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H.R. 6844 seeks to regulate the siting, design, construction, and operation of facilities to be used for the transportation, storage, and conversion of liquefied natural gas (LNG). Current Administration policy which calls for a case-by-case analysis of LNG import proposals is inadequate because it does not alleviate uncertainties associated with such imports. After an LNG accident occurred in October 1944 at a plant in Cleveland, Ohio, the Bureau of Mines recommended that plants dealing with large quantities of liquefied flammable gases should be isolated at considerable distances from inhabited areas and that extreme caution should be taken to prevent spilled gas from entering storm sewers. Safety aspects of LNG were studied in relation to the following: the vulnerability of storage facilities to natural occurrences and sabotage, the transportation of LNG in ships and trucks, liability and compensation in case of accident, and research programs. Key decisions on the location and nature of LNG imports will be made in the next few years and research efforts should be directed to the most urgent problems. Issues to be resolved involve: siting and expansion of LNG facilities in urban areas, the need for regulatory bodies to assess safety and recommend actions, the need to assess existing safety regulations changes in the liability and compensation area, and the formation of an Energy Health and Safety Regulatory Agency. (HTW)

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TESTIMONY OF
MONTE CANFIELD, JR. DIRECTOR
ENERGY AND MINERALS DIVISION
ON LIQUEFIED NATURAL GAS
BEFORE THE
HOUSE SUBCOMMITTEE ON ENERGY & POWER
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE

Dear Mr. Chairman:

You have asked us here today as you consider H.R. 6844, a bill to regulate the siting, design, construction, and operation of facilities to be used for the transportation, storage, and conversion of liquefied natural gas (LNG).

GAO has recently completed one study dealing with the need for improvements in LNG import policy and has underway a separate study dealing with safety considerations in the storage and transportation of liquefied energy gases (LEG). These include LNG as well as liquefied petroleum gas (LPG) and naphtha.

LNG IMPORT POLICY

In our December 1977 report on the "New National Liquefied Natural Gas Import Policy Requires Further Improvements" (EMD-78-19) we concluded that the current Administration policy which calls for a case-by-case analysis of LNG import proposals is inadequate because it does not alleviate uncertainties associated with such imports. Specifically, we saw the need for a policy which:

--clearly indicates the role LNG imports are to play in meeting future gas needs,

--establishes clear criteria for defining what level of LNG imports in total or from a single country, would constitute over-dependence,

--improves the lengthy regulatory process now faced by LNG import proposals,

--addresses complex issues dealing with curtailments and incremental pricing of LNG. For example, industry may not be willing to accept high-priced LNG if its supply could be curtailed during shortages. Not to curtail, however, would mean that low-priority users would receive gas during shortages when it is needed by high-priority users.

Although there was general agreement with the thrust of our recommendations, some agency officials criticized the report as premature since the Administration has been in the process of developing a more definitive LNG policy.

LNG SAFETY

Let me turn now to the work we have underway on LNG safety.

Our study began by isolating what we believed to be the critical questions about LNG and LPG safety. We determined what answers were available to these questions and the basis for the answers. We then isolated various aspects of the safety problem to explore in depth.

We visited more than 35 import, storage, shipyard, design, and transportation facilities in the United States and Japan, and made a detailed study of the plans and blueprints of many of them. We spoke with concerned Federal, State and local officials, and industry and citizen organizations. We offered each group we visited a briefing on the problems we were examining and suggested to each of them that they look into the same problems so that they could be in a position to comment on our findings. On the whole, we received excellent cooperation from companies, organizations, and Federal agencies.

Today's hearings, however, are taking place prior to completion of our work and prior to the preparation of our final report. While I can summarize for you our tentative findings and overall conclusions, they are subject to change based on comments received on the draft now out for comment. It is our usual and longstanding practice to obtain comments from affected parties--particularly where decisions reached could have major impacts on them.

We expect to receive comments on the total draft report from the Departments of Energy, Transportation, Commerce, and State, and the Interstate Commerce Commission. In addition, over 50 LNG and LPG companies have been furnished for comment, copies of parts of the report where they are discussed. Because the report is quite technical and detailed, we expect to receive many comments on the draft. all of which must be carefully considered. Changes will be made as appropriate before the final report is issued.

As everyone is aware, at least a portion of the draft report was leaked to the press, apparently by one of the agencies to which we sent it for comment. I am sure you also know that this has caused a great clamor on the part of the press, the public, the companies, and many in the Congress for complete release of the draft report. We have not, however, released the draft. In accord with longstanding GAO policy, a draft is just that, and is subject to revision based on review of agency and corporate comments. Accordingly. it is not available for public distribution.

While I will focus my comments on LNG, our study covered both LNG and LPG and many of our tentative findings apply to both. Some brief background could help to place current use of the two commodities in perspective.

There are now operating 10 major LPG import terminals, but only one LNG impo terminal. Three other LNG import terminals have been licensed, and seven LNG and five LPG import terminals have been proposed.

Eighty-six percent of all LPG storage is in underground salt domes or mined caverns. There are only 12 LPG above-ground storage facilities with more than 23,000 cubic meters of storage. There are 45 LNG storage facilities at least this large.

There are about 75 LNG trucks, carrying 40 cubic meters, now operating. In contrast, there are over 25,000 LPG transport and delivery vehicles. Some carry 40 cubic meters and others much less.

LPG is also carried in pipelines and trains. There are 70,000 miles of LPG high pressure pipeline and more than 16,000 railcars. LNG is moved on land only by truck.

A typical new LNG ship carries about 125,000 cubic meters of LNG. A typical new LPG ship carries about 75,000 cubic meters.

<u>THE CLEVELAND ACCIDENT</u>

The first and only LNG accident in this country to cause off-site damage and injury occurred in October 1944 at a plant in Cleveland, Ohio. The plant received natural gas from fields in West Virginia, liquefied it for storage, and regasified it for distribution through the regular gas distribution system when needed. While no analogy is perfect, a brief review of the circumstances of that accident may be useful.

Before the plant was built, an intensive laboratory study of the process was conducted and a pilot plant built. The pilot plant produced, stored, and liquefied natural gas for six months with no major problems. Extensive testing determined that an alloy steel having at least 3.5 percent nickel was satisfactory and less costly than alternative materials. The steel used in U.S. LNG tanks today is 9 percent nickel which increases its ability to withstand cold.

In February 1941, after the satisfactory pilot plant operation, three 2,100 cubic meter spherical tanks were built at the Cleveland site. They operated satisfactorily for two and one-half years. In the fall of 1943, a 4,200 cubic meter cylindrical tank was added.

In October 1944, the cylindrical tank failed. While much of the fluid stayed on site, liquid flowed offsite and down the street where some entered sewers and basements. Ignited vapors caused streets and buildings to explode and burn. About 20 minutes later, the legs holding the closest spherical tank collapsed from the heat, releasing another 2,100 cubic meters. The final death toll from the fires and explosions was 130 and there were 225 injuries.

From our study of the Cleveland experience, we believe the following things are important:

--Both the manufacturer and the company assumed that a small leak would precede any more serious spills. They also assumed that a small leak would be noticed and corrected before it became serious. When frost spots appeared on the bottom of the cylindrical tank several months before the failure, indicating signs of an inner tank leak, they were misinterpreted by both operating personnel and the construction company when it was called in for consultation.

--The Company took precautions to control small and moderate rates of LNG spillage. They assumed that a sudden massive spill was not credible. The same assumption is made today in designing dikes around LNG facilities. This is not unique to LNG facilities. In fact, it is made in designing dikes around most facilities which store large amounts of all dangerous fluids.

--The site for the Cleveland LNG plant was selected because it was already company property and was appropriately located on the distribution system. The storage tanks were placed on a small site in a thickly populated and highly industrialized section. The Vice President and General Manager of the company told the Mayor's Board investigating the accident, that the company felt it was building a safe plant that could be located anywhere. Similar assumptions about the safety of LNG plants in urban areas are made today.

--The nearby presence of other industrial facilities, residences, storm sewers, or other conduits was not considered.

--The Cleveland accident was caused by an amount of LNG which is very small by modern standards. Less than 6,300 cubic meters of LNG spilled and a large part of that remained on company property. A typical large LNG storage tank today could hold up to 100,000 cubic meters. A site may have several storage tanks.

The Bureau of Mines study done after the disaster included the following recommendations which we believe still are worthy of consideration today.

--Plants dealing with the large quantities of liquefied flammable gases should be isolated at considerable distance from inhabited areas.

--Extreme caution should be taken to prevent spilled gas from entering storm sewers or other underground conduits.

MAJOR LNG SAFETY ISSUES

There is no question but that LNG is a dangerous substance to handle.

The remainder of my statement sets forth our tentative findings and conclusions as to deficiencies in the current practices, policies and procedures applicable to LNG in this country. I want to make clear at the outset, though, that my testimony is not directed toward the conclusion that LNG is too dangerous a substance to rely upon as an energy source. The principal thrust of the tentative findings which follow is that because LNG is the dangerous sustance it is, and because its potential for damage is so great, serious consideration needs to be given to intensified safety measures and to whether new or expanded old storage facilities should be built in densely populated urban areas; further, that transportation through such urban areas should be highly controlled.

With this perspective in mind, let me summarize briefly the following major areas covered by our work.

--The vulnerability of storage facilities to natural occurrences and sabotage.

--The transportation of LNG in ships and trucks.

--Liability and compensation in the case of an LNG accident.

--LNG research programs.

VULNERABILITY OF STORAGE FACILITIES

Natural Phenomena

Most LNG storage tanks have metal walls. Metal LNG tanks have double walls with insulation in between, while LPG and naphtha tanks have single walls. Tanks are designed to meet the requirements of the Uniform Building Code for the area in which they are built. While the standards are uniform, the requirements under the standards vary from location to location. The standards all require that the tanks be able to withstand the largest earthquake, wind, flood, etc. experienced in the area in the last 50, 100, or 200 years. Generally, they are the same standards which apply to inhabited buildings or structures in the area.

This means that the probability of the uniform building standards being exceeded at a particular site in a particular year is low. However, as the number of facilities and years increase, the probability rises. If more than one natural phenomenon must be protected against, this further increases the risk. Given the present number of large facilities and their expected lifetime, it is apparent that the uniform building code standards will be exceeded many times during the lifetime of these facilities. Just because an earthquake or other natural phenomenon exceeds these standards, however, does not mean that a facility necessarily will fail.

Although all five tanks we evaluated were adequately designed for the Uniform Building Code earthquake and the 100-year maximum wind design criteria, three of the five tanks had earthquake safety margins less than 25 percent. Two of these are next to one another in an urban area.

As a point of comparison, even though nuclear plants are located in non-urban areas, they are built to much higher standards than LNG facilities in urban areas, because of the perceived potential for causing off-site damage.

Sabotage

Public utilites and petroleum companies have been targets of sabotage. Many domestic and foreign groups have the weapons, explosives, and ability to sabotage LNG facilities. Instructions for the construction and use of appropriate explosives from easily available materials are widely published in open literature.

Security procedures and physical barriers at LNG and LPG facilities are generally not adequate to deter even an untrained amateur saboteur. Our research also indicates that storage tanks are vulnerable to sabotage efforts within the known capabilities of terrorists groups. Such sabotage efforts could lead to failure of the tank walls and subsequent massive spilling of the contents.

Dike Containment

Our work indicates that in case of a natural disaster such as an earthquake or tornado, the most likely mode of tank failure would be a shearing of the steel straps which hold the tank wall to its foundation causing all of its contents to spill.

Existing dikes constructed to National Fire Protection Association safety criteria generally would not contain the surge of liquid from a massive rupture or collapse of a tank wall. We calculated how much fluid would escape from the dikes in six actual facilities. The figures range from 13 to 64 percent.

Five of the facilities would allow more than 54 percent of the fluid to escape. The facility where only 13 percent would escape has a close, high, concrete dike which might possibly be brought down by the same force which destroyed the tank that it surrounds.

TRANSPORTATION

SHIPS

Let me turn now to LNG transporation, discussing first ships and then trucks.

Collisions and Sabotage

Our tentative view is that LNG ships, because of their double-hull construction, are the least vulnerable of all the systems involved in LNG transportation and storage.

In contrast, single-hulled LPG ships are built to the lower standards used for tank bulkheads in oil tankers. The stress analysis performed is also much less than for LNG ships. Thus, LPG ships are much more vulnerable in collisions than LNG ships.

Similarly, single-hull LPG ships would be much more vulnerable to sabtage than LNG ships.

Crew Training

Human error is a contributing factor in 85 percent of all marine casualties and operating problems. Both LNG and LPG ships need particularly skilled operators for safe operation. We have tentatively expressed some concerns about the adequacy of the Coast Guard's contemplated Waterfront Facility Regulations for LNG in Bulk and the rules for LNG terminals proposed by the Office of Pipeline Safety Operations. As we understand it, both rules as now contemplated would be only recommendations rather than requirements on companies.

Ship Operations and Harbor Security

Other areas where we believe the Coast Guard could improve its oversight of LNG include:

--providing improved training for Coast Guard personnel, particularly for hazardous materials officers, on LNG and LPG hazards,

--expanding onboard inspection to include the operating condition of the ship control equipment of LNG ships before they enter the harbor,

--providing the local Captain of the Port with criteria for deciding whether the condition of an LNG ship is serious enough to warrant keeping the ship out of the harbor,

--developing specific plans to cope with a major LNG spill, or to partially offload and thus lighten an LNG ship that has gone hard aground in inland waters,

--using its existing authority to require adequate security at LNG harbor facilities.

TRUCKS

Accidents

LNG truck trailers have a higher center of gravity than most tank trucks, which makes them particularly susceptible to rolling over; but they have an inner and outer tank with insulation in between and thus are quite resistent to puncture and cargo loss. In contrast, LPG trucks also have a high center of gravity, although not as high as LNG trucks, but they are single-walled and under pressure, and thus are more vulnerable to cracks and punctures and more likely to explode in fires.

Routing

Interstate Commerce Commission trucking certificates do not restrict truck routes and LNG and LPG trucks move routinely through large cities. Driving such trucks on elevated urban highways is particularly dangerous because if one were to go through the guard rail and split open on the street below, such a spill could fill sewers, tunnels, subways, and basements with invisible, odorless, explosive gas.

Hijacking and Sabotage

LNG trucks have little protection against hijacking since they are not considered a commodity with potential resale value. For this reason, it would not be difficult for a terrorist to hijack a truck. The intentional urban release of LEG from one or more trucks could create major problems.

LIABILITY AND COMPENSATION

What would happen if there were a major LNG accident which caused significant off-site damage? It is unlikely that injured parties could be fully compensated under existing arrangements. Present corporate structures and legal limits on liability protect the parent corporation and diminish incentives for safety. No Federal agency considers the question of off-site liability of LNG operations.

Information gathered by us indicates that present and planned liabilty coverage for LNG import terminals ranges from $50 million to $190 million per incident. Ten states require proof of liability insurance for LPG facilities, but the maximum required is $100,000 per incident.

Claimants after a major LNG accident face long, complex, and expensive litigation. If the defendant corporation is foreign owned, it and its assets may be out of reach. If the accident resulted from an act of sabotage, or from an "act of God" such as an earthquake, flood, or tornado, the company may not be liable at all. In any case, it is not always possible to prove the primary cause of a major accident, since critical evidence may be destroyed in the accident itself.

LEG SAFETY RESEARCH

Since LNG is hazardous, one could reasonably ask what research has the Government done to determine the extent of the hazard and to help design corrective or preventive measures.

The Coast Guard has been responsible for some good hazard analyses, primarily on the effects of a small spill on water. Isolated pieces of research have been done by other government and private laboratories around the world. All of the research has been on a very small scale.

Among the topics which our work indicates have been insufficiently explored are:

--the interaction of LNG with man-made structures such as buildings, subways, sewers, and ships;

--under what conditions a large LNG cloud ignited on its downwind edge will burn back to its source;

--under what conditions LNG clouds can detonate; and

--how far a large LNG cloud can travel, under varying atmospheric conditions, before reaching its lower flammable limit.

Key decisions on the location and nature of LNG import terminals will be made in the years immediately ahead. It is important that the Federal Government's research efforts be directed at the most urgent problems so that decision-makers who must act in the near future, can understand the risk and uncertainty.

The Federal Government's present plan is to channel the bulk of LNG safety research through the Department of Energy. The Department developed a proposed plan which would take 5 years and cost $50 million. Our review of that plan tentatively indicates that many of the crucial safety questions described above would still have not been addressed. What is more, most of the facilities which will be built would be already planned before the end of the 5-year period. In our draft report, we suggest a more immediate research program directed at the key problem areas we identified.

FEDERAL REGULATION OF LNG IMPORT TERMINAL SITING

Adequate resolution of complex safety issues requires a process which ensures that evaluation and input is obtained from technically qualified persons. The system developed at the former Federal Power Commission to regulate LNG import terminal siting, in our opinion, did not provide for adequate assessment of potential safety problems. The extent to which procedures will be changed under the Department of Energy is unclear. Our analysis indicated that initial decisions on LNG projects were based on inaccurate safety findings and that none were questioned by the Commission.

The burden that the Atomic Energy Act imposes on the Nuclear Regulatory Commission is to "adequately protect the public health and safety." This basic burden of government is implicitly laid upon every agency regulating or approving potentially dangerous activity. Since the risks associated with the large scale use of any dangerous, modern technology cannot be rigorously quantified, the requirement is essentially one of prudence in the face of potential danger and uncertainty. Such prudence must be based on skepticism of material presented by interested parties, and a vigorous, timely, independent investigation of the critical issues. The evidence must be evaluated by people with the time, resources, and training to understand it. Most important, the government must inform the public of the benefits and dangers involved in different choices.

OTHER POINTS

Before discussing our overall tentative conclusions, two other major points should be noted. First, our analysis shows that non-urban LNG terminals could easily handle all of the LNG imports through 1990 under the highest LNG import scenario we found.

Second, other countries are approaching LNG safety differently than the United States. For example, Japan has built many of its LNG storage tanks inground. Also, above ground tanks in Japan are built to generally higher standards.

TENTATIVE OVERALL CONCLUSIONS

The potential danger associated with the handling of LNG underlines the need for close examination of the adequacy of the Nation's current approach to energy health and safety regulation. It is particularly important that any changes in approach be decided soon, if they are to affect near-term decisions on the siting of LNG import facilities.

To date, much interest has focused on the large LNG ships. Yet, our work indicates that the double-hulled ships may be the least vulnerable of all the systems involved in transporation and storage of LNG. This, however, is not true for the single-hulled LPG ships, which generally are built to the same standards as oil tankers.

Conversely, there has not been enough interest in the safety aspects of land storage and transportation of LNG. We believe the information we have developed raises important questions regarding:

--Any future siting of LNG facilities in large urban areas.

--Any expansion of existing LNG facilities in large urban areas.

--The need for appropriate regulatory bodies to assess on a case-by-case basis, the safety of LNG facilities now located in large urban areas and to recommend any actions needed to safeguard the public.

--The need to assess the adequacy of existing regulations which (1) require that storage tanks for LNG be built only to uniform bulding code standards and (2) allow LNG to be transported through urban areas in trucks.

In addition, our work indicates that the direction and focus of the Federal Government's planned LNG safety research efforts could be improved by concentrating first on the immediate concerns which need to be addressed soon before major LNG siting decisions are made.

Also, we see a need to carefully examine the liability and compensation area and to consider changes (1) which would better assure the adequacy of compensation for off-site damages and (2) increase the owners liability.

Finally, we believe our work indicates need to reconsider forming an Energy Health and Safety Regulatory Agency. GAO previously recommended that the Congress consider this in a March 1977 report on energy reorganization and in testimony before the Senate Governmental Affairs Committee on legislation creating the Department of Energy. Because we recognize reorganization proposals are often controversial, let me expand briefly on our view.

In our earlier report, we stated our skepticism as to whether health and safety regulation could any longer be construed as truly "not economic" in nature. In LNG, as in other areas, health and safety regulatory decisions are likely to affect the cost and timing of facilities and to have significant impact on the options available to energy policymakers. We also pointed out the problems involved in having regulation focus narrowly on the health and safety aspects of individual energy sources. We supported the idea of bringing together all energy health and safety regulatory functions so that the trade-off developing one form of energy as opposed to another could be considered. In the years ahead, such trade-offs will become increasingly important since almost all forms of energy development appear to have some form of adverse environmental and/or health and safety impacts.

We provided three options for Congressional consideration in the reorganization of Federal energy regulatory activities:

--Include energy regulatory functions--both economic and health and safety related--in the Department of Energy. Under this approach, economic and health and safety regulation could be separate entities but both would fall under a single Assistant Secretary. Statutory provisions should be included to assure maximum insulation of regulatory decisions from the policy process.

--Include only economic regulation in the Department of Energy because of the perceived importance of establishing energy price regulatory policies which are consistent with other energy goals and consolidate health and safety regulation of energy in a separate independent Energy Health and Safety Regulatory Agency. Statutory provisions should be included to assure maximum insulation of economic regulation from the policy process.

--Continue to separate energy regulation--both economic and health and safety related--from energy policy formulation. Should this be done, we believe that the creation of a single energy regulatory agency is desirable. Such an agency could provide a forum for more carefully considering the trade-offs among problems involved in different forms of energy development.

Since our earlier report, the Department of Energy Organization Act transferred FPC's responsibilities to the new Department. No action was taken to consolidate energy health and safety regulatory activities.

Given the problems we found in consideration of safety issues under the process used by the FPC to regulate LNG, we believe the current regulatory model used by the Nuclear Regulatory Commission (NRC) would more likely insure adequate and competent technical coverage of health and safety questions. A typical regulatory action in NRC involves interaction among the Commissioners, the staff, the Advisory Committee on Reactor Safeguards, the Atomic Safety and Licensing Board, and Atomic Safety and the Licensing Appeals Board. The two boards each have 3 members processing a variety of legal and technical skills relevant to the safety problems which come before them.

With a mandate to adequately protect the public health and safety, an Energy Health and Safety Regulatory Agency could assemble a technical staff competent to investigate complicated questions raised by others and to raise important new questions itself.

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Mr. Chairman, that concludes my prepared statement.