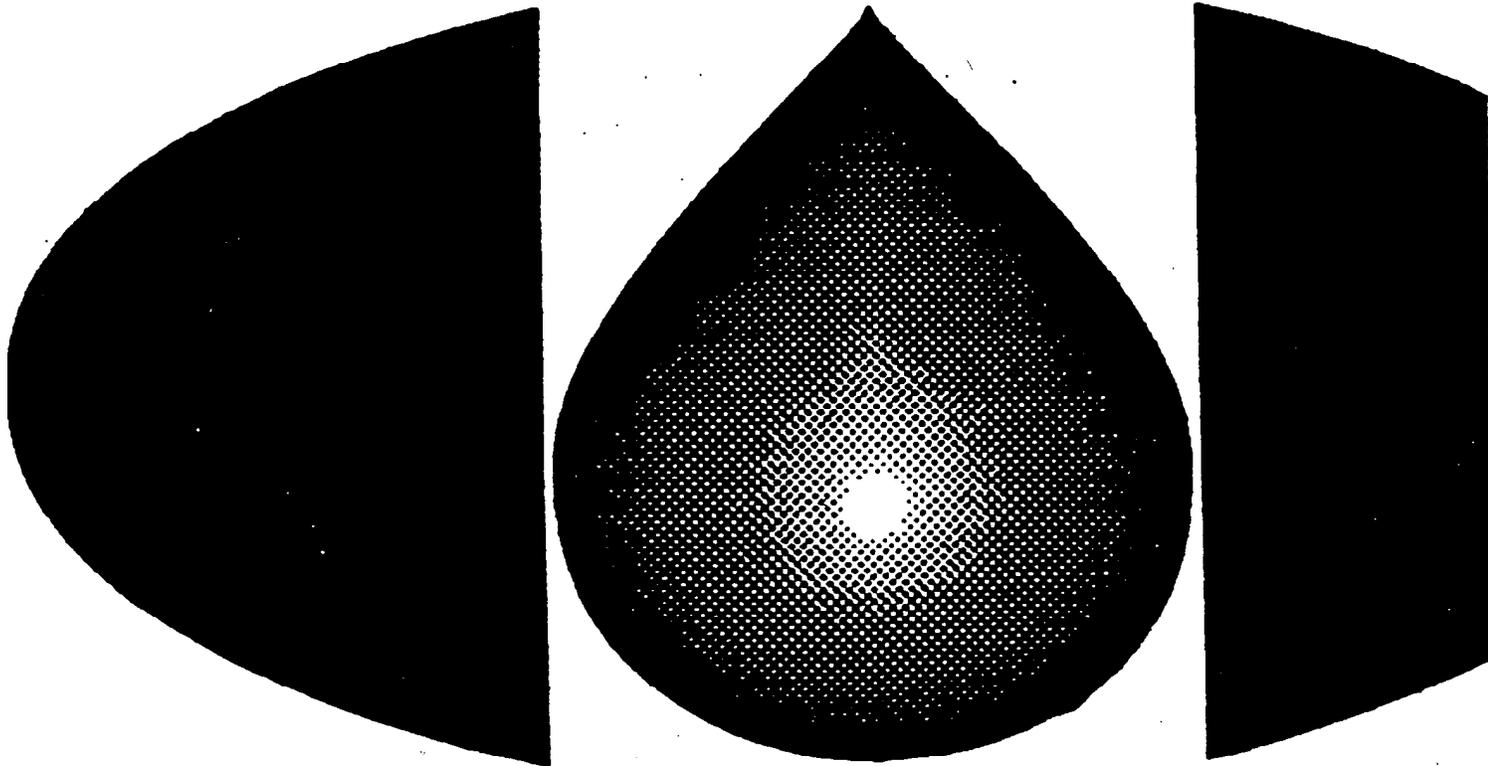




Expert Review Of EPA Chemical Accident Investigation Report

Terra Industries, Inc.
Nitrogen Fertilizer Facility,
Port Neal, Iowa



EPA 550-R-96-002
September 1996

EXPERT REVIEW

OF

EPA CHEMICAL ACCIDENT INVESTIGATION REPORT
TERRA INDUSTRIES, INC. NITROGEN FERTILIZER FACILITY
January 1996

Chemical Emergency Preparedness and Prevention Office
Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

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FOREWORD

This document presents the comments and recommendations of five expert independent reviewers, with whom EPA contracted to examine an EPA Chemical Accident Investigation Report, "Terra Industries, Inc. Nitrogen Fertilizer Facility, Port Neal, Iowa." The EPA investigation report was written by an investigation team at its Region VII office in Kansas City and published in January 1996.

The Clean Air Act Amendments of 1990, Section 112(r), mandated the creation of an independent Chemical Safety and Hazard Investigation Board (CSHIB) to investigate chemical accidents and recommend steps to reduce the risk and hazards of chemical releases. However, the CSHIB was never formed. In January 1995, the Administration asked EPA and OSHA, under their own existing authorities, to investigate chemical accidents and issue public reports containing recommendations on what the government, industry, and other stakeholders could do to prevent similar accidents from occurring in the future. The EPA Terra Industries Investigation Report is the first such report, dealing with a chemical accident in Port Neal, Iowa in December, 1994. Since Iowa is one of 23 States having an OSHA State Plan: the federal OSHA was not a joint investigator with EPA in this case.

In the spring and summer, 1996, EPA assembled a group of experts, charging them to examine the scope, approaches, and methods of this first report to guide future studies and investigations. Dr. Paul Hill of the National Institute for Chemical Studies served as Chair of the review group.

The five reviewers independently examined the EPA report, documenting their analyses in written comments. The Chair then circulated all comments to all reviewers, and convened a meeting of the reviewers at EPA's regional offices in Kansas City to enable them to share their comments from their different perspectives, to question the authors of the report, and to examine photographs and other available documents. The Chair then wrote a summary of the meeting and recommendations of the reviewers. This document includes copies of the reviewers' comments, the Chair's summary, EPA's charge to the reviewers, and EPA's reply to the reviewers' recommendations.

Expert Review: Chair's Report

National Institute for Chemical Studies

**A REVIEW OF USEPA'S
CHEMICAL ACCIDENT INVESTIGATION REPORT:
TERRA INDUSTRIES, MC.,
NITROGEN FERTILIZER FACILITY
PORT NEAL, IOWA**

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by
National Institute for Chemical Studies
August, 1996

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DR. PAUL L. HILL (Chairman)
NICS

EXECUTIVE SUMMARY

The NICS and Dr. Paul L. Hill, in conjunction with, Drs. Irv Rosenthal and Geraldine Cox, Ms. Pamela Nixon and Mr. Joel Varian, were requested to conduct independent reviews of EPA's investigative report on Terra Industries 1994 accident. In order to improve future reports as well as future efforts to systematically collect data at accident sites, the review team offers the following major recommendations for consideration:

EPA should:

- Include time lines in future reports.
- Expand and continue to model the scenario-by-scenario approach.
- Adopt or specify rigorous technical procedures sanctioned by the engineering and research communities.
- Develop a defined protocol for accident investigations.
- Hold public meetings to seek stakeholders' input on the protocol.
- Consider accident oversight committees at affected sites which include public liaisons.
- Initiate agreements with other federal, state, and local entities with accident response authorities or consider legislative recommendations to accomplish same.
- Create increased public and private awareness of it's investigative program.
- Clearly articulate the national goals and criteria for accident investigation.
- Draw upon the existing experience of NTSB and other agencies for assistance in the evolving program.

Industry should:

- Take note and seriously address EPA's January 23, 1996 recommendations for accident prevention.
- Initiate greater awareness of process safety regarding ammonium nitrate through the research and engineering communities.
- Proactively embrace mechanisms for accident prevention.

States and Communities should:

- Initiate dialogue with industry and EPA to construct effective protocols
- Consider agreements for resource and authority coordination.

BACKGROUND AND STATEMENT OF PURPOSE

At approximately 0606 hours on December 13, 1994, an explosion occurred in the ammonium nitrate plant at the Terra International, Inc., Port Neal Complex. Four persons were killed as a direct result of the explosion, and 18 were injured and required hospitalization. The explosion resulted in the release of approximately 5,700 tons of anhydrous ammonia to the air and secondary containment, approximately 25,000 gallons of nitric acid to the ground and lined chemical ditches and sumps, and a large volume of liquid ammonium nitrate solution into secondary containment. Off site ammonia releases continued for approximately six days following the explosion and drifted several miles. Chemicals released as a result of the explosion have resulted in extensive environmental contamination including groundwater under the facility.

The U. S. Environmental Protection Agency (EPA) Region VII was directed by EPA Headquarters to conduct an investigation to determine the cause of the explosion and to develop recommendations that would help prevent similar occurrences in ammonium nitrate production facilities in the future. A report released by the Agency on January 23, 1996 contains conclusions reached by the EPA chemical accident investigation team regarding the cause of the explosion at the Terra International, Inc., Port Neal Complex and recommendations for prevention of future similar occurrences. The investigation team from EPA was led by On-Scene coordinator (OSC) Mark Thomas, Ph.D. of the Region VII Office with additional assistance defined in the report.

Shortly after the issuance of the report, EPA Headquarters initiated discussions with the National Institute for Chemical Studies (NICS) to develop an independent review of EPA's investigation and findings. As an independent non-profit organization with environmental, industry, labor and community advocate constituents, NICS has a reputation for objective reports on chemical accident prevention and preparedness. On March 5, 1996, EPA reached agreement with NICS to oversee the review and designate Dr. Paul L. Hill as chairman of a proposed panel of individuals who would conduct the review. Panelists were selected on the basis of their expertise in process engineering, chemical safety, previous accident reviews and management disciplines as well as their broad representation of different stakeholder perspectives. NICS developed a slate of potential reviewers and provided the list to the Agency who selected and contracted with four (4) individuals in addition to Dr. Hill. Reviewers were not asked or retained to conduct independent research in order to supplement their technical knowledge and professional judgement or to verify the technical information contained in the EPA Terra Industries Report. Reviewers and their affiliations are listed on the previous page.

Among the charges of the Chairman were to provide copies of the report to the reviewers, solicit their written comments on the report, develop his own critique, distribute all five (5) commentaries to each of the participants as well as EPA, organize a meeting to discuss their reviews, chair the meeting and provide a final report of collective findings and recommendations to the Agency. After the receipt of individual, initial comments in July, 1996, the Chairman called a meeting on July 28-30, 1996 at the EPA Regional Office in Kansas City, Kansas. The review meeting was attended by all five (5) members of the panel as well as EPA staff. (See Appendix 1).

The purpose of this meeting was not to form consensus on the issues of causality or absolute recommendations to the agency. Rather, it was a forum to exchange ideas about the report's findings and probe the records and recorded testimony for additional clarifications. Agency staff were present by request of the Chairman to respond to questions and provide details of data collection, procedure and scenario development used to compile the report. The charge of the review panel members was quite narrow: (a) to assess the plausibility of the report findings based on all evidence collected by the agency and (b) to make recommendations on procedure, technique and report formulation which would improve future Agency accident investigation products.

The review team considered only the immediate information surrounding EPA's report. While the team was aware of additional reports and documents developed by other parties, these were not considered germane to the limited charge given by the Agency. In the possession of reviewers was: (a) the settlement agreement between Terra International, Inc. and Iowa OSHA Employment Appeal Board and (b) the Terra Port Neal Explosion report dated July 17, 1995 issued by a group of outside experts retained by the General Counsel of Terra Industries, Inc. Technical and legal assertions raised by the other parties involved in the Terra Industries, Inc. accident fell clearly outside the scope of the review team's charge. No opinions are surmised or offered on these issues.

THE REVIEW

Accident investigations and the attempt to reconstruct conditions which lead to an accident are inherently difficult to pursue. The current report indicates that certain evidence, diagrams, and requested documents were either destroyed or unavailable for this investigation report. Even with satisfactory provision of existing management, operations and training materials, reliance upon human knowledge and recollections as well as potential nondisclosure makes the job of accident investigation for root cause all the more difficult. In light of the Clean Air Act Amendments of 1990, the review team recognizes that as a nation, significant insights of investigation, and review, must be assessed to fully implement the Act.

During the review meeting, held in Kansas City, the review team had unlimited access to numerous photographs, drawings, analyses, transcripts and other evidence and documentation collected by the Agency for development of the report. The team did not speak with any employee of Terra International, Inc. and did not visit the accident site in Port Neal, Iowa. While a broader investigation would have logically involved greater efforts to carry out these activities, this review was limited to the January 23, 1996 report and the in-house information cited above. To more clearly define the limited scope of this investigation report review, an outline of the key questions addressed by the team are as follows. Reviewers were asked to:

- a. Comment on the technical soundness.
- b. Comment on the approach scenario by scenario.
- c. Comment on the findings of the report and the most plausible scenario.
- d. Comment on the comprehensiveness and reasonableness of the technical conditions under which the accident occurred.
- e. Are specific roles of certain equipment appropriately considered?
- f. Is the discussion of ammonium nitrate (AN) appropriate?
- g. Were all external factors considered in a proper way?
- h. Comment on the overall conclusions and recommendations.
- i. What activities or report components should be modeled for future investigations?
- j. Were prevention recommendations appropriately presented?
- k. Were the roles of other entities appropriately addressed?
- l. Are there additional recommendations for actions that could have been or should be taken in the future?

After providing initial comments and after meeting for a total of more than 18 hours, the review team provided a series of comments about the report for the agency's consideration. These comments, again, do not represent any absolute consensus of the team, in that many individual stakeholder perspectives are included. However, the team was unanimous in its support that all pertinent comments be offered to the Agency. In addition to individual comments provided by the reviewers (which are included in Appendix 2 of this report), team commentary on the basic issue questions cited above are intended to provide a constructive critique. Follow-up comments were provided by two members of the team (See Appendix III).

APPROACH

Generally the team considered the overall approach to the report to be sound and appropriate. The text was straight forward and lacked overly technical jargon which was considered beneficial for public policy makers and the general public. Both constituent groups have expressed keen interest in this report and it seems to be sensitive to these broad audiences. The "scenario by scenario" approach used in the report is a valid and useful approach which was also viewed as helpful to the reader.

In response to the question of whether this was the "correct" approach, this becomes a philosophical discussion of the technical community on process safety and investigations. There exists a vast literature on approaches to accident investigation as evidenced by a recent publication by the Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers called "Guidelines for Investigating Chemical Processing Incidents." While this document and others describe numerous accepted approaches for accident investigation such as the one at Terra, the key point of the review team was that a referenced, accepted methodology be utilized and clearly described by the report (and future reports). After meeting with the OSC and others involved in the investigation in Kansas City, it became apparent that several methodologies were considered. To the reader of the report, and there are many, it is not readily apparent that such were utilized for this investigation. All reports in the future should specify the process, procedure or guidelines within which the investigation team was operating.

While the team viewed the "scenario by scenario" approach as useful and informative, it was incomplete. Team members understood the need to truncate activities into a readable and concise document. However, the omission of the range of scenarios (including sabotage) and why these were dismissed should always be stated. Without questioning the investigators, reviewers had no indication whether all scenarios had been considered and why/how some were dismissed.

The scenarios presented did a good job of systematically narrowing the scope of possibilities for root cause based on evidence and good science. The use of a metallurgist was particularly helpful. The overall findings of the report based on these scenarios and the evidence presented seem reasonable to the entire review team. Given that Terra International, Inc. has presented a report with slightly different findings relating to one piece of equipment (the sparger), this scenario could have been pursued in greater detail (see sparger discussion).

PLAUSIBILITY OF EPA CONCLUSIONS

Overall, the team agreed that EPA's conclusions were plausible given the evidence collected and presented. It must be noted however that some evidence, samples and data were either destroyed or never collected due to conditions under which the investigation took place. Lack of clear control and coordination at the site seem to be primarily responsible for this. As the final report conclusions indicate, several conditions at the plant were outside the range of standard or safe operating procedures and parameters and led to this tragic accident.

The only reservation raised by the reviewers dealt with the issue of the sparger. The committee was unable to come to consensus on the role the sparger did or did not play in the overall stimulus of the explosion of the neutralizer. This single uncertainty however, does not negate the reasonableness of the six conclusions put forward by EPA. There is significant evidence that numerous problems existed at the facility. The review team's only concern with EPA's major conclusions are of definition. That is, the conclusions themselves are less explanatory of "root cause" than is the body of the report discussion. Since root causes are "prime reasons which lead to an unsafe act or unsafe condition or constitute an underlying condition and result in an accident; if the condition is removed the particular incident would not have occurred." Given this definition, the management system failures that led to or allowed the existence of the unsafe acts or unsafe conditions that the report concludes caused the accident was less than adequate. The report discussion does a better job of identifying these causes than do, the conclusion and recommendation sections of the report. Attention to the relationships between root cause and conclusions reached would assist future readers and future reports.

COMPLETENESS

The team agreed that the investigators made a concerted effort to provide complete information and analyses. Reviewers recognized that investigators were somewhat challenged by the circumstances of cooperation, authority and coordination at the site. Given the conditions at the Port Neal facility both before and after the December 13, 1994 explosion, the investigators did a thorough job. While the review team initially raised questions regarding various technical issues (for instance, sampling, sources of contamination of ammonium nitrate stocks and inert coatings of vessels) these were sufficiently answered by the OSC and members of the investigation staff.

DISCUSSION OF CONDITIONS

Though historical records are not overly extensive on ammonium nitrate explosions, the report discussion of pre-incident-conditions was both valuable and thorough. This discussion helped to establish the plausibility of certain scenario building exercises which were undertaken by the investigators. It also added value to the basis of discussion for non-technical stakeholders who have or are likely to review the report. This type of background search on basic chemistry and literature should be included in future reports.

EXTERNAL ENTITIES AND FACTORS

Given that a clear lack of coordination with other agencies and interests existed during this investigation, the report does not deal adequately with external factors. Only upon interview with agency personnel was it apparent to the reviewers just how difficult this issue was. Because Iowa is a designated "state OSHA" by its parent federal agency, coordination and, therefore, consideration of more complete information exchange was greatly lacking. If detailed, coordinated investigations and joint reports are to be achieved as intended by the CAAA of 1990, a broad protocol, comprehensive in nature and definitive of the roles of all stakeholders must be developed. State agencies, local response organizations, industry, labor and community advocates should be coordinated by federal agencies into a cohesive, informed and collaborative effort. Externally, an interface with all stakeholders would ensure accurate information is presented for public consumption. Due to circumstances surrounding this particular report, these significant issues were not addressed,

ADDITIONAL ACTIONS

In its release of the report on January 23, 1996, EPA made several recommendations based on its findings during the investigation. These ranged from recommending thorough process hazards analyses, to reviews of safe operating procedures and increased emphasis on training, communication and preventive maintenance. The review team supports these recommendations and notes that many are now contained in OSHA and/or EPA regulations. From this incident, facility management must recognize the value and meaning of compliance with existing rules and overall safe management practices.

EPA should follow up with both the research community, trade associations and all ammonium nitrate producers to fully inform them of the findings of this report. Additional research, if properly structured should address ammonium nitrate sensitivity, confinement and activation. Also, the emergency response community should be provided with detailed reviews of this accident and how responders should prepare for responses to similar incidents.

RECOMMENDATIONS

The Accident Report Review Team recommends that EPA assess its objectives and clearly articulate a strategy to be commented upon by the various stakeholders. Major problems observed in the Port Neal, Iowa investigation were (a) lack of understanding that EPA had authority to conduct the investigation and (b) lack of coordination with other parties who also had interests or authorities to collect information. These two issues precipitated most other deficiencies found in both the investigation and the written report. Lack of clear authority and direction were the greatest hindrances to EPA's staff.

The Team's recommendation for a uniform accident investigation policy should allow for consideration of the numerous stakeholders including the public. Although the latter would not be directly involved in evidence collection and technical work, the concept of an oversight committee which includes public representation should be considered. Those parties or agencies with existing authorities should be organized, through agreements or statutory changes, into a structured, mutually beneficial approach. Recognized is the fact that EPA could be executing agreements with 50 states plus countless local entities. In the Terra incident, a local fire chief, acting on his independent authority, destroyed evidence by "hosing down" the area shortly after the event. Such seemingly random actions will continue to occur at accident sites until a uniform protocol is issued.

Timing should be addressed also, as the agency's response did not begin until six days after the event. While stabilization of the site was necessary and time consuming, the OSC was required to develop an investigation strategy and implement that strategy impromptu. By this time, weather, movement of debris, loss or destruction of evidence (e.g. the pry bar opening of 416J pump by Terra personnel) or the actions of other agencies (e.g.. fire department) had degraded or eliminated potentially critical evidence. The initial resistance of Terra personnel to take seriously the EPA investigation team as demonstrated by the 26 site visits also slowed the initiation and completion time of the investigation.

EPA should consider a national network of response capabilities and expertise as its accident investigation program matures. In an effort to reduce costs, personnel or contract services with particular expertise could be integrated into an overall approach at the direction of Headquarters or among the Regional Offices. The previous recommendations regarding the expertise of other agencies including OSHA, states, etc. should also be integrated into this potential network.

EPA should consider how it might leverage industry response to this and future reports. Clearly, other ammonium nitrate producers will review this report for its implications on their operations. However, other mechanisms such as working with trade associations or specific groups like AIChE's CCPS, the Ammonia Institute, and others may provide a comprehensive yet focused approach.

Due to the nature of several key issues raised by the review team as well as the limited time in which they had to consider the report, numerous issues remain unaddressed. The Agency should continue to deal with these over time by seeking additional internal and external expertise on several key subjects. Given the circumstances, EPA and particularly Mark Thomas of Region VII, have made a valuable contribution to the Agency's evolving investigative process. While inclusion of analytical protocols, time lines and additional data may have improved EPA's Terra Industries report, the content provides plausible support of the agency's conclusions and actions. Given the nature of industrial facilities which handle hazardous materials and existing regulatory requirements, numerous deficiencies surfaced at Terra's Port Neal operation. Based on the agency's evidence and the report, an array of management, equipment, training and safety parameters were pushed beyond their safe operating range. When this occurs, disastrous consequences are the result.

**APPENDIX
I**

**PROPOSED AGENDA
TERRA INDUSTRIES - EPA ACCIDENT INVESTIGATION
REVIEW TEAM**

July 28, 1996	-	Arrive Kansas City 5:00p.m.	Intro/Procedures Dinner Meeting
July 29, 1996	-	8:00a.m.	Meet in Hotel Lobby for Transportation To EPA
		8:30a.m. - 10:30a.m. - Break	Mark Thomas
		10:15a.m.-12:00p.m. -	Questions & Examination Material
		12:00p.m.-1:30p.m. -	Lunch
		1:30p.m.-3:00p.m. -	Panel Discussion
		Break	
		3:15p.m.-5:00p.m. -	Panel Discussion
July 30, 1996	-	8:00a.m.	Meet for Transportation
		8:30a.m-10:30a.m. -	Meeting with Mark Thomas
		Break	
		10:45a.m.-1:00p.m. -	Final Discussion

Depart as individual schedules demand

Note: EPA Region VII and Headquarters staff will be on hand to assist the review team with information, logistics or other assistance as needed Private (panel only) sessions are optional on both days.

**APPENDIX
II**

National Institute for Chemical Studies

for CHEMICAL ACCIDENT INVESTIGATION REPORT:
TERRA INDUSTRIES, INC.
NITROGEN FERTILIZER FACILITY
PORT NEAL, IOWA

REVIEWER'S COMMENTS

A Review of
EPA Chemical Accident Report
"Terra Industries, Inc.
Nitrogen Fertilizer Facility"

by

Geraldine V. Cox, Ph.D.

under EPA Order Number 6W-4637-NATA
Reference Number EAR203

Submitted July 15, 1996

Under contract to the United States Environmental Protection Agency, I reviewed the Chemical Accident Investigation Report entitled, TERRA INDUSTRIES, INC. NITROGEN FERTILIZER FACILITY PORT NEAL, IOWA. As background materials, I also read the State of Iowa Occupational Safety and Health Citation documents and the Report of the Incident Investigation Committee prepared by Terra on the Port Neal Explosion, dated July 17, 1995.

EPA charged the reviews to respond to the questions that follow.

1. *Comment on the technical soundness, overall approach, and completeness of the report, to derive recommendations for approaches to accident investigations in the future and accident prevention.*

The overall approach was appropriate, but the number of possible scenarios was somewhat truncated. All plausible scenarios should have been identified, and then eliminated by data or reasoning. It appears that the “solution” to the cause was identified early, and not all of the possible causes were identified and retained or eliminated as appropriate. Or, if the scenarios were dismissed, it was not reflected in the report.

The Iowa OSHA citation indicated an evacuation that placed employees in the plume of ammonia gas for a period of time following the incident. Understanding the charges to EPA and OSHA regarding chemical safety incidents, I was surprised to see that the report did not extend to the actions and plans following the incident. I would have expected to see a discussion of the emergency response - both company and with local emergency response teams. Was there any community exposure? Was there a review of the entire post-incident events? If not, this should be included in the review. While information from the response will not go to prevention, lessons learned from the response will be valuable in the future to mitigate the effects of similar incidents.

The description of structures surrounding the plant is lacking. If there were no surrounding structures, that should have been indicated.

2. *Comment on the approach taken (scenario by scenario) as a correct approach to take.*

Scenario 1 - AN Plant Pumps

The discussion of the AN scrubber recirculation pump and the product pumps, based on data presented, is plausible. I concur that the pumps were not the site of initiation.

Scenario 2 - AN Scrubber

This analysis seems valid based on the data presented. The AN scrubber was not a source of the explosion.

Scenario 3 - Neutralizer

All data presented are consistent with an explosion originating in the neutralization vessel. There was no discussion of the lining of the neutralization vessel, if any existed. If the vessel was not lined with Teflon®, then the prolonged exposure to a pH of less than 1 might have introduced a local increased concentration of iron or chromium from the steel tank that might have contributed to the reaction. There was no discussion of the materials of fabrication of the pipes, and this might have contributed to activation of the reaction. Since several of the metallurgical analyses indicated pitting, some degradation of the vessel must have occurred before the explosion. Whether this contributed to the explosion, or not, is unclear. In the report, there was a discussion of the abandoned steam heating lines due to corrosion. What was the material of construction for the pipes, and why did they corrode so badly that the steam lines could not be used? Was there a leak that was causing the corrosion? If so, could that have introduced contamination?

Under item 2. of the determination of conditions prior to the explosion, the presence of chlorides is mentioned. Was there a higher level of chromium and/or iron? These compounds can also contribute to the explosion.

Spargers

The report did not discuss the “bathtub ring” that was mentioned in the Terra report. Was any evidence of this “ring” found in the sample analyzed by EPA labs? There is a clear discrepancy between the EPA and Terra report on this item. The EPA metallurgist’s report specified that the force originated outside of the sparger, not inside. Were sufficient samples provided to the metallurgist to assure that the event was not triggered in another section of the sparger. Since it appears that a single sample was analyzed, and the ring had a rather large diameter, although unspecified in the report, could the initiation been in another section of the sparger that was not analyzed?

The discussion of titanium “healing” is accurate and would argue against titanium being an initiator, since the “reactive material” would be the relatively inert titanium dioxide.

Neutralizer contents

Clearly the low pH, <1, contributed to the sensitization of the ammonium nitrate. Since the pH sensors were isolated relative to the central portion of the reaction vessel, it is difficult to understand if the contents were uniformly distributed, or channeled as proposed by EPA. No one argues that bubbles were absent, and that the bubbles may have contributed to the event. The scenario of local areas of convection with low pH, contamination and bubbles is a reasonable explanation for initiation of the explosive reaction.

3. *Comment on the findings of the report examining various explosion scenarios and on the identification of the most plausible scenario. Were any significant scenarios missed?*

The scenarios presented seem plausible, but the development of possible accident scenarios seems somewhat truncated. For example, the normal approach to such an accident investigation would normally list all possible, and often some improbable causes, and then a method to eliminate those without substance based on data from the event. This approach would structure the data collection effort, and would take place prior to chemical and physical sampling at the site. One scenario, for example, should always be sabotage. Most probably sabotage can be eliminated in this case, but it should always be included in the analysis. For example, the chloride ion presence in the AN 83% storage tank could have been introduced deliberately. (While I see no evidence that this occurred, it cannot be ruled out.) Since the stainless steel neutralization tank was constructed from 304L stainless steel, with a high chromium content, 19%, combined with the fact that a pH of less than 1 may have been present for a significant time, would possible chromium contamination be a contributing factor. Chromium (and its oxo complexes) is a sensitizing factor in ammonium nitrate decomposition reactions. If the vessel were Teflon®-lined to prevent such solution of chromium and iron, it is not indicated in the text. For that matter, iron could possibly contribute as a sensitizing agent as well.

The chloride contamination scenario does not seem to have adequate explanation. The normal chloride content of water is less than 100 ppm, so the 557 ppm found in the nitric acid absorption column seems very high. The description of the surface condenser/absorption column was insufficient to understand how 557 ppm of chlorides could accumulate. To contaminate the ammonium nitrate storage tank to the level of 157 ppm, a lot more chloride than found in drinking water would be necessary. Did anyone calculate the total amount of chloride necessary to contaminate the Ammonium Nitrate to a level of 157 ppm in the tank? I did not find the total capacity of the 83% Ammonium Nitrate tank or the estimates of the amount of Ammonium Nitrate present in the tank at the time of the incident. This would have been useful to determine the total amount of chloride. If the volume of the tank were significant, then the amount of contamination from chloride would be quite large, especially if it came from water.

Titanium is embrittled by ammonia. Was it possible that a high ammonia excursion occurred sometime in the history of the system? With the pH probe function under question, it is possible that the reaction was not controlled to a level where some embrittlement did not occur - although it appears that the pH excursion was on the acid, not alkaline range.

4. *Comment on the comprehensiveness and reasonableness of the statements about technical conditions under which the accident occurred. Are specific roles of certain equipment, notably the sparger, appropriately considered?*

As noted in the discussion of scenarios, the “bathtub ring” that Terra claims in the sparger pieces found after the explosion, and from the sparger removed from the vessel previously, this might have been a contributing factor. Was the sparger welded to form the shape? If so, what was used in the welding process. Could it have contributed to the failure? If the EPA conclusions about sparger integrity were based on a single sample, and that sample was obtained from the other side of the vessel from the site of initiation, it might not have the same characteristics. Therefore, multiple samples from different locations of the sparger should have been analyzed. From the report it is unclear if multiple samples were analyzed by EPA.

While the discussion of the materials of construction for the vessel and sparger were good, the dimensions were absent. Also, the materials of construction for the piping of the vessel were missing. The piping might be a possible source of contamination. Were the vessels or pipes lined with an inert material such as Teflon®? Thickness of the tank walls and sparger were not presented in the description. This would have been helpful.

5. *With no prior history of accidental detonating of AN solution, is the discussion of the conditions existing before the accident appropriate? Please comment on the conclusions reached and whether they lead to the root causes identified.*

The discussion of the pre-incident conditions was very thorough. The discussion could have been stronger if the sizes of the involved vessels were identified, as well as the materials of construction of the pipes, and an indication of whether the neutralization tank was lined and the thickness of the respective vessels.

In Figure 2-2, I believe that the arrow head is pointing in the wrong direction on the line connecting the urea and 83% AN sales line. I believe the AN flow goes to the nitrogen solutions storage where it is mixed with urea. In fact, the line should go directly to the storage tank, where I believe it is mixed with urea, rather than flowing into the urea line.

The possible contamination of the reactive materials should have included chromium, and possibly iron. The discussion of sensitizing agents mentions these materials, and there is a possibility that they could be present due to construction materials, so they should have been included. A discussion of the concentration of these contaminants as concentration alters the reaction would have been helpful.

6. *Were all external factors considered in a comprehensive way? Also, please comment on whether human factors and broad management issues were identified appropriately, in appropriate sequences, in ways to lead to reasonable conclusions and recommendations.*

As stated earlier, the report should have included a review of the actions taken after the incident. This should have included employee evacuation procedures and the role of

the plant personnel with local emergency response and planning groups and any community surrounding the plant.

The mention of the corroded steam pipes, to the point where the pipes were unusable, bothers me. What caused the corrosion and could the leaks have contaminated the system. From the limited description, it is impossible to understand if they contributed to, or were symptomatic of other problems that this report did not identify.

The high concentration of chloride seems to be hard to explain on the basis of water contamination. The mass of chloride ion should be calculated to understand the extent of contamination. Is there a possibility of sabotage? From the operations history, I do not believe there was sabotage, but it should still be considered and ruled out based on the data.

The pre-incident report mentions an "outside operator" who was present, and is present in startup and shutdown operations. It was unclear if this individual was a Terra employee or a contract employee. Did this individual receive the same training as the Terra full-time operators of the ammonium nitrate unit? What is the full role of the outside operator, and what is the familiarity of this individual with the process? This could possibly be a source of error, especially because Terra apparently did not have written shutdown and startup procedures.

7. Please comment on the conclusions and recommendations. What of the overall approach could be modelled for future such investigations? Was information for prevention of similar accidents appropriately presented in this report?

The conclusions are valid, and the rationale for the conclusions seems to be sound. The recommendations highlight the poor documentation of the facility in terms of written procedures. If the facility had been conforming to OSHA 1910, this incident would most likely not have occurred. However, the possible degradation of the sparger might have contributed to the system failure even if these procedures were in place. There is no reason why a suspected faulty pH probe could not have been replaced within the time period, although if the tank were not discharging, then it would be of little use since it was outside of the neutralization tank. I question whether the fluctuations in the readings that Terra employees believe was due to a faulty probe might have, in fact, been accurate and the pH fluctuation might be longer than stated in the incident report,

In recommendation 3., the startup procedure should be specified as well as shutdown

In recommendation 4., the engineer should not only approve changes, he should sign off on any changes so the documentation is incontrovertible.

In recommendation 6., any outside contractors should be included in the training program. Anyone who works in the unit should have training and understand the

procedures. This training should include what type of safety equipment is appropriate, and that equipment should be available.

8. *Concerning the role-of federal, state local agencies; the public; labor; trade associations; and public interest groups: please comment on whether roles of these entities were appropriately addressed. Are there any recommendations for actions they could have taken, or should in future take to reduce accident risks?*

The role of the local emergency responders was not addressed at all. The EPA report was thorough, but seemed more appropriate for OSHA than EPA. However, in a quick reading of the Iowa Occupational Safety and Health Department citation, they did not prepare a causative report of the depth of EPA. This type of report should be done, and it is worth an understanding on a national level when states have OSHA primacy, such as Iowa. Perhaps the federal OSHA should review the EPA report or the state citation in cases where explosions in chemical operations cause death.

Labor is not part of the review process, although there is a strong national program in worker safety run by the AFL-CIO. Perhaps in future incidents, one of their technical staff can be included on the review panel for EPA.

The Fertilizer Institute should receive this report and be asked to develop an approach for its members to prevent similar incidents. Trade associations can be valuable allies in understanding events such as this and to develop viable approaches to preventing similar incidents or at least mitigating the consequences. There was no mention of any industry-wide practices for this type of operation.

No mention of public interest groups was made in the report, however, incorporation of the local emergency planning commission should include an outreach to the public interest groups most likely to be effected by the facility operations,



Geraldine V. Cox, Ph.D

Review of EPA
Chemical Investigation Report
Terra Industries, Inc.
By
Pamela Nixon, MS MT (ASCP)

The investigation of Terra Industries, Inc. of Port Neal, Iowa, by EPA appeared to be thorough. The investigation team's recommendations were focused primarily on the ammonium nitrate (AN) unit, due to the > 1 explosion that occurred there. However, the historical data of the most recent incidents that lead up to the event, indicated that plausible contributing factors could have come from the feed streams including Area I and Area II as described in Section 2: Background:

In Section 10: Recommendations, the investigation team's recommendations (#1 through #5 and # 8) could possibly be augmented to include the units of Areas I and II. Recommendations #6 & #7 appear to be more broad-based, and not specific to the AN unit

In reading the recommendations, I have taken them literally thereby, possibly interpreting them more narrowly than the investigation team intended My experience has been to look at industrial accidents from outside the fence-line. When discussing accidents with company officials I have discovered that they respond to the literal interpretation of questions and recommendation, and that is why I have chosen this route.

In Section 2: Background, Area I and Area II are differentiated into distinct smaller plants which include the ammonia plant, tank farm, utilities, nitric acid plant, the urea plant, and the AN plant. These smaller plants are either feed streams or they lead-off the AN plant

- Petroleum spills in the ammonia plant (September 1994 and October 1994), possibly causing the hydrocarbon contamination
- Water leak in the Nitric Acid plant (December 5 to 8, 1994) possibly being the contributing factor of chloride contamination

page 2 of 3

- Uncontrolled off-gas flow production of ammonia from the Urea Plant to the AN neutralizer, possibly affecting the pH in the neutralizer and being responsible for the ammonia leak during the several days that followed the explosion

It is EPA's responsibility to protect the public from similar events that may impact their lives in a negative manner. In order to minimize such occurrences, I believe the recommendations should be enhanced to include the following:

- I suggest that the PA of the AN plants (recommendation 1) be expanded to include PA of all Plants, storage units, and utilities as described in Area I and Area II Section 2: Background. If the AN plant lacked completed PA, there is possibly the need for performed on the Terra Industries facility as a whole, or to show documentation that it has been performed as changes have occurred in other areas.
- I suggest that the safe process operating parameters for the AN plants (recommendation 2) be expanded to include all plants, storage units, and utilities as described in Area I and Area II Section 2: Background rather than only monitoring the feed streams for the presence of known contaminants on a periodic basis as well as periodically reevaluating operating parameter ranges, or provide documentation that it already exists in the other area.
- I suggest that the development of the written, safe operating procedures for the AN unit (recommendation 3) be expanded to include all plants, storage units, and utilities as described in Area I and Area II and Area II in Section 2: Background and the procedures should be developed for activities conducted in each unit in all modes of operation, including periods when the units are shut down and the vessels are charged... If written, safe operating procedures exist in the other unit provide the documents.
- I suggest that 4 complete management of change procedure for all operating parameter range changes for the AN unit (recommendation 4) be expanded to include all plants, storage units, and utilities as described in Area I and Area II in Section 2: Background, and this should include approval to operate the unit outside of approved parameter ranges by the engineer responsible for these units, and docu-

page 3 of 3

mentation of these activities - If written, safe operating procedures exist in the other units, provide the documents.

- I suggest the development of the maintenance program that will anticipate problems in the AN unit (recommedation 5) be expanded to include all plants storage units, and utilities as described in Area I and Area II in Section 2: Background. This program should include predictive failure analyses - If this program exists in the other units, provide documents.
- I suggest that information on the hazards of substances handled, the prevention measure a in place or planned to prevent releases and the emergency response measure a (recommendation 8) be taken for all plants, storage units, and utilities (as described in Area I and Area II Section 2: Background) with the State Emergency Response Commission, Local Emergency Planning Committee, first responders, and the public surrounding the facility. If this information from the other units has been given to the above mentioned agencies, provide the documentation.

I feel that if the recommendations are not explicit to include the other units, the programs procedures and training in the other units may be overlooked. Then the potential for an incident of equal or greater magnitude occuring in other units of Terra Industries, will continue to be list

There should be a system in place where by OSHA and EPA can work together on a safety board to protect the health, safety, and environment of the workers and the public.

Review of the EPA Region VII Report on the 12/13/94 Accident
at the Port Neal, Iowa Facility of Terra Industries.

Isadore Rosenthal, Ph. D., 7/14/96.

Scope of the report.

This report is organized around the specific areas that reviewers were asked to address in the “Charge to Reviewers” and “ Statement of Work for Expert Reviewers” (Appendix I).

The general charge to reviewers was to “use your technical knowledge and professional judgement to comment on the technical soundness, overall approach, and completeness of the report, to derive recommendations for approaches to accident investigations in the future and accident prevention.” The report on which the reviewers were to comment was Region VII’s report¹ on the accident at the Terra Industries facility in Port Neal, Iowa (EPA Terra Report).

Reviewers were not asked or retained to do independent research in order to supplement their “technical knowledge and professional judgement” or to verify the information contained in the EPA Terra Report being reviewed.

Two additional documents dealing directly with the Terra Industries accident were supplied to this reviewer in connection with his assignment:

1. The settlement agreement² between Terra International, INC. And the Iowa OSHA Employment Appeal Board (OSHA - Terra Agreement).
2. The July 17, 1995 report³ on the accident at the Terra Industries facility in Port Neal prepared by a group of outside experts retained by the General Counsel of Terra Industries Inc (Terra Port Neal Report).

This report is organized around the following specific items that the “Charge to Reviewers” asked each reviewer comment on:

- 1.- Whether the scenario by scenario approach taken was correct.
- 2.- The findings of the report examining various explosion scenarios.
- 3.- The identification of the most plausible scenario.
- 4.- The omission of significant scenarios.
- 5.- The comprehensiveness and reasonableness of statements about technical conditions under which the accident occurred.
- 6.- The appropriateness of the consideration given to the roles of certain equipment, notably the sparger.
- 7.- Is discussion of the conditions existing before the accident appropriate with no prior history of the accidental detonating of AN solution”?
- 8.- The conclusions reached and whether they lead to the root causes identified.
- 9.- Were all external factors considered in a comprehensive way?
- 10.- Whether human factors and broad management issues were identified appropriately, in appropriate sequences, in ways to lead to reasonable conclusions and recommendations.
- 11.- The conclusions and recommendations.
- 12.- What part of the overall approach could be modeled for future such investigations?
- 13.- Was information for the prevention of similar accidents appropriately presented in this report?

14.- Were the roles of federal, state local agencies; the public; labor; trade associations and public interest groups appropriately addressed?

15.- Recommendations for actions they (federal, state local agencies; the public; labor; trade associations and public interest groups ?) could have taken or should in the future take to reduce accident risks

1.- Comments on whether the scenario by scenario approach taken was correct.

This reviewer feels that the “scenario by scenario approach” used in Region, VII’s report on the accident at the Terra Industries facility in Port Neal, Iowa (EPA Terra Report) is a valid approach.

However, there is no such thing as a “correct” approach.

There is a vast literature on approaches to accident investigation. A relatively recent authoritative survey of this literature and its learnings, “Guidelines for Investigating Chemical Processing Incidents⁴”, has been published by the Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers (CCPS Guidelines). These “Guidelines” describe numerous different ‘accepted’ approaches for the investigation of accidents similar to the one that occurred at the Terra facility. Each of these accepted approaches is used and endorsed by different reputable authorities.

2.- The findings of the report examining various explosion scenarios.

The findings of the report examining various explosion scenarios seem reasonable given the information presented in the EPA Terra report with the possible exception of some of the findings related to the Sparger (see comments in item 6)

3.- The identification of the most plausible scenario.

The physical findings after the accident indicated that there were two explosions the first of which occurred in the Neutralizer and the subsequent one in, the Rundown tank.

Three of the four scenarios presented dealt with possible sequences of events, and conditions related to the initial explosion. The third of these four scenarios, which dealt with initiation within the Neutralizer was sub-divided into two scenarios, one dealing with decomposition originating within the nitric acid Sparger, the other with decomposition originating in the contents of the Neutralizer tank external to the nitric acid sparger.

The fourth scenario was the only scenario that dealt with the second explosion which occurred in the Rundown tank.

This reviewer agrees with the EPA Terra Reports conclusion that scenario 3 was the most plausible of the three scenarios for the first explosion and that scenario 4 was plausible.

However based on information presented in the Terra Port Neal Report, there are questions which need further analysis before this reviewer is comfortable with choosing which of the two sub- scenarios considered under scenario 3 is most plausible.

4.- The omission of significant scenarios.

Based on the information available this reviewer does not believe that significant scenarios were omitted, though perhaps sub-scenario 3 might have been broadening given the information maintained in the subsequently issued Terra Port Neal Report(see specific comments under item 6 dealing with the considerations given to the role of the Sparger).

5.- The comprehensiveness and reasonableness of statements about technical conditions under, which the accident occurred.

Overall the comprehensiveness and reasonableness of statements about technical conditions under which the accident occurred was good given the conditions and less than complete documentation and records that apparently existed at the Terra Port Neal facility before and after the 12/13/94 accident.

6.- The appropriateness of the consideration given to the roles of certain equipment, notably the sparger.

Based on the information given in the EPA Terra report in regard to possible role of titanium and in particular the statement on p. 86 of this report which states that "The forces that distorted and destroyed the Spargers were applied to the external surface, not the interior surface", this reviewer initially believed that appropriate consideration was given to the role of other equipment, notably the sparger.

However some doubts were raised in regard to this reviewer's initial belief on the appropriateness of the consideration given to the role of the sparger by the information in the Terra Port Neal Report. This report contained information related to the possible sensitization role of titanium and in particular the statement (Exhibit 8, p. 8) that "The titanium fragments provided evidence that the acid sparger had ruptured due to internal overpressurization. In addition, most of the interior and some of the exterior surface of the fragments showed corrosion".

7.- Is discussion of the conditions existing before the accident appropriate with no prior history of the accidental detonating of AN solution”?

The simple answer to this question is yes, though this reviewer- has difficulty with the meaning of this question. Clearly there have been previous AN solution explosions at other locations. Given that it has been established that AN and its solutions have this potential for injury and that the amount of AN (and other highly hazardous substances) being

processed at the Port Neal facility that could give rise to major accidents, discussion of the conditions existing before the accident seem appropriate to this reviewer.

8.- The conclusions reached and whether they lead to the root causes identified.

The one significant reservation that this reviewer has on the conclusions put forward in the EPA Terra Report rests conditionally on the resolution of questions raised above concerning the role of the sparger. However even if the Sparger is shown to have played a more significant role in initiating the explosion in the neutralizer, this would not negate the reasonableness of the six conclusions put forward.

The conclusions reached in Section 9 of the EPA Terra Report deal adequately⁵ with the “unsafe acts or unsafe conditions” resulting from employee action or inaction. However this reviewer believes that the conclusions reached in Section 9 of the EPA Terra Report EPA Terra Report deals less than adequately with Root causes.

This reviewer’s definitions of ‘Root’ causes is;

“Prime reasons, such as failures of some management systems, that allow faulty design, inadequate training or improper changes, which lead to an unsafe act or unsafe condition and result in an incident. Root causes are also known as underlying causes. If root causes were removed, the particular incident would not have occurred.”

Given this definition, the management system failures that might have led to or allowed for the existence of the unsafe acts or unsafe conditions that the report concludes led to the accident was less than adequate. The body of the EPA Terra Report does a much better job in relating management system failures to the factors that presumably led to the accident than do the recommendations.

In the reviewer's opinion, use of a presentation approach such as the MORT based Root Cause Analysis Form 7 would more clearly show relationships between Root causes and the conclusions reached in the EPA Terra Report..

9.- Were all external factors considered in a comprehensive way?

This question is unclear to the reviewer. What are examples of the external factors that were to be considered? The weather? Power failures? Possible health epidemics in the community that affected employees or management in an unforeseeable fashion?

10.- Whether human factors and broad management issues were identified appropriately, in appropriate sequences, in ways to lead to reasonable conclusions and recommendations.

The body of the EPA Terra Report contained the information required to ensure that human factors and broad management issues were identified appropriately, in appropriate sequences, in ways to lead to reasonable conclusions. However, this information was less than adequately summarized and related to the conclusions and recommendations made in Sections 8 and 10. (See comments under item 8 and 10).

11.- The conclusions and recommendations.

This reviewer commented in item 8 on the conclusions given in Section 9 of the EPA Terra Report. However, there is an additional conclusion given in the first paragraphs of Section 10, Recommendations. While this reviewer agrees that the EPA Terra Report presents evidence that the lack of safe operating procedures was an important factor in the sequence of events leading to the accident, it is somewhat disingenuous to claim that "the conditions that caused the explosion existed primarily (emphasis added) 'because of the lack of safe operating procedures' without defining "safe operating procedures" operationally.

To this reviewer “safe operating procedures” can only be developed and implemented after a facility implements all of the eight specific numbered (1 to 8) recommendations made in Section 10. All of these recommendations appear to be in order and are generally considered to constitute ‘good practice’ for facilities handling the quantities and type of materials and processes present at the Terra’ Port Neal facility.

12.- What part of the overall approach could be modeled for future such investigations?

EPA should adopt a standard Type 3 accident investigation protocol for all of its accident investigations. Most of such approaches include almost all of the elements in employed in the “scenario by scenario” approach used in the Region VII investigation but in a more structured way.

This protocol should be modeled after one of the broadly accepted multiple-cause, system oriented investigation approaches in the public domain that is focused on the determination of ‘root’ causes. To the extent consistent with its constraints, this standard EPA protocol should use the terminology, methodology and presentation styles used in the literature associated with the broadly accepted multiple-cause, system oriented investigation approach used as model for EPA’s standard protocol.

If this approach is feasible, EPA will achieve greater clarity, understanding and acceptance of its investigations in the technical community and will benefit from the continuing research work that the broad technical community does on the particular Type 3 model that EPA uses as the basis for developing its own standard protocol.

13.- Was information for the prevention of similar accidents appropriately presented in this report?

See comments under items 3, 6, 8, 10 & 11 above.

14.- Were the roles of federal, state local agencies; the public; labor; trade associations and public interest groups appropriately addressed?

This reviewer could not locate sections of the EPA Terra Report that addressed roles for Federal, state local agencies; the public; labor; trade associations and public interest groups other than recommendation that imply that Terra Industries should supply information to the public surrounding the facility and state and local agencies dealing with emergency response (recommendation. 8, section 10).

In this reviewer's opinion this does not appropriately address the roles that all elements of federal, state local agencies; the public; labor; trade associations and public interest groups should or desire to play.

15.- Recommendations for actions federal, state local agencies; the public; labor; trade associations and public interest groups could have taken or should in the future take to reduce accident risks.

This reviewer feels that it is relatively unproductive to speculate about actions that this group of stakeholders might have taken in the past. In any case the scope of possible actions was limited by practical difficulties in obtaining concise information on the risk management programs that existed within facilities and the relative lack resources available to these groups with the possible exception of trade associations.

In the future the new EPA rule dealing with the prevention of major chemical accidental releases should make process safety information and accident histories much more readily available. This should allow all of the above entities to do a better job in screening the adequacy of facility safety programs with the limited resources available to them.

Public interest groups and Federal, State and local agencies could use this information to make the public aware of the type and magnitude of facility risks that might affect them. This should lead to an informed

public that could chose to directly pressure facilities that they feel have a less than adequate risk management program and/or generate pressure to provide resources that would allow agencies to do a more effective job on their behalf.

Trade, associations could follow the lead of the CMA by making membership conditional on the implementation of process safety programs similar those embodied in Responsible Care or generate model safety programs to assist their members.

Labor unions and Agencies could offer accessible, appropriate process safety training to employees that do not have adequate training available through their employer and inform them of the appropriate actions they might take if less than adequate safety programs exist in their workplaces.

ckr Galsby, 1995

End Notes

1. Region 7, "Chemical Accident Investigation Report. Terra Industries. Inc. Nitrogen Fertilizer Facility, Port Neal, Iowa", released 1/23/96.
2. "Settlement Agreement", DIA Docket No. 95 DES- 20. IOASHA Docket 4446. Citation No. S7510 - 115072555.
3. "The Terra Port Neal Explosion. December 13, 1994". Report of the Investigation Committee, July 17, 1995.
4. "Guidelines for Investigating Chemical Processing Incidents", Center for Chemical Process Safety of the American Institute of Chemical Engineers, N Y City, NY, 1992.
5. The one exception on the conclusions put forward in the EPA Terra Report rests conditionally on the resolution of questions raised above concerning the role of the sparger. However even if the Sparger is shown to have played a more significant role in initiating the explosion in the neutralizer, this would not negate the reasonableness of the six conclusions put forward
6. "Guidelines for Investigating Chemical Processing Incidents", Center for Chemical Process Safety of the American Institute of Chemical Engineers, N Y City, NY, 1992, p 8.
7. "MORT Based Root Cause Analysis", EG&G Idaho, Inc., P.O. Box 1625, Idaho Falls. Idaho 83415, June 1989, pp.1 to 3.

Appendix I

- A. Charge to Reviewers
- B. Note on Required Deliverables

CHARGE TO REVIEWERS
For the EPA Chemical Accident Report,
TERRA INDUSTRIES, INC. NITROGEN FERTILIZER FACILITY

EPA Region VII (Kansas City, KS) prepared the above report, released January 23, 1996, concerning an accident on December 13, 1994 occurring at Terra Industries, Inc. The report is 108 pages long, and includes an executive summary, an overview of the investigation, discussion of plant operations and events at the facility, conditions and facts derived by the investigators, scenarios for the explosion, conclusions and recommendations. The principal investigators were Mark Thomas of EPA; Alan Cummings of Dynamac Corporation, an EPA contractor; and Mariano Gomez, an EPA contractor with its Technical Assistance Team.

As a reviewer of this document, you should use your technical knowledge and professional judgment to comment on the technical soundness, overall approach, and completeness of the report, to derive recommendations for approaches to accident investigations in the future and accident prevention.

The report seeks to ascertain the root cause of this accident, in order to further the goal of preventing accidents. Your review should include the following aspects of this concern.

Comment on the approach taken (scenario by scenario) as a correct approach to take. Comment on the findings of the report examining various explosion scenarios, and on the identification of the most plausible scenario. Were any significant scenarios missed? Comment on the comprehensiveness and reasonableness of the statements about technical conditions under which the accident occurred. Are specific roles of certain equipment, notably the sparger, appropriately considered?

With no prior history of accidental detonating of AN solution, is the discussion of the conditions existing before the accident appropriate? Please comment on the conclusions reached and whether they lead to the root causes identified.

Were all external factors considered in a comprehensive way? Also, please comment on whether human factors and broad management issues were identified appropriately, in appropriate sequences, in ways to lead to reasonable conclusions and recommendations.

Please comment on the conclusions and recommendations. What of the overall approach could be modelled for future such investigations? Was information for prevention of similar accidents appropriately presented in this report? Concerning the role of federal, state local agencies; the public; labor; trade associations; and public interest groups: please comment on whether roles of these entities were appropriately addressed. Are there any recommendations for actions they could have taken, or should in future take to reduce accident risks?

Statement of Work
For Expert Reviewers

Title: Expert Review of EPA Chemical Accident Report, "Terra Industries, Inc. Nitrogen Fertilizer Facility"

Purpose: The purpose of this statement of work is to provide external expert review of the above EPA chemical accident investigation report, including its recommendations and implications for prevention activities by all parties and future investigations. The report discusses the cause of an explosion at the subject facility and presents recommendations to prevent future similar occurrences.

Background: On December 13, 1994, an explosion occurred in the ammonium nitrate plant at the Terra International, Inc. complex in Port Neal, Iowa. Four persons were killed and 18 were injured as a result of the accident. The explosion released a large quantity of anhydrous ammonia to the air, nitric acid to the ground, and resulted in contamination of the groundwater under the facility. The EPA report investigating the incident was developed as part of the Agency's ongoing responsibilities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Clean Air Act, Section 112(r), and as a component of EPA's chemical safety programs. The report was released to the public on Tuesday, January 23, 1996 to become a part of the examination of the causes of chemical accidents and efforts to prevent them. The report was prepared by staff at EPA's Region VII office.

As part of its investigative program, EPA desires the review of a panel of experts who from their individual perspectives and disciplines can provide comment on the scope, approach and conclusions of the report and its implications. This task is designed to purchase the services of reviewers for this comment.

Statement of Work: The reviewers will have the following tasks in accomplishing the objectives of this statement of work (see companion statement of work for chair):

1. Prior to any meetings, all reviewers will be required to review and analyze a copy of the subject report.

---Each reviewer will prepare written pre-meeting technical comments on the report, based on the EPA charge and adhering to the organization and directions of the Chair, a reviewer so designated by EPA.

---Reviewers' written comments are due to EPA, with copies to the Chair, two weeks prior to a meeting, to be held at EPA's regional office in Kansas City, KS. The Chair will distribute copies of all reviewers' comments to all reviewers prior to a meeting, and organize the meeting. The Chair will chair this meeting.

All reviewers will prepare for the meeting by studying comments prepared by other reviewers. All reviewers may review or consult any other background documents provided by EPA or at the direction of the Chair.

2. Attend the two-day review meeting in Kansas City convened by the Chair to exchange comments and discuss issues raised by the subject document. Based on the comments and discussions, develop recommendations to EPA. This meeting is not to be convened for the purpose of achieving consensus but to exchange views and comment, expected from the different perspectives of the reviewers.

Deliverables:

1. Written comment on the subject report.
2. Active participation in exchange of views/ comment at two-day meeting of reviewers in Kansas City, KS.

Cost Reimbursement Procedures:

The EPA will pay an agreed upon fixed fee to the reviewers. This fee is intended to cover the reviewers' consulting fee. In addition, this negotiated fee includes expenses for economy or excursion airfare, local transportation, miscellaneous and incidental expenses (i.e. meals), and lodging for two nights at a ceiling specified in the attached instructions, "Travel Constraints," that may be required for the reviewers.

To estimate the consulting fee, EPA is estimating that no more than a total of four days will be required. The total amount of the agreement will be negotiated by an official from EPA's Office of Acquisition Management. Once all the deliverables that are listed above have been provided, the reviewer may submit an invoice to EPA for reimbursement of a properly justified sum up to the negotiated amount.

Period of Performance:

Upon award of the contract through September 15, 1996.

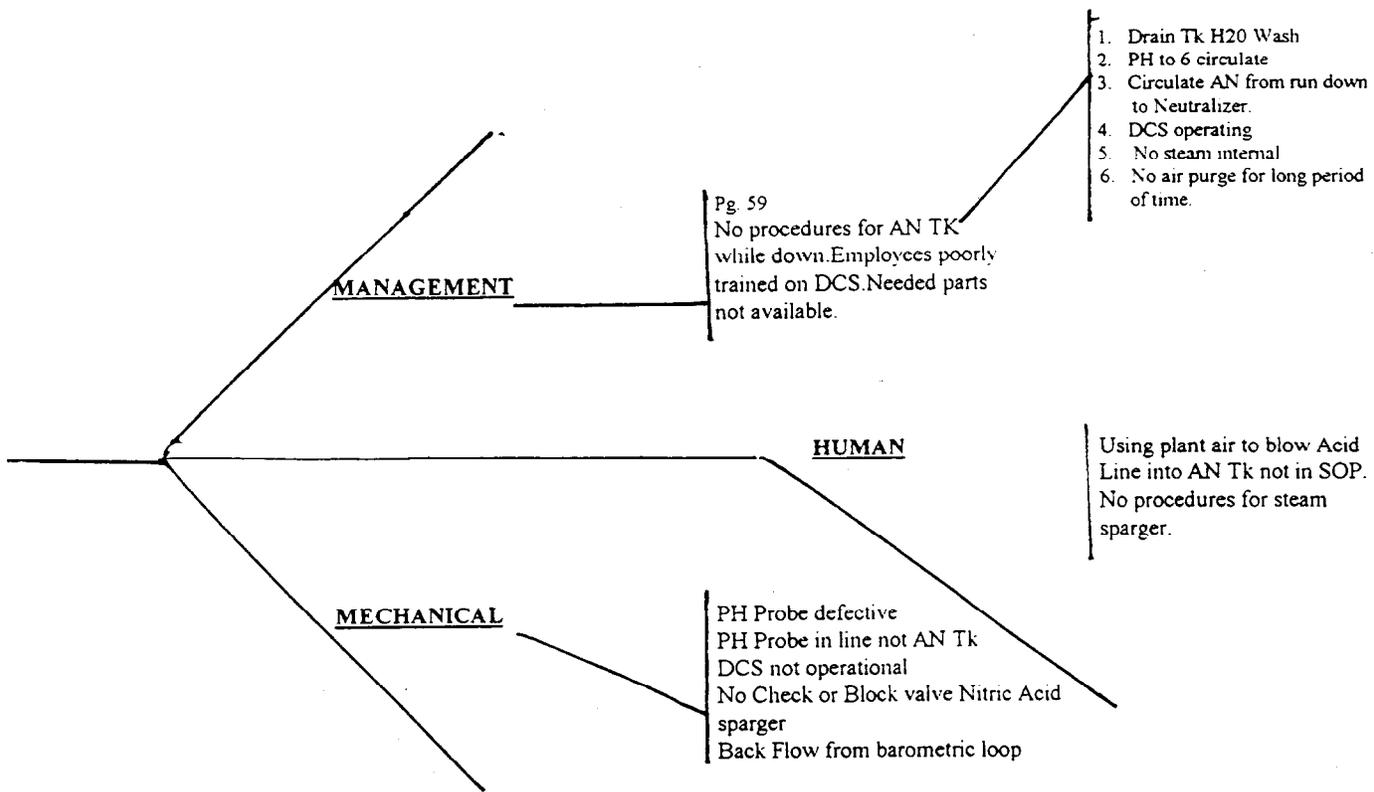
Notice Regarding Guidance Provided under this Statement of Work:

The contractor shall not engage in activities of an inherently governmental nature such as the following:

- Formulation of Agency policy
- a. Selection of Agency priorities
- c. Development of Agency regulations.

Should the contractor receive any instruction from an EPA staff person that the contractor ascertains to fall into any of these categories or goes beyond the scope of the contract or work assignment, the contractor shall immediately contact the Project Manager or the Contracting Officer.

Prior to initiation of review, the reviewer shall disclose any conflict or potential conflict of interest, and shall sign a conflict of interest/confidentiality form. Forms will be provided by the EPA project officer. Any COI that surfaces subsequently during the review process is reported to the project officer.



The major cause of the explosion was no procedures for controlling, monitoring or blow down of H2O wash of the AN Neutralizer Tk during the time the Tk was down with material in the tank.

***EPA CHEMICAL ACCIDENT INVESTIGATION
REPORT
TERRA INDUSTRIES, INC***

***COMMENTS AND QUESTIONS COMPILED BY
JOEL VARIAN
SUBMITTED JULY 15, 1996***

***PERSPECTIVE: Labor
Hourly Employee
Accident Investigations (Mining)
Accident Investigations (Chemical)***

PLANT BACKGROUND INFORMATION

---PROFILE---

- ▶ Accident Incident Rate
- ▶ Lost Time Accidents
- ▶ Union/Non-Union
- ▶ Downsizing? If so, how much & what department?
How much overtime per department?
How many hours?
Is overtime mandatory?
- ▶ Recordkeeping compare lost time records with state compensation records.
- ▶ How much contracting of work, normally performed by Terra employees?
- ▶ Number of excursions reported in last 10 years?
How many inspections by State OSHA EPA, etc. in last 10 years?
How many citations?
What were they?
- ▶ Routine Maintenance (RM) program in place at the time of the December 13, 1994 explosion in the Ammonium Nitrate Plant?
- ▶ Request a copy of the Chemical Safety Audit (CSA) recommendations, performed February 1994.
What good faith changes were made by Terra after the Audit?

Ammonium Nitrate sensitization information on page 18 of report - PH, concentration, tempature, contamination, low density areas are conditions that can sensitize and increase hazards.
How much of this information did Terra have?
How much was available to them but did not have available to the operators and/or maintenance department?
- ▶ The Acid Plant was shut down Dec. 12 at 0430 hours on emergency basis. What was the nature of the emergency?
- ▶ Request copy, if available, of the inspection report on the Neutralizer and Nitric Acid sparger (Sept. 1994).

OPERATIONAL

---MAINTENANCE---

- ▶ Procedures, Parts, Inventory, Upkeep Mechanical
- ▶ On November 27, 1994, Operations and Maintenance personnel determined the PH probe located in the neutralizer rundown line was defective. There were no spare probes available: the defective probe was in service until the time of the explosion.
- ▶ **Procedures**
 - AN Neutralizer shut down changed without monitoring what was going on in the vessel.
 - No circulation of a AN vessel during shut down.
 - The DCS was down - no parts available.
 - No written SOP on AN Neutralizer while shut down.
 - No written SOP on checking AN Neutralizer thickness.
 - Corrosion coil during turnaround.
 - Steam coils in the Neutralizer jacket had corroded and could not be used for several years.
- ▶ **Parts**
 - What procedure on spare parts was in effect at the time of the explosion?

**should involve metalegists inspection.*

HUMAN

- ▶ Blowing Nitric Acid line into neutralizer with plant air was not in SOP provided by Terra.
- ▶ No specific procedure for connecting steam to sparger.
- ▶ No check or block valve attached to the Nitric Acid sparger where they exit the vessel as per required by Mississippi Chemical. A Barometric loop that allowed back flow into the spargers and into the Nitric Acid line back into the barometric loop.
- ▶ Terra employees stated that the addition of steam was a normal procedure to prevent back flow into Neutralizer Nitric Acid sparger and to keep the sparger from salting out. Thus, adding heat to Neutralizer.

PLANT AIR

- ▶ The plant air was applied to the Nitric Acid line to purge the line to prevent freezing. The Nitric Acid was discharged from the line to the AN Neutralizer. The plant air purged the line from 1500 hrs. until 2030 hrs. 5 ½ hrs. (If my military time is correct) Air and steam was the last two materials induced into the AN Neutralizer before the explosion.
- ▶ On page 37: Terra had experienced problems with Hydrocarbons in the plant air. The Question is: Did the EPA team request piping diagram of the plant air system and if they received a diagram, were all the precautions necessary to prevent Hydrocarbons from entering the plant air systems?
- ▶ Blowing the Nitric Acid line from the acid unit was not in the SOP. Why? What was the problem using plant air?

Initial Comments on the USEPA Chemical Accident Investigation Report:
Nitrogen Fertilizer Facility
Terra industries Inc.
Port Neal, Iowa

PAUL L. HILL, Ph.D.
Review Panel Chairman

In undertaking this review I have referenced the "Charge to Reviewers" provided by the contracting agency, USEPA. Based upon the USEPA Region VII report released January 23, 1996 concerning the accident on December 13, 1994, the agency has requested comment on various aspects of their performance as well as content of the report itself. These include the approach taken; plausibility of scenarios; technical, human and management considerations related to conclusions; roles of associated agencies and interest groups and overall recommendations toward a model approach for future investigations.

As the designated Chairman of the Review Panel, I am charged with conducting a preliminary review to determine appropriate expertise and diversity of interests for potential reviewers; provide USEPA with an ample list of potential reviewers; organize the review by collecting preliminary comments and distributing them among the panelists selected by USEPA; calling a meeting of the panelists to discuss their reviews of the report; chair said meeting and prepare a written summary of reviewers comments and recommendations. As a prelude to actual discussions with others my own personal comments are provided.

Although not charged with reviewing any materials outside the document (written report) itself, associated materials including Terra Industries' report dated July 17, 1995, Iowa Division of Labor, Occupational Safety and Health Bureau Inspection No. 115072555 dated May 25, 1995 and USEPA's supplemental copies of "Drawings and Graphs" were in my possession for reference and personal review. Because these documents report on the same circumstances (the accident) their availability is considered appropriate and valuable. Upon this submission no other documents, evidence or expartate communications have been considered.

THE CHARGE OF REVIEW

EPA has asked each reviewer, within the limited scope and resources provided, to answer ten associated questions which roughly correspond to those outlined in paragraph 2 above. In issuing the charge, EPA has stated that "the response seeks to ascertain the root cause of this accident, in order to further the goal of preventing accidents. Your review should include the following aspects of this concern."

1. Comment on the approach taken scenario by scenario. ...

This was valuable to the reviewer in ensuring that all plausible avenues of theoretical causality had been pursued. It was also presented from a physical evidence point of view which helped the reviewer understand the support for, or lack thereof, of evidence for each potential cause for the actual explosion. This approach should be replicated in future investigations. If coordinated protocols for joint accident investigations are achieved, the scenario by scenario approach may be the basis for closer agreement between vested parties.

2. Comment on the findings of the report and on the identification of the most plausible scenario.

Findings seem valid. The most plausible scenario is simply the causal theory which generated the most supportive evidence. In fact much of the chemical, physical and spatial evidence collected by other assessments supports that of the EPA's most plausible scenarios. While there are no unequivocal answers to lingering questions about contamination sources, titanium ions, chlorides, etc. as discussed by the less plausible scenarios, the conclusions reached by the report are reasonable.

3. Comment on the comprehensiveness and reasonableness of the statements about technical conditions under which the accident occurred.

This position of the report is supported by known AN chemistry principles, historical production and laboratory tests. All parties who expressed views on the technical conditions in the neutralizer, rundown tank, etc. are closely aligned with few exceptions. The report does a good job at putting this information forward in the discussion but takes the added approach of "scenario building" through which the reviewer can actually pursue technical conditions in light of physical evidence.

4. Are specific roles of certain equipment, notably the sparger, appropriately considered?

A degree of uncertainty exists here. The report dismissed most of the theories about the sparger and titanium ions rather readily as compared to the contentions of likely cause presented by other parties. Further pursuit by the review team is needed to properly address the basis for this disparity. Due to the limited scope of this review, it is also recommended that EPA continue research and discussions with technically competent and affected parties to resolve discrepancies in either

theory or evidence.

5. Is the discussion of AN solution appropriate?

Generally, yes. Introductory, theoretical, chemical, technical and operational background on AN solution properties, management and handling were appropriate for the discussion: Suggest this kind of literature search for state-of-the-science become a standard fixture for well prepared, comprehensive reports. (Up through section 6). Continued monitoring of AN production and research literature is properly noted but perhaps should be more emphasized or gathered and circulated by the fertilizer industry, associated agencies, other?

6. Were all external factors considered in a comprehensive way? And, were human and management factors identified in such a way as to lead to reasonable conclusions and recommendations?

The report does not provide a surplus of details about the investigation team's interaction with management or the depositions of hourly employees. Obvious however, is the lack of, or inability to produce, procedures, instructions and training logs or PID's for the proper understanding of the operation and therefore the ability to operate it safely. When coupled with the physical and chemical evidence, human factors, as presented, lead one to the conclusions and recommendations as presented in sections 9 & 10 of the report.

7. Comment on the overall conclusions and recommendations. What of the overall approach could be modeled for future investigations?

Readability and sequence of information lay-out are generally good. However, information on page 33, 34 could be developed into standard time-line information to gain graphic illustration of events. For plausibility and causality, the scenario by scenario approach is very good. This provides the reviewer with the investigation team's "thinking" and second guesses as they attempted to reconstruct conditions of the accident. Successfully eliminating scenarios based on the evidence ensures the reviewer that other theories of causality were investigated. However, not all potential scenarios were presented. See Additional Questions & Comments.

8. Was information for the prevention of similar accidents appropriately presented in this report?

Although presented clearly within the report itself, it is unclear how EPA or other agencies may convey, in an ongoing fashion, results and recommendations of this nature. Industry-wide advisories, special notices to the fertilizer industry, etc. should be considered. Special bulletins and advisories similar to those of NTSB should be issued in the interests of all facilities, workers and potentially affected parties. Currently, within the report, it is unclear that such parties will receive

this information

9. Comment on whether the roles of other entities were appropriately addressed

It is difficult to determine how the needs, if any, of other entities have been addressed by this report since there was no coordinated effort which involved all the parties in the actual investigation. Iowa has a designated "State OSHA" authorization from the federal agency therefore making this particular investigation even more disjunct than might have otherwise been possible. If coordinated investigations and joint reports are to be achieved as envisioned by the CAAA of 1990, then a broad protocol, clearly defining roles of all interested entities must be developed and codified.

10. Are there any recommendations for actions that could have been taken or should in the future take to reduce accident risks?

The agencies, both EPA and OSHA as well as state program officials should follow-up with AN producers regarding the extensive recommendations provided by this report. The agencies should also continue to monitor from an R&D perspective, the use of titanium materials as presented by the Terra review. Both reports strongly agree that proper procedures, training and monitoring must be continuously in place for proper prevention to occur

ADDITIONAL QUESTIONS & COMMENTS

- Did EPA compile any emergency response documentation of this case and integrate it with the findings for consumption by all parties, particularly lay public?
While this in an accident investigation report it provides an opportunity for other EPA sponsored initiatives.
Is this, or will it be, addressed elsewhere?
- Is there ongoing review or reconsideration of the metallurgists' findings?
Much of the evidence for direction, impact of physical damage, etc. rests on this report
Is EPA reviewing?
- Was sampling adequate given the suggestion by Terra that small isolated areas may have initiated deflagration?
Chlorides and "low density areas" were noted as potentially plausible factors on page 36 and 38 of the report but were later dismissed as the initiating factor.
Could this be due to lack of samples from various sites?
How much collective data was reviewed by the investigative team to reach this decision?
- What about additional evidence (e.g.pump) which was never recovered?
Might there be other significant evidence which supports other theories? (e.g. the initiation occurred in the sparger).
Was the entire sparger (all pieces) recovered so as to completely eliminate the concept of "isolated site initiation"?
- Sabotage. This was not dealt with. Why?
If, via the depositions of parties, this (theory) was successfully eliminated then it should be stated in the report.

EPILOGUE

First, accident investigations and the attempt to reconstruct the conditions which led to accidents are inherently difficult to pursue. The report indicates in its introduction that certain evidence, diagrams and requested documents were either destroyed or unavailable for this investigation report. Even with satisfactory provisions of existing management, operations and training materials, reliance upon human knowledge and recollections as well as potential nondisclosure makes the job of reconstruction all the more difficult.

Although not only pertinent to this review, the investigating agency needs to clearly define its investigative approach to future investigations from a purely professional/scientific view. If called into question (most contentious reports are likely to be litigated) the agency (s) needs to simply describe their command of the existing literature on investigative techniques and which of these they either chose to use, modify for use or discard as inappropriate, given the particular investigation. Many such technical approaches also have the added advantage of providing the reader or reviewer with a graphic representation of the approach (e.g. fault tree), as well as the technique or combinations of techniques used to approach the investigation process. CCPS's "Guidelines for Investigating Chemical Process Incidents" copyright 1992 provides at least one good example of various inductive, deductive, morphological and non-systems techniques for accident investigation.

While I have responded to the agency's needs to the best of my abilities, at this time, I reserve the right to respond further after seeking the advice and considerable expertise of my colleagues. Therefore these comments are subject to modification after the discussions in Kansas City.

**APPENDIX
III**

**Addendum to Review of EPA
Chemical Investigation Report
Terra Industries, Inc.**

By
Pamela Nixon

This addendum is to fulfill my charge as reviewer.

1. *Comment on the approach taken (scenario by scenario) as a correct approach to take.*
The scenarios regarding plausible cause(s) of the explosions appear to be well thought out. However, I can not comment as to whether any significant scenarios were missed.

NOTE: On page 1 of my original report, please disregard the first bullet that began as follows: "Petroleum spill in the ammonia plant..." - the EPA investigation had eliminated it as being a possible contributing factor.

2. *With no prior history of accidental detonation of AN solution, is the discussion of the conditions existing before the accident appropriate?*
This reviewer believes that the discussion of the conditions was necessary to give the reviewers a description of the process operations leading up to the explosions.
3. *Please comment on the conclusions reached and whether they lead to the root causes identified.*
This reviewer believes that one or all of the conditions that existed in the neutralizer just prior to the explosions could have caused the event of December 13, 1994.
 - The strongly acid conditions in the neutralizer
 - The application of 200 psig steam to the nitric acid spargers and the superheat that possibly reached the neutralizer
 - The application of compressed air which created low density zones in the AN solution
 - Lack of flow in the neutralizer and from the neutralizer into the rundown tank which isolated critical sensors
 - Chlorides contamination in the nitric acid and ammonium nitrate
 - Lack of monitoring of the AN plant when in shut down

In this reviewer's opinion, the primary cause of the > 2 explosions was the lack of a process safety management system which should have included safe operating procedures, a hazard communication program, and process hazard analyses of the different units/plants within the facility.

If a safety management system had been in place, the employees would have known how to safely shut-down and start-up the process. The employees also would have known the risks and potential consequences involved in performing improper procedures. The PHA would have identified critical areas in the process that needed modifications to minimize or manage the type of incident that occurred at Terra.

4. *Were all external factors considered in comprehensive way?*
This reviewer has no way of measuring whether all external factors were considered. This question is outside my field of expertise.

5. *What of the over all approach could have been modelled for future such investigations?*

The over all approach which could be modelled for future investigations should include the following:

- Diagrams and photos (especially aerial photos) of the facility before the event, and immediately after the incident to show the direction and magnitude of the event.
- Development of scenarios using historical data and the evidence found following the explosions
- The use of experts, such as metallurgists, and other professionals knowledgeable of the particular process.

This reviewer recommends the inclusion of all of the stake-holders at the beginning of the investigational process. The team should include the necessary federal, state, and local agencies; the first responders; and members of industry (i.e., management, safety engineers, and on-line workers - unionists if the plant is unionized)

The agency in charge should let the team know (from the start) who the coordinator is, what the objectives are, and what the role is for each of the members. This will give the group focus and allow them work together more efficiently.

**Addendum to Report of Geraldine V. Cox on Terra Report.
Dated August 5, 1996**

After further discussions with chemists familiar with Ammonium Nitrate and the meeting of the reviewers in Kansas City last week, I would like this addendum to be attached to my initial report.

1. Sensitizer(s). Clearly something or multiple chemical compounds acted to sensitize the reaction. EPA believes that the chloride ion may be the sensitizer. After review of the limited chemical data presented in the Terra report two other, equally plausible materials could have acted as sensitizers, either alone or in combination with each other or with chloride. These additional sensitizers are chromium and iron (ferrous and ferric complex). Both could have been formed from the metal in the neutralizer tank, especially after the prolonged contact with very low pH, e.g., 0.8. The metallurgist's report indicated pitting on the walls of the stainless steel tank. This pitting is an additional indication that solution of the stainless steel reaction vessel probably occurred. The values of the chromium and iron in the AN storage tank indicated the presence of all three elements. I doubt that the sensitizer will ever be defined at this point, but three candidates were present in the finished product, so any of these could have contributed. The limited data do not seem to have sufficient concentrations of oil to make that a likely contributor to the sensitizing process.
2. After reviewing the original photographs of the site before and after the event, the probable chain of events is even more compelling. The EPA report seems to provide the most plausible sequence of events, i.e., that the reaction began in the middle of the neutralizer and then the run down tank had a secondary explosion.
3. The actual incident may never be fully defined. However, the conditions were present - namely heat, sensitizers, low pH, and bubbles that all contributed to the event. The absence of written procedures for shut down and the warnings for unsafe operating conditions, i.e., documented procedures and training for the workers clearly allowed the development of these critical conditions for the event.
4. More chemical analysis of the residues in the tank and at the site would have been helpful to understand the chemistry, but, since the State Fire Marshall hosed the site with water, I am not sure how useful samples would have been after that contamination from the fire hose.
5. While we were not asked to review the report prepared by Terra, the chemical analysis were of some use. The table was not identified as well as it might have been. for example, the sources of the two water analyses. In particular, the sodium value for the water did not match for the two water samples in the Terra Table. (Also, there was no indication of replicates, deviations of the values for replicates, and the instrumentation and methods used for the analyses.) This high sodium value might be an indication of high chloride concentration, although a chloride analysis was not provided for the water. The variation for chromium and iron are interesting for the various sources and do indicate a higher level than I would have expected for such a process.
6. Clearly the first responsibility when responding to a chemical accident, such as this, will be to stabilize the site to mitigate harm to the plant, community and environment. Yet, at the same time, one must begin to approach such events from a forensic perspective. If such an event were sabotage, which I do not believe this incident was, one would want to protect the site until a criminal investigation could be conducted. Therefore, I think that EPA needs to consider how to secure the site for such an investigation during and immediately following the incident. This is easy to say, but more difficult to do - especially with various jurisdictions all having some authority at the site from the plant personnel to the multiplicity of local state and federal agencies with a legitimate role at the site. Perhaps discussions with the National Transportation and Safety Board might be useful to determine how they would handle such a situation. Do they have prearranged agreements and procedures that might be used?
7. In future incidents, a review of the reported accidents and injuries and a comparison with worker compensation claims would be a good indication of the ongoing safety record at any plant under review. This might be made a normal part of the incident report.
8. EPA needs a better definition of its role relative to state OSHAs. This might require legislative change since state primacy is a legislative initiative. In serious chemical accidents where the

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surrounding community could be endangered, the normal state or federal OSHA review might not be adequate.

9. Several typographical errors appear in the original report. The most significant is on page 2, in the last paragraph on the page, 4th line. The word "absent" should be replaced by the word "present."
Other corrections are: Same paragraph on page 2: second line Since the pH sensors was; page 5, 1st full paragraph, third line first word, system?; same page, item 7, 7th line of response, should read: "period, although, . . ."; page 6, 1st paragraph of response, 4th line ". . . report of the depth of the one prepared by EPA."

Submitted 7th August 1996,

A handwritten signature in cursive script, reading "Geraldine V. Cox".

Geraldine V. Cox, Ph.D.

EPA Response to Expert Review Recommendations

**EPA Response to Expert Review of
EPA Investigative Report on Terra**

RECOMMENDATION: EPA should include time lines in future reports.

REPLY: EPA agrees that this element would enhance future reports and is explicitly including it in the EPA/OSHA joint protocol on investigations, now being prepared.

RECOMMENDATION: EPA should expand and continue to model the scenario-by-scenario approach.

REPLY: EPA has included this as well in the proposed protocol. We would expect that the approach will become more and more refined as the program matures. This is a valuable tool for those investigations when this approach is appropriate. Reports should include a full discussion of scenarios discarded as well as considered.

RECOMMENDATION: EPA should adopt or specify rigorous technical procedures sanctioned by the engineering and research communities.

REPLY: EPA is aware of the available established methodologies for accident investigation. Its investigators will receive training on several of these procedures. The EPA investigation team will choose one or more of these procedures for a given investigation and will describe the investigative methodology in its report.

RECOMMENDATION: EPA should develop a refined protocol for accident investigations.

REPLY: EPA agrees that such a protocol is necessary and has been developing a joint protocol with OSHA during the past year. This protocol defines the purpose and goal of investigations; spells out cooperation among EPA, OSHA, local investigators, and local stakeholders; includes discussion of technical approaches and procedures for conducting various elements of investigations; addresses protection of confidential business information; and addresses production of the accident report and alerts which may stem from information gathered during the investigation. This will be a public document which will inform all of the investigative program.

RECOMMENDATION: EPA should hold public meetings to seek stakeholders' input on the protocol.

REPLY: EPA plans to share the proposed protocol with stakeholders who will be potentially affected by investigations conducted according to its directives. To obtain these comments, we will make the draft protocol available through electronic and other means and will consider actions such as holding a public meeting as recommended. We expect that the protocol will be revised periodically as needed.

RECOMMENDATIONS: EPA should consider accident oversight committees at affected sites which include public liaisons.

REPLY: EPA agrees that vehicles should be available for public input into and communication with the review team. Existing elements such as Local Emergency Planning

Committees could serve this function.

RECOMMENDATION: EPA should initiate agreements with other federal, state, and local entities with accident response authorities or consider legislative recommendations to accomplish same.

REPLY: We agree such agreements are essential. EPA and OSHA have been developing a Memorandum of Understanding to set forth terms of cooperation and coordination between the agencies, to ensure the most effective investigations and to avoid duplication of effort. EPA has initiated efforts to establish agreements with State OSHAs. We are investigating means to coordinate with other entities such as State Emergency Response Commissions (SERCs) and State Fire Marshals.

RECOMMENDATION: EPA should create increased public and private awareness of its investigative program.

REPLY: EPA has already presented its accident investigation program at numerous national public conferences and state workshops during the last year. We are developing an outreach program to share results of investigations to all stakeholders and to alert them to particular hazards identified in the course of investigations. This activity will assist in making the program known and can be the occasion for working with particular industries or trade associations about specific hazards defined after an accident. We are preparing such an alert for ammonium nitrate facilities, which will be of use not only to the affected industry but also to communities having such facilities nearby. We can build on our existing work with professional societies like the American Institute of Chemical Engineers (AIChE) Center for Chemical Process Safety (CCPS) and others, as well as trade associations, with whom we have worked on aspects of the chemical accident provisions of the Clean Air Act Amendments. We have begun developing fact sheets and will continue to explore other vehicles and opportunities for outreach.

RECOMMENDATION: EPA should clearly articulate the national goals and criteria for accident investigation.

REPLY: We agree that this is important to the integrity and acceptance of our investigations. We will include this element explicitly in the outreach activities noted above, as well as in our agreements with federal, state and local entities with whom we will work in particular investigations. As noted above, our protocol for investigations can serve this purpose as well, as it will include discussion of goals and objectives of investigations; an explanation of EPA and OSHA authorities; and procedural steps for the conduct of investigations. The document will be available to the public and to all stakeholders.

RECOMMENDATION: EPA should draw upon the existing experience of NTSB and other agencies for assistance in the evolving program.

REPLY: We are drawing upon the experiences of the National Transportation Safety Board (NTSB), the Bureau of Alcohol, Tobacco and Fire Arms (BATF), OSHA, and the National Institute of Standards and Technology (NIST) in accident investigation in developing draft protocols and training for our investigators. We will continue to work

closely with these agencies and others. We also can access expertise from the National Response Team, a coordinating body of 15 federal agencies having responsibilities for various aspects of dealing with hazardous materials. It should be noted that we are working with these agencies and others to assemble ways to obtain expert assistance for very specific expertise which may be needed in the course of a particular accident investigation.

Additional notes and recommendations:

The expert reviewers of EPA's report, in addition to articulating the above recommendations for EPA in their summary, commented on a number of specific issues concerning the Terra Industries investigation and included additional recommendations in the text of their report:

ROLE OF THE SPARGER:

One issue is the particular role of the sparger in the accident at Terra Industries. To date, EPA has not received any additional evidence or scientific data that would lead to altering any findings, conclusions, or recommendations in the final report.

IDENTIFICATION OF ROOT CAUSES: Another issue raised by the reviewers was that EPA should provide more attention to the relationships between root causes and conclusions in the report. That is, the conclusions themselves were less explanatory of root cause than was the body of the discussion of the report. EPA acknowledges that some root causes should have been better explained in the conclusion section of the report. In future accident investigation reports, EPA will provide better identification and summary of root causes of the accident as well as correlating the root causes with the recommendations. In addition, EPA provided in the Terra report general recommendations to the ammonia fertilizer industry as a whole to prevent conditions such as those existing at Terra from recurring.

NATIONAL NETWORK OF INVESTIGATIVE CAPABILITIES:

The reviewers noted that EPA should consider a national network of investigative capabilities and expertise as its accident investigation program matures, and should include in the network integrating the use of personnel or contract services with particular expertise and should also include the expertise of OSHA, states, etc. The joint EPA/OSHA investigation protocol now being prepared notes that EPA has a contract in place to provide technical assistance for accident investigations. This contract also allows EPA to access, as needed, experts in various technical fields to assist in information gathering and analysis. In addition, EPA is developing a list of available EPA regional staff and contactors with their expertise whom EPA could rely upon for assistance in investigations. As noted above in a reply to a related recommendation, EPA can also utilize capabilities of other federal agencies, for example the testing and analysis laboratories of NTSB, NIST, and EPA. EPA and OSHA will also solicit the expertise of other Federal agencies, for example, BATF, NTSB, DOD, and DOE.

APPENDIX A

CHARGE TO REVIEWERS
For the EPA Chemical Accident Report,
TERRA INDUSTRIES, INC. NITROGEN FERTILIZER FACILITY

EPA Region VII (Kansas City, KS) prepared the above report, released January 23, 1996, concerning an accident on December 13, 1994 occurring at Terra Industries, Inc. The report is 108 pages long, and includes an executive summary, an overview of the investigation, discussion of plant operations and events at the facility, conditions and facts derived by the investigators, scenarios for the explosion, conclusions and recommendations. The principal investigators were Mark Thomas of EPA; Alan Cummings of Dynamac Corporation, an EPA contractor; and Mariano Gomez, an EPA contractor with its Technical Assistance Team.

As a reviewer of this document, you should use your technical knowledge and professional judgment to comment on the technical soundness, overall approach, and completeness of the report, to derive recommendations for approaches to accident investigations in the future and accident prevention.

The report seeks to ascertain the root cause of this accident, in order to further the goal of preventing accidents. Your review should include the following aspects of this concern.

Comment on the approach taken (scenario by scenario) as a correct approach to take. Comment on the findings of the report examining various explosion scenarios, and on the identification of the most plausible scenario. Were any significant scenarios missed? Comment on the comprehensiveness and reasonableness of the statements about technical conditions under which the accident occurred. Are specific roles of certain equipment, notably the sparger, appropriately considered?

With no prior history of accidental detonating of AN solution, is the discussion of the conditions existing before the accident appropriate? Please comment on the conclusions reached and whether they lead to the root causes identified.

Were all external factors considered in a comprehensive way? Also, please comment on whether human factors and broad management issues were identified appropriately, in appropriate sequences, in ways to lead to reasonable conclusions and recommendations.

Please comment on the conclusions and recommendations. What of the overall approach could be modelled for future such investigations? Was information for prevention of similar accidents appropriately presented in this report? Concerning the role of federal, state local agencies; the public; labor; trade associations; and public interest groups: please comment on whether roles of these entities were appropriately addressed. Are there any recommendations for actions they could have taken, or should in future take to reduce accident risks?