Pressure Vessel Accidents: Safety Approach

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Abstract - ***A pressure vessel is a container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. The pressure differential is dangerous, and fatal accidents have occurred in the history of pressure vessel development and operation. The bursting of pressure vessel results in loss of lives and property. Consequently, pressure vessel design, manufacture, and operation are regulated by various engineering authorities backed by legislation. This paper mainly focuses on the reasons behind pressure vessel failure, pressure vessels accidents and preventive measures to be taken during design, manufacture, and operation stages in order to avoid accidents.***

Key Words: Pressure vessel, failure, accidents.

INTRODUCTION

Pressure vessels is closed containers used to store fluids (Liquids or gases) under pressure higher than atmospheric pressure. Pressure vessel is used in process, petrochemical industries. Due to operating conditions, high stresses are developed in Pressure Vessel which results in cracking and bursting of vessel. Failure of pressure vessel resulted in loss of several lives and property. Pressure vessel has to withstand against high pressure and temperature and in some cases flammable fluids or highly radioactive materials. Because of these hazards it is important to design the pressure vessel such that no leakage can take place. Plant safety and integrity are of fundamental concern in pressure vessel design and these depend on adequacy of design codes

Horizontal Pressure Vessel

Vertical Pressure vessel

Steam Boiler

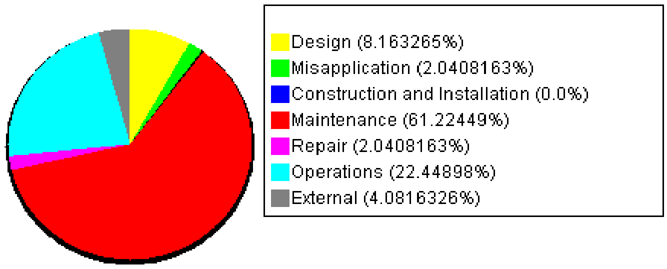
Heat exchanger

2. COMPONENTS OF PRESSURE VESSEL

1. Vessel shell
2. Nozzles
3. Vessel Support
4. Vessel Mountings
5. Vessel accessories

3. REASONS OF FAILURE

Reasons of pressure vessel failures are as follows:
1. Improper design
2. Misapplication
3. Construction and Installation
4. Maintenance
5. Repair
6. Operations



4. PRESSURE VESSEL ACCIDENTS

Feyzin Explosion:
On Jan. 4, 1966, an operation to drain off an aqueous layer from a propane storage sphere was attempted. Two valves were opened in series on the bottom of the sphere. When the operation was nearly complete, the upper valve was closed and then cracked open again. No flow came out of the cracked valve, so it was opened further. The blockage, assumed to be ice or hydrate, cleared and propane gushed out. The operator was unable to close the upper valve and by the time he attempted to close the lower valve this was also frozen open. The alarm was raised and traffic on the nearby motorway was stopped. It is theorized that the resulting vapor cloud found its source of ignition from a car about 525 feet (160 meters) away. The storage sphere was enveloped in a fierce fire and upon lifting of the relief valve a stream of escaping vapor was ignited. About 90 minutes after the initial leakage, the sphere ruptured, killing the men nearby. A wave of liquid propane flowed over the compound wall and fragments of the ruptured sphere cut through the legs of the next sphere, which toppled over. The relief valve on this tank began to emit liquid. The fire killed 18 people and injured 81 others. Five of the storage spheres were destroyed.

Flixborough:
The Nypro (UK) site at Flixborough was severely damaged by a large explosion On Saturday, June 1, 1974,. Twenty-eight were killed and 36 suffered injuries. It is widely assumed that the casualty rate would have been higher if it were a weekday, as the main office block was not occupied. Offsite consequences resulted in 53 reported injuries. Property in the surrounding area was damaged to a varying degree., on March 27, 1974, it was discovered that a vertical crack in reactor No. 5 was leaking cyclohexane Prior to the explosion. The plant was subsequently shutdown for an investigation. The investigation that followed identified a serious problem with the reactor and the decision was taken to remove it and install a bypass assembly to connect reactors No. 4 and No. 6 so that the plant could continue production. During the late afternoon on June 1, 1974, a 20-inch bypass system ruptured, which may have been caused by a fire on a nearby 8-inch pipe. This resulted in the escape of a large quantity of cyclohexane. The cyclohexane formed a flammable mixture and subsequently found a source of ignition. Eighteen fatalities occurred in the control room as a result of the windows shattering and the collapse of the roof. The fires burned for several days, and within 10 days rescue efforts were finally being made to the people involved.

Seveso:
A chemical reactor ruptured On Saturday July, 10, 1976, Maintenance staff heard a whistling sound and a cloud of vapor was seen to issue from a vent on the roof. The release lasted for roughly 20 minutes. About an hour after the release, the operators were able to admit cooling water to the reactor. Among the substances of the white cloud released was a small deposit of TCCD, a highly toxic material. The nearby town of Seveso, located 15 miles from Milan, had roughly 17,000 inhabitants. Over the next few days following the release, there was a lot of confusion due to the lack of communication between the company and the authorities in dealing with this type of situation. No human deaths were attributed to TCCD, but many individuals fell ill.

San Juanico LPG:
The San Juanico Disaster was caused by a massive series of explosions at a liquefied petroleum gas (LPG) tank farm in San Juanico, Mexico, on Nov. 19, 1984. The explosions consumed 11,000 cubic-meters of gas, which represented one-third of Mexico City's entire LPG supply. The explosions destroyed the facility, killed close to 600 people while 5,000-plus suffered severe burns, making San Juanico one of the

deadliest industrial disasters in history. Three refineries supplied the facility with LPG on a daily basis. The plant was being filled from a refinery 250 miles (400 kilometers) away, as it had become almost empty on the previous day. Two large spheres and 48 cylindrical vessels were filled to 90% and four smaller spheres to 50% full. A drop in pressure was noticed in the control room and also at a pipeline pumping station. An 8-inch pipe between a sphere and a series of cylinders had ruptured. The operators could not identify the cause of the pressure drop. The release of LPG continued for about 5 to 10 minutes when the gas cloud, estimated at 650 feet x 500 feet x 7 feet high (200 meters x 150 meters x 2 meters high), drifted to a flare stack. It ignited, causing a violent ground shock. The explosions were recorded on a seismograph at the University of Mexico.

Bhopal:
Widely considered the greatest tragedy in chemical industry history, the Bhopal Disaster was a gas leak incident in India that occurred on Dec. 2, 1984, at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya, Pradesh, India. During the night of Dec. 2-3, water entered a tank containing 42 tons of MIC. The resulting exothermic reaction increased the temperature inside the tank to more than 392°F (200°C) and raised the pressure. The tank vented, releasing toxic gases into the atmosphere. The gases were blown by northwesterly winds over Bhopal. Theories differ on how water entered the tank. Operators assumed that bad maintenance and leaking valves made it possible for the water to leak into the tank. Some suggest sabotage by a disgruntled employee via a connection to a missing pressure gauge on the top of the tank. A leak of methyl isocyanate gas and other chemicals from the plant resulted in the exposure of hundreds of thousands of people. A government affidavit in 2006 stated the leak caused as many as 25,000 deaths, as well as 558,125 injuries (3,900 severely)

Baia Mare:
This is worst disaster in Europe,the 2000 Baia Mare cyanide spill was a leak of cyanide near Baia Mare, Romania, into the Somes River. The polluted waters eventually reached the Tisza and then the Danube, killing large numbers of fish in Hungary and Yugoslavia. On Jan. 30, 2000, a dam holding contaminated waters burst and 100,000 cubic meters of cyanide-contaminated waters (containing an estimated 100 tons of cyanides) spilled over some farmland and then into the Somes River. Large quantities of fish died due to the toxicity of cyanide floating in the the river waters, affecting 62 species of fish.

Grande Paroisse Fertilizer Plant Explosion:
A huge explosion occurred in the AZF fertilizer factory in Toulouse, France On Sept. 21, 2001, Three hundred tons of ammonium nitrate was stored in Hangar 221 and it was concluded that improper handling of this dangerous material contributed to the explosion. Specifically, experts believe that a mislabeled 1,100-pound (500-kilogram) bin of sodium dichloroisocyanate, which was mistakenly thought to be ammonium nitrate, was dumped in the off-spec ammonium nitrate warehouse. Under hot and humid conditions, it reacted with the ammonium nitrate to form nitrogen trichloride, which is an extremely unstable compound. The entire factory was destroyed and the explosion measured 3.4 on the Richter scale. The disaster caused 29 deaths, seriously wounded 2,500, as well as injured an additional 8,000. Two-thirds of the city's windows were shattered. The total damages already paid by insurance groups currently exceed 1.5 billion euros. Roughly 40,000 people, or 10% of the population, were homeless for a few days.

Texas City:
On March 23, 2005, a fire and explosion occurred at BP's Texas City refinery in Texas City, Texas, killing 15 workers and injuring more than 170 others. The explosion occurred in an isomerization unit at the site, resulting in the deaths and injuries. According to a report issued after the accident, actions taken or not taken led to overfilling the raffinate splitter with liquid, overheating of the liquid, and the subsequent over pressurization and pressure relief. Hydrocarbon flow to the blow down drum and stack overwhelmed it, resulting in liquids carrying over and out of the top of the stack, flowing down the stack, accumulating on the ground, and causing a vapor cloud, which was ignited by a contractor's pickup truck as the engine was left running. The report identified numerous failings in equipment, risk management, staff management, working culture at the site, maintenance and inspection, and general health and safety assessments. In 2011, BP announced that it was selling the refinery. The U.S. Chemical Safety and Hazard Investigation Board found that BP had failed to implement safety recommendations made before the blast. OSHA ultimately found more than 300 safety violations and fined BP $21 billion, the largest fine in OSHA history at the time.

5. RATE OF ACCIDENTS

The study of previous accidents shows that about maximum accidents took place because of improper maintenance and wrong operations. 6 accidents were took place in between 1966-2000 afterheat rate of accident reduced because of advanced technologies and awareness amongst people to follow laws and safety standard. National Board of Boiler and Pressure Vessel Inspectors recorded the number of accidents involving pressure vessels at an increase of 24% Over the course of a year between 1999 to 2000.[2] These Accidents includes pressure vessel, high water heating boilers, steam boilers, unfired pressure vessel.
Reporting year 2000 saw the highest number of accidents at 2,686 with the lowest at 2,011 in 1998. The number of fatalities as a direct result of boiler and pressure vessel accidents has been recorded as 127 over the past 10 years. [During the reported period between 2001 and 2008, the statistics show that the rate of accidents that were directly linked to pressure vessels is not yet on the Decline.

6. SAFETY APPROACH

Pressure vessels are designed to operate safely at a specific pressure and temperature technically referred to as the Design Pressure and Design Temperature. A vessel that is inadequately designed to handle a high pressure constitutes a very significant safety hazard. Because of that, the design and certification of pressure vessels is governed by design codes such as the ASME Boiler and Pressure Vessel Code in North America, Australian Standards in Australia and other international standards like Lloyd's, Germanischer Lloyd.

7. PRECAUTIONARY MEASURES

1. Inspection is critically important to the safe operation of the pressure vessels not only for the refinery but for the surrounding community.
2. Inspection and maintenance routines should carry out to check whether all processing units are working in proper conditions.
3. Testing and inspection of vessel to detect leaks, corrosion and erosion which causes holes in wall of vessel which results in bursting of vessel.
4. In order to operate vessel under safe condition different valves like pressure relief valve, temperature gauges should work to handle design pressure and temperature.
5. Design, fabrication and construction of pressure vessels should carried out according to standard safety codes.
6. Keeping records of inspection reports and monitoring potential problem, so that the vessel may be taken out of service before it becomes dangerous. Also, having all information displayed prominently.
7. Ensuring that repairs of vessels are only done by qualified and experienced authorized person and the repair must meet the accepted industry quality standards for pressure vessel repair.

CONCLUSION

We cannot fully eliminate pressure vessel accidents but can work towards reducing risk of the same. Many countries follow standard codes and establish good practices for safety. Some countries still do not adopt safety standards and codes which results in increasing pressure vessel accidents. Inspection and maintenance routines are recommended to ensure that all pressure equipment is safely operated. Special training and instruction for irregular work conditions. Permit the system that allows only qualified workers access to certain areas. Preventive maintenance of plant should carry out to avoid possible accidents.

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