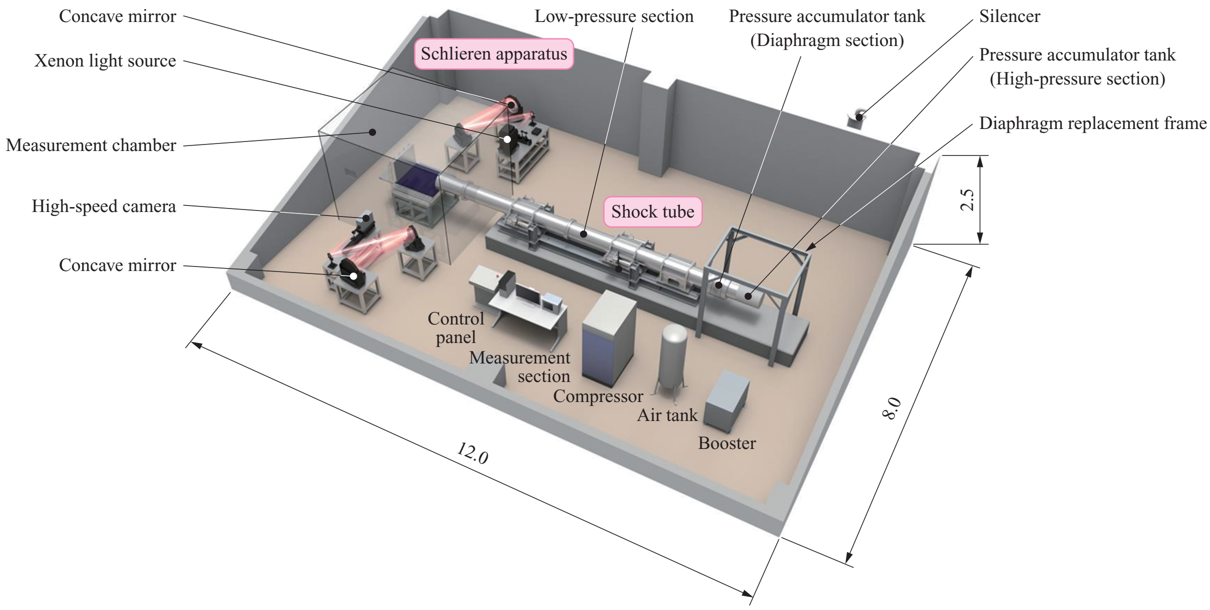
Saving Lives from Blast! Making Contributions to Blast Injury Treatment

Defense technology created next to the patients' room
Shock tube for blast injury research

The threat of bomb terrorism is growing year by year. To develop protective clothing and pursue research on how to treat blast injuries, we have developed a large shock tube exclusively for blast injury evaluation, making full use of structural strength simulation technology, fluid analysis simulation technology, and noise and vibration reduction technology.



Overall view of the shock tube for blast injury research (unit : m)

Shock tube for blast injury research

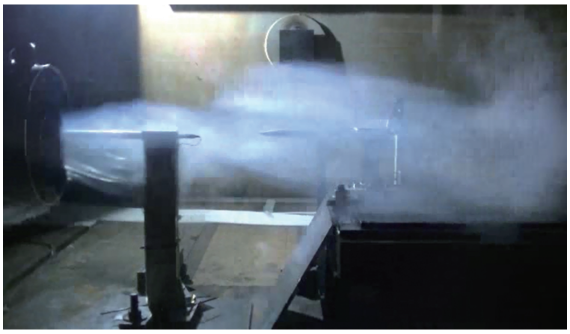
In the midst of a situation in which conflicts and terrorism are becoming increasingly intense and the threat of these is spreading rapidly all over the world, the number of blast attacks with explosive devices such as bombs and Improvised Explosive Devices (IEDs) by armed insurgents is increasing, and, for this reason, blast injury research is being actively pursued in Europe and North America. It has been reported that many people who have been involved in a blast attack have suffered damage to internal organs, or impaired memory or attention due to brain abnormalities, without there being any visible injuries on the surface of their bodies.

In Japan also, the National Defense Medical College is focusing on blast injury research[*1]. The college planned a 'shock tube for blast injury research.' IHI developed and delivered the shock tube in 2017.

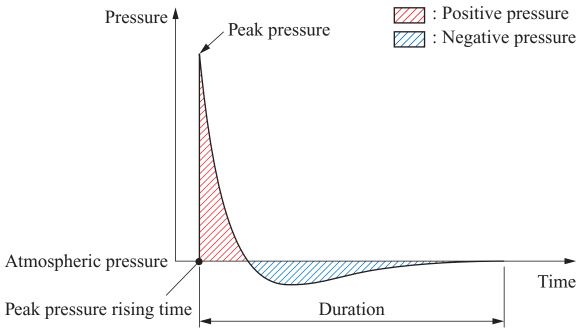
The equipment was installed in a room of length 8.0 m, width 12.0 m, and height 2.5 m in the National Defense Medical College Research Institute (Tokorozawa City, Saitama Prefecture). The shock tube, which constitutes the main part of the equipment, is a stainless-steel tubular structure of approximate length 7.5 m and outlet diameter 400 mm, and has a pressure accumulator tank at the rear.

'Blast' means the explosive wind pressure (compression wave) generated by an explosion, and since it propagates faster than sound, a shock wave is formed at the crest of the blast. The equipment can generate a shock wave to simulate blast and allows the blast to act on a specimen.

This equipment instantaneously releases the high-pressure gas in the pressure accumulator tank. The high-pressure gas expands rapidly as it passes through a tube of a certain



Simulated blast



Shock wave pressure waveform

length, which causes the low-pressure side to compress, thereby generating an supersonic compression wave. The principle is simple, but it is necessary to accurately reproduce the blast pressure waveform in a limited indoor space. This equipment was therefore completed by utilizing IHI's strengths, including knowledge of shock wave generation technology, structural strength simulation with finite element method (FEM) technology, pressure and fluid simulation by computational fluid dynamics (CFD) technology, and technology to reduce the noise and vibration from equipment.

Simulation that reproduces blast accurately

With a shock tube, any pressure waveform can be generated by adjusting the pressure of the high-pressure gas in the pressure accumulator tank, the volume of the tank, and the shape and length of the tube.

For the purpose of blast injury research, the shock tube is required to be capable of generating a pressure waveform having the following positive and negative pressures.

- Peak pressure: Up to 400 kPa (gauge pressure)
- Duration time from the rise to peak pressure to the return to atmospheric pressure: Maximum of around 10 ms

For accurate pressure waveform generation, we conducted a series of CFD simulations and element tests examining how shock waves propagate, and used equipment fabrication technology that reproduces simulated conditions (e.g., knowledge of instantaneous pressure release, and fabrication accuracy) in order to carry out efficient equipment fabrication. Consequently, this equipment has achieved the world's highest level of peak pressure in this field.

Installation in an existing building in order to meet the customer's needs

In the shock tube for blast injury research, since the accumulator tank pressure is released to atmospheric pressure, a shock load is applied and an explosion sound is generated.

To meet the customer's needs, we succeeded in installing this equipment in a building close to residences and patients' rooms through building renovation. This means that it was possible for research to be conducted in an existing building, without the necessity of constructing a new laboratory.

To achieve this, the foundation for the equipment was separated from the foundation for the building. In addition, a damper mechanism was incorporated into the equipment in order to absorb shock, thereby reducing the amount of vibration transmitted to the foundation.

With regard to noise insulation, the inner walls were covered with sound-absorbing materials, and a measurement chamber was provided that has sufficient strength to withstand blast. This made it possible to reduce the value of the noise generated around the noise source (the outlet of the shock tube) when a shock wave is generated in the equipment. The value can be reduced from 160 dB or more to approximately 60 dB outside the room.

Future prospects

This shock tube for blast injury research is highly evaluated. For example, it is frequently used by the customer, and many experts come to observe it from overseas. In addition, this equipment received the "Defense Structure Improvement Foundation Award," which — with respect to defense equipment — recognizes companies or individuals that have achieved particularly excellent results in their pursuit of independent private sector research and development, or production technology improvement.

Going forward, we will contribute to medical research, and propose and produce defense equipment that accurately meets customers' needs by utilizing the comprehensive strength of the IHI Group.

*1 Y. Sekine, D. Saitoh, Y. Yoshimura, M. Fujita, Y. Araki, Y. Kobayashi, H. Kusumi, S. Yamagishi, Y. Suto, H. Tamaki, Y. Ono, T. Mizukaki and M. Nemoto : Efficacy of Body Armor in Protection Against Blast Injuries Using a Swine Model in a Confined Space with a Blast Tube, Annals of Biomedical Engineering, 2021.3

Inquiries:
Defense/Security Equipment Engineering Department,
Defense System Division,
Aero Engine, Space & Defense Business Area,
IHI Corporation
Phone: +81-42-568-7177
https://www.ihi.co.jp/en