LIQUEFIED ENERGY GASES

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

NINETY-FIFTH CONGRESS

SECOND SESSION

ON

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CONTENTS

LIQUEFIED ENERGY GASES

MONDAY, AUGUST 21, 1978

U.S. SENATE,
COMMITTEE ON COMMERCE,
SCIENCE AND TRANSPORTATION,
Boston, Mass.

The committee met at 9 a.m. in room 2003A of the John F. Kennedy Federal Building, Hon. John A. Durkin presiding.

OPENING STATEMENT BY SENATOR DURKIN

Senator DURKIN. This morning the U.S. Senate Commerce Committee is opening the first in a series of hearings to investigate the problems associated with the storage and transportation of liquefied energy gases. We are pleased to have with us a range of experts and Government officials knowledgeable of the problems relating to liquefied energy gases.

Liquefied energy gases, LEG for short, include both liquefied petroleum gas, LPG and liquefied natural gas, LNG. Although we use the term "LEG" to refer to both LNG and LPG, the two substances are quite different and have different properties and dangers. LNG is regular natural gas, consisting mostly of methane, and is easier to store and transport. LPG, on the other hand, is mostly propane and butane, and is processed from natural gas or crude oil. Experts generally agree that LPG is more hazardous than LNG because it is heavier and clings to the ground at normal temperatures and can explode, whereas LNG becomes lighter than air and explodes only in confined spaces. However, both must be handled with caution.

Both—and I underline "both"—of these gases supply an important and growing part of New England's energy supply. LNG was first imported into this country at the nearby Everett Distrigas facility in 1972. Now with decreasing supplies of domestic natural gas, LNG import facilities to transport LNG from overseas have been proposed at sites throughout the United States. LNG currently supplies New England with 6 percent of its total gas supply. By 1985, this may increase to 20 percent.

Liquefied petroleum gas, consisting mainly of propane, is especially important in northern New England to heat homes and commercial establishments. Much of New England's LPG is supplied through the Newington, N.H., facility near Portsmouth, by truck and railroad deliveries directly to customers.

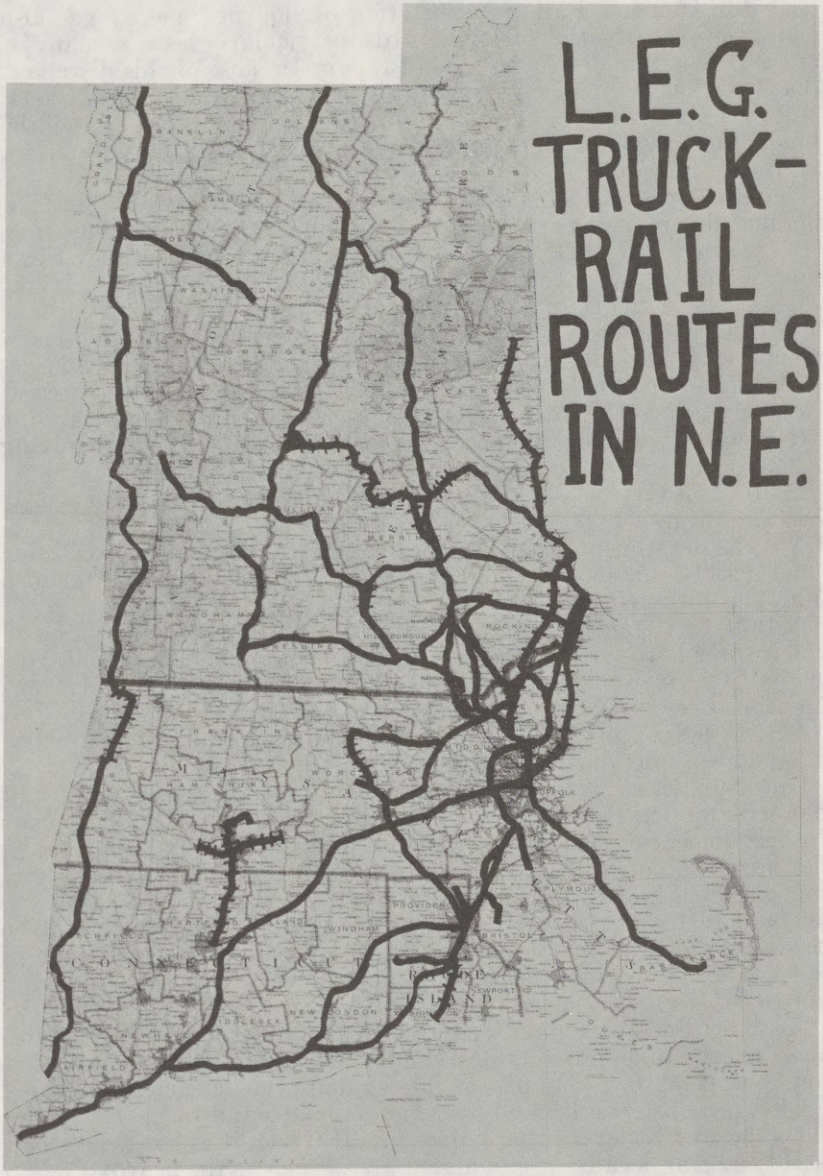
The precise extent of the danger of transporting and storing liquefied energy gases has not been clearly established. However, on the basis of what we do know, the hazards of LEG can be fairly described as very serious and potentially catastrophic. Experts have estimated that if the LNG commonly carried in one tanker, which is approximately 125,000 cubic meters, were to accidentally escape, it could expand to form a low-lying vapor cloud that would drift with the prevailing winds and cover an area of many square miles. The U.S. Bureau of Mines estimates that if only one-fifth of this quantity of LNG was spilled on water, it could spread a vapor cloud 25 to 50 miles from the point of spill. Such a cloud would be so explosive that it could be ignited by something as simple as the spark generated by an automobile horn.

If the vapor cloud exploded in a crowded metropolitan area such as Boston or New York, it could cause a unimaginable catastrophe. As a map of the Boston area demonstrates, a liquefied energy spill in Boston Harbor which spreads over a radius of 10 miles could damage the entire metropolitan area.

LNG and LPG transported on land by truck and by train also pose serious hazards to public safety. If the 40 cubic meters of LNG in one truck were to spill and vaporize, it could mix with air and produce enough highly flammable gas to fill more than 110 miles of sewerlines or 15 miles of subway tunnels. This is particularly significant for the Boston area because most of New England's LNG is transported by tanker truck, often through Boston on the Southeast Expressway.

The map of New England at my side shows the various routes used by LEG trucks in our region to deliver gas to consumers. It is important to note that most of these routes pass through heavily populated and industrialized areas.

(The maps follows:)


L.E.G.
TRUCK-
RAIL
ROUTES
IN N.E.

Senator DURKIN. Rail transportation of liquefied energy gas also creates serious potential safety hazards, particularly because many of our railbeds are in desperate need of repair. Because of this disrepair, I have worked hard in the Senate this past year to insure additional funds are available to upgrade New England's rail beds, and the Senate passed an amendment I offered authorizing $100 million for rail rehabilitation.

The need for rehabilitation is clear, and we are fortunate that New England has not yet experienced as serious LEG rail disaster. However, recently an LPG tanker car derailed in Portsmouth, N.H.; a potential mishap was averted because the tanker was empty at the time. Other parts of the country have not been so fortunate. On February 25 of this year a derailed railroad tank car carrying 30,000 gallons of propane exploded during cleanup operations 48 hours after the derailment had occurred. The explosion leveled a 4-square-block area of the town of Waverly, Tenn., killing 12 people and injuring scores more.

Regrettably. this has not been the only serious accident involving LEG. Consider the following:

A 1975 LPG truck explosion near Eagle Pass, Tex., claimed 16 lives and injured 45 persons.

A 1974 derailment near Oneonta, N.Y., resulted in an explosion which rocketed a 45,000-pound section of a steel tank a quarter of a mile. The mishap injured 45.

A 1974 LPG tank car pucture in Decatur, Ill., resulted in a cloud which spread from the site of the accident and exploded over an area one-half by three-quarters of a mile, killing 7, injuring 349, and strewing debris over 20 city blocks. Damage was $24 million.

A 1944 LNG spill in Cleveland caused fires and explosions which killed 130 people and injured 225 others.

I mention these accidents not to indicate that LEG is a menace or that it is too hazardous to be a commercially feasible energy source. Rather, I mention the accidents because I believe it is important to recognize the potential problems involved in the storage, transportation, and handling of LNG and LPG so that we may undertake reasonable and realistic precautions. This is necessary, for at this point no consistent Government policy regarding safety and transportation of liquefied energy gases has been developed to minimize the potential hazards of these vital energy sources.

Existing Federal regulations are marred by inconsistent enforcement, overlapping jurisdictions, regulatory blind spots, and unnecessary redtape. A few examples of the regulatory deficiencies pertaining to LEG demonstrate the need for congressional action:

The lack of Federal siting policy for LEG facilities has led to these facilities being located in populated areas, such as the nearby facility in Everett. More recently, the new Columbia Gas Facility at Cove Point, Md., was sited within 5 miles of the Calvert Cliffs nuclear plant, even though the Nuclear Regulatory Commission recommended a 12-mile safety range.

Coast Guard inspections of LNG tankers, such as the ones delivering LNG to the Everett facility, do not include the operating condition of control equipment, such as steering engines, navigational equipment, propulsion machinery, and electronic devices.

The Department of Transportation has no special inspection program for LEG trucks. No regulations govern the passage of trucks through populated areas.

The Office of Pipeline Safety, which is charged with regulating on-land LNG facilities, has been without a permanent director for 7 out of the last 10 years.

The committee hopes that this hearing will focus on these problems and begin to provide viable solutions to the serious regulation problems associated with LEG. The concern of the committee is threefold. First, we hope to assure the absolute safety of existing methods of transportation and storage; second, the committee hopes to develop effective legislation to deal with the complex problems of LEG transportation and safety. Third, our concern is to meet, in an environmentally and economically a manner as possible, the growing energy needs of our Nation.

In short, the issue before us poses a difficult challenge. The dangers are real, the problem complex, the investment enormous, and the need for energy, great. I am sure the testimony presented at this hearing will help the committee meet this challenge.

The film which we are going to show in a moment is a training film made by the National Fire Protection Association. Although this film shows an actual incident with LPG, such events are not frequent occurrences and should not be viewed as inevitable results of LPG transportation and storage. However, the film does vividly demonstrate the potential hazard of one of these types of energy gases, LPG. The magnitude of the possible disaster from an accident involving LPG or LNG caused by human error, equipment error or whatever, mandates that the public be adequately informed and protected.

I think just the recitation of the number of Federal instrumentalities involved or not involved in the regulation of liquefied energy gases illustrates very vividly the scope of the problem. Today the regulation of liquid energy gases is a symphony of chaos. It is a half a dozen agencies all partially involved, all involved to a limited sense. No agency has the overall responsibility, and no agency has the responsibility to make sure that the transportation and storage dangers inherent in these gases are minimized. It is a typical situation where no one agency has the overall responsibility, and each agency looks to the other four or five that are involved to solve the question.

That is why we are here. It is the beginning of the deliberation in the Senate of what is a very, very real and very, very severe problem and one that the Congress is going to have to face up to very, very shortly.

Now, for the benefit of everyone, we will proceed with the film.

[Film shown.]

Senator DURKIN. I want to thank the National Fire Protection Association for making the film available.

At this time I would like to announce that Senator Kennedy had a conflict, but his full statement will be available shortly and will be printed in the record. Furthermore, Congressman Markey will be added to the witness list and will testify around 10 o'clock. As you know, Congressman Markey has been very substantially involved in this problem. He is one of the leaders in the House, along with Congressman Dingell, in trying to resolve some of the many, many problems involved.

We will depart from the witness list to a certain extent. Miss Sullivan was taken ill and has a replacement here. One of the GAO witnesses has a scheduling problem and so at this time we turn to Mr.

Canfield and Mr. Rosenbaum of the GAO. Even though this is not the scheduled order I think it is fortuitous to have the GAO testify at this time to set the stage. As you know, the GAO is the investigatory, nonpartisan arm of Congress, and is noted for its thoroughness and objectivity. Without further discussion at this time I would turn to the GAO witnesses.

Please introduce yourself for the record and then proceed in the manner you feel most comfortable.

STATEMENT OF MONTE CANFIELD, JR., DIRECTOR, ENERGY AND MINERALS DIVISION ON LIQUEFIED ENERGY GASES, GENERAL ACCOUNTING OFFICE; ACCOMPANIED BY DAVID ROSENBAUM, COMPTROLLER GENERAL CONSULTANT, PHYSICIST; AND CARL SPECTOR, PHYSICIST

Mr. CANFIELD. Thank you, Mr. Chairman. My name is Monte Canfield. I am the Director of the Energy and Minerals Division of the GAO. On my immediate right is Dr. David Rosenbaum, who is a comptroller general consultant, assigned directly to my office. He is a physicist and he led this study under my direction. To his immediate right is Mr. Carl Spector, who is also a physicist who worked on this study.

We are happy to be here today to discuss this GAO report which as you can see is rather voluminous, some 1,300 pages altogether. We issued it on July 31 of this year. It was a coordinated effort involving GAO employees, companies under contract and distinguished consultants.

My testimony will begin with a brief primer and then focus on five major areas which I think will be of concern to the committee: Storage facilities; transportation; liability; research; and regulation. A short discussion of the potential consequences of a large LEG spill is given in the addendum to my testimony, which I will not read, but I would appreciate it if you would make it part of the record.

Senator DURKIN. Your entire statement will be included in the record.

Mr. CANFIELD. Energy gases—natural gas, propane, and butane—are liquefied in order to reduce their volume hundreds of times and this facilitates their transportation and storage, but it also magnifies the potential hazards.

LEG are often stored and transported in densely populated areas. Outside their containers, these liquids rapidly vaporize and become highly flammable and explosive gases. One cubic meter of liquefied natural gas—LNG—makes 424,000 cubic feet of highly flammable natural gas-air mixture. One cubic meter of liquefied petroleum gas, propane and/or butane, makes a slightly larger volume of flammable gas-air mixture, and a major spill in a densely populated area, whether by accident, natural forces or sabotage, could be catastrophic.

Because of this potential danger and the possible increase in the use of these liquefied gases, we believe that now is an appropriate time to examine the critical safety issues and take those actions necessary to protect the public.

We believe that the Nation's LEG needs can be met without posing undue risk to the public if the recommendations developed in our report are adopted by the Congress and the Federal agencies involved.

LEG facilities must be located away from densely populated areas and built to stronger codes and standards. The movement of LEG in densely populated areas must be restricted, and the security of LEG facilities and vehicles upgraded. Regulations need to be coordinated, and Federal research programs redirected and stepped up.

Let me give you a very brief primer. Although there are many differences in their physical properties and technologies, LNG and liquefied petroleum gas, LPG, are similar substances and have many safety and security problems in common. This has made it convenient to consider them together as LEG. Naphtha, a less hazardous substance, is included in the report simply to compare its regulations and handling with those of LEG.

All three products together make up about 3 percent of the energy used in this country and they are produced domestically and are imported. All three are used to supplement domestic natural gas supplies.

LNG and LPG will only burn at the surface of the liquid. When spilled, however, both substances quickly vaporize and because the LPG vapor and cold LNG vapor are heavier than air, they form a low spreading cloud, which becomes highly flammable as it mixes with air. An LNG vapor cloud is flammable when the LNG concentration is between 5 and 14 percent, the balance being air. The flammable range for an LPG cloud is between 2 and 9 percent.

In the summer, when natural gas demand is low, excess gas is liquefied and stored in highly insulated tanks. A typical large LNG storage tank can hold 95,000 cubic meters, enough to make nearly 2 billion cubic feet of natural gas. When demand peaks in cold weather, the LNG is either regasified and pumped through gas pipelines to customers, or delivered by truck to other gas companies where it is similarly processed.

Such peak-shaving plants have been operating in the United States for several years. Most large LNG storage facilities are for peak-shaving. There are currently 45 of these which hold more than 23,000 cubic meters. There are about 75 LNG trucks, each with about 40 cubic meters capacity.

Recently, LNG has been imported in ships. These imports, which now supply less than one-tenth of 1 percent of U.S. natural gas demand, could supply up to 15 percent by 1985. This would require more than 40 LNG tankers to operate regularly in and out of U.S. harbors. A typical new LNG tanker carries about 125,000 cubic meters.

The 14 major LNG import terminals now operating throughout the world are baseload facilities. The LNG is piped from the ship to storage tanks from which it is constantly regasified or reshipped, instead of being saved for peak demand periods.

There are three LNG import terminals currently operating in this country. The Everett, Mass. terminal began operations in 1971, and as you know, the Cove Point, Md., terminal and the Elba Island, Ga., terminal began operations this spring. Two terminals are now under construction, and several more have been proposed.

The much greater use of LPG has drawn less public attention than the relatively new LNG industry. LPG has been used for many years for a variety of purposes, including making synthetic natural gas and providing power on farms.

About 85 percent of the LPG in bulk storage is kept under pressure in underground salt domes or mined caverns. LPG is also stored in

above-ground tanks, many of which are small. There are only 20 LPG above-ground storage facilities that hold more than 23,000 cubic meters.

Domestic transportation of LPG is mostly by pipeline, with the remainder distributed in trucks or railcars. There are 70,000 miles of LPG high-pressure pipeline, 16,000 LPG rail cars, and 25,000 LPG transport and delivery vehicles. A large LPG truck trailer holds about 40 cubic meters.

Ten major LPG import terminals are now operating in the United States, and imports of LPG may rise substantially. LPG ships are smaller than LNG ships; typical new ones hold 75,000 cubic meters.

We may turn now to LEG storage facilities and the vulnerability of those to natural forces. LEG storage tanks are usually designed to the Uniform Building Code standards for their particular geographic areas, the same standards used for most inhabited buildings—say, this building here. They essentially require that LEG tanks be able to withstand the largest earthquake, wind, flood, et cetera, locally experienced in the last 50, 100, or 200 years.

The probability of these natural forces exceeding UBC standards at a given site in a given year is low. However, the probability that the standards will be exceeded some time at some facility increases with the number of facilities and with the number of years each facility operates.

Because there are already many large LEG facilities, it is virtually certain that during their lifetime many of them will experience natural forces greater than those the UBC standards require them to withstand. This does not necessarily mean that the facilities will fail. The UBC standards are minimum criteria, and most structures have built in safety margins that are designed to be stronger than the standards require.

By failure of a tank, we mean a permanent distortion or rupture that causes significant leakage of the contained fluid. A failure is not necessarily a complete collapse.

We evaluated the LEG tank designs at five sites and found that while they were adequately designed for the UBC earthquake and 100-year wind criteria, tanks at three of the sites had very small earthquake safety margins, and two of these three, containing three large tanks, are located next to each other in Boston Harbor.

Nuclear powerplants are built to higher standards than any other type of energy installation, much higher than those for LEG installations. Nevertheless, they are never located in densely populated areas. We believe that new large LEG facilities should be located in remote areas and they should not be located in densely populated areas.

Most LNG storage tanks have double metal walls with insulation in between. Some are made of prestressed concrete. LPG and naphtha tanks have single walls.

The outer steel walls of LNG tanks are not normally made to withstand intense cold. Thus, if the inner tank alone fails for any reason, it is almost certain that the outer tank will rupture from the pressure and thermal shock.

The most likely cause of failure of large steel LEG tanks in an earthquake appears to be from breaking the steel straps which anchor the steel tank sides to the concrete foundation. The tank's walls will then separate from its bottom, causing a massive spill.

Large LEG tanks made of prestressed concrete are usually much more resistant to natural forces than most made of steel.

We also looked at the ability of dikes to contain large spills. National Fire Protection Association standards require that each large LEG tank, or group of tanks, be surrounded by a dike which can hold at least the volume of the largest tank. However, most of these dikes are only designed to contain LEG spilled from relatively slow leaks. They cannot contain the surge of LEG from a massive rupture or collapse of a tank wall.

We selected six LEG facilities, with dikes built to the National Fire Protection Association criteria, and calculated how much liquid could escape over the dikes. Our calculations were verified by actual experiments.

Our results indicated that a massive rupture or collapse of a tank wall could spill over 50 percent of the LEG at five of the facilities. The largest overflows we calculated were the two tanks at Distrigas with 64 and 62 percent. The adjacent Exxon facility ranked next with 58 percent.

Our calculations assumed an immediate, total spill of a full tank, with the fluid moving toward the nearest dike wall. Such an LNG spill occurred in Cleveland in 1944. A similar, much larger LPG spill occurred at a Shell facility in the country of Qatar in 1977.

Senator DURKIN. Excuse me, Mr. Canfield. On that point, if I understand you correctly, the thrust of your testimony is that the Everett facility does not meet the national fire protection standards with respect to the diking of those tanks. Is that a fair statement?

Mr. CANFIELD No, sir, it does meet the standards. It is the standards which are designed in such a way to hold the amount of storage which is in the largest tank within the dike, and those standards assume a fairly slow gradual leakage. What we have tried to study is catastrophic events caused by an earthquake or perhaps sabotage, which I will get to later. In those cases where you have a massive surge of most of the liquid, the dikes are not designed to stand that, but that was not the standard for which they were designed.

Senator DURKIN. You say the Everett facility meets the national fire protection standards, but that those standards are inadequate in your opinion, for a catastrophic event?

Mr. CANFIELD. They will not withstand a catastrophic spill, according to our estimates and our studies.

I turn now to vulnerability, to sabotage. Public utilities and petroleum companies in this country have often been the targets of sabotage. Many domestic and foreign groups have weapons, explosives, and ability to sabotage LEG facilities. Successful sabotage of an LEG facility in an urban area could cause a catastrophe.

We found that security procedures and physical barriers at LEG facilities are generally not adequate to deter even an untrained saboteur.

None of the LEG storage tanks we examined are impervious to sabotage, and most are highly vulnerable. Some designs provide greater protection than others against explosive peneration. Stronger designs complicate sabotage by requiring specially designed charges, more powerful explosives. and more onsite preparation. Concrete tanks are much more penetration resistant than single-wall LPG tanks. Double-wall metal LNG tanks fall in between.

In many facilities, just by manipulating the equipment, it is possible to spill a large amount of fluid outside the diked area through the drawoff lines.

LEG storage facilities in cities are often adjacent to sites that store very large quantities of other hazardous substances, including other volatile liquids. Thus, a single cause might simultaneously destroy many tanks, or a spill at one facility might cause further failures at adjacent facilities.

Our major conclusions and recommendations on LEG storage are as follows:

It is virtually certain that the level of natural forces LEG facilities are required to withstand will be exceeded at many facilities in the next 50 years. This could lead to tank failure, particularly where safety margins are low.

Little attention has been paid to sabotage at LEG facilities, and most of them are inadequately protected and highly vulnerable to sabotage. Sabotage could also lead to tank failure.

If an LEG tank fails in a densely populated area, it could cause a catastrophe.

In the event of a massive rupture or collapse of a tank wall, over 50 percent of the LEG could escape over the dikes at five of the six LEG facilities we examined.

Our recommendations to Federal agencies are that the Secretaries of Transportation and Energy and the Federal Energy Regulatory Commission take steps to insure that: All new, large LEG storage facilities are built in remote areas. However, if in spite of our recommendations, new LEG storage facilities are built and operated in other than remote areas, standards similar to those used in building and operating nuclear plants should be applied. No existing large LEG storage facilities in other than remote areas should be expanded in size or use. Any new, large LEG storage facilities not built in remote areas should have inground tanks, with the highest level of fluid below ground level.

We also recommend that the Secretary of Energy evaluate each existing, large LEG storage facility and recommend to the President and the Congress the actions necessary to protect the public from the hazards associated with them.

We recommend that the Congress—enact legislation requiring that guards at LEG facilities carry weapons and be authorized to use them if necessary to prevent sabotage, and—enact legislation extending Federal authority to cover large LEG storage facilities which are presently not covered by Federal regulation. Many large urban LPG storage areas are not presently covered.

Regarding LEG transportation, LNG ships, which hold up to 165,000 cubic meters, are probably the least vulnerable of all the systems involved in LNG transportation and storage. They are double-hulled and have insulated cargo tanks made of welded 9 percent nickel-alloy steel or aluminum alloy, both of which can withstand intense cold.

On the other hand, most LPG and naphtha ships are single-hulled. These ships, the largest of which hold 100,000 cubic meters, are much less resistant to collisions and sabotage than LNG tankers.

Ships are most susceptible to collision while entering ports through narrow, winding ship channels. They are most vulnerable to sabotage while tied up at terminals.

Since human error is a contributing factor in 85 percent of all marine casualties and operating problems, the best precaution against accidents and sabotage is to have highly skilled, well trained personnel operating the ships and terminals.

We have studied the Coast Guard's port operating procedures, and the training requirements for LEG ship's crews, and believe that they need to be improved.

Senator DURKIN. On that point, the Coast Guard recently published an advance notice of proposed rulemaking regarding the safety of LNG import facilities. One aspect deals with sabotage. Do you think it goes far enough and adequately deals with the problem?

Mr. CANFIELD. Have either of you seen that?

Dr. ROSENBAUM. We have not seen that yet. We will take a look at it and submit it for the record.

[The following information was subsequently received for the record:]

REPLIES TO COAST GUARD STATEMENTS ON THE GAO LEGS REPORT AT THE SENATE COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION ON AUGUST 21, 1978

I. Senator Durkin had asked Captain Hein, COTP of Boston, if the GAO statement "that the Coast Guard inspection does not now include in each Port of Call a check of the navigational equipment, steering, emergency steering and what have you" is true. Captain Hein replied that the statement is not true, and referred to the Navigational Safety Regulations, which came into effect in June 1977.

The Navigational Safety Regulations cited by Captain Hein do not contradict GAO's original statement, because they permit equipment testing to be left to ship personnel. The regulations list various requirements for ship navigational equipment—including radar, compasses, and charts—and operating procedures. For example, section 164.25 states that

"No person may cause a vessel to enter into or get underway on the navigable waters of the United States unless, no more than 12 hours before entering or getting underway, the following equipment has been tested: a) Primary and secondary steering gear . . . e) Main propulsion machinery, ahead and astern."

The regulations do not require that Coast Guard personnel inspect the operating condition of this equipment.

When we visited Boston Harbor in the spring of 1977, before the Navigational Safety Regulations became effective, the Coast Guard inspection did "not include the operating condition of ship control equipment such as steering engines, propulsion machinery, and electronic devices." (GAO report p. 6–35.)

When we visited the Port of Houston in June 1977, we were shown a checklist being uesd in anticipation of the new regulations. This checklist was merely a certification by the ship captain that the required equipment was aboard and that the mandatory tests had been run. The checklist put into use in Boston instructed the Coast Guard inspecting officer to see that the required tests has been duly noted in the ship's log. Neither the Boston nor the Houston checklist ensured that the Coast Guard itself had inspected the operating condition of the equipment.

We are gratified to learn that the Captain of the Port of Boston has recently promulgated an operational plan which incorporates some of our recommendations. The "LNG-LPG Operation/Emergency Plan for the Port of Boston", promulgated September 7, 1978, indicates that, in the Port of Boston, the Coast Guard now inspects the operations of the engine room, tests the rudder, and performs a "navigation safety exam" on all *foreign* LEG ships. We note that this plan covers only Boston. We recommend that similar regulations be issued for all LNG and LPG ships entering U.S. waters.

II. On p. 6–31 of the GAO report we state that "the Coast Guard has no mandatory training program in LEG hazards except that included in the Marine Safety Basic Indoctrination Course required for officers and warrant officers." Captain Hein, in response to a question from Senator Durkin about special training, referred to this course, and also to "a one week LNG course there (Yorktown), which most of them have attended, and several have taught at it."

GAO's statement is correct as it stands. We discussed this with Captain Hein, who agreed with us that the LNG course is not mandatory. Furthermore, this course deals only with LNG, and does not include LPG.

III. Senator Durkin requested GAO's comments on the security provisions of the Coast Guard's Advance Notice of Proposed Rulemaking for LNG Facilities (CGD–78–038). They are as follows.

1. GENERAL COMMENTS

The proposed rules provide minimal security system requirements. The only absolute requirement involves the provision of a chain-link security fence enclosing the facility (126.2610 (b)). With this exception, security systems standards and approval authority are at the discretion of each Captain of the Port (COPT).

In summary, the proposed rules would rquire that LNG facility operators provide:

a. A security system with controlled access, acceptable to the COTP;

b. A chain-link fence enclosing the facility;

c. Adequate security personnel physically capable of performing guard duty with appropriate training in the purpose, layout, hazards, and vulnerable portions of the facility;

d. Basic instruction in security procedures for operator and supervisor level employees;

e. Advanced security instructions for supervisor level employees;

f. Procedures for security in an operations manual.

These proposed provisions are too general and are subject to varied interpretation by individual operators and COTPs. This could result in the implementation of disparate security standards at the various facilities. The ANPRM contains no references to existing security standards, nor are there industry-wide standards for the security of LNG facilities. This contrasts with paragraph 126.2050 of the proposed rules, which incorporates 18 NFPA standards or codes for fire prevention/protection systems.

Recommendation

LNG facility security standards which provide guidance and specifications should be promulgated for the following areas as a minimum:

a. Physical protection system design, selection, installation, inspection, and maintenance;

b. Standards and test criteria for system performance;

c. Levels of security required for various facilities by type, size, key components, status, and plant operation;

d. Selection and screening of personnel;

e. Training and qualification standards; and

f. Definition of terms as applicable to physical security.

As a first step to the introduction of industry-wide standards, the documentation of technology applicable to physical security would provide a basis for determining achievable levels of security and practicable requirements. The DOE Nuclear Safeguards Technology Handbook of December 1977 (HCP/D 6540–01) is representative of the type of publication required.

2. COMMENTS ON AND RECOMMENDATIONS FOR SPECIFIC SECTIONS

126.2031 Alternative.—The fact that authorizing approval of alternative procedures, methods, and equipment standards is set at the COTP level can result in varying levels of performance standards between facilities. Although terminal facility design or ship types might make certain procedures and methods unique for specific locations, equipment standards should be uniform throughout the LNG industry. Alternatives and compliance exemption (126.2035) should be approved by the Commandant with COTP and District Commander input. This would ensure consistent assessment of the need for deviation from published regulations.

126.2036 Appeals.—The above comments also apply to appeals. Procedures for requesting deviation from published regulations should provide for a single point of final resolution. This would ensure equivalent consideration for all parties and consistent implementation of the rules.

126.2050 Reference specifications, standards and codes.—Add to subparagraph (b): . . . . not susceptible to routine vessel movement "and adjacent industrial activities. Location should also preclude easy access by unauthorized persons and allow continuous surveillance."

126.2214 Piers and wharves.—Consideration should also be given to security fencing and continuous surveillance of pier area and access points.

126.2217 Quality assurance.—Under subparagraph (b) add: "(7) physical security systems."

126.2220 Electrical power systems.—Emergency lighting should be provided for continued surveillance of facility perimeter, pier installation, and key components of plant.

126.2222 Communication systems.—Add provision that the independent emergency communications system for security force should be able to reach local law enforcement officials.

126.2310 Detection systems.—This should include sensor requirements for surveillance and detection of unauthorized intruders.

126.2410 Maintenance, repair and retests.

126. 2420 Maintenance requirements.

126.2430 Inspection requirements.

126.2440 Testing and calibration.

126.2460 Repairs.

Requirements applicable to installed security systems should be included in all of the above sections.

126.2610 LNG facility security.—The following comments are in addition to the general comments.

Subparagraph (a).—Security standards should be promulgated by these rules, not left to the discretion of individual operators as acceptable to the COTP.

The security system should immediately detect unauthorized entry. Installed devices should include peripheral lighting of fenced area; a fence protection system to detect cutting or crossing of the fence; and low light TV cameras which can view the entire fence boundary, the pier area, and vulnerable plant components. The installation should provide 24-hour surveillance.

Subparagraph (c).—Security force should also be aware of the potential threat and receive training in recognition of hazardous devices, special safety precautions, preventive measures, and incident response.

126.2710 Emergency response personnel.—During periods of plant operations and process plant shutdown with LNG in storage tanks, the emergency response personnel requirements should be in addition to the security force. Provision should be made for liaison and coordinated response with local law enforcement agents to incidents involving sabotage or malicious action.

126.2712 Personnel requirements.—Add: "(d) Selection and screening requirements."

126.2722 Training requirements.—This section should incorporate references to or include documentation which outlines training in security procedures and sets forth requirements for basic instruction and advanced instruction. These requirements should be part of plant Security Manual (see 126.2821 below).

126.2821 Operations manual.—Security procedures should either be contained in a separate manual or as an appendix to the operations manual. Certain procedures and security installation plans and capabilities should be closely held and made known only to security personnel as required for the performance of assigned duties.

126.2822 Emergency manual.—This should include procedures for responding to bombing incidents and sabotage threats, i.e. facility search evacuation, protection of off-site lives and property, etc.

126.2842 Motor vehicles.—This section should include authorizations and procedures for vehicle inspection and driver/passenger identification before vehicle enters facility.

126.2851 Transfer operations: prior to transfer.—Add: "(11) Security procedures and stationing of patrol craft (USCG) and security force."

126.2852 Declaration of inspection.—Add security force requirements for:

(a) Waterfront

(b) Pier and Plant Area

(c) Perimeter, gates, access roads, etc.

(d) USCG and local law enforcement agency assistance.

126.2853 Requirements for LNG transfer.—Add requirement for waterfront patrol and delineate security force responsibilities.

126.2907 Tests.—Include tests performed on security system.

126.2908 Personnel Records.—Subject to a determination of legal implications and employee rights, operators should maintain files of results of individual screening and processing prior to employment.

3. THE NEED FOR INTERIM STANDARDS

The rules as currently proposed do not provide adequate standards for the security of LNG facilities or the transportation, handling, and storage of LNG associated with plant operations. The lack of specificity in the proposed requirements will result in a piecemeal approach to the implementation of security procedures with the possibility of disparate standards between the various LNG facilities.

Because several facilities are currently in operation, it is essential that minimum standards for security be implemented in the shortest possible time. Towards this end, we recommend that security requirements be phased. This would allow for the establishment of interim standards which are achievable with off-the-shelf systems. The interim standards should be upgraded as determined by a comprehensive analysis of security requirements and the development of performance objectives and criteria for security programs and systems.

As a minimum, Phase I should specify responsibilities and authority, and promulgate specific standards, for:

a. Fencing, lighting, communications, and surveillance;

b. Security force manning levels and personnel selection, training, and qualifications;

c. Contingency plans and emergency incident response procedures;

d. Security plans and procedures; and

e. Phase I program implementation.

Senator DURKIN. Thank you.

Mr. CANFIELD. The Coast Guard inspects all LNG ships before they enter U.S. harbors. These inspections do not include the operating conditions of control equipment such as steering engines, propulsion machinery, and electronic devices.

In February 1976, the Coast Guard issued "Liquefied Natural Gas—Views and Practices, Policy and Safety." The publication offers valuable guidance, but its procedures are not mandatory. Its implementation is left to the discretion of each captain of the port. It is the captain of the port who decides whether malfunctions in ships' safety system are serious enough to bar their entry into a U.S. harbor. There are no specific Coast Guard guidelines covering LPG.

While LEG trucks carry only 40 cubic meters, far less than LEG ships, they move routinely through major metropolitan areas, where a relatively small spill can have very serious consequences.

LNG truck trailers have a higher center of gravity than most tank trucks, which makes them particularly susceptible to rolling over. However, they have inner and outer tanks with insulation in between and thus are quite resistant to puncture and cargo loss. LPG trucks also have a high center of gravity, although lower than LNG trucks; but they are single-walled and pressurized, and are therefore more vulnerable than LNG trucks to cracks and punctures and more likely to explode in fires.

We confirmed through discussions with LNG transport companies at least 12 LNG trailer accidents. Two of the accidents, which led to LNG spills, pointed out two vulnerable areas on LNG truck tanks—the unprotected portion of the trailer face, and the rear piping.

There have been many LPG truck accidents, some with severe consequences. For example, a 1975 LPG truck accident near Eagle Pass, Tex., caused explosions which killed 16 people and injured 45.

If an LEG truck fell off of an urban elevated highway, it would probably split open on the street below. LEG and its vapors could then flow down into sewers, subways, and basements. Because of its low boiling point, LEG would quickly vaporize, generating a pressure which would spread the invisible, odorless, explosive gas. The 40 cubic meters of LNG in one truck, vaporized and mixed with air in flam-

mable proportions, are enough to fill more than 110 miles of a 6-foot-diameter sewerline, or 15 miles of a 16-foot-diameter subway system. Other types of large trucks have fallen off urban elevated highways.

DOT has no special inspection program for LEG trucks. For all U.S. trucking, there are only 128 inspectors to monitor 160,000 licensed carriers and 3 million commercial vehicles.

The ICC issues special certificates for LNG transport, but LNG can also be hauled under ICC certificates for the bulk transportation of petroleum products or liquid chemicals. An ICC certified company can hire leased operators to operate under its certificate. This means that LNG may be trucked by companies which have not had to prove their competence to ICC. ICC certificates do not restrict truck routes.

LEG trucks could be easily hijacked or sabotaged. A truck might be hijacked for extortion or for malicious use of the cargo. Trucks that routinely operate over established routes are easy targets for saboteurs. LEG trucks are particularly dangerous, because they allow the easy capture, delivery, and release of a large amount of explosive material any place the terrorist chooses.

As to LPG railcars, 10 percent of America's 1.7 million railroad freight cars are hazardous materials tank cars. About 16,000 of these, each with approximately 115 cubic meters capacity, carry LPG. LNG is not transported by rail.

LPG cars are involved in many of the 10,000 railroad accidents that occur in this country each year. There are often more than 10 consecutive LPG cars on a train, as you saw in the film. If vapors from one LPG car ignite, the fire may cause a second, unpunctured car to rupture in a "boiling liquid expanding vapor explosion" or BLEVE, as you saw in the film. Each fire and explosion contributes to the heating and weakening of neighboring cars and makes additional explosions more likely.

The latest LPG railroad catastrophe occurred in February 1978, in Waverly, Tenn. An LPG car exploded 2 days after a derailment, apparently as a result of internal damage during the accident and a rise in the atmospheric temperature. Fifteen were killed and over 40 injured.

LPG railcars travel through densely populated areas of cities, even cities which prohibit LPG storage. An LEG rail car or truck accident in densely populated areas could cause far greater damage.

The DOT believes that their proposed new regulations for tank car construction are sufficient for their safe operation. We believe that restriction of routes is also necessary.

LPG tank cars are as vulnerable to sabotage as LPG trucks. The tanks can be breached with readily available weapons and explosives, and the cars can be derailed at predetermined times and places. The fact that they must stay on the tracks, however, greatly limits the possibility of hijacking and the places they can be taken.

Our major conclusions and recommendations on LEG transportation are as follows:

LNG ships are probably the least vulnerable of all the systems involved in LNG storage and transportation. Single hull LPG and naphtha ships are more vulnerable than LNG ships in the event of an accident or sabotage. No plans or equipment exist to cope with a major LEG spill. If the Coast Guard is to effectively supervise the increasing number of LEG cargo transfer operations, it will need more money and manpower, revised regulations, and new plans and policies.

LEG trucks and railcars moving through densely populated areas pose a serious threat to public safety. The dangers present in trucking LEG are far greater than those involved in trucking less volatile petroleum products as fuel oil, naphtha, and gasoline. Both LEG trucks and LPG railcars are vulnerable to accidents and sabotage. An LEG spill in a densely populated area could lead to a catastrophe.

Therefore we recommend that the Secretary of Transportation and the ICC: Prohibit trucking of LEG through densely populated areas and any areas that have features that increase the vulnerability to a major LEG spill, for example sewer systems, tunnel openings, subways—unless delivery is otherwise impossible. The DOT should also give particular attention to avoiding routes with highway configurations which make tank rupture accidents likely—for example, elevated roadways, overpasses, high speed traffic, roadside abutments.

Senator DURKIN. That would include the Southeast Expressway. Much of it is elevated, I believe.

Mr. CANFIELD. It would qualify, yes.

Prohibit the travel of LPG railcars through densely populated areas unless it is impossible to deliver the LPG otherwise.

Let me turn now to liability and compensation, which is something that is often overlooked.

A major LEG accident could cause damage of such severity that injured parties could not be fully compensated under existing arrangements. Present corporate structures and legal limits on liability offer great protection to the parent corporations. This may diminish their incentives for safety. At present, no Federal agency addresses the question of offsite liability for LEG accidents.

Each LNG ship is usually owned or leased by a separately incorporated subsidiary of a parent firm, and the LNG is stored in terminals owned by other subsidiaries. In many cases, the parent firms are wholly-owned subsidiaries of still larger firms.

Most of the assets in the system are protected by these corporate chains, and the top corporations, which derive all of the profits, would generally not be liable for the consequences of an accident. The front line companies, which are most vulnerable to liability claims, are usually the most thinly capitalized in the chain. Most of their assets may be the ship or terminal itself, which is unlikely to survive an accident that does extensive offsite damage.

The liability of shipowners and bareboat ship charterers is limited by U.S. statute to the post-accident value of the vessel, plus any amounts owing for freight, if they can prove that they did not know about the causes of the accident.

Claimants after a major LNG accident would face long, complex, and expensive litigation involving potential complications at every step in the legal process. If the defendant corporation is foreign-owned, it and its assets may be out of reach. In fact, it may be impossible to serve legal papers on the corporation unless it maintains an agent in the United States.

It is not always possible to prove the primary cause of a major accident, since critical evidence may be destroyed by the accident itself. If the accident results from sabotage or natural forces, the company may not be liable at all.

Present and planned liability coverage for LNG import terminals ranges from $50 million to $190 million per incident. Ten States re-

quire proof of liability insurance for LPG facilities, but the maximum required is only $100,000 per incident.

The present liability and compensation system is not equitable and does not provide sufficient incentives for safety. We believe that the corporate owners who profit from LEG operations should bear liability for a major accident.

The banks and insurance companies which finance LEG ships and terminals insist that all companies in the corporate chain cosign notes. This insures that, in the event of a catastrophic accident, the lending institutions will be protected by the assets of the whole corporate chain. Public safety deserves no less protection.

We recommend that the Congress enact legislation which would:

Require corporations transporting, storing or using significant amounts of flammable materials to (1) carry the maximum liability insurance available from the private sector, and (2) contribute money to a Federal hazardous materials compensation fund.

Provide that the United States be subrogated to the rights of injured persons compensated by the fund so that the Attorney General of the United States can sue companies or persons responsible for an LEG incident to recover whatever monies the fund has paid out.

Allow injured parties to sue all companies in the corporate chain for all damages beyond those covered by insurance and the fund.

We also recommend that the Congress: Enact legislation which requires that strict liability be applied in all accidents involving LNG and LPG, and consider requiring that strict liability be applied to other highly hazardous materials. And also, amend the 1851 act, 46 United States Code, 183, which limits the liability of owners and bareboat charterers of ships and barges by substantially raising the statutory limit for vessels carrying hazardous materials.

We recommend that the Secretary of Energy and the Federal Energy Regulatory Commission:

Insure that adequate compensation for offsite damage will be available to injured parties before permitting LNG projects to proceed, and,

Use their authority to require that importers and LNG tanker companies maintain agents for the receipt of legal documents in all States in which they operate.

The limited research that has been carried out on LEG spills and LEG vapor cloud behavior does not provide a sound basis for assessing LEG hazards.

LEG risk assessment studies have not reached a stage where their conclusions can be relied on. Until they do, regulators will have to attempt to make timely, prudent, siting and other critical judgments with the realization that many important safety questions cannot yet be answered with confidence.

DOE's currently planned LNG safety research program will not provide answers soon enough. We believe that an effective safety research program, focusing on those issues most important to decisionmakers, can be carried out within 2 years for less than one-fifth of the $50 million DOE is planning to spend on long-term LNG research. We have made detailed suggestions for such a program in our report.

Present Federal efforts to regulate LEG and naphtha do not adequately protect public health and safety. We believe that most Federal regulatory responsibilities for energy health and safety should be consolidated into a single, independent agency. This was one of the options for congressional consideration provided in GAO's 1977 report

entitled "Energy Policy Decisionmaking, Organization, and National Energy Goals."

With a mandate to adequately protect the public health and safety, such an agency could assemble a technical staff capable of developing appropriate regulations and inspecting and enforcing the implementation of those regulations.

We recommend that the Congress:

Consider creating an Energy Health and Safety Regulatory Agency. The new agency could include the NRCS; the pipeline safety aspects of fuel transportation on land, now handled by DOT; and safety aspects of importing energy, now handled by DOE, plus all safety responsibilities formerly carried out by the Federal Power Commission.

Consider including within the Energy Health and Safety Regulatory Agency the safety regulation of LEG carried by truck and train. DOT would continue to be responsible for all safety regulation of motor carriers and railroads, except those transporting nuclear materials and LEG. The EPA should retain the responsibility for setting air and water quality standards impacting on energy development use, and waste disposal.

Consider making the Energy Health and Safety Regulatory Agency completely independent of DOE, or including it within DOE with strong statutory provisions to insure its independence.

That concludes my testimony, Mr. Chairman. I would be happy to answer any questions on it. My colleagues and I are available to answer any questions the committee may have.

Senator DURKIN. Thank you, Mr. Canfield, for an excellent statement and an excellent report. I would like to commend the GAO for the excellent work you have done, not just in this area, but specifically in this area today.

I gather the bottom line is that until we have one agency with the legislative authority and responsibility, we are not going to begin to solve the very real problems we have.

Mr. CANFIELD. I would say that with one agency you could solve those problems much more quickly, but I would say—and as you go through the report you will see—that even though we have a collection of agencies involved in this now, there is not a single one of those which couldn't be doing more; and even if we didn't consolidate them all in one agency, I think we could do much, much more in solving the problem. It would be a lot easier if we had one place we could go to solve the problem, and I think that is a major bottom line. But there is much we can do in the meantime and we ought to get about doing it with the existing agencies that we have.

Senator DURKIN. In other words what you are saying is that as desirable as one agency would be, that each one of the existing agencies today could be doing substantially more than they are doing.

Mr. CANFIELD. Absolutely. There is no question. As we went through agency after agency, we found each one of them was deficient in implementing regulations. They had ordered proposed rulemaking out and many of the regulations were not mandatory. There were various stages of array and disarray in how they handled the problem. We were less concerned with whether or not there was too much duplication and overlap, than with the agencies' tendency to point at each other and say, "It's his responsibility, not mine."

Dr. Rosenbaum may want to elaborate on that, but I think there are many things that existing agencies can do. There is additional legislation required, but much can be done now.

Dr. ROSENBAUM. One example of that, Senator, is that from the beginning a certain amount of overlapping responsibility between the Coast Guard and the Office of Pipeline Safety Operations was recognized. Although they are both in the DOT, it took them more than 3 years to finally come to a memorandum of understanding delineating the responsibilities between them. That memorandum of understanding consists of two pages, one page of which is boilerplate.

I think a lot could be cleared up even within the present structure, and it shouldn't take so long to do simple things.

Senator DURKIN. For the record I would appreciate your comments on the American Gas Association's critique of your recent study which was outlined this morning.

Mr. CANFIELD. We would be pleased to do that.

Senator DURKIN. And also for the record, the Office of Technology Assessment questions the safety of marine transportation of LEG, and I would like to receive your analysis of their review for the record.

Dr. ROSENBAUM. They did a good deal more limited job than what we did, and under instructions from a congressional committee, they did in a much shorter amount of time. It is not so much that we thought that LNG ships didn't present a number of safety problems. It is that we felt that the other parts of the LNG system, which hadn't been looked at as much, presented even greater ones. I would be glad to provide that for the record, but I don't think we have any very substantial disagreements with the OTA studies.

[The following information was subsequently received for the record:]

GAO ASSESSMENT OF "AGA COMMENTS ON GAO'S STUDY RELATING TO SAFETY AND SITING OF LNG"

We note that although the (appended) AGA comments were issued on July 31, 1978, the same day the Liquefied Energy Gases Safety report was released, they are based on a GAO draft which was circulated for review on January 13, 1978. We have not repeated the AGA comments in full, but have referred to them by the number and title AGA has given them. (In our quotes from the AGA comments we have corrected any typographical errors and misquotes.)

1. *Non-urban siting.*—The AGA comment cites the existence of ". . . very detailed and extensive safety design siting requirements which will confine an accidental liquid spill of LNG within the property lines of the facility." As we show in Chapter 5 of the report, dikes constructed to National Fire Protection Association (NFPA) safety criteria generally cannot contain the surge of liquid from a massive rupture or collapse of a tank wall. At most facilities more than half of the fluid in the tank could escape. Three-dimensional experiments conducted by GAO, which were finished too late for inclusion in the report, show that even a relatively small hole in the bottom of a tank wall could cause most of the fluid in the tank to go over the dike. They also show that the report's calculations of dike overflow from a ruptured or collapsed tank wall (up to 64 percent of the fluid contained in the tank) were conservative. The new experiments show that even more can go over the dike.

In addition, even a hole punched roughly halfway up a tank wall could cause a great deal of fluid to go over the dike. At the facilities cited in the report as much as 46 percent of the total fluid contained in the tank could go over the dike from a frictionless hole. Although the amount of friction in a real hole is impossible to calculate, and depends greatly on the details of the hole, friction would reduce the actual amount of dike overflow from spigot flow.

The AGA comments also cite the present review mechanisms in FERC, ERA, and the Department of Transportation as assuring public safety even for urban sites. Our report is critical of the performance of government regulatory agen-

cies in adequately protecting public safety and documents the basis for our criticisms. We conclude, for example, that the Federal Power Commission's system for approving LNG projects was clearly inadequate to protect the public. The Federal Power Commission's responsibility and staff have been transferred to the FERC, ERA, and elsewhere in the Department of Energy.

Our broad concern, however, is that LEG tanks containing enormous amounts of energy are built to the lowest common construction standards—the Uniform Building Code. If the fluid in these tanks were to be suddenly released, a catastrophe could follow. The AGA suggests that "Uniform Federal siting criteria for LNG facilities would either prove so broad as to be meaningless for a specific site, or so restrictive as to prevent siting almost anywhere." We believe that prohibiting the construction or expansion in size or in use of large LEG storage facilities except in remote areas is both meaningful and unlikely to substantially affect the growth of the industry. Most new large import facilities are being proposed for remote areas.

2. *Storage.*—The first paragraph of AGA's "Facts" on this section repeats statements that are in the GAO report. Nothing in that paragraph contradicts anything in the report. The result of having a standard which is based on the largest earthquake, wind, or flood experienced in the last 100 years in the area where a tank is located (the one the AGA mentioned) is that if 100 such tanks operate for 50 years, then there is a 50/50 chance that during the lifetime of the tanks there will be at least 150 times when this design level of phenomena will be exceeded at some tank. There is virtually a 100 percent chance that this level of phenomena will occur more than 100 times.

We found that some of the very large tanks in big cities have very small safety margins above the Uniform Building Code. Tanks with such small safety margins may present a serious danger. It is, of course, true that any particular tank is unlikely to be exposed to natural phenomena greater than it is required to withstand in any particular year. Nevertheless, the implications for the country as a whole of having many large tanks, over a long period of time, in densely populated areas are quite strong. It is also true, as our report makes clear, that even when tanks are impacted by natural phenomena beyond those they are designed to withstand they will not necessarily fail.

It makes little sense to us that nuclear power plants, which are never built in densely populated areas, should have to withstand the largest natural phenomena that can occur in 100,000 or even 10,000,000 years and yet to demand such low standards of urban LEG tanks.

The second paragraph in AGA's "Facts" deals with an effect which is not discussed in the report but which was included in the initial draft. It is unlikely to occur and its initial inclusion was due to a misunderstanding between technical experts and editors. The mistake had been noticed and deleted by GAO before any comments were received on our draft.

3. *Sabotage.*—The AGA says that "GAO's study is obsessed with the concept of sabotage." The vulnerability of LEG storage facilities and transportation systems to sabotage is considered seriously in our study. We believe it would be irresponsible to deal superficially with this issue. Sabotage is dealt with at length, however, in only 1 chapter out of 21 and 1 appendix out of 31 in the report. This does not seem to us to indicate an "obsession".

It is impossible to evaluate the AGA's claim that "The threat of sabotage LNG facilities, trucks, and ships is no different than the threat to a number of other major energy and general public facilities located throughout the continental United States." The threat depends on a number of indeterminable factors including decisions by unknown terrorists which may be made some time in the future. Another AGA statement, however—that "Gasoline, ammonia, chlorine, phenol, and LPG storage facilities, and associated trucks, carriers and tanks represent substantially no different risks of sabotage than LNG"—makes no sense. The AGA list does include enormously dangerous chemicals, such as chlorine, but these are not stored in large quantities in cities. The list also includes much less dangerous chemicals. The reason that gasoline, for example, is much less dangerous than LEG is discussed in the report. Unlike LEG, gasoline is a liquid at normal temperatures and pressures. Since liquids only interface with oxygen at their surface, a liquid can burn only at its surface. A vapor, however, can be thoroughly mixed with oxygen in the air and thus can release its energy very rapidly. LEG is a vapor at normal temperatures and pressures. This is what makes an LEG spill so much more dangerous than a spill of a similar amount of gasoline.

We do not see any basis on which we or anyone else can profitably speculate that, as the AGA says, "LNG is less attractive to a potential saboteur than gasoline or any of the other energy forms." The "attractiveness" of various types of sabotage to any of the many terrorist groups or other potential saboteurs in the

world is impossible to determine. The explosiveness of LNG vapor (which is simply natural gas) is well known and is demonstrated by many explosions of buildings each year. What is more, recent tests conducted by the Navy at China Lake show that typical LNG vapors can be detonated with quite small primers in the open air.

The AGA charges that "The GAO report irresponsibly provides potential saboteurs with a how-to-do-it handbook on LNG sabotage, which is absolutely counter to the public interest and safety." We have been careful not to do this. We believe that a reading of our report will show that we have not done it.

4. *Containment dikes.*—Contrary to the AGA comments, the GAO report does not suggest that a "properly designed" concrete dike would be any less effective for containment than an earthen dike. Our discussion deals with high concrete dikes that are designed to the same building code standards as the tanks they surround. While this level of design does not mean that a failure of a tank necessarily means a failure of the dike it certainly suggests this possibility. It might be, for example, that the dike would fail before the tank. It would be necessary to look at a particular situation to determine whether the tank or dike would fail first. (We did look in detail at the design of one high concrete dike in our report.)

There is no evidence whatsoever to justify the AGA's assertion that the perlite insulation between the walls of an LNG tank (there is no such insulation in an LPG tank) would ". . . absorb leaks from the inner wall." It might very well be swept aside by the force of the flow. In the event of any collapse of the tank wall or a large hole in the wall, the insulation is unlikely to play a major role in stopping the rush of the fluid.

5. *Effects of spillage.*—We are not sure what the AGA means when it says that "The likelihood of a large spill of LNG is exceedingly small." They have presented no evidence that it is exceedingly small, and we know of no such defendable argument. They claim that "There is no factual documentation given in GAO's conclusion as to how such a large spillage could reasonably occur." The report is full of such factual documentation.

It is true that significant advances in cold temperature metallurgy for cryogenic fuels have been made since 1944, but none of the studies made of the Cleveland disaster at that time concluded that it was caused by inadequate metallurgy. The assurances of safety given by the industry at the time, however, are very similar to those given today.

The AGA says that "GAO's lumping of LNG along with LPG, butane, etc. as LEG with regard to hazards is misleading because, of these fuels, LNG is the least volatile." In fact, LNG is the most volatile. Volatility is a measure of how easy it is to evaporate something.

The AGA also makes the point that (since 1944) ". . . the only other accident that has occurred in an LNG site in the United States is the incident on Staten Island in 1973. . . ." This statement should be qualified. It is the only such accident which has caused deaths. The fact is that the LNG safety record has been less than perfect since Cleveland. Although no other catastrophes have occurred, accidents—including uncontrolled spills of material—have happened at LNG storage facilities around the world and from ships and trucks. These accidents, including the one on Staten Island, demonstrate the uncertainties involved in the large-scale use of new technology. For example, according to the New York City Fire Department, the Staten Island tank was closed for repairs because the lining had developed holes and LNG was leaking into the insulation. The insulation, which was stamped nonflammable, nevertheless caught fire. Since it was polyurethane foam, it released hydrogen cyanide fumes. According to the coroner's report, all 40 workmen died of asphyxiation before the roof fell into the tank. It was a failure of technology which caused the leak into the insulation, and thus caused the tank to be removed from service and repaired. The possibility of such unanticipated technological failures makes it unwise to permit large-scale transportation or storage of these highly dangerous materials in densely populated areas.

6. *Insurance.*—Our report concludes that "A major LEG accident could cause damage of such severity that injured parties could not be fully compensated under existing arrangements." The AGA's comments do not seem to contradict this statement but rather claim that a severe accident is not "credible." Thus, they should have no objection to our suggestion that injured parties be able to sue up the corporate chain regardless of corporate veils and that strict liability be applied to major LEG accidents. Surely companies which routinely take sizeable risks in the course of their business should not object to assuming a risk which they consider not to be credible.

7. *Research.*—The AGA quotes our study as saying that "LEG risk assessment studies have not reached the stage where they give confidence in their conclusions. Therefore, safety decisions cannot logically be based on them." The discussion that follows does not seem to contradict the statement directly. We have supported it in great detail throughout the report. In Chapter 12, in particular, we discuss one of the more recent and perhaps the most elaborate such study. We show specifically why some of the critical conclusions reached in that study are not justified.

Some types of risks, such as sabotage, cannot be included in such numerical studies at all. There is no way to assign a "probability" to the possibility that someone might attempt to sabotage a particular installation. Nevertheless, if such sabotage is carried out the results may produce a grave threat to the surrounding community. However, it is possible to examine the vulnerability of facilities to both natural phenomena and sabotage. Our study does this.

The AGA discussion mentions the research that has been carried on by the government. We have reviewed this research extensively in the report. Because present plans are to concentrate such research in the Department of Energy, we reviewed their future program in some detail. We consider it highly inadequate for the reasons given in the report.

Referring to safety techniques developed by government and private industry, the AGA says: "These safety techniques have been incorporated in the standards and codes promulgated by such authoritative parties as the NFPA 59A Committee. The LNG industry strictly adheres to those standards, and it can be expected that the results from future research will be similarly applied." The NFPA 59A standards for dikes are reviewed in our chapter on dike overflow. These standards are inadequate to contain either the surging flow from a tank wall rupture or "spigot flow" from a high hole in a tank wall.

We met with the man who was the director of the NFPA 59A Committee at the time it drew up the regulation intended to prevent spigot flow over the dike. He told us that the inadequacy of the current regulation was due to a mistake in calculations by the member of the committee charged with looking into spigot overflows. Such industry committees are generally known as "consensus committees." The consensus standards which they promulgate are necessarily those to which the institutions from which the members are drawn will consent. Such standards cannot always be expected to protect the public interest.

8. *The Federal Power Commission.*—The AGA report quotes our statement that "The Federal Power Commission system for approving LNG projects was clearly inadequate to protect the public health and safety." Deficiencies in the Federal Power Commission's handling of LNG safety issues are discussed in Chapter 18 of the report. None of the comments by AGA contradict the material in that chapter.

9. *Federal, state, and local regulations.*—The AGA states that "While GAO has implied that the NFPA codes may not be adequate, it has provided no factual information to support such implication." In Chapter 5 of our report "Flow Over Containment Dikes" we have shown in detail why the NFPA codes for dikes are not adequate. This chapter is backed up with an original theoretical treatment by one of the world leaders in this field, and a commuter code written especially for GAO. Detailed experiments (done at MIT) validated the commuter code and the theory.

Response to Summary of Comments by Distrigas of Massachusetts Corporation on the GAO Liquefied Energy Gases Safety Report

General criticisms in Distrigas comments

Distrigas focuses its opening comments on how GAO did the study and wrote the report. In this regard some points we made in the introduction to the report (Chapter 1) and in Chapter 21 (GAO Treatment of Agency and Company Comments) bears repeating. No one at GAO had any preconceived notion about LNG before the study was begun. We demanded of everyone working on the project, whether as a GAO employee or a consultant or a contractor, that they be both expert in their field and have no stake in the answer. We demanded not only that the participants have no financial stake in the answer but that they have no intellectual stake as well. Thus, with two exceptions, we used no one on the project who had taken a previous position on any of the issues. The two exceptions were Professor Reid of MIT, whose laboratory has heavy industry

sponsorship and who has publicly written his views on the subject, and Arthur D. Little, who won a competitive contract to look at Federal, state, and local regulations and who had previously done work for the industry.

We spent most of our time during the fact-gathering stage of the project talking to industry people and visiting their installations. During each such visit we gave them a thorough briefing on the questions we would be examining and asked them to go into the questions themselves so that they would be able to make substantive technical criticisms if any were warranted. We spent very little time talking to opponents of LNG or LPG.

Distrigas comments that "Industry participation in its drafting was minuscule despite industry protests and offers to participate." Even before drafts were sent out for comment we convened a special group of eminent people with different points of view and asked them to read the report privately and give us their comments. The report was sent to eight such people. Seven of them read the report and gave us their comments. The suggestions were very helpful, and the draft was appropriately modified. The eighth was a high executive of an LNG company. The LNG official, instead of attending the meeting and presenting his company's views, set a lawyer with the message that they had not had time to review the draft.

Distrigas says: "No justification is given for singling out LNG and subjecting it to this extraordinary treatment. Many other fuels, chemicals and volatile materials pose equal or greater hazards to the public, but the implication of this Report is that LNG is uniquely hazardous. This is wrong."

We discuss the motivation of the report on page 21–3 of Chapter 21 as follows:

"Many comments complained that we had singled out LEG for scrutiny. They named other dangerous substances which are used in much greater quantities than LEG, such as gasoline and fuel oil, and others which may be more hazardous, such as chlorine.

"There are other hazardous materials used, stored, and transported in the United States, and we do not mean to imply that LEG is the only one worthy of public attention. We chose LEG for examination because of its widespread and possibly growing use, and its storage and transportation in very large quantities in urban areas. GAO has examined the storage and transportation of other hazardous materials in the past—for example, nuclear materials—and may do similar studies in the future.

"Although LEG is very dangerous, we believe it can be used in a way that does not pose undue risk to the public. Our recommendations are pointed toward making its use adequately safe. Many of our conclusions and recommendations may be applicable to other hazardous materials."

Distrigas states: "The Report nowhere gives weight to the exemplary safety record of the LNG industry. In the modern industry's 15 years of existence, there has not been a single injury to any member of the public resulting from an accident involving an LNG tank, ship, or truck." The 1973 Staten Island disaster, which killed 40 workmen, was caused by the burning of a supposedly nonflammable insulation in an LNG tank out of service for repairs. The tank was out of service because of a failure of LNG technology. According to the report on the accident by the Fire Department of the City of New York, small holes developed in the tank liner which allowed the LNG to seep into the insulation. Gas was eventually detected outside the tank. This caused the tank to be shut down and led to the accident. The rest of this Distrigas comment is answered by the section *The LEG Safety Record* starting on page 21–4 of Volume 1 of the report.

In the same part of the comments Distrigas states that our report ". . . is against the overwhelming weight of informed scientific opinion." We disagree. The consultants who worked with us on the report were preeminent in their technical fields. We have carefully considered all comments on the report to date and as yet have not, in our view, been presented with a single substantive mistake in the report. We believe the report is correct and stands on its own.

Distrigas says that urban LNG sites are necessary to meet peak winter demands for natural gas. Two paragraphs of the comments discuss this point:

"New England, even before LNG was imported into the United States, was forced to design and construct an LNG network in urban sites to store natural gas for the peak winter demands that pipeline supplies could not meet. These tanks must remain in service at their urban sites with or without an urban import terminal.

"New England derives enormous benefit from the use of LNG as a peak shaving supply of gas. Due to the geology of the region, which precludes underground storage of natural gas, storage of natural gas as LNG has provided

desperately needed flexibility to the New England distribution system for winter use."

However, Distrigas is now planning to import additional LNG not for peak-shaving, but for baseload. According to Mr. McKenna, Vice President, Gas Supply, Boston Gas Company, in his testimony before the Senate Commerce, Science and Transportation Committee on August 21, 1978, "Surprisingly enough, the amount of natural gas coming through our pipelines has been increasing in the last couple of years and we now have an ample supply to serve the customers that would like to use clean burning natural gas." Why then would it be necessary to import baseload LNG into a terminal in the middle of Metropolitan Boston? The following exchange may make this clear.

"Senator Durkin: Are you adding customers to your system?

"Mr. McKenna: We are attempting to replace those customers that we have lost and some more customers, yes."

Distrigas ends its introduction with the following: "It is particularly disappointing that the author of this report spent one million dollars of taxpayers money and missed an opportunity to make a significant contribution to the understanding of LNG by offering an objective and balanced study." The report was a product of the General Accounting Office and cost approximately $560,000, including direct staff time. consultants' fees, contract costs, and related travel costs. We believe it is an objective and balanced study.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 3, VULNERABILITY OF STORAGE TANKS AND CONTAINMENT DIKES TO NATURAL FORCES

This section of the Distrigas comments was reviewed by Dr. John M. Stevenson, President of John M. Stevenson Associates of Cleveland, Ohio. Dr. Stevenson is an internationally recognized authority on the ability of structures to resist natural forces. He has represented the United States Government abroad on a number of occasions. The import of Dr. Stevenson's necessarily technical response (because Distrigas's comments were highly technical) is that in these matters the GAO report is entirely correct as it was published.

Our response concentrates on the following main areas:

(1) The magnitude of Safe Shutdown Earthquake loading (e.g. 0.2 g Zero Period Ground Acceleration versus 0.05 g as required by the U.B.C.—1970 Zone 2.) as compared to the earthquake load intensity considered in design.

(2) The evaluation criteria used to define failure and safety factors.

(3) Mode of failure considered in the report.

(4) Probability of Tank Failure as a Function of Earthquake Intensity.

Seismic Load Intensity

The current Tentative Provisions for the Development of Seismic Regulations for Buildings (1) classifies the Boston Area as 0.10 g seismic zone with a 10 percent chance of being exceeded in 50 years and 50 percent chance of being exceeded in approximately 475 years. No specific probability study has been done for the 0.2 g level earthquake in Boston but using the data trends presented in Reference 2 correlated with the Reference 1 probabilities it would appear that 0.2 g level earthquake would have a 50 percent change of being exceeded in approximately 5000 years. The estimates of intensity felt in Boston due to the Cape Ann earthquake of 1755 range from Modified Mercalli VII to VIII(2). Based on the mean Trifunac and Brady(3) correlation of intensity with ground acceleration this gives a range of peak zero period ground acceleration ranging from 0.12 g to 0.25 g in Boston. Therefore, the selection of 0.2 g as a Safe Shutdown Earthquake is not "much greater in magnitude than the most severe earthquake known to have taken place in New England (Cape Ann, 1755)", as stated on page 3–6 of the Distrigas comments, but may actually be less than the peak acceleration seen in Boston as a result of the 1755 earthquake.

Evaluation Criteria Used to Define Failure and Safety Factors

Distrigas is their comments, particularly on page 3–3 to 3–6, continue to disregard the fact that normal allowable stress levels as shown in page 3–25 of the report are not used in evaluation of the tanks for earthquake. Higher allowables for earthquake design are permitted by existing codes and were used in the evaluation. These higher allowables reduce the inherent safety margins to failure which are present for normal loads. For the OBE earthquake an allowable stress approximately equal to yield is used in the evaluation of the tie down straps. Please also note that under the SSE loading an allowable stress 20 percent above yield is permitted, hence some plastic distortion of the hold down straps is an-

ticipated and permitted at the SSE earthquake design level. It should also be understood that the reason the tie down straps are installed is to insure that the seal weld between the tank sides and bottom would not have to carry overturning lift off loads, a load that these welds are not designed to resist. A 50 percent elongation of a tie down strap a nominal 2.0 feet long would permit an approximate 12-inch lift-off at the edge of the tank thus negating the design intent of the tie down strap.

Mode of Failure Considered in the Report

The Distrigas comments (page 3–3) seem to take exception to the mode of failure described as dominant in the report (e.g. failure of the tie down straps which would permit lift off of the tank walls and bottom from its foundation which leads to failure of the side to bottom joint). The characteristic buckle observed in tanks damaged by earthquake is a consequence of this lift off where high compressive stresses are caused on the side opposite to the lift off. This opinion and description of the failure mode presented in the report is not unique to our report. The following is a quote from a recent paper (4) which was subject to peer review and published by the American Society of Civil Engineers.

"PAST PERFORMANCE OF STEEL RESERVOIRS

"The Alaska earthquake of 1964 caused the first large-scale damage to reservoirs of modern design. The San Fernando earthquake of 1971 produced similar damage. During an earthquake a reservoir will vibrate and be subjected to overturning moments. These moments tend to lift an unanchored shell off the foundation at one side, and cause high compressive shell stresses on the opposite side, one during each cycle of vibration. In some cases the shell will buckle under the compressive load, producing a characteristic crease usually near the reservoir bottom. This type of failure is of concern because it can lead to failure of attached piping and because the shell and the shell-to-bottom joint become vulnerable to failure. The failure of the Olive View Hospital 700,000 gallon steel reservoir during the San Fernando earthquake is a perfect example of shell buckling and failure of the shell-to-bottom joint which led to a release of the reservoir contents."

Probability of Tank Failure as a Function of Earthquake Intensity

Distrigas has characterized the report as "misleading" on the basis that ". . . the wording is . . . carefully chosen to convey the impression that there is a high likelihood for catastrophic failure" due to earthquake. Distrigas implies that there has been an effort to falsely convey to the uninformed reader "an image of imminent danger of a failure which would result in release of the liquid." The attached Table 1 has been prepared in an effort to clarify to the informed and uninformed reader alike the expected interaction between failure and earthquake probability presented in the report. The table expresses our judgment as to what interaction probability between earthquake intensity and failure might be expected. It should be understood that the actual determination of failure load for any tank, as explained in Appendix III–3 of the report, is extremely difficult and costly. For this reason the material presented in Table 1 is based on our professional judgment rather than on detailed calculation. There is no evidence that such detailed calculations have ever been done by anyone for the Distrigas tanks. Failure of Storage Tanks as defined in Chapter 3 of the report means the significant and uncontrolled leakage of LEG from its primary insulated container.

TABLE 1.—A TYPICAL RELATIONSHIP BETWEEN EARTHQUAKE INTENSITY, PROBABILITY OF EARTHQUAKE AND TANK FAILURE

Earthquake intensity peak zero period ground acceleration	Probability of tank failure for a tank just meeting UBC criteria	Probability of earthquake
UBC–0.05g	0.0001 or 1 tank in 1,000	50–percent probability of being exceeded in 100 yr.
0.075g	0.015 or 15 tanks in 1,000	50-percent probability of being exceeded in 200 yr.
0.10g	0.05 or 50 tanks in 1,000	50-percent probability of being exceeded in 500 yr; 10-percent probability of being exceeded in 50 yr.
0.15g	0.20 or 200 tanks in 1,000	50-percent probability of being exceeded in 2000 yr.
SSE–0.20g	0.50 or 500 tanks in 1,000	50-percent probability of being exceeded in 5,000 yr.

Note: For purposes of the report "failure" sould be defined when the probability of failure exceeds 0.01 or more than 1 tank in 100 would be expected to fail.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 4, CRACK-INDUCED FAILURE OF METAL LNG TANKS

The response to this section was prepared by Professor Bernard Budiansky, Gordon McKay Professor of Structural Mechanics of Harvard University. Professor Budiansky is an internationally renowned authority on these matters.

1. Distrigas: "The author of Chapter 4 envisions crack-induced catastrophic failures of LNG tanks, even though his own research has provided him with ample evidence that this is a baseless fear. By his own words (on pg. 4–1), ' . . . it is generally accepted that the . . . materials currently used for LNG tanks . . . are very resistant to crack growth under cryogenic conditions.' The author nevertheless, and without reason, mistrusts his own calculations."

GAO reply: We find these statements incomprehensible, since we cannot identify any of our calculations that we "mistrust", nor any of our "research" that provides evidence against the possibility of crack-induced failure. The whole point of Chapter 4 was to show that despite the excellent cryogenic properties of 9% Ni steel and 5083 aluminum, the introduction of sufficiently large cracks could induce catastrophic failure, and to provide estimates of the critical crack sizes. A well-designed tank will, of course, be safe in the presence of the small cracks that may be inevitable in normal service. The Distrigas comments, however, convey the unsupported implication that tank rupture is impossible no matter how large a crack is introduced.

2. Distrigas: "He (the author of Chapter 4) goes on to say, however, that he has ' . . . neglected plasticity, and . . . (its) inclusion . . . would make the calculated 'critical crack lengths' shorter . . .' This conclusion apparently is based on conjecture or guesswork. In reality, exactly the opposite is the case."

The conclusion was based on well-known principles of fracture mechanics, which we summarize briefly. Linear elastic fracture mechanics (LEFM), can be extended approximately to plasticity conditions beyond small-scale yielding by using an effective stress-intensity-factor K based on a crack length that is increased by a fraction (about ⅓) of the plastic zone size. Since K increases with increasing crack size—and much more so for cracks in cylinders than in flat plates—the critical crack length for a given critical Kc will be smaller when plasticity is taken into account than when it is neglected.

3. Distrigas: "It should be pointed out that the validity of linear elastic fracture mechanics is limited strictly and without exception to cases of 'plane strain' states of stress, and furthermore to cases in which the bounds of linear elasticity are not exceeded."

GAO reply: Neither limitation is correct. LEFM is applicable to plane stress, as well as to plane strain, with the understanding that the critical values of K used would be appropriate to the regime involved. Further, intermediate cases, in which neither plane stress nor plane strain conditions hold, can be treated approximately with the use of appropriate critical values of mixed-mode K's. Indeed, the very use of a thickness dependent Kc reflects the effect of mixed-mode conditions. Further, linear elasticity is always violated at a crack tip in a metal. The correct statement of the limitation of LEFM is that it is restricted to small-scale-yielding conditions, in which plastic zone size is small relative to the crack size. But, as mentioned above, LEFM can still be used approximately even when the small-scale yielding limitation is violated if a plastic correction is added to the effective crack size.

4. Distrigas: "Neither of these limitations is applicable in the case of welded, cylindrical LNG tanks. First, the 0.44 inch plate thickness (using the author's example in Appendix 4) is too thin for plane strain conditions; . . . "

GAO reply: Yes, the conditions are closer to plane stress than plane strain, but, as stated above, plane stress fracture-mechanics is a well-established discipline

5. Distrigas: ". . . and second, 9 percent nickel steel retains ductility at —260° F and will not propagate a clean sharp crack front without causing considerable plastic deformation in the neighborhood of the crack tip . . ."

GAO reply: Yes, there is plastic deformation at the crack tip, though not as much as Distrigas implies. In the example quoted, with an assumed $K_c = 265$ ksi $\sqrt{in}$ and a yield strength of about 100,000 psi, the plastic zone size should be no more than a few inches long—a very small fraction indeed of the 4½-foot crack length. Thus, small-scale yielding conditions very nearly prevail.

6. Distrigas: "The author himself has computed that stable crack lengths up to 4½ feet are predictable, equivalent to about 100 plate thickness."

GAO reply: We find this statement of particular concern, in view of the following very explicit warning in our report: "Moreover, the numbers we have calculated for critical crack length should not be interpreted as saying that shorter cracks will be 'safe', i.e., non-propagating. Present technical knowledge is insufficient to support such a claim in the crack-size range we are discussing.

7. Distrigas: "It can be shown easily that the internal pressure would plastically deform and bend outward the lips of any crack in such a plate, well before it had grown to these extreme dimensions."

GAO reply: The calculations of critical crack size are based on a shell theory that includes the effects of bending of the lips of the crack. Further, the reference to the crack having "grown to these extreme dimensions" seems to indicate that Distrigas has not appreciated that suddenly introduced cracks of critical size were contemplated, rather than cracks that grew to their critical state from some smaller size.

8. Distrigas: "The elastic stress field in the neighborhood of one crack tip could no longer be influenced by the tress field associated with the other. In layman's language, each crack tip 'would no longer know' that the other was there, i.e., a rapid extension of the crack in the unstable fracture mode would not be predictable, independent of the current crack length."

GAO reply: Plasticity does not preclude the interaction of the crack tip stress states with the crack length—it just alters it—and the longer the crack, the higher will be the crack tip stress intensities. To state otherwise is flatly incorrect mechanics.

9. Distrigas: "In view of realistic material mechanics ,the author's predictions of unstable cracks 'unzipping' to nearly the full height of the tank are nonsensical at best. The inherent ductility and fracture toughness characteristics of 9% nickel steel at cryogenic temperature would preclude the kind of disaster scenario that has been postulated by the GAO."

GAO reply: These final remarks were not unsupported by data, calculations, or rational explanation, and are without merit. We did not "postulate" a disaster scenario; rather, we presented engineering estimates of critical crack sizes that could be expected to lead to disaster. Distrigas offers no counter-estimates or revisions to our calculations, but simply insists, without any supporting analysis, that cracks will not propagate, no matter how long they may be.

We note that Distrigas' comments are directly contradictary to those of Columbia LNG Corporation. In reviewing a draft of this chapter, Columbia said that we had made certain simplifying assumptions and that if the calculations were done more exactly the critical crack length, which we estimated conservatively at between 4½ and 8½ feet long for cylindrical tanks, is actually only between 1 and 1½ feet for the 9 percent nickel alloy steel tanks and between 3 and 4 feet for aluminum alloy tanks.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 5, FLOW OVER CONTAINMENT DIKES

Distrigas says: "There is no credible mechanism by which . . . (metallic walls) vanish, or light clear of the liquid, or unzip instantaneously."

Because of the short critical crack length, the walls of LEG tanks may very well unzip virtually instantaneously. But such a dramatic event is not the only danger. A relatively small hole in the bottom of a tank allows nearly the same amount of fluid to go over the dike. Nor is there any necessity, as Distrigas claims in their comments, for both walls of an LNG tank to be penetrated "on exactly the same horizontal radial line" in order for spigot flow to go over the dike. Indeed, if the walls were penetrated on a downward slant from the outside to the inside, even more fluid would go over the dike. It is easy to achieve such a downward slanting hole.

The comments below were provided by Dr. Harvey P. Greenspan, Professor of Applied Mathematics at MIT and a world-renowned fluid dynamicist.

Analysis of flow over a dike shows conclusively that present impounding walls are inadequate to contain a sudden massive release of fluid from an LNG storage tank. In our first set of experiments, one wall of a rectangular tank was suddenly removed to simulate, realistically and in an exactly reproducible manner, the essential features of fluid release and overflow. (The sophisticated use of explosives could duplicate these conditions in actuality and could also produce more violent effects than those postulated if, for example, the top of the tank

were imploded downward like a piston.) In a later set of experiments, the total spillage over the dike from a relatively small hole in a cylindrical tank (which would correspond roughly to a 20′ by 20′ puncture) approximated that determined earlier from full collapse. Indeed, the emerging liquid easily vaulted the dike like water directed from a high pressure hose. The point is that whatever the mechanism of fluid release—a tilt of the tank due to earthquake, destruction due to explosion, etc.—the dike cannot contain the transient flow.

There are many uncertainties associated with spigot flow, and since considerable overflow can occur in realistic situations, all factors should be scrutinized carefully. For example, how is the puncture produced? What is the effect of an explosion, or a rocket impact on the perlite insulation? (It seems clear that two relatively thin metal walls and three feet of insulation are easily penetrated by an anti-tank missile and that the holes so made would be essentially aligned and could be approximately horizontal.) Would the perlite fuse to make a convergent channel? Does it collapse to seal the hole or would the insulation simply wash out with the emerging jet of LNG? How large a puncture is required in the latter case? Spigot flow is potentially serious and cannot be dismissed out of hand.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 10, CLEVELAND FIRE

It is true that the tank that failed in Cleveland in 1944 was built with 3.5 percent nickel steel rather than the 9 percent nickel steel, aluminum, or concrete which are used today. None of the reports that were done after the disaster, however, attributed the tank failure to insufficient cryogenic properties of the steel.

There are always large uncertainties in the large-scale introduction of new technology. The 1973 Staten Island LNG tank fire, which killed 40 people, and the recent catastrophic collapse of a large LPG tank built by Shell in Qatar are more recent examples of technology that was considered completely safe by large, reputable companies but which turned out to be extremely dangerous. The recent leakage of LNG through both walls of a large LNG tank built in Abu Dhabi by IHI, a Japanese tank construction company, is another example.

The people who planned, built, and operated the Cleveland facility were trained, experienced, and reputable. Mr. W. G. Hagan, Vice President and General Manager of the East Ohio Gas Company, told the Mayor's board, convened after the disaster, that the company felt it was building a safe plant that could be located anywhere. Extensive provisions were made at the site to contain spills. The provisions were adequate, however, only for slow leaks. Current LNG storage site dikes are also designed to contain only relatively slow leaks. Both the designer, the Pittsburgh Des Moines Steel Company, and the operator, East Ohio Gas Company, assumed that a small leak would be detected before a catastrophic collapse could occur. The same assumption is made today.

No thought was given in Cleveland to the nearby presence of other industrial facilities, residences, storm sewers, or other conduits. Little thought is given to similar neighbors in planning some facilities today.

Less than 6300 cubic meters of LNG spilled and a large part of that remained on gas company property. This is a very small amount compared to the capacity of today's facilities. The Distrigas facility can store more than 150,000 cubic meters of LNG and the adjacent Exxon facility can store up to 62,500 cubic meters of LPG.

Even though 130 people died in the Cleveland disaster, it could have been much worse. The National Fire Protection Association said the casualities could have been much higher if the explosion had taken place at a different time of day. At the time of the fire most children were in school, and most men were at work. The NFPA also said that, if the wind had been blowing in the opposite direction, a very large part of the East Side of Cleveland could have been destroyed.

The casualties in Cleveland were not due solely to thermal radiation. Streets were blown up, manhole covers hurdled into the air, water lines broken, and windows shattered. Buildings were seen to explode from the inside. The zones of thermal radiation mentioned by Distrigas are only applicable to fires from contained fluid. Once the fluid goes over the dike and down into sewers and basements, the danger becomes far greater.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 12, SAFETY RESEARCH AND DISPERSION MODELS

Our report did not say that ". . . an LNG pool fire could become a fireball." There is a great deal of disagreement among experts about whether this is possible. The statement in the report was: "It is not presently known, however, whether a very large pool of burning LNG on the water could produce a large fireball in the air".

The spills we were concerned with on land are not solely those from trucks or trains but include those from storage facilities. While many commonly transported materials such as gasoline and fuel oil are not nearly as hazardous as LEG, it is possible that other hazardous materials should be investigated. LNG vapor has the unusual property that it is heavier than air when cold and thus flows down into basements and sewers. When it eventually warms up it becomes lighter than air and thus can go up into the buildings. This can lead to violent explosions and internal fire, as happened in Cleveland.

We certainly hope that accidents with LEG and other hazardous substances remain "rare isolated events", but as the recent disasters in Spain and Mexico make clear, it is important for the government to consider the effects of such spills very carefully. The models referred to by Distrigas have to do with a contained (in a dike) pool fire and the radiation from it. In a spill which breaches containment the effects will depend heavily on the interaction of the material with the environment. Present models do not consider interaction of the escaped fluid with sewers, subways, tunnels, buildings, or other nearby storage facilities.

Like Distrigas, we are unhappy with the present Department of Energy research program, but for different reasons. These reasons are made clear in Chapter 12 of the report.

Distrigas' statement that "In fact the risks associated with LNG are not significantly effected by the variations in distance traveled by the hypothetical vapor clouds is wrong.

The most comprehensive risk studies to appear so far are the SAI (Science Applications Incorporated) studies of Los Angeles, Oxnard, and Point Conception.

The SAI study of the proposed Los Angeles LNG facility finds that the probability of a marine accident causing the rupture of a tank on a ship is rather high, approximately 1 in 10 over the 20 year lifetime of the faciilty. SAI, however, used a dispersion model in which vapor typically spreads only 1.2 miles in a flammable state. Since they claim the likely collision region is 2 to 7 miles offshore, they find the onshore risk from such spills to be small. Professor J. Havens, in his April 1, 1977, report for the Coast Guard quotes comparable estimates made by other investigators. The estimate he lists for Cabot Corporation, the owner of Distrigas, is 11.5 miles. If 11.5 miles instead of 1.2 miles is used for Los Angeles, the probability of a catastrophe becomes very large.

It is not at all clear that the penetration of flammable vapor into populated areas is limited to the first ignition source. Flame in a natural gas-air cloud typically propagates at 6–12 miles per hour. In a wind of 20 or 25 miles per hour the flame front might be carried through a city rather than burning back to the source. It is not possible from present knowledge to tell. Recent tests at China Lake also suggests that rather than burning back to the source the flame front might also stay stationary at the point where it was ignited or some other point in the city. The fire in Cleveland spread upwind in a very strong wind. The fact that there are no currently available, validated dispersion models on which one can rely to predict LEG vapor dispersion is one of the critical uncertainties in predicting the effects of an LEG vapor spill.

The usefulness of risk analyses is also limited by their inability to take into account the possibility of sabotage and the fact that so many critical factors are unknown. Among these are the dispersion of the vapor, the interaction of the spilled fluid and vapor with manmade structures, and the controlability of very large urban fires with multiple ignition points. Without these it is not possible, as Distrigas claims, to put bounds on the estimates of the likelihood of major spills and to obtain an estimate of the total risk.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 13, DETONATION AND FLAME PROPAGATION RESEARCH

Distrigas states: "Of the hydrocarbons contained in large quantities, methane is most difficult to detonate in air, even in confined spaces." A central point over-

looked in this argument is that LNG is not always pure methane. The Distrigas gas supply contracts, for example, allows LNG of 86.65% methane, the rest being higher hydrocarbons (primarily ethane and propane). Because methane evaporates more readily than the higher hydrocarbons, the methane precentage decreases further during the time LNG is transported and stored. The ethane and propane in the mixture considerably increases its ease of detonation. (See Specific Response No. 8 below.)

As noted on page 13–9 of the report, Lind at the Naval Weapons Center, China Lake, California, has recently detonated LNG vapor with 81% methane using a small charge (1.4 kg). It seems likely that a not too much larger charge could detonate the vapor from a spill at Everett.

Of all the sites we evaluated, the Distrigas site not only had the smallest safety factors for natural phenomena but also the most fluid going over the dike in the event of a rapid spill. The added possibility of the detonation of Everett LNG vapors makes the danger to Boston from the Everett facilities much greater.

The following specific responses were prepared by R&D Associates of Marina del rey, California.

Specific Responses

1. To Distrigas comments on Page 13–1, 1st para., 2nd sentence, and pages 6 and 9 of detailed comments: Flame propagation is mentioned on a number of pages instead of only on page 13–4 as stated by the Distrigas commenter. Flame propagation is involved in a non-ideal explosion as well as in a slow deflagration. It is not clear what the commenter means by the term flame propagation, but it appears that he might be referring to that associated with explosion, only. We mention transition from deflagration to detonation (explosion aspects of flame propagation) on page 13–4, 3rd paragraph; on page 13–10, 2nd, 3rd, and 4th paragraphs; on page 13–11, 1st and 2nd paragraphs; on page 13–12, 3rd paragraph; on page 13–13, last paragraph, and on page 13–27, 2nd paragraph. Experiments addressing rapid flame propagation are recommended on page 13–27. Flame propagation as applied to slow deflagrations is discussed on pages 13–15. 13–16, 13–17, and 13–18, including findings from the latest experiments with LNG spills on water.

2. To Distrigas comments on page 13–1, 1st para., 3rd and 4th sentences: Whether the chapter is helpful or threatening depends upon who the reader is. We can see that it might be threatening to the owner of an LNG facility located close to populated areas if that owner does not have quantitative answers for questions about explosion and flame questions. However, it would seem helpful to those who live near such a site or to organizations interested in performing the research required for obtaining quantitative answers to the technical questions. We agree that the review presented in the chapter is biased—biased toward safety. We agree that it is selective, since to discuss and appraise all research on explosions would be lengthy and would serve no useful purpose. We recognize that the review is not presented in the detail one would include in a scientific publication. Such detail would not serve the purpose of informing the non-technical readers to whom the report was addressed. However, we maintain that the key technical points on detonation are covered.

3. To Distrigas comments on page 13–1, 2nd and 3rd para., and portions of pages 2, 3, 4, and 5 of detailed comments: We are well aware of the importance of showing that a detonation is self-sustaining (that is, has moved beyond the influence of the initiator), and of the Chapman-Jouguet detonation conditions. The self-sustaining requirement was not discussed explicitly since it is well known. It was implied, however, in our discussion of some of the experimental data and was part of the reason for not discussing the experiments of Vanta et al. in detail. Their bags were too short to establish whether a detonation was sustained (and the 4 x 4 x 20 feet bags were also too small in the lateral dimensions). This is why Bendick used bag length up to 40 feet. (See our responses 8 and 9). Moreover, it is not necessary to measure both pressure and detonation front velocity to establish whether a Chapman-Jouguet detonation has occurred. Either will suffice, since they are directly related to each other by the Chapman-Jouguet theory. Thus, high speed photography can be used for instrumentation.

4. To Distrigas comments on pages 13–1, last para., 13–4, 2nd para., and page 7, last para. of detailed comments: We agree that a planar blast wave can produce a detonation with a smaller weight of explosive than a spherical or hemispherical wave. However, we do not agree with the conclusion that only spherical or

hemispherical waves are applicable to unconfined clouds that would result from an accidental spill. A detonation emerging from a duct or tunnel would be essentially planar on the scale of the dimensions required for initiating detonation (about three meters for methane-air mixtures) and might be essentially cylindrical for an explosive stored along the corner formed by a wall and the ground, for example. It remains for research to determine whether such potential initiators might be found near LEG facilities. Indeed, the spherical case would seem least likely to occur and the hemispherical case less likely than the planar unless high explosives are found to be compactly stored near or transported past LEG facilities.

5. To Distrigas comments on page 13–2, 1st numbered para, and page 4, 1st para. of detailed comments: The second paragraph on page 13–6 states that none of the spills ignited have resulted in detonation. The "negative" observation referred to is written in the technical sense of the word and not in the apparently emotional sense interpreted by the commenter. Indeed, we are fortunate that such clouds do not detonate from weak ignition. We note that the commenter acknowledges that a detonation occurred in the propane accident described in Reference 12 and implies that it was because propane was under pressure. He apparently is trying to say that LNG clouds will not detonate because LNG is not stored under significant pressure. First, on page 3 of his detailed comments regarding GAO's page 13–6, the commenter casts doubt as to whether a detonation occurred in the same propane accident he is using for illustration. Second, the fact that the propane was under pressure has no apparent relevance to the comparison.

6. To Distrigas comments on page 13–2, last para.: We disagree that Lind's report indicates that a stoichiometric unconfined, homogeneous methane-air mixture cannot be detonated. The abstract of the report just states that such mixtures cannot be detonated with moderate-size explosive boosters (i.e., 1.7 to 4.1 kg of explosives in spherical geometry). In fact, pages 12 and 13 of the report state that a detonation would have to exist from a confined space through an opening larger than 2.25 m in diameter in order to produce a sustained detonation in an unconfined methane-air cloud outside. This implies that a detonation can be produced by a sufficiently large opening, not that it cannot. Indeed the work of Benedick suggests that about a 3 m diameter opening would be required.

7. To Distrigas comments on page 13–3, 1st para: This comment merely restates what is already well known, except for the statement that the anti-knock rating for methane as a motor fuel is unknown. We discuss the difficulty of detonating methane in paragraph 2 of GAO's page 13–2. As to anti-knock, the French use an octane number of 130 for methane burned in engines (Annex A of a letter from E. Thornton, British Gas Corporation to Mr. D. T. King, American Gas Association, 1 August 1975). We point out that the commenter uses here the same estimate of initiation energy required to detonate methane-air relative to propane-air that he attempts to discredit on the following page of his comments.

8. To Distrigas comments on page 13–3, last two para., page 13–4, first two para., and page 1, last para., page 2, 1st and 2nd para., page 5 2nd para., page 8, 2nd para, and "Note", page 9, 1st para., and page 10, 3rd para, of detailed comments: Our use of the word "may" was meant to be that detonation might be possible or it might not be possible with initiators that might be found near an LNG site. Perhaps the word "might" would have been a better choice. The work discussed in Reference 16 is now published (See our comment 6). The commenter implies that unpublished information is not reliable. We maintain that not to use important, available information even if unpublished would be irresponsible. Benedick's work on methane (Reference 7) is still not published. However, we visited Benedick, viewed his films, and discussed his work in detail. He obtained what appears to us and him to be a detonation in the test described in Chapter 13. Three cameras were used for viewing the phenomena. One ran at 64 frames per second (fps), one at 4,500 fps, and the third at 6,700 fps. The fastest camera provided about 45 frames over the travel time of the combustion front down the 40 foot long bag. The cameras showed the average speed of the detonation front to be 1,750 m/s, only 3 percent less than the Chapman-Jouquet Theoretical value of 1,819 m/sec. This difference could easily be the result of a slight deviation from stoichiometry, or a slight error in the theoretical value. We have a copy of the three film strips.

We do not agree that Bon's theoretical calculation shows that the extrapolation of the Bull and Martin data is *highly* questionable. Unknowns in the com-

plex combustion kinetics involved render any calculation only qualitative. For example, Boni and Wilson use a two-step reaction model when up to 63 credible reactions have been identified for methane combustion (Olsen and Gardiner, Combustion and Flame *32*, 151–161 (1978)). We do not defend the extrapolation to 22 kg tetryl by Bull and Martin as being accurate for methane and neither did Bull and Martin. But we view the calculations of Boni and Wilson for methane-air as qualitative, only. Experiments are needed to provide a high confidence answer. However, except for Alaskan gas (which is almost pure methane) the energy required to detonate methane-air mixtures is almost academic in regard to safety of the LNG currently imported by the U.S. This is because the ethane and propane contained in this product considerably increases its ease of detonation. A quantitative knowledge of the energy required to detonate methane-air would serve mainly as an end-point for the curve of initiation energy versus percent ethane/propane. We do not agree that high-speed photography cannot establish whether a self-sustaining detonation was achieved. With a sufficiently long run of the combustion front in the mixture in a transparent container, photography is an excellent method for establishing whether a detonation occurred. There is a direct relationship between the front speed and the detonation pressure. If the front is moving at near the Chapman-Jouguet velocity, then the peak pressure must be near that of a Chapman-Jouguet detonation.

9. To Distrigas comments on page 13–4, last para., 13–5, first para., and page 4, third and fourth para. of detailed comments: We inadvertently left the Vanta et al. reference out of our reference list; however, we not only reviewed the report carefully, but also spoke at length with its three authors. Benedick had already shown that a bag 5.5 x 5.5 x 33 feet was marginal for supporting a sustained detonation; therefore, the 4 x 4 x 20 feet bag used by Vanta et al. would clearly be too small in lateral dimension to support a detonation. This was also corroborated by Lind's work at China Lake. The 8 x 8 x 8 feet bag used by Vanta et al. was clearly not long enough for establishing whether a sustained detonation was achieved. However, erratic detonations were reported by the authors for both size bags for near-stoiciometric mixtures. Benedick went to 8 x 8 x 40 foot long bags to obtain more conclusive answers. The commenter might have been "fooled" by the geometry but few others versed in this subject would be. Methane-air just requires a much larger initiation energy and thus larger bags than other hydrocarbons, which we, the commenter, and many others have pointed out.

10. To Distrigas comments on 13–5, second para., and page 1, second para. of detailed comments: This paragraph hardly makes a point *for* LNG safety or the safety of the Everett terminal. As shown by Bull and Martin, ethane is easier to detonate than propane, and the Everett terminal could have up to 13 percent ethane in the gas per the second paragraph of the detailed comments.

11. To Distrigas comments on page 13–5, third para.: Apparently the commenter is trying to indicate that the Vanta et al. experiments indicate no detonation can occur. We disagree. (See 9 above).

12. To Distrigas comments on page 13–5, fourth para.: When writing our input we did not have access to Boni and Wilson's paper, the one apparently referred to in the commenter's Reference A (the second and third authors named apply only to the unrevised version of the paper), although we tried to get it. To use this theoretical treatment as a basis for establishing LNG safety, however, would be quite irresponsible, in our view. As already stated, we do not read the commenter's References B and C as pointing "in the direction of detonation not being a credible event."

13. To Distrigas comments on page 13–5, last para. and page 1, fourth para., page 3, fourth and fifth para. of detailed comments: We see only an inaccurate page number for Reference 5 and our mistake in referring to Vanta, et al. as Reference 15 but failing to include the reference, as our only completely inaccurate statements. Perhaps unfortunately, we used the term "methane-air mixtures" on page 13–2, line 13. While methane was the main constituent, the test gases referred to did contain some other hydrocarbons, as we point out on page 13–12 for Reference 6. We did not specify pure methane on page 13–2, line 13, and many use the term "methane" loosely to describe natural gas, in spite of the fact that natural gas and LNG are seldom pure methane. Nevertheless, it would have been more accurate to specify the mixtures completely.

We agree that Bull and Martin did not actually show that pure methane-air vapors will detonate by producing a detonation. But they did *show* that pure methane mixtures with ethane at percentages which might be found in LNG will detonate, as did Lind with methane-propane-air mixtures. Reference 5 on GAO's

page 13–2, line 17 should have been further explained at that point or the reference omitted.

On line 3 of GAO's page 13–6 we referred to the detonation of the propane cloud that Burgess and Zabetakis reported in Reference 12. Upon further study of their results, we too doubt that a detonation propagated through the unconfined cloud. However, the important point is that a destructive explosion occurred whether or not a true detonation occurred.

As to "misleading statements, assertion without foundation, and first class distortion," it appears to us that the commenter is the guilty one. Perhaps worse, he seems to be asking us to depend on theory where theory has never been able to provide reliable answers and to conclude that no detonation or destructive explosion can occur.

Finally, it is clear that the commenter is not well versed in the important technical aspects of detonation and non-ideal explosions. He appears to be trying to defend himself with inadequate and unfamiliar means. Indeed while some data are available, no one has adequate data at this point for evaluating the potential explosive hazards of large LNG and LPG spills. We hold to our belief that a research plan of about the size recommended in Chapter 13 is required for investigating detonation and that similar work is needed for investigating non-ideal explosions.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 15, THE CAPACITY OF NON-URBAN SITES TO MEET TOTAL U.S. IMPORTS REQUIREMENTS FOR LNG

The thrust of these Distrigas comments is that natural gas pipelines alone are not capable of distributing natural gas to consumers in the Northeast. Distrigas argues that a system of LNG peakshaving facilities, supplied in large part by Distrigas LNG import terminal, is necessary.

We made no claim as to the capacity of the natural gas pipeline system. We said specifically that: "We have not looked at the capacity of the main gas transmission lines to distribute . . ." all of the LNG imports projected for 1990.

We did not perform a network analysis of the natural gas pipeline system in the United States. We do not believe that anyone else has done such an analysis properly. Consequently, we cannot definitively agree or disagree with the Distrigas position. The need for any new LNG facilities is impossible to determine without a thorough analysis. We recommend in Chapter 18 that the Department of Energy and the Federal Energy Regulatory Commission "require a staff study of the feasibility of using only non-urban sites to receive all LNG imports and developing a gas exchange program using existing pipelines to ensure appropriate distribution of gas supplies."

We agree with Distrigas that trucking LNG from the Cove Point, Maryland, terminal is not a satisfactory alternative. We did not suggest that it is. Nor did we recommend the "construction of major new pipeline systems for use only a couple of months each winter." A relatively inexpensive beefing up of existing pipelines, with a gas exchange program, might suffice. There are also other alternatives. Tenneco, for example, is seeking approval from United States and Canadian regulatory agencies to import LNG through a terminal in New Brunswick, Canada, mainly for distribution to Northeast United States markets via a pipeline. We did not include this potential rural LNG terminal in Chapter 15 because it is not located in the United States.

Distrigas gives no evidence to support its statement that peak demand can no longer be met by liquefying summer pipeline gas. As we noted earlier, however, Distrigas has applied to the FERC to import additional LNG for baseload, not peakshaving needs.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 18, THE FEDERAL POWER COMMISSION

The Distrigas comments are a recitation of their opinions and feelings, rather than a contradiction of any of our material. Thus, no reply from us seems to be necessary.

GAO RESPONSE TO DISTRIGAS COMMENTS ON CHAPTER 19, LNG USE IN JAPAN

The only substantive comment in the chapter is a letter to the Editor of Oil and Gas Journal, from Robert O. Parker. He in turn quotes from a letter from Dr. Masanori Maezawa of Osaka Gas Company. Dr. Maezawa's comments are directed to statements in a January 26, 1978, New York Times article.

The statement from the newspaper article on which Dr. Maezawa comments is "For greater safety all future Japanese LNG tanks will be built in the ground." No such statement appears in the GAO report.

It is difficult to interpret some of his other statements. He points out that "there still are many unknown factors about engineering techniques in underground tank construction and, consequently, many questions on the safety of LNG tanks whether underground or inground."

This is undoubtedly true, but it is aslo true for above-ground LNG tanks. For example, Abu Dhabi is faced with spending from $15 to $20 million dollars to repair a leak in an LNG storage plant on Das Island. The tank is a large, standard, aboveground type. A second above ground LNG tank at the same site is also experiencing serious problems. Both tanks were built by IHI—the largest Japanese LNG tank builder.

Dr. Maezawa seems to imply that Osaks Gas has no inground LNG tanks and that Japan's largest gas company, Tokyo Gas, build inground tanks at its Sodegaura terminal only because of "exceptionally favorable soil conditions" there.

Osaka Gas itself has an inground LNG tank at its Semboku Works. It has been operating since 1975.

Tokyo Gas Company has inground LNG tanks not only at Sodegaura but also at its other terminal at Negishi. Tokyo Gas officials told us they plan to construct all their new LNG tanks inground. Tokyo Electric Power Company also has inground LNG tanks.

Nothing in Dr. Maezawa's letter contradicts anything in the GAO report.

REFERENCES

1. Tentative Provisions for the Development of Seismic Regulations for Buildings, NRS Special Publication 510, Prepared by the Applied Technology Council of the Structural Engineers Association of California for the National Science Foundation and National Bureau of Standards, June, 1978.

2. Cornell, C. A. and Merzy H. A., "Seismic Risk Analysis of Boston," Journal of the Structural Division, ASCE, Vol. 101, No. ST 10 October, 1975, pp. 2027–2043.

3. Trifunac, M. D. and Brody A. G., "On the Correlation of Seismic Intensity Scales with Peaks of Recorded Strong Motion," Bulletin of the Seismological Society of America, 65 (1975) p. 139.

4. Miles, R. W. "Practical Design of Earthquake Resistant Steel Reservoirs," Proceedings Technical Council on Lifetime Earthquake Engineering Specialty Conference, Los Angeles, California, August, 1977.

Senator DURKIN. I gather that the bottom line is that while bureaucrats are playing in their own backyard and are worried about their own concerns, we have a disaster looking for the geographic coordinates to happen in. Nothing effective is being done by the Federal regulatory agencies.

Dr. ROSENBAUM. I think some things are being done. We don't feel that enough is being done. Hopefully, there will never be a disaster, but it is a very grave chance to take, and we think more should be done as soon as possible to minimize the chances that such a thing will happen.

Senator DURKIN. Gentlemen, I want to thank you. We will leave the record open and look forward to your answers.

Mr. CANFIELD. Thank you, Mr. Chairman. I will proceed on to New York, if that is all right with you. Dr. Rosenbaum and Mr. Specter will be here if you want to ask any additional technical questions or any other questions regarding our report in the light of other comments you may hear in your testimony.

Senator DURKIN. Thank you for coming this morning. I know you have a very busy schedule.

At this time I would like to introduce into the record the statement of Senator Kennedy. The statement will be available at the corner of the desk.

[The statement follows:]

STATEMENT OF HON. EDWARD M. KENNEDY, U.S. SENATOR FROM MASSACHUSETTS

Mr. Chairman, within two hundred yards of this room as many as 70 trucks pass by carrying liquid natural gas during times of high demand for natural gas. These trucks exit from the Southeast Expressway on High Street, travel through residential and commercial areas, enter on the Southeast Expressway again and then proceed to numerous sites, again frequently through residential areas.

A report issued by the General Accounting Office on July 31 said that transportation of LNG or liquid petroleum gas by truck in this manner constitutes a safety hazard and recommended that new standards be established for such transportation. These hazards range from the risk of sabotage or hijacking to a simple traffic accident. If the 40 cubic meter cargo of a typical LNG truck spilled into an underground sewer or subway, it would produce enough gas vapor to fill 15 miles of a 16 foot diameter area. LNG burns in a five to fifteen percent concentration with air and a small spark would be enough to ignite a cloud of vapor. This is a matter of particular concern since LNG trucks have a higher than normal center of gravity and are more likely, than other similar vehicles, to turn over.

This is just one aspect of the storage and transportation of hazardous liquid materials which will concern your committee today. I extend to you a warm welcome to Boston and express my personal appreciation that you have chosen to begin your study near the site of the country's largest LNG import terminal.

While recognizing that LNG has made an important contribution to our natural gas supply during times of high demand, concern for LNG safety has risen as additional information has become available and imports of this fuel increased. I stress transportation by truck as a safety hazard because little attention has been paid to this danger during the past year of rising concern.

As chairman of the Office of Technology Assessment, I oversaw the publication, in September 1977, of a study on LNG transportation which gave particular emphasis to ocean transportation and LNG storage. This study made a major contribution to our understanding of LNG safety questions. It identified, for example, the very real possibility that victims of an LNG accident at sea could be left with little or no compensation. The report identified the need for additional attention to the siting of major import terminals, storage facilities and regasification plants. The report pointed out that the federal decision making process, in establishing and acting on criteria for siting decisions, was not designed to encourage local participation in an industry's proposed site.

The report identified the confusion which exists with regard to responsibility among the various federal authorities over safety and siting standards. In addition, it considered all of the important questions with regard to ocean transportation, including ship design and construction, crew training, transportation, shipping paths and tanker inspection.

I draw attention to this report, Mr. Chairman, because most of the critical problems remain to be dealt with.

The federal government has not developed a coherent policy on LNG imports. Conflicting jurisdictions continue to exist. The Coast Guard has not completed its work regarding navigational sides. The Department of Transportation has not established improved standards for transportation by rail and truck.

It is for this reason that on July 31 I asked Secretary of Transportation, Brock Adams, to undertake a new study on the transportation of LNG by truck and to quickly establish tighter safety standards. Secretary Adams tells me he is now prepared to go forward with a $75,000, six-month study specifically aimed at the question of truck transportation of LNG from the Distrigas facility at Everett, Massachusetts.

In addition, Mr. James King, Chairman of the National Transportation Board, in a letter to me of June 9, agreed that the Board will make the transportation of liquefied natural gases a priority during the next fiscal year. More recently, Mr. King agreed to include transportation by truck as part of that study.

Progress is being made in other areas as well. The State of Massachusetts has recently strengthened its authority and will improve its standards for the storage of liquefied natural gases at new facilities. Hearings in the House of Representatives and action expected in that body gives us hope that some legislation to improve safety in the handling of liquefied natural gases will soon be implemented. Congressman Edward Markey of Massachusetts deserves particular

praise for his role in bringing this critical issue to public attention and getting action in the House.

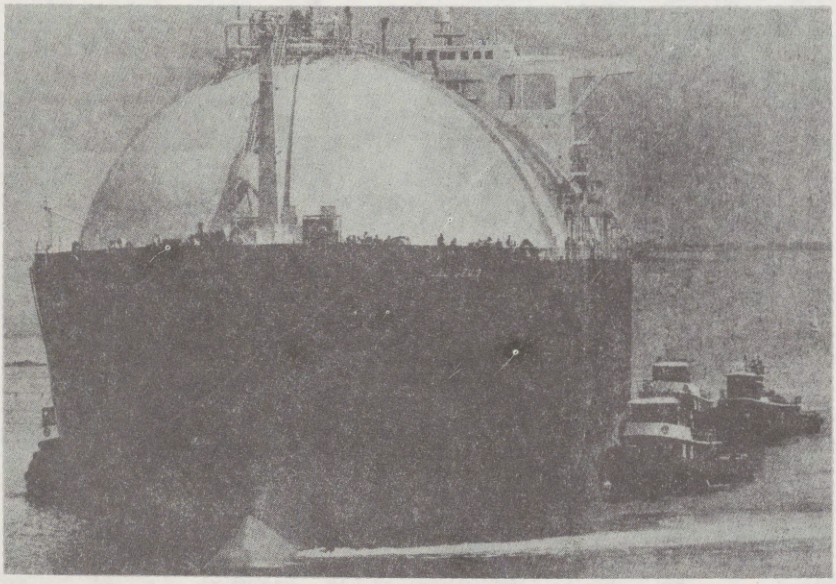
When the Dingell-Markey bill comes to the Senate these hearings will be very important in shaping the Senate bill. I believe we will be able to improve upon the legislation likely to come from the House. It is important that the Congress insist that the executive branch move quickly through the numerous studies to rapid, remedial action. It is important that the Senate bill recognize the need for a state contribution in determining LNG policy. Siting and ocean transportation are absolutely critical but, it would be my hope that the Senate will also concentrate on transportation standards on land. This is where the greatest danger may lie, where controls are most lax because so many individuals and means of transportation are involved in thousands of sites around the country. With LNG imports inevitably increasing and spreading throughout the distribution system we cannot wait for years of study before taking action.

Mr. Chairman, I stand ready to work with you and members of your committee on this important task. Your hearings today, with its impressive list of witnesses and its thorough treatment of the subject, will take us a long way along the right path.

Senator DURKIN. While we are getting ready for the next witness. I would also insert in the record, a picture from the Boston Globe of Saturday, August 19, 1978, page 6, which graphically demonstrates the liquefied natural gas tank of Gemini approaching the Fore River Bridge in Quincy for a sea trial on its outward bound journey. The previous day the vessel struck an open drawbridge, causing minor damage to the ship. I think we all can be happy that was the maiden voyage and wasn't loaded and inbound for Everett.

[The picture follows:]

[From the Boston Globe, Aug. 19, 1978]



TANKER HITS BRIDGE

Liquefied natural gas tanker Gemini approaches Fore River Bridge in Quincy after its first sea trial yesterday. On its outbound journey the previous day, 156-foot-wide vessel struck open drawbridge, causing minor damage to both span and ship. (Globe photo by Rachel Ritchie.)

In a minute we will go to Fire Commissioner Paul. I know he has a busy schedule, but I would like to turn for just a few minutes to Congressman Markey, who has been a leader in the House and has spent considerable time, energy, and effort in trying to resolve the many problems with respect to LNG. I would like to commend Congressman Markey for his foresight and his efforts in this area.

STATEMENT OF HON. EDWARD J. MARKEY, U.S. REPRESENTATIVE FROM MASSACHUSETTS; ACCOMPANIED BY DAVID GOLD

Mr. MARKEY. Thank you, Senator. I have accompanying me today, David Gold, who worked with me on the Energy and Power Subcommittee of the Commerce Committee on the House side, working on the corresponding legislation to what you are dealing with here today. I thank you for the opportunity of being able to appear before your hearing this morning on this very important subject of LNG and LPG safety.

First of all, as you know, together with Congressman John Dingell of Michigan, I have coauthored legislation on LNG and LPG safety entitled the "Fuels Transportation Safety Amendments Act of 1978." That bill is scheduled for consideration by the House of Representatives on September 9 on the floor of the House.

Shortly thereafter, the House and Senate Commerce Committees will meet in conference on our bill, H.R. 11622. My purpose in appearing before you this morning is to describe our legislation in the hope that you and the entire Senate Commerce Committee will be able to assist us in seeing that its provisions are enacted when we meet in conference.

Our bill is the product of many months of work by the House Energy and Power Subcommittee and the Interstate and Foreign Commerce Committee. In May of last year, Chairman Dingell and I introduced H.R. 6844, the "Liquefied Natural Gas Facility Safety Act." Subsequently that bill was incorporated into H.R. 11622 which was the subject of over 40 hours of hearings this year in the House.

This legislation is a very significant measure. First, the bill authorizes appropriations for the pipeline safety activities of the DOT. I might note that the Senate has already passed legislation, S. 1895, addressing this necessary action. Second, our bill seeks to coordinate the safety regulation activities of DOT's Office of Pipeline Safety Operations into a coherent package and to close existing gaps in these safety regulations.

The importance of so doing can easily be seen from the following. In 1976 alone, 63 people were killed, 366 injured and millions of dollars of property damage occurred as a result of fires and explosions along the more than 1.4 million miles of natural gas, petroleum, and petroleum product pipelines in this Nation. Our legislation establishes mechanisms which seek to prevent such accidents from occurring. I believe its passage will save lives.

In addition, our bill mandates strict new national safety standards with respect to the location, design, construction, operation, and maintenance of liquefied natural gas facilities. LNG is a very useful source of energy, but its transportation and storage present extraordinary hazards to public safety.

In 1944, 130 persons were killed by a series of fires which followed the rupture of an LNG storage tank in Cleveland. Federal studies of that accident led to recommendations that future LNG facilities be located away from populated areas. Thirty-four years later, however, no such action has been taken. It is time for Congress to take that action.

LNG is created by supercooling natural gas to a temperature of minus 260° F. At that temperature, natural gas is compressed in volume over 600 times, thus making possible its storage as well as its marine and truck transportation.

If an LNG truck or storage tank were ruptured, however, a cloud of LNG vapor would be created. Keep in mind that this vapor cloud would be 600 times greater in volume than the original amount of liquid. This heavier than air vapor cloud would hug the ground, go down into sewers, subways, and basements through any available opening. Widespread fires and explosions could easily be ignited, since the vapor is so combustible that it could be set off even by the spark generated by an automobile horn.

Under the provisions of the "Fuels Transportation Safety Amendments Act," the Department of Transportation will be required to establish standards regulating the siting and design of any new LNG facility or any construction at any existing facility. These standards would require remote siting to the maximum extent possible, thus implementing the recommendations I mentioned earlier which followed the tragic LNG accident in Cleveland.

In addition, all LNG facilities will be required to comply with strict new operating standards covering such areas as antiterrorist security and firefighting capabilities.

Mr. Chairman, the hazards associated with LNG, LPG, and natural gas pipeline transportation are clear. Recent LPG tragedies in Tennessee, Iowa, Spain, and Mexico have greatly heightened public awareness of the extraordinary hazards associated with these fuels. The public has a right to expect that Congress will require that the Federal Government develop a coordinated policy to assure the greatest possible safety in the transportation and storage of these fuels.

I believe that our bill represents the essential action which Congress must take this year. Too many lives are at stake to delay. As the Christian Science Monitor has stated in an editorial: "Congress ought not to wait for a disaster to drive them to enact these needed precautions."

Mr. Chairman, once again I want to applaud your initiative in holding this hearing and I believe that with your leadership in the Senate, coordinated with the activities in the House, that we will be able to provide for the protection of the public and give them the assurances that the kinds of actions that could very likely occur will not occur because we will give them the safeguards and the legislative mandates of the Department of Transportation which will preclude such accidents from ever occurring in this country. Thank you, Mr. Chairman.

Senator DURKIN. Thank you, Congressman. Hopefully we can get action this year in the conference. I just hope the conference on LNG and related matters moves a little faster than the conference on natural gas and related matters. It is something we can't overlook any longer.

Mr. MARKEY. I agree with you. We cannot wait for an infinity as we have with the natural gas situation, to come to a resolution of a very

serious problem in our country. I think that doing something about the preventing of any further siting of LNG facilities in urban areas, precluding the possibility of expansion of existing facilities of LNG in urban areas and providing for the safeguards in already existing facilities and for providing for strict new antiterrorist, antisabotage regulations, which will give the public assurances that accidents are very unlikely to happen, is something that at a minimum we can provide for the public before the year is done, and I hope that the Senate and the House will be able to get together and enact the legislation which is so needed.

Senator DURKIN. Also we have the transportation of LPG, a very real problem in your area, a very real problem in New Hampshire, especially the seacoast area. We can't postpone action on that much longer. Thank you, Congressman.

At this time we call Commissioner Paul. Commissioner, your entire statement will be printed in the record, and you are free to proceed in whatever manner you find most comfortable. Thank you for taking the time out of your busy schedule to provide your insight for the Senate Commerce Committee.

STATEMENT OF GEORGE H. PAUL, FIRE COMMISSIONER, BOSTON FIRE DEPARTMENT

Mr. PAUL. Thank you, Mr. Chairman. For the record, my name is George H. Paul. I am the fire commissioner for the city of Boston. I have been a member of the Boston Fire Department for over 30 years, serving in all ranks and capacities within the department.

On behalf of the city of Boston I would like to thank the chairman and the members of the committee for giving us an opportunity to present our views on this very timely subject.

The city of Boston is presently being used as a transit route for large capacity LNG carriers. When I say large capacity, I mean 40 to 45 cubic meters or approximately 11,000 gallons in capacity. These tankers are serving communities outside of the city of Boston. There are presently no enforceable regulations that control the methods used to transport these products, the routes the tankers may use, or the conduct or qualifications of the drivers of these vehicles.

It is the position of the city of Boston that liquid energy gas and other hazardous cargo carriers must be properly regulated and in particular that the safety of those who live and work in the city be better protected by prohibiting the travel of these carriers through one of the busiest and most congested areas of the city and indeed the State. In the event of an accident that resulted in the release and almost certain ignition of one of these products, a serious loss of life and property could result. This city is faced with a very perplexing problem, as a large number of these vehicles regularly travel the Southeast Expressway, an elevated highway, which cuts a swath through the center of the downtown area of the city. The city government does not have any authority or jurisdiction over these heavily traveled roadways.

Of great concern is the fact that the LNG carriers and other carriers using the expressway are traveling to locations outside of the city and in some cases outside of the Commonwealth. It does not seem practical that such vehicles should be permitted to use a route along which hun-

dreds of thousands of people live and work on a daily basis to get to some location outside of our city.

It has come to my attention recently that plans are being discussed to permit as many as 21 trips a day to travel from Distrigas in Everett to Providence, R.I. I must assume that these tankers will use the Southeast Expressway. If this were to become a reality, it would only be a matter of time before an accident involving one of these tankers may occur, and depending upon the circumstances at the time, a very serious threat to public safety could result.

I believe that the time has come for action. that we must stop having studies and having hearings and that the Federal Government should first provide enforcement tools for the present Federal regulations regarding the transportation of hazardous commodities. These regulations admittedly are very vague and broad in their coverage. However, such enforcement would provide a short-term solution to the problems of this city.

In addition to this, State and local regulations must be adopted to deal with the specific local situation. Let's not wait for a loss of life to occur before action is taken. Let's react before the fact rather than after the fact. If I may digress for just a moment, I would like to make the point that Government agencies often in some of their decisions create new problems when trying to solve an existing problem. A case in point is on the subject that relates to the material being discussed in this hearing. I speak of the pressure from the environmentalists that resulted in the discontinuance of Freon as a propellant in aerosol containers.

As a result of this decision, every grocery store, warehouse, supermarket, drug, department, and other specialty stores are loaded with aerosol-contained cans, containing highly flammable propane gas which is now used as a replacement as a propellant for most aerosol containers. It seems to me that there must have been a better alternative than this, and that more people should have been involved, more agencies and jurisdictions should have been involved in the final decision.

Just consider for a moment a smoker with a cigarette in his mouth or in his hands using one of these new aerosol cans. There could be disastrous results for this individual as these containers can become veritable flamethrowers. Obviously we must regulate the storage and use of liquid energy gases as well as other hazardous commodities. In so doing, I don't believe that it is necessary or advisable to use scare tactics and cite worst possible case situations and create the impression with the general public that the worst possible case situation is most likely to occur should there be an accident involving one of these products.

I believe that we all realize that this source of energy is here to stay for the foreseeable future, and it is therefore apparent that we must learn to live with it, and we can, as we have in the past with gasoline and many other hazardous commodities in common use. To accomplish this end, I believe that everyone involved should get together and draw up some practical regulations that all involved can live with and through which the general public will be safeguarded.

Thank you, Mr. Chairman. If you have any questions, I would be most happy to try to answer them.

Senator DURKIN. Thank you, Commissioner. I note with interest your concern with the new propane propellant. In New Times Magazine, this past month, a very detailed article appeared on the hazards of the replacement propellant for aerosol cans—a very disturbing article.

I gather your recommendation is to prohibit the transportation of LPG through highly populated areas?

Mr. PAUL. Yes, sir.

Senator DURKIN. Do you have an alternative route for Boston?

Mr. PAUL. I have an alternative route in mind. There is a route out I–93 to 128. Many of these carriers, and indeed most of them, are traveling through the city to get to the south shore of the Commonwealth, and there is a route. Granted it is a little longer, but the hazards attendant to it are far less. There are presently some Federal regulations that do prohibit the transit of hazardous cargos through densely populated areas, under tunnels, over bridges, narrow streets, et cetera, but to the best of my knowledge, the council for the city of Boston, or people in my office, have not been able to find any enforcement vehicle for this regulation.

We transmitted this to Brock Adams of DOT and we have been told that they are in the process of hiring a consulting firm to do a study on the relative hazards of different transit routes.

Senator DURKIN. I gather there is no transit through the tunnel in Boston?

Mr. PAUL. That is correct. And that compounds our problem. These vehicles come down the Southeast Expressway, which is a problem in and of itself, and then because they are prohibited from going through the tunnels—there is a tunnel on the expressway, the Dewey Square Tunnel—these tankers are then required to exit the expressway at the High Street Ramp. This takes them through a very congested financial section of this city, in through Chinatown, and then they go back onto the expressway on the other side of the tunnel. Very frankly, in my own personal opinion, I wonder sometimes whether they wouldn't be better off continuing on through the tunnel rather than coming down into the congested narrow streets of the city of Boston.

Senator DURKIN. In your alternative route, Route 128 and what have you, would you recommend the restriction of travel to nonpeak drive time hours? In my experience, 128 is like Indianapolis 500 twice a day, at rush hour.

Mr. PAUL. I think that should be considered. As I said, I think we should get together with industry and everyone involved should have some input when we make these regulations. I realize that 128 is a high-speed road and the experience of accidents is much greater on that type of a roadway, but it's a far less densely populated area and if an accident were to occur, with disastrous results, and a fire did ensue, I believe the loss of life would be far less than it would be if there were, for example, an accident with one of these tankers coming down the High Street Ramp from the expressway.

Senator DURKIN. Are you prepared to recommend to the city council or whatever is the appropriate body in the city of Boston, to ban the transport of LPG?

Mr. PAUL. As fire commissioner, I am a member of the traffic and parking commission in the city of Boston, and at a meeting last week, I made the recommendation, or made a motion, that these vehicles be banned from the city streets. On discussion of the motion, it was apparent that it is a much more difficult and complex problem to deal with than such a straightforward motion.

The traffic and parking commissioner has indicated that they intend to get in contact with the industry people in the area. We will have a meeting and try to draw up some kind of an alternative. One of our problems in the city is that the Southeast Expressway is under the control of State jurisdiction. We have no control over that roadway at all, and that is a very serious problem.

Senator DURKIN. What contingency plans do you have in the event of an LEG accident? And how fast could they be put in operation?

Mr. PAUL. We look at liquid energy carriers and all hazardous cargos in the same general way. We do not have any specific plan for these products. We have response patterns, special response patterns, set up to gain access to the Southeast Expressway. We have pumping sites so that we can pump water up onto the expressway and supply water to firefighting companies without the need of having apparatus on the expressway.

Our general plan is that we would handle liquid energy carriers in the same way that we would handle any of the other hazardous cargos. We have hundreds and hundreds of gasoline tankers traveling over that expressway daily. We have had some incidents with gasoline tankers and we have fortunately been able to handle them.

Senator DURKIN. Has the Boston Fire Department ever simulated emergency response in a drill to an LEG truck accident, facility accident, tanker accident?

Mr. PAUL. Yes; we do this on a regular basis. We have a general procedure in the fire department, what we call "Prefire Planning". What this is basically—it's a rehearsal for a fire. If you can accurately try to anticipate what the circumstances would be—we have the first alarm response company that would go to the area on the first alarm, with the chief officers, and they simulate their operation. We have ongoing training programs in cooperation with the gas companies in the area. For all of our officers, all of our chief officers, that are located along the route of this expressway we have demonstrations down at our fire academy on Moon Island. Through actual use, actually having LNG spilled in a diked area we ignite the gas and use the various extinguishants so that the men will get firsthand experience and have an understanding of how this material does react under different conditions, because it is a bit of an unusual product from our point of view.

Senator DURKIN. Commissioner, this committee has had testimony by Chairman King of the NTSB to the effect that the Materials Transportation Bureau of the DOT has been remiss, especially in marking railcars, so that firefighters know what is in the car. And that the placarding has been inconsistent, confusing. How do you know what is in one of those cars when you arrive on the scene?

Mr. PAUL. As far as the railroad tank cars, approximately 2 or 3 months ago the Boston Fire Department incidentally was the first major fire department in the country to do this, we adopted the Con-

Rail hazardous identification system. Through this system all of these cars carrying hazardous cargos have a number which is plainly marked on, I believe, five locations on the tank car. On both sides, the ends and on the bottom. We have issued instructions to our men that when they respond to any kind of a railroad incident involving tank cars or any kind of cars, that may be carrying hazardous cargos, to obtain this number. They relay this number back to our fire alarm office, we relay it to the ConRail offices in Brighton. It goes into a computer and in a very, very short period of time we get all of the hazardous properties of this material, the recommended firefighting procedures and any special precautions that should be taken. So I feel that we are as well covered as far as rail transportation as we can be. With truck transportation it's a little different situation.

The tankers are marked as flammable. There are a number of categories they are marked—flammable, corrosives, oxidizing agents, that type of thing. But I don't believe they are as well marked as they should be.

Senator DURKIN. It has been suggested that the DOT set up a hot line where the firefighters, in a particular area where there is an accident, could call for up to date recommendations. I believe in Waverly, Tenn., the fire chief was killed when, operating with ancient data, the tank blew. Do you think that for the smaller fire department not as well equipped as you are in Boston, such a hot line would provide immediate information?

Mr. PAUL. Yes; I think it would. I think it should be done and I think it can very easily be done, because there presently is a Federal agency—I'm not sure whether it is a Federal agency, but they work out of Washington, which we have available to us. It's Chemtrack. This is a 24-hour telephone number, but to be able to use Chemtrack you have to have identified the chemical. Once you get the name of the chemical you can call Chemtrack and get very fast information on all of its physical properties, hazards and a recommended firefighting procedure.

Senator DURKIN. The problem is getting the chemical.

Mr. PAUL. The problem is getting the chemical, and I think ConRail has an identification system which is a step forward in this, and if all of the trucks as well as the railroad cars were marked with the special hazard identification number it could be transmitted through, as you say, a hot line and have 24-hour, 7-day-a-week service, and then the fire chief on the scene could get some better information as to what he is dealing with.

Today there are so many varied chemicals and compounds that it has made our business extremely difficult. We never know what we are dealing with. In many cases the most apparent extinguishing agent is probably the worst thing you could use.

Senator DURKIN. Do you have cooperative planning with the other fire jurisdictions in the metropolitan area?

Mr. PAUL. Yes; we do.

Senator DURKIN. In your judgment do the LEG companies now have adequate capabilities and training to deal with emergencies on their own sites?

Mr. PAUL. I am really only intimately familiar with the Boston Gas Co. as they have an installation located within our city, and I must

say that they do a reasonably good job in providing the necessary equipment and the training. We have a program of regular visitations from our people, the chief officers and the fire companies to the commercial point area, and I am comfortable that the men that work in that area are very familiar with all of the installations they have on Commercial Point. I think that the people that work on Commercial Point are probably as well versed in fire emergency as you could expect a novice to be.

Senator DURKIN. Commissioner, I gather that the Federal Government can help you and the other firefighters across the country the most by consolidating the various regulations and enforcement of those regulations in one agency and promulgating regulations that are sound from a technical as well as commonsense viewpoint, and doing that as rapidly as possible?

Mr. PAUL. Yes, sir, that would be very helpful to us.

Senator DURKIN. Commissioner, I want to thank you very much again. I appreciate your taking the time. The record will remain open. If there are any additional thoughts you would like to add, feel free. If we have any questions we will forward them to you in writing and would appreciate a response. I thank you again very much.

Mr. PAUL. Thank you, sir.

Senator DURKIN. At this time we will proceed with the New Hampshire Panel, Assistant Mayor Jim Splaine, city of Portsmouth; Councilor Dudley Dudley, from Durham; and Fire Chief Paul Long of the city of Portsmouth. I want to welcome you all.

As we are shifting gears, I would like to thank Councilor Dudley and Mr. Splaine for your tireless efforts in raising this very serious problem as it impacts on a substantial portion of our State and the entire New England region. When you look at the map and see the route where liquid energy gases are transported, and if you take a look at the chart which shows the projected increase in liquid energy gas utilization in New England, the problem becomes even more immediate and much greater.

Please proceed in the manner you find most comfortable. Your entire statement will be included in the record.

STATEMENTS OF JIM SPLAINE, ASSISTANT MAYOR, CITY OF PORTSMOUTH, N.H.; MRS. DUDLEY DUDLEY, EXECUTIVE COUNCIL OF THE STATE OF NEW HAMPSHIRE; AND PAUL LONG, FIRE CHIEF, CITY OF PORTSMOUTH, N.H.

Mr. SPLAINE. Thank you, Senator. Councilor Dudley has to leave for another engagement so we would like to have her start off.

Mrs. DUDLEY. Thank you, Jim. Senator Durkin, we have seen a liquefied energy gas catastrophe become a nightmarish reality on the screen today. We have read with alarming regularity reports of LEG derailments throughout our Nation, and we fear that the word bleve may become a household word just as has spill.

In the invitation to come here today you asked the question, "Is the public safety adequately protected against the hazards associated with these essential energy sources?" My answer is, no. In fact we are not adequately protected. We are discussing a loaded, in transit, lethal bomb. We are concerned. How shall we safeguard our rights to life,

safe property and ecological integrity? Shall we improve our rail system? Install proper traffic signals on key highways? Insure working, professional relationship between fire companies, first aid squads and the generators and transporters of LEG?

Shall we prohibit the coupling of LEG cars to one another in a train? The answer is "Yes" to all of these, but more than these safeguards must be taken. We must find a common thread that ties the fundamental reality of energy need with our desire for survival. Energy sources with inherent risk can be delivered safely so long as the best materials are used, the latest technology is implemented, the most stringent standards for safety are met. The common thread here is dollars and cents.

We must make it economically unpalatable for producers and distributors of hazardous materials to apply anything but the most stringent standards, the most fastidious precautions in the storing, processing and distribution of those materials. So I advocate strict liability in the event of accidental or negligent bleve. Industries confronted with strict liability after a bleve for all damages will pay for the most scrupulous attention to safeguarding the lives, property, resources, and integrity of the community. With accountability fixed I believe we will find only the best trucks, only the most durable valves and only the best trained employees.

Regulations in the area of liability should, first of all, assure that all damage from liquid gas explosions will be compensated for efficiently, and second, they should provide incentives to prevent future calamity. The burden of proof imposed on an injured party, the unrealistic and unfair time frame for litigating claims, diminishes the effectiveness of law suits as a deterrent and control. If industrial enterprises responsible for the handling of hazardous materials see these impediments to successful litigation and recovery of damages as indications that injury from accidents or negligence will be borne by others and remain external to their own operations, the deterrent factor is lost.

Strict liability for escaping pollutants is imposed without regard to fault. Liability for resulting injury becomes an integral part of conducting inherently dangerous activities.

There is much to be done, particularly in the State of New Hampshire, and I would like to run down for you briefly just what the conditions are regarding the regulation of LEG in New Hampshire right now. We have a turning basin that by all accounts is very inadequate, by about 100 feet. I would ask that the Army Corps of Engineers be directed to look into that very soon. There is complete agreement that it is 100 feet short.

Senator DURKIN. This is in Portsmouth Harbor?

Mrs. DUDLEY. In Portsmouth Harbor, right. We have weighing stations that are closed all across the State in a move to save money. We have a State fire marshal who has said that one of his solutions to the problem would be to link all LEG cars together in one long train. That's the State fire marshal.

We have a bankrupt railroad that carries LEG over class I tracks, the worst possible tracks. That railroad reports only those derailments it chooses to. We have no track inspector in the public utilities commission. Only one track inspector trainee.

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The B. & M. has consistently refused to allow elected officials to look at track inspection reports. We have no stricter regulations covering the transportation of LEG over the rails than those that would cover the transportation of lumber or chickens. We have overlapping and conflicting responsibilities. We have a nonrelationship between fire companies and the transporters of LEG. We have trucks going through our most densely populated residential areas when there are alternate routes. We have trucking company officials who speak in familiar terms of John, as in "John says our trucks can take this route." John being John Clements, commissioner of public works and highways, who has the authority to route trucks.

We have a Governor who negated a 5 to zero vote of the executive council in a resolution which sought to bring together the department of works and highways, the department of safety, and the PUC to assess the problems associated with LEG. Instead our Governor created his own special committee made up one-third of gas and oil industry officials and no representative of the PUC.

The Federal Government has given the States the opportunity to make regulations themselves. New Hampshire has not taken this opportunity and the result is a regulatory vacuum. We must act to safeguard our public from the hazards of LEG. Politics in the purest and strongest sense of our American system must play an integral part in our attempts to minimize risk.

Unfortunately, politics in the person of the Governor of New Hampshire continues to preclude even the most innocuous attempts to regulate and manage the frightening quantities of hazardous materials and waste circulating through our State.

Senator DURKIN. Excuse me just a second. I would like to note for the record that the committee invited John Clements, the New Hampshire highway director, and he declined to testify.

Mrs. DUDLEY. Well, clearly we have problems in New Hampshire in getting atention and help from the executive department and from the Governor. I am therefore all the more grateful to you and your committee for your concern. I thank you for this opportunity today.

Senator DURKIN. Thank you, and again, I think everybody in New Hampshire, especially the seacoast area, appreciates your drive, tireless energy, and your initiative.

Mr. Splaine.

Mr. SPLAINE. Thank you, Mr. Chairman. I certainly would echo everything that Councilor Dudley said. I would add a couple of comments, though. You have the testimony before you that I would present today along with several exhibits which might be of interest to you and I do hope you can review it at your convenience.

One of the fascinating, if unfortunate, aspects of this entire issue that I found during my involvement, particularly in the last 5 or 6 weeks, is the unfortunate politics of the isue. It seems to me that the work of the U.S. Commerce Committee is going to be very important in reducing the influence of industries and in the users of the LPG, the large industrial users and transporters, and making sure that "safety" is a guide word in implementing those precautions and regulations which you might decide upon.

In the final analysis, what we have tried to do in Portsmouth is provide—and in the seacoast areas—is to provide a margin of safety

for the transportation. The map which you had up a moment ago shows very well the fact that the entire seacoast area, going down through Boston, is where the core of transportation centers for LPG, in both rail as well as road traffic.

We have worked in the seacoast area, along with Councilor Dudley and local officials, to try to guarantee that that transportation on the road would be as safe as possible. We communicated with State officials, including Governor Thompson and Commissioner Clement, to try to get an agreement that would authorize local communities like Portsmouth to be able to have ordinances which would be enforced prohibiting at least to the point of regulating traffic which might come in carrying liquid energy gases.

Up until a little while ago those efforts were stymied, but because of the constant pressure of local people, Mr. Clements did agree to a permit system which is still being written out and which I am submitting to you in draft form in the testimony which I passed on to you this morning.

Second, we tried with Boston & Maine Railroad to get an agreement that B. & M. would improve the rail lines in our community so that we would have a margin of safety. We found much to our dismay and great surprise that the rail line that had gone through Portsmouth and that now is being used for transportation of LEG, and I assume this is true in many other cases, is the lowest rail line that the transportation of anything can be allowed on. It is called class I, which has a speed limit of 10 miles per hour.

It wouldn't bother us so much if we were talking about the transportation of coal. In the event that a derailment occurred and a car tipped over, only a few rocks and coal would be smashed, but in this case we are talking about something which is extremely volatile as the movie "BLEVE" shows. So, we urged B. & M. through some consentual agreement to improve the line and they agreed to do so. They improved it, and they are currently with a crew improving it to class 2, which allows for a speed of up to 25 miles per hour, but our margin of safety is being recognized in that they have so far verbally agreed—we want it in writing from B. & M.—that the speed limit for all cargo on our line will remain at 10 miles an hour.

That is one thing that I think the U.S. Commerce and Transportation Committee probably should work on to guarantee that margin of safety throughout the country on all rail lines, at least guaranteeing that there is going to be that element of safety.

Senator DURKIN. We have yet another Federal agency involving itself, the FRA. To date, the FRA seems to be more interested in not utilizing the money that Congress authorizes and appropriates to rehabilitate rail lines, than aggressively using the money that Congress has mandated.

Mr. SPLAINE. The discussions of the Traffic Safety Commission, which I share, incidentally, found that after discussing the situation of the Federal regulations with the Boston & Maine Railroad, we learned that most of the regulations which had been put together by the FRA ended up being agreed to by industry, by transportation—LEG users, and by the railroad companies themselves, and to me that means that the minimal safeguards, the minimal regulations for safety,

are going to be implemented rather than the maximum and that concerns all of us, too—how these regulations can end up being adopted with the politics of special interests coming into play.

Irrespective of that, I would like to sum up by passing on to you three specific recommendations which the city of Portsmouth and the seacoast area would like to see implemented. These are positions of the city council or the traffic safety committee in Portsmouth.

No. 1, we would urge you to do everything that you can on the Federal level to see that improved inspection procedures and expanded inspection reporting by railroad companies is implemented. We found, much to our dismay, that inspection reports on rail lines made by the Boston & Maine Corp., and I assume this has to do with every railroad line company, are for internal use only. Our fire chief, our police chief, city manager, mayor, the city council, traffic safety commission, no one in the local community can have access to those reports.

These reports are supposed to be done once a week if the line is being used for LEG transportation. But nevertheless, no one can have access, other than the FRA, to those reports. I urge you to see if you can have those reports readily accessible to local communities because I think some interesting self-policing would occur as well as some followup by local officials.

Second, again much to our dismay, we found after becoming involved in this issue, derailments do not have to be reported to the local community. If a derailment is deeemed by the experts who work for the company themselves, to be serious enough in nature, necessitating outside help, such as calling in the fire department, then they will communicate with the local officials. The derailment which you referred to, Senator, in your opening testimony in Portsmouth—and I include it in the testimony I present to you today—a copy of a story on that issue—that derailment was not reported to our local officials. Our fire chief learned about it the next day from one of his men who had heard about it from somebody he had talked with. And our police chief learned about it from the radio the next day.

I don't think that can be continued to be tolerated. Furthermore, any derailment in our opinion should be reported to local authorities because all derailments of any nature, no matter how supposedly minor they are, are indicative of a fault, and if we can have a file within city government where we know where the derailments occur, we can followup and make sure corrective action occurs.

Third, and I think it is extremely important, not only to the city of Portsmouth and the seacoast, but any community, I urge you to make sure that all LEG cars, whether they be trucks or trains, be parked away from population centers, and if at all possible in a fenced in area similar to what GAO suggested, having some sort of protection against any outside abuse or mishandling. I think this is important because if you don't, you are going to end up having a situation develop where a lot of these cars are going to be parked in population centers.

They say in Portsmouth—B. & M. says—that they do not allow loaded cars to be parked in the city of Portsmouth on our rail lines, in our railyards. But as everyone admits, there is no such thing as an empty LEG car. There is always some degreee of residue—not only the vapor, but some other residue as well. You can never guarantee that

they are going to be totally empty. So I urge you to make sure there is going to be that margin of safety as well.

In concluding, the key term in our work has been margin of safety. We want to assure that every precaution is taken on providing a margin of safety in the handling of LEG. It is government's obvious obligation to do everything it can to provide that margin of safety for the public and anything else would be negligence. I think that position should be a mandate, for State, local, as well as national Government.

Thank you. Our fire chief, Paul Long, is here and he has some additional comments to make.

Senator DURKIN. Thank you, Mr. Splaine. Chief, it is good to see you again.

Mr. LONG. Thank you. I would like to make some brief comments. My name is Paul Long. I am chief of the city of Portsmouth Fire Department in Portsmouth, N.H. I would like to thank Senator Durkin's office and the Senate Commerce Committee for the opportunity to appear at this hearing and express my personal concern, and the concern of a great number of fire chiefs in the State of New Hampshire relative to the transportation of hazardous materials both by rail and highway systems, and by other systems that we have.

Senator DURKIN. You are expressing the concern of the Portsmouth Fire Department, but you are also expressing the concern of many firefighters and fire chiefs all across the State.

Mr. LONG. Yes, sir. To give you a brief background, I have been a permanent member of the fire service for the past 32 years, having served with fire departments both in Massachusetts and New Hampshire.

During the last 10 years I have served as chief of department in New Hampshire and hold positions as a member of the Board of Directors of the New Hampshire Fire Chiefs Association, member of the International Association of Fire Chiefs Research Committee representing the New England Division, and a member of the Factory Mutual's Fire Service Advisory Committee.

During the past few years there has been an increased awareness in the fire service of the need to pre-plan certain operations which would provide a higher level of protection to individual communities exposed to rail, highway, water, and air transportation of hazardous materials.

Portsmouth, N.H., because of its geographical location as a port city, is unique in the respect that it must address itself to all four methods of transportation on a day-to-day basis.

Certain basic contingency plans have been developed with government agencies, as you mentioned with Commissioner Paul, and that is Pease Air Force Base and Portsmouth Naval Shipyard, surrounding Portsmouth. However, there is no current pre-plan in effect that considers rail and/or highway transport emergencies.

The increase of incidents in New Hampshire and throughout the country indicates a need for greater cooperation between Federal, State, and local agencies with regard to this problem.

A program has been recently initiated by our department to develop a plan of operation. In order for any contingency program to be effective we must be aware and apprised of Federal and State

regulations, standards, and codes that apply to the transportation of hazardous material, and be reasonably assured that those regulations are effectively monitored, and second, we must establish effective communications at the highest level between responsible officials of local government and common carrier agencies to determine what resources would be available to the parties involved in an emergency situation.

I won't bore you with the reports as far as the billions of tons of hazardous materials carried across the country, and the incidents that have been reported to your committee, but I would bring to your attention that there were 1,500 incidents involving rail transportation reported in the past year, with one fatality and 233 injured.

The latest report of an incident in Fire Engineering magazine, dated July 1978, refers to a 20-car freightcar derailment near Abilene, Tex. I don't know whether you are familiar with this particular incident, where faulty information supplied by the train crew to the fire chief caused many problems. There were incidents at this particular time when there were three cars, supposedly containing methyl alcohol and another car that was supposedly empty. As a result of the fire and after the fire had been extinguished, which took over a day and a half, it was reported that the car that was apparently empty was labeled acetaldehyde which is a very volatile fluid, liquid. The car that was reportedly empty contained that, and had the chief probably known that, he would have taken a different approach. These are the problems that we have. The accuracy of the information throughout the incident was a problem.

As I mentioned, this car that was supposedly empty was later found to be full, and this discovery came 1½ hours after the car had been reported empty, nearly 2 hours after the incident started.

I believe these incidents that have been cited reveal a need for more comprehensive regulation of rail and highway transportation of hazardous materials, and that the resources of these agencies be available to assist the fire service in planning for the protection of life and property should an incident that involves those agencies occur.

Past experience has shown that, in the final analysis, the fire chief in every community throughout the United States bears the sole responsibility for decisions that must be made to successfully control these emergencies, and all available information and assistance should be at his disposal.

The Fire Chiefs Association of the State of New Hampshire at a meeting on August 10 of this month, drafted a resolution to the Governor of the State of New Hampshire and in it they respectfully requested to instruct the department of safety, department of public works and highways, and the public utilities commission to examine this problem that we have, report to the Governor and council at their earliest possible convenience their assessment of the adequacy of existing statutes and regulations, their ability to enforce these statutes and regulations and to make recommendations for the safety of the people and the property in the State. I believe that is in essence what I am looking for, that there be better regulations and that the regulations are monitored to a better degree.

Thank you.

Senator DURKIN. Thank you. Public Law 93–633 authorized an emergency Federal information system, but for reasons that can only be explained by the DOT, they have essentially ignored the mandate from Congress. Do you think a hotline system where in the event of an emergency you could be patched in to a sophisticated computer center would facilitate saving lives in New Hampshire?

Mr. LONG. Absolutely, sir. I think that is one of our primary objectives, to develop a communications system that is effective, and at the present time there is none. In many instances we get misinformation from different areas. We do not have a direct line or know of a person that we can talk to after the fact of a derailment that might involve LEG, where we can inform them as to what their problems are, what we observed, so we could get this transfer of information. Also I think one of the main points that I would like to make is that there should be some type of a system that would allow us to find out what the resources of that particular agency are, to assist us in our work. Because when we get there, that is the time to make the decision and make the judgment and the chief of the department must make that. If he makes wrong decisions based on misinformation or no information at all, there could be a tremendous cost that would have to be borne by somebody and usually it is the city within which we work.

Senator DURKIN. Earlier in the year we held authorization hearings on the Materials Transportation Board which is responsible for the Hazardous Materials Transportation Act and Pipeline Safety Act. They didn't even know how many people they had working in their division. To date, DOT has an extremely sorry record; this was not just my criticism, but is the criticism of Chairman King of NTSB.

How can the Federal Government best help you?

Mr. LONG. I think there are many different ways. The primary purpose of my being here is to try and see if there would be effective communications developed that would allow us to preplan and set up contingency plans for such emergency, using the mutual aid systems that we have within our area, so that we could be more effective in what we are doing. We've got to have input. Everybody has a tendency not to want to talk about what might happen in a catastrophe. I think this is what we are going to have to address because we have four areas that we are very much concerned with in the city of Portsmouth, and I am sure we are not unique.

Each community within the State of New Hampshire has its problem in transportation of hazardous materials: relative to the size, probably, but they each have their problem. What we would like to do—and I am not speaking for the New Hampshire Fire Chiefs Association, but only as a member and I do not represent them and I wouldn't want that to be misunderstood. But we would like to get together and get all of the information we could from the systems that we have now, so that we could work more closely with them to find out what their resources are. There are many small cities and towns within the State of New Hampshire who have volunteer fire departments and they need all of the assistance that they can get.

Senator DURKIN. Earlier we had testimony with respect to the Materials Transportation Board placarding system of marking cars, railcars, whereupon when firefighters get on the scene they instanta-

neously know what is in the car. I gather from your recounting of the Abilene incident that there was inadequate placarding in that instance. Have you had any experience yourself in viewing the placarding used on the railcars?

Mr. LONG. I think that the intent of the placarding is great. As you know, there has been a problem as far as DOT is concerned in trying to establish a definitive system for placarding on the international level. There are two factions now that are talking and NFPA has set up a placarding system, internationally recognized.

Senator DURKIN. But DOT doesn't follow that standard.

Mr. LONG. That's right. But again, I think we should come up with some reasonable solution to this problem and the placarding is only as good as the people who apply that. You can't legislate morality. I understand that. But we have found in many instances that placards do not keep up with the system, in cases of shipments of different types of materials.

Senator DURKIN. I forget the exact incident—it might have been Waverly—but we had testimony that a chief was killed. The placard on the tank car was green, which I understand denotes to a firefighter that that is relatively safe material. It turned out to be anhydrous ammonia or something, some very volatile material. What is the frequency of inspections for an LEG facility by State officials in New Hampshire?

Mr. LONG. I would have to defer to the assistant mayor on that.

Senator DURKIN. You may supply that for the record, if you like, and also your views as to what is an acceptable minimum.

Mr. SPLAINE. The facilities are not inspected at all, that we know of. In fact the one biggest facility in the State is Sea 3, S-e-a–3, which is in Newington, N.H., which our rail line supplies, and our commissioner of highways who is chairman of the supposed committee that Governor Thompson has appointed, refers to it as C–3. I am not even sure that he has visited the location.

The rail lines, however, are supposed to be inspected once a week by B. & M., regularly by PUC, but we have only one inspector to cover all of the rail lines in the State from the PUC. His name is Walter King. I will get additional information to you, though.

Senator DURKIN. I know it was a cold winter not so long ago. Implicit throughout our deliberations is that the people of northern New England were fortunate that we had the Sea 3 plant during the curtailment of natural gas shipments. I think it should be clearly stated on the record that the Sea 3 plant came in very handy for New Hampshire schools, hospitals, industry, and homeowners. The concern of this committee is not to impact adversely on Sea 3. I think Commissioner Paul said it is a dangerous substance, yes, but it is one that we are going to have to use, transport, and store and provide liability insurance in the most economically reasonable manner until we find an alternative.

Mr. SPLAINE. It should also be added that Sea 3 in the seacoast area has been very cooperative with our traffic commission and all of our efforts to improve transportation.

Senator DURKIN. I gather that implicit in your statement is that the Federal Government is not doing an adequate job with respect to truck transportation of LEG, as well.

Mr. SPLAINE. Implicit in everything I am trying to say is that nobody is doing the adequate job that needs to be done and even though the Federal Government is a bureaucracy unto itself, it does have a unique ability to coordinate other bureaucracies and other administrations.

Senator DURKIN. That's what they teach us in civics 1 and 2, but with my 3 years in the Senate, I am not sure that is as manifest as it was to the civics teacher I had in high school. That's one of the major problems in Government today.

Just for the record, what has the State of New Hampshire done to reduce the hazards of LEG, and what has the city of Portsmouth done to reduce the hazards?

Mr. SPLAINE. What the city of Portsmouth has done, I included in the testimony which was presented to you. We have an ordinance which you have a copy of. Three years ago the State of New Hampshire helped us by voiding it. Instead of recognizing it, they voided our ordinance.

Senator DURKIN. Preempted it?

Mr. SPLAINE. That's another term, yes. They said that we didn't have the authority to regulate or control the shipments. We wanted to guarantee that an alternate route, similar to the suggestion here in Boston, that an alternate route would be utilized to transport the shipments, away from the population centers.

Senator DURKIN. Was that an opinion of the Attorney General, or was that a legislative enactment?

Mr. SPLAINE. That was a position of the Highway Commissioner John Clements, who was appointed by Governor Thompson. Irrespective of that, the State has now done the first thing that it has done to date. Last Friday a committee of sorts has been appointed, that Councilor Dudley referred to, a 13-member committee, 7 of which—7 members of which are people who are involved in the supply business. One is the State representative and two others are Portsmouth city officials. Perhaps something might be achieved through this committee, but irrespective of optimism, the fact of the matter remains that it is controlled by persons who might not necessarily be desirous of providing the kind of public margin of safety that the committee in Portsmouth, the traffic safety commission, has been trying to achieve. So obviously, State government in New Hampshire I think is not going to respond.

The Governor's efforts to try to get State coordination was defeated. It passed the Governor's council five to zip and it was vetoed by the Governor of New Hampshire. So as long as we have that kind of attitude of a lack of concern, the Federal Government and your committee, which I know has been very concerned about this because your staff has been working with us, must become involved. And that is why we are here today.

Senator DURKIN. I appreciate very much Councilor Dudley's and you and Chief Long's coming. I am a little disappointed that Commissioner Clement did not accept our invitation to testify, but on behalf of the committee and clearly for the record, I would invite the continued cooperation of the elected and appointed officials in Portsmouth and throughout the State of New Hampshire, the New Hampshire Fire Chiefs Association and the Governor's new committee. This

committee stands ready to work with all groups to resolve a problem that is bigger than any one segment of the working coalition. On behalf of the committee, I want to thank all of you for your time.

Christine Sullivan is ill and we wish her a speedy recovery. I understand there are two representatives to testify in her place. Your full statements will be included in the record. If you could paraphrase the high points, knowing full well your full statement will be included in the record, we would appreciate it.

STATEMENT OF CHRISTINE B. SULLIVAN, SECRETARY OF CONSUMER AFFAIRS AND CHAIRPERSON, ENERGY FACILITIES SITING COUNCIL, PRESENTED BY TOM KASTANOTIS; ACCOMPANIED BY PHILIP SHAPIRO, SITING COUNCIL STAFF

Mr. KASTANOTIS. My name is Tom Kastanotis. I am assistant to the secretary of consumer affairs, Christine Sullivan, who is also the chairperson of the State's energy facilities siting council. With me is Phil Shapiro who is a staff member of the siting council and who will be happy to answer with me any questions you have after the testimony. The testimony is brief and I would like to present it to you.

Mr. Chairman and members of the Committee on Commerce. Science and Transportation, I am delighted that you have taken the time to come to Boston to discuss the problems of liquefied natural gas and other liquefied energy gases. I hope you will take the message back to Washington that we in Massachusetts are disappointed in the lack of strict Federal standards governing siting of LNG storage facilities and truck transportation. I speak specifically of LNG because it is the LNG area in which we have the most experience.

We are disappointed for two reasons. First, Massachusetts relies on LNG more than any other State in the Nation. In Massachusetts there are 34 LNG storage tanks, one-third of the Nation's 104 storage tanks. More than two-thirds of all the trucks delivering LNG are driving through Massachusetts cities and towns.

Mr. Chairman, I do not want to cry wolf, but if there is going to be an LNG accident it will probably happen in Massachusetts—and it will probably be the result of negligence by the Federal Government. Why is this a Federal problem? Because the bulk of LNG traffic and sites are for interstate facilities.

We, as a State, have no legal jurisdiction over interstate commerce. Regulations applying to transportation of siting for interstate facilities have a valid application for the interstate facilities. As matters now stand, each State has different siting and transportation standards—a nightmare for the industry and for the consumer.

In addition, the department of public utilities and the department of public works enforce Federal and State transportation and siting regulations and may find themselves in the anomolous position of enforcing two separate sets of regulations. While the industry claims there is consistency within NFPA–59A, we believe that that standard is inadequate to protect the public safety. We are talking about a much tougher set of standards.

Mr. Chairman, we have personally called upon the Federal Government to adopt regulations governing the siting and transportation of

LNG. But year after year, the Federal Government refuses to do anything. Perhaps the best way to show the low levels of concern of LNG by the Federal Government is to supply this committee with some background information.

Almost 2 years ago, October 26, 1976, in testimony before the Federal LNG Interagency Import Task Force, we called for and showed the need for a clear Federal initiative toward adoption of specific safety standards for LNG terminals and for transportation and storage of LNG. Nothing happened.

By April 1977. doubtful that anything would be accomplished on the Federal level, the Massachusetts Energy Facilities Siting Council began work on regulations for siting intrastate LNG storage tanks. Coincidentally that same month the DOT's Office of Pipeline Safety Operation published its advance notice of proposed rulemaking on essentially the same topic.

Obviously, we would prefer Federal regulations, because they are not limited to intrastate storage tanks alone. But the continuous delaying and stalling by the Department of Transportation led us to believe that DOT has been attacked by an acute case of the bureaucratic mumbles and will delay action for years.

Therefore, we moved on our own and after 16 months of study, drafting and hearings the Massachusetts Energy Facilities Siting Council adopted the Nation's first thorough standards for siting and safety standards for LNG storage tanks. We took 16 months because we gave the industry three separate delays based on the hope that DOT would finally come forth with their regulations. However, the DOT, as of August 21, 1978, still has not even proposed a formal rulemaking hearing.

Mr. Chairman, we think a comparison of what the State and Federal Government has done highlights an interesting point. That is, if you want something badly enough, you can do it. If you don't think there is a problem and you don't want to do anything, you can stall and delay forever. I would hope that this committee, when it returns to Washington, will push DOT until you get what you want.

One way this committee can help end the delay by the Federal Government is by supporting the Dingell-Markey, H.R. 6844 bill which requires the DOT to promulgate final regulations within 180 days. This time mandate is crucial to any real step forward. The problem with the bill, however, is that although it requires DOT regulations, it does not deal with their substance. Therefore, continued oversight of the DOT is needed to make sure their regulations provide necessary safeguards. For that purpose, I am submitting into the record a copy of our newly enacted regulations with the hope that DOT may find them useful as a model for Federal action.

While our regulations represent a substantial advance, they alone are not sufficient. We need standard Federal regulations governing interstate facilities which are beyond State jurisdiction. We need standard Federal regulations governing interstate facilities which are beyond State jurisdiction and we need strong Federal oversight of LNG trucking and transport. We need a Federal mandate for liability insurance so that losses associated with LNG accidents are compensated adequately.

Finally, as we worked on our regulations, it became increasingly apparent that the issues of siting and transportation are so interrelated that no final satisfactory solutions can be found until that relationship is fully understood. Let me explain.

The siting council regulations deal almost exclusively with the siting of LNG facilities. Transportation to and from the site becomes a factor in site selection, but general transportation of LNG is really not a siting issue in these regulations because the council lacks jurisdiction in the area.

The GAO report, however, strongly recommends that no large LNG facilities be sited in urban areas. The council discussed placing a similar prohibition in its regulations but decided not to. The reason for this decision is the question of the risk of transportation versus the risk of the site. In other words, if you put an LNG storage tank far from an urban area and the gas in that tank is to be used in that urban area, would the increased trucking required to get the gas to the pipeline constitute a greater safety risk than siting the facility nearer to the pipeline and diminishing the amount of trucking required.

To my knowledge, no one has ever done this kind of risk analysis. I would therefore hope that the committee would require DOT to answer this critical question before final siting and transportation regulations are promulgated.

I appreciate the opportunity to testify before you today on this crucial issue, and we will now answer any questions you may have.

Senator DURKIN. Thank you. I think you raised an excellent point, whether remote siting is the real solution. We hope more work will be done on that. I share your concern and dismay with the Department of Transportation. I think it is obvious that their response has been, in the most charitable terms, inadequate. I would like to commend the State of Massachusetts for going as far as you have with your siting legislation and recognizing that some of the problems can only be resolved by expeditious action by the Congress. I think it is readily apparent that one agency has to have the primary responsibility.

It goes back to Aesop's fables. Two people have the responsibility and both think the other one has carried it out, and both blame the other one for failure.

The record will remain open, should you care to add any further thoughts, suggestions, or recommendations. We invite you to work with the Senate Commerce Committee, as we try to move as expeditiously as possible consistent with the complexity of the problem. We look forward to your continued cooperation.

[The statement follows:]

STATEMENT OF CHRISTINE SULLIVAN, SECRETARY, MASSACHUSETTS CONSUMER AFFAIRS

Ladies and gentlemen of the task force, I am grateful for the opportunity to appear before you today. My name is Christine Sullivan. I am Secretary of Consumer Affairs for the Commonwealth of Massachusetts and in that position I also am Chairman of the Massachusetts Energy Facilities Siting Council. In addition both the Department of Public Utilities and the State's Energy Policy Office are part of my Secretariat.

At the present time, Massachusetts and the rest of New England are caught in the grip of the highest energy prices in the nation. Since our area produces

negligible amounts of energy and we are located a great distance from the source of most domestic energy supplies, we have very little effective control over our source, level, or type of energy supply. This means we have little or no control or choice in the matter of price. We are at the very end of the national natural gas pipeline system. During shortages we are the first area affected and we suffor a disproportionate economic burden because of our poor bargaining position in trying to acquire the least expensive fuel supplies for Massachusetts consumers. Therefore, our ability to be assured of stable supply of energy takes on extreme importance.

Because of these and other factors, we in Massachusetts rely on LNG as much as any other state in the Nation. Understandably the questions raised here today will have a much more dramatic effect on the citizens of our Commonwealth than on those in other less intensively affected areas. For this reason, Governor Dukakis, Lieutenant Governor O'Neill, and officials throughout Massachusetts are vitally interested in the decisions made in this field.

I am not here to advise you as to the most appropriate volume of imported LNG supplies to our region or the Nation as a whole, but I would like to make you fully aware of our current situation. In New England, growth in natural gas distribution capacity is very heavily slanted toward LNG and particularly imported LNG. Should this development be curtailed, we would most likely be in a position where our needs would dictate importation of larger amounts of foreign oil products, and we would face the problem of conversion of some homes and industries now using natural gas to oil or liquified petroleum gas. In policy terms, the restricting of LNG imports and not oil imports will have little effect on furthering the goal of energy independence. We feel a combination of vigorous conservation, research and development, and judicious development of domestic supplies is a much preferable path to restrictions on imports. In Massachusetts, the demand for natural gas has outstripped the supply and the issue of whether or not and how much to import should be determined primarily by safety and price considerations.

The Massachusetts Energy Facilities Siting Council was recently created by the Legislature to review the long-range forecasts of all electric and natural gas companies operating in the Commonwealth. No power plant or major LNG facility may be built in the future unless it is part of a long-range energy forecast. The Council has the authority to rule on these supply and demand forecasts through an adjudicatory hearing process. All proposed facilities must be included in the five-year plans for the gas industry and ten-year plans for the electric industry, and these facilities are evaluated by the Council. We review a proposed facility to determine whether it provides a necessary energy supply with minimum impact on the environment at lowest possible cost. In carrying out this task our jurisdiction supercedes all other state and sub-state agencies and authorities. The Department of Public Utilities, also part of my Secretariat, is responsible for administering a detailed safety code governing the design, construction, and operation of these facilities.

LNG has long been a focus of controversy in Massachusetts. For instance, the question of whether LNG facilities should be located in the Boston urban area has been a public issue for many years. The Energy Facilities Siting Council is now holding hearings in the city of Fall River, Mass., on a proposal to locate an LNG storage facility in that city. This has become a major local and regional issue and the hearings have made it clear that there is a great deal of public distrust of industry and governmental decision making. The residents of that community, who question the adequacy of safety precautions, have fought the facility through the courts. The question of the Council's jurisdiction over the facility is now being adjudicated.

In addition, the Energy Facilities Siting Council has just issued its first approval of the contstruction of an LNG facility with our recent approval of a satellite LNG tank in Greenfield, Mass. In reviewing plans for the facility and in researching the area of standards and regulations, we have found that there is an alarming lack of guidelines and safety standards for the transportation of LNG and the siting of LNG facilities.

We all know that there are hazards which accompany the use of all fuels. Our primary concern is with the lack of governmental standards on vapor cloud dispersion. In this area the Energy Facilities Siting Council and the Department of Public Utilities share responsibility. In determinng the travel of an LNG vapor

cloud in the Berkshire Gas case, the company's consultant, Elizabeth M. Drake, assumed a "design accident" which would cause a spill into the diked area surrounding the tank. In this "design accident" the company set meteorological conditions under which vapor would travel farther than it would 95 percent of the time. The calculations estimated that the vapor under their original proposal would travel 235 feet before becoming harmless. In this instance homes and public roadways were within 110 feet and could have been the scene of disaster for individuals in the adjacent private homes or in automobiles. The Company agreed to the application of a layer of concrete to the dike to a level sufficient to contain the maximum possible liquid volume level of the tank. These provisions indicated that the vapor cloud would travel 70–80 feet before becoming harmless and therefore would be contained on the LNG site.

This was done on a one time *ad hoc* basis. Neither the Council nor the Department of ublic Utilities have any comprehensive standards to protect individuals and property from LNG accidents. We have relied on testimony on consultants in this case. But we feel strongly that siting guidelines should be developed before the next large facility is proposed. It is difficult for a state independently to develop comprehensive guidelines in the LNG Safety area. The expertise and cost necessary would strain our modest resources. We have found no Federal Standards in this area. In our deliberations we have accepted a design based in part on the National Fire Protection Association Code prepared by a non-governmental body and in part on the judgment of a consultant hired by the applicant. For the Council and Massachusetts Department of Public Utilities to have to accept non-governmental standards and *ad hoc* judgments such as these, puts us and, I am sure, many other agencies in the position of having to make decisions in the public interest with no nationally set and accepted standards. This situation is clearly not in the best interests of those we represent. We intend to continue improving our review process at the state level regardless of what happens on the Federal level, but it is also vital for "the Federal Government must come to grips with the safety problem. Problems in this area are shared by all states involved in the use of natural gas. It is clearly of national magnitude and legitimately a matter of a Federal responsibility."

Neither of the agencies that I am associated with has been called upon to consider seriously the implication of water-borne transportation of LNG. This may be the single most important safety issue that we need to face. I personally do not know whether LNG should be shipped in large quantities into highly populated areas, but I know this question must be answered and answered soon.

We want to see a clear Federal initiative toward adoption of specific safety standards for LNG terminals and for the transportation and storage of LNG. I expect that the form and policy approach of these deliberations would be submitted to the interested states prior to any substantive work. I believe this effort on adoption of standards for LNG safety can be accomplished. I feel that it can only be successful, however, if it is undertaken in an open, public manner, without hint of influence. Regulations must not only be adequate to deal with the problems of LNG but also, just as importantly, they must meet the public's criteria for protection of the public interest. This whole process and these proposals must assure the public that the safety and welfare of individuals is the crucial consideration in establishing the criteria.

Because government ignored serious safety considerations for too long, the very future of nuclear power is in doubt at a time when the only near-term alternative is massive coal development with severe adverse environmental and, perhaps, economic consequences. Bitter battles concerning virtually every proposed plant, along with redesign to take new safety considerations into account, and indecisive regulatory bodies have all led to expensive delays without leading to better siting and design decisions.

If we do not act quickly and credibly to develop better LNG criteria, LNG development will suffer the same fate as nuclear power, and we will all bear the consequences. I do not believe anyone in this room would like to see LNG siting procedings become a battlefield similar to what nuclear power development is in many areas today. I am including for the record our Berkshire Gas Decision and the related consultant testimony.

Again thank you for this opportunity to appear and I welcome any questions you might have.

SITE SIZE REQUIREMENTS OF EFSC PROPOSED GUIDELINES FOR THE SITING OF LNG STORAGE FACILITIES

CONSULTANT'S REPORT

AUGUST 16, 1978.

(Commonwealth of Massachusetts—Energy Facilities Siting Council)

CHAPTER K—REGULATIONS FOR THE SITING OF INTRASTATE LIQUEFIED NATURAL GAS STORAGE FACILITIES

PART 85 GENERAL PROVISIONS

Rule 85.1 Scope and purpose

This chapter implements the Siting Council's statutory mandate under G.L.c. 164, §§ 69 H, I, J and sets forth regulatory standards for the siting of intrastate liquefied natural gas (LNG) facilities proposed for construction in Massachusetts. This chapter includes forecast data requirements and siting standards.

The purpose of this chapter is to ensure systematic review of information which is necessary for the Council's determination of need, cost, and acceptable environmental impact.

This chapter includes performance standards for thermal radiation and flammable vapor dispersion in the event of specified design accidents which define acceptable site size, radiation, and environmental impact. Requirements set forth in this chapter are in addition to requirements of chapters E, G, and J of the Council's regulations. In the case of conflict, this chapter shall govern in the final instance.

Nothing in this chapter is to be construed as an infringement upon the authority of the Department of Public Utilities to assure safe and prudent design, construction, operation, and maintenance of LNG facilities. Where an applicant is required to obtain licensing or permit approval from the Council and the Department of Public Utilities, it is encouraged to seek joint review by these agencies.

Rule 85.2 Definitions

(1) *General Definitions—*

As used in this chapter:

"*Accepted method of calculation*" means a formula or technique which is specified in these guidelines or which has been approved by the Council through a rulemaking proceeding.

"*Dike*" means a structure surrounding an LNG storage tank which may consist of natural geological formation, compacted earth, concrete, or other material and must be of sufficient size to contain a minimum of 150 percent of the maximum liquid content of the tank.

"*Industrial zone*" means an area zoned for industrial use or an unzoned area shown by the company to be currently used primarily for industry.

"*Insulating material*" means a substance which may be applied to the external wall of the storage tank and/or dike surfaces and whose properties will decrease the rate of vaporization in the event of a spill.

"*Site*" means the area owned or controlled by the operator surrounding the LNG storage tank; has a minimum size equal to the greater of the required thermal protection zone or vapor dispersion exclusion zone.

"*Thermal protection zone*" means an area which the operator owns or controls surrounding the LNG storage tank; this zone must be of sufficient size such that in the event of a fire resulting from a spill, thermal flux levels at the outer boundary may not exceed those specified in these regulations.

"*Vapor dispersion exclusion zone*" means an area which the operator owns or controls surrounding an LNG storage tank; this zone must be of sufficient size such that in the event of a spill, no flammable vapor having an average gas to air concentration of more than 2 percent will travel beyond the zone's outer boundary.

(2) *Matrix Factor Definitions—*

(a) *Capital Cost Factors:*

"*Land acquisition*" includes cost of acquiring land, land rights, permits, approvals and associated legal fees.

"*Site preparation*" includes soil testing, clearing, grading and underground piping, water supply, and electrical supply to the site.

"*Structures and improvements*" includes structures associated with LNG processing operations, fencing and roadways.

"*LNG processing equipment*" includes the installed cost of equipment used to receive, liquefy, hold and regasify LNG for delivery into the operator's distribution system.

"*LNG transportation facilities*" includes the initial cost of connecting mains and transportation equipment.

"*Other equipment*" includes measuring and regulating equipment, compressor station equipment, communication equipment and equipment not assignable to any of the foregoing factors.

(b) *Annual Cost Factors:*

"*Operating expenses*" includes labor; expenses; materials and supplies for engineering, processing and transporting LNG; depreciation, gas purchases, fuel, power, property taxes and gas losses.

"*Maintenance expenses*" includes labor, expenses, materials and supplies for maintenance of land, structures and improvements, processing equipment, transportation facilities and other equipment.

(c) *Environmental Factors:*

"*Ease of acquisition*" includes information on number of parcels to be assembled, present land use, projected land use, number of land owners, type of land owner (governmental, corporate, private, etc.), estimated land value, current zoning. (Appropriate Data Source: Municipal tax map, Municipal zoning map.)

"*Climatology*" includes information on precipitation, temperature, and prevailing winds. (Appropriate Data Source: U.S. Weather Service Climatological Summary.)

"*Geology*" includes soil type, depth to bedrock, soil permeability, seismic design criteria. (Appropriate Data Source: U.S. Soil Conservation Service, U.S. Geological Survey.)

"*Hydrology*" includes permeability, depth to groundwater, location of surface water, location of aquifers, location of flood plains, water quality classifications of contiguous surface water. (Appropriate Data Source: U.S. Geological Survey Soil Conservation Service, Commonwealth of Massachusetts Department of Environmental Quality Engineering, U.S. Department of Housing and Urban Development Flood Plain Zoning Maps.)

"*Transportation access*" includes verbal or pictorial description of primary access routes to proposed sites. (Appropriate Data Source: Massachusetts Department of Public Works, Town Maps, U.S. Geological Survey Quadrangle Maps.)

"*Ecological sensitivity*" includes an estimate of the uniqueness of the area as a habitat, possibility of the presence of rare or endangered species of plants or animals resulting from a review of 50 CFR 17, the List of Endangered & Threatened Wildlife & Plants, estimate of the amount of site which will be permanently altered. (Appropriate Data Source: MacConnell Cover Maps, Massachusetts Department of Environmental Management, U.S. Fish & Wildlife Service.)

"*Socioeconomics*" includes projection of land use, expected property tax payments, employment opportunities, air quality and recreational opportunities both with and without the proposed projects. (Appropriate Data Source: Town zoning maps. Regional Planning Commission, Office of State Planning, Air Pollution Control Districts, Massachusetts Regional Statistical Profiles, Massachusetts Department of Commerce.)

"*Special resource commitment*" includes description of any special resource which will be impacted by the proposed facility. (Appropriate Data Source: Regional Planning Commission.)

"*Other*" includes description of unique features of the site not covered by any of the other matrix factors.

PART 86 FORECAST DATA REQUIREMENTS

Rule 86.1 Facility need requirement

The applicant shall provide a statement of need which will consist of:

(1) a description of the ways in which the applicant's existing facilities will not be adequate to serve the requirements forecasted;

(2) a description of the ways in which all other "no-build" alternatives and other supply alternatives such as pipeline system expansion, SNG, propane, etc. considered by the applicant would not be adequate and preferred to serve the requirements forecasted; and

(3) for two or more sites, at least one of which must be in a nonurban area, a description of how the facility/site proposed will be used to meet the requirements forecasted.

Rule 86.2 Mapping requirements

(1) The applicant shall provide a map or series of maps of the preferred site and all alternative sites proposed which show the following at a useful scale:

(a) location of property;

(b) property boundaries and dimensions;

(c) major existing structures and equipment on the property;

(d) location of the following zones:

(i) 2,000 BTU/ft^2 hr zone;

(ii) 1,000 BTU/ft^2 hr zone;

(iii) 460 BTU/ft^2 hr zone; and the

(iv) vapor dispersion zone.

(e) anticipated location and dimensions of the storage tank, new ancillary facilities, and dike;

(f) topography of the site out to and including the most distant zone specified in Rule 86.2(1)(d);

(g) current zoning scheme out to and including the most distant zone specified in Rule 86.2(1)(d);

(h) special land uses including agricultural land, parks, forests, recreational areas, and areas designated by a governmental agency for protection as natural preserves or historic or scenic districts out to and including the most distant zone specified in Rule 86.2(1)(d);

(i) location of all hospitals, schools, nursing homes and churches, and places of outdoor assembly out to and including the most distant zone specified in Rule 86.2(1)(d);

(j) surface water and groundwater resources out to and including the most distant zone specified in Rule 86.2(1)(d);

(k) population densities out to and including the most distant zone specified in Rule 86.2(1)(d);

(l) alternative truck routes from exit of nearest highway to site, showing local street names, bridges and elevated roadways, underpasses and tunnels, unpaved roads, and all locations on these routes requiring the exercise of additional caution. Information proved here should also include a general demographic description of the area through which these routes will pass;

(m) nearby gas pipelines and point of interconnection for new facility;

(n) sewers, subway tunnels, drainage systems, underground electrical systems, and all other underground conduits out to and including the most distant zone specified in Rule 86.2(1)(d) as well as for all truck routes specified in Rule 86.2(1)(d).

(2) The applicant shall provide a system map, showing location of preferred and alternative sites.

Rule 86.3 Demonstration of conformity with siting standards

(1) The applicant shall demonstrate quantitatively that the preferred site and all alternative sites meet each siting standard contained in Part 87.

(2) All such demonstrations must be based upon the methods of calculation specified in Part 87.

Rule 86.4 Alternative sites evaluation matrices

(1) Purpose: The purpose of the evaluation matrices is to provide a means by which the applicant can demonstrate, in a standardized way, the bases upon which the preferred site was chosen from among the alternative sites proposed.

(2) Methodology: (a) Cost matrices—

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(i) The cost matrices shall be assembled as follows:

FIGURE 1

CAPITAL COST MATRIX

Factors	Site A	Site B
Land acquisition		
Site preparation		
Structures and improvements		
LNG processing equipment		
LNG transportation facilities		
Other equipment		
Total		

FIGURE 2

ANNUAL COST MATRIX

Factors	Site A	Site B
Operating expenses		
Maintenance expenses		
Total		

(ii) Current dollar figures shall be estimated for each cost item.

(iii) The cost matrices must be accompanied by a narrative explaining the sources of the estimated cost figures.

(b) Environmental Matrix—

(i) The environmental matrix should be assembled as follows:

FIGURE 3

ENVIRONMENTAL MATRIX

Factors	Comparative rating	
	Site A	Site B
Ease of acquisition		
Climatology		
Geology		
Hydrology		
Transportation access		
Ecological sensitivity		
Socioeconomics		
Special resources commitment		
Other		

(ii) The ratings should be based upon the total number of sites proposed (number of sites=n). The most preferred site for each factor should receive a rating of n. The site preferred next should be rated $n-1$, and so forth.

(iii) Reconnaissance level data may be employed in constructing the environmental matrix, including existing studies and reports completed by public or private agencies. If such sources are not available or adequate, site analyses must be conducted.

(iv) The environmental matrix shall be accompanied by a narrative which references the sources of the data used for each factor and an explanation of how these data were used to arrive at the relative rating for each proposed site.

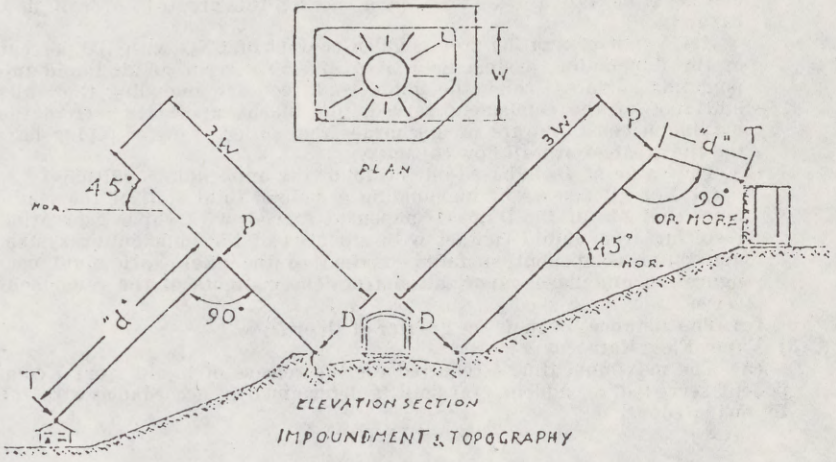
(3) Summary of Alternative Sites: The applicant must synthesize from the matrices the comparative cost and environmental data for each alternative site, and discuss, in detail, the bases upon which the preferred site was selected over the other proposed site or sites.

Rule 87.1 Thermal radiation protection

(1) The area of the property must be sufficiently large to provide a thermal protection zone.

(2) Within the protection zone, the dike constructed to impound the LNG may not be located closer to targets listed in paragraph (4) of this section than distance *d*.

(3) The protection distance *d* is measured as shown in FIGURE 4 along the line *PT* in a vertical plane defined by the points *T* and *D*, where *T* is a point at the top of the target; *D* is a point closest to *T* on the top inside edge of the dike; *PD* is a line in the vertical plane which intersects *D* at an angle of 45° above horizontal; *w* is the inside distance across the top of the impounding space measured normal to *PD*; and *P* is located where *PT* and *PD* intersect at an angle of 90° or where *PD* equals 3*W*, whichever results in the shortest length of *PD*.



(4) The length of a protection distance in feet may not be less than the distance *d* determined in accordance with the following formula for the target concerned, when *A* equals inside area in square feet measured across the top of the impounding space:

Target	*Protection distance*
(a) Any point in an area outside the property line which is not zoned for industrial use	$d=3.6(A)^{0.5}$
(b) Any point in an area outside the property line which is zoned for industrial use	$d=2(A)^{0.5}$

(5) For any facility which depends upon surrounding industrially-zoned land for compliance as provided in Rule 87.1 (4), the applicant must conduct a safety consultation session with the local planning board and with each owner of land in the affected portions of the surrounding industrial zone. Prior to conducting safety consultations, the applicant must confer with the Department of Public Utilities on the scope and content of the safety consultation sessions. The applicant must give notice to the Department of Public Utilities that such consultations have been completed prior to the transfer of any LNG to the site or processing of LNG at the site.

(6) The method described in Rule 87.1 (3) and (4) shall be the accepted method of calculation of the thermal protection distance. Any interested party may request a rulemaking procedure to qualify an additional method of calculation. No facility may be evaluated using a new method of calculation unless the method has been submitted to the Council six months prior to the filing of the forecast containing the facility proposal, and unless that method is approved and accepted by the Council prior to the filing of the forecast containing the facility proposal.

Rule 87.2 Vapor dispersion exclusion zone

(1) Zone Requirement: Each LNG faciilty shall be designed to prevent flammable vapor from a design spill as defined in Rule 87.2 (2) from crossing the property line. The boundary of the vapor dispersion exclusion zone will be determined by the minimum exclusion distance computed in accordance with this section. The vapor dispersion exclusion zone will be determined by a standard at the property line of an average gas to air concentration of no more than 2.0 percent. The boundary or estimated dispersion distance D is measured radially from the inside edge of the imopunding system along the ground contour to the vapor dispersion zone boundary.

(2) Design Accidents for the Calculation of Dispersion Distance D: In computing dispersion distance D under paragraph 4 of this section, the following applies:

(a) The value of D_1 is the lesser of the values resulting from the following vapor generation conditions:

(i) Vapor generation rate equals the maximum constant rate of discharge from failed transfer piping having the greatest overall flow capacity.

(ii) Vapor generation from sudden contact of LNG with 100 percent of the impounding system floor area and 50 percent of all liquid impounding surfaces which the liquid could contact, including the walls and roof of the component served, plus flash vaporization from the maximum constant rate of discharge from failed transfer piping having the greatest overall flow capacity.

(b) The value of D_2 is based on the following applicable conditions:

(i) For all classes of impounding a sudden total spill of the maximum contents of the largest component served, with vapor generation resulting from liquid contact with surfaces of the impounding system and outer component surfaces exposed to the final static fluid configuration and flash vaporization from the contents of the component served.

(c) The distance D equals the greater of D_1 or D_2.

(3) Vapor Flow Rate:

(a) The maximum time t required for the release of liquid from a component served in a sudden total spill is determined in accordance with the following equation:

$$t=9(h/G)^{0.5}$$

where t is the time, h is the difference between the maximum height in feet of the contained liquid and the equilibrium height of liquid when impounded, G is the acceleration of gravity.

(b) Impounding and other surfaces which may be contacted by LNG under conditions described in the preceding paragraphs 2(a) and 2(b) may be insulated. The heat transfer value and application technique of the proposed insulating material must be satisfactory to the Department of Public Utilities. The boiling rate of LNG on which D is based, is determined by multiplying 0.9 times the weighted average value of $KPC^{0.5}$ determined from eight representative experimental tests on the contact surfaces in the impounding space, where

K=thermal conductivity in (BTU/(HR) (ft) (°F)),

P=density in (1 lb/ft.^{3}), and

C=heat capacity in (BTU/(lb) (°F)).

The test conditions should vary in terms of the spills' elevation, velocity, and quantity.

(c) Dispersion distance D is determined on the basis that vapor detention space does not exceed:

(i) For conditions described in paragraph 2(a)(ii) of the preceding section, all space provided for liquid impoundment and vapor detention outside the component served; and

(ii) For conditions described in paragraph 2(b)(i) of the preceding section, all space provided for liquid impoundment and vapor detention outside the component served less the volume of the liquid that would have entered the impounding space when generating vapor escapes the vapor detention barriers, assuming liquid to be entering the impound-

ing space outside the component served at a constant rate over the time period prescribed by paragraph 3(a) of this section.

(4) Calculation of Vapor Dispersion Distance: The boundary or estimated dispersion distance D must be calculated in accordance with the applicable parts of Appendices A, B, and C of the publication, "Evaluation of LNG Vapor Control Methods' (American Gas Association, Arlington, Va., 1974), subject to the following parameters and other requirements of this section:

(a) Average gas concentration in air is 2.0% by volume.

(b) Wind speed w is 5.0 miles per hour.

(c) Source height H is zero.

(d) Source width L is $A^{.5}$, where A is the inside area measured across the top of the impounding space, as in Rule 87.1(4).

(e) The Gifford-Pasquill atmospheric stability category is F (moderately stable).

(f) The temperature of the impounding and storage vessel surface is 47° C.

(5) Additional Methods of Calculation: The method referenced in Rule 87.2 (4) shall be the accepted method of calculation of the vapor dispersion distance. Any interested party may request a rulemaking procedure to qualify an additional method of calculation for vapor dispersion. No facility may be evaluated using a new method of calculation unless that method has been submitted to the Council six months prior to the filing of the forecast containing the facility proposal, and unless that method is approved and accepted by the Council prior to the filing of the forecast containing the facility proposal.

PART 88 ANCILLARY REQUIREMENTS

Rule 88.1 Dike requirements

1. Each storage tank must be located in a separate dike which has a configuration or design which will—

(a) prevent liquid from escaping under the spill conditions defined in Rule 87.2(2) (a) and (b).

(b) intercept a jet of liquid discharged from any feasible location of the component served and at any predictable vertical and horizontal angle of exit and resulting trajectory, except that for low pressure storage tanks having multiple conventionally built vertical cylindrical walls with at least two such walls having full load bearing capability, vertical angles of discharge above the horizontal need not be considered.

2. The basic form of the dike may be an excavation, a natural geological formation, manufactured diking, any combination thereof, or any other retaining structure which can be demonstrated to meet the other requirements of this section.

3. The impoundment capacity of each dike must have a minimum volumetric liquid impoundment capacity equal to 150 percent of the volume of liquid in the tank.

Rule 88.2 Separation of components

The applicant must design and construct the storage tanks at the site as required by the Department of Public Utilities to enable the predictable movement of personnel, maintenance equipment, and emergency equipment within and around the facility.

Rule 88.3 Inspection of insulating material

The integrity of the insulating material and sealant at each facility must be certified yearly by a registered professional engineer. The results of such inspections must be provided to the Department of Public Utilities as required by that agency. If the insulating material fails to meet the inspection standards, the Department of Public Utilities may order the repair or replacement of the material with the same or superior insulating characteristics as the material originally installed.

Rule 88.4 Plan for removal of precipitation

The applicant must present a plan for the removal of rain, ice, and snow from the diked area surrounding the storage tank. The plan must provide for completion of snow removal within 48 hours after the commencement of the snowfall.

Rule 88.5 Safety plan

The company must submit a coprehensive safety plan describing actions to be taken by company personnel and public safety officials in the event of any accident as well as a program of yearly safety consultations with each property owner within the affected portion of the industrial zone. These consultations will be conducted as prescribed by the Department of Public Utilities. The purpose of this requirement is to ensure the maintenance of necessary levels of information and preparedness for those persons who are within the affected portion of the industrial zone.

Rule 88.6 Alarm system

Each facility must be equipped with an alarm system which must be sounded simultaneously with the alerting of the fire department of an accident. The alarm system must be sufficiently loud to alert persons out to and including the most distant zone specified in Rule 86.2 (1) (d). The company shall notify the Council that this system is operational and that persons within that zone have been acquainted with the system. The alarm system shall be installed and periodically tested as may be required by the Department of Public Utilities.

SUMMARY AND CONCLUSIONS

The proposed EFSC guidelines for the siting of LNG storage vessels include provisions for determining minimum distances between the impounding system and the property line of a proposed site. This report develops an analysis of those provisions which permits determining the minimum site area needed as a function of the volume of LNG to be stored. The analysis provides for the protection against thermal radiation hazard and dispersion of combustible vapor, as specified in the guidelines, for releases of LNG within the impounding space in accordance with specified design accidents.

The report determines the minimum site areas and the optimum proportions of the impounding system for storage volumes between 55,000 and 13,000,000 gallons of LNG. When the impounding systems are thermally insulated, these minimum site areas lie between 4 and 44 acres for the storage volumes considered. These areas are not significantly changed if the storage vessel exterior is not insulated or if 10% of the dike floor insulation fails.

Insulating the surfaces of the impounding system very substantially reduces the rates of formation of LNG vapor in an accidental release and leads to the much reduced site areas previously noted. The use of tall dike walls to enclose a large hold-up volume for vapor evolved from a spill also aids in reducing site size. The analysis shows that the optimum (but unconventional) proportioning of the impounding system design is required if these minimum site areas are to be qualified under the proposed guidelines.

1.1 Introduction

The Energy Facilities Siting Council (EFSC) is considering the establishment of guidelines for the siting of LNG storage vessels. In part, its proposed guidelines require a minimum distance between a storage vessel and the property line of the site based upon consideration of safety from fire hazard of persons and property off site. The specification is technical in nature, but a consequence of applying such a guideline will be the limitation of the minimum site area which will be needed to satisfy these safety requirements. The purpose of this analysis is to determine what minimum site area will be required as a function of the volume of LNG stored on the site and to indicate what design features of the storage vessel and its impounding system will be needed to minimize this site area.

The draft guidelines determine, by means of a calculation, the minimum radial distance from an impounding system wall to the nearest point of the site boundary for each of two categories of hazard: thermal radiation from a fire within the impounding system and dispersion by wind motion of inflammable vapor from an LNG spill within the impounding system. Naturally, the larger of these two distances will control the minimum site area since protection must be afforded for both hazards. These guidelines implicitly set forth a performance standard at the site boundary, that is, an upper limit of a hazard (thermal radiation intensity or combustible vapor concentration) which should not be exceeded following an accidental spill by virtue of selecting a site sufficiently

large with respect to the volume of LNG stored within it. Because the intensities of the hazardous effects decrease with distance from the impounding system (other things remaining the same), site size provides a method of reducing such hazards to an acceptable level in regions surrounding the storage site.

The ensuing analysis considers the determination of the minimum distances to the site boundary for a prototype LNG storage vessel (whose height is equal to its diameter), as a function of the volume stored. Its purpose is to estimate the minimum site area which will be needed for an LNG storage site so that the effects on land use needs of adopting the guidelines can be foreseen by the EFSC. Any particular design, which will not necessarily be identical to the prototype, may require somewhat less or more area, depending upon the design parameters. The prototype impounding system design has been optimized to minimize the site area, however, so that much smaller sites are not likely to qualify under the guidelines.

The extent of the safety hazard is related to the characteristics of the storage vessel and its impounding system and the amount or rate of release of LNG accidentally discharged from the storage vessel into the impounding system. The guidelines consider two design accidents as specifying this release of LNG: a failure of the transfer piping and a rapid (but not instantaneous) release of the full contents of the storage vessel into the impounding system. Each design accident affects the vapor dispersion distance in a different way, but the thermal protection distance is unaffected by the nature of the design accident.

The determination of the vapor dispersion distance, or the minimum distance from the impounding system to the site boundary which will prevent flammable vapor from drifting beyond it, is primarily affected by the amount of surface area of the impounding system which is exposed to LNG in a design accident, the thermal properties of that surface, and the volume within the impounding system which can fill up with vapor early in the spill history (thereby limiting the maximum loss rate of vapor which occurs when it first escapes from the impounding system). The proposed guidelines permit the use of thermally insulating surfaces on the exterior of the impounding system and the storage vessel in order to minimize the vapor dispersion distance (and hence site area).

Thermal radiation intensity at the site boundary is limited implicitly to 2,000 or 1,000 BTU/ft^2 hr depending upon whether or not the land use exterior to the site is zoned for industrial use. In either instance, the separation distance of the site boundary from the impounding system is simply related to the size of the latter.

Appendix A describes scientific data on the response of human skin to radiant heating. It has been added as background information.

Sections 2–4 of this report set forth the basic principles of the analysis used in determining the relation between the storage facility characteristics and the site size. In section 5 the site sizes for a set of storage vessel volumes between 55 000 and 13,000,000 gallons are determined for the optimum proportions of the impounding system when the latter is fitted with a thermally insulating surface.

2.1 Prototype storage system

For the purpose of the site area analysis, a prototype LNG storage vessel/impounding system is used. The cylindrical storage vessel of volume V has a diameter D and a height equal to its diameter. Thus the storage volume is

$$V = \pi D^3/4 \tag{2.1.1}$$

The impounding system consists of a concentric cylindrical impounding wall of diameter βD and height αD, (where $\beta \geq 1$ and $\alpha \leq 1$), the floor of the impounding system being at the same level as the floor of the storage vessel. Since the volume of the impounding system should exceed that of the containment vessel by 50%,

$$\frac{\pi}{4}(\beta^2 D^2)(\alpha D) \geq \frac{3\pi}{8} D^3$$

or

$$\beta^2 \alpha \geq 1.5 \tag{2.1.2}$$

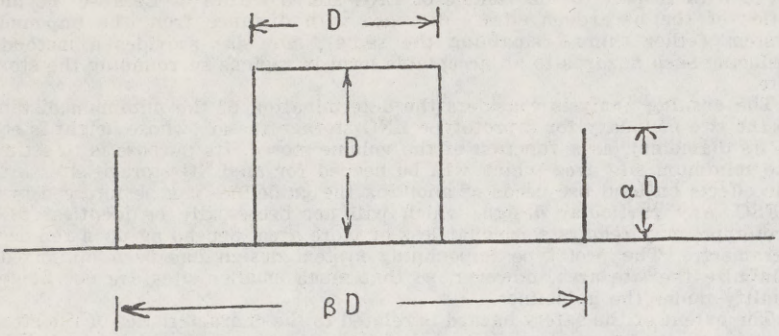


FIGURE 2.1.1

A sketch of the prototype vessel and impounding system is given in Fig. 2.1.1.

3.1 Vapor concentration and vapor dispersion distance

The guidelines specify that the vapor concentration should not exceed 2% by volume at the site boundary when calculated according to the method given in Appendices A, B, and D of the report, "Evaluation of LNG Vapor Control Methods" (American Gas Association, Arlington, VA. 1974). Accordingly, the concentration fraction c would be:

$$c = \frac{Q}{wv}\left(\frac{2}{\pi}\right)^{1/2} \frac{erf\left\{\dfrac{w}{2\sqrt{2}\sigma_y}\right\}}{\sigma_z} \tag{3.1.1}$$

where

Q=volume flow rate of vapor out of the impounding system, considered as pure vapor at atmospheric temperature and pressure (m^3/s)

w=effective width of impounding system, or $0.886\ \beta D\,(m)$

v=wind speed of 5 miles per hour (2.235 m/s)

$\sigma_y \sigma_z$=horizontal and vertical standard deviations, respectively, for Gifford-Pasquill atmospheric stability category F, as a function of distance d downwind from the impounding system wall m.

Equation (3.1.1.) must be solved implicitly for the vapor dispersion distance d which will result in a concentration c of 0.02. Using this value of c, d can be found from:

$$\frac{\sigma_z}{erf\left\{\dfrac{0.313\ \beta D}{\sigma_y}\right\}} = \frac{20.15\ Q}{\beta D} \tag{3.1.2}$$

in SI units.

3.2 Unit vaporation rate from contact of LNG with solid surfaces

It is assumed that the mass rate of evaporation per unit area $\dot{m}$ when LNG is suddenly placed in contact with a solid surface is limited by the rate of transfer of heat from the solid to the liquid at its boiling temperature. At a time t after initial contact, this rate is given by:

$$\dot{m} = \frac{\Delta\tau}{h_v}\left(\frac{k\rho c}{\pi t}\right)^{1/2} \tag{3.2.1}$$

where

$\Delta\tau$=temperature difference between the boiling point of LNG (−162°C) and the surface (47°C), or 209°C

h_v=heat of vaporization of LNG, or 5.1×10^5 j/kg

$k\rho c$=product of thermal conductivity and volumetric heat capacity of the substrate, averaged over the temperature change ($j^2/m^4\ s[°C]^2$)

For comparison with experimental determination of boiling rates on different surfaces, Eq. (3.2.1.) may be written as:

$$\dot{m} = Kt^{1/2} \tag{3.2.2}$$

where K is an empirical constant having the SI dimensions of $Kg/m^2\ s^{1/2}$. In engineering units, 1 $Kg/m^2\ s^{1/2}$ = 12.29 $lb/ft^2\ hr^{1/2}$).

Tests on insulating concrete of 35 lb/ft^3 density give a value of 0.9 $lb/ft^2\ hr^{1/2}$ (0.0732 $Kg/m^2\ s^{1/2}$) for K. The corresponding value of $(k\rho c)^{1/2}$ is 1 $Btu/ft^2\ hr^{1/2}$ (341 $j/m^2\ °C\ s^{1/2}$). This value of K will be used in subsequent calculations as typical of insulated surfaces.

For ordinary concrete and carbon steel respectively, K has values of 3.75 and 34.9 $lb/ft^2\ hr^{1/2}$. Dry soil has about the same value of K as concrete. These values will be used subsequently for uninsulated surfaces.

3.3 Vapor flow rate from failed transfer piping—flow rate limit

The rate of flow of LNG through the transfer piping is determined by operating requirements. It may be desirable to fill or empty the storage vessel quickly so as to load (or unload) transportation vehicles or to supply vapor to a pipeline. We will characterize the maximum transfer piping flow rate by specifying the time τ needed to fill the storage volume V $(=\pi D^3/4)$ with LNG when transferring at the maximum flow rate. The maximum vapor volume flow rate Q to be used in Eqs. (3.1.1.) or (3.1.2) thus becomes:

$$Q = \frac{\rho_l(\pi D^3)}{4\,\rho_n \tau} \tag{3.3.1}$$

where

ρ_n = vapor density at atmospheric pressure and temperature (21°C), or 0.666 Kg/m^3

ρ_l = LNG density, or 425 Kg/m^3

τ = filling time (s)

In SI units, Eq. (3.3.1) becomes:

$$Q = 501.2\ D^3/\tau \qquad (m^3/s) \tag{3.3.2}$$

In subsequent calculations, τ is assumed to be 24 hours (8.64×10^4 s), so that Q becomes:

$$Q = 5.8\times10^{-3}\ D^3 \qquad (m^3/s) \tag{3.3.3}$$

When the vapor flow rate is limited by heat transfer, a lower value of Q should be used, as determined in Section 3.4 following.

3.4 Vapor flow from failed transfer piping—heat transfer limit for insulated insulated tank and impounding system

The vapor flow out of the impounding system from failed transfer piping might be less than the maximum rate calculated above in Section 3.3 when there is insufficient heat transfer area to vaporize the LNG at a rate equal to its escape rate from the piping failure. To determine the volume flow rate Q of vapor over the top of the impounding system wall we must consider both the area exposed to LNG released in the transfer piping failure and the volume of vapor help up within the impounding system between the time of onset of LNG release and the time when vapor first flows over the top of the impounding system wall.

For the transfer piping failure, the proposed guidelines specify that all of the floor area of the impounding space and one half of the remaining area of the impounding system and the external tank surface constitute the effective area A for heat transfer. For the prototype system, A becomes:

$$A = \frac{\pi}{4}(\beta^2-1)D^2 + \frac{1}{2}\left\{\pi\alpha\beta D^2 + \frac{\pi D^2}{4} + \pi D^2\right\}$$

$$= \frac{\pi D^2}{4}\left\{\beta^2 + 2\alpha\beta + \frac{3}{2}\right\} \tag{3.4.1}$$

Assuming the volume of LNG discharged in a transfer piping failure is small compared with the volume of the impounding system, the volume V_v available for hold up of vapor within the prototype impounding system is:

$$V_v = \frac{\pi}{4}(\beta^2 - 1)\alpha D^3 \tag{3.4.2}$$

We now consider the time t_f required to fill the volume V_v with vapor. At any time, the mass of vapor M which has been evolved since the beginning of the spill is:

$$M = A\int_0^t \dot{m}\,dt$$

$$= 2AKt^{1/2} \tag{3.4.3}$$

by use of Eq. (3.2.2). If, at time t_f, the volume V_v is completely filled with vapor at a density ρ_v ($=1.8$ kg/m^3) then

$$2AKt_f^{1/2} = \rho_v V_v \tag{3.4.4}$$

At the same time t_f, the mass rate of evaporation mA is equal to the mass flow rate $\rho_n Q$ over the top of the impounding system:

$$\rho_n Q = KAt_f^{-1/2} \tag{3.4.5}$$

Combining Eqs. (3.4.4) and (3.4.5) to eliminate t_f,

$$Q = \frac{2K^2A^2}{\rho_n \rho_v V_v} \tag{3.4.6}$$

Substituting the values of A and V_v given by Eqs. (3.4.1) and (3.4.2) for the prototype system into Eq. (3.4.6), we find that Q becomes

$$Q = \frac{\pi K^2 D\{\beta^2 + 2\alpha\beta + 3/2\}^2}{2\rho_n \rho_v(\beta^2 - 1)\alpha} \tag{3.4.7}$$

Examination of Eq. (3.4.7) shows that there will be an optimum value of β and α which will minimize Q, and hence the vapor dispersion distance d. For this optimum, the impounding system wall height αD should be as large as possible. We shall assume $\alpha = 1$, from practical considerations. For this value of height, the minimum of Q occurs when $\beta = 2.11$. Inserting these values in Eq. (3.4.7), we obtain the minimum vapor flow rate Q_m:

$$Q_m = 47.08\frac{K^2 D}{\rho_v \rho_n} \quad (\text{m}^3/\text{s}) \tag{3.4.8}$$

Using SI values of $K = 0.0732$ kg/m^{2}s$^{1/2}$, $\rho_v = 1.8$ kg/m^3 and $\rho_n = 0.666$ kg/m^3, the minimum vapor flow rate becomes:

$$Q_m = 0.21\,D \quad (\text{m}^3/\text{s}) \tag{3.4.9}$$

The time t_f at which the vapor first completely fills the impounding space volume may be found by combining Eqs. (3.4.1), (3.4.2) and (3.4.4) to give:

$$t_f = \left(\frac{\rho_v D}{2K}\right)^2 \left\{\frac{\alpha(\beta^2 - 1)}{\beta^2 + 2\alpha\beta + \frac{3}{2}}\right\}^2 \tag{3.4.10}$$

3.5 Vapor flow rate from a rapid discharge of the storage vessel contents into an insulated impounding space

In this case the guidelines provide that the area wetted by the spilled LNG includes all the area which would be contacted by the LNG in the final static configuration of the spilled LNG. For the prototype facility, this area A_t would be given by:

$$A_t=\frac{\pi}{4}(\beta^2-1)D^2+h(\beta+1)\pi D \tag{3.5.1}$$

where the hydrostatic height h of the liquid is determined by:

$$\frac{\pi\beta^2 D^2}{4}h=\frac{\pi}{4}D^3 \tag{3.5.2}$$

Combining to eliminate h,

$$A_t=\pi D^2\left\{\frac{\beta^2-1}{4}+\frac{\beta+1}{\beta^2}\right\} \tag{3.5.3}$$

The volume V_v available for the holdup of vapor is:

$$\begin{aligned}V_v&=(\alpha D-h)(\beta^2-1)\pi D^2/4\\&=\left(\alpha-\frac{1}{\beta^2}\right)(\beta^2-1)\pi D^2/4\end{aligned} \tag{3.5.4}$$

The volume flow rate Q of vapor at the time the vapor first spills over the impounding system wall is found by substituting Eqs. (3.5.3) and (3.5.4) into Eq. (3.4.6):

$$Q=\frac{8\pi K^2 D\left\{\frac{\beta^2-1}{4}+\frac{\beta+1}{\beta^2}\right\}^2}{(\alpha-1/\beta^2)(\beta^2-1)\rho_v\rho_n} \tag{3.5.5}$$

Again, a minimum value of Q may be determined by selecting $\alpha=1$ and $\beta=2.6$ in which case Q_m becomes:

$$Q_m=19.92\frac{K^2D}{\rho_v\rho_n} \tag{3.5.6}$$

Since this vapor flow rate is less than that (Eq. 3.4.8) for a failed transfer piping release (assuming a filling time of 24 hours), the latter would control the combustion protection distance.

Using the same values of K, ρ_v and ρ_n as were used in Section 3.4, Q_m becomes (in SI units):

$$Q_m=0.089\,D \qquad (\mathrm{m^3/s}) \tag{3.5.7}$$

The time t_f at which the vapor first completely fills the impounding space volume may be found by combining Eqs. (3.5.3), (3.5.4) and (3.4.4) to give:

$$t_f=\left(\frac{\rho_v D}{2K}\right)^2\left\{\frac{(\alpha-1/\beta^2)(\beta^2-1)}{\beta^2-1+4(\beta+1)/\beta^2}\right\}^2 \tag{3.5.8}$$

4.1 Thermal protection distance

The guidelines specify a manner of measuring a thermal protection distance d as shown in Fig. 4.1.1, where for the prototype facility we assume level ground and a ground level target

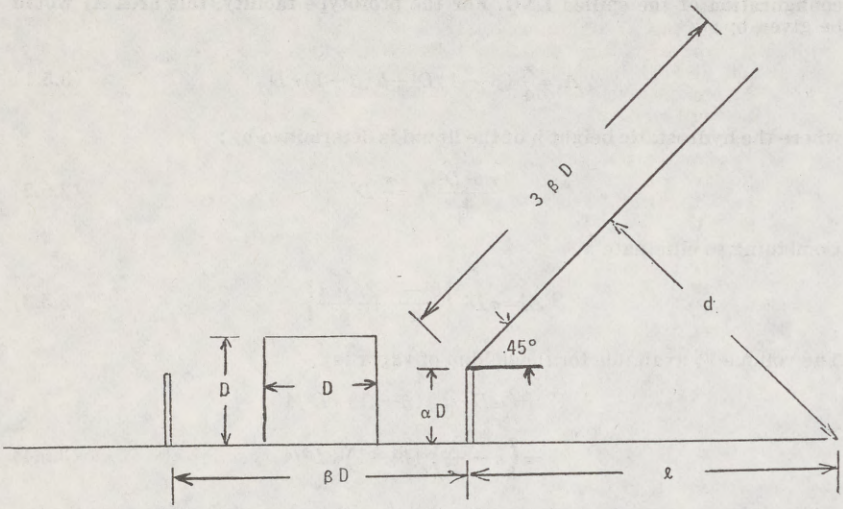


FIGURE 4.1.1

By geometry, the horizontal distance l from the impounding system wall to the target is related to the thermal protection distance d by:

$$l+D=\sqrt{2}d \tag{4.1.1}$$

But the area A of the impounding system is

$$A=\frac{\pi}{4}\beta^2 D^2 \tag{4.1.2}$$

Combining,

$$l=\left(\frac{\pi}{2}\right)^{1/2}\beta D\left(\frac{d}{\sqrt{A}}\right)-\alpha D \tag{4.1.3}$$

Equation (4.1.3) is valid provided that

$$d\leq 3\beta D+\sqrt{2}\alpha D$$

or

$$\frac{d}{\sqrt{A}}\leq\frac{6}{\sqrt{\pi}}+2\sqrt{\frac{2}{\pi}}\frac{\alpha}{\beta} \tag{4.1.4}$$

which is the case for the two values (3.6 and 2) of $d/\sqrt{A}$ used in the guidelines.

For the prototype facility which is optimized to reduce the dispersion distance to a minimum, for which $\alpha=1$ and $\beta=2.11$, Eq. (4.1.3) becomes:

$$l=2.64\,D\left(\frac{d}{\sqrt{A}}\right)-D \tag{4.1.5}$$

5.1 Site areas for an insulated tank and impounding system

In this section we determine the site area needed to satisfy the requirements of the proposed guidelines for protection from thermal radiation and vapor dispersion. This area is equal to that of a circle whose radius is the distance from the center of the storage vessel to a point which just satisfies the performance

criteria with respect to thermal or dispersion effects. Naturally, an actual site, which would not be circular in shape, would require more area since it would have to enclose the circular area defining the minimum sized site. For sites containing several storage vessels of the same size, the site area would be somewhat larger than the minimum so defined, since the several vessels would have to be spaced apart from each other.

In determining a minimum site area, it is useful to determine separately the site areas corresponding to each of the vapor dispersion distances and the termal protection distance, and then select the largest of these as the controlling site area. Since each of these distances varies with storage volume V in a different manner, it will be found that the controlling criteria depends upon storage volume as well as, of course, the design parameters.

For illustrative purposes, four storage vessel capacities have been selected as representative of present or prospective facilities in Massachusetts, and site areas were determined for them. Table 5.1.1 lists the characteristics of these vessels and their site areas.

In the following we indicate how the table entries were determined through use of the preceding analysis.

(1) Storage volume in m^3 was determined by conversion from 1 U.S. gal$=3.785\times10^{-3}m^3$.

(2) Vessel diameter D was determined from the volume by Eq. (2.1.1).

(3) Vapor dispersion site areas A_c were determined by:

$$A_c=\pi\left(\frac{\beta}{2}D+d\right)^2 \tag{5.1.1}$$

and converting the area in m^2 to acres by 1 acre$=4.047\times10^3m^2$. In Eq. (5.1.1), the optimum value of β was used and d was determined as explained below for each design accident.

(4) For a failed transfer piping accident in which vapor flow rate is limited by the liquid transfer rate, the vapor flow rate of Eq. (3.3.3) was used in Eq. (3.1.2) to obtain d. It was assumed that $\beta=2.11$, although the value of d is quite insensitive to the assumed value of β.

(5) For a failed transfer piping accident for which the vapor flow is limited by heat transfer area, Eq. (3.4.9) was used to determine the vapor flow rate to be inserted in Eq. (3.1.2) for d. β was taken to be 2.11.

(6) For vapor flow resulting from the rapid discharge of the storage vessel contents, Eqs. (3.5.7) and (3.1.2) were used to determine d, with $\beta=2.6$.

(7) For the thermal protection criterion, the minimum site area A_r, was determined from

$$A_r=\pi\left(\frac{\beta}{2}D+l\right)^2 \tag{5.1.2}$$

(5.1.2)

where l is given by Eq. 4.1.5) with $d\sqrt{A}$ having the value of 2 or 3.6 depending upon whether or not (respectively) the surrounding land use is zoned industrial. β was assumed to be 2.11.

TABLE 5.1.1.—SITE AREAS FOR LNG STORAGE VESSELS*

Storage volume (gal)	55×10^3	2×10^6	5×10^6	13×10^6
Storage volume (m^3)	208	7.57×10^3	18.9×10^3	49.2×10^3
Vessel diameter (m)	6.42	21.3	28.9	39.7
	Site area (acres)			
Criterion:				
Failed transfer piping—flow rate limit	6.4	706	2,360	8,320
Failed transfer piping—heat transfer limit	††4.5	8.1	9.4	11.5
Sudden loss of vessel contents	0.76	2.0	2.9	4.3
Thermal protection—industrial zone	0.89	†9.82	†18.1	†34.1
Thermal protection—nonindustrial zone	2.89	‡31.8	‡58.5	‡111

*Based on dike diameter which minimizes vapor flow rate.
†Controlling value, industrial zoning.
‡Controlling value, nonindustrial zoning.

5.2 Optimum site areas for an insulated tank and impounding system

In the previous section it was shown that site size would be determined either by the dispersion or the thermal protection criterion, depending upon the storage volume (Table 5.1.1). In cases where the thermal protection criterion controls, and hence the dispersion distance is less than the thermal protection distance, a smaller site size will result if the impounding dike diameter is decreased until the smaller thermal protection distance just equals the larger dispersion distance. Such a choice of impounding system diameter is termed an optimum design.

Calculations of optimum site size were made for the same four amounts of LNG storage volume as used in the previous section and are tabulated in Table 5.2.1. For all storage volumes, the optimum site areas are less than those shown in Table 5.1.1. showing the advantage to be gained from optimum proportioning of the impounding system.

(These calculations were performed as outlined in section 5.1, except that a value of β was selected by trial so as to make A_c and A_r equal. In all cases, the dispersion distance for the design accident involving sudden loss of vessel contents was smaller than for the transfer accident and so was not a controlling factor in the optimum design or site area.)

The time required to fill the impounding system with vapor was determined from Eq. (3.4.10). For the four volumes (in ascending order) this time was 11.8, 118, 163 and 223 minutes respectively. If a transfer piping accidental discharge were terminated at an earlier time, vapor would still escape from the impounding volume because of the evaporation of liquid accumulated on the impounding space floor.

TABLE 5.2.1.—OPTIMUM CHARACTERISTICS OF SITES FOR INSULATED LNG STORAGE VESSELS

Storage volume (gal)	55×10^3	2×10^6	5×10^6	13×10^6
Vessel diameter (m)	6.42	21.3	28.9	39.7
Industrial zone:				
Dike diameter (m)	25.7	43.2	53.2	66.7
Radius to property line (m)	72	110	131	157
Circular area (acres)	4.0	9.3	13.2	19.1
Nonindustrial zone:				
Dike diameter (m)	16.9	34.5	43.1	55.6
Radius to property line (m)	75	152	187	239
Circular area (acres)	4.4	17.9	27.2	44

5.3 Optimum site areas or an uninsulated steel outer tank and insulated impounding system

Insulation on the exterior of the tank roof and walls would protect the outer shell of the storage vessel from being subject to LNG temperatures in a transfer piping accident. However, if the storage vessel is not so insulated, the portion of the bare metal shell exposed to LNG will enhance the rate of vapor formation at the beginning of the accidental discharge but ultimately will contribute nothing to vapor formation when the exposed surface has been cooled to the temperature of LNG.

In this section we determine the maximum vapor flow for an uninsulated tank by assuming that the exposed tank surface is cooled to the temperature of LNG before the vapor fills the impounding volume. We first determine the volume of vapor formed when the exposed tank surface is so cooled, which is subsequently subtracted from the impounding space volume to give a net volume. The vapor formed from contact with the insulated surfaces (dike floor and dike wall) is then determined as before so as to fill this net volume, at which time the vapor flow rate evolved from the insulated surfaces is equal to the vapor escape rate from the impounding volume.

The thickness r of the outer shell of the storage vessel is assumed to be proportional to the tank diameter D. Typically, a 200 ft. diameter tank has an outer wall thickness of ½ in. of steel. We therefore assume:

$$r=2\times10^{4}\,D \qquad (5.3.1)$$

The volume V_m of the metal outer surface of the tank is:

$$V_m = \tau \left\{ \frac{\pi D^2}{4} + \pi D^2 \right\} \tag{5.3.2}$$

For a transfer piping accident, the volume of vapor V_{vm} formed in cooling one half of this metal volume V_m through a temperature change delta T is:

$$V_{vm} = \frac{V_m}{2} \frac{\rho_m c_m \Delta T}{\rho_v h_v} \tag{5.3.3}$$

where ρ_m (=7.85 x 10^3 kg/m^3 is the density of steel, c_m (=0.493 x 10^3 j/kg °C) is the specific heat of steel, ρ_v (=1.8 kg/m^3) is the density of LNG vapor, h_v (=5.1 x 10^5 j/kg) is the heat of vaporization of LNG, and delta T (=209°C) is the temperature change of the steel from the ambient temperature (47°C) to the boiling point of LNG (−162°C). Inserting these numerical values and using Eq. (5.3.1), the volume V_{vm} becomes:

$$V_{vm} = 0.346\, D^3 \tag{5.3.4}$$

The net volume V_{nv} available to the vapor evolved from the insulated surfaces is obtained by subtracting V_{vm} from the volume of the impounding space:

$$V_{nv} = \frac{\pi D^3}{4} \{(\beta^2 - 1)\alpha - 0.44\} \tag{5.3.5}$$

The area A_i of insulating surface, composed of the dike floor and one half of the dike wall, is:

$$A_i = \frac{\pi D^2}{4} \{\beta^2 - 1 + 2\alpha\beta\} \tag{5.3.6}$$

Combining Eqs. (5.3.5) and (5.3.6) with (3.4.6), we find the maximum volume flow rate Q of vapor over the dike wall:

$$Q = \frac{\pi K^2 D \{\beta^2 - 1 + 2\alpha\beta\}^2}{2\rho_t \rho_n [(\beta^2 - 1)\alpha - 0.44]} \tag{5.3.7}$$

which is to be used in Eq. (3.1.2) to determine the dispersion distance for a transfer piping accident.

For the accident involving a loss of the total contents of the storage vessel to the impounding volume, the volume of metal V_m of the outer shell immersed in the LNG is:

$$V_m = \pi D h \tau \tag{5.3.8}$$

where the depth h of the LNG pool is given by Eq. (3.5.2). Combining Eqs. (3.5.2), (5.3.1), (5.3.3) and (5.3.8) gives the volume of vapor V_{vm} formed by cooling of the metal volume V_m:

$$V_{vm} = \frac{0.554\, D^3}{\beta^2} \tag{5.3.9}$$

Substracting this from the total volume available to the vapor (Eq. 3.5.4), we find the net volume V_{nv} available to the vapor formed from the insulated surfaces to be:

$$V_{nv} = \frac{\pi D^3}{4} \left\{ \alpha(\beta^2 - 1) - \frac{0.705}{\beta^2} \right\} \tag{5.3.10}$$

The area A_i of the insulated surfaces (dike floor and wall) exposed to the LNG pool is:

$$A_i = \frac{\pi D^2}{4} (\beta^2 - 1) + \pi \beta D h \tag{5.3.11}$$

Combining Eqs. (5.3.10) and (5.3.11) with (3.4.6), we find the maximum volume flow rate Q vapor over the dike wall for an accidental loss of the storage vessel contents into the impounding space:

$$Q=\frac{\pi K^2 D\{\beta^2-1+4/\beta^2\}^2}{2\rho_v\rho_n[(\beta^2-1)\alpha-0.705/\beta^2]} \tag{5.3.10}$$

Calculations of optimum site size were made for the four storage vessel sizes previously considered. Equation (5.3.7) was used to determine the dispersion distance (assuming $\alpha=1$) and Eq. (4.1.3) to determine an equal thermal protection distance. The corresponding dike diameters, radial distances to the property line and circular site areas are listed in Table 5.3.1.

5.4 Effect of partial failure of insulation on dike floor

In either type of design accident, the floor of the impounding space is continuously covered with LNG until all of it has been evaporated. There is some possibility that a portion of the floor surface will loose its insulating properties through deterioration over time or as a consequence of an accident. In this section we determine the effect on optimum site characteristics of such a partial failure of the insulating properties of the dike floor when the insulation on the tank and dike wall remain intact.

We shall assume that 90% of the dike floor remains intact but that the remaining 10% of the floor area has only the insulating properties of dry soil or normal concrete. For these latter materials, the value of $(kpc)^{1/2}$ is 4.17 Btu/ft^2 hr$^{1/2}$, compared with 1 Btu/ft^2 hr$^{1/2}$ for insulating concrete (see section 3.2). Thus the effective area of insulating material which will have the same vapor evolution rate as the partially failed dike floor will be larger than the actual floor area by the factor f:

$$f=0.9+0.1\ (4.17)=1.32 \tag{5.4.1}$$

Thus the effective area A_e to be substituted for the actual area A, given by Eq. (3.4.1), in the transfer piping failure accident becomes:

$$A_e=\frac{\pi D^2}{4}\{1.32\,(\beta^2-1)+2\alpha\beta+5/2\} \tag{5.4.2}$$

TABLE 5.3.1.—OPTIMUM CHARACTERISTICS OF SITES FOR UNINSULATED LNG STORAGE VESSELS

Storage volume (gal)	55×10^3	2×10^6	5×10^6	13×10^6
Vessel diameter (m)	6.42	21.3	28.9	39.7
Industrial zone:				
Dike diameter (m)	19.3	35.1	43.3	58
Radius to property line (m)	53	84	106	132
Circular area (acres)	2.2	5.5	8.7	13.5
Nonindustrial zone:				
Dike diameter (m)	12.8	29.8	39.6	53
Radius t property line (m)	56	134	167	219
Circular area (acres)	2.4	13.9	21.6	37.2

The site areas for the insulated storage vessels are somewhat less than those for insulated tanks because the heat absorbing capacity of the relatively thin shells assumed is less than that of the insulation which is needed to protect them from prolonged exposure to LNG in either type of accident. The differences in site areas are not considered significant, considering the various simplifying assumptions involved in making the calculations.

The optimum site characteristics listed in Table 5.3.1 were examined to determine if the loss of contents accident would result in greater dispersion distances as calculated from Eq. (5.3.10). It was found that the transfer piping accident was controlling.

The volume flow rate Q of vapor is:

$$Q=\frac{\pi K^2 D\{1.32\beta^2+2\alpha\beta+1.18\}^2}{2\rho_n\rho_v(\beta^2-1)\alpha} \qquad (5.4.3)$$

Using this expression for the vapor flow rate, optimum site characteristics were determined for the four sizes of storage vessels and are listed in Table 5.4.1. Also listed below each entry in parentheses is the corresponding value for a perfect insulation layer on the dike floor. It can be seen that the effect of failure of 10% of the dike floor insulation on the optimum site size is relatively minor.

TABLE 5.4.1.—EFFECT OF FAILURE OF 10-PERCENT INSULATION OF DIKE FLOOR FOR FULLY INSULATED SYSTEM

[Perfect insulation values in parentheses]

Storage volume (gal)	55×10^3	2×10^6	5×10^6	13×10^6
Industrial zone:				
Dike diameter (m)	16.7 (25.7)	48.6 (43.2)	56.4 (53.2)	71.1 (66.7)
Radius to property line (m)	88 (72)	126 (110)	14) (131)	170 (157)
Circular area (acres)	6.1 (4.0)	12.0 (9.3)	14.1 (13.2)	21.3 (19.1)
Nonindustrial zone:				
Dike diameter (m)	16.7 (16.9)	36.4 (34.5)	44.8 (43.1)	57.4 (55.6)
Radius to property line (m)	88 (75)	162 (152)	195 (187)	247 (238)
Circular area (acres)	6.1 (4.4	20.2 (17.9)	29.7 (27.2)	47.3 (44)

APPENDIX A

HUMAN RESPONSE TO THERMAL RADIATION FROM FLAMES

I have reviewed references which describe various experiments on the physiological reaction of humans when exposed to thermal radiation (see list of references below). Generally speaking, subjects were exposed to a uniform level of radiation for exposure times which produced ascending levels of reaction: pain threshold, unendurable pain, full blisters and third degree burns (which is the most serious level of burn damage). I have correlated the reported measurements in the form of a graph of exposure time (horizontal axis) as a function of thermal radiation intensity (vertical axis) in the accompanying figure. In the following, I comment on the nature of the data and the type of correlation.

Buettner (1951) showed that thermal intensities of 460 Btu/hr ft^2 or less could be endured for an indefinite time with no harmful effects. At this level, blood flow to the skin is sufficient to remove the incident heat and still keep the skin temperature sufficiently low that no damage or extreme pain results. In my correlations of all of the response data, I correlate the time of response with the amount of thermal flux in excess of 460 Btu/hr ft^2 to account for this effect. This appears to give very good correlations over the range of intensities for which measurements were made.

The time to pain threshold was measured by Stoll and Greene (1959) for thermal fluxes between 1,330 and 5,300 Btu/hr ft^2. For a given thermal flux level, this time is shorter than the time to unendurable pain as measured by Buettner (1951), as indeed it should be. The later measured unendurable pain response times for thermal fluxes less than about 7,000 Btu/hr ft^2. Stoll and Greene (1959) also list exposure times which subsequently produced a full blister, for the same thermal flux range as for pain threshold. These times are longer than those of Buettner (1951) for unendurable pain.

Hardee and Lee (1971) describe an analysis which they use for estimating the occurence of third degree burns. The analysis is suitable for exposure durations greater than 3 seconds and intensities less than 16,500 Btu/hr ft^2. Their criterion for a third degree burn is a heat input of 11 Btu/ft^2, which they state is satisfactory as long as the thermal flux level is sufficiently in excess of the rate at which blood flow can remove the heat absorbed by the skin. My extrapolation of the Hardee and Lee criterion to lower flux levels gives exposure times for third degree burns which are about 15% longer than that for inducing a full blister, as measured by Stoll and Greene (1959).

My correlation formulae are the following:

Pain threshold

$$q=460+9953\ t^{-0.94}$$

Unendurable pain

$$q=460+9554\ t^{-0.8}$$

Full blister

$$q=460+34170\ t^{-1}$$

Third degree burn

$$q=460+39600\ t^{-1}.$$

In these formulae, q is the thermal heat flux (Btu/hr ft^2) and t is the exposure time (sec) for which the reaction has been measured or determined.

In a recent paper, Hardee and Lee (1977) propose a skin conduction model for evaluation of burns resulting from exposure to chemical fireballs. For exposure to a constant intensity of flame radiation, their time for a third degree burn is practically identical to that given above.

These experiments were conducted with radiation sources having black body temperatures of about 600°C; that is, having spectral characteristics approximately the same as that of flames for which most of the thermal energy is emitted at infrared wave lengths. Büttner (1950) notes that skin absorbed about 95% of the light from black body sources at this temperature. In contrast, solar light has an effective black body temperature of about 5300°C, for which Büttner (1950) shows a skin absorptance of 65%. On a clear day at 40° north latitude, the solar intensity at noon is about 300 Btu/hr ft^2 (Yellott 1976), so that the solar heat absorbed by skin under such conditions is only 195 Btu/hr ft^2, or an equivalent of 205 Btu/hr ft^2 of flame radiation. This maximum solar skin heating is only 45% of the level of 460 Btu/hr ft^2 which can be endured indefinitely. This level is shown in the attached figure A.1 as the "equivalent maximum solar flux".

The following table lists the times for heat flux levels of 2,000 and 1,000 Btu/hr ft^2 as determined from the formulae above:

	Thermal Flux (Btu/hr ft.²)	
Time (sec) for:	1,000	2,000
Pain threshold	23	7, 4
Unendurable pain	36	9. 5
Full blister	66	23
Third-degree burn	74	26

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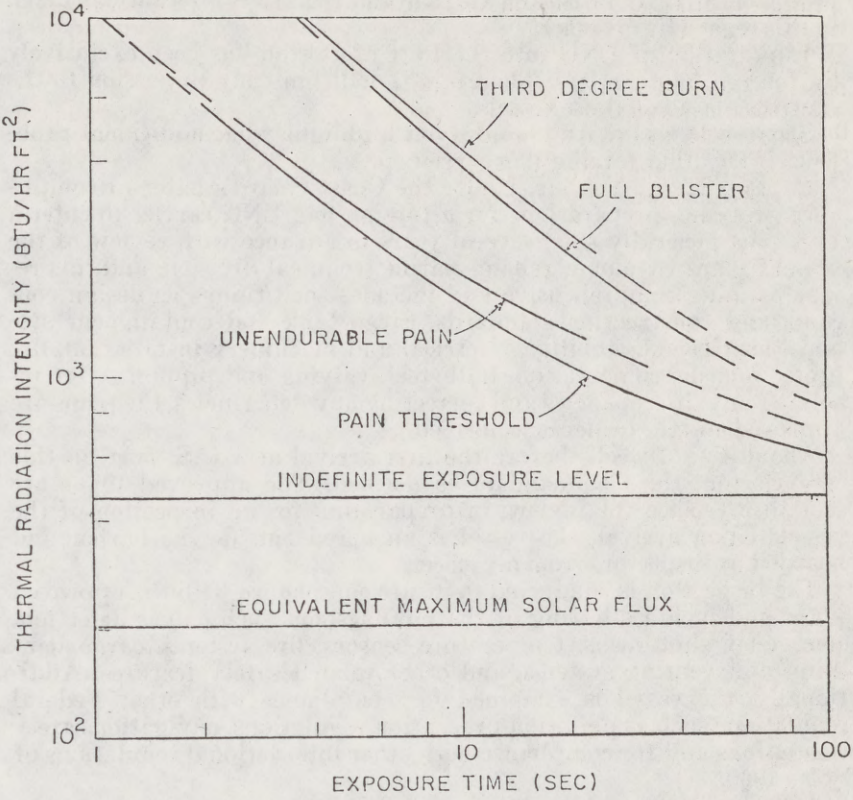

FIGURE A–1

Senator DURKIN. At this time I would like to hear from the Coast Guard commanding officer and Mr. Santman from the Materials Transportation Bureau. Could we also have Mr. Elwood Driver of the NTSB sit in on this panel as well.

Gentlemen, your full statements will be included in the record. Mr. Santman, I appreciate your coming up from Washington today. Inasmuch as time is a problem, if you would submit your full statement for the record. We will address the followup questions to the Materials Transportation Bureau at a subsequent hearing in Washington. I realize that Mr. King could not be here and appreciate his sending Mr. Driver in his stead.

Captain, if we could proceed with you first.

STATEMENTS OF CAPT. LYNN N. HEIN, COMMANDING OFFICER, U.S. COAST GUARD MARINE SAFETY OFFICE, BOSTON, MASS.; L. D. SANTMAN, DIRECTOR, MATERIALS TRANSPORTATION BUREAU, RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION, DEPARTMENT OF TRANSPORTATION; AND ELWOOD T. DRIVER, MEMBER OF NATIONAL TRANSPORTATION SAFETY BOARD

Captain HEIN. Sir, I am Capt. Lynn Hein, commanding officer, Marine Safety Office, Boston. I am here to discuss the marine trans-

portation of LNG in Boston Harbor and the safety precautions taken in this regard by my office.

Importation of LNG into the Port of Boston has been exclusively by foreign flag carriers. Therefore, I will limit my discussion to the controls placed on those vessels.

Senator DURKIN. And would you highlight what additional problems, if any, that foreign-flag carriers pose?

Captain HEIN. Yes, sir. Under the Coast Guard's letter of compliance program, preparations for a foreign-flag LNG carrier to enter a U.S. port generally start several years in advance with review of the vessel's plans by our merchant marine technical division, and this review is quite comprehensive and includes such things as design concepts and construction standards, cargo tank and containment systems, ventilation, stability, electrical and machinery installation, fire protection, instrumentation, hull steel, valving and piping. After resolving any discrepancies and correcting any deficiencies, the plans are approved and the owner is so notified.

About 4 to 6 weeks before the first arrival at a U.S. port, in this case Boston, the Commandant is notified. The approved plans are sent to my office for review, in preparation for an inspection of the vessel. Upon arrival, the vessel is anchored outside the harbor and boarded by inspectors from my office.

The inspection is conducted to insure consonance with the approved plans and includes testing of the vital systems such as gas detection, emergency shutdowns, temperature sensors, fire systems, cargo handling and venting systems, and other related safety features. Additionally, the vessel is examined for compliance with other Federal regulations such as pollution prevention regulations, navigation safety regulations and for compliance with other international regulations of Solas 1960.

After a satisfactory completion of this inspection, a letter of compliance is issued, valid for a period of 2 years, and the vessel is allowed to proceed into the harbor for cargo discharge.

Senator DURKIN. Captain, if I am in error please correct me, but it is my understanding that the Coast Guard inspection does not now include in each port of call a check of the navigational equipment, steering, emergency steering and what havee you. If that is true, why?

Captain HEIN. It is not true, sir. In June of 1977, the navigation safety regulations came into force. We do enforce those in all foreign-flag ships over 1,600 gross tons that come into a U.S. port, and that includes LNG or LPG carriers.

Senator DURKIN. Do you check their radar and what have you as well?

Captain HEIN. Yes, sir.

Senator DURKIN. Is that done on a periodic basis or each time they call on the Port of Boston?

Captain HEIN. On an LNG, LPG ship, we do it each time. Other ships, we spot check. Through our information systems they have been checked somewhere else, tankers for example, we may or may not check them. It depends on how recently they have been checked.

Senator DURKIN. Do you feel the check-off system that you follow today is adequate?

Captain HEIN. It has proven adequate, very well, in the Port of Boston. Yes, sir.

Senator DURKIN. Fine. Let the record reflect that I was incorrect in my opening statement where I indicated that the Coast Guard did not check navigational equipment.

Captain HEIN. Numerous restrictions are placed on LNG vessels and harbor traffic during a transit of Boston Harbor. Preparations are started approximately 72 hours in advance when the vessel is required to give notice of arrival and state that the vessel's machinery and equipment and all cryogenic systems are operating properly.

Senator DURKIN. Captain, just one more question. Had that standard to check navigational and steering equipment been adopted in the Port of Boston? That isn't a national regulation followed in Cove Point, Md., or somewhere else?

Captain HEIN. I can only speak of it being done every time in the Port of Boston. It is title 33, Code of Federal Regulations, part 164, that require them to have the operating radar, test the steering gear, test emergency generator, et cetera. It is a Federal regulation.

Senator DURKIN. Thank you. Please proceed.

Captain HEIN. All organizations and agencies, after we receive this notification, are notified of the arrival and an inspection, as previously described, is arranged. An abbreviated inspection is held if the vessel holds a valid letter of compliance, but it is conducted on each arrival, nevertheless.

The transit is allowed only during daylight hours and with at least 2 miles visibility. The harbor is closed to traffic 2 miles ahead and 1 mile astern of the LNG vessel, except for tugs without tows and vessels of less than 100 gross tons that can safely navigate outside the main ship channel. A Coast Guard escort vessel is provided to enforce these restrictions and to broadcast security messages to keep mariners advised. The LNG vessel is also required to have a tug escort of a minimum of three tugs and is limited to a speed of 8 knots.

After docking at the facility, the Coast Guard escort remains on the scene during the entire cargo transfer operation. Cargo connections, establishment of communications with the facility and initial cooldown are monitored by a Coast Guard officer who ultimately will approve the start of the transfer operations and issue the necessary permit when all is satisfactory. A Coast Guard security watch with direct communications to our communication center is maintained aboard during the entire cargo transfer operation. Upon completion of the transfer operation, the vessel is escorted out of the harbor at which time Coast Guard control ends.

I thank you very much for the opportunity to address this committee and would be pleased to answer any further questions that you might have.

Senator DURKIN. Captain, do they have special pilots for the LNG carriers? I understand that they have some unique handling characteristics. Or are the pilots taken out of the general, available Boston pilots?

Captain HEIN. As far as I understand it they are taken in rotation with the Boston Pilots' Association. I would assume that the windage factor, such as on a container ship, would be the difference in high-sided LNG–LPG ships.

Senator DURKIN. On page 6–35, paragraph 2, of their report, GAO states, "the Coast Guard carries out a 2½-hour inspection before an LNG ship is permitted to enter Boston Harbor." It says:

This does not include the operating condition of the ship control equipment such as steering engine, propulsion machinery, electronic devices.

If GAO and the Coast Guard could get together and resolve that inconsistency and supply it for the record, we would appreciate it.

[The following information was subsequently received for the record:]

Navigation Safety Regulations, 33 CFR 164, became effective 1 June 1977. There does not appear to be any discrepancy between the GAO report and Captain HEIN's testimony in that at the time of GAO observation of the inspection procedures, the implementation of 33 CFR 164 had not yet been carried out. The procedures were fully implemented by Marine Safety Office Boston by September 1977 and subsequently have been applied in all LNG/LPG ship arrivals.

Senator DURKIN. Captain, without getting in trouble with the Commandant and OMB and various other nonelected powers in Washington, are you adequately staffed to carry out the scope of your responsibility? As I understand it, you've got the search and rescue, fishing fleet, pleasure craft plus a host of other responsibilities. Is there adequate staffing in the Coast Guard in this region?

Captain HEIN. I really can't speak for the entire region. I can only speak for the Marine Safety Office in Boston, which we have gone through and we are, I am told, being supplied with three more officers to supplement our inspection staff for the foreign tank vessel examination program. I do need these officers and the Coast Guard is coming through with this. We just recently had a study on our work load throughout the country and Boston has come up with three more officers.

Senator DURKIN. Have their orders been cut? When do they report aboard?

Captain HEIN. I would assume it would be the next fiscal year.

Senator DURKIN. So for the rest of this fiscal year you are inadequately staffed in the Marine Safety Division, by definition?

Captain HEIN. Yes, sir; by definition.

SenatorDURKIN. Can you describe the contingency planning for a potential LEG accident in Boston Harbor?

Captain HEIN. We have, which I believe has been supplied to the committee here, the LNG–LPG contingency plan, and in the back of that plan is a basic list and call up procedure, and what happens such as if there is an incident at Distrigas, Exxon in Everett, and what happens in a flow chart diagram of who we call, and what happens and when. There are several different incidents in Boston Harbor, or Boston Gas in Dorchester. They are covered in the back with a list of people to call, what the different responsibilities are of those people.

Senator DURKIN. At what point does your jurisdiction begin, inbound?

Captain HEIN. Basically when they come within the navigable waters of the United States.

Senator DURKIN. We've had a dispute over the definition of navigable waters in Lake Winnepesaukee.

Captain HEIN. Basically within 12 miles of our coast, Senator.

Senator DURKIN. Is that true in calm weather or in rough weather, the same 12 miles?

Captain HEIN. Yes, sir.

Senator DURKIN. I forget how far offshore the *Argo Merchant* was——

Captain HEIN. 27.3, I believe it was.

Senator DURKIN. So how about if the *Argo Merchant* had been an LNG carrier? You would just go down and get the Extra at the Boston Globe and read about it, I guess.

Captain HEIN. Yes, sir. That was the first intervention on the high seas that was invoked by this country.

Senator DURKIN. The hurricane season is approaching here in New England. What plans, if any, do you have to divert the LNG carrier in the event of a severe northeaster or hurricane or line storm moving up the coast, or to get one underway and back out to sea, if that is a problem?

Captain HEIN. Everett is quite a protected anchorage and harbor. If we had one blow through at that time I would very definitely just as soon leave it right in Everett. If they are anchored out, which one was in the February 6 storm, it picked up the anchor and went to sea. This was a LPG ship, by the way.

Senator DURKIN. Was that your direction, or was that the skipper's good sense?

Captain HEIN. That was the skipper's good sense and with us working with the Boston Pilots, which I do quite regularly. There have been a number of questions—I shouldn't say a number, but at one point in time we did have a question on transit of an LNG ship. We worked quite closely with the Boston Pilots and resolved it, that they would not transit that particular day. We waited another day.

Senator DURKIN. How about when inbound? At what point would you have authority to recommend diversion?

Captain HEIN. Whenever they come within our waters, sir.

Senator DURKIN. So if they are 27.5 miles out, it's up to the skipper. If it is 12 miles, you have a voice?

Captain HEIN. Yes, sir.

Senator DURKIN. Do you think that authority is adequate, or should you have further authority within the 200-mile limitation, or some other limitation?

Captain HEIN. That has proven adequate for my office in Boston. I really don't know the other parts of the country that well.

Senator DURKIN. Do you think 12 miles is adequate in Boston?

Captain HEIN. Yes, sir.

Senator DURKIN. To your knowledge, how often has an LEG ship had a radar breakdown or lost power in one or more engines, or run significantly off its planned course, or any other problem that has a potential to significantly affect safety in the Boston area?

Captain HEIN. In my 2 years' experience in this area, it has never actually happened.

Senator DURKIN. If one of your inspectors finds a potential serious defect on an inbound LEG ship, do you have the authority to divert it and order it back out to sea?

Captain HEIN. Yes, sir.

Senator DURKIN. Once it is within the 12 miles.

Captain HEIN. Yes, sir.

Senator DURKIN. But you still could have an *Argo Merchant* 27.5 miles off course, and then you are restricted to praying and whatever moves the skipper takes.

Captain HEIN. That's right, sir.

Senator DURKIN. Do you have any recommendations for further steps to improve the competence of the LEG crews?

Captain HEIN. I have read the IMCO resolution on training, which will be implemented through Coast Guard regulations in the future. I don't know exactly how we stand on it, since I am not in headquarters. But I am sure this will be a great improvement on crew training.

Senator DURKIN. As I understand it, the current procedure is to close the port when an LEG ship is inbound. How feasible is that in light of projected increase in LNG and LEG imports?

Captain HEIN. In the Port of Boston I understand the increase is going to be taken care of by an increase from 14 to 17 ship arrivals a year, using a larger vessel. Therefore it would have very little impact on the closing of the port: Just three more arrivals a year.

Senator DURKIN. I served a couple of years in the Navy stationed here in Boston. The fog can be tough out there this time of year. Do you think we need a *Valdez* type handling system for the Port of Boston to handle the LNG carriers?

Captain HEIN. I feel the Port of Boston is quite an easy port, in a sense, with a short run to the dock. Basically it is an hour and a half from the time you enter Deer Island until the time you are at the Everett facility. Normally, even though we have a contingency plan for either anchoring at Anchorage 2 or Anchorage 1, if the weather does close, in that 1½ hour we can be relatively assured that in the daylight operation, 2 miles visibility, that it won't close in. It hasn't at this time.

There is one transit we did not allow because the weather was questionable, until the next day.

Senator DURKIN. What did they do? Anchor out?

Captain HEIN. Yes, sir. Anchor out in Broad Sound.

Senator DURKIN. When they are anchored out with the low ceiling, how do you protect against collision?

Captain HEIN. Basically the general rules of the road are in force.

Senator DURKIN. If they are inbound and the weather socks in, then the port does not close. They anchor out, and we have to rely on normal rules of the road which produce three collisions a day worldwide, the last figures I saw?

Captain HEIN. They anchor outside in the precautionary area, much further north of the main ship channel. This is not inside the Port of Boston. There is a contingency to put them inside a protective anchorage. It has never been used.

Senator DURKIN. If the fog is heavy, if it is too hazardous to bring them into Everett, how realistic and safe is it to move them to the protected anchorage? What about the shoals at Deer Island and other things out there?

Captain HEIN. If the weather is bad they would be anchored outside well away from the traffic lane, and not allowed in. If they are in

transit and it socks in, then they would go to the nearest anchorage, either 1 or 2. Which means it would be less transit time, less time under way, in poor visibility.

Senator DURKIN. But during that poor visibility, which has required the interruption of the transit inbound to Everett, I understand during normal transit the port is closed.

Captain HEIN. Essentially; yes.

Senator DURKIN. But during a hazardous transit is the port also closed?

Captain HEIN. It can be. In the fog, there would still be the 2-mile safety zone ahead and the astern of the vessel whenever it is transiting, whichever way it is going. If they had to go to anchorage, there would be a safety zone around the vessel.

Senator DURKIN. Do you feel that safety zone is adequate in light of you might have some rust bucket, a foreign-flag oil tanker, which wanted to steam on in anyway?

Captain HEIN. Yes, sir, I feel it is adequate, working with the number of vessels coming through the port, which is not a great number in Boston Harbor, and with the well-marked main ship channel, and the anchorage is away from that ship channel. It certainly should be adequate.

Senator DURKIN. Do you provide any special training for your Coast Guard officers who are doing business with LNG and LPG?

Captain HEIN. Yes, sir. We have the regular 12-week marine safety basic indoctrination course at Yorktown. We also have a 1 week LNG course there, which most of them have attended, and several have taught at it. As Commissioner Paul mentioned, we do go to the Moon Island facility that Boston Gas runs, and actually work with the fire department personnel there in LNG fires. Every time they have put that on, we have attended it.

Senator DURKIN. GAO seems to have a little different point of view on page 6–31 of their report. I would like to resolve that conflict for the record.

Captain, I want to thank you very much. If on reflection you want to add anything to the record, we will keep the record open. We appreciate your cooperation and look forward to your continued cooperation as we move along with our responsibilities.

[The following information was subsequently received for the record:]

There does not appear to be a discrepancy between the GAO report and Captain HEIN's testimony. There is no Coast Guard wide mandatory training program in effect for "LEG" hazards as stated in the report. Captain HEIN's testimony was in the context of the two years experience at MSO Boston during which time training of the inspectors and monitors assigned was carried out by that office, 88% of the officers assigned had attended the Marine Safety Basic Indoctrination Course. In the previous two years, five of the seventeen officers had attended the four-day LNG course at Yorktown, two of whom had participated during a segment as instructors; six of the seventeen officers have attended locally sponsored fire department demonstrations on LNG/LPG properties, handling and firefighting; 52% of MSO Boston active duty enlisted personnel have completed the locally prepared training course in LNG/LPG monitoring detail (Copy of training plan attached); all reserve personnel who augment the monitoring detail are also required to complete the local training program. All inspectors actually assigned to inspect the ship have had at least one part of this additional training.

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TRAINING GUIDE FOR LNG/LPG MONITORING-DETAIL WATCHSTANDER

Item	*Reference*
1. Demonstrate knowledge of the following terms:	
(1) Density with respect to air	LNG–LPG O/E plan.
(2) Specific gravity	CG–446–3 p. 34.
(3) Flashpoint	CG–123–30.10.
(4) Flammability	CG–123–30.10.
(5) Firepoint	CCGD1 INST P 16455.1 p. 19.
(6) Ignition source	Do.
2. Demonstrate knowledge of the following properties on LNG (liquified natural gas):	
(1) Density with respect to air.	
(2) Specific gravity.	
(3) Flashpoint.	
(4) Firepoint.	
3. Demonstrate knowledge of the following properties of LPG (liquified petroleum gas)	LNG–LPG O/E plan.
(1) Density with respect to air.	
(2) Specific gravity.	
(3) Flashpoint.	
(4) Firepoint.	
4. Demonstrate knowledge of LNG hazards	Do.
(*a*) Fire.	
(*b*) Brittle fracture.	
(*c*) Vapor clouds.	
5. Demonstrate knowledge of LPG hazards	Do.
(*a*) Fire.	
(*b*) Brittle fracture.	
(*c*) Vapor pockets.	
6. Demonstrate knowledge of LNG/LPG event chart	Do.
(*a*) Phase I.	
(*b*) Phase II.	
(*c*) Phase III.	
(*d*) Phase IV.	
7. Demonstrate knowledge of phase III discharge operation	Do.
(a) CG arrival safety inspection.	
(b) Minimum-cargo crew.	
(c) Venting requirements.	
(d) Operation during electrical storms.	
(e) Notification of departure time.	
8. Demonstrate knowledge of facility requirements	Do.
(a) Bunkering.	
(b) Communication between vessel and facility control.	
(c) Certified person in attendance during discharge operations.	
(d) Other transfer operations during LNG/LPG transfer.	
(e) Loading of inert gas.	
(f) Hot work.	
(g) Visitors.	
9. Demonstrate knowledge of the duties of the monitoring detail	Do.
(a) Primary function.	
(b) Duration of monitoring.	
(c) Procedure for relief of one detail watchstander by another.	
(d) Emergency procedure:	
(1) Clearing.	
(2) Informing.	

TRAINING GUIDE FOR LNG/LPG MONITORING-DETAIL WATCHSTANDER—Continued

Item	*Reference*
10. Demonstrate knowledge of the Duton/Kichner guidelines for the monitoring detail aboard LNG/LPG vessels	D/K guideline.
(*a*) Uniform of the day.	
(*b*) Maximum continuous monitoring for personnel.	
(*c*) Communications requirements.	
(*d*) Procedure after a safety violation has been identified.	
(*e*) Log requirements.	
(*f*) Resources.	
11. Demonstrate knowledge of LNG/LPG contingency plan for the Port of Boston	LNG–LPG O/E plan.
(*a*) Type of response expected by COTP.	
(*b*) Responsibilities of CG representatives on scene.	
(1) Duration of on-scene command.	
(2) Notification of GRU BSN.	
(3) Fire department notification.	
12. Demonstrate ability to perform the duties of a monitoring-detail watchstander during each of the following operations	D/K guideline.
(1) Hookup.	
(2) Commencement of cooldown.	
(3) Commencement of transfer operations.	
(4) Completion of transfer operations.	
(5) Commencement of warmup operations.	
(6) Disconnect.	

Item	*CG–123 paragraph reference*
13. Demonstrate knowledge of the Federal regulations and safety standards applicable to the monitoring detail:	
(*a*) Means of escape	32.01–1.
(*b*) Lifelines	32.01–5.
(*c*) Rails	32.01–10.
(*d*) Guards at dangerous places	32.01–15.
(*e*) Pumprooms (cargo pumps and ventilation)	32.60–20.
(*f*) Firefighting equipment:	
(1) Application	34.01.
(2) Where required	34.05.
(3) Portable and semiportable extinguishers	34.50.
(4) Sand	34.55.
(5) Fire axes	34.60.
(*g*) General safety rules:	
(1) Warning signals (read warning signal gangway, and radio room)	35.30–1.
(2) Fires (responsibility of senior deck officer, boiler, galey, smoking; matches)	35.30–5.
(3) Flame screens	35.30–10.
(4) Indicator	35.30–15.
(5) Emergency equipment	35.30–20.
(6) Explosives	35.30–25.
(7) Portable electrical equipment	35.30–30.
(8) Spark-producing devices	35.30–35.
(9) Flammable liquid and gas fuels as ship's stores	35.30–40.
(10) Motion picture film	35.30–45.
(*h*) Cargo handling:	
(1) Men on duty	35.35–1.
(2) Electrical bonding	35.35–5.
(3) Closing scuppers and sea valves	35.35–10.

TRAINING GUIDE FOR LNG/LPG MONITORING-DETAIL WATCHSTANDER—Continued

Item	*CG–123 paragraph reference*
13. Demonstrate knowledge etc.—Continued	
(*h*) Cargo handling—Continued	
(4) Connecting for cargo transfer (relative movement, supported connections; drip pans or buckets)	35.35–15.
(5) Inspection prior to transfer	35.35–20.
(6) Approval to start	35.35–25.
(7) Conditions (electrical storm; fire in vicinity)	35.35–40.
(8) Vessel coming alongside	35.35–42.
(9) Auxiliary energy	35.35–45.
(10 Termination of transfer	35.35–50.
(11) Transfer of other cargo or stores	35.35–60.
(12) Maintenance of cargo-handling equipment	35.35–70.
(13) Handling equipment in emergencies	35.35–75.
(*i*) Venting and ventilation	38.20–1, –5; –10.
(*j*) Person in charge	154.710, 154.730.
(*k*) Person in charge: limitations	156.110.
(*l*) Requirements for oil transfer	156.120.
(*m*) Supervision by person in charge	156.160.

Senator DURKIN. Mr. Santman, your full statement will be included in the record, but I do have a couple of questions. Then I would like to proceed to Mr. Driver.

Have you or your people made any inspections of the New England LEG facilities since the storm last winter?

Mr. SANTMAN. We have, Senator. The Federal pipeline safety program is structured in part upon a Federal-State relationship. The facilities, other than the Everett facility, the 28 or so LNG facilities in the State of Massachusetts are addressed by State inspectors and in the year 1977 there were 104 or 109 inspections performed by the State inspectors under the partially federally-funded State program.

The facility in Everett, as is indicated in my prepared statement, has been visited by our inspectors twice within the last month, as a matter of fact. Once to observe a repair. We contemplate additional visits there.

The principal LNG facilities that are under direct Federal responsibility as part of this Federal-State inspection program, are the true interstate facilities, the three large import facilities at Everett, Mass., Cove Point, Md., and Elba Island, Ga. As a matter of fact, we have two inspectors at Elba Island this week. This is their second round of inspections. They performed an inspection before the facility started receiving LNG and they are back there now looking at operations.

Senator DURKIN. Does extreme cold or extreme heat pose any additional safety problems with respect to LNG?

Mr. SANTMAN. It is extremely cold by its nature. As a matter of fact, to the limited extent that we have records of personal injuries, the cold or cryogenic temperature has been the primary cause.

Senator DURKIN. No; I am not talking about the LNG itself. I mean, it was 104 or so a couple of weeks ago here in the Boston area, and last winter it was quite cold, below zero. Does that pose any additional safety problems?

Mr. SANTMAN. No. The system is designed to accommodate extreme chill factors and temperature changes. Regarding the temperatures you are talking about and the situations you cite, perhaps you can get

more specific answers as to actually how the Everett facility is affected thereby from the Distrigas witness a little bit later.

Senator DURKIN. Why hasn't DOT implemented the hotline system as rather clearly suggested by Congress?

Mr. SANTMAN. Again, we are covering ground that I believe you and I have covered before, but I think it is well worth while.

Senator DURKIN. I would be glad to put that exchange in this record as well.

Mr. SANTMAN. I just wanted to recognize that we had talked about this a bit before, and I want to recite a bit of what we said before as background for discussing what we have gone on to do since we last talked about it.

The Department, back in about 1970, according to the records that I have reviewed, went to the Manufacturer Chemists Association and suggested the development of what has now turned into the Chemtrec facility that was mentioned earlier this morning. Since the beginning of this year, Secretary Adams has had his special assistant conducting a broad examination of how the Department is functioning in the hazardous materials business. One of his areas of focus is emergency response. He is due to report back to the Secretary any day now and there has been an exchange of correspondence indicating that we will be sending the committee a copy of that report.

He is examining the possible expansion of the Coast Guard's National Response System, the Coast Guard communication system that was developed primarily in connection with oilspills and oil pollution activities and will necessarily be expanded to cover hazardous polluting substances to support the EPA program. We are examining the possibility of further expansion of the system without losing the benefits of what Chemtrec has accomplished. Obviously the Government has got a communications capability that can be married together with and complemented by the Chemtrec system.

I cannot predict at this time exactly what the report will say, but this is one of the top items in the examination the Secretary requested.

Senator DURKIN. After your April appearances before the Commerce Committee, there was some discussion of my suggestion that GAO do an audit investigation of DOT's inadequacies in this area and more specifically the chaos which existed in the Materials Transportation Bureau. At that time the Secretary hustled around with a water can and put together a blue ribbon committee to look into these problems. What has that blue ribbon committee done? Has it met yet?

Mr. SANTMAN. That is the group I referred to as being in charge of the study. Mr. Woody Price, the Secretary's special assistant, is exercising leadership over that examination and I believe there is correspondence to your committee indicating that a copy of this report will be delivered by about the 9th of September.

Senator DURKIN. Is the report being delivered by the 9th of September because the investigation is complete, or is it because he is leaving in a couple of weeks?

Mr. SANTMAN. The commitment of September 9 was made before Mr. Price decided to leave. Whether or not his chosen date of departure has anything to do with that or not, I can't say.

Senator DURKIN. Do you know where he is going?

Mr. SANTMAN. I believe he is going to one of the railroads, Seaboard Coastline Railroad.

Senator DURKIN. He is leaving the public sector and going to the private sector.

Mr. SANTMAN. I believe that is correct. I have not conversed with Mr. Price as to his plans. I only know what I read.

Senator DURKIN. It is my understanding that the DOT was expected to issue final regulations for LNG facilities late this year, and that date has been pushed back. When can we expect those final regulations? How firm is that date, and what is the problem?

Mr. SANTMAN. There was not a commitment for final regulations. There was a commitment for a formal notice of proposed rulemaking growing out of the advance notice that was discussed or mentioned here earlier this morning. That advance notice drew in the neighborhood of 4,000 pages of comment. I might add that the point made by GAO as to the lack of good comprehensive R. & D. to back up some of the decisions that have to be made, is making it a bit more difficult to get to the formal proposal stage.

We will be issuing, right about the end of this year, a notice of proposed rulemaking covering construction, design, and construction siting of LNG facilities.

Senator DURKIN. Right about the end of this year. Is that December, November, March of next year, or what?

Mr. SANTMAN. I am personally committed to December, but I must recognize that there are a number of people in our department who review my work, and it may very well slip into January.

Senator DURKIN. How many people have to review your work?

Mr. SANTMAN. The Secretary has established and there has been published in the Federal Register, the schedule of rulemaking actions that the various elements of the Department of Transportation are committed to. A number of those are identified in accordance with the President's Executive order as being major ones or significant ones. When such a document is prepared by an issuing office, it is sent to the Office of the Secretary for a 30-day review. This regulation, this notice of proposed rulemaking, is one of those. That is why I am aiming to have it to the Office of the Secretary before Thanksgiving to allow the full 30-day period for the Office of the Secretary before the end of the year.

Senator DURKIN. Will that proposed regulation cover already proposed projects?

Mr. SANTMAN. It will not, sir. The second proposal will, the maintenance and operation part. scheduled for issuing in March of next year.

Senator DURKIN. So the siting proposal will not cover proposed projects. Those are left to some other subsequent date?

Mr. SANTMAN. Our ability to reach back to facilities that are already established——

Senator DURKIN. I am not saying established. I said proposed. There is a difference.

Mr. SANTMAN. I am not sure I understand your question, sir?

Senator DURKIN. Well, get a dictionary and look up "proposed" and look up "existing" and I think you will understand the question. I am talking about additional proposed facilities, not existing facilities.

Mr. SANTMAN. It will reach proposed facilities.

Senator DURKIN. All right, then the answer should have been yes. Do you agree that there should be one agency with the responsibility

and the authority to carry out that responsibility, rather than the mish-mash we have today?

Mr. SANTMAN. I am compelled to reserve judgment to managers of my department for a specific answer to your question.

Senator DURKIN. Every bureaucrat wants the responsibility, because he gets more people, a higher labor grade, a limousine to drive him around Washington. What is your personal opinion?

Mr. SANTMAN. I experience a lot of difficulties in getting the tasks done. I have heard witnesses this morning I think accurately point out that when you have overlapping jurisdictions and overlapping agencies; there is a tendency of one agency to say the other agency did it. There is also another phenomenon. Where you have overlapping agencies, it becomes difficult for one of those agencies, on many occasions, to get a task done because there is always that question of "what about this other agency?" When you get into the budget process, you get into the question of dealing with a small agency competing with a large agency. I think that this perhaps was the case that led to the GAO observation that it was 3 years before my agency, Materials Transportation Bureau, and the Coast Guard came to an agreement in a memorandum of understanding. I recognized that problem when I came into my position last November, and it was 2 months later that I managed to get that thing resolved and I think in a proper fashion. I think that the memorandum recognizes the very strong capability of the Coast Guard in areas of security, fire fighting, in waterfront activities, and I think it marries into the arrangement the limited but sound skills that my people have in the field of cryogenics and natural gas.

I don't think it should have taken that long, either, but that is an example of the kind of problems we have with overlaps and where somebody says let George do it.

Senator DURKIN. I appreciate your answer but I don't know what it was.

Mr. SANTMAN. Your question, sir, I think was do I think that one agency could do it better. As the GAO has said, I think an awful lot of improvement can be realized with the existing structure, and I don't know whether one agency can do it better.

Senator DURKIN. The buck list is 1½ feet long. There are so many agencies involved.

Mr. SANTMAN. I agree, and I would cite one other problem that we have in this regard: that is, in the research and development area. Again, I believe the GAO report points out quite accurately that major responsibility for research and development in the LNG area is in the DOE. We, of necessity, except for small nickel-and-dime acquisitions, look to the DOE for the major R. & D. commitment. We do not structure their budget. We do not have the ability to make it happen over there, but we are heavily dependent upon the results of the R. & D. that they do perform in the energy field.

Senator DURKIN. And relying on the DOE troubles a growing number of the Members of Congress. I might add parenthetically, thank God it does.

Mr. SANTMAN. In this area, sir, I might add the observation that the public statements by the DOE on the matter of LNG indicate a strong

desire on their part that we not become heavily dependent on foreign LNG as we are on foreign oil, and I am sure this is a factor in their planning and commitment of R. & D. funds. Nevertheless, we in the safety regulatory business, feel a bit shortchanged in what we have in the way of R. & D. answers, and this is part of the reason for the slowness in us coming to the required steps in rulemaking in the LNG regulations.

Senator DURKIN. I think we both agree that any corporation that organized itself like the Federal regulatory agencies and had the same flow chart would be bankrupt before your proposed regulations come forth. But I would like to thank you, Mr. Santman. If we have any further questions, we will ask you to supply the answers so they can be incorporated into the record. We appreciate your coming up this morning. I know you have a busy schedule.

I now will turn to Mr. Driver. I really appreciate the work that the NTSB has done under the leadership of Jim King and you, Mr. Driver.

Mr. DRIVER. Thank you very much, Senator. As indicated, my name is Elwood T. Driver, a Board member of NTSB, of which Jim King is the chairman. Chairman King sends his regrets that he cannot be here. He is out of town. However, his concern over this matter has been expressed on many occasions before and particularly during the April 1978 hearings. In general, those concerns as expressed by Mr. King at that time are still our concerns. My prepared statement addresses each one of these.

Senator DURKIN. That will be included in full into the record.

Mr. DRIVER. Thank you very much, sir. I would like to put things in proper perspective as far as the Board is concerned. As you and perhaps most of the observers realize, we are a separate agency and we are not in the regulation field, and we are not a part of the DOT. Our mandate, as given by Congress, is to investigate all transportation accidents with one sole objective, and that is to find out what caused it, determine the facts, and to come up with specific recommendations to prevent recurrence of those accidents. You might even call it accident control.

However, our main purpose is to prevent accidents from occurring in the first place and in those cases where they occur anyway, at least mitigate the catastrophic results of those accidents. So our sole purpose and objective is the enhancement of safety in all modes of transportation, specifically in hazardous materials, by the proper identification of the cause and specific recommendations for remedial corrective action.

Senator DURKIN. If I could interject here just a moment. My comments earlier in no way should be construed that I was suggesting that the NTSB be incorporated to any single agency that would have overall responsibility. You have a very clear function. I think under the direction of Chairman King, you are doing an excellent job and should not be merged or incorporated or brought under the protective umbrella of any other agency. I think you are doing a fine job now. I commend you and hope you continue.

Mr. DRIVER. Thank you, Senator. This is one time when we prefer to be excluded.

We feel that the public is not going to be adequately protected until either there are no more accidents or until a good solid risk analysis shows that the possibility of accidents has been reduced to an irreducible minimum. And even under those circumstances we feel that maximum effort should be devoted to the mitigation of those accidents once they occur.

The Safety Board is most gratified by the committee's support expressed in its report 95–814 on amendments to the Hazardous Materials Transportation Act, authorizing appropriations for fiscal year 1979. We are particularly pleased on the position taken on the need to identify the risk before accidents occur, and might I say this is the crux of any accident prevention program as opposed to accident control. It applies to the need for a bulk carrier registration program, the need for improved Federal leadership in helping local communities cope with emergencies involving liquefied gases, and other hazardous materials, and improvement in the department's exemptions program.

Senator DURKIN. The DOT's program.

Mr. DRIVER. Yes, DOT.

We are particularly concerned about the quality of evaluations in its exemptions program because the LNG, moving in cargo tanks by highway, presently moves under exemptions. Exemptions have been granted for large cargo tanks, up to 11,900 gallons, and for aluminum cargo tanks with foam insulations.

Senator DURKIN. Could you elaborate on that exemption process? I know it concerns many people.

Mr. DRIVER. Yes, sir.

Senator DURKIN. My understanding is that much of the so-called regulations of the Materials Transportation Bureau has been confined to granting exemptions.

Mr. DRIVER. Judging from this annual report of the Secretary of Transportation, Hazardous Materials Control, I would probably agree with you, sir. There is a list of exemptions—this happens to be 1976—which gives the numbers and purpose and reasons, and we are particularly concerned about the Reason No. 1, which is "to develop information and gain experience concerning innovative forms of packaging, shipping conditions, or carrier operations". In most of the cases that was the reason for granting exemptions for the shipment of LNG. And I might cite, the reason for our concern.

We believe there must be more appropriate ways to test this innovative packaging than to test them by allowing them to move through densely populated areas in normal transportation channels.

For example, use of innovative vehicles for transportation of nonhazardous materials and a clear statement of the test data to be acquired by the operation of these innovative packagings would seem much more prudent than the present practice of testing the equipment in public usage in liquefied natural gas service and waiting for accidents or incidents to indicate whether or not they are satisfactory.

Other concerns previously expressed by the Board involve risks during unloading, and use of the safest possible routes for the movement of hazardous materials. As a result of a 1971 unloading accident from a bulk tank vehicle in Berwick, Maine, the Safety Board recommended that DOT investigate risks during unloading of hazard-

ous materials. The transfer of such materials from the transport vehicle into the receiving storage tank continues to be a high-risk operation, and accidents can produce disastrous and catastrophic consequences. In Philadelphia, a major fire occurred during the unloading of a tank vessel in 1971. Many of you may recall the fire and explosion at a liquefied petroleum gas depot in Waltham, Mass., several years ago. So far as we know, the DOT has not undertaken a special effort to examine these unloading risks.

With respect to routing controls for the movement of hazardous materials, the Safety Board in 1977 recommended that the DOT provide local communities with guidelines for developing local hazardous materials highway routing restrictions. This would enable local communities, who usually do not have the specialized risk analysis capabilities that are needed to establish effective routing restrictions, to formulate such restrictions quickly and efficiently, and thus improve safety through local actions.

The DOT issued an advance notice of proposed rulemaking concerning possible methods for establishing routing requirements applicable to highway carriers of radioactive materials on Thursday, August 17, 1978. However, they have not issued any advance notice or other notice of rulemaking concerning problems associated with the highway transport of liquefied energy gases.

I don't want to appear totally negative about progress on matters that are addressed by this hearing. The Coast Guard, for example, has responded favorably to Board recommendations in a March 1972 report on the safety of transportation of hazardous materials on navigable waters of the United States. The Coast Guard, alone among the DOT administrations, has made a diligent effort to identify the dangers associated with liquified natural gas and other hazardous materials when releases occur. The Coast Guard is committed to a large-risk management research project, another first among DOT modal administrations. Its participation in the national contingency plan and national response team activities for hazardous polluting substances also reflects its concerns and leadership among DOT administrations in the emergency response area. Its vessels traffic control system also constitutes a constructive safety control measure.

It is my understanding that the local storage facilities here were in place before the Department of Transportation's jurisdiction over loading, unloading and storage of hazardous materials was clarified in Public Law 93–633, which became law in January 1975. I also understand that H.R. 11622, the Dingell-Markey bill, provides further clarification in that area. Since these facilities are now in place, their operations must be controlled utilizing the best available safety technology to assure adequate protection of the public, and that is where we should have risk analysis conducted in the best manner possible, as a good way to prevent accidents in this area. Your committee's hearings today will help to achieve this objective.

Mr. Chairman, this concludes my remarks. If you have any questions, I would be happy to try to answer them for you.

Senator DURKIN. Thank you, Mr. Driver. On April 18 Mr. King testified and made several points. The first point was that the Materials Transportation Bureau had failed to publish safety guidelines to identify accident risks before a catastrophe occurs. This is now the

20th of August. Is there any reason to change that first statement of Mr. King?

Mr. DRIVER. Not at all, sir.

Senator DURKIN. The second point Mr. King made was that the Materials Transportation Bureau, which is a subdivision of DOT, has refused to establish a central data system to provide information and advice to firefighters and local safety personnel. Is there any reason to change that statement of April 18 on August 20?

Mr. DRIVER. It is our understanding that this has not yet been accomplished and according to the previous testimony it is vitally needed.

Senator DURKIN. The third point Mr. King made was that the Materials Transportation Board had refused to register bulk carriers of hazardous materials. Is there any reason to change that statement on August 20 which was made on April 18?

Mr. DRIVER. Not to my knowledge, sir.

Senator DURKIN. Fourth, the Materials Transportation Bureau had permitted its exemption procedures to become a "free-for-all" for the hazardous materials industry. Is there any reason to change that statement of Mr. King in light of the facts today?

Mr. DRIVER. I have no information to refute that statement.

Senator DURKIN. Fifth, Material Transportation Bureau had declined to become a leader in the development of new emergency response techniques. Is there any reason to change Mr. King's statement of April 18 in light of the facts today on August 20?

Mr. DRIVER. It is still a matter of grave concern to the Board, sir.

Senator DURKIN. The report of NTSB on derailments and hazardous materials, amongst other things, says that the entire process used to improve the design of the new large tank cars lacked any documented safety methodology. In fact, the larger tank cars removed the safeguards found on the older smaller tank cars. It goes on to say that this is an unreasonable risk to the public as shown by 10 years of derailments. Is there any reason to change that statement or modify that statement?

Mr. DRIVER. No, sir.

Senator DURKIN. In 1971, NTSB recommended the DOT adopt a risk based framework to evaluate dangerous goods transportation safety regulations. It has still not done so. Is that true today?

Mr. DRIVER. To the best of our knowledge, it is still true today, sir.

Senator DURKIN. On page 5, your report states, "there seems to be no sense of urgency by the parties involved." Have we injected any new pangs of urgency since that report was published?

Mr. DRIVER. I have not heard Mr. Santman's testimony, sir. I just read his prepared statement and there appear to be some indications of taking action by a rulemaking which would indicate some urgency in the matter.

Senator DURKIN. On page 5 the report says that hazardous materials routes have no priority in getting maintenance. Any evidence that that has changed?

Mr. DRIVER. I am not well versed in that particular area, sir. I would like to get that for the record, though.

(The following information was subsequently received for the record.)

As of this date (August 21, 1978), there is no regulation requiring that hazardous materials routes be given priority for maintenance purposes.

Senator DURKIN. You can submit that for the record.

The frequency of derailments has been increasing steadily for the last 10 years.

Mr. DRIVER. Still true, to the best of my knowledge.

Senator DURKIN. The NTSB recommendation that the Secretary of Transportation in compliance with congressional legislation establish and maintain a central reporting system, has not yet been done.

Mr. DRIVER. To the best of my knowledge, that is still true.

Senator DURKIN. Page 31, the report states, that "current emergency response methods are unreliable, untimely and rely on unstructured individual decisions." Any evidence that that statement should be modified in light of today?

Mr. DRIVER. Not that I know of, sir. I would like to respond for the record on that particular one.

(The following information was subsequently received for the record.)

Answer: No, sir.

Senator DURKIN. It is my understanding that NTSB has recommended to the DOT that regulations for LPG pipelines be improved. What is the status of that regulation?

Mr. DRIVER. We have no feedback on that yet, sir.

Senator DURKIN. Mr. Santman, is that response the promulgation of Thursday, August 10, 1978, the notice of proposed rulemaking——

Mr. SANTMAN. That is one of them. There will be another one later this month or early next month, going to all liquid lines but focusing in particular on those involving LPG. The first batch are aimed at upgrading emergency response, emergency preparedness, and shutdown facilities.

Senator DURKIN. In fairness to you, Mr. Santman, the same question I asked the Coast Guard——

Mr. SANTMAN. The answer is no, sir.

Senator DURKIN. You don't have adequate staff?

Mr. SANTMAN. No; I suspect that the Captain's office is probably about half the size of mine and he's got only Port of Boston to be responsible for.

Senator DURKIN. So the record should show that it is your opinion that you do not have adequate staff to carry out the fragmented responsibilities that are imposed on your office?

Mr. SANTMAN. It's a combination of that. plus the answers that you get through research and development and the exploration of some of these problem areas. I believe, sir, that one of the real benefits in these hearings today, the GAO report and all that is around it, is a focusing on the catastrophic potential, when one has to go into the budget process armed only with the statistics of what the average accident has been. And we are talking about annual figures of roughly 30 to 40 people a year killed from hazardous materials directly, matched up against the likes of Mr. Driver's format organization, the NHTSA, that can cite figures of 30,000. 40,000, and 50,000 people a year who were killed—and the only thing you have going for you is hard statistics—it becomes difficult to compete for the resources.

I think that one of the things that we have been trying to bang away at from my office's perspective, and which is receiving impetus by the GAO report and by this study, is that there is more to it than that. There is the catastrophic potential. The thing that hasn't happened. The thing that we do not have an actuarial table on, but which thorough analysis—even skimpy analysis—tells you that there is a strong potential for catastrophe. I think the heightening, the surfacing, of this kind of thinking and the resulting discussion are going to be great tool to us, whether the test is to be done by one agency or still done by a handful of agencies.

Senator DURKIN. You mentioned actuarial tables. Where has the insurance industry been in this, or is the liability question so fragmented between the daisy chain of corporate entities that there is really no great insurance exposure so that the insurance risk managers have not come into focus on this?

Mr. DRIVER. I am not prepared to address that particular problem, sir.

Senator DURKIN. The insurance industry has been responsible for a considerable number of safety initiatives. Underwriters Laboratory on down——

Mr. DRIVER. I think you are referring to the type of action that the insurance companies have taken in the automotive safety field, where they have been very innovative and supported safety regulations and so forth. I personally have no evidence of that being accomplished in the hazardous materials area. Do you know of any?

Mr. SANTMAN. No. I do find the discussion in the GAO report in this area most interesting. I think the surfacing of this area of concern will serve a useful purpose. It certainly is going to stimulate a lot of discussion and examination of what the liability regime does and doesn't do to enduce safe practices.

Senator DURKIN. Just a brief aside in the spirit of proposition 13, by the number of people waving copies of testimony trying to cool themselves, you can see we are not wasting the taxpayers' money on the air conditioning system in the building, or at least in this room.

Mr. Driver, why do you think the DOT has not yet changed its treatment of liquid petroleum gas from an oil to a gas?

Mr. DRIVER. I really don't know, sir.

Senator DURKIN. Why do you think DOT has not yet implemented new regulations for LNG transportation?

Mr. DRIVER. Having come out of a regulatory agency myself, I know that there is certain leadtime imposed by the Administrative Procedures Act, which dictates that a standard can't just be arbitrarily promulgated. I think that is one factor. Another one might be waiting for the development of further research and development. Of course you can wait forever if you do that. I think they are the two primary ones.

Senator DURKIN. That LPG incident in Spain—does the NTSB send people overseas to see what has happened, so we can profit from accidents in other corners of the globe rather than waiting for our own local, homegrown accident to study?

Mr. DRIVER. Absolutely, sir. In this particular case we were invited by the respective countries to attend. We did have personnel over at that particular accident. We did pick up some information, and as

I recall their safety standards are such that they don't carry release valves in their vehices. They just leave ullage in the top so they can carry more. There are certain things that they do differently from us.

Senator DURKIN. You do have adequate financing to investigate to the extent possible, accidents overseas, with an eye to preventing them here?

Mr. DRIVER. That is correct, sir. We are running short this year, but we have been so provided in the past.

Senator DURKIN. Well, gentlemen, I want to thank you very much. The record will remain open. If you have any further comments, or there are any further questions, we will be in touch. We urge your continued cooperation with the committee. Captain, on the basis of the testimony this morning, I think the Coast Guard should be complimented for the work the Coast Guard is doing in this area.

We now will hear from John McKenna, vice president, gas supply and planning, Boston Gas Co. and Mr. Norton, vice president of Distrigas.

I appreciate the detail and the thought that obviously went into the preparation of the testimony, Mr. Norton. Mr. McKenna and Mr. Norton, your full statements will be included as well. We would appreciate your paraphrasing the high points of the statement. Please proceed in the manner most comfortable for you.

STATEMENTS OF JOHN T. McKENNA, VICE PRESIDENT, GAS SUPPLY AND PLANNING, BOSTON GAS CO.; AND ROBERT G. NORTON, VICE PRESIDENT, DISTRIGAS CORP.

Mr. MCKENNA. Good afternoon. I am John T. McKenna, vice president of gas supply and planning and director of Boston Gas Co., the Nation's second oldest and New England's largest gas distributor.

Boston Gas has a long history as a provider of economical, clean and essential energy to its customers. The company has been meeting the energy needs of residential, commercial and small industrial consumers safely for 156 years, since 1822. We serve a half a million customers in 74 cities and towns in eastern Massachusetts.

Before I begin, let me outline for you my experience with the gas distribution industry and specifically with liquefied natural gas and liquefied petroleum gas.

I have a bachelor of science degree in chemical engineering from MIT and a master of business administration degree from Northeastern University. In addition to my affiliations with the American Gas Association and several other natural and international gas organizations, I am a professional engineer in the Commonwealth of Massachusetts.

I have participated in several international LNG congresses, and I have inspected LNG plants around the world, in Algeria, Germany, Italy, England and Japan. I also have extensive experience with the use of propane, a liquid petroleum gas.

I have been in the gas industry for almost 30 years. During these three decades, Boston Gas has used propane for peak shaving purposes in propane-air facilities. The company now has 10 propane-air peak

shaving facilities located strategically throughout its system. For the past 4 years, the company has also used propane even more efficiently in a substitute natural gas, or SNG, plant. Most of this propane is purchased from Exxon and is delivered directly to our SNG plant by a half-mile pipeline.

Senator DURKIN. Where is that facility?

Mr. MCKENNA. In Everett, Mass. In addition to this use of propane for peak shaving, the company has extensively utilized liquefied natural gas or LNG. Ten years ago Boston Gas became the first utility in the United States to import LNG from overseas through our LNG facility located in the Dorchester section of this city. Boston Gas was also the first utility to import LNG by truck from Canada. The company operates LNG facilities in Salem, Lynn, and the facility I mentioned in Dorchester. So you can see that Boston Gas has extensive experience in liquefying, storing, vaporizing, and transporting LNG for peak shaving purposes.

From this background of practical experience with LNG and LPG I speak to you today.

The substance of my remarks can be summarized in two sentences. First: The use of LNG and LPG for peak shaving is vital to the continuation of gas service to high-priority residential and small commercial customers, especially in the Northeast. And second: Existing methods of handling and transporting LNG and LPG are safe and necessary.

Let me expand on these thoughts. Boston Gas Co. is absolutely dependent upon peak shaving gases to serve its customers' high-priority requirements. Ninety-eight percent of Boston Gas' half million customers are residential and small commercial consumers. These consumers have no practical energy alternatives. They use gas for heating and cooking, basic human needs. They cannot readily or economically switch to alternative energy sources—alternatives which are less attractive environmentally, economically, and politically.

As you know, the last two winters have been particularly trying in New England, and yet, because of its ability to supplement pipeline supplies, Boston Gas has not had to curtail gas deliveries to any firm winter customers.

Overall, in each of these two winters, the company has relied on LNG to serve approximately 15 percent of its customers' needs. But the most critical need for LNG is during prolonged severe cold periods. During a typical 3-day cold period in New England, LNG would provide over 30 percent of daily sendout, and on the peak day, LNG could constitute as much as 50 percent of the gas sent out by the company. In addition, Boston Gas utilizes propane to serve 10 percent of its customers' winter needs.

We all recall conditions in America's Midwest two winters ago, when industries and schools were closed because of gas shortages. We had no such curtailments here in Massachusetts. Nor did we during the oil embargo 4 years ago. And this was no accident, no good luck or matter of chance. It is because of the planning we did 10 years ago, in building the supplemental gas facilities, the LNG and LPG facilities we are talking about today.

I need not remind you, Senator, that New England is in a unique position. We are remote from conventional domestic pipeline sources

of gas and from underground gas storage facilities. We have essentially no heavy industries requiring consistently large volumes of gas. In addition, as we all very well know, this region is subject to severe weather fluctuations. For these reasons, substantial peak shaving capabilities have always been required. So it is important that you understand what peak shaving means.

Peak shaving is the process by which a gas utility supplements its basic pipeline supplies during periods of high or peak customer demand. Peak shaving is not a new term or a new method of delivering gas service. Boston Gas has been peak shaving, or supplementing its pipeline supplies, since 1953 when domestic pipeline natural gas first became available in New England.

Various fuels have been used, such as carbureted water gas, high BTU oil gas, propane, and propane-air. And now LNG, which is particularly suited to large volume peak shaving. When vaporized, LNG is completely interchangeable with pipeline natural gas; therefore, there is no volume limitation on its use. It can be stored efficiently and regasified quickly and economically.

Let me emphasize that our peak shaving facilities have been in operation safely and economically for years. These are crucial facilities providing much needed energy supplies for Massachusetts and the New England area. The loss of these facilities would threaten the gas supply of residential consumers with no alternatives. I am in charge of gas supply planning for Boston Gas, and I must tell you that without LNG and propane for peak shaving, New England would be in severe trouble. Let me reemphasize that these facilities are, and have been, consistently safe.

Let me now discuss the trucking of LNG. An LNG tanker truck has a rugged double-wall design, a tank within a tank. The inner tank, which contains the LNG, is constructed of aluminum. Aluminum's tensile strength is greater at the extremely low temperature of LNG—minus 260° F, than at ordinary room temperature. This inner tank is housed within a high strength, reinforced steel outer tank. And the annular space between the two tanks is filled with perlite, an inert insulation, and evacuated to form an effective insulation system.

LNG tanker trucks meet or exceed all Federal requirements for cryogenic trailers. In addition, they meet State highway weight and dimensional limitations. These trucks are constructed and authorized under a special permit of the Federal DOT, granted only upon thorough review by officials of DOT's Hazardous Material Division.

Senator DURKIN. Is that the same exemption that was criticized in earlier testimony?

Mr. MCKENNA. Yes, sir. However, the reason given was not the reason. There are no rules for this type of vehicle, so the only way you can get permission is to ask for exemption under the proposed rule.

Senator DURKIN. But the extent of that intensive regulation that you refer to in your statement, on the basis of GAO study and the testimony of Mr. Driver, is basically granting you an exemption.

Mr. MCKENNA. That is correct, because there are no rules to follow. If there are no rules you can't meet them, so they have to be granted an exemption. Otherwise they couldn't be used.

Senator DURKIN. Let me clarify. The intensive regulation is a rubber stamp that says "Exemption" on it.

Mr. MCKENNA. It is not a rubber stamp. It is a very highly and clearly technical study of the materials used and the way it is constructed.

Senator DURKIN. How many exemptions have been denied?

Mr. MCKENNA. I don't know. You would have to ask someone else. In our particular case I know there was a very thorough investigation before it was granted.

Senator DURKIN. Why have they been so tough on you and so easy on the rest? I would think your officers would be concerned that they were discriminating against you and giving you such intensive scrutiny when the record shows the other applicants are granted routine exemptions.

Mr. MCKENNA. If I went and asked for something that was different and somebody rubberstamped it, I would not think the piece of paper was worth anything. Therefore, I would insist upon an intensive review to make sure the materials——

Senator DURKIN. Would you supply for the record the intensive review that each one of your exemption applications has received and document that?

Mr. MCKENNA. We will have to go through the manufacturer who built the tanker truck, but we can do that.

Senator DURKIN. If you could, please, because there seems to be a conflict.

Mr. MCKENNA. Well, LNG vehicles are different from the standards that are given for new types of fuel trucks or oil tanks.

Senator DURKIN. I realize that. And different from LPG.

Mr. MCKENNA. That is correct.

Senator DURKIN. The standards are tougher for LNG than for LPG. I think we can accept that.

Mr. MCKENNA. Besides the approval, Boston Gas has traditionally required specific authorization from the ICC for its LNG handlers.

Let me emphasize again that LNG trucking is safe. Over the past 10 years, more than 15,000 truckloads of LNG have been delivered to our facilities without serious incident from as far away as Canada, California, and Tennessee, as well as locally from Distrigas in Everett.

Throughout more than a decade of experience with LNG, we at Boston Gas have kept safety foremost in our minds. Our facilities have been constructed and are operated in accordance with rigid standards of the Federal DOT and the Massachusetts Department of Public Utilities.

We have also maintained close liaison with the fire department personnel in our area. The most recent example of this was an LNG seminar which Boston Gas conducted for fire department officials of the city of Boston and other cities and towns in our service area, along with members of the U.S. Coast Guard, State fire marshal's office, Massachusetts Turnpike Authority and the Massachusetts Department of Public Utilities.

LNG is vital to the Boston Gas supply strategy. Without trucking, it would be impossible to replenish LNG inventories at the end of a cold winter. And our entire gas supply plan would be in jeopardy.

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The fact that LNG trucking is safe is the direct result of the rigid specifications to which LNG transports have been built and operated.

Senator DURKIN. Mr. McKenna, I think I would be remiss if I didn't observe that many of the LNG trucks that are admittedly safer, are manufactured by a New Hampshire concern.

Mr. MCKENNA. That is correct. Because an important ingredient of our business is safety, we strongly support the current strict regulations.

I hope you will agree with me from what I have told you today and from a close review of the record, that LNG and LPG are vital to the energy needs of our customers and that they have been and will continue to be handled and transported safely. Thank you.

Senator DURKIN. Thank you. Let me ask a couple of questions. Why is LNG so necessary? And where do you plan to get it from—Algeria, Alaska?

Mr. MCKENNA. We have been purchasing LNG—we did from Canada for a while. The majority of our purchased LNG has come from Algeria since about 1968. In the beginning by direct importation by Boston Gas from Algeria, and since from about 1971 on, through Distrigas Corp.

Senator DURKIN. Is not the increased importation of LNG from Algeria duplicating the problem we had with OPEC—that more and more of our supply of energy comes from the same corner of the world, subject to the same problems and conditions?

Mr. NORTON. I don't think they are quite the same, Senator. Algeria is an Arabic country and is a member of OPEC, but they only have barely a billion barrels a day of oil and they have a lot more gas. They are dependent on the gas and the gas is a very capitally intensive operation. The reasons that they might shut down would be modified by the capital obligations they have and the fact that it is one of the most populous of the Arabic countries. They are a Socialist country, also, and they have a number of obligations that make it difficult for them to participate in an oil type embargo.

Senator DURKIN. I don't mean to express—and I hope it was not misconstrued—any concern because the OPEC countries happen to be Arabic or Irish. The fact that they are Arabic has no significance as far as I am concerned whatsoever. But the point is, in New England we were led down the pipe, the empty pipe, in getting hooked on OPEC's oil. When it was $1.25 a barrel, we were not allowed to buy it; through no fault of yours, but we were not allowed to buy it. Now at $14 a barrel we are allowed to buy much more than we can afford. My concern is, are we repeating the same mistake with respect to LNG from a foreign source?

Mr. MCKENNA. As far as Boston Gas is concerned, we looked at this and we determined that a certain percentage of our supply could come from a foreign source. We have also determined that, as Mr. Norton has said, because of the intense capitalization of an LNG project the shipper or the producer cannot very easily cut it off. He can't sell it anywhere else.

Senator DURKIN. What about a coup in Algeria?

Mr. MCKENNA. OK. Let me get one more point in first. More important to me is the fact that as far as the Algerian government is con-

cerned and the Algerian people are concerned, their well being is determined upon the revenue they get from the sale of their only strategic natural resource, natural gas. They can't sell sand. They can't sell anything else. But they do have natural gas and their whole economy——

Senator DURKIN. Boston Sand and Gravel might be interested in sand.

Mr. MCKENNA. Oh, no. The grounds of sand in the desert are rounded from the wind and they make very poor concrete.

It is a legitimate issue and we have looked at it very carefully. We have set ourselves a percentage that we will maintain ourselves with. We have also set up a contingency plan which we have shown to the Federal energy regulatory authority of what we would do if it did get cut off. Because we do have the four storage tanks and a large volume on hand at all times, we can stand a very good shutoff, and that is part of our plan.

Senator DURKIN. What is the cost per thousand cubic feet of that LNG today and what is projected?

Mr. MCKENNA. Roughly the price we are paying today is about $3 per million Btu's. If we look at what we get from the pipeline at the present time, our present pipeline rate is about—on the Tennessee system, there are two systems—it's a little bit over $2.25, but it has been rising very fast.

Senator DURKIN. Wait until the natural gas bill makes it, if it does. What is the projected increase in LNG?

Mr. MCKENNA. Our projected increase on LNG is about the same rise as the price of oil products, because it is tied to the price of oil products in New York Harbor.

Senator DURKIN. So it will go up 5 percent in December, if we can believe the rumors coming out of OPEC.

Mr. MCKENNA. Well, it's a mix of what New York Harbor prices are, so even though OPEC would go up 5 percent it may not go up 5 percent in U.S. terms.

Senator DURKIN. Are you adding more customers to your system?

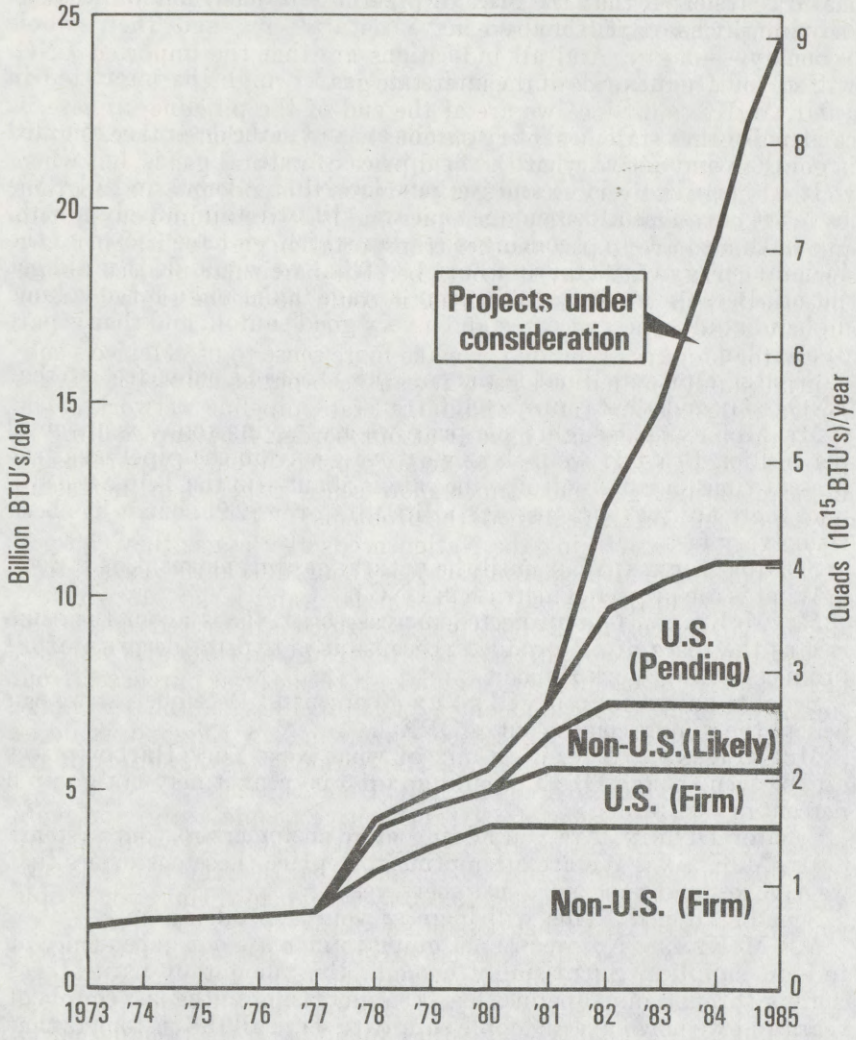
Mr. MCKENNA. We are attempting to replace those customers that we have lost and some more customers, yes.

Senator DURKIN. This will increase your dependence on——

Mr. MCKENNA. No, we are not going to increase our dependence on foreign supplies. Surprisingly enough, the amount of natural gas coming through our pipelines has been increasing in the last couple of years and we now have an ample supply to serve all the customers that would like to use clean burning natural gas.

(The following information was subsequently received for the record.)

How world LNG shipments could grow



Source: American Gas Association.

Senator DURKIN. Do you roll in the price of the LNG?

Mr. MCKENNA. That is correct. In previous years the price of the LNG was cheaper than the price of pipeline. We have had an increase in price which now puts it above it.

Senator DURKIN. And all indications are that the imported LNG will stay above the price of the interstate gas.

Mr. MCKENNA. Since we are at the end of the pipeline up here, I can't make that statement very succinctly and say that is true. Yes, it is going to stay above what the field price of natural gas is, but when you add in the delivery charges, et cetera, on this end, and the fact that the LNG comes into Boston at the pier and is delivered into our system and we don't have to pay another transportation cost for it. There are some scenarios which say it would be. The particular project we are concerned with which is Distrigas, it could be at the same level or slightly cheaper.

Senator DURKIN. Wouldn't it make more sense to use Mexico's substantial supply of natural gas? It can be brought across the Texas border into existing inter- and intra-State pipeline networks. The Mexican Government can have it at our border. They are willing to sell it to us at $2.50, at least at today's price. Wouldn't purchasing Mexican natural gas make much more sense rather than increasing our dependence on LNG with all the problems?

Mr. MCKENNA. I think the Nation needs all the gas they can get. If you look at the Mexican contract it is about $2.65 at the border. Add 50 cents for transportation to New England and it is $3.15 which is higher than the cost of the Distrigas gas which is delivered to us at the present time. If we can purchase for New England through Distrigas, gas distinctly for use in New England—if the gas was purchased from Mexico it would be spread among a lot of pipelines and the percentage we would get to help the energy consumers in New England would be a small percentage of the total net. The Nation needs the supply of gas from Mexico, and it also needs the LNG from Algeria.

Senator DURKIN. Some fairly authoritive people are giving more and more credence to the strong possibility that in New Hampshire and other parts of northern New England that there may well be substantial natural gas deposits at 15,000 feet and below. Have you people concerned yourself with that possibility at all?

Mr. MCKENNA. We always keep our minds open as to new sources of gas supply and followed very clearly the Baltimore Canyon exploration. However, in the timeframe we are looking at for supply, it was not going to be available even if they found it. In the time period we are looking at—we look 10 and 20 years out in the future—we expect by 1985 we ought to see the first signs of domestically proven offshore reserves, and they will be available for use in our market. Our problem is that we have to have gas supply to get us to that period of time.

If we lost 50 percent of our customers and then all of a sudden we had a big new gas supply, we couldn't get those 50 percent of our customers back. We have to be able to supply the needs of our present customers.

Senator DURKIN. With the price of oil they wouldn't be on oil. They might be on wood or solar.

Mr. MCKENNA. A lot of my neighbors use wood.

Senator DURKIN. What you are saying is that even if there is substantial gas in northern New England at substantial depth, you are still going to need LNG in the interim?

Mr. MCKENNA. That's correct, in order to get us to the point in time in which we can exploit those resources, yes.

Senator DURKIN. Are you familiar with the Knutson study that was done by the old ERTA, which is now the DOE? During Energy Committee oversight hearings earlier this year, Dr. Knutson presented his analysis that the North American continent, onshore and offshore, is swimming in natural gas, from Alberta all the way to Mexico. His hypothesis has never been adequately refuted.

Mr. MCKENNA. There have been many studies but the proof of the pudding in natural gas discovery is putting that well down and finding it. For example, I can cite the example of the Australians. They went out looking for oil. Found natural gas. In the first three places they drilled they found lots of natural gas. They started a whole gas industry based on that. The next 50 fields were dry. So you really can't tell until you put that hole down and see if the gas will move to the wellhead.

Senator DURKIN. Well, enough for Energy Committee matters. More particularly, and either one of you can answer this—what are your contingency plans in the case of accidents at your facilities or transporting liquid energy gas?

Mr. MCKENNA. I think both of us have the same contingency plans. We have worked very directly with all the fire departments through all the areas in which we transport LNG or LPG. We inform them the routes they are taking. In fact the route that we use in Boston, when we first started back in 1971 was the route that was recommended to us by the present fire chief at that time. We had a slightly different route. We follow his route. We have been using it ever since 1971. We have training sessions with the fire department at our plant facilities and as the commissioner mentioned earlier, at the Boston Fire Department facilities at Moon Island, where you can have live fires and demonstrations.

Senator DURKIN. How often do you simulate emergency responses?

Mr. MCKENNA. About once a month the fire department bring their trucks into our facilities, goes through all the different areas, all our fire equipment, knows where everything is, how to operate it, and how we operate it.

Senator DURKIN. For the record, I would like your view on the conundrum, if you will, between remote siting and transporting LNG to highly densely populated areas.

Mr. NORTON. We would be glad to.

Senator DURKIN. GAO has recommended better measures to take care of the possibility of sabotage. I don't want you to set forth your antisabotage plans in the record for the benefit of some deranged personality, but do you feel your antisabotage procedures are adequate?

Mr. NORTON. I think our procedures are adequate to take care of what we would call a normal intruder. I have had many discussions with people in the industry and people who have read the draft report of the GAO cookbook of how to sabotage an LNG plant. Basically we come back to the same problem that they have in England.

They have guards at all their nuclear facilities in England and they don't let them carry guns because it is against the law to carry guns in Great Britain. They don't even let the guards carry guns. A bill was introduced in the House of Parliament to allow them to carry guns and the testimony there indicated that even if they had guns a determined saboteur could overcome any defense you had.

Senator DURKIN. I appreciate your comments on the liability insurance question and the questions articulated by the GAO. I understand that Distrigas was planning to expand its facilities. If expansion is approved, what specific safety features will be included? Would you provide that for the record as well.

Mr. NORTON. We will certainly do that.

[The following information was subsequently received for the record:]

DISTRIGAS OF MASSACHUSETTS CORP.,
Boston, Mass., December 7, 1978.

The Honorable JOHN A. DURKIN,
Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR SENATOR DURKIN: At the August 21, 1978 public hearings in Boston concerning transportation, storage and use of LNG, I promised to send to the Committee information concerning safety features that would be included with the additional facilities being installed to permit the handling of the larger LNG volumes resulting from the December 31, 1977 approval by the Department of Energy of our "Long-Term" Import Program.

I have listed below the various safety and security measures that are actually part of the increased volume program and a list of those safety and security items being installed which, although not directly associated with the long-term program, do contribute to the safety and to the security of our plant, I believe that is what you are really interested in.

A. Security and safety items included as part of the additional equipment for the increased volume program:

1. Vaporizer area.

(a) Trenching, grading, and sump to safely contain any LNG spills.

(b) A halon system for fire extinguishment included in the vaporizer electrical area.

2. We have improved our electrical reliability by tieing into two separate electrical supply sources.

3. A vapor return blower has been added which makes return of vapor back to the ship more positive and reliable.

4. We are adding two additional Chiksan unloading arms which will allow the ship to be unloaded more rapidly thereby spending less time at our dock.

B. Safety and security items added that are not specifically a part of the "Long-Term" increased volume program:

1. Fire protection improvement.

(a) Additional dry chemical systems added at dock.

(b) Dry chemical extinguishers mounted on top of the tank at vents.

2. Plant lighting will be increased substantially.

3. The truck loading area has been provided with water curtains to disperse vapor in the unlikely event of a spill.

4. A redundant ladder has been added to each tank to facilitate operator egress.

5. The truck loading flexible steel hoses will be replaced with Chiksan arms which will be easier and safer for operators to handle.

6. Remote control has been provided for the Chiksan arms at the dock giving dual locations from which operations can be conducted.

7. Additional combustible vapor detectors has been added at the dock area.

8. Additional intercom stations are being added to improve plant communication.

9. Water deluge systems will be installed on top of each tank.

10. Redundant automatic alarm shut-down systems have been added to prevent over filling the tank.

11. Installation is complete of a system which eliminates the slight tank vibration problem experienced with tank #2.

12. The plant fencing has been replaced with higher more secure cyclone fencing topped with "Razor Ribbon."

13. Several security systems to prevent and/or warn of intrusion have been added.

14. Automatic gates have been added which are under the surveillance of security guards.

15. Safety devices are installed to shut-down the unloading system to be actuated in case the ship drifts forward, backward or outward more than an acceptable distance.

16. Additional leak detection devices are being installed underneath the full length of the unloading line.

17. We will be setting up microwave communication systems direct to the Everett City Police and City Fire Departments.

18. Over the past several months we have increased the number of security guards and guard dogs.

When reading the above list, you must remember that all of these items have been added to a plant, which even before these additions had a reputation as being a very safe and secure plant.

I will be pleased to provide answers to any other questions you may have or to provide additional detail concerning the items listed above. Thank you very much for your interest in our plant operations.

Sincerely,

ROBERT G. NORTON,
Vice President
Marketing and Supply.

Mr. NORTON. Would it be appropriate if I gave my brief oral summary of the written statement at this time?

Senator DURKIN. Yes.

Mr. NORTON. Mr. Chairman, ladies and gentlemen, I appreciate the opportunity to appear before you to speak about the importation of liquefied natural gas at this time. My name is Robert Norton and I am vice president of marketing and supply for the Distrigas Corp. In my prepared statement I have described in great detail the contribution of LNG to the energy requirements of New .ngland and the safety record of the industry. I would now just briefly summarize that.

For nearly 7 years now, Distrigas has been importing LNG into Boston safely and economically. We have made a significant contribution to the New England economy in fuel supply and until this year we were the only importing LNG terminal in the United States.

Today we want to discuss the role this facility plays in the New England gas supply system, the safety of the Everett facility, the risks from LNG operations in proper perspective and the reasons it makes sense to site certain LNG facilities in urban areas.

LNG is indispensable to New England. The role of LNG in helping supply the energy needs of the area is vital and is increasingly so each year. Due to the geology of this area, underground storage of gas is not practical, so aboveground storage of LNG, first liquefied from pipeline gas, now supplemented with imported LNG, has been utilized. The Distrigas terminal serves a network of LNG facilities throughout the Northeast United States. There are 30 urban sited LNG tanks in Massachusetts alone. They are urban sited to connect with gas systems that bring natural gas directly to the consumer.

The demand for gas in New England is closely responsive to the weather, since so much gas is used for heating and cooking, with very little going to an industrial use. As a result, far more gas is used in winter than in summer, with sharp peaks in demand on the coldest days of winter.

Gas supplies from the Southwest come more or less evenly through the pipeline. Since New England is at the end of the pipeline, there is much less flexibility available to meet the peakload needs of consumers on very cold days. LNG, with its capacity to deliver gas into the local distribution system on very short notice, performs a service equivalent to the existence of an additional pipeline connected to each of the New England distribution companies.

Alternative supplemental fuels, such as propane-air can only be mixed with the gas stream in limited amounts. LNG, on the other hand, is chemically the same as pipeline gas and can be vaporized into the pipeline without limit. Distrigas' vaporizers connect directly into the Boston gas distribution ssytem, so that on very cold days, gas consumers can have a nearly instantaneous access to LNG to supply their peak needs.

It is not surprising that some Massachusetts gas distribution companies rely on LNG for as much as 50 percent of their total gas deliveries on the coldest days of winter. This quick response to cold weather household needs for heating is possible because 30 separate LNG storage tanks are located throughout Massachusetts. Great reliability and flexibility exist because Distrigas can replenish its customers' storage tanks throughout the winter, so that their response capacity remains undiminished.

Now I would like to talk a little bit about safety; 3,800 shiploads of LNG have been safely delivered throughout the world to Tokyo and Osaka, Japan, London, England, LeHavre and Fos, France, Barcelona, Spain, LaSpezia, Italy, and Boston, Cove Point, and Savannah; in the United States.

The operations of Distrigas' Everett terminal, as well as the other New England LNG facilities, have proven to be safe. A comparison between LNG and other fuels, particularly gasoline, that are transported and stored in the Boston and New England area in far greater volume indicates that the chances of a large accident are much lower with LNG, while the damage is roughly comparable. In any event, the largest realistic accident projections for either LNG or gasoline are far less dramatic than recent scenarios which have been theorized for LNG.

Our facility is located in an industrial zone in the city of Everett in the Port of Boston. The immediate area surrounding the terminal contains storage tanks, junkyards and other industrial facilities. It is not located in a densely populated area as one might imagine if one did not actually see the site or photographs of the site.

We are vitally concerned with the safety of our employees as well as our neighbors. This concern led to the establishment back in 1971 of an independent LNG Safety Review Committee composed of technical experts, not employed by Distrigas, who monitor our activities and report directly to the board of directors of our parent company. There is no one more concerned with our safety than we are.

As pioneers in LNG commerce, we have sponsored a large share of the analytical work on LNG safety. Attention to operating performance in our Everett plant has prevented not only accidents, but even the smaller mishaps which are common in industry.

At the beginning of this statement I referred you to my written testimony. You will find in it extensive and detailed information on

LNG safety issues and records of the thoroughness of existing LNG regulation by 26 Federal, State and local agencies to date. I believe it is convincing evidence that drastic and severe legislative treatment of the LNG industry is not needed and should not be considered. Title 2 of H.R. 11622, the Dingell-Markey bill, creates a reasonable approach for establishing LNG siting and operation standards. With a couple of minor changes only for clarification, we support this bill and we feel it should be passed.

I thank you for your attention.

Senator DURKIN. Thank you, Mr. Norton, and Mr. McKenna. If you have any other thoughts you would like to add to the record, please do. And if we have any additional questions we will forward them as things progress. We will appreciate your continued cooperation and thank you for spending a long humid morning with us.

At this time we turn to Conrad and Ellen Casarjian.

STATEMENT OF CONRAD CASARJIAN; ACCOMPANIED BY PAUL SCHLOSBURG, AFFILIATED WITH NATIONAL COUNCIL OF BLAST

Mr. SCHLOSBURG. Senator, my name is Paul Schlosburg. Ellen Casarjian couldn't make it today, and this is Conrad Casarjian. I would like to make a brief opening statement and then have Mr. Casarjian speak.

We represent Massachusetts BLAST, Bring Legal Action to Stop the Tanks, and we are here representing several thousand people across the country from Eugene, Oregon, Los Angeles, New York, Providence, Fall River, part of the National BLAST organization.

Very briefly let me tell you that the Everett City Council, the Malden City Council, and the Chelsea Board of Aldermen have all voted to urge that the present levels of importation be maintained. In other words to stop the *Ben Boula* from coming in. The Chelsea board also recommended that the Everett facility be phased out.

I just want to bring to your attention the most recent potentially catastrophic accident that happened August 7, 1978, between 5 and 6 p.m. It was raining heavily on Route C–1 south from Saugus to Revere, Mass. An Algonquin LNG truck jackknifed, hit a guardrail on an elevated roadway in a densely urban populated area. The State police responded. The fire chief responded to this accident. This was in Malden, Mass. at the Lynn Street exit, which is the Granada Highlands exit in Malden. It was very rainy that night. It was during a rush hour. I spoke to the fire chief of Malden and he said accidents are always happening on this roadway, especially during rain.

Senator DURKIN. This was the State police. Do you know what barracks conducted that investigation?

Mr. SCHLOSBURG. Lynnfield. Lynnfield Barracks has a full report on it. They do have a sign which states, during rain, trucks go 35 miles an hour. It is the fire chief's recommendation that they put 25 miles an hour on it, and the resurfacing and restructuring of that entire roadway. A recommendation that we have—Massachusetts BLAST—is there should be no rush hour truck transportation. That 35 miles an hour is fine, but it is obstructed by trees and something should be done about that by the department of public works. GAO recommendations should be adopted by the State of Massachusetts; the entire regulations

should be implemented. The State legislature has a $50,000 committee, a study committee, which will report in December and I urge that you report some findings to them and they specifically look into this trucking and transporting situation. Thank you very much.

Senator DURKIN. Hopefully the Massachusetts people are still here, and will take cognizance of the situation that you referred to at that particular location. The committee will try to get a police report with respect to the situation that you highlighted.

I think the problem is that the State feels it has gone as far as it can because you have an interstate angle. It is high time for the Federal Government and the Congress to meet up with its responsibility and give an agency authority commensurate with that responsibility. Thank you.

Mr. CASARJIAN. My name is Conrad Casarjian, I am a lifelong resident of Everett, Mass. I have heard earlier people mentioning their credentials and their scientific background. I just wanted to point out that members of MASSACHUSETTS BLAST and Everett citizens have always felt that one needs no special grasp on scientific engineering to nnderstand the basics of this, and really all that it boils down to is commonsense and a certain degree of intelligence.

I would, before I begin, correct one statement that appears on your release and that is that LNG is not as dangerous as LPG because it is lighter than air, and when LNG vaporizes from the liquid, which is about 260 degrees below zero, it very definitely is heavier than air and tends to cling to the ground. If you need to validate this I suggest you look at a Coast Guard movie entitled, "LNG, A Burning Issue" and that very clearly shows how the vapor will hug and cling to the ground.

Senator DURKIN. I have visited LNG facilities in Alaska. I won't be able to visit facilities here today because of the time problem. But I think that statement should be taken in context. In relation to the transportation of LPG, there seems to be a more immediate problem and a greater risk, although the potential risk may ultimately be greater for LNG.

Mr. CASARJIAN. We do not take issue with Distrigas' safety record of the past. We find no fault with that. In fact, we don't fault anyone that says New England needs LNG. In fact, we feel it is probably the best of the fossil fuels.

Senator DURKIN. It is certainly much cleaner than coal.

Mr. CASARJIAN. Yes. The Everett terminal has been in safe operation for about 6 years, and it is set up to accept shipments from Algeria. The company has told us and we have also learned that Algeria has had a terrible record for living up to its contractual agreements, and a large part of this is because France gets first bids on the natural gas supply. That is part of the reason they haven't been able to fill the *Ben Boula*, a direct result of the gas being drawn off and utilized by other countries.

In Everett one of the main problems we see with the present siting is the fact that LNG is stored among many, many other hazardous fuels including LPG and gasoline. This is especially dangerous in light of the fact that if there are evacuation procedures, being an Everett resident I can assure you that no other Everett residents are aware of these procedures. There are neighbors within 1,200 feet and it is just strange

credulity to hear industry representatives call this an industrial zone, while just 1,200 feet from the tank you can speak to the residents on Bow Street in Everett. In fact, so many of the fuels that are stored in Everett including LNG are destined for consumption in other States and in fact beyond New England. We resent this fact. We resent the fact that Everett has to store fuel that will be consumed by the Brooklyn Union Gas Co. We feel the magnitude of any potential disaster is in direct proportion with the quantity of fuels that are stored on that site and we feel that other States should take care of their fuel needs rather than depending upon Everett to be the one storage receptacle for the entire region.

This is in addition to the fact that now the are planning to build residential housing both at the site of the Boston navy yard and the site of the old naval hospital, both of which are approximately 1,000 to 1,500 feet away from the Everett terminal. As you leave the Everett terminal the roadway is in such bad disrepair that it has led many Everett residents to refer to it as the Ho Chi Min Trail.

As we set our sights on the facility itself, there are a number of aspects of it that worry us. First of all, the tank construction. We have been told that the walls are especially thick. But of course the walls are two barriers, in between which is loose perlite insulation that acts as no safety edge. In fact, we have been told on many occasions that these are extremely safe tanks because they are double-walled and the double wall construction on both the storage tank and the transporting trucks gives some great safety margin.

Well, the outer containers are always made of noncryogenic steel, so if the inner container should rupture there is nothing to hold back the liquid from issuing forth out of the tanks or the trucks. In fact, we felt that a very small step that might be taken is for an insulating liner to be established between the tank, the dike floor and the dike walls, and it is our understanding that this would cut vaporization in the event of any spill, by a factor of 10.

The double wall construction is intended to be an insulating factor rather than a safety factor. It is simply to keep the LNG at 260 degrees below zero. The facility in Everett—I can speak from first hand experience—is ill equipped to contend with any act of sabotage. In fact, the Dorchester, Boston gas tanks have only a part-time guard on duty. The LNG pipe in Everett that would offload the ship in fact directly overrides an excessible street, a street accessible to any citizen in the city, so we feel some corrective action should take place in this regard.

Also there is a vibrational problem in connection with the larger of the storage tanks in Everett. At first we were told this vibration problem, the fact that the walls of the tank vibrated, for reasons not understood, was concerned with the rollover problem, the fact of mixing two liquids of different density in the same tank. We later learned that indeed this was a separate and distinct problem. We were told by company officials that the walls were made to withstand many, many more times the force generated by the as-yet not understood vibrations, and yet we wonder what might happen over time due to stresses that might build up in the material.

Senator DURKIN. I would hope that the NTSB, to the extent that they have jurisdiction, would address the problem of the vibration.

I understand Mr. Santman has left, but his office should look into it as well. It appears to be something that should be resolved.

Mr. CASARJIAN. Yes; to the best of our knowledge the problem is not adequately understood, never mind being resolved.

Truck routes, should you visit the vicinity, are lined with other trucks—gasoline trucks. To come down onto Route 99, Broadway in Everett, you would see all sorts of volatile fuel trucks lined up, their drivers having donuts and coffee in local establishments, and yet that is one of the main routes out of the facility for the LNG and LPG trucks.

Mr. Flynn of the Boston City Council felt that the city of Boston should not be used for the convenience of the trucking companies. He feels that in the past such has been the case, that they have merely driven through Boston and not necessarily making deliveries that would be utilized within the city of Boston.

On hearing a Mr. Pratt speak at the Flynn hearings, he said that the 112 hazardous inspectors in the United States are doing their job. Well, you divide 50 States into 112 and it gives you about two inspectors per State and we have researched the fact that there are only two hazardous material inspectors east of Worcester. They may be doing their job, but it would certainly imply that we needed a lot more of them on the job doing their job.

I would like to flash back to this double-hull construction that is always pointed out as being an especially great safety feature for the LNG trucks. In fact it is always gotten to us that the industry describe its accidents and near catastrophes as examples of how safe the transport of LNG actually is. We have learned of an accident on the Vermont Thruway, a case in which an LNG truck went off the highway and was actually impaled on a granite ledge, the rock ledge having pierced both the outside and the inside container. So as far as the trucks being impenetrable, we can only say that they are less penetrable than conventional trucks.

Senator DURKIN. I would appreciate it if you have details with respect to that Vermont incident, that you would provide them for the committee.

Mr. CASARJIAN. Yes. Now the company wants to break in the *Ben Boula*, transporting three times more LNG than has ever been brought into the Port of Boston. I would like to point out that this—the largest of LNG tankers in the entire world—is too high at high tide to bring in. It will hit the Mystic River Bridge. It is too low at low tide to bring in because it will scrape bottom. So the plan is to bring it in at mid tide and to offload as the tide goes down. To me that seems a bit ludicrous. It is no more reassuring to learn that ships such as the Isabella, a Liberian tanker, are also brought into Boston, given the record of Liberian tankers in the past.

We do realize that the Coast Guard does the absolute best job that they can. However, in Peter Vanderlynn's book, "Time Bomb", it is mentioned and Massachusetts BLAST has sent us from the New York office information that on the second passage of the *DeCarte* into Boston, there was a leak as a result of a crack in one of the ship's membranes, internal membranes, and LNG escaped into the internal hold of the ship. This thereupon vaporized. However the vapor was flushed with nitrogen in order to hide the leak from the Coast Guard.

Now the flushing is advised, it's necessary. However, the Coast Guard was not informed of this leak and the ship was brought into the port. Of course for the Coast Guard to do their job, they have to be aware of what might in fact be wrong with the ship. And I would agree with you, it has always been my understanding that the Coast Guard has never checked navigation, propulsion, and steering on these ships as they come into port, so I was glad to learn that such was not the case today.

Senator DURKIN. With respect to the incident on the *DeCarte*, we will appreciate any further details you can submit.

Mr. CASARJIAN. I will research and see if I can find the primary source on that.

Overflights over inbound LNG ships have been stopped. However, it is our knowledge that airplane overflights still occur during the offloading of those ships. I think it has already been brought out that an LNG shipped crashed into a bridge near the Fore River Shipyard in Quincy. We suggest a study of the possibility of stopping traffic on the Mystic River Bridge during importation for two reasons. One being the possibility of an accident, maybe even melting the Mystic River Bridge. The second being the fact that—well, someone threw off a device onto Harry Truman's yacht as it drove up the Potomac River. This same opportunity is afforded anyone who might attempt to sabotage a ship by standing on the Mystic Bridge as the ship underrides.

Another reason why we feel that somehow the plans, the safety plans for these things are inadequate—if you read the contingency plans of the Boston Fire Department they follow about the same suggestions as put forth by the New York Fire Department and that is, should a ship be involved in an accident in the harbor and LNG be released onto the water, part of the plan involves driving the vapor cloud out to sea with a mist spray from fireboats. And that just sounds a bit ludicrous to me, especially to get the vapor cloud to make a righthand turn as they move it up the Mystic River Channel.

Senator DURKIN. I am not sure I would like to be on that fireboat.

Mr. CASARJIAN. No. In fact, they suggest—keep the fireboat out of any LNG on the water for fear it will crack the hull of the fireboat. As you read the entire list of procedures it seems to be something out of Walt Disney rather than a list of safety procedures.

We were very encouraged by the recent siting suggestions made by the energy facilities siting council, but it does disturb us that there is no grandfather clause and the Everett facility could not be made safer under those guidelines because we aren't going back in time to look at the older facilities and because of Everett's unique position as an import terminal. In fact today, even though we have heard from industry saying it is safe and the neighborhoods are very far away, the Everett facility could not pass the current siting standards because it is built on too small a piece of land. We think it would be a good idea to look at some of the sitings—look at the siting laws, some of the few that exist around the country, specifically California, in which there can be no siting in any areas having a population density of greater than 10 persons per square mile for I think something on the idea of 6 miles from the facility.

Senator DURKIN. Let me ask you a question. Do you think there has been adequate public participation in the siting and safety proceedings?

Mr. CASARJIAN. I think that today this is coming about but that certainly was not the case—in fact, I think most Everett residents awoke to the dangers as a result of the CBS show, "60 Minutes," that when they were putting in the facility first of all it was done under Federal auspices and citizens were not called in for any sort of input. We were simply told that there would be more fuel storage down there but not to worry about it because we have always stored gasoline down there for many, many years. Later we learned that you cannot equate the storage of gasoline with the storage of LNG or LPG.

Senator DURKIN. Have you been able to obtain adequate data and adequate cooperation from the local, State, and Federal Government entities involved?

Mr. CASARJIAN. I would say not at all. Industry has been most cooperative with extending to us any factual material they might have at their disposal, but when you get down to local politics you need to invoke the Freedom of Information Act to get any information out of anyone on the city level, and part of the reason is because Everett government officials are so fearful that we might lose $1.1 million in taxes each year. They feel they would much rather live with the degree of danger.

Senator DURKIN. So you feel the industry has cooperated and provided you with data, but that the governmental entities have not been forthcoming.

Mr. CASARJIAN. That is basically correct, but of course the industry doesn't set standards. They don't propose new changes or new guidelines and, yes, they have lived up to all of the rules that presently exist, but we feel those rules need to be made a lot stronger and a lot more stringent. You mentioned having viewed this facility in Alaska. It seems strange to us that we are importing from Algeria and we send our natural gas from Alaska to Japan. It doesn't make much sense.

Senator DURKIN. We could be here for the next 3 weeks on the problems of Alaska and the oil pipeline, the Al-Can pipeline. But I share your concern.

Mr. CASARJIAN. What it boils down to—mistakes have been made in the past. Certainly they wouldn't have expected to locate a nuclear reactor in Everett. Not that a nuclear reactor is unsafe. These facilities are always built to be made safe, but unfortunately they don't always turn out to be. A probability somehow, following Murphy's law, has a way of working into and becoming eventualities and we certainly don't want that to happen when Everett has about 45,000 people packed into about 2 square miles. And because mistakes have occurred in the past, this is no reason to perpetuate them. Our escape time in Everett is a matter of seconds, should there be a large-scale rupture and ensuing fire. We don't even have 1 minute's time to escape third-degree burns, and I think that is a sad commentary on the siting of that facility in Everett in the first place.

Senator DURKIN. If I lived in Everett, I would share your concern.

Mr. CASARJIAN. And I might mention that the company executives certainly do not live in Everett. They are at a safe distance.

The question of liability is another question that we could probably get into for about 2 weeks. I will quickly state that I think we need strict liability, that we need protection whereby we can work right up to the top of the chain in holding individuals and companies liable, and we have to look into the problem of foreign shippers because they don't assume responsibility until the LNG is in the process of unloading.

Pretty much that is what I have to say. I would welcome any questions at this time.

Senator DURKIN. I want to thank you very, very much. I asked the few questions I had during your presentation. The record will remain open. I urge that you provide the information to the extent possible that you have alluded to in your statement. We look forward to your continuing cooperation with this committee as we try to resolve what is a very real problem to the people of Everett, Boston, and New England.

Mr. SCHLOSBURG. Mr. Chairman, I would like to say just two quick things. Our intention is to stop the *Ben Boula* from coming into the Port of Boston. We sent letters to the Congressmen, to the President, to the Governor, urging that the facility not be expanded in volume. We also intend to try to get the attorney general of this State to close the Distrigas facility down because it is, we feel, a clear and present danger to the people of not only Everett, but to the people of the city of Boston, Chelsea, Cambridge, and Malden. Thank you very much for your cooperation, Mr. Chairman.

Senator DURKIN. Thank you. The committee will now adjourn, subject to reconvening at the notice of the chairman. I would like to thank Chairman Cannon of the Senate Commerce Committee for giving us the opportunity to come here today to hear from people who are exposed to the problem rather than to sit in Washington listening to professional Washington witnesses.

Thank you all once again. This hearing is adjourned.

[Whereupon, at 1:45 p.m., the hearing in the above-entitled matter was adjourned, subject to reconvening at the notice of the chairman.]

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