U.S. CHEMICAL SAFETY AND

HAZARD INVESTIGATION BOARD

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T2 Laboratories Explosion and Fire

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Public Meeting
Jacksonville, Florida

Marriott Hotel Jacksonville
Florida Room
September 15, 2009

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6:00 p.m.

PRESENT:

JOHN BRESLAND, Chairman

GARY VISSCHER, Board Member

WILLIAM WARK, Board Member

WILLIAM WRIGHT, Board Member

CHRIS WARNER, General Counsel

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(6:00 p.m.)

CHAIRMAN BRESLAND: We'll be starting in about 30 seconds so if I could ask everybody to take a seat and we'll get going.

That's the official gavel. Good evening and welcome to the public meeting of the U.S. Chemical Safety Board or as we know it the CSB. I'm John Bresland, Chairman and CEO of the board. With me today are board members Gary Visscher on my right, William Wark and William Wright on my left. Also joining us is our General Counsel, Chris Warner, and CSB staff members whose efforts have facilitated this evening's meeting.

The CSB is an independent non-regulatory federal agency that investigates major chemical accidents of fixed facilities.

Our investigation examines all aspects of chemical accidents including physical causes related to equipment design as well as inadequacies in regulations, industry standards and safety management systems.

Ultimately we issue safety recommendations which are designed to prevent similar accidents in the future.

The purpose for this evening's meeting is to allow the CSB investigative team to present their findings. The board members will then vote on the final report into the December 19th, 2007 explosion and fire at the T2 Laboratories in Jacksonville, Florida.

Following that presentation we will open the floor to comments from members of the public who are here this evening. The meeting will conclude with a discussion by the board and the vote on the final report.

Before we begin I'd like to point out some safety information. Please take a moment to note the locations of the exits from this meeting room. The exits are at the back of the room and over here and lead to the outside in case of an emergency.

I also ask that you please mute your cell phones so that these proceedings are not disturbed. I'll pause and give you a second to mute your cell phones. Thank you.

At 1:30 p.m. on December 19th, 2007 an explosion destroyed the T2 Laboratories facility in Jacksonville. A runaway reaction occurred during the production of methylcyclopentadienyl manganese tricarbonyl, or MCMT as we'll refer to it this evening. It resulted in an explosion and fire. It killed four employees and injured four others. It also injured 28 members of the public.

The incident at T2 Laboratories included one of the most powerful explosions that the CSB has ever investigated, a blast that was felt 15 miles away in downtown Jacksonville. Debris from the explosion was found up to one mile away. The blast damaged buildings within one quarter mile of the facility. This was a tragic unnecessary loss of life and the CSB immediately began an investigation.

Many of you here this evening were affected by the devastation that resulted from this incident. To those of you in the audience who lost friends, family members or were yourself injured by the incident, please allow me to extend my deepest sympathy.

Let me explain the process the board follows to complete an investigation:

Each independent board member, the four board members who are here this evening have had an opportunity to study the draft report. At this public meeting we will hear a presentation by the investigation team. The board members may direct questions about the investigation to the team. There will then be a board member vote on the report and its recommendations.

Our objective is to leave here this evening with strong effective recommendations based on the report's findings. The board's goal is that the report and it's recommendations will help prevent, and I emphasize prevent, similar accidents in the future.

If anyone in the audience wishes to comment publicly after the investigations -- the investigators' presentation, please sign up at the table in the check-in area and I will call your name at the appropriate time. However, if you haven't signed up we certainly will offer the opportunity for additional people to make comments also. Please note that we will have to limit the public comments to three minutes each.

Also note that we are not able to take questions for the investigators directly from the audience so I'll ask that all questions or comments be directed to me as the presiding official. If there's a point that it raised in your comment where I believe the investigation staff can provide some immediate clarification, I will ask them to do so.

I would like to thank the team for their diligent work on this investigation.

I will now recognize any other board members for an opening statement.

Mr. Visscher?

MR. VISSCHER: I have none.

CHAIRMAN BRESLAND: Mr. Wark?

MR. WARK: I have none.

CHAIRMAN BRESLAND: Mr. Wright?

MR. WRIGHT: I have none.

CHAIRMAN BRESLAND: Thank you.

At this time I'll ask the investigation supervisor Robert Hall to introduce the investigation team.

Mr. Hall is a Registered Professional Engineer with a bachelor's degree in nuclear engineering and a master's degree in mechanical engineering. He has more than 25 years experience in the design, inspection and evaluation of hazardous systems for the chemical, nuclear and the aerospace industries. Mr. Hall served as the investigator in charge for this investigation. Now let me turn it over to Mr. Hall.

MR. HALL: Thank you, Mr. Bresland.

With me tonight is the team that helped me investigate this accident. On the far end of the table Mary Nikityn. She holds a bachelor's degree in psychology from Southern Adventist University and is currently a doctoral student in clinical psychology at George Washington University. Prior to joining the CSB Ms. Nikityn worked as a regulatory specialist in the compliance training industry with expertise in EPA hazardous waste and DOT hazardous materials regulation.

Next to Mary is Lucy Sciallo. She is a graduate out of Pennsylvania State University with a Bachelor of Science degree in Industrial Health and Safety. Prior to joining CSB Lucy worked in the oil industry as a health and safety specialist. She holds a

Graduate Safety Practioner designation from the Board of Certified Safety Professionals.

And lastly Mr. Jeffrey Wanko. Mr. Wanko received a bachelor's degree in chemical engineering from Syracuse University and a master's from the Illinois Institute of Technology. Mr. Wanko has been a safety professional for more than 16 years specializing in process safety in the pharmaceutical, specialty chemical and food sectors. Mr. Wanko is a licensed Professional Engineer and a Certified Safety Professional.

Chairman Bresland, members of the board, Chief Counsel, ladies and gentlemen, good evening.

The investigation team is pleased to present the facts, findings and causes of the runaway reaction, explosion and fire that occurred at T2 Laboratories in Jacksonville on December 19th, 2007.

The incident at T2 laboratories included one of the most powerful explosions that the CSB has ever investigated, a blast that was felt 15 miles away in downtown Jacksonville. The explosion caused wide spread community damage, flinging debris in all directions. Four T2 employees were skilled. T2 employees and many members of the public working at nearby businesses were injured. Dozens of firefighters spent many hours battling the chemical fire. Businesses were damaged. Buildings had to be demolished and rebuilt. And the environmental clean up is still ongoing.

The impact of this incident on the community was severe and the CSB has spent many months researching and analyzing the incident in the hope of preventing future such occurrences. Tonight we are presenting our findings and recommendations to both the board and the Jacksonville community.

The presentation includes a summary of the incident, a computer reenactment of the most likely scenario as well as the presentation of the team's findings and recommendations. Following the presentation we'll have an opportunity for the public to comment and the board will vote on the team's report and recommendations.

Before I discuss the incident I'd like to give you a very brief background on 2T Laboratories.

T2 Laboratories, which is no longer in business, was a chemical manufacturing facility located on the north side of Jacksonville. T2 began as a specialty solvent blending company in 1996. In 2000 T2 began research and development on a manufacturing process for a chemical called methylcyclopentadienyl manganese tricarbonyl or MCMT.

Over the next few years T2 designed and built the chemical process line and began producing MCMT at the Faye Road site. By 2007 at the time of the incident T2 had 12 employees and had manufactured 174 batches of MCMT. T2 produced MCMT from 2004 until the incident in 2007 selling it under the tradename Ecotane.

MCMT is used as an octane booster in gasoline and is sold in the U.S. primarily as a specialty product in automotive stores.

T2 sold MCMT to a U.S. distribution company and other companies internationally. MCMT is highly toxic through inhalation and skin absorption. It is regulated by the Environmental Protection Agency as an extremely hazardous substance. T2 manufactured MCMT in a single reactor in batches using a three-step chemical process.

On the morning of December 19th, 2007 T2 began producing its 175th batch. The reaction proceeded normally throughout the morning; however, shortly after 1:00 p.m. a cooling problem was reported. The reaction temperature began to rise past the normal operation point and the reaction proceeded uncontrollably. As temperature and pressure rapidly increased, the reactor burst and its contents exploded in a blast equivalent to 1400 pounds of TNT. Video footage shows the very energetic nature of this explosion.

This first clip was taken by an infrared surveillance camera located several miles away. The two large cooling towers that you see in the center of the screen are 460 feet high. As the heat from the blast dissipates, you can see smaller objects twinkling. These are like pieces of sodium metal from inside the reactor reacting with the moisture in the air as they fall.

You can also see a smokestack in line with the explosion. This smokestack is 640 feet high.

This business is located about 620 feet from the reactor structure. The building was damaged and eight of the 16 employees working there were injured.

This business is located about 700 feet away. As you see in the security video, debris rained down on the workers outside. Inside workers looked towards the reactor shortly before being showered by glass as the windows shattered.

This is an aerial photograph of the T2 site the day after the incident. Here in the center you can see the area where the reactor structure stood. Large pieces of the reactor shell were thrown here and here.

Another large piece of the reactor weighing about 2000 pounds was found about 400 a feet away in this direction. Two steel columns that supported the reactor were found a thousand feet down Faye Road in both directions.

This area of the facility was the tank farm and contained thousands of gallons of flammable solvents. After the explosion those ignited and continued to burn for many hours.

The control room where two T2 employees were killed was a square 12-foot concrete building located here just 50 feet from the reactor. As you see the damage on site was devastating. The damage off site and the impact to the community were also extensive. The explosion killed four T2 employees and injured 31 of 118 people that were working within a thousand feet of the reactor.

One T2 employee sustained life-threatening injuries that required extensive hospitalization.

Many of the injuries to people working in nearby businesses were caused by secondary missiles as pieces of structure, office furniture and glass shards were thrown by the blast.

Five buildings belonging to businesses on Faye Road sustained so much damage that they were condemned as unsafe structures and had to be rebuilt. Debris flew in all directions throughout a one mile radius.

This building is near T2. Is it one of those that was condemned as unsafe. The business had to relocate operations while the building was reconstructed.

You see here a trailer used by a trucking company adjacent to T2. This structure was destroyed by the blast shortly after trucking company employees had been dismissed for the day. Had anyone been working here, it is likely they would have been severely injured or killed.

Many organizations responded to the large explosion, huge fire and extensive damage. The City of Jacksonville Fire and Rescue Department and the sheriff's office managed the incident. While the Environmental Resource Management Division assessed the environmental impact and the Planning and Development Department surveyed damage and condemned unsafe structures.

The Naval Air Station Mayport and the Jacksonville Internation Airport Fire

Department helped fight the blaze. The Florida Department of Environmental Protection and the American Red Cross responded to oversee site clean up and assist emergency workers respectively.

The emergency response to this incident was excellent as many of the agencies cooperated to safely control the fires and event further harm. Over 90 firefighters entered the fight to battle the chemical fire. None were injured.

Due to the impact of this incident, the CSB decided to deploy a team on December 19th. The team arrived in Jacksonville on the next morning and began the investigation activity but was unable to enter the site for another five weeks because of the highly toxic MCMT and the difficulty of testing for its presence on site.

While waiting to access the site, the team conducted many investigation activities. The team conducted 48 interviews with T2 employees and eyewitnesses from other businesses. We also examined the reactor vessel fragments found on site and collected more parts of the reactor from the surrounding woods.

The team examined and catalogued all of the damaged structures and used this information to determine the strength of the explosion. The CSB submitted dozens of document requests to T2 and other companies and agencies and reviewed thousands of documents received in response.

Finally the CSB recreated T2's chemical reaction in a laboratory and duplicated the runaway reaction that occurred on December 19th. A reenactment of what most likely occurred is presented as an animation which is part of a CSB full safety video on T2 which will be released soon. I will now present the animated reenactment to you.

VOICEOVER: "T2 produced MCMT, a gasoline additive in batches using a 2500 gallon reactor. An operator controlled the process with a computerized system in a nearby control room. In the first step liquid chemicals and sodium metal were loaded into the reactor, heated and then mixed with an agitator.

"The reaction produced hydrogen which was vented to the atmosphere. In normal operations when the temperature reached 300 degrees Farenheit the operator would turn off the heating system. But because this reaction was exothermic or heat producing, the temperature inside the reactor would continue to rise.

"At 360 degrees operators would begin to periodically fill the reactor's cooling jacket with water. As the water boiled heat was removed controlling the temperature.

"However, on the day of the accident the CSB found that the operator tried to cool the reactor as usual but the cooling system likely malfunctioned perhaps due to a blockage in the water supply piping or a valve failure. The temperature and pressure inside the reactor began to rise in a runaway chemical reaction.

"T2's co-owners returned to the plant after a worker called to report the cooling problem. While one owner searched for the plant mechanic the other went to the control room. Concerned about a possible fire, he warned employees to move away from the reactor.

"Inside the reactor the pressure was still increasing reaching 400 pounds per square inch and bursting the rupture disk. Witnesses heard a sound like a jet engine as high pressured gas began to vent from the reactor. But it was too late. Within ten seconds there as a massive explosion equivalent to about 1400 pounds of TNT."

MR. HALL: As you've just seen in the animation, the explosion that occurred at

T2 was very powerful and destroyed the facility. The following photos show the same views of T2 before and after the incident.

I will now present the team findings that the team determined from the investigation.

Based on our evidence collection, the team identified several key investigation areas. First the chemistry used by T2 was exothermic or heat producing. Exothermic chemistry presents specific hazards and requirements for reactor cooling and relief system design. Hazard recognition is of particular importance when designing exothermic chemical processes.

The team investigated T2's recognition of the reactive hazards as well as agitation on reactive hazards that are commonly provided to undergraduate chemical engineers. These ares were key in understanding incident causes and the team will present each one in more detail. First

Investigator Wanko will present the results of our chemical testing.

MR. WANKO: Thank you, Mr. Hall.

T2's owners based the process on a three-step chemical recipe they found in patents dating back to 1950. The patents described the different chemicals that could be used to reach the final product, the intermediate steps and the processes condition. The patents though do not describe the safety measures that must be in place for full scale production.

The patents also do not address the heat production or exotherm that occurs in the first step of the process. The first step was about two and a half hours into the production of the batch when the incident occurred.

The first stage of the process required initial heating to start the reaction. At a predetermined set point heating is shut off as the reaction produces enough heat to sustain itself. At this point the reaction requires periodic cooling to remove heat from the system.

The team hypothesized that an uncontrolled chemical reaction caused the T2 explosion so we recreated the standard chemical recipe of the first step that T2 used and were using on the day of the incident.

The recipe included methylcyclopentadiene and diethylene glycol dimethyl either, also known as diglyme, and sodium metal. Using only 50 grams of material in the same proportions as T2, the team found that the first step exhibits an initial exotherm or heat generating period that can be controlled through cooling and venting hot gasses.

However, above 390 degrees Fahrenheit, only 30 degrees higher than the normal operating temperature, a second undesired reaction occurs that exhibits a second and more energetic exotherm.

If cooling or venting were to have failed during the first step of the process, temperature and pressure and therefore reaction rate would continue to rise.

If conditions are not corrected quickly a second undesired reaction occurs and the temperature and pressure rises very quickly and uncontrollably.

T2's development work was incapable of determining exothermic activity and this uncontrollable outcome went undetected.

This graph illustrates the results of one of the teams' laboratory run using the T2 recipe of MCPD, diglyme and metal.

Here in the first desired reaction temperature and pressure rise gradually over two and a half hours. At about 390-degrees Farenheit the second undesirable reaction begins. Then at about 500 degrees Farenheit the temperature and pressure rise very quickly.

In this region the temperature is rising at about 70 degrees Farenheit per second, and pressure at over 500 pounds per square inch per second.

Since this chemistry is so energetic we tested a very small amount in this apparatus. It's about half the size of a soda can.

Here you can see the test apparatus before and after the second undesired reaction which occurred with less than two ounces of material. The T2's reactor in contrast held over six tons during the first step.

With pressure rising over 500 pounds per square inch per second, pressure inside the vessel reached 5000 pounds per square inch and burst in less than 10 seconds after the emergency vents opened.

Here you can see two large pieces of the reactor. This large piece is from the bottom of the reactor. And this piece is a portion of the top weighing about 2000 pounds. It was thrown through a pipe rack, impacted and bent a railroad track and damaged a building about 400 feet away.

Mr. Hall.

MR. HALL: Thank you Investigator Wanko.

As you saw in the video, before the incident the reactor was held vertically in a tall steel support structure. The reactor itself was about ten feet high and seven feet wide.

As Investigator Wanko discussed, exothermic reactions generate high temperatures and pressure. To control these cooling and pressure release systems are extremely important. Cooling for the reactor was provided by an exterior cooling jacket. City water was piped in from the bottom of the jacket and allowed to boil and vent. The heat required to boil the water was taken out of the reaction.

Water was piped into the jacket and boiled off repeatedly throughout the part of the reaction that required cooling.

Pressure relief was provided at the top of the reactor via a one-inch center relief line. A four-inch emergency vent line was also at the top of the reactor. This line was closed until the reaction pressure reached 400 pounds per square inch at which point a rupture disk burst opening the emergency vent line.

On the day of the incident the reaction temperature rose uncontrollably likely because cooling was not applied to the reactor. The T2 operator reported a cooling problem about ten minutes prior to the explosion. When the team investigated this we found that the cooling system lacked redundancy. This means that a single failure of any one of several parts of the cooling system would cause the entire system to fail.

Potential failure points included

the drain and supply valves, supply piping blockage, scale build up in the jacket or even a faulty temperature indicator. Because no emergency system was immediately available operators would need to manually attach hoses to access an additional water supply in the event of a failure. During the incident as the reaction quickly ran away operators would not have had the time to perform these necessary actions.

CSB investigators found that the emergency vent system was designed for normal operation and not designed to consider a runaway reaction. Additionally the set pressure of the emergency vents was set too high. Had it been lower it would have activated before the second exothermic reaction and could have stopped or slowed the runaway by venting at a lower pressure allowing chemicals to boil and remove heat and chemicals from the reactor.

Although T2 owners conducted

laboratory testing of the MCMT process chemistry, this testing did not look for the potential exothermic reaction in the first step of the process. The need to cool the first step was not identified until the first full-scale production batch.

Temperature control issues and near miss exothermic reactions occurred in three of the first ten production batches but T2's owners did not systematically investigate these anomalies to determine their cause.

Throughout the production history poor yields and batch flow variations occasionally occurred due to temperatures rising too high in the first step. However T2 was never able to fully control these batch variations and continued to use the same recipe that it had established in the early batches.

Although T2's owners had chemical industry experience, neither had previously worked with reactive chemistry and hence did not have any experience developing and designing a reactive exothermic process like the MCMT chemistry.

Additionally although T2 was owned by a chemist and chemical engineer, neither of them learned about process safety and the specific hazards of chemicals of reactive chemistry in their education program.

Chemistry programs are not intended to address process design and plant production. Chemical engineering programs, while they do cover process and plant design, often do not address process safety.

The Mary K. O'Connor Process Safety Center operated by the Texas A&M University developed programs to promote safety in the chemical industry.

In 2006 the center conducted a survey of undergraduate chemical engineering programs and found that process safety was a part of the required curriculum in only 11 percent of the programs. Within these specific inclusion of reactive hazard recognition and management was even more limited.

Recognizing the need for increased education and process safety in reactive hazards, the American Institute of Chemical Engineers, AIChE, designed and implemented a process safety certificate program which began issuing certificates in 2008. The process safety certificate program is free to members. It consists of four modules two of which specifically address reactive hazards. AIChE has more than 150 chapters and student membership is free.

Now to present the root and contributing causes as determined by the team.

The root cause of the incident was that T2 did not recognize the runaway reaction hazard associated with the MCMT it was producing. As a result the contributing causes were that the reactor cooling system was susceptible to single point failure and it failed on the day of the incident. The reactor relief system was incapable of releasing the pressure from a runaway reaction which resulted in the reactor bursting and the contents exploding.

Since 1998 the CSB has investigated a number of reactive chemical accidents and in 2002 issued a comprehensive study of reactive chemical incidents. These investigations and the study included regulatory and industry recommendations aimed at reducing chemical accidents. The recommendations that we propose here today seek to further this work by addressing chemical reactive hazard recognition as part of chemical engineering undergraduate education.

Accreditation is a voluntary peer review process to assure quality and specific educational programs. The Accreditation Board for Engineering and Technology, or ABET, reviews degree programs in engineering, including chemical engineering. Specialized curriculum criteria are used to review undergraduate chemical engineering programs.

The team recommends that the American Institute of Chemical Engineers work with ABET to add reactive hazard awareness to the required chemical engineering curricula and accredited programs.

The Process Safety Certificate Program which includes reactive hazard management is offered free to AIChE student chapter members. The team recommends that AIChE inform its student members about the process of specific programs and encourages student members to participate.

Mr. Bresland, at this point in time the team will entertain any questions that the board has regarding our report.

CHAIRMAN BRESLAND: I thank you, Mr. Hall and Mr. Wanko, number one for your diligent work on this and for your excellent presentation this evening.

We will start on my left with Mr. Wark.

MR. WARK: Thank you, Mr. Chairman.

I do have a couple questions but I too would like to commend the investigators on an outstanding job. From all accounts this was an outstanding response to a very serious incident and I'd like to also commend the fire community, the other first responders for a job well done as well.

I understand that you were delayed in getting onto the site because of the hazardous nature of the materials, the MCMT.

How long was it before you could get on the site, if you haven't already mentioned that, and how was the entry made?

MR. HALL: After the team arrived we quickly evaluated the hazards associated with the MCMT that T2 was producing. As I mentioned it's a regulated material by the EPA and it's on the list of extremely hazardous substances.

As we investigated this we found that there were no commonly available immediate measurement techniques that could be used in the field to detect the MCMT. And we had to go through a lengthy process of taking samples and having them sent to a specialized lab of which there's only one in the country that does this analysis to determine the MCMT levels. And this kept us out of the very core of the site for five weeks.

I'd like to also point out that in the emergency response the fire community in entering the site wore protective gear that prevented any injury from this particular highly toxic material.

MR. WARK: I have just one more question and that is were there any off site exposures to the chemical?

MR. HALL: There were no recorded instances of off site exposure to this particular chemical. The chemical does break down in sunlight so as it was released it broke down in a relatively short period of time so the real danger from exposure to this chemical was within the site, within the structures of the site where they were storing the MCMT where sunlight didn't reach.

MR. WARK: That's all I have, Mr. Chairman.

CHAIRMAN BRESLAND: Mr. Wright.

MR. WRIGHT: Thank you, Mr. Chairman.

I too would like to commend all those involved with this incident because I think they did an outstanding job. I have several questions for Investigator Hall. One having to do with our scaled down experiment, if you will, to replicate the explosion. You showed a picture of the vessel before and after it under went the secondary thermal reaction or exothermic reaction.

My question is did we scale down the vents on that particular vessel so it replicated the same size vents as here?

MR. HALL: That particular test that was performed was performed in what's known as a closed cell, which is not a vented cell. In order to achieve the actual measurements of the heat production and the pressure rise, it's a standard practice to do that in a closed cell.

MR. WRIGHT: So we didn't have a relief valve?

MR. HALL: No, there was no relief valve.

MR. WRIGHT: And my assumption is because they were unaware of the hazards that they probably didn't conduct any hazard analysis.

My question is did you find any evidence of anybody performing any hazard analysis with respect to explosive impacts that may occur during the chemical runaway reaction.

MR. HALL: We did not find any

evidence of a hazard analysis being performed. We did find, however, and it's detailed in the report, that one of the consultants to T2 had recommended that they perform a hazard analysis and yet this recommendation was never followed up on.

MR. WRIGHT: My final question deals with the -- I believe I read in the report that they scaled up production more than once. Initially they started with a small vessel, table top if you will, analysis and then went to full production.

And then I believe they raised the level of the production again just before this incident?

MR. HALL: That is correct. They began their testing with a one-liter reactor, basically a table top device, and did their developmental work in that one-liter reactor and went straight to the large reactor that was in the incident.

For the first 42 batches they used

a recipe that was three quarters the size of the recipe that was used the day of the incident. So after batch 42 they began producing a larger quantity, increasing the quantity of chemicals in the reactor by one third. The importance of that is when you do that it increases the energy input and makes the situation more dangerous.

MR. WRIGHT: Thank you very much.

CHAIRMAN BRESLAND: Board member Visscher.

MR. VISSCHER: Thank you, Mr. Chairman. I want to join Mr. Hall and Mr. Wark in mentioning commending the emergency response community and the incident command. They talked about the fact that the response was done in a safe manner, which is the most important thing. And we mentioned, just so you know, the board recently issued a video on emergency response and one of the incidents that's held out as an example of good emergency response is the response to this incident.

But I also wanted to mention I was a board member who went on at the time of the deployment and wasn't just, although as I said, the most important thing is the safety of the emergency responders. But I was so impressed by the incident command structure and how smoothly all those different agencies were able to work together. And that's to the leadership of the emergency response community and the fire department and the way in which that was handled.

So this isn't always the case on our deployments that everything goes so smoothly when you have so many different agencies and local and state and federal agencies involved.

We talk about these issues around the country I often use this as one where it really did go very smoothly and again a tribute to the leadership.

Question: I gather that the

company and the owners were aware of the first exothermic reaction but not the second one in that first step. They wanted the first one to happen.

They needed the first exothermic but they weren't aware of the second one was a possibility?

MR. HALL: That's correct. I mean we did find that actually in their developmental testing when they were testing it in a one-liter reactor they detected no exotherms. And wasn't until the very first production batch that they discovered the exotherm, the initial exotherm, in the first reaction. They did have occasions where they allowed the temperature to get too high but in every case they were able to stop this before it proceeded into the uncontrolled part of the second exotherm.

MR. VISSCHER: Is that also what happened, they had previous incidents where it had sort of gotten away?

MR. HALL: Gotten away but they
reestablished cooling and were able to control
the incident.

MR. VISSCHER: How many of those
incidents, do you know? Was that fairly
frequent?

MR. HALL: WELL, the documentation
of that is somewhat limited. All the
documentation was destroyed. All the on site
documentation destroyed and we were able to
obtain some back ups from individuals that had
documentation off site. But in the initial
batches, the first ten batches, three of those
first ten had exothermic excursions that
didn't fully run away but were a cause of
great concern.

MR. VISSCHER: In each case they
were able to bring those down by using
cooling?

MR. HALL: By using cooling to
slow it.

MR. VISSCHER: If you were

starting out a process and you wanted to know what those hazards were, one way to determine what those hazards were would be laboratory testing which they did some of I guess, but not as thoroughly perhaps.

What would be other -- how would you know what the hazards are?

THE WITNESS: Well, they did their laboratory testing in standard lab equipment. And there's a very specific test process that's used to evaluate exothermic hazards and they refer to it as a thermal hazard evaluation test where they used a very specialized device that minimizes heat transfer across the test cell and it more closely behaves like a full-scale reactor. And that was a test device that we had done our testing in that Investigator Wanko had shown that with just 50 grams of the material we were able to duplicate a burst vessel like occurred the day of the incident.

MR. VISSCHER: So they had done

laboratory testing but not necessarily the right kind or the laboratory testing that would show -- would indicate those kinds of reactions?

MR. HALL: That's correct.

Mr. VISSCHER: It would seem to me that another source of information about hazards would be a literature search.

Is there literature available in terms of the reactive hazards or the possibilities of an exothermic or runaway reaction of this in the literature? Is there a literature search?

MR. HALL: In looking at the literature that's available, and they did an extensive literature search in their development.

This material was developed in the late 1950s by a company called Ethol who got a number of patents for the material. There are some 25 or so patents that are listed in the appendix of the report. These patents detail how the chemicals were combined to make this product. But the patents don't address hazards or safety aspects of the production. They're purely written to achieve getting the patent from the patent office to give them product protection.

Apart from the patent, MCMT from a production standpoint is largely absent from the literary universe. There is not much information out there on this particular material. The information that does exist has to do with the hazards and toxicity.

MR. VISSCHER: Presumably at least now there will be some literature with our report that will highlight some of the hazards to put other people on notice if anyone is thinking of producing it.

How did they decide on the rupture disk being set at 400 psig? Was there a formula that was used? I think the report indicated that if it had been set significantly lower that would have relieved the pressure at a much earlier time.

MR. HALL: From our understanding, and there was very limited documentation on this. And this particular evidence comes from interviews and it's really secondhand information because those that had done this work were unfortunately killed in the accident.

The set point, the size and the set point were based on the normal production of hydrogen from the reaction and also looking at the MAWP of the vessel as well as all three steps and what pressure they wanted to operate all three steps of the chemical process at, not really focusing on the first step and looking at the exothermic requirements of the exothermic chemistry.

MR. VISSCHER: One last question, Mr. Chairman.

The recommendations really focus on improving education in chemical education for a better awareness of looking for hazardous reactions or hazards of reactions.

Sort of a two-part question. First, why did you focus on education in this report and second of all I think in your introduction the chairman mentioned that your own background is in nuclear engineering. If you would compare sort of the safety awareness in nuclear engineering to the safety awareness in chemical engineering.

I take it that what we're doing with this recommendation is urging that the chemical education process, the chemical process, chemical engineering education move in the direction of what's already been done in nuclear engineering.

Is that a fair assessment?

MR. VISSCHER: That's a fair assessment, Mr. Visscher.

When looking at this particular case we saw similarities with a number of other cases where you had a small entrepreneurial company that was going in and developing a process using a highly hazardous reactive chemistry. In these small entrepreneurial companies each one had a similarity that there was really a lack of recognition that this hazard existed. When we looked at these small companies, typically they were unregulated. They were outside the regulatory environment. The owners were unaware of what happened.

And we've made regulatory recommendations. We made industry recommendations. We've made recommendations that reach out to the big chemical companies and we're really looking for a way as to how can we reach these small companies. And one of the answers is to reach through the education system. It's something we have not done in the multitude of reactive incidents that we've investigated.

And as you point out, within the nuclear industry there's a big emphasis on education and the learnings that go into the initial process design and the like in making sure the people fully understand the hazards that they're dealing with and there are checks and balances in the learning aspect of it.

So in that respect that we had not previously gone this route as a presentation measure, we thought that it would be appropriate in this case.

MR. VISSCHER: Thank you, Mr. Chairman.

CHAIRMAN BRESLAND: Other board members for your questions.

I have a few questions myself. And let me start with I guess it's a follow up to Mr. Visscher's question, maybe in a more general sense.

We've had this explosion. We've had this tragedy with the four killings.

If you were to go back to the beginning here, what should have been done that would have prevented this accident from happening in terms of starting at the beginning, developing the process, developing the information, designing the process and operating it?

What could have been done that would have prevented this from happening?

MR. HALL: Well initially in the developmental stage would be to perform the thermal hazard evaluation testing, to actually test for exothermic reactions and get the kinetic, reaction kinetic data to use in the process design. That was kind of the initial point that was missed in the process design.

Secondly when we look at the -- those first ten batches that they produced and we saw that they had ten occasions or three occasions in that first ten batches where the temperature went beyond what they had desired and indicating some exothermic activity that may not be desirable, they just kept going rather than stopping and trying to evaluate that. With each one of those they were able to catch it. The reactor didn't blow up.

They were able to move on. And they normalized that deviation.

And that's much the same way in the Challenger incident, how each time the O rings failed, NASA normalized the deviation. The shuttle didn't blow up. We launched again and eventually one caught them. And the same thing caught them here.

So there was multiple opportunities, multiple near misses that occurred throughout the production that were clues to what they should have done.

CHAIRMAN BRESLAND: So one of the things they should have done was the more sophisticated laboratory testing which I assume they didn't have the capability of doing.

How many laboratories are there in the United States that have the expertise to do this sort of testing? For example how much money did we spend on the testing?

MR. HALL: There's about six

laboratories in the United States that perform this testing commercially. Also some of the big chemical companies perform the testing internally. But those that perform it as a service there's about six laboratories in the country performing it commercially.

The CSB spent about $125,000 to perform this particular test and got some of the top people in the country known for this particular type of testing to guide the test and evaluate the results.

CHAIRMAN BRESLAND: Who else makes this chemical in this country?

MR. HALL: There is one other domestic producer and that is a company called Afton. It used to be called Ethyl Corporation. And they have been producing this particular material since the late 1950s.

CHAIRMAN BRESLAND: Have they had any incidences that we know of?

MR. HALL: We found no record of incidents that they had had that were publicly known.

CHAIRMAN BRESLAND: The vessel exploded at you say about 5000 psi and it was a three-inch vessel so it was a very significant explosion.

Assuming that it -- that the system was designed properly, how big would the rupture disk have to have been? Keeping in mind that the rupture disk is something that as you know is something that blows before the vessel blows so it avoids the catastrophic explosion of the vessel.

Do we know, do we have any estimates from any of our experts how big that rupture disk would needed to have been to avoid this catastrophic destruction of the vessel?

MR. HALL: From our testing we looked at what relief size. And there's two components to the relief size, the set pressure as well as the physical size. And at 400 psi, which was the set pressure chosen by

T2, there was not a size big enough that would relieve the pressure and protect the vessel.

However, if you drop that set point down to 75 psi, and what this allows to happen is when it relieves at the lower pressure the chemicals inside the reactor immediately boil. And once they start boiling that removes heat as well as the chemicals then vent and it removes the chemicals from the reaction. So a relief device set at 75 psi of approximately the size they had would have protected this vessel. But at 400 psi there was no way to relieve the pressure. There was not a device big enough.

CHAIRMAN BRESLAND: In your presentation, just changing topics here, you discuss the cooling system which is the -- not the emergency cooling system but the routine cooling temperature control system, but you said there was not a back up to that.

What would have -- in your experience what would a typical back up system look like?

MR. HALL: Several of the employees at T2 indicated that they had a secondary source of water. It wasn't hooked up. And what we mean by hooked up is we would need a second line into the cooling jacket with its own dedicated automatic valve controlled by the control room. And because this secondary source that they were talking about just came from a tank, it would also need a pump or a power supply. So you would need a whole duplicate supply system that could feed water to the reactor jacket.

CHAIRMAN BRESLAND: I don't have any other questions.

Do any of the board members?

Board member Wark.

MR. WARK: Thank you, Mr. Chairman. Just to follow up with Mr. Hall.

My presumption is that if people were aware and that if the recommendation is heeded in the future, people will do a proper hazard analysis and will be aware of what potential catastrophic events may occur and hopefully will then site their facilities in areas to prevent damage to their neighbors or neighboring businesses.

Am I correct in that presumption, that that's a hope that we have for the future?

MR. HALL: Yes, sir.

MR. WARK: Thank you.

MR. HALL: You know, we found with the T2 company that there were some hazards that they were aware of. And on those hazards they spent money and they took protecting action. But in this case it was a hazard they were unaware of and hence appropriately did not deal with it.

CHAIRMAN BRESLAND: Any other questions?

That concludes the questions from the board members. We did have a sign up sheet as people walked in and I have a copy of it. I have the sign up sheet here but unfortunately it's blank. So I don't have any, but that doesn't prevent you from asking questions. So if there are members of the audience who would like to either make a comment or ask a question, please do so now.

With the gentleman here. If you would state your name, please, and spell your name for the person who is taking the dictation.

MR. McDONALD: George McDonald.

Had that jacket on the vessel been descaled or do you know if they regularly descaled that vessel, the water jacket?

CHAIRMAN BRESLAND: Let me repeat the question. The question as I understand it was had the vessel been descaled, meaning?

MR. OTHER: You have a water jacket around the vessel where you're putting the City of Jacksonville water.

MR. BRESLAND: You're asking if there was scale inside?

MR. McDONALD: That's correct. It boils off so you get a limestone deposit inside the jacket. You could normally remove that with an acidic wash.

Do you know if that was done?

CHAIRMAN BRESLAND: Let me turn that question over to Mr. Hall.

MR. HALL: We have no evidence as to whether or not that was ever done. We looked very carefully at the vessel and the jacket after the explosion but the explosion was of such magnitude that we felt that any scale that might have been there could have been taken off through the very energetic nature of the explosion. And it was listed as one of potential single point failures for the cooling system and it's one of the possible failures that the team considered causing a failure of the cooling system.

MR. McDONALD: We've got a very hard water here, 175 without descaling it would have significantly reduced the ability to cool.

That's all I have.

CHAIRMAN BRESLAND: We have someone else coming to the microphone. No, we don't. He's one of the audio/visual people.

Again if you could tell us your name and spell it, please.

MS. PADRICK: My name is Sandra Padrick, last name is P-A-D-R-I-C-K.

I'm curious about whether or not you're subject to standard -- but you did talk about the presence of solvents also in and of course if there were such they would have been required to conduct a hazard analysis. So . . .

CHAIRMAN BRESLAND: The question is were they covered by the OSHA process safety standard?

MR. OTHER: Yes.

CHAIRMAN BRESLAND: Mr. Hall.

MR. HALL: The first step of this process OSHA did extensive testing following the accident to determine if the first step was not a covered step, would not be covered under process safety management because the mixture in the reactor did not meet the flammability requirement. None of the chemicals listed were covered chemicals so the flammability requirement was the only requirement they could have met and OSHA determined in their testing that it did not meet the flammability requirement.

We did find that T2 Laboratories never did any testing to determine wether or not they were covered and did not do what OSHA did to make a determination of coverage. And in fact there were several of the employees that indicated that there may have been some belief that they were covered and they were planning at some time to implement some of those OSHA process safety management but they had not at the time of the incident.

MS. PADRICK: Thank you.

CHAIRMAN BRESLAND: Thank you.

MR. WHEELER: My name is Wess Wheeler. And one of the questions that I have, Mr. Bresland, is as a requirement of back up systems, the emphasis and recommendations from the CSB actually say that, you know, we want to deal with education, which I agree with wholeheartedly. But one of the other things that can come from this board is a recommendation to OSHA or to process safety management systems to have a required documentation of at least a back up system in place, operational and checked out prior to any of these pilot plants actually going into production.

What kind of processes or what kind of recommendations can be made in that endeavor?

CHAIRMAN BRESLAND: Let me turn that over to Mr. Hall and I can get back to it as well and maybe some of the board members would like to comment on that.

MR. HALL: As I mentioned in the

presentation, the CSB has investigated a number of reactive chemical incidents over the years since our formation and since we began investigating incidents in 1998 and have made a large number of regulatory and industry recommendations with regard to that.

The back up systems are covered as part of standard design practice, it's something OSHA refers to as generally accepted engineering practice. So they really do come into the regulations in that regard because there are standards and guidelines out there that address how to design the system and they're included in those guidelines and OSHA incorporates those within their regulations.

CHAIRMAN BRESLAND: Back almost seven years to the day, I think it was on September l7th, 2002, we did make a recommendation to OSHA on the issue of reactive chemicals and that's still an open recommendation. It's a complex recommendation.

But if a facility like this, regardless of whether it's covered under reactive chemical or under the facts that it has flammable solvents, there would be a standard list of activities that they would be required to comply with. And one of them would be looking at doing a process hazard analysis which is what we talked about earlier.

And in that process analysis I would hope that they would look at the process and decide maybe a single source of emergency cooling, a single source of cooling water is not appropriate and they would need a back up source of cooling water that would be controlled separately from the controlled system. It would be what we call a hard wired system which would automatically come on immediately.

I know I struggle with this whole issue of why did this accident happen. Why did the company not do the appropriate testing to determine what are the hazards associated with this? Because when we did the testing we were able to find quite quickly that there certainly was a hazard when you got to a certain temperature in the reaction.

MR. WHEELER: I agree that the back up system in place might have helped prevent this and prevent the loss of businesses and the loss of life that we actually had. And that was one of the things that I would have liked to have seen come out of this, some way we could document that the back up system is in place like you said hard wired and separate from the automation so that we have that in place before these entrepreneurs actually go out and venture into this realm of an unknown uncertainty.

Thank you very much.

CHAIRMAN BRESLAND: It's certainly not unusual to have a back up system, a back up shut down system, a back up emergency system that is hard wired separate from the distributive control system that operates the process. I'm not talking about this process but just in the chemical and refining industry in general. That there's a particular hazard that's a particularly dangerous hazard, that would be a common practice that would be put in place.

MR. WHEELER: Thank you.

CHAIRMAN BRESLAND: One more gentleman coming up.

MR. McMASTER: Jim McMaster. And I have a question.

You mentioned that a company, Afton, produces the same product.

Have they been investigated or looked over to see if they have in place the needed safety measures to continue operation so this doesn't happen again?

CHAIRMAN BRESLAND: Mr. Hall.

MR. HALL: The CSB did not conduct an investigation of Afton. Afton is, though, a large chemical company that's been operating for many years and we, you know, look to see from our data, from the public domain if there had ever been any accidents with this material and detected no accidents with this material. Our particular charter to investigate here really didn't allow us to go investigate Afton's activities after the fact.

MR. McMASTER: All right. Thank you.

CHAIRMAN BRESLAND: In your conversations with Afton, Mr. Hall, were they aware of the second exotherm that we discovered in our testing?

MR. HALL: We did have several conversations with Afton and they were fully aware of the behavior of this material.

CHAIRMAN BRESLAND: Thank you.

Any more people who'd like to come up and make a comment or ask a question?

MR. ROGERS: Good evening. My name is AAron Rogers. You've referred to Afton several times here.

So if they were aware of the second exothermic reaction, had they conducted a process hazard analysis?

MR. BRESLAND: Mr. Hall.

MR. HALL: Because we didn't investigate Afton I really don't know the answer to that question.

MR. ROGERS: Thank you.

CHAIRMAN BRESLAND: Do we have anyone else who would like --

MR. SCOPPA: My name is Rick Scoppa, S-C-O-P-P-A.

You mentioned that there's one other company that makes this material and that this company started making it and it's an extremely hazardous material. I don't understand how they could get started to make this without one of the regulatory agencies being heavily involved with making sure that they did do the testing necessary to ensure their process system was accurate or proper.

CHAIRMAN BRESLAND: Are you

referring to Afton or are you referring to T2?

MR. SCOPPA: T2.

CHAIRMAN BRESLAND: Okay.

MR. SCOPPA: With it being an extremely hazardous material, I don't understand how a company can get started without at least the fire department knowing they were making it so they could have had some response drills prior to the incident.

CHAIRMAN BRESLAND: Well, I see there are some members of the fire department here this evening and I'm not going to put them on the spot. But I know that there are requirements not connected to the actual design construction operation of the facility. But there are requirements that companies report to the fire department and to the local emergency planning committee the chemicals that they have on site so that the appropriate emergency response procedures and planning can be put in place.

I think my understanding is, I'm

going to ask Mr. Hall this question, was that there was a partial reporting but not a complete reporting of the chemicals that were on site at that location. And let me ask Mr. Hall to expand on that.

MR. HALL: In the investigation we found there's a particular regulation which requires reporting of materials under a tier two report to the local emergency planning commission, the fire department and the like.

They submitted a report under this particular regulation, it's an EPA regulation, that reported the various solvents and the raw materials and the sodium that they had on site. What they failed to include in this particular report was the actual methylcyclopentadiene and diethylene glycol which is an extremely hazardous substance and it was not included in the report that was sent to the LAPC and the fire department.

The fire department was aware of the solvents that were on the site and did inspections. They were aware of the sodium that was on site and did inspections. And I believe they actually did drills dealing with a sodium mishap on site. But they were never informed of the MCMT production that was going on at the site. The fire department was there and looked at the hazards they were told about.

CHAIRMAN BRESLAND: Thank you.

Do we have anyone else who would like to make a comment or ask question? Okay.

We'll move on to the next phase of the meeting which is when we take a vote on the report and the recommendations.

And I'd like to ask if one of the board members would like to make a motion?

MR. WARK: Yes, Mr. Chairman, I'd like to make a motion. I'd like to move that the board approve the CSB investigative report and recommendations No. 2008-03-I-FL regarding the agency's investigation into the explosion and chemical fire that occurred on December

19, 2007 at the T2 Laboratories, Incorporated in Jacksonville, Florida.

CHAIRMAN BRESLAND: Thank you Board Member Wark.

Do we have a seconder?

MR. WRIGHT: I second, Mr. Chairman.

CHAIRMAN BRESLAND: I'd like to restate the motion. And the motion is to approve the CSB investigative report and Recommendation No. 2008 dash 03 dash 1 dash Florida, regarding the agency's investigation into the explosion and chemical fire that occurred on December 19th, 2007 at the T2 Laboratories, Incorporated in Jacksonville, Florida.

Do we have any discussion on this motion from the board members?

Board Member Wark?

MR. WARK: No, I have no discussion.

CHAIRMAN BRESLAND: Board Member

Wright?

MR. WRIGHT: No.

CHAIRMAN BRESLAND: Board Member Visscher?

MR. VISSCHER: No.

CHAIRMAN BRESLAND: In that case we'll close the discussion on this motion and we'll call for a vote and we'll start at the far end with Board Member Wark. You either approve or disapprove of the motion.

MR. WARK: Approve.

CHAIRMAN BRESLAND: Board Member Wright?

MR. WRIGHT: Mr. Chairman, I approve.

CHAIRMAN BRESLAND: Board Member Visscher?

MR. VISSCHER: Approve.

CHAIRMAN BRESLAND: And I approve also board members.

Based on that the motion has been approved and the investigation report and its recommendations have been approved by the board. Which brings us to some closing remarks. Just a couple of points I'd like to make.

The members this evening have made reference to the emergency responders who responded to this incident. To those of you who saw the photographs of the incidents, the dramatic photographs of the fire, some of them are here this evening. Let me just ask, I see a lot of firefighters here just a show of hands of firefighters if you did actually respond to the incident.

(Applause)

CHAIRMAN BRESLAND: Any other emergency responders, EMTs, paramedics? Okay.

Well, again thank you very much for your response under very dangerous circumstances.

I'd also like to point out that this morning we had a separate meeting with the family members of some of the people who were either killed or injured in the accident and also some of -- there were some people there who actually were at the site on the day of the explosion and in one case very seriously injured. We were able to give them basically the same presentation that we gave here this evening but in a quieter, more sober setting. And a lot of them could get an education what actually happened.

For me and for Mr. Hall who was there, it was a very sobering experience to meet those people and realize the terrible tragedy that impacted them and the fact that they are going to be dealing with this for the rest of their lives, especially the people who were very seriously injured.

I would like to thank each of the board members for your participation. My thanks go to Mr. Hall and his team for their diligence in carrying out this complex and difficult investigation. All of us here have a strong interest in preventing these tragic incidents from occurring.

Our goal at the Chemical Safety Board is to ensure that accidents do not occur in the future as a result of runaway chemical reactions, and that future chemical engineering students will be educated about the hazards associated with reactive chemistry.

In the next few months the CSB will be working with the American Institute of Chemical Engineers and the Accreditation Board to ensure implementation of the safety recommendations that were approved here this evening.

Just because we pass a vote and we make recommendations, it doesn't stop here this evening. We continue for several years with follow up on the recommendations to make sure that to the best of our ability that the recommendations are complied with and we will be in communication with AIChE and with the Accreditation Board to make sure that they do move forward in the way that we would recommend.

I would like to thank all of today's participants. I'd like to thank the audience for your attention. I'd like to thank the people who took the opportunity to come up and make comments also.

And with that this evening's meeting is adjourned.

(Whereupon, the proceedings were adjourned at 7:30 p.m.)