REEDY ENGINEERING, INC.

ENGINEERING MANAGEMENT CONSULTANTS

80,000 NON-ASME PRESSURE VESSELS

Pressure Vessel Explosion

I was retained as an expert witness in a lawsuit concerning the explosion of pressure vessel that killed a welder during an air test. The welder was trying to assure that the welds were leak-tight when the explosion occurred. The welder was killed when he was cut in half, as a result of the pressure vessel head blowing off and hitting him. A summary of the facts involved in the lawsuit are as follows.

On December 28, 2006, Mr. Theodore C. Potsko was employed as a welder by Structural Dynamics, Inc. (d/b/a Silvi Concrete), in Morrisville, Pennsylvania. On that day, he was assigned to repair a 200-gallon aluminum pressure vessel that was used to wash out the mixer drum of a concrete truck manufactured by Oshkosh Truck Corporation. The vessel was a component part of the Oshkosh truck and was fabricated by McIntire Fabricators, Inc., a subsidiary of McNeilus Companies, Inc., who designed and manufactured the vessel. Oshkosh acquired McNeilus in 1998. For the purposes of this letter, any reference to Oshkosh is intended to include all three entities. Attachment 1 shows a similar pressure vessel on an Oshkosh ready-mixed concrete truck.

The subject pressure vessel was removed from the Oshkosh truck on the morning of December 28, 2006. It was reported that the vessel was leaking and in need of repair, which required welding on one of the two torispherical heads. The repair consisted of identifying the leaks, welding over the damaged area, and leak testing the tank after the weld repair had been made.

The fill nozzles were located in the knuckle region of the torispherical head on one of the pressure vessel as shown in Attachment 2. Mr. Potsko completed the weld repair, closed the pressure vessel, and started filling it with air. The intent of filling the pressure vessel with air was to determine whether or not the leak was successfully sealed. However, while the pressure vessel was being pressurized, it exploded. The explosion blew the unrepaired torispherical head off the pressure vessel as shown in attachments 3 and 4. In other words, the explosion was not related to the welded repairs made by Mr. Potsko.

Mr. Potsko sustained fatal injuries as a result of the explosion. I conducted an investigation to determine the cause of the explosion. Below are my opinions and conclusions, all of which are stated to a reasonable degree of professional and engineering certainty.

The subject pressure vessel was defective as designed and manufactured, and these defects were the primary cause of the explosion. Neither the engineering design nor the manufacturing details were in compliance with the American Society of Mechanical Engineers (ASME) Section VIII Pressure Vessel Code as required by Pennsylvania law, and by the laws of most of the other states of the United States and most of the provinces of Canada..

A 200-gallon aluminum vessel was mounted on an Oshkosh ready-mixed concrete truck. The vessel was designed to be pressurized using the truck's air brake system. When the vessel was pressurized, the air pressure would push water from the vessel and through a hose. The water from the hose was used to wash out the mixer drum and the outside surface of the truck to prevent build-up of concrete residue.

On May 20, 2009, I visited the Silvi Concrete facility in Morrisville, PA, to examine the subject pressure vessel and the welding bay area where the explosion took place.

My examination and subsequent evaluation revealed that the pressure vessel exploded at a pressure of less than the design pressure, which was 60 psi. The point of failure is located at the top point of the fill nozzle. At this point, the attachment weld is a fillet weld only, on the outside surface of the head. The stress at a point with that type of detail is much greater than the stress in the smooth portion of the head. The stress is significantly increased at that point, because of the unreinforced cut-out area in the torispherical head, and the discontinuity between the head and the nozzle at the fillet weld.

Specifically, the vessel failed to meet basic pressure vessel engineering standards by placing the fill spout in the knuckle region of the torispherical head. A far better and safer location would have been to place the opening in the top portion of the horizontal cylindrical shell. Secondly, the areas surrounding the holes cut for the fill spouts should have been reinforced with doubler plates, or a thicker head plate should have been installed, to comply with ASME Code requirements. To compensate for the material lost when the hole was cut in the vessel, the eight-inch diameter holes required doubler plates of at least sixteen inches in diameter or a thickened head of twice the normal thickness of the head

It should also be pointed out that even if doubler plates or a thickened head had been used, the reinforcing would have been compromised, because the location of the fill nozzles would have caused the material to overlap the highly-stressed knuckle radius area.

To complicate matters further, the fill nozzles were not properly welded to the head, because they did not use standard welding details required by the ASME Pressure Vessel Code. The Code requires nozzles to be attached using full penetration or partial penetration welds with fillet welds, or fillet welds inside and outside where the nozzle is attached. The Oshkosh vessel only had a single fillet weld on the outside. It is no coincidence that the failure started at the top of the fill nozzle, at the fillet weld, in the area of the highly stressed knuckle. The point of initiation is shown in Attachment 5.

Further, the aluminum used for the torispherical heads had much lower strength than the aluminum material used for the shell. It was grossly negligent and completely illogical to design torispherical heads made of weaker material than that used for the cylindrical shell, because the torispherical head with the unreinforced openings is much more highly stressed than the cylindrical shell.

The cylindrical shell was made of aluminum alloy 5052, which has a specified tensile strength of 25 ksi and a yield strength of 9.5 ksi, whereas the strength of the aluminum alloy 3003 material used in the torispherical head has a specified tensile strength of 14 ksi and a yield strength of 5 ksi. This means the material used for the torispherical head is only slightly more than one half the strength of the cylindrical shell. This is a gross design error that further demonstrates the alarming degree to which this product is defective.

When evaluating the as-built vessel, by applying the ASME Boiler and Pressure Vessel Code design formulas and other Code requirements, without considering the design defects in the torispherical heads, the design pressure of the vessel is only 24 psi. However, the torispherical head had no doubler plates or other reinforcement around the opening. Therefore, the effective thickness must be considered to be one-half of the actual thickness of the torispherical head, to account for the missing reinforcing doubler plates. (In reality, this assumption is very conservative and benefits the manufacturer of the pressure vessel.) When the thickness is cut in half, the calculated design pressure is reduced to 12 psi. This calculated design pressure is less than one fourth the design pressure stated by Oshkosh in manuals and other literature.
At the time the pressure vessel was designed and manufactured, the design factor required by the Code was four, which means that the pressure vessel would be expected to fail at about four times the design pressure. Therefore, the subject pressure vessel would be expected to fail at a pressure of approximately 48 psi, which is far less than the design pressure stated on the nameplate.

However, the pressure vessel was made of aluminum and intended to contain water. Water will corrode aluminum. Therefore a corrosion allowance should have been added to the required thickness. Based on data from the vessel that exploded, a corrosion allowance of more than 1/8 in. should have been used. If that corrosion allowance is accounted for, the Code allowed design pressure would only be about 2.5 psi. The Oshkosh aluminum pressure vessels are defective and unsafe, because they do not even come close to meeting the requirements of the ASME Section VIII Pressure Vessel Code.

In answer to a question from OSHA regarding whether the "water tank" was considered to be a pressure vessel, Mr. Peterson, a vice-president and attorney for Oshkosh stated, "this tank is not considered a pressure vessel under ASME definitions, because it contains water under pressure using air as a cushion or compression and, the design pressure is less than 300 psi and the water temperature is under 210°F." This interpretation of the ASME Code is absolutely incorrect as shown in the attached ASME Interpretation. (Attachment 6.)

The pressure vessels carried on the Oshkosh ready-mixed concrete trucks should have been registered, inspected, and repaired in accordance with the National Board Inspection Code as required by most state and provincial laws.

Another disturbing fact is that there was an explosion of the same type of pressure vessel at the McIntire facility on June 7, 2000, causing an arm amputation and other permanent injuries to a McIntire employee. The explosion of this brand new pressure vessel occurred at a pressure of less than 90 psi, or less than 1.5 times the purported design pressure. I have reviewed the McNeilus Company Standard S-001, "Preliminary Leak Testing Tanks," dated June 12, 2000. This standard was prepared within a week after the "water tank" exploded.

Other Pertinent Facts

Because of my concerns regarding the safety of personnel working with these non-Code, under-designed pressure vessels, I feel that actions should be taken to eliminate them from service. Therefore, in my expert report, I informed Oshkosh that I would notify the states and provinces of the United States and Canada that the pressure vessels on the ready-mixed concrete trucks are unsafe and do not comply with most state and provincial laws. I have a moral obligation and the engineering Codes of Ethics require that these facts be brought to the attention of the proper authorities. Some other pertinent facts are:

1) Oshkosh has sold about 80,000 ready-mixed concrete trucks in the United States and Canada. Other truck manufacturers have furnished about 20,000 ready-mixed concrete trucks in these two countries. All of the trucks are similarly equipped with non-Code pressure vessels that are used to wash out the ready-mixed concrete drums.

2) There have been other accidents in the United States and Canada that have caused serious and permanent harm to personnel working around these trucks.

3) Replacement pressure vessels are not ASME Code stamped to the requirements of Section VIII of the ASME Code.

4) None of the pressure vessels on the Oshkosh ready-mixed concrete trucks are registered with the National Board.

5) There are suppliers of “water tanks” that furnish non-Code pressure vessels to replace damaged or worn-out “tanks.”

Suggested Actions

I feel the issues raised in this report are very serious and must be addressed. However, each state and province is different, and I know the actions to be taken by each Jurisdictional Authority must vary according to their laws. I am offering some suggested actions only to highlight the situation on the basis of my experience. My suggestions are offered as a "laundry list" from which authorities may select some, none, or all.

1) Meetings could be held with the National Ready Mixed Concrete Association and the Canadian Ready Mixed Concrete Association to inform them of state and provincial laws that apply. These organizations could also be notified that pressure vessels must be repaired in accordance with the National Board Inspection Code in most states and provinces.

2) This report may be given the widest distribution possible to affected or interested parties. This report can be copied or distributed as necessary for the safety of personnel.

3) State and Federal OSHA could be notified of the safety hazards associated with these pressure vessels.

4) The owners of ready mixed concrete companies could be informed that the non-Code "water tanks" must be replaced. They could also be notified of National Board registration requirements. They could also be notified that the "water tanks" could be used as-is, if a pump were added between the tank and the cleaning hose, thus eliminating the use of pressure in the tank.

5) Because there was an explosion of a "water tank" in Missouri and some related safety issues in Alberta, information could be gathered regarding all explosions of "water tanks," regardless of whether of not injuries or fatalities occurred.

6) States and provinces that have pressure vessel laws could consider the best and most effective means to enforce those laws. One approach might be to prohibit the use of brake system air to pressurize these tanks, or require that "water tanks" not be pressurized.

Should any authorities wish to question me concerning this letter or any of the facts about the explosion, I am willing to cooperate in every way possible.

Roger F. Reedy
Registered Professional Engineer

Attachment 1 - Typical Oshkosh Pressure Vessel

Attachment 2 - Potsko Welded Repairs

Attachment 3 - Part of Torispherical Head

Attachment 4 - Cylinder Without Head

Attachment 5 - Initiation of Failure

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November 6, 2009

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Subj: ASME Boiler Code, Division 1, Section VIII, Introduction, U-1(c)(2) Pressurized Air in a Vessel Containing Water

Ref: Your inquiry of 05/07/2009

Item: 09-771

Dear Mr. Reedy,

Our understanding of the questions in your inquiry and our replies are as follows:

Background: Paragraph U-1(c)(2)(f) recognizes that a vessel may be designed with a constant mass of air that serves as a cushion of pressurized air. When water enters the pressure vessel, the air pressure so created is directly related to the increase in water volume and the associated decrease in air volume in the vessel.

Question: Is a pressure vessel containing water with a design pressure of less than 300 psi (2 MPa) and a design temperature of less than 210 F (99 C) and is designed to be pressurized by air from an external source a class of vessel that is not included in the Scope of ASME Section VIII, Division 1 per U-1 (c)(2)(0?

Reply: No.

Very truly yours,

Thomas Schellens
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