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THAILAND-UNITED STATES NATURAL GAS UTILIZATION SYMPOSIUM

FINAL REPORT

Sponsored by

The Petroleum Authority of Thailand

United States Agency for International Development

The United States Embassy - Bangkok

Submitted by

AER ENTERPRISES

16 April 1984

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TABLE OF CONTENTS

	page
1.0 Introduction	1
2.0 Preparatory Work	2
3.0 Presymposium Seminars	5
4.0 Symposium	6
5.0 Workshop	13
5.1 Training	13
5.2 Energy Plan	15
5.3 Gas Pricing Structure	16
5.4 Alternatives to Natural Gas	17
6.0 Field Trip	17
7.0 Post Symposium	18
8.0 Proceedings	19
9.0 Cost Analysis	19
10.0 Unsolicited Letters	21
Appendices	
List of Participants	A
Press Clippings	B
Economic Format	C
Advertising Brochure	D
Professors' Summary Report	E
Abstracts and Biosketch Data Handout	F
Request From Dr. Woraphat	G
Field Trip Handout	H
Unsolicited Letters	I

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FINAL REPORT

1.0 Introduction

The subject symposium was held during the week of February 6, 1984. One hundred and twenty nine (129) registered with AER Enterprises (AER) and two hundred and fifty (250) registered with The Petroleum Authority of Thailand (PTT) for a total of 379. Of those that registered with AER, about 60 American companies were represented and about 20 delegates were present that represented Malaysia, Indonesia, Singapore, Brunei, Indonesia, New Zealand and Pakistan.

This symposium was extremely successful by whatever criteria are used to measure success. The attendance was higher than expected. In fact, people had to be refused admittance because the capacity of the meeting and luncheon rooms were too small to accomodate the much larger than expected crowd. When we first started working on this meeting, we were told by PTT that 50 Thais would be present. We expected that approximately 50 Americans would attend. As a result, AER booked a hotel (Siam Intercontinental) that could comfortably handle 200. No one ever expected the attendance to exceed that which was estimated. Appendix A contains the List of Participants.

The attendance was so high because the timing of the symposium was perfect. The Thais recognized their need for US technology and also realized that if they weren't careful, their country would become an economic and technologic satellite of Japan. The Americans finally realized that the Thais were serious about their proposed $5 billion petrochemical complex and that they were politically committed to its design, construction and operation. In fact, they already have much of the financing in place. Appendix B contains the press clippings.

2.0 Preparatory Work

This project started 30 June 1983. Soon thereafter (18 July 1983), a visit was made to Thailand to develop a tentative technical outline with the Petroleum Authority of Thailand (PTT) and the US Embassy in Thailand. Interested companies were invited to present papers using this outline as a basis.

An economic format was developed at this meeting in order to provide American companies with some idea that could be used to help them prepare their economic evaluations on their specific technology. Each author that presented a paper was sent a copy. This format was completed with the approval of PTT. Appendix C contains a copy of this format.

By having the format, the American authors had a more precise concept of the terms and conditions that are acceptable to the Thais. As a result, this format was not only helpful to the

Americans in preparing their papers but will also be helpful to the US companies in preparing future proposals that are submitted to Thai agencies.

Finally, a dry run of the field trip was made in order to make certain that it was worthwhile and to make certain that there wouldn't be any logistical nightmares.

This was the time PTT indicated that there would be 50 Thais attending this symposium. PTT also felt that the presymposium seminar would also attract 50 people. They raised this estimate to 100 in December and to 200 one week before the symposium.

These presymposium seminars were suggested by Mr. Charles Bliss of the office of S&T/EY of USAID. When the idea was presented to Dr. Charan, Deputy Director of PTT, he thought it was an excellent idea because he recognized that the people that will be working with natural gas were lacking sufficient knowledge concerning the chemical and physical properties of natural gas as well as appreciating the concerns associated with the safety and handling of natural gas. These seminars went a long way in helping the Thais understand natural gas and helped prepare them for the information they received during the actual symposium.

In August and September, the speakers were invited, abstracts were received and accepted and the advertising brochure was finalized, printed. Enlisting speakers was a difficult task for

the same reasons cited above; it took twice as much time as it usually does.

The brochure was mailed to 10,000 people in the United States on or about 1 October. A copy of the brochure can be found in Appendix D.

Phone calls were made and many letters were written by AER personnel during November, December and January to make sure that as many people as possible knew about the symposium and its importance. AER intensified its effort in December because we had 17 participants on 15 December. Thankfully, articles began appearing in the Thailand newspapers that substantiated AER's claims and finally people started registering for the symposium. The turn around in attendance began approximately on 20 December.

The effort to gain the required attendance to the symposium was, of course, troubled by the poor economic condition of the American companies that were expected to attend. The A & E firms such as Fluor, Lummus, Stone & Webster, Ralph M. Parsons etc. have never been worse. They just didn't have the business and, as a result, had cut their travel budgets to the bone. The change in the Thai attitude persuaded these companies that they couldn't afford not to attend.

3.0 Presymposium Seminars

Just prior to the actual symposium, 2 presymposium seminars were held that discussed the chemical and physical properties of natural gas as well as the safety and handling of natural gas. The Chemical and Physical Properties seminar was presented in the morning and the Safety seminar was presented in the afternoon. These seminars were only open to the Thai delegates and approximately 130 attended.

The paucity in attendance from the anticipated 200 was due to the unusual traffic jams that resulted Monday morning as a result of the major reorientation of Bangkok's vehicular traffic pattern; they changed two-way streets to one-way and everyone was confused.

Two Professors from Northeastern University were retained to make the above presentations; Professor Drake, Professor and Head of the Chemical Engineering Department of the University presented the seminar on safety and handling and Associate Professor Goodwin presented the seminar on the natural gas properties. These Professors were invited to remain in Thailand during the week after the symposium to further discuss the seminar subjects with the Thais. Appendix E contains the final report of the two professors along with their documentation.

4.0 Symposium

The actual symposium began on 7 February. During registration, all participants received a copies of the abstacts of each paper and biographical information on each author. This information can be found in Appendix F. The agenda follows:

TUESDAY-FEBRUARY 7, 1984

0730 REGISTRATION

Session Chairman - Charan Achalabhuti, Deputy Governor, Petroleum Authority of Thailand (PTT), Thailand

0900 Opening Ceremonies

John Gunther Dean, Ambassador to Thailand, USA
H.E. Mr. Wongse Polnikorn, Deputy Minister of Industry, Thailand

0930 Coffee Break

1000 Thailand's Infrastructure

Thailand's Economic Structural Transformation and Direction of Energy Policy

Phisit Pakkasem, Deputy Secretary-General, National Economic & Social Development Board (NESDB), Thailand

Investment Policy

Chira Panopongse, Deputy Secretary-General, Board of Investment (BOI)

Energy Resources and Reserves

Sivavong Changkasiri, Director-General, Department of Mineral Resources (DMR), Thailand

Thailand's Energy Supply/Demand Pattern and Petroleum Development Program

Tongchat Hongladaromp, Governor, (PTT), Thailand

Tuesday - February 7, 1984 (continues)

Afternoon Session Chairman - Arnold H. Pelofsky, President, AER Enterprises, USA

1330 Current Projects

Union Oil Company of Thailand, Harold M. Lian, President, USA

"B" Structure, Gulf of Thailand, Joe R. Clark, President, Texas Pacific Oil Co., Inc., USA

Summary of Exploration Drilling Results - Northeast Thailand, George W. Grader, Vice President and Managing Director, Esso Exploration and Production Khorat Inc., USA

1500 Coffee Break

1530 An Overview of Worldwide Standards for Natural Gas Utilization

Elisabeth Drake, Chairman, Chemical Engineering Department, Northeastern University and Marian H. Long, Arthur D. Little, Inc., USA

1600 A Model for Evaluation of Natural Gas Development Strategies

James F. Houle, Manager, Projects for Research and Engineering, Bechtel Group, Inc., USA

1900 Reception

Cohosted by Minister of Industry and US Ambassador Hilton International

WEDNESDAY, FEBRUARY 8, 1984

Experiences of Other Countries

Session Chairman - Brooks Ryno, Counselor for Commercial Affairs, US Embassy

0830 LNG Production Experience in Brunei

H. Joubert, Manager, Brunei LNG, Brunei

0900 Natural Gas Utilization in Indonesia - Present and Future

Nurani Munjab, Head of Sub-Directorate, Natural Gas Processing and Transportation of MIGAS, Indonesia

Wednesday - February 8, 1984 (continues)

0930 Malaysian Experience in Developing its Gas Resources

Hashim Selleh, Manager, Gas Development Department, Petronas as Malaysian, Malaysia

1000 Coffee Break

1030 The Utilization of Natural Gas in New Zealand

Stephen J. Gale, Scientist, Planning and Forcasting Directorate, Ministry of Energy, New Zealand

1100 Pakistan Experiences With Natural Gas

Munir Ahmad, Director General, Gas Ministry of Petroleum and Natural Resources, Pakistan

1200 Lunch

TWO SESSIONS WILL BE HELD THIS AFTERNOON

TRANSPORTATION - Ballroom
ENERGY APPLICATIONS - Board Room

Transportation Session

Session Chairman - Charles Bliss, USAID

1330 Use of Gaseous Fuels in the Transportation Sector

Tom Joyce, President, Tom Joyce Associates and Jack G. Edwards, Manager, Engineering Services, GDC, Inc., USA

1400 Automobile Equipment Required to Use Compressed Natural Gas as a Fuel

Gregory Macosko, Principal, Hayes/Hill Inc., USA

1430 The New Zealand Experience With Compressed Natural Gas (CNG) in Motor Vehicles

Donald Hertzmark, ASEAN Consultant, Asian Institute of Technology

1500 Coffee Break

1530 Production, Use and Economics of Methanol

Bert W. Struth, Executive Vice President, Chem Systems Inc., USA

Wednesday - February 8, 1984 (continues)

1600 Further Development of the Methanol-Fueled Escort

Robert J. Nichols, Principal Research Engineer, Turbine and Alternate Fuels Research Development Department, Ford Motor Company, USA, (paper presented by Sommai Suvanapima, Director, Manufacturing, Anglo Thai Motors Ltd.

1630 Gasoline From Natural Gas

Gerald F. Tice, Supervising Engineer and Hal C. Spohn, Principal Engineer, Advanced Technology Planning Department, Fluor Engineers, Inc., USA

1700 The Production, Economics and Uses of Synthesis Gas

Frank A. Demers, Stone & Webster Engineering Corp. and Samuel A. Tabak, Mobil Research and Development Corp., USA

Energy Applications Session

Session Chairman, Robert Ichord, USAID

1330 Current EGAT Power Generation Using Fuel Gas

Robert G. Settle, Project Manager, Black & Veatch International, USA

1400 Combined Cycle Cogeneration

R.I. Gavin, Partner and Project Director, Sargent & Lundy, USA

1430 Direct Heating

W.H. Thorbecke, Chairman, Energy Support Services, Inc., USA

1500 Coffee Break

1530 Reciprocating Engines in On-site Power Plants

D.A. Noelkin, Regional Manager, Caterpillar Tractor Co., USA

1600 Gas Turbines for Industrial Use

George J. Milici, Manager, Turbo Machinery, Ingersoll-Rand SEA Pte. Ltd., USA

Wednesday - February 8, 1984 (continues)

1630 Turboexpanders in Natural Gas Applications

John Holm, Director, International Marketing, Rotoflow Corp., USA

THURSDAY, FEBRUARY 9, 1984

Chemical Production

Session Chairman, To Be Announced, Thailand

0830 The Removal of Carbon Dioxide

R.E. Meissner III, Direcor, Gas Technology and H. Robert Scivally, Manager, Business Development, The Ralph M. Parsons Company, USA

0900 Economics and Production of Fertilizer

Giovanni Lorenzo Farina, Project Director, Foster Wheeler International Corp., USA

0930 Phosphate Potash & Soda Ash

G. Russell James, President, James Chemical Engineering, USA

1000 Coffee Break

1015 Make Ammonia With Less Energy

Joseph R. LeBlanc Jr., Manager, Inorganic Chemical Division, M.W. Kellogg Co., USA

1045 Firing With Gas in Cement Kilns

Werner Ostberg, Vice President, Engineering Operations, The Kuljian Corp., USA

Petrochemical Production

Session Chairman, Siri Jirapongphan, Thailand

1115 The Petrochemicals Industry in Today's Economy

Gordon D. Mounts, Vice President/General Manager, Process Systems and Services Department of the Catalysts and Process Systems Division, Union Carbide Corp., USA

Thursday - February 9, 1984 (continues)

1145 Planning Petrochemical Complexes Based on Natural Gas

Andrei Rhoe, Vice President, Lummus Technical Center and M.J. Maddock, Manager, Process Planning and Economics, C-E Lummus Co., USA

1215 Lunch

1330 Managing a Petrochemical Project

William Burner, Project Director, Foster Wheeler International Corp., USA

1400 Ethane/Propane Cracking Technology

Colin P. Bowen, Business Development Manager and Erich Kranz, Business Development Manager, Stone & Webster Engineering Corporation, USA

1430 The Production and Economics of Olefins From Ethane and Propane LPG

Reno Zack, Manager, Olefins Development, C.F. Braun Inc., USA

1500 Polypropylene Production Processes and Economics

B.P. Belles, Research Supervisor, Polypropylene Division, Amoco Chemicals Corp., USA

1530 Dynamic Digital Simulation in Process Operations

S.M. Solomon, President, M. Asgari, Vice President and General Manager and R. Uttamsingh, Business Development Manager, Far East and Pacific Basin, C-E Simulation and Advanced Process Control, Inc., USA

1600 Coffee Break

1615 <u>Closing Ceremonies</u>

H.E. Chirayu Isarangkun Na Aruthaya, Deputy Minister of Industry and Chairman, Eastern Seaboard Subcommittee on Petrochemical Industry

1630 <u>FIELD TRIP BEGAN</u>

FRIDAY, FEBRUARY 10, 1984

0930 Departure to the LDPE Plant, Rayong Province

1030 Briefing and tour of the LDPE Plant

1200 Lunch

1400 Departure to the Gas Separation Plant

1430 Briefing and tour of the Gas Plant

SATURDAY - FEBRUARY 11, 1984

0900 Departure to the Marine Terminal at Khao Bo Ya, Laem Chabang Deep Seaport, Chonburi Province

0930 Tour of the Marine Terminal

1015 Departure to the Gas Monitoring Station, Operation Center, Chonburi Province

1100 Briefing and tour of the Operation Center

1145 Departure to the Bang Pakong Power Plant

1230 Lunch

1330 Briefing and tour of the Bang Pakong Power Plant

1530 Departure back to Bangkok

During the morning of the second day of the symposium, papers were presented by representatives of Brunei, Indonesia, Pakistan, Malaysia and New Zealand. The authors of these papers were high level representatives of their respective governments except for Brunei who nominated the Manager of Brunei LNG which is a subsidiary of Shell Oil Company. Traveling funds were supplied by AID for all the representatives except the Brunei representative because he was an employee of an American company (Shell Oil Company).

5.0 Workshop

During the evening of the second day of the symposium, a workshop was held that attracted the leading decision makers of Thailand along with about 15 delegates representing the American companies. The objective of this workshop was to identify projects of major interest to the Thais that would be of interest to the US Government and to US industry. Dr. Pelofsky moderated the workshop. The following concepts came to light:

Compressed Natural Gas

The Thais are extremely interested in converting their transportation fleet to use Compressed Natural Gas (CNG) rather than diesel fuel or gasoline. Approximately 40-60% of their transportation fleet uses diesel. They feel they need to make this conversion not only to become less dependent of foreign sources of oil but also to reduce the pollution levels in Thailand especially in Bangkok.

A problem to using CNG in Thailand, is that no one in the United States, as yet, has successfully demonstrated a technique that could be used to convert diesel vehicles to CNG.

5.1 Training

The Thais are extremely interested in having their people trained to understand and work with natural gas both "as is" and also in the production of chemicals and petrochemicals. Dr. Charan would also like the Thais to understand and appreciate the safety and

handling risks associated with natural gas. He wants a safety program set up in Thailand which is rigidly enforced.

Thailand would like visiting experts from US universities and industries to visit Thailand and present short courses on the various aspects of using, analyzing and studying natural gas both in a theoretical sense and in a practical one.

The Thais also want to set up a Petroleum Institute that could help evaluate pertinent technology, manage and/or conduct research, analyze and evaluate gas and oil samples and train Thai personnel that will be working in the field. At present, gas and oil samples are sent to Singapore for analysis.

As part of this activity, Chulalongkorn University asked AER to help them organize, manage and coordinate the "University/Industry Interaction in the Development of the Petrochemical Industry" Symposium which they wish to schedule for the end of August or the beginning of September 1984. This symposium could very easily be the mechanism to not only initiate the Institute but also help define its goals, objectives and mode of operation. Involvement of AID in this symposium is crucial.

This symposium is supported by the Ministry of Education, The Ministry of University Affairs, The Ministry of Industry, The Petroleum Authority of Thailand and the Engineering Institute of Thailand.

The package of information including the cover letter from Dr. Woraphat Arthayukti, Head of the Department of Chemical Engineering is in Appendix G. They want this symposium to be a regional symposium which involves the other ASEAN countries and they are anxious for AID support.

This program is extremely important to the US since if could insidiously persuade the Thais to "buy American" because the Thai engineers, operating personnel and students will be trained to follow the American design, environmental and economic criteria over those criteria that are used by other countries especially if US educators and engineers are employed in this training exercise.

5.2 Energy Plan

There is the need to develop a very detailed and complete energy plan that encompasses natural gas as well as oil, lignite and oil shale. This energy plan should also look at the refinery structure within Thailand with a view of determining whether these refineries should be revamped, modernized or dismantled. If a refinery should be dismantled, then a project should be initiated to determine whether new refineries should be designed, constructed and installed. The design and construction of new refineries could mean significant income to US firms. The design and construction of a new refinery could involve an expenditure of about $50,000/daily barrel of product produced or 5 billion dollars for a 100,000 barrel/day refinery.

5.3 Gas Pricing Structure

There is the need to investigate the possibility of developing an acceptable pricing structure for natural gas as it comes from the well head. At present, both Union Oil and Texas Pacific Oil Company are negotiating the price for the gas they discovered. Exxon has already started discussing the subject.

This subject is extremely controversial among the Thais and among the oil companies. When and if Esso finds significant gas in the northeast of Thailand, the subject will become even more difficult. If this issue is resolved successfully, it might have the effect of accelerating the exploration and production efforts of not only Esso but also the other companies that have oil and gas concessions.

I am not certain how AID could help or whether the US Government or the Government of Thailand would be even interested in pursuing the matter. The fact remains, however, that the USGS has a wealth of information on the subject and, to my knowledge, no one seems interested in their views. There is no doubt that if this situation can be resolved, the influence of the United States would be strengthened.

5.4 Alternatives to Natural Gas

It is important for Thailand to consider the alternatives of using natural gas as an automotive fuel principally because there isn't the infrastructure in place to transport the gas to where it can be used to fill vehicles. An alternative might be to use the methane as the feedstock to produce methanol and/or petroleum equivalent white products. The comparative economics of these routes and their energy efficiencies are important to Thailand and should be included in the evaluation.

6.0 Field Trip

Approximately 100 people comprising both Americans and Thais departed on the field trip in 3 air conditioned buses to Pattaya on Thursday afternoon at 1700 hours. The buses were escorted by Thai police throughout the entire field trip in order to insure the safety of everyone but most importantly, to eliminate traffic delays and minimize travel time for the delegates.

A handout was provided to everyone on the field trip. It can be found in Appendix H. This handout describes the Bang Pakong Power Plant, the Natural Gas Separation Plant, the Gas Transmission System and the proposed Chemical Fertilizer Plant along with the future Petrochemical Complex. The only part of the field trip that wasn't described was the Low Density Polyethylene (LDPE) plant which is owned by the Thai Petrochemical Industry Co., Ltd. This plant was down during the visit and as a result

the attendees were not permitted to go into the plant.

The Thais were most cordial and hospitable during the field trip. They were extremely open and didn't seem to hold back on any information that was requested by the Americans. By going on the field trip, the Americans had much more time to discuss, in-depth, subjects that were of significant interest to them with the Thais. It was very pleasing to see groups comprising of Thais and Americans discussing topics of mutual interest in a friendly but serious manner.

There is no doubt that the Thais and Americans formed relationships that could only help cement American influence in Thailand. It is also certain that the Americans gained a deeper appreciation of the level of sophistication of the technology that can be sold within Thailand.

7.0 Post Symposium

The professors that presented the presymposium seminars stayed on for another week after the symposium to present lectures at the Gas Separation Plant, the Bang Pakong Power Plant and Chulalongkorn University on the same subjects that were presented just prior to the symposium. See Appendix E.

8.0 Proceedings

The entire symposium including the field trip went off without the slightest hitch. The papers presented by the Thais on Tuesday were professionally prepared and well presented. Copies of all the papers that were presented will be submitted under separate cover in the form of printed Proceedings.

9.0 Cost Analysis

The cost to AID which is listed below was, perhaps, the smallest portion of the total cost of having this symposium if one considers the contribution of each author and each participant. Each author's company contributed salaries and indirect costs to prepare their presentations along with travel and per diem expenses. Each company that sent participants had to contribute his salary, per diem and travel expenses. Consequently, each company probably contributed at least $30,000 and, perhaps, as much as $50,000 towards the preparation and presentation of each paper. Since there were 32 American authors that presented papers, the total cost had to exceed $1,000,000. The total cost per participant had to fall between $15,000 and $20,000 each. For the 93 participants that didn't present papers, the cost had to total close to $2,000,000. This does not include the cost to the Thais for preparing their papers and their logistical costs nor the cost of the other people that presented papers from the other countries. If one was to add up the costs associated with everyone, the total amount would be in the range of $3 to 3.5 million.

The cost to AID follows:

Professional time	$37,181
Secretarial time	5,375
Two Trips to Thailand prior to symposium	6,468
Prepare and print advertising brochure	1,140
Stuff, stamp and mail advertising brochure	425
Stamps @ $0.20 each	1,740
Rental of mailing list	620
Prepare and print handout material	2,552
Telephone	1,766
Telex	623
Reproduction	200
Preparation, printing and distribution of Proceedings	15,000
Trip to Thailand to work symposium, (2 people)	7,848
Travel and per diem for foreign speakers	6,692
Food functions	5,417
Taxis to go to meetings	56
Professors for presymposium and post symposium stay*	18,000
Consultants Fee	6,107
TOTAL	117,210
Less registration fees collected	28,316
GRAND TOTAL	$ 88,894

* About $10,000 was on a Purchase Order direct to the Professors.

The time spent on this symposium was higher than anticipated because of the low number of registrants up to the month of November and because of the difficulty in enlisting speakers at the beginning of the project. As a result, the amount of time that was spent to encourage attendance and enlist speakers was high. The budgeted amount was approximately half of that which was realized.

AER had to call and write letters to quite a few people to "sell" them on the idea of attending. This effort paid for itself since the total of the registration fees collected was higher than normal. Based on the experience of AER, the remainder of the costs are within expected levels.

10.0 Unsolicited Letters

Letters from some of the participants can be found in Appendix I. All of the enclosed letters mention the success of the meeting and the writer's desire to hope that USAID sponsors more of them.

APPENDIX A

LIST OF PARTICIPANTS

THAILAND-UNITED STATES
NATURAL GAS UTILIZATION SYMPOSIUM

LIST OF PARTICIPANTS & FULL ADDRESS

ABBAS YUSUF
MANAGER SUB DIVISION
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120.	MR. KIGUCHI SAM	BROWN & ROOT INC., U.S.A.
121.	MR. KELLY J. THOMAS	C.F. BRAUN & CO.
122.	MR. KRANZ S. ERICH	STONE & WEBSTER ENGINEERING CORPORATION
123.	MR. KROG P. HERB	UNION CARBIDE CORPORATION
124.	MR. KAROON KOOLTASNASILP DISBURSEMENT VERIFICATION DIRECTOR	PTT
125.	MRS. KAMKEO HONGSAPRABHAS	PTT
126.	DR. KRISANAPOL KOMOLBOON ENGINEER	PTT
127.	MR. KHANIT VORRARAKSA MECH. ENG.	PTT
128.	MR. KAIWAL WAIYAHONG ECONOMIST	PTT
129.	MR. KIJJA USAYAPHAN GAS MARKETING ENGINEER	PTT
130.	MR. KRISANA KAEWDANG THERMODYNAMIC CONSIDERATIONS & SAFETY AND HANDLING OF NARURAL GAS & GAS LIQUI	PTT
131.	MR. KROEKCHAI SUKANJANAJTEE ASSOCIATE PROF.	CHULALONGKORN UNIVERSITY

133.	MR. KOSOL PETCHSUWAN	VICE-RECTOR AND ACTING RECTOR KING MONGKUL'S INSTITUE OF TECHNOLOGY
134.	MR. KAMTHORN UTHARNVUTHIPONG	METRO COMPANY LTD.
135.	MR. KHAMROB THIRAKAOSAL SENIOR ASSISTANT MANAGER, BUSINESS DIVISION I	SCT CO., LTD.
136.	MR. KRISADA VANGSIRIRUNGRUANG SENOIR VICE PRESIDENT, TECHNICAL	PACIFIC ARCHITECTS AND ENGINEERING CO., LTD.
137.	MR. KOOMPOL SABHAVASU VICE PRESIDENT, MARKETING	PACIFIC ARCHITECTS AND ENGINEERING CO., LTD.
138.	MR. KITTI JIVACATE ASSISTANT MARKETING MANAGER	UNION CARBIDE THAILAND LIMITED
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140.	MR. K. OUCHI	TOYO ENGINEERING CORP.
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143.	MISS KANDA TAIPANICH ENERGY PLANNING	ENERGY POLICY AND PLANNING DIVISION NATIONAL
144.	MRS. KRUAMAS BUNNAG CHIEF OF PETROLEUM PRODUCTS PRICING ANALYSIS BRANCH	NATIONAL ENERGY ADMINISTRATION
145.	MRS. KORNIKA TAWEESUP SENIOR HYDROLOGIST	NATIONAL ENERGY ADMINISTRATION
146.	MR. KWANCHAI LAMUBOL SCIENTIST	MINISTRY OF SCIENCE, TECHNOLOGY AND ENERGY
147.	MR. KURUJIT NAKORNTAP PETROLEUM ENGINEER	MINISTRY OF INDUSTRY
148.	MR. KOMIN PIMTANOTAI	THE SIAM CEMENT CO. LTD.

150.	MR. KAMOLCHAI PATTARODOM	EGAT
151.	DR. LADPLIE LEK SINDUSOPON MANAGING DIRECTOR	PRESSURE CONTAINER INDUSTRY CORP., LTD.
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156.	MR. MARTIN F. MILLER MANAGER OF OPERATIONS	UNION
157.	MR. MARTIN MILL	JOHN BROWN ENGINEERING & CONSTRUCTOR INC.
158.	MR. MALEK BILL	AMERICAN GAS ASSOCIATION, U.S.A.
159.	MR. MACOSKO GREGORY	HAYES/HILL, INC.
160.	MR. M.J. MADDOCK	C-E LUMMUS
161.	MR. MEISSNER E. ROLAND	THE RALPH M. PARSONS CO.
162.	MR. MILICI J. GEORGE	INGERSOLL-RAND
163.	MR. MOSHARRAF HOSSAIN	PETROBANGLA
164.	MR. MOUNTS GORDON	UNION CARBIDE CORPORATION
165.	MR. MUNIR AHMAD	MINISTRY OF PETROLEUM & NATURAL GAS
166.	MR. MCPHERSON, J.I.	PHILLIPS PET. CO.

167.	MR. NARONG RATTANA DIRECTOR, TECHNOLOGY TRANSFER CENTRE	MINISTRY OF SCIENCE, TECHNOLOGY AND ENERGY
168.	MR. NART TUNTANWIROON DEAN	MAHIDOL UNIVERSITY
169.	MR. NARONGLIT EAMCHAROENYING MANAGING DIRECTOR	PHAN ANAKE CO., LTD.
170.	MR. NIPHON WONGCHINGCHAI ENGINEERING MANAGER	THAI PLASTIC & CHEMICAL CO., LTD.
171.	MR. NERSESIAN A. GEORGE	AMOCI CHEMICALS FAR EAST LTC.
172.	MR. NOELKIN DAVE	CATERPILLAR FAR EAST LTD.
173.	MR. NURANI MUNJAB	NATURAL GAS PROCESSING AND TRANSPORTATION OF MIGAS
174.	MR. NAGARVALA J. PHIROZE	RESEARCH AND ENGINEERING OPERATION
175.	MR. NUTTACHAT CHARUCHINDA CHIEF OF PIPELINE SYSTEM OPERATION DIVISION	PTT
176.	MR. NUNTACHAI PRAPAWATWECH ASSISTANT MANAGER TERMINAL & RESERVE OPERATION DIVISION	PTT
177.	MISS NITIMA CHEEPPAKDEE	PTT
178.	MR. NIMITCHAI SNITBHAN GENERAL MANAGER	THAI PROJECT MANAGEMENT CONSULTANTS CO. LTD.
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180.	MR. PRATIN PATHANAPORN DEPUTY GOVERNOR, MARKETING	PTT
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182.	MISS PATCHARA PARIWATVORN DIRECTOR, R & D DEPARTMENT	PTT

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186.	MR. PREECHA ORPRASIRTH INSPECTING COMMISSIONER	LAND TRANSPORT DEPARTMENT
187.	DR. PATTARAPAN PRASASSARAKICH ASISTANT PROFESSOR	CHULALONGKORN UNIVERSITY
188.	DR. POONSAB SAMOOTSAKORN	MAHIDOL UNIVERSITY
189.	MR. POONSAK CHIRACHINDA ASSISTANT CHIEF	EGAT
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200.	MISS PHENCHAN CHAROONPASURAKUL R & D ENGINEER	METRO COMPANY LIMITED
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209.	MR. POTTER S. WALTER	STONE AND WEBSTER ASIA CORPORATION
210.	MR. PHILLIPS BILLY J.	TEXAS PACIFIC THAILAND, INC,
211.	DR. PELOFSKY, ARNOLD H.	ARE ENTERPRIES
212.	MRS.PELOFSKY, LORETTA K.	ARE ENTERPRISES
213.	MR. PIGG, GARRY	AGRICO OVERSEAS INVEST. CORP.

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215.	MR. PRAKAL OUDOMUGSORN DEPUTY DIRECTOR R & D DEPARTMENT	PTT
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226.	MR. SCHIPPERIJN, ADRIAAN	C F BRAUN & CO.
227.	MR. SMITH, DON B	BROWN & ROOT INTL.
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253.	MR. SAROJ HONGLADAROM ASSISTANT GENERAL MANAGER	THAI PETROCHEMICAL INDUSTRY CO., LTD.
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258.	MR. SALLEH HASHIM	GAS DEVELOPMENT PETRONAS
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AND QUALYSIS DIVISION — PTT

234. LT.COL. SULEE BOON-LONG
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DEPARTMENT — PTT

235. MR. SOMSAK TEERACHAICHAYUTI
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AND STATE ENTERPRISE SALES
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MARKETING DEPT. — PTT

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242. MR. SULAIMAN ABDULIAH — PETRONAS

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LECTURER OF ECONOMICS — NIDA

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264.	MR. SONGWUT CHINNAWAT CHIEF OF PIPELINE MAINTENANCE DIVISION	PTT
265.	MR. SUWANUNT CHATIUDOMPUNTH CHIEF OF PIPELINE MAINTENANCE DIVISION	PTT
266.	MISS SUMON POCHANART TECHNICAL OFFICER	PTT
267.	MR. SUPATTANAPONG PONMEECHOOW CHEMICAL ENGINEER, SYSTEMS PLANNING & ANALIST	PTT
268.	MR. SIRI JIRAPONGPHANE HEAD OF SYSTEMS PLANNING & ANALYST	PTT
269.	MR. SUTHEP AUCHARIYAVONG CHIEF OF GAS ENGINEERING AND SAFETY STANDARD SECTION	PTT
270.	MR. SCHNIN SUIDLAH ENGINEER	PTT
271.	MRS. SUGANYA SAI-NGAM SCIENCE	PTT
272.	DR. SONGKIERT TANSAMRIT ENGINEER	PTT
273.	MR. SOMPHONGSE TANTISUVANICHKUL ASST. DIRECTOR MECHNICAL CONSTRUCTION DIVISION	PTT
274.	MR. SUTHICHAI KASEMPANICH MECH. ENGINEER	PTT
275,	MR. TABAK, SAMUEL A.	MOBIL R & D CORP.
276.	MR. TANUDEE SINHASENI	BANK OF AMERICA NT & SA
277.	MR. THANAPATT VICHAITHANAPATT	PTT
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280.	MR. THIRAPHONG VIKITSET ASSOCIATE DEAN	NIDA
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282.	MR. T. EASTER	WILLIAMS BROTHERS ENGINEERING LTD.
283.	MR. TABAK A. SAMUEL	MOVIL R & D CORPORATION
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286.	MR. TRAIN R. PETER	FOSTER WHEELER INTERNATIONAL
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288.	MR. VISET CHOOPIBAN DIRECTOR OF POLICY & PLANNING DEPARTMENT	PTT
289.	MR.VITHAYA TIVAYANONDA DIRECTOR OF TECHNOLOGY & DEVELOPMENT DIVISION	PTT
290.	MR. VICHAI POLVANICH DIVISION DIRECTOR	PTT
291.	MR. VORAVIT PRICHACHARN	BANK OF AMERICA NT & SA, BANGKOK BRANCH
292.	M.R. V. CHIRAPRAVATI INSPECTOR GENERAL	EXPRESS TRANSPORTATION ORGANIZATION
293.	MR. VEERA CHANVATTANA LECTURER IN DEPT. OF MECHANICAL ENGINEERING	KING MONGKUT'S INITITUTE OF TECHNOLOGY
294.	MR. VASANT CHATIKAVANIJ	CENTRE FOR INTEGRATED PLAN OF

295.	MRS. VILAILAK SUVARNAPRADIP	PTT
296.	MR. VIRAVAT CHOLVANICH DEPUTY MANAGING DIRECTOR	SCT CO., LTD.
297.	MR. VINIJ PANPANICH DEPUTY MARKETING DIRECTOR	THAI PLASTIC & CHEMICAL CO., LTD.
298.	MR. VUDICHAI NEERANARTRONG ANALYST	THE SIAM CEMENT CO.,LTD.
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304.	DR. WIRAT SAKORNWIMON INSTRUCTOR	CHULALONGKORN UNIVERSITY
305.	MR. WICHIT CHAIYADHIROJ MARKETING MANAGER/SPECIALTIES DEPARTMENT	METRO COMPANY LTD.
306.	MR. WILLIAM PURCELL MANAGER OF PLANNING & EVALUATION	UNION OIL
307.	MR. YONGYUDH KINGHAKORN ASSISTANT MANAGER	SCT CO., LTD.
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APPENDIX B

PRESS CLIPPINGS

Business II

Nation

BANGKOK, MONDAY MORNING, FEBRUARY 6, 1984

TP chief to offer gas production forecasts

• Major gas symposium due

PRESIDENT of Dallas-based Texas acific Co, Joe Clark, who is due to fly ito Bangkok today to hold talks with enior Thai officials over his company's atural gas concessions in the Gulf of hailand, is confident that if negotiaions hit a breakthrough, TP's "B" Strucure could produce 150 million cubic eet per day, increasing to 250 million ubic feet a day eventually.

This forecast is expected to be made y Clark when he delivers a paper tonorrow to the Thailand-US Natural Gas Jtilization Symposium beginning today.

Over 200 officials from the Petroleum Auhority of Thailand (PTT), Electricity Generatng Authority of Thailand (EGAT), and Departnent of Mineral Resources (DMR) will kick off he symposium this morning.

The workshop will be joined by two Ameriian professors to discuss 'Physical and Chemical Properties of Natural Gas: Handling and Safety' t Siam Intercontinental Hotel.

Alternate Energy Research (AER)'s President and the symposium coordinator Arnold H. Pelofsky told *The Nation* on Saturday that oday's workshop precedes the official sympoium which will begin tomorrow.

He said that over 140 foreign participants will join some 200 Thai officials in the largestever gathering of international and Thai experts nd investors in natural gas. The cost of the five ays symposium is roughly estimated at US$2 million (46 million baht).

He said that he is very impressed with the presentations to be made by Thai, American, nd foreign participants who include representatives from Malaysia, Indonesia, Pakistan, Bangladesh, Brunei, India, and New Zealand. "Everyone has done a lot of work," he added.

President of Texas Pacific Inc, Joe Clark will make a presentation tomorrow and he is expected to continue further talks with Thai officials over key issues of natural gas sales and exploration in the Gulf of Thailand.

Part of Clark's paper to be presented to the symposium entails his expectation of the company to provide an initial target gas sales rate of 150 million cubic feet per day. Initial planning will also include provisions for eventually increasing the sales rate to 250 million cubic feet per day.

He is expected to say, as part of his statement that Texas Pacific began its search for hydrocarbons in the Gulf of Thailand in 1976. "B" Structure was discovered in the fall of that same year with the drilling and testing of the 15-B-4X well. Subsequent exploratory and delineation wells outlined a sizable, and geologically complex gas accumulation. Three-dimensional seismic and data obtained from the exploratory and delineation wells including comprehensive well testing programmes provided sufficient technical information to indicate development of this gas accumulation is economically viable. It is presently anticipated that sales of "B" Structure gas will be to the Petroleum Authority of Thailand (PTT) and negotiations for such a sale are presently in progress.

Union Oil Company of Thailand's President Dr Harold M. Lian will peresent a paper on "Operation in the Gulf to Thailand". He is expected to say in part that the natural gas accumulations in the Gulf of Thailand occur in largely non-marine Tertiary sediments. The products of erosion of the neighboring highlands accumulated as stream channel deposits, river flood plain deposits, delta systems, lake beds and swamp deposits. Aggregate thickness reaches 9-10 kilometres in the deeper parts of the basin. Structural uplift and a complex system of north-south faults localized the accumulations of natural gas and condensate.

The Union Oil Company of Thailand, together with the South East Asia Petroleum Exploration Co Ltd, and Mitsui Oil Exploration Co Ltd, have been actively exploring and developing four concessions in the Gulf of Thailand since the Erawan field was discovered in 1973.

Erawan field went on production in August, 1981. Development operations are continuing and production has resched 160 million cubic feet of gas per day, together with 6,000 barrels of condensate. Eight well platforms have been set to date, and if future delineation drilling is successful, more may be installed.

A second field, Baanpot, commenced production in October, 1983 from a single platform. Current production is 25 million cubic feet per day plus 1,500 barrels of condensate.

G.W. Grader, vice-president and managing director of Esso Exploration and Production Khorat Inc will summarize the exploration drilling results in Northeast Thailand. Esso has been exploring in the Khorat Basin of Northeast Thailand and to date has drilled 7 wells. One is a gas discovery, one is an indicated gas discovery, one is an outpost discovery, one has noncommercial gas shows, and three are dry holes.

Esso's assessment of the undiscovered potential of the Khorat Basin remains optimistic. However, complex geology and high drilling costs are restraining factors to further exploration drilling.

51

PHISIT: ECONOMIC TRANSFORMATION:

Deputy Director General of the National Economic and Social Development Board, Phisit Pakkasem will deliver a paper on "Thailand's Economic Transformation and Future Direction of Energy Policy" and part of his statement will say that Thailand's mix of economic policies has always been formulated to strengthen and diversify the country economic base using our resource-rich position, comparative advantage, social cohesion and agroeconomic position in Southeast Asia. The key growth components leading to our sound economic performance during the last two decades are: • resource-rich economy and net food exports; • conservative fiscal policies; • strong private sector; • stability in economic management.

"Our economic outlook for the next five years could be viewed as transformation from the traditional agricultural-rural resource based to more urban and industrialized. The economic transformation will "take-off" aided by the availability of natural gas and oil and development of basic industries. The central feature of the current National Development Plan is the industrial development programme of Thailand's Eastern Seaboard (ESB). The programme will involve investment of $5 billion in its first stage and will make the ESB a "new industrial spring-board of Southeast Asia". The success of the programme will make Thailand one of the so-called "newly industrializing countries (NIC)".

"With this economic policy, Thailand's GDP growth rate is projected to be 6.5% per annum for the next five years. Demand for energy is also projected to increase at rates above 6% per annum which is higher than the Plan's 4.7% target. However, the discoveries and production of indigenous natural gas and oil will reduce Thailand's dependence on imported oil from 65% of total energy consumption in 1981 to 45% in 1987 and 33% by 1990. Investment by the public sector for energy related projects is estimated at $7 billion.

"The national energy policy of supply management through maximum production of indigenous energy, diversify energy supply structure in order to reduce dependence on imported oil and of demand management in restraining growth in energy demand will have to address the following issues: • reliability of reserve estimates; • economics of exploration and production; • joint venture structure; • energy pricing.

BoI'S PRESENTATION:

Deputy Secretary General of the Office of the Board of Investment Chira Panupongse is expected to present a paper on "Thailand's Investment Policy" which in part explains that the basis of Thailand's investment policy has always been to support and encourage productive and profitable investment by the private sector in order to enhance economic, financial and social stability. Throughout the remainder of this decade, large volume of private investment will be required to implement the large-scale, capital intensive projects planned for the Eastern Seaboard Development Programme. The Royal Thai Government is committed to maintaining the favourable investment environment that the private investors, both Thai and foreign, have enjoyed with three major supports: • reduction of risk of investment; • reduction of initial investment cost; • improvement of overall rate of return on investment.

The Board of Investment, has granted privileges involving both tax and non-tax incentives for even investments with many of these benefits: • tax holidays; • special deductions from taxable income; • exception of duties and business taxes of imported machinery and raw materials; • exception of duties and business taxes on export sales; • temporary tariff surcharge to prevent unfair dumping; • free repatriation of capital and remittance of profit.

Department of Mineral Resources's Director General Sivavong Changkasiri will make a statement on "Energy Resources and Reserves" which in part will say that a solution to energy-self-reliance for Thailand is to put more emphasis on developing the country's energy resources such as oil, gas, coal, oil shale, geothermal and radioactive minerals.

Exploration and evaluation of new petroleum prospects are constantly being conducted. At present, proved natural gas reserves in the Gulf of Thailand is estimated at 6.94 trillion SCF plus 119.5 million barrels of condensate. Onshore recoverable oil reserve in the central plain is estimated at 30 million barrels. The country's total natural gas production is about 184.6 MMSCFD whereas the total crude oil and condensate production is about 18,500 barrels per day.

Coal deposits have been found in the northern and southern parts of the country. Total proved coal reserve is about 678.05 million tonnes.

Oil shale has been found in a large quantity in the Mae Sod area of Tak Province where total reserve is about 18,600 million metric tonnes.

Several hot springs in Chiang Mai and Chiang Rai provinces are under studies for utilization as geothermal energy source.

Monazite sand straddled along the southern part of the country has been found to yield some low-grade uranium and thorium. Also, potential source of uranium oxide is situated in the Khorat plateau in the north-eastern part of the country.

Govenor of Petroleum Authority of Thailand Tongchat Hongladaromp will deliver a statement on "Thailand's Enegy Supply/Demand Pattern and Petroleum Development Programme" which in part will describe current status and the outlook of the energy situation in Thailand and the programme for the development of Thailand's petroleum resources and its utilization. Energy in Thailand is supplied from both imported oil and indigenous commercial and non-commercial sources which includes hydropower, coal, lignite, charcoal and firewood. However, these indigenous sources of energy are limited in availability and are rapidly diminishing. By the same token, the dependence on petroleum as a source of energy will be more and more dominating. Therefore, emphasis have been placed on the developments in the oil and gas industries which will enormously change the pattern of energy supply and consumption.

"The development of petroleum exploration in Thailand started more than 10 years ago with the exploration for petroleum in the Gulf of Thailand. We have now discovered more than ten fields bearing gas and condensate and one field bearing crude oil and have also completed the main transmission pipeline bringing ashore natural gas from the Erawan field in the Gulf of Thailand to two power plants in Bangkok and to two cement plants 150 kms north of Bangkok. The natural gas that is being delivered and which is planned for up to 1990 has all been committed to supply domestic demand to achieve the following: • savings in energy cost; • reduce foreign currency outflow; • reduce dependency on imported petroleum; • provide feedstock for basic petrochemical industries.

The Petroleum Authority of Thailand, which is Thailand's national oil company, is currently building a gas separation plant to produce LPG and ethane/propane from natural gas. The plant is scheduled for operation in 1985. Other projects to utilize our natural gas and to maximize its benefit to the country includes a petrochemical complex and a fertilizer complex. These projects are expected to be completed in 1988.

This petroleum development programme is planned base on estimated offshore gas reserves of 10 trillion cubic feet supplying gas at a rate of 700 MMSCFD by 1990. However, the discovery of new gas and oil reserves onshore in the central part of Thailand may provide new opportunities for Thailand.

In the afternoon session tomorrow, other foreign participants begin their presentations starting with Elizabeth Drake from Northeastern University and Marian Long of Arthur D. Little Inc presenting "An Overview of Worldwide Standards for Natural Gas Utilization".

Business II

BANGKOK, TUESDAY MORNING, FEBRUARY 7, 1984

Natio

US experts brief on natural gas

PRE-SYMPOSIUM Seminar on Thailand-US Natural Gas Utilization kicked off yesterday on "Chemical and Physical Properties of Natural Gas" and "Safety and Handling of Natural Gas and Gas Liquids".

The seminar, held at Siam Inter-Continental Hotel, was addressed by two American professors from Northeastern University and attended by over 70 officials from Petroleum Authority of Thailand (PTT) and other private companies.

Associate Professor Bernard M. Goodwin gave a presentation on "Chemical and Physical Properties of Natural Gas" in which he explained that knowing how to deal with physical properties of chemicals are important to the engineering.

He said that the presentation is mainly on technical aspects of gas components in their relevance to the proposed designs of the new petrochemical complex, fertilizer plant and gas separation plant.

Professor Elizabeth Drake gave a presentation on "Safety and Handling of Natural Gas and Gas Liquids" in which she explained that potential safety problems could arise if the fuels are not handled with care.

However, with proper design and training, accidents can be avoided.

Minister of Industry Ob Vasuratna and US Ambassador to Thailand John Gunther Dean will preside over official opening ceremony of the symposium today at nine o'clock.

BANGKOK POST WEDNESDAY FEBRUARY 8, 1984

Phisit: Next five years crucial

Excellencies, Distinguished Participants, Ladies and Gentlemen:

I am delighted to be invited here to speak on Thailand's economic transformation and future direction of our energy policy. This is an immensely broad subject. And because of it, I would like to focus on a few strategic issues which might be of special interest to this high-tech group gathering here today.

On the "Economic Transformation"

I should like to begin my presentation by reporting to you that *Euromoney* magazine of October 1983 ranked Thailand fifth in the category of the world's best economic performance once again in its survey of more than 85 developed and developing countries.

This was in terms of the overall economic growth rate, rate of inflation, strength of exchange rate, and balance of payments performance.

The Asian Wall Street Journal of August, 1983 also headlined that the Thais have lined up new international financing at the very low interest rate, or at 0.37 of a percentage point over the London interbank offered rate, of which very few countries anywhere in the world today can have access to funds at this rate. This demonstrates the Thai top-notch credit rating, the *Wall Street* said.

I must say that the Thai Government has demonstrated continuously its commitment to strengthen and diversify our economic base with its own mix of economic policies shaped by our resource rich position, our comparative advantage, social cohesion, and our geo-economic position in Southeast Asia.

But like other countries Thailand too has some elements of uncertainty. However the following seem to be key growth components leading to high credit rating stand in our sound economic performance during the last two decades.

First, Thailand is a "resource-rich economy" with substantial food surplus which puts Thailand among the world's top five countries with "net food exporting position."

Second, The Thai Government tends to follow somewhat conservative fiscal-monetary policies.

Third, control of major key economic sectors of the economy by "private sector" without too much government interference.

Fourth, control of economic policy-making by an elite corps of technocrats which provides a degree of built-in stability for economic management and continuity of major economic policies.

However, the next five years will be indeed a crucial turning point in our economic history. Thailand's medium-term economic outlook should be viewed as a "transformation stage" from traditional agricultural-rural-resource based to more modern and complex forms of urban-industrial activities which will definitely reinforce the faster rates of urbanisation in the 1980s and beyond.

This transformation is taking place very rapidly in the 1980s since our economy now has attained the capacity to transform itself or the so-called "take off" from traditional to a modern economic system with availability and better use of more efficient technology, capital, and management transfers from abroad.

At the same time, the recent discovery and development of natural gas in the Gulf of Thailand and oil from the onshore field at Lan Krabue, have dramatically changed our whole resource picture of the country and opened up entirely new opportunities for creation of viable "basic industries" for Thailand.

The current Fifth National Development Plan has a very comprehensive industrial restructuring programme to make our industries more competitive, outward looking, and less dependent on foreign inputs, and to decentralise our industrial activities away form Bangkok metropolitan area to the new industrial zone at the Eastern Seaboard.

The Eastern Seaboard investment programme will be about US$5 billion at the first stage for the new basic industries and related deep-sea ports. The new basic industries at the Eastern Seaboard will use our natural gas resources either for energy supply or as feedstock. This ESB is a major industrial breakthrough in Thailand.

Japan's best-known industrial and international spokesman, Dr Saburo Okita, called the ESB a "new industrial spring-board of Southeast Asia." This new industrial-locational facilities will enable the private and international investors of large industries to invest in this new seaboard industrial zone of Thailand. Many peole thus expect that Thailand, together with other ASEAN countries, will definitely join the ranks of "newly industrialising countries," or the NIC group, by the end of this decade.

The NIC group of Southeast Asia are now carving out for themselves an enlarged share of world trade, investment, and total output. This transformation of our economy will change the composition of our production, demand, external trade, employment patterns, and future technology and energy requirements in Thailand. However our fate in these structural transformation will depend also on world environment trends and a few domestic uncertainties, namely, the world economic recovery, price of oil, and domestic production and additional discovery of gas and crude oil in the immediate future.

A joint NESDB-World Bank simulation of the medium-term outlook of the Thai economy up until 1987 under the above domestic and world environment assumptions shows that Thailand's economy will grow with an average of 6.5% per annum up until 1987 with the outputs in the non-agriculture, especially industry, energy, construction and service sector expanding at higher rates of 7.7% 8.3%, 5.5%, and 6.8% respectively. For the energy sector in this medium-run simulation, the imminent economic recovery together with faster rate of urbanisation will push up the demand for energy growing more than 6% per annum compared with the current Fifth Plan's target of 4.7%

Meanwhile the substitution of imported oil by natural gas from the Gulf of Thailand will be slightly lower than the Fifth Plan's target of 525 mcfd in 1986. This is however compensated by the discovery of Lan Krabue oil. As a result, our dependence on imported energy will decline from 65% of total

energy consumption in 1981 to 45% in 1987.

It now seems clear that additions to domestic energy supplies and reserves will make dramatic reduction in energy import-dependence during the rest of 1980s. We are now spending more on energy at an unprecedented rate. Our public investment target for the energy sector during the Fifth Plan is about $7 billion. This covers the EGAT, PTT, PEA, MEA and NEA development projects to accelerate development of our domestic hydro, lignite, gas and oil resources over the current Fifth Plan period. This would definitely reduce our dependence on imported energy sources down to about 33% by 1990, after which period our projections show that imported energy, both oil and possibly coal, in meeting domestic "primary energy demand will begin to climb again to about 44-45% share by year 2001." This causes some serious concern among the planners in Thailand.

Some Critical Issues and Future Directions of Energy Policy

Our current energy policy under the Fifth Plan period is fundamentally twofold:

First, to maximise production of domestic energy resources and diversify energy supply structure, in order to reduce Thailand's dependence on imported oil (on supply side).

Second, to restrain the growth of energy demand, particularly petroleum demand, through improved efficiency of energy use, conservation and pricing policies (on demand management side).

I think the prospects are good for Thailand, which is a net petroleum importer at present, becoming less dependent on petroleum in the future. But both supply and demand management in Thailand's energy sector depend so much on the following policy direction and issues:

First, on the natural gas, the "reliability of reserve estimates" is a key issue. This is not only vital to our future import-oil substitution and other transport uses as well as the new industrialisation programme in the Eastern Seaboard, but also the future of the LNG scheme depends on the gas reserves which need further proving.

Some reserve estimates must be treated with some caution. Attempt to quantify the oil and gas potential normally requires a high degree of "subjectivity." Another associated issue to any gas development programme is the new and additional discoveries. The Government must therefore have some flexibility in order to meet these uncertainties.

Second, the economics of oil and gas exploration and development in Thailand is another issue. We realise that the hydro-carbon exploration and development is of high risk and high gain nature. In addition, this industry is very politically sensitive toward the continuity of the Government policies.

However, I feel at the moment that Thailand's petroleum law and tax regimes are quite attractive by international standard. The private industry has already invested more than one billion dollars in this country since the promulgation of our Petroleum Act of Thailand. This incentive should therefore be preserved. Many international experts believe that the 1990s could be a repeat of the 1970s with international oil price rising again.

To offset these possible price rises and to contain our energy import bill, Thailand must do what it can to step up exploration and increase the level of production to ensure that energy production does not decline in the 1990's. Because of the long lead time oil and gas exploration has to be strong through the middle 1980's for there to be hope of stabilising oil imports in the 1990s.

It is imperative to create right conditions for continued exploration, including newcomer companies. A most important facet of Thailand's energy policy is the need to maintain an environment which will encourage vigorous exploration for oil and gas. Those companies making discoveries will be assured that there will be reasonable prospects for economic development. When adequate domestic market demands are satisfied, exports will also be seriously considered.

Allowing producers access to both domestic and foreign markets in certain circumstances can transform an otherwise uneconomic scheme into a viable one.

Third, joint ventures are another key policy issue. I feel the basic right and terms of joint venture should be determined by Thailand, not by the concessionaire. This view is also shared by two recent World Bank reports. This would reduce negotiating time.

Recent negotiations between the Texas Pacific Group and the Thai Government have moved one step forward with the suggestion of PTT participation in field development. However, further delay impose high costs to both parties. We must find ways of speeding up the negotiating process so that gas comes on stream sooner because the potential gas use is in excess of supply. In the longer run, steps should be taken to gradually develop an independent petroleum capability through joint venture operations.

Fourth, the energy pricing policy is also critical to both supply and demand management of energy sector in Thailand. Our early choice of domestic oil pricing policies in the 1970s was strongly influenced by the desire to maintain high growth rate of GDP. The Government thus chose to absorb a substantial part of increase in the costs of imported fuel. However after 1978 domestic energy prices had been drastically adjusted.

Thailand now has domestic petroleum prices roughly comparable to those of our neighbours. Our average level of taxation on petroleum products is now comparable to other oil importing countries. We have finally eliminated subsidies to most of our petroleum products.

Regarding oil and gas pricing, regulations should set out a mechanism for pricing domestic crude oil and gas. Present pricing approach based on forecast costs has led to slow and time-consuming negotiations. We might consider an alternative by establishing a reference to international parity and possibly reducing the reference price by a small discount for user's incentives.

In sum, the economic transformation in Thailand during the 1980s and 1990s with further intensification of agricultural production, increased industrialisation, and higher level of urbanisation will definitely increase the average level of per capita consumption of commercial energy. And according to our Energy Master Plan study, Thailand is not and will not be an energy-surplus country. It is necessary for us to diversify our supply sources with an objective to reduce dependence on imported petroleum.

This will remainbasically unchanged in the future direction of our natural gas. Substantial amounts of capital and technology will be required in the gas development and utilisation programmes during the next two decades. The public investment programme in gas-related field has already been in the pipeline. We also would like to see more private investment in the downstream projects by creating conditions conducive to smooth financing.

Finally, I must emphasise that continued intensive searching for domestic energy must be further encouraged. We are doing our best to reinforce and rationalise our energy planning and coordination apparatus, to develop political support for energy sector development, and to encourage private sector participation in the field of energy exploration, development, and conservation programmes. We will do our best to attract and retain international investments and technologies required to support our energy policy and development programme.

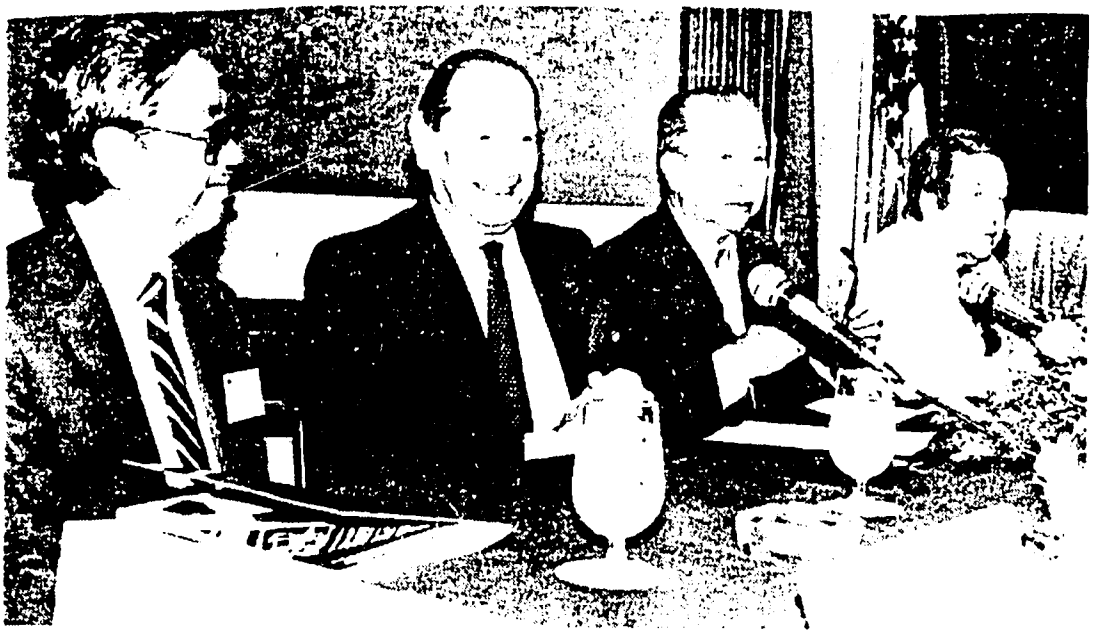
Thank you.

Dr Phisit Pakkasem, Deputy Secretary-General of the National Economic and Social Development Board, yesterday gave a speech on Thailand's Economic Transformation and Future Direction of Energy Policy at the Thailand-United States Natural Gas Utilisation Symposium at the Siam Inter-Continental Hotel. Here is the full text of the speech.

"The next five years will be indeed a crucial turning point in our economic history. Thailand's medium-term economic outlook should be viewed as a "transformation stage" from traditional agricultural-rural-resource based to more modern and complex forms of urban-industrial activities which will definitely reinforce the faster rates of urbanisation in the 1980s and beyond."

BUSINESS POST

Vol. XXXIX No. 38 BANGKOK WEDNESDAY FEBRUARY 8, 1984 SECTION II



THE three-day symposium on Thailand-United States Natural Gas Utilisation was opened yesterday at the Siam Intercontinental Hotel by Deputy Industry Minister Wong Polnikorn and US Ambassador to Thailand John Gunther Dean.

The symposium is jointly organised by the Petroleum Authority of Thailand (PTT), the US Agency for International Development (USAID) and the US Embassy.

The aim of the symposium is to give local and foreign petroleum professionals insights about Thailand's total energy picture and related government policy as well as general investment policy.

Picture shows Ambassador Dean and Mr Wong, flanked by PTT Governor Tongchat Hongladaromp (with glasses) and the US Counsellor for Commercial Affairs Brooks Ryno.

US may give aid for gas projects

THE US Government may consider giving financial assistance to Thailand for natural gas-related projects, US Ambassador to Thailand John Gunther Dean said yesterday.

The envoy, in his opening remarks at the Thailand-US Natural Gas Utilisation Symposium, said a meeting has been scheduled for February 13 when a list of these high-priority projects will be presented to US government agencies for consideration.

The agencies are the US Agency for International Development, the US Trade Development Programme, the US Department of Commerce and the US Department of State.

Mr Dean said the US Government supports Thailand's gas development efforts and American firms also look forward to working with Thailand on gas-based projects.

บางกอกโพสต์ วันพ

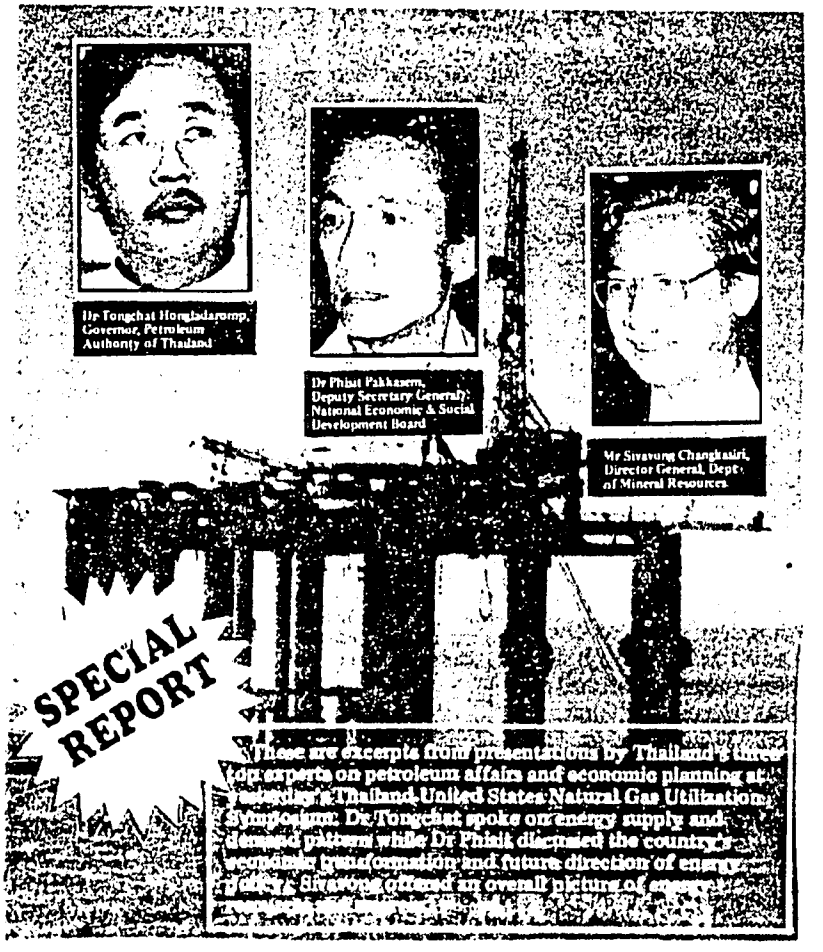
TRADE TALK

BANGKOK POST THURSDAY FEBRUARY 9, 1984

Industry Minister Ob Vasuratna and US Ambassador John Gunther Dean hosted a welcome reception for the participants in the Thai-US Natural Gas Utilisation Symposium at the Hilton International Bangkok Hotel early this week. In conversation are (from left) President G. Grader of Esso Exploration and Production Korat Inc, Deputy Industry Minister Wong Polnikorn, Mr Dean and Petroleum Authority of Thailand Deputy Governor Charan Achalabhuti.

NATIONBUSINESS

Critical issues facing energy search



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At the same time, the recent discovery and development of national gas in the Gulf of Thailand and oil from the onshore field at Lan Krabue, have dramatically changed our whole resource picture of the country, and opened up entirely new opportunities for creation of viable "basic industries" for Thailand. The current Fifth National Development Plan has a very comprehensive industrial restructuring programme to make our industries more competitive, outward looking, and less dependent on foreign inputs, and to decentralize our industrial activities away from Bangkok metropolitan area to the new industrial zone at the Eastern Seaboard.

The ESB investment programme will be about US$5 billion at the first stage for the new basic industries and related deep-sea ports. The new basic industries at the Eastern Seaboard will use our natural gas resources either for energy supply or as feedstock. This ESB is a major industrial breakthrough in Thailand.

The top Japan's best-known industrial and international spokesman, Dr Saburo Okita call the ESB a "new industrial spring-board of Southeast Asia." This new industrial-locational facilities will enable the private and international investors of large industries to invest in this new seaboard industrial zone of Thailand. Many people thus expect that Thailand, together with other ASEAN countries, will definitely join the ranks of "newly industrializing countries", or the NIC group by the end of this decade.

This NIC group of Southeast Asia are now carving out for themselves an enlarged share of world trade, investment, and total output. This transformation of our economy will change the composition of our production, demand, external trade, employment patterns, and future technology and energy requirements in Thailand.

However, our fate in these structural transformation will depend also on world environment trends and two few domestic uncertainties, namely, the world economic recovery, price of oil, and domestic production and additional discovery of gas and crude oil in the immediate future.

A joint NESDB-World Bank simulation of the medium-term outlook of the Thai economy up until 1987 under the above domestic and world environment assumptions shows that Thailand's economy will grow with an average of 6.5% per annum up until 1987 with outputs in the non-agriculture, especially industry, energy, construction and service sector expanding at higher rates of 7.7%, 8.3%, 5.5% and 6.8% respectively. For the energy sector in this medium-run simulation, the imminent economic recovery together with faster rate of urbanization will "push-up" the demand for energy growing more than 6% per annum compared with the current Fifth Plan's target of 4.7%.

Meanwhile the substitution of imported oil by natural gas from the Gulf of Thailand will be slightly lower than the Fifth Plan's target of 525 mcfd in 1986. This is, however, compensated by the discovery of Lan Krabue Oil. As a result, our dependence on imported energy will decline from 65% of total enegy consumption in 1981 to 45% in 1987.

It now seems clear that additions to domestic energy supplies and reserves will make dramatic reduction in energy import-dependence during the rest of 1980s. We are now spending more on energy at an unprecedented rate. Our public investment target for the energy sector during the current Fifth Plan is about $7 billion. This covers the EGAT, PTT, PEA, MEA, and NEA development projects to accelerate development of our domestic hydro, lignite, gas and oil resources over the current Fifth Plan period.

This would definitely reduce our dependence on imported energy sources down to about 33% by 1990. After which period our projections show that imported energy both oil and possibly coal, in meeting domestic primary energy demand will begin to climb again to about 44-45% share by year 2001. This causes some serious concerns among the planners in Thailand.

Some Critical Issues and Future Directions of Energy Policy

Our current energy policy under the Fifth Plan period is fundamentally twofold:-

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Second, to restrain the growth of energy demand, particularly petroleum demand, through improved efficiency of energy use, conservation and pricing policies (on demand management side)

I think the prospects are good for Thailand, which is a net petroleum importer at present, becoming less dependent on petroleum in the future. But both supply and demand management in Thailand's energy sector depend so much on the following policy direction and issues:—

First, *on the natural gas, the reliability of reserve estimates is a key issue.* This is not only vital to our future import-oil substitution and other transport uses as well as the new industrialization programme in the Eastern Seaboard, but also the future of the LNG scheme depends on the gas reserves which need further proving. Some reserve estimates must be treated with some caution. Attempt to quantify the oil and gas potential normally requires a high degree of subjectivity. Another associated issue to any gas development programme is the new and additional discoveries. The Government must therefore have some flexibility in order to meet these uncertainties.

Second, *the economics of oil and gas exploration and development in Thailand is another issue.* We realize that the hydro-carbon exploration and development is of high risk and high gain nature. In addition, this industry is very politically sensitive toward the continuity of the government policies. However, I feel at the moment that Thailand's petroleum law and tax regimes are quite attractive by international standard. The private industry has already invested more than one billion dollars in this country since the promulgation of our Petroleum Act of Thailand. This incentive should therefore be preserved.

Many international experts believe that the 1990's could be a repeat of the 1970's with international oil price rises again. To offset these possible price rises and to

contain our energy import bill, Thailand must do what it can to step up exploration and increase the level of production to ensure that energy production does not decline in the 1990's. Because of the long lead time oil and gas exploration has to be strong through the middle 1980's for there to be hope of stabilizing oil imports in the 1990's.

It is imperative to create right conditions for continued exploration, including newcomer companies. A most important facet of Thailand's energy policy is the need to maintain an environment which will encourage vigorous exploration for oil and gas. Those companies making discoveries will be assured that there will be reasonable prospects for economic development. When adequate domestic market demands are satisfied, exports will also be seriously considered. Allowing producers access to both domestic and foreign markets in certain circumstances can transform an otherwise uneconomic scheme into a viable one.

Third, *Joint Ventures are another key policy issue.*

I feel the basic right and terms of joint venture should be determined by Thailand, not by the concessionaire. This view is also shared by two recent World Bank's report. This would reduce negotiating time. Recent negotiations between the Texas Pacific Group and the Thai Government have moved one step forward with the suggestion of PTT participation in field development. However, further delay in gas availability and negotiation will probably impose high costs to both parties. We must find ways of speeding up the negotiating process so that gas come on stream sooner because the potential gas use is in excess of supply. In the longer run, step should be taken to gradually develop an independent petroleum capability through joint venture operations.

Fourth, *The energy pricing policy* is also critical to both supply and demand management of energy sector in Thailand. Our early choice of domestic oil pricing policies in the 1970s was strongly influenced by the desire to maintain high growth rate of GDP. The governments thus chose to absorb a substantial part of increase in the costs of imported fuel. However, after 1978 domestic energy prices had been drastically adjusted. Thailand now has domestic petroleum prices roughly comparable to those of our neighbours. Our average level of taxation on petroleum products is now comparable to other oil importing countries. We have finally eliminated subsidies to most of our petroleum products.

Regarding oil and gas pricing, regulations should set out a mechanism for pricing domestic crude oil and gas. Present pricing approach based on forecast costs has led to slow and time consuming negotiations. We might consider an alternative by establishing a reference to international parity and possibly reducing the reference price by a small discount for user's incentives.

In sum, the economic transformation in Thailand during the 1980s and 1990s with further intensification of agricultural production, increased industrialization, and higher level of urbanization will definitely increase the average level of per capita consumption of commercial energy.

And according to our Energy Master Plan study, Thailand is not and will not be an energy-surplus country. It is necessary for us to diversify our supply sources with an objective to reduce dependence on imported petroleum. This will remain basically unchanged in the future direction of our energy policy. It is essential to devise the best energy supply mix by taking into full consideration the role of our natural gas. Substantial amounts of capital and technology will be required in the gas development and utilization programmes during the next two decades. The public investment programme in gas-related field has already been in the pipeline. We also would like to see more private investment in the downstream projects by creating conditions conducive to smooth financing.

Finally, I must emphasize that continued intensive searching for domestic energy must be further encouraged. We are doing our best to reinforce and rationalize our energy planning and coordination apparatus, to develop political support for energy sector development, and to encourage private sector participation in the field of energy exploration, development, and conservation programmes. We will do our best to attract and retain international investments and technologies required to support our energy policy and development programmes.

Business II

Nation

BANGKOK, MONDAY MORNING, FEBRUARY 6, 1984

TP chief to offer gas production forecasts

• Major gas symposium due

PRESIDENT of Dallas-based Texas acific Co, Joe Clark, who is due to fly to Bangkok today to hold talks with nior Thai officials over his company's atural gas concessions in the Gulf of hailand, is confident that if negotiaons hit a break through, TP's "B" Strucre could produce 150 million cubic et per day, increasing to 250 million ubic feet a day eventually.

This forecast is expected to be made y Clark when he delivers a paper toorrow to the Thailand-US Natural Gas tilization Symposium beginning today.

Over 200 officials from the Petroleum Auhority of Thailand (PTT), Electricity Generatng Authority of Thailand (EGAT), and Departnent of Mineral Resources (DMR) will kick off e symposium this morning.

The workshop will be joined by two Ameriin professors to discuss 'Physical and Chemical roperties of Natural Gas: Handling and Safety' t Siam Intercontinental Hotel.

Alternate Energy Research (AER)'s Presient and the symposium coordinator Arnold H. Pelofsky told *The Nation* on Saturday that oday's workshop precedes the official sympoium which will begin tomorrow.

He said that over 140 foreign participants vill join some 200 Thai officials in the largestver gathering of international and Thai experts nd investors in natural gas. The cost of the five ays symposium is roughly estimated at US$2 nillion (46 million baht).

He said that he is very impressed with the resentations to be made by Thai, American, nd foreign participants who include repreentatives from Malaysia, Indonesia, Pakistan, Bangladesh, Brunei, India, and New Zealand. "Ever one has done a lot of work," he added.

President of Texas Pacific Inc, Joe Clark will make a presentation tomorrow and he is expected to continue further talks with Thai officials over key issues of natural gas sales and exploration in the Gulf of Thailand.

Part of Clark's paper to be presented to the symposium entails his expectation of the company to provide an initial target gas sales rate of 150 million cubic feet per day. Initial planning will also include provisions for eventually increasing the sales rate to 250 million cubic feet per day.

He is expected to say, as part of his statement that Texas Pacific began its search for hydrocarbons in the Gulf of Thailand in 1976. "B" Structure was discovered in the fall of that same year with the drilling and testing of the 15-B-4X well. Subsequent exploratory and delineation wells outlined a sizable, and geologically complex gas accumulation. Three-dimensional, seismic and data obtained from the exploratory and delineation wells including comprehensive well testing programmes provided sufficient technical information to indicate development of this gas accumulation is economically viable. It is presently anticipated that sales of "B" Structure gas will be to the Petroleum Authority of Thailand (PTT) and negotiations for such a sale are presently in progress.

Union Oil Company of Thailand's President Dr Harold M. Lian will peresent a paper on 'Operation in the Gulf to Thailand". He is expected to say in part that the natural gas accumulations in the Gulf of Thailand occur in largely non-marine Tertiary sediments. The products of erosion of the neighboring highlands accumulated as stream channel deposits, river flood plain deposits, delta systems, lake beds and swamp deposits. Aggregate thickness reaches 9-10 kilometres in the deeper parts of the basin. Structural uplift and a complex system of north-south faults localized the accumulations of natural gas and condensate.

The Union Oil Company of Thailand, together with the South East Asia Petroleum Exploration Co Ltd, and Mitsui Oil Exploration Co Ltd, have been actively exploring and developing four concessions in the Gulf of Thailand since the Erawan field was discovered in 1973.

Erawan field went on production in August, 1981. Development operations are continuing and production has resched 160 million cubic feet of gas per day, together with 6,000 barrels of condensate. Eight well platforms have been set to date, and if future delineation drilling is successful, more may be installed.

A second field, Baanpot, commenced production in October, 1983 from a single platform. Current production is 25 million cubic feet per day plus 1,500 barrels of condensate.

G.W. Grader, vice-president and managing director of Esso Exploration and Production Khorat Inc will summarize the exploration drilling results in Northeast Thailand. Esso has been exploring in the Khorat Basin of Northeast Thailand and to date has drilled 7 wells. One is a gas discovery, one is an indicated gas discovery, one is an outpost discovery, one has noncommercial gas shows, and three are dry holes.

Esso's assessment of the undiscovered potential of the Khorat Basin remains optimistic. However, complex geology and high drilling costs are restraining factors to further exploration drilling.

62

PHISIT: ECONOMIC TRANSFORMATION:

Deputy Director General of the National Economic and Social Development Board, Phisit Pakkasem will deliver a paper on "Thailand's Economic Transformation and Future Direction of Energy Policy" and part of his statement will say that Thailand's mix of economic policies has always been formulated to strengthen and diversify the country economic base using our resource-rich position, comparative advantage, social cohesion and agroeconomic position in Southeast Asia. The key growth components leading to our sound economic performance during the last two decades are: • resource-rich economy and net food exports; • conservative fiscal policies; • strong private sector; • stability in economic management.

"Our economic outlook for the next five years could be viewed as transformation from the traditional agricultural-rural resource based to more urban and industrialized. The economic transformation will "take-off" aided by the availability of natural gas and oil and development of basic industries. The central feature of the current National Development Plan is the industrial development programme of Thailand's Eastern Seaboard (ESB). The programme will involve investment of $5 billion in its first stage and will make the ESB a "new industrial spring-board of Southeast Asia". The success of the programme will make Thailand one of the so-called "newly industrializing countries (NIC)".

"With this economic policy, Thailand's GDP growth rate is projected to be 6.5% per annum for the next five years. Demand for energy is also projected to increase at rates above 6% per annum which is higher than the Plan's 4.7% target. However, the discoveries and production of indigenous natural gas and oil will reduce Thailand's dependence on imported oil from 65% of total energy consumption in 1981 to 45% in 1987 and 33% by 1990. Investment by the public sector for energy related projects is estimated at $7 billion.

"The national energy policy of supply management through maximum production of indigenous energy, diversify energy supply structure in order to reduce dependence on imported oil and of demand management in restraining growth in energy demand will have to address the following issues: • reliability of reserve estimates; • economics of exploration and production; • joint venture structure; • energy pricing.

BoI'S PRESENTATION:

Deputy Secretary General of the Office of the Board of Investment Chira Panupongse is expected to present a paper on "Thailand's Investment Policy" which in part explains that the basis of Thailand's investment policy has always been to support and encourage productive and profitable investment by the private sector in order to enhance economic, financial and social stability. Throughout the remainder of this decade, large volume of private investment will be required to implement the large-scale, capital intensive projects planned for the Eastern Seaboard Development Programme. The Royal Thai Government is committed to maintaining the favourable investment environment that the private investors, both Thai and foreign, have enjoyed with three major supports: • reduction of risk of investment; • reduction of initial investment cost; • improvement of overall rate of return on investment.

The Board of Investment, has granted privileges involving both tax and non-tax incentives for even investments with many of these benefits: • tax holidays; • special deductions from taxable income; • exception of duties and business taxes of imported machinery and raw materials; • exception of duties and business taxes on export sales; • temporary tariff surcharge to prevent unfair dumping; • free repatriation of capital and remittance of profit.

Department of Mineral Resources's Director General Sivavong Changkasiri will make a statement on "Energy Resources and Reserves" which in part will say that a solution to energy-self-reliance for Thailand is to put more emphasis on developing the country's energy resources such as oil, gas, coal, oil shale, geothermal and radioactive minerals.

Exploration and evaluation of new petroleum prospects are constantly being conducted. At present, proved natural gas reserves in the Gulf of Thailand is estimated at 6.94 trillion SCF plus 119.5 million barrels of condensate. Onshore recoverable oil reserve in the central plain is estimated at 30 million barrels. The country's total natural gas production is about 184.6 MMSCFD whereas the total crude oil and condensate production is about 18,500 barrels per day.

Coal deposits have been found in the northern and southern parts of the country. Total proved coal reserve is about 678.05 million tonnes.

Oil shale has been found in a large quantity in the Mae Sod area of Tak Province where total reserve is about 18,600 million metric tonnes.

Several hot springs in Chiang Mai and Chiang Rai provinces are under studies for utilization as geothermal energy source.

Monazite sand straddled along the southern part of the country has been found to yield some low-grade uranium and thorium. Also, potential source of uranium oxide is situated in the Khorat plateau in the north-eastern part of the country.

Govenor of Petroleum Authority of Thailand Tongchat Hongladaromp will deliver a statement on "Thailand's Enegy Supply/Demand Pattern and Petroleum Development Programme" which in part will describe current status and the outlook of the energy situation in Thailand and the programme for the development of Thailand's petroleum resources and its utilization. Energy in Thailand is supplied from both imported oil and indigenous commercial and non-commercial sources which includes hydropower, coal, lignite, charcoal and firewood. However, these indigenous sources of energy are limited in availability and are rapidly diminishing. By the same token, the dependence on petroleum as a source of energy will be more and more dominating. Therefore, emphasis have been placed on the developments in the oil and gas industries which will enormously change the pattern of energy supply and consumption.

"The development of petroleum exploration in Thailand started more than 10 years ago with the exploration for petroleum in the Gulf of Thailand. We have now discovered more than ten fields bearing gas and condensate and one field bearing crude oil and have also completed the main transmission pipeline bringing ashore natural gas from the Erawan field in the Gulf of Thailand to two power plants in Bangkok and to two cement plants 150 kms north of Bangkok. The natural gas that is being delivered and which is planned for up to 1990 has all been committed to supply domestic demand to achieve the following: • savings in energy cost; • reduce foreign currency outflow; • reduce dependency on imported petroleum; • provide feedstock for basic petrochemical industries.

The Petroleum Authority of Thailand, which is Thailand's national oil company, is currently building a gas separation plant to produce LPG and ethane/propane from natural gas. The plant is scheduled for operation in 1985. Other projects to utilize our natural gas and to maximize its benefit to the country includes a petrochemical complex and a fertilizer complex. These projects are expected to be completed in 1988.

This petroleum development programme is planned base on estimated offshore gas reserves of 10 trillion cubic feet supplying gas at a rate of 700 MMSCFD by 1990. However, the discovery of new gas and oil reserves onshore in the central part of Thailand may provide new opportunities for Thailand.

In the afternoon session tomorrow, other foreign participants begin their presentations starting with Elizabeth Drake from Northeastern University and Marian Long of Arthur D. Little Inc presenting "An Overview of Worldwide Standards for Natural Gas Utilization".

BUSINESS POST
INCORPORATING BUSINESS WEEKLY
Vol. XXXIX No. 36 BANGKOK MONDAY FEBRUARY 6, 1984 SECTION II

Energy experts meet

MORE than 100 American businessmen representing more than 60 companies and high-ranking government officials from six other countries will participate in a three-day symposium on natural gas utilisation and the Eastern Seaboard Development Project beginning tomorrow at the Siam Inter-Continental Hotel.

Besides more than 200 Thai participants, there will be delegations from Bangladesh, Brunei, Indonesia, Malaysia, New Zealand and Pakistan. Presiding at the opening will be Deputy Industry Minister Wong Polnikorn and US Ambassador to Thailand John Gunther Dean.

The Thai side will include representatives from the Petroleum Authority of Thailand, the Board of Investment, the Department of Mineral Resources, the Electricity Generating Authority of Thailand, the National Economic and Social Development Board and several private-sector industries.

An extensive two-day field trip to the Eastern Seaboard site will follow the technical session, which will be closed by Deputy Industry Minister Chirayu Isarangkura na Ayutthaya.

Tomorrow PTT Governor Tongchat Hongladaromp and other high-ranking Thai officials will make presentations on the economic structure, energy and investment policies, energy resources and the Petroleum Development Programme of Thailand.

Thirty presentations on transportation, energy applications, and chemical and petrochemical production will be made on Wednesday and Thursday by some of the largest firms in the United States, including Bechtel, Black and Veatch, Caterpillar Tractor, C-E Lummus, Chem Systems, Energy Support Services, Esso Exploration, Fluor, Ford Motor, Foster Wheeler, GDC, Hayes/Hill, Ingersoll-Rand, James Chemical Engineering, Kellogg, Kuljian Corp, Arthur D. Little, Mobil, Ralph M. Parsons, Rotoflow, Sargent and Lundy, Stone and Webster, Union Carbide, Union Oil and Texas Pacific.

Dr Arnold Pelofsky, president of AER Enterprises and an energy expert, is responsible for coordinating and managing the symposium which he reportedly said is the largest and most widely accepted symposium he has coordinated.

Business II

BANGKOK, TUESDAY MORNING, FEBRUARY 7, 1984

Natio

US experts brief on natural gas

PRE-SYMPOSIUM Seminar on Thailand-US Natural Gas Utilization kicked off yesterday on "Chemical and Physical Properties of Natural Gas" and "Safety and Handling of Natural Gas and Gas Liquids".

The seminar, held at Siam Inter-Continental Hotel, was addressed by two American professors from Northeastern University and attended by over 70 officials from Petroleum Authority of Thailand (PTT) and other private companies.

Associate Professor Bernard M. Goodwin gave a presentation on "Chemical and Physical Properties of Natural Gas" in which he explained that knowing how to deal with physical properties of chemicals are important to the engineering.

He said that the presentation is mainly on technical aspects of gas components in their relevance to the proposed designs of the new petrochemical complex, fertilizer plant and gas separation plant.

Professor Elizabeth Drake gave a presentation on "Safety and Handling of Natural Gas and Gas Liquids" in which she explained that potential safety problems could arise if the fuels are not handled with care.

However, with proper design and training, accidents can be avoided.

Minister of Industry Ob Vasuratna and US Ambassador to Thailand John Gunther Dean will preside over official opening ceremony of the symposium today at nine o'clock.

BANGKOK POST WEDNESDAY FEBRUARY 8, 1984

Phisit: Next five years crucial

Excellencies, Distinguished Participants, Ladies and Gentlemen:

I am delighted to be invited here to speak on Thailand's economic transformation and future direction of our energy policy. This is an immensely broad subject. And because of it, I would like to focus on a few strategic issues which might be of special interest to this high-tech group gathering here today.

On the "Economic Transformation"

I should like to begin my presentation by reporting to you that *Euromoney* magazine of October 1983 ranked Thailand fifth in the category of the world's best economic performance once again in its survey of more than 85 developed and developing countries.

This was in terms of the overall economic growth rate, rate of inflation, strength of exchange rate, and balance of payments performance.

The Asian Wall Street Journal of August, 1983 also headlined that the Thais have lined up new international financing at the very low interest rate, or at 0.37 of a percentage point over the London interbank offered rate, of which very few countries anywhere in the world today can have access to funds at this rate. This demonstrates the Thai top-notch credit rating, the *Wall Street* said.

I must say that the Thai Government has demonstrated continuously its commitment to strengthen and diversify our economic base with its own mix of economic policies shaped by our resource rich position, our comparative advantage, social cohesion, and our geo-economic position in Southeast Asia.

But like other countries Thailand too has some elements of uncertainty. However the following seem to be key growth components leading to high credit rating stand in our sound economic performance during the last two decades.

First, Thailand is a "resource-rich economy" with substantial food surplus which puts Thailand among the world's top five countries with "net food exporting position."

Second, The Thai Government tends to follow somewhat conservative fiscal-monetary policies.

Third, control of major key economic sectors of the economy by "private sector" without too much government interference.

Fourth, control of economic policy-making by an elite corps of technocrats which provides a degree of built-in stability for economic management and continuity of major economic policies.

However, the next five years will be indeed a crucial turning point in our economic history. Thailand's medium-term economic outlook should be viewed as a "transformation stage" from traditional agricultural-rural-resource based to more modern and complex forms of urban-industrial activities which will definitely reinforce the faster rates of urbanisation in the 1980s and beyond.

This transformation is taking place very rapidly in the 1980s since our economy now has attained the capacity to transform itself or the so-called "take off" from traditional to a modern economic system with availability and better use of more efficient technology, capital, and management transfers from abroad.

At the same time, the recent discovery and development of natural gas in the Gulf of Thailand and oil from the onshore field at Lan Krabue, have dramatically changed our whole resource picture of the country and opened up entirely new opportunities for creation of viable "basic industries" for Thailand.

The current Fifth National Development Plan has a very comprehensive industrial restructuring programme to make our industries more competitive, outward looking, and less dependent on foreign inputs, and to decentralise our industrial activities away form Bangkok metropolitan area to the new industrial zone at the Eastern Seaboard.

The Eastern Seaboard investment programme will be about US$5 billion at the first stage for the new basic industries and related deep-sea ports. The new basic industries at the Eastern Seaboard will use our natural gas resources either for energy supply or as feedstock. This ESB is a major industrial breakthrough in Thailand.

Japan's best-known industrial and international spokesman, Dr Saburo Okita, called the ESB a "new industrial spring-board of Southeast Asia." This new industrial-locational facilities will enable the private and international investors of large industries to invest in this new seaboard industrial zone of Thailand. Many peole thus expect that Thailand, together with other ASEAN countries, will definitely join the ranks of "newly industrialising countries," or the NIC group, by the end of this decade.

The NIC group of Southeast Asia are now carving out for themselves an enlarged share of world trade, investment, and total output. This transformation of our economy will change the composition of our production, demand, external trade, employment patterns, and future technology and energy requirements in Thailand. However our fate in these structural transformation will depend also on world environment trends and a few domestic uncertainties, namely, the world economic recovery, price of oil, and domestic production and additional discovery of gas and crude oil in the immediate future.

A joint NESDB-World Bank simulation of the medium-term outlook of the Thai economy up until 1987 under the above domestic and world environment assumptions shows that Thailand's economy will grow with an average of 6.5% per annum up until 1987 with the outputs in the non-agriculture, especially industry, energy, construction and service sector expanding at higher rates of 7.7% 8.3%, 5.5%, and 6.8% respectively. For the energy sector in this medium-run simulation, the imminent economic recovery together with faster rate of urbanisation will push up the demand for energy growing more than 6% per annum compared with the current Fifth Plan's target of 4.7%

Meanwhile the substitution of imported oil by natural gas from the Gulf of Thailand will be slightly lower than the Fifth Plan's target of 525 mcfd in 1986. This is however compensated by the discovery of Lan Krabue oil. As a result, our dependence on imported energy will decline from 65% of total

nergy consumption in 1981 to 45% in 1987.

It now seems clear that additions to domestic energy supplies and reserves will make dramatic reduction in energy import-dependence during the rest of 1980s. We are now spending more on energy at an unprecedented rate. Our public investment target for the energy sector during the Fifth Plan is about $7 billion. This covers the EGAT, PTT, PEA, MEA and NEA development projects to accelerate development of our domestic hydro, lignite, gas and oil resources over the current Fifth Plan period. This would definitely reduce our dependence on imported energy sources down to about 33% by 1990, after which period our projections show that imported energy, both oil and possibly coal, in meeting domestic "primary energy demand will begin to climb again to about 44-45% share by year 2001." This causes some serious concern among the planners in Thailand.

Some Critical Issues and Future Directions of Energy Policy

Our current energy policy under the Fifth Plan period is fundamentally twofold:

First, to maximise production of domestic energy resources and diversify energy supply structure, in order to reduce Thailand's dependence on imported oil (on supply side).

Second, to restrain the growth of energy demand, particularly petroleum demand, through improved efficiency of energy use, conservation and pricing policies (on demand management side).

I think the prospects are good for Thailand, which is a net petroleum importer at present, becoming less dependent on petroleum in the future. But both supply and demand management in Thailand's energy sector depend so much on the following policy direction and issues:

First, on the natural gas, the "reliability of reserve estimates" is a key issue. This is not only vital to our future import-oil substitution and other transport uses as well as the new industrialisation programme in the Eastern Seaboard, but also the future of the LNG scheme depends on the gas reserves which need further proving.

Some reserve estimates must be treated with some caution. Attempt to quantify the oil and gas potential normally requires a high degree of "subjectivity." Another associated issue to any gas development programme is the new and additional discoveries. The Government must therefore have some flexibility in order to meet these uncertainties.

Second, the economics of oil and gas exploration and development in Thailand is another issue. We realise that the hydro-carbon exploration and development is of high risk and high gain nature. In addition, this industry is very politically sensitive toward the continuity of the Government policies.

However, I feel at the moment that Thailand's petroleum law and tax regimes are quite attractive by international standard. The private industry has already invested more than one billion dollars in this country since the promulgation of our Petroleum Act of Thailand. This incentive should therefore be preserved. Many international experts believe that the 1990s could be a repeat of the 1970s with international oil price rising again.

To offset these possible price rises and to contain our energy import bill, Thailand must do what it can to step up exploration and increase the level of production to ensure that energy production does not decline in the 1990's. Because of the long lead time oil and gas exploration has to be strong through the middle 1980's for there to be hope of stabilising oil imports in the 1990s.

It is imperative to create right conditions for continued exploration, including newcomer companies. A most important facet of Thailand's energy policy is the need to maintain an environment which will encourage vigorous exploration for oil and gas. Those companies making discoveries will be assured that there will be reasonable prospects for economic development. When adequate domestic market demands are satisfied, exports will also be seriously considered.

Allowing producers access to both domestic and foreign markets in certain circumstances can transform an otherwise uneconomic scheme into a viable one.

Third, joint ventures are another key policy issue. I feel the basic right and terms of joint venture should be determined by Thailand, not by the concessionaire. This view is also shared by two recent World Bank reports. This would reduce negotiating time.

Recent negotiations between the Texas Pacific Group and the Thai Government have moved one step forward with the suggestion of PTT participation in field development. However, further delay impose high costs to both parties. We must find ways of speeding up the negotiating process so that gas comes on stream sooner because the potential gas use is in excess of supply. In the longer run, steps should be taken to gradually develop an independent petroleum capability through joint venture operations.

Fourth, the energy pricing policy is also critical to both supply and demand management of energy sector in Thailand. Our early choice of domestic oil pricing policies in the 1970s was strongly influenced by the desire to maintain high growth rate of GDP. The Government thus chose to absorb a substantial part of increase in the costs of imported fuel. However after 1978 domestic energy prices had been drastically adjusted.

Thailand now has domestic petroleum prices roughly comparable to those of our neighbours. Our average level of taxation on petroleum products is now comparable to other oil importing countries. We have finally eliminated subsidies to most of our petroleum products.

Regarding oil and gas pricing, regulations should set out a mechanism for pricing domestic crude oil and gas. Present pricing approach based on forecast costs has led to slow and time-consuming negotiations. We might consider an alternative by establishing a reference to international parity and possibly reducing the reference price by a small discount for user's incentives.

In sum, the economic transformation in Thailand during the 1980s and 1990s with further intensification of agricultural production, increased industrialisation, and higher level of urbanisation will definitely increase the average level of per capita consumption of commercial energy. And according to our Energy Master Plan study, Thailand is not and will not be an energy-surplus country. It is necessary for us to diversify our supply sources with an objective to reduce dependence on imported petroleum.

This will remain basically unchanged in the future direction of our natural gas. Substantial amounts of capital and technology will be required in the gas development and utilisation programmes during the next two decades. The public investment programme in gas-related field has already been in the pipeline. We also would like to see more private investment in the downstream projects by creating conditions conducive to smooth financing.

Finally, I must emphasise that continued intensive searching for domestic energy must be further encouraged. We are doing our best to reinforce and rationalise our energy planning and coordination apparatus, to develop political support for energy sector development, and to encourage private sector participation in the field of energy exploration, development, and conservation programmes. We will do our best to attract and retain international investments and technologies required to support our energy policy and development programme.

Thank you.

67

Dr Phisit Pakkasem, Deputy Secretary-General of the National Economic and Social Development Board, yesterday gave a speech on Thailand's Economic Transformation and Future Direction of Energy Policy at the Thailand-United States Natural Gas Utilisation Symposium at the Siam Inter-Continental Hotel. Here is the full text of the speech.

"The next five years will be indeed a crucial turning point in our economic history. Thailand's medium-term economic outlook should be viewed as a "transformation stage" from traditional agricultural-rural-resource based to more modern and complex forms of urban-industrial activities which will definitely reinforce the faster rates of urbanisation in the 1980s and beyond."

BUSINESS POST

Vol. XXXIX No. 38 BANGKOK WEDNESDAY FEBRUARY 8, 1984 SECTION II

THE three-day symposium on Thailand-United States Natural Gas Utilisation was opened yesterday at the Siam Intercontinental Hotel by Deputy Industry Minister Wong Polnikorn and US Ambassador to Thailand John Gunther Dean.

The symposium is jointly organised by the Petroleum Authority of Thailand (PTT), the US Agency for International Development (USAID) and the US Embassy.

The aim of the symposium is to give local and foreign petroleum professionals insights about Thailand's total energy picture and related government policy as well as general investment policy.

Picture shows Ambassador Dean and Mr Wong, flanked by PTT Governor Tongchat Hongladaromp (with glasses) and the US Counsellor for Commercial Affairs Brooks Ryno.

US may give aid for gas projects

THE US Government may consider giving financial assistance to Thailand for natural gas-related projects, US Ambassador to Thailand John Gunther Dean said yesterday.

The envoy, in his opening remarks at the Thailand-US Natural Gas Utilisation Symposium, said a meeting has been scheduled for February 13 when a list of these high-priority projects will be presented to US government agencies for consideration.

The agencies are the US Agency for International Development, the Trade Development Programme, the US Department of Commerce and the US Department of State.

Mr Dean said the US Government supports Thailand's gas development efforts and American firms also look forward to working with Thailand on gas-based projects.

69

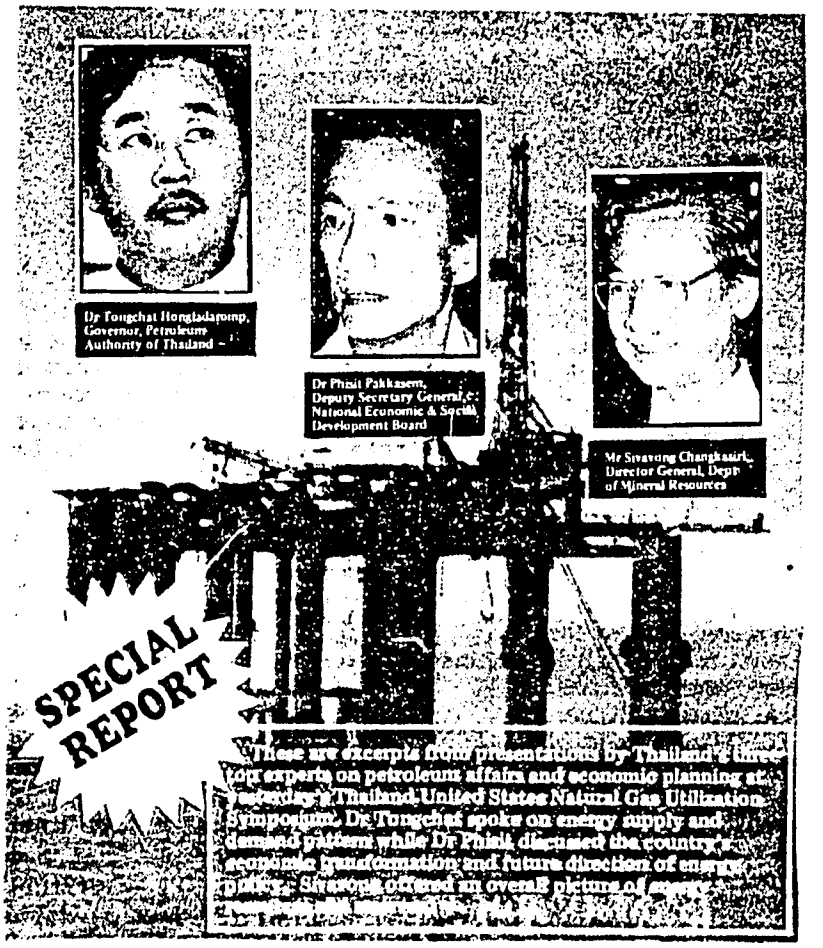
TRADE TALK

BANGKOK POST THURSDAY FEBRUARY 9, 1984

Industry Minister Ob Vasuraina and US Ambassador John Gunther Dean hosted a welcome reception for the participants in the Thai-US Natural Gas Utilisation Symposium at the Hilton International Bangkok Hotel early this week. In conversation are (from left) President G. Grader of Esso Exploration and Production Korat Inc, Deputy Industry Minister Wong Polnikorn, Mr Dean and Petroleum Authority of Thailand Deputy Governor Charan Achalabhuti.

NATIONBUSINESS

Critical issues facing energy search



These are excerpts from presentations by Thailand's three top experts on petroleum affairs and economic planning at yesterday's Thailand-United States Natural Gas Utilization Symposium. Dr Tongchai spoke on energy supply and demand pattern while Dr Phisit discussed the country's economic transformation and future direction of energy policy. Siwavong offered an overall picture of

SHOULD like to begin my presentation by reporting to you that "*Euromoney*" magazine of October 1983 ranked Thailand fifth in the category of the world's best economic performance once again in its survey of more than 85 developed and developing countries.

This was in terms of the overall economic growth rate, rate of inflation, strength of exchange rate, and balance of payments performance. The *Asian Wall Street Journal* of August, 1983 also headlined that the Thais have lined up new international financing at the very low interest rate, or at 0.37 of a percentage point over the London interbank offered rate, of which very few countries anywhere in the world today can have access to funds at this rate. This demonstrates the Thai top-notch credit rating, the *Wall Street* said.

by Phisit Pakkasem

I must say that the Thai Government has demonstrated continuously its commitment to strengthen and diversify our economic base with its own mix of economic policies shaped by our resource rich position, our comparative advantage, social cohesion, and our geoeconomic position in Southeast Asia. But like other countries, Thailand too has some elements of uncertainty. However the following seem to be key growth components leading to high credit rating stand in our sound economic performance during the last two decades.

First, Thailand is a "resource-rich economy" with substantial food surplus which puts Thailand among the world's top 5 countries with "net food exporting position."

Second, the Thai Government tends to follow somewhat conservative fiscal-monetary policies.

Third, control of major key economic sectors of the economy by "private sector" without too much government interference.

Fourth, control of economic policy-making by an elite corps of technocrats which provides a degree of built-in stability for economic management and continuity of major economic policies.

However, the next five years will be indeed a crucial turning point in our economic history. Thailand's medium-term economic outlook could be viewed as a "transformation stage" from traditional agricultural-rural-resource based to more modern and complex forms of urban-industrial activities which will definitely reinforce the faster rates of urbanization in the 1980s and beyond.

This transformation is taking place very rapidly in the 1980s since our economy now has attained the "capacity to transform itself" or the so-called "take off" from traditional to a modern economic system with availability and better use of more efficient technology, capital, and management transfers from abroad.

At the same time, the recent discovery and development of national gas in the Gulf of Thailand and oil from the onshore field at Lan Krabue, have dramatically changed our whole resource picture of the country, and opened up entirely new opportunities for creation of viable "basic industries" for Thailand. The current Fifth National Development Plan has a very comprehensive industrial restructuring programme to make our industries more competitive, outward looking, and less dependent on foreign inputs, and to decentralize our industrial activities away from Bangkok metropolitan area to the new industrial zone at the Eastern Seaboard.

The ESB investment programme will be about US$5 billion at the first stage for the new basic industries and related deep-sea ports. The new basic industries at the Eastern Seaboard will use our natural gas resources either for energy supply or as feedstock. This ESB is a major industrial breakthrough in Thailand.

The top Japan's best-known industrial and international spokesman, Dr Saburo Okita call the ESB a "new industrial spring-board of Southeast Asia." This new industrial-locational facilities will enable the private and international investors of large industries to invest in this new seaboard industrial zone of Thailand. Many people thus expect that Thailand, together with other ASEAN countries, will definitely join the ranks of "newly industrializing countries", or the NIC group by the end of this decade.

This NIC group of Southeast Asia are now carving out for themselves an enlarged share of world trade, investment, and total output. This transformation of our economy will change the composition of our production, demand, external trade, employment patterns, and future technology and energy requirements in Thailand.

However, our fate in these structural transformation will depend also on world environment trends and two few domestic uncertainties, namely, the world economic recovery, price of oil, and domestic production and additional discovery of gas and crude oil in the immediate future.

A joint NESDB-World Bank simulation of the medium-term outlook of the Thai economy up until 1987 under the above domestic and world environment assumptions shows that Thailand's economy will grow with an average of 6.5% per annum up until 1987 with outputs in the non-agriculture, especially industry, energy, construction and service sector expanding at higher rates of 7.7%, 8.3%, 5.5% and 6.8% respectively. For the energy sector in this medium-run simulation, the immirent economic recovery together with faster rate of urbanization will "push-up" the demand for energy growing more than 6% per annum compared with the current Fifth Plan's target of 4.7%.

Meanwhile the substitution of imported oil by natural gas from the Gulf of Thailand will be slightly lower than the Fifth Plan's target of 525 mcfd in 1986. This is, however, compensated by the discovery of Lan Krabue Oil. As a result, our dependence on imported energy will decline from 65% of total enegy consumption in 1981 to 45% in 1987.

It now seems clear that additions to domestic energy supplies and reserves will make dramatic reduction in energy import-dependence during the rest of 1980s. We are now spending more on energy at an unprecedented rate. Our public investment target for the energy sector during the current Fifth Plan is about $7 billion. This covers the EGAT, PTT, PEA, MEA, and NEA development projects to accelerate development of our domestic hydro, lignite, gas and oil resources over the current Fifth Plan period.

This would definitely reduce our dependence on imported energy sources down to about 33% by 1990. After which period our projections show that imported energy both oil and possibly coal, in meeting domestic primary energy demand will begin to climb again to about 44-45% share by year 2001. This causes some serious concerns among the planners in Thailand.

Some Critical Issues and Future Directions of Energy Policy

Our current energy policy under the Fifth Plan period is fundamentally twofold:-

First, to maximize production of domestic energy resources and diversify energy supply structure, in order to reduce Thailand's dependence on imported oil (on supply side)

Second, to restrain the growth of energy demand, particularly petroleum demand, through improved efficiency of energy use, conservation and pricing policies (on demand management side)

I think the prospects are good for Thailand, which is a net petroleum importer at present, becoming less dependent on petroleum in the future. But both supply and demand management in Thailand's energy sector depend so much on the following policy direction and issues:—

First, *on the natural gas, the reliability of reserve estimates is a key issue.* This is not only vital to our future import-oil substitution and other transport uses as well as the new industrialization programme in the Eastern Seaboard, but also the future of the LNG scheme depends on the gas reserves which need further proving. Some reserve estimates must be treated with some caution. Attempt to quantify the oil and gas potential normally requires a high degree of subjectivity. Another associated issue to any gas development programme is the new and additional discoveries. The Government must therefore have some flexibility in order to meet these uncertainties.

Second, *the economics of oil and gas exploration and development in Thailand is another issue.* We realize that the hydro-carbon exploration and development is of high risk and high gain nature. In addition, this industry is very politically sensitive toward the continuity of the government policies. However, I feel at the moment that Thailand's petroleum law and tax regimes are quite attractive by international standard. The private industry has already invested more than one billion dollars in this country since the promulgation of our Petroleum Act of Thailand. This incentive should therefore be preserved.

Many international experts believe that the 1990's could be a repeat of the 1970's with international oil price rises again. To offset these possible price rises and to

contain our energy import bill, Thailand must do what it can to step up exploration and increase the level of production to ensure that energy production does not decline in the 1990's. Because of the long lead time oil and gas exploration has to be strong through the middle 1980's for there to be hope of stabilizing oil imports in the 1990's.

It is imperative to create right conditions for continued exploration, including newcomer companies. A most important facet of Thailand's energy policy is the need to maintain an environment which will encourage vigorous exploration for oil and gas. Those companies making discoveries will be assured that there will be reasonable prospects for economic development. When adequate domestic market demands are satisfied, exports will also be seriously considered. Allowing producers access to both domestic and foreign markets in certain circumstances can transform an otherwise uneconomic scheme into a viable one.

Third, *Joint Ventures are another key policy issue.*

I feel the basic right and terms of joint venture should be determined by Thailand, not by the concessionaire. This view is also shared by two recent World Bank's report. This would reduce negotiating time. Recent negotiations between the Texas Pacific Group and the Thai Government have moved one step forward with the suggestion of PTT participation in field development. However, further delay in gas availability and negotiation will probably impose high costs to both parties. We must find ways of speeding up the negotiating process so that gas come on stream sooner because the potential gas use is in excess of supply. In the longer run, step should be taken to gradually develop an independent petroleum capability through joint venture operations.

Fourth, *The energy pricing policy* is also critical to both supply and demand management of energy sector in Thailand. Our early choice of domestic oil pricing policies in the 1970s was strongly influenced by the desire to maintain high growth rate of GDP. The governments thus chose to absorb a substantial part of increase in the costs of imported fuel. However, after 1978 domestic energy prices had been drastically adjusted. Thailand now has domestic petroleum prices roughly comparable to those of our neighbours. Our average level of taxation on petroleum products is now comparable to other oil importing countries. We have finally eliminated subsidies to most of our petroleum products.

Regarding oil and gas pricing, regulations should set out a mechanism for pricing domestic crude oil and gas. Present pricing approach based on forecast costs has led to slow and time consuming negotiations. We might consider an alternative by establishing a reference to international parity and possibly reducing the reference price by a small discount for user's incentives.

In sum, the economic transformation in Thailand during the 1980s and 1990s with further intensification of agricultural production, increased industrialization, and higher level of urbanization will definitely increase the average level of per capita consumption of commercial energy.

And according to our Energy Master Plan study, Thailand is not and will not be an energy-surplus country. It is necessary for us to diversify our supply sources with an objective to reduce dependence on imported petroleum. This will remain basically unchanged in the future direction of our energy policy. It is essential to devise the best energy supply mix by taking into full consideration the role of our natural gas. Substantial amounts of capital and technology will be required in the gas development and utilization programmes during the next two decades. The public investment programme in gas-related field has already been in the pipeline. We also would like to see more private investment in the downstream projects by creating conditions conducive to smooth financing.

Finally, I must emphasize that continued intensive searching for domestic energy must be further encouraged. We are doing our best to reinforce and rationalize our energy planning and coordination apparatus, to develop political support for energy sector development, and to encourage private sector participation in the field of energy exploration, development, and conservation programmes. We will do our best to attract and retain international investments and technologies required to support our energy policy and development programmes.

APPENDIX C

ECONOMIC FORMAT

ECONOMIC FORMAT

	Basis
Constant Dollars	1983 $
Project Life	15 years
Operating Factor	330 days/yr.
Capital Investment	
Cost of capital	10%
Working capital	60 day inventory 60 day cash supply
Land required	$11,000/acre
Startup expense & organization	2% of capital investment
Annual Operating Cost (Next to the total dollars for each item list the unit cost in $/MMBTU of product)	
Product, $/ton or $/MMBTU (By-Product credits should be listed as $/ton or $/MMBTU)	Do a sensitivity analysis by varying the price of the product vs. profitability of venture
Natural Gas ($/MMBTU)	4.00
Utilities	
Power ($/KWH)	0.06
Water ($/MGal)	0.75
Fuel ($/MMBTU)	4.00
Operating labor	
Skilled	$4,000/yr.
Unskilled	$1,650/yr.
Operating labor supervision	20% of labor year
Maintenance	5% of total investment
Administrative & support labor	20% of all other labor
Payroll extras -- fringe benefits, etc.	20% of all other labor
Insurance	2% of facilities investment
General administrative expenses	2% of facilities investment
Taxes (Assume no tax holiday)	35% of net profit
Depreciation	Straight line -- 10 yrs.

APPENDIX D

ADVERTISING BROCHURE

Thailand - United States Natural Gas Utilization Symposium & Field Trip

February 7 - 11, 1984

Siam Intercontinental Hotel
Bangkok, Thailand

Organized and Sponsored by

The Petroleum Authority of Thailand (PTT)
The United States Agency for International Development (USAID)

THAILAND · U.S. NATURAL GAS UTILIZATION SYMPOSIUM

FEBRUARY 7-11, 1984

PRELIMINARY TECHNICAL OUTLINE

Tuesday · February 7, 1984

Registration (0800)

Opening Ceremonies
H.E. Ob Vasurat, Minister of Industry, Thailand
John Gunther Dean, Ambassador to Thailand, USA

Thailand Energy Policy
Snoh Unakul, Secretary-General, National Economic & Social Development (NESDB), Thailand

Thailand Energy Supply/Demand Pattern
Tongchat Hongladaromp, Governor, Petroleum Authority of Thailand (PTT), Thailand

Role for Natural Gas
Charan Achalabhuti, Deputy Governor, Petroleum Authority of Thailand (PTT), Thailand

Current Projects
Pratin Patanaporn, Deputy Governor or Pala Sookawesh, Assistant Governor, PTT, Thailand

Union
Electricity Authority of Thailand (EGAT)
Texas Pacific
Esso
The Gas Separations Plant,
Don Boone, Vice President,
The Randall Corp., USA.

Energy Resources and Reserves
Speaker to be announced

Investment and Financial Policy
Chanchai Leetavorn, Secretary-General, Board of Investment (BOI), Thailand

Experiences of Other Countries
Bangladesh
Brunei
India
Indonesia
Malaysia
New Zealand
Pakistan

Wednesday · February 8, 1984

An Overview of Worldwide Standards for Natural Gas Utilization
Elizabeth Drake, Chairman, Chemical Engineering Department, Northeastern University, USA

Decision Analysis in Natural Gas Utilization
Phiroze Nagarvala, Manager, Energy Planning, Bechtel Corp., USA

Transportation
The Role of Natural Gas in the Thai Transportation System
To be announced

Compressed Natural Gas
Frank Schora, Senior Vice President, Gas Development Corp., USA

Wednesday, February 8, 1984 (Continued)

Automobile Equipment Required to Use Compressed Natural Gas as a Fuel
Bill Malek, Vice Chairman, American Gas Association, Natural Gas Vehicle Committee, USA

Infrastructure Required to Use Compressed Natural Gas As an Automotive Fuel
Donald Ian Hertzmark, Asian Institute of Technology, Thailand

The Production, Use and Economics of Methanol
Bert W. Struth, Executive Vice President, Chem Systems, USA

Methanol as an Automotive Fuel
I. MacPherson, Director, Power Train Research, Ford Motor Company, USA

Energy Applications
Power Generation Utilizing Fuel Gas
Robert G. Settle, Project Manager, Black & Veatch Inc., USA

Combined Cycle Cogeneration
J.M. Osborn, Advanced Energy Specialist and *W.C. Walke*, Project Manager, Fossil Fuels, Sargent & Lundy, USA

Direct Heating
W.H. Thorbecke, Chairman, Energy Support Services, USA

The Production, Economics and Uses of Synthesis Gas
J.M. Mac Neil, Assistant Chief Engineer, Stone & Webster, USA

Gas Turbines as Industrial Drives
George J. Milici, Manager, Turbo Machinery, Ingersoll-Rand, USA

Turbo Expanders in Various Natural Gas Applications
John Holms, Director, International Marketing, Rotoflow Corp., USA

Natural Gas Reciprocating Engines in On-Site Power Plants
D.R. Sickenger, Senior Staff Engineer, Caterpillar Tractor Company, USA

Thursday · February 9, 1984

Chemical Production
Methods and Economics of Hydrogen and CO_2 Separation
Robert Scivaily and *Roland Meissner III*, Ralph M. Parsons Co., USA

Economics and Production of Fertilizer
Peter R. Train, Regional Vice President, Foster Wheeler Energy Corp., USA

Phosphate, Pot Ash and Soda Ash
Russell James, President, James Chemical Engineering, USA

Make Ammonia With Less Energy
J.R. LeBlanc, Manager, Inorganic Process Division, M.W. Kellogg Company, Inc., USA

Thursday, February 9, 1984 (Continued)

Cement Production
Werner Ostberg, Vice President, Cement Division, Kuljian Corp., USA

Gasoline from Natural Gas
Gerald F. Tice, Supervising Engineer, Advanced Technology Division, Fluor Engineers, Inc., USA

Petrochemical Production

The Production and Economics of LPG
Jim Hardy, McDermott, USA

The Petrochemicals Industry in Today's Economy
Bill Silvia, Division President, Union Carbide, USA

Planning Petrochemical Complexes and Dynamic Digital Simulation in Process Operations
A Rhoe, Vice President Lummus Technical Center, *M. Asgari*, Vice President, Digital Technical Center and *M.J. Maddock*, Manager Process Planning and Economics, C.E. Lummus, USA

Ethylene Cracking Technology
C.P. Bowen, Manager, Business Development-Chemicals, Stone & Webster, USA

The Production and Economics of Polyethylene
Speaker to be announced, Foster Wheeler Energy Corp, USA

The Production and Economics of Polypropylene
Terry R. Eihl, Manager, International Business Development, Amoco Chemical, USA

The Production and Economics of VCM and PVC
Sam Kiguchi, General Manager, Monomer and Polymer Division, Brown & Root Inc., USA

FIELD TRIP:

Leave Bangkok the afternoon of February 9.
Overnight Royal Cliffs Hotel

Friday · February 10, 1984

Visit the:
Gas Separation Plant,
Petrochemical Complex site,
LDPE Plant.

Overnight Royal Cliffs Hotel.

Saturday · February 11, 1984

Visit the:
LEAM Chabang Deep Seaport Site,
Gas Monitoring Station
Bangpakong Power Plant.

Return to Bangkok.

SYMPOSIUM DESCRIPTION

Discovery of large natural gas reserves in the Gulf of Thailand has benefited Thailand in many ways. Wholly apart from the obvious savings in foreign exchange, and gaining a reliable domestic reserve of fuel, natural gas can be utilized as a feedstock in numerous industries, particulary in petrochemical and fertilizer production.

The plans call for a petrochemical complex to be located adjacent to the gas separation plant in Mabtapud, the area where the natural gas submarine pipeline comes ashore, commonly referred to as the Eastern Seaboard. Ethane and propane from the gas separation plant will be converted at the olefins plant into 300,000 tons of ethylene and 70,000 tons of propylene per year. The olefins plant and a central utilities plant together will form the basic upstream complex. This is to be 51% government ownod. The intent is also to use natural gas as a fuel for power generation and as a fuel for automobiles.

The SCOPE of this meeting is to discuss the utilization of Thailand's natural gas, their infrastructure and policies with respect to its development; to present, examine, analyze and evaluate available U.S. technologies relevant to Thailand and to define areas for joint action.

The OBJECTIVES are:

- To define and discuss technical and economic problems in the development and utilization of natural gas.
- To identify programs and to formulate and recommend action plans in areas of Thailand-United States interest.

FOR WHOM INTENDED

Companies that represent the following industries should consider attending this symposium:

A & E Firms

Consulting Firms

Exploration and Production Companies

Investment Bankers

Petrochemical Companies

Process Developers

Process Equipment Manufacturers

The Kingdom of Thailand desires to utilize natural gas to the fullest possible extent. It will present its technical, business and incentive plans.

This meeting will offer a forum for U.S. company decision makers to meet the decision makers of the Thai public and private sectors that are charged with the responsibility of replacing imported oil with indigenous energy resources such as natural gas.

GENERAL CHAIRMAN

Dr. Tongchat Hongladaromp
Governor
Petroleum Authority of Thailand

PROGRAM CHAIRMEN

Charan Achalabhuti
Deputy Governor
Technical and Planning
Petroleum Authority of Thailand

Charles Bliss
Office of Energy
United States Agency for International Development

SYMPOSIUM COORDINATOR

Arnold H. Pelofsky
President
AER Enterprises, U.S.A.

THIS APPLICATION MUST BE RETURNED TO ENSURE ENROLLMENT

February 7 - 11, 1984
Siam Intercontinental Hotel
Bangkok, Thailand

Meeting alone	$ _____
Field trip alone	$ _____
Both	$ _____
Siam Intercontinental	$ _____
Royal Cliffs Hotel	$ _____
Total	$ _____

REGISTRATION FEES:

Meeting Alone, February 7-9, 1984	$350
Field Trip Alone, February 9-11, 1984	$150
Both	$450

The registration fee includes admission to the Symposium, admission to the receptions, lunches and coffee breaks every day and reprints that are available.

Arr. Date _____ Dep. Date _____

The field trip will start the afternoon of February 9, 1984. Air conditioned buses will take the participants and their spouses to the Royal Cliffs Hotel in Pattaya. Everyone on the field trip will stay at the Royal Cliffs Hotel for the nights of February 9 and 10 and return to Bangkok the afternoon of February 11.

Dr. Mr.
Miss Mrs. Ms. _____ Spouse's Name _____

Signature _____

Job Title _____

Company/Institution _____

Company Address _____ Street _____

City _____ State _____ Zip _____

Business Phone/Telex _____ Home Phone _____

FIELD TRIP:

Leave Bangkok the afternoon of February 9.
Overnight Royal Cliffs Hotel

February 10, 1984 · Friday

Visit the
Gas Separation Plant,
Petrochemical Complex site
LDPE Plant.

Overnight Royal Cliffs Hotel.

February 11, 1984 · Saturday

Visit the
LEAM Chabang Deep Seaport Site,
Gas Monitoring Station
Bangpakong Power Plant.

Return to Bangkok.

HOTELS:

Siam Intercontinental ☐ $60/single ☐ $66/double
Royal Cliffs Hotel ☐ $50/single ☐ $50/double

Rates are subject to government tax and service charges.

A ONE NIGHT'S DEPOSIT IS REQUIRED TO RESERVE HOTEL ACCOMMODATIONS

MAKE CHECKS PAYABLE TO AER EXTERPRISES

FOR INFORMATION ON HOTELS AND THE MEETING

Contact : AER ENTERPRISES P.O. Box 454, East Brunswick, New Jersey 08816 • (201) 254-6930, Telex: 701950 • AERENT

Cancellations of registration fee are subject to a service charge of $75.00. Hotel cancellations can be made up to January 30, 1984. SUBSTITUTIONS MAY BE MADE AT ANY TIME.

40

APPENDIX E

PROFESSORS' SUMMARY REPORT

SUMMARY REPORT

SEMINARS AND VISITS IN THAILAND IN CONJUNCTION WITH THE THAILAND - U.S. NATURAL GAS SYMPOSIUM

FEBRUARY 2-19, 1984

PROF. BERNARD GOODWIN
PROF. ELIZABETH DRAKE

NORTHEASTERN UNIVERSITY
BOSTON, MASSACHUSETTS 02115

MARCH 22, 1984

TABLE OF CONTENTS

		PAGE
1.0	Scope of Work	1
2.0	Background	3
3.0	Pre-Symposium Seminars	4
	3.1 Objectives	5
	3.2 Presentation	7
	3.3 Comments and Suggestions	8
4.0	Presentation and Discussions at the EGAT Power Plant	8
	4.1 Prior Plant Tour	8
	4.2 Seminars	9
	4.3 Comments and Suggestions	11
5.0	Seminar and Visit to PTT Gas Separations Plant	12
	5.1 Prior Plant Tour	12
	5.2 Presentation of Seminars	12
	5.3 Comments and Suggestions	12
6.0	Chulalongkorn University	14
	6.1 Visit to Chemical Engineering Dept.	14
	6.2 Presentation of Seminars	15
	6.3 Comments and Suggestions	15
7.0	Petroleum Institute Planning	17
8.0	PTT Headquarters and R&D Group	20
9.0	Conclusions and Suggestions	21
10.0	Acknowledgement	23

APPENDICES:

A. Chemical and Physical Propertus of Natural Gases.

B. Safety and Handling of Natural Gas and Gas Liquids.

C. Attendees at Pre-Symposium Seminars.

D. Presentation at Bang Pakong Power Plant.

E. Presentation at PTT Gas Separations Plant.

1.0 Scope of Work

The Thailand - U.S. Natural Gas Symposium was organized under joint sponsorship of the Petroleum Authority of Thailand (P.T.T.) and the U.S. Agency for International Development (U.S.A.I.D.). It was held at the Siam International Hotel in Bangkok from February 7 - 11, 1984. Under contract with U.S.A.I.D., Professors Goodwin and Drake of Northeastern University (Boston, Massachusetts, USA) each prepared and presented on February 6, 1984, a half-day pre-symposium seminar for conference attendees and others interested in gaining further background related to planned natural gas and gas liquids projects in Thailand.

Of the several hundred people attending the symposium, about 130 attended each of the pre-symposium seminars. Because of late arrivals and other problems associated with the registration of more attendees than expected, only 82 of the participants were identified by name and affiliation. This information is presented in Appendix C.

The conference General Chairman was Dr. Tongchat Hongladaromp, the Governor of PTT. Program Chairmen were Dr. Charan Achalabhuti, Deputy Governor, Technical and Planning of PTT and Charles Bliss, Office of Energy, U.S.A.I.D. The symposium was coordinated by Dr. Arnold Pelofsky, President, A.E.R. Enterprises, U.S.A.

At the request of PTT, Professors Goodwin and Drake were asked to spend the week after the symposium visiting organizations in Thailand involved in the development or use

of the natural gases. Under subcontract to A.E.R. Enterprises, these visits were made to the Electricity Generating Authority of Thailand (EGAT) new power station in Bang Pakong (February 13, 1984), to the PTT Gas Separation Plant at Rayong (February 14, 1984) and to the Chemical Engineering Department at Chulalongkorn University in Bangkok (February 15, 1984). A seminar was presented at each location on the chemical and physical properties of the Thailand natural gases and on the safety and operational aspects of the technologies involved. Facility tours and discussions with some key personnel were also held. The objective of these visits was to identify areas where U.S. - Thai joint programs might be useful, particularly in areas relating to safety and training programs. During the visit, discussions were held with a number of people concerning the planned organization of a Thai Petroleum Instiute. On February 17, 1984, a visit was made to PTT headquarters and discussions with the PTT research and development group were held. A summary discussion was also held with Dr. Charan at that time.

The actual scope of work involved in each of the pre-symposium seminars and in the subsequent facility visits included four phases:

I Preparation of Seminars and Seminar Materials.

II Coordinations of Material Between Seminars.

III Presentation and Visits.

IV Preparation of Summary Report on Findings.

This report includes the Phase IV summary report and findings for each of the presentations, visits and discussions.

2.0 Background

Thailand has been embarking on a major energy program since the discovery of natural gas reserves in the Gulf of Thailand over a decade ago. Currently, gas (predominantly methane) is being produced from the offshore Erawan field. Additional reserves in the Gulf will be brought onstream during the next few years and continuing exploration may identify further reserves. The produced gas also contains ethane, propane and butane (liquefied petroleum gases or "LPG"), and natural gasolines (pentane and some heavier hydrocarbons). At present, most of the heavier fractions are removed as condensate and sent to existing refineries in Thailand for reprocessing. The remaining gases (methane, ethane, and some LPG) are pipelined north for use as a fuel in cement plants and for power generation at EGAT facilities. The use of this energy reduces Thailand's dependence on fuel imports. In addition, the materials can be useful in future production of petrochemical derivatives which also will reduce imports.

Next year, PTT will commission a gas-liquids separations plant in Rayong which will allow separation of the LPG fractions of the natural gas. This LPG will be distributed by PTT as an alternative motor vehicle fuel displacing imported gasoline. LPG will also be available for industrial, commercial, and residential fuel use. Since LPG

is stored as a liquid under pressure in transportable tanks, it is also a convenient fuel to use in rural areas.

The remaining methane/ethane fraction will continue to be pipelined for use as a fuel. The pipeline distribution system to Bangkok will also allow development of compressed natural gas (CNG - methane as a high pressure gas stored at around 150 to 200 atmospheres). This can be used as a motor fuel - either directly or in mixtures with diesel fuel. Ethane and propane fractions will be separated at a later date as downstream petrochemical industries are developed (e.g fertilizer, plastics, methanol, etc.)

PTT was formed about 5 years ago and is currently operating a gas pipeline system. The PTT gas separations plant is being constructed and is expected to be onstream early in 1985. PTT is in the process of acquiring and training the additional staff necessary to meet their present and future gas utilization project needs.

3.0 Pre-Symposium Seminars

The seminars were designed to give information in two areas of importance to the understanding and growth of the developing industry built around a natural gas feed stock.

SEMINAR I: Physical and Chemical Properties of Natural Gas

SEMINAR II: Safety and Handling of Natural Gas & Gas Liquids

3.1 Objectives

3.1.1 Seminar I

The objective of this seminar was to present information on the physical and chemical properties of natural gas. Natural gas is primarily a mixture of methane, ethane, propane, and butane with smaller amounts of higher hydrocarbons. In addition, it usually contains smaller amounts of undesirable materials such as carbon dioxide and water. The first stages in a gas separations plant involve the removal of the carbon dioxide, water, and some other impurities. Such materials were not included in the discussion of the physical properties of natural gas. The presentation focussed on the physical and chemical properties of low molecular weight hydrocarbons; both pure and in mixtures.

For pure materials these physical properties included molecular weight, critical properties, heat capacity, vapor pressure and P-V-T relationships both in the vapor and the two-phase region. For mixtures, relationships were developed to implement the calculation of vapor-liquid equilibrium, bubble points and dew points as functions of pressure, temperature, and composition. Thermodynamic methods for the development of equilibrium K values and the enthalpies of saturated liquid and vapor mixtures were presented. These data are essential to the design and understanding of such gas separation equipment as the demethanizer.

In the near future, Thailand will be using the products of its separations plant as feed stocks for petrochemical plants and a fertilizer plant. A quantitative understanding of the proposed processes requires additional thermodynamic information. This information is needed to calculate energy effects accompanying chemical reactions and to understand the restrictions placed on yield by equilibrium considerations. Key reactions include propane and ethane cracking to produce olefins and cracking or reforming of methane to produce hydrogen. Thermodynamic methods for predicting energy requirements and equilibrium limitations on chemical reactions are presented in the seminar notes.

Finally the seminar included a discussion of flammability limits of hydrocarbons as background for the safety and handling seminar.

3.1.2 Seminar II

The second seminar was planned to present a general introduction to safety issues related to gas and gas-liquids handling and processing. While the worldwide petrochemical industry has a good safety record, some very serious accidents involving harm to tens or hundreds of people have occurred. Human error has been involved in most of these accidents; whether due to mistakes in design, operation, maintenance or repair. While some human error is always possible, good training programs and a strong organizational commitment to safe operation can reduce the likelihood of such events.

The objectives of the seminar were first to present the basic hazards, next to discuss methods used elsewhere in the world to identify weaknesses in facilities and/or their operation, and then to suggest ways that Thailand might adapt some of these techniques in planning and implementing their developments associated with gases from the Gulf of Thailand.

3.2 Presentation

The materials distributed at the seminar are contained in Appendices A and B. Names of 82 of the approximately 130 attendees are included in Appendix C. Visual aids included both transparencies (included in the handout) and 35 mm slides (in the safety seminar only) showing examples of vapor leaks and fires with gas and gas liquids. The presentations lasted from 9:00 - 11:30 and from 13:30 - 17:00 hours with two short breaks for coffee.

During the early planning of the seminar in the U.S., it was indicated to us that we would be addressing a small group (about 25-30) of people with technical training in engineering or chemistry. Later, the size of the group was increased, first to 50 and then to 100. These increases occurred just prior to our leaving for Thailand.

Upon our arrival, we learned that a further increase in attendance had occurred and that the audience would include some non-technical people with diverse backgrounds. As a result, during the weekend prior to the seminar, some major changes were made in the planned presentation to adjust to

the actual audience. Following the modified presentations, feedback to us and to others involved in coordinating the seminars was generally favorable.

3.3 Comments and Suggestions

The seminar could have been presented more effectively to a smaller and less diverse group (the original plan). Perhaps a better method of either limiting and controlling registration could be found; or at least a better description of the audience could be made before the seminar materials are developed.

The room was well-prepared with tables set up for attendees. The transparencies could be seen easily from the back of the room, but the slides were more difficult to see. The projector illumination also was inadequate for so large a room.

Finally, as we learned at later presentations, many people are more comfortable in submitting questions in writing than in asking them directly. However, on balance, the seminars went well and the audience appeared receptive and interested.

4.0 Presentation and Discussions at the EGAT Power Plant

4.1 Prior Plant Tour

On Saturday, February 11, 1984, we toured the power plant at Bang Pakong as part of the group on the Symposium

Field Trip. We took advantage of this visit to learn not only about the facility, but also about their operations and training. We learned that the group we would be addressing would include both engineers and operators. Many would be engineers, but with limited background in chemistry and properties of natural gas liquids (other than as boiler fuel).

In anticipation of our safety presentations, we identified special features of the facility pertinent to safety. The turbine generators are hydrogen-cooled. The boilers can be fueled either with natural gas or with heavy fuel oil. The facility is very modern and has extensive monitoring and control systems. A computer has been provided to monitor alarms, operations, and other plant functions. In addition, a training simulator has been provided (we were told that it cost around $1 million U.S.). This unit is used for training new operators. It does allow for an instructor to modify normal operations to simulate various types of upsets and shutdowns for operator training exercises.

4.2 Seminars

The seminar entitled "Gasous and Liquid Fuels: Properties and Safety" was presented jointly by Profs. Goodwin and Drake. The focus was changed slightly to include hydrogen and fuel oil in the presentation and to eliminate petrochemical feed stock materials.

Some emphasis was placed on the present and future operating conditions of the gas separations plant. As this facility comes on-line the fuel stream composition will change. Now the plant receives everything but condensate. In the early operation of the gas separations plant, the LPG's will be stripped. Then, when an ethylene plant is built, the ethane fraction will also be removed.

Discussions were also held on possible other interactions with the gas separations plant. However, the 169 Km pipeline contains enough buffer fuel (line packing) so that upsets at the gas separations plant (an emergency shutdown, for example) should not have an immediate effect on the power station. The power station would initiate a change to fuel oil in the event of an extended outage.

Hazards evaluations were expanded to include high pressure gas lines, fuel oil lines and the special hazards associated with hydrogen.

A final section of the presentation was developed on training programs for continuing safe operation. This included discussions of training (including use of simulators), safety organizations and safety reviews. The final slide of the seminar included a summary.

The summary suggested benefits of the formation of a visible safety group which reports to management at the highest level. Such a group would in itself, represent a

strong management commitment to safety. The group could have broad responsibilities including administration of initial and ongoing training programs, continuing review of any changes in equipment and/or procedures with respect to safety and operability (perhaps using some of the tools of risk and reliability analysis presented in the seminars), investigation of accidents or incidents which might indicate ways to improve future safety, and organization of periodic independent safety audits.

4.3 Comments and Suggestions

While operational training at the Bang Pakong Power Plant seems of good quality, the overall safety level -- particularly with respect to possible accidents involving various fuels -- might be improved further. Some indication was given of having a few personnel attend a fire school at the Esso oil refinery. However, such training has not been extensive so far.

Also, there apparently have been some minor accidents at the facility. While it isn't surprising that people would be reluctant to discuss these with outsiders, the idea of investigating accidents to learn from them might be useful. We also suggested that the training simulator might be used in a continuing training mode.

5. Seminar and Visit to PTT Gas Separations Plant

5.1 Prior Plant Tour

We visited the Gas Separations Plant as part of the Symposium field trips on February 10, 1984. The plant includes the dew point control unit (presently operating) and the separations equipment which will be commissioned in 1985. Again, we took advantage of the plant tour to learn more about training and operations as background for the seminars. We learned that Linde (Germany) had been retained as an overall consultant by PTT on the separations plant and has supervised the contractors who are Japanese and U.S. companies.

5.2 Presentation of Seminars

A seminar on "Properties and Safe Handling of Natural Gas and Gas Liquids" was presented by Profs. Goodwin and Drake on February 14, 1984 to about 30 people at the PTT Gas Separations Plant. The slides used are included in Appendix E. In the seminar, material was included on the properties of ethylene and on safety training programs.

5.3 Comments and Suggestions

The role of Linde in overseeing the design and construction of the PTT gas separations plant is important and Linde personnel are highly qualified for this function. They presumably will have an active role in developing, operating maintenance and emergency procedures for the facilities and will be present during commissioning and early

operations.

PTT does presently have a safety group of about 6-7 people based at their Operations Center. Some of these people attended the seminar. However, it seemed that this group --which will eventually be involved in safety at the gas separations plant -- is not bein involved in the pre-commissioning phase of the project. This is unfortunate, we think, since they could learn much more from some of the pre-commissioning testing and from working with Linde and contractors as procedures are finalized before start-up. In effect, an opportunity for training these safety personnel seems to be being missed. We would suggest their exposure to the pre- and post-commissioning work starting as soon as possible.

While everyone at the seminar seemed concerned about safety, there appeared to be a relaxed attitude about safety during construction. A number of workers were without hard hats and some welders were not wearing safety glasses. Although this may not be relevant to the safety of the facility itself, it may also be indicative of an overall attitude that treats safety as a theoretical, rather than practical, objective.

The operational personnel for the separations plant will need to be trained for response to potential hazards as well as for normal operations. It was not evident that this was being done even though this would be an ideal time to be building an effective training program.

We suggested a format which PTT might consider in developing an effective safety and training organization at the facility. This is along the lines of the recommendations made in our summary as outlined on page E-86.

6. Chulalongkorn University

6.1 Visit to Chemical Engineering Department

Profs. Drake and Goodwin visited Chulalongkorn University on February 15, 1984. We met with the Dean (Dr. Tavee), the Associate Dean of Engineering (Dr. Sutham), the Head of the Chemical Engineering Department (Dr. Woraphat), and with several faculty members. The department has twelve faculty members, most with Ph.D. degrees from universities in the U.S. and Europe. About half the faculty are involved in some research. The department is developing programs in petrochemical engineering in response to Thailand's needs.

Several other parts of the university also offer programs that would be pertinent to the training of personnel in the gas liquids developments.

The Department of Mining Engineering and Mining Geology is developing a Petroleum Engineering Option which includes studies in petroleum exploration and extraction technology. A former Shell employee in offshore operations (Susan Dewardt) is assisting in the development of these programs.

The University has also had a program in Chemical Engineering Technology which is over 20 years old and which

is affiliated with the chemistry department. The program is focussed on applied chemistry but overlaps considerably with the program offered by the nine-year old Chemical Engineering Department. Merger of these department seems sensible but past attempts have been unsuccessful.

6.2 Presentation of Seminars

The seminar presented by Profs. Goodwin and Drake generally followed the materials presented in Appendix E. The orientation of the seminar was, however, shifted toward the education of engineers and technicians for Thailand's present and future petrochemical industry.

The seminar was presented to about 15 people including representatives from the Industrial Mining and Mechanical Engineering Departments. The portions ofthe seminar relating to incorporation of computer techniques in courses and utilization of software packages seemed to be of particular interest. The university still has batch processing for its main frame computer. The department is starting to acquire some micro-computers at the present time.

6.3 Comments and Suggestions

The Chemical Engineering Department at Chula presents a solid undergraduate program as well as a graduate program. They seem to be a qualified and valuable resource for starting a variety of programs to provide personnel for the developing petrochemical industry in Thailand. However, there are other resources in Chula -- the Petroleum Eng-

ineering Program in the Mining Engineering Department and the Chemical Engineering Technology Program -- which should be involved in an integrated set of training programs. A variety of programs will probably be required. These will range in level from training technicians to graduate level education and in scope from all aspects of the technology involved to management techniques and petrochemical economics.

Since the University structure is not particularly conducive to interdepartmental cooperation, the role of an outside group was discussed. Some consideration was being given to formation of a "Thailand Petroleum Institute", although the final objectives of such a group were not yet defined. One objective could be the coordination of training programs drawing on the various resources at Chula and other universities in Thailand and supplementing these resources with outside experts as required.

We also understand that laboratory facilties for various analyses in support of the petroleum industry activities do not now exist in Thailand. We are told that gas liquids samples are currently sent to a lab in Singapore for analysis. It would seem that the growing petrochemical activities in Thailand would justify establishment of such a lab. Considering the present resources at Chula, the university or its near environs would seem a logical location

for such a lab. While the lab would be a separate entity from the university, the training of lab personnel could be supervised initially by Chula staff and other petroleum industry experts.

Finally, with regard to lab facilities in the Chemical Engineering Department at Chula, we noticed less attention to safety than is usual at U.S. universities. The department (or university) might wish to conduct a lab safety review in the interest of improving the safety of students and faculty in the laboratories -- especially as departmental activities expand to meet Thailand's growing needs for petrochemical engineers.

7.0 Petroleum Institute Planning

During our visit, discussions were held with people at PTT and at Chula concerning preliminary plans for formation of a Thailand Petroleum Institute. Two concepts were mentioned.

The first concept is to establish the Institute as a separate educational entity to provide various training programs for petrochemical industry personnel and to administer a laboratory for petrochemical industry analytical requirements.

The alternate concept is to establish the Institute as an administrative group with broad responsibilities for support of the petrochemical industry in Thailand. The Institute would organize training programs by drawing on

101

resources existing inside and outside of Thailand and would take an active role in establishing an endowment which could support and strengthen programs. The Institute would initiate the establishment of a petroleum laboratory, but would not actually manage the day-to-day activities of the lab.

We feel this second concept is greatly preferable to the first. It seems desirable to have a Petroleum Institute which acts in a role of coordinator and organizer of a variety of activities, drawing on existing resources rather than duplicating some of them. One model for the organization is the American Petroleum Institute. (API)

In the U.S., companies involved in the petroleum industry (directly or indirectly) become members of API and provide both financial backing and expertise to the organization. The API acts as the industry spokesman on a national level and also provides a variety of services to the industry in general.

One important service is the development of codes and standards for the petroleum industry. This is done by committees of selected experts from industrial member companies. The committees play a continuing function in keeping the codes and standards current with changes in technology.

A Thailand Petroleum Institute should consider adopting a consistent set of standards for the petroleum industry in

Thailand. While the API actually developed standards over the years, Thailand can select its standards from already existing world practices and make any further modifications it wishes to meet any special requirements of Thailand.

At present, we understand that contractors on individual projects are allowed to choose the particular set of standards they will use. Thus, Thailand may have facilities constructed to many different standards (e.g. U.S., British, German, Japanese, Australian, etc.) While all of these standards are well-proven, they do reflect somewhat different approaches to design and safety.

From a practical basis, it would seem useful for Thailand to adopt a single set of standards for national use. This would provide a consistent design and safety philosophy and would avoid the pitfalls of letting a contractor choose standards while preparing a competitive bid on a project.

In the development of training programs, a Thai Petroleum Institute can draw both on the academic resources in Thailand and on the practical expertise of staff made available by member companies. With endowment monies, experts can be brought to Thailand to provide training in areas not presently developed in Thailand. Also, fellowships or other exchanges with universities outside Thailand can help provide trained personnel in the period where programs inside Thailand are being developed or strengthened.

The Thai Petroleum Institute may also be useful in

assisting the industry in developing good safety programs and procedures, in the conduct of fire-fighting training programs and in facility safety audits. Again, these services would be coordinated through the Institute, but be provided by others. One final area of assistance may be in providing programs and materials to assist the public in learning about new fuels and their safe useage.

8.0 PTT Headquarters and R & D Group

Discussions with the PTT R&D Group provided us with background on current research projects which include investigation of the use of natural gas (CNG) in diesel engines. The R&D group has also participated in the development of materials to educate the public in the safe use of LPG.

Dr. Charan and others expressed concerns relating to LPG safety on the consumer level. This is clearly a difficlut task since PTT is only one part of a large distribution chain. From a PTT viewpoint, it might be feasible for them to require all their direct customers to provide safety information to the next line of customers. This information could cover a number of different aspects -- from consumer use to the safe operation of filling stations and bottling depots.

A preferable alternative would be working with other industrial partners through an organization like the proposed Petroleum Institute to institute a code of practice for LPG distribution and use and to provide a program of consumer

education.

We also discussed with Dr. Charan our comments and suggestions concerning the gas separations plant. Since the plant will be coming on line in early 1985, it is important that personnel be trained now and that safety as well as operations be part of the training. We suggested that Linde could be one resource in developing safety training programs for this immediate need.

In addition to such a program, we suggested that PTT strengthen their safety group and provide them with resources for on-going training. PTT should evaluate their needs for trained technical personnel over the next 10-15 year period and support educational programs to provide the necessary skills and manpower.

Since PTT is a relatively young organization, it does not yet seem to have established career paths which encourage personnel to develop new skills. For example, in establishing training programs for facilities like the gas separations plant, consideration should be given to providing means for the better operators to move into supervisory positions. Also, it may be beneficial to rotate some staff through the corporate safety group, so that when these individuals return to operations, maintenance or management positions, they will be aware of the importance of safety.

9.0 Conclusions and Suggestions

- Thailand is rapidly developing a modern petrochemical

industry and, at present, does not seem to have adequate numbers of personnel with appropriate types of training to operate it reliably and safely.

- In the short term, a variety of training programs are needed -- ranging from practical programs relating to operations and maintenance to university level programs for technical managers.

- Many of the skills needed for such training now exist in Thailand, but need to be supplemented in some areas. In particular, computer training is somewhat limited at Chula and this area could be strengthened by facutly and student exchanges.

- In the short term, the need for more Thai engineers may be met by study at universities outside Thailand.

- While many of the people we met who are involved in Thailand's gas utilization programs are concerned with safety, we did not observe strong safety organizations nor much practical emphasis on safe practices.

  While serious accidents are rare, safety should not be left to chance. One major accident involving one of the new fuels could provide a major setback in the public acceptance of such a fuel. Training programs related to safety (including fire-fighting schools) should be developed. These probably can best be taught initially by bringing outside experts to Thailand.

- Preliminary plans for a Petroleum Institute seem to be excellent and such an organization could be an effective catalyst in organizing various types of training programs, in raising an endowment to be used to support petroleum industry objectives, in administering a gas analysis laboratory and in providing a national basis for establishing safety-related standards and practices.

10. Acknowledgements

Finally, Professor Drake and Professor Goodwin thank U.S.A.I.D. and A.E.R. Enterprises for their support for our seminars and visits in Thailand. The hospitality of all our Thai hosts was sincerely appreciated. In particular, we thank Dr. Charan of PTT for coordinating our visits.

Appendix C

Attendees At Pre-Symposium Seminars, 6 Feb. 84

(Partial List)

1.	MR. NARONGLIR EAMCHAROENYING	PHAN ANAKE CO., LTD.
2.	DR. PRAMUAN LEOPHAIRATANA	THAI PETROCHEMICAL INDUSTRY CO., LTD.
3.	MR. TEERAWAT ISRAPORNCHAI	INDUSTRIAL ESTATE AUTHORITY OF THAILAND
4.	MS. PENCHAN CHAROONPASURAKUL	METRO COMPANY LTD.
5.	MR. PICHAI JINDATHONGPRABHA	METRO COMPANY LTD.
6.	MR. NIPHON WONGCHINGCHAI	THAI PLASTIC & CHEMICAL CO., LTD.
7.	MR. NART TUNTAWIROON	MAHIDOL UNIVERSITY
8.	MR. POONSAB SAMOOTSAKORN	MAHIDOL UNIVERSITY
9.	MR. KURUJIT NAKORNTAP	DMR, MINISTRY OF INDUSTRY
10.	MR. SUTHAM VANICHSENI	CHULALONGKORN UNIVERSITY
11.	MR. PRASERT MANGKORNKARN	THAI-NAM PLASTICS CO., LTD.
12.	MS. CHINTANA SAKULPRAHM	NESDB
13.	MR. FUENGLARB KHAMBHARATANA	CHULALONGKORN UNIVERSITY
14.	MR. PATTARAPAN PRASASSARAKICH	CHULALONGKORN UNIVERSITY
15.	MR. WICHIT CHAIYADHIROJ	METRO COMPANY LTD.
16.	MR. SOMPAN POOLPOL	CHULALONGKORN UNIVERSITY

17. MR. AKOM NANTARECHSANIT	SIAM CEMENT CO., LTD.
18. MR. CHATCHAI BOONBAWORNRATAKUL	NESDB
19. MR. WIRAT SAKORNWIMON	CHULALONGKORN UNIVERSITY
20. MR. VEERA SUKHAKIT	SIAM CEMENT CO., LTD.
21. MR. MONGKOL SUKULKAO	EGAT
22. MR. CHAIRIT SATAYAPRASERT	CHULALONGKORN UNIVERSITY
23. MR. PISOOT SUDASNA	BOONYIUM & ASSOCIATED, LTD.
24. MR. CHALERMKIAT TONGTAO	DMR, MINISTRY OF INDUSTRY
25. MR. ANAN SIRIPONG	THAI ASAHI CAUSTIC SODA CO., LTD.
26. MR. KOSOL PETCHSUWAN	KING MONGKUT'S INSTITUTE OF TECHNOLOGY
27. MR. BOONYIUM MEESOOK	BOONYIUM & ASSOCIATED, LTD.
28. MR. BUNDIT FUNGTAMMASAN	KING MONGKUT'S INSTITUTE OF TECHNOLOGY
29. MR. VEERA CHANVATTANA	SIAM CEMENT CO., LTD.
30. MR. CHINDA VATHANANAI	EGAT
31. MR. SAMRAN NANTAKWANG	THAI PLASTIC & CHEMICAL CO., LTD.
32. DR. LADPLIE LEKSINDUSOPON	PRESSURE CONTAINER INDUSTRY CORP., LTD.
33. MR. KOMIN PIMTHANOTHAI	SIAM CEMENT CO., LTD.
34. MR. SAWITRI ROJANASAROJ	KING MONGKUT'S INSTITUTE OF TECHNOLOGY

35.	MR. VINIJ PANPANICH	THAI PLASTIC & CHEMICAL CO., LTD.
36.	MR. CHAIYAN AKKAWAT	SIAM CEMENT CO., LTD.
37.	MR. CHANCHAI JIVACATE	DOW CHEMICAL THAILAND LTD.
38.	MR. KITTI JIVACATE	UNION CARBIDE THAILAND LTD.
39.	MR. RUNGYOD RUNGRUANGANUN	THAI-NAM PLASTICS CO., LTD.
40.	MR. PIN TECHASIRIWAN	UNION CARBIDE THAILAND LTD.
41.	MR. KROEKCHAI SUKANJANAJTEE	

PTT Participants

42.	MR. AMON PENPIBOONRATANA	NATURAL GAS MARKETING DIVISION
43.	MISS. ACHARA SAENGHAI	CHIEF ENGINEER
44.	MR. BUNDIT GUAESA-ARD	CHIEF OF TECHNOLOGY
45.	MR. BORPITR SRIVAROM	
46.	MR. CHERDCHAI SUANKAEW	
47.	MR. CHAIVAT CHURITTI	CHIEF OF NATURAL GAS MARKETING DIVISION
48.	MR. CHUMPOL SUKHATHUMMO	ENGINEER
49.	MRS. CHINTANA WONGSA-ARD	RESEARCH & DEVELOPMENT DEPARTMENT
50.	MR. CHINAWAT RATANASATIEN	ENGINEER
51.	MR. CHAROEN THITILUCK	HEAD OF MAINTENANCE DIVISION OPERATION SERVICE DEPARTMENT (MARKETING)

52.	MR. JAKCHAI BARLEE	DIVISION CHIEF
53.	MRS. KAMKEO HONGSAPRABHAS	
54.	MR. KAROON KOOLTASNASILP	
55.	DR. KRISANAPOL KOMOLBOON	ENGINEER
56.	MR. KAIWAL WAIYAHONG	ECONOMIST
57.	MR. KIJJA USAYAPHAN	GAS MARKETING ENGINEER
58.	MR. KRISANA KAEWDANG	THERMODYNAMIC CONSIDERATIONS & SAFETY AND HANDLING OF NATURAL GAS AND GAS LIQUID
59.	MR. NUNTACHAI PRAPAWATWECH	ASSISTANT MANAGER TERMINAL & RESERVE OPERATION DIVISION
60.	MR. PRATIN PATHANAPORN	DEPUTY GOVERNOR, MARKETING
61.	DR. PRAJYA PHINYAWAT	DIRECTOR, PETROLEUM PROCUREMENT AND CONTRACT DEPARTMENT
62.	MISS. PATCHARA PARIWATVORN	DIRECTOR, R & D DEPARTMENT
63.	MR. PICHATE ROOKAPIBAL	MECHANICAL ENGINEER
64.	MR. PICHET TAKOLPUCKDEE	
65.	MR. PANYA KANJANARAT	MECHANICAL CONSTRUCTION DIVISION
66.	MR. SEREE WONGKAOMTONG	ENGINEER
67.	MR. SUTHEP AUCHARIYAVONG	CHIEF OF GAS ENGINEERING AND SAFETY STANDARD SECTION
68.	MR. SCHNIN SUIDLAH	ENGINEER

69.	MRS. SUGANYA SAI-NGAM	SCIENCE
70.	DR. SONGKIERT TANSAMRIT	ENGINEER
71.	MR. SOMPHONGSE TANTISUVANICHKUL	ASST. DIRECTOR MECHANICAL CONSTRUCTION DIVISION
72.	M. L. SARASAK HASDIN	ACTING DIRECTOR OF PLANNING AND EVALUATION DIVISION
73.	MR. SUTHI PARITPOKEE	DIRECTOR, ADMINISTRATION AND MARKETING DEPT. (NATURAL GAS)
74.	MR. SALA SIRIVAIDYAPONG	
75.	MR. SANAN SUNMANEE	CHIEF, COMPUTER R & D DIV.
76.	MR. SUDHEP SUWANSOMBOON	
77.	MR. THANAPATT VICHAITHANAPATT	
78.	MR. TORBOON CHEOYJAICHUEN	PROCESS ENGINEER
79.	MR. VACHIRA CHITTAMAS	HEAD OF S.P. SECTION, COMPUTER CENTRE
80.	MR. VITHAYA TIVAYANONDA	DIRECTOR OF TECHNOLOGY & DEVELOPMENT DIVISION
81.	MR. VICHAI POLYVANICH	DIVISION DIRECTOR
82.	MR. VEERA MAHASARINANO	PTT

GASEOUS AND LIQUID FUELS

PROPERTIES AND SAFETY

13 FEBRUARY 84
BANG PAKONG POWER PLANT

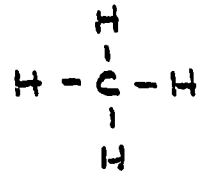
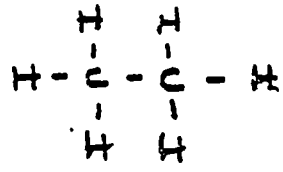
PROF. BERNARD GOODWIN
PROF. ELISABETH DRAKE

NORTHEASTERN UNIVERSITY
BOSTON, MASSACHUSETTS
U.S.A.

CHEMICAL ELEMENTS

NAME	SYMBOL	ATOMIC WEIGHT
CARBON	$-\overset{|}{\underset{|}{C}}-$	12
HYDROGEN	H-	1
OXYGEN	-O-	16

CHEMICAL COMPOUNDS

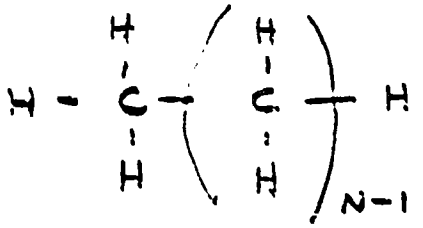
WATER (H_2O)	H-O-H	18
CARBON DIOXIDE (CO_2)	O=C=O	44
METHANE (CH_4)		16
ETHANE (C_2H_6)		30

CHEMICAL REACTION

$$CH_4 + 2H_2O \xrightarrow{T,P} 4H_2 + CO_2$$

HYDROCARBONS

COMPOUNDS CONTAINING ONLY CARBON AND HYDROGEN. GENERAL FORMULA FOR SATURATED HYDROCARBONS IS $C_N H_{2N+2}$ OR



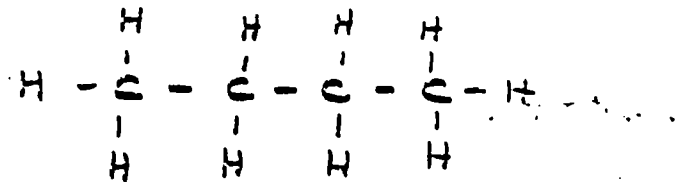
SIMPLEST HYDROCARBON IS METHANE (CH_4).

N	NAME	FORMULA	MOL. WT.
1	METHANE	CH_4	16
2	ETHANE	C_2H_6	30
3	PROPANE	C_3H_8	44
4	BUTANE	C_4H_{10}	58
5	PENTANE	C_5H_{12}	72
6	HEXANE	C_6H_{14}	86
7	HEPTANE	C_7H_{16}	100

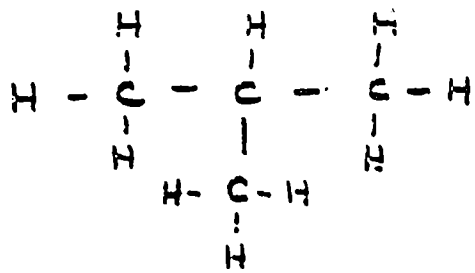
SPECIAL NOMENCLATURE

A. SATURATED HYDROCARBONS

1. "NORMAL" - WHEN ALL CARBONS ARE IN A ROW. EG. N-BUTANE

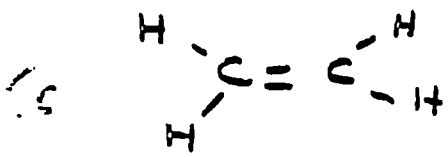


2. "ISO" - WHEN CARBONS BRANCH
   EG. ISO-BUTANE

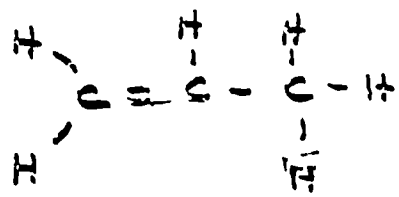


B. UNSATURATED HYDROCARBONS (OLEFINS)

WHEN MORE THAN ONE BOND EXISTS BETWEEN THE SAME TWO CARBONS. FOR A DOUBLE BOND THE "....ANE" IS CHANGED TO "....YLENE". EG. ETHYLENE



OR PROPYLENE



PHYSICAL MIXTURES

- SEPARATE COMPOUNDS (OR ELEMENTS) ARE COMBINED TOGETHER IN VARYING AMOUNTS TO FORM A MIXTURE. NO REACTIONS OCCUR.

- COMPOUNDS IN SUCH MIXTURES MAY BE SEPARATED BY PHYSICAL MEANS E.G. HEATING, COOLING, BOILING, FREEZING, COMPRESSING (CHANGING T AND P), DISTILLING, ETC.

  EXAMPLES: SALT IN WATER, WATER IN AIR

CHEMICAL MIXTURES (REACTIONS)

- COMPOUNDS REACT AND ARE CHANGED TO PRODUCTS IN RATIOS DETERMINED BY A BALANCED CHEMICAL REACTION EQN.

- CHEMICAL BONDS MUST BE BROKEN AND REFORMED DIFFERENTLY TO REVERSE PROCESS

  EXAMPLES: $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$

  $C_2H_6 \rightarrow C_2H_4 + H_2$

THAILAND NATURAL GAS

- MIXTURE OF SATURATED HYDROCARBONS C_1 THROUGH C_9
- ALSO INCLUDES THE USUAL UNWANTED COMPOUNDS: CARBON DIOXIDE HYDROGEN SULFIDE, WATER AND SOME OTHER MATERIALS
- CURRENTLY 180 MMSCFD OF METHANE PRODUCED WITH EXCELLENT POTENTIAL TO INCREASE PRODUCTION
- ANALYSIS (AFTER PURIFICATION)

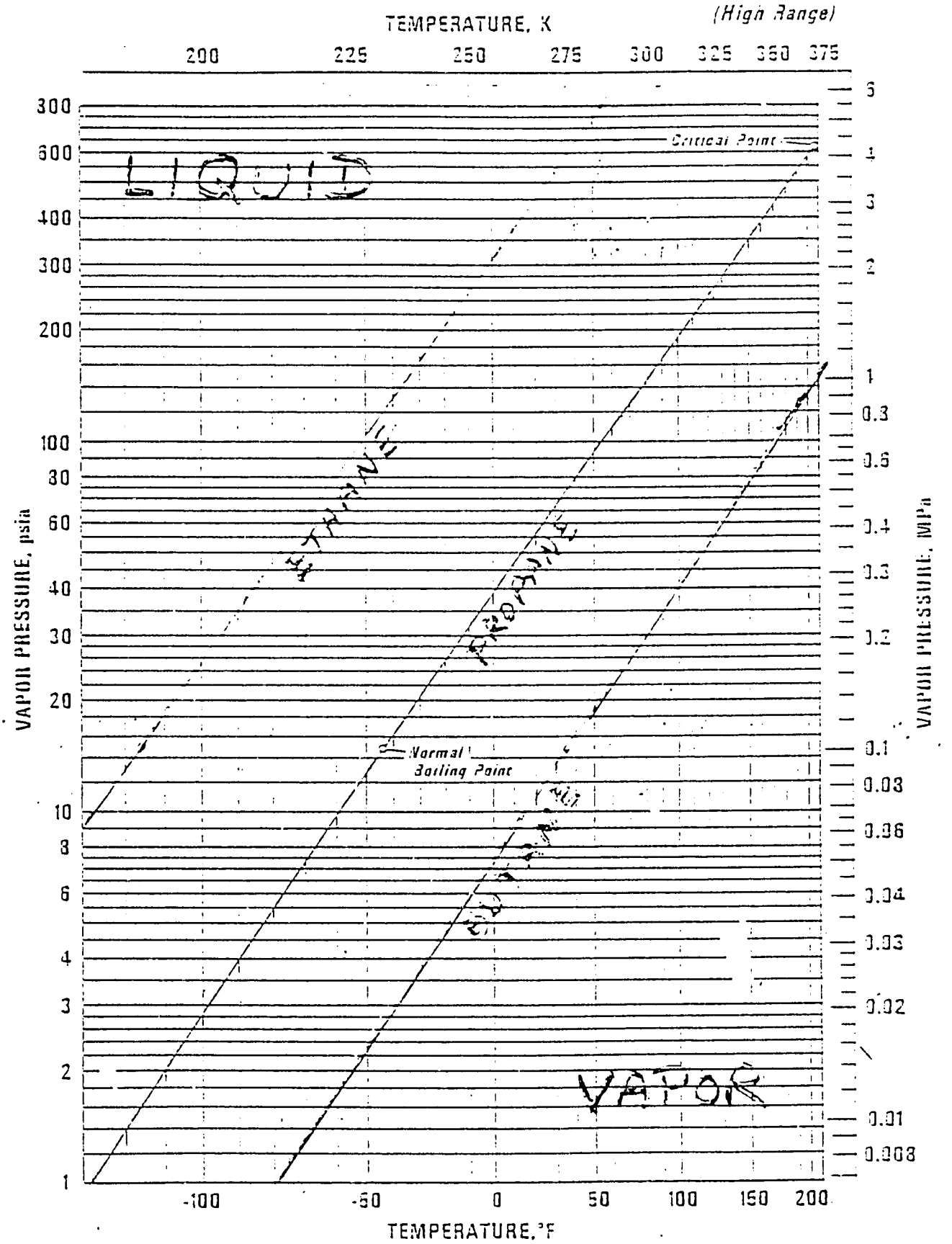
COMPOUND	WEIGHT %	MOL %
CH_4	65.1	81.7
C_2H_6	13.4	9.5
C_3H_8	12.1	6.5
C_4H_{10}	6.7	1.5
C_5^+	2.7	0.8

SOME TYPICAL PROPERTIES

	HYDROGEN	METHANE	ETHANE	PROPANE	BUTANE	TYPICAL LIGHT GASOLINE
CHEMICAL FORMULA	H_2	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5^+
MOLECULAR WEIGHT	2	16	30	44	58	86^+
NORMAL BOILING PT. N.B.P. (1 ATM) °C	-253	-162	-89	-42	0	47^+
LIQUID DENSITY AT N.B.P. kg/m³	67	427	544	583	602	656^+
VAPOR DENSITY AT N.B.P. kg/m³	1.2	1.75	2.06	2.43	2.71	3.0^+
VAPOR PRESSURE AT 50°C ATM	N.A.	N.A.	50	18	5	1^-
LOWER - UPPER FLAMMABILITY LIMITS IN AIR MOL %	~2 - 90	5-15	3-12.5	2.1 - 9.5	1.9 - 8.5	$1^- - 7^-$
HEAT OF COMBUSTION KCAL/KG	23,900	13,100	12,000	11,600	11,400	11,000

PROPANE

Vapor Pressure - Temperature (High Range)



Thermophysical Properties Division NBS-NBL, Boulder, Colorado

Chart 1069 [illegible]

5.3.

PRELIMINARY SAFETY ANALYSIS

PURPOSE: TO AID IN SITE SELECTION FOR A PARTICULAR PROJECT

METHOD:

- FROM BASIC FLOW SHEET AND PRELIMINARY SIZING OF MAJOR VESSELS AND TANKS, IDENTIFY QUANTITIES AND TYPES OF HAZARDOUS MATERIALS THAT MIGHT BE RELEASED ACCIDENTALLY
- USE HAZARD ESTIMATION MODELS TO PREDICT POTENTIAL HAZARD AREAS (FIRE, EXPLOSION, TOXIC VAPOR) FOR EACH SUCH EVENT
- REVIEW AMOUNT AND TYPE OF PAST EXPERIENCE WITH THE SAME OR SIMILAR TECHNOLOGY
- SELECT SAFETY DISTANCES FOR SITE SELECTION (MULTIPLE CRITERIA)

SAFETY DISTANCE CRITERIA:

- DISTANCE TO PREVENT FIRE SPREAD OFFSITE (OR CAUSE DAMAGE TO ADJACENT FACILITIES)
- DISTANCE TO NEAREST INDUSTRY WITH SIGNIFICANT NUMBER OF LIQUORS
- DISTANCE TO NEAREST RESIDENCE
- DISTANCE TO IMPORTANT FACILITY (SCHOOL, HOSPITAL, SPORTS AREA)
- POTENTIAL FOR DAMAGE FROM NEARBY ACTIVITIES (HAZ. MATERIALS PLANTS, AIRPORT, ETC.) OR NATURAL DISASTERS

APPLICATION IN SITE EVALUATION

- USE CRITERIA AS GUIDELINES — NOT AS ABSOLUTE REQUIREMENTS
- ELIMINATE SITES WHERE SAFETY IS CLEARLY A PROBLEM
- USE CRITERIA IN EVALUATING OTHER SITES FOR RELATIVE SAFETY
- BALANCE SAFETY WITH OTHER SITING FACTORS

WHEN DO ACCIDENTS HAPPEN?

- DURING STARTUP AND EARLY OPERATION

- WHEN CHANGES ARE MADE IN CONTROLS, EQUIPMENT AND/OR PROCEDURES WITHOUT A COMPLETE ANALYSIS OF EFFECT OF CHANGE ON TOTAL SYSTEM

- WHEN PERSONNEL (AT ANY LEVEL) GET USED TO ROUTINE OPERATION AND FORGET ABOUT SAFETY. (THIS IS PARTICULARLY TRUE FOR VERY RELIABLE FACILITIES)

- DURING NON-ROUTINE MAINTENANCE (PROCEDURES SHOULD BE DEVELOPED AND CAREFULLY REVIEWED FOR SAFETY BEFORE MAINTENANCE STARTS)

DEFINITION OF RISK

RISK IS THE POTENTIAL FOR REALIZATION OF UNDESIRABLE CONSEQUENCES ARISING FROM AN EVENT OR ACTIVITY.

POTENTIAL:

- WHAT UNDESIRABLE CONSEQUENCES MIGHT OCCUR?
- HOW LIKELY ARE THEY?

HOW IS RISK MEASURED?

- RISK HAS TO BE DISCOVERED FIRST
- RISK HAS PROBABILISTIC COMPONENTS
- RISK HAS DETERMINISTIC COMPONENTS
- MEASURE OF RISK VARIES WITH PROBLEM SITUATION

RISK MANAGEMENT

WHAT IS RISK MANAGEMENT?

- DEALING WITH UNCERTAINTY
- MAKING DECISIONS TODAY BASED ON KNOWN OBJECTIVES WITH PROBABILISTIC OUTCOME
- QUANTIFYING PROBABILISTIC AND DETERMINISTIC DECISION PARAMETERS
- SYSTEMATICALLY EVALUATING OPTIONS
- OPTIMIZING PROFITS

AREAS OF APPLICATION OF RISK ANALYSIS

NUCLEAR INDUSTRY

AEROSPACE INDUSTRY

MARINE TERMINALS

CHEMICAL PLANTS

FUEL DEPOTS

SHIPPERS OF HAZARDOUS MATERIALS

CRYOGENIC FACILITIES

REFINERIES/PETROCHEMICAL INDUSTRY

SPECIALTY CHEMICAL INDUSTRY

PHARMACEUTICALS

ETC.

A SUCCESSFUL RISK ANALYSIS WILL:

- PROVIDE SAFETY INSIGHT ON THE NATURE OF THE OPERATION
- SUGGEST WAYS OF REDUCING THE RISK
- PROVIDE INPUTS ON THE EXTENT OF LIABILITY BEING INCURRED
- BE A USEFUL TOOL IN EDUCATING THE PUBLIC
- PROVIDE A BASIS FOR COMPARISON WITH RISKS IN OTHER ACTIVITIES

FORMAL QUANTITATIVE RISK ANALYSIS WOULD CONSIST OF THE FOLLOWING GENERAL STEPS:

IDENTIFICATION OF RISKS -- THE QUALITATIVE LISTING OF ALL SIGNIFICANT FAILURE PATHWAYS

QUANTIFICATION OF RISK -- QUANTIFYING THE PROBABILITIES OF THE FAILURE MODES IDENTIFIED AND ESTIMATING THE CONSEQUENCES OR IMPACTS WHICH RESULT

RISK EVALUATION -- ASSESSING THE COMPOSITE RISKS WITH RESPECT TO GUIDE-LINES PROVIDED BY A SUPERVISORY AGENCY OR BY COMPARISON WITH OTHER RISKS BOURNE BY SOCIETY

CONSIDERATION OF RISK CONTROL OPTIONS -- SELECTION OF PRACTICAL AND EFFECTIVE RISK REDUCTION OPTIONS AS NEEDED TO CONTROL THE RISK AND MANAGE IT AT AN ACCEPTABLY LOW LEVEL

RISK IDENTIFICATION DURING DESIGN REVIEW

HAZARD AND OPERABILITY STUDY (HAZ-OP)*:

- LINE-BY-LINE AND COMPONENT-BY-COMPONENT CHECK OF PIPING + INSTRUMENTATION DRAWINGS
- FOR EACH ELEMENT ASK EFFECT OF:

HIGH T ?	HIGH FLOW ?
LOW T ?	LOW FLOW ?
HIGH P ?	NO FLOW ?
LOW P ?	BACK FLOW ?

  REACTION RATE VARIATIONS ?
  ETC.

- ANY EXCURSION LEADING TO A HAZARD AND/OR OPERABILITY PROBLEM IS NOTED FOR RESOLUTION IN FINAL DESIGN

* METHOD DEVELOPED BY ICI IN THE U.K.

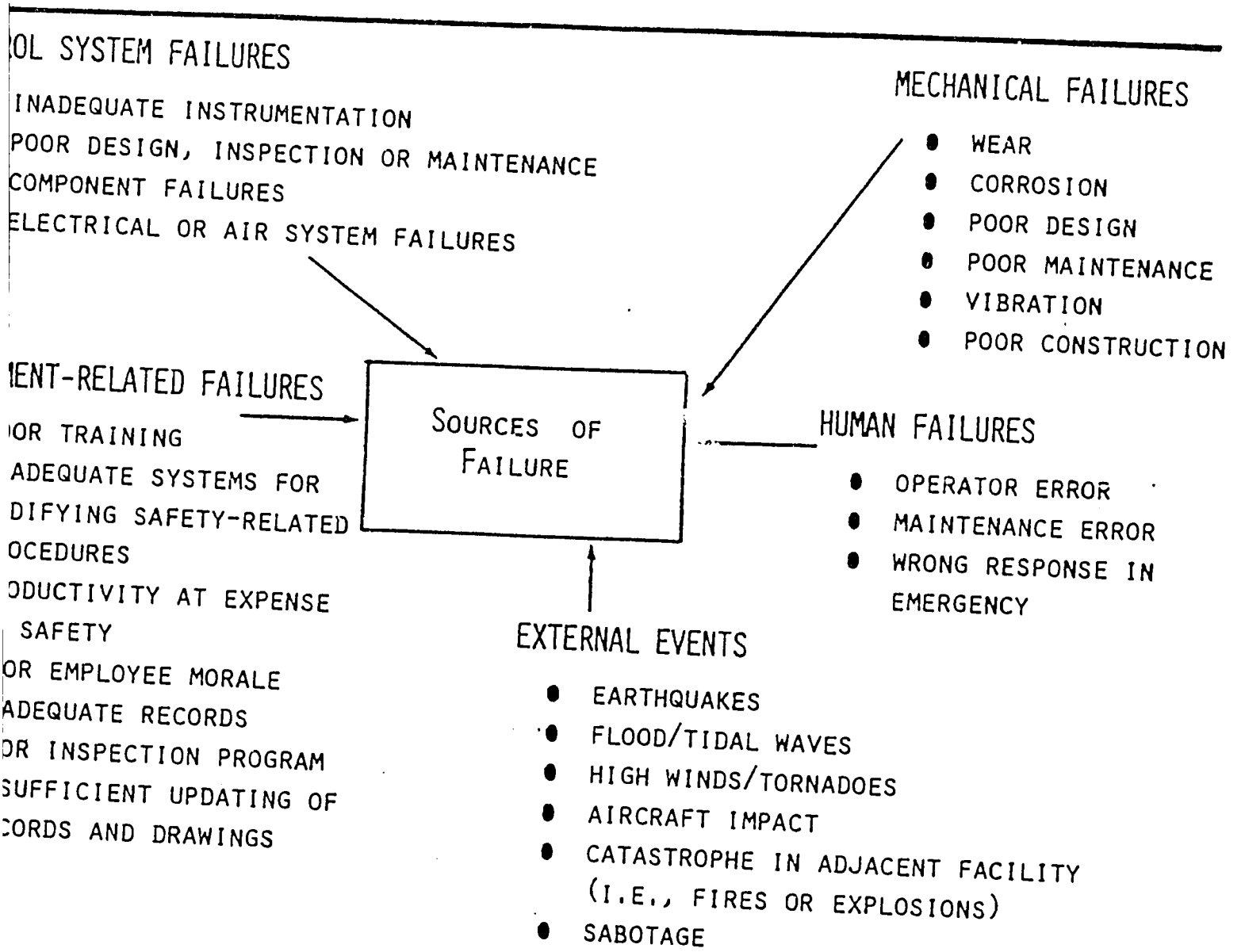
RISK IDENTIFICATION

- ITEMS FOUND IN HAZARD AND OPERABILITY STUDY
- PAST EXPERIENCE - DIRECT OR RELATED
- FAULT TREE ANALYSIS GENERATED BY TEAM WITH VARIED BACKGROUNDS INCLUDING EXPERIENCE WITH DESIGN, CONSTRUCTION, TESTING, OPERATIONS, MAINTENANCE AND EMERGENCY RESPONSE SYSTEMS
- EXAMINATION OF SITE AND ENVIRONS FOR EXTERNAL FACTORS WHICH MIGHT INITIATE FAILURES

RISK IDENTIFICATION TEAM

- FACILITY MANAGEMENT
- ENGINEERING DESIGN
- OPERATING SUPERVISOR
- MAINTENANCE SUPERVISOR
- INSTRUMENTATION EXPERT
- OTHER SPECIALISTS (AS NEEDED)
- INDEPENDENT TECHNICAL EXPERT
- FAULT TREE ANALYST (RECORDER)

RISK IDENTIFICATION

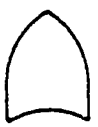


FAULT TREE CONSTRUCTION

PURPOSE: TO DISPLAY IN LOGICAL FORMAT ALL IDENTIFIED SEQUENCES OF FAILURES WHICH CAN LEAD TO A "TOP EVENT". THE TOP EVENT IS A FAILURE EVENT OR SET OF EVENTS HAVING SIMILAR CONSEQUENCES.

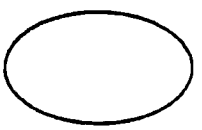
NOTATION:

"AND" GATE (OUTPUT FAULT OCCURS ONLY IF ALL INPUT FAULTS OCCUR; INPUT PROBABILITIES MULTIPLIED TO GIVE OUTPUT PROBABILITY)

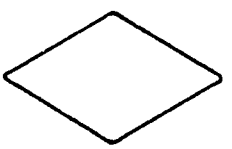


"OR" GATE (OUTPUT FAULT OCCURS ONLY IF ONE OR MORE OF THE INPUT FAULTS OCCUR; INPUT PROBABILITIES ADDED TO GIVE OUTPUT PROBABILITY)

RECTANGLES REPRESENT STATES WHICH ARE THE PRODUCT OF SEVERAL INITIATING AND/OR CONTRIBUTING EVENTS THROUGH AN "AND" OR "OR" GATE (THEY MAY THEREFORE HAVE RATES OF OCCURRENCE WHICH ARE YEARLY OR PER DEMAND)



CIRCLES OR OVALS REPRESENT INITIATING FAILURES OR EVENTS WITH YEARLY RATES OF OCCURRENCE WHICH ARE NOT ANALYZED FURTHER



DIAMONDS REPRESENT CONTRIBUTING FAILURES OR EVENTS WHICH ARE NOT ANALYZED FURTHER AND HAVE RATES OF OCCURRENCE PER DEMAND

FAULT TREE ANALYSIS

1. DEFINE TOP EVENTS (ON THE BASIS OF HAZ-OP).

2. DEVELOP FAILURE SEQUENCES LEADING TO EACH TOP EVENT.

3. EXPRESS SEQUENCES IN LOGIC DIAGRAM.

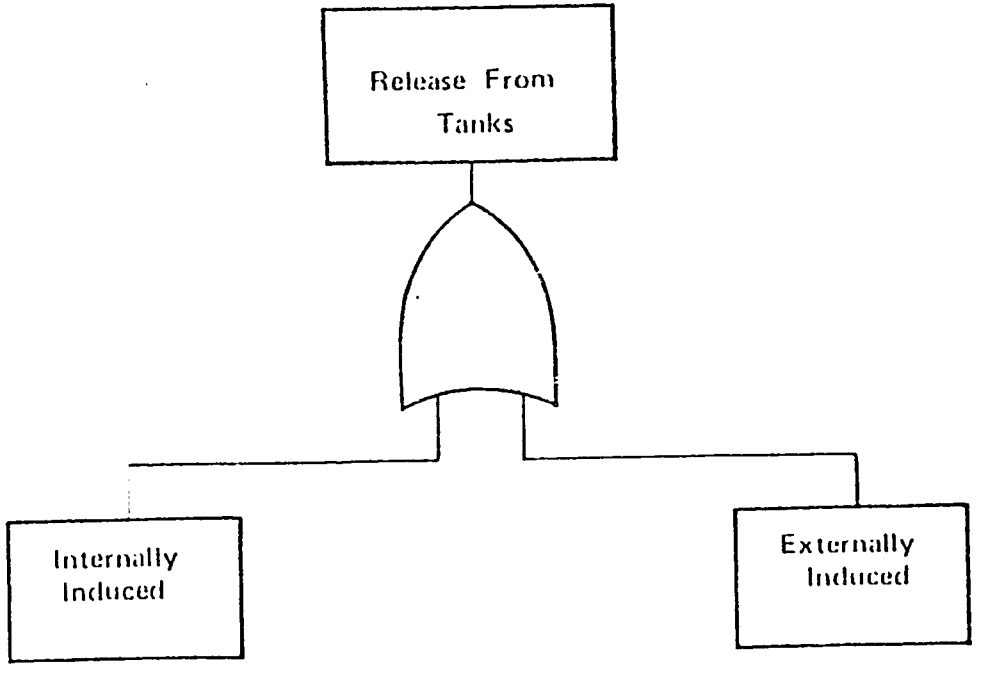
4. ASSIGN PROBABILITIES TO EACH STEP.

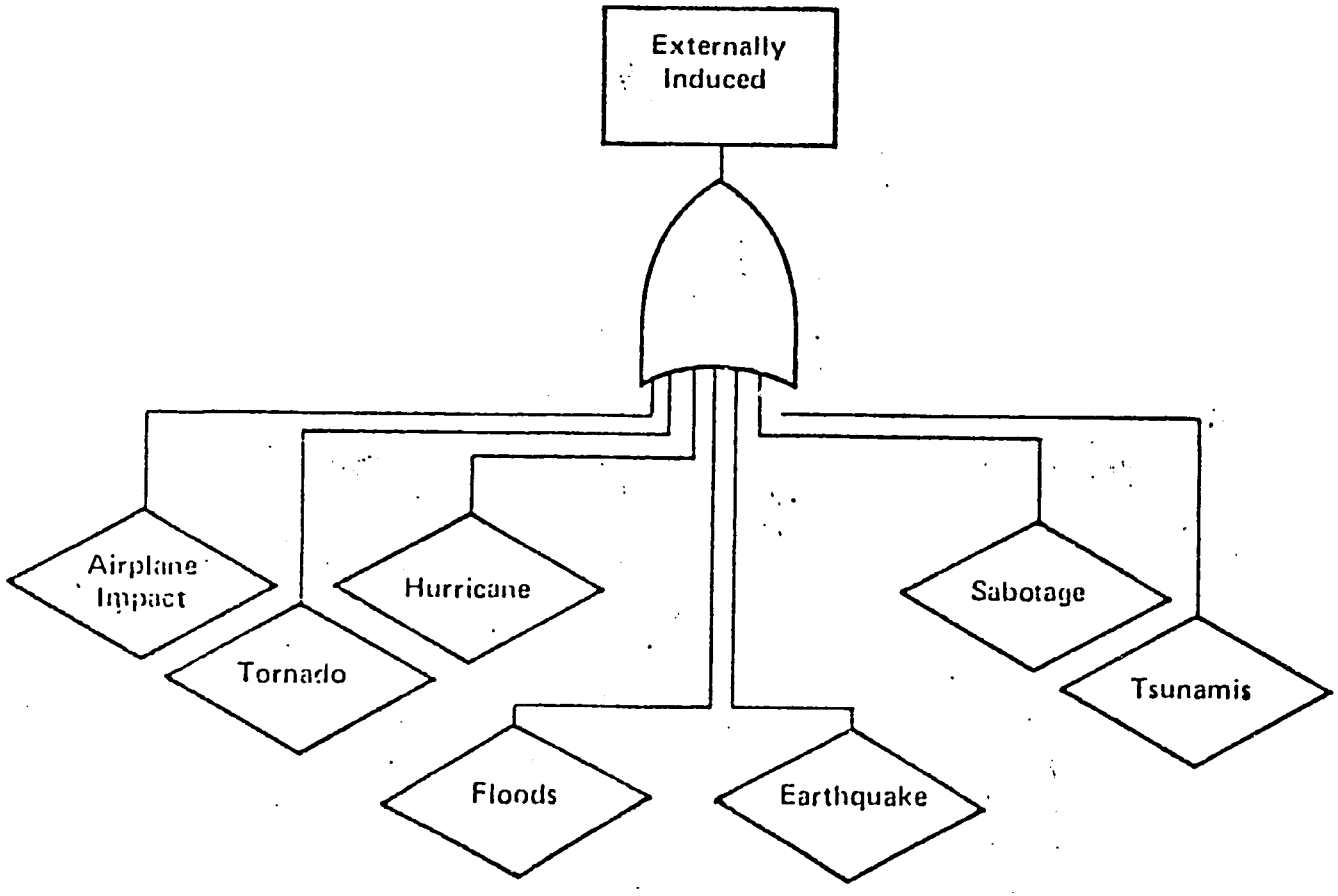
5. ESTIMATE PROBABILITY OF EACH TOP EVENT.

FAILURE EVENTS

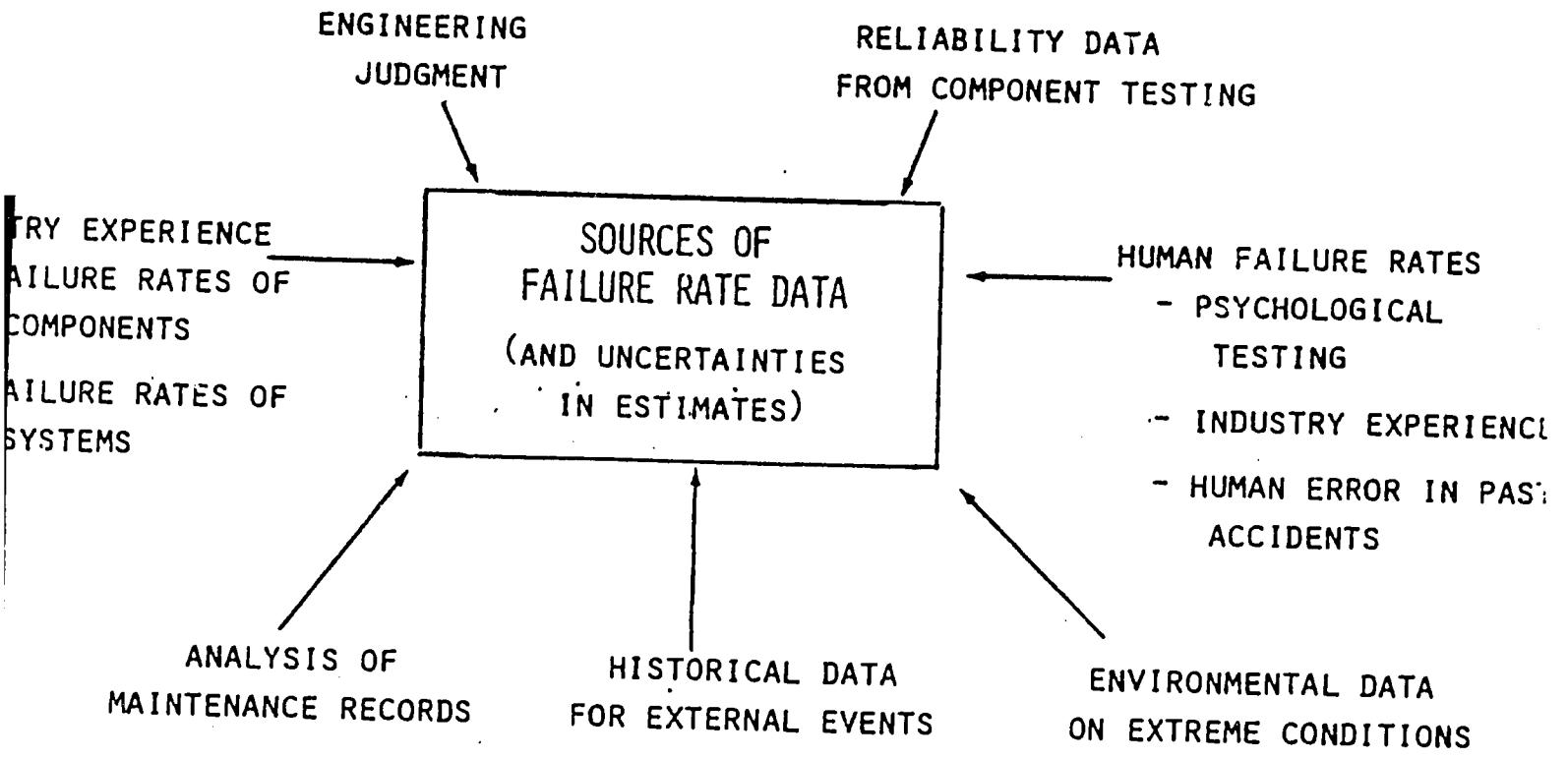
INTERNALLY INDUCED: COMPONENTS FAILURES, HUMAN FACTORS, ETC.

EXTERNALLY INDUCED: AIRPLANE IMPACT, SABOTAGE, EXTERNAL FIRES, MISSILES, ETC.


Release From Tanks
Internally Induced
Externally Induced


Externally Induced
Airplane Impact
Tornado
Hurricane
Floods
Earthquake
Sabotage
Tsunamis

QUANTIFICATION OF RISK



RISK QUANTIFICATION

BILITIES OF FAILURE

DATA SOURCES:

RASMUSSEN - REACTOR SAFETY STUDY - WASH 1400

FLUOR ENGINEERS AND CONSTRUCTORS, INC. - RELIABILITY STUDY - OXNARD AND LOS ANGELES TERMINAL ISLAND LNG FACILITIES, 1977

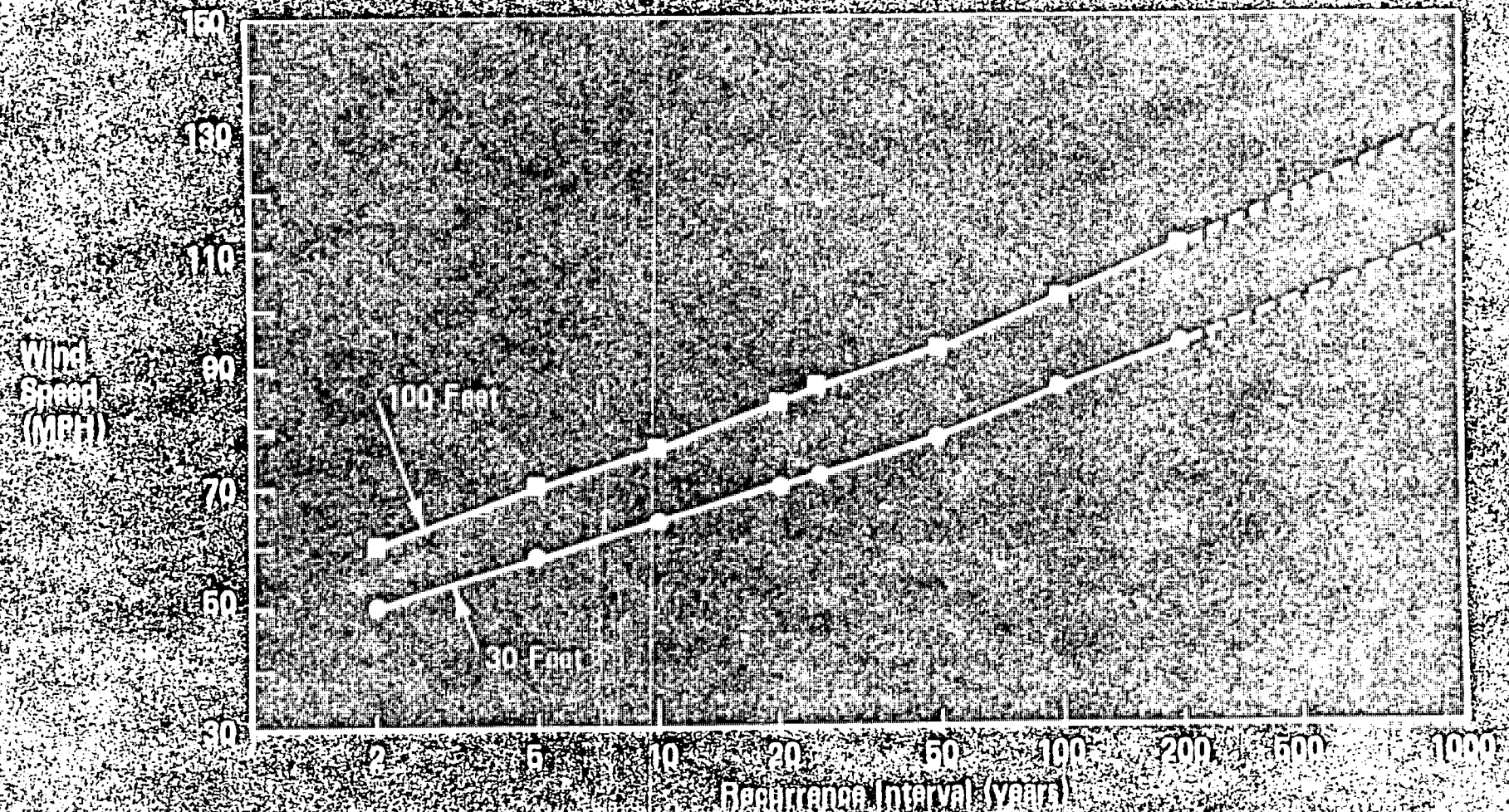
HUGHES AIRCRAFT - NONELECTRIC RELIABILITY NOTEBOOK, NTIS, 1975

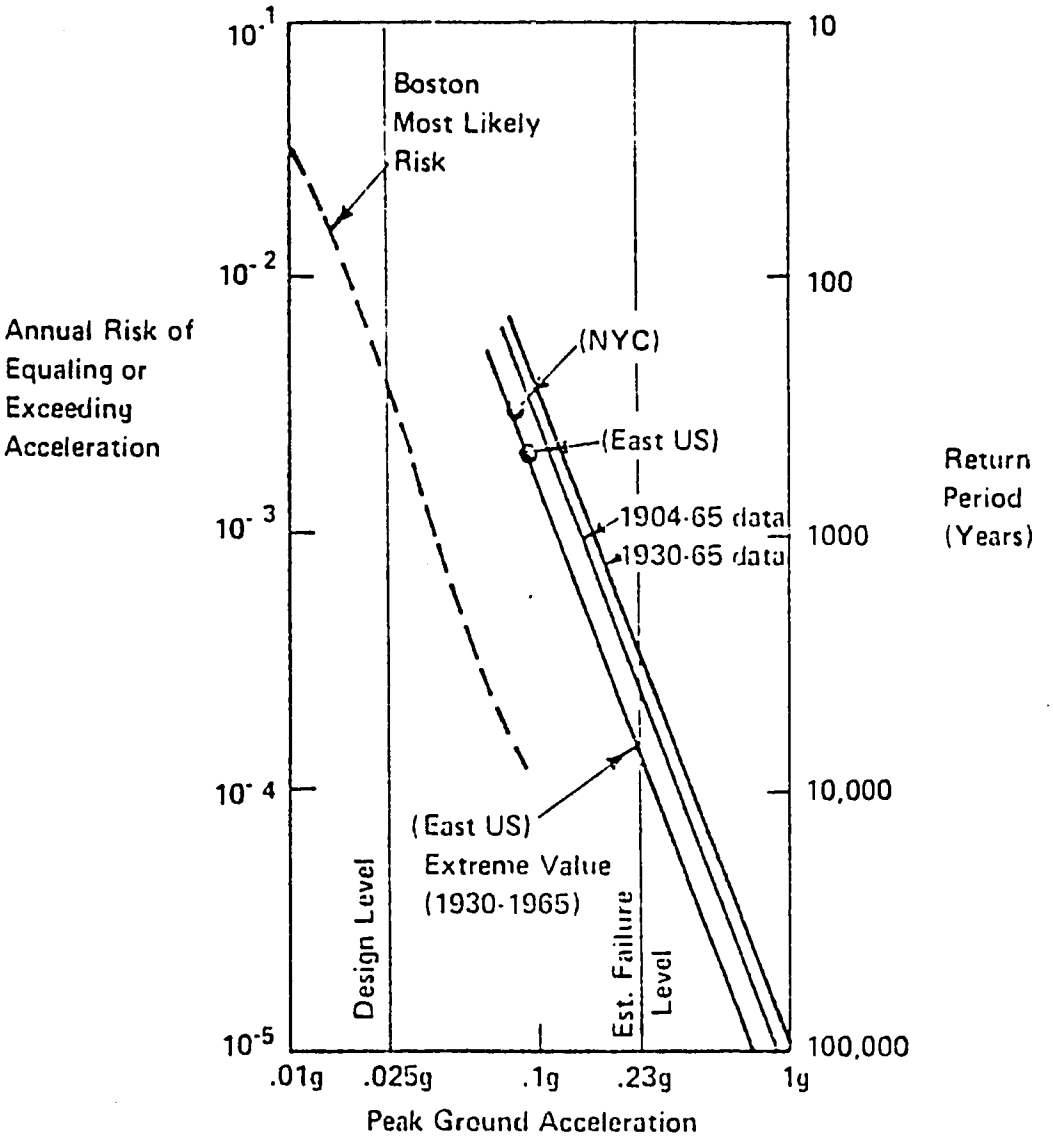
IEEE - REPORT ON RELIABILITY SURVEY OF INDUSTRIAL PLANTS, 1974

INSTITUTION OF CHEMICAL ENGINEERS - PROCEEDING OF SYMPOSIUM ON PROCESS INDUSTRY HAZARDS, 1976

OTHER PROPRIETARY DATA ACCUMULATED BY ADL

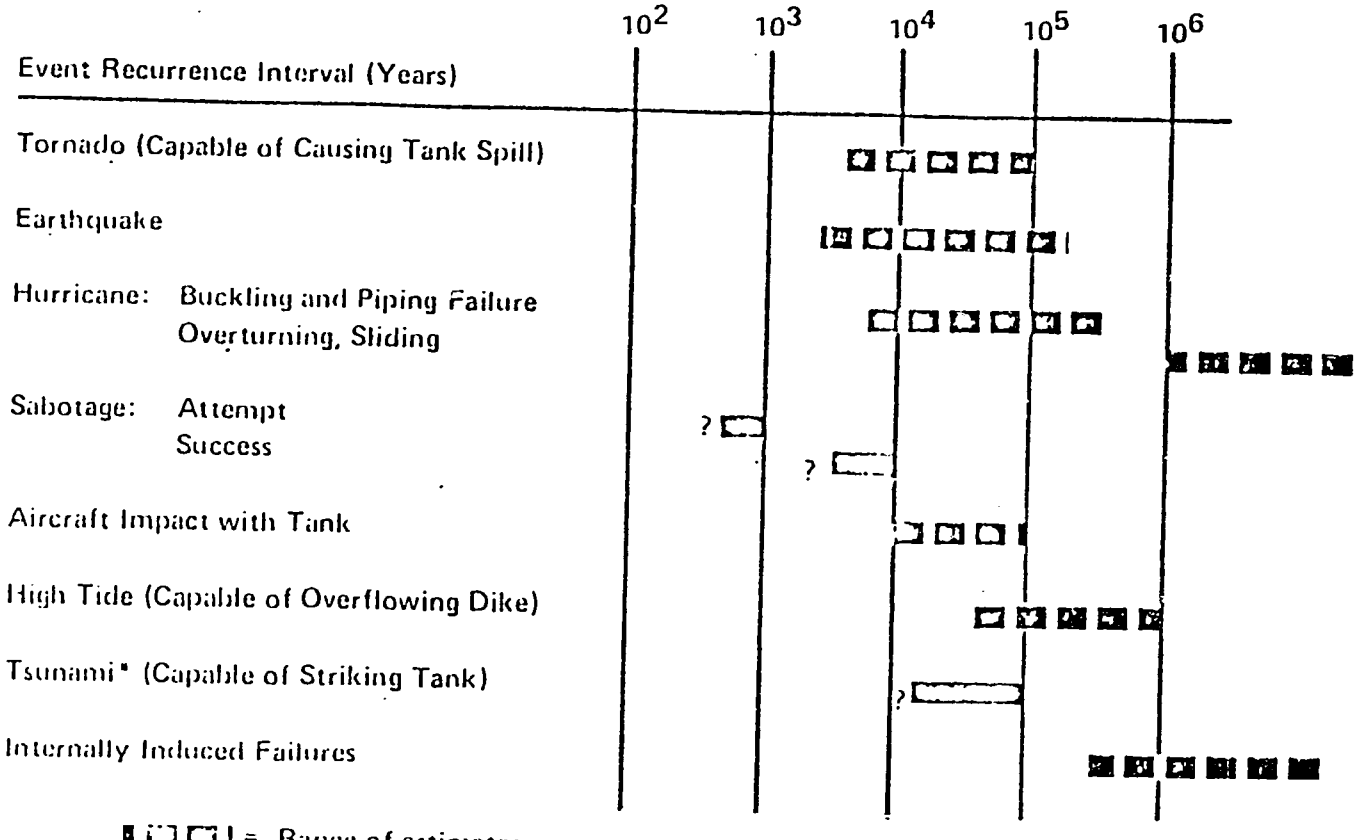
RECURRENCE INTERVAL VS SPEED OF ANNUAL EXTREME MILE WIND




Annual Risk of Equaling or Exceeding Acceleration
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10
100
1000
10,000
100,000
Return Period (Years)
Boston Most Likely Risk
(NYC)
(East US)
1904-65 data
1930-65 data
(East US) Extreme Value (1930-1965)
Design Level
Est. Failure Level
.01g
.025g
.1g
.23g
1g
Peak Ground Acceleration

142

RECURRENCE INTERVALS FOR ABNORMAL EVENTS WHICH MIGHT INDUCE A MAJOR LNG RELEASE



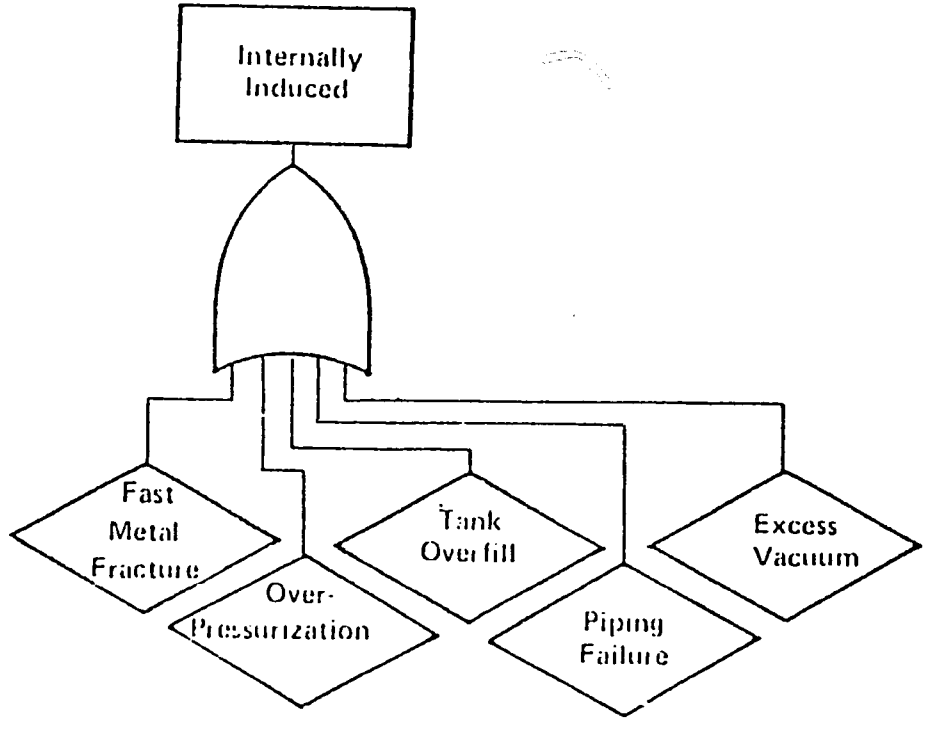
= Range of estimates

? = A number was obtained but the analysis contains considerable uncertainties

* = Tidal wave

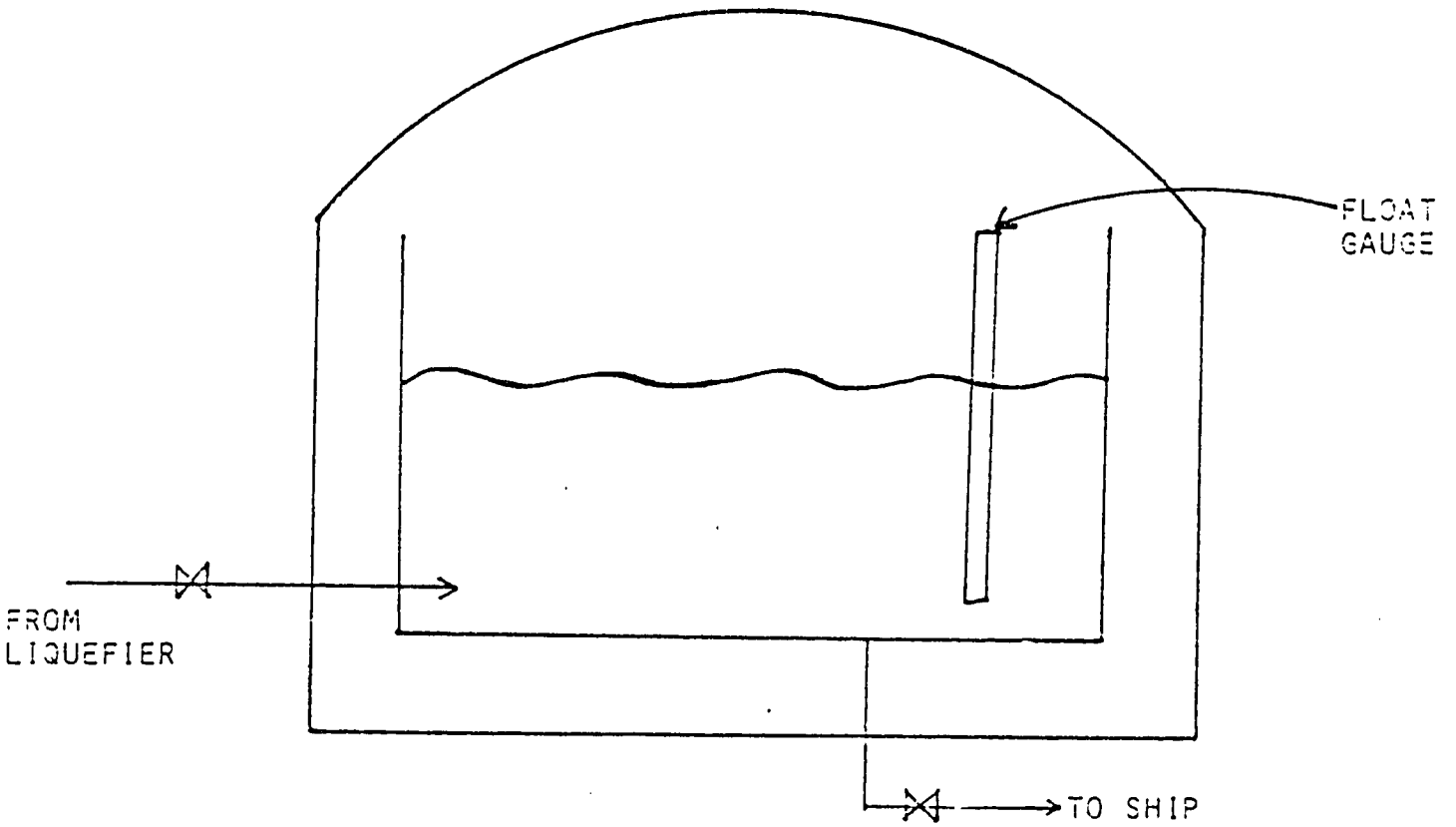
D-31

147


Internally Induced
Fast Metal Fracture
Over-Pressurization
Tank Overfill
Piping Failure
Excess Vacuum

144

TANK OVERFILL PROBLEM



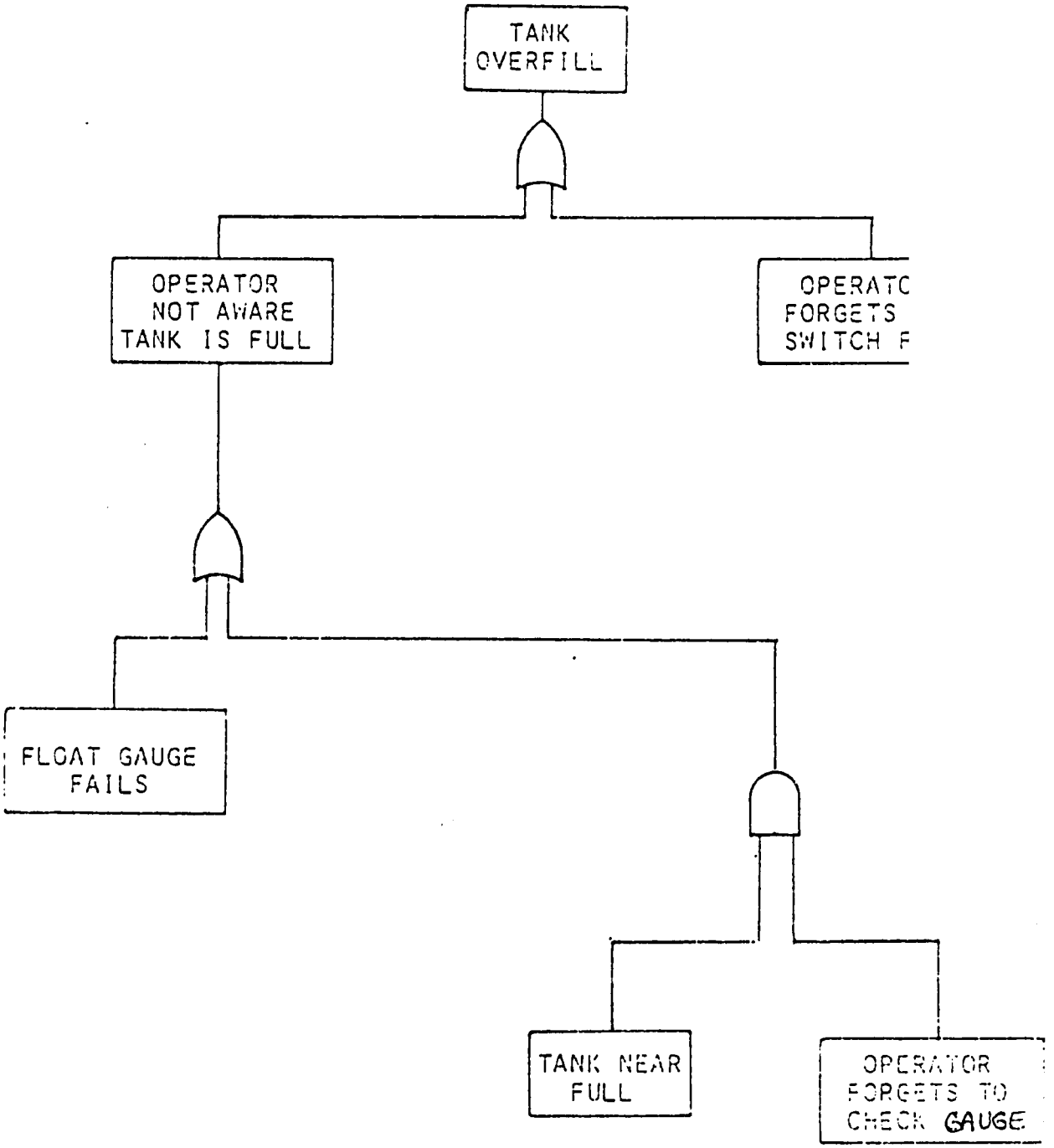
TANK FILL TIME = 5 DAYS

OPERATOR READS LEVEL ON FLOAT GAUGE EACH SHIFT

MAXIMUM LIQUID HEIGHT = 15 M

MAXIMUM INNER TANK HEIGHT = 15.5 M

OPERATOR DIVERTS FEED TO ANOTHER TANK WHEN THIS TANK IS FULL.


TANK OVERFILL
OPERATOR NOT AWARE TANK IS FULL
OPERATC FORGETS SWITCH F
FLOAT GAUGE FAILS
TANK NEAR FULL
OPERATOR FORGETS TO CHECK GAUGE

TYPICAL HUMAN ERROR RATES

Type of Activity	Example	Probability of Error
Critical routine task	Sub-system design, operation of well-designed plant	10^{-3}
Non-critical routine task	Misreading label, omitting step in procedure	3×10^{-3}
Non-routine normal operations	Start-up, maintenance	10^{-2}

TYPICAL COMPONENT FAILURE RATES

RELIEF VALVE FAILURE	10^{-5}/DEMAND
INSTRUMENT FAILURE	10^{-6}/HOUR
PUMP FAILURE	4×10^{-5}/HOUR
SOLENOID OPERATED VALVE FAILURE	10^{-3}/DEMAND

FILL RATE: 1 M PER 8 HOUR SHIFT

(TANK CAN OVERFILL IN 1 SHIFT)

NUMBER OF FILLINGS PER YEAR = $\frac{365}{5}$ = 73

TANK NEARLY FULL 1/15 OR 8.3% OF THE TIME

FLOAT GAUGE FAILURE:

WITH NO DETECTION:

(10^{-6} PER HOUR) (8760 HOURS/YEAR)

= 8.8×10^{-3} PER YEAR

OPERATOR FORGETS TO CHECK GAUGE

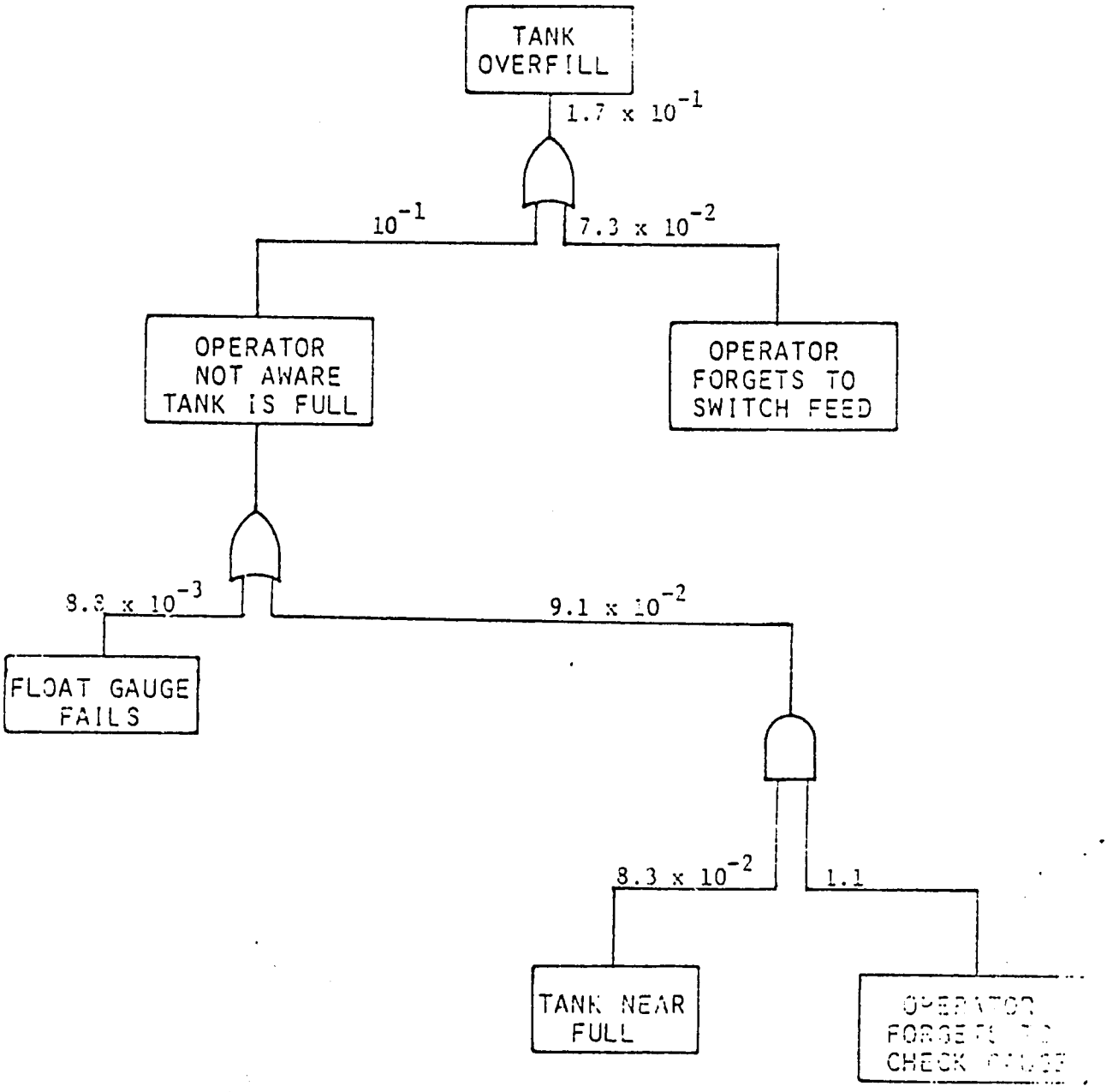
(10^{-3} PER DEMAND)(1 DEMAND PER SHIFT)(1095 SHIFTS PER YEAR)

= 1.1 PER YEAR

OPERATOR FORGETS TO SWITCH FEED

(10^{-3} PER DEMAND)(73 DEMANDS PER YEAR)

= 7.3×10^{-2} PER YEAR


TANK OVERFILL
1.7 x 10^-1
10^-1
7.3 x 10^-2
OPERATOR NOT AWARE TANK IS FULL
OPERATOR FORGETS TO SWITCH FEED
8.3 x 10^-3
9.1 x 10^-2
FLOAT GAUGE FAILS
8.3 x 10^-2
1.1
TANK NEAR FULL

CONCLUSIONS:

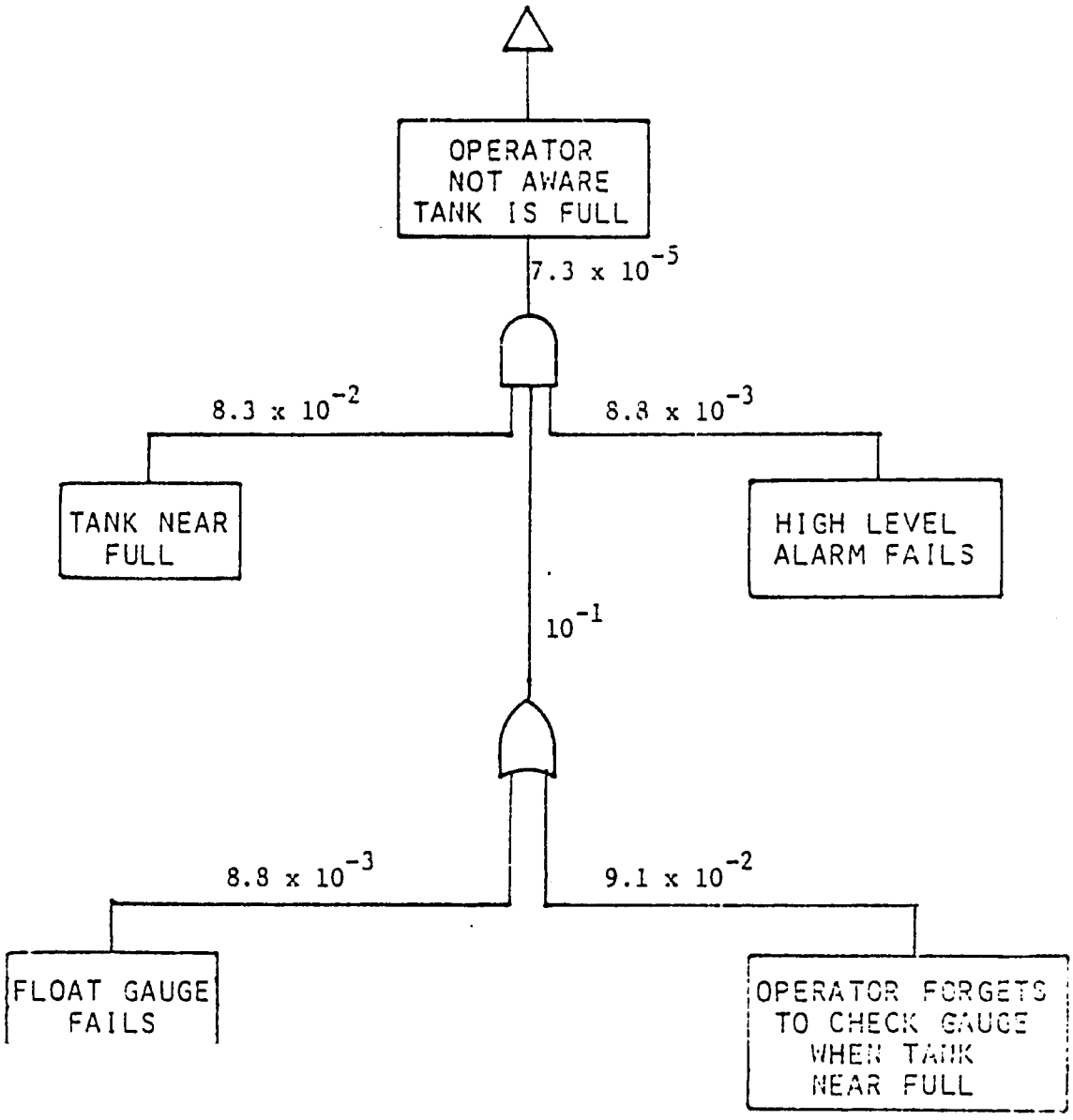
SYSTEM AS DESCRIBED HAS A 17% CHANCE PER YEAR OF AN OVERFILLING.

MOST RISK DUE TO OPERATOR ERROR.

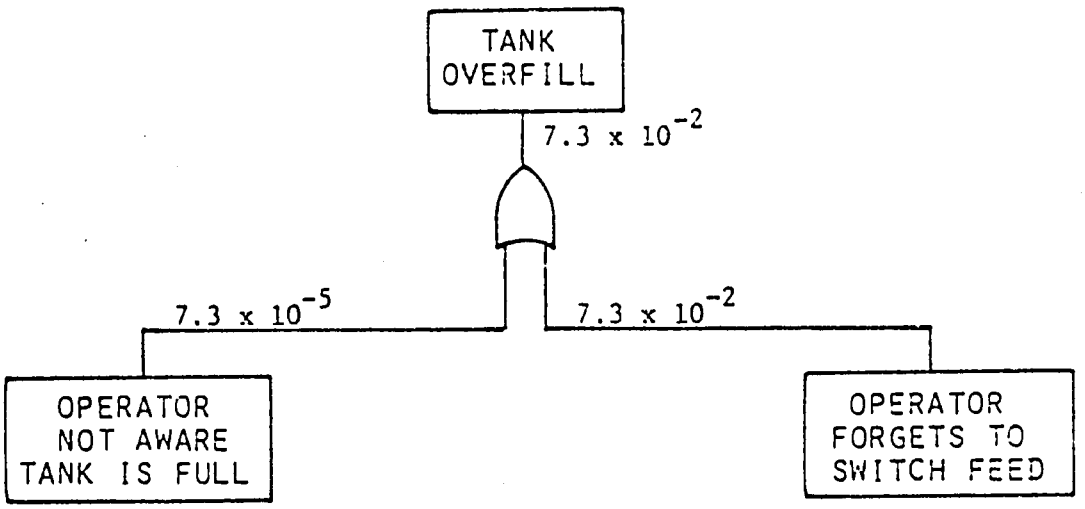
IMPROVEMENTS:

ADD HIGH LEVEL SENSOR AND ALARM.

WITH ADDITION OF HIGH LEVEL ALARM



AFTER ADDITION OF HIGH LEVEL SENSOR/ALARM



CONCLUSIONS:

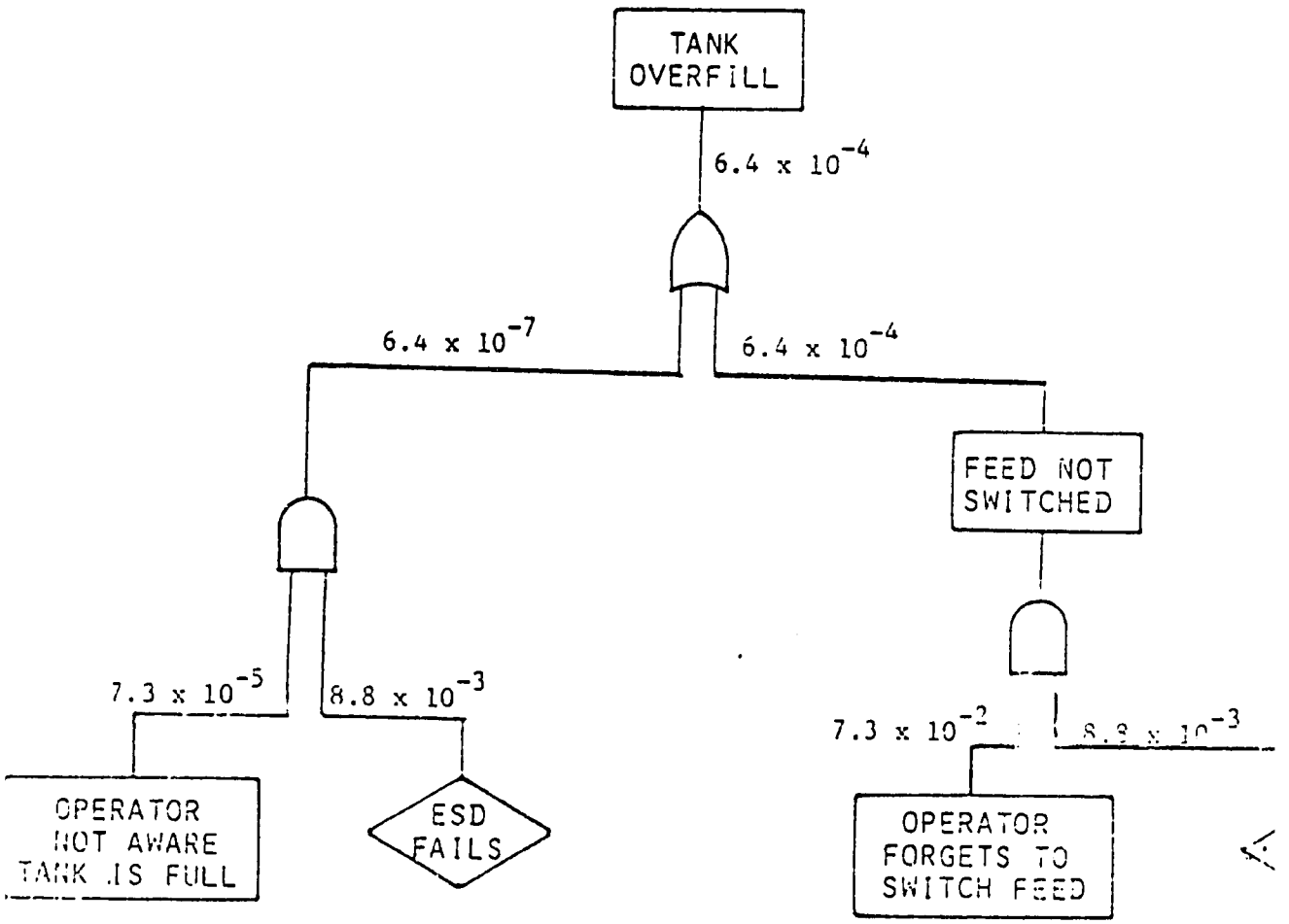
TANK OVERFILL CHANCE HAS BEEN REDUCED TO 7% PER YEAR

RISK NOW CONTROLLED BY OPERATOR NEGLECTING TO SWITCH FEED.

IMPROVEMENT:

ADD HIGH-HIGH LEVEL SENSOR AND AUTOMATIC EMERGENCY SHUTDOWN.

AFTER SECOND IMPROVEMENT



CONCLUSIONS:

OVERFILL CHANCE REDUCED TO LESS THAN 0.1% PER YEAR

FOR 30-YEAR FACILITY LIFE, CHANCE IS ABOUT 2%.

SOME FURTHER RISK REDUCTION IMPROVEMENTS

OPERATOR TESTS FLOAT GAUGE EACH SHIFT

TANK LEVEL DISPLAYED AND RECORDED IN CONTROL ROOM

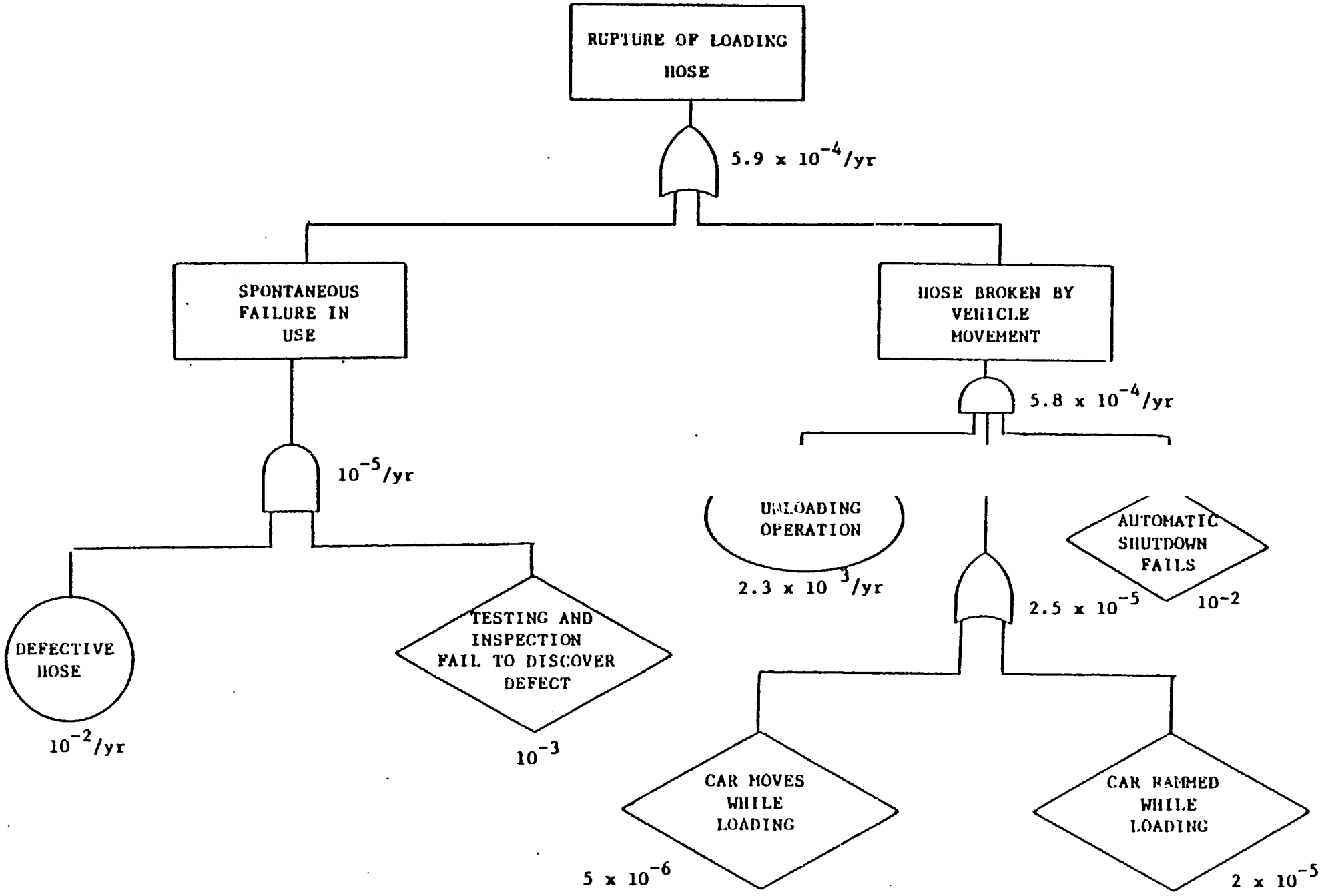
ADD REDUNDANT LIQUID LEVEL GAUGE

USE MORE THAN ONE INSTRUMENT TO INITIATE AUTOMATIC SHUTDOWN AT HIGH-HIGH LEVEL POINT

HAVE PROGRAM FOR TESTING AND MAINTAINING IMPORTANT SYSTEM COMPONENTS

HAVE CONTINGENCY PLANS PREPARED IF OVERFILL SHOULD OCCUR

PREVENT EMPLOYEE PROBLEMS THAT MIGHT LEAD TO INTENTIONAL MISOPERATION



FAULT TREE OF A HOSE RUPTURE

CONSEQUENCE OF EVENT

- IMPACT ON THE ENVIRONMENT
- IMPACT ON PROPERTY
- IMPACT ON PEOPLE
- IMPACT ON PROFITS

TYPES OF RISKS FROM HAZARDOUS MATERIAL RELEASES

FIRES	-	LIQUID FUELS
	-	FLAMMABLE VAPOR CLOUDS
	-	FIREBALLS
EXPLOSIONS	-	RUNAWAY REACTIONS
	-	CONFINED RAPID BURNING
	-	DETONATIONS
	-	SUPERHEAT PHENOMENA
TOXIC EFFECTS	-	TOXIC VAPOR CLOUDS (BOTH ACUTE AND DELAYED HEALTH EFFECTS)
	-	CONTAMINATION OF WATER

FOR COMBUSTION TO OCCUR

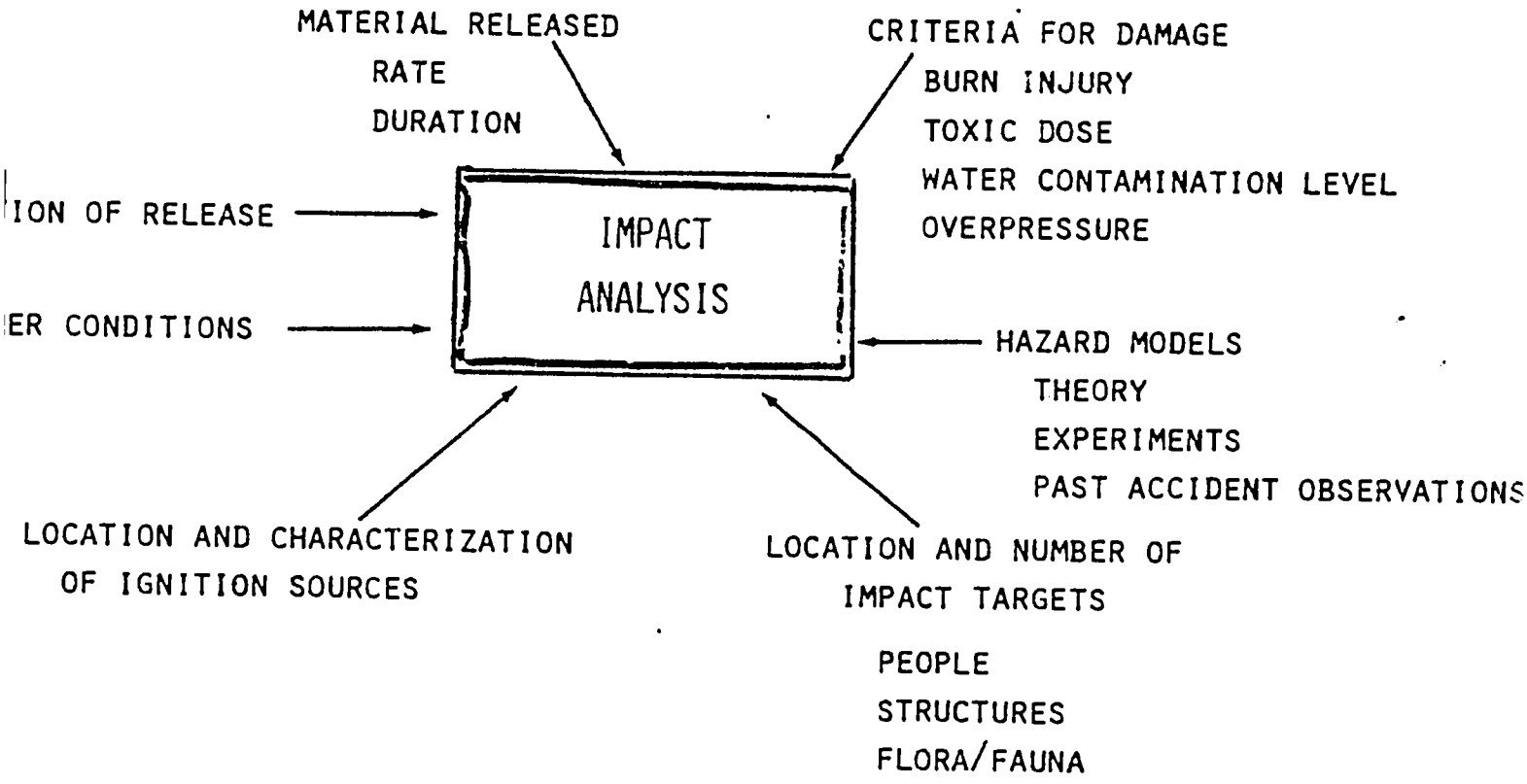
THREE CONDITIONS ARE REQUIRED

1. FUEL IN VAPOR PHASE
2. MIXTURE WITH AIR WITHIN FLAMMABILITY LIMITS
3. IGNITION SOURCE

PRACTICAL RULES:

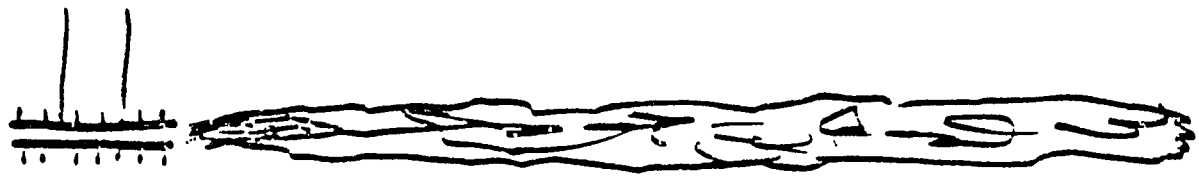
- IF ONLY ONE CONDITION EXISTS, IGNITION AND FIRE/EXPLOSION ARE UNLIKELY
- IF TWO CONDITIONS EXIST, BE EXTREMELY CAREFUL IF THE REMAINING CONDITION IS POSSIBLE

CONSEQUENCE ANALYSIS



TYPES OF FIRES:

1. JET FIRE (HIGH PRESSURE GAS)

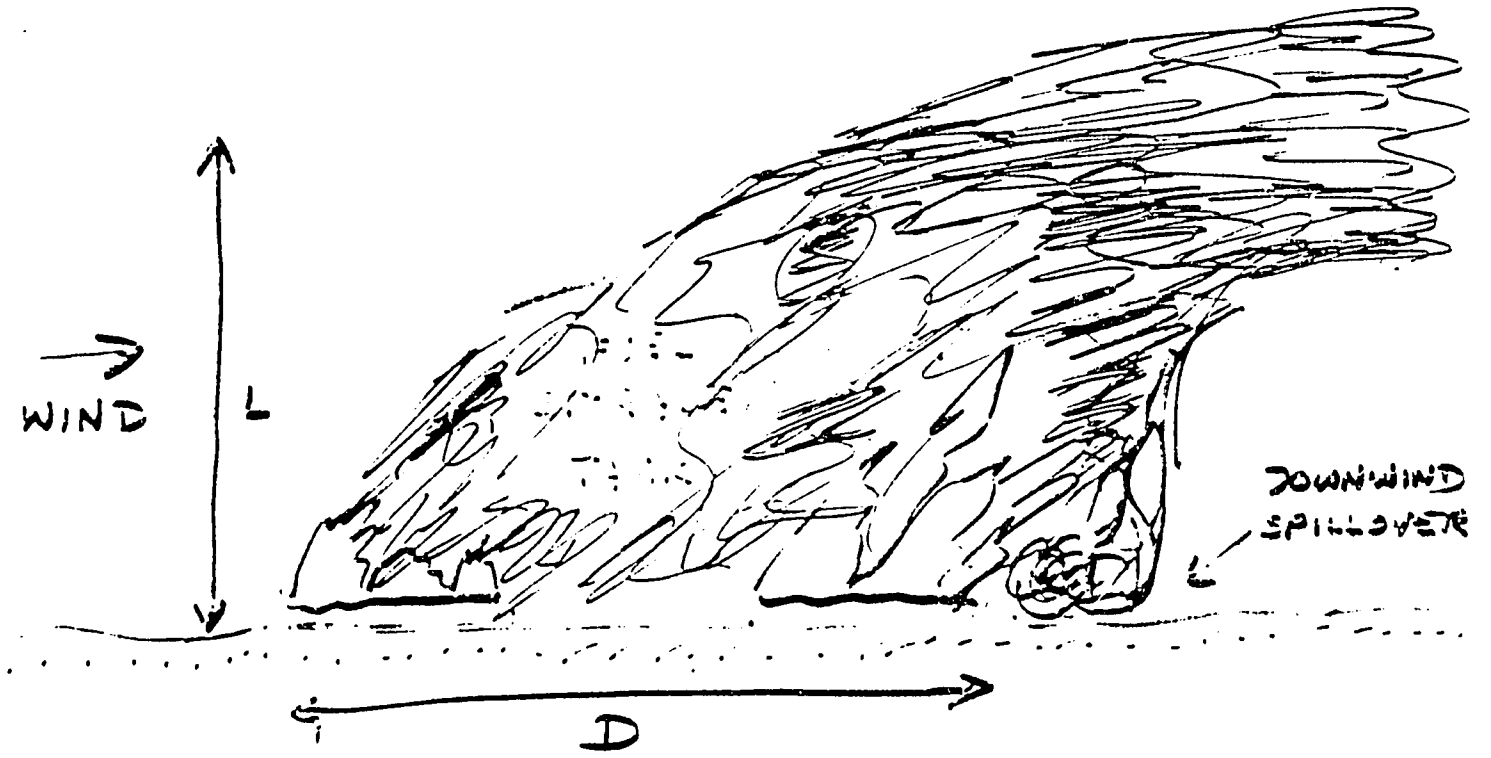


LENGTH OF FLAME ABOUT 20-40 TIMES DIAMETER (OR EQUIVALENT DIMENSION) OF LEAK.

- IF UNIGNITED*, FLAMMABLE ZONE IS ABOUT SAME AS FLAME ABOVE.
- FLAME MAY IMPINGE ON OTHER EQUIPMENT (SHIELD OR COOL)
- CONTROL BY SHUTTING OFF SOURCE OF FUEL

* DO NOT STAND IN FUEL JET ZONE. IGNITION MAY OCCUR UNEXPECTEDLY

2. POOL FIRE (LIQUID FUELS)
L/D ≈ 1.0



ACCIDENT SEQUENCE:

1. SPILL OF FUEL – THE MORE VOLATILE THE GREATER THE FLAMMABLE ZONE ABOVE THE POOL

2. IGNITION – (SOURCES INCLUDE STATIC CHARGE, RESPONSE VEHICLES, ELECTRICAL COMPONENTS THAT ARE NOT EXPLOSION PROOF, CARELESS SMOKING, ETC.)

3. FIRE DEVELOPMENT. BACK THERMAL RADIATION FROM FIRE SPEEDS VAPORIZATION OF FUEL

1KV

ARAMETERS REQUIRED TO CHARACTERIZE THERMAL RADIATION HAZARDS FROM POOL FIRES

- FIRE SHAPE AND SIZE (DIAMETER AND HEIGHT)
- EMISSIVE POWER OF THE FIRE
- TRANSMISSIVITY IN THE ATMOSPHERE
- GEOMETRIC VIEW FACTOR

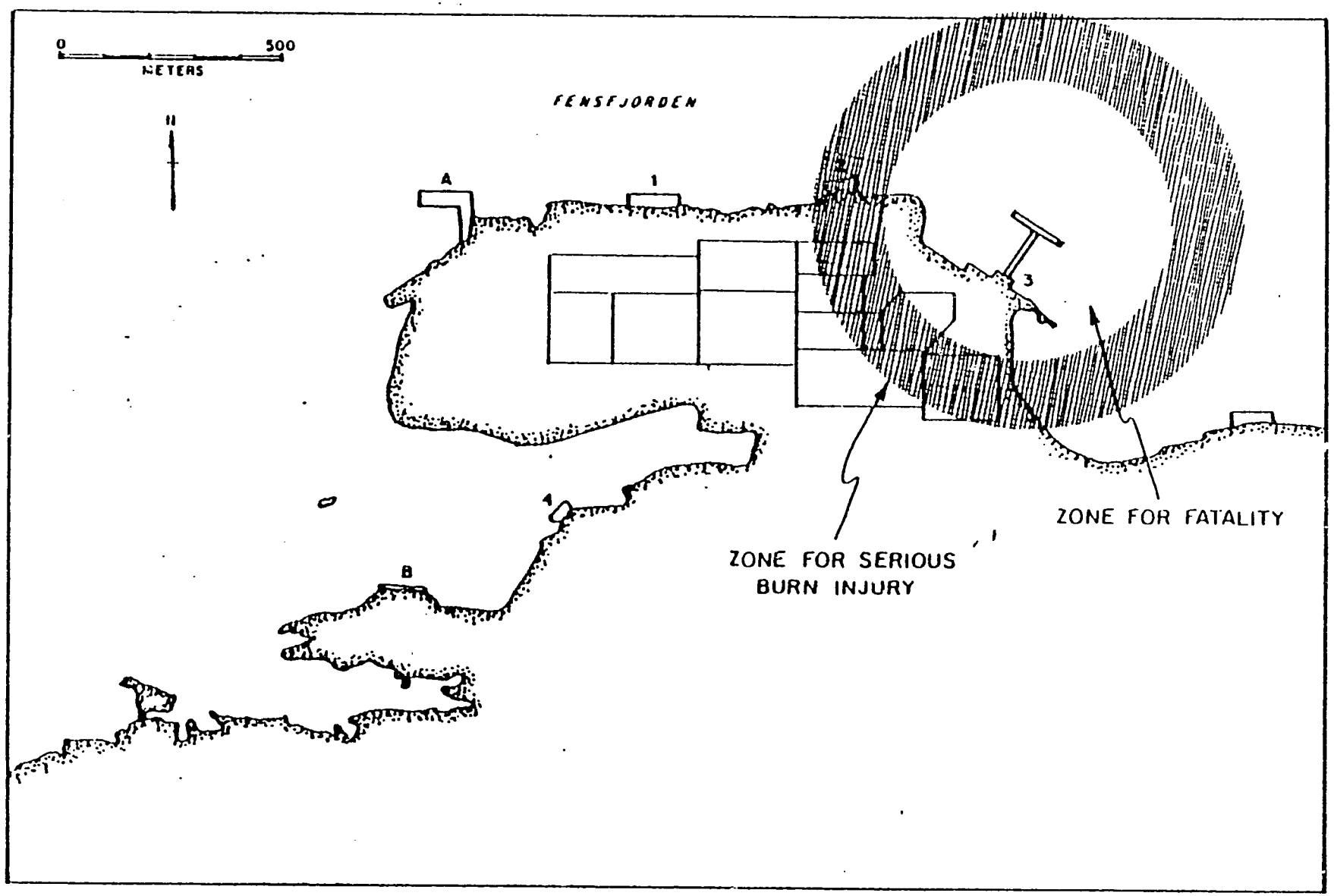


FIGURE 9. THERMAL RADIATION HAZARD FROM A 150m^3 REFRIGERATED LPG SPILL AT JETTY NO. 3.

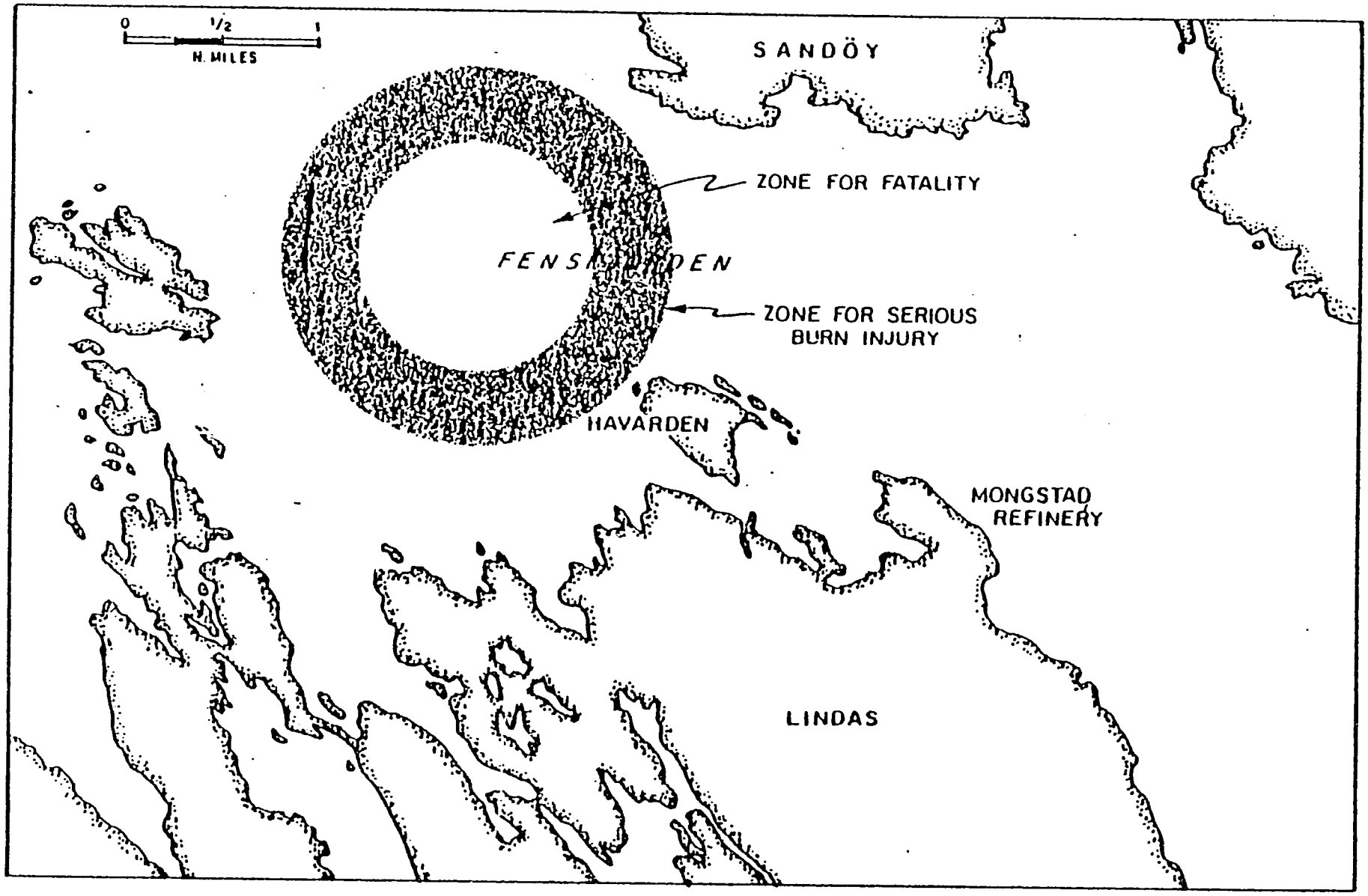
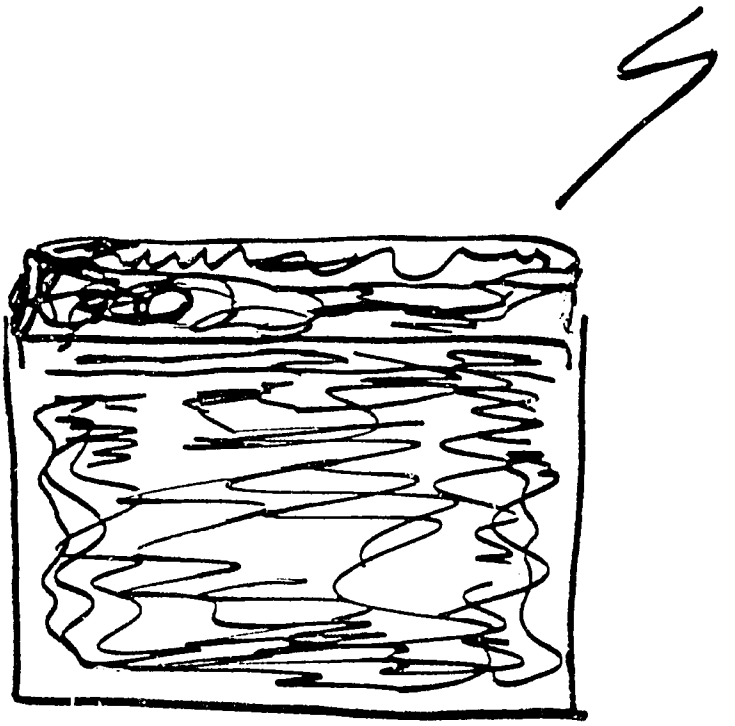


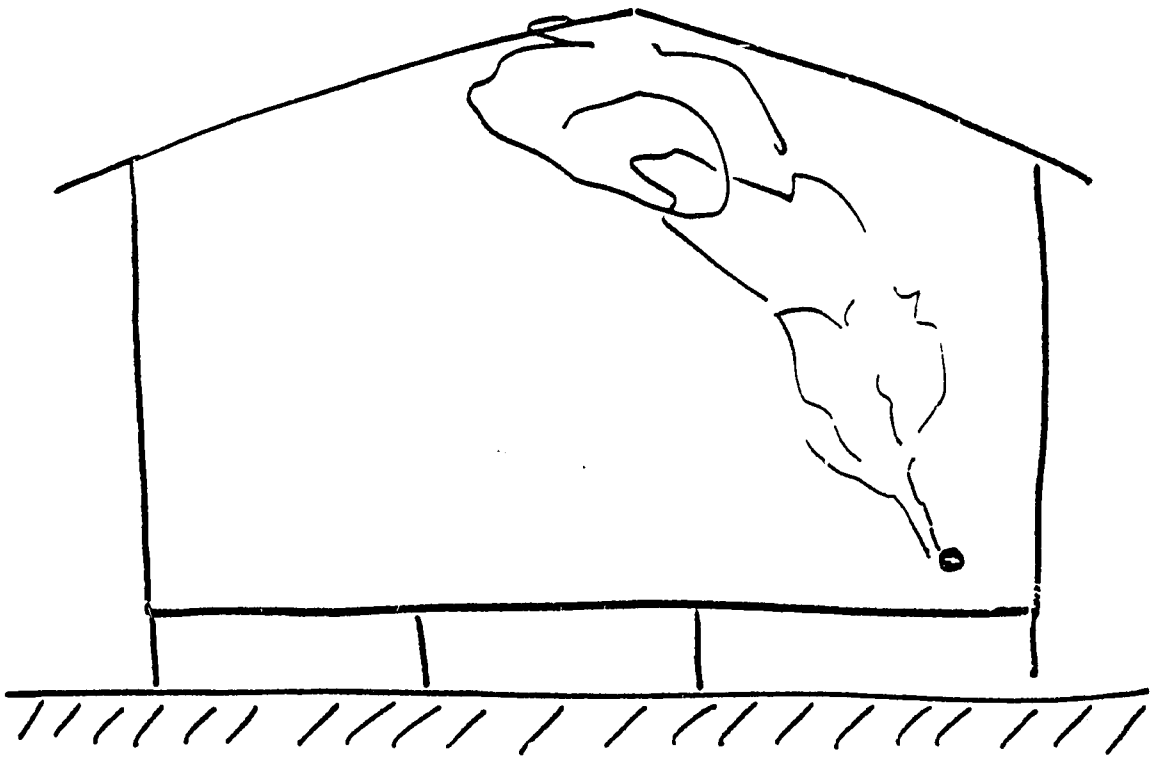
FIGURE 10. THERMAL RADIATION HAZARD FROM A 7400m^3 REFRIGERATED LPG SPILL IN TRANSIT AREA.

3. RIM FIRES (FLOATING ROOF FUEL STORAGE TANKS)



VAPOR LEAKS FROM SEAL. IGNITION USUALLY BY LIGHTNING OR STATIC DISCHARGE. SHOULD HAVE EXTINGUISHING SYSTEM IN PLACE AROUND RIM.

4. VAPOR CLOUD FIRE (FLASH FIRE)



SLOW LEAK OF LIGHT GAS

UPON IGNITION, FLAME WILL SPREAD THROUGHOUT PORTION OF FLAMMABLE AND FUEL RICH VAPOR CLOUD. FLAME SPREAD VELOCITIES IN RANGE OF 1 - 50 M/S

EXPLOSIONS / DETONATIONS

- EXPLOSION - PRESSURE BUILDUP IN VESSEL OR ENCLOSURE CAUSES SPONTANEOUS FAILURE OF STRUCTURE
  - PRESSURE WAVE
  - MISSILES FROM FAILED STRUCTURE

- DETONATION - COMBUSTION FRONT MOVES AT SONIC VELOCITY
  - HIGH OVERPRESSURES

PRACTICAL RULES:

- UNSATURATED HYDROCARBONS AND REACTIVE PRODUCTS ARE MORE LIKELY TO DETONATE

- FUEL/AIR RATIOS FOR DETONATION ARE NARROWER THAN FLAMMABILITY LIMITS

- PARTIAL CONFINEMENT AIDS DETONATION INITIATION

- DOES FUEL VAPOR ACCUMULATE ABOVE OR → BELOW LEAK?

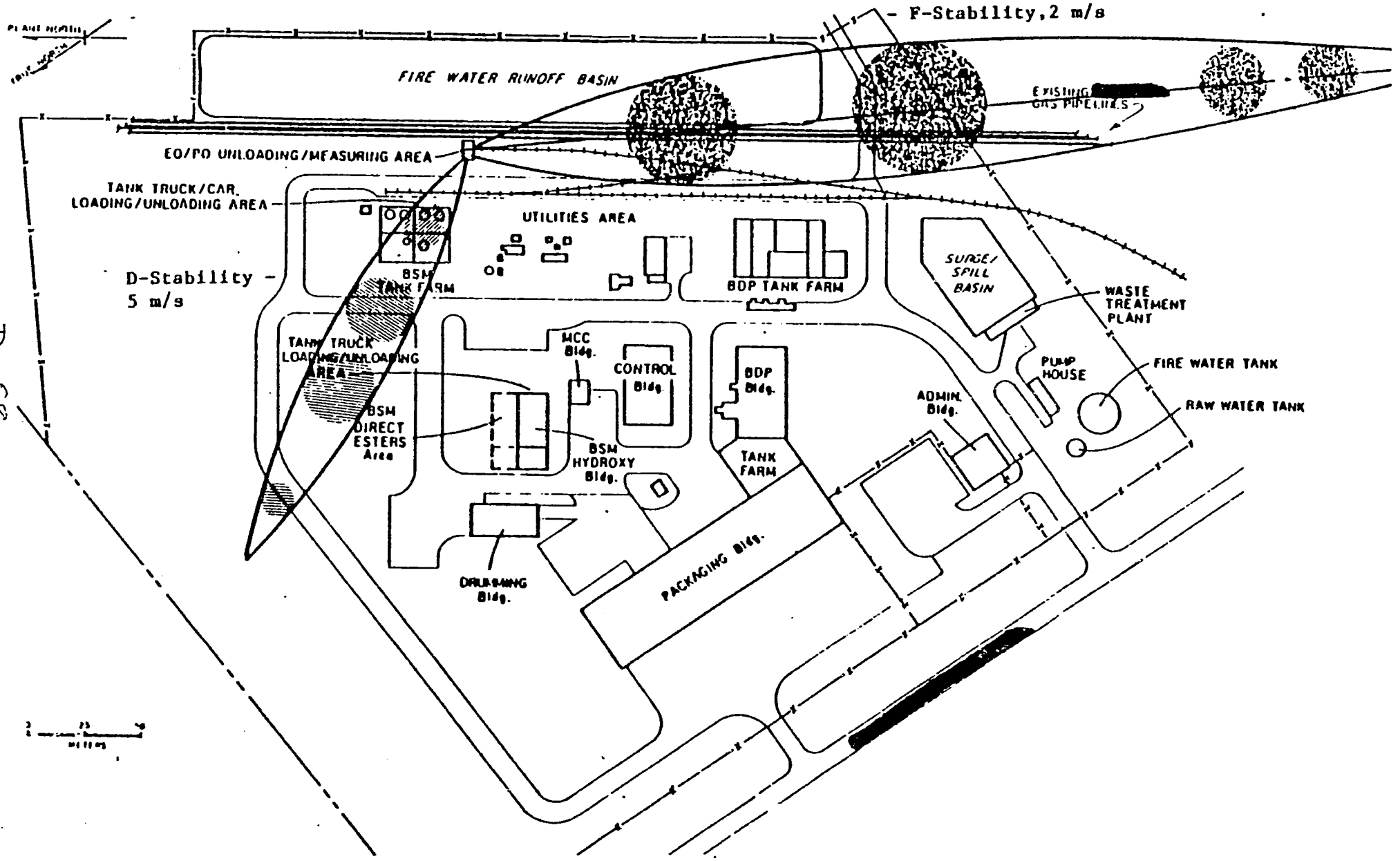
VAPOUR DISPERSION

VAPOUR EVOLUTION

- LIQUID SPILL RATE AND DURATION
- LIQUID SPREADING (CONFINED OR UNCONFINED)
- BOILING OR EVAPORATION

VAPOUR DISPERSION

- BUOYANT OR DENSE GAS GRAVITATIONAL EFFECTS
- ATMOSPHERIC DISPERSION
  - WIND SPEED
  - ATMOSPHERIC STABILITY


F-Stability, 2 m/s
FIRE WATER RUNOFF BASIN
EXISTING GAS PIPELINES
EO/PO UNLOADING/MEASURING AREA
TANK TRUCK/CAR LOADING/UNLOADING AREA
UTILITIES AREA
D-Stability - 5 m/s
BSM TANK FARM
BDP TANK FARM
SURGE/ SPILL BASIN
WASTE TREATMENT PLANT
TANK TRUCK LOADING/UNLOADING AREA
MCC Bldg.
CONTROL Bldg.
BDP Bldg.
PUMP HOUSE
FIRE WATER TANK
RAW WATER TANK
ADMIN. Bldg.
BSM DIRECT ESTERS Area
BSM HYDROXY Bldg.
TANK FARM
DRUMMING Bldg.
PACKAGING Bldg.

D-58

"ROLLOVER"

LNG, LPG AND NATURAL GAS LIQUIDS ARE MIXTURES AND VARY IN DENSITY AS COMPOSITION VARIES.

THESE DENSITY VARIATIONS CAN LEAD TO STRATIFICATION IN A STORAGE TANK.

LOWER LAYERS, UNDER HYDROSTATIC PRESSURE CAN ACCUMULATE HEAT.

EVENTUAL DENSITY EQUALIZATION CAUSES MIXING AND SUDDEN VAPORIZATION.

SYSTEMS WITH STRATIFICATION AND SUDDEN MIXING POTENTIAL

- OCEAN – SALINITY + THERMAL DIFFERENCES BOTH INFLUENCE DENSITY → "SALT FINGERS"

- REFRIGERATED AMMONIA STORAGE ($\simeq -40°F$ or $°C$) – WATER CONTENT AND THERMAL DIFFERENCES

- REFRIGERATED LPG STORAGE (C_3's + C_4's) AT $-40°C$ to $0°C$ COMPOSITION AND TEMP. VARIATION

- LNG STORAGE ($\sim -160°C$) (C_1's and some C_2's)

- ETHANE, ETHYLENE ETC. HAVE POTENTIAL BUT ARE NOT BULK COMMODITIES AND USUALLY ARE QUITE PURE

SUPERHEAT "EXPLOSIONS"

WITHIN CERTAIN COMPOSITION RANGES LNG MIXTURES MAY SUPERHEAT WHEN SPILLED ON WATER. WHEN THE SUPERHEAT LIMIT TEMPERATURE IS REACHED (HOMOGENEOUS NUCLEATION OCCURS EXTREMELY RAPIDLY), SUPERHEAT ENERGY IS RELEASED SUDDENLY IN A VIGOROUS INTERACTION WITH WATER.

- MORE LIKELY FOR HEAVIER LNG MIXTURES.
- ENERGY RELEASE LIMITED - NO REACTION.

HYDROGEN RISKS

VERY WIDE FLAMMABILITY LIMITS
EASILY IGNITABLE
SMALL MOLECULE WHICH CAN LEAK THROUGH PINHOLES
CAUSES EMBRITTLEMENT OF SOME METALS
BURNS WITH A PALE BLUE FLAME THAT MAY NOT BE VISIBLE UNDER CERTAIN LIGHTING CONDITIONS — NEED SPECIAL CARE IF A FIRE MIGHT BE POSSIBLE

GOOD PRACTICE:

- AT CRITICAL SEAL LOCATIONS, CAN USE A DOUBLE SEAL WITH SPACE BETWEEN SEALS FILLED WITH AN INERT GAS (LIKE N_2) AT A PRESSURE ABOVE HYDROGEN OPERATING PRESSURE*

* GAS WILL LEAK FROM HIGHER TO LOWER PRESSURE IF THERE IS A CONNECTING PATH.

19

TYPICAL OUTPUT OF RISK ASSESSMENT

A GRAPH OF

PROBABILITY OF VARIOUS EVENTS VS DEGREE OF IMPACT

Y – AXIS:

FREQUENCY OF OCCURRENCE

$$10^{-2}/YR = \frac{1}{10^2 YR} = \frac{1}{100 YR}$$

$$10^{-6}/YR = \frac{1}{10^6 YR} = \frac{1}{1{,}000{,}000 YR}$$

$10^{-6}/YR \equiv$ 1 CHANCE IN 1 MILLION THAT IT WILL HAPPEN NEXT YEAR

$10^{+6} YR \equiv$ EXPECTED INTERVAL BETWEEN EVENTS OF SUCH SEVERITY

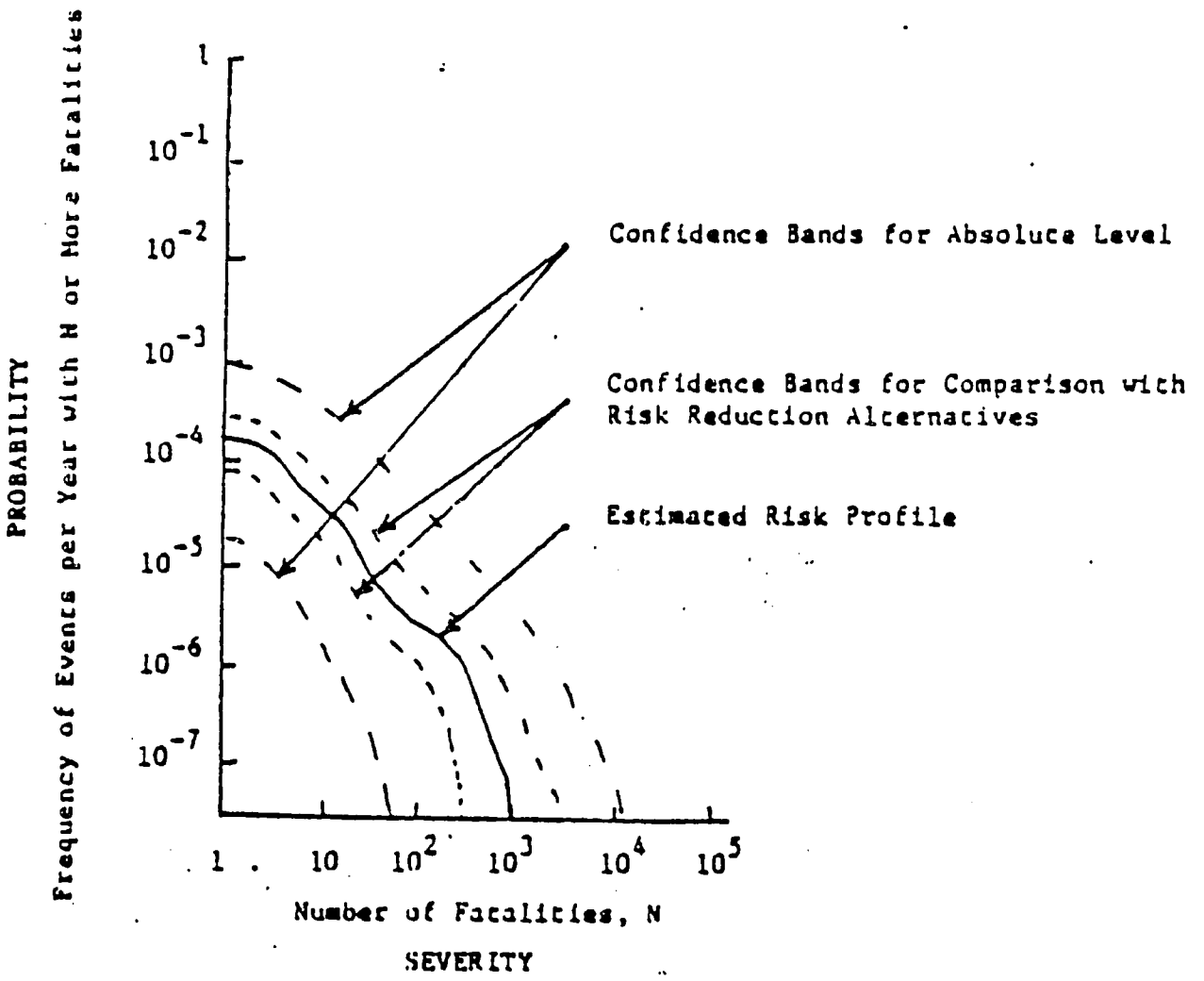
X – AXIS:

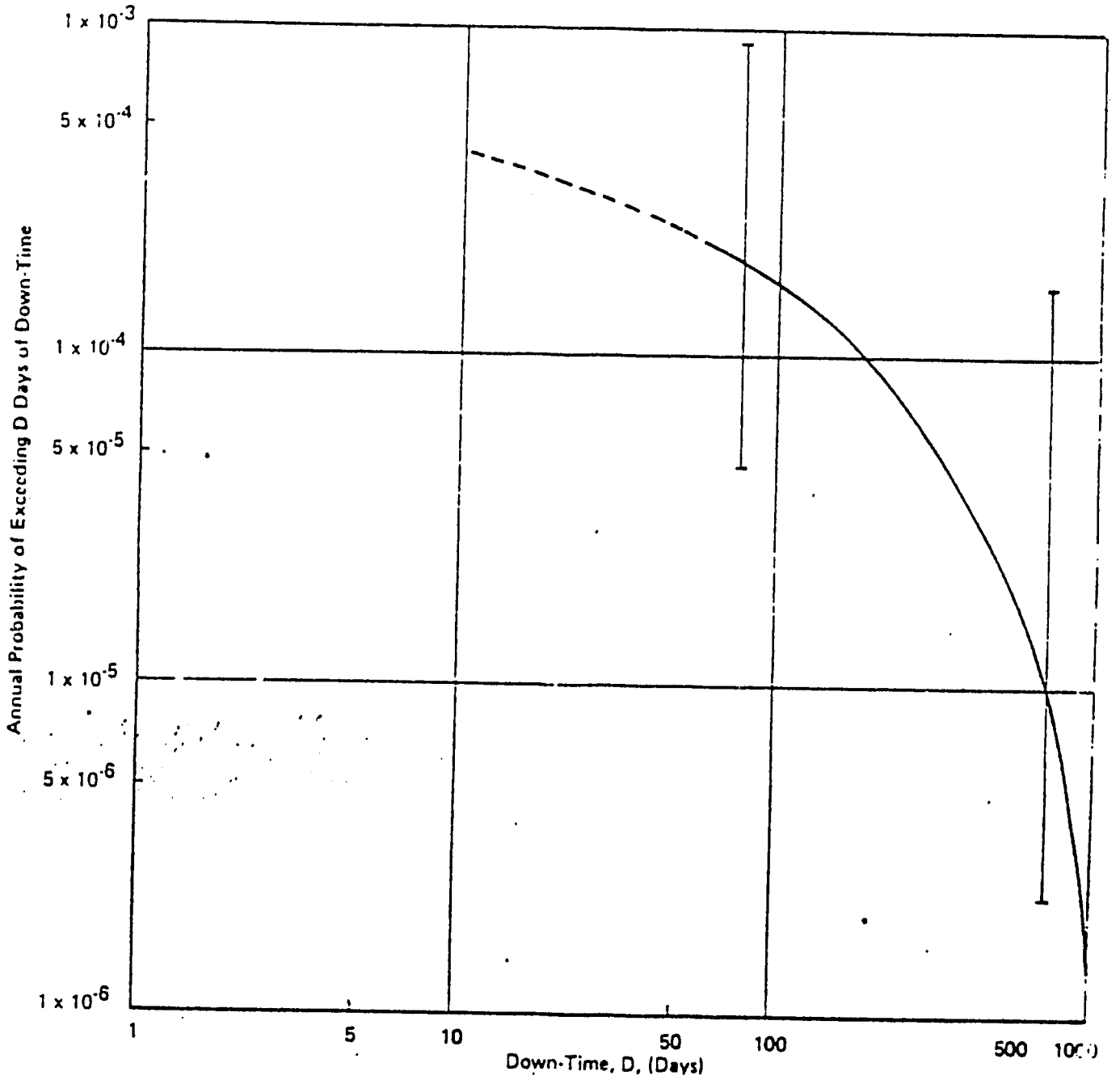
SEVERITY INDEX

- DOWNTIME
- BAHT LOST
- LIVES LOST
- INJURIES
- ENVIRONMENTAL DAMAGE

TYPICAL RISK PROFILE

EXAMPLE BASED ON SEVERITY MEASURED IN TERMS OF FATALITIES





*Down-time is defined as the days during which crude oil either cannot be received, be sent out or both as a result of an accident in the LPG or ethane/propane system.

ACCEPTABILITY OF RISKS ____

- WHAT RISKS ARE LOW ENOUGH TO BE CONSIDERED ACCEPTABLE?
- HOW DOES AN INDIVIDUAL VIEW RISKS?
- HOW DOES A GOVERNMENT REGULATORY AGENCY VIEW RISKS?
- HOW DOES A BUSINESS OR INDUSTRY VIEW RISKS?

AN INDIVIDUAL'S PERCEPTION OF RISKS

- VOLUNTARY
- INVOLUNTARY

D-68

FACTORS INFLUENCING ACCEPTABLE LEVELS OF RISK TO INDIVIDUALS

(MEASURED IN TERMS OF THE INDIVIDUAL'S PROBABILITY OF DYING DUE TO AN ACCIDENT)

- IS EXPOSURE VOLUNTARY OR INVOLUNTARY?
- WHAT BENEFITS ACCRUE TO THE EXPOSED INDIVIDUAL?
- HOW DOES THE RISK COMPARE TO OTHER RISKS BORNE BY THE INDIVIDUAL?
- ARE OVERALL RISKS DISTRIBUTED EQUITABLY AMONG THE INDIVIDUAL MEMBERS OF SOCIETY?

ANNUAL MORTALITY RATES FOR ACCIDENTAL CAUSES
OF DEATH IN THE UNITED STATES
SUBDIVIDED BY CAUSE OF DEATH, 1978

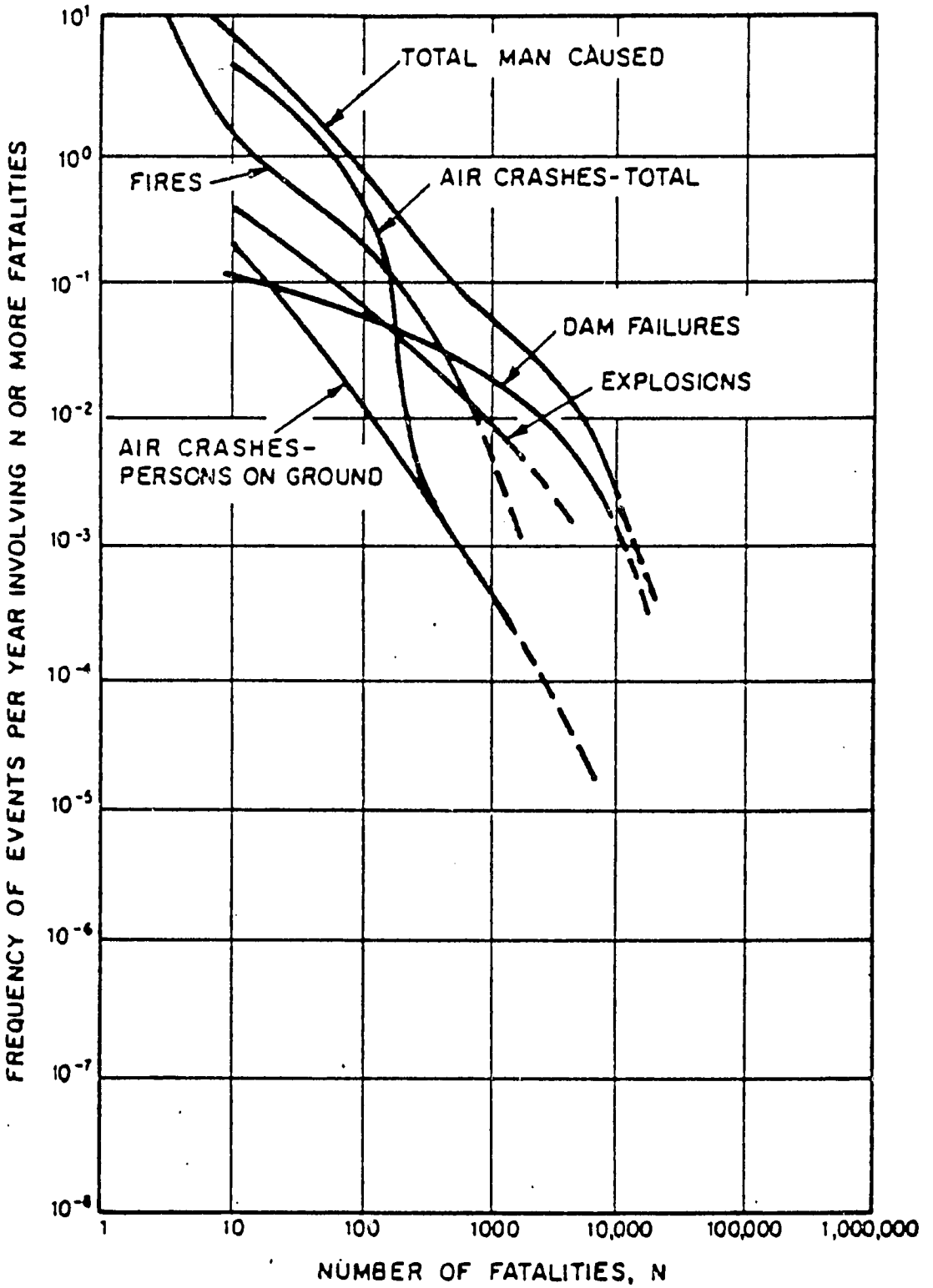
CAUSE OF DEATH	ANNUAL MORTALITY RATE
ALL ACCIDENTS	4.8×10^{-4}
TRANSPORT ACCIDENTS	2.6×10^{-4}
RAILWAY ACCIDENTS	2.8×10^{-6}
MOTOR VEHICLE ACCIDENTS	2.4×10^{-4}
WATER TRANSPORT	6.7×10^{-6}
AIR AND SPACE TRANSPORT	8.6×10^{-6}
POISONING BY SOLIDS AND LIQUIDS	1.4×10^{-5}
POISONING BY GASES AND VAPORS	8.0×10^{-6}
FALLS	6.3×10^{-5}
FIRES AND FLAMES	2.8×10^{-5}
NATURAL AND ENVIRONMENTAL FACTORS	7.5×10^{-6}
LIGHTNING	4.5×10^{-7}
CATACLYSM (TORNADO, FLOOD, EARTHQUAKE)	5.7×10^{-7}
DROWNING	2.7×10^{-5}
FIREARMS	8.3×10^{-6}
ELECTRIC CURRENT	4.5×10^{-6}

(TAKEN FROM "ACCIDENT FACTS," NATIONAL SAFETY COUNCIL, 1981.)

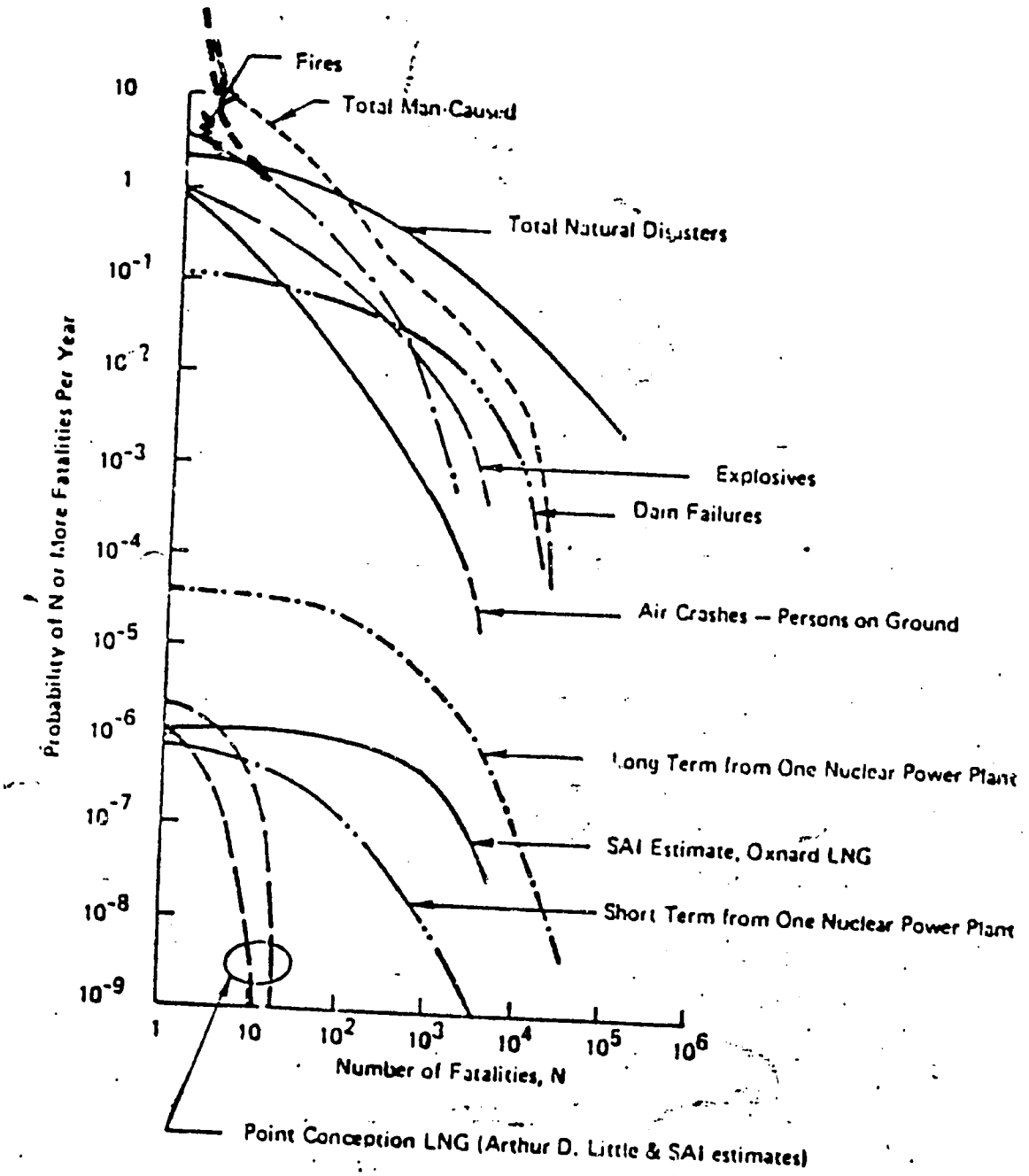
FACTORS INFLUENCING ACCEPTABLE LEVELS OF RISK TO SOCIETY AS A WHOLE

(MEASURED IN TERMS OF THE LIKELIHOODS OF ACCIDENTS OF VARIOUS SEVERITIES)

- HOW MANY FATALITIES COULD RESULT FROM A MAJOR DISASTER?
- WHAT IS THE LIKELIHOOD OF SUCH A MULTIPLE-FATALITY ACCIDENT?



(Source: "Reactor Safety Study", US Nuclear Regulatory Comm., 1975)



COMPARISON OF MULTI-FATALITY ACCIDENT PROBABILITIES*

* Adapted from WASH-1400 Reactor Safety Study, SAI Reports and Arthur D. Little Tech. Report 16.

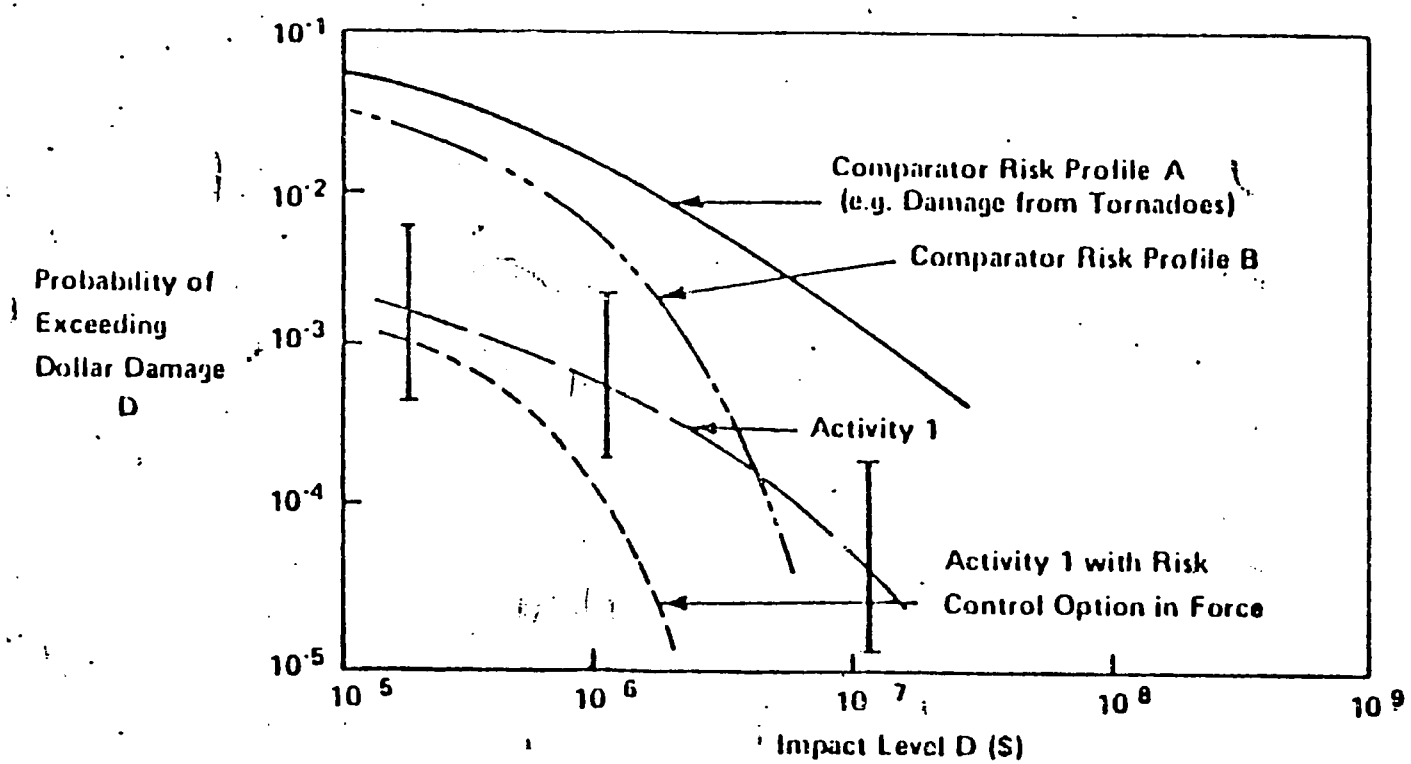
RISK CONTROL

REDUCE PROBABILITY OF OCCURRENCE

REDUCE CONSEQUENCES

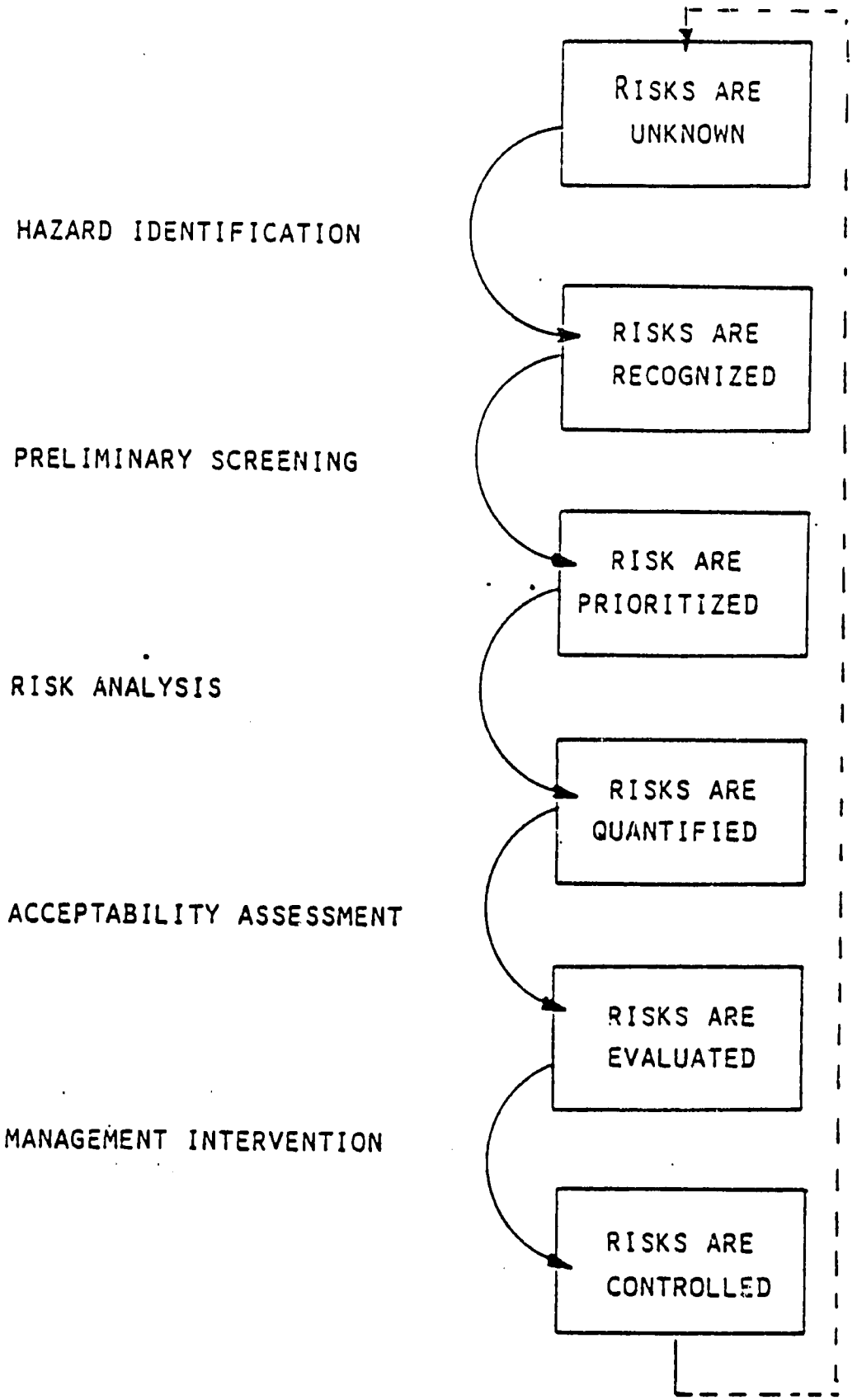
D-74

HYPOTHETICAL RISK PROFILE



MAINTAINING SAFE OPERATION

AN OVERVIEW OF THE CORPORATE RISK MANAGEMENT PROCESS



CONTINUING SAFE OPERATION

- PROGRAMS FOR NEW PERSONNEL
- PERIODIC REFRESHER PROGRAMS FOR ALL PERSONNEL

GOAL: ALL PERSONNEL SHOULD BE THOROUGHLY EXPERT IN THEIR OWN JOB RESPONSIBILITIES AND SHOULD HAVE GENERAL FAMILIARITY WITH PROCEDURES FOR:

- OPERATIONS
- MAINTENANCE
- EMERGENCY SHUTDOWN
- EMERGENCY RESPONSE
  - NOTIFICATION, CHAIN OF COMMAND
  - SOURCES OF HELP
  - COORDINATION WITH LOCAL SERVICES (FIRE, POLICE)
- FIRST AID
- FIRE FIGHTING

TRAINING SIMULATORS

- EXCELLENT FOR TRAINING NEW PERSONNEL

- MAY NOT BE EXACTLY IDENTICAL TO ACTUAL CONTROL SYSTEM (DIFFERENCES CAN BE IDENTIFIED AND NOTED)

- CAN BE USED FOR GIVING EXPERIENCED OPERATIONS PERIODIC PRACTICE IN RESPONDING TO EMERGENCY SITUATIONS

COMPUTER CONTROL OF PROCESSES

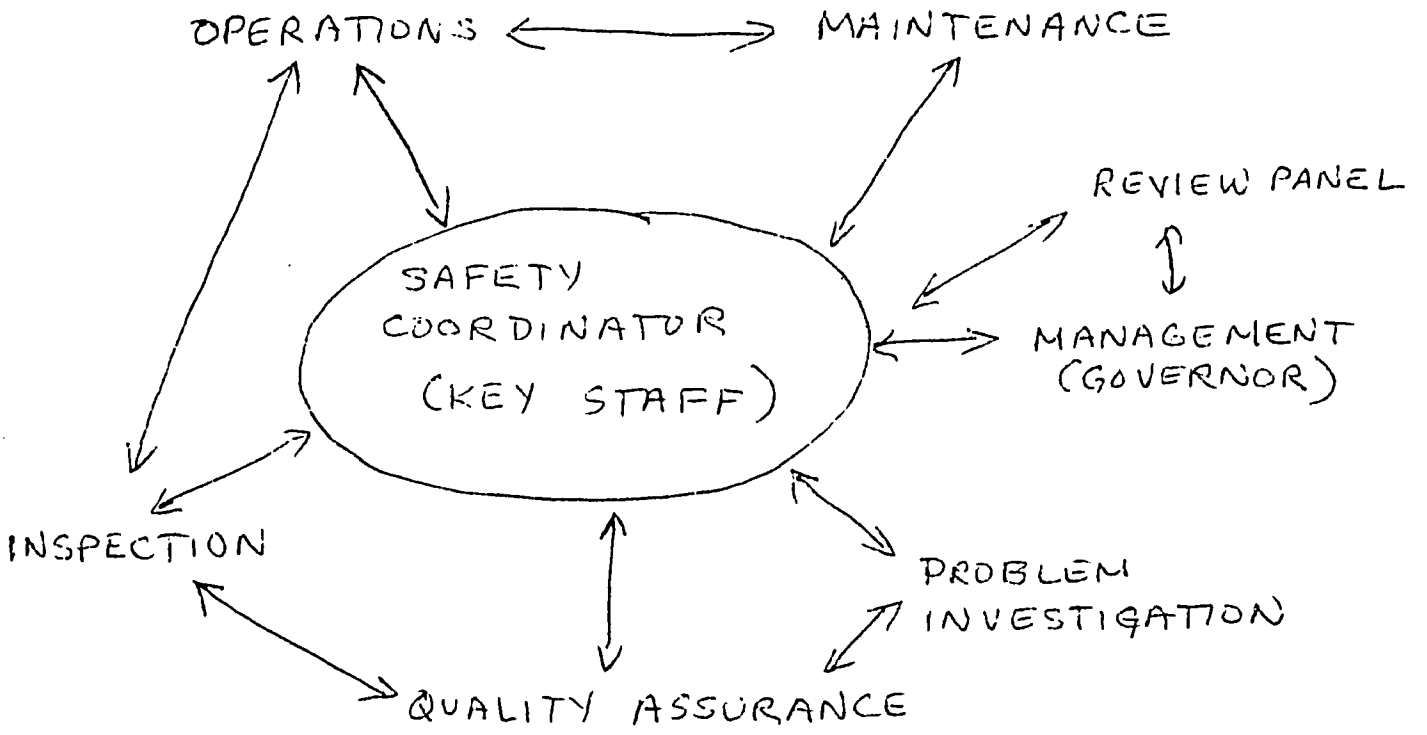
TOO MUCH: OPERATOR SERVES MINIMAL FUNCTIONS AND STAYS MAINLY IN CONTROL ROOM. OPERATOR BECOMES BORED. OPERATOR MAY PANIC IN AN EMERGENCY IF AUTOMATIC SHUTDOWN SYSTEMS FAIL.

TOO LITTLE: FOR A COMPLEX FACILITY, MANY OPERATORS AND SUPERVISORS ARE NEED. FEW KNOW THE TOTAL SYSTEM AND SUBSYSTEM INTERACTIONS. IN AN EMERGENCY ⟶ CONFUSION!

JUST RIGHT: OPERATORS ARE COMPUTER PROFICIENT BUT ALSO KNOW EQUIPMENT FROM ACTUAL OPERATING/MAINTENANCE EXPERIENCE. THEY THOROUGHLY KNOW:

OPERATING PROCEDURES
MAINTENANCE PROCEDURES
EMERGENCY PROCEDURES

THE SAFETY TEAM



- INFORMATION FLOWS ARE TWO-WAY
- SAFETY COORDINATOR REPORTS TO TOP MANAGEMENT
- TOP MANAGEMENT EMPHASIS AND COMMITMENT TO SAFETY

QUALIFICATIONS FOR SAFETY COORDINATOR

- STRONG TECHNICAL KNOWLEDGE
- EXTENSIVE PRACTICAL EXPERIENCE
- INDEPENDENT
- GOOD COMMUNICATION SKILLS
- LEADERSHIP
- SKEPTICISM

SOME RESPONSIBILITIES OF SAFETY COORDINATOR

- SET AND ENCOURAGE HIGH SAFETY STANDARDS
- ESTABLISH AND INTERPRET DATA FROM:

  OPERATIONS – FAULTS, ALARMS, CAUSES OF DOWNTIME

  MAINTENANCE – EARLY WEAR POINTS

  ACCIDENTS – MINOR UPSETS, PLANT SHUTDOWNS, MORE SERIOUS ACCIDENTS

- REVIEW ANY CHANGES IN EQUIPMENT AND/OR PROCEDURES FOR SAFETY
- SUPPORT ANNUAL FACILITY SAFETY AUDIT

PERIODIC SAFETY REVIEW

- ANNUAL FOR EARLY YEARS OF OPERATION (LESS FREQUENT IF OPERATING EXPERIENCE INDICATES)

- ASSEMBLE REVIEW TEAM (8-10 PEOPLE)
  - KEY PEOPLE FROM FACILITY OPERATIONS, MAINTENANCE
  - OUTSIDE PEOPLE FROM SIMILAR FACILITIES
  - TECHNICAL EXPERTS

- CONDUCT INTENSIVE 2-3 DAY REVIEW ON-SITE

- REPORT TO SAFETY COORDINATOR AND TOP MANAGEMENT.

IN SUMMARY

- RISK ANALYSIS IS USEFUL IN THE INITIAL DESIGN OF A "SAFE" FACILITY
- THE SAME TYPE OF ANALYSIS CAN BE USED TO ACHIEVE DESIRED SYSTEM RELIABILITY
- RISK ANALYSIS IS USEFUL IN DEVELOPING OPERATING, MAINTENANCE AND EMERGENCY PROCEDURES
- THE METHODOLOGY OF RISK ANALYSIS FORCES A SYSTEMATIC AND THOROUGH REVIEW OF SYSTEM SAFETY — A VALUABLE TOOL IN IDENTIFYING POTENTIAL HAZARDS
- SAFETY IS A CONCERN THROUGHOUT THE LIFETIME OF THE FACILITY
- TRAINING PROGRAMS FOR NEW PERSONNEL AND FOR EXPERIENCED PERSONNEL WILL REDUCE ACCIDENTS DUE TO HUMAN ERROR. SUCH PROGRAMS ARE VERY IMPORTANT
- CHANGES IN EQUIPMENT AND/OR PROCEDURES SHOULD BE REVIEWED FOR SAFETY IMPACTS
- ACCIDENTS SHOULD BE STUDIED CAREFULLY TO IMPROVE SAFETY
- MANAGEMENT SHOULD SHOW STRONG COMMITMENT TO SAFETY INCLUDING PERIODIC INDEPENDENT AUDITS

PROPERTIES AND SAFE HANDLING OF NATURAL GAS AND GAS LIQUIDS

14 FEBRUARY 84

GAS SEPARATION PLANT SITE AT RAYONG

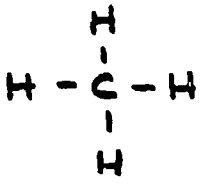
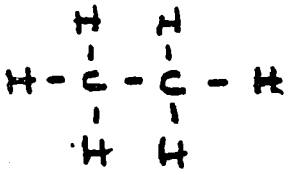
PROF. BERNARD GOODWIN
PROF. ELISABETH DRAKE

NORTHEASTERN UNIVERSITY
BOSTON, MASSACHUSETTS
U.S.A.

CHEMICAL ELEMENTS

NAME	SYMBOL	ATOMIC WEIGHT
CARBON	$-\overset{|}{\underset{|}{C}}-$	12
HYDROGEN	H-	1
OXYGEN	-O-	16

CHEMICAL COMPOUNDS

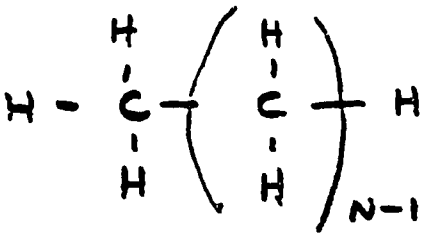
WATER (H_2O)	H-O-H	18
CARBON DIOXIDE (CO_2)	O=C=O	44
METHANE (CH_4)		16
ETHANE (C_2H_6)		30

CHEMICAL REACTION

$$CH_4 + 2H_2O \xrightarrow{T,P} 4H_2 + CO_2$$

HYDROCARBONS

COMPOUNDS CONTAINING ONLY CARBON AND HYDROGEN. GENERAL FORMULA FOR SATURATED HYDROCARBONS IS $C_N H_{2N+2}$ OR



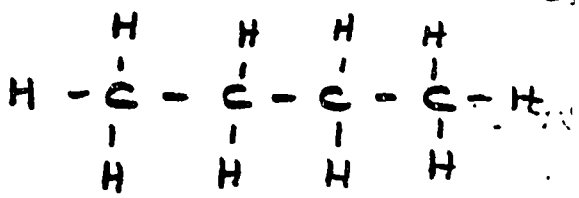
SIMPLEST HYDROCARBON IS METHANE (CH_4).

N	NAME	FORMULA	MOL. WT.
1	METHANE	CH_4	16
2	ETHANE	C_2H_6	30
3	PROPANE	C_3H_8	44
4	BUTANE	C_4H_{10}	58
5	PENTANE	C_5H_{12}	72
6	HEXANE	C_6H_{14}	86
7	HEPTANE	C_7H_{16}	100

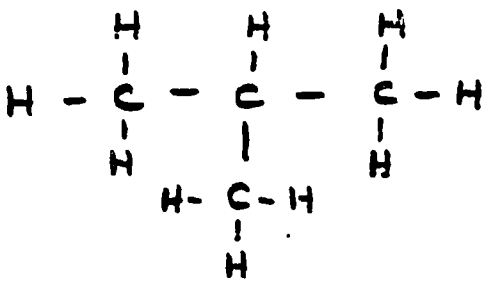
SPECIAL NOMENCLATURE

A. SATURATED HYDROCARBONS

1. "NORMAL" - WHEN ALL CARBONS ARE IN A ROW. EG. N-BUTANE

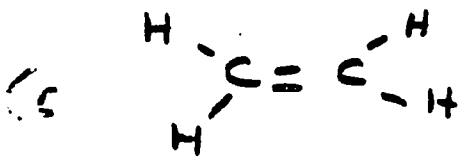


2. "ISO" - WHEN CARBONS BRANCH
   EG. ISO-BUTANE

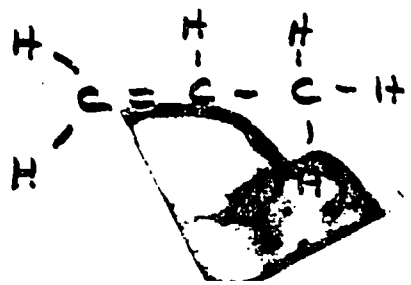


B. UNSATURATED HYDROCARBONS (OLEFINS)

WHEN MORE THAN ONE BOND EXISTS BETWEEN THE SAME TWO CARBONS. FOR A DOUBLE BOND THE "....ANE" IS CHANGED TO "....YLENE". EG. ETHYLENE



OR PROPYLENE



PHYSICAL MIXTURES

- SEPARATE COMPOUNDS (OR ELEMENTS) ARE COMBINED TOGETHER IN VARYING AMOUNTS TO FORM A MIXTURE. NO REACTIONS OCCUR.

- COMPOUNDS IN SUCH MIXTURES MAY BE SEPARATED BY PHYSICAL MEANS E.G. HEATING, COOLING, BOILING, FREEZING, COMPRESSING (CHANGING T AND P), DISTILLING, ETC.

  EXAMPLES: SALT IN WATER, WATER IN AIR

CHEMICAL MIXTURES (REACTIONS)

- COMPOUNDS REACT AND ARE CHANGED TO PRODUCTS IN RATIOS DETERMINED BY A BALANCED CHEMICAL REACTION EQN.

- CHEMICAL BONDS MUST BE BROKEN AND REFORMED DIFFERENTLY TO REVERSE PROCESS

  EXAMPLES: $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$

  $C_2H_6 \rightarrow C_2H_4 + H_2$

THAILAND NATURAL GAS

- MIXTURE OF SATURATED HYDROCARBONS C_1 THROUGH C_7
- ALSO INCLUDES THE USUAL UNWANTED COMPOUNDS: CARBON DIOXIDE, HYDROGEN SULFIDE, WATER AND SOME OTHER MATERIALS
- CURRENTLY 180 MMSCFD OF METHANE PRODUCED WITH EXCELLENT POTENTIAL TO INCREASE PRODUCTION
- ANALYSIS (AFTER PURIFICATION)

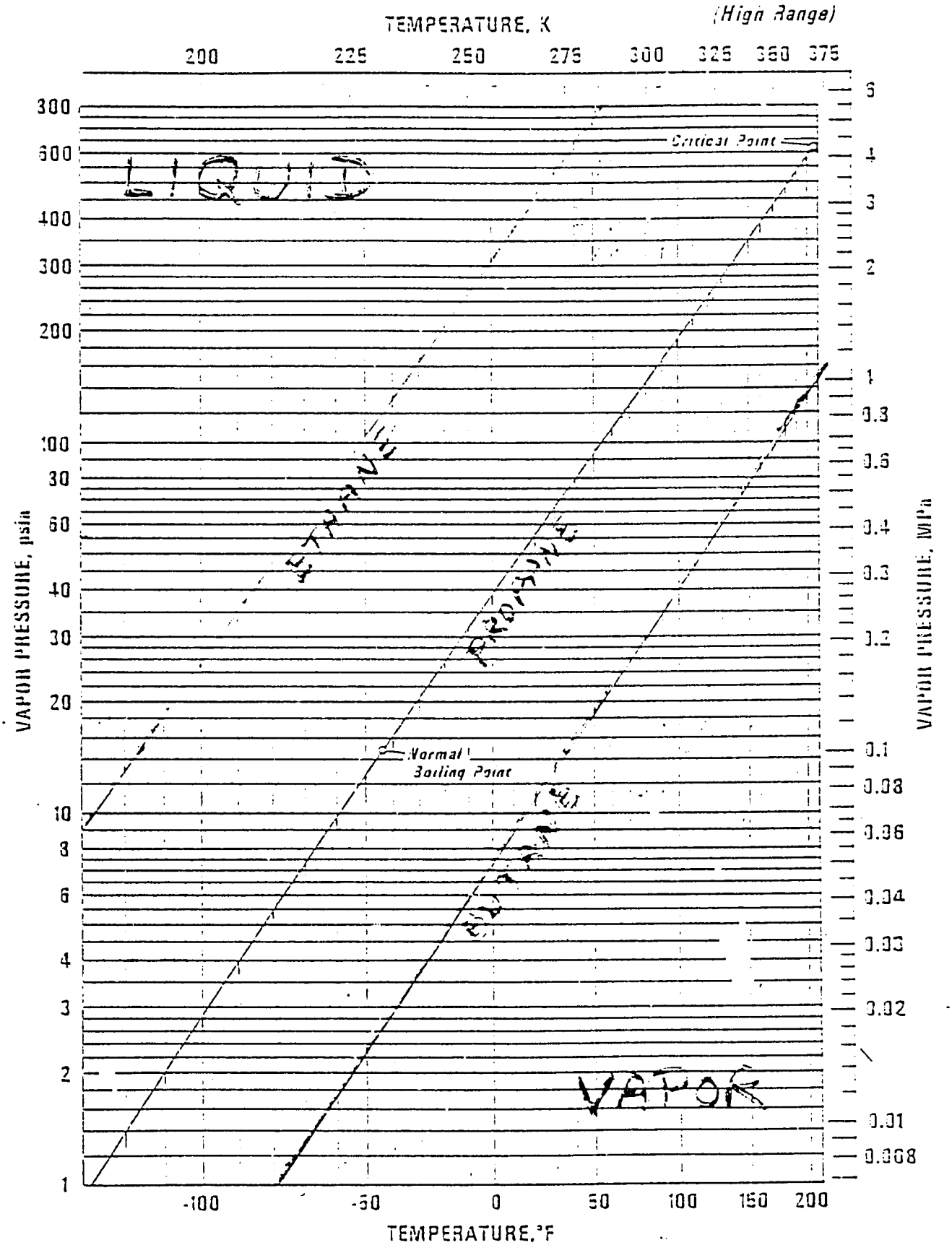
COMPOUND	WEIGHT %	MOL %
CH_4	65.1	81.7
C_2H_6	13.4	9.5
C_3H_8	12.1	6.5
C_4H_{10}	6.7	1.5
C_5^+	2.7	0.8

SOME TYPICAL PROPERTIES

	METHANE	ETHYLENE	ETHANE	PROPANE	BUTANE	TYPICAL LIGHT GASOLINE
AL .A	CH_4	C_2H_4	C_2H_6	C_3H_8	C_4H_{10}	C_5^+
LAR T	16	28	30	44	58	86^+
PT. ATM) °C	-162	-104	-89	-42	0	47^+
AT kg/m³	427	567	544	583	602	656^+
AT kg/m³	1.75	2.09	2.06	2.43	2.71	3.0^+
RE AT ATM	N.A.	N.A.	50	18	5	1^-
-UPPER BILITY IN AIR %	5-15	3.1-12.5	3-12.5	2.1-9.5	1.9-8.5	$1^- - 7^-$
F COM- kcal/kg	13,100		12,000	11,600	11,400	$11,000^-$

PROPANE

Vapor Pressure - Temperature (High Range)



Thermophysical Properties Division NBS-NBL Boulder Colorado

Chart 1069 2-15-73

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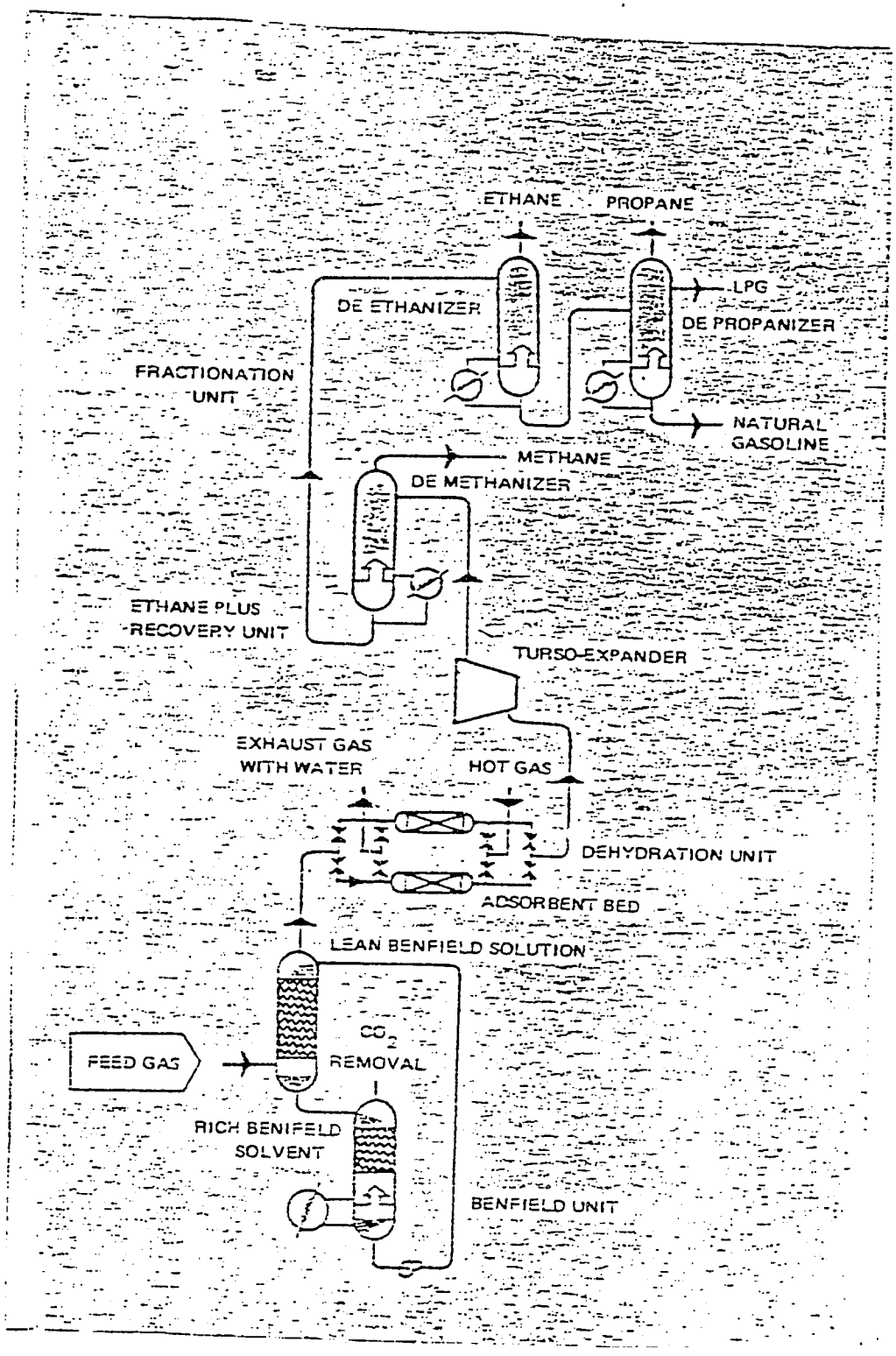
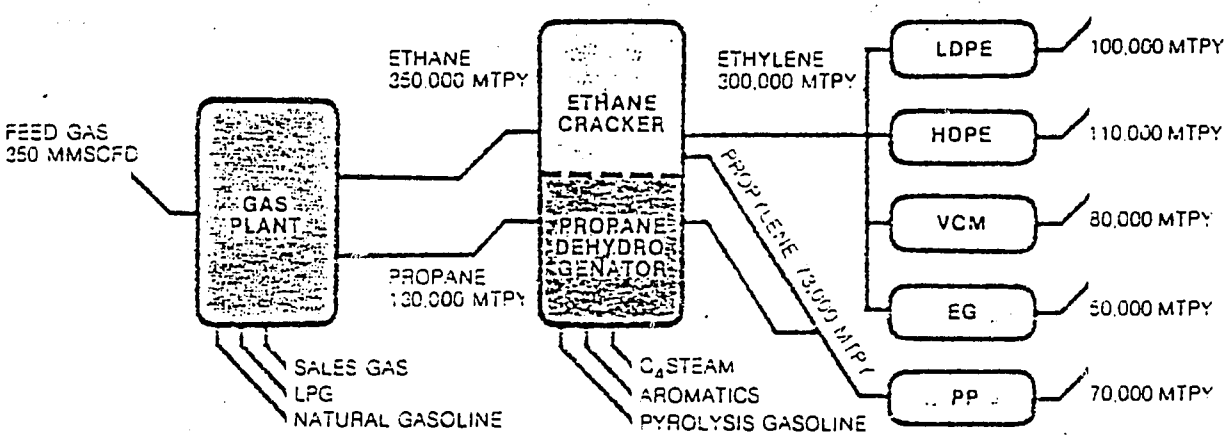
204


ETHANE
PROPANE
LPG
DE ETHANIZER
DE PROPANIZER
FRACTIONATION UNIT
NATURAL GASOLINE
METHANE
DE METHANIZER
ETHANE PLUS RECOVERY UNIT
TURSO-EXPANDER
EXHAUST GAS WITH WATER
HOT GAS
DEHYDRATION UNIT
ADSORBENT BED
LEAN BENFIELD SOLUTION
FEED GAS
CO_2 REMOVAL
RICH BENIFELD SOLVENT
BENFIELD UNIT

E-9

PROPOSED PETROCHEMICAL COMPLEX



PRELIMINARY SAFETY ANALYSIS

PURPOSE: TO AID IN SITE SELECTION FOR A PARTICULAR PROJECT

METHOD:

- FROM BASIC FLOW SHEET AND PRELIMINARY SIZING OF MAJOR VESSELS AND TANKS, IDENTIFY QUANTITIES AND TYPES OF HAZARDOUS MATERIALS THAT MIGHT BE RELEASED ACCIDENTALLY

- USE HAZARD ESTIMATION MODELS TO PREDICT POTENTIAL HAZARD AREAS (FIRE, EXPLOSION, TOXIC VAPOR) FOR EACH SUCH EVENT

- REVIEW AMOUNT AND TYPE OF PAST EXPERIENCE WITH THE SAME OR SIMILAR TECHNOLOGY

- SELECT SAFETY DISTANCES FOR SITE SELECTION (MULTIPLE CRITERIA)

SAFETY DISTANCE CRITERIA:

- DISTANCE TO PREVENT FIRE SPREAD OFFSITE (OR CAUSE DAMAGE TO ADJACENT FACILITIES)
- DISTANCE TO NEAREST INDUSTRY WITH SIGNIFICANT NUMBER OF WORKERS
- DISTANCE TO NEAREST RESIDENCE
- DISTANCE TO IMPORTANT FACILITY (SCHOOL, HOSPITAL, SPORTS AREA)
- POTENTIAL FOR DAMAGE FROM NEARBY ACTIVITIES (HAZ. MATERIALS PLANTS, AIRPORT, ETC.) OR NATURAL DISASTERS

APPLICATION IN SITE EVALUATION

- USE CRITERIA AS GUIDELINES — NOT AS ABSOLUTE REQUIREMENTS
- ELIMINATE SITES WHERE SAFETY IS CLEARLY A PROBLEM
- USE CRITERIA IN EVALUATING OTHER SITES FOR RELATIVE SAFETY
- BALANCE SAFETY WITH OTHER SITING FACTORS

WHEN DO ACCIDENTS HAPPEN?

- DURING STARTUP AND EARLY OPERATION

- WHEN CHANGES ARE MADE IN CONTROLS, EQUIPMENT AND/OR PROCEDURES WITHOUT A COMPLETE ANALYSIS OF EFFECT OF CHANGE ON TOTAL SYSTEM

- WHEN PERSONNEL (AT ANY LEVEL) GET USED TO ROUTINE OPERATION AND FORGET ABOUT SAFETY. (THIS IS PARTICULARLY TRUE FOR VERY RELIABLE FACILITIES)

- DURING NON-ROUTINE MAINTENANCE (PROCEDURES SHOULD BE DEVELOPED AND CAREFULLY REVIEWED FOR SAFETY BEFORE MAINTENANCE STARTS)

209

DEFINITION OF RISK

RISK IS THE POTENTIAL FOR REALIZATION OF UNDESIRABLE CONSEQUENCES ARISING FROM AN EVENT OR ACTIVITY.

POTENTIAL:

- WHAT UNDESIRABLE CONSEQUENCES MIGHT OCCUR?
- HOW LIKELY ARE THEY?

HOW IS RISK MEASURED?

- RISK HAS TO BE DISCOVERED FIRST
- RISK HAS PROBABILISTIC COMPONENTS
- RISK HAS DETERMINISTIC COMPONENTS
- MEASURE OF RISK VARIES WITH PROBLEM SITUATION

RISK MANAGEMENT

WHAT IS RISK MANAGEMENT?

- DEALING WITH UNCERTAINTY
- MAKING DECISIONS TODAY BASED ON KNOWN OBJECTIVES WITH PROBABILISTIC OUTCOME
- QUANTIFYING PROBABILISTIC AND DETERMINISTIC DECISION PARAMETERS
- SYSTEMATICALLY EVALUATING OPTIONS
- OPTIMIZING PROFITS

AREAS OF APPLICATION OF RISK ANALYSIS

NUCLEAR INDUSTRY

AEROSPACE INDUSTRY

MARINE TERMINALS

CHEMICAL PLANTS

FUEL DEPOTS

SHIPPERS OF HAZARDOUS MATERIALS

CRYOGENIC FACILITIES

REFINERIES/PETROCHEMICAL INDUSTRY

SPECIALTY CHEMICAL INDUSTRY

PHARMACEUTICALS

ETC.

A SUCCESSFUL RISK ANALYSIS WILL:

- PROVIDE SAFETY INSIGHT ON THE NATURE OF THE OPERATION
- SUGGEST WAYS OF REDUCING THE RISK
- PROVIDE INPUTS ON THE EXTENT OF LIABILITY BEING INCURRED
- BE A USEFUL TOOL IN EDUCATING THE PUBLIC
- PROVIDE A BASIS FOR COMPARISON WITH RISKS IN OTHER ACTIVITIES

A FORMAL QUANTITATIVE RISK ANALYSIS WOULD CONSIST OF THE FOLLOWING GENERAL STE

- IDENTIFICATION OF RISKS -- THE QUALITATIVE LISTING OF ALL SIGNIFICANT FAILURE PATHWAYS

- QUANTIFICATION OF RISK -- QUANTIFYING THE PROBABILITIES OF THE FAILURE MODES IDENTIFIED AND ESTIMATING THE CONSEQUENCES OR IMPACTS WHICH RESULT

- RISK EVALUATION -- ASSESSING THE COMPOSITE RISKS WITH RESPECT TO GUIDE-LINES PROVIDED BY A SUPERVISORY AGENCY OR BY COMPARISON WITH OTHER RISKS BOURNE BY SOCIETY

- CONSIDERATION OF RISK CONTROL OPTIONS -- SELECTION OF PRACTICAL AND EFFECTIVE RISK REDUCTION OPTIONS AS NEEDED TO CONTROL THE RISK AND MANAGE IT AT AN ACCEPTABLY LOW LEVEL

RISK IDENTIFICATION DURING DESIGN REVIEW

HAZARD AND OPERABILITY STUDY (HAZ-OP)*:

- LINE-BY-LINE AND COMPONENT-BY-COMPONENT CHECK OF PIPING + INSTRUMENTATION DRAWINGS

- FOR EACH ELEMENT ASK EFFECT OF:

HIGH T ?	HIGH FLOW ?
LOW T ?	LOW FLOW ?
HIGH P ?	NO FLOW ?
LOW P ?	BACK FLOW ?

REACTION RATE VARIATIONS ?
ETC.

- ANY EXCURSION LEADING TO A HAZARD AND/OR OPERABILITY PROBLEM IS NOTED FOR RESOLUTION IN FINAL DESIGN

* METHOD DEVELOPED BY ICI IN THE U.K.

RISK IDENTIFICATION

- ITEMS FOUND IN HAZARD AND OPERABILITY STUDY
- PAST EXPERIENCE - DIRECT OR RELATED
- FAULT TREE ANALYSIS GENERATED BY TEAM WITH VARIED BACKGROUNDS INCLUDING EXPERIENCE WITH DESIGN, CONSTRUCTION, TESTING, OPERATIONS, MAINTENANCE AND EMERGENCY RESPONSE SYSTEMS
- EXAMINATION OF SITE AND ENVIRONS FOR EXTERNAL FACTORS WHICH MIGHT INITIATE FAILURES

RISK IDENTIFICATION TEAM

- FACILITY MANAGEMENT
- ENGINEERING DESIGN
- OPERATING SUPERVISOR
- MAINTENANCE SUPERVISOR
- INSTRUMENTATION EXPERT
- OTHER SPECIALISTS (AS NEEDED)
- INDEPENDENT TECHNICAL EXPERT
- FAULT TREE ANALYST (RECORDER)

RISK IDENTIFICATION

CONTROL SYSTEM FAILURES

- INADEQUATE INSTRUMENTATION
- POOR DESIGN, INSPECTION OR MAINTENANCE
- COMPONENT FAILURES
- ELECTRICAL OR AIR SYSTEM FAILURES

MECHANICAL FAILU

- WEAR
- CORROSION
- POOR DESIGN
- POOR MAINTE
- VIBRATION
- POOR CONST

ANAGEMENT-RELATED FAILURES

- POOR TRAINING
- INADEQUATE SYSTEMS FOR MODIFYING SAFETY-RELATED PROCEDURES
- PRODUCTIVITY AT EXPENSE OF SAFETY
- POOR EMPLOYEE MORALE
- INADEQUATE RECORDS
- POOR INSPECTION PROGRAM
- INSUFFICIENT UPDATING OF RECORDS AND DRAWINGS

SOURCES OF FAILURE

HUMAN FAILURES

- OPERATOR ERROR
- MAINTENANCE ERRO
- WRONG RESPONSE I EMERGENCY

EXTERNAL EVENTS

- EARTHQUAKES
- FLOOD/TIDAL WAVES
- HIGH WINDS/TORNADOES
- AIRCRAFT IMPACT
- CATASTROPHE IN ADJACENT FACILITY (I.E., FIRES OR EXPLOSIONS)
- SABOTAGE

FAULT TREE ANALYSIS

1. DEFINE TOP EVENTS (ON THE BASIS OF HAZ-OP).

2. DEVELOP FAILURE SEQUENCES LEADING TO EACH TOP EVENT.

3. EXPRESS SEQUENCES IN LOGIC DIAGRAM.

4. ASSIGN PROBABILITIES TO EACH STEP.

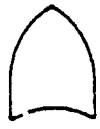
5. ESTIMATE PROBABILITY OF EACH TOP EVENT.

FAULT TREE CONSTRUCTION

PURPOSE: TO DISPLAY IN LOGICAL FORMAT ALL IDENTIFIED SEQUENCES OF FAILURES WHICH CAN LEAD TO A "TOP EVENT". THE TOP EVENT IS A FAILURE EVENT OR SET OF EVENTS HAVING SIMILAR CONSEQUENCES.

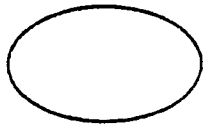
NOTATION:

"AND" GATE (OUTPUT FAULT OCCURS ONLY IF ALL INPUT FAULTS OCCUR; INPUT PROBABILITIES MULTIPLIED TO GIVE OUTPUT PROBABILITY)

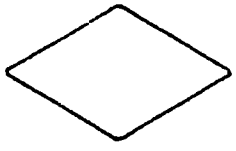


"OR" GATE (OUTPUT FAULT OCCURS ONLY IF ONE OR MORE OF THE INPUT FAULTS OCCUR; INPUT PROBABILITIES ADDED TO GIVE OUTPUT PROBABILITY)

RECTANGLES REPRESENT STATES WHICH ARE THE PRODUCT OF SEVERAL INITIATING AND/OR CONTRIBUTING EVENTS THROUGH AN "AND" OR "OR" GATE (THEY MAY THEREFORE HAVE RATES OF OCCURRENCE WHICH ARE YEARLY OR PER DEMAND)



CIRCLES OR OVALS REPRESENT INITIATING FAILURES OR EVENTS WITH YEARLY RATES OF OCCURRENCE WHICH ARE NOT ANALYZED FURTHER



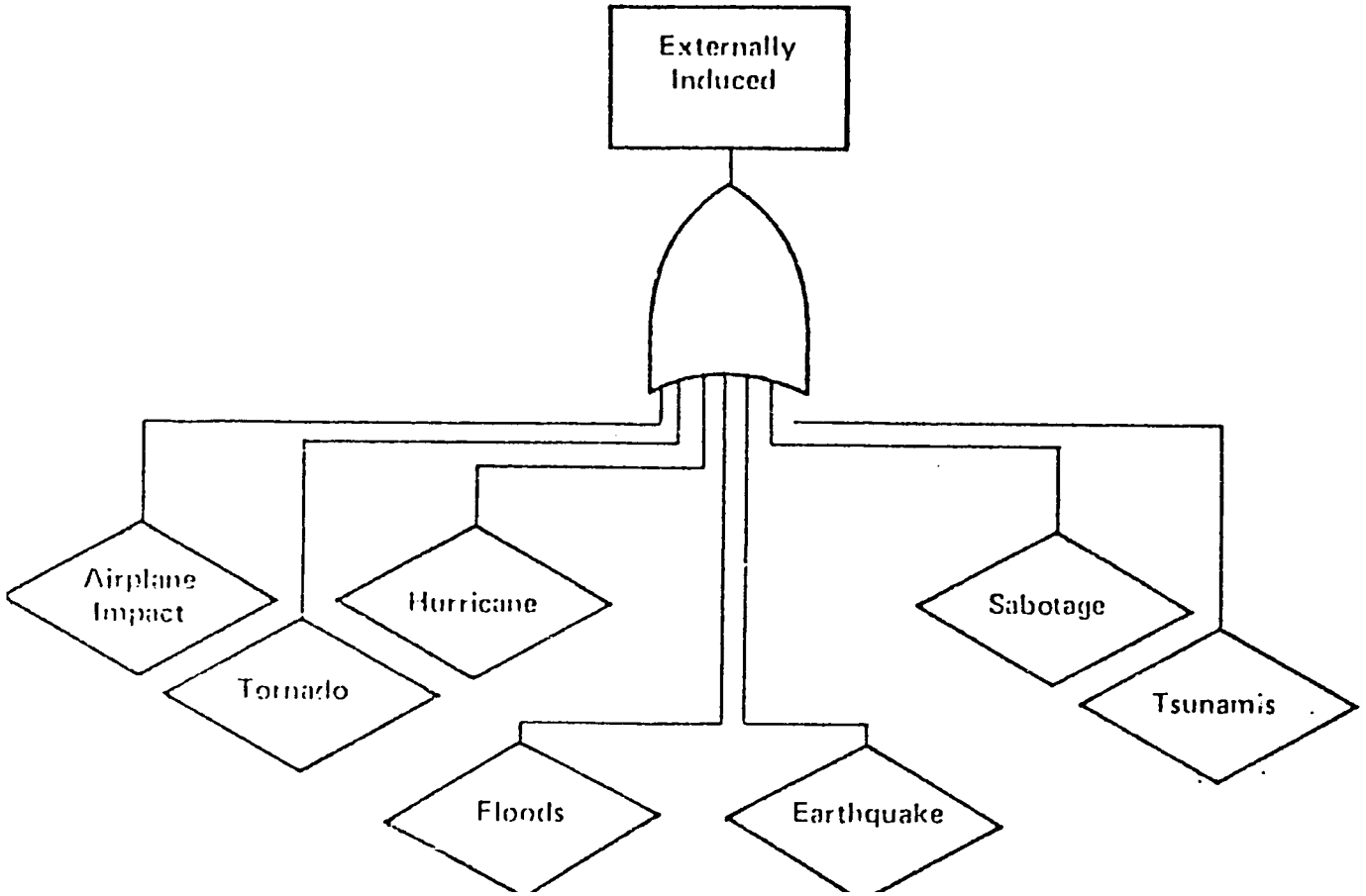
DIAMONDS REPRESENT CONTRIBUTING FAILURES OR EVENTS WHICH ARE NOT ANALYZED FURTHER AND HAVE RATES OF OCCURRENCE PER DEMAND

FAILURE EVENTS

INTERNALLY INDUCED: COMPONENTS FAILURES, HUMAN FACTORS, ETC.

EXTERNALLY INDUCED: AIRPLANE IMPACT, SABOTAGE, EXTERNAL FIRES, MISSILES, ETC.

Release From Tanks
Internally Induced
Externally Induced


Externally Induced
Airplane Impact
Tornado
Hurricane
Floods
Earthquake
Sabotage
Tsunamis

224

RISK QUANTIFICATION

PROBABILITIES OF FAILURE

DATA SOURCES:

RASMUSSEN - REACTOR SAFETY STUDY - WASH 1400

FLUOR ENGINEERS AND CONSTRUCTORS, INC. - RELIABILITY STUDY - OXNARD AND LOS ANGELES TERMINAL ISLAND LNG FACILITIES, 1977

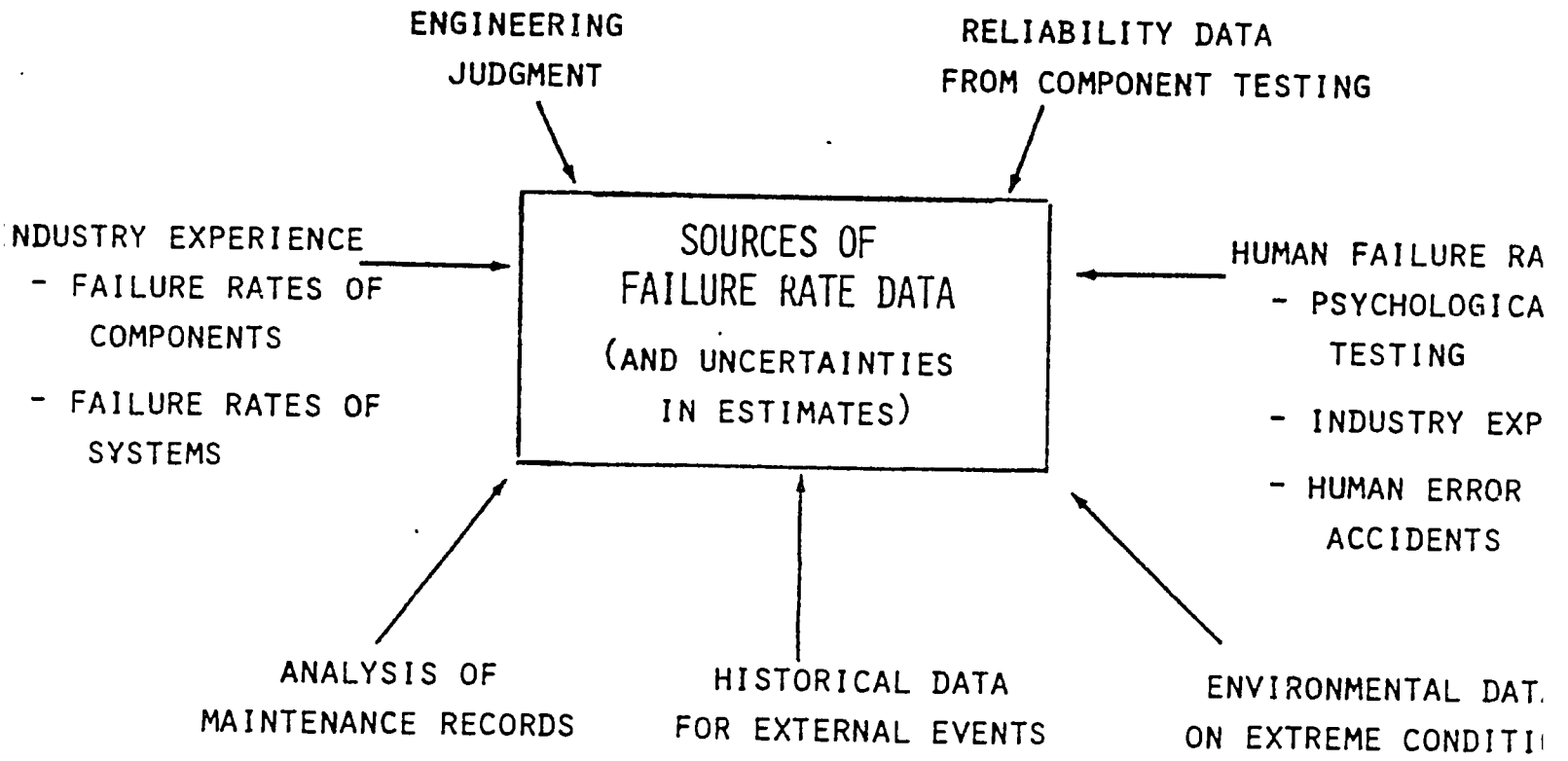
HUGHES AIRCRAFT - NONELECTRIC RELIABILITY NOTEBOOK, NTIS, 1975

IEEE - REPORT ON RELIABILITY SURVEY OF INDUSTRIAL PLANTS, 1974

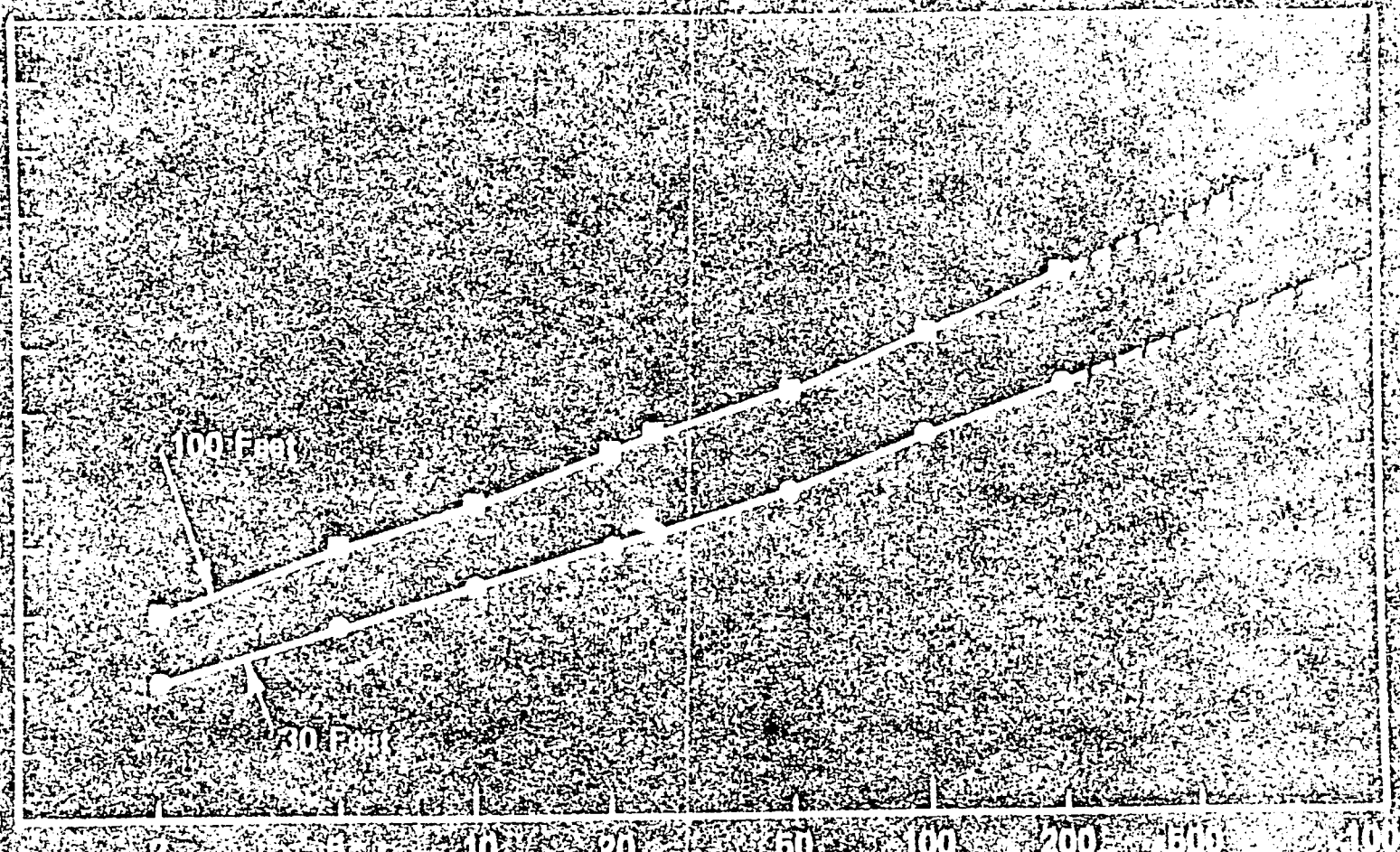
INSTITUTION OF CHEMICAL ENGINEERS - PROCEEDING OF SYMPOSIUM ON PROCESS INDUSTRY HAZARDS, 1976

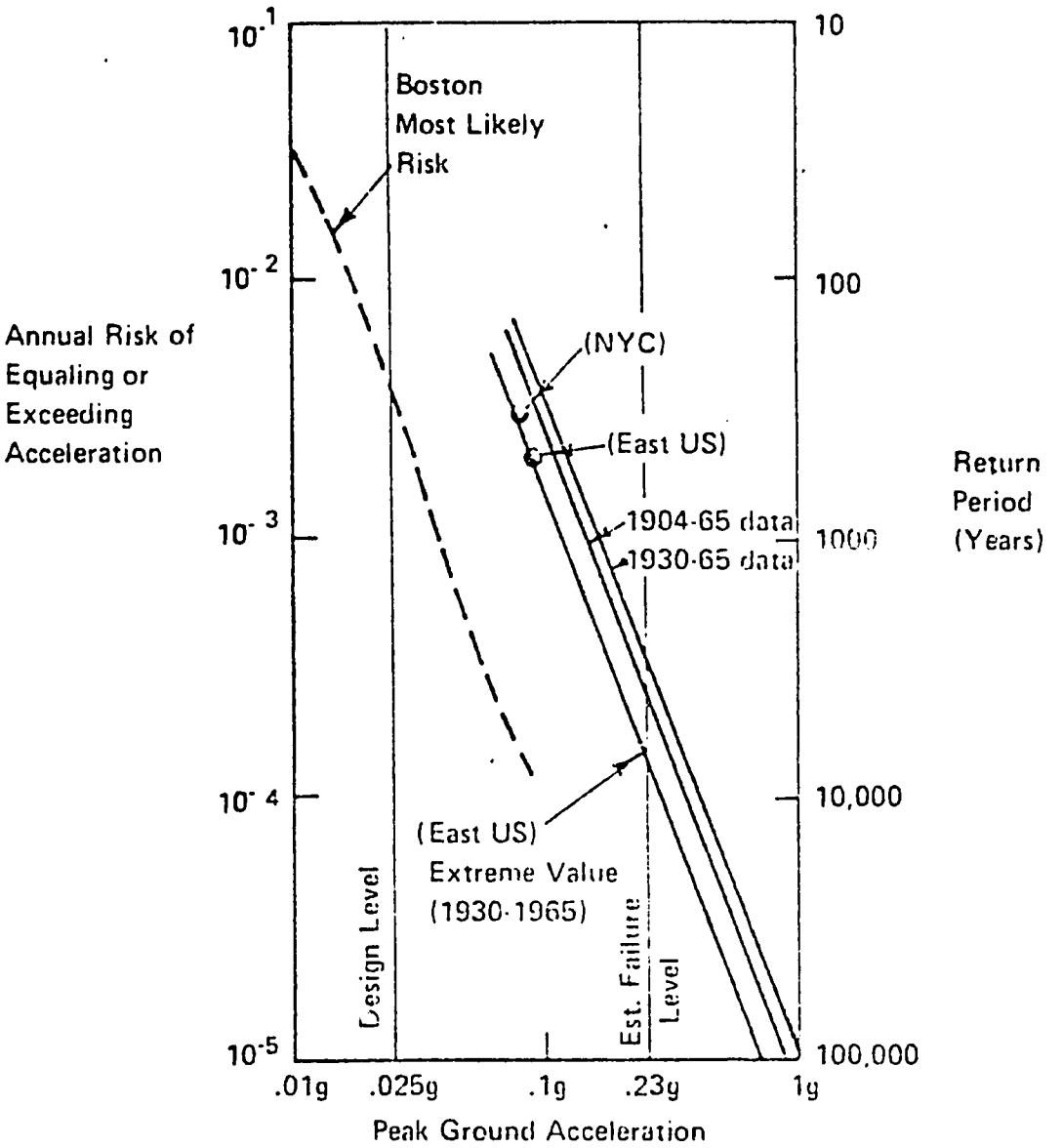
OTHER PROPRIETARY DATA ACCUMULATED BY ADL

QUANTIFICATION OF RISK



376

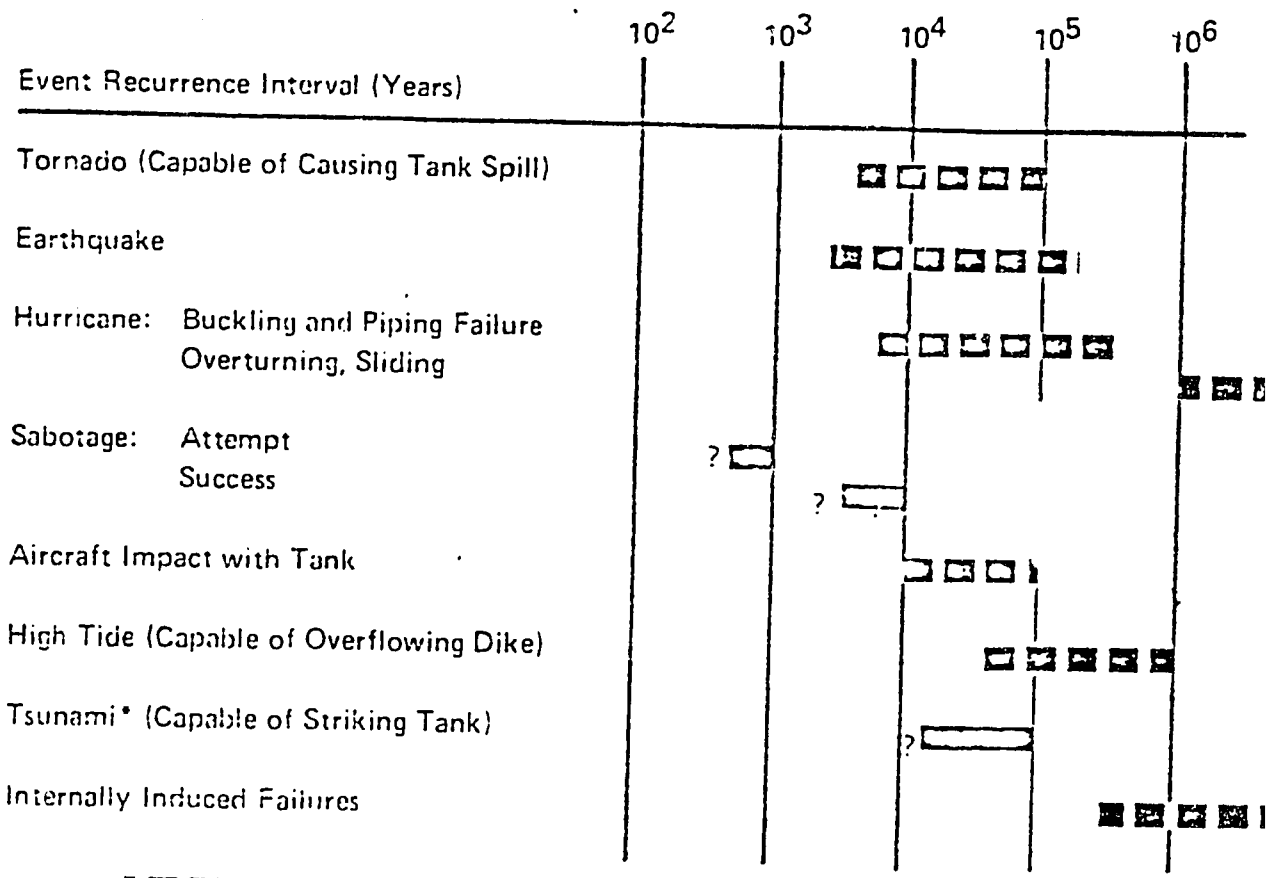

100 Feet
80 Feet
10
20
60
100
200


Annual Risk of Equaling or Exceeding Acceleration
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
Boston Most Likely Risk
(NYC)
(East US)
1904-65 data
1930-65 data
(East US) Extreme Value (1930-1965)
Design Level
Est. Failure Level
10
100
1000
10,000
100,000
Return Period (Years)
.01g
.025g
.1g
.23g
1g
Peak Ground Acceleration

E-32

228

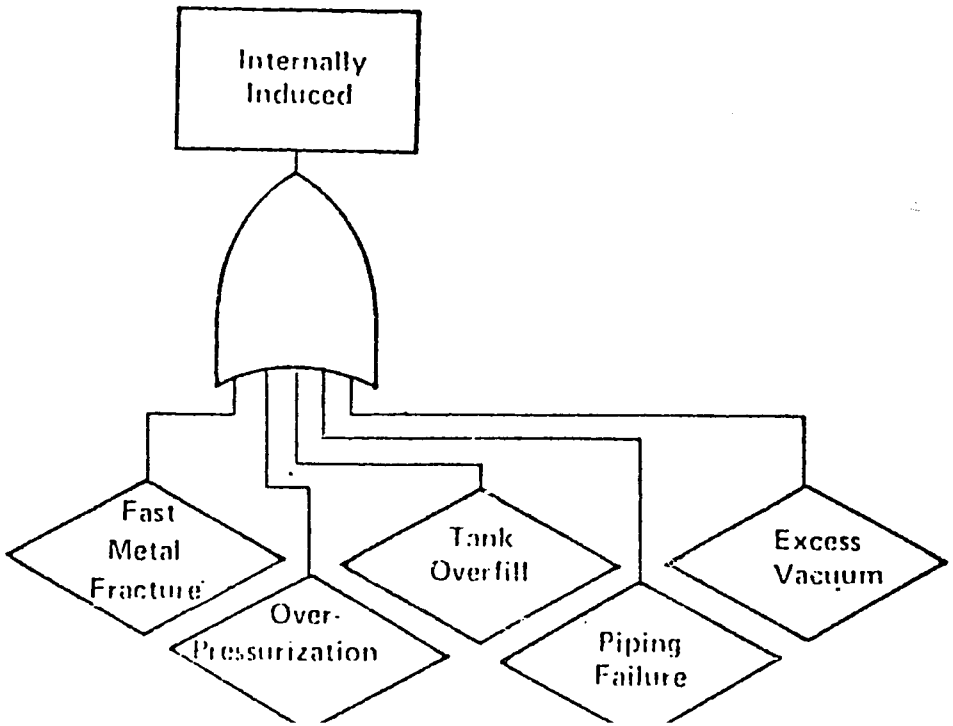
RECURRENCE INTERVALS FOR ABNORMAL EVENTS WHICH MIGHT INDUCE A MAJOR LNG RELEASE



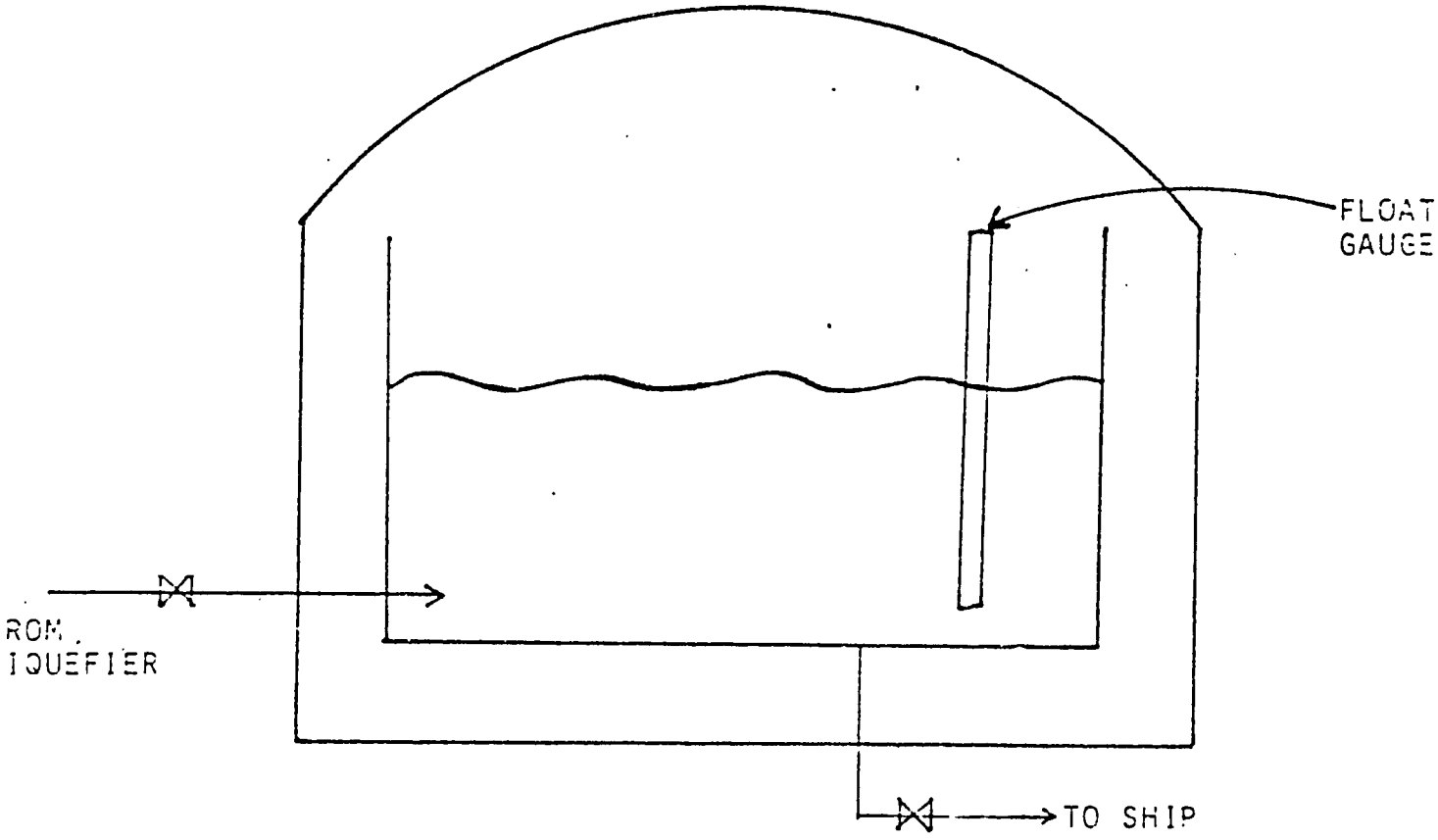
= Range of estimates

? = A number was obtained but the analysis contains considerable uncertainties

* = Tidal wave


Internally Induced
Fast Metal Fracture
Over-Pressurization
Tank Overfill
Piping Failure
Excess Vacuum

TANK OVERFILL PROBLEM



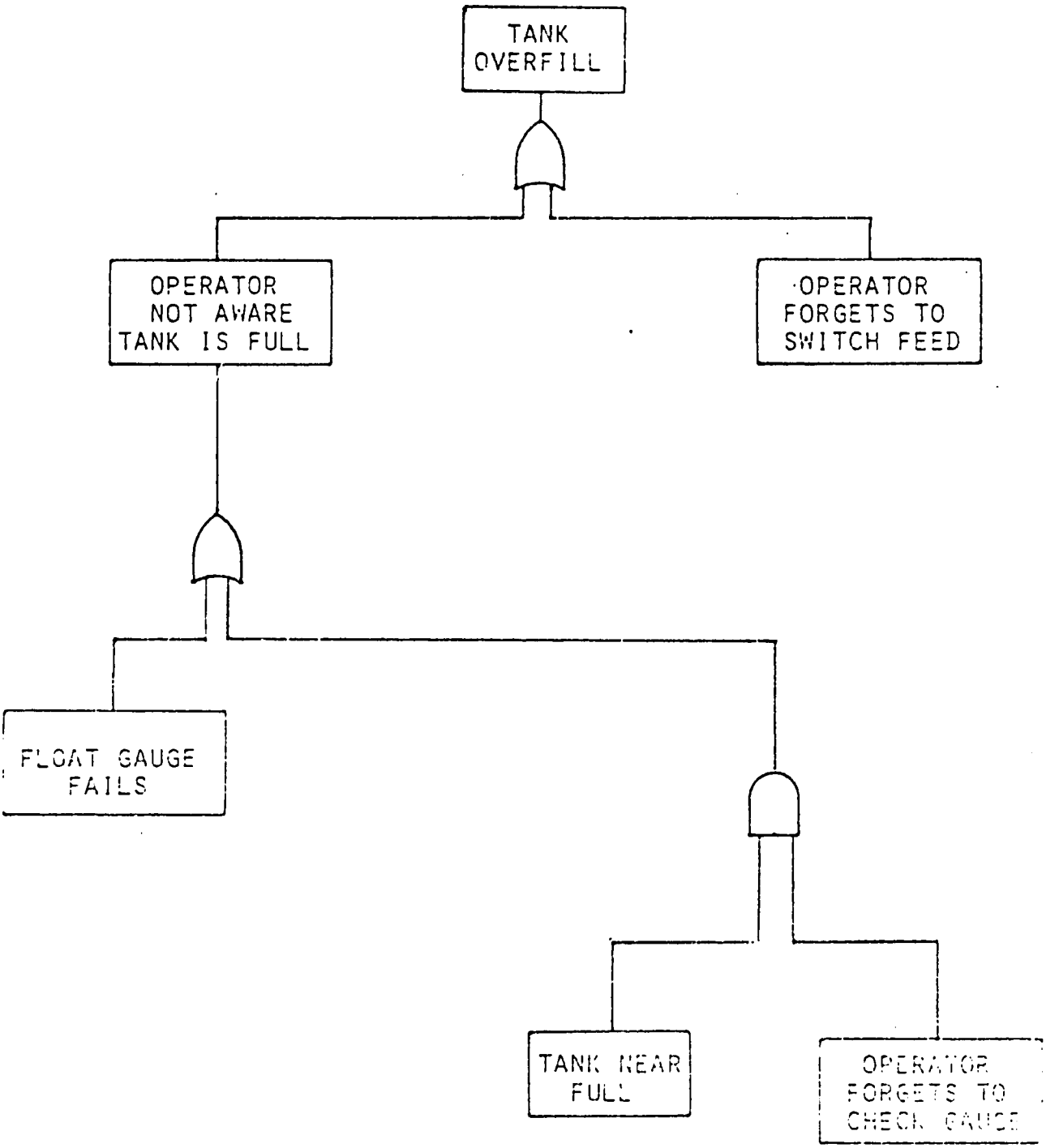
TANK FILL TIME = 5 DAYS

OPERATOR READS LEVEL ON FLOAT GAUGE EACH SHIFT

MAXIMUM LIQUID HEIGHT = 15 M

MAXIMUM INNER TANK HEIGHT = 15.5 M

OPERATOR DIVERTS FEED TO ANOTHER TANK WHEN THIS TANK IS FULL.


TANK OVERFILL
OPERATOR NOT AWARE TANK IS FULL
OPERATOR FORGETS TO SWITCH FEED
FLOAT GAUGE FAILS
TANK NEAR FULL
OPERATOR FORGETS TO CHECK GAUGE

TYPICAL HUMAN ERROR RATES

Type of Activity	Example	Probability of Error
Critical routine task	Sub-system design, operation of well-designed plant	10^{-3}
Non-critical routine task	Misreading label, omitting step in procedure	3×10^{-3}
Non-routine normal operations	Start-up, maintenance	10^{-2}

TYPICAL COMPONENT FAILURE RATES

RELIEF VALVE FAILURE	10^{-5}/DEMAND
INSTRUMENT FAILURE	10^{-6}/HOUR
PUMP FAILURE	4×10^{-5}/HOUR
SOLENOID OPERATED VALVE FAILU	10^{-3}/DEMAND

FILL RATE: 1 M PER 8 HOUR SHIFT

(TANK CAN OVERFILL IN 1 SHIFT)

NUMBER OF FILLINGS PER YEAR = $\frac{365}{5}$ = 73

TANK NEARLY FULL 1/15 OR 8.3% OF THE TIME

FLOAT GAUGE FAILURE:

WITH NO DETECTION:

(10^{-6} PER HOUR) (8760 HOURS/YEAR)

= 8.8×10^{-3} PER YEAR

OPERATOR FORGETS TO CHECK GAUGE

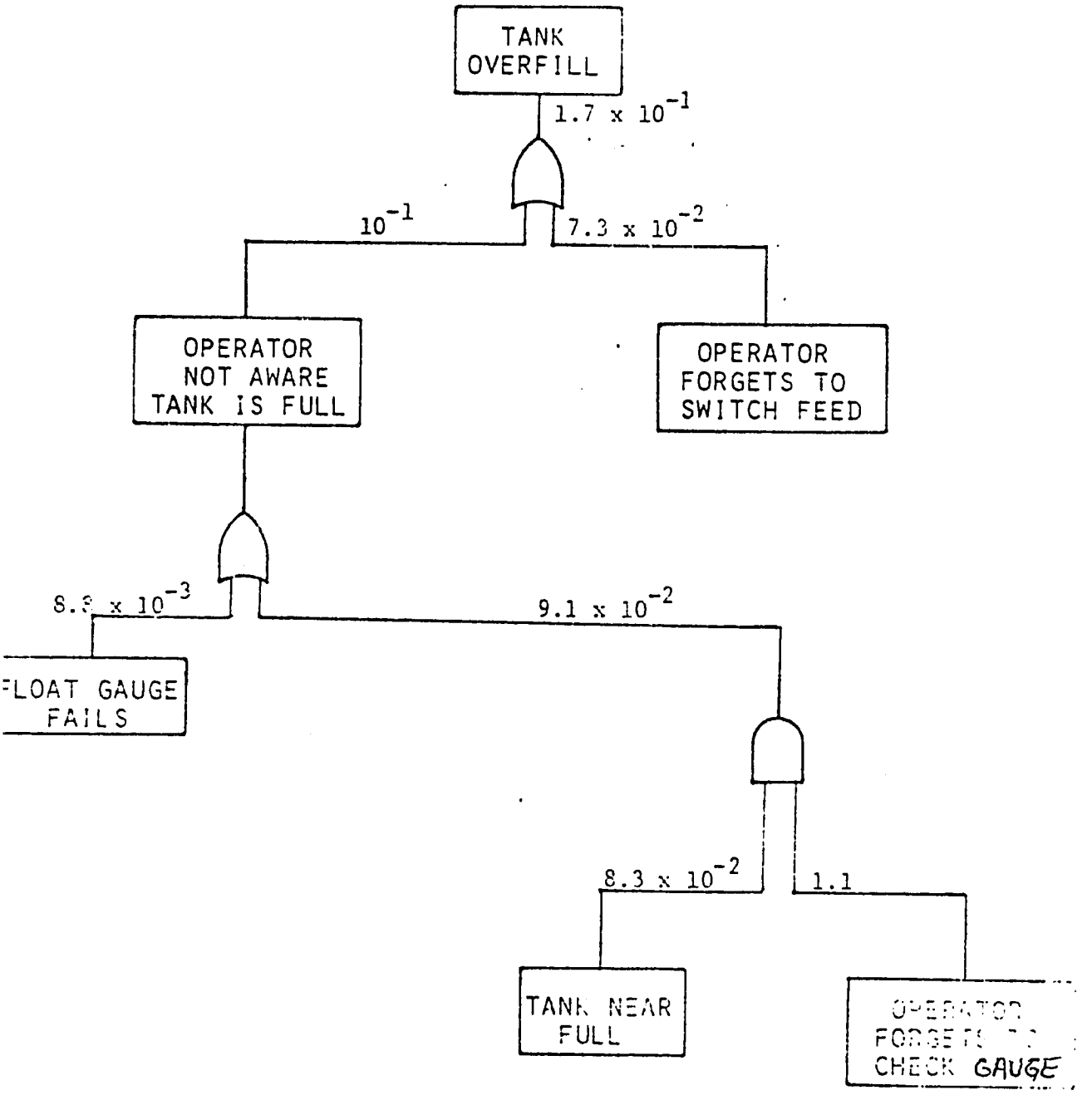
(10^{-3} PER DEMAND)(1 DEMAND PER SHIFT)(1095 SHIFTS PER YEAR)

= 1.1 PER YEAR

OPERATOR FORGETS TO SWITCH FEED

(10^{-3} PER DEMAND)(73 DEMANDS PER YEAR)

= 7.3×10^{-2} PER YEAR


TANK OVERFILL
1.7 x 10^-1
10^-1
7.3 x 10^-2
OPERATOR NOT AWARE TANK IS FULL
OPERATOR FORGETS TO SWITCH FEED
8.3 x 10^-3
9.1 x 10^-2
FLOAT GAUGE FAILS
8.3 x 10^-2
1.1
TANK NEAR FULL
CHECK GAUGE

236

CONCLUSIONS:

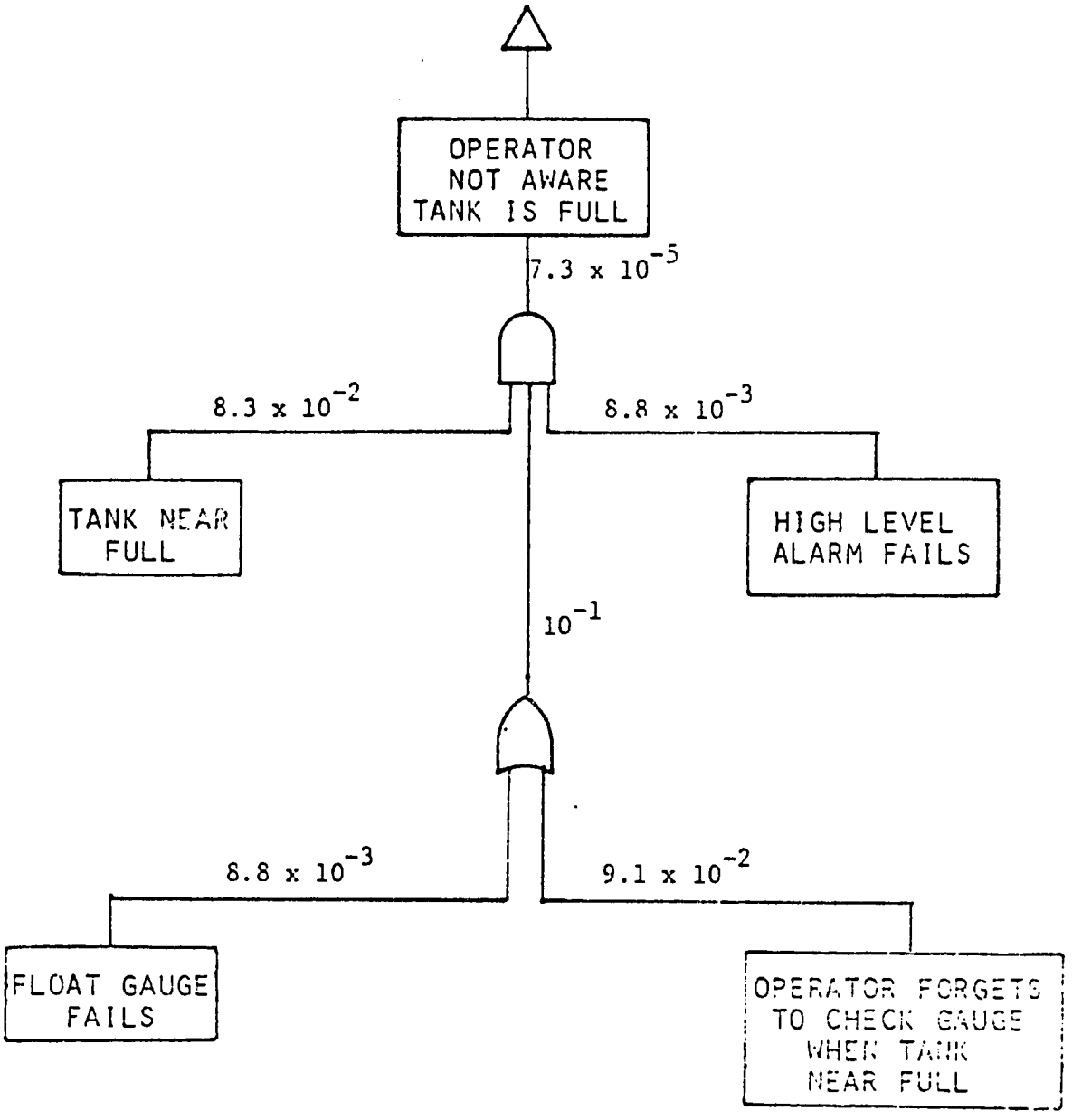
SYSTEM AS DESCRIBED HAS A 17% CHANCE PER YEAR OF AN OVERFILLING.

MOST RISK DUE TO OPERATOR ERROR.

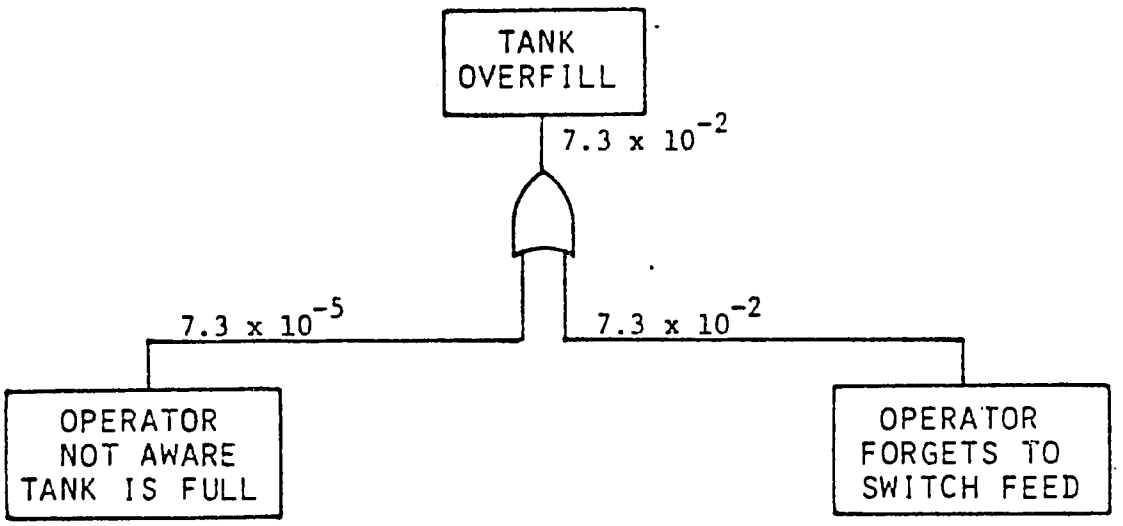
IMPROVEMENTS:

ADD HIGH LEVEL SENSOR AND ALARM.

WITH ADDITION OF HIGH LEVEL ALARM



AFTER ADDITION OF HIGH LEVEL SENSOR/ALARM



CONCLUSIONS:

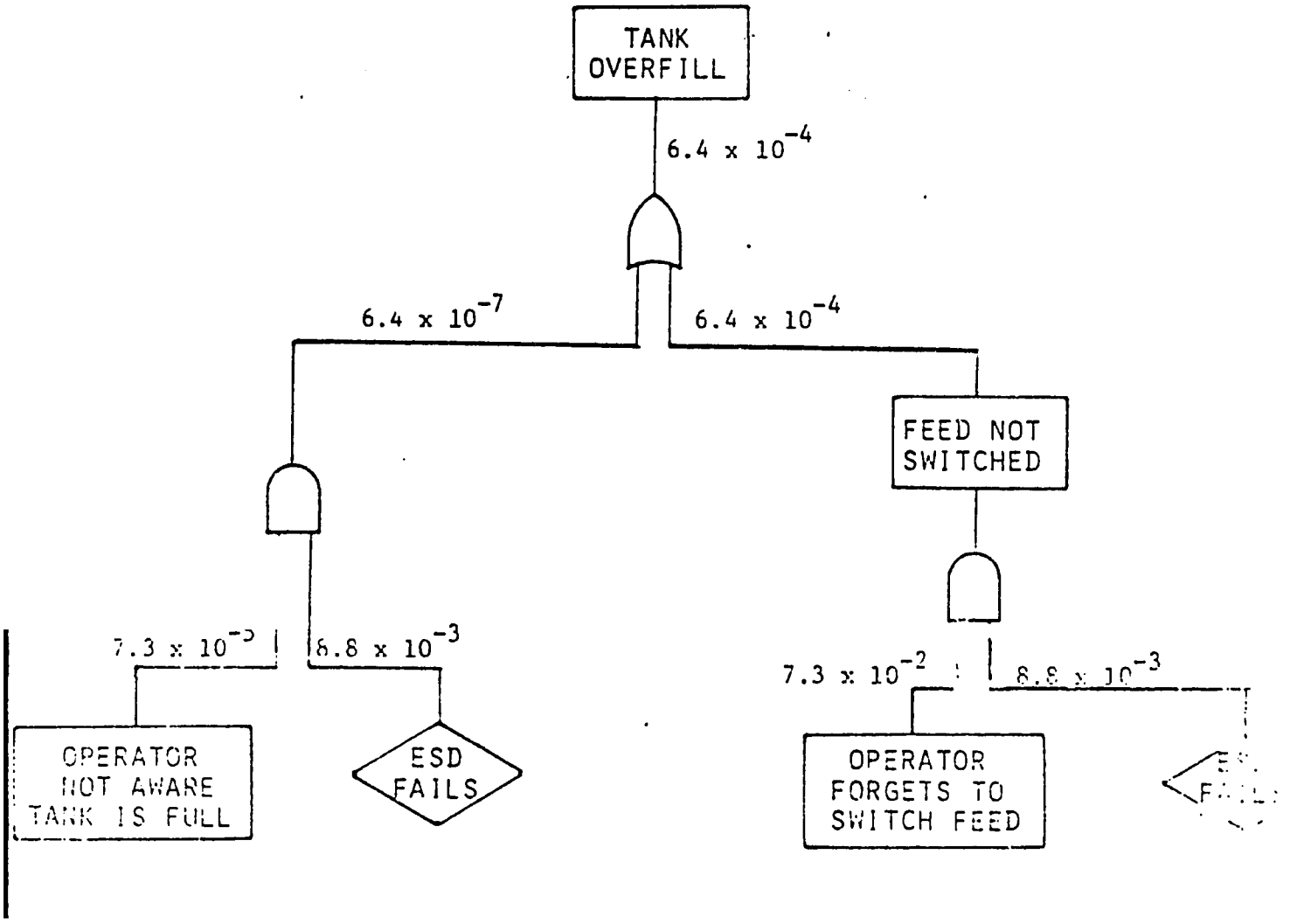
TANK OVERFILL CHANCE HAS BEEN REDUCED TO 7% PER YEAR

RISK NOW CONTROLLED BY OPERATOR NEGLECTING TO SWITCH FEED.

IMPROVEMENT:

ADD HIGH-HIGH LEVEL SENSOR AND AUTOMATIC EMERGENCY SHUTDOWN.

AFTER SECOND IMPROVEMENT



CONCLUSIONS:

OVERFILL CHANCE REDUCED TO LESS THAN 0.1% PER YEAR

FOR 30-YEAR FACILITY LIFE, CHANCE IS ABOUT 2%.

SOME FURTHER RISK REDUCTION IMPROVEMENTS

OPERATOR TESTS FLOAT GAUGE EACH SHIFT

TANK LEVEL DISPLAYED AND RECORDED IN CONTROL ROOM

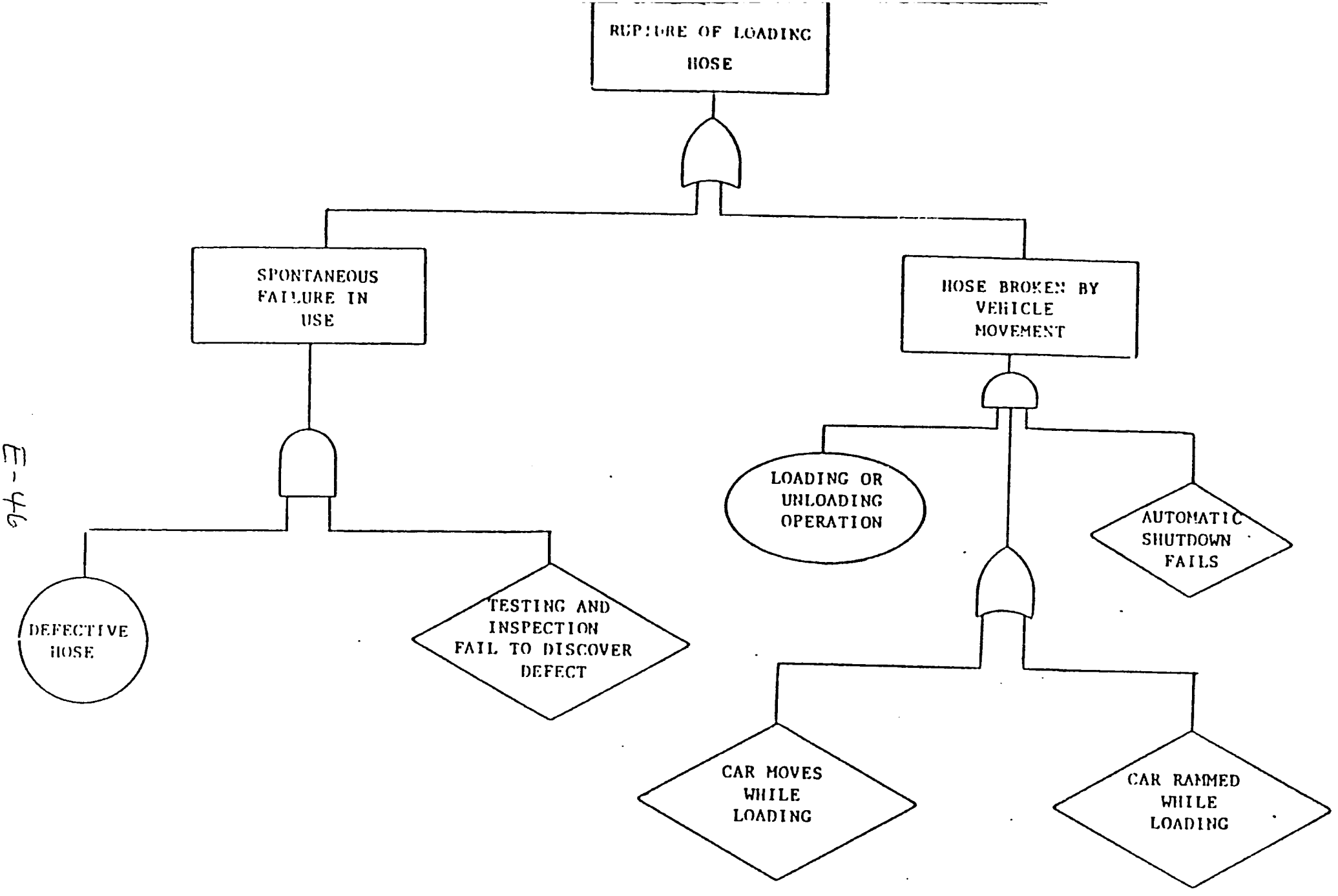
ADD REDUNDANT LIQUID LEVEL GAUGE

USE MORE THAN ONE INSTRUMENT TO INITIATE AUTOMATIC SHUTDOWN AT HIGH-HIGH LEVEL POINT

HAVE PROGRAM FOR TESTING AND MAINTAINING IMPORTANT SYSTEM COMPONENTS

HAVE CONTINGENCY PLANS PREPARED IF OVERFILL SHOULD OCCUR

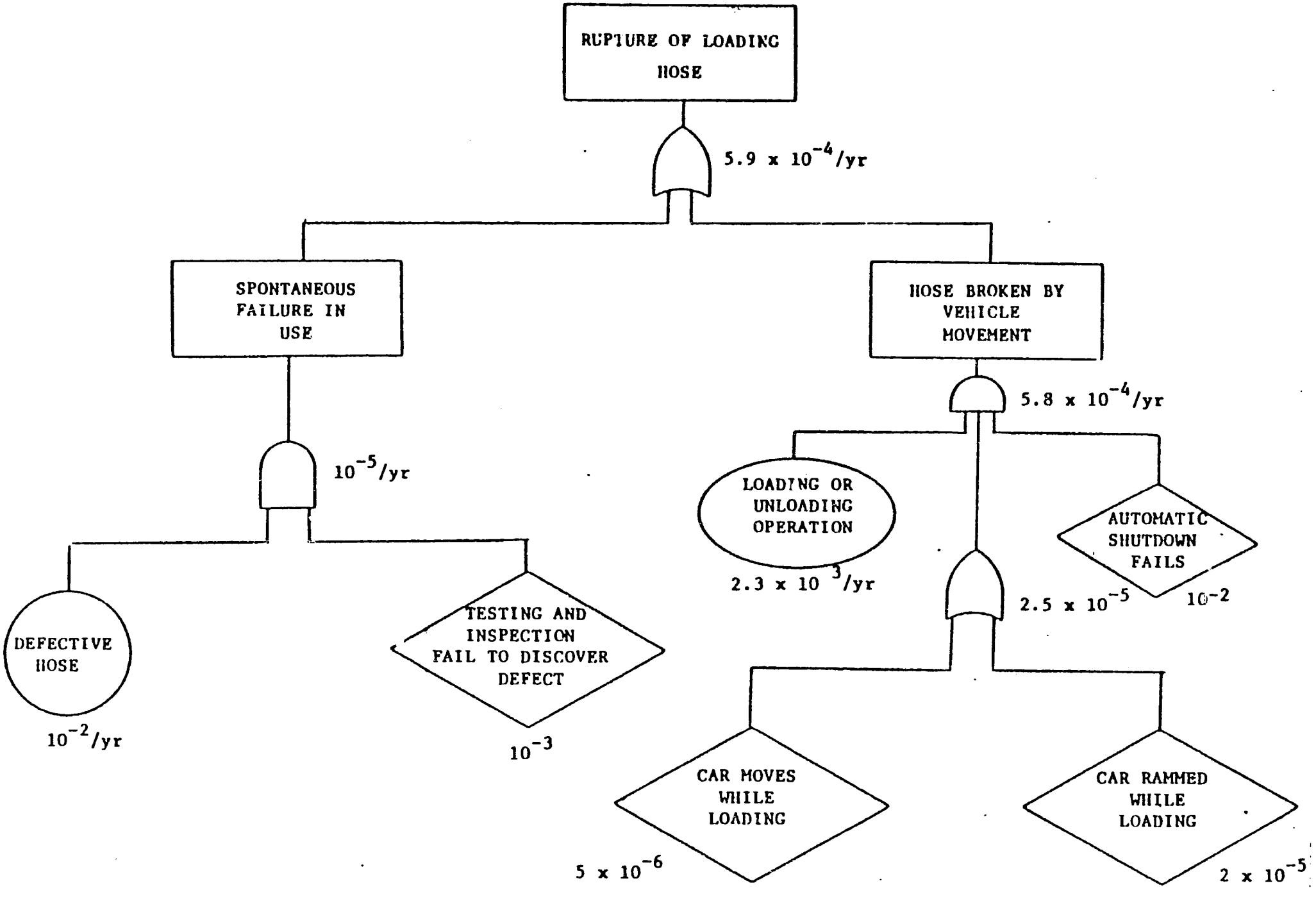
PREVENT EMPLOYEE PROBLEMS THAT MIGHT LEAD TO INTENTIONAL MISOPERATION



FAULT TREE OF A HOSE RUPTURE

E-46

242



FAULT TREE OF A HOSE RUPTURE

CONSEQUENCE OF EVENT

- IMPACT ON THE ENVIRONMENT
- IMPACT ON PROPERTY
- IMPACT ON PEOPLE
- IMPACT ON PROFITS

E-48

TYPES OF RISKS FROM HAZARDOUS MATERIAL RELEASES

FIRES	-	LIQUID FUELS
	-	FLAMMABLE VAPOR CLOUDS
	-	FIREBALLS
EXPLOSIONS	-	RUNAWAY REACTIONS
	-	CONFINED RAPID BURNING
	-	DETONATIONS
	-	SUPERHEAT PHENOMENA
TOXIC EFFECTS	-	TOXIC VAPOR CLOUDS (BOTH ACUTE AND DELAYED HEALTH EFFECTS)
	-	CONTAMINATION OF WATER

FOR COMBUSTION TO OCCUR

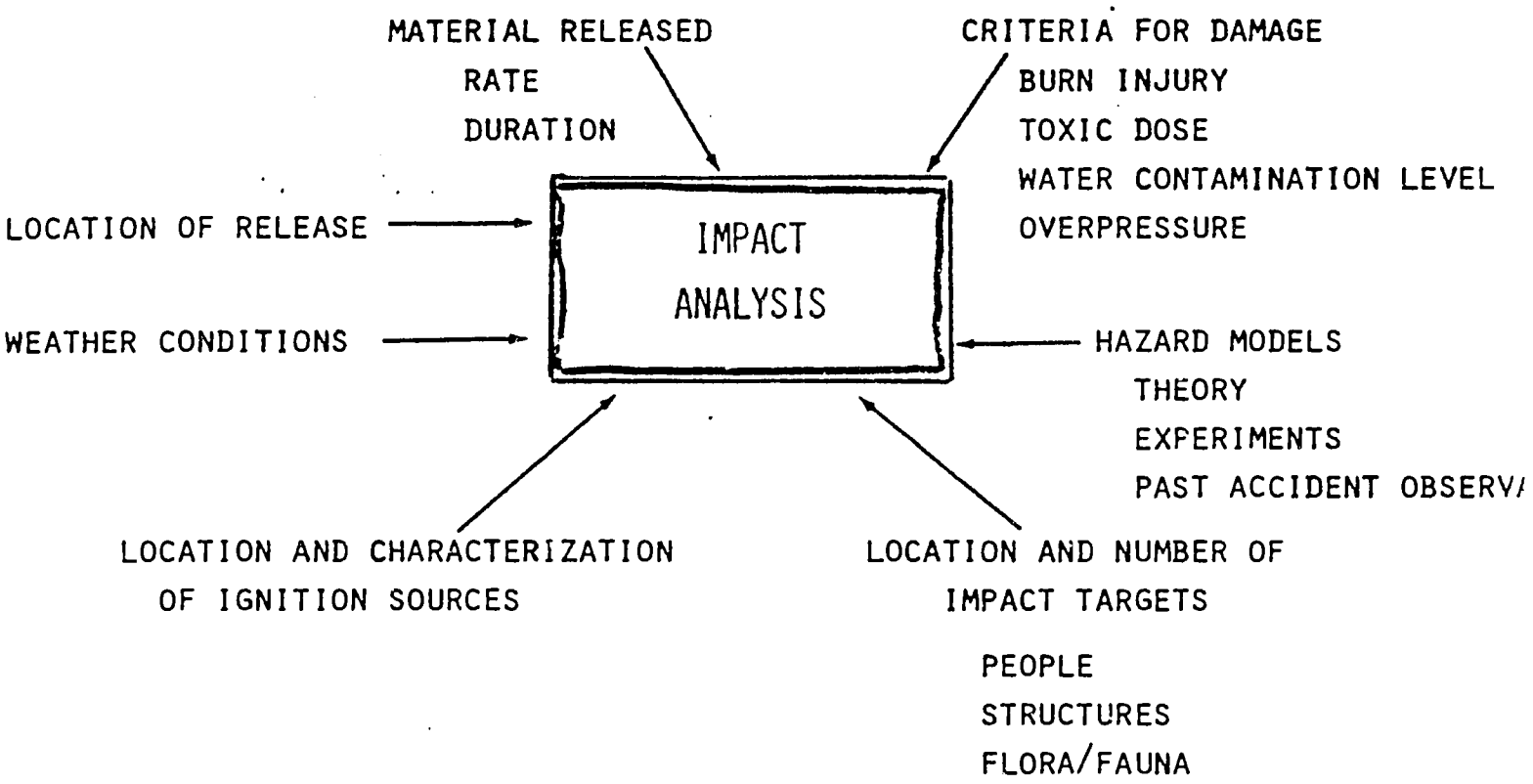
THREE CONDITIONS ARE REQUIRED:

1. FUEL IN VAPOR PHASE
2. MIXTURE WITH AIR WITHIN FLAMMABILITY LIMITS
3. IGNITION SOURCE

PRACTICAL RULES:

- IF ONLY ONE CONDITION EXISTS, IGNITION AND FIRE/EXPLOSION ARE UNLIKELY
- IF TWO CONDITIONS EXIST, BE EXTREMELY CAREFUL IF THE REMAINING CONDITION CAN EXIST — E-SU

CONSEQUENCE ANALYSIS



TYPES OF FIRES:

1. JET FIRE (HIGH PRESSURE GAS)

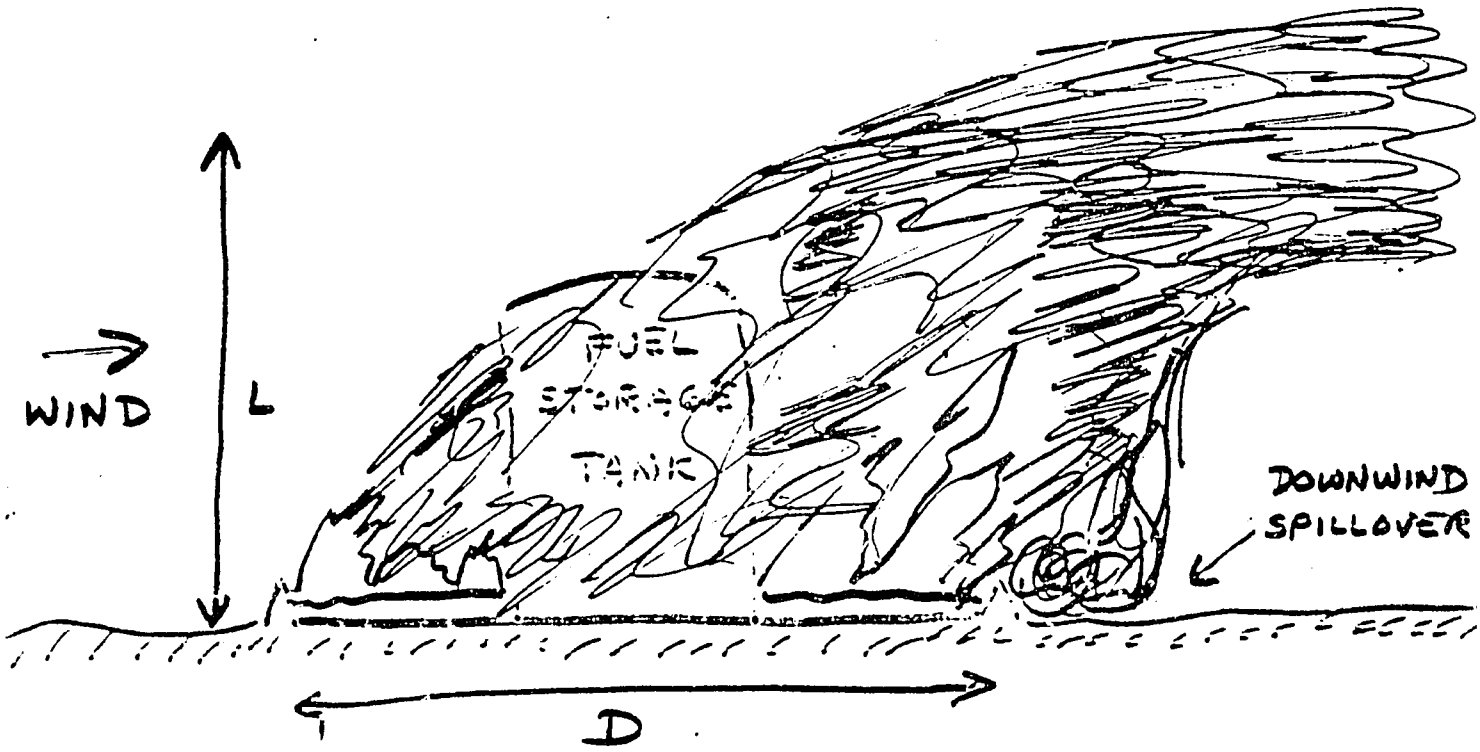
LENGTH OF FLAME ABOUT 20-40 TIMES DIAMETER (OR EQUIVALENT DIMENSION) OF LEAK.

- IF UNIGNITED*, FLAMMABLE ZONE IS ABOUT SAME AS FLAME ABOVE.
- FLAME MAY IMPINGE ON OTHER EQUIPMENT (SHIELD OR COOL)
- CONTROL BY SHUTTING OFF SOURCE OF FUEL

* DO NOT STAND IN FUEL JET ZONE. IGNITION MAY OCCUR UNEXPECTEDLY

2. POOL FIRE (LIQUID FUELS)

L/D ≈ 1.0



ACCIDENT SEQUENCE:

1. SPILL OF FUEL – THE MORE VOLATILE THE GREATER THE FLAMMABLE ZONE ABOVE THE POOL

2. IGNITION – (SOURCES INCLUDE STATIC CHARGE, RESPONSE VEHICLES, ELECTRICAL COMPONENTS THAT ARE NOT EXPLOSION PROOF, CARELESS SMOKING, ETC.)

3. FIRE DEVELOPMENT. BACK THERMAL RADIATION FROM FIRE SPEEDS VAPORIZATION OF FUEL

PARAMETERS REQUIRED TO CHARACTERIZE THERMAL RADIATION HAZARDS FROM POOL FIRES

- FIRE SHAPE AND SIZE (DIAMETER AND HEIGHT)
- EMISSIVE POWER OF THE FIRE
- TRANSMISSIVITY IN THE ATMOSPHERE
- GEOMETRIC VIEW FACTOR

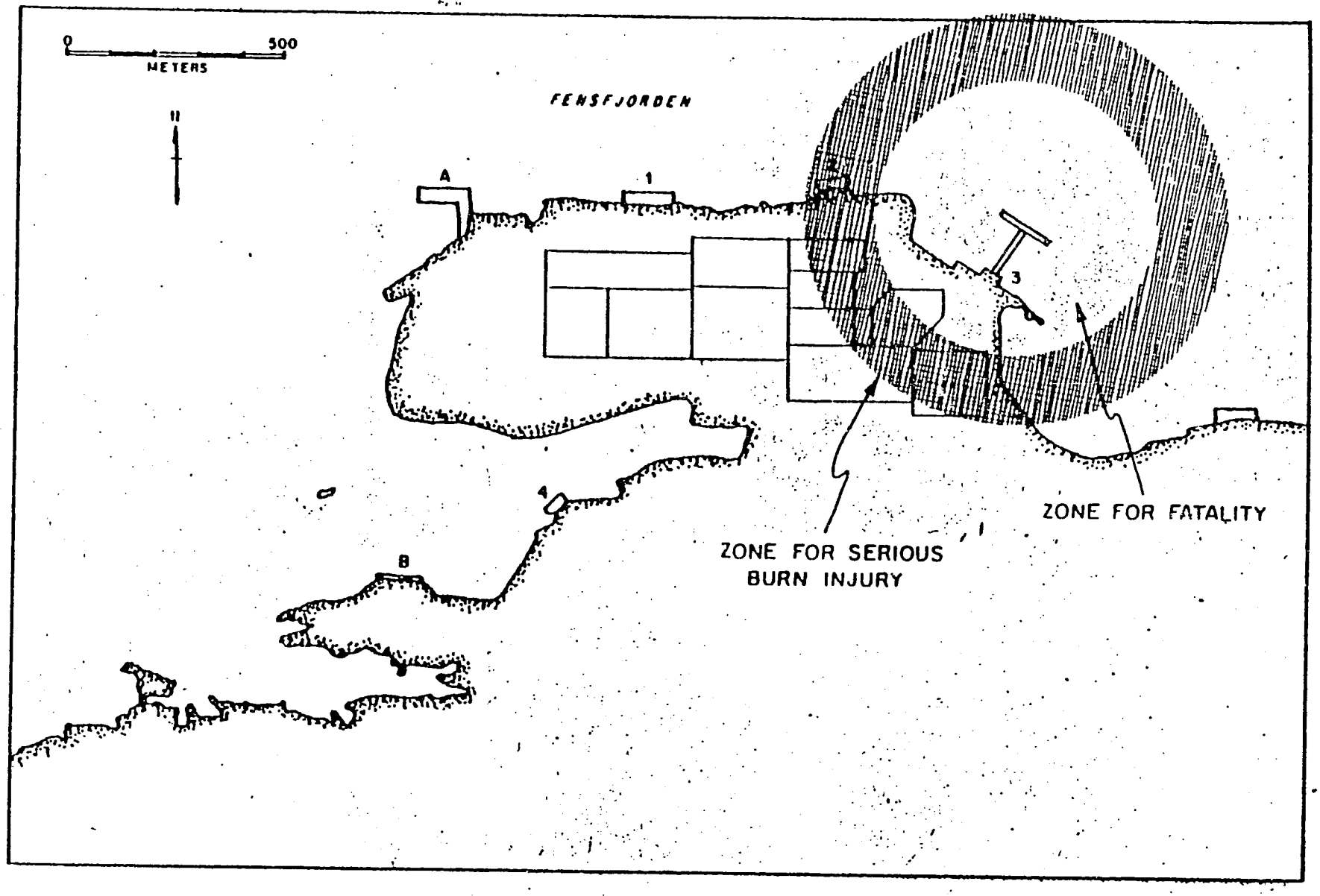


FIGURE 9. THERMAL RADIATION HAZARD FROM A 150m^3 REFRIGERATED LPG SPILL AT JETTY NO. 3.

E-55

251

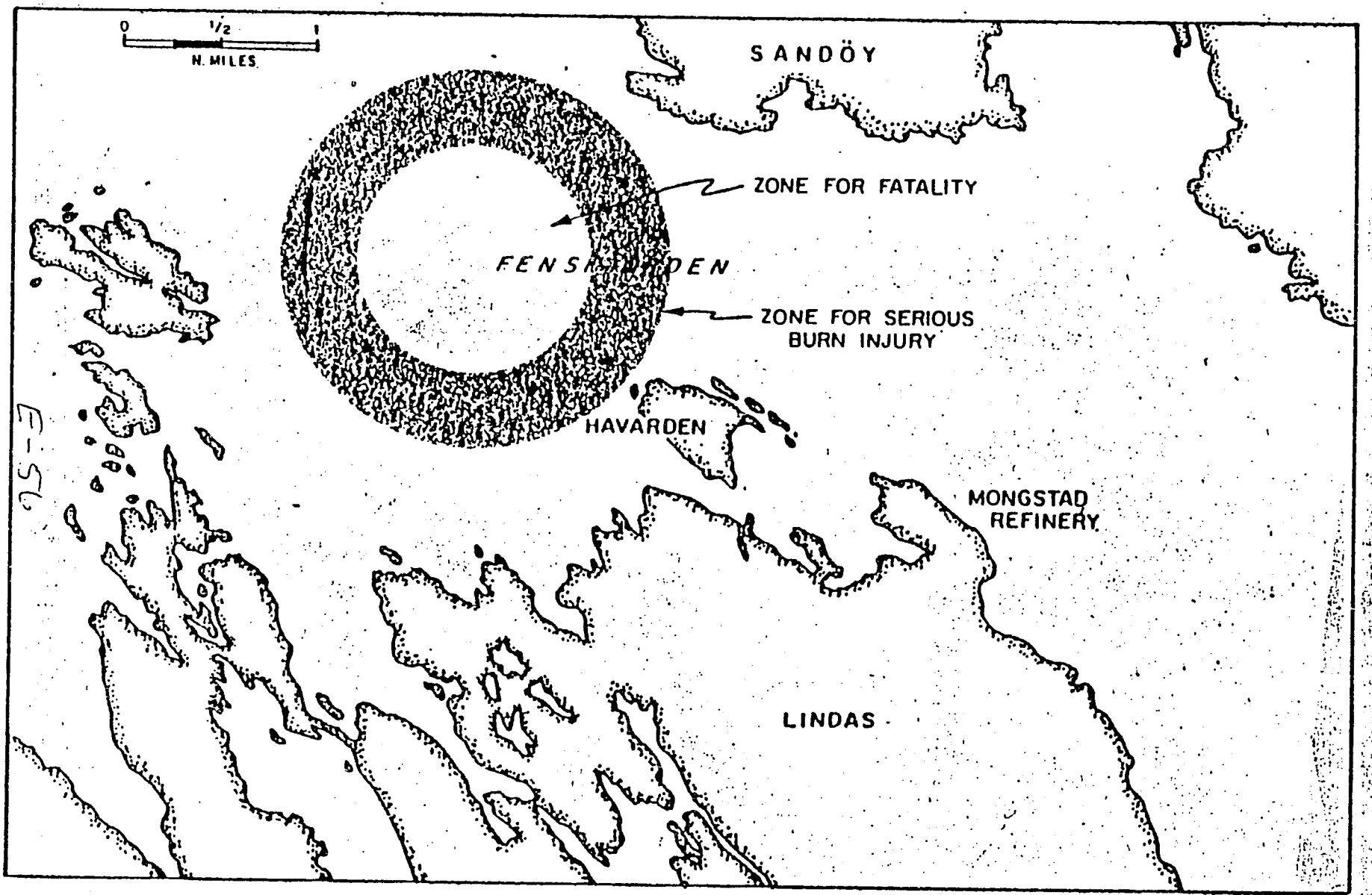
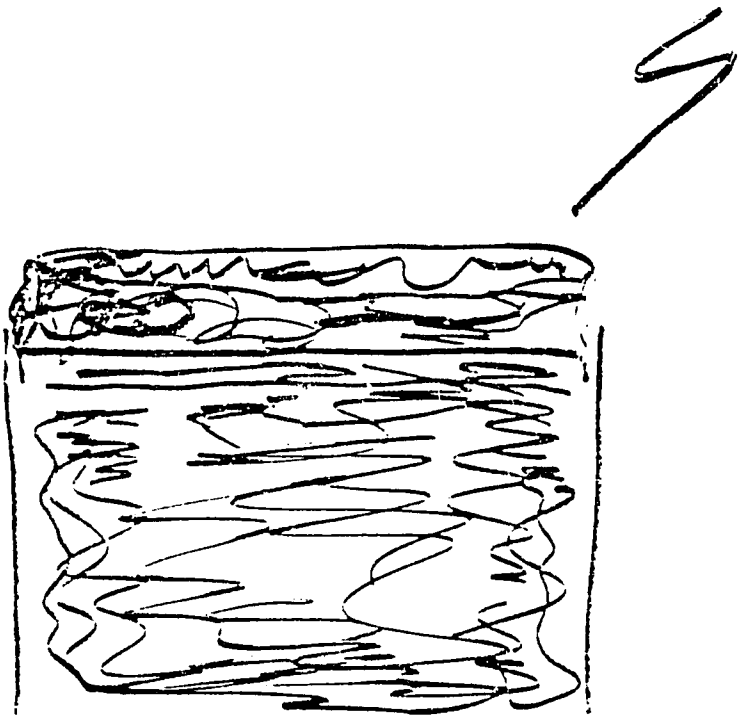


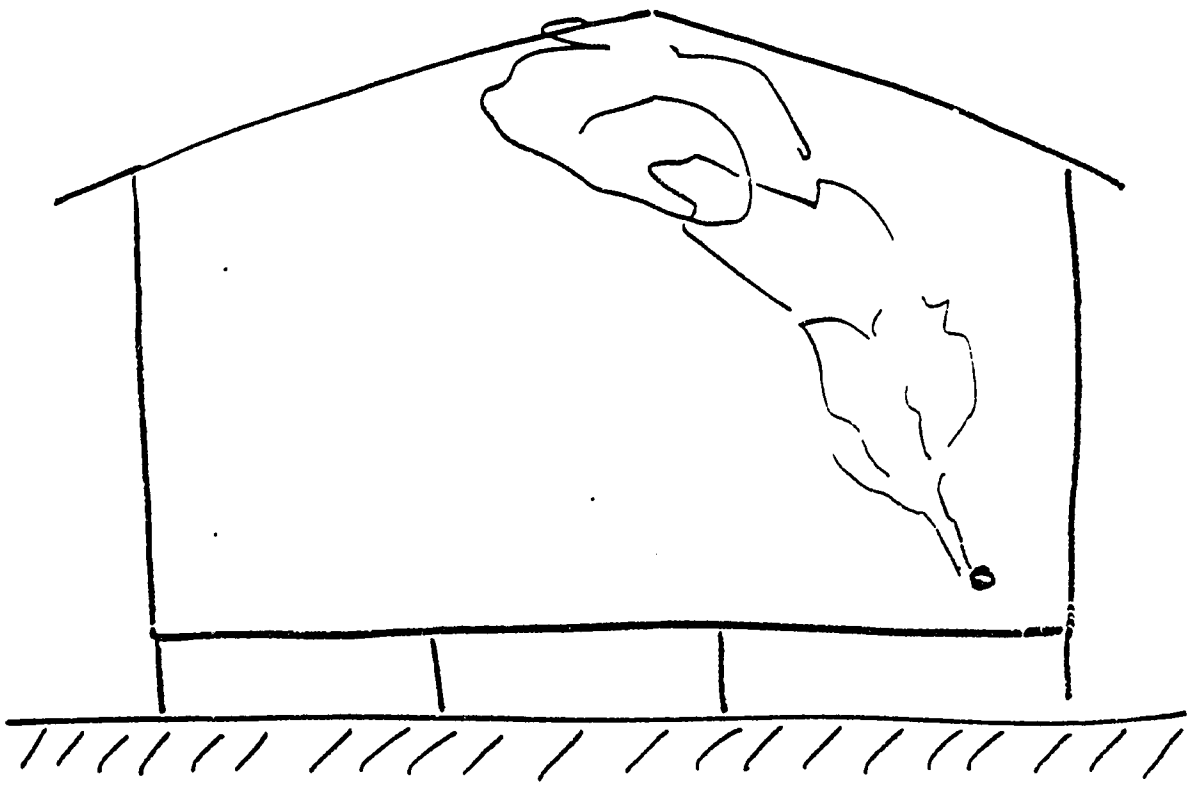
FIGURE 10. THERMAL RADIATION HAZARD FROM A 7400m^3 REFRIGERATED LPG SPILL IN TRANSIT AREA.

3. RIM FIRES (FLOATING ROOF FUEL STORAGE TANKS)



VAPOR LEAKS FROM SEAL. IGNITION USUALLY BY LIGHTNING OR STATIC DISCHARGE. SHOULD HAVE EXTINGUISHING SYSTEM IN PLACE AROUND RIM.

4. VAPOR CLOUD FIRE (FLASH FIRE)



SLOW LEAK OF LIGHT GAS

UPON IGNITION, FLAME WILL SPREAD THROUGHOUT PORTION OF FLAMMABLE AND FUEL RICH VAPOR CLOUD. FLAME SPREAD VELOCITIES IN RANGE OF 1 - 50 M/S

EXPLOSIONS / DETONATIONS

- EXPLOSION - PRESSURE BUILDUP IN VESSEL OR ENCLOSURE CAUSES SPONTANEOUS FAILURE OF STRUCTURE
  - PRESSURE WAVE
  - MISSILES FROM FAILED STRUCTURE

- DETONATION - COMBUSTION FRONT MOVES AT SONIC VELOCITY
  - HIGH OVERPRESSURES

PRACTICAL RULES:

- UNSATURATED HYDROCARBONS AND REACTIVE PRODUCTS ARE MORE LIKELY TO DETONATE

- FUEL/AIR RATIOS FOR DETONATION ARE NARROWER THAN FLAMMABILITY LIMITS
- PARTIAL CONFINEMENT AIDS EXPLOSIONS
- [illegible]

E-59

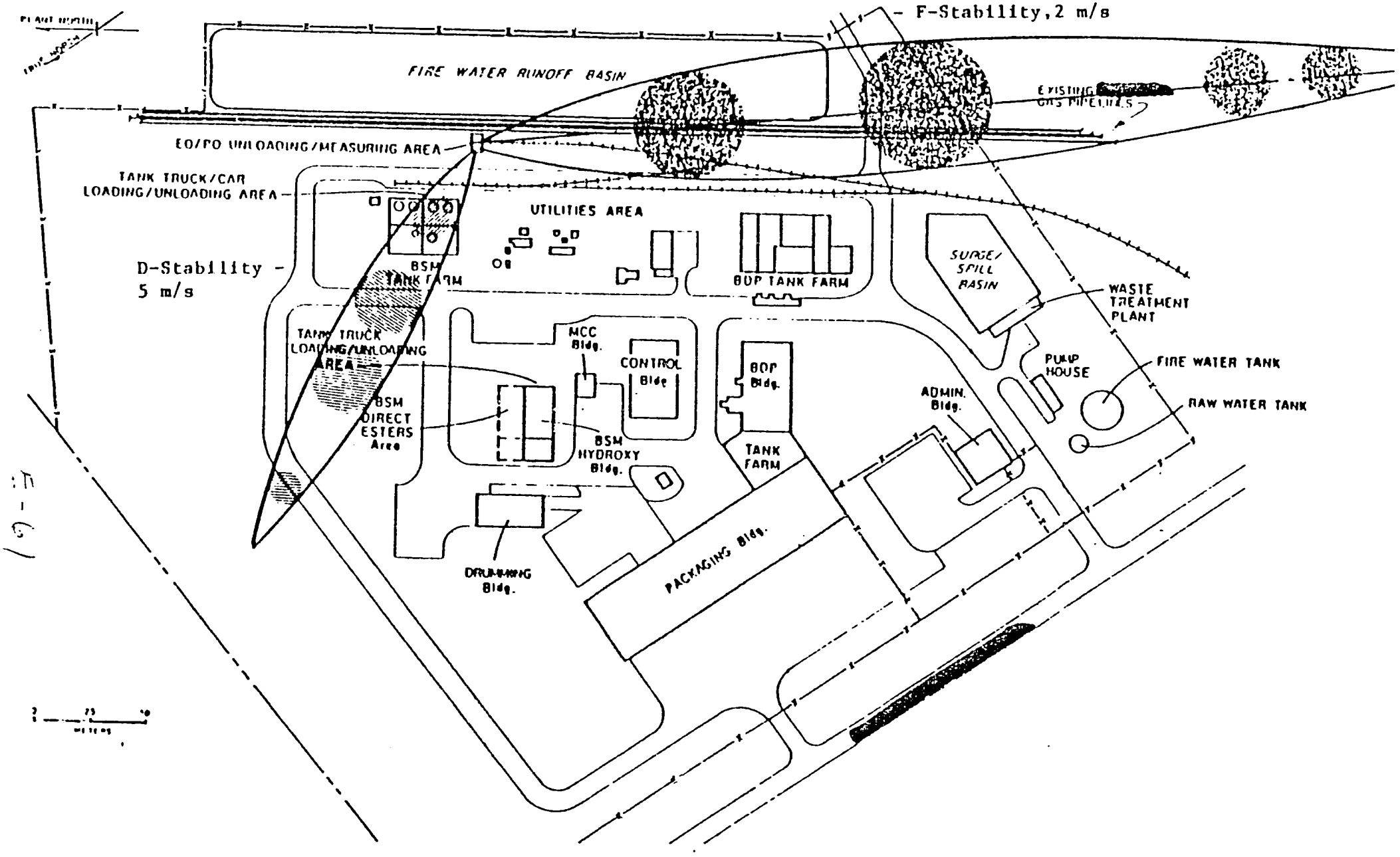
VAPOUR DISPERSION

VAPOUR EVOLUTION

- LIQUID SPILL RATE AND DURATION
- LIQUID SPREADING (CONFINED OR UNCONFINED)
- BOILING OR EVAPORATION

VAPOUR DISPERSION

- BUOYANT OR DENSE GAS GRAVITATIONAL EFFECTS
- ATMOSPHERIC DISPERSION
  - WIND SPEED
  - ATMOSPHERIC STABILITY


F-Stability, 2 m/s
FIRE WATER RUNOFF BASIN
EXISTING GAS PIPELINES
EO/PO UNLOADING/MEASURING AREA
TANK TRUCK/CAR LOADING/UNLOADING AREA
UTILITIES AREA
D-Stability - 5 m/s
BSM TANK FARM
BOP TANK FARM
SURGE/ SPILL BASIN
WASTE TREATMENT PLANT
TANK TRUCK LOADING/UNLOADING AREA
MCC Bldg.
CONTROL Bldg
BOP Bldg.
PUMP HOUSE
FIRE WATER TANK
ADMIN. Bldg.
RAW WATER TANK
BSM DIRECT ESTERS Area
BSM HYDROXY Bldg.
TANK FARM
PACKAGING Bldg.
DRUMMING Bldg.

E-6

257

"ROLLOVER"

LNG, LPG AND NATURAL GAS LIQUIDS ARE MIXTURES AND VARY IN DENSITY AS COMPOSITION VARIES.

THESE DENSITY VARIATIONS CAN LEAD TO STRATIFICATION IN A STORAGE TANK.

LOWER LAYERS, UNDER HYDROSTATIC PRESSURE CAN ACCUMULATE HEAT.

EVENTUAL DENSITY EQUALIZATION CAUSES MIXING AND SUDDEN VAPORIZATION.

SYSTEMS WITH STRATIFICATION AND SUDDEN MIXING POTENTIAL

- OCEAN — SALINITY + THERMAL DIFFERENCES BOTH INFLUENCE DENSITY → "SALT FINGERS"

- REFRIGERATED AMMONIA STORAGE (≈ -40° F or °C) — WATER CONTENT AND THERMAL DIFFERENCES

- REFRIGERATED LPG STORAGE (C_3's + C_4's) AT -40°C to 0°C COMPOSITION AND TEMP. VARIATION

- LNG STORAGE (~ -160°C) (C_1's and some C_2's)

- ETHANE, ETHYLENE ETC. HAVE POTENTIAL BUT ARE NOT BULK COMMODITIES AND USUALLY ARE QUITE PURE

SUPERHEAT "EXPLOSIONS"

WITHIN CERTAIN COMPOSITION RANGES LNG MIXTURES MAY SUPERHEAT WHEN SPILLED ON WATER. WHEN THE SUPERHEAT LIMIT TEMPERATURE IS REACHED (HOMOGENEOUS NUCLEATION OCCURS EXTREMELY RAPIDLY), SUPERHEAT ENERGY IS RELEASED SUDDENLY IN A VIGOROUS INTERACTION WITH WATER.

- MORE LIKELY FOR HEAVIER LNG MIXTURES.
- ENERGY RELEASE LIMITED - NO REACTION.

TYPICAL OUTPUT OF RISK ASSESSMENT

A GRAPH OF

PROBABILITY OF VARIOUS EVENTS VS DEGREE OF IMPACT

Y - AXIS :

FREQUENCY OF OCCURRENCE

$$10^{-2}/YR = \frac{1}{10^2 YR} = \frac{1}{100 YR}$$

$$10^{-6}/YR = \frac{1}{10^6 YR} = \frac{1}{1{,}000{,}000 YR}$$

$10^{-6}/YR \equiv$ 1 CHANCE IN 1 MILLION THAT IT WILL HAPPEN NEXT YEAR

$10^{+6} YR \equiv$ EXPECTED INTERVAL BETWEEN EVENTS OF SUCH SEVERITY

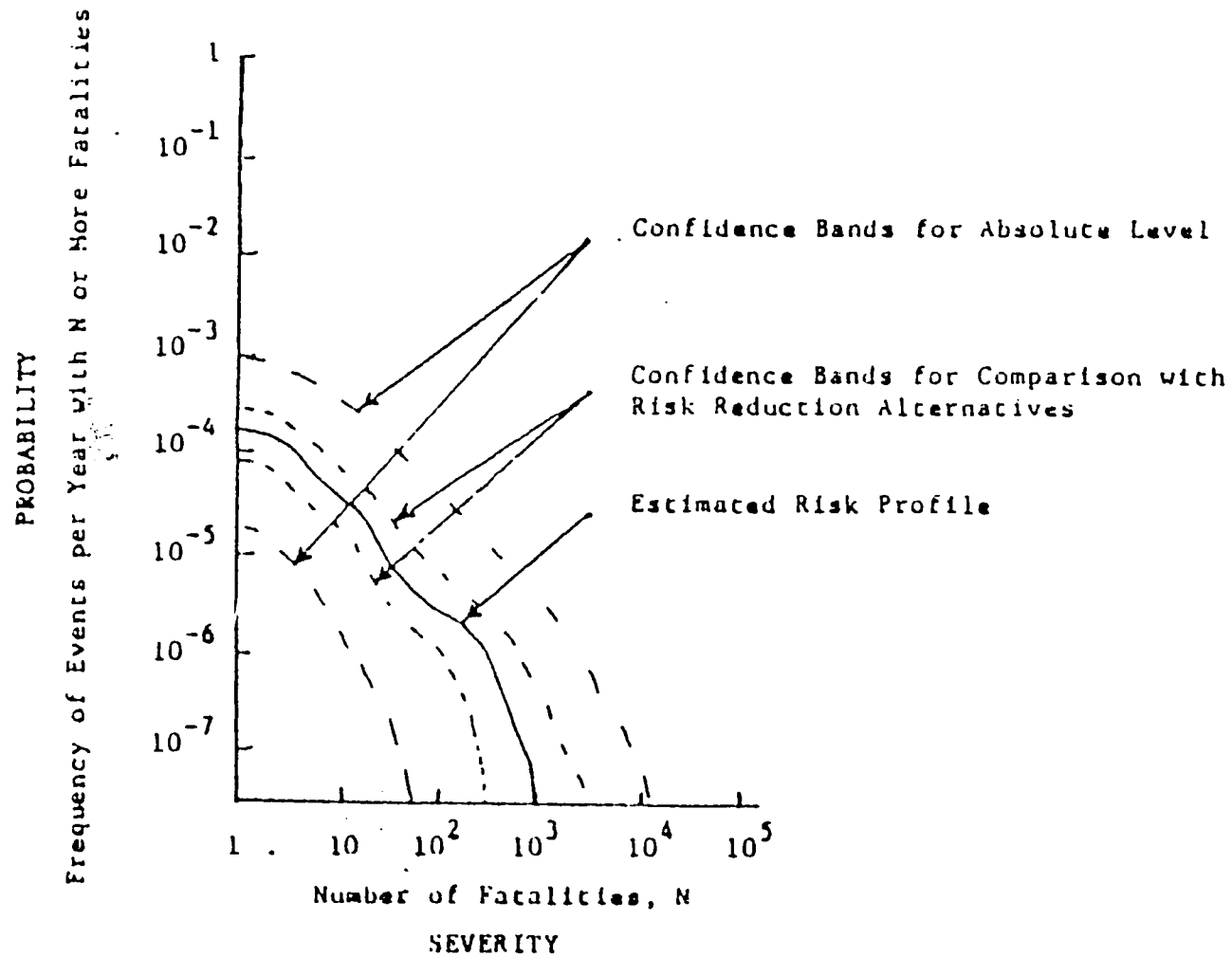
X - AXIS :

SEVERITY INDEX

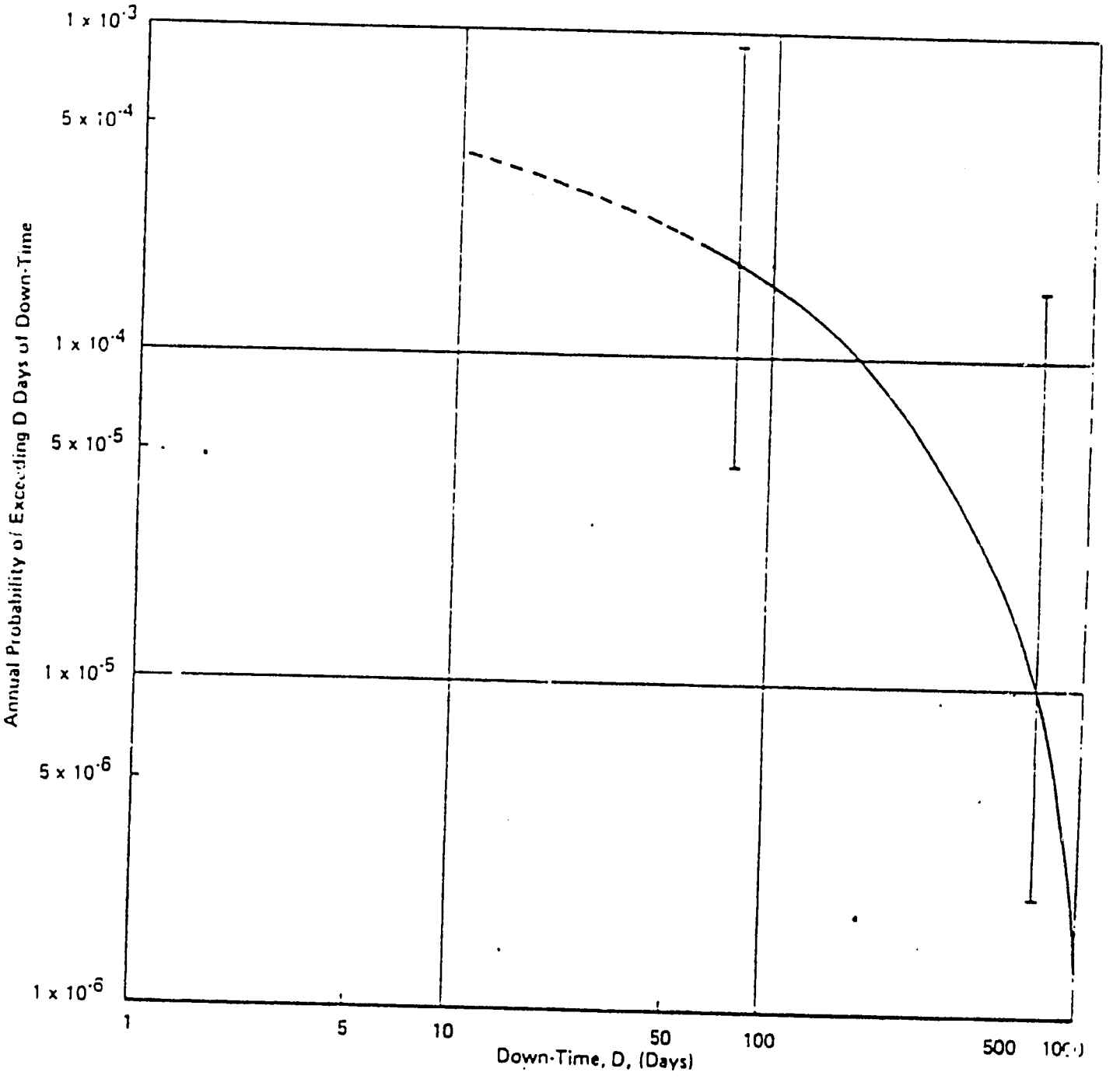
- DOWNTIME
- BAHT LOST
- LIVES LOST
- INJURIES
- ENVIRONMENTAL DAMAGE

TYPICAL RISK PROFILE

EXAMPLE BASED ON SEVERITY MEASURED IN TERMS OF FATALITIES



E-67



*Down-time is defined as the days during which crude oil either cannot be received, be sent out or both as a result of an accident in the LPG or ethane/propane system.

DOWN-TIME* RISK PROFILE FOR THE BO TERMINAL

E-68

ACCEPTABILITY OF RISKS

- WHAT RISKS ARE LOW ENOUGH TO BE CONSIDERED ACCEPTABLE?
- HOW DOES AN INDIVIDUAL VIEW RISKS?
- HOW DOES A GOVERNMENT REGULATORY AGENCY VIEW RISKS?
- HOW DOES A BUSINESS OR INDUSTRY VIEW RISKS?

AN INDIVIDUAL'S PERCEPTION OF RISKS

- VOLUNTARY
- INVOLUNTARY

E-70

266

FACTORS INFLUENCING ACCEPTABLE LEVELS OF RISK TO INDIVIDUALS

(MEASURED IN TERMS OF THE INDIVIDUAL'S PROBABILITY OF DYING DUE TO AN ACCIDENT)

- IS EXPOSURE VOLUNTARY OR INVOLUNTARY?
- WHAT BENEFITS ACCRUE TO THE EXPOSED INDIVIDUAL?
- HOW DOES THE RISK COMPARE TO OTHER RISKS BORNE BY THE INDIVIDUAL?
- ARE OVERALL RISKS DISTRIBUTED EQUITABLY AMONG THE INDIVIDUAL MEMBERS OF SOCIETY?

ANNUAL MORTALITY RATES FOR ACCIDENTAL CAUSES
OF DEATH IN THE UNITED STATES
SUBDIVIDED BY CAUSE OF DEATH, 1978

CAUSE OF DEATH	ANNUAL MORTALITY RATE
ALL ACCIDENTS	4.8×10^{-4}
TRANSPORT ACCIDENTS	2.6×10^{-4}
RAILWAY ACCIDENTS	2.8×10^{-6}
MOTOR VEHICLE ACCIDENTS	2.4×10^{-4}
WATER TRANSPORT	6.7×10^{-6}
AIR AND SPACE TRANSPORT	8.6×10^{-6}
POISONING BY SOLIDS AND LIQUIDS	1.4×10^{-5}
POISONING BY GASES AND VAPORS	8.0×10^{-6}
FALLS	6.3×10^{-5}
FIRES AND FLAMES	2.8×10^{-5}
NATURAL AND ENVIRONMENTAL FACTORS	7.5×10^{-6}
LIGHTNING	4.5×10^{-7}
CATACLYSM (TORNADO, FLOOD, EARTHQUAKE)	5.7×10^{-7}
DROWNING	2.7×10^{-5}
FIREARMS	8.3×10^{-6}
ELECTRIC CURRENT	4.5×10^{-6}

(TAKEN FROM "ACCIDENT FACTS," NATIONAL SAFETY COUNCIL, 1981.)

ANNUAL MORTALITY RATES FOR ACCIDENTAL CAUSES
OF DEATH IN THE UNITED STATES
SUBDIVIDED BY CAUSE OF DEATH, 1978

CAUSE OF DEATH	ANNUAL MORTALITY RATE
ALL ACCIDENTS	4.8×10^{-4}
TRANSPORT ACCIDENTS	2.6×10^{-4}
RAILWAY ACCIDENTS	2.8×10^{-6}
MOTOR VEHICLE ACCIDENTS	2.4×10^{-4}
WATER TRANSPORT	6.7×10^{-6}
AIR AND SPACE TRANSPORT	8.6×10^{-6}
POISONING BY SOLIDS AND LIQUIDS	1.4×10^{-5}
POISONING BY GASES AND VAPORS	8.0×10^{-6}
FALLS	6.3×10^{-5}
FIRES AND FLAMES	2.8×10^{-5}
NATURAL AND ENVIRONMENTAL FACTORS	7.5×10^{-6}
LIGHTNING	4.5×10^{-7}
CATACLYSM (TORNADO, FLOOD, EARTHQUAKE)	5.7×10^{-7}
DROWNING	2.7×10^{-5}
FIREARMS	8.3×10^{-6}
ELECTRIC CURRENT	4.5×10^{-6}

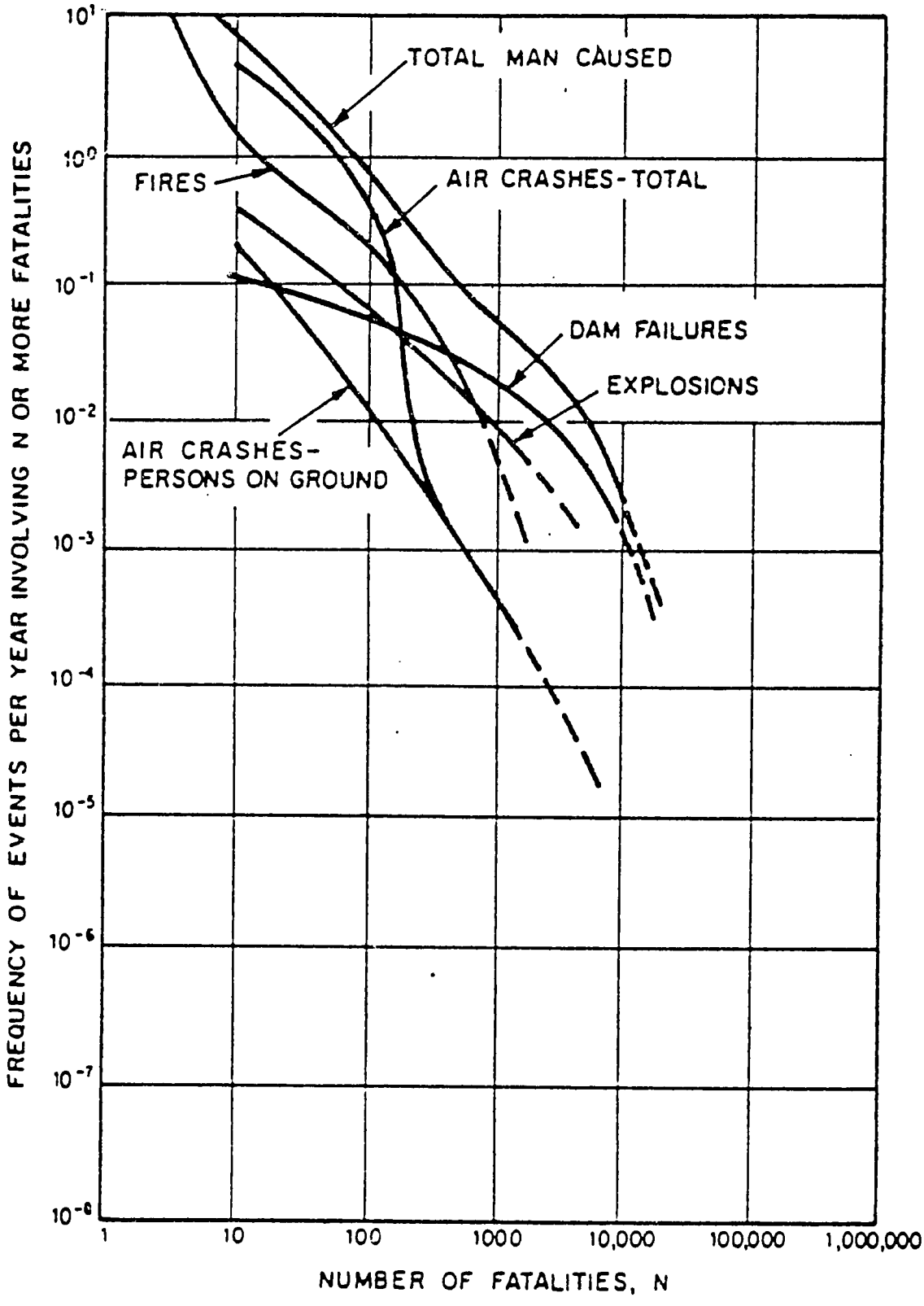
(TAKEN FROM "ACCIDENT FACTS," NATIONAL SAFETY COUNCIL, 1981.)

FACTORS INFLUENCING ACCEPTABLE LEVELS OF RISK TO SOCIETY AS A WHOLE

(MEASURED IN TERMS OF THE LIKELIHOODS OF ACCIDENTS OF VARIOUS SEVERITIES)

- HOW MANY FATALITIES COULD RESULT FROM A MAJOR DISASTER?
- WHAT IS THE LIKELIHOOD OF SUCH A MULTIPLE-FATALITY ACCIDENT?

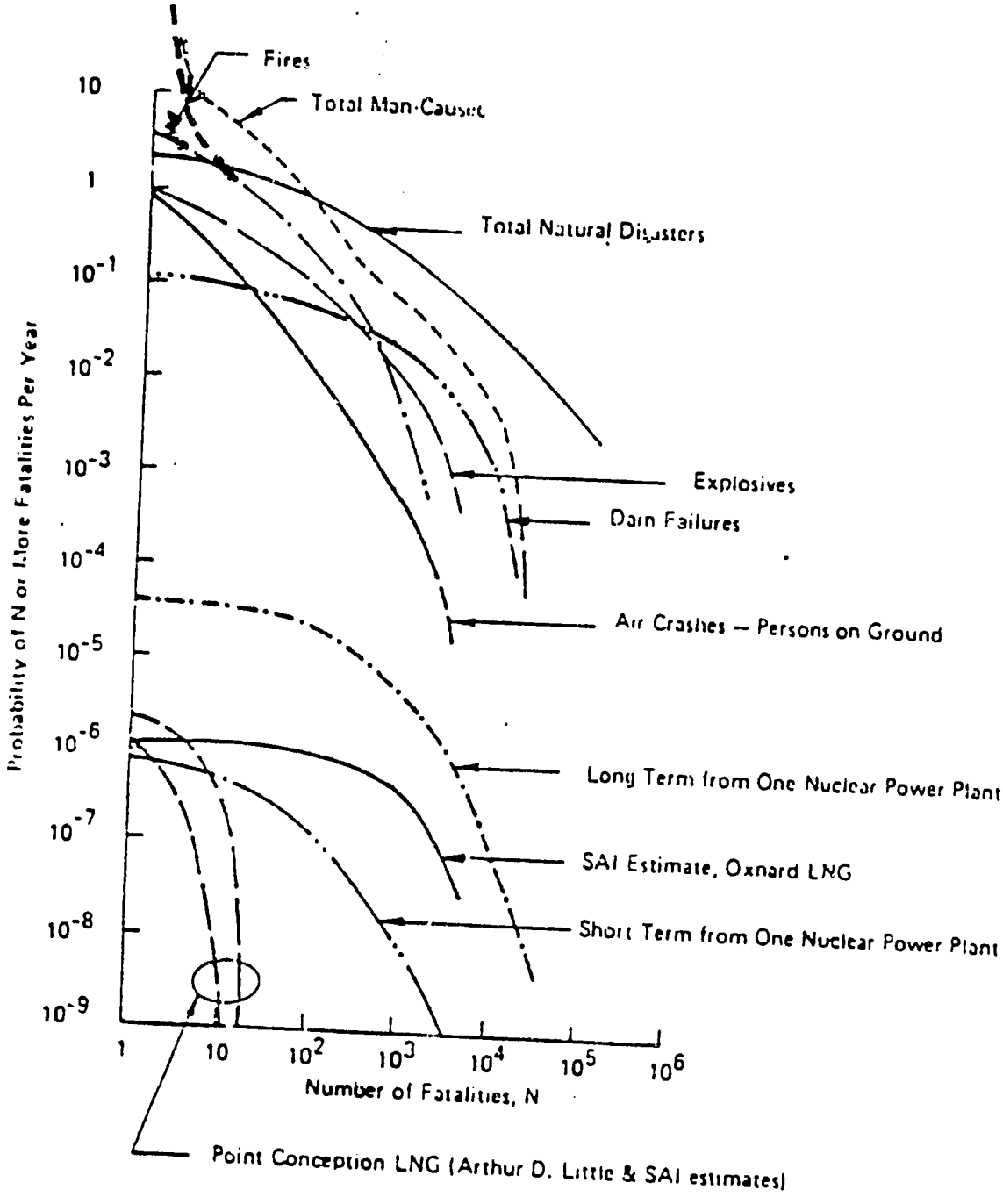
E-73



(Source: "Reactor Safety Study", US Nuclear Regulatory Comm., 1975)

E-74

271



COMPARISON OF MULTI-FATALITY ACCIDENT PROBABILITIES*

* Adapted from WASH-1400 Reactor Safety Study, SAI Reports and Arthur D. Little Tech. Report 16.

E-75

272

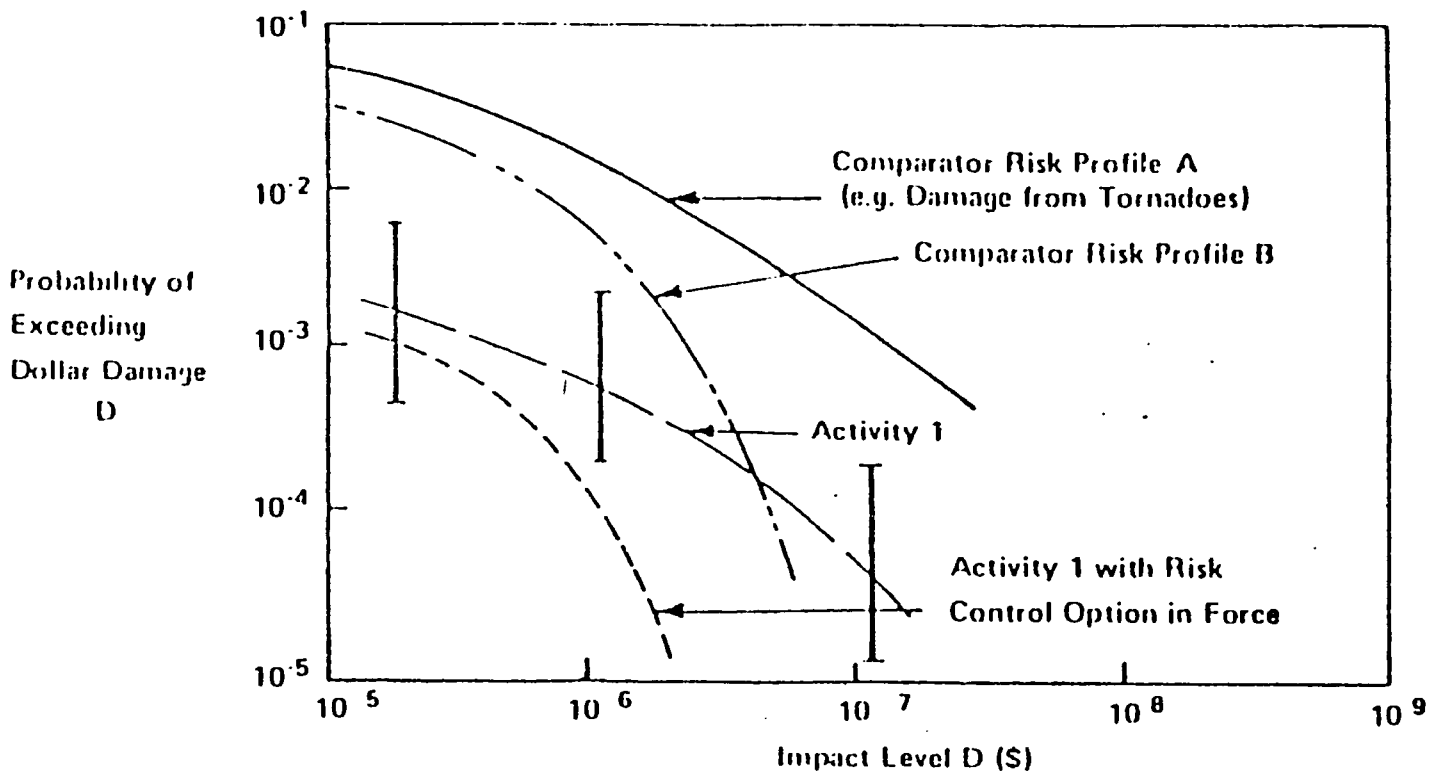
RISK CONTROL

-- REDUCE PROBABILITY OF OCCURRENCE

-- REDUCE CONSEQUENCES

E-76

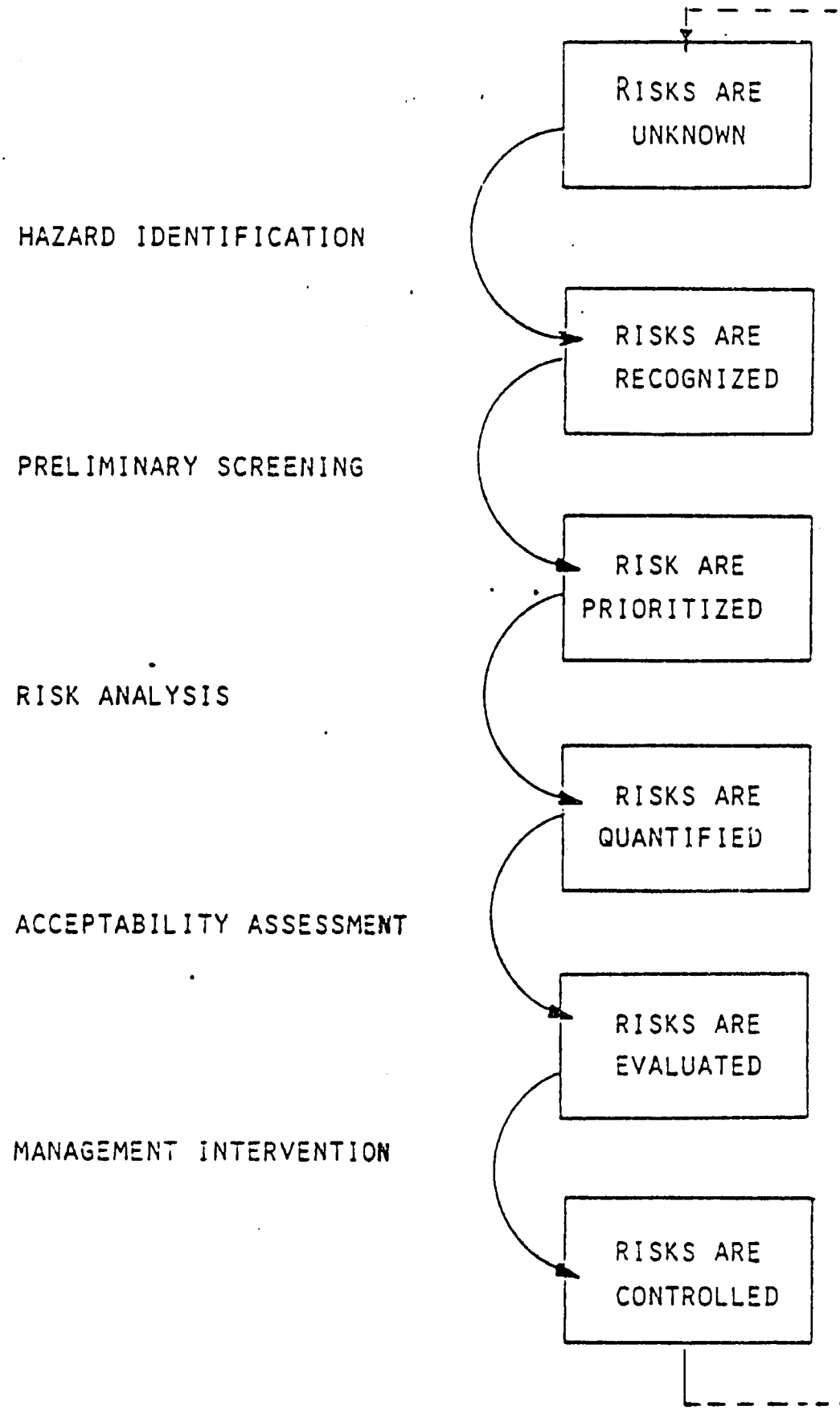
HYPOTHETICAL RISK PROFILE



MAINTAINING SAFE OPERATION

E-78

AN OVERVIEW OF THE CORPORATE RISK MANAGEMENT PROCESS



TRAINING PROGRAMS FOR CONTINUING SAFE OPERATION

- PROGRAMS FOR NEW PERSONNEL
- PERIODIC REFRESHER PROGRAMS FOR ALL PERSONNEL

GOAL: ALL PERSONNEL SHOULD BE THOROUGHLY EXPERT IN THEIR OWN JOB RESPONSIBILITIES AND SHOULD HAVE GENERAL FAMILIARITY WITH PROCEDURES FOR:

- OPERATIONS
- MAINTENANCE
- EMERGENCY SHUTDOWN
- EMERGENCY RESPONSE
  - NOTIFICATION, CHAIN OF COMMAND
  - SOURCES OF HELP
  - COORDINATION WITH LOCAL SERVICES (FIRE, POLICE)
- FIRST AID
- FIRE FIGHTING

TRAINING SIMULATORS

- EXCELLENT FOR TRAINING NEW PERSONNEL

- MAY NOT BE EXACTLY IDENTICAL TO ACTUAL CONTROL SYSTEM (DIFFERENCES CAN BE IDENTIFIED AND NOTED)

- CAN BE USED FOR GIVING EXPERIENCED OPERATIONS PERIODIC PRACTICE IN RESPONDING TO EMERGENCY SITUATIONS

COMPUTER CONTROL OF PROCESSES

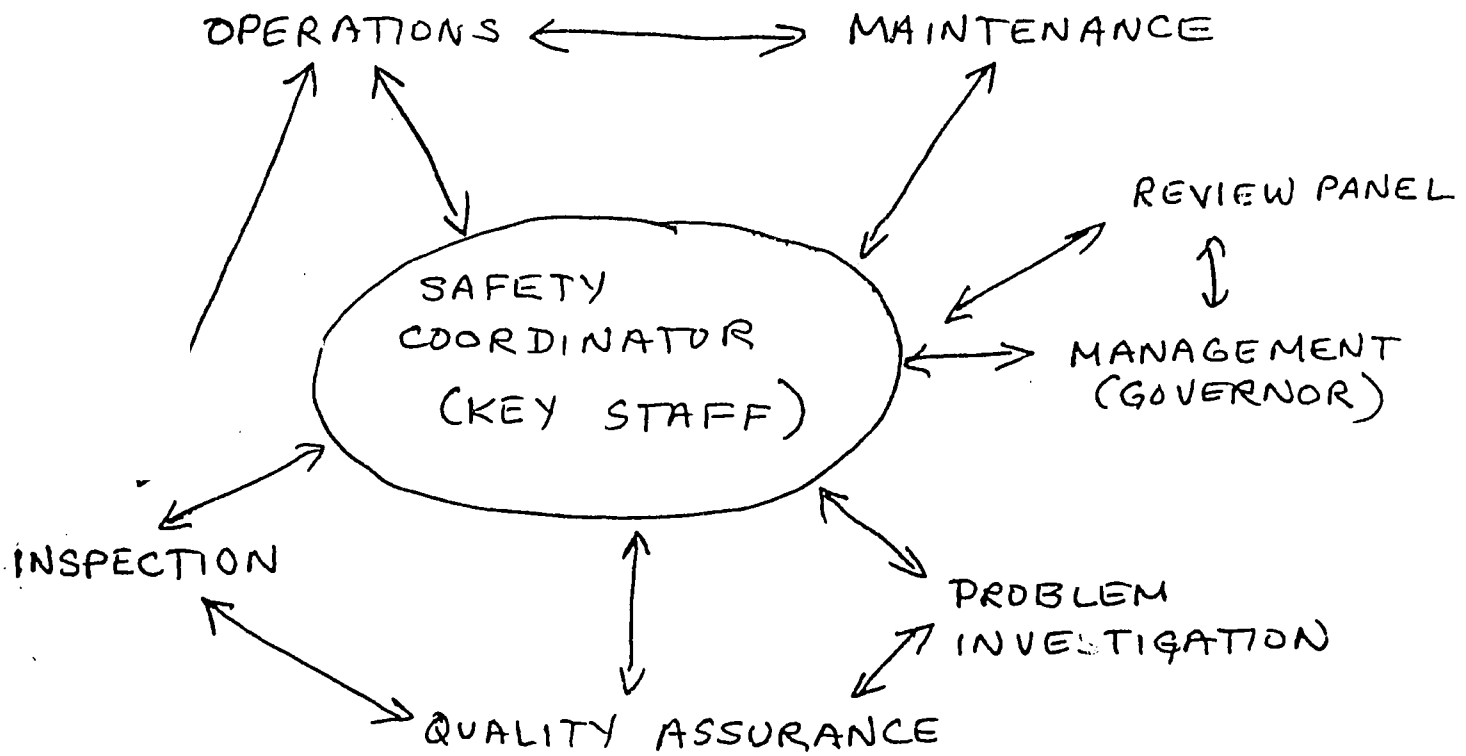
TOO MUCH: OPERATOR SERVES MINIMAL FUNCTIONS AND STAYS MAINLY IN CONTROL ROOM. OPERATOR BECOMES BORED. OPERATOR MAY PANIC IN AN EMERGENCY IF AUTOMATIC SHUTDOWN SYSTEMS FAIL.

TOO LITTLE: FOR A COMPLEX FACILITY, MANY OPERATORS AND SUPERVISORS ARE NEED. FEW KNOW THE TOTAL SYSTEM AND SUBSYSTEM INTERACTIONS. IN AN EMERGENCY ⟶ CONFUSION!

JUST RIGHT: OPERATORS ARE COMPUTER PROFICIENT BUT ALSO KNOW EQUIPMENT FROM ACTUAL OPERATING/MAINTENANCE EXPERIENCE. THEY THOROUGHLY KNOW:

OPERATING PROCEDURES
MAINTENANCE PROCEDURES
EMERGENCY PROCEDURES

THE SAFETY TEAM



- INFORMATION FLOWS ARE TWO-WAY
- SAFETY COORDINATOR REPORTS TO TOP MANAGEMENT
- TOP MANAGEMENT EMPHASIS AND COMMITMENT TO SAFETY

QUALIFICATIONS FOR SAFETY COORDINATOR

- STRONG TECHNICAL KNOWLEDGE
- EXTENSIVE PRACTICAL EXPERIENCE
- INDEPENDENT
- GOOD COMMUNICATION SKILLS
- LEADERSHIP
- SKEPTICISM

SOME RESPONSIBILITIES OF SAFETY COORDINATOR

- SET AND ENCOURAGE HIGH SAFETY STANDARDS
- ESTABLISH AND INTERPRET DATA FROM:

  OPERATIONS – FAULTS, ALARMS, CAUSES OF DOWNTIME

  MAINTENANCE – EARLY WEAR POINTS

  ACCIDENTS – MINOR UPSETS, PLANT SHUTDOWNS, MORE SERIOUS ACCIDENTS

- REVIEW ANY CHANGES IN EQUIPMENT AND/OR PROCEDURES FOR SAFETY
- SUPPORT ANNUAL FACILITY SAFETY AUDIT.

PERIODIC SAFETY REVIEW

- ANNUAL FOR EARLY YEARS OF OPERATION (LESS FREQUENT IF OPERATING EXPERIENCE INDICATES)

- ASSEMBLE REVIEW TEAM (8-10 PEOPLE)
  - KEY PEOPLE FROM FACILITY OPERATIONS, MAINTENANCE
  - OUTSIDE PEOPLE FROM SIMILAR FACILITIES
  - TECHNICAL EXPERTS

- CONDUCT INTENSIVE 2-3 DAY REVIEW ON-SITE

- REPORT TO SAFETY COORDINATOR AND TOP MANAGEMENT.

282

IN SUMMARY

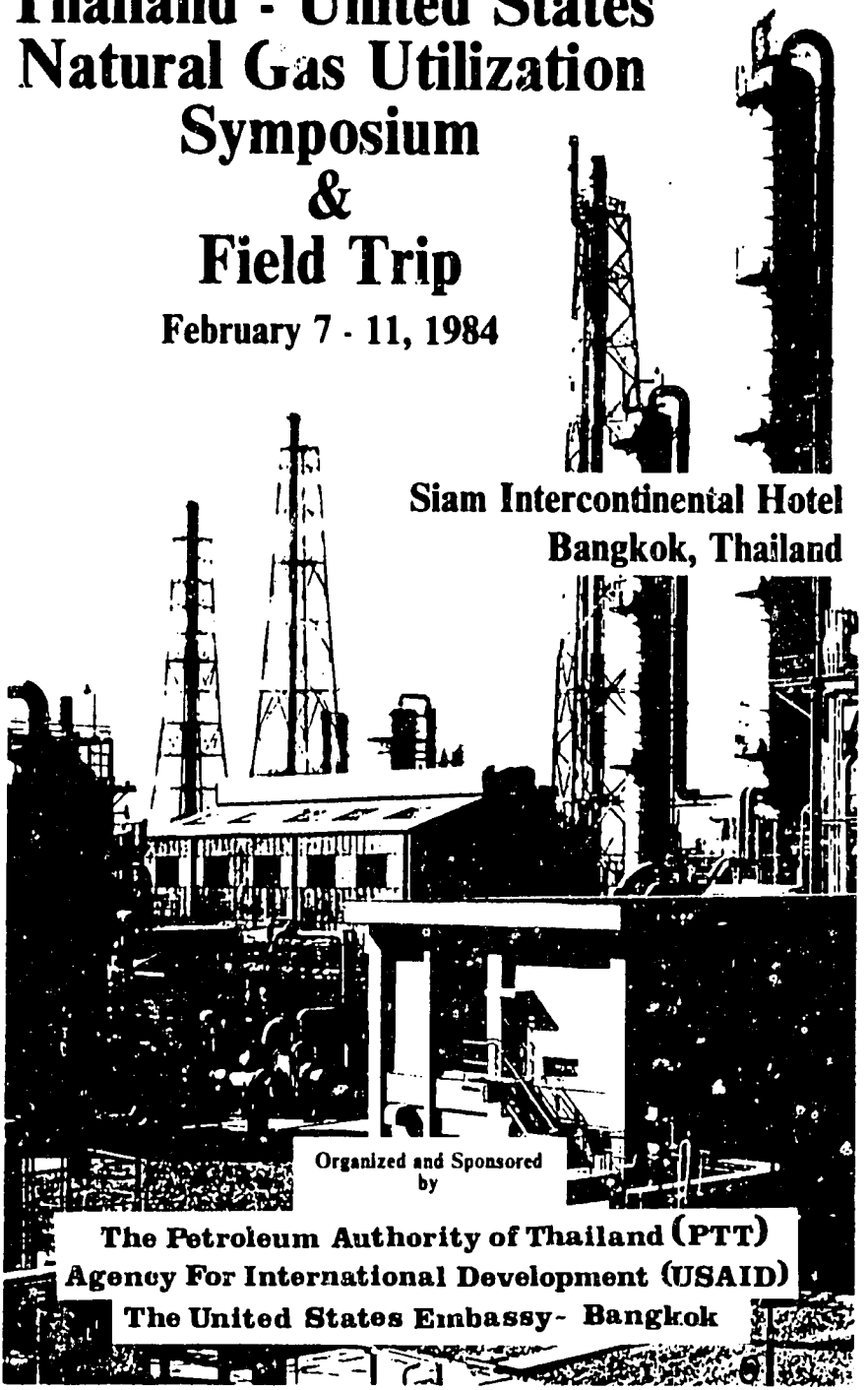
- RISK ANALYSIS IS USEFUL IN THE INITIAL DESIGN OF A "SAFE" FACILITY
- THE SAME TYPE OF ANALYSIS CAN BE USED TO ACHIEVE DESIRED SYSTEM RELIABILITY
- RISK ANALYSIS IS USEFUL IN DEVELOPING OPERATING, MAINTENANCE AND EMERGENCY PROCEDURES
- THE METHODOLOGY OF RISK ANALYSIS FORCES A SYSTEMATIC AND THOROUGH REVIEW OF SYSTEM SAFETY — A VALUABLE TOOL IN IDENTIFYING POTENTIAL HAZARDS
- SAFETY IS A CONCERN THROUGHOUT THE LIFETIME OF THE FACILITY
- TRAINING PROGRAMS FOR NEW PERSONNEL AND FOR EXPERIENCED PERSONNEL WILL REDUCE ACCIDENTS DUE TO HUMAN ERROR. SUCH PROGRAMS ARE VERY IMPORTANT
- CHANGES IN EQUIPMENT AND/OR PROCEDURES SHOULD BE REVIEWED FOR SAFETY IMPACTS.
- ACCIDENTS SHOULD BE STUDIED CAREFULLY TO IMPROVE SAFETY.
- MANAGEMENT SHOULD SHOW STRONG COMMITMENT TO SAFETY, INCLUDING PERIODIC INDEPENDENT AUDITS.

APPENDIX F

ABSTRACTS AND BIOSKETCH DATA HANDOUT

Thailand - United States Natural Gas Utilization Symposium & Field Trip

February 7 - 11, 1984



Siam Intercontinental Hotel
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The Petroleum Authority of Thailand (PTT)
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Petroleum Authority of Thailand

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Charles Bliss
Office of Energy
United States Agency for International Developement

SYMPOSIUM COORDINATOR

Arnold H. Pelofsky
President
AER Enterprises, U.S.A.

TABLE OF CONTENTS

ABSTRACTS.....Page 1

BIOGRAPHICAL INFORMATION.....Page 15

287

ABSTRACTS

AN OVERVIEW OF WORLDWIDE STANDARDS FOR NATURAL GAS UTILIZATION

Elisabeth Drake, Chairman, Chemical Engineering Department, Northeastern University and Marian H. Long, Arthur D. Little, Inc., USA

As countries develop their natural fuel resources, governments and industries are faced with many decisions about what standards should be set to establish the levels of safety they wish. In countries where technology is well established and standards have evolved for fifty years or so, society seems willing to accept somewhat higher levels of hazard than in countries just developing the resources involved.

This paper will define natural gas utilization broadly to include "natural pipeline gas" (primarily methane), "LPG" (primarily propane and butane stored under pressure as liquids), and refrigerated liquefied gases such as liquefied natural gas (LNG) and liquefied ethane or ethylene and liquefied propane.

For these natural gases, we examine major existing practices and standards worldwide and some of the factors of concern for countries in the process of establishing their own standards today as energy resources are developed, processed and introduced into consumer markets.

A MODEL FOR EVALUATION OF NATURAL GAS DEVELOPMENT STRATEGIES

James F. Houle, Projects for Research and Engineering, Bechtel Group, Inc., USA

An increasing number of developing countries are seeking ways to develop their indigenous reserves of natural gas and thereby reduce reliance on imported oil as well as non-commercial fuels. In order to assist in these efforts Bechtel has developed a computer based gas pricing model. This model is the result of extensive experience in gas development projects. The model will be a useful tool for countries for the following reasons:

- It provides a consistent framework for assessing the economic and financial merits of a gas project, thereby serving as a basis for seeking external funding.
- It can be used as a planning tool to evaluate different development options.
- It can generate results quickly and test for sensitivity, once the required inputs are prepared.

258

This paper describes a model developed for use in pricing natural gas from a basic production, processing and delivery system. The paper analyzes a system consisting of a single producing field (associated or unassociated) dedicated to meeting the needs of an industrial center containing electric power, fertilizer, methanol and other gas-fed industries.

The analysis is divided into three sections: system sizing, capital and operating cost estimation and price determination. System sizing includes an analysis of the magnitude and relative timing of peak demands for the potential users. Capital and operating cost approximations are based upon the type of field, system size and configuration and the associated material, equipment and labor requirements. The last section develops a formal economic evaluation of the system. The purpose is to determine one or more unit price trajectories which will generate sufficient revenues for the system to cover all projected capital and operating costs including returns to equity investors and debt service.

NATURAL GAS AND ITS UTILIZATION IN BANGLADESH

Mosharraf Hossain, Director,
Planning, Petrobangla, Bangladesh

Bangladesh has 13 gas fields with an estimated reserve of about 11 to 13 tcf of gas. Exploration efforts are in the process of increasing its gas reserves and finding liquid hydrocarbons. Utilization of natural gas is in limited areas. Present gas projects include:

- Development of gas fields
- Expansion of transmission and distribution lines for consumers such as power stations
- Development of industries including fertilizer plants
- Expansion of commercial and domestic gas utilization

At present, gas consumption is approximately:

30% for power
42% for fertilizer production
20% for industry
2% for commercial
6% for domestic purposes

New projects are under consideration to increase the utilization of natural gas in Bangladesh.

LNG PRODUCTION EXPERIENCE IN BRUNEI

H. Joubert, Manager, Brunei LNG, Brunei

Natural gas produced offshore in Brunei from gas and oil wells is transferred by pipeline to onshore receiving and liquefaction facilities. Acid gases, predominantly hydrogen sulfide and carbon dioxide are removed by extraction with the solvent sulfinol. Water is consequently removed in a dehydration unit. Heavy hydrocarbon components, containing CS and heavier hydrocarbon components are removed and the dried and lean natural gas is used as feed to the liquefaction train, acid gases water and heavy hydrocarbon component removal is carried out to prevent freezing and corrosion in the subsequent steps.

Natural gas from the heavies removal system is liquefied in the main cryogenic exchanger and subcooled to -163°C. Refrigeration is achieved by compressing expanding and evaporating multi component refrigerant. The liquefied natural gas is stored in atmospheric storage tanks. Gases are boiled off and continuously withdrawn to maintain tank pressures slightly above atmospheric.

Operations in Brunei LNG have been governed by three clear priorities: safety, reliability and efficiency. Basic safety requirements are met through stringent safety procedures and an extensive work permit. In Brunei LNG there have only occurred ten cost time accidents in eleven years of operation.

The dedicated nature of LNG projects is based on firm contractual commitments for a large number of years. In the case of Brunei a contractual supply commitment for twenty years entail the requirement of a very high degree of reliability. Plant availability in BLNG is in the order of 85 percent. Programmed commitments have always been met. Efficiency improvements have been implemented throughout the years, resulting in a reduction of thirty five percent in the ratio of fuel and losses over feed. This improvement is significant related to the fact that the fuel element accounts for two thirds of the total operating cost of the Brunei LNG facilities.

THE UTILIZATION OF NATURAL GAS IN NEW ZEALAND

Stephen J. Gale, Scientist, Planning and Forecasting Directorate, Ministry of Energy, New Zealand

This paper will examine New Zealand's experience of synthetic fuels and compressed natural gas (CNG) for automotive use. The overall depletion policy for natural gas will be outlined to provide a background, and the specific reasons behind the choice of technology, project organization, (government participation, private sector involvement, sale of gas or tolling arrangement) and methods of implementation (design and construction management by contractor or consortium etc) will be described. Important objectives include an improved balance of payments, reduced dependence on imported oil and more rapid returns from gas resources. The places found for U.S. technology and project management in these two areas provide insights into where the best match of Thailand's needs and U.S. expertise may be found. The alcohol, synthetic diesel and MTBE possibilities for the future that are currently being studied in New Zealand will be covered.

PAKISTAN EXPERIENCES WITH NATURAL GAS

Munir Ahmad, Director General, Gas Ministry of Petroleum and Natural Resources, Pakistan

Pakistan has a fairly old and well established gas industry. Its network comprises 3758 km of high pressure transmission lines and 12500 km of distribution lines in 78 major towns/cities in the country. Large reserves of good quality natural gas were found in 1952 at Sui in Baluchistan with a recoverable reserve of 8.6 trillion cubic feet followed by another big strike at Mari in the Province of Sind with a recoverable reserve of 3.943 trillion cft in 1957. The recoverable reserves so far discovered in the country are estimated at 18.78 trillion cft of which 3.28 trillion cft have since been utilized.

Present utilization of gas in Pakistan is 850 million cft/day which level has gradually been achieved ever since the inception of gas era in 1955. It is meeting well over 40 percent of the commercial energy requirements of the country. Its use has been extended for the manufacture of fertilizer, generation of electricity and for industrial, commercial and domestic consumption. Through progressively increased use of gas in fertilizer manufacturing Pakistan has not only attained autarky but has also become its exporter. The use of natural gas in power generation was the highest till 1981-82 but its consumption in urea production surpassed all other users in 1982-83 when 33 percent of the total gas produced was used for the manufacture of fertilizer, 25 percent for power generation and the remaining for industrial, commercial and domestic consumers whose number has grown from 100,000 in 1970-71 to 850,000 in 1982-83.

In Pakistan, like other energy deficit countries, the demand management of gas with careful planning and rigid enforcement has become sin-qua-non in the past 2-3 years. Such efficacious measures as conversion to oil of cement plants has been completed and that of power plants is underway to balance the precarious gas supply demand proposition.

During the 6th five year plan viz: 1983-84 to 1987-88 development of all known gas resources, augmentation of the gas purification, transmission and distribution facilities would be undertaken at an estimated capital investment of 842 million US dollars with the generous help of World Bank, Asian Development Bank and other international financial institutions.

With a view to popularizing the use of gas in the initial periods its prices were kept conventionally low. However, with change in policy from expansion oriented to conservation the consumers' prices had to be rationalized in January, 1982. Incentives which encouraged high gas consumption have been withdrawn to cut down its ever increasing demand. The consumers' prices of gas were increased from an average of RS. 10.00 (dols 1.00) per mcft in 1981 to RS. 20.00 (dols 1.5) per mcft in July, 1983. Government has also announced price incentives for producers to encourage development of new gas resources in the country.

The two major gas companies in Pakistan viz: Sui Northern Gas Pipelines Limited and Sui Gas Transmission Company Limited are and have been undertaking major gas transmission and distribution projects of national importance. The loan giving agencies, i.e., Asian Development Bank and World Bank have recognized and appreciated the professional capability of these companies. Government of Pakistan will be only too glad to have the capability of these companies extended to the benefit of Thailand in the field of planning, designing and execution of the pipeline construction projects.

USE OF GASEOUS FUELS IN THE TRANSPORTATION SECTOR

Tom Joyce, President, Tom Joyce Associates and Jack G. Edwards, Manager, Engineering Services, GDC, Inc., USA

Natural gas and liquefied petroleum gas (LPG) have been utilized in a number of countries for many years as a fuel for automobiles, trucks, tractors, ships and other vehicles. Each country and each application present specific technical, economic and social problems which must be considered when selecting the preferred fuel. Usually the major factors when considering gaseous fuels for vehicular use are twofold: economics and environmental. The clean burning characteristics of gaseous fuels lead to justifiable adaptation for vehicles to be used primarily indoors, such as fork-lift trucks for warehouse service. The use of gaseous fuels in over-the-road vehicles is dependent primarily upon economic justification. Countries with an excess of natural gas or other gaseous fuels and those with a heavy dependence on the importation of crude oil or refined liquid fuels are good candidates for the consideration of operating vehicles on gaseous fuels.

This paper will review current programs for converting the transportation sector to gaseous fuel usage, with particular emphasis on programs in developing countries. Techniques for estimating potential markets, the economic costs and benefits of conversion of over-the-road vehicles to gaseous fuels will be reviewed. A case study of a conversion program which the authors are currently conducting in a developing country will be presented.

AUTOMOBILE EQUIPMENT REQUIRED TO USE COMPRESSED NATURAL GAS AS A FUEL

Gregory Macosko, Principal, Hayes/Hill Inc., USA

The use of natural gas as a vehicle fuel and the equipment necessary for engine conversion to compressed natural gas (CNG) has been proven under a wide range of actual operating conditions. Compared with gasoline, natural gas has a higher octane rating, burns cleaner, improves ignition, reduces certain maintenance requirements and costs, and provides significant fuel cost savings.

CNG conversion involves trade-offs between cost, driving range, performance and weight. To optimize this trade-off and to make CNG as attractive as possible, U.S. manufacturers have done a considerable amount of technical development to improve their products. Such R&D includes light weight cylinders, gas flow meters, small compressors, electronic applications for engine conversion and new gas storage technology.

CNG conversion decision factors influence investment payback and determine what types of vehicles and fleets are the most attractive conversion candidates. Fleet size, differential between gasoline and natural gas price and fuel usage per vehicle are three basic factors which are critical to the decision to convert. The first step towards market development should be commitment to a CNG program by both government and industry with incentives for both parties.

THE NEW ZEALAND EXPERIENCE WITH COMPRESSED NATURAL GAS (CNG) IN MOTOR VEHICLES

Donald Hertzmark, ASEAN Consultant, Asian Institute of Technology

Compressed Natural Gas has been used as a motor fuel for over 30 years. Recent developments in liquid fuels supply have improved the prospects for using CNG in cars, trucks, and buses. This paper examines the infrastructure needs of a switch to CNG fuel. In particular, the refuelling and transport systems are described. Financial analysis is then performed; first on refuelling stations to determine selling prices for CNG under various alternatives, then on fleet vehicle and refuelling systems to determine rates of return on investment. The analysis shows that fleet use of CNG will be cheaper than diesel (US$ 0.20 - 0.25/1) and will yield a discounted cash flow rate of return of about 20% using conservative assumptions.

THE PRODUCTION, USE AND ECONOMICS OF METHANOL

Bert W. Struth, Executive Vice President, Chem Systems, Inc., USA

The methanol business is faced with a period of oversupply which will last until the late 1980's. The supply surplus has been caused by new capacity built in anticipation of high cost fuel-related markets which are now developing at a slower than expected rate.

The supply/demand imbalance will result in an extended period of low prices which will lead to rationalization in the USA, Western Europe and Japan.

However, the dynamic state of the methanol business does present opportunities. New export-oriented producers will be dependent on experienced marketers, just as traditional marketers will become more dependent on new suppliers for competitive sources of supply.

Considerable market development is required to achieve significant penetration in fuels-related applications. Global demand is expected to increase from 12 million metric tons in 1983 to 29 million by 1995. Fuel-related uses are expected to increase from 8% to 40% of total demand during this time frame. The major driving force will be the price of methanol in relation to its value as a gasoline blending component which is 1.6 to 2.0 times its cost of production.

243

FURTHER DEVELOPMENT OF THE METHANOL-FUELED ESCORT

Robert J. Nichols, Principal Research Engineer,
Turbine and Alternate Fuels Research Development Department,
Ford Motor Company, USA

The results obtained from the 40-vehicle fleet of methanol-fueled Escorts in service since 1981 are reviewed. These results provided the basis for an upgraded vehicle built on the production line. A total of 587 vehicles were built, including five advanced technology vehicles with more stringent emissions goals at an equivalent thermal efficiency. Vehicle configuration, fuel and oil specifications, and emission, fuel economy and performance data are discussed. One of the major challenges when developing the vehicle was the selection of fuel system materials compatible with methanol. A follow-on program to find cost reduction solutions is underway.

GASOLINE FROM NATURAL GAS

Gerald F. Tice, Supervising Engineer and
Hal C. Spohn, Principal Engineer, Advanced Technology
Planning Department, Fluor Engineers, Inc., USA

The alternative of synthetic gasoline from natural gas is presented in the context of Thai transport fuels demand and natural resource potentials. Technical options are described, and the results of an economic analysis are presented. A sensitivity analysis explores the effects of variations in major economic parameters on project profitability.

THE PRODUCTION, ECONOMICS AND USES OF SYNTHESIS GAS

Frank A. Demers, Stone & Webster Engineering Corp. and
Samuel A. Tabak, Mobil Research and Development Corp., USA

Recent technological innovations have broadened the spectrum of uses for natural gas and natural gas liquids. The development of unique catalytic processes designed for synthesis gas conversion now make it possible to produce from natural gas, conventional liquid transportation fuels such as gasoline and diesel. In addition, natural gas will be an important feedstock for the production of a complete range of base chemicals including methanol, olefins, and aromatics including such intermediate products as vinyl acetate, ethylene glycol, acetic anhydride and oxo alcohols, to name a few.

Most of the emphasis in syngas conversion technology in the last few years has been directed towards the production of liquid transportation fuels. The

294

discovery of new capabilities for zeolite catalysts marks what may be the technological turning point in increasing the uses for natural gas through single carbon chemistry. Mobil Oil Corporation was the first to capitalize on the use of zeolites in their process for the conversion of methanol to high octane gasoline. Further developments of this technology will soon make it possible to produce high quality diesel and jet fuel as well as olefins and aromatics indirectly from syngas.

This paper will present the economics for producing synthesis gas and the potential for its use as a feedstock for chemicals and liquid transportation fuels. Additional emphasis will be directed towards intermediate syngas conversion process such as Methanol and Fischer-Tropsch Synthesis together with the application of the Mobil Olefins to Gasoline and Distillate (MOGD) process for the production of gasoline and diesel fuel. Yield data, product quality and commercial status of the Mobil process will also be presented.

CURRENT EGAT POWER GENERATION USING FUEL GAS

Robert G. Settle, Project Manager,
Black & Veatch International, USA

Discovery of natural gas in the Bay of Thailand created the opportunity for the Electricity Generating Authority of Thailand (EGAT) to reduce the import of fuel oil which had caused an unfavorable balance of trade for the Kingdom of Thailand in the late 1970's. EGAT, as the sole available user of the new natural gas discovery, immediately initiated studies to determine feasible courses of action for full utilization of the gas when available.

The first action of EGAT was to convert the South Bangkok Thermal Plant to permit firing of natural gas as an alternate fuel to the number 6 fuel oil.

The second action was to purchase eight 60 MW gas turbines and combined cycle equipment designed to fire either natural gas or fuel oil.

The third action was to initiate construction of two new 550 MW thermal units at Bang Pakong.

EGAT, in cooperation with the Fuel Organization of Thailand (PTT) was able to use the natural gas as soon as it first became available in September, 1981, and has successfully used all natural gas available to them.

This paper describes the plants and the experiences of the initial fuel gas firing.

295

COMBINED CYCLE COGENERATION

R.I. Gavin, Partner and Project Director,
Sargent & Lundy, USA

Cogeneration is the simultaneous production of electric power and process steam in a single thermodynamic cycle. This paper discusses four cycles using natural gas. These cycles are a simple boiler plant producing steam only (base case), a cogeneration plant consisting of a boiler and noncondensing steam turbine generator, a cogeneration plant consisting of a gas turbine with unfired heat recovery steam generator, and a combined cycle cogeneration plant consisting of a gas turbine with a supplementary fired waste heat recovery steam generator and a noncondensing steam turbine generator. The cycles are characterized by production of a constant quantity of process steam and varying amounts of byproduct electric power. Capital and operating cost estimates are presented for each cycle. The combined cycle plant evaluates favorably in comparison to the other cycles due to its high specific electric power output (kW-hr/10^6 Btu steam output). The combined cycle cogeneration plant is particularly attractive in applications with high natural gas fuel costs and high electric power demand.

DIRECT HEATING

W.H. Thorbecke, Chairman, Energy Support Services, Inc., USA

Since energy supply sources are expected to change dramatically during the next 50 years, Thailand should carefully weigh the economics of utilizing its indigenous natural gas to develop its economy and create jobs as opposed to conservation or export. The paper discusses a number of direct heating applications for natural gas.

RECIPROCATING ENGINES IN ON-SITE POWER PLANTS

D.A. Noelkin, Regional Manager, Caterpillar Tractor Co., USA

With steady industrial development, Thailand's energy requirements grew at the rate of 7.6 percent annually between 1978-1981. By 1981, Thailand was consuming the equivalent of 300,000 barrels of crude oil a day. Because of escalating oil prices, the need was obvious for expediting the search for alternative future sources of energy. Recent discoveries of natural gas resources have been found off the Gulf of Thailand which will ease the drain on the Thai economy from imported oil.

This natural gas can be burned in reciprocating engines to produce a reliable source of electricity. This paper deals with the basics of natural gas engine operation, heat balance of these units, potential applications, along with system considerations when installing such units. An economic analysis which compares on-site power generation to electrical purchases from the utility are also included in this presentation. The paper concludes with several key principles when installing on-site generating systems.

GAS TURBINES FOR INDUSTRIAL USE

George J. Milici, Manager, Turbo Machinery
Ingersoll-Rand S.E.A. PTE. LTD., USA

The author's paper describes, in general terms, various drivers to be considered when deciding on a project installation. Different drivers are most suitable for different applications, depending on geographic location, available utilities and available fuels, or energy sources.

A review of steam turbines, electric motors, industrial engines, hydraulic turbines, gas expanders and gas turbines was made, briefly, to give the reader general background information on where and when these drivers should be considered.

Following completion of the review of drivers, the author's years of experience were drawn upon to discuss considerations that must be taken into account when designing a gas turbine for industrial use. This includes discussion on environment, atmospheric conditions, fuels, noise, controls, physical dimensions and installation requirements.

The design criterion considered the most advanced, yet proven turbine technology, and concludes that aero derivative type machines have considerable advantages over the heavy duty type machines. Logically, therefore, the two basic types of industrial turbines are compared with respect to fuel consumption, reliability, availability, service/maintenance and installation. The comparison shows strong evidence of the flexibility and superiority of the aero derivative type in certain applications.

Since this type of machine is relatively new to Thailand, a history of its development, from early aircraft use to today's industrial applications describes how the machinery introduction was possible.

Finally, a representative economic evaluation, based upon Discounted Present Worth is documented to show the relative costs of these machines when fuel, maintenance, installation and capital costs are accounted for. This calculation uses the basic economic format prescribed and is simplified by use of differential costs only.

TURBOEXPANDERS IN NATURAL GAS APPLICATIONS

John Holm, Director, International Marketing, Rotoflow Corp., USA

Turboexpanders have been used commercially for processing of natural gas for more than twenty years.

This paper describes the advantages of turboexpanders, the proven features that have contributed to their success giving expander operators a long, efficient, low maintenance service.

Conservation of energy has opened a new market for turboexpanders recovering energy from natural gas pressure letdown and low grade waste heat.

297

THE REMOVAL OF CARBON DIOXIDE

R.E. Meissner III, Director, Gas Technology and
H. Robert Scivally, Manager, Business Development,
The Ralph M. Parsons Company, USA

The removal of CO_2 from natural gas is desirable before the gas is used as a feed stock for petrochemical and fertilizer production. In the production of hydrogen and ammonia within a petrochemical or fertilizer complex, CO_2 removal is necessary. This paper discusses processes and economics for separation of CO_2 from natural gas, hydrogen, and ammonia synthesis gas. Processes include those which use physical and chemical solvents. The BASF activated MDEA process is introduced as a low capital and low energy alternative which is applicable to all three separations.

ECONOMICS AND PRODUCTION OF FERTILIZER

Giovanni Lorenzo Farina, Project Director,
Foster Wheeler International Corp., USA

This paper is a general overview of Thai agriculture demand of fertilizers used to determine the production capacity of the Complex and the range of fertilizer grades. Alternative configurations of the Complex with assessment of their technical and economical aspects are shown along with a description of the selected configuration with indication of the profitability of the investment.

Role of the Project Management Consultant to implement the Fertilizer Complex project is described.

PHOSPHATE POTASH & SODA ASH

G. Russell James, President, James Chemical Engineering, USA

Phosphate and potash are essential components of all vegetation and are therefore required, along with nitrogen, in fertilization of crops to maintain optimum production.

Soda ash is an indicator of industrial activity because it is required in so many basic commercial products (glass, chemicals, pulp and paper, soap, etc.).

For both phosphate and potash, agricultural use far outdistances industrial applications. Phosphate manufacture is based on phosphate rock, for which the major producing areas are the USA, USSR and Morocco. Processing moves through production of phosphoric acid; there are several available technologies and competition is keen.

Major source areas for potash are the USSR, Canada, Germany, the USA and France, and production processing, by recrystallization, depends on the nature of the ore as mined.

Production of soda ash historically has been based primarily on salt and limestone. Economic and environmental considerations have caused significant changes in recent years in the synthetic process, whereas in North America production from natural trona has almost eliminated competition from the synthetic route.

THE MALAYSIAN PENINSULAR GAS UTILIZATION PROJECT

Hashim Salleh, Technical Manager, Petronas Gas, Malaysia

Since Malaysia has relativley abundant gas reserves, gas will play a predominant role in the fuel supply of the country and as a feedstock for industries. Several gas and gas-based projects that are being implemented include the Liquefied Natural Gas and the Ammonia/Urea Plants in Bintulu (Sarawak), the Methanol and Direct Reduction Iron Plants in Labuan (Sabah) and the Peninsular Gas Utilization Project of Peninsular Malaysia.

This paper describes the Peninsular Gas Utilization Project in Malaysia undertaken by Petronas, the Malaysian National Oil Co.

The Peninsular Gas Utilization Project involves piping the natural gas produced from oil and gas fields offshore Terengganu on the east coast of Peninsular Malaysia to an onshore gas processing plant where the gas is treated and LPG and condensates are extracted. The LPG's are piped to an export terminal where it is stored in a refrigerated form for export.

In Stage I of this project, gas will be delivered to a 900 MW combined cycle power station and a 600,000 tons/year Direct Reduction Iron Plant. A pilot gas distribution system to supply gas to commercial and domestic consumers and a pilot CNG station to supply gas for motor vehicles will also be implemented in Terengganu. In Stage II of the project, gas will be piped to power stations and to consumers on the west coast and to the south of Peninsular Malaysia.

Construction work for Stage I of the project is well underway. Work is scheduled to be completed in two phases: Phase I by the middle of 1984 and Phase II towards the end of 1984.

The Gas Processing Plant will have an initial capacity of 250 million scfd and an ultimate capacity of 1.1 billion scfd.

MAKE AMMONIA WITH LESS ENERGY

Joseph R. LeBlanc Jr., Manager, Inorganic Chemical Division, M.W. Kellogg Co., USA

Ammonia, one of the largest volume industrial chemicals, is absolutely essential to world food production. The manufacturing process used to produce ammonia is a very energy intensive operation. In recent years much attention has been given to reducing the energy consumption in making ammonia. In this paper, both new plants and retrofitting existing ammonia plants for increased energy efficiency will be discussed.

FIRING WITH GAS IN CEMENT KILNS

Werner Ostberg, Vice President, Engineering Operations, The Kuljian Corp., USA

A short description of types of kilns used in the cement industry and a short description of fuels used in cement kilns are given. The properties of gas and the use of gas firing versus other fuels in cement kilns is explained.

A detailed description of using gas in modern pre-calciner kilns and the difficulties encountered herewith and remedies to eliminate such difficulties are described.

THE PETROCHEMICALS INDUSTRY IN TODAY'S ECONOMY

Gordon D. Mounts, Vice President/General Manager, Process Systems and Services Department of the Catalysts and Process Systems Division, Union Carbide Corp., USA

The petrochemical industry will be evaluated as a business in today's economy. The important elements of business strategy in petrochemicals will be defined. One of the important elements of business strategy is technology implementation especially in the petrochemicals business. The importance of the owner/operator perspective in technology implementation will be examined. In particular the examples of ethylene and ethylene glycol will be evaluated. Using ethylene glycol as an example of petrochemicals in today's industry, the markets, manufacturing and economics of ethylene glycol will be discussed.

PLANNING PETROCHEMICAL COMPLEXES BASED ON NATURAL GAS

Andrei Rhoe, Vice President, Lummus Technical Center and M.J. Maddock, Manager, Process Planning and Economics, C-E Lummus Co., USA

The presence of natural gas reserves provides the impetus and opportunity for Thailand for the development of petrochemical industries in the country. After years of planning, a major petrochemical complex will be erected in the Eastern Seaboard industrial area to produce major basic petrochemical products.

This paper presents other major petrochemical products that can be produced from natural gas. This paper also discusses the long range overall planning of future expansion and development of petrochemical industries as well as the planning and execution experiences of such petrochemical complexes.

MANAGING A PETROCHEMICAL PROJECT

William Burner, Project Director, Foster Wheeler International Corporation, USA

Foster Wheeler is currently the managing contractor for a petrochemical complex in Nigeria and for refinery and fertilizer projects in Thailand. Based on this experience, the principles of managing a petrochemical project are presented. The paper discusses the principal decisions, problems and progressive steps that must be considered in the developments and implementation of a grassroots petrochemical project.

ETHANE/PROPANE CRACKING TECHNOLOGY

Colin P. Bowen, Business Development Manager and Erich Kranz, Business Development Manager, Stone & Webster Engineering Corporation, USA

The choice of basic technology is the key decision facing the Thai Petrochemical Partnership. There are many superficial similarities between the various olefins production processes as would be expected in a mature technology sector. Nonetheless, in major processing facilities, apparently small advantages translate into large annual production cost differences. Because incorrect technical selection decisions can have enormous long term profitability consequences, the owner must be keenly aware of the relative process performance differences between the candidate technologies.

This paper will therefore identify those design elements which distinguish the successful olefins production process and examine the economic implications of these key process-related factors. The specific feedstock and product interrelationships for the intended Thai Project will be considered, and various options to satisfy the intended propylene: ethylene ratio will be discussed. Recent advances in the areas of ethane/propane pyrolysis, product recovery, energy integration, and process control will be cited. Finally the role of the olefins technology supplier to the new industry entrant will be outlined.

201

PRODUCTION AND ECONOMICS OF OLEFINS FROM ETHANE AND PROPANE LPG

Reno S. Zack, Manager of Olefins Development, C F Braun & Co., USA

Thailand wishes to produce ethylene and a relatively high proportion of propylene from limited indigenous supplies of ethane and propane LPG. It may not be feasible or economical to produce the high proportion of propylene desired by steam pyrolysis alone. Additional propylene can be produced by propane dehydrogenation. The recovery of propylene from dehydrogenation can be done separately or together with the pyrolysis effluent.

This paper discusses and compares the various options for optimizing the utilization of Thailand's feedstocks, and recommends the optimum selection for Thailand's conditions.

POLYPROPYLENE PRODUCTION PROCESSES AND ECONOMICS

B.P. Belles, Research Supervisor, Polypropylene Division, Amoco Chemicals Corp., USA

Amoco Chemicals operates both slurry and gas phase processes for the production of polypropylene. Process features are compared, and operational considerations are discussed. Relative economics comparing the two processes are presented, highlighting areas of significant savings provided by the more modern gas phase process.

DYNAMIC DIGITAL SIMULATION IN PROCESS OPERATIONS

S.M. Solomon, President, M. Asgari, Vice President and General Manager and R. Uttamsingh, Business Development Manager, Far East and Pacific Basin, C-E Simulation and Advanced Process Control, Inc., USA

Simulators have substantially benefited the process industries, providing faster and more effective training of operations personnel than was ever possible with traditional methods. These same simulators are also used successfully to assess the impact of alternative process plant control systems without disrupting operations, and to perform instrumentation checkouts.

In its design, a simulator must take into account process dynamics, control system configurations, plant operations, and training requirements, as well as the latest simulation techniques. Only by addressing all these factors can engineers deliver a simulator that reflects the client's training needs, the backgrounds of trainees and instructors, the actual operations of the plant, and the procedures which operators must handle in the actual control room.

C-E Simulation and Advanced Process Control, Inc., a leading supplier of process training simulators will address: assessing simulator requirements, defining simulator specifications, integrating simulators into a training program, training instructors, and implementing simulator training exercises.

BIOGRAPHICAL INFORMATION

ASGARI, MAXWELL is Vice President and General Manager of C-E Simcon, Inc., a unit of Combustion Engineering, Inc.

With more than 15 years of experience in Process Control, Mr. Asgari joined C-E in 1972. His positions with C-E have included General Manager of the Digital Products group, Commercial Manager of the Company's Control and Automation Department, Manager of its European section, Project Section Manager, and Engineering Manager.

Prior to joining C-E, Mr. Asgari held engineering and systems control positions in the process industry. He is a graduate of Fairleigh Dickinson University where he earned a Bachelor's Degree in Electrical Engineering and a Master of Science Degree in Physics.

BELLES, B.P. is Research Supervisor in the Polypropylene Division of Amoco Chemicals Research and Development at Naperville, Illinois. His experience includes various assignments in R&D, Manufacturing, and Engineering, nearly all involving polypropylene technology. Currently, he is responsible for the technical aspects of licensing in the Polymers and Plastic Area, and for Polypropylene Process Design and Economics.

BOWEN, COLEN is employed by Stone & Webster Engineering Corporation, Boston in the capacity of Business Development Manager. His experience in the Hydrocarbon Processing Industry includes 20 years involvement in the areas of plant design, commissioning, and international project execution. Mr. Bowen has worked on several overseas assignments; in his current capacity he has developed extensive contacts with the Asian Petrochemical Industry.

Mr. Bowen holds a degree in Chemistry from the University of Birmingham and a degree in Chemical Engineering from the University of London. He is a chartered member of the British Institutes of Chemical & Mechanical Engineering.

BURNER, WILLIAM (BILL) is the Foster Wheeler Project Director currently responsible for the Nigerian Petrochemical Complex, Phase II.

Mr. Burner was educated at Fairmont State College, West Virginia, USA, and West Virginia School of Mines. He graduated from Florida State University and later worked on an advance degree in Finance and Accounting at Pace College, New York.

Mr. Burner's working career extends over 40 years in the field of engineering and construction.

CLARK, JOE R. with more than 30 years in the petroleum industry, began his career as junior petroleum engineer with Stanolind Oil and Gas Company (now AMOCO Production Company) joining Texas Pacific Oil Company, Inc. in May, 1964, as Chief Reservoir Engineer. Mr. Clark was promoted to Chief Engineer, Production Department in November, 1966, Production Manager in December 1967; Vice President of Production in June 1969; Executive Vice President, International in May of 1979; Executive Vice President Production - Exploration in August of 1980, and his present position of President in March, 1983.

Through Mr. Clark's active participation with the oil industry trade associations, he served as president of the Dallas Petroleum Club during 1977 and is currently serving on its advisory committee. Additionally, he is affiliated with the Society of Petroleum Engineers of AIME, Texas Mid-Continent Oil and Gas Association, American Petroleum Institute, National Society of Professional Engineers, and International Association of Oilwell Drilling Contractors.

DEMERS, FRANK A. has 18 years of experience in the engineering industry. Currently, as Senior Process Projects Engineer, he is responsible for International Synfuels Project Development activities.

Prior to joining Stone & Webster and since 1974, he has worked in a management capacity on two projects for the conversion of coal to liquid fuels. These have been associated with the design of a fluidized bed Fischer-Tropsch reactor pilot plant and the process design, follow-up and field operation of two world scale Fischer-Tropsch (Synthol) facilities for SASOL II and III in Secunda, South Africa.

He has worked on a number of "first of a kind" petrochemical projects and has served as Process Development Group Leader having responsibility for a number of feasibility and market-related studies directed at establishing priorities for pilot plant research.

EDWARDS, JACK G. is Manager of Engineering Services for GDC, Inc., an energy services organization which is a subsidiary of the Institute of Gas Technology. His responsibilities include consulting services for industrial training, natural gas technology, energy utilization, energy planning and renewable energy. Prior to his affiliation with GDC, Mr. Edwards spent twelve years with the Columbia Gas System in various positions with a major emphasis on the development of automation systems. Mr. Edwards received a BS in electrical engineering from Tri-State University and an MS in Management and Supervision from Central Michigan University.

FARINA, LORENZO GIOVANNI is the Project Director for the Fertilizer Project of the National Fertilizer Corporation of Thailand. He is an employee of Foster Wheeler International Corporation.

304

GAVIN, RICHARD I. is a Partner and a Project Director at Sargent & Lundy. As a project director, Mr. Gavin is responsible for the implementation of the work and the technical integrity of the project. In the course of discharging these responsibilities, Mr. Gavin directs several project teams, each staffed by a project manager, project engineers, and other technical personnel. Mr. Gavin consults with his clients and project teams in planning and scheduling each project, and developing the appropriate cost control systems.

During his work at Sargent & Lundy, he has been involved in the preparation of reports and studies on various subjects pertinent to the electric utility industry as well as for steam and electric power facilities for industrial installations. Included in these investigations were cogeneration feasibility studies, plant siting studies, cooling lake and cooling towers studies, water usage studies, and many others.

Mr. Gavin has had extensive experience in all phases of the mechanical design of major steam-electric generating plants for utility systems as well as steam and electric power facilities for industrial systems. His work has included responsibility for the design of 51 steam-electric power plant projects ranging in size from 20 MW to 985 MW. Fuel experience with these units has involved 7867 MW of coal and lignite capacity, 4055 MW of gas and oil capacity, and 985 MW of nuclear capacity.

Mr. Gavin earned his B.S.M.E. at Cornell University and he is a registered Professional Engineer and a member of numerous engineering societies.

HERTZMARK, DONALD currently holds the position of ASEAN Energy Consultant. In that role, he is responsible for performing consulting on new energy projects tasks as requested by energy companies or agencies in the ASEAN countries. His projects range from natural gas to biomass. Dr. Hertzmark performed his investigations into compressed natural gas under the auspices of ESCAP. In addition to consulting, Dr. Hertzmark teaches at the Asian Institute of Technology, Bangkok. Previously, Dr. Hertzmark has worked in the oil industry and for the Solar Energy Research Institute (U.S.). He received his graduate training at the University of Wisconsin (1978) and undergraduate training at Georgetown University (1971). Dr. Hertzmark has published widely in the fields of energy efficiency and alternative fuels.

HOLM, JOHN is the Director of Technical Planning and Sales for the Rotoflow Corporation. His present responsibilities include exploring and developing new markets for the company. He also coordinates all sales on the national and international level.

HOULE, JAMES F. is Manager of Projects for Research and Engineering, Bechtel Group, Inc. He directs international development projects in regional planning, industry and infrastructure planning, water and agricultural development and energy resources.

Currently, he is Project Director for the USAID multicountry "Technical Assistance in Conventional Engergy" program and coordinates teams in Morroc-

405

co, Sudan, Bangladesh and Indonesia. These projects involve gas resources development, power transmission system improvements, coal development and transport planning.

Mr. Houle is a Chemical Engineer and a registered Professional Engineer in California. His career has involved 10 years in the design and operation of petroleum production, pipelines and refining facilities and over 15 years in the international development planning area.

HOSSAIN, MOSHARRAF is Director of Planning for Petrobangla, Bangladesh. He received his BS in Engineering from the University of Lahore in 1964; his MSc in Engineering from Imperial College, UK in 1967 and his D.I.C. Degree from London University in 1976.

JAMES, RUSSEL G. is President/Owner of James Chemical Engineering. Since 1964, he has carried technical, commercial, project and budgetary responsibilities for the wide range of assignments handled by JCE. Originally based on expertise of natural gas processing to syngas, ammonia and methanol, these assignments have covered the full range of fertilizers and natural gas derivatives and have diversified into similar work on inorganics (soda ash and cement) competitive fuels, energy conservation and pollution control.

JOUBERT, HENRI is the Manager of Brunei LNG. From 1978-1982, he was Operations Manager of Shell Curacao. From 1976-1978, Mr. Joubert was Refinery Superintendent of the PSPC Philippines Refinery. He was involved in manufacturing planning in the head offices of SIPM, the Hague.

JOYCE, THOMAS J. is President of Tom Joyce Associates and serves as a consultant to the worldwide energy industry, the World Bank, US-AID and other United States governmental agencies. He has held positions of Chief of the Bureau of Natural Gas of the Federal Power Commission and Vice President of Management Sciences at the Institute of Gas Technology. Mr. Joyce is a registered professional engineer in West Virginia, Illinois and Michigan. He is a member of the American Gas Association and a recipient of the Federal Power Commission Distinguished Service Award. Mr. Joyce received a BS in chemical engineering from West Virginia University.

KRANZ, ERIEN is employed by Stone & Webster Engineering Corporation, Boston in the capacity of Business Development Manager with particular responsibility for olefins. His experience in this area is based on 12 years of international plant design. Mr. Kranz's experience at Stone & Webster has included design and economic evaluations for several chemical plant projects requiring frequent contact with the major olefin producers of the world.

Mr. Kranz holds a Masters and Bachelors of Science degree from Massachusetts Institute of Technology. He is a member of the American Institute of Chemical Engineering.

LEBLANC, J.R. is Manager, Inorganic Chemical Division, for the M.W. Kellogg Company. He supervises and directs process design of plant facilities for production of chemical and petrochemical products including ammonia, hydrogen, methanol, urea, and nitric acid.

Before joining Kellogg, Mr. LeBlanc was a senior development engineer for Dow Chemical, and earlier a process and production engineer for Allied Chemical.

He holds a BSChE in Chemical Engineering from Tulane University, is a registered professional engineer in Texas and Louisiana, and a member of the American Institute of Chemical Engineers.

Mr. LeBlanc has authored/co-authored numerous papers in the chemical and petrochemical process field, and in addition is co-inventor on three patents relating to ammonia production.

LEWIS, JAMES E. is a Vice President of Hayes/Hill Incorporated. Mr. Lewis has been active in marketing, new product planning, business strategy and acquisition/corporate development assignments. He has managed projects in a variety of consumer and industrial product areas including industrial minerals, heating and air conditioning, industrial process equipment, consumer durables, business services and energy resources.

Mr. Lewis is responsible for the firm's energy and HVAC practice and is Chairman of the firm's Marketing Practice Committee. He is a member of the North American Society for Corporate Planning, the American Marketing Association and the American Management Association.

MACOSKO, GREGORY is a Principal for Hayes/Hill Inc. He has concentrated on new products/market evaluation studies for both domestic and foreign clients. His areas of specialization are the automotive market and the gas industries. He managed a study of the potential retrofit market of Compressed Natural Gas (CNG) - powered vehicles in the US and has consulted with a number of gas utilities on their marketing strategies.

MADDOCK, M.J. is Manager of Process Planning and Economics, responsible for direction of a group of senior engineers in planning and optimization studies, conceptual engineering in early phases of a project, and process studies in new technology. Previous experience included responsiblity for technical supervision in process design for projects and proposals in the Olefins area.

Dr. Maddock earned a Ph.D. in Chemical Engineering at the Birmingham University in the United Kingdom.

MEISSNER, ROLAND E., III is Director of Gas Technology for the Ralph M. Parsons Company, Pasadena, California where he is responsible for the process design of oil production and gas processing facilities. He holds a B.S. Degree in Chemical Engineering from the University of Wisconsin and an M.S. Degree in Chemical Engineering from the University of Southern California. He is a registered professional engineer in California.

MILICI, GEORGE J. is Manager of Turbo Machinery for Ingersoll-Rand. He is involved with engineering, applications, sales marketing and service of centrifugal and positive displacement pumps, steam turbines, Centrifugal compressors and gas turbines.

MOUNTS, GORDON D. is Vice President/General Manager of the Process Systems and Services Department of the Catalysts and Process Systems Division of Union Carbide Corporation. Mr. Mounts' experience includes fifteen years in engineering and ten years in operations, marketing, sales and business management. Mr. Mounts started his career as a process engineer in South Charleston, West Virginia. He progressed through process design, operation analysis, project management, and engineering management. From engineering management he proceeded to product and operations management in several areas, including ethylene oxide derivatives, amine products, acrylic esters, vinyl acetate and high and low density polyethylene. He then became Director of Marketing for polyethylene before moving to his current job. He led the Market Team that introduced Unipol resins to the U.S. marketplace.

NICHOLS, ROBERTA J. is Supervisor of Alternate Fuels Engine Development, including designing ethanol engines for Ford of Brazil. She came to Ford in December, 1979. Under her direction several demonstration vehicles have been built to operate on LPG (liquefied petroleum gas), CNG (compressed natural gas), LNG (liquefied natural gas) and methanol.

Prior to joining Ford, she worked at The Aerospace Corporation for 19 years as a Member of the Technical Staff, Environment and Energy Conservation Division, Vehicle Performance Office. In 1978-79, she served as Consultant to the State of California, Synthetic Fuels Program.

In 1974, Dr. Nichols was given an Outstanding Engineer Merit Award by the Institute for the Advancement of Engineering; and in 1975 she received a Woman of the Year Award from The Aerospace Corporation. She has been actively engaged in racing for many years and was holder of the Women's Water Speed Record as a drag boat driver from 1966 to 1969. She is currently involved with vintage car racing.

NOELKIN, DAVE is a Senior Application Engineer for Caterpillar Far East Ltd. Before this position, he was the OEM Regional Manager covering the entire CFEL area. From 1978-1981, he was the Engine Sales Representative covering Indonesia. He graduated with a BS degree in Mechanical Engineering in 1976 from the University of Missouri.

OSTBERG, WERNER has thirty-eight years of diversified experience in the cement industry in projects, operations and corporate management in the United States, Canada, South America, Africa, the Middle East and Europe.

Currently, as Head of Engineering Operations for the Kuljian Cement Division, he has overall responsibility for 1,000 TPY Juffrah Cement Plant Project for Secretariat of Heavy Industries, Tripoli, Libya.

Recently, as General Manager of International Projects for the largest cement plant manufacturing company in the United States, he handled many proposals worldwide, including complete, large cement plants using latest technology - conversions to the dry process, and coal conversion.

As an independent consultant, he was appointed to such organizations as UNIDO and IBRD. He headed a team of experts commissioned by the World Bank in 1979, which performed complete evaluation of the Indian Cement Industry, considering growth and conversion of existing plants to dry, coalfired units. In 1977, under a special grant from IBRD, he performed an assessment of earthquake damages for the Rumanian Construction Industry.

RHOE, ANDREI is Senior Vice President of Technology for Lummus Crest Inc., a unit of Combustion Engineering, Inc.

Mr. Rhoe is in charge of the entire operation of the Lummus Technical Center, Engineering Development Center, and Operations, Maintenance and Training Divisions of Lummus Crest. He brings to this position over 25 years of experience as an engineer in research, design, and development for the petroleum and petrochemical industries.

Mr. Rhoe earned a Bachelor's degree in Chemical Engineering at the Petroleum and Gas Institute in Romania and a Masters of Business Administration degree at the Centre de Perfectionnement aux Affaires (CPA) in France.

SCIVALLY, H. ROBERT is currently Manager Business Development for Petroleum and Chemical Division of The Ralph M. Parsons Company.

Recently Managing Director of Saudi Arabian Parsons, Ltd. Member of Board of Directors, Board of Control of Parsons - Daniel Joint Venture and Executive Committee of American Businessmen of Jeddah.

Prior to this, Scivally held positions in a major Japanese Chemical Engineering and Construction company.

He is a licensed Professional Engineer and holder of seven U.S. patents on new processes.

SALLEH, HASHIM is in charge of developing gas utilization projects in Malaysia. One of the most important energy projects in the country, involving tapping off-shore gas fields, gas processing and gas transmission for power generation and the petrochemical industry is under his responsibility.

SPOHN, HAL C. is a Principal Engineer in Fluor's Advanced Technology Planning Department. He is responsible for market and economic analyses for feasibility studies and resource evaluations. His experience includes a wide range of functions in the energy and chemical industries. Mr. Spohn received his B.S. in Mechanical Engineering from the University of Colorado and holds a Business Management Certificate from the University of California.

301

GALE, STEPHEN J. received his doctorate in Physics from Cambridge University, UK. He has been with the Ministry of Energy since 1978 and has been involved with the synthetic petrol project since the earliest investigations. He was assigned to Mobil for several months and later became a member of the Ministry of Energy's three-man negotiating team that settled the project contracts with Mobil Oil. He was also a member of the team that completed the economic review of the venture for the final government decision. In the last two years, Dr. Gale has served as coordinator in the Planning Division for the gas sector. This task has involved participation in studies of industrial and domestic reticulation (optimal system expansion rules), establishment of gas resource costs (for intersectoral allocations of gas) and review of options for expansion of production facilities.

STRUTH, BERT, has been an Executive Vice President of Chem Systems Inc. since 1976. He joined Chem Systems, an international consulting company, in 1965. Prior to that, Bert Struth was employed by Exxon Research & Engineering for eleven years in both refining and petrochemical planning, design, and start-up. He currently heads Chem Systems' consulting services in the Western Hemisphere and Far East.

Bert Struth received his PhD in Chemical Engineering from the Brooklyn Polytechnic Institute in 1954.

TABAK, SAM joined the Process Research and Technical Service Division of Mobil Research and Development Corporation in 1976 after receiving his PhD in Chemical Engineering at the Pennsylvania State University. His initial assignment was in Exploratory Process Research where he contributed to development of new catalytic technologies for aromatic isomerization and olefin processing. He then transferred to Process Development where he contributed to commercialization of technologies for catalytic dewaxing, gasoline hydrotreating, and olefin processing. His work has resulted in 21 patents and 6 publications. Presently Sam is project leader for development of the Mobil Olefin to Gasoline and Distillate (MOGD) Process.

THORBECKE, WILLEM H. is a veteran of two multi-nationals and one domestic company which he built up into a worldwide international company.

He has conceived, developed and built up international businesses on six continents comprising total assets in excess of one billion dollars.

As Chairman of Energy Support Services, Inc. he formed joint ventures with prominent companies in Saudi Arabia, the Netherlands, Indonesia and Thailand and appointed representatives in Taiwan and the Philippines.

Previously, while serving as President of Dravo International, he put together a worldwide management and marketing organization. Regional offices were established in Europe, Africa, the Middle East, Latin America, and in the Far East, thereby successfully pioneering the entry into eight new international markets, including Saudi Arabia, the Peoples Republic of China, Thailand and the Philippines. During the period 1977-1981 cumulative international business booked exceeded $1.2 billion.

30

He is a Director of the World Affairs Council, a member of the American Management Association's International Management Division Council and a member of the National Association of Corporate Directors.

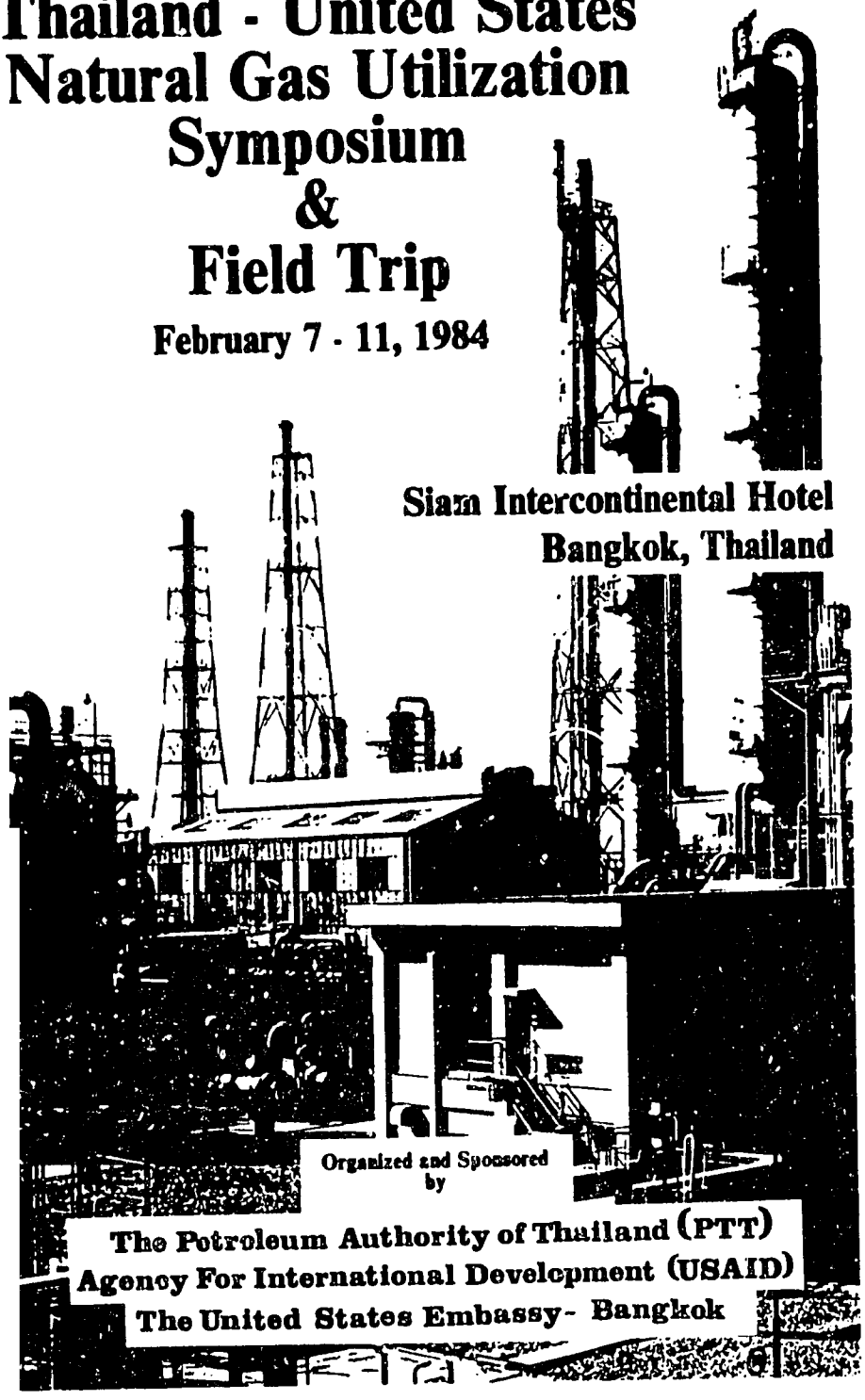
In March of 1982, he was one of the Founders of Energy Support Services, Inc. (ESSI) which is an international company providing services to the Electric Power, Petroleum and Gas Industries. Its United States operations are located in North Carolina, Louisiana, Texas, Pennsylvania and Alaska and its international network consists of experienced business associates in Japan, Taiwan, the Philippines, Indonesia, Thailand, Saudi Arabia, Western Europe, North Africa and Latin America. In June of 1983 he was elected Chairman of the Board of Directors.

TICE, GERALD F. is a Supervising Engineer in Fluor's Advanced Technology Planning Department. He is responsible for technology evaluation and acquisition, with emphasis in the chemicals and energy fields. His prior experience includes process development work. Mr. Tice received his B.S. in Chemical Engineering from the University of Wisconsin and studied Business Management at the University of Chicago and UCLA.

ZACK, RENO S. is Manager of Olefins Development for C F Braun & Co. He is responsible for defining the company's development programs in all theirtechnological aspects and coordinating execution. Mr. Zack received his BS in Chemical Engineering from The University of Texas and a Business Management certificate from UCLA.

Thailand - United States Natural Gas Utilization Symposium & Field Trip

February 7 - 11, 1984



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312

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United States Agency for International Developement

SYMPOSIUM COORDINATOR

Arnold H. Pelofsky
President
AER Enterprises, U.S.A.

TABLE OF CONTENTS

ABSTRACTS Page 1

BIODATA Page 8

314

Thailand - United States Natural Gas Utilization Symposium
Bangkok, February 7-11, 1984

Energy Resources and Reserves

Sivavong Changkasiri

Director General
Department of Mineral Resources, Ministry of Industry

Abstract

A Solution to energy-self-reliance for Thailand is to put more emphasis on developing the country's energy resources such as oil, gas, coal, oil shale, geothermal and radioactive minerals.

Exploration and evaluation of new petroleum prospects are constantly being conducted. At present, proved natural gas reserves in the Gulf of Thailand is estimated at 5.94 trillion SCF plus 119.5 million barrels of condensate. Onshore recoverable oil reserve in the central plain is estimated at 30 million barrels. The country's total natural gas production is about 184.6 MMSCFD whereas the total crude oil and condensate production is about 18,500 barrels per day.

Coal deposits have been found in the northern and southern parts of the country. Total proved coal reserve is about 678.05 million tonnes.

Oil Shale has been found in a large quantity in the Mae Sod area of Tak province where total reserve is about 18,600 million metric tonnes.

Several hot springs in Chiangmai and Chiangrai provinces are under studies for utilization as geothermal energy source.

Monazite sand straddled along the southern part of the country has been found to yield some low-grade Uranium and Thorium. Also, potential source of Uranium oxide is situated in the Khorat plateau in the north-eastern part of the country.

25

Thailand - United States Natural Gas Utilization Symposium
Bangkok, February 7-11, 1984

Thailand's Economic Transformation and Future Direction of Energy Policy

Phisit Pakkasem

Deputy Director General
National Economic and Social Development Board.

Abstract

Thailand's mix of economic policies has always been formulated to strengthen and diversify the country economic base using our resource-rich position, comparative advantage, social cohesion and agroeconomic position in Southeast Asia. The key growth components leading to our sound economic performance during the last two decades are:

- resource-rich economy and net food exporter
- conservative fiscal policies
- strong private sector
- stability in economic management

Our economic outlook for the next five years could be viewed as transformation from the traditional agricultural-rural resource based to more urban and industrialised. The economic transformation will "take-off" aided by the availability of natural gas and oil and development of basic industries. The central feature of the current National Development Plan is the industrial development program of Thailand's Eastern Seaboard (ESB). The program will involve investment of $ 5 billion in its first stage and will make the ESB a "new industrial spring-board of Southeast Asia". The success of the program will make Thailand one of the so-called "newly industrializing countries (NIC)".

With this economic policy, Thailand's GDP growth rate is projected to be 6.5 % per annum for the next five years. Demand for energy is also projected to increase at rates above 6 % per annum which is higher than the Plan's 4.7 % target. However, the discoveries and production of indigenous natural gas and oil will reduce Thailand's dependence on imported oil from 65 % of total energy consumption in 1981 to 45 % in 1987 and 33 % by 1990. Investment by the public sector for energy related projects is estimated at $ 7 billion.

The national energy policy of supply management through maximum production of indigenous energy, diversify energy supply structure in order to reduce dependence on imported oil and of demand management in restraining growth in energy demand will have to address the following issues:

- reliability of reserve estimates
- economics of exploration and production
- joint venture structure
- energy pricing

The policy also emphasizes and encourages continued intensive search for additional indigenous energy resources and efficient utilization.

Thailand - United States Natural Gas Utilization Symposium
Bangkok, February 7-11, 1984

Thailand's Investment Policy

Chira Panupongse.

Deputy Secretary General,
Office of the Board of Investment

Abstract

The basis of Thailand's investment policy has always been to support and encourage productive and profitable investment by the private sector in order to enhance economic, financial and social stability. Throughout the remainder of this decade, large volume of private investment will be required to implement the large-scale, capital intensive projects planned for the Eastern Seaboard Development Program. The Royal Thai Government is committed to maintaining the favorable investment environment that the private investors, both Thai and foreign, have enjoyed with three major supports:

- reduction of risk of investment
- reduction of initial investment cost
- improvement of overall rate of return on investment

The Board of Investment, the Thai Government's designated investment promotion agency has granted privileges involving both tax and non-tax incentives for even investments with many of these benefits:

- tax holidays
- special deductions from taxable income
- exception of duties and business taxes of imported machinery and raw materials
- exception of duties and business taxes on export sales
- temporary tariff surcharge to prevent unfair dumping
- free repatriation of capital and remittance of profit

2,18

In addition to these incentives, the Board of Investment has established the "One Stop Services Center" to speed up the procedures required for securing investment and industrial permits to within 90 days. BOI's priority guidelines have always been developed to harmonize with our national development plans and to help investors identify the most profitable investment opportunities.

Thailand - United States Natural Gas Utilization Symposium
Bangkok, February 7-11, 1984

Thailand's Energy Supply/Demand Pattern and Petroleum Development Program

Tongchat Hongladaromp

Governor
Petroleum Authority of Thailand

Abstract

The paper describes current status and the outlook of the energy situation in Thailand and the program for the development of Thailand's petroleum resources and its utilization. Energy in Thailand are supplied from both imported oil and indigenous commercial and non-commercial sources which includes hydropower, coal, lignite, charcoal and firewood. However, these indigenous sources of energy are limited in availability and are rapidly diminishing. By the same token, the dependence on petroleum as a source of energy will be more and more dominating. Therefore, emphasis have been placed on the developments in the oil and gas industries which will enormously change the pattern of energy supply and consumption.

The development of petroleum exploration in Thailand started more than 10 years ago with the exploration for petroleum in the Gulf of Thailand. We have now discovered more than ten fields bearing gas and condensate and one field bearing crude oil and have also completed the main transmission pipeline bringing ashore natural gas from the Erawan field in the Gulf of Thailand to two power plants in Bangkok and to two cement plants 150 kms north of Bangkok. The natural gas that is being delivered and which is planned for up to 1990 has all been committed to supply domestic demand to achieve the following:-

- savings in energy cost
- reduce foreign currency outflow
- reduce dependency on imported petroleum
- provide feedstock for basic petrochemical industries

The Petroleum Authority of Thailand, which is Thailand's national oil company, is currently building a gas separation plant to produce LPG and ethane/propane from natural gas. The plant is scheduled for operation in 1985. Other projects to utilize our natural gas and to maximize its benefit to the country includes a petrochemical complex and a fertilizer complex. These projects are expected to be completed in 1988.

This petroleum development program is planned base on estimated offshore gas reserves of 10 trillion cubic feet supplying gas at a rate of 700 MMSCFD by 1990. However, the discovery of new gas and oil reserves onshore in the central part of Thailand may provide new opportunities for Thailand which may enable her to earn foreign exchange through export of excess supply of petroleum in the future.

BIODATA

Name	:	Sivavong Changkasiri
Current Title	:	Director General Department of Mineral Resources, Ministry of Industry
Education	:	MS. in Industrial Management, Massachusetts Institute of Technology BS. in Mechanical Engineering, Massachusetts Institute of Technology

BIODATA

Name	:	Phisit Pakkasem
Current Title	:	Deputy Director General
		National Economic and Social Development Board
Education	:	Ph.D. in Development Economics, Pittsburgh University
		MPA. in Development Economics, Harvard University
		BA. in Economics, Claremont Men's College

BIODATA

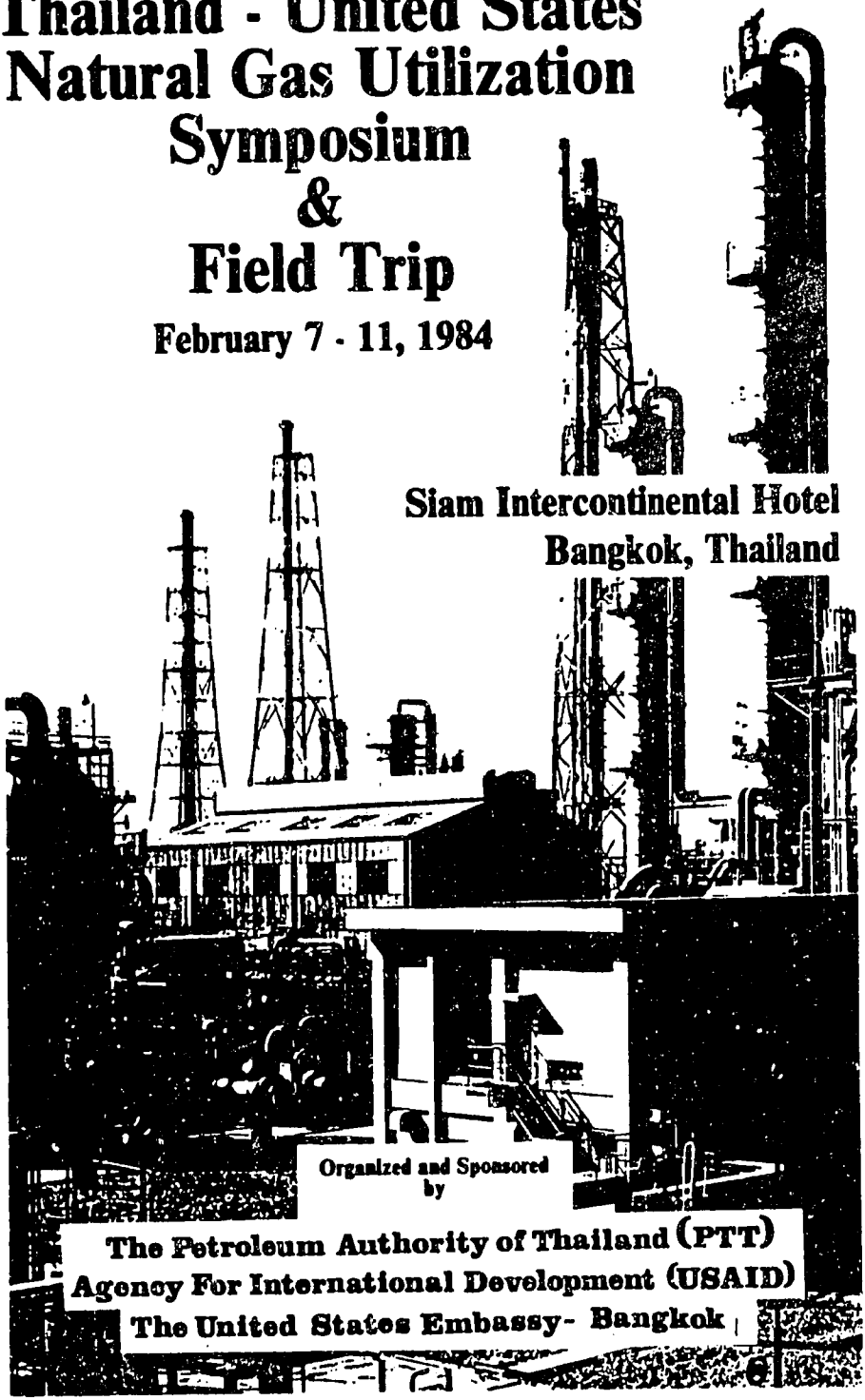
Name	:	Chira Panupongse
Current Title	:	Deputy Secretary General
		Board of Investment
Education	:	MA. in Economics, University of London
		BA. in Economics, Thammasat University

BIODATA

Name	:	Tongchat Hongladaromp
Current Title	:	Governor
	:	Petroleum Authority of Thailand
Education	:	Ph.D. in Civil Engineering, Northwestern University
		M.S. in Civil Engineering, Asian Institute of Technology
		MS. in Civil Engineering, Chulalongkorn University

Thailand - United States Natural Gas Utilization Symposium & Field Trip

February 7 - 11, 1984



Siam Intercontinental Hotel
Bangkok, Thailand

Organized and Sponsored by

The Petroleum Authority of Thailand (PTT)
Agency For International Development (USAID)
The United States Embassy- Bangkok

GENERAL CHAIRMAN

Dr. Tongchat Hongladaromp
Governor
Petroleum Authority of Thailand

PROGRAM CHAIRMEN

Charan Achalabhuti
Deputy Governor
Technical and Planning
Petroleum Authority of Thailand

Charles Bliss
Office of Energy
United States Agency for International Developement

SYMPOSIUM COORDINATOR

Arnold H. Pelofsky
President
AER Enterprises, U.S.A.

TABLE OF CONTENTS

ABSTRACTS Page 1

BIODATA Page 4

Thailand - United States Natural Gas Utilization Symposium
Bangkok, February 7-11, 1984

The Union Oil Company of Thailand's Operations in the Gulf of Thailand

Dr. Harold M. Lian

President
Union Oil Company of Thailand

Abstract

The natural gas accumulations in the Gulf of Thailand occur in largely non-marine Tertiary sediments. The productr of erosion of the neighboring highlands accumulated as stream channel deposits, river flood plain deposits, delta systems, lake beds and swamp deposits. Aggregate thichness reaches 9-10 kilometers in the deeper parts of the basin. Structural uplift and a complex system of north-south faults localized the accumulations of natural gas and condensate.

The Union Oil Company of Thailand, together with the South East Asia Petroleum Exploration Co. Ltd., and Mitsui Oil Exploration Co., Ltd., have been actively exploring and developing four concessions in the Gulf of Thailand since the Erawan field was discovered in 1973.

Erawan field went on production in August, 1981. Development operations are continuing and production has reached 160 million cubic feet of gas per day, together with 6,000 barrels of condensate. Eight well platforms have been set to date, and if future delineation drilling is successful, more may be installed.

A second field, Baanpot, commenced production in October, 1983 from a single platform. Current production is 25 million cubic feet per day plus 1500 barrels of condensate.

329

Thailand - United States Natural Gas Utilization Symposium
Bangkok, February 7-11, 1984

Summary of Exploration Drilling Results - Northeast Thailand

G.W. Grader

Vice-President & Managing Director,
Esso Exploration and Production Khorat Inc.

Abstract

Esso has been exploring in the Khorat Basin of Northeast Thailand and to date has drilled 7 wells. One is a gas discovery, one is an indicated gas discovery, one is an outpost discovery, one has non-commercial gas shows, and three are dry holes.

Esso's assessment of the undiscovered potential of the Khorat Basin remains optimistic. However, complex geology and high drilling costs are restraining factors to further exploration drilling.

330

Thailand - United States Natural Gas Utilization Symposium
Bangkok, February 7-11, 1984

"B" Structure - Gulf of Thailand

Joe R. Clark

President, Texas Pacific Oil Company, Inc.

Abstract

Texas Pacific began its search for hydrocarbons in the Gulf of Thailand in 1976. "B" Structure was discovered in the fall of that same year with the drilling and testing of the 15-B-4X well. Subsequent exploratory and delineation wells outlined a sizable, and geologically complex gas accumulation. Three-dimensional seismic and data obtained from the exploratory and delineation wells including comprehensive well testing programs provided sufficient technical information to indicate development of this gas accumulation is economically viable. It is presently anticipated that sales of "B" Structure gas will be to the Petroleum Authority of Thailand (PTT) and negotiations for such a sale are presently in progress. Upon completion of these negotiations, development will proceed toward providing an initial target gas sales rate of 150 million cubic feet per day. Initial planning will also include provisions for eventually increasing the sales rate to 250 million cubic feet per day.

BIODATA

Name :	Dr. Harold M. Lian
Company/Organization :	Union Oil Company of Thailand
Position :	President and Chief Operating Officer
Education :	University of California (B.Sc. in Geology)
	Received Ph.D. in 1952
Experience :	Manager of Alaska Operation, Chief Geologist and Manager of Exploration, Union Oil
	18 years involvement in Union Oil's operations in Thailand
	One of the founders and directors of the Circum-Pacific Council for Energy and Mineral Reserves
	Author of many papers on Geology in California, Alaska, Austria and Southeast Asia

BIODATA

Name :	Mr. G.W. Grader
Company/Organization :	Esso Exploration and Production Khorat Inc. Esso Udon Inc. Esso Sakon, S.A.
Position :	Vice President and Managing Director
Education :	University of Massachusetts - 1974 Clark University B.A. 1950 Boston University M.A. 1953

Experience :

1945-1946	U.S. Navy
1953	Merchant Marine
1954-1960	Creole Petroleum Corp., Venezuela (Wellsite and Surface Geologist)
1960-1965	Esso Standard Libya Inc., Benghazi (Subsurface Geologist)
1966	Esso Production Research, Houston
1967-1970	Esso Standard Libya Inc., Tripoli (Regional Geologist)
1971	Esso Exploration Inc., Spain (Geologic Advisor)
1972-1979	Esso Exploration Inc., England (Project Supervisor)
1979-Present	Esso Exploration and Production Khorat Inc. (Vice President and Managing Director)
Career Summary	30 Years Experience, International Petroleum Exploration

BIODATA

Name :	Mr. Joe R. Clark
Company/Organization :	Texas Pacific Oil Company, Inc.
Position :	President
Education :	Texas A & M
Experience :	President of the Dallas Petroleum Club (1977) More than 30 Years experience in the petroleum industry Active participation in the oil industry, trade associations Member of the Advisory Committee of the Dallas Petroleum Club Presently affiliated with the Society of Petroleum Engineers of AIME, Texas Mid-Continent Oil and Gas Association, American Petroleum Institute, National Society of Professional Engineers, and International Association of Oilwell Drilling Contractors.

BIODATA

Name :	Dr. Tongchat Hongladaromp
Company/Organization :	Petroleum Authority of Thailand
Position :	Governor
Education :	
1956 - 1960	B. Eng. in Civil Engineering, Chulalongkorn University, Bangkok, Thailand
1960 - 1962	M. Eng. in Civil Engineering, Asian Institute of Technology, Bangkok, Thailand
1964 - 1967	Ph.D. in Civil Engineering, Northwestern University, Illinois, U.S.A.
Experience :	
April 1962 - August 1963	Research Associate, Asian Institure of Technology, Bangkok, Research in Structural Engineering.
March 1967 - June 1968	Senior Engineer, Skidmore Owings and Merrill, Chicago, Illinois, U.S.A. Analysis and design of tall buildings.
June 1968 - May 1969	Engineering Analyst, Sargent Lundy Engineers, Chicago, Illinois, U.S.A. Computer Analysis of Structures.
August 1969 - November 1976	Faculty member, Director of Computer Center of Asian Institute of Technology
1976 - 1979	General Manager of Expressway and Rapid Transit Authority of Thailand, Ministry of Interior.

BIODATA

Name :	Dr. Phisit Pakkasem
Company/Organization :	National Economic & Social Developme Office of the Prime Minister
Position :	Deputy Secretary - General
Education :	B.A. Economics, Claremont Men's Col California, U.S.A.
	MPA. Development Economics, Harvard Universtiy, MASS.
	Ph.D. Development Economics, Pittsb University, PA.
Experience :	Economic Advisor to the Prime Minis
	Chairman of Joint World Bank - NESD Long - term Economic Projection for
	Chairman of Price Structure Adjustm Petroleum Products Subcommittee
	Member of the Board of Provincial E Authority
	Member of the Board of Krung Thai B
	Member of the Board of Thai Airways

336

APPENDIX G

REQUEST FROM DR. WORAPHAT

Department of Chemical Engineering
Faculty of Engineering
Tel. 251-1510, 252-5001

February 20, 1984

Dr.Arnold H. Pelofsky
AER Enterprises
P.O. Box 454
East Brunswick,
N.J. 08816
U.S.A.

Dear Dr.Pelofsky :

First of all I should like to extend my congratulations to you and Mrs.Pelofsky for the very successful USAID-PTT symposium on Natural Gas Utilization from which our Department learned many things that will be useful to future teaching and research programs in the Department. Enclosed herewith is a very tentative agenda for a Regional Conference on Petrochemicals to be held in August or September 1984 and for which the Department already has $7,000 from the Government budget and from Chulalongkorn University's own budget. I should like to investigate the possibility of making use of your services in order to be able to arrange such a conference. I would also be interested in requesting USAID help in organizing this Regional Conference. My objectives in this Conference will be to focus on topics that will involve Universities and that will be topics that Thailand will have to develop during the various phases of the Eastern Seaboard Project. I propose that you rewrite the agenda according to your ideas and past experience in case you would accept to act as co-organizer with my Department and send me further details.

It was very nice to have met you in Bangkok and I hope that this new project will be as equally as successful as the last one.

Sincerely yours,

Woraphat Arthayukti

(Dr.Woraphat Arthayukti)
Head, Dept. of
Chemical Engineering

358

Regional Conference

on

UNIVERSITY/INDUSTRY INTERACTION IN THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY

organized and convened by

The Faculty of Engineering, Chulalongkorn University

supported by

The Ministry of Education, Thailand

The Ministry of University Affairs

The Ministry of Industry

The Petroleum Authority of Thailand

and

The Engineering Institute of Thailand

September 1984

Bangkok, Thailand

1. BACKGROUND

With the advent of oil and gas explorations and discoveries in Southeast Asia and the Pacific many countries in that region have made decisions to expand their industrial base to include petrochemicals manufacture. As a leading University scientists and engineers for Thailand's development, and in support of Thailand's Eastern Seabord Project, where petrochemical plants are being built, Chulalongkorn University is currently assessing its role in producing technical personnel and expertise to complement the Government and private Industry in the development of a Petrochemical Industry.

This Regional Seminar on University/Industry interaction in the Development of the Petrochemical Industry will serve to focus on the role of the University in the development of an Industry within a regional context. As a result of the Seminar it is hoped that the participants will have gained a deeper understanding of macroperspectives of the Petrochemical Industry on a global and regional level and will obtain a better understanding of the interaction that is needed between Universities and Private Industry to promote the development of the Petrochemical Industry.

Besides dwelving into the overview of the subject matter the Seminar will also focus on areas of Research and Development into the Technology, Project planning on a national scale, Project management at single levels, Energy Conservations in Petrochemical Plants and Environmental impacts of Petrochemical Industries.

2. PURPOSE

To provide information on the National Development Programs of the Petrochemical Industry in Southeast Asia and the Pacific; as well as regional and global perspectives.

To provide information on the trends of Petrochemical technology and advances.

To present and discuss several topics relevent to University and Industry in the development of the Petrochemical Industry. Specifically the area of Projects planning, Project management, Energy conservation and environment impact.

To explore additional areas of common interest between University and Industry in the Development of the Petrochemical Industry in Southeast Asia and the Pacific.

3. DATE AND VENUE

The Regional Conference will be held in Bangkok, Thailand in early September 1984.

4. ANTICIPATED PARTICIPANTS

The participants and exports will come from Universities, Government Planning Offices, and from Industry dealing with Petrochemicals from various countries in Southeast Asia and the Pacific.

5. CONFERENCES ARRANGMENT

The Conference will be held at the Conference room of Chulalongkorn University, Bangkok. The medium of communication of the Conference will be English.

6. PROGRAMME AND AGENDA

Day 1 , September 1984

08.30 - 09.00	Registration
09.00 - 09.30	Opening Ceremony
09.30 - 10.00	Coffee Break
10.00 - 12.00	Session 1: Invited Papers of the Petrochemical Industry Global Perspectives of the Petrochemical Industry. Status of the Technology of Petrochemical Production and research and development trends.
12.00 - 13.30	Lunch Break
13.30 - 15.00	Session 2: National Development Programs of Petrochemical Industry and Engineering Expertise Development (country papers).

15.00 - 15.30	Coffee break
15.30 - 17.00	Session 2: continued.

Day 2, September 1984

08.30 - 10.00	Session 2: Continued
10.00 - 10.30	Coffee Break
10.30 - 12.00	Session 3: Research and Development in Petrochemical Technology
12.00 - 13.30	Lunch Break
13.30 - 15.00	Session 3: continued
15.00 - 15.30	Coffee Break
15.30 - 17.00	Session 4: Project Planning and Project Manane-ment.

Day 3, September 1984

08.30 - 10.00	Session 4: Continued
10.00 - 10.30	Coffee break
10.30 - 12.00	Session 5: Energy Conservation and Environmental Impact
12.00 - 13.30	Lunch Break
13.30 - 15.00	Session 5: continued
15.00 - 15.15	Coffee break
15.15	Departure for Eastern Seabord

Day 4, September 1984

Visit to Eastern Seabord Projects

Day 5, September 1984

08.30 - 10.00	Session 6: Round table discussion on University/ Industry interactions
10.00 - 10.30	Coffee Break
10.30 - 11.30	Session 6: continued
11.30 - 11.45	Closing of the Conference

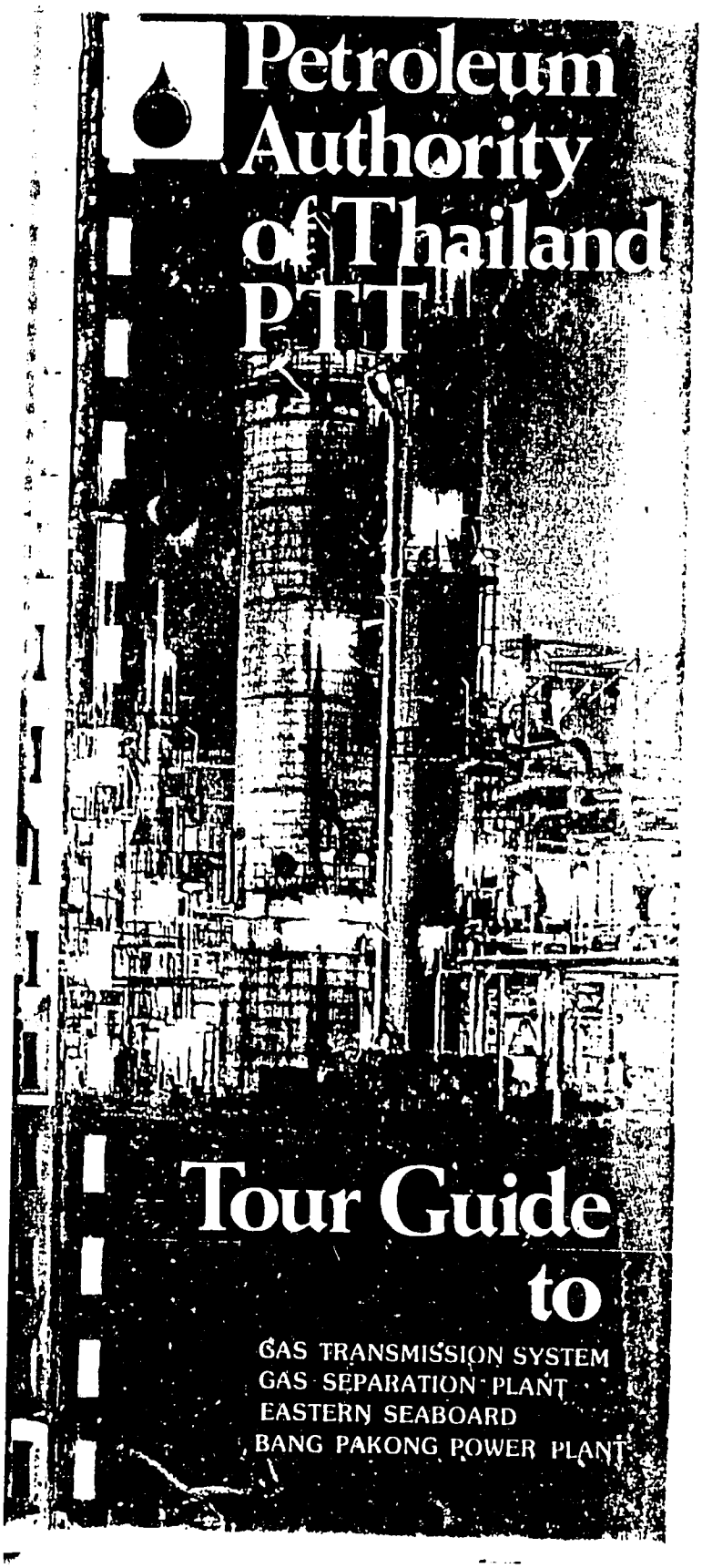
For further information please contact .

Dr. Woraphat Arthayukti
Head, Department of Chemical Engineering
Faculty of Engineering
Chulalongkorn University
Bangkok 10500, Thailand
Tel. 251-1510 ext. 53.52
Cable: ENGCHULA,THAILAND.

APPENDIX H

FIELD TRIP HANDOUT

Petroleum Authority of Thailand PTT



Tour Guide to

GAS TRANSMISSION SYSTEM
GAS SEPARATION PLANT
EASTERN SEABOARD
BANG PAKONG POWER PLANT

345

FIELD TRIP
FEBRUARY 9-11, 1984
ITINERARY

THURSDAY, FEBRUARY 9, 1984

16.30 Hrs. - Departure from Bangkok to the Royal Cliff Hotel, Pattaya

19.30 Hrs. - Arrival at the Hotel

FRIDAY, FEBRUARY 10, 1984

09.30 Hrs. - Departure to the LDPE Plant, Rayong Province

10.30 Hrs. - Briefing and Tour of the LDPE Plant

12.00 Hrs. - Lunch hosted by the Thai Petrochemical Industry Co., Ltd.

14.00 Hrs. - Departure to the Gas Separation Plant Site

14.30 Hrs. - Briefing and Tour of the Gas Plant

15.45 Hrs. - Departure back to the Royal Cliff Hotel

SATURDAY, FEBRUARY 11, 1984

09.00 Hrs. - Departure to the Marine Terminal at Khao Bo Ya, Laem Chabang Deep Sea-port, Chonburi Province

09.30 Hrs. - Tour of the Marine Terminal

10.15 Hrs. - Departure to the Gas Monitoring Station, Operation Centre, Chonburi Province

11.00 Hrs. - Briefing and Tour of the Operation Centre

11.45 Hrs. - Departure to the Bang Pakong Power Plant

12.15 Hrs. - Arrival at the Bang Pakong Power Plant

12.30 Hrs. - Lunch hosted by the Electricity Generating Authority of Thailand (EGAT)

13.30 Hrs. - Briefing and Tour of the Bang Pakong Power Plant

15.30 Hrs. - Departure back to Bangkok

17.00 Hrs. - Arrival in Bangkok

ELECTRICITY

'AKONG POWER PLANT

'akong Power Plant of the Electricity Generating Authority d (EGAT) shall consist of the Bang Pakong Thermal nt (4 x 550 MW) and the Bang Pakong Combined Cycle nt (2 x 360 MW), both of which are located on the left : Bang Pakong River at approximately 69 kms southeast k in Chachoengsao Province

AKONG COMBINED CYCLE POWER PLANT

consists of two gas steam combined cycle blocks Each prises 4 by 60 MW gas turbine units and one 120 MW cycle heat recover steam generator unit which are now on

AKONG THERMAL POWER PLANT

g Pakong Thermal Power Plant has been planned to date four 550 MW steam generating units

ect has already been approved for the construction of MW thermal power plants which were designed to be th either oil or natural gas or both The first plant is now ion whereas the second plant is under construction

gas is supplied by the Petroleum Authority of Thailand ough the pipeline from the gas field in the Gulf of Thailand.

GAS TRANSMISSION SYSTEM

OPERATION CENTRE (OC)

The Operation Centre is located in Chonburi Province, approximately 80 kms. from Bangkok

Information of the whole pipeline system is sent via the communication system to the control centre i e the Operation Centre (OC) in Chonburi The Supervisory Control and Data Acquisition System (SCADA) is installed to supervise the system so that the operators at OC will be informed of all the status of the system. Alarms will alert of any irregularity in the system Automatic shut off valves at various critical points e g. the Mainline Pressure Regulating Station (Station BV#6) at Bang Pakong are also provided to insure safety of the system

Data sent to the main computer at OC will be compiled, analyzed, evaluated and compared with field data Vital data will be recorded and stored in computer memory

The PTT communication system consists of a microwave system, VHF radio and satellite system to transmit voice and data from the offshore and onshore station to the centre of communication at OC. VHF and Single Side Band Radio are used as back up system when the main communications break down.

TERMINAL SITE (TS)

Natural Gas is supplied through a submarine transmission pipeline, 415 kms in length and 34 inches in diameter from the Union Oil Production Platform, block 12, in the Gulf of Thailand, extending north to the onshore Dew Point Control Unit (DPCU) at the Terminal Site, Mab Tapud, Rayong Province, approximately 200 kms from Bangkok

DEW POINT CONTROL UNIT (DPCU)

The facilities at DPCU consist of a scraper, receiver and launcher, pressure regulator, metering station, slug catcher and the Dew Point Control Unit. The DPCU itself consists of two refrigeration units, a gas/gas exchanger, condensate flash drum, condensate knock out drum, NGL storage and truck loading facilities.

The DPCU will control the hydrocarbon dew point of gas to an acceptable level for use as industrial and domestic fuel (normally at 60°F, 650 psig)

Recovered condensate (Natural Gasoline) will be piped to the Gas Plant, presently under construction for further processing. In the meantime, the Natural Gasoline is trucked to the nearby refinery (TORC).

A 28 inch onshore gas pipeline connects the DPCU to the Bang Pakong and South Bangkok Power Plant. The 169 km route of the pipeline follows an irregular course primarily alongside existing highways

Another 24 inch gas pipeline system, 99 km. in length, branches to Nongkae Junction from where the 16 inch and 18 inch gas pipelines are routed to Ta-Luang and Kang-Koi Cement Factories in Saraburi Province, respectively

NATURAL GAS SEPARATION PLANT

The Natural Gas Separation Plant is being constructed at the Te rminal Site, Mab Tapud, Rayong Province, on the Eastern Seaboar

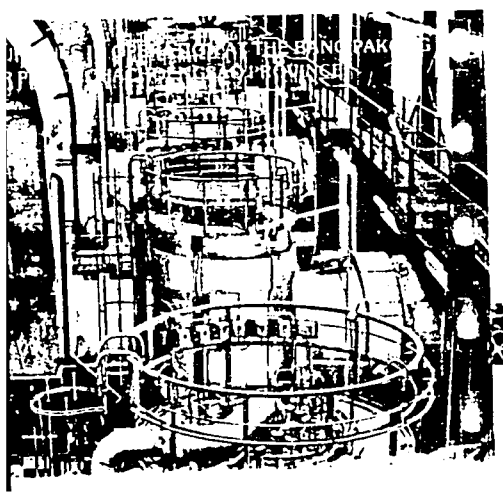
The project consists of the following main sections :

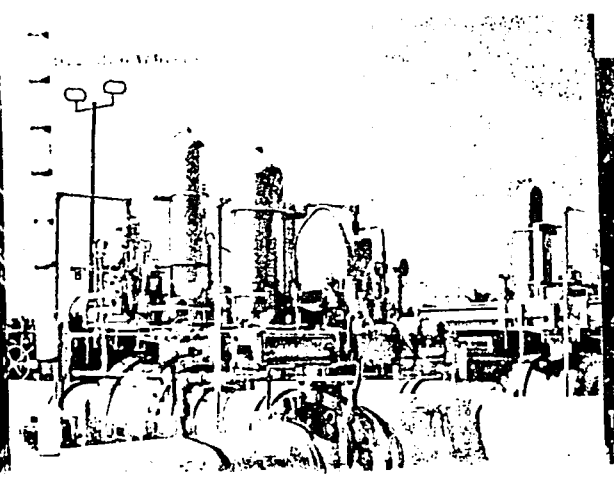
- Gas Separation Plant at Rayong (GS)
- Product Transfer Pipeline (TP)
- Marine Terminal at Khao Bo Ya (MT)

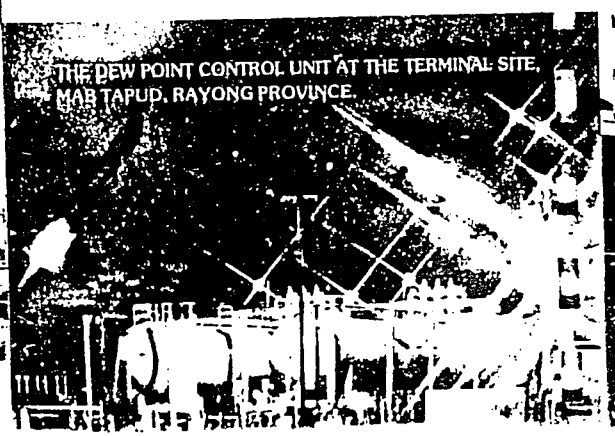
The Gas Separation Plant will have a total capacity of 350 MMSCF of feed gas This feed gas comes from the gas fields located in th Gulf of Thailand In the initial stage, the plant will produce liquefie petroleum gas (LPG), a mixture of propane and butane, to b used for cooking and motor fuels

Subsequently, ethane will be extracted to be used together wi propane as feedstock for the olefins plant in the petrochemic industry. And methane, besides being supplied as fuel for pow and industrial plants, will be used as feedstock for the chemic fertilizer plant.

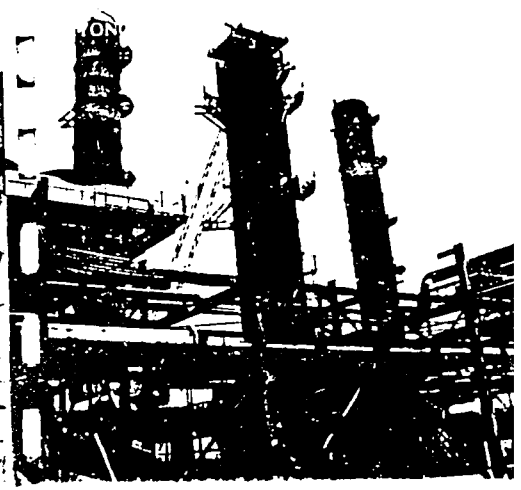
The propane, LPG and natural gasoline will be transported v the Transfer Pipelines to the Marine Terminal and natural gasoli further supplied via pipeline to the TORC refinery nearby







THE DEW POINT CONTROL UNIT AT THE TERMINAL SITE, MAB TAPUD, RAYONG PROVINCE.



MARINE TERMINAL AT KHAO BO YA

At the Marine Terminal, the products arriving by pipeline will be stored at the tankfarm and shipped out either by truck/truck-loading station or by barge/shiploading station located on a 1300 m long Jetty. It is also foreseen to unload/load and store natural gasoline/crude oil in the future.

Linde AG, Werkgruppe TVT Muenchen is the CONSULTANT for the Gas Plant Project, supplying basic design, bid evaluation and assistance in selecting the Contractor (Phase I) as well as management and supervision of the Project (Phase II).

The CONTRACTOR for the Work, responsible for detailed design, material, supply, construction and commissioning is the Consortium of TOYO Engineering Corporation (TEC), the Randall Corporation and Mitsui & Co., Ltd.

CHEMICAL FERTILIZER PLANT

The National Fertilizer Corporation Ltd. was established in October 1982 with PTT as the largest shareholder. Early this year, a consultant firm was hired to conduct feasibility studies on the fertilizer plant including the establishment of the production process most suitable to Thailand. The feasibility study was completed in August 1983.

The National Fertilizer Corporation Ltd. is currently preparing documents to tender for the engineering and construction of the fertilizer plant.

FUTURE PETROCHEMICAL INDUSTRY

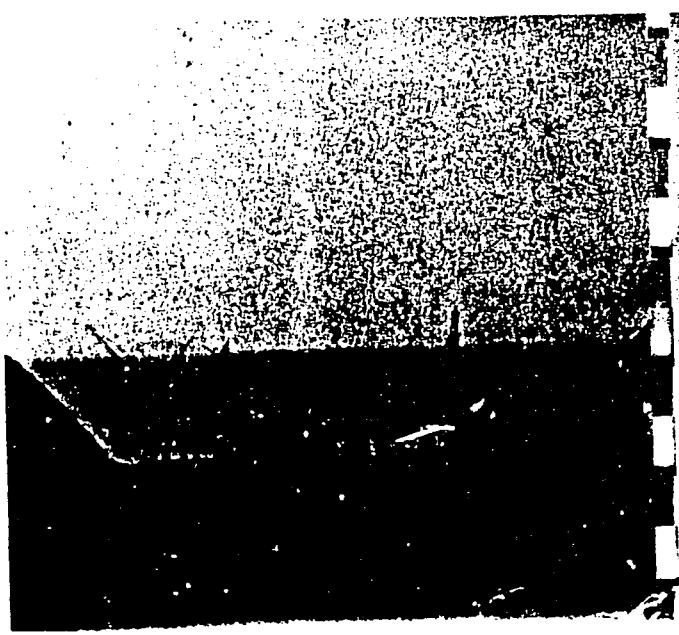
A petrochemical complex is being established to use ethane and propane from natural gas to supply petrochemicals and plastics for domestic demand. The complex consists of an olefin plant, which is the upstream unit, to produce 300,000 tons/day of ethylene and 73,000 tons/day of propylene and the downstream plants which consist of the following :

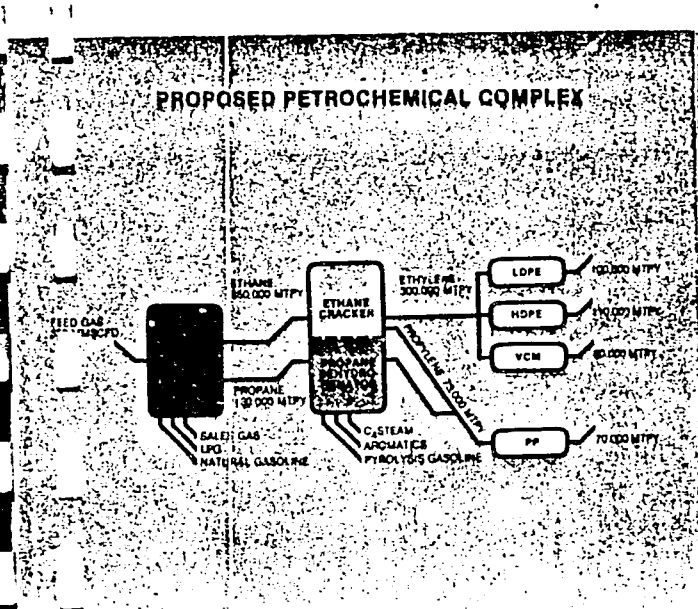
Plant		Capacity (Metric tons)
Low Density Polyethylene	(LDPE)	100,000
High Density Polyethylene	(HDPE)	110,000
Polypropylene	(PP)	70,000
Vinyl Chloride Monomer	(VCM)	80,000

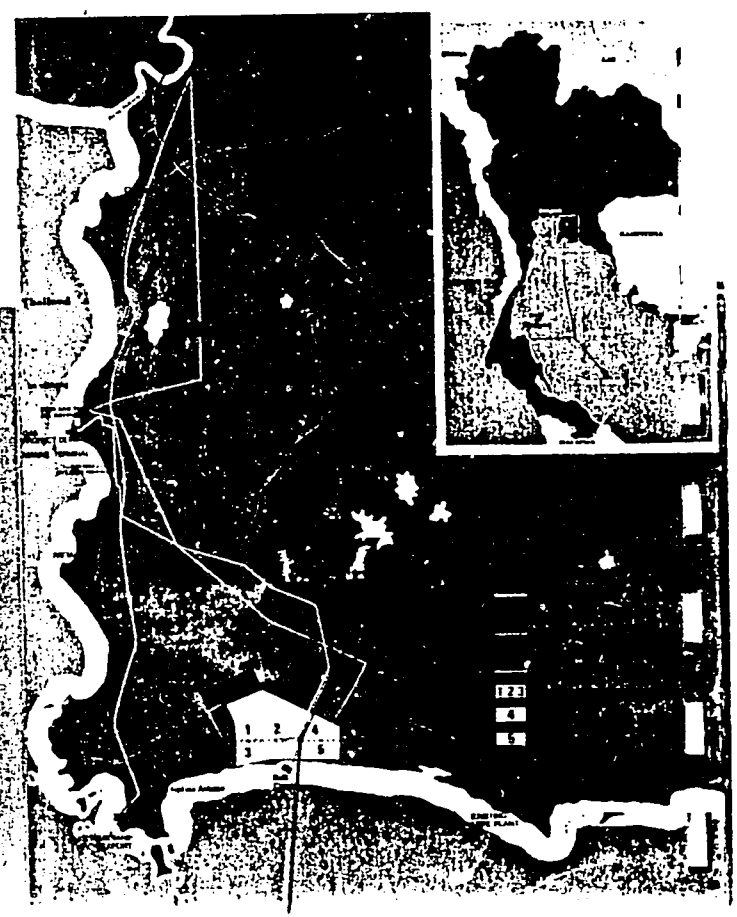
EASTERN SEABOARD DEVELOPMENT

In order to boost and expand the country's economic status, the Government has given top priority to the development of natural gas related industries on the Eastern Seaboard. Equally important is the development of a new urban populated centre which will become the nucleus for future development and expansion of other areas. Therefore, besides the construction of the Natural Gas Separation Plant, there will be an enormous amount of investment for several projects e.g.

- the development of the deep seaport
- the ethylene cracking plant
- other downstream industries using natural gas as feedstock and energy.
- other related industries
- the development of infrastructure i.e. telecommunications services, rail and road network, provision of water supply and electricity to support future development







APPENDIX I

UNSOLICITED LETTERS

Ministry of Energy

Lambton House
152-172 Lambton Quay
Wellington
Telephone: 727 044
Telex: ENMIN NZ31488

Please address all correspondence to the Secretary to Energy
Private Bag
Wellington New Zealand

Our Ref.

Your Ref.

6 March 1984

Dr Arnold H Pelofsky
President
AER Enterprises
P O Box 454
E Brunswick
NJ 08816
U.S.A.

Dear Arnold

Just a note to thank you for your help and congratulate you on the organisation of the symposium. "You" obviously includes Loretta. I'm briefing the US economics attache here about the meeting so your fame spreads.

I hope your holiday in Israel went well.

Kindest regards

Stephen Gale

358

T. JOYCE ASSOCIATES, INC.
CONSULTANTS-ENERGY RESOURCES
POST OFFICE BOX 421
FAIRFAX, VIRGINIA 22030
703-323-6740

March 4, 1984

Mrs. Loretta K. Pelofsky
Meetings Coordinator
AER Enterprises
P.O. Box 454
East Brunswick, NJ 08816

Dear Loretta and Arnie:

I know I am not the first to congratulate both of you on a well-organized and informative meeting. But having gone through the mill several times myself, I can appreciate the effort that was required. I heard nothing but good comments about the arrangements, the program and the participation. We have already followed-up with TDP and AID here in Washington and feel the meeting was very helpful to us in getting acquainted with the right people. I know the meeting will generate more business for you and I hope more for me as well.

Thanks for all the help you gave me. If there is anything I can do anytime, or any information I might provide, don't hesitate to call.

Best personal regards,

Tom

Thomas J. Joyce

Air Products

PROCESS SYSTEMS GROUP

Air Products and Chemicals, Inc.

Houdry Division
Box 538, Allentown, PA 18105 USA
Telephone: (215) 481-4911
Telex: 847416 Cable: AirProd

19 March 1984

Arnold H. Pelofsky, Ph.D
AER Enterprises
P.O. Box 454
East Brunswick, NJ 08816

Dear Arnold:

I apologize for being late in writing this.

On behalf of myself and Dave Phillips, I want to tell you how thoroughly impressed we were with the organization of the Thai-USA Symposium which you headed in February. Seldom have we attended a meeting where the various speakers, accommodations, lunches and dinners, and field trips were better organized and executed. In addition, the content of the various meetings was outstanding. You deserve a pat on the back and we want you to know that.

Having said that, I now want to point out an interesting thought that ran through my mind while I was in Thailand and which perhaps you would care to share with people at US AID. It seems to me, as an average American businessman, that our Foreign Aid policy presents us with a bit of a dilemma. The US appears to enter a developing nation with nothing but good intentions, money, and the technical expertise to build the needed infrastructure. Without this infrastructure, these nations cannot move forward. We virtualy donate the schools, the roads, the dams, the irrigation systems that enable these countries to survive. We do good deeds. We give our fellow neighbors in the world a chance. Unfortunately, in my opinion, we then seem to step back and allow Japan Inc., France Inc., UK Inc., etc. to take the gravy. And along with the gravy, the long term business relationships that make nations trust and work together.

When I visited on the field trip at the gas separation plant and saw the phenomenal work that Toyo Engineers had done with the gas separation equipment, and then when I saw how the Linde-German engineer was working hand-in-glove with the P.T.T. facility, it struck me how important it is for our foreign aid policy to move further down stream in the development process of the nation. Somehow we must get the US Export-Import Bank to be more aggressive in supplying finance to American projects. We must get TDP and US AID to move further down stream beyond symposiums and past feasibility studies to help assist American business compete with the foreign firms that do count on their nations to sponsor their projects. Given our desire to maintain a "laissez-faire" government business interface this may prove to be a difficult task. Nevertheless, we must try to do something so that average American businessmen can compete

358

Perhaps one way we might do this in the specific Thai situation would be for the government to sponsor a delegation of ten key Thai Petrochemical people on a visit to the USA. I would suggest that you organize this for TDP and US AID in much the same way that you did the symposium in Bangkok. It is my thought that if the US government were to bring over a delegation of ten key Thai's VIPs, companies could then on a day by day basis take charge of these people and show them how American technology works. Air Products would enjoy hosting these VIPs for three days. We would like to show them our facilities in Allentown and perhaps one or two of our plants. I believe that this kind of presentation would be impressive to them and would help guide them to eventual purchase of American equipment and American technology. We would also work with you in coordinating the entire trip as appropriate. Please give this concept some thought and if you do feel it has merit, speak about it with people in Washington. I can suggest names of key Thai people that might be considered for such a mission.

In any case, once more it was a pleasure to participate in the symposium in Bangkok. You did an excellent job and you have certainly impressed the entire Air Products organization.

Very truly yours,

Jerome L. Glazer
Business Manager - Far East
Houdry Division

JLG/bah