--that can be used to restore services. They have also agreed to standardize the equipment and supplies they use so these will be interchangeable. The power companies are also tied into the national grid, so they can obtain emergency power when they need it. It is estimated that within 5 days after the occurrence of the Tokai Earthquake one-third of all consumers will have power, and that within 10 days, two-thirds of all consumers will have power.

**Gas**

It is expected that the city gas distribution network will become inoperable, and that it would take approximately one month for service to be restored. Bottled LPG is expected to be the emergency fuel. At a consumption rate of 70 g per person per day, the daily consumption for the 3.5 million citizens of Shizuoka will be 245 tons. Assuming that no transportation facilities will be available for 7 days, the amount to be stored will be 1,715 tons. At present, the total stock at all suppliers and distributors is approximately 1,650 tons, which is barely sufficient for one week.

Local governments are to take stock of the total amount of gas available at all distributors and suppliers within their jurisdictions, compile a list of locations that will need gas (e.g. hospitals, refuge areas, disaster headquarters), increase the normal inventory, and prepare cartridge-type gas stoves.

**Communications - Telephone**

Emergency provisions by Nippon Telephone and Telegraph (NTT) are as follows: Upgrading of facilities so their earthquake resistance will be better. In order to increase reliability of the transmission network, (a) provide at least two routes (wired and wireless) between exchanges, (b) use communications satellite Sakura 2.

Measures to prevent interruption of communications: Wireless sets (Type TZ-60) have been installed in 118 places within the prefecture in order to prevent isolation. Wireless sets for emergency communications (Type TZ-41) have been installed in Shizuoka, Hamamatsu, Numazu, Shimizu, Fuji, Shimoda, and at city offices and disaster related organizations - a total of 63.

Priority will be given to disaster related communications and news agencies. Blue and yellow public telephones will be operable. These phones have been installed in refuge areas designated by local governments. More of these will be installed in public places such as train stations. Special telephones have been installed in Japan National Railroad (JNR) stations that serve the bullet train.

Recovery: Within the first week: (a) Provide more than one line for organizations involved in emergency response, transportation facilities, power facilities, and public agencies. (b) Restore service to public telephones in refuge areas, and other commercial areas. (c) Restore service to important routes, within the capabilities of materials and personnel available within the prefecture.

Within one month: Continue activities described above, while expanding the area of restoration. Restore service to households.

## CONCLUSION

The overall measures being implemented by the prefectural government are certainly impressive. Industry is seen as playing a positive role in the overall life of the prefecture, and the government is determined to reduce the damage that this valuable source of revenue would sustain.

# Section 4
# CORPORATE EARTHQUAKE HAZARD REDUCTION PROGRAMS

A significant part of the motivation on the part of the private sector in Japan to implement hazard reduction practices at their facilities comes from the social responsibility that industries and businesses are expected to have. This concept is interpreted to comprise:

1. Protecting the life safety of employees, customers, and guests.

2. Preventing a disaster within the facility from affecting its surrounding areas, especially the life of private citizens living nearby.

3. Maintaining service, especially when the specific business or industry performs a service that is essential in nature, such as water companies, banks, or gas companies. These companies are also expected to play important roles in the recovery process.

It has also been pointed out that major Japanese companies consider investment in earthquake and other natural disaster hazard reduction practices as an integral part of their overall risk management strategy.[15] While the term "risk management" in the United States is interpreted primarily in a financial sense, probably because of the high occurrence of natural disasters in Japan, Japanese companies consider it necessary to hedge themselves against being wiped out by a single major natural disaster, which means earthquakes within the special confines of this report.

Several individuals indicated the 1964 Niigata earthquake was the turning point in terms of industrial earthquake preparedness. While it was considered important, little progress was made until the occurrence of the 1971 San Fernando Earthquake in the United States. This forced a change from "thinking" to "doing". Most of the earthquake hazard reduction programs at companies visited had been initiated in the mid-1970's. From this point on periodic changes in regulations, as was pointed out in Section 2, have also compelled businesses and industries to implement appropriate hazard reduction measures.

Table 6 lists the companies visited during the first research trip to Japan in August 1985. Several government agencies were also visited during this trip. In addition to the information gathered from these site visits, information on corporate emergency preparedness was obtained from a variety of other published sources.

TABLE 6

LIST OF JAPANESE COMPANIES VISITED DURING RESEARCH TRIP

August 1985

| Date | Name of Company | Products Manufactured |
|---|---|---|
| Aug 5 | Kajima Corp. | General Contractors |
| | Urban Safety Research Inst. | Nonprofit Research |
| Aug 6 | Nippon Telegraph & Telephone | Telecommunications |
| Aug 7 | Tokyo Electric Power Co. | Electric Power Utility |
| Aug 8 | Tokyo Water Authority | Water Utility |
| Aug 9 | Tokyo Gas | Gas Utility |
| Aug 13 | Tohoku Petroleum | Petroleum Refinery |
| | Tohoku Electricity | Electric Power Utility |
| Aug 14 | Showa Petroleum | Petroleum Refinery |
| Aug 15 | Sony | Electronic Products |
| Aug 16 | Nippon Petroleum | Petroleum Refinery |
| Aug 17 | Fuji Bank | Bank |
| Aug 19 | Hitachi | Electrical Products |
| Aug 20 | Shizuoka General Hospital | Hospital |
| | Shizuoka Bank | Bank |
| | Toa Nenryo | Petroleum Refinery |
| Aug 21 | Shizuoka Gas | Gas Utility |
| | Chubu Power | Electricity Utility |
| | Ohbayashi | General Contractor |
| Aug 22 | Fujitec | Elevators |
| Aug 23 | Osaka Gas | Gas Utility |

The second research trip to Japan in July 1986 included visits to some of the same companies, and the preliminary research findings of the project were presented at seminars in Tokyo, Sendai, Shizuoka, and Osaka.

The first part of this section will concentrate on describing corporate earthquake hazard reduction programs from a general perspective. The second part will give examples of earthquake hazard reduction measures implemented at a number of industries, including a detailed profile of one company.

Earthquake preparedness planning and countermeasures are typically divided into two major categories - what the Japanese call **SOFT** countermeasures and **HARD** countermeasures. (These are words that come from computer terminology, viz., software and hardware, and the English words are used.) Both of these elements are an integral part of the overall planning.

## SOFT COUNTERMEASURES - ORGANIZATION AND EDUCATION

**SOFT** countermeasures center around the organizational capability of the industry to respond to an earthquake. These would normally include an emergency response organization, and education and training programs.

All major corporations have the equivalent of a safety department (though the specific name varies quite frequently), and it is the responsibility of the department manager to implement hazard reduction programs - both hard and soft. The safety department is in general contained within a division called the General Affairs Division, which is unique to the Japanese corporate structure, there being no direct equivalent in the U.S. corporate structure. In the case of businesses such as banks, or head offices located in Tokyo, certain individuals within this division are assigned the task of being responsible for earthquake safety. In the case of production facilities, such as factories, a separate safety department, again within the general affairs division, exists. In the following text the individual responsible for earthquake safety and hazard reduction will be referred to generically as the "safety manager."

The position of safety manager is a position on a management career track within the corporate structure, as is the case with other personnel in the department. Safety department personnel are not restricted to those with an educational background in public safety, industrial hygiene, or firefighting, but rather they are assigned from other departments within the company, to serve a finite period of time in safety, before being assigned to another department. Another important point that should be made is that, within the corporate structure, safety department personnel do not have an advisory role, but rather a regulatory role. In real terms this means that safety department personnel have the authority to prohibit leaving stray items on top of filing cabinets, for example, and furthermore they have the authority to confiscate or otherwise remove such items.

During initial development of the earthquake program, personnel from top management are usually in charge. After sufficient development, it is turned over to the safety department for maintenance, implementation, and further development, but still linked to top management, even if indirectly. In the case of Sony, for example, the deputy president of the company was in charge of developing Sony's earthquake program; he is now the chief executive officer. In the case of Kajima, the internal earthquake preparedness program of the corporation was ultimately the responsibility of the deputy president, who also is now the chief executive officer. This was found to be quite typical.

One of the main tasks of the safety manager is to organize emergency response organizations that would become operational in the event of a disaster. In general, at least two such organizations have to be planned for - one for the event that a disaster occurs during normal working hours, and one for the event that the disaster occurs after hours or during weekends and holidays. In either case, the Emergency Response Organization typically has top management (president or deputy president in the case of a head office, and factory manager or his assistant in the case of a factory) of the facility as the chief of operations during an emergency.

Formulation of an emergency response organization constitutes not just pulling the necessary people together, but also organizing them in such a manner that they will operate as a team with the overall goal of mitigating the effects of the disaster. An important part of this objective is to organize the message flow sequence, including decisionmaking powers. Examples of emergency response organizations in a hospital and a petroleum refinery are outlined in Sections 5 and 6.

Education and training is another important task within the jurisdiction of the safety department and the general affairs division. Disaster prevention education is implemented by a variety of means, including lectures, distribution of pamphlets, posters, and drills at regular intervals. Though the details differ from company to company, several hold drills in conjunction with drills planned by local, prefectural, or national government. Some companies hold drills based on damage scenarios - these being different from location to location within the same company, based upon the hazards present at each location. The national government holds one drill a year - on September 1, which is the anniversary of the 1923 Kanto Earthquake. Local governments and fire departments hold drills on this date and on other dates as well. The number of drills held by companies visited varied from one per year to six per year. This number depended not just on company policy, but also on the level of training already achieved. Several companies held six drills per year at the beginning of their earthquake programs, and then gradually reduced the number as the employees became more familiar with emergency procedures. The training program at a petroleum facility is summarized in Section 6.

Another important aspect of emergency preparedness is securing the necessary finances. Two main points were made in this area: (1) Without the support of top management, it is extremely difficult to secure the necessary finances, and (2) The required expenditures are spread out over a period of time (say, 10 years) so the expenditure in any one given year will not be unreasonably large. In some of the companies, expenditure for earthquake hazard reduction has become a routine item, and is included in their annual budgets in much the same way other budget items are planned.

## HARD COUNTERMEASURES - ENGINEERING

HARD countermeasures mean engineering the upgrading of facilities so they can physically withstand the forces of an earthquake. This generally begins with a structural evaluation of the building, and a geological investigation of the site, which is usually carried out by consultants. Even if the building itself can withstand an earthquake, however, nonstructural and secondary damage could be severe, with possible adverse effects on life safety as well. The total range of possible countermeasures is invariably very broad, with specific countermeasures being relevant to specific industries or even equipment. The safety department or the general affairs division normally initiates these and uses either the engineering group(s) within the company or outside consultants for the actual design and fabrication work necessary for hazard reduction. A group of countermeasures, however, transcending differences from facility to facility includes:

1. Emergency power supply - Type and capability would depend on requirements of each facility. It is important here to ensure that this power supply does not depend on other elements that could be damaged by an earthquake, and thus render the power supply inoperable.

2. Storage of ample food, water and medical supplies - Three days' supply for employees was typical; often this food is stored along with hardhats and flashlights in a knapsack under each employee's desk.

3. Anchoring of tall bookshelves, filing cabinets, lockers, etc. so they do not overturn during an earthquake - While some companies have designed their own hardware for this purpose, other companies use strap ties, angle iron brackets, or one of a variety of commercially available seismic brackets and straps. Kajima Corporation has carried out extensive shake table tests as part of an internal research program in this area. They have used these results to restrain their furniture. The results of their research program have also been summarized and published in the form of a book. Uchida Yoko, a furniture manufacturer, has also conducted similar tests, and now has a special line of earthquake-resistant furniture available.

4. Protection of glass - In the case of glass windows, several brands of plastic film can be applied to the window panes. Special "security films" with stronger adhesives are used, rather than ordinary "solar films", and a Japanese Industrial Standard for these products has been developed. Though this will not prevent the glass from breaking, it will prevent glass fragments from flying out and injuring human beings. In the case of office partitions, it is also possible to use a non-glass material such as polycarbonate or acrylic.

5. Installation of base isolation mountings for raised computer floors - A large architectural and engineering firm, Ohbayashi Corporation, has designed and installed 40 such systems in important facilities in Japan. A similar product is also manufactured by another major AE firm - Takenaka Komutem.

6. Maintaining a duplicate set of computerized data files, at a separate location, so that damage incurred at one location will not affect the operability of the company - this is particularly relevant to financial institutions such as banks.

7. Laboratories - Several hazard reduction techniques for the chemical laboratory exist, the primary purpose being to prevent reagent bottles from breaking, and instruments from being damaged. Reagent bottles are kept in shelves that have slots into which the bottles fit. Instruments are anchored to countertops.

8. Installation of flexible pipe sections on piping connections to and from tanks, including fuel oil, gas, and other liquids.

9. Installation of seismically activated automatic shutoff valves that would shut off gas, power and fuel supply - This can prevent leakage due to ruptured pipelines or electrical short circuits due to ruptured power lines. About one-fifth of Tokyo Gas Company's 11 million customers have automatic shutoff valves.

10. Anchoring of manufacturing equipment.

11. Strengthening of storage tanks.

12. Securing lighting fixtures to structural members to ensure that they do not fall down.

13. Provision for emergency communications, within the facility, between the facility and local emergency response agencies, and also between the facility and its head office, if located in a different region. Several of the companies visited had gathered employees who were interested in amateur band radio, provided them with the necessary facilities, and encouraged them to operate from within the company. There were also periodic exercises.

14. The importance of avoiding secondary damage was stressed at every facility visited. This was considered particularly important at facilities such as petroleum refineries where large quantities of hazardous materials are stored, and damage to any of the storage tanks could pose a severe threat to the environment.

In a recent survey of 91 large Tokyo companies conducted by the weekly magazine Shukan Toyo Keizai, it was found that two-thirds of the firms had implemented nonstructural protection measures, and over half had their buildings structurally analyzed. At least one earthquake drill a year was common. A full translation of the results of this survey is attached in Appendix A.

## COMPANY PROFILE: YAMANOUCHI PHARMACEUTICALS

One of the companies that has been active in emergency preparedness and planning is Yamanouchi Pharmaceuticals. One of the most striking things was the extremely cordial and friendly relationship between the prefectural officials of Shizuoka prefecture and the company officials. It was definitely an attitude of: "We have to help each other."

This company started its earthquake and disaster preparedness activities in 1974. A Disaster Prevention Committee consisting of six full-time employees was formed initially to get the program off the ground. In 1984 they were reorganized into the Environmental Management Section, with Mr. Tohno as the section manager, and two employees under him. According to Mr. Tohno, the first activity of the committee was to educate the employees on disaster prevention and countermeasures.

The next activity was to tie down all equipment in the factory and offices. Mr. Tohno has been given personal authority by management to discard any material left sitting on top of filing cabinets, etc. All fuel oil, acid, and gas tanks are connected to feed and outlet pipings with flexible connections, and are also equipped with emergency shutoff valves. In the first ten years (1974 to 1983) they had spent a total of $500,000 on earthquake preparedness hardware alone, not including time spent by factory personnel in planning and training. All employees are trained in CPR and first aid. Sixty employees (out of a total of 600) are trained in firefighting, and form the company's fire brigade.

The communications line to the prefectural office (for earthquake prediction and/or warning) is open 24 hours a day. Mr. Tohno will receive the announcement from the prefectural office, and announces the warning over the PA system. The plant will begin shutdown once the Assessment Committee meets. There are evacuation maps for each floor and each department. Three evacuation drills are held each year. The company has complete plans for its employees to return home; they return in groups of three, and no one goes alone. People living farther away leave earlier. The homes of all employees have been surveyed, and information on them has been filed in the company's computer. A group of 100 employees will remain to carry out disaster prevention activities, plant shutdown, and other necessary tasks. These people are expected to take turns going home to confirm the safety of their families, before returning to the factory. The company also recommends that this group of people not live in areas prone to tsunamis. Over the last three years the company has aided some employees to relocate away from tsunami areas by providing them with loans. These one hundred essential employees will be housed in an existing one-story building and buses in the parking lot. None of the management personnel is expected to return home in the event of a short-term prediction!

Some of the specific earthquake countermeasures taken by this industry at its Yaizu factory site to date are:

1. All buildings have been analyzed for earthquake vulnerability.

2. Installation of an 800-kW diesel and several smaller standby generator sets.

3. Automatic release of halon at 80°C in the chemistry laboratory.

4. All acid and reagent bottles are placed in drawers that have bottle holders made from PVC piping; this prevents the bottles from knocking against each other, overturning, or sliding.

5. All filing cabinets, copying machines, portable furnaces, etc. have been tied down with brackets.

6. All partitions using glass have been replaced with polycarbonate.

7. Automatic emergency shutoff valves are installed on all gas piping.

8. All compressed gas cylinders have valves that would automatically shut them off if they fall over.

9. All tanks containing fluids have flexible connections.

10. There is a strict company policy of not putting anything on top of filing cabinets, or any other location from which it could slide and fall off.

11. All window panes in the plant are being covered with an adhesive, transparent film to prevent their shattering.

12. The hydrochloric acid tank has been located adjacent to a sodium hydroxide (alkaline) tank. Leakage from one will trigger the other to discharge, so that the leak is neutralized.

13. Dike retaining walls are designed to contain 110% of the capacity of tanks containing fluids. (For non-earthquake purposes, standard practice is to design the dikes to contain only slightly more than the largest tank's contents.)

14. All lockers are fixed at top and bottom.

EXAMPLES OF EARTHQUAKE HAZARD REDUCTION MEASURES IMPLEMENTED TO REDUCE NONSTRUCTURAL AND SECONDARY DAMAGE

**Case A:** Ihara Chemicals Co., Ltd., Manufacturer of agricultural chemicals, chlorotoluene products, marine chemicals, organic sulphurous compounds.

1. Reinforcement of Liquefied Chlorine Tank Foundations and Building.
   Tanks, which had been installed on separate foundations, were modified so they would all be on the same foundation. The foundation was also enlarged as much as possible. The number of anchor bolts per footing was increased from two to four, and extra reinforcing bars were added to the concrete in order to hold the anchor bolts. Dikes capable of holding leakage were built. Diagonal

bracing rods, for the building, were increased from 16 mm diameter to 22 mm diameter. Installation bolts were upgraded from M16 to M20 high tension. Gusset plates of 6 mm were replaced by 9-mm gusset plates. The piping was completely replaced, and the operation panel was installed together with the storage tanks. The piping was also redesigned to form a loop. Seismometers were installed and programmed to issue a warning signal at 40 gal acceleration, to shut off the outlet valve at 80 gal acceleration, and to shut off the inlet valve at 150 gal acceleration.

The chlorine gas neutralization tower, made of polyvinyl chloride (PVC), was designed to withstand a horizontal acceleration of 0.6 g. This was further strengthened on the outside with fiberglass reinforced plastics (FRP). The equipment for this neutralization tower has been designed so it can operate with commercial power, with power from the emergency generator in the event commercial power is cut off (which is expected to happen at an acceleration of 150 gal), or with power from a portable generator.

2. Underground Installation of Hazardous Materials Tanks.
Hazardous materials having low flashpoints have been removed from the hazardous materials storage area, and stored in underground tanks. Three 30,000-liter capacity tanks for diethyl amine were built in 1978, and three 37,000-liter tanks for 1PC (Type 4 special flammable materials) were built in 1980.

3. Emergency Operations in Cafeteria Building.
The cafeteria building (housing the cafeteria, locker rooms, showers, etc), which was built in 1979, was designed to withstand an acceleration of 0.3 g, as is the case with hazardous materials facilities, so it can serve as the emergency operations center during a disaster. This is a two-story steel reinforced concrete building, using 25 mm reinforcing bars, and 400 mm x 250 mm H beams in the columns and 750 mm x 200 mm H beams in the beams. (Japanese steel reinforced concrete construction is a composite type of frame. A complete steel frame is wrapped with reinforcing bars and concrete.) Utilities for this building are independent of the rest of the facilities, with a standby power generator.

4. Emergency Shutdown.
There are ten separate buildings within the factory, each building being dedicated to an individual product. Each building has an emergency STOP button in the operations panels. At times of emergencies, pushing this button will cause the plant to stop production. Employees will then follow emergency

instructions in shutting down individual production units in the right sequence. Large tanks installed recently have emergency shutoff valves connected to seismometers.

5. Piping Joints.
   All tank outlet pipes and pipelines that travel considerable distances have flexible tubes installed in them to minimize the risk of rupture due to excessive strain or differential displacement.

6. Other Measures.
   Chemical racks in the research and analytical laboratory, lockers, filing cabinets, and book shelves in offices have been anchored to prevent falling over.

Case B: Touyou Bearing Co., Ltd. Manufacturer of bearings.

1. Power Supply.
   Incoming power supply is at 70 kV. At accelerations exceeding 80 gals, the seismometer will shut off incoming power to the facility. Battery-pack emergency lighting, however, will stay on.

2. Gases.
   Automatic shutoff valves have been installed for propane, butane, LPG, methanol, and ammonia gas cylinders or storage tanks. Flexible tubes have also been installed to reduce the risk of pipeline rupture.

3. Equipment Anchoring.
   All equipment has been anchored, either to the floor or to the building, so that it will not fall over. This has been done with a variety of anchor bolts, metal jiggs, and wire bracing.

4. Pollution Control and Other Measures.
   The sewage system has been thoroughly inspected, and wornout items replaced. Capacity of storage pits for waste oil has been expanded. Concrete block walls are either being strengthened with diagonal bracing, or are being replaced with chain link fencing. Important drawings and documents have been microfilmed and stored.

Case C: Touray Co., Ltd. Manufacturer of polyester fibers and resins.

1. Safety of Storage Tanks.
   Risk assessment was undertaken first. Since rupturing of these tanks could lead to secondary damage, all piping had flexible tubing sections installed. As a further precaution, emergency shutoff valves that could be remotely operated

from the control room were also installed. Since 1978, along with amendments to the Fire Code, the dikes have been strengthened and their capacity increased. A second set of dikes has been built for the fuel oil tanks, in case the first set fails. To prevent accidental release of chemicals and reagents into the sewer system, emergency shutoff valves have been installed on the storm drain outlet from the factory premises. A third dike has been built along the factory perimeter to prevent any accidental release from the factory premises. Provisions have also been made to convert one part of the premises into a "pool" to contain accidental releases and spills. Diesel pumps were purchased and installed in 1980, so that such accidental releases can be transferred into a 2000 cubic meter emergency tank and/or other standby tanks.

2. Safety of Chemicals and Gases.
   A major incentive to anchor or tie down equipment is to prevent fires. All cylinders containing flammable gases have been anchored so they do not fall down. Bottles and drums containing chemicals have been placed in boxes with partitions between them in order to minimize damage to them. The question of compatibility of chemicals was also taken into consideration before deciding which chemicals to store together.

3. Glass.
   Glass windows, especially those along evacuation routes, have been treated with plastic films so that, even if they break, pieces of glass will not fly. Frames for sliding doors and windows have been strengthened. Windows with blinds will have their blinds lowered once the National Disaster Warning is issued. HVAC ducts and fluorescent light fixtures, especially those located in designated evacuation routes, have been strengthened by bracing wires.

4. Concrete Block Perimeter Fence.
   The perimeter fence was checked, and found to be weak in certain areas. This was strengthened, and where necessary, the foundation was also strengthened.

5. Communications.
   The public address system was checked, to make sure all employees could hear announcements. Where it was either difficult to hear announcements, or the equipment had deteriorated, new speakers were installed. Diesel standby generators for in-house communications systems have been installed and are tested periodically. The standby battery power supply, for the telephone system, had its anchoring and bracing strengthened. An amateur ham radio club, consisting of employees, has been formed to ensure that communications with other organizations can be maintained, even if the telephone system goes down.

6. Other.
   At all locations where there was danger of overhead objects falling down, prominent warning signs have been posted. Helmets, and other suitable head protection, have been distributed to employees.

Case D: Tomoegawa Paper, Co., Ltd. Paper and paper products manufacturer.

This company did something unique. It requested its own personnel to generate a list of earthquake hazard reduction measures, and used this list as a guide.

1. Listing of Countermeasures.
   All departments were requested, in April 1971, to produce standards for earthquake countermeasures, including upgrading of equipment and other desirable features. The items that emerged from this listing included the following:
   a. Removal of idle equipment that posed any danger
   b. Replacement of tiles and strengthening of roofs and walls of high-rise buildings
   c. Increase capacity for storage of hazardous materials
   d. Installation of emergency lighting inside factory
   e. Changes to part of the overhead power transmission lines
   f. Construction of new, and improvement to existing, emergency exits

   These and other measures were implemented either by using normal funds or special allocations.

2. Seismometer Control.
   In-house power generators were installed in 1974, in order to reduce power costs. This opportunity was taken to install seismometers on power reception and generation equipment, so secondary damage caused by power lines could be eliminated. The seismometers were set to detect accelerations of 150 gals (equivalent to an intensity of 5 on the JMA scale). They were installed in both the power generation room and power distribution room, to cut off power generation and distribution only if both seismometers detected this level of earthquake. Installation was completed in 1977.

3. Dikes for Fuel Oil.
   A new boiler for power generation was installed, in 1974, adjacent to the existing boiler. New fuel oil tanks had to be installed too. The dikes were strengthened and increased in capacity so they would be able to contain the new quantities, and also to meet newer regulations.

4. Amateur Radio.
   An amateur wireless radio club was formed in 1978. Wireless equipment was bought and installed within the factory premises. Though this equipment is routinely used by club members for recreational purposes, it will be used in times of emergency for communications with outside facilities and agencies.

5. Hazardous Materials and Reagents.
   Reagents contained in glass jars, used in laboratories and for analyses, are always kept in boxes specially provided for this purpose. The bottom of these boxes has a layer of sand in it, and the jars stored in this box are wrapped in nets to minimize the risk of breakage. If the National Disaster Warning is issued, all reagents will be stored in these boxes, and the boxes locked up. Lab ware and chemicals that are in use will be put into special 55-gallon drums provided for this purpose, and wheeled to a safe area. Reagents and chemicals that have gone through testing are routinely transported by a special vehicle (trolley). To minimize the risk of secondary damage from these chemicals, containers are filled only two-thirds; the wheels of the trolley have special stoppers to prevent it from moving; rags are placed on top of the containers to prevent damage from falling objects; and a wooden frame is placed inside the containers to prevent spills from sloshing.

6. Warehouse.
   Storage racks are fixed to walls to prevent their falling over. Measures have also been taken to keep items from falling off the shelves. Gasoline drums and other drums either have a special strap around them or are lowered and placed on the floor.

7. Product.
   The product is paper rolls; these are normally stacked vertically and frequently along passageways. Special wooden frames have been installed to prevent their falling over and blocking exit routes.

Case E: Nihon Gakki. Manufacturer of musical products.

1. Communications.
   Public address systems have been installed in all factories. In the case of the main factory, it has been divided into four blocks, and it is possible to make announcements to just one block or to the whole factory. All factories have wireless sets operated by members of the Amateur Radio Club; these members will be in charge of emergency communications in the event of a telephone failure. Normal activities of the radio club include emergency communications exercises. There is also a mobile wireless unit.

2. Emergency Supplies.
   Each block of the main factory has an emergency supplies store, which contains a portable fire pump, a small power generator, a water filter, emergency medical supplies, shovels, crow bars, axes, ropes, etc. All employees have been issued helmets, which are to be kept at their normal job sites. Visitors are also expected to use helmets.

3. Seismic Evaluation and Upgrading of Buildings.

4. Evacuation Routes and Evacuation Sites.

5. Emergency Shutoff Valves.
   Emergency shutoff valves have been installed for all equipment using fuel oil and gas. These valves are connected to seismometers, which would sense an earthquake and activate the valves.

6. Mechanical Equipment and Furniture.
   As a rule, all equipment is anchored to the floor. All shelves higher than approximately 4 ft have been anchored either to the floor or the walls. Chemicals and reagents are being kept in special cabinets. Stoppers or gates have been added to shelves so the contents will not slide out.

Case F: Fujisawa Pharmaceuticals

In this case, the earthquake hazard reduction measures implemented are shown in chronological order to illustrate how the objective can be achieved by long range planning.

During 1976 - 1977

Installation of automatic shutoff valves on tanks containing high pressure gases, fuel oil, and other hazardous materials

Installation of flexible pipes on tank pump suction line and toxic materials tanks

Anchoring of production and packaging machinery, and shelves in warehouse

During 1977 - 1978

Strengthening of facilities (buildings) to withstand an earthquake of intensity 7 (JMA)

Strengthening of outdoor tank supports

Strengthening of oil dike

During 1979

Installation of seismometers on boilers and other power generation equipment
Installation of automatic sprinklers on annealing furnace
Strengthening of stack
Automatic and emergency shutoff valves installed on hazardous and toxic materials containers so they will not leak and flow outdoors

During 1981

Installation of film on window glass
Improvement of emergency exit route markings
Preparation of emergency supplies such as hammers, crowbars, jacks
Distribution of emergency flashlights, radios, helmets, safety shoes
Improvement of fire extinguisher markers (purple tapes from ceiling)
Improve distribution of fire extinguishers and fire hydrants, and purchase of portable fire pump
Construction of a "capsule" room within the security office to ensure safety of security personnel

During 1982 and after

Installation of automatic shutoff equipment for continuous processes
Expansion of cooling tower capacity to ensure emergency water supply in case of pipeline breakage or other water cutoff
Periodic check of emergency food supplies such as rice, crackers and canned goods. Check of emergency medical supplies, and renewal of expired items
Microfilming of important documents, and duplicate storage at factory site and head office

Case G: Fuji Steel

This company distributed a questionnaire to its employees, seeking ideas on what the company should do to make the workplace safer in the event of an earthquake. Of the 804 employees surveyed, 759 (94%) responded. The results of this questionnaire are listed first, followed by the company's earthquake hazard reduction implementation record in chronological order.

Items identified by employees as necessary to improve earthquake safety:

- Installation of nets at entrances to factory buildings so falling roofing slates can be caught
- Installation of film on window glass
- Anchoring of all equipment
- Periodic inspection, preventive maintenance, and training in use of fire hydrants, fire extinguishers and portable fire pump

- Distribution of helmets to all employees
- Anchoring of equipment adjacent to evacuation routes, on a preferential basis, to minimize risk of evacuation route blockage
- Illumination of exit doors
- Evacuation exercises
- Keeping evacuation routes free at all times, and preventing placement of pallets and products on evacuation routes
- Clarifying role of all employees during disaster situation
- Listing of items to be removed during a disaster
- Prevention of panic
- Installation of flexible piping for fuel oil piping
- Strengthening oil dikes
- Increasing capacity of water tank
- Installation of automatic shutoff valves, first for heat treating gases, followed by other gases
- Reconstruction of tanks
- Installation of flexible pipes on all piping, including steam piping
- Special evacuation route for control room

During 1980

Installation of a 60 hp engine for firefighting
Purchase of a 40 hp portable fire pump
Installation of flexible pipes on butane gas piping
Purchase of air respirators
Purchase of water filters
Installation of emergency alarm connected to earthquake sensor
Installation of emergency LPG shutoff valves (20 locations)
Repair and upgrading of fire detectors
Repair of 50 m of concrete block wall
Increase capacity of oil dikes.

During 1981

Installation of emergency shutoff valves for heat treating gases
Relocation of ammonia gas tank
Installation of flexible pipes on butane and ammonia tanks and boiler steam pipes
Installation of nets to catch roofing slates that would fall off (10 locations)
Strengthening of 150 m of concrete block perimeter wall
Installation of 30 m of netting on heat treating furnaces
Installation of film on window glasses
Distribution of helmets to all employees
Purchase of 100 emergency supplies stores

During 1982

Purchase of two more portable fire pumps
Anchoring of factory equipment
Purchase of fireproof cabinets for document storage
Installation of flexible pipes on piping for fire hydrants
Purchase of smoke ventilators
Renovation of security room to serve as emergency operations center
Installation of more nets to prevent falling of roofing slates
Drilling of water well for emergency water supplies

Case H: Kyowa Hakko, Co., Ltd. Pharmaceuticals manufacturer

Machinery for punching out pills and for filling capsules has been restrained so it does not slide.

Large machinery, such as mixers, has been anchored with J-type anchor bolts.

Equipment that has supports (feet) with flanges or flat plates, such as some of the tanks, has been anchored directly to the floor with grip anchors.

Anchoring of equipment with height adjustors attached to the feet, such as fillers, cartoners, printers, has been done with a special attachment that adjusts on one side and is anchored to floor on the other side.

Equipment on wheels (vacuum cleaners, portable compressors) has been anchored to the floor with special attachments that facilitate detachment.

Storage racks and other equipment placed alongside walls: restrained by anchoring to wall studs.

Raw materials racks, and other equipment or racks placed in center of room, anchored to floor, and also banded together.

Equipment on countertops or pedestals: table with counter anchored to floor, and countertop equipment such as gas chromatograph are then anchored to ledge built up on counter.

# Section 5
# CASE STUDY - SHIZUOKA GENERAL HOSPITAL

Shizuoka prefecture operates three hospitals. The first hospital, called the Central Hospital, was built in 1948 and had a total of 155 beds. The second, called the Fujimi Hospital, was built in 1958 and had a total of 400 beds. In 1983, the third hospital, called the **Shizuoka General Hospital**, was completed. This hospital was planned and constructed after it was realized that Shizuoka Prefecture would be the site of a future major earthquake, therefore, several earthquake resistant features were incorporated during the design and construction stage.

Construction was completed and the hospital opened for business in February 1983, with a total of 700 beds. There were 561 employees, including 75 medical doctors and 356 nurses. The Prefectural Government played a major role during the design stage, and seismic resistance was a major consideration in the design and construction of the hospital. The seismic design criteria included the following:

1. Buildings should behave elastically at ground accelerations of less than 200 gals.

2. There should be no structural collapse at ground accelerations of up to 400 gals.

3. The hospital should be operable after an earthquake of magnitude 8.

By April 1983, two months after the hospital opened for business, an official **Disaster Prevention Manual**, containing detailed responsibilities and duties, was issued by the hospital. Though the manual is aimed at disaster prevention in general, special importance is placed on **Earthquake Emergency Preparedness.**

## RESPONSIBILITY FOR PREPAREDNESS

The Director of the General Affairs Division has been named as the individual responsible for emergency preparedness. His/her duties have been outlined as follows:

1. Drawing up of emergency action plans, including their maintenance and updating.

2. Implementation of training exercises for emergency response, including firefighting, evacuation, communications, and distribution of emergency supplies.

3. Implementation and supervision of periodic inspection and maintenance of facilities, hazardous materials, and firefighting equipment.

4. Safety of all drugs during times of emergency.

5. Supervision of all employees, patients, visitors and outsiders during emergencies.

6. Reporting to and assisting the Hospital Director.

7. Other tasks necessary for emergency management.

EMERGENCY PREPAREDNESS COMMITTEE

The hospital regulations provide for establishing an Emergency Preparedness Committee, consisting of a chairperson and members, who are designated by job functions rather than individuals. The committee's responsibilities include:

1. Establishing, modifying, and updating hospital regulations pertaining to emergency preparedness and response.

2. Procurement of potable water in the case of water supply failure, and addressing sanitation problems.

3. Considerations regarding firefighting equipment and evacuation facilities.

4. Establishing and equipping autonomous (internal) emergency response organizations.

5. Education necessary for emergency preparedness and prevention.

6. Implementation of evacuation, firefighting, and communications exercises.

7. Modifications to, and upgrading of, hazard reduction equipment and measures.

8. Other matters pertaining to emergency preparedness.

The Emergency Preparedness Committee is chaired by the Director of the Hospital. Committee members include the following job titles: Assistant Director of Hospital (2), Hospital Administrator, Assistant Hospital Administrator, and Directors of all the divisions within the hospital, for a total membership of twenty.

## UTILITIES AND LIFELINES

### Electricity

Electricity supply is from Chubu Power Company, at 77 kV, and with closing type gas circuit breakers. These circuit breakers are a new development in Japan, and are considered to be more resistant to earthquake damage than the conventional oil circuit breakers because they (gas circuit breakers) have a lower center of gravity. There are two 77kV/6.6kV, 3500 kVA transformers. In addition, the hospital has two 1000 kVA standby emergency turbine generators, and a set of alkali accumulators (batteries) capable of supplying 1000 ampere hours at 100 V d.c.

### Water Supply

Potable water is bought from the city. The hospital has a 300-cubic-meter capacity reservoir, and a 110-cubic-meter capacity elevated water tank. Well water, which is not for drinking, is also stored in a 190-cubic-meter capacity reservoir, and an 80-cubic-meter elevated water tank. The elevated water tanks are important for being able to supply water in the event of either a power failure or pump breakdown. There are also two 9-ton capacity hot water storage tanks.

### Gases

The gases used are oxygen, nitrogen, and nitrous oxide (laughing gas). These are stored in compressed air cylinders, with a 2.4-cubic-meter liquid oxygen tank.

### Fuel

There are two 20-cubic-meter capacity fuel oil tanks and also 600 square meters of solar collectors for hot water supply.

## EARTHQUAKE HAZARD REDUCTION

To prevent or reduce damage if an earthquake occurs, it is recommended that all equipment, including medical equipment, be attached to structures, and that it be inspected for possibility of tipping over or falling down. It is also recommended that all cabinets, etc., where hazardous materials, reagents, and drugs are stored be inspected. Examples of countermeasures implemented to prevent damage follow.

**Regular Inspection for Hazard Reduction**

1. Building: To be inspected as necessary for overall condition. It should be added here that the building itself has been designed with considerable seismic resistance.

2. All locations where open flames are present: Inspect daily, especially electrical heaters, gas valves, ashtrays, and space heaters.

3. Electrical Equipment: Inspect once a year - resistance and insulation.

4. Hazardous Materials (fuel): Inspect daily for safety practices.

5. Fire Prevention Equipment: Twice a year, with special attention to fire doors, and operability of firefighting equipment. Inspect water supply system daily.

6. Alarms and Detectors: Inspect twice a year for operability.

7. Evacuation Equipment: Inspect twice a year - especially stairways and equipment. Inspect evacuation routes daily.

8. Medical Gases: Inspect daily for available quantity and leakage.

9. Water and other supplies: Inspect twice a year - sterilizer, reagent tanks, control panel and filters. Test as necessary.

MEASURES TO TAKE WHEN AN EARTHQUAKE OCCURS

1. All employees are to ensure the safety of the patients first.

2. If a fire occurs, work towards putting the fire out.

3. During evenings and weekends, first priority is the safety of the inpatients. Only after ensuring this should employees contact other employees for further actions.

4. Duties of individual departments are as follows:

**Director's Office:** The Director is responsible for overall coordination, and depending upon the severity of the situation may convene the Emergency Preparedness Committee.

**General Affairs Division:** (1) The Division Director is to assess the situation and assist the Hospital Director. (2) The Asst. Division Director is to communicate with related disaster organizations. (3) Announcements through the PA system, with emphasis on panic prevention. (4) Division employees are to start getting in touch with others necessary for emergency response. (5) Asst. Director (Finance) is to prepare records and documents that should be removed from the building.

**Medical Division:** (1) The Division Director is in charge of coordinating rescue of patients and family members, preservation of medical records, and safety within the division. (2) Asst. Division Director in charge of safety of visitors. (3) Asst. Division Director in charge of preservation of admission records.

**Nutrition Division:** The Division Director directs employees to check safety of gas supplies, electricity supplies, and autoclaves, including shutdown.

**Inspection Division:** (1) Stop all normal duties, and concentrate on protection and safety of patients and their family members. (2) Shut down all inspection equipment. (3) Ensure safety of test drugs and hormalin. (4) All employees not involved in above to help with rescue of patients.

**Radiology and Nuclear Medicine Divisions:** (1) Shutdown of X-ray equipment. (2) Safety of patients. (3) Technical staff to check for safety of equipment. (4) Stop use of isotopes, and make sure that they are safely stored.

**Pharmacy:** (1) Shut all gas valves. (2) Safe storage of hazardous materials. (3) The Director is to ensure safety within the pharmacy, and also make sure that sufficient supplies are available for emergency first aid.

**Surgery:** (1) The attending surgeon is to make decisions about patients undergoing surgery. (2) The head nurse is responsible for directing nurses to aid with ongoing surgery.

**Central Supplies:** (1) Shutdown of autoclaves and washers. (2) Safety within facilities.

**Outpatient:** (1) Attending physicians are to terminate all examinations, and cooperate with employees from other divisions to remove patients to a safe location. (2) Make sure that all equipment used is safe.

**Inpatient Wards:** (1) Ensure safety of patients. (2) Ensure safety of equipment. (3) Details to be decided by individual wards.

**Doctors:** Go to wards as soon as possible, and help with safety and evacuation of the patients.

**Nursery:** Protection and safety of infants.

**Other:** (1) Operability of elevators. (2) Inspection of premises. (3) Extinguish any fires that might have started.

## EMERGENCY MEDICAL TEAMS

The hospital has organized four emergency medical teams. Three of these teams consist of two medical doctors, two nurses, and one support employee each. The doctors are to be either surgeons or plastic surgeons. The fourth group, which is a surgical team, consists of four medical doctors, two nurses, and one regular employee. Of the four doctors, three are to be surgeons and one an anesthesiologist. The nurses are also to be from the surgery division, or have surgical experience. Pharmacists and drivers will be added to each of the teams as necessary.

The main task of these emergency medical teams is to provide medical aid to remote parts of the prefecture, especially areas that are lacking in medical facilities and are difficult to reach. A good portion of the prefecture is mountainous, and in recognition of this, the hospital has available a helicopter to fly in the emergency medical teams as necessary. Their duties include provision of medical aid beyond the capabilities of first-aid teams, recording emergency medical aid activities, and proper handling and recording of deaths.

The message flow scenario for requisitioning these emergency medical teams has also been established. Individual villages and townships are to requisition their aid through the prefectural office's emergency command post. Despatch is via wireless, and a dedicated channel has already been set aside.

## EMERGENCY FOOD SUPPLIES

The hospital estimates that it should have emergency food supplies sufficient for 11,470 meals. This number was estimated from the following:

1. Inpatients: 700 x 0.9 x 0.3 x 7 days x 3 meals/day = 3,970 meals
   where 0.9 is the occupancy rate and
   0.3 represents the 30% of patients who cannot return home.

2. Outpatients: 1000 x 0.1 x 7 days x 3 meals/day = 2,100 meals
   where 0.1 represents 10% of outpatients who cannot return home.

3. Shizuoka City's requirements for general beds:
   600 x 0.75 x 4 days x 3 meals/day = 5,400 meals

   TOTAL 11,470 meals

As of August 1985, the hospital had in its reserve 20,200 meals, 16,210 of which were for patients and 3,990 for employees.

## EMERGENCY EXERCISE

On September 3, 1985 the hospital conducted an emergency exercise based on a magnitude 8 earthquake occurring in the Suruga Trough. The earthquake was "scheduled" to occur at 2:30 p.m., with subsequent outbreaks of fire at 2:33 p.m., and evacuation of the hospital beginning at 2:34 p.m. The whole exercise was carefully preplanned, with detailed minute-by-minute actions by the individuals who would normally be involved in emergency response charted out. Besides evacuation of the buildings, other factors such as fire outbreak, chemical and reagents spills, communications with public agencies, and feeding of patients and employees were also addressed during this exercise. The exercise, which started at 2:00 p.m., ended at 4:30 p.m., after which patients and employees returned to their normal duties.

# Section 6
# EARTHQUAKE HAZARD REDUCTION TECHNIQUES AT PETROLEUM FACILITIES*

The Japanese are particularly concerned with earthquake damage to petroleum facilities for two fundamental reasons:

1. Japan imports crude oil from practically every available corner of the world and refines it domestically. These refineries and the adherent storage facilities fuel the nation's industries.

2. Petroleum facilities are particularly prone to secondary damage, viz., fires, explosions, and spills, which could lead to property damage and life loss.

This section discusses damage to Japanese petroleum facilities during past earthquakes and current hazard reduction practices. The four major petroleum facilities visited were: (1) Tohoku Petroleum in Miyagi Prefecture, (2) Showa-Shell Petroleum in Niigata, (3) Nihon Sekiyu in Yokohama, and (4) Toa Nenryo in Shizuoka.

One of the most impressive things in Japan is the extent to which damage information is disseminated. This results in other facilities, even if they have not suffered damage, taking the necessary countermeasures so that they will not suffer the same damage. For example, as a result of learning from the 1964 Niigata earthquake, non-sparking weather seals are used on all floating roof storage tanks.

Regulatory agencies have also been quick to respond by updating and improving their standards. The 1978 Miyagi-ken-oki earthquake resulted in the fire department instituting new inspection criteria for storage tanks.

## EARTHQUAKE DAMAGE AT JAPANESE PETROLEUM FACILITIES

Of all the earthquakes that have occurred in Japan during the post-war years, two inflicted especially heavy damage on petroleum facilities. These were the 1964 Niigata earthquake and the 1978 Miyagi-ken-oki earthquake. One other earthquake, the 1983 Nihonkai-chubu earthquake, inflicted minor damage.

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* The contents of this section, practically in its entirety, were presented at the Third U.S. National Conference on Earthquake Engineering, Charleston, South Carolina, August 24-27, 1986.

**The 1964 Niigata Earthquake and Showa Petroleum**

This earthquake, of magnitude 7.7, occurred on June 16, 1964 at 1:01 p.m. Two fires occurred at Showa Petroleum's refining and storage facility, as a result of this earthquake. Based on the cause and time of ignition, these have been named "primary" and "secondary" fires.

The "primary fire" occurred at 1:03 p.m., immediately after the earthquake, at the new processing facility, which had been completed in 1963. The conflagration was eventually extinguished at 5 a.m. on July 1, 1964, after it had burned for more than 14 days. By the time the fire burned out, it had consumed three 30,000 liter crude oil tanks, two 45,000 liter crude oil tanks (total crude lost was 122 million liters), and a portion of the processing equipment in the new 40,000 barrels/day multipurpose plant.

Investigation of the cause of this fire led to the conclusion that friction and impact between the floating roof and side wall of the storage tank led to sparking. The seal material between the roof and the side wall was metallic, and it actually was the seal that led to sparking when it scraped against the side wall. These sparks ignited the petroleum vapors contained inside the tank, leading to a major conflagration.

Five hours after the occurrence of the earthquake, at approximately 6 p.m. on June 16, 1964, another fire broke out, at the site where a 5,000 barrels/day line was operating. This fire, which has been called the "secondary fire", was caused by sparks from a fire at another factory nearby. Totally destroyed were 144 tanks containing a total of 32 million liters of assorted petroleum liquids, and 69 structures having a total floor area of 13,828 square meters, and the equipment contained therein. This fire was eventually extinguished at approximately 5 p.m. on June 20, 1964, i.e., four days later.

Both of these fires caused considerable damage to the surrounding residential area. The primary fire caused the loss of 18 private homes (1,253 sq. m. floor area, with 59 people affected), and the secondary fire caused the loss of 229 structures (21,003 sq. m. floor area), affecting 328 households with 1,375 people. Resources employed for extinguishing both fires were also considerable: 2,547 person-days of labor power, 148,000 liters of extinguishing liquids, and 7 trucks and 27 airplanes for transporting chemicals.

Other damage at the site included the following:

**Oil dikes:** Existing fire codes required 1.5 m high concrete block walls with vertical steel reinforcement. Damage to the dikes was primarily from the fire and pressure of the spilled oil rather than from the earthquake itself. Some cracks were observed immediately after the earthquake, but there was no instance of collapse of these retaining walls. Cracks were also observed at four locations where pipelines passed through the walls.

**Storage Tanks:** Overflow of oil due to sloshing occurred at 10 tanks. Two tanks lost oil when pipelines ruptured. Several raised tanks (5,000 and 10,000 liters capacity) collapsed because the reinforced concrete columns failed. None of the cylindrical steel storage tanks constructed on grade suffered structural damage.

**The 1978 Miyagi-ken-oki Earthquake and Tohoku Petroleum***

A magnitude 7.4 earthquake occurred at 5:14 p.m., on June 12, 1978. At the time of its occurrence, only one package boiler (capacity of 56 tons/hr) was operating. The rest of the plant had been shut down for turnaround maintenance. As a consequence of this shutdown, all the storage tanks were filled to capacity.

Five storage tanks, having a combined total capacity of 139 million liters, were damaged, and about 68 million liters of heavy oil were released. In all five cases the bottom section of the tanks was damaged, and in three of the five cases the bottom plates broke. The oil spill was not successfully contained within the dikes; some of it overflowed the dikes, and some passed under the dike. The pipes running under the dikes were displaced sufficiently to create an underground passage through which the spilled oil passed. Approximately 2.9 million liters of oil actually found its way into Sendai Port via storm drains, despite shutting of dampers and sandbagging. Fortunately, the oil spill was not ignited, and no fire resulted. Since the plant had been closed down for maintenance the potential for ignition had been lessened. Figure 11 shows the oil spill and the damage to one of the storage tanks.

Other damage included:

1. Foundations: Several cracks, up to 5 cm in width and 5 m in length.
2. Plant process and utility equipment:
   a. Furnace: Crumbling of upper section of inside partition wall in one furnace, and damage to branching.
   b. Tower and vessel: Stretching of anchor bolts, and bending and failure of piping supports.

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* "Miyagi-ken" means Miyagi Prefecture, and "oki" means bay, indicating the earthquake was centered offshore. This earthquake is also sometimes referred to as the Sendai earthquake, Sendai being the capital city of Miyagi Prefecture. It is also far better known internationally than Miyagi Prefecture. It is interesting to note that the 1971 San Fernando earthquake is known in Japan as the Los Angeles earthquake.

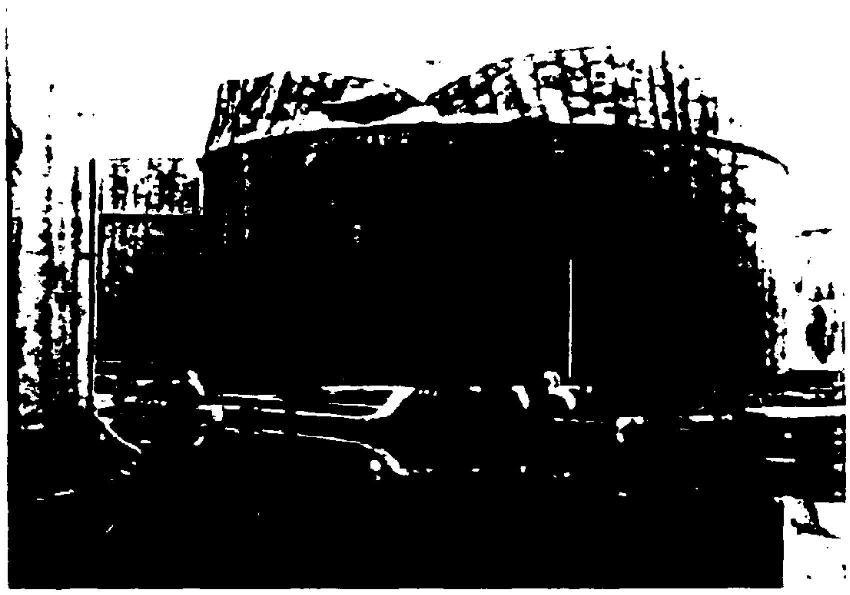

Figure 11. Photograph of Oil Spill and Damage to Storage Tank (Tohoku Petroleum - 1978 Miyagi-ken-oki Earthquake).

c. Heat exchangers: Damage to saddles (6 sets), stretching of anchor bolts, and cracking of pedestals.
d. Pumps: Warpage of pump shafts.
e. Piping: Damage to piping support, and dislodging of piping shoes.
f. Stack: Collapse of one of three legs.
g. Steel structures: Collapse of pipe rack subframe, and loss of mortar for fireproof coating.
h. Oil dikes: Several cracks.
i. Tanks: Subsidence of tanks, especially under the side wall, collapse of internal ladder at three large floating roof tanks, damage to weather seal, damage to gauge pole rolling stopper, and swelling of side plate caused by collision of floating roof stopper.
j. Water tank: Loss of 14 anchor bolts, and minor sloshing.

**The 1983 Nihonkai-chubu Earthquake and Showa-Shell Petroleum***

At 12:01 p.m. on May 26, 1983, a magnitude 7.7 earthquake occurred off the coast of Niigata. The damage to petroleum facilities during this earthquake was primarily to oil storage tanks, with sloshing the main problem. It was storage tanks with floating roofs, rather than storage tanks with fixed roofs, that had sloshing problems. The tanks themselves, their foundations, and oil dikes were not damaged. Weather seals, foam dams, rolling rudders and gage balls were also damaged. In particular, the tanks where sloshing occurred had natural frequencies (of the liquid) of from 8 to 10 seconds.

## EARTHQUAKE HAZARD REDUCTION PRACTICE

**Organizational Measures for Reducing Earthquake Hazards**

One of the points stressed by all the four refineries investigated during this study was the importance of having an organization capable of responding to emergencies. Though specific responsibility for responding to emergencies was almost always contained within a specific department, such as the Safety Department, the overall responsibility for managing and coordinating this response, especially at the time of an emergency, usually lies with top management. The organizational chart for emergency operations and disaster prevention at one of the refineries visited is shown in Figure 12. All the companies have their own emergency preparedness committees, which work constantly on implementing hazard reduction measures before a disaster occurs; this includes a company fire brigade. One of the major roles of the safety committee is to study damage incurred by petroleum refineries in

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* "Nihon-kai" means Japan Sea, and "chubu" means central.

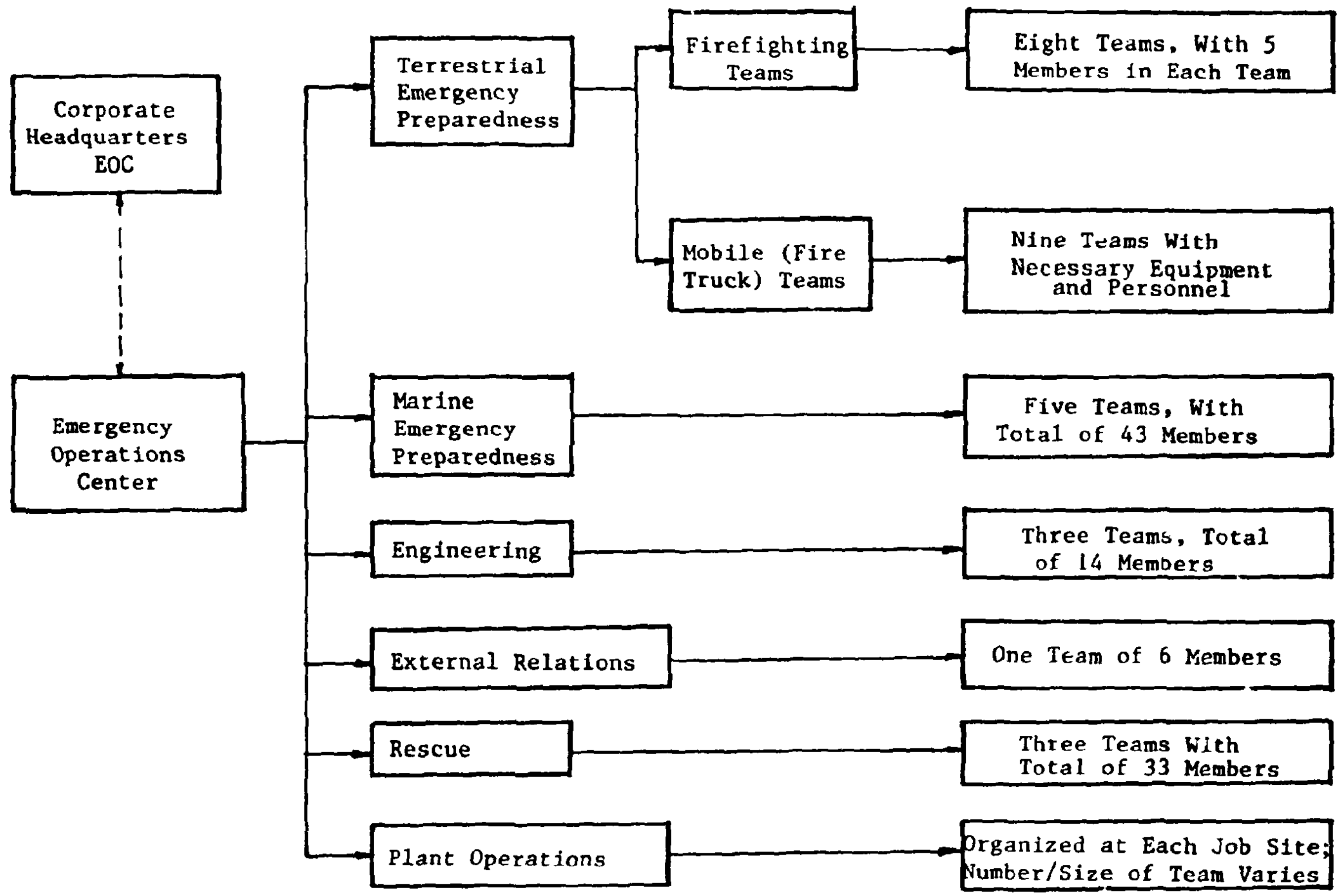


Figure 12. Organizational Chart of Emergency Operations Center and Disaster Prevention Teams

past earthquakes, as well as to keep abreast of recent developments in safety technology in general. This information is also fed into the engineering and design division for incorporation into design criteria for newer plant equipment.

In addition to their own internal organization, companies located in industrial zones (called petrochemical complexes in Japan) also have mutual aid agreements with other companies located in the same zone. Each industrial zone normally has its own emergency preparedness committee, in which all the companies located within the zone are represented. In addition to establishing mutual aid agreements, these committees also organize and conduct disaster preparedness exercises involving both the member companies and public agencies that have jurisdiction over their areas.

Education and training is another important task. Disaster prevention education is implemented by a variety of means, including lectures, distribution of pamphlets, posters, and exercises at regular intervals. Though the details differ from company to company, several hold exercises in conjunction with drills planned by local, prefectural, or the national government. Some companies hold drills based on damage scenarios - these being different from location to location within the same company, based upon the hazards present at each location. In the Sendai region, there is one joint exercise every year, involving the city government, the prefectural government, and major companies and industries located in the industrial zones. Table 7 outlines the annual training program at Toa Nenryo.

Communications programs planned by these companies provide for communications not only within the refinery, but also with outside agencies, the head office if it is at another location, and with industries in the vicinity. A flow chart of emergency communications, including message flow scenario, is shown in Figure 13.

The budgetary requirements for hazard reduction are normally included as part of the normal operations budget and are allocated in a routine manner, not as any sort of special allocation. In the case of retrofitting to improve earthquake resistance, it is never attempted to implement all hazard reduction measures in any one year; instead, five- and ten-year plans are laid out, with achievements for each year clearly defined. In the case of new design, in addition to national standards, there are usually company standards that surpass national standards.

**Nonstructural and Secondary Damage Reduction**

Japanese petroleum companies have implemented a wide variety of measures aimed at reducing earthquake-caused damage. The first impetus came in the aftermath of the 1964 Niigata earthquake and the extensive damage suffered by Showa Petroleum. Implementation of hazard reduction measures, however, is in no

TABLE 7
DISASTER PREVENTION EDUCATIONAL PROGRAM AT TOA NENRYO
for the Year 1985

| Training Item | Implementation Schedule |
|---|---|
| 1. Comprehensive Exercise/Drill | 3 times/year |
| a. Earthquake Preparedness | 1 |
| b. Joint Exercise With Public Agencies (e.g., Fire Dept.) | 1 |
| c. Oil Spill Exercise | 1 |
| 2. Night Shift/Holiday Work Force Training | |
| a. Emergency Assembly | 2 times/year |
| b. Employee Exercise | 2 times/year |
| c. Special Training for New Employees | 1 time/year |
| 3. General Employee Training | |
| a. Firefighting | 3 hrs/year/person |
| b. Petroleum Fires | 2 times/year |
| c. Evacuation Exercise | 2 times/year |
| d. Rescue, First Aid, CPR | 4 hrs/year/person |
| 4. Firefighting Brigade | |
| a. Firefighting Equipment | 12 hrs/year/person |
| b. Fire Prevention and Firefighting Exercises | 75 times/year/shift |
| 5. Individual Work Areas | |
| a. Emergency Training | 2 times/year/shift |
| b. Work Area Emergency Exercise | 4 times/year/shift |
| c. Other Safety-Related Training | 6-12 times/year/shift |
| 6. Emergency Communications Exercise | 12 times/year |

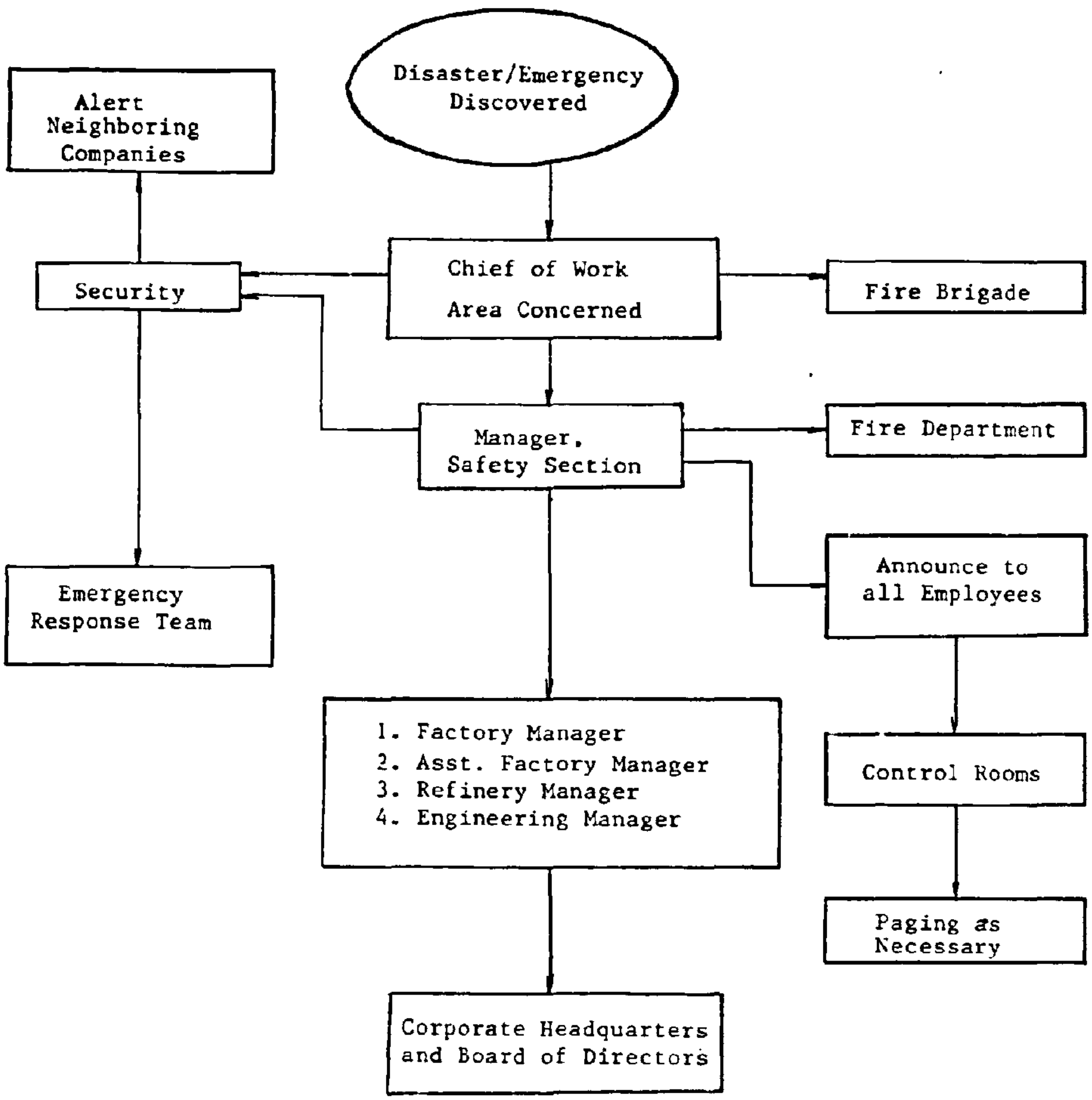


Figure 13. Flow Chart of Emergency Communications Message Flow Scenario. (Applicable during normal working hours)

way restricted to petroleum facilities that have actually suffered damage in past earthquakes; newer refineries that have never experienced damaging earthquakes are implementing hazard reduction measures with as much vigor as those that have. Part of the credit for this goes to the regulatory authorities who have utilized earthquake damage information to modify and update regulations. This section discusses some of the engineering measures implemented at the four petroleum refineries visited.

1. **Plant and Equipment Design Criteria:** The design division at the corporate headquarters generally has the responsibility of developing appropriate design criteria for the company's facilities. It is stressed that the corporate design criteria must not only meet the regulatory requirements, but must actually surpass them in order to better ensure corporate survivability in the event of an earthquake. This is done by analysis of data from earthquakes and disasters worldwide, by monitoring appropriate technological developments, and by studying design criteria employed by other companies. Some of the earthquake hazard reduction considerations in the design criteria include:

- Choice of corrosion-resistant materials for construction of equipment.
- Choice of fire-resistant or fire-retardant materials.
- Choice of impact-resistant materials (e.g. cast steel valves rather than cast iron valves).
- Specification of non-sparking electrical equipment for use in areas where flammable gases are used or stored.
- Layout of plant and equipment to minimize spread of disasters.

2. **Storm Drain Shutoff Valves:** During the 1978 Miyagi-ken-oki earthquake spilled oil was released into Sendai Port via the storm drains. As a result of this experience, shutoff valves have been installed at all points from which water from the facility is discharged.

3. **Perimeter Water Curtain:** A water curtain, consisting of sprinklers and water jets, has been installed along the perimeter to prevent spreading of fires to the surrounding regions. The water supply pumps for this purpose can also be driven by standby generators.

4. **Perimeter Green Zone:** This is an added measure to prevent disasters within a facility from affecting, or spreading to, the surrounding regions. Plant equipment and storage tanks are located as far away from the perimeter fence as possible, with a roadway in between, in addition to trees and shrubs. The perimeter fence generally is a reinforced concrete block wall.

5. **Liquefaction Countermeasure:** This pertains specifically to storage tank construction practice where foundations have been placed on unconsolidated water-saturated alluvial soil. The new practice calls for piles to be driven in first. Soil, in excess of the weight of the tank to be built, is piled on top of these piles, and excess water from the soil is pumped out. The soil is subsequently compacted as much as possible before construction of the storage tank.

6. **Maintenance:** Implementation of regular preventive maintenance and inspection schedules to ensure that damage from weakening caused by environmental degradation will not arise. Particular attention is paid to welds, corrosion, and loosening of anchor bolts. Emphasis is placed on executing repairs on time.

7. **Fire Prevention and Safety:** Because of the nature of the materials handled, great emphasis is placed on both proper practice and sufficient firefighting capability within the company. Safety procedures related to fire prevention include:

- Restriction of locations where smoking and electric heaters are permitted.
- Removal of all flammables from work sites where open flames or sparks will be used.
- Use of non-sparking tools.
- Explosion proofing of electrical equipment.
- Restriction and control of roadways that can be used by tank cars.
- Regulating pipeline flow rates to control static electricity generation.
- Proper grounding for discharge of accumulated potential.
- Sufficient gas purge of trucks.
- Choice of materials for overalls and safety shoes so that they do not generate static electricity.
- Sprinkler rings on storage tanks to minimize fire spread from nearby installations.

The fire protection and oil spill recovery equipment at one of the refineries visited is shown in Table 8.

8. **Oil Spill Countermeasures:** Not only can oil spills contaminate the environment, but they can also lead to major conflagrations. Measures implemented to prevent the occurrence of oil spills, and to control them should they occur, include:

- Installation of level indicators, with limit switches and alarms, to detect loss due to leakage, and also to prevent overfilling.

TABLE 8
FIRE PROTECTION AND OIL SPILL RECOVERY EQUIPMENT

| Item | Quantity | Remarks |
|---|---|---|
| Chemical fire truck | 4 | Discharge capacity 4,000 ℓ/min<br>Air foam liq. capacity 5,000 ℓ |
| Squirt truck | 3 | Nozzle height 22 m, 23 m, 27 m |
| Air foam liq. carrier | 3 | Air foam liq. carrying capacity<br>5,000 ℓ x 1, 8,000 ℓ x 2 |
| Air foam liquid | 189,800 ℓ | Legally required cap. 41,040 ℓ |
| Fire water pump (fixed) | 12 | Total discharge rate 6,470 kℓ/hr<br>Pressure 10.5 $kg/cm^2$ |
| Fire water line | | Total length 28,200 m |
| Fire hydrant | 554 | Others (hose reel) 188 |
| Fire extinguisher | 2,178 | Each type total (350, 200, 20, 10) |
| Reservoir | 8 | Total capacity 36,300 kℓ |
| Water gun | 10 | Air foam discharge 3,000 ℓ/min<br>Effective range 70 m |
| Fireproof uniform | 5 | |
| Fire resistant uniform | 345 | |
| Oil recovery boat | 1 | 67 gross tons<br>Recovery rate 31 kℓ/hr<br>Jet recovery 60 kℓ/hr |
| Oil fence extension boat | 6 | |
| Oil fence | 6,000 m | Legally required 2,160 m |
| Oil spill remover | 18,780 ℓ | Legally required 11,000 ℓ |
| Oil spill absorbent | 4,420 kg | Legally required 4,400 kg |
| Firefighting boat | 1 | 291 gross tons 17,000 ℓ/min<br>Fire pump 3,000 ℓ/min |

- Regulation of upper limit on fluid level, taking into consideration the magnitude of sloshing that can occur.
- Installation of equipment for recovery of oil in waste waters.
- Preparation of oil fences and ships for recovery of spilled oil.
- Oil dikes: See Item 9 below.

Table 8 lists the equipment purchased and maintained by one refinery for use in the event of an oil spill.

9. **Primary and Secondary Oil Dikes:** In addition to the dikes surrounding storage tank installations, a secondary dike, higher than the primary dike, is constructed along the plant perimeter. This is to make doubly sure that there will be no release of oil spills to the environment. In some cases the secondary dike is also meant to serve as protection against tsunamis. This is particularly important since all petroleum refineries in Japan are located along the coast.

10. **Storage Tanks:** Periodic inspection of storage tanks for weld failure and corrosion. This is now part of the new code requirements, and was included in the codes as a result of damage at the Tohoku Petroleum Refinery during the 1978 Miyagi-ken-oki earthquake. Based on structural analysis, steel strengthening bands are also added to the side walls. In floating roof storage tanks, synthetic rubber weather seals are used, instead of the metal seals that caused sparking during the 1964 Niigata earthquake. Figure 14 shows how storage tanks and their surroundings have been redesigned since 1964.

11. **Piping:** It is important that piping be able to absorb the torsion, tension, or compression that could occur during earthquakes. Measures implemented to reduce potential piping failure include:

- Addition of loops at suitable distances.
- Re-laying of underground pipes above grade.
- Redesign of pipes that go through dikes (see Figure 15).
- Structural analysis and reinforcement of overhead pipeline supports and racks.
- Use of flexible piping connections, especially where piping is connected to equipment or storage tanks (see Figure 16).

12. **Plant Shutdown:** Seismometers have been installed at several locations onsite so that plant equipment can be shut down in an orderly and safe manner when an earthquake is sensed. This includes installation of automatic shutoff valves as well.

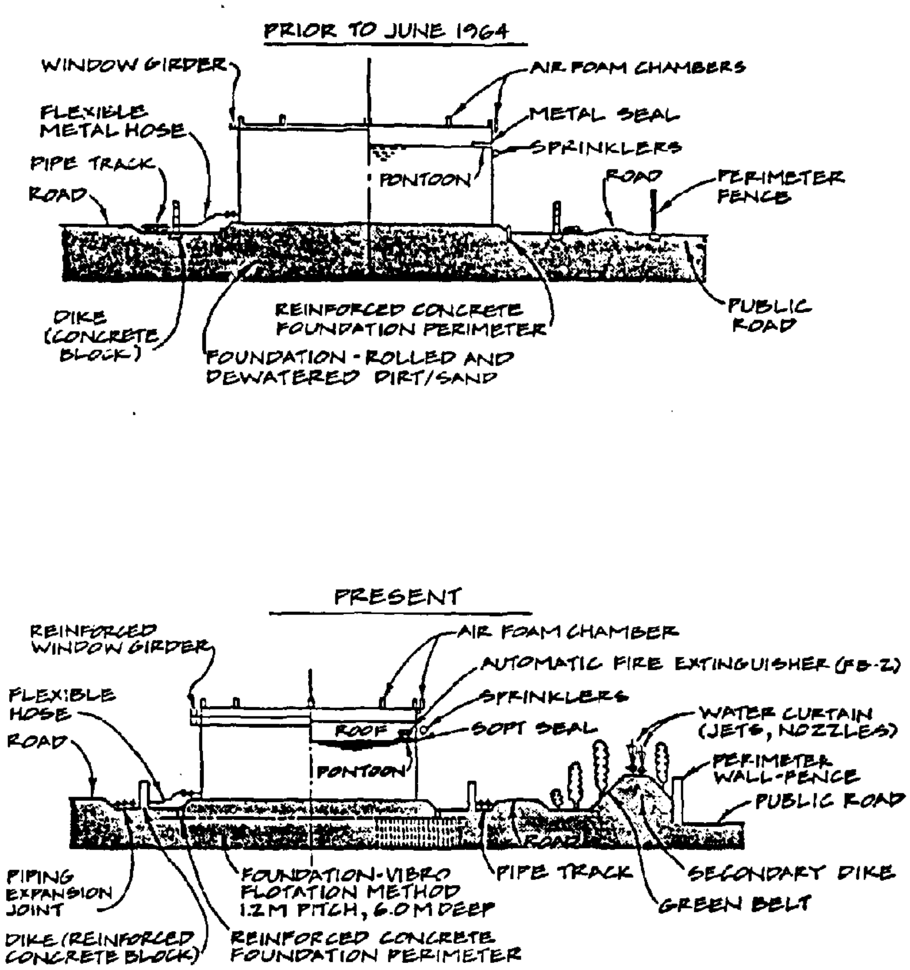


Figure 14. Design Modifications Implemented for Storage Tanks and Surrounding Facilities Since the 1964 Niigata Earthquake

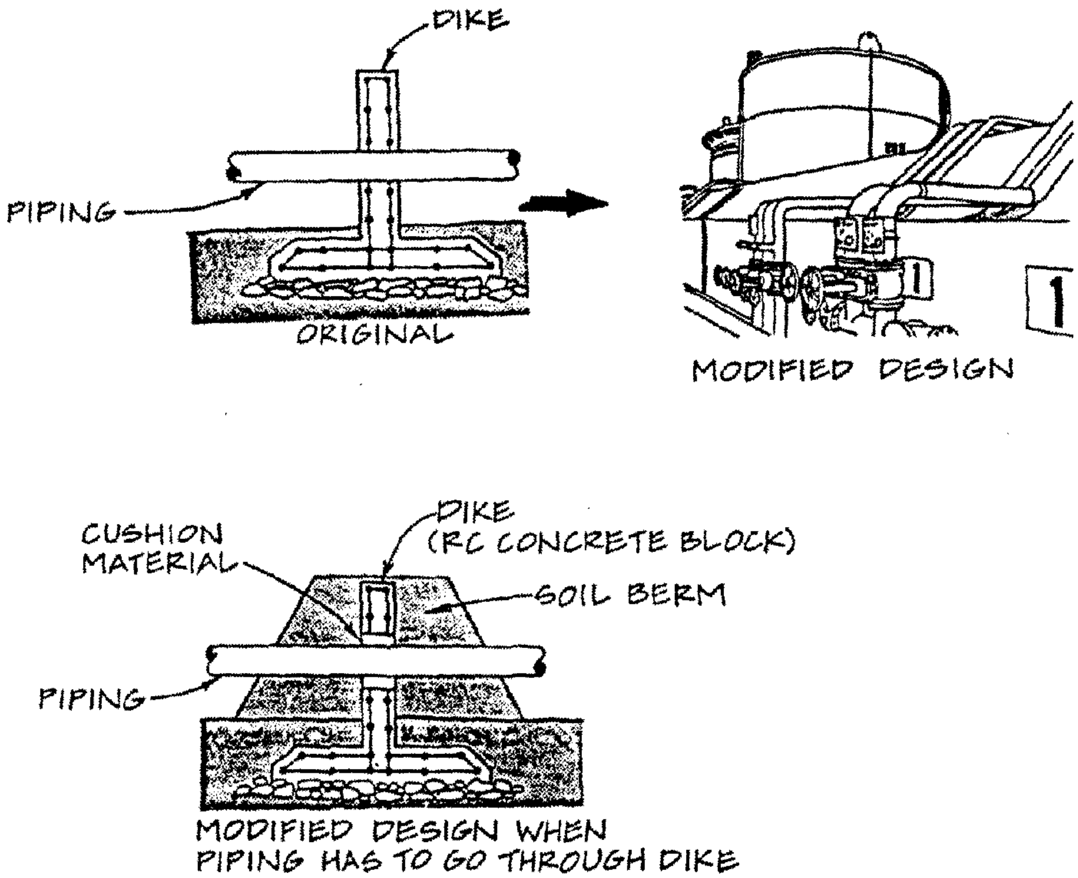


Figure 15. Redesign of Pipelines to Reduce Earthquake Damage Arising From Differential Motion Between Pipelines and Dikes

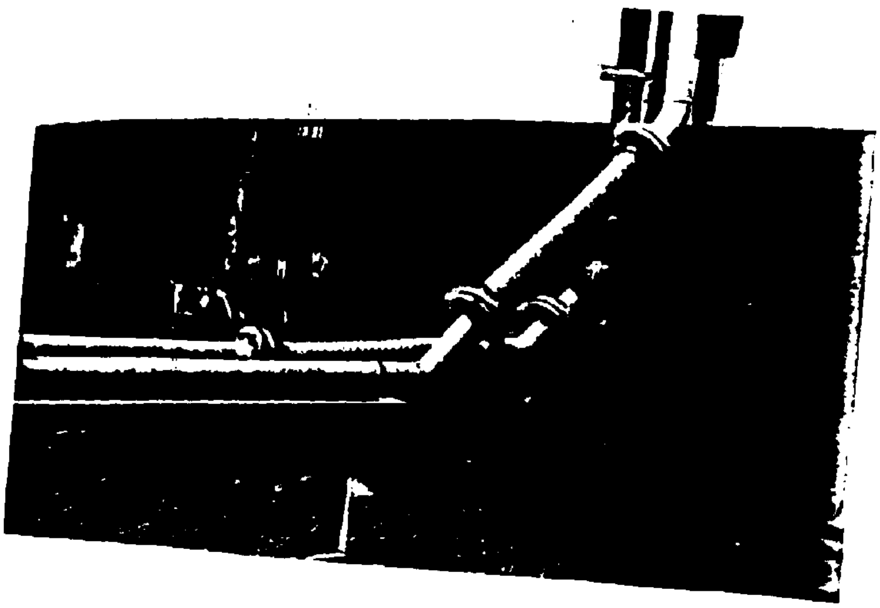

Figure 16. Installation of Flexible Tubing on Pipelines, Especially Where They are Connected to Storage Tanks.

## Section 7
## DEVELOPMENT OF EARTHQUAKE HAZARD REDUCTION EQUIPMENT IN JAPAN*

Today there are several products in the Japanese marketplace that are intended for earthquake hazard reduction. They range in variety from simple anchoring devices to sophisticated instrumentation. Though some have apparently been developed for the individual homeowner, most of these products have been developed for industries and businesses. These products are aimed at reduction of nonstructural and secondary damage. Table 9 summarizes these products.

One noteworthy point that should be mentioned is that, with one exception, all items were developed commercially by private companies. The one exception is an electronic emergency alarm that will turn on radio and TV sets when a predetermined signal is broadcast by NHK (Japan Broadcasting Corporation). This was a joint development by government agencies and electronics companies. The author met with the manufacturers of several other hazard reduction items during the course of his field trips to Japan, and in each instance the point that there was no government financing or aid for the development of the devices described here was stressed. The companies perceived a need and a market for the particular line of products, and carried out the research and development effort with their own financing. It is significant that earthquake hazard reduction technology is considered to be economically viable, and that several companies have developed and brought to the marketplace equipment and devices for this purpose.

### KEROSENE SPACE HEATERS

Although the newer homes in Japan are centrally heated, a very large percentage of the population still lives in one- or two-room apartments that use unvented kerosene stoves for space heating. The winter months, during which these space heaters are used, are also the driest, and therefore pose the greatest fire hazard. The Japanese have also not forgotten the 1923 Kanto earthquake during which more people died from the secondary fires than from the initial earthquake. Small charcoal cooking appliances, similar to the modern kerosene heater or stove, are usually credited as being the cause of most of the ignitions in 1923.

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* The contents of this section, practically in its entirety, were presented at the Third U.S. National Conference on Earthquake Engineering, Charleston, South Carolina, August 24-27, 1986.

TABLE 9

COMMERCIALLY AVAILABLE EARTHQUAKE HAZARD REDUCTION ITEMS

| Item | Purpose | Manufacturer |
|---|---|---|
| Kerosene Space Heaters | Automatic shutoff in case of shaking, due either to earthquakes or to other causes | several |
| Braces, Latches, Anchors, and Straps | Tiedown of furnishings in the home and in office environments. Special latches for cabinets | several |
| Seismometers | Detection of earthquake, and subsequent shutdown of equipment or facilities. See Table 10 for details | several |
| Gas Valves | Shutoff of LP gas cylinders, pipelines, and in some cases appliances and equipment | several |
| Oil Damper | Earthquake protection of spherical gas holders | Tokico |
| Emergency Alarm | Developed by NHK and MITI. Attached to radio or TV and actuated by micro-wave signal | several |
| Dynamic Floor System | For protection of computer installa-tions on raised floors, and other equipment, including museum articfacts | Ohbayashi, Takenaka |
| Low CG Circuit Breakers | Vacuum circuit breakers with low center of gravity, so that they will be less susceptible to damage from earthquakes | Meidensha |
| Furniture | Earthquake protection of the office environment | Uchida-Yoko |

For almost ten years a new variety of kerosene space heater has appeared in the marketplace. These have incorporated in them a device that will automatically shut the flame off in the event of an earthquake, or any similar shaking, such as an individual knocking against the heater. It is not necessary for the device to tip over for the shutoff mechanism to be activated. It is also no longer possible to buy kerosene space heaters without this feature.

This development took place in response to a request from the Tokyo Fire Department in the period 1974 to 1975. The Fire Department pointed out that in the case of a major earthquake in the Tokyo area, there would be more than 10,000 fires occurring simultaneously, that it would not only be impossible to respond to all these fires, and that a major disaster could result. The specific request from the Fire Department was for manufacturers to develop household appliances that would automatically shut off in the event of an earthquake.

## ANCHORING DEVICES FOR HOME FURNISHINGS

Probably in part because of high land prices, Japanese homes tend to be much smaller in floor area than American homes. Space is at a premium and is frequently used three dimensionally, i.e., the walls are frequently lined with cabinets, etc., so that the available space can be used efficiently. It is not uncommon to see two cabinets (such as china cabinets) placed one on top of the other. Construction of Japanese homes is normally wooden, and is relatively earthquake resistant, although very combustible. There is great concern over these cabinets falling down during an earthquake. All pamphlets, brochures, and literature published by public agencies for the general public address this question, and recommend a variety of ways in which homeowners can anchor their cabinets to prevent their falling down.

Today a variety of hardware is available in hardware and even department stores for the homeowner to use for anchoring his/her furniture and cabinets, including safety catches for installation on cabinet doors so that they will not fly open and allow the contents to fall out during an earthquake, chain and hook assemblies for securing tall shelves to walls, and brackets that have been developed for the same purpose, i.e., to keep cabinets and shelves from falling over.

## SEISMOMETERS

Several industries, including the Japan National Railways, have installed seismometers to detect earthquakes. These seismometers are normally linked with other control circuits, including alarms, that serve either to shut down equipment or to warn employees. In the case of Japan National Railways' Shinkansen (the Bullet Train, which travels at over 240 kph or 150 mph), power is shut off, and the trains stop.

There are a variety of seismometers that are commercially available. Figure 17 shows one type based on a steel ball that rests on "pipes" of different diameters. Depending on the diameter of the pipe, the horizontal acceleration required to cause the ball to fall down will vary. Based on the number of balls that fall down, different signals are emitted and can be displayed on panels. These signals can also be used to activate other circuits for emergency announcements or equipment shutdown.

Figure 18 shows another type of seismometer based on a swinging "pendulum". This device detects the amplitude and frequency of the earthquake. This variety is also designed to emit electric signals that can be subsequently used for other purposes, such as warning announcements or equipment shutdown.

The seismometers described above are capable of detecting earthquakes with horizontal ground accelerations ranging from 10 to 500 gals (about 0.01 to 0.5 g), depending on the particular model. They can also be programmed to issue different signals at different accelerations. Detection of earthquakes with an acceleration of 40 gals or less, for example, could result in the issuance of one type of command, and those with an acceleration of more than 40 gals could result in a different command.

A simpler seismometer detects only a preset acceleration and issues one command. This equipment is designed to detect earthquakes having horizontal accelerations in the 100 to 170 gals range, and is based on a steel ball that activates a switch. Connections to warning indicators and equipment shutoff circuits are also possible.

The three largest gas utilities in Japan, namely Tokyo Gas, Nagoya Gas, and Osaka Gas, use seismographs to monitor their overall distribution systems, but do not automatically shut off the systems' supply in the event of an earthquake. Personnel in the control center can quickly refer to strong motion data to decide what actions to take. In the case of Tokyo Gas, 27 seismographs, three each in nine different blocks or sections of the overall system, send their data to the control room where it is retrievable within three minutes. Peak accelerations, as well as conversions to the JMA intensity scale, are provided within about a minute. If all 27 seismometers report accelerations of at least 240 gals, the earthquake plan calls for a system shutdown.

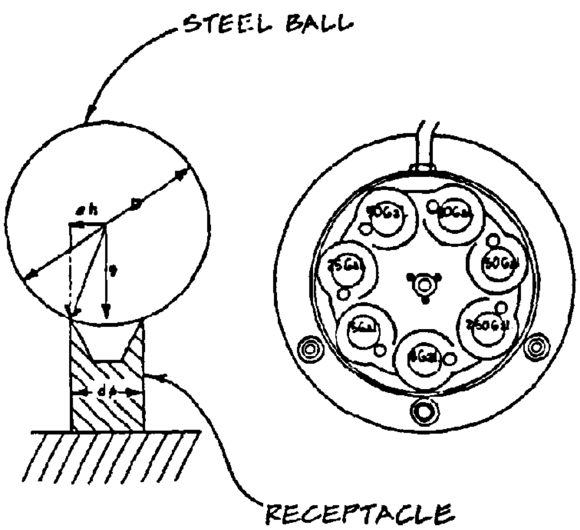
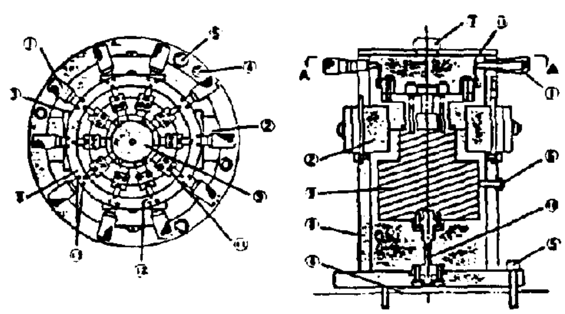



Figure 17. Diagram of Falling Steel Ball Type Seismometer



1. Sensitivity Set Screw (Micrometer)
2. Air Damper
3. Level
4. Level Adjuster Screw
5. Installation Bolts
6. Clamp
7. Inspection Cap
8. Case
9. Pendulum Weight
10. Spring
11. Detection Set
12. Spindle Set Screw
13. Micrometer Set Screw

Figure 18. Diagram of Pendulum Type Seismometer

Table 10 summarizes the different types of seismometers in use in Japan today.

## GAS VALVES

The primary fuel used in Japan is gas (including city gas, natural gas, and liquefied petroleum gas). This is used not just in homes for cooking and heating, but more recently even in larger commercial buildings. There is great concern that gas facilities should be properly protected so that secondary fires and explosions can be prevented. A variety of gas valves has been developed, both for use in individual homes as well as industries.

The gas utilities, notably Tokyo Gas and Osaka Gas, have introduced a system called "MY SAFE". This is a new type of gas meter that incorporates detection and shutoff capabilities - it is not a separate valve or meter. Figure 19 shows the installation and circuit diagrams for this gas meter. It is designed to shut off gas supply to the consumer under any of the following three conditions: (1) When there is an abnormally high flow rate (for example when there is a downstream pipeline rupture); (2) When gas consumption over a long period is irregular (such as when there is a gas leak, or an appliance has not been turned off); and (3) When an earthquake is detected. The gas companies are encouraging consumers to install these new meters. The lease cost is approximately US$3.00 per month. In the case of Tokyo Gas, the company guarantees proper operation of these meters and undertakes to pay compensation if they do not. Approximately 20% of the six million customers, or 1.2 million customers, are now served by this device in the Tokyo area.

The larger cities are normally served by piped gas, but several of the smaller cities do not have this facility, and consumers buy bottled gas - normally liquefied petroleum gas. The bottle is installed below the kitchen counter, and a rubber hose connects it to gas appliances. A safety valve for these bottles, shown in Figure 20, has been developed. It is installed between the main valve of the bottle and the pressure regulator (Figure 20a). The safety catch is attached by a chain to the wall. If the bottle falls over, the safety catch is pulled out and gas flow is interrupted (Figure 20b).

Another shutoff valve has been developed not just for gases, but also fluids. This also uses the falling steel ball, is designed for direct attachment to pipelines of 1-inch diameter or less, and operates at accelerations between 140 and 215 gals.

LP gas leaks due to either pipeline ruptures or falling cylinders are addressed by the valve shown in Figures 21a and 21b. This valve has been designed to replace

TABLE 10: LIST OF SEISMOMETERS AND THEIR CAPABILITIES

| Manufacturer | Detection Mechanism | Sensitivity Range | Remarks |
|---|---|---|---|
| Saginomiya | Steel ball moved by earthquake, establishing electrical contact | 100-170 gal with 0.3 to 0.7 sec period for horizontal motion | Detects one preset horizontal acceleration |
| Akashi | 1. Pendulum type | 50-500 gals horizontal, 25-200 gals vertical | Detects one preset acceleration |
| | 2. Falling steel ball | 80-350 gals horizontal, 30-150 gals vertical | Detects at discrete accelerations |
| | 3. Servomechanism measures current flow generated by servoamp | 40-120 gals horizontal | Detects at discrete accelerations |
| Tokico | Falling steel ball detector coupled to automatic shutoff valve for gases and liquids on pipelines of 1-inch diameter or less | 140-215 gals horizontal | Detects at one preset acceleration |
| Katsura Seisakusho | Magnetic switch, coupled to gas shutoff valve, which is actuated by condenser discharge | 150-250 gals horizontal | Detects at one preset acceleration |
| Fujitec | Reflection of light waves from surface of mercury drop | 25-150 gals horizontal 5-20 gals vertical | Continuous detection |

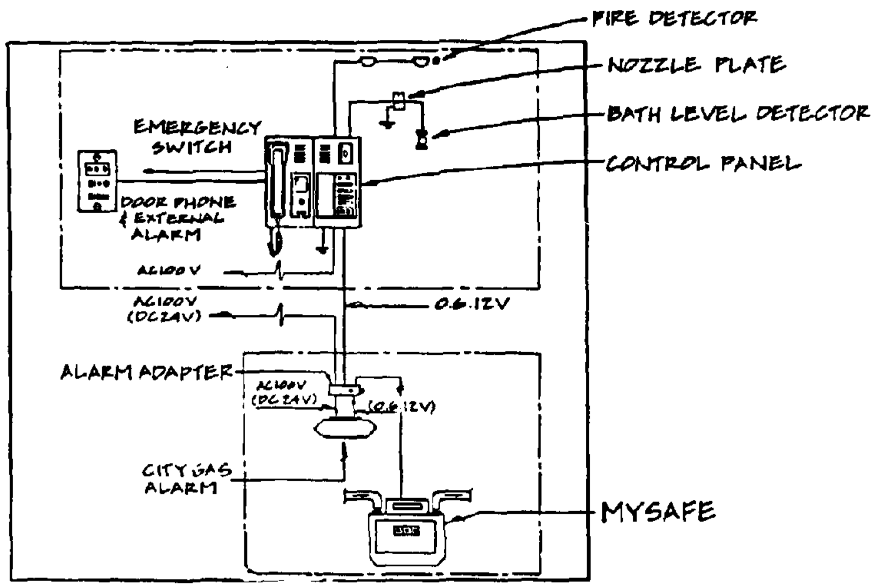



Figure 19. Schematic of Installation and Wiring of MY SAFE Gas Leak Detector

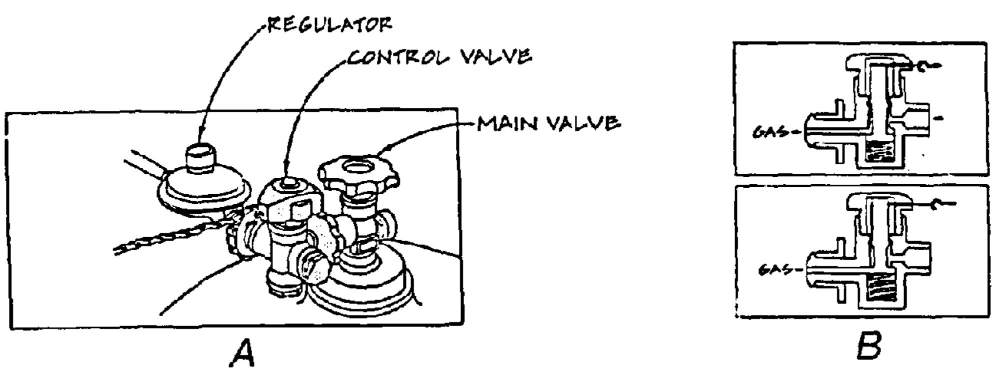



Figure 20. Diagram of Installation and Operation of LPG Cylinder Shutoff Valve

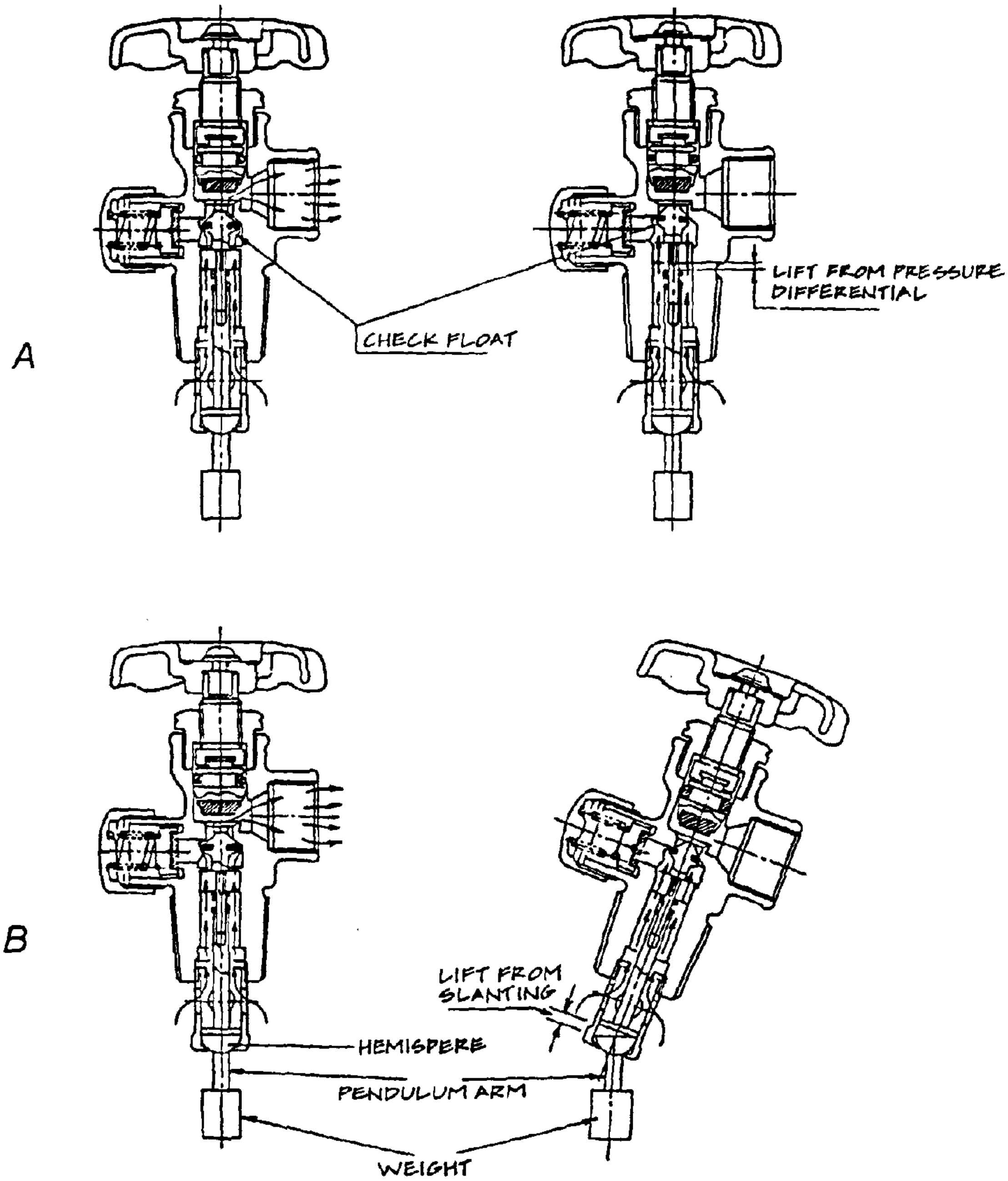



Figure 21. Diagram of Bottled Gas Safety Shutoff Valve Operation: (A) Under Excess Flow Conditions; (B) When Cylinder is Tilted.

the conventional valve attached to gas cylinders, and will automatically shut off either when there is excess flow or when the cylinder is in a slanting position. Excess flow can be expected to occur in the event of a pipeline rupture downstream, or damage to appliances using gas as a heat source. As shown in Figure 21a, the check float will be activated when the pressure drop across it exceeds a preset value, and will automatically shut off the gas supply. The mode of operation to shut off the gas supply when the cylinder leans over or falls down is shown in Figure 21b. The pendulum weight will still try to maintain its upright position, which results in its pushing the check float upwards, thus shutting off gas supply.

Another manufacturer has developed an LPG automatic shutoff valve for industrial installations, and offers sizes to fit up to 4-inch diameter pipelines. This valve is connected to a seismometer. The valve is normally held in the open position by a magnet assembly. When the seismometer detects an earthquake, it sends a pulse to the valve and triggers the actuator. Gas flow is shut off. This shutoff valve can also be actuated by gas leak detectors. The manufacturer offers a wide variety of installations, including centralized control panels and remote control of these valves. One such installation is shown in Figure 22.

Tokico, a major automobile parts manufacturer, has been manufacturing shutoff valves that are operated by carbon dioxide from a small pressurized cylinder. The original version of this valve was designed to be operated by remote control. When an earthquake occurs, it is detected in the central control room, and an electrical signal sent to the shutoff valve. Carbon dioxide is then released from the pressurized cylinder, shutting off the valve (see Figure 23). The valve that has been thus shut off is then reopened manually. Newer versions of this same valve now contain a seismic detector, and can be set so that the valve can be shut off at different accelerations.

## GAS STORAGE TANKS

Conventional large cylindrical gas holders with floating roofs have been damaged in past earthquakes in Japan. Current practice in Japan calls for the use of spherical storage tanks. This is especially the case for LPG and LNG storage, which are the main gases used both industrially and in individual homes. A special oil damper shock absorber to be installed between the foundation and the base of the trussed superstructure has been developed to offer better earthquake protection for these tanks. The manufacturers envisage this damper being used for other structures and equipment as well.

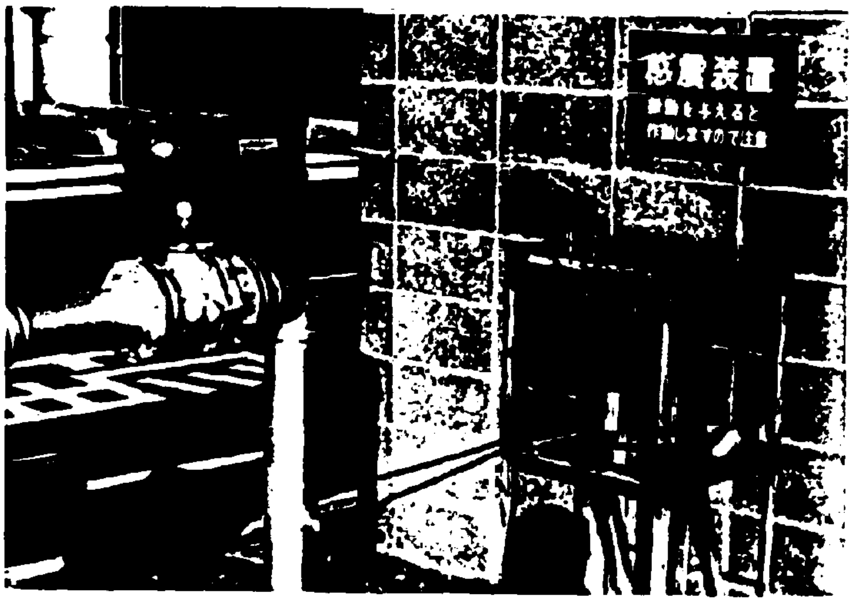
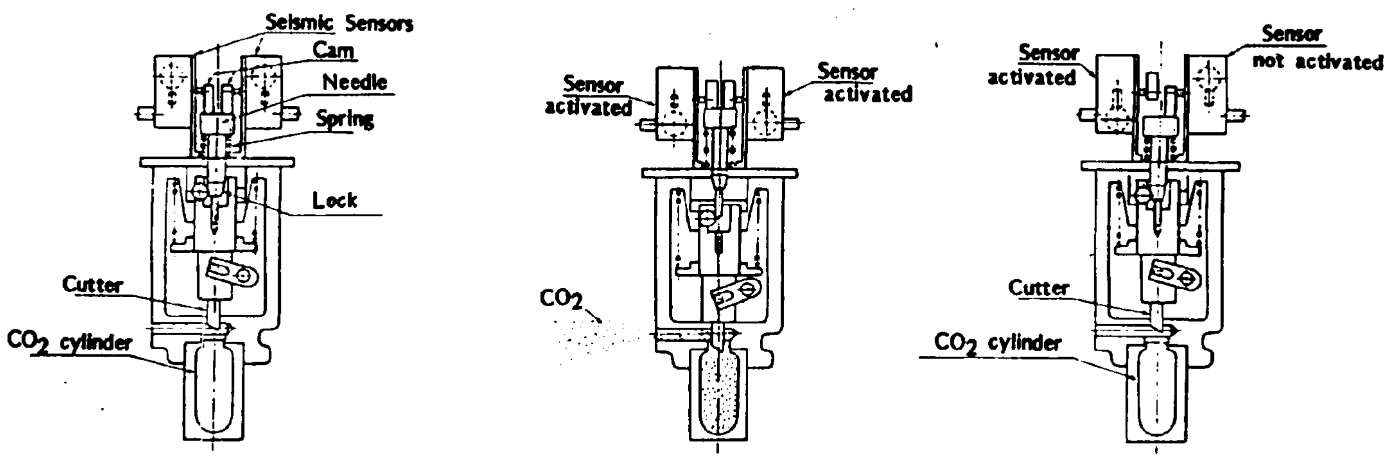



Figure 22. Automatic Shutoff Valve Actuated by a Seismometer. Installed on a 3-Inch Natural Gas Line.




(a)
Normal Position

(b)
Emergency Shutoff Position

(c)
Valve Position With
One Sensor Activated

Figure 23. Emergency Shutoff Valve With Two Seismic Sensors. (a) Normal position - open. (b) Emergency shutoff position when both sensors are activated. (c) Valve remains open if only one sensor is activated.

EMERGENCY ALARMS

A new electronic device designed to give warnings of not only earthquakes, but also tsunamis and other emergencies, became available at electronic stores in September 1985. In case of an emergency, this audio warning device will be set off by microwave signals sent out by NHK (the nationally owned Japan Broadcasting Corporation). Some versions of this device have been designed to be incorporated into television or radio sets and will automatically turn the sets on upon receiving the signals. NHK would then begin broadcasting emergency information and instructions. When incorporated into a TV or radio set, it is expected to add approximately US$50 to the cost of the set. Figure 24 presents part of a brochure advertising this device.

This system is the result of several years of research by the Ministry of Posts and Telecommunications, NHK, and several electronics companies. The project was initiated by the ministry in 1980 when it began establishing standards for wave transmission of emergency signals.

COMPUTER FLOORS

A base isolation mounting for raised computer floors (called the DYNAMIC FLOOR SYSTEM) has been developed by Ohbayashi Gumi, a major architectural and engineering company. A photograph of this mount is shown in Figure 25. The raised floor, usually 18 inches above the fixed floor, bears on vertical springs encased in steel cylinders. This spring assembly, together with a pair of oil dampers mounted between the cylinder and its base, absorbs and neutralizes most of the vertical seismic shock. To prevent a spring action response to persons walking in the computer room and other loads, the dynamic floor bears on steel rods inside the cylinders. The raised floor is released from these rods by a spring latch under the impact of a vertical earthquake shock. The floor's weight is then transferred to the spring and dampers.

To counteract horizontal movements, each cylinder has a mechanism that allows it to slide. This consists of a teflon-coated steel shoe around the cylinder base that can slide on a 3.3-ft square stainless steel plate on the fixed floor. The steel cylinder's horizontal movements are limited by four horizontal springs, anchored to the fixed floor.

The system was first marketed during 1976, but attracted renewed attention after the 1978 Miyagi-ken-oki earthquake, during which a number of computers were

## ●この製品はラジオも聞ける「緊急警報放送」受信機です。
## ●普段はラジオとしてお使い下さい。
## ●「緊急警報放送」はこんなときに放送されます。

* 東海地震の警戒宣言がでたとき。
* 津波警報が発令されたとき。
* 自治体の放送要請があったとき。

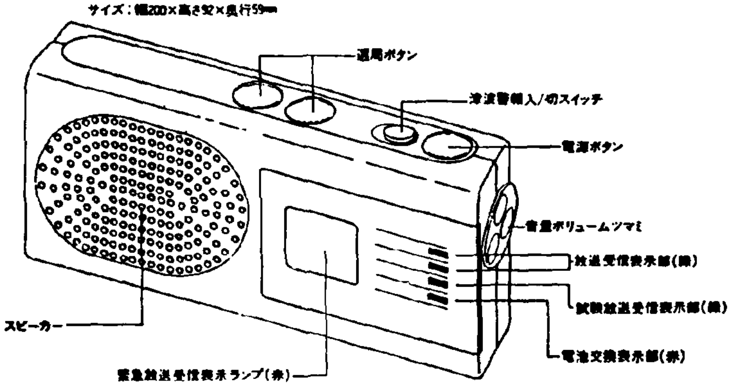
## ●従来のラジオではこんなときに聞きもらしてしまいます。

* ラジオのスイッチが入っていないとき。
* 音を小さくしてあるとき。
* ラジオのダイアルが合っていないとき。
* 停電のとき。

## ●今度開発された製品は「緊急警報放送」を確実にキャッチする工夫がされています。

* NHK静岡第一放送とSBS放送のどちらでもワンタッチで選局する方式です。
  クリスタル(水晶)を使用してありますから周波数のズレはまったくありません。
* 「緊急警報放送」が放送されるとスイッチが切ってあっても、ボリュームがしぼってあっても、また停電のときでも自動的に大きな音量で鳴り出します。
  「緊急警報放送」が終わると自動的に切れます。
* 停電のときでも動作するように乾電池が内蔵できます。

サイズ：幅200×高さ92×奥行59mm




## ●「緊急警報放送」を聞いたらおちついて行動して下さい。

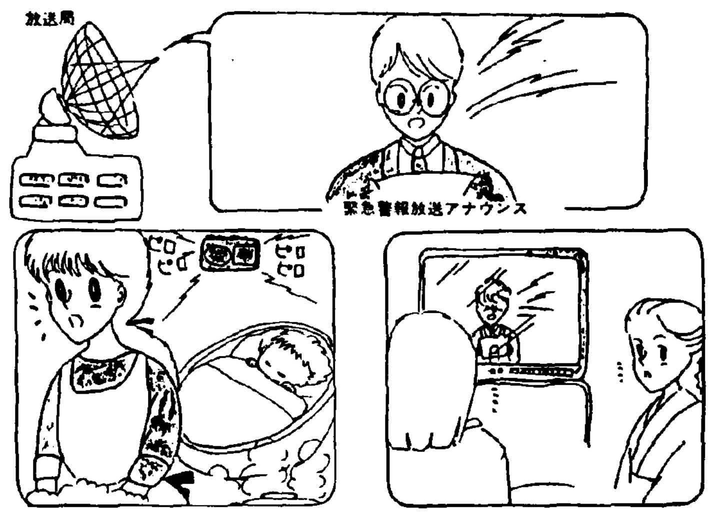
* 正しい情報を自分自身で確認しましょう。
  正しい情報は、ラジオやテレビの放送、市町村の広報、警察消防の広報車などがお知らせします。

●警報ラジオ"ピロピロ"をお申込の際、つぎのことに注意して下さい。

1. お取り付けする場所は
   NHK静岡第一放送とSBS放送が良好に受信できますか？
   山間地や鉄筋ビル、地下室などラジオが聞けないところではご利用できません。
2. 警報ラジオ"ピロピロ"はご利用場所のNHK静岡第一放送とSBS放送に合わせてありますので、それ以外の放送を選ぶことはできません。
3. 各地域に合わせて生産するため、お申込いただいてから納品までに3ヵ月位かかるばあいがあります。ご了承下さい。
4. 低廉価格でご利用いただくために工場から団体様に直接発送いたします。
   できるだけ10台以上にして代表者が申し込んでください。
5. 代金は品物到着後、現品に同封の払込書用紙をご利用下さい。
   申込単位で代表者が払込願います。
6. 不明な点がありましたらお問い合わせ下さい。

●お問い合わせ先
駿河電子産業株式会社
〒420 静岡市岳美39番地
☎(0542)46-2525代
警報ラジオ"ピロピロ"係

### 緊急警報放送システム




●内蔵型ラジオ受信機
(警報ラジオ"ピロピロ")
自動的に警報音が鳴って引き続き緊急情報が受信できる。

●従来型受信機
(普通のテレビやラジオ)
テレビやラジオのスイッチを入れて聞く。

Figure 24. Brochure Illustrating Emergency Alarm Device for Radios and TV Sets.

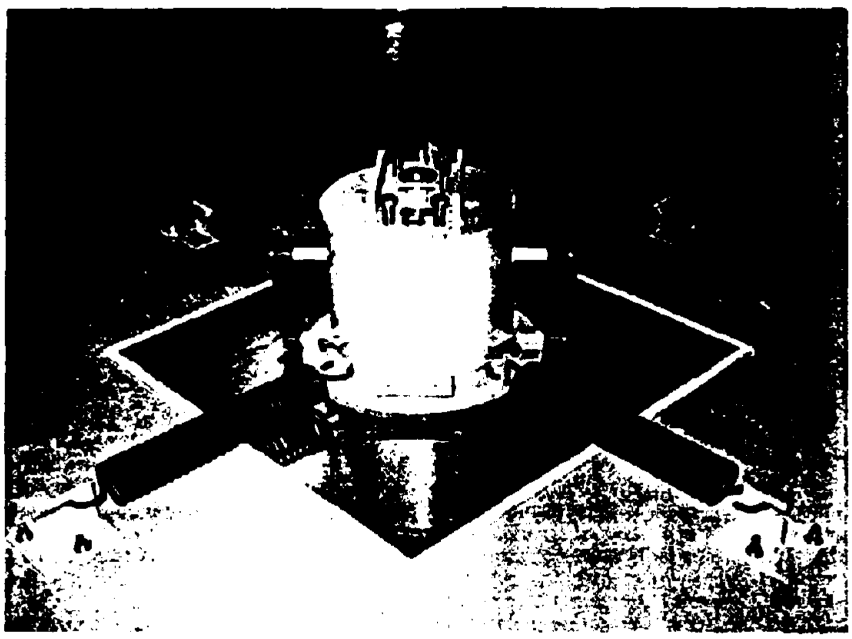


Figure 25. Photograph of Base Isolation Mount for Computer Floor. (courtesy Ohbayashi Gumi)

damaged. Although the system was designed to protect computers, there is potential application for the protection of other shock-sensitive or difficult to restrain equipment as well. This product has been installed in 40 major facilities in Japan.

A similar system has also been developed by another major architectural and engineering firm, Takenaka Komuten. In both instances, the development of these base isolators was undertaken jointly by an AE firm and a firm experienced in the manufacture of mechanical components. Ohbayashi and Tokico cooperated to develop their base isolator while Takenaka Komuten cooperated with Oiless Industries.

## ELECTRICAL EQUIPMENT

Past earthquakes have shown that electrical installations, particularly transformers, circuit breakers, and panels, could suffer severe damage.

One company has developed a high tension distribution panel, including circuit breakers, that can withstand horizontal accelerations of 980 gals (about 1 g). This has been done by redesigning the panel, and by using vacuum circuit breakers rather than the conventional circuit breakers. The manufacturer has shake-table-tested this design, with wave characteristics representative of the El Centro earthquake and the Tokachi-oki earthquake and confirmed that the equipment suffered no mechanical or functional damage.

## OFFICE FURNISHINGS

At least two office furnishings companies have conducted their own tests and developed office and home furniture, including storage facilities, that would be more resistant to damage from earthquakes. Modular units that can be tied to one another have been developed. All cabinet doors have latches to prevent their flying open. Stock racks and shelves have been fitted with cross braces at the back, horizontal connectors between shelves, connectors between adjacent shelves, and floor anchors. Restraint bars for computer magnetic tape racks smoothly push down out of the way, and then pop back up into position.

Uchida Yoko has paid special attention to protection of furnishings in computer facilities, particularly magnetic tape cabinets and the like. They have also developed standard hardware that can be used for retrofitting restraints on their older product lines.

## ELEVATORS

The newly revised building code in Japan, which became effective on June 1, 1981, requires all high-rise building elevators to be fitted with earthquake protection devices. The fundamental aim of such devices is to bring the elevator to a halt, as soon as possible, at the nearest floor, open the doors, and let the passengers go out.

Two companies have developed safety equipment for this purpose. One company uses an inverse pendulum type of air damping sensor (seismometer) to detect the earthquake, and then employs control circuits to cause the elevator to stop at the nearest floor. This sensor is capable of two-step sensing, i.e., at 80 gals and 150 gals acceleration. The mode of operation at each of these accelerations is slightly different. Normal elevators that stop at each floor come to a halt at the nearest floor in both cases. When an elevator is on a long run in an express service zone, however, and an acceleration of 150 gals is sensed, it comes to an emergency stop, and the cage is driven in the direction opposite to the counterbalance before it stops at the nearest floor. This company also manufactures another sensor that is capable of detecting primary waves (vertical motion).

Another company employs light rays reflected off the surface of a fixed volume of mercury, measures the characteristics of this reflected light, and determines if an earthquake is occurring. The main feature of this device is that one unit is capable of detecting both primary and secondary waves. When the primary wave sensor operates, the elevator car is automatically landed at the nearest floor, the doors open, the passengers leave, and the doors close after a predetermined time. The elevator stays in this position for a predetermined time span. If the secondary wave sensor is activated, i.e., a secondary wave is detected, the elevator is shut down until operation is resumed manually. If the secondary wave is not detected within the preset time span, the elevator resumes normal operation.

In Japan, because many of the large earthquakes originate offshore where the subduction process is occurring, there is a significant length of travel path to the nearest cities. Because P waves travel faster than S waves, this means that there is often a significant difference in arrival times of the two types of vibrations, frequently on the order of 20 seconds.

## Section 8
## CONCLUSION

This report is but a brief account of earthquake hazard reduction activities undertaken by Japanese companies. An exhaustive report containing all the details would be too voluminous. Rather than a detailed account, emphasis has been placed on illustrating and highlighting specific points that make Japanese programs unique.

The effort to reduce earthquake hazards in Japan is really national--involving not just the national government, but the nation as a whole. It is national policy today, and all sectors, including local governments and the private sector, cooperate. Corporate earthquake hazard reduction practice hinges not only on national regulations, but also on an awareness that, in order to maintain a competitive edge, businesses have to reduce outage time due to natural disasters to a minimum.

In addressing this issue, Japanese companies have taken to long-range planning rather than short-term patchwork remedies. This approach not only makes the annual budget outlays manageable, it also develops the required expertise in-house. Long-range planning is characteristic of the non-earthquake programs of Japanese firms as well.

Most remarkable is the total lack of a fatalistic attitude toward natural hazards in general, even though the largest Japanese earthquake disaster could be far more calamitous than the comparable scenario in the United States. The Japanese are fully aware that sooner or later different portions of their country might be hit by one type of natural disaster or another. With specific reference to earthquakes, the national government has divided the country into different risk zones, with different regulations and standards applicable to each zone.

The governments, national and local, not only call upon industry to practice earthquake hazard reduction, but practice it themselves as well. Both at the National Land Agency and at the Shizuoka Prefectural Offices for example, the extent of structural and nonstructural hazard reduction measures implemented would serve as a model for any other organization to follow.

Japan has also been very adroit in learning from past damage examples in Japan and elsewhere. Even in areas of Japan that have not had damaging earthquakes in recent history, new standards based on recent damage examples have either been adopted or been enforced by regulation.

Japanese industries have also developed a wide variety of equipment for earthquake hazard reduction. With one exception, all such equipment has been developed by the private sector at its own expense. Most sophisticated among these are probably the computer floor base isolation system and the elevator control system. With the exception of the elevator control system, none of this equipment is required by codes or regulations. Nevertheless, the market for them obviously exists, and the major corporations whose products or services relate to earthquakes also feel an obligation to develop such products to fulfill their responsibility as leaders of industry and to maintain the prestige associated with that role.

It must also be pointed out here that all Japanese companies visited were extremely cordial and open about sharing their information with us, regardless of the fact that, not only was there no monetary return for them, but they were incurring an expense in terms of their employees' time in meeting with us and providing us with the necessary information. In fact, in some cases the companies had gone to great trouble to prepare the appropriate material for us ahead of time, and even had a good portion of it translated into English. An approximate estimate of the staff time spent to prepare for each of our visits is one person-week.

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## APPENDIX A

## Survey of Corporate Emergency Preparedness

# SURVEY OF CORPORATE EMERGENCY PREPAREDNESS

A weekly magazine in Japan, called TOYO KEIZAI has conducted two surveys of major companies in the Tokyo and Tokai region. Eighty-nine companies having their main offices or place of business in the Tokyo and Tokai regions were surveyed in 1984. A similar survey was conducted in 1981 when questionnaires were sent to 53 companies. This appendix provides an English summary of their findings, which are both a report of the current status quo, and the differences between 1981 and 1984.

**Organizing for emergency preparedness**

Table 1 shows the number of companies with organizations that deal with earthquake preparedness. While 81% of the companies (72) have an organization today, in 1981 the corresponding percentage was 46%, representing an increase of 35%. However, the fact that 17 companies (19%) have no internal organization at all must be reported as surprising. Companies with no organizations for earthquake preparedness, also, are rather unprepared for earthquakes, in terms of the countermeasures implemented to date. As can be expected, a well formulated internal organization is necessary before meaningful earthquake countermeasures can be implemented.

More than half the companies surveyed started earthquake preparedness activities after passage of the Large Scale Earthquake Countermeasures Act (LECA) in 1978. Some companies had started earlier, and had built their organization around their company fire brigades. In most of the cases, the individual responsible was the general affairs manager/director, and earthquake preparedness and countermeasures are frequently thought of as being the business of the general affairs department. However, tasks like these are accomplished best when top management is supportive. In the case of 24 companies, either the company president or deputy presidents were in charge of earthquake preparedness.

In the case of Itoh-Chu (a trading company), as soon as it is announced that the national Assessment Committee is going to meet to evaluate an earthquake prediction, its own Emergency Countermeasures Headquarters, with the Director of Personnel and General Affairs as head, convenes at its head offices in Aoyama, Tokyo. Disaster prevention measures are implemented, and personnel are released from the company according to a predetermined timetable, in order to avoid overloading the transportation network. (See Table 2).

**Table 1A**
**Status of Earthquake Preparedness Organizations at Head Offices of Japanese Companies**

| Status | No. of Companies |
|---|---|
| 1. Established | 68 |
| 2. Included within another organization in company | 4 |
| 3. In process of being established | 3 |
| 4. None established as yet | 12 |
| 5. Unknown | 2 |
| TOTAL | 89 |

**Table 1B**
**Year in Which Earthquake Preparedness Organization Was Established**

| Time Period | No. of Companies |
|---|---|
| 1. 1960 - 1974 | 7 |
| 2. 1975 - 1978 | 12 |
| 3. 1979 - 1981 | 33 |
| 4. 1982 - 1984 | 12 |
| 5. Unknown | 4 |
| TOTAL | 68 |

In the case of Chiyoda Kako (a plant engineering company), the Corporate Disaster Prevention Headquarters is established at its head offices in Tsurumi, Yokohama. This office is headed by an executive director of the company, and it will coordinate the activities of the various Disaster Prevention Offices at its job sites. Condition A (emergency measures and refuge) is implemented first, followed by Condition B (safety of the team that stays behind).

Only two companies had no drills or instruction programs for its employees; in 1981 there were 10 such companies (19%), which indicates that the number of companies doing absolutely nothing to prepare themselves has decreased. The vast majority of the companies (57%) have one to two drills per year. However, on the top end are Bridgestone (tire and rubber products manufacturer) with six drills per year, and Mitsukoshi (department store) with five to six drills per year. Fifty-five companies have all employees participating in drills, while 12 companies have only representative employees participating.

Among instructional activities, emergency manuals, newsletters, and pamphlets are the three main measures, though the detailed manner in which these are prepared and published are quite varied. In the case of Chiyoda Kako, a 73-page manual, which includes the fundamentals of earthquakes, company organization, transportation, communications, etc., has been distributed to all 5,500 employees. However superior a manual, if it stays on the shelf and is not read, it will be of no use. To make sure that this does not happen, companies such as Fuji Bank and Nihon Denso have distributed condensed booklets in the form of pocket-sized cards. Employees are expected to carry them in their pockets, because earthquakes need not happen during office hours. Thirty companies use movies and video tapes for earthquake education of their employees; 35 companies use slogans and posters. These numbers were only 6 and 8 respectively in 1981, reflecting a growth in earthquake educational activities among the companies. The methods employed by companies to train and/or educate their employees are summarized in Table 3.

**Go home or remain?**

Two situations are expected: either the earthquake occurs suddenly, or it is predicted by detection of abnormalities by the Tokai Earthquake Observation instrumentation. In the latter case, the National Assessment Committee will announce if the earthquake is expected within the next two to three days, or the next several hours.

In the case of an unexpected occurrence, the only option left is to delve into emergency response immediately. The problem arises when an earthquake is

**Table 2**
**Decisions Regarding Sending Employees Home When a National Disaster Warning is Issued**

| | Decision | Tokyo Metro Area (82 companies) | Tokai Region (69 companies) |
|---|---|---|---|
| 1. | To be returned home immediately | 2 | 7 |
| 2. | Decisionmaking committee or individual has been determined | 60 | 51 |
| 3. | To be decided when warning is issued | 11 | 4 |
| 4. | Employees will be permitted to return home only after safety check | 4 | 4 |
| 5. | Other | 5 | 3 |
| | TOTAL | 82 | 69 |

**Table 3**
**Methods Employed to Train and Educate Employees**
(Multiple Answers)

| | Method | No. of Companies |
|---|---|---|
| 1. | Exercises and drills | 80 |
| 2. | Training Manuals | 44 |
| 3. | Internal broadcasts | 45 |
| 4. | Lectures and Tutorials | 28 |
| 5. | Posters | 29 |
| 6. | Films, videos | 30 |
| 7. | Pamphlets | 57 |
| 8. | Slogans | 6 |
| 9. | Other | 10 |
| 10. | No special educational program | 2 |

predicted to occur. Here again, the vast majority of the companies (60 companies or 73% in the Tokyo region, and 51 companies or 74% in the Tokai Intensified Region) have already determined the manner in which their employees will return home; the organization or individual who makes these decisions has also been fixed. During the survey of 1981 there were 14 companies (26%) that had no specific plans on returning employees home when an earthquake was predicted. This number has dropped to 11 (13%) in the Tokyo region and 4 (6%) in the Tokai region.

One of the key problems is means of transportation. In the case of Tokyo, those living nearby are expected to walk home. Those who have to use the railway and subway system are expected to leave at different times so as to not to overload the transportation network. However, most of the companies have not outlined detailed criteria on how they expect to implement this. Ricoh has established the following: (1) Employees will return in groups consisting of people living in the same area. (2) Those living less than 1 km away will walk. (3) Priority in returning will be female employees, male employees, company fire brigade members, and managerial staff. In the case of Itoh-Chu, all female employees, and male employees living west of Kanagawa Prefecture, will be permitted to leave the company within 40 minutes of an announcement from the National Assessment Committee. All other male employees will be released within an hour. The 25 members of the company fire brigade and 30 members of the security group will then leave the company. The seven members of the coordinating committee will remain in the company.

**Emergency supplies**

Storage of food and water supplies has also progressed. The 1981 survey showed that there were 12 companies (23%) that had stored no supplies whatsoever, compared with 7 companies (11%) in 1984. The three most common food items that have been stored are "kanpan" (crackers), canned foods, and rice. Details of the types of food stored are shown in Table 4A. Crackers need to be replaced every two to three years, and disposal of the old stock is a problem. Some of the innovative solutions include consumption during overtime work (Taisei Construction), and storage of chocolate flavored crackers, which can be distributed to children (Chiyoda Kako). Rice, of course, needs to be cooked; 28 companies consider this to be a possibility even in a post-disaster situation.*

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* Pre-cooked packages of rice are kept on hand at Kokubu, a large grocery wholesaler. In a country where the preparation of rice is not taken lightly--one major U.S. cake manufacturer learned this when it found that there was a taboo against using the common household rice cooker for any other purpose--pre-cooked rice is quite a novelty.

**Table 4**
**Preparation of Food and Water Supplies**
(75 companies, multiple answers)

**A: Types of Food in Storage**

| Types of Food | No. of Companies |
|---|---|
| Crackers | 50 |
| Canned food | 36 |
| Rice | 27 |
| Packaged emergency food | 14 |
| Juice | 6 |
| Processed fish and meat | 7 |
| Other | 22 |
| Unknown | 7 |

**B: Number of Meals, for All Employees, Prepared by Company**

| Number of Meals | No. of Companies |
|---|---|
| 1 to 2 | 7 |
| 3 | 13 |
| 4 to 5 | 4 |
| 6 | 14 |
| 7 to 8 | 1 |
| 9 | 11 |
| More than 12 | 8 |
| Other | 2 |
| Quantity uncertain | 8 |
| Unknown | 7 |

**C: Water Supplies, for Employee Consumption, Stored by Company**

| Amount Stored | No. of Companies |
|---|---|
| One-day supply | 8 |
| Two-day supply | 12 |
| Three-day supply | 16 |
| Four to nine days | 4 |
| 10 to 19 days | 3 |
| More than 20 days | 3 |
| Other | 11 |
| Unknown | 2 |

Other measures taken for provision of food and water have included maintaining a minimum inventory in the company cafeteria, and use of company products (Meiji Confectioneries, Takashimaya, etc.). Quantities of food stored vary, from one to three meals to tide employees over until they can return home, to more than a three day supply. Though banks in the Tokai region can close down when an Earthquake Warning is announced, banks in other areas are to remain open. As a consequence, Fuji Bank has a four-day food supply in most areas, and a seven-day supply in the Tokai region.

**Nonstructural damage prevention**

Other than those outlined above, the main concern of companies seems to be computers. Sixty-three companies (71%) store their data at multiple locations. The 1981 survey showed only 29 companies (55%) had taken similar measures. Nineteen companies (21%) have dual computer centers. Ironically, computer manufacturers themselves, such as Hitachi, Toshiba, and Fujitsu, do not have dual centers. Banks, simply because they will not be able to operate if their computers quit, are ahead of the rest in protection of their computers. At the same time, provisions have also been made for manual deposits and withdrawals, as in times gone by.

Fifty-three companies have had the earthquake safety of their buildings evaluated by an expert. (Only 79 of the companies surveyed had this necessity, and the number 53 therefore represents 67%.) Of these 53 companies, 8 are located in buildings that can withstand an earthquake of intensity 5 (JMA Scale), 13 can withstand 6, 20 can withstand 7, with no specific data on another 12.

Forty-nine companies (62%) have taken at least some measures to protect their building contents, compared to only 45% during the 1981 survey. The others are either unprepared, or no information is available regarding them.

In both the 1981 and 1984 surveys, approximately half the companies (51% and 47% respectively) are concerned about damage to glass. There has been a marked improvement in the number of companies that have taken measures to prevent the occurrence of fires from boilers, water heaters, etc. In 1981, 19% had paid attention to this problem whereas in 1984, 43% had.

Fifty-five companies (62%) reported having some form of emergency communications. However, these are centered around amateur ham radios and CB's; these are considered not to have much practical value in a major disaster and the confusion that would follow it.

Thirty-eight companies (43%) have made provisions for emergency transportation, though the main means provided appears to be bicycles. This decision has been based on the consideration that most roads would be impassable to automobiles and trucks, and furthermore that even motorbikes would require gasoline.

Nihon Sanso (Japan Oxygen) plans to move its Information Center from its Corporate Headquarters in Tokyo to its North Kanto Regional Office in Koyama City, Ibaragi Prefecture. A dedicated communications link between Koyama and Tokyo will be used to maintain communications, but other offices in Central Kanto are expected to "communicate" with the Headquarters by couriers using bicycles and/or rubber boats. This is their emergency communication network.

**Table 5**
**Hazard Reduction Measures Implemented by Companies**

| Hazard Reduction Measure | | Implemented | Not Implemented | Unknown |
|---|---|---|---|---|
| 1. Dual computer centers | | 19 | 61 | 9 |
| 2. Computerized data stored at multiple locations | | 63 | 19 | 7 |
| 3. Professional structural analysis of buildings | | 53 | 18 | 8 |
| 4. Building contents protection | | 49 | 20 | 10 |
| 5. Glass windows: | | | | 9 |
| - Glass will most probably not shatter | - 37 | | | |
| - Glass might shatter | - 33 | | | |
| 6. Safety of boilers, water heaters, etc: | | | | 13 |
| - Total shutoff at a predetermined ground acceleration | - 34 | | | |
| - Equipment without shut-off valves still exists | - 32 | | | |
| 7. Emergency communication equipment | | 55 | 30 | 4 |
| 8. Emergency transportation means secured | | 38 | 45 | 6 |