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EXPERT REVIEW OF EPA/OSHA JOINT CHEMICAL ACCIDENT INVESTIGATION REPORT

Napp Technologies, Inc.
Lodi, New Jersey

EXPERT REVIEW

CONTENTS

INTRODUCTION

Under a Memorandum of Understanding (MOU), EPA and OSHA have worked together to investigate certain chemical accidents. The fundamental objective of this joint effort is to determine and report to the public the facts, conditions, circumstances, and causes or probable causes of any chemical accident that results in a fatality, serious injury, substantial property damage, or serious off-site impacts, including large scale evacuation of the general public. The ultimate goal is to determine the root causes in order to reduce the likelihood of recurrence, minimize the consequences associated with accidental releases, and to make chemical production, processing, handling and storage safer. (Section 112 (r) (6) of the Clean Air Act Amendments of 1990 established an independent Chemical Safety and Hazard Investigation Board to investigate and determine the cause or causes of chemical accidents and recommend steps to prevent similar incidents. At the time of the Napp accident, the Board had not been formed. The Chemical Safety Board is now in operation and conducting accident investigations.)

On April 21, 1995, an explosion and fire took place at the Napp Technologies (Napp) facility in Lodi, New Jersey, resulting in deaths, injuries, public evacuations, and serious damage both on and off site. The accident occurred when Napp employees were attempting to blend sodium hydrosulfite, aluminum powder, potassium carbonate and benzaldehyde, in order to make a gold precipitating agent. Napp was performing the blending operation under a contractual (or toll) arrangement with the owner of the gold precipitating agent, Technic, Inc (Technic) of Cranston, Rhode Island.

EPA and OSHA formed a joint chemical accident investigation team (JCAIT) which undertook an investigation of this accident because of the serious consequences and characteristics of the substances involved. In October of 1997, the JCAIT published the **EPA/OSHA Joint Chemical Accident Investigation Report: Napp Technologies, Inc., Lodi, New Jersey (EPA 550-R-97-002).** In the report, the JCAIT noted six findings as root causes and contributing factors of the event. The JCAIT also developed six recommendations that address the root causes and contributing factors to prevent a reoccurrence or similar event at other facilities. For copies of the report, contact www.epa.gov/ceppo/ or call 1-800-490-9198.

This **Expert Review** of the investigative report presents the comments and recommendations of five expert reviewers with whom EPA contracted to provide an independent examination of the EPA/OSHA Joint Chemical Accident Investigation Report. Included are EPA's and OSHA's responses to their comments and recommendations.

We asked Timothy Gablehouse, chair of the Jefferson County Local Emergency Planning Committee and member of the Colorado State Emergency Response Commission, to chair the review and to suggest other reviewers who could, like himself, render independent opinion about the EPA/OSHA report. Upon his recommendations and our own examination, we selected the

four other reviewers: Dr. Wade Freeman of the University of Illinois, Dr. Geraldine Cox of Ampotech Corporation, Michael Sprinker of the International Chemical Workers Union Council, and Jerry Scannell of the National Safety Council. All five reviewers then independently commented upon the report in writing, and the Chair circulated all comments to all reviewers. EPA and OSHA investigators then briefed all reviewers in Washington on September 14, 1998 and answered questions about the conduct of the investigation. The reviewers then met alone to discuss their comments. The Chair wrote a summary of the meeting and recommendations, which were then forwarded to EPA. EPA and OSHA, in this Expert Review document, are publishing the Chair's report, all reviewers' initial and final comments, and EPA/OSHA's response.

EXECUTIVE SUMMARY

This report contains the complete analyses of all five external expert reviewers of the joint EPA/OSHA investigative report of the Napp Technologies. Also included are EPA and OSHA's response to their major recommendations and comments.

EPA and OSHA have determined that the comments of the reviewers did not change the determination of root causes and contributing factors (which were the focus of the investigation). Therefore, there is no need to materially change the Napp investigation report. However, the agencies will utilize the comments and recommendations in upcoming accident reports as well as in Alerts and other products that stem from this investigation.

The following is a summary of the general comments and recommendations of the panel and a summary of EPA's and OSHA's responses to these comments.

Major reviewer comments and recommendations (from the Chair's summary):

- The report appeared to correctly state the root causes of the accident both in terms of technical mechanisms and technical failures.

- EPA and OSHA are encouraged to consider detailed recommendations on the special risks associated with tolling operations and the handling of water reactive chemicals, and consider rulemaking by either EPA or OSHA.

- Several elements which could have enhanced the report's usefulness:
  --discussion of the types of chemical analyses done,
  --discussion of the rationale used to eliminate plausible scenarios,
  --clearer depiction of difficulties presented by the extent of destruction, which made certain analyses impossible and information difficult to obtain,
  --better tracking of individuals involved through the chronology of the accident,
  --time line of events.

- The pre-release review which EPA and OSHA allowed Napp, but not the other stakeholders, should have been shared by all stakeholders, and the report should have been peer-reviewed.

EPA/OSHA response:

- In the report, we cite specific management deficiencies (i.e. lack of training, inadequate process hazard analysis, inadequate SOPs) as the root causes and contributing factors of the incident. We agree with those reviewers who noted that we could have made more explicit fundamental management system failure as a root cause, with the various specific management system failures as subparts.

- The statutes (Occupational Safety and Health Act and the Clean Air Act Amendments) that provide the authorities for the agencies' accident prevention programs make the owner or operator of the stationary source (or the employer) who is handling the hazardous chemicals solely responsible for compliance with safety regulations at the facility. Hence, owners or operators of tolling operations, provided they fall under the regulations promulgated under these statutes, are already regulated, and for this reason, the agencies do not agree that further regulations specific to the tolling industry are necessary. However, the Agencies agree that more can be done to increase the safety of performing tolling operations and handling water reactive chemicals. Each agency is considering the addition of chemicals that were involved in this incident to the list of chemicals that are subject to each agency's accident prevention program. Specifically, OSHA has announced an upcoming Advanced Notice of Proposed Rulemaking (ANPRM) that will discuss the regulation of reactive chemicals under the Process Safety Management Standard. EPA is also in the process of reviewing its list of regulated substances promulgated in the Risk Management Program regulations under the Clean Air Act Amendments, section 112(r). In addition, the agencies are taking more immediate steps to address the risks of tolling operations by a combination of actions: first, working with the American Institute of Chemical Engineers' (AIChE) Center for Chemical Process Safety to develop guidance for the chemical industry; this would include identification of risks and procedures recommended for better safety in tolling operations. EPA is also developing an Alert directed to local responders regarding information resources during emergency responses, and OSHA has issued a Hazard Information Bulletin describing the potential hazards of utilizing MSDSs as the primary sources of information for conducting hazard analyses for chemical process activities. Finally, EPA has worked with the National Oceanic and Atmospheric Administration to develop and promote the use of a database on reactive substances.

- The suggested additions to the report would have enhanced its clarity, although some of the suggestions would have been impossible to include given the level of physical destruction at the Napp facility.

- The factual information that formed the basis of the EPA/OSHA investigation report was obtained through the authority of Section 8 of the Occupational Safety and Health Act [P.L. 91-596]. OSHA regulations at 29 CFR part 70, implementing Executive Order 12600, require OSHA to show the factual part of a report--not its recommendations and conclusions-- to the facility before publication, to allow for their identification of trade secrets. Sharing this with other parties (i.e. an external expert review panel) prior to the facility's review would not have allowed protection of trade secrets.

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EXPERT REVIEW

EXPERT PEER REVIEW
OF EPA/OSHA JOINT CHEMICAL ACCIDENT INVESTIGATION REPORT
"NAPP TECHNOLOGIES, INC., LODI, NEW JERSEY

BACKGROUND AND STATEMENT OF PURPOSE

An explosion and fire took place at the Napp Technologies facility at Lodi, New Jersey, on April 21, 1995, resulting in deaths, injuries, public evacuations, and serious damage both on and off site. The accident involved a commercial chemical mixture, a gold precipitating agent, identified as ACR 9031 GPA, owned by Technic Inc. of Cranston, Rhode Island and comprised of sodium hydrosulfite, aluminum powder, potassium carbonate and benzaldehyde (GPA). At the time of the accident at the Napp facility, Napp was performing a toll blending operation for Technic.

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), as a component of EPA's chemical safety programs and in conjunction with OSHA's enforcement investigation. The report was released to the public in October 1997 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 Headquarters and Region II office and at OSHA Headquarters and the Area Office.

As part of its investigative program, EPA arranged for this review by a panel of experts. The purpose of the review is for each of the reviewers to comment on the scope, approach and conclusions of the report and its implications from their individual perspectives and disciplines.

PROCESS OF THE REVIEW

EPA contracted with Timothy R. Gablehouse to Chair the expert review panel. Mr. Gablehouse then selected, Drs. Geraldine Cox and Wade Freeman, Mr. Jerry Scannell and Mr. Michael Sprinker to form the rest of the review panel.

It is important to note that it was not the function of the panel to reach a consensus point of view on any of the following issues. Instead, each member of the panel prepared independent evaluations based upon their experience, the materials provided by EPA and OSHA, impressions gained during a group meeting, and the text of the report. The members of the panel did not perform any independent investigation of facts specific to the Napp Technologies accident.

As an initial effort each member of the panel was asked to prepare their initial thoughts based only upon a review of the report. These initial thoughts were shared among the panel members and agency representatives planning to participate in a group meeting. This sharing of initial thoughts allowed the panel members to consider additional issues and to help prepare the agency participants for the group discussion.

The panel members met with the principle investigators from OSHA and EPA and other senior level agency representatives on September 14, 1998 at EPA Headquarters in Washington, DC. At this meeting the panel members viewed a video tape prepared by the agencies intended to depict the chain of events leading to the accident as well as participating in a detailed discussion of the findings of the report. Agency participants were well prepared and extremely cooperative in sharing their thoughts and observations with the panel members. The panel members held a private discussion during the afternoon to exchange ideas, concerns and comments.

Following the group meeting each panel member prepared their individual comments in written form. These comments follow this introductory material and form an integral part of the report of this panel.

In its charge to reviewers, EPA asked that the following questions be considered:

Comment on the report's organization. In general, was there a logical progression in the chain of reasoning - were conclusions adequately supported by the facts?

Was the focus on identifying potential sources of heat and water appropriate? Were the sources of reaction initiation which were identified plausible? Were all possible sources of the reactions identified?

Was the discussion of root cause adequate? Were root causes and contributing factors appropriately and correctly identified?

Are recommendations appropriate and drawn logically from the preceding discussion and conclusions? Are recommendations sufficient to address the potential of a recurrence of this kind of accident in other facilities? How will other facilities be able to apply the findings and recommendations of this report to their particular circumstances?

Were the appendices sufficient and appropriate? Were the photos appropriate to illustrate the narrative, clear, and properly presented?

Were all external factors considered? Were human factors and management issues considered appropriately?

What aspects of this report could help inform future investigations? Was the approach sufficiently broad for application to other industry sectors? Were roles of all stakeholders properly addressed in the report, including roles of federal, state and local agencies, the community, labor and any others? Are recommendations sufficiently broad to include all elements in addressing prevention of like accidents in the future?

CHAIR'S SUMMARY OF COMMENTS AND RECOMMENDATIONS

With the caveat that the other members of the panel have discussed many of these issues in greater depth in the following materials, the Chair believes that it is reasonable to state the following summary observations and conclusions:

The investigation was complicated by the catastrophic level of destruction of the facility and records, the death of many of the people with direct knowledge of events immediately prior to the accident, and the fact that this was the initial cooperative investigation between EPA and OSHA under a formal MOU. The investigators are to be commended for performing a thorough and useful analysis given these hardships.

The report appears to correctly state the root causes of the accident both in terms of technical mechanisms and management failures. Later discovered information discussed during the group meeting support the findings of the report.

In addition to the root causes identified in the report, it appears that there were additional problems with communications and relationships between the local emergency response agencies and Napp. While it cannot be known with certainty, it appears that these problems may have caused Napp personnel to respond in a less-than-adequate fashion as the emergency developed.

The usefulness of the report to other companies and later investigators could have been enhanced by a more detailed discussion of the types and results of the chemical analyses performed during the emergency response to the incident, and by a more detailed discussion of the rationale used to eliminate plausible scenarios. It would also have been useful to note the difficulties presented by the level of destruction and death by more clearly describing where information may have existed but was destroyed and where information is third-hand or even more remote because of the death of persons with direct knowledge. Certainly the investigators might have wanted to perform more analysis or interviewed more people, but the conditions made this simply impossible.

It was difficult to track the various individuals through the chronology leading to the accident. A tabular time line of events with details on which people were involved would have been useful.

The agencies should have considered and discussed more detailed recommendations on the special risks that seem to exist in tolling operations and in the handling of water reactive materials. While some formal and informal initiatives seem to be under consideration, the risks seem to justify a meaningful effort to better allocate the accident prevention responsibilities in these situations. While guidance is certainly a possibility, rulemaking by either EPA or OSHA should be considered.

The photos were not very useful as the reproduction process removes many details. The agencies should consider the use of higher quality reproduction or the use of the internet to post higher quality photos using color. High resolution photos posted on the internet as an appendix to the report would appear to be a low-cost solution to this problem.

The video was helpful to understanding the incident. Even though it may contain technical inaccuracies due to financial constraints, video recreation is a useful tool to understanding complex incidents.

COMMENTS OF TIMOTHY R. GABLEHOUSE, CHAIR

EXPERT PEER REVIEW OF EPA/OSHA JOINT CHEMICAL ACCIDENT INVESTIGATION REPORT

NAPP TECHNOLOGIES, INC., LODI, NEW JERSEY

In summary the investigators are to be commended for their efforts and analysis. The level of destruction and the death of so many people with necessary information about the events shortly before the accident made the investigation very difficult.

1. *Comment on the report's organization. In general, was there a logical progression in the chain of reasoning - were conclusions adequately supported by the facts?*

In general the report is well organized. It would have been helpful for the report to contain greater detail regarding why certain scenarios were discarded. It also would have been useful for the investigators to state when the level of destruction or lack of first-hand knowledge made it impossible to conduct certain analyses they might have desired.

It was difficult to track events in conjunction with the people involved as one goes through the text of the report. In some cases it is not clear when information is third-hand due to the death of individuals with primary information or when information is limited or no longer exists due to destruction of the facility. It would have been useful for events to be tracked along with the people that were directly involved so that the reader could determine who was present and whether or not they were a survivor of the incident. Clearer discussion of where conclusions were limited due to lack of surviving information would have been useful.

2. *Was the focus on identifying potential sources of heat and water appropriate? Were the sources of reaction initiation which were identified plausible? Were all possible sources of the reactions identified?*

It is not certain that all possible sources of the reactions were identified. It appears fairly certain that all the most plausible sources of the reactions were identified. It seems most likely that water was introduced into the blending vessel as suggested by the report.

The possibilities of product impurities, including water, being present could have been explored. These impurities could have been present in the raw materials depending upon the grade purchased, contamination could have occurred during storage (package damage apparently did occur), or during other handling activities. It is not at all clear whether such studies could have been conducted due to the level of destruction and loss of records.

3. *Was the discussion of root cause adequate? Were root causes and contributing factors appropriately and correctly identified?*

While the discussion is adequate, it appears that a more fundamental management failure was present and should have been described as the root cause with the various specific management failures as subparts. All of the failures of process hazards analysis, operating procedures, training, emergency response and decision making correctly identified in the report, are due to the absence of a comprehensive and coordinated health, safety and environmental management system. The failures identified are symptoms of this larger failure.

The discussion of the relationship between Napp and the local emergency response agencies is limited. It appears that this relationship may have contributed to Napp's failure to notify the fire department during the early stages of the incident. The EPCRA compliance of Napp and whether the awareness of the local fire department could have been improved by LEPC activities should have been discussed. These sources of information might be useful to agencies and companies seeking to prevent future accidents.

4. *Are recommendations appropriate and drawn logically from the preceding discussion and conclusions? Are recommendations sufficient to address the potential of a recurrence of this kind of accident in other facilities? How will other facilities be able to apply the findings and recommendations of this report to their particular circumstances?*

In general the recommendations are logical but do not always reach an appropriately strong statement. The report describes two matters that appear to present a high risk that might not be fully appreciated by those effected. These two matters are tolling arrangements and blending of water reactive materials with other materials that could provide reaction energy.

In the case of tolling arrangements, it appears that both OSHA and EPA should have considered regulatory initiatives to clearly place responsibility for developing information and communicating risk information. While all parties to tolling arrangements carry some level of responsibility, the default application of existing regulations and the limitations of the information presented in MSDSs did not ensure that the companies understood the risks. Possible regulatory initiatives include increasing and eliminating contradictory information available on MSDSs for reactive materials and requiring that tolling arrangements include a detailed process hazards analysis.

5. *Were the appendices sufficient and appropriate? Were the photos appropriate to illustrate the narrative, clear, and properly presented?*

The photos were difficult to use due to the loss of detail in reproduction. The internet could be used to post high quality photos at a reasonable cost.

6. *Were all external factors considered? Were human factors and management issues considered appropriately?*

In general these issues were adequately considered. The discussion of the management issues noted above could have been improved.

7. *What aspects of this report could help inform future investigations? Was the approach sufficiently broad for application to other industry sectors? Were roles of all stakeholders properly addressed in the report, including roles of federal, state and local agencies, the community, labor and any others? Are recommendations sufficiently broad to include all elements in addressing prevention of like accidents in the future?*

The approach was adequately broad so as to provide a basis for future investigations. It would have been useful for the report to have noted analyses that the investigators would like to have performed or information they would have likely to develop but could not due to the destruction present in this case.

I am concerned about stakeholder involvement. Most specifically the pre-release review by Napp in a non-public forum is troubling. It would be better for the report to have been prepared and then shared with all stakeholders at the same time.

Certainly the agencies involved in the investigation need to have some sensitivity to their respective enforcement roles and the potential impact of the report on civil or criminal litigation. Nonetheless, the greatest benefit of this type of report is accident prevention. The users of the report need to rely upon the fact that the report has not be so sanitized or influenced by the facility as to be missing key information elements.

Initial Summary Comments on EPA/OSHA Napp Accident Investigation

Tim Gablehouse

1. The report does a good job of analyzing a complex incident. Clearly the number of deaths and the magnitude of the physical damage increased the difficulty of the job. The report does demonstrate the value of accident investigation and evaluation of causes. The follow through is, of course, critical.

2. It appears, but is not certain, that all potential causes of the chemical reaction and/or sources of water in the system were evaluated. It appears that the writers of the report discounted certain possibilities for reasons that are not always discussed in detail.

3. Analytical analysis, sampling methodology and lab reports are not discussed in depth.

4. Napp's compliance with EPCRA is not adequately reviewed. The role of the LEPC, interactions with first responders, exercises and emergency response procedures should have been discussed in greater depth. Knowledge of facility operations within the community and first responders could have lead to some recommendations relevant to these programs.

5. It appears that management system failures were at the root of failures of training, hazard analysis and maintenance. The analysis of these failures is limited and should have been expanded.

6. An analysis of the role of employees and their participation in training, emergency response, and maintenance programs is not discussed in adequate depth. It would have been useful to understand more about the degree to which these employees had discretion in these areas, failed to exercise this discretion, or failed to follow established procedures.

7. More about the role of supplier of the materials to be blended would have been appropriate. An analysis of whether they were in a better position to advise Napp about potential hazards for this process and equipment could have lead to meaningful recommendations of regulatory changes dealing with tolling agreements. For example, are there regulatory changes under TSCA that could require more sharing of information and customer control in tolling arrangements.

8. An analysis of Napp's compliance with employee health and safety regulations along with EPCRA could have lead to an understanding of whether regulatory gaps existed that lead to this accident. Recommendations on filing these gaps could have resulted.

9. Recommended compliance without an analysis of why noncompliance existed is not as useful as it could be. For example, is the noncompliance due to lack of awareness, criminal intent, failure in enforcement, complexity of the regulations or other reasons? If these could be evaluated in greater detail some specific recommendations might have resulted.

10. By the time the report was written, were any recommendations being implemented?

11. It would have been better for the report to have been released prior to review by Napp.

Geraldine V. Cox, Ph.D.

NAPP Technologies, Inc.

EPA/OSHA JOINT CHEMICAL ACCIDENT INVESTIGATION REPORT

A Critical Review

September 17, 1998

Chapter 1

Executive Summary

Overview

Overall the EPA/OSHA Joint Chemical Accident Investigation Report, EPA 550-R-97-002 dated October 1997 is a competent review of an industrial accident. Some areas of the report would have benefited from additional information, but, given the resources available and the other commitments of the staff who wrote the report, it is a sound document.

Technical Soundness

The review of the incident included:

- A review of each material used with a summary of the potentially hazardous properties of the individual chemicals involved in the incident;
- A discussion of the potential hazards involved in formulating the gold precipitating agent, GPA;
- A synopsis of the previous blending experience by Napp Technologies, Inc.;
- A chronology of the events before and after the incident;
- A discussion of the hazard management procedures used in this incident;
- A postulation for the cause of the incident with supporting evidence; and
- A limited discussion of emergency response.

A good incident review should focus on the systems operating before the incident, the chronology and probable cause of the incident itself, and the response to the incident. The first two were covered well — although worker and supervisor training (especially for out-of-norm events) is weak, and it appears that the assessments of cause are accurate. The discussion of the equipment and the water leak was good, but left some areas that would have benefited from additional discussion. For example, any information on the analysis of the residues of reactants from the vessels would be useful. The damage described to the equipment seems to justify the conclusions about the evolution of the deflagration. The discussion of prevention of future incidents could be stronger.

In cases where records are destroyed in the incident and not available for review, the situation should be specified in the accident report. In addition, when presenting the chronology of events, specification as to source, *i.e.,* first-hand *vs.* second-hand information, is important. In this incident, some of the first-hand observers were lost in the incident, as were operating records. Some observations stemmed from the memory of survivors and what some of those lost in the incident told the survivors before the deflagration.

Future reports should review the emergency response to the incident — from the com pany employees and the local emergency responders — in much greater detail. Are the responders trained properly, are the recommended methods of response appropriate, was the level of response, *e.g.,* local evacuations, in accord with the real hazards of the incident? Did conflicts exist between responders as to who was in charge? Did too many agencies respond to the incident causing problems for the responders? The investigators should have included a discussion of the lack of notification of the neighboring community and the local emergency responders of an incident in progress.

While I believe it to be a minor point, I am concerned about the odor observation by employees prior to the incident. Benzaldehyde is artificial almond flavoring and has a strongly distinct odor of almonds. The employees noticed a smell of vanilla before the deflagration, not almond. This may simply be a confusion of "food smells" and not significant, or it may indicate that some material other than benzaldehyde was introduced into the blender. An explanation of the inconsistency would strengthen the report. Were chemical analyses performed on the residue to determine if the reactants were what would be anticipated? This should be a routine part of these investigations. One hypothesis, probably the correct one, appeared for the reaction. Were others considered and discarded? If so, the report should present this and discuss why the reactions did not seem to reflect the incident that occurred.

The timing of the report is ancient history relative to the incident. Can the reports be available in less than 90 days? This would be more relevant to preventing future incidents. Staff resources were not fully available to complete the effort in a timely manner.

Overall Approach and Completeness

The organization of the investigation and report seems sound. Two objectives seem paramount to this type of report. The first — to identify the factors that contributed to the incident. The second — to identify how to improve existing systems based on lessons learned from the incident review.

The investigators logically developed an understanding of the incident. The organization of the incident report is sound. One topic leads to the next, and the reader builds knowledge of the process, the management, the hazards, and the incident in a logical progression. The photographs are difficult to evaluate because the printing process does not allow retention of detail. Unless the photographs are printed on photo quality paper — and perhaps in color, too much detail is lost with the present printing method to give the reader a full appreciation of the authors' intent with the illustration.

Perhaps in a formulation incident, the investigators should review the customer's hazard assessment procedures in addition to the formulators. The report was unclear as to the origin and completeness of the MSDS from the client, Technic, Inc. Was a product MSDS available, or did Technic only provide Napp Technologies, Inc. with MSDS sheets for the individual components? Did Technic perform a hazard assessment before the company decided to use GPA for recovery of precious metals?

Recommendations for enhancement of accident prevention approaches and accident investigations in the future

Then the investigators clearly identified some weaknesses in the process safety system — specifically:

- The need for better communication with the client about the process hazards prior to formulation;
- Using Material Safety Data Sheet, MSDS, information on the individual ingredients while not looking as the combined potential hazards during the blending operation;
- The need for group discussion of process hazard assessment by management — not sequential review for reactive materials;
- Confusing information presented on MSDSs concerning appropriate response protocol for an incident, *e.g.*, for a compound that reacts with water — the recommendation is to flood with water;
- Using blending equipment that may not be appropriate for the mixing operation;
- Need for better employee training — especially with proper procedures to recognize and respond to deviations from the norm;
- A protocol on building reentry during an incident;
- Need for better emergency responder training; and
- Recommendations for improvement of federal guidance for process hazards.

Additional suggestions

From a prevention aspect, the issue of tolling and associated process hazards is not adequately addressed from a regulatory aspect. The report might have suggested a possible rulemaking that would require the customers of tolling operations to provide process hazard information beyond the information about the individual ingredients. This might include information of how the process of mixing can go wrong, how to identify trouble in the mixing process and what to do if a digression from norm occurs.

The authors might consider a recommendation to initiate an OSHA emphasis program for tolling.

Consensus groups such as the National Fire Protection Association should be asked to reconsider the classification of reactive and to revisit the recommendations for emergency response — specifically the "flood with water" directions. Metal powders, water-reactive, and other reactives such as perchlorates, chlorates and sulfur compounds deserve NFPA reconsideration for storage and emergency response information.

Operations and quality control records were lost in the incident. Perhaps the report should contain a recommendation to maintain real-time remote operating records. For example, record operating logs in a server located remotely from the operations floor. This would allow reconstruction of incident chronology and might be considered as an operating requirement for tolling and other hazardous materials operations.

Chapter 2

Root Causes of the Accident

Underlying Prime Reasons

Accidents are almost never due to a single cause. Rather most incidents involve a cascade of factors that result in an accident.

This is the case at Napp Technologies, Inc. The management systems in place before accepting the GPA formulation were structured for less reactive pharmaceutical formulations rather than for toll blending of reactive components.

The sequential and solitary process safety assessment procedure practiced by Napp Technologies management did not benefit from the exchange that a group review would generate. The investigators identified solitary and sequential review as a problem. However, in many firms conflicting schedules often make group hazard assessments almost impossible. Perhaps a better solution exists. Toll blenders could activate a special group assessment procedure when reactive materials are part of a formulation. This focuses attention on truly hazardous formulations while allowing sequental review of less hazardous formulations. This special assessment should include identification of the norm and discuss how to identify and respond to potential out-of-norm excursions.

The customers asking for mixtures of reactive materials should provide more than simple material safety data sheets for each component of the mixture. They should provide a process safety assessment analysis and a discussion of the risks; how to determine if the process is out-of-norm; and what to do if problems appear during mixing. This information should be reviewed as part of the process safety review by the toller and should be reviewed with the supervisors and the workers assigned to the mixing process.

Blending equipment used primarily for pharmaceuticals is not always appropriate for blending reactive materials, as was the case for GPA. In addition, workers detected a small water leak in the equipment before loading, and the workers tried to stop the leak. A small leak should not be allowed in a pharmaceutical formulation, but it usually would not have the fatal consequences. The decision to load the blender in spite of the continued leak was a poor management decision. Maintenance protocol should not allow a leaking blender to be used in any formulation.

Water is the apparent trigger for the deflagration. The employees should understand not to allow **any** water to contact the blend. A stronger employee training and understanding of the importance of water contamination might have prevented the blending. If the workers and supervisor fully understood the reactivity of some of the ingredients, they would not have allowed the mixing in the Patterson-Kelley 125 Blender.

The sequence of events once the blending process began to digress from the norm indicates that no one established procedures to handle excursions from the norm. This is

clearly an area for improvement in this incident and in the process safety management system in general.

The investigators provide solid evidence of the sequence of events, and the evaluation of the actual incident seems based on an accurate evaluation of the evidence presented in the report. Subsequent discussions with the authors of the report identified that all of the observed chronology was not first-hand. Some of the information was reported based on conversations with other workers who expired in the incident. What was personal observation (and by whom) and what was reported as second-hand should be identified and the source of the information included.

Workers reported the smell of "vanilla" before the incident. Benzaldehyde (part of the formulation) is used in cooking as artificial almond flavoring. None of the other materials in the formulation has a vanilla odor. The workers could have misidentified the odor by associating a food odor — vanilla or perhaps they smelled or another compound that was inadvertently added in place of (or in addition to) benzaldehyde. The report did not present sufficient chemical analyses of the residues to provide further insight.

The sources of heat and water received adequate elucidation. Since both heat and water contribute significantly to the reaction, these topics were appropriate at the level of detail presented. The discussion of initiation seems plausible, and appropriate for the circumstances. Because there were problems with the introduction of benzaldehyde into the blender, can one assume that sufficient quantities of benzaldehyde were present to cause the reactions identified in Appendix A? Decomposition of the insulation seems to be the likely source of the large quantities of phenol and methylphenol.

In summary, the investigators presented an excellent review of the events leading to the incident and the chemistry that supported the deflagration.

Organization of the Report

The report followed a logical plan. It allows the reader to develop an understanding of the background, the materials involved, the history, and operation of the facility before the incident began.

The chronology was clear and logical. The blend of technical terms with definitions as necessary allows a lay reader to grasp the intent of the authors. I would have liked to see the actual MSDSs for the ingredients and the GPA, but that level of detail might not be appropriate for this report.

Appendix B provided the most plausible reactions based on chemistry and observations, but it did not provide other possible reactions. These should have been included as well as a discussion as to why these alternative mechanisms were not considered the probable route. There were some typographical errors in the formulas. The documentation was adequate, but not overwhelming.

Appendix C is enlightening, however, greater detail would be helpful. How did the incident begin, and how did emergency responders handle the incident? Was the treatment method good or bad? Were recommendations presented about avoiding and/or mitigating incidents of this nature?

Standard Xerox®-type reproductions of black and white or color photographs is a waste of natural resources. These photographs can be scanned into a computer program and made into half-tones or printed directly with much greater clarity. I found the photographs difficult to study because the photocopy reproduction was so poor.

Chapter
3

Recommendations

Process hazards

- The first recommendation —

> Facilities need to fully understand chemical and process hazards, failure modes and safeguards, deviations from normal and their consequences, and ensure that all relevant personnel know the proper actions to take to operate the process safely, recognize and address deviations, return to normal operations, or safely shutdown. This is best achieved through process hazard analyses, standard operating procedures, and training. —

is the ideal. With small and batch operations the ideal is seldom achieved. In this case, GPA was formulated **once** before, more than **three** years earlier. Elaborate process safety analyses are a valid goal for large, continuous processes. With formulators who will mix a (or many) different product every day, comprehensive process safety analyses are a luxury that a small staff would cherish. Saying that, however, does not preclude appropriate process safety analyses when the mixture or ingredients are sufficiently reactive to warrant more intense process evaluation. In this particular incident, GPA was blended safely in the past, so it probably received less attention from management on the second batch. It is not clear if the workers who formulated the first batch were the same as those who formulated the ill-fated mixture.

As a recommendation, however, the report might wish to distinguish the level of hazard with the level of process safety analyses. For example, formulations using reactive materials might require a group evaluation where less reactive materials might be reviewed sequentially on an individual basis.

As stated earlier in this review, the customers should provide some process safety analysis information to the toller rather than the individual material safety data sheets for the ingredients. This information should describe the hazards of the combined materials and the combination process. The process safety analysis should also identify out-of-norm conditions and how to handle excursions from normal.

The toller's procedures should define excursions from normal and specify a procedure to follow if an excursion occurs. This process safety assessment should be reviewed by the supervisors and the workers mixing the ingredients.

- The second bullet —

> Guidance is needed to address the unique circumstances surrounding tolling arrangements and the responsibilities for hazards assessments and communication of process safety information. —

is unclear. Who needs the guidance — the toller, supervisors, workers or the government? Businesses, especially small groups such as tollers, have more government than they have staff to handle. The goal should be to raise awareness of the importance of hazard analyses and imprint the need to perform process safety analyses for reactive materials – especially to identify the norm and what to do when the reaction is no longer within normal parameters. The government might consider an internet site to walk small businesses through the steps for hazard assessment. This would be easily available and low cost for all.

- The third bullet —

> Facilities should ensure that equipment manufacturers' recommendations for proper use of equipment are followed. —

seems weak in the report. According to the manufacturer, the Patterson-Kelley 125 Blender is not appropriate for formulation of reactive materials such as those found in GPA. As stated on page 28 of the report, the Aluminum Association recommends a conical blender with no moving parts. The customer might have specified the type of equipment appropriate for the mixing and might have determined if Napp Technologies had the appropriate equipment for the job. Napp should have reviewed the equipment specifications to determine if their equipment would be considered appropriate for the mixing of these reactive materials.

- The fourth bullet —

> OSHA and EPA should review the lists of substances subject to the Process Safety Management standard and Risk Management Program regulations to determine whether reactive substance should be added. —

seems like a reasonable recommendation. Perhaps some consideration of the degree of reactivity might be appropriate in the review. This review might include perchlorates, cholorates, and other reactive sulfur compounds. OSHA might consider a special emphasis program on tolling operations.

- The fifth bullet —

> OSHA needs to review the role of MSDS s in conjunction with HazCom, HazWoper, and PSM Standards to clarify that MSDSs should not be used beyond their intended design. Industry should consider additional consensus standards or guidelines to address MSDS consistency and use. —

is appropriate. This recommendation still will not address the issue of combination of materials such as those used to formulate GPA. Emergency response advice to address reactive materials needs better clarification and perhaps research. For mixtures, a combined MSDS and a process safety analysis of the formulation process might be of great value.

- The last bullet —

> OSHA and EPA should consider whether additional guidance or outreach is needed for users to understand the limitations of MSDSs and industry awareness that more than the MSDS is needed to conduct full process hazards analyses. —

The internet might be an appropriate outreach tool to reach small businesses. If OSHA developed a skeleton for a process hazard evaluation and showed how and how not to use MSDSs, this might be a good public service. In fact a training module might help those companies with limited travel budgets to train their staff and keep current.

Additional Comments

Application of the some specifics of this report may not have wide application. However, the general hazard assessment process and the excursion from normal operations have wide application. If:

- definitions of norm,
- what to do when the processes varies from the norm, and
- how to handle an emergency with the process

could be incorporated as standard operating procedure with reactive mixing situations, then we could reduce the severity and probably the number of incidents. (This assumes a strong worker and supervisor training component to the management function.) Process safety assessment of mixing operations with reactive materials has wide applications to all industry involved with hazardous materials handling.

The report did not dwell on the community emergency response or impact very much, other than to give a general description of the surrounding area. The other area that should be expanded is the internal and external emergency responders and their preparedness. A discussion about the lack of local notification during the events before the deflagration would strengthen the report.

In incidents such as this, the federal and even state governments play a preventative role in terms of regulations and guidance to help industry than an immediate response role. The governments can offer advice at the time of the incident, but only the local responders can be on site quickly enough to assist in these incidents. The governments can help to train and equip these responders, but in the critical first hour, there is little a remote government person can do other than to offer advice.

This report provides a good model for future investigations. The report develops the information rationally and is easy to follow. While each incident will differ, the overall outline should remain relatively consistent.

The recommendations identified have implications for industries beyond the formulating industry, and the lessons learned from this incident should help other companies prevent problems, or at least minimize problems, from reactive materials.

Geraldine V. Cox, Ph.D.

NAPP Technologies, Inc.

EPA/OSHA JOINT CHEMICAL ACCIDENT INVESTIGATION REPORT

A Critical Review
September 2, 1998

Chapter 1

Executive Summary

Overview

Overall the EPA/OSHA Joint Chemical Accident Investigation Report, EPA 550-R-97-002 dated October 1997 is a competent review of an industrial accident.

Technical Soundness

The review of the incident included:

A review of each material used with a summary of the potentially hazardous properties of the individual chemicals involved in the incident;

A discussion of the potential hazards involved in formulating the gold precipitating agent, GPA;

. A synopsis of the previous blending experience by Napp Technologies, Inc.;
. A chronology of the events before and after the incident;
. A discussion of the hazard management procedures used in this incident;
. A postulation for the cause of the incident with supporting evidence; and
. A limited discussion of emergency response.

A good incident review should focus on the systems operating before the incident, the chronology and probable cause of the incident itself, and the response to the incident. The first two were covered well - although worker training (especially for out-of-norm events) is weak, and it appears that the assessments are accurate. The discussion of the equipment and the water leak was good. The damage described to the equipment seems to justify the conclusions about the evolution of the deflagration. The discussion of prevention of future incidents could be elaborated more.

I would like to see future reports review the emergency response to the incident - from the company employees and the local emergency responders in much greater detail. Are the responders trained properly, are the recommended methods of response appropriate, was the level of response, e.g., local evacuations, in accord with the real hazards of the incident? Did conflicts exist between responders as to who was in charge? Did too many agencies respond to the incident causing problems for the responders?

While I believe it to be a minor point, I am concerned about the odor observation by employees prior to the incident. Benzaldehyde is used as artificial almond flavoring and has a strongly distinct odor of almonds. The employees noticed a smell of vanilla before the deflagration, not almond. This may simply be a confusion of "food smells" and not significant, or it may indicate that some material other than benzaldehyde was introduced into the blender. An explanation of the inconsistency would strengthen the report. Were chemical analyses performed on the residue to determine if the reactants were what would be anticipated? This should be a routine part of these investigations.

The timing of the report is ancient history relative to the incident. Can the reports be available in less than 90 days? This would be more relevant to preventing future incidents.

Overall Approach and Completeness

The organization of the investigation and report seems sound. Two objectives seem paramount to this type of report. The first - to identify the factors that contributed to the incident. The second - to identify how to improve existing systems based on lessons learned from the incident review. The investigators logically developed an understanding of the incident. The organization of the incident report is sound. One topic leads to the next, and the reader builds knowledge of the process, the management, the hazards, and the incident in a logical progression. The photographs are difficult to evaluate because the printing process does not allow retention of detail. Unless the photographs are printed on photo quality paper -and perhaps in color, too much detail is lost with the present printing method to give the reader a full appreciation of the authors' intent with the illustration.

Perhaps in a formulation incident, the investigators should review the customer's hazard assessment procedures in addition to the formulators. The report was unclear as to the origin and completeness of the MSDS from the client, Technic, Inc. Was a product MSDS available, or did Technic only

provide Napp Technologies, Inc. with MSDS sheets for the individual components? Did Technic perform a hazard assessment before the company decided to use GPA for recovery of precious metals?

Recommendations for enhancement of accident prevention approaches and accident investigations in the future

The investigators clearly identified some weaknesses in the process safety system - specifically:

-The need for better communication with the client about the process hazards prior to formulation;
-Using Material Safety Data Sheet, MSDS, information on the individual ingredients while not looking as the combined potential hazards during the blending operation;
-The need for group discussion of process hazard assessment by management - not sequential review for reactive materials;
-Confusing information presented on MSDSs concerning appropriate response protocol for an incident, e.g., for a compound that reacts with water - the recommendation is to flood with water;
-Using blending equipment that may not be appropriate for the mixing operation;
-Need for better employee training - especially with proper procedures to recognize and respond to deviations from the norm;
-A protocol on building reentry during an incident;
-Need for better emergency responder training; and
-Recommendations for improvement of federal guidance for process hazards.

Root Causes of the Accident

Underlying Prime Reasons

Accidents are almost never due to a single cause. Rather most incidents involve a cascade of factors that result in an accident.

This is the case at Napp Technologies, Inc. The management systems in place before accepting the GPA formulation were structured for pharmaceuticals rather than for toll blending of reactive components.

The sequential and solitary process safety assessment procedure practiced by NAPP Technologies management did not benefit from the exchange that a group review would generate. The investigators identified solitary and sequential review as a problem. However, in many firms conflicting schedules often make group hazard assessments almost impossible. Perhaps a better solution exists. Toll blenders could activate a special group assessment procedure when reactive materials are part of a formulation. This focuses attention on truly

hazardous formulations while allowing sequental review of less hazardous formulations. This special assessment should include identification of the norm and discuss how to identify and respond to potential out-of-norm excursions.

Blending equipment used primarily for pharmaceuticals is not always appropriate for blending reactive materials, as was the case for GPA. In addition, workers detected a small leak in the equipment before loading, and the workers tried to stop the leak. A small leak should not be allowed in a pharmaceutical formulation, but it usually would not have the fatal consequences. The decision to load the blender in spite of the continued leak was a poor management decision. Maintenance protocol should not allow a leaking blender to be used in any formulation.

Water is the apparent trigger for the deflagration. The employees should understand not to allow any water to contact the blend. A stronger employee training and understanding of the importance of water contamination might have prevented the blending. If the workers and supervisor fully understood the reactivity of some of the ingredients, they would not have allowed the mixing in the Patterson-Kelley 125 Blender.

The sequence of events once the blending process began to digress from the norm indicates that no one established procedures to handle excursions from the norm. This is clearly an area for improvement in this incident and in the process safety management system in general.

The investigators provide solid evidence of the sequence of events, and the evaluation of the actual incident seems based on an accurate evaluation of the evidence presented in the report.

Workers reported the smell of "vanilla" before the incident. Benzaldehyde (part of the formulation) is used in cooking as artificial almond flavoring. None of the other materials in the formulation has a vanilla odor. The workers could have misidentified the odor by associating a food odor - vanilla or perhaps they smelled or another compound that was inadvertently added in place of (or in addition to) benzaldehyde. The report did not present chemical analyses of the residues to provide further insight.

The sources of heat and water received adequate elucidation. Since both heat and water contribute significantly to the reaction, these topics were appropriate at the level of detail presented. The discussion of initiation seems plausible, and appropriate for the circumstances.

In summary, the investigators presented an excellent review of the events leading to the incident and the chemistry that supported the deflagration.

Chapter 2

Organization of the Report

The report followed a logical plan. It allows the reader to develop an understanding of the background, the materials involved, the history, and operation of the facility before the incident began.

The chronology was clear and logical. The blend of technical terms with definitions as necessary allows a lay reader to grasp the intent of the authors. I would have liked to see the actual MSDSs for the ingredients and the GPA, but that level of detail might not be appropriate for this report.

Photocopies of black and white or color photographs is a waste of natural resources - trees. These photographs can be scanned into a computer program and made into half-tones or printed directly with much greater clarity. I found the photographs difficult to study because the reproduction was so poor.

Appendix C is enlightening, however, greater detail would be helpful. How did the incident begin, and how did emergency responders handle the incident? Was the treatment method good or bad?

The Chemistry Appendix, B, is well presented, and logical. The documentation was adequate, but not overwhelming.

Chapter 3

Recommendations

Process hazards

. The first recommendation -

Facilities need to fully understand chemical ad process hazards, failure modes and safeguards, deviations from normal and their consequences, and ensure that all relevant personnel know the proper actions to take to operate the process safely, recognize and address deviations, return to normal operations, or safely shutdown. This is best achieved through process hazard analyses, standard operating procedures, and training. - is the ideal. With small and batch operations the ideal is seldom achieved. In this case, GPA was formulated once before, more than three years earlier. Elaborate process safety analyses are a valid goal for large, continuous processes. With formulators who will mix a (or many) different product every day,

comprehensive process safety analyses are a luxury that a small staff would cherish. Saying that, however, does not preclude appropriate process safety analyses when the mixture or ingredients are sufficiently reactive to warrant more intense process evaluation. In this particular incident, GPA was blended safely in the past, so it probably received less attention from management on the second batch. It is not clear if the workers who formulated the first batch were the same as those who formulated the ill-fated mixture. -
As a recommendation, however, the report might wish to distinguish the level of hazard with the level of process safety analyses. For example, formulations using reactive materials might require a group evaluation where less reactive materials might be reviewed sequentially on an individual basis.

The procedures should define excursions from normal and specify a procedure to follow if an excursion occurs.

. The second bullet -

Guidance is needed to address the unique circumstances surrounding tolling arrangements and the responsibilities for hazards assessments and communication of process safety information. - is unclear. Who needs the guidance - the toller or the government? Businesses, especially small groups such as tollers, have more government than they have staff to handle. The goal should be to raise awareness of the importance of hazard analyses and imprint the need to perform process safety analyses for reactive materials - especially to identify the norm and what to do when the reaction is no longer within normal parameters. The government might consider an internet site to walk small businesses through the steps for hazard assessment. This would be easily available and low cost for all.

. The third bullet -

Facilities should ensure that equipment manufacturers' recommendations for proper use of equipment are followed. - seems unsupported by the report. In the description of the equipment, no mention appears relative to the appropriateness of the Patterson-Kelley 125 Blender for this reaction. This bullet implies that the Patterson-Kelley 125 Blender is inappropriate for use to formulate GPA. If inappropriate, this should have been documented in the report.

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The fourth bullet -

OSHA and EPA should review the lists of substances subject to the Process Safety Management standard and Risk Management Program regulations to determine whether reactive substance should be added. - seems like a reasonable recommendation. Perhaps some consideration of the degree of reactivity might be appropriate in the review.

. The fifth bullet -

OSHA needs to review the role of MSDS s in conjunction with HazCom, HazWoper, and PSM Standards to clarify that MSDSs should not be used beyond their intended design. Industry should consider additional consensus standards or guidelines to address MSDS consistency and use. - is appropriate. This recommendation still will not address the issue of combination of materials such as those used to formulate GPA. Emergency response advice to address reactive materials needs better clarification and perhaps research.

. The last bullet -

OSHA and EPA should consider whether additional guidance or outreach is needed for users to understand the limitations of MSDSs and industry awareness that more than the MSDS is needed to conduct full process hazards analyses. The internet might be an appropriate outreach tool to reach small businesses. If OSHA developed a skeleton for a process hazard evaluation and showed how and how not to use MSDSs, this might be a good public service. In fact a training module might help those companies with limited travel budgets to train their staff and keep current.

Additional Comments

Application of the some specifics of this report may not have wide application. However, the general hazard assessment process and the excursion from normal operations have wide application. If definitions of norm, what to do when the processes varies from the norm and how to handle an emergency with the process could be incorporated as standard operating procedure with hazardous reactions, then we could reduce the severity and probably the number of incidents. (This assumes a strong worker training component to the management function.) This has wide applications to all industry involved with hazardous materials handling.

The report did not dwell on the community very much, other than to give a general description of the surrounding area. The other area that should be expanded is the internal and external emergency responders and their preparedness.

In incidents such as this, the federal and even state governments play a preventative role in terms of regulations and guidance to help industry than an immediate response role. The governments can offer advice at the time of the incident, but only the local responders can be on site quickly enough to assist in these incidents. The governments can help to train and equip these responders, but in the critical first hour, there is little a remote government person can do other than to offer advice. This report provides a good model for future investigations. The report develops the information rationally and is easy to follow. While each incident will differ, the overall outline should remain relatively consistent.

The recommendations identified have implications for industries beyond the formulating industry, and the lessons learned from this incident should help other companies prevent problems, or at least minimize problems, from reactive materials.

Comments of Jerry Scannell, National Safety Council

Peer Review

The EPA/OSHA Joint Chemical Accident Investigation Report Of Napp Technologies, Inc.

Summary: The joint teams did a good job under very difficult conditions of what was left after this destructive deflagration. Although the EPA/OSHA Joint Chemical Accident Investigation Report explains the event that occurred at the Napp Technologies, Inc. facility on April 21, 1995, it should have examined further why the event occurred and what can be done to avoid these occurrences in the future. The report should have noted any environmental consequences of the explosion, any failures in facility's management systems to prevent, mitigate and respond to the event, and any regulatory gaps and inconsistencies.

GENERAL

- The report was issued over two years after the incident. This causes it to lose any impact it might otherwise have! Two years is unacceptable.

- The investigation's methodology should be further defined to include its objectives and review parameters. In addition, the investigative team should be individually identified to include area of expertise and organizational affiliation.

- The investigation did not indicate that its analysis was peered review or that it solicited a review from stakeholders - other than Napp Technologies, Inc. officials. A broader review may have added information and other perspectives on the accident analysis. The report should indicate whether the team interviewed all stakeholders - company officials, labor, state and community officials, and citizens.

- The report did not review Napp Technologies, Inc.'s compliance with applicable state and Federal regulations governing the safe handling of hazardous chemicals, worker safety and public safety. Nor, did the report review the company's accident prevention and emergency response procedures against industry standards and best practices.

- The report states that the ultimate goal of the accident investigation is "...to determine the root cause in order to reduce the likelihood of recurrence...." etc. And the report goes on to recognize that examples of root causes include "...failure of particular management systems, that allow faulty design, inadequate training or deficiencies in maintenance to exist." The report, however, focuses on the faulty design, the inadequate training and the deficiencies in maintenance but the treatment of the failure of management systems that allow these deficiencies to exist is handled poorly at best.

Management System Issues

- Management system issues that need to be developed further include:

  * The qualifications, credentials and competence of the managers involved in the decision-making, from New Product Review to the emergency response. This review is especially important in light of the series of apparent bad decisions by management as the crisis developed.

  * The existence, effectiveness, and/or the results of the company's audit program, safety and health program and/or the safety committee including any finding of noncompliance with SOPs and any recommendations for improvement.

  * The role employees had or failed to have in the company's safety and health program.

  * A discussion of the existence of any review of prior incidents and Federal: by the company, in interviews with employees, or as part of the compliance investigations. Was there anything that could be learned from any prior incidents that could have alerted management to deficiencies in their SOPs or systems?

- The report recognizes that contributing factors "facilitated the occurrence of the event." However the report falls short in adequately dealing with the contributing factors. Contributing factors that needed to be developed include:

  * No discussion whatsoever on the level of regulatory oversight, neither specific to this location or to the industry as a whole or to the type of operation-tolling.

  *No discussion of the violations or level of compliance found in the enforcement investigations, including company history or previous regulatory history. The same deficiency applies to the industry as a whole.

*More discussion on what Technic knew. Did they have more information that could have been given to Napp to better equip Napp to make an informed decision about the hazards of the *process*?

*While the report recognizes the inadequacy of the "hazard analysis", it does a poor job of discussing the underlying and contributory causes of this inadequacy.

EMERGENCY PREPAREDNESS

- There is a much greater need for an in-depth discussion of emergency preparedness. The report focuses on training deficiencies. But there is more to it than that. How could an emergency plan be so inadequate as to not include what action to take during deviations from normal operations? How could deviations exist for almost 16 hours with no one on site with the authority or willingness to safely shutdown the operation? In light of the emergency, how could a decision be made not to notify the local fire department and instead send employees back in to dump the batch at that stage of the crisis?

- There was no discussion of whether Napp Technologies, Inc. had an emergency plan. If Napp did have an emergency plan, was staff trained to implement it? Did they have a history of table top and full-scale exercises to test and refine the plan? Did Napp have an operational relationship with local emergency responders? There was no discussion of an on-site incident command structure.

- The report did not review whether Napp was in compliance with the Emergency Planning and Community Right To Know Act, particularly in reference to Section 304, Emergency Release Notification, and Sections 311-312, Hazardous Chemical Reporting.

- Finally, the report did not discuss Napp Technologies emergency spill response plan.

REGULATORY REVIEW

- A review of the regulatory safety net should have been undertaken to ensure that no gaps existed between PSM, Haz Comm, HazWoper, EPCRA and RMP.

- If as the report says, the root causes and the contributing factors "should be considered lessons for the chemical processing industries which operate similar processes, especially the tolling industry" then the recommendations fall far short of having the impact necessary to minimize the likely occurrence of a similar incident in the future. Specifically, the recommendations fail in the following areas:

  * In those areas such as emergency preparedness, management competencies and regulatory oversight, where the discussion itself was

inadequate, the report was almost devoid of any meaningful recommendations.

*One of the major recommendations is essentially that companies should comply with existing regulations such as PSM and RMP. What does this change? Do companies not know about the rules? Don't they care?

*One recommendation is for the industry and/or government to develop guidelines to be used in tolling contracts. This is good but needs to be developed stronger. For instance, can OSHA and EPA take a lead role in serving as a catalyst to get the industry together to work on such guidelines? If voluntary action doesn't work, is regulatory action necessary?

*The report makes a number of recommendations for OSHA and EPA. It is not clear what actually was done in response to those recommendations since the memos and directives referred to in the report are not part of the appendices. But regulatory action on the part of these agencies doesn't seem to be enough. The report should have considered extensive outreach activities to reach the regulated industry as part of the recommended actions.

EXTERNAL REVIEWS

- Finally, it is understood that a draft of this report was shared with the company before it was finalized. That being so, then the report should have been shared with all stakeholders.

September 24, 1998

Comments of Jerry Scannell, National Safety Council
Peer Review The EPA/OSHA Joint Chemical Accident Investigation Report Of Napp Technologies, Inc.

Summary: Although the EPAJOSHA Joint Chemical Accident Investigation Report explains the event that occurred at the Napp Technologies facility on April 21, 1995, ft should have explained further why the event occurred and what can be done to avoid these occurrences in the future. The report should have noted any environmental consequences of the explosion, any in facility's management Systems to prevent, mitigate and respond to the event, and any regulatory gaps and inconsistencies.

GENERAL

The report was issued over two years after the Incident. This causes it to lose any impact it might otherwise have! Two years is unacceptable.

The investigation methodology should be further defined to include its objectives and review parameters. In addition. the investigative team should be individually identified to include area of expertise and organizational affiliation.

The investigation did not indicate that its analysis was peered review or that it solicited a review from stakeholders - other than Napp Technologies, Inc. officials. A broader review may have added information and other perspectives on the accident analysis. The report should indicate whether the team interviewed all stakeholders - company officials
labor, state and community officials, and citizens.

The report did not review Napp Technologies, Inc.'s compliance with applicable state and Federal regulations governing the safe handling of hazardous chemicals, worker safety and public safety. Nor, did the report review the company's accident prevention and emergency response procedures against industry standards and best practices.

The report states that the ultimate goal of the accident investigation is "...to determine the root cause in order to reduce the likelihood of recurrence...." etc. And the report goes on to recognize that examples of root causes include "..fai1ure of particular management systems, that allow faulty design, inadequate training or deficiencies in maintenance to exist." The report, however, focuses on the faulty design, the inadequate training and the deficiencies in maintenance but the treatment of the failure of management Systems that allow these deficiencies to exist is handled poorly at best.

The report did not recommend follow-up actions to share information resulting from the investigation among industry, government, and other concerned groups and citizens. There are no outreach recommendations that could result in revised engineering and management standards and best practices to improve safety In this industry.

The report did not review The role that state and Federal regulatory and safety agencies played in the incident, nor whether there were gaps and deficiencies in the regulations or in their implementation.

Management System Issues

Management system issues that need to be developed further include:

* The qualifications, credentials and competence of the managers involved in the decision-making, from New Product Review to the emergency response. This review is especially important in light of the series of apparent bad decisions by management as the crisis developed.

* The existence,. effectiveness, and/or the results of the Company's audit program, safety and health program and/or the safety committee including any finding of noncompliance with SOPs and any recommendations for improvement.

* The role employees had or failed to have in the company's safety and health program.

* A discussion of the existence of any review of prior incidents and Federal: by the company, in interviews with employees, or as part of the compliance investigations. Was there anything that could be learned from any prior incidents that could have alerted management to deficiencies in their SOPs or systems?

The report recognizes that contributing factors "facilitated the occurrence of the event." However the report falls short in adequately dealing with the contributing factors. Contributing factors that needed to be developed include:

No discussion whatsoever on the level of regulatory oversight, neither specific to this location or the industry as a whole or to the type of operation-tolling.

No discussion or the violations or level of compliance found in the enforcement investigations including company history or previous regulatory history. The same deficiency applies to the industry as a whole,

More discussion on what Technic knew. Did they have more information that could have been given to Napp to better equip Napp to make an informed decision about the hazards of the process?

While the report recognizes the inadequacy of the "hazard analysis", it does a poor job of discussing the underlying and contributory causes of this inadequacy.

EMERGENCY PREPAREDNESS

There is a much greater need for an in depth discussion of emergency preparedness. The report focuses on training deficiencies. But there is more to it than that. How could an emergency plan be so inadequate as to not include what action to take during deviations from normal operations? How could deviations exist for almost 16 hours with no one on site with the authority or willingness to safely shutdown the Operation? In light of the emergency, how could a decision be made not to notify the local fire department and instead send employees back in to dump the batch at that stage of the crisis?

There was no discussion of whether Napp Technologies, Inc. had an emergency plan. If Napp did have an emergency plan, was staff trained to implement it? Did they have a history of table top and full-scale exercises to test and refine the plan? Did Napp have an operational relationship with local emergency responders? There was no discussion of an on-site incident command structure.

The report did not review whether Napp was in compliance with the Emergency Planning and Community Right To Know Act, particularly in reference to Section 304, Emergency Release Notification, and Sections 311-312, Hazardous Chemical Reporting.

Finally, the report did not discuss Napp Technologies emergency spill response plan.

REGULATORY REVIEW

A review of the regulatory safety net should have been undertaken to ensure that no gaps existed between PSM, Haz Comm, HazWoper, EPCRA and RMP.

If as the report says, the root causes and the contributing factors 'should be considered lessons for the chemical processing industries which operate similar processes, especially the tolling industry' then the recommendations fall far short of having the impact necessary to minimize the likely occurrence of a similar incident in the future. Specifically, the recommendations fail in the following areas:

* In those areas such as emergency preparedness, management competencies and regulatory oversight, where the discussion itself was inadequate. The report was almost devoid of any meaningful recommendations.

*One of the major recommendations is essentially that companies should comply with existing regulations such as PSM and RMP. What does this change? Do companies not know about the rules? Don't they care? Aren't they worried about the consequences of noncompliance? Or don't they think they will get caught? Essentially the question is why did this company ignore the law and what should be done to reduce the likelihood of companies ignoring the law in the future?

*One recommendation is for the industry and/or government to develop guidelines to be used in tolling contracts. This is good but needs to be developed further. For instance, can OSHA and EPA take a lead role in serving as a catalyst to get the industry together to work on such guidelines? If voluntary action doesn't work, is regulatory action necessary?

*The report makes a number of recommendations for OSHA and EPA. It is not clear what actually was done in response to those recommendations since the memos and directives referred to in the report are not part of the appendices. But regulatory action on the part of these agencies doesn't seem to be enough. The report should have considered extensive outreach activities to reach the regulated industries part of the recommended actions.

EXTERNAL REVIEWS

* Finally, it is understood tat a draft of this report was staved with the company before it was finalized. At best, this will undermine the credibility of the findings with stakeholders and at worse, it could lead to avoidance of recommendations that could prevent similar catastrophes in the future.

Review of
EPA/OSHA Joint Chemical Accident Investigation Report
Napp Technologies Inc., Lodi NJ
(Including points developed at the Sept. 14, 1998 review panel meeting)

by Wade A. Freeman
September, 1998

This review comments on the completeness, technical soundness, and overall approach of the report on the investigation of the April 21, 1995 explosion at the Napp Technologies facility.

Comment on the Overall Approach
The Joint Chemical Accident Investigation Team (JCAIT) assembled background information and gathered testimony to create a chronological description of actions and events preceding the accident. The team evaluated this record, physical evidence at the scene, documents describing the equipment and chemicals in use, and descriptions of similar equipment located elsewhere to arrive at a list of Significant Facts in the accident. JCAIT then listed possible causes of the accident and used "engineering analyses of this information…and professional judgement" to determine root causes and contributing factors. This led to a set of recommendations.

This overall approach is sound. However, some possible and even plausible causes for the unwanted chemical reactions are not explicitly considered in the report. JCAIT should have gathered data relative to such possibilities and sought to rule them out. The analyses described in the report do not firmly establish the chemistry of the accident. Discussion at the Sept. 14 meeting revealed that some of chemical analyses were selected adventitiously and not as part of a fully conceived program of analysis in support of the investigation. Finally, some evidence and testimony are insufficiently discussed.

Were Analyses Sufficient?
Chemical analyses of the residues left by an explosion can reveal important details of the reactions that took place. JCAIT discusses their chemical

analyses in Section 3.1 (page 18) and details them in Appendix A (page 31) of the report.

1. Insufficient detail is provided on the chemical analyses. JCAIT fails to state or reference the analytical methods that were used. No account is given of the selection of sampling sites, the number of samples taken, or the number of samples analyzed.

2. Analytical results are given in non-numerical terms (such as "percentage amounts" or "large amounts"). Numerical findings should appear in Appendix A.

3. The analyses were poorly selected. Mere elemental analysis of the residues is unhelpful (as the report notes). A program of qualitative and quantitative analysis for a range of inorganic compounds should have been conducted. Finding specific substances or classes of substances in the residues would allow conclusions to be drawn about the chemical changes within the blender over the course of the accident. For example, finding residual elemental sulfur would support the reaction scenario laid out in Appendix B. Detection of sul*fide* sulfur would show that reactions took place other than those discussed in the report. As it is, the report makes no mention at all of sulfur in the residues.

4. Analyses for sulfur and sulfur-containing compounds should have been carried out.

5. Three organic compounds were identified "in large amounts" in internal and external residues of the explosion: phenol, 2-methylphenol, and 4-methylphenol. The report concludes that these compounds probably derived from the insulation that lined the blender but could also have derived from the benzaldehyde that was added to the mix. Appendix A proposes a route to phenol and the two methylphenols starting with benzaldehyde. This portion of Appendix A should have been omitted. It adds nothing to the conclusions of the report and is chemically improbable, as the following comments show:

a) Other passages in the report indicate that benzaldehyde was never in the blender. Page 20 includes, as part of a Significant Fact, the statement that "operators were unable to inject benzaldehyde, the sole liquid component of GPA, into the blender." Page 24 has the sentence: "However, given that operators were not able to inject the benzaldehyde into the blender it

is unknown if any water in the feed line actually entered the blender." Obviously, if benzaldehyde never got into the blender, the phenol compounds did not derive from it. At the Sept. 14 meeting, investigators stated finally that was impossible to conclude from the available evidence whether any benzaldehyde actually got into the blender. Even if a small amount of benzaldehyde made it into the blender, it would not explain the detection of these organic compounds "in large amounts."

b) The proposed route to the phenol compounds is inconsistent with known chemistry. Toluene would *not* be converted to phenol under the reducing conditions in the blender.[1] The report seems to call this conversion, which is an oxidation, a "classic electrophilic aromatic substitution." It is not. It may be that the report refers to the methylation of phenol as the electrophilic aromatic substitution. Such a methylation would require acidic conditions, a methylating agent and phenol.[2] All three were absent in the blender.

Aqueous sodium hydrosulfite reduces benzaldehyde to benzyl alcohol ($C_6H_5CH_2OH$) in a two-electron reduction.[3] This reaction is also plausible under the conditions in the blender. Benzyl alcohol is presumably the "methyl hydroxy (alcohol) intermediate" mentioned in the report, although benzyl alcohol (and benzaldehyde) contain no methyl groups. Four-electron reduction of benzaldehyde to toluene is also conceivable:

$$C_6H_5COH + 4\,H^+ + 4e^- \text{ ---> } C_6H_5CH_3 + HOH$$

However, both reductions require H^+ in addition to the electrons supplied by the reducing agent. The H^+ would have to come from impurities containing active hydrogen (such as water or benzoic acid) because the nominal contents of the blender furnish no hydrogen.

c) The chemical composition of the "rigid foam material" used to insulate the walls of the blender and any additives in the aqueous coolant solution should have appeared in the report. During the Sept. 14, 1998 meeting, members of JCAIT stated that the insulation of the blender was polyurethane foam. Most polyurethane foam is made by reacting 2,4-diisocyano-1-methylbenzene with a

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[1] Roberts, John D., and Caserio, Marjorie C., Basic Principles of Organic Chemistry, 2nd Edition, W. A. Benjamin, Inc., 1977, page 405-10.

[2] See the discussion of Friedel-Crafts alkylation in any organic chemistry text. For example, Roberts, John D., and Caserio, Marjorie C., Basic Principles of Organic Chemistry, 2nd Edition, W. A. Benjamin, Inc., 1977, page 1047.

[3] deVries and Kellogg, J. Org. Chem. 45, 4126, 1980.

suitable dialcohol and then adding water.[4] Oxidation of a functionalized methylbenzene in a fire is consistent with the generation of phenol and methylphenols.

d) The speculation concerning the source of the phenol compounds is misplaced. Appendix A should detail experimental and observational results. Interpretation properly belongs in the body of the report.

6. The first paragraph describing the analysis of the blender (in Appendix A) states: "The damage initially appeared to be the result of a steam explosion inside the water jacket lining." This statement leaves it uncertain whether a steam explosion was excluded and, if it was, why. At the Sept. 14 review meeting, members of JCAIT explained that they rejected the steam explosion scenario because the portion of the blender that sustained the provocative damage housed insulation, not coolant.

7. Analysis of the physical condition of the bodies of the victims is the sole basis used to classify this event as a deflagration ("soft explosion") rather than as an explosion or detonation. The analysis of the remains of the blender should have been extended with a view to confirming or denying this conclusion.

8. JCAIT reports (page 17) that a USEPA mobile laboratory of "downwind air samples of inorganic/acid gases, organic, and ketones" as part of the emergency response. No other mention is made of these samples. Does this sentence mean that acidic gases, organic compounds and ketones were in fact *found* in the samples? What analyses were performed on the mobile laboratory samples? What were the results? At the Sept. 14 meeting, members of JCAIT explained that this sampling was for population protection, gave negative results, and had no significance to the investigation. These facts should have been in the report.

9. The report states (page 23) that JCAIT conducted "metallurgical analysis of the blender after the accident." This is somewhat misleading. Appendix A details a thorough *visual* examination of the blender and a single microscopic measurement (to obtain the depth of the grooves in the graphite seal).

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[4] Roberts, John D., and Caserio, Marjorie C., Basic Principles of Organic Chemistry, 2nd Edition, W. A. Benjamin, Inc., 1977, page 1455.

10. An attempt should have been made to establish the conditions of temperature and humidity prevailing in the blender room over the course of the operation.

11. Members of JCAIT stated during the review meeting of Sept. 14 that the ARC analyses discussed in Appendix B were performed not by design, but by happenstance when professional acquaintances offered to do them. Taking advantage of such opportunities is certainly acceptable. However, it is obviously unsound to rely on such circumstances.

Are all sources of information properly identified?

Reports of this type should adhere to standard practices of attribution. JCAIT is erratic in this respect. The reference on page 39 to "EPA Trip Report, July 5, 1995" does not appear in Appendix D. Did the report originate with EPA members of JCAIT or with other representatives of the EPA? The in-text details about Tartani and Contessa's paper on page 40 mostly duplicate the citation in Appendix D. A flash point for powdered aluminum/air mixtures is quoted without attribution. The NIST report on the remains of the blender is not properly cited in Appendix A. During the Sept. 14 meeting, it was stated by an investigator that discussion in Appendix A concerning the conversion of benzaldehyde to phenol and the two isomeric methylphenols was a personal communication from a retired chemist. Relying on such sources is inferior to checking facts in standard references. The "Events and Causal Factors and Hazard-Barrier-Target techniques" that are mentioned on page 26 as part of the engineering analysis of the event require a reference.

Were the sources of reaction initiation plausible?

JCAIT identifies two "most likely" sources of initiation: accidental wetting of the blend and frictional heating from over-use of the intensifier bar. Both are plausible. It is essentially certain (see below) that water was reacting in the blender during the time preceding the explosion. Two very likely sources of water are identified: leakage past the intensifier bar seal and residual water in the liquid feed line. These are reasonable possibilities. Both might have contributed concurrently to wet the blend.

Were all possible sources of initiation identified? Were the likely causes of the chemical reaction explored fully?

The most likely causes of the chemical reaction were identified and explored. Other possible causes were not explored sufficiently. The approach should have been to consider all possibilities at first and obtain testimony, analysis and other evidence to rule out as many as possible.

1. The report does not deal effectively with the possibility that wrong ingredients or the contamination of ingredients contributed to the chemical events in the blender. A few sentences suggest that the chance of inadvertent substitution or contamination entered the deliberations of JCAIT. Page 34 states that the benzaldehyde chemistry that the report has just elaborated ". . . tends to eliminate the possibility that phenol, rather than benzaldehyde, had been inadvertently added. . . ." Page 8 notes the fact that benzaldehyde is oxidized to benzoic acid when exposed to the air and inserts some descriptive chemistry of benzoic acid. Page 23 states (correctly) that moisture present in any of the raw materials could have sufficed to initiate a reaction. Page 31 mentions "inadvertent mixing of different chemicals that could…occur."

Elsewhere however, JCAIT accepts the quality of the raw materials without proof. Page 3 states: "The 1995 blending ingredients were virtually the same as in 1992." This assertion requires analytical confirmation. (Incidentally, if "virtually" means "very nearly," then in what ways did the ingredients in the 1995 disaster *differ* from the ingredients in the 1992 success?) Any details that support the "virtually" belong in the report. Page 23 mentions a quality assurance check that Napp performed on the raw materials that did not find moisture. Details should appear in the report. JCAIT apparently accepts the lack of apparent reaction during the loading of the blender to rule out the presence of moisture in the raw materials. This overlooks possible delayed onset of reaction, a common occurrence.

Residual portions of the ingredients should have been collected (from the bottoms of supply drums, for example) and analyzed. These drums were present in the blending room at 7 p.m. (page 13). At the Sept. 14 review meeting, it was established the fire that followed the blast destroyed all the supply drums. The report should have mentioned this and any other adverse circumstances. In the

absence of residual ingredients, JCAIT could have attempted to confirm the chemical identity of the materials loaded into the blender inferentially. This would involve checking the source of the materials, conducting analyses of materials from the same production lot, and making inquiry into conditions of transport, storage, and handling.

2. The report does not consider the possible influence of "normal" impurities.

a) According to Kirk-Othmer[5], the highest grade of industrial anhydrous sodium hydrosulfite contains 88% $Na_2S_2O_4$ by mass mixed with 3% sodium disulfite ($Na_2S_2O_5$), 3% sodium sulfite (Na_2SO_3), 3% sodium sulfate (Na_2SO_4), and 3% sodium carbonate (Na_2CO_3). A lower grade of sodium hydrosulfite contains only 80 percent $Na_2S_2O_4$ by mass. According to the same source, anhydrous sodium hydrosulfite is produced by four methods: formate reduction, amalgam reduction, zinc reduction and electrolytic reduction. Each naturally leaves a different set of impurities. It would have been informative to find out whether the GPA components in the April 1995 accident were of the same grade and produced by the same reactions as those that were successfully blended in July 1992.

b) Depending on the way in which anhydrous potassium carbonate (K_2CO_3) is prepared, it contains as much as 3% water by mass.[6] Potassium carbonate is hygroscopic; its recommended mode of storage is in bunkers ventilated with dry air.[7] The hydrate $K_2CO_3 \cdot 1.5H_2O$, which contains about 16% water by mass and deliquesces in moist air, is readily available in commerce as dustless crystals. Conceivably, water associated with the potassium carbonate initiated the reaction events in the blender. This possibility should certainly have been investigated, as members of JCAIT agreed at the Sept. 14 review meeting.

3. Particle size and shape can affect the progress of dry blending operations. JCAIT should have checked the state of subdivision of the materials in the

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[5] Kirk-Othmer Encyclopedia of Chemical Technology, 4th edition, John Wiley & Sons, New York, 1998, Vol.

[6] *Ullman's Encyclopedia of Industrial Chemistry*," 5th edition, VCH Weinheim, Germany, 1993, Vol. A22, page 99.

[7] *Ullman's Encyclopedia of Industrial Chemistry*," 5th edition, VCH Weinheim, Germany, 1993, Vol. A22, page 99.

accident to that of the materials that were successfully blended in 1992. This goes as well to the issue of undue heating from the turning of the intensifier bar.

4. With a view to confirming the proposed reaction scenario, JCAIT should have sought samples of authentic GPA and run experiments in which varying amounts of water are added under the conditions prevailing in the blender. These experiments would resemble the experiments described in Appendix B, but would aim to identify the products as well as to measure the temperature rise.

5. JCAIT failed to consider some clues to the reactions taking place in the blender. An employee who entered the blending room at 7 p.m. reported a smell of "rotten eggs" (page 13). An employee who entered the blending room at 10 p.m. noticed a "dead animal" smell. Employees arriving for work the next morning also reported a rotten-egg odor (page 14) that ". . .had escaped the building and was noticeable in the parking lot. . . ." The witnesses are reporting the presence of hydrogen sulfide (H_2S). The presence of hydrogen sulfide was specifically indicated by testimony (quoted by a JCAIT member at the Sept. 14, 1998 review meeting) from another witness who *named* the smell as hydrogen sulfide. It is worth nothing that H_2S deadens the sense of smell,[8] a fact that accords with the prevalence of rotten-egg reports among newcomers to the scene. JCAIT focuses on the generation of sulfur dioxide from sodium hydrosulfite (page 37). Sulfur dioxide has a characteristic choking or suffocating odor that is never compared to rotten eggs. It is a serious error to write off the odor of H_2S as a generic "sulfur smell" (page 28).

Sulfide sulfur (sulfur in the –2 oxidation state) would form if aluminum reduced sodium hydrosulfite fully. Thus the reaction

$$10\ Al + 3\ Na_2S_2O_4 \text{ ---> } 3\ Na_2S + 4\ Al_2O_3 + Al_2S_3$$

might accompany or replace the second reaction on page 39. Reduction to S(–2) is quite plausible. Such a reduction would be exothermic. The conversion of sulfides to H_2S, which boils at –60.7°C, requires a source of H^+. Hence, detection of H_2S at 7 p.m. indicates that a substance with active hydrogen (such as water or benzoic acid) was in the blender by that time; the rotten-egg odor rules out the "friction-only" scenario at the bottom of page 25 of the report. Despite the overall basic

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[8] Lewis, Richard J., *Hazardous Chemicals Desk Reference*, Van Nostrand Reinhold, New York, 1993, page 691-2.

conditions in the blender, local concentrations of H^+ donors could easily generate H_2S, which would out-gas rapidly because of its high volatility.

The emission of H_2S does not prevent simultaneous or subsequent generation of gaseous sulfur dioxide (SO_2) according to the equations on page 37. Indeed, the puffs of white smoke coming from the blender at 5:30 a.m. might well have been an acid mist formed as vented SO_2 reacted with moisture in the air; H_2S would not form such a mist.

6. JCAIT should have checked Napp's records to ascertain the contents of the liquid feed system in its last prior use. Residual content might account for the "vanilla-like odor" detected in the tank when operators prepared to add the benzaldehyde (page 12). This odor is a loose end in the report. It is (remotely) conceivable that the material with the vanilla-like odor entered the blender and influenced the chemistry within. At the Sept. 14 review meeting, members of JCAIT stated that these production records were destroyed in the accident (if they ever existed). This point should have been included in the report.

Comment on the Discussion of Root Causes and Contributing Factors
The report does not satisfactorily exclude the possibility that one (or more) of the raw materials originally contained water or another initiating substance or became contaminated with water or such a substance during transportation and storage. This point gains importance because it is known that one of the bags of potassium carbonate had been broken open and taped over (page 10).

Reactions in the blender could have been taking place at several hot spots, of which only one was observed. Reactions could also have been taking place throughout the batch but with particular intensity at the observed hot spot. Therefore, the assertion (on page 23) "…the bubbling noted towards the middle of the blender reveals that the reactions did not take place at the walls of the blender…" is logically faulty.

Page 10 of the report establishes that the operators knew that they were processing water-reactive chemicals. Page 12 states that the operators found water in an internal filter on the liquid feed line and adds: "The operators did not consider the liquid feed line to be functioning properly. The liquid spray head and spray system had not been completely dried prior to the charging of the blender." This was clearly on-the-spot opinion because the operators proceeded next to attempt to

dry the liquid feed system by rinsing it with isopropyl alcohol and blowing nitrogen through it. Page 24 in fact implies that other attempts took place ("…several drying/vacuum procedures were performed"). JCAIT should have attempted to learn what made the operators think the liquid feed system was dry enough to permit injection of the benzaldehyde. An error in judgment on this point was probably the proximate cause of the accident. It is not clear in the report whether the personnel who made this judgment survived the explosion.

JCAIT should have included all it knew of the events of the last 47 minutes before the explosion. A video describing the accident was shown at the Sept. 14 meeting. It reported (and members of JCAIT confirmed) that during this climactic period, the operators readied receiving drums under a nitrogen blanket and managed to off-load four drum-fulls of material. At this point the blender before it made a loud noise, which caused the operators to retreat from the room. The explosion occurred after they had returned to the room and as they unloaded a fifth drum-full of material. These facts belong in the written report.

On page 23, the report states that information was received to indicate that operators might have used water or steam to unclog the liquid feed line. The report then immediately states that JCAIT was able to confirm that attempts to clear the feed line did *not* involve water or steam. At the Sept. 14 meeting members of JCAIT further confirmed that investigation showed the allegation concerning the use of water was mistaken. The sources and resolution of the conflicting testimony should appear in more detail in the written report.

On page 28, JCAIT concludes ". . . there is no evidence to suggest that Napp was aware that off-loading the blender may have exacerbated the reaction mechanisms by exposing the contents to air or that the contents could violently erupt and deflagrate." This is at odds with the reported prolonged efforts by

Napp to protect the blend from the air by use of a nitrogen blanket. Also, exposure to the air would not aggravate the reactions already proceeding, but would (and did) occasion a *new* set of reactions, namely, air oxidations.

"The training of the fire brigade and emergency responders was inadequate" cannot be sustained as contributory to the accident. The investigation develops a picture of firefighters standing ready to charge hoses and direct water on

command. What could they have done otherwise, no matter what their training? JCAIT does not mention training records or other background on emergency

responders who were not members of the fire brigade. Concluding that the training of these people was inadequate is not justified without information about their training.

Comment on Recommendations

JCAIT makes helpful and appropriate recommendations. The recommendation against the use of liquids to cool or purge seals in processing equipment if the liquids are chemically incompatible with the materials being processed is particularly important. It should appear in full in the Executive Summary. The version ". . . ensure that equipment manufacturers' recommendations for proper use of equipment are followed. . ." is vague.

Comments on Appendices and Illustrations

ILLUSTRATIONS

Figure 3A (page 14) shows neither the route along which the benzaldehyde was intended to flow nor the route by which it ended up in the vacuum separator bowl. A proper schematic diagram of vacuum collection system would help the reader far more. A member of JCAIT at the Sept. 14 review meeting sketched an adequate figure.

APPENDIX A

As noted in the preceding, detail on the nature of chemical analyses and their results are lacking.

APPENDIX B

Equation 3 (showing the disproportionation of sodium disulfite) has a typographical error. It should read $2Na_2S_2O_5$ ---> $2\ Na_2SO_4 + SO_2 + S$.

In the second paragraph, the formula of sodium thiosulfate is given as $Na_2S_2O_4$.

The correct formula is $Na_2S_2O_3$.

The calorimetry studies described on page 39-40 require additional detail:

a) A description of the ARC method, or a reference to a suitable background paper should appear.

b) The sources and purity of the substances used in the studies should be stated.

c) The amounts and the method of mixing of the reactants should be given for each experiment.

d) The report should have established the products of the reactions when Al was present. The observations confirm a redox reaction in which Al(0) is oxidized and hydrosulfite reduced. Was S(–2) formed?

e) The report states that heats of reaction were determined in the ARC experiments. If so, they should be given. These may be estimates of the number of joules generated per gram of mixture in each experimental run. A "heat of reaction" more usually refers to the enthalpy change associated with occurrence of a single chemical reaction (as represented by a chemical equation). Without knowing the products of a reaction, no chemical equation can be written and true heats of reaction are unobtainable.

Page 39 states: "Benzyl alcohol is produced by the reaction of benzaldehyde with sodium hydrosulfite." This is incorrect. Some source of H^+ must also be present.

Page 39 states: "The reaction products expected are consistent with the results of the chemical analysis of the site." This is technically true, but misleading. The chemical analyses detailed in Appendix A establish only the elemental composition of the inorganic residues and are "consistent" with *any* set of reactions that includes compounds of sodium and potassium among their products.

The sentence on page 39: "*The source of the large phenol concentration noted in the grab samples from the blender does not seem to be a result of the reactions of the reported mixture materials but most likely occurred at some time during initial attempts to blend the GPA components.*" is self-contradictory. The generation of phenol "during initial attempts to blend the GPA" would *have* to result from "reactions of the reported mixture materials." That is, "GPA components" equal "mixture materials." If the sentence means that the phenol arose from the GPA

components, it opposes the earlier conclusion (page 34) that "[p]henol and the methylphenol compounds were likely due to the insulating material remnants...."

Other Comments

Page 3. Potassium carbonate is not an alkali metal but rather a compound of an alkali metal. Its physical and chemical properties differ sharply from those of the alkali metals.

Page 8. A pyrophoric substance is one that takes fire on contact with air under ordinary conditions, not "under appropriate conditions." Newspaper bursts into fire spontaneously ''under appropriate conditions" but newspaper is not pyrophoric.

Page 8. The statement: "Benzaldehyde readily oxidizes to benzoic acid," should be replaced by "Benzaldehyde is readily oxidized to benzoic acid upon exposure to the air."

Page 18. "A deflagration releases energy at a lower rate. . .and is less destructive than a detonation." The following definitions from the literature would clarify this discussion: "a deflagration is a soft explosion [in which] pressure are relatively low. . . . Explosions involve pressures of several atmospheres. . . . Detonation is a severe form of explosion when pressures are much higher and are propagated at a high rate (as much as several miles per second)."[9]

Page 20. The report states: "At 10:00 am on April 20, operators detected a vanilla-like odor in the liquid feed tank...." This contradicts the Timeline of Events exhibited on page 11 of the report, which sets the detection of the vanilla-like odor at 12:30 p.m.

Page 22. The list of the most likely predominant reactions omits the combustion of the hot sodium hydrosulfite, upon contact with the air.

Page 25. It is stated: "If a large amount of water was injected into the material in the blender, the JCAIT believes a large hydrogen gas bubble would have been formed, causing a detonation with greater energy th[a]n was released in the accident." The belief needs justification. Presumably, the gaseous hydrogen would result from reaction of the large amount of water with the powdered aluminum. The rate of this reaction depends strongly in the temperature (see report page 38). Did JCAIT estimate the temperature? How? Did JCAIT estimate the amount of energy released in an accident? Hydrogen bubbles (as in

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[9] Mahn, W. J., *Academic Laboratory Chemical Hazards Guidebook*, Van Nostrand Reinhold, New York, 1991, page 7.

balloons) deflagrate when ignited in the air. If hydrogen forms, why must it detonate?

RECOMMENDATIONS

Complete and release the report more promptly.

Include details of the analytical methods used in the course of an investigation and at least some representative analytical findings in an appendix.

Integrate decisions about the type and extent of chemical analysis fully into the investigations.

Take care to avoid loose ends. If observations or physical findings are judged irrelevant, then the report should state as much, and tell why.

Use the chemical literature more aggressively to check facts.

Include full literature references in some uniform format.

Use a technical editor. This report is not very well written.

Review of
EPA/OSHA Joint Chemical Accident Investigation Report Napp Technologies Inc., Lodi NJ
by Wade A. Freeman August, 1998

This review comments on the completeness, technical soundness, and overall approach of the report on the investigation of the April 21, 1995 explosion at the Napp Technologies facility.

Comment-on the Overall Approach

The Joint Chemical Accident Investigation Team (JCAIT) assembled background information and gathered testimony to create a chronological description of actions and events preceding the accident. The team evaluated this record, physical evidence at the scene, documents describing the equipment and chemicals in use, and descriptions of similar equipment located elsewhere to arrive at a list of Significant Facts in the accident. JCAIT then listed possible causes of the accident and used _engineering analyses of this information+and professional judgement - to determine root causes and contributing factors. This led to a set of recommendations.

This overall approach is sound. However, some causes of the onset of the unwanted chemical reactions are not explicitly considered in the report.

JCAIT should have gathered data relative to such possibilities and sought to rule them out. The analyses performed do not firmly establish the chemistry of the accident. Some evidence and testimony are insufficiently discussed.

Were Analyses Sufficient?

Chemical analyses of the residues left by an explosion can reveal important details of the reactions that took place. JCAIT discusses their chemical analyses in Section 3.1 (page 18) and details them in Appendix A (page 31) of the report.

1. Insufficient detail is provided on the chemical analyses. JCAIT fails to state or reference the analytical methods that were used. No account is given of the selection of sampling sites, the number of samples taken, or the number of samples analyzed.

2. Analytical results are given in non-numerical terms (such as -Percentage amounts6 or large amounts6). Numerical findings should appear in Appendix A.

3. The analyses were poorly selected. Mere elemental analysis of the

residues is unhelpful (as the report notes). A program of qualitative and quantitative analysis for a range of inorganic compounds should have been conducted. Finding specific substances or classes of substances in the residues would allow conclusions to be drawn about the chemical changes within

the blender over the course of the accident. For example, finding residual elemental sulfur would support the reaction scenario laid out in Appendix B. Detection of sulfide sulfur would show that reactions took place other than those discussed in the report. As it is, the report makes no mention at all of sulfur in the residues.

4. Analyses for sulfur and sulfur-containing compounds should have been carried out.

5. Three organic compounds were identified -in large amounts- in internal and external residues of the explosion: phenol, 2-methylphenol, and

4-methylphenol. The report concludes that these compounds probably derived from the insulation that lined the blender but could also have derived from the benzaldehyde that was added to the mix. Appendix A proposes a route to phenol and the two methylphenols starting with benzaldehyde. The following comments apply to this portion of Appendix A:

a) other passages in the report seem to indicate that benzaldehyde was never in the blender. Page 20 includes, as part of a Significant Fact, the statement that -operators were unable to inject benzaldehyde, the sole liquid component of GPA, into the blender. - Page 24 has the sentence: -However, given that operators were not able to inject the benzaldehyde into the blender it is unknown if any water in the feed line actually entered the blender.
-obviously, if benzaldehyde never got into the blender, the phenol compounds did not derive from it. Even if a small amount of benzaldehyde made it into the blender, it would not explain the detection of these organic compounds _in large amounts.-
b) The proposed route to the phenol compounds is inconsistent with known chemistry. Toluene would not be converted to phenol under the reducing conditions in the blender. The report seems to call this conversion, which is an oxidation, a -classic electrophilic aromatic substitution.- It is not. It may be that the report refers to the methylation of phenol as the electrophilic aromatic substitution. Such a methylation would require acidic conditions, a methylating agent and phenol. All three were absent in the blender.

Aqueous sodium hydrosulfite reduces benzaldehyde to benzyl alcohol (C6H5CH20H) in a two-electron reduction, This reaction is also plausible under the conditions in the blender. Benzyl alcohol is presumably the -methyl hydroxy (alcohol) intermediate - mentioned in Appendix A, although benzyl alcohol (and benzaldehyde) contain no methyl groups. Four-electron reduction of benzaldehyde to toluene is also conceivable:

C6HSCOH + 4 H+ + 4e- ---> C6H5CH3 + HOH

However, both.reductions require H+ in addition to the electrons supplied by the reducing agent. The H+ would have to come from impurities containing active hydrogen (such as water or benzoic acid) because the nominal components of the blender furnish no hydrogen.

c) The chemical composition of the-rigid foam material- used to insulate the walls of the blender and any additives in the aqueous coolant solution should have been ascertained (for example, by asking the manufacturer). This might rule out the insulation and coolant as a source of the phenol and methylphenols.

d) The speculation concerning the source of the phenol compounds is misplaced. Appendix A should detail experimental and observational results. Interpretation properly belongs in the body of the report.

6. The first paragraph describing the analysis of the blender (in Appendix A) states: The damage initially appeared to be the result of a steam explosion inside the water jacket lining. Did JCAIT later retreat from this assessment? If so, why? Strong heating inside the blender conceivably boiled the coolant and so caused the rupture of the outer jacket just before the explosion. In this sequence coolant water might even have touched off the explosion. Such a series of events is not inconsistent with the report (page 16) of three loud hissing noises and a -whoosh- sound preceding the explosion.

7. Analysis of the physical condition of the bodies of the victims is the sole basis used to classify this event as a deflagration (_soft explosion - rather than as an explosion or detonation. The analysis of the remains of the blender should have been extended with a view to confirming or denying this conclusion.

B. JCAIT reports (page 17) that a part of the emergency response was acquisition by a USEPA mobile laboratory of _downwind air samples of inorganic/acid gases, organic, and ketones.- No other mention is made of these samples. Does this sentence mean that acidic gases, organic compounds and ketones were in fact found in the samples? What analyses were performed on the mobile laboratory samples? What were the results? Were the results evaluated with respect to the chemistry of the explosion? Perhaps the mobile laboratory intended solely to check for toxic releases and obtained negatives for deleterious compounds in their analyses. If so, the report should say so explicitly.

9. The report states (page 23) that JCAIT conducted -metallurgical analysis of the blender after the accident.- This is somewhat misleading. Appendix A details a thorough visual examination of the blender and a single microscopic measurement (to obtain the depth of the grooves in the graphite seal).

10. An attempt should have been made to establish the conditions of temperature and humidity prevailing in the blender room over the course of the operation. Are all sources of information properly identified?

Reports of this type should adhere to standard practices of attribution. JCAIT is erratic in this respect. The reference on page 39 to -EPA Trip Report, July 5, 1995- does not appear in Appendix D. Did the report originate wi the EPA members of JCAIT or with other representatives of the EPA? The in-text details about Tartani and Contessa_s paper on page 40 mostly duplicate the citation in Appendix D. A flash point for powdered aluminum/air mixtures

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JCATT identifies two -most likely_ sources of initiation: accidental wetting of the blend and frictional heating from over-use of the intensifier bar. Both are plausible. it is essentially certain (see below) that water was reacting in the blender during the time preceding the explosion. Two very likely sources of water are identified: leakage past the intensifier bar seal and residual water in the liquid feed line. These are reasonable possibilities. Both might have contributed concurrently to dampen the blend.

Were all possible sources of initiation identified? Were the likely causes of the chemical reaction explored fully?

The most likely causes of the chemical reaction were identified and explored. other possible causes were not explored sufficiently. The approach should have been to entertain all possibilities and analyze the facts to rule out as I many as possible.

1. The report does not deal effectively with the possibility that wrong ingredients or the contamination of ingredients contributed to the chemical events in the blender. A few sentences suggest that the chance of inadvertent substitution or contamination entered the deliberations of JCAIT. Page 34 states that the benzaldehyde chemistry that the report has just elaborated . . . tends to eliminate the possibility that phenol, rather than benzaldehyde, had been inadvertently added - Page 8 notes the fact that benzaldehyde is oxidized to benzoic acid when exposed to the air and inserts some descriptive chemistry of benzoic acid. Page 23 states (correctly) that moisture present in any of the raw materials could have sufficed to initiate a reaction. Page 31 mentions -inadvertent mixing of different chemicals that could+occur. Elsewhere however, JCAIT accepts the quality of the raw materials without proof. Page 3 states: -The 1995 blending ingredients were virtually the same as in 1992. This assertion requires analytical confirmation. (Incidentally, if -virtually_ means -very nearly,- then in what ways did the ingredients in the 1995 disaster differ from the ingredients in the 1992 success?) Any details that support the -virtually__ belong in the report. Page 23 mentions a quality assurance check that Napp performed on the raw materials that did not find moisture. Details should appear in the report. JCAIT apparently accepts the lack of apparent reaction during the loading of the blender to rule out the presence of moisture in the raw materials. This overlooks possible delayed onset of reaction, a common occurrence.

Residual portions of the ingredients should have been collected (from the bottoms of supply drums, for example) and analyzed. These drums were present in the blending room at 7 p.m.

(page 13). If unmixed starting materials failed to survive the accident and clean-up, then the report should say so. In the absence of residual ingredients, JCAIT could have attempted to confirm the chemical identity of the materials loaded into the blender inferentially.

This would include checking the source of the materials, conducting analyses of materials from the same production lot, and making inquiry into conditions of transport, storage, and handling.

2. The report does not consider the possible influence of -normal- impurities.
a) According to Kirk-othmer, the highest grade of industrial anhydrous sodium hydrosulfite c ontains 889. Na2S204 by mass mixed with 39. sodium disulfite (Na2S205), 3%- sodium sulfite (Na2SO3), 3t sodium sulfate (Na2SO4), and 3t sodium carbonate (Na2CO3). A lower grade of sodium hydrosulfite contains only 80 percent Na2S204 by mass. According to the same source, anhydrous sodium hydrosulfite is produced by four methods: formate reduction, amalgam reduction, zinc reduction and electrolytic reduction. Each naturally leaves a different set of impurities. it would have been informative to find out whether the GPA components in the April 1995 accident were of the same grade and produced by the same reactions as those that were successfully blended in July 1992.

b) Depending on the way in which anhydrous potassium carbonate (K2CO3) is prepared, it contal. ins as much as 3'@ water by mass. Potassium carbonate is hygroscopic; its recommended mode of storage is in bunkers ventilated with dry air. The hydrate K2CO3.1.5H20, which contains about 16t water by mass and deliquesces in moist air, is readily available in commerce as dustless crystals. Conceivably, water associated with the potassium carbonate initiated the reaction events in the blender.

3. Particle size and shape can affect the progress of dry blending operations. JCAIT should have checked the state of subdivision of the materials in the accident to that of the materials that were successfully blended in 1992. This goes to the issue of undue heating from the intensifier bar as well.

4. With a view to confirming the proposed reaction scenario, JCAIT should have sought samples of authentic GPA and run experiments in which varying amounts of water are added under the conditions prevailing in the blender. These experiments would resemble the experiments described in Appendix B, but would aim to identify the products as well as to measure the temperature rise.

5. JCAIT failed to consider some clues to the reactions taking place in the blender. An employee who entered the blending room at 7 p.m. reported a smell of -rotten eggs_ (page 13). An employee who entered the blending room at 10 p.m. noticed a -dead animal- smell. Employees arriving for work the next morning also reported a rotten-egg odor (page 14) that - . . had escaped the building and was noticeable in the parking lot. . . .- it is a mistake to write off these odors as a generic -sulfur smell6 (page 28). The witnesses are almost certainly reporting the presence of hydrogen sulfide (H2S). The odor of H2S is universally compared to rotten eggs or other decayed material (the rotting of eggs in fact generates hydrogen sulfide). Furthermore, H2S deadens the

sense of smell. This fact accords with the prevalence of rotten-egg reports among newcomers to the scene. JCAIT focuses on the generation of sulfur dioxide from sodium hydrosulfite (page 37). Sulfur dioxide has a characteristic choking or suffocating odor that is never compared to rotten eggs. Sulfide sulfur (sulfur in the +2 oxidation state) would form if aluminum reduced sodium hydrosulfite fully. Thus the reaction 10 Al + 3 Na2S204 --- > 3 Na2S + 4 A1203 + A12S3 might accompany or replace the second reaction on page 39. Reduction to S(2) is quite pl ausible. Such a reduction would be exothermic. The conversion of sulfides to H2S, which boils at +60.7oC, requires a source of H+. Hence, detection of H2S at 7 p.m. indicates that a substance with active hydrogen (such as water or benzoic acid) was in the blender by that time; the rotten-egg odor rules out the -friction-only_ scenario at the bottom of page 25 of the report. Despite the overall basic conditions in the blender, local concentrations of H+ donors could easily generate H2S, which would out-gas rapidly because of its high volatility.

The emission of H2S does not prevent simultaneous or subsequent generation of gaseous sulfur dioxide (SO2) according to the equations on page 37. Indeed, the puffs of white smoke coming from the blender at 5:30 a.m. might well have been an acid mist formed as vented S02 reacted with moisture in the air; H2S would not form such a mist.

6. JCAIT should have checked Napp_s records to ascertain the contents of the liquid feed system in its last prior use. Residual content might account for the -vanilla-like odor- detected in the tank when operators prepared to add the benzaldehyde (page 12). This odor is a loose end in the report. It is (remotely) conceivable that the material with the vanilla-like odor entered the blender and influenced the chemistry within.

Comment on the Discussion of Root Causes and Contributing Factors

The report does not satisfactorily exclude the possibility that one (or more) of the raw materials originally contained water or another initiating

substance or became contaminated with water or such a substance during transportation and storage. This point gains importance because it is known that one of the bags of potassium carbonate had been broken open and taped over (page 10).

Reactions in the blender could have been taking place at several hot spots, of which only one was observed. Reactions could also have been taking place throughout the batch but with particular intensity at the observed hot spot. Therefore, the assertion (on page 23) +the bubbling noted towards the middle of the blender reveals that the reactions did not take place at the walls of the blender+- is logically faulty.

Page 10 of the report establishes that the operators knew that they were processing water-reactive chemicals. Page 12 states that the operators found water in an internal filter on the liquid feed line and adds: -The operators did not consider the liquid feed line to be functioning properly. The liquid spray head and spray system had not been completely dried prior to the charging of the blender.- This was clearly on-the-spot opinion because the operators proceeded next to

attempt to dry the liquid feed system by rinsing it with isopropyl alcohol and blowing nitrogen through it. Page 24 in fact implies that other attempts took place (- +several drying/vacuum procedures were performed-); these problems are not detailed elsewhere in the report. JCAIT should clarify what made the operators think the liquid feed system was dry enough to permit injection of the benzaldehyde. An error in judgment on this point might have been the proximate cause of the accident.

JCAIT should have confronted the issue of the missing 47 minutes. A great deal might have happened in the blender room between 7 a.m., when Napp employees reentered with the intention of unloading the blender, and 7:47 a.m., when the blender exploded. was actual progress made in removing the contents of the blender? If facts are not available, the report should say SO.

On page 23, the report states that information was received to indicate that operators might have used water or steam to unclog the liquid feed line. The report then immediately states that JCAIT was able to confirm that attempts to clear the feed line did not involve water or steam. The sources and resolution of the conflicting testimony should be given in more detail. On page 28, JCAIT concludes there is no evidence to suggest that Napp was aware that off-loading the blender may have exacerbated the reaction mechanisms by exposing the contents to air or that the contents could violently erupt and deflagrate. This is at odds with the reported prolonged efforts by Napp to protect the blend from the air by use of a nitrogen blanket. Also, exposure to the air would not aggravate the reactions already proceeding, but would (and did) occasion a new set of reactions, namely, air oxidations.

-The training of the fire brigade and emergency responders was inadequate is difficult to sustain as contributory to the accident. The picture is of the fire brigade standing ready to charge their hoses and direct water on command.

What could they have done otherwise, no matter what their training? JCAIT does not report the employee training records or the capabilities of the emergency responders who were not members of the fire brigade. In the absence of such information the conclusion that the training of this group was inadequate is not justified.

Comment on Recommendations

JCAIT makes helpful and appropriate recommendations. The recommendation against the use of liquids to cool or purge seals in processing equipment if the liquids are chemically incompatible with the materials being processed is particularly important. it should appear in full in the Executive Summary. The version - . . . ensure that equipment manufacturers- recommendations for proper use of equipment are followed. . .- is vague.

Comments on Appendices and Illustrations ILLUSTRATIONS

Figure 3A (page 14) shows neither the route along which the benzaldehyde was intended to flow nor the route by which it ended up in the vacuum separator bowl. A proper schematic diagram of vacuum collection system would help the reader far more. APPENDIX A

As noted in the preceding, detail on the nature of chemical analyses and their results are lacking.
APPENDIX B

Equation 3 (showing the disproportionation of sodium disulfite) has a typographical error. It should read 2Na2S205 --- > 2 Na2SO4 + S02 + S

The calorimetry studies described on page 39-40 require additional detail:
a) A description of the ARC method, or a reference to a suitable background paper should appear.
b) The sources and purity of the substances used in the studies should be stated.
c) The amounts and the method of mixing of the reactants should be given for each experiment.
d) The report should have established the products of the reactions when Al was present. The observations confirm a redox reaction in which AI(o) is oxidized and hydrosulfite reduced. was S(2) formed?
e) The report states that heats of reaction were determined in the ARC experiments. If so, they should be given. These may be estimates of the number of joules generated per gram of mixture in each experimental run. A -heat of reaction- more usually refers to the enthalpy change associated with occurrence of a single chemical reaction (as represented by a chemical equation). Without knowing the products of a reaction, no chemical equation can be written and true heats of reaction are unobtainable.

Page 39 states: -Benzyl alcohol is produced by the reaction of benzaldehyde with sodium hydrosulfite.- This is incorrect. Some source of H+ must also be present.
Page 39 states: -The reaction products expected are consistent with the results of the chemical analysis of the site. - This is technically true, but misleading. The chemical analyses detailed in Appendix A establish only the elemental composition of the inorganic residues and are -consistent- with any set of reactions that includes compounds of sodium and potassium among their products.

The sentence on page 39: -The source of the large phenol concentration noted in the grab samples from the blender does not seem to be a result of the reactions of the reported mixture materials but most likely occurred at some time during initial attempts to blend the GPA components._ is self-contradictory. The generation of phenol _during initial attempts to blend the GPA- would have to result from -reactions of the reported mixture materials.- That is, -GPA components_equal -mixture materials.- If the sentence means that the phenol arose from the GPA components, it opposes the earlier conclusion (page 34) that plhenol and the methylphenol compounds were likely due to the insulating material remnants .....

Other Comments

Page 3. Potassium carbonate is not an alkali metal but rather a compound of an alkali metal. Its physical and chemical properties differ sharply from those of the alkali metals.

Page B. A pyrophoric substance is one that takes fire on contact with air under ordinary conditions, not -under appropriate conditions._ Newspaper bursts into fire spontaneously -under appropriate conditions- but newspaper is not pyrophoric.

Page B. The statement -Benzaldehyde readily oxidizes to benzoic acid, - should be replaced by _Benzaldehyde is readily oxidized to benzoic acid upon exposure to the air.

Page 18. -A deflagration releases energy at a lower rate. . and is less destructive than a detonation.. The following definitions from the literature would clarify this discussion: -a deflagration is a soft explosion [in which] pressure are relatively low. . . . Explosions involve pressures of several atmospheres . . . . Detonation is a severe form of explosion when pressures are much higher and are propagated at a high rate (as much as several miles per second).

Page 20. The report states: At 10:00 am on April 20, operators detected a vanilla-like odor in the liquid feed tank....- This contradicts the Timeline of Events exhibited on page 11 of the report, which sets the detection of the vanilla-like odor at 12:30 p.m.

Page 22. The list of the most likely predominant reactions omits the combustion of the hot sodium hydrosulfite, upon contact with the air.

Page 25. It is stated: - If a large amount of water was injected into the material in the blender, the JCAIT believes a large hydrogen gas bubble would have been formed, causing a detonation with greater energy th[a]n was released in the accident. The belief needs justification. Presumably, the gaseous hydrogen would result from reaction of the large amount of water with the powdered aluminum. The rate of this reaction depends strongly in the temperature (see report page 38). Did JCAIT estimate the temperature? How? Did JCAIT estimate the amount of energy released in an accident? Hydrogen bubbles (as in balloons) deflagrate when ignited in the air. If hydrogen forms, why must it detonate?

RECOMMENDATIONS

Include details of the analytical methods used in the course of an investigation and at least some representative analytical findings in an appendix.

Take care to avoid loose ends. If observations or physical findings are judged irrelevant, then the report should state as much, and tell why.

2. Use the chemical literature more aggressively to check facts. Include full literature references in some uniform format.

Use a technical editor. This report is not very well written.

I devries and Kellogg, J. org. Chem. 45, 4126, 1980.

2 Kirk-Othmer Encyclopedia of Chemical Technology, 4th edition, John Wiley Sons, New York, 1998, Vol.

3 Ullman-s Encyclopedia of Industrial Chemistry,_ Sth edition, VCH Weinheim, Germany, 1993, Vol. A22, page 99.

4 Ullman-s Encyclopedia of Industrial Chemistry,_ 5th edition, VCH Weinheim, Germany, 1993, Vol. A22, page 99.

5 Lewis, Richard J., Hazardous Chemicals Desk Reference, Van Nostrand Reinhold, New York, 1993, page 691-2.

6 Mahn, W. J., Academic Laboratory Chemical Hazards Guidebook, Van Nostrand Reinhold, New York, 1991, page 7.

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NAPP Technologies, Inc.
EPA/OSHA JOINT CHEMICAL ACCIDENT INVESTIGATION REPORT
EPA 550-R-97-002

A Critical Review
September 23, 1998

General Observations

Overall, the report answered many questions about the incident (especially given the unfortunate and preventable deaths of five workers with knowledge of the events, the destruction of production records, and what appeared to be some reluctance of Napp upper management and owners to provide all necessary information). The investigation team did a good job on the inspection and the report. It is unfortunate that the staffing levels of both agencies was (and remains) such that more time and personnel could not be dedicated to getting the report out in a faster manner. I agree completely with the other peer review team members that these reports need to be written and released as soon as possible after the incident, in order to ensure that the report can have a greater impact.

The Facility Information, Process Information, and Chemical information sections clearly provided the necessary background information. However, it would have been useful to have (if it survived the fire or was otherwise available) a copy of Napp's hazard analysis on the operation, a copy of the MSDSs supplied to Napp, and a copy of any correspondence between Napp and Technic (or other companies) which was relevant to the operation. In addition, a copy of the incident report from the Lodi Fire Department would have been helpful. These could all be placed in the report as appendices.

A description of Technic Inc. and its expertise in chemical blending / processing would have been useful, if that information was available and if the writers were allowed to include that information. This would, perhaps, help to place some of the potential problems with tolling into perspective. If OSHA and EPA were not able to investigate Technic's expertise due to some legal reason, those reasons should have been noted in the report (in most circumstances) and recommendations on how to eliminate such reasons should have been included in the report.

The Description of the Accident was helped greatly by the timeline in Exhibit 1. However, it was difficult to keep the personnel straight, given the number of workers, supervisors, foremen, etc. over the three days and four shifts covering the incident. It was difficult to know how many shift supervisors were involved and if the same night shift supervisor was involved on successive days (while names cannot be used, perhaps a number or letter designation would be helpful in future incident reports).

The discussion of the possible sources of water was very good and the conclusions as to the causes of the deflagration appear to be very reasonable.

The photos were difficult to understand due to poor reproduction which eliminated much of the contrast needed to make out important details.

I would have preferred to see a greater amount of emphasis on the failures of the Napp "management system" and how those lead to the incident. (I cannot refer to the oversight system at Napp as a management system without putting that term in quotations, since it appears that it was a safety management system in name only.)

Executive Summary / Overview

◆ In general, the report seems to clearly identify root causes. However, I believe that while the report does address some issues of potential problems in tolling operations (as shown in this incident), the Executive Summary/Overview seems to de-emphasize the potential problems surrounding tolling. These specifically are the issues of:

- accountability of the contracting company (owner of the process/technology) versus that of the contractor (Napp) for training, hazard evaluation and oversight of the process; and, potentially,

- the need to conduct an on-site evaluation of the contractor facility and equipment.

While I understand that there may be no rules or guidance to require/encourage this, these are still, potentially, root causes or contributing factors.

◆ My second concern with the Executive Summary/Overview is probably more one of wording. Many employers look at the words "training" and "employees" and apply them only to non-supervisory employees. Clearly, a major problem identified throughout the report is the lack of training of supervisors in the areas of hazard recognition, procedures to follow when operations are "out of spec" (even when to call responsible parties within Napp), and emergency response. I strongly believe that the report should make clear that training was inadequate for both hourly employees and supervisory personnel, if that is what the investigation team found. If the team had concerns as to the ability of top management to adequately determine hazards, then that should also be clearly stated as a factor.

Chapter 1 Background

1.1 Facility Information

Facility Chemical Review Procedures

It would have been helpful to have a copy of Napp's "New Product Review" procedure included in the report, along with a description of the general deficiencies within that review process. This could help others in determining where their PHAs may be deficient. Also, the description of those involved shows that no operators or other line workers had any role in the review. Trevor Kletz and other experts in this field identify the need for line worker involvement.

1.2 Process Information

This section was quite thorough. It would have been useful to have Figures 2 and 3 situated vertically; this would make it easier to refer from the text to the diagrams. In addition, a scale should be added to provide some sense of actual dimensions. The descriptions proved here are very useful.

1.3 Chemical Information

In rereading this section, it strikes me that the instructions in the MSDS for the Gold Precipitating Agent to "... flood the material with water to ensure complete wetting ...", could be correct for a drum of material. If so, that should be noted as well as whether or not those instructions should apply to much larger amounts. Many users and others may not be aware of the difference. This raises the question of whether MSDSs should be required to note whether precautions and emergency procedures apply to any amount of material.

I think it would have been useful to many users to have a section which showed the ideal system for blending such reactive chemicals. A summary of why each specific piece of equipment Napp used was improper for the job would also have been useful.

Other Background Issues / Concerns

I would have liked to have seen a broader discussion of the tolling industry, possibly as an appendix. A listing of significant incidents at such operations would also be valuable; however, I realize that finding such information is often very difficult since I don't believe that OSHA or EPA code such operations in their data bases. A discussion of whether or not tolling operations should be investigated in more depth by OSHA, EPA or the CSHIB would be useful.

If the reviewers had any specific regulatory recommendations regarding tolling operations or recommendations for guidance (versus regulations) which were not included in the final report, they should have been. However, I understand that it is often difficult to include such recommendations in official reports, given the potential legal implications to the agencies. These might include such issues such as making both employers responsible for the PHA and other requirements, as well as legal responsibility (for civil and criminal citations and penalties). OSHA and EPA should look into this area and, possibly, begin the rulemaking process to address such problems (e.g., a Notice of Proposed Rulemaking).

Chapter 2 Description of the Accident

◆ While the length of time over which the event occurred was extremely long, the description was generally quite complete. However, as noted above, it would be useful in future reports to provide some designation for each worker and supervisor so that actions and observations can be connected to specific people. This would help the reader to better understand where there were communication breakdowns.

◆ The report should be specific that there was no reason why a non-cooled (or at least a non-water cooled) blender could not have been used. Also, the report should state:

- Whether or not such blenders were available at Napp; and,

- Whether or not the blender could have been made "safe" by disconnecting the water feed and the blanking off the flange without affecting the proper operation of the blender.

◆ If there was any testimony as to why the first shift supervisor did not check the liquid feed line and intensifier bar for leakage, that should have been included in that, given that a very slow leak might not introduce enough water to be noticed immediately after repair. This would help others to make proper decisions in similar circumstances.

◆ It appears that there had been no testimony as to why the night shift foreman assumed the water was condensation. It seems obvious in hindsight that this was a major error and could have been avoided had the SOP called for some other action. One question which still remains in my mind is whether the decision to wipe out the condensation rather than investigate all the possible sources was based on time and cost concerns or whether it was based on a lack of training and/or real power to make decisions. With the information that the site was expecting an FDA inspection the next Monday, the decision to fill rather than investigate could also be due to a need to finish and clean up before that FDA inspection. To me, this suggests that a tolling operation, knowing when inspections by a regulator will occur, could end up taking unnecessary risks. Is this problem?

◆ I strongly believe that the term "accident" should be avoided. That term implies "unforeseeable" and/or "unavoidable" to many readers.

Chapter 3 Analyses and Significant Facts

This section is very informative and well laid out. I have only few comments.

◆ A literature review and laboratory study of the hazards of the GPA mixture of the is noted on page 19. From a review of Appendix B, it appears that this refers to the OSHA Salt Lake City Technical Center. If so, this should be clearly stated here; if not, the reviewer / experimenter should be stated. Also, it would be helpful to have the term "small quantities" quantified (e.g., milliliters). This would help reviewers and others using this document.

◆ On page 21, it is noted that the use of an internal alarm would have notified the local emergency responders. It would be useful to know whether or not an automatic sprinkler system or other fire suppression system was in place and functioning at the plant, or whether one was required by code or could be required (if the lack of one was "grandfathered"). At one plant where ICWUC represents workers, a fire of what turned out to be water-reactive chemicals in the warehouse caused the fire sprinklers to activate, compounding the extent of the fire and damage. The sprinkler system was required under NFPA and/or NFC. While this did not happen at Napp, contradictory standards for reactive chemicals could pose a serious hazard at other tolling operations and at chemical processing / storage operations in general. This may be an area which OSHA, EPA and the fire code organizations should investigate.

Chapter 4 Causes of the Accident

◆ The discussion of possible causes of the chemical reaction did not address a possibility raised on page 7 of this document: the potential reaction of aluminum powder with sulfur dioxide (a decomposition product of sodium hydrosulfite). Since both compounds could have been present once decomposition started, it seems that this should have addressed, even if only to suggest that it would be a minor contribution, if any, to the deflagration or to be eliminated as a possible reaction. Otherwise, this section looks very good.

◆ One item seems to be missing from the discussion of root causes and contributing factors: the seeming breakdown, or perhaps, nonexistence of a clear chain of command in decision making when serious problems arose with the blending operation. The lack of communication within the Napp management "structure" throughout this event (as related in the summary in this report) was astounding. I would have liked to see some discussion of this. Napp also appeared to leave operators and other hourly workers out of the decision making loop in evaluating hazards. OSHA strongly advises this (and to some degree requires this) in the PSM standard, while EPA does not address this in the RMP rules. The report should have addressed this as at least a contributory cause of the incident.

◆ I believe that is important to stress that training for management was inadequate for foremen, supervisors and even upper management to make proper decisions or properly direct the workers in the plant, if that was the belief of the investigators. If training had been done but was inadequate, it would be helpful to spell out those inadequacies point by point.

Chapter 5 Recommendations

The recommendations noted in the report are all clearly supported by the report itself and should help to reduce risk in other operations, if they are read. I agree with other reviewers that there needs to be good, simple methods of getting this information out to those most affected: the plants, workers, unions, supervisors, engineers and process designers, chemists, fire department personnel (including fire marshals and investigators), etc.

In addition, the need for employers to involve their workers (at all affected levels) in the recognition and evaluation of abnormal situations, the proper use of equipment, and in the development of PHAs, SOPs and training, needs to be stressed. Again, in my experience, that is OSHA's policy and belief and should be clearly stated here, in order to make these more proactive recommendations. Too many employers are still content to tell workers to "look it up on the MSDS" rather than train workers as required under the HazCom standard. Those same employers are usually not much better at training supervisors.

Chapter 6 Outcomes of OSHA/Napp Technologies Settlement

A number of OSHA settlements have given both OSHA and the Union specific rights of entry and involvement in evaluating the progress under the settlement agreement. If OSHA and/or the union were given any specific rights under this agreement, this should be noted here. As written, this looks like OSHA will rely on Napp's "good will" to ensure compliance.

As I understand our discussions, Napp's attorneys were allowed to review the preliminary report for errors and confidential business information. A list of which outside groups were able to review the report, prior to release, should be noted in the preface.

Appendices

Appendix B - Chemical Reactions

◆ There were two significant typographical errors in this section. In the second paragraph, the formula for sodium thiosulfate is wrong. On page 39, the reaction arrows for both aluminum reactions are missing.

◆ The third paragraph states that "only catalytic amounts of water are needed ...". I would find it helpful to know what are considered to be "catalytic amounts" in the case of this mixture, with some discussion of how those catalytic amounts must be dispersed in a mixture (e.g., will 0.5% in a small portion of the mixture cause a self sustaining reaction or does it take that amount in a much larger volume of the mixture).

Appendix E - Photos

◆ The photos are helpful but would be much more so if they were reproduced better and details were labeled. They are difficult to understand due to poor reproduction which has eliminated much of the contrast needed to make out important details. In a number of cases, the backgrounds fade into the surrounding page, making it difficult to orient one's view. The use of a scale would be helpful, as would labeling of parts noted in the descriptions. The vacuum head (or spray nozzle?) in the two photos which make up Figure 5 would have been best adjusted to the same size and then joined together. Again a scale would be useful here.

I realize that this was the first joint investigation report done by OSHA and EPA. These reports are quite valuable as shown by the information provided by this report. I hope that my comments are taken in the spirit of building on the strong foundation which this report provides for future work. I know that the authors of this report worked under a great deal of time pressure as well as the pressures of trying to complete their other work on ongoing serious incidents. They should be commended for work well done.

Michael Sprinker initial comments - September 2, 1998

Here are my initial observations regarding the EPA/OSHA Joint Chemical Investigation Report for the Napp Technologies incident. As these are preliminary, additional readings of the report and discussions during the upcoming meeting may result in changes to these observations.

The Facility Information, Process Information, and Chemical information sections clearly provide the background information. As a minor point, it would have been useful to have Figure 2 situated vertically; this would make it easier to refer from the text to the diagram.

The Description of the Accident was helped greatly by the timeline in Exhibit 1. However, it was difficult to keep the personnel straight , given the number of workers, supervisors, foremen, etc. over the three days and four shifts covering the incident. It was difficult to know how many shift supervisors were involved and if the same night shift supervisor was involved on successive days (while names cannot be used, perhaps a number or letter designation would be helpful in future incident reports).

Observations - Executive Summary/Overview

1. In general, the report seems to clearly identify root causes. However, I believe that while the report does address some issues of potential problems in tolling operations (as shown in this incident), the Executive Summary/Overview seems to de-emphasize the potential problems surrounding tolling. These specifically are the issues of accountability of the contracting company (owner of the process/technology) versus that of the contractor (Napp) for training, hazard evaluation, oversight of the process, and, potentially, the need to conduct an on-site evaluation of the contractor facility and equipment. While I understand that there may be no rules or guidance to require/encourage this, these are still, potentially, root causes or contributing factors.

2. My second concern with the Executive Summary/Overview is probably more one of wording. Many employers look at the words ôtrainingö and ôemployeesö and apply them only to non-supervisory employees. Clearly, a major problem identified throughout the report is the lack of training of supervisors in the areas of hazard recognition, procedures to follow when operations are ôout of specö (even when to call responsible parties within Napp), and emergency response. I strongly believe that the report should make clear that training was inadequate for both hourly employees and supervisory personnel, if that is what the investigation team found. If the team had concerns as to the ability of top management to adequately determine hazards, then that should also be clearly stated as a factor.

General Observations - Description of the Accident

1. I would have liked to have seen a broader discussion of the tolling industry, possibly as an appendix. This would be useful if it included a listing of significant incidents at such operations; however, I realize that finding such information is often very difficult since I donÆt believe that OSHA or EPA code such operations in their data bases. Perhaps some discussion of whether or not tolling operations should be looked at in more depth might be useful.

2. Did the reviewers have any specific recommendations regarding tolling operations and the recommendations for guidance (versus regulations?) which did not make it into the report? These might include such issues such as making both employers responsible for the PHA and other requirements, as well as legal responsibility (for civil and criminal citations and penalties).

3. Was there any reason why a non-cooled (or at least non-water cooled) blender could not have been used? Were such blenders available at Napp? Could the water feed have been disconnected and the flange blanked off with affecting the proper operation of the blender? If so, this might have provided a positive isolation from water. I don't recall reading this in the report.

4. Was there any testimony as to why the first shift supervisor did not check the liquid feed line and intensifier bar for leakage, given that a very slow leak might not introduce enough water to be noticed immediately after repair? (Pages 9-10)

5. Was there any testimony as to why the night shift foreman assumed the water was condensation? Was there anything in the SOP which called for some other action on the foreman's part? Is there any conclusion which pointed to whether this decision to wipe out the condensation rather than investigate all the possible sources was based on time and cost concerns or whether it was based on a lack of training and/or real power to make decisions? (Pages 10-12)

6. In my opinion, the term accident should be avoided. That term implies unforeseeable and/or unavoidable to many readers.

General Observations - Analyses and Significant Facts

This section is very informative and well laid out. I have only few comments.

1. A literature review and laboratory study of the hazards of the GPA mixture of the is noted on page 19. From a review of Appendix B, it appears that this refers to the OSHA Salt Lake City Technical Center. If so, this should be clearly stated here; if not, the reviewer / experimenter should be stated. Also, it would be helpful to have the term small quantities quantified (e.g., milliliters). This would help reviewers and others using this document.

2. On page 21, it is noted that the use of an internal alarm would have notified the local emergency responders. I could not find any discussion earlier of whether such an alarm was present or even of what alarms were present. In addition, it would be useful to know whether or not an automatic sprinkler system or other fire suppression system was in place and functioning at the plant. At one plant where ICWUC represents workers, a fire of what turned out to be water-reactive chemicals in the warehouse caused the fire sprinklers to activate, compounding the extent of the fire and damage. While this did not happen at Napp, this could be problem at other tolling operations and chemical operations in general.

General Observations - Causes of the Accident

1. The discussion of possible causes of the chemical reaction do not address a possibility raised on page 7 of this document: the potential reaction of aluminum powder with sulfur dioxide (a decomposition product of sodium hydrosulfite). Since both compounds could have been present once decomposition started, it seems that this should have addressed, even if only to suggest that it would be a minor contribution, if any, to the deflagration. Otherwise, this section looks very good.

2. One item (in my mind) seems to be missing from the discussion of root causes and contributing factors: the seeming breakdown, or perhaps, nonexistence of a clear chain of command in decision making when serious problems arose with the blending operation. The lack of communication within the Napp management structure throughout this event (as related in the summary in this report) was astounding. I would have liked to see some discussion of this.

General Observations - Recommendations

My comments above may, to some degree, affect the recommendations section. The recommendations noted in the report are all clearly supported by the report itself and should help.

General Observations - Appendices

Appendix B - Chemical Reactions

1. There were two significant typographical errors in this section. In the second paragraph, the formula for sodium thiosulfate is wrong. On page 39, the reaction arrows for both aluminum reactions are missing.

2. The third paragraph states that ôonly catalytic amounts of water are needed ...ö. I would find it helpful to know what are considered to be catalytic amounts in the case of this mixture, with some discussion of how those catalytic amounts must be dispersed in a mixture (e.g., will 0.5% in a small portion of the mixture cause a self sustaining reaction or does it take that amount in a much larger volume of the mixture).

Appendix E - Photos

1. The photos are helpful but are somewhat difficult to understand due to poor reproduction which has eliminated much of the contrast needed to make out important details. In a number of cases, the backgrounds fade into the surrounding page, making it difficult to orient ones view. The use of a scale would be helpful, as would labeling of parts noted in the descriptions. The vacuum head (or spray nozzle?) in the two photos which make up Figure 5 would have been best adjusted to the same size and then joined together. Again a scale would be useful here.

I do appreciate the excellent work of the investigation team and look forward to meeting with the team and the reviewers to discuss this document further.

EPA/OSHA RESPONSE TO REVIEWERS

EPA/OSHA have summarized and consolidated reviewers' comments and recommendations for the purpose of providing EPA/OSHA responses. Several comments were shared by several reviewers, and the Chair's report summarizes comments common to the group.

I. Comments and recommendations from the Chair's summary statement
II. Additional comments and recommendations noted by several reviewers
III. Additional comments and recommendations noted by individual reviewers

I. Comments and Recommendations from Chair's Summary

The Chair in his summary listed the following comments and recommendations as emphasized by all reviewers:

Reviewers noted that the report appeared to state correctly the root causes of the accident in terms of both technical mechanisms and technical failures.

They enumerated several elements which could have enhanced the report's usefulness:
--discussion of the types of chemical analyses done,
--discussion of the rationale used to eliminate plausible scenarios,
--clearer depiction of difficulties presented by the extent of destruction, which made certain analyses impossible and information difficult to obtain,

--better tracking of individuals involved through the chronology of the accident,
--time line of events.

EPA/OSHA Comment: We agree that these elements would have made the report clearer and will consider inclusion of such elements in any future reports on accidents.

The Agencies agree that information regarding the chemical analyses performed adds value and understanding to the accident investigation report. However, the agencies chose to summarize the findings of these analyses in the report and provided the names of the chemical analysis reports in the reference section of this report. The reports on the chemical analyses are quite extensive and were simply too large to feasibly incorporate into the report.

The Agencies agree that a clearer depiction of the difficulties presented by the physical destruction at the facility would have provided a greater understanding of the investigatory process. Due to the extent of the fire, most of the documentation of the blending process was destroyed (or could not be located). Because most of the information for this report came from interviews, and since the witnesses of the explosion perished, the investigators used what information they could find. There was a large amount of information that the investigators were unable to obtain. The Agencies agree that noting the information that was not available in the report would have provided value.

In the report, the Agencies had to strike a balance between tracking individuals who were involved in the accident and maintaining the confidentiality of these persons. The Agencies recognize that other ways of identifying the individuals (e.g. operator#1, manager #1, etc.) could have added clarity to the report, without compromising confidentiality.

The report contained supporting information for the investigators' rejection of plausible scenarios and a time line of events. The agencies agree that other tools (e.g. events and causal factors chart, MORT chart, etc.) could have enhanced the understanding of the investigation process.

Reviewers strongly encouraged EPA/OSHA to consider more detailed recommendations on the special risks associated with tolling operations and in the handling of water reactive materials. While guidance is certainly a possibility, rulemaking by either EPA or OSHA should be considered.

EPA/OSHA Comment: EPA and OSHA have taken several steps to address the risks associated with tolling operations, as a result of the information gathered during this accident investigation.

1. EPA is working with the Center for Chemical Process Safety (CCPS) (at the American Institute of Chemical Engineers) to develop guidance for the industry, to define the risks more precisely and to lay out practices and procedures in this important area. This is an important and logical first step to examine aspects of the problem and to then determine the best approach to disseminating information and ensuring better safety in the industry. We anticipate that CCPS will complete this project within one year.

2. EPA is developing an Alert for local officials that provides guidance on information resources during emergency responses, as well as managing reactive chemicals.

3. EPA and the National Oceanic and Atmospheric Administration (NOAA) have worked together to develop a database of reactivity information for more than 4,000 common hazardous chemicals. The database includes information about the special hazards of each chemical and whether a chemical reacts with air, water, or other materials. (http://response.restoration.noaa.gov/chemaids/react.htm)

4. OSHA is currently developing an Advanced Notice of Proposed Rulemaking (ANPRM) which seeks further comment on the applicability of the PSM Standard to reactive chemicals.

5. EPA is also reviewing the list of regulated substances subject to the Risk Management Program (RMP) regulations and will consider reactives.

However, EPA and OSHA do not believe that regulations specific to the tolling industry are necessary. The Occupational Safety and Health Act and the Clean Air Act Amendments, which are the authorities for the agencies' accident prevention programs, make the owner or operator of the stationary source (or the employer) who is handling the hazardous chemicals solely responsible for compliance with safety regulations at the facility.

The reviewers did not find the photos very useful and recommended higher quality photos using color, with high resolution photos posted on the Internet as a low-cost appendix to reports.

EPA/OSHA Comment: EPA has taken steps to acquire such capabilities and expects to have higher quality photographs in future reports.

The investigators are currently finishing a computer animated video based on the accident investigation report. This video is meant to support presentations where the audience can discuss the report with the investigators.

II. Additional Comments and Recommendations raised by Several Reviewers

Reviewers: The pre-release review which EPA and OSHA allowed Napp, but not the other stakeholders, should have been shared by all stakeholders, and the report should have been peer-reviewed.

EPA/OSHA Comment: Prior to releasing investigation reports, OSHA and EPA must ensure that the report contains no confidential business information. The Freedom of Information Act (FOIA), the Trade Secrets Act, and Executive Order 12600 require federal agencies to protect confidential business information from public disclosure. OSHA has issued regulations in 29 CR part 70, specifying the review process. To meet these provisions, OSHA and EPA have established a clearance process in which the companies mentioned in the report are provided a factual portion of the draft report. This portion contains only the factual details related to the investigation (not the findings, the conclusions or the recommendations). Companies are asked to view this factual portion to confirm that the draft report contains no confidential business information (CBI) or trade secrets.

Napp, Technic and Patterson-Kelley had ten business days to review the document for trade secrets and inform the Agencies. Napp claimed that the report contained CBI, but both OSHA and EPA found that these claims were without merit. Neither of the other employers claimed that publication would disclose trade secrets. Therefore, the Agencies published the report.

Prior to publication, the investigative report was extensively reviewed within the Agencies by technical and management staff. Release of the report to peer reviewers constitutes public release. Therefore, once the CBI review process described above was complete, the report was immediately made public and an expert review process began. The expert review, which is documented in this publication, is the external scrutiny which we agree is necessary for establishing the credibility of the investigative report and its conclusions.

Reviewers: The accident investigation report should have been published more promptly after the incident itself.

EPA/OSHA Comment: We agree. In the future, staff resources will be marshaled for any publications whose effectiveness can be blunted by a lack of timeliness. As a matter of Agency practice, EPA and OSHA, upon becoming aware of a hazard or safety issue during the course of an investigation, have promptly published Alerts to the stakeholder community. These precede publication of accident investigation reports. During the course of this investigation, OSHA issued a Hazard Information Bulletin describing the potential hazards of utilizing MSDSs as the primary sources of information for conducting hazard analyses for chemical process activities.

Reviewers: Information should have been included in the report about the actions taken during the response operation and about the notification of local authorities and their relationship with the company.

EPA/OSHA Comment: Early in the EPA/OSHA investigation, the Agencies decided to limit its scope to the events leading up to and including the explosion. This included the actions of persons at Napp

Technologies, as well as Technic Inc., that contracted for the tolling operation. More information about the emergency response would have allowed the reader to understand the context better, and will be considered for inclusion in any future reports.

Reviewers: While the discussion [of root cause] was adequate, it appears that a more fundamental management failure was present and should have been described as the root cause with the various specific management failures as subparts. Elements that should have been developed further in the report include:
--qualifications of managers,
--SOPs, audits, safety and health programs, hazard analysis, and employees' roles in them, prior incidents,
--training (of both hourly employees and supervisors),
--accountability of the contracting company (for this tolling operation).

EPA/OSHA Comment: In the identification of the root causes of the accident (for example, inadequate hazard analysis, inadequate SOPs and training not addressing emergency shut-down procedures), management failures are implied since management is responsible for these actions. The subsequent recommendations focus on steps management should take in the future to address the problems encountered by Napp in this scenario. Although the Agencies' identification of root cause could have been expanded to make explicit the management failure, the steps to be taken in future would be the same. Since the root causes and contributing factors of this accident were management system failures, the Agencies considered it inappropriate that they be ascribed to individuals or their qualifications.

III. Additional Comments and Recommendations from Individual Reviewers:

Scannell

Scannell: The report did not include the company's compliance with applicable state and federal regulations concerning hazardous materials, nor did the report review the company's prevention and response procedures against industry standards.

EPA/OSHA Comment: The report's purpose and focus were on root cause of the accident, and the report was intended to document an event and its causes, rather than to discuss overall regulatory compliance issues. Expanding the report to address such issues may well result in unnecessary delays in publication, as an employer's state of compliance often becomes a subject of litigation following an incident of this nature.

The Agencies agree that a review of applicable regulations and standards could be included in the accident investigation report. The agencies will incorporate a more detailed review in future reports.

Freeman

Freeman: Use the chemical literature more aggressively to check facts; include full literature references in some uniform format; use a technical editor.

EPA/OSHA Comment: EPA/OSHA will adhere to these conventions in future reports. The agencies included a reference section in Appendix D of the Napp report.

Sprinker

Sprinker: Certain further information (appendices for Napp's hazard analysis, MSDS, description of tolling operations, and other information) would have been helpful.

EPA/OSHA Comment: Inclusion of these elements would have lengthened- the report. Since this information is available elsewhere, the decision was made not to include it

Sprinker: Need for employers to involve their employees (at all levels) in aspects of safety and proper procedures should have been emphasized.

EPA/OSHA Comment: We agree that this point could have been made more explicit.

APPENDIX A

CHARGE TO REVIEWERS
for the EPA/OSHA Joint Chemical Accident Investigation Report
Napp Technologies, Inc.
Lodi, New Jersey
October 1997

EPA and OSHA jointly released the above report in October 1997, concerning an accident on April 21, 1995 occurring at Napp Technologies, Inc. at Lodi, New Jersey. The report is 67 pages long and includes an executive summary, background and description of the accident, analysis of the event, discussion of causes of the accident, and recommendations. Also included are a description of the OSHA/Napp settlement, appendices containing references, and figures. The principal investigators were John Ferris and Paul Kahn of EPA and Michael Marshall, Michael Yarnell, and Efraim Zolden of OSHA.

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 and to derive recommendations for enhancement of accident prevention approaches and accident investigations in the future.

The report seeks to ascertain the root causes of this accident to further the goal of preventing future accidents in similar facilities. Your review should address the following aspects of this concern.

Comment on the overall approach taken in the report and its organization.

Comment on the analyses undertaken. Were these sufficient? Were methodologies appropriate? Were methodologies identified? Were all sources of information properly identified?

Were the sources of reaction initiation plausible? Were all possible sources identified? Were the likely causes of the chemical reaction explored fully?

Was the discussion of root cause adequate? Were root causes and contributing factors appropriately and correctly identified? Was evidence for the conclusions drawn sufficient and plausible? Were methodologies identified? Were all alternative root causes explored?

Are recommendations appropriate and drawn logically from the preceding discussion and conclusions? Are recommendations sufficient to address the potential of a recurrence of this kind of accident?

Were the appendices sufficient and appropriate? Were the photos appropriate to illustrate the narrative, clear, and properly documented and presented?

Were all external factors considered? Were human factors and management issues considered appropriately?

What of the overall approach could be used for future investigations? Was the approach sufficiently broad for application to industry sectors? Were roles of all stakeholders properly addressed in the report, including roles of federal, state and local agencies, the community, labor and any others? Are recommendations sufficiently broad to include all elements in addressing prevention of like accidents in the future?