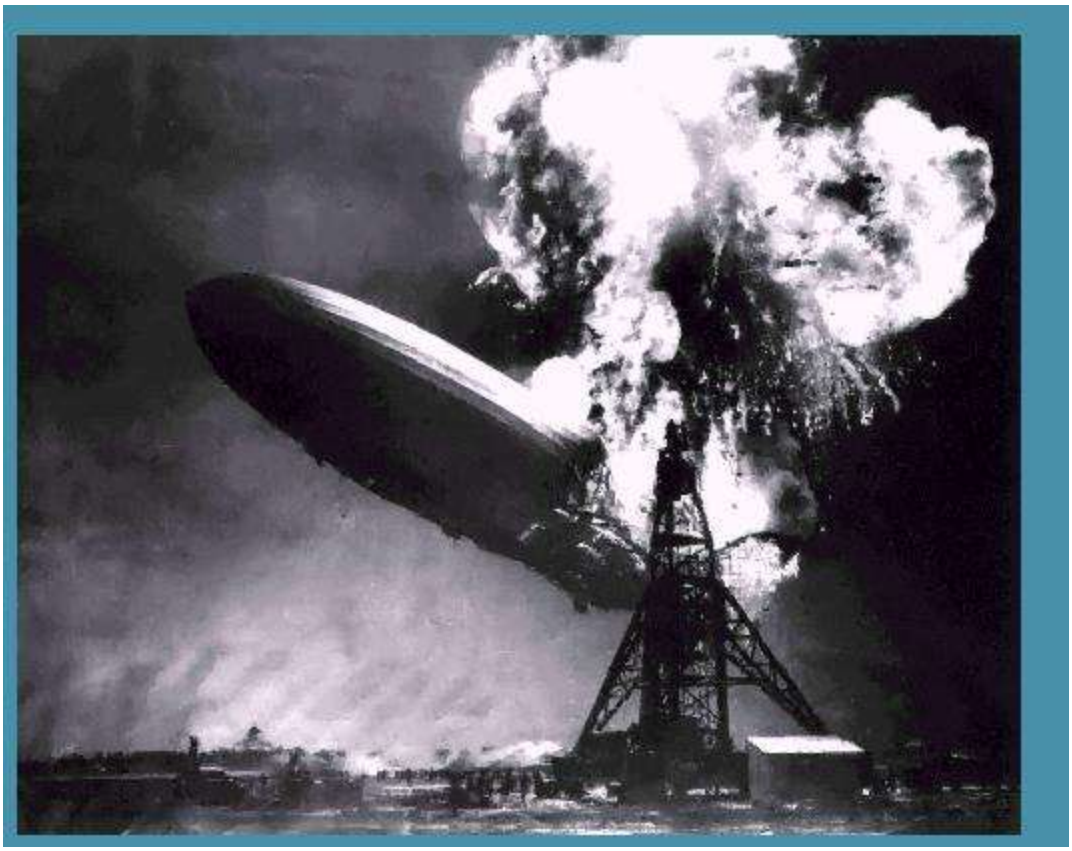

In 1997, I served as Panelist at the 8th Annual U.S. Hydrogen Meeting sponsored by National Hydrogen Association and DoE. For the most part, the attendees were industry professionals and technically astute. Nevertheless, during the Q&A period a question was directed at me concerning the safety of hydrogen. In particular, the person in the audience suggested that hydrogen is unsafe and referenced the Hindenburg Disaster. After gaining my composure, I mentioned hydrogen's characteristics that refuted this notion of hydrogen being a sleeping atomic bomb.

At that time, some technical information was available the suggested hydrogen was not the key culprit causing the disaster. Today, modern science has come to hydrogen's deference with indisputable evidence showing that other factors were to blame. Still, from time-to-time the Hindenburg disaster keeps coming up with fingers pointing to hydrogen. It is time to set the record straight and share this information with the world. Here goes the story.

What Can We Learn from the Hindenburg Disaster?

The explosion of the luxury airship Hindenburg at Lakehurst, NJ, on May 6, 1937, serves as one of the most spectacular moments recorded by the media. Until very recently, it has aided in paralyzing the development of widespread hydrogen use as a fuel, due to concerns for safety (and viewing the fiery picture above, understandably so). But knowing the actual nature of the Hindenburg disaster, as well as knowing the behavior of hydrogen allows us to dispel this stigma associated with hydrogen.

The Facts on the Hindenburg Disaster:

1. The bags of hydrogen that provided the lifting force for the Hindenburg were NOT the main contributor to the fire. The surface of the ship was coated with a combination of dark iron oxide and reflective aluminum paint. These components are extremely flammable and burn at a tremendously energetic rate once ignited. The skin of the airship was ignited by electrical discharge from the clouds while docking during an electrical storm. This reaction has been proven chemically for years, and was demonstrated with actual remnants of the Hindenburg sixty years later, which burned as vigorously as on the day of the disaster.
2. The hydrogen burned quickly, safely, above the occupants. When the escaping hydrogen was ignited by the burning skin of the airship, it burned far above the airship, and was completely consumed within 60 seconds of the ignition. During this period of time, the airship descended to the ground from the 150-foot docking tower.
3. Almost all deaths were caused by jumping or falling from the airship. Of the 35 deaths from the disaster, 33 were caused by jumping or falling. Only two deaths were caused by burning, and it is likely that those two were from proximity to the burning skin of the airship, or from the stores of diesel fuel that were ignited by the covering. Whereas the hydrogen burned within one minute of ignition, the diesel fires burned for up to ten hours after the ignition.
4. The Hindenburg would have burned if it had been filled with inert helium gas. Even if the Hindenburg had not been lifted by hydrogen, the ignition of the covering would still have happened, and would then have set ablaze the diesel stores, resulting in the same disaster.

5. The main cause of the disaster was pilot error. The only way to prevent the disaster would have been if the pilot had chosen to land in better conditions elsewhere, which was very feasible, considering he had had enough fuel remaining to reach all the way to California.

The Nature of Hydrogen:

- Hydrogen is less flammable than gasoline. The self-ignition temperature of hydrogen is 550 degrees Celsius. Gasoline varies from 228-501 degrees Celsius, depending on the grade. When the Hindenburg burned, it took some time before the hydrogen bags were ignited.
- Hydrogen disperses quickly. Being the lightest element (fifteen times lighter than air), hydrogen rises and spreads out quickly in the atmosphere. So when a leak occurs, the hydrogen gas quickly becomes so sparse that it cannot burn. Even when ignited, hydrogen burns upward, and is quickly consumed, as shown in the Hindenburg picture. By contrast, materials such as gasoline and diesel vapors, as well as natural gas are heavier than air, and will not disperse, remaining a flammable threat for much longer.
- Hydrogen is non-toxic. Hydrogen is a non-toxic, naturally-occurring element in the atmosphere. By comparison, all petroleum fuels are asphyxiants, and are poisonous to humans.
- Hydrogen combustion produces only water. When pure hydrogen is burned in pure oxygen, only pure water is produced. Granted, that's an ideal scenario, which doesn't occur outside of laboratories and the space shuttle. In any case, when a hydrogen engine burns, it actually cleans the ambient air, by completing combustion of the unburned hydrocarbons that surround us. Compared with the toxic compounds (carbon monoxide, nitrogen oxides, and hydrogen sulfide) produced by petroleum fuels, the products of hydrogen burning are much safer.
- Hydrogen can be stored safely. Tanks currently in use for storage of compressed hydrogen (similar to compressed natural gas tanks) have survived intact through testing by various means, including being shot with six rounds from a .357 magnum, detonating a stick of dynamite next to them, and subjecting them to fire at 1500 degrees F. Clearly, a typical gasoline tank wouldn't survive a single one of these tests.

What Have We Learned?

No fuel we currently use or have yet to develop will be totally without hazards, through all the processes of production, transportation, and consumption, just as no kitchen knife can be used without risk to the chef. Hydrogen has long been considered close to ideal as a fuel due to its abundance, non-toxic characteristics, and international availability. We must recognize that each of us has learned to use knives safely, and do

so daily. As long as we use wisdom in our methods of production, storage, and use of hydrogen, we'll enjoy the same safety we have had with petroleum fuels, with the additional benefit of fewer health hazards when leaks do occur.

Sources

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