## II. Description ~ Triple Point Vehicle Protection Technology

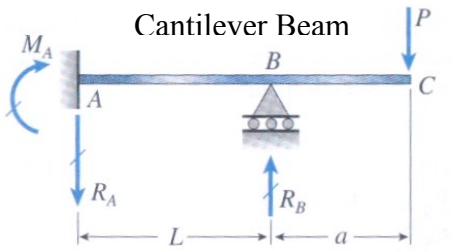
### Present Technology

Imagine you are driving home on the average day. Maybe you are driving home from work, school, the store or maybe you were just out in the town. You are enjoying yourself, but this enjoyment is about to take an ugly turn. Up ahead you see a stop light, and you slowly press down on the breaks. You hear a screeching coming from…where? Was that your brakes? As you ponder over the noise you hear it again, this time louder and closer. A car turns the corner and you see the swerving colors of the vehicle as it comes towards you. Your heart pounding and your palms gathering sweat you scramble to try to get out of the way. But you are too late, and the vehicle crashes into the front of your car. The whole hood of the car is crushed, the headlights are smashed, and the air bags deploy as a result. You smash forward into the cushioning of the air bag, but it feels like a rock punching into your face. *What has happened? What is going on?* The searing pain of the force of the air bag has frozen your mind. As you leave the accident listening to the siren of the ambulance you lay in, you think: *Why? Why has this happened?* Such a normal day has gone so terribly wrong, and what was supposed to save you has severely injured you. Accidents like these happen everyday, and when they do air bags fail to fully protect you. They can severely injure, and even kill, a person. They put lives at stake. This is why the Triple Point Vehicle Protection Technology was created to improve the safety of vehicles, and save your live in such a horrible accident.

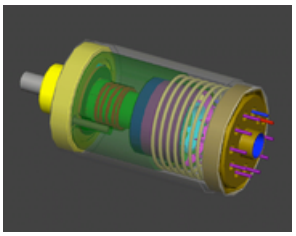
The present form of the technology used for T.P.V.P.T. is used in air bags today. Air bags have a somewhat simple design that is run by a central "Air Bag Control Unit", or ACU. An ACU is a form of ECU, or "Electronic Control Unit", that controls one or more of the electrical systems or subsystems in a vehicle through its embedded system. The ACU monitors sensors in

the vehicle, such as accelerometers, impact sensors, wheel speed sensors, gyroscopes, brake pressure sensors, and seat occupancy sensors.

The accelerometer is a very important part of the ACU. Accelerometers are typically small micro electro-mechanical systems, or MEMS. MEMS is simple; containing not much more than a cantilever beam, a beam supported only on one end. Cantilever beams are used is cranes, buildings, towers, and bridges. For a cantilever beam to stay supported, there needs to be more weight on one side and very little weight on the other side. There are no supports on the lighter side, so the weight on the opposite side puts enough weight on it for it to be supported. Accelerometers are made to detect movement, so when you stop the vehicle abruptly it triggers the air bag. The signals from accelerometers and the other various sensors are sent into the ACU and determine the angle of the impact, the intensity, and force from the crash. The ACU may then trigger safety devices including seat belt pre-tensioners and airbags.




Accelerometer



The airbags that are deployed could include frontal bags, side bags, and “curtain bags”. Each of these devices is usually activated using an electric match, or initiator. This electric match is made up of an electrical conductor wrapped in a combustible material. It activates with a current pulse between one to three amperes in less than two milliseconds. The combustible material is ignited when the conductor gets hot enough, causing the gas generator to ignite as well. Inside the airbag inflator, the initiator is used to ignite solid propellant that generates inert gas as it burns. The gas inflates the airbag in approximately 20 to 30 milliseconds. The initiator

is also used to tighten a seat belt in a seat belt pre-tentioner. The hot gas drives a piston that pulls the seat belt closer to you.

Airbags inflate only once and then begin to deflate, so this increases the chance of injury. During a rollover crash, seat belt pre-tensioners are designed to protect you from flying around the vehicle, but if you are lunged around the seat belt can begin to cut into your skin. If the accident is not a rollover crash, then the seatbelt pre-tensioner helps to properly position your body to increase the airbags benefits as they deflate.

**History**

In 1953, John W. Hetrick, a retired industrial engineering technician, received a patent for the first airbag prototype. The idea for the safety device came to him after a 1952 accident with his wife and daughter. He wanted to create something that could come out to stop you from hitting into the dashboard or the windshield. Getting the patent for his "safety cushion" took about a year and cost $250. A German inventor named Walter Linderer invented an inflatable cushion and received a patent for that also in 1953. This was another invention to protect drivers in case of accidents. These early models of airbags inspired car companies like Ford and General Motors to start working on inflatable restraints a few years later. When in designing phases, car makers discovered that passengers could also be hurt when they hit the airbag and that the airbag needs to inflate in at least 40 milliseconds. Due to design problems in early airbag systems, some deaths in accidents were caused exclusively by the airbags. In 1967 Mercedes-Benz started developing airbags in their cars because of the increase of accidents in the 1960's and the new federal law put in place in 1969 that said that every automobile needed to have an 'automatic occupant protection system'. Around that same time, Allen Breed, a New Jersey mechanical engineer, invented a reliable crash sensor that was the only one of its time. Many people agree

that this system started the airbag industry. This was the world's first electromechanical automotive airbag system. The first recorded accident in which airbags deployed to protect both the driver and the passenger happened on March 12, 1990. In 1991, Allen Breed created an airbag that vented air as it inflated, decreasing the amount of injury from hitting the airbag by reducing its firmness. Still, there were over 238 recorded deaths caused by the deployment of the airbags from 1990 to 2002. Not to mention the hundreds of disabilities caused by the airbag system. Breed later started his own company which is now the leading manufacturer of crash sensors and inflator modules. Four years later Volvo made side and torso side protection airbags available in their 850 models. Duel frontal airbags were mandated in all passenger vehicles by the federal government in 1998 and three years ago, Honda even introduced an airbag system for their motorcycles.

**Future Technology**

In twenty years, triple-point water bag technology will benefit all passengers in many different ways. The idea behind this technology is that it will be able to stop you like a solid while feeling like a liquid. This system is based on a three-inch thick blanket of triple-point water falling from the ceiling. The basic design of this system is a collapsed pocket on the ceiling of the car (folded up like an accordion) and water kept at just the right temperature and pressure stored in the roof of the car. When in an accident, an accelerometer can tell when you negative accelerate rapidly, so it activates the water to fill the bag. Then the bag drops, the water turns to triple-point so that it is a solid, liquid, and gas all at the same time and that works with your momentum to slow down your head's motion and it cushions the impact on the steering wheel. The rest of your body should be safely secured by the seatbelt during the time of impact.

One of the most important parts of this system is the accelerometer. To deploy common airbags, a mechanical switch is flipped when there is a mass shift that closes an electrical contact, telling sensors that a crash has occurred. These sensors receive information from an accelerometer built into a microchip. In traditional airbags, accelerometers consist of a ball that goes back and forth depending on acceleration and negative acceleration similar to the technology in some of today's cellular phones (Figure 1). If it moves forward quickly, the airbags would deploy suspecting there was a collision. For our technology, we would use what most airbags use today which is the system with the electrical contact, so when that contact is broken, it would activate a small airbag on the steering wheel and it would activate the water deploy system so that the triple-point water airbag would deploy as well. The airbag on the steering wheel would be much smaller than today's airbags only going out around four to five inches just to provide extra cushion, but the most important part is the triple-point water bag.

**Figure 1: Some of today's cell phones use accelerometers that allow you to turn the phone on its side and still produce the same picture**

This blanket of triple-point water is designed to work with your momentum to slow you down and stop you instead of having an airbag blast into your face working against your momentum, and there's a delicate science behind it. This is meant to be dense while it is a solid to stop you and then it turns to a liquid and a gas and it gradually and comfortably slows you down acting well with the Law of Inertia.

The Law of Inertia is often simplified as "A body would continue its state of rest or of uniform motion unless acted upon by an external unbalanced force." This means that if you

were moving and you were moving , and you had momentum, you wouldn't stop until another force acted upon you. So, if you were riding in a car, your body would have momentum, and you wouldn't stop unless another force stopped you. So if another automobile hit your car, it would stop the car, but your body would keep moving because of the momentum of your head, so that is where the water bags come in.

The roof would be made of two layers, one layer to hold the bags themselves and another layer to keep the water. The layer holding the water would be temperature and pressure controlled and slightly tilted down towards each bag, and the different sections would be divided and tilted especially for each bag. The temperatures and pressures would be monitored and controlled by in-car computers (which would probably be a lot cheaper in twenty years). Plus, if there is an issue, that the computer cannot control, such as a leak, It could contact a service center similar to OnStar which could then contact the driver and tell you about the problem. When in an actual collision, panels would open allowing the water to pour into the bags and a hydraulic system would push the water into the bags to speed up the process, and the bag would drop a few inches in front of the steering wheel and dropping to around seven to nine inches above the seat. The bags would be measured so that they are a certain length that allows it to only drop a few feet until it dangles high enough to give your legs enough room to still move. For the windows, they would drop to the bottom edge of the window, and for the rear seats, another small airbag would deploy out of the seat front seats and the triple-pointed water bag would drop a few inches behind the front seats and to a length around seven to nine inches above the rear seats. The bags would be made of threads made partially of carbon nanotubes so that they would last a lifetime and wouldn't break under the strain of the water pouring into the bags.

There is also the challenge of storing the water and keeping it under the right conditions. To keep the water under proper conditions, it would need a pressure and temperature regulator. The bags would have tubes of liquid chilled at exactly 32.18 degrees Fahrenheit so that the water will stay at triple-point for as long as possible. Those tubes would be around half of a centimeter in diameter. When storing the water it would require an impressively sophisticated refrigeration unit. One candidate for this refrigeration unit could be a thermoelectric cooler. A thermoelectric cooler is a cooling system that uses the Peltier effect to create a heat flux in the junction of two different types of materials. A Peltier cooler, heater or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other side against the temperature gradient (from hot to cold), with consumption of electrical energy. Because heating can be achieved more easily and economically by many other methods, Peltier devices are mostly used for cooling. However, when a single device is to be used for both heating and cooling, a Peltier device may be desirable. Simply connecting it to a DC voltage will cause one side to cool, while the other side warms. Thermoelectric junctions are generally only around 5-10% as efficient as the ideal refrigerator (Carnot cycle), compared with 40-60% achieved by conventional compression cycle systems (reverse Rankine systems like a compressor). Due to the relatively low efficiency, thermoelectric cooling is only used in environments where the solid state nature (no moving parts, maintenance-free) outweighs pure efficiency. However, recent developments prove that series Peltier effect modules could soon surpass I.C. engines both in efficiency and power density for fuel based power generation. To regulate pressure would be a much more difficult and complex task One possible way is to use a hydraulic system to apply just the right amount of pressure on the water so that it is at triple-point for as long as possible.

Some problems with this is that it would require energy, add weight, and it would be difficult to monitor and constantly adjust for the computer.

This concept of a triple-point water safety device involves plenty of sophisticated future technologies, but this could change automobile safety for generations to come.

**Breakthroughs**

There are some scientific breakthroughs that must happen before the triple-point airbag will become a reality. The main things that must happen include getting the substance to an exact temperature and pressure, creating the triple-point state of matter. The unit would have to keep, for example, water, at its exact triple-point temperature of $0.01^{o}C$ at storage, release, and impact.

Another issue that would need to be resolved is the proper storage of multiple packages of the triple-point material within the vehicle. Multiple packages would be *vital* in the scenario of several consecutive impacts. Currently, only one single airbag-per-person may be stored. But, in the case of more than one impact, such as a multi-car pile-up, or even in a rollover, one single airbag will not do. Vehicle safety will improve greatly with more than one deployment of a restraint system.

Another potential issue would be using the triple-point's strengths appropriately to protect the rider. There would have to be a sure way that the triple-point would protect like a solid, feel like a liquid, and release like a gas. If this combination gets messed up, then the driver would go right through the triple-point, or smash their face into the triple-point, defeating the purpose all along.

Also, storing the substance at the proper pressure and temperature would need some sort of scientific breakthrough. The storage chamber would need the exact pressure and temperature required for the substance to enter the triple-point state. This would especially be an issue when

released out to the open area of the car where the driver and passengers are located. A way around the issue would be to have the container of the substance at the correct pressure, that way the substance would always be at the triple-point state, no matter whether it in within storage, or in the interior of the car. Also, you could have many small P/T (pressure/temperature) regulators throughout the car. P/T regulators are in the form of small pistons and thermoelectric coolers, which are commonly used to cool computer parts. Another way of achieving this desired temperature and pressure would be using a similar system that is used in the human body to keep the internal temperature steady. The way to do this would be to equip the chamber with tubes that expand and contract according to the conditions. These mechanical tubes would work perfectly at keeping the temperature and pressure in the right place at all times.

The final breakthrough that must happen before this invention can be a reality is the proper containment of the triple-point substance. If the substance is released at the wrong time, the substance will get into the working parts of the vehicle. (e.g. engine) Also, it would just be an empty bag and the riders' heads would smash into the dashboard and seats. All of these breakthroughs are key in bringing the triple-point protection system to a reality.

**Design Process**

There were many ideas that we discussed before getting to the Triple-Point Vehicle Protection Technology. Our first way of trying to find an idea for this contest was to combine or use some of the technologies we already knew a lot about. Between the four of us we knew a lot about carbon nanotubes, air propulsion, Electromagnetic Self Propulsion System (ESPS), and robots/artificial intelligence. These made us first lean toward an air or electromagnet powered engine for a car. The pressurized air or the electromagnet would move the pistons up and down, powering the engine. Even though this was a good idea, we wanted to look at some others. To

get these new ideas, we looked at some serious problems that we could use as a base for our future technology. We figured that fuel or energy efficiency was a big problem so that made us go back to the electromagnet or air powered engine. This wasn't our project choice because this technology would have a lot of problems that we would have to solve and it would take way too long. Another idea that came up went along with robots/artificial intelligence. It was a car that uses a GPS system to drive itself wherever you want to go. This, of course would also be a very difficult task to complete in the time we had. Our last idea before getting to our triple-point system was a way for ambulances to skip the bumper to bumper traffic when they need to transport or get to a patient. We would use an ESPS to make the ambulance able to hover over the traffic so they could get to the patient or hospital in time. This provided more problems than any other of the ideas combined. There would have to be a way to have it stably hover so that the patient's condition would not be affected. Also, the electromagnet would have to be very powerful to lift an ambulance. The group wanted to design a future technology that directly impacted a person's well-being. So we came up with a safer alternative to the modern airbag material, triple-point. All of the other technologies including the air/ESPS powered engine, the self-driving car, and the hovering ambulance led us up to the triple-point airbag. They also helped us to develop the triple-point technology. We didn't use the previous technologies probably because we liked other ideas that we explored more. Maybe in a few cases we decided that it would take too long or be very difficult to complete ever. That was our thought process that brought us to the Triple-Point Vehicle Protection Technology.

**Consequences**

All technologies have both negative and positive sides to them, including T.P.V.P.T. When water is at it's triple point, it has to be at a very cold temperature of 0.01 degrees Celsius

exactly. While this cold temperature is not deadly, it would feel somewhat uncomfortable to fall into something so cold. The triple point would also have to be able to remain at this specific temperature and pressure point of 0.6117 long enough to protect you during a series of crashes or a rollover crash. This is possible to do, but it requires a very insulated material that can keep the cold in and the heat out. This would also allow pressure. But once this is done, T.P.V.P.T will improve the safety of vehicles.

Current airbags can save you, but they can also seriously injure you. They cannot be used in the back seats because of their ability to kill small children. With our invention, it is hard enough to protect you from the impact of another vehicle, but it is soft enough to protect you as you collide with it. The T.P.V.P.T. will sense the impact of the crash, determine where it came from, and inflate the T.P.V.P.T. bag in approximately 60-80 milliseconds total after the impact of the crash. The air bag behind the T.P.V.P.T. also inflates in this period of time as a support for the triple point. This airbag is not large enough to cushion you on it's own, and it is not too much to injure you severely or kill you. This way, it is not a safety hazard for children or smaller people.

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