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H_2FC

Integrating European Infrastructure to support science and development of Hydrogen- and Fuel Cell Technologies towards European Strategy for Sustainable, Competitive and Secure Energy

Deliverable

D10.8 Database of High Quality Experimental Reference Data

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28.02.2014	1.0	Alexei Kotchourko
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1 Database for H2FC

1.1 Introduction

As it was stated in the H2FC Project Dow the testing of the quality of each numerical model and code requires a reliable experimental database. The goal of the current task is to gather the best quality experimental data for validation of existent and forthcoming tools to model and simulate hydrogen and fuel cell phenomena and processes.

1.2 Database characteristics

To fulfil the requirements for the technical basics of the database coming from the database goal, several candidates presenting different internal software architecture were analysed. Taking into account the fact that the data which has to be included into database is of different format and character, it was decided that the use of the standard database software as MySQL, which is freely available can constitute the adequate software basis able to provide all necessary features.

1.3 Database sources

In the current initial stage of the database formation we were focussed on testing of the essential features of the database functionality, as input of the data, data presentation, data selection and data extraction. So, the data were obtained mostly from public sources and from previous and ongoing projects in the field, namely it was using the existing experimental data collection from NoE HySafe, which was created in the frames of benchmarking activities in HySafe. These data were widely used in the former simulations, thus providing the required level of quality and authenticity for the purpose of the H2FC Project.

1.4 Data structuring

The data in the database is appropriately structured and classified. The classification addresses the following topics: thermodynamic and thermochemical properties, transport properties, physical and chemical properties, hydrogen releases and dispersion, ignition and fires, deflagrations and detonations, transitional combustion phenomena (FA, DDT), etc.

At the current stage seven different main categories based on relevant physical phenomena studied in the experiments are included in the database:

Release (leakage) of hydrogen gas
Distribution of hydrogen gas
Ignition of hydrogen gas
Deflagration of hydrogen gas
Deflagration to detonation transition (DDT)
Detonation of hydrogen gas
Fire

The next steps in the data selection provide possibility to evaluate each experiment in more details, starting from the short summary, which gives the experimental data outline, and ends up with the possibility to obtain the deeply detailed information as, e.g., pictures, movies, drawings, etc., and the data themselves, as e.g., transducer recording, tables, and diagrams.

The experimental data in the database are given in uniform format which helps the users selecting appropriate data for code validation easily. In one experiment data, following 10 topics are provided.

Summary

Author
Experimental Setup
Objective of the experiment
Applicable calculations
Experimental procedure
Experiment data
Performed simulation
References
Comments

1.5 Database content

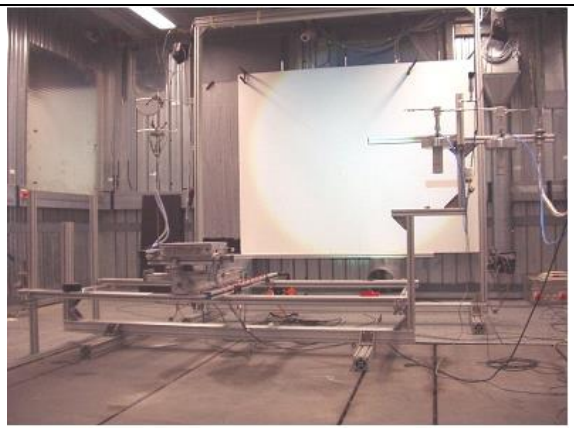
Currently, the database is residing on the KIT server and is accessible either inside local network or from outside for H2FC partners. Since the first set of data were prepared by KIT personal, most of experiments focus on deflagration. Latter more data concerning other physical phenomenon will be prepared as well and the database will be open to the public when enough experiments will be prepared. Following table shows the ID and types of the experiments available now:

Release of hydrogen
FZK hydrogen distribution tests in free turbulent jet HSL Un-ignited High-Pressure Hydrogen Releases in the Atmosphere – Experiment no7
Deflagration
Deflagration in a Sphere UU 01 GexCon MOGELEG channel FIKE Experiments HYCOM-MC043 HYCOM-HC020 HYCOM-HC027 HYCOM-MC003 HYCOM-MC012 HYCOM-HYC01 HYCOM-HYC12 HYCOM-HYC14 HYCOM experiments on flame acceleration in vented tube LACOMECO deflagration in A2 LACOMECO deflagration in A3 Shell Hydrogen Refuelling Station (HRS-1)
Deflagration to detonation transition (DDT)
FZK-R0498_09
Detonation
Open atmosphere detonation KI RUT hyd5

2 Content of the Database

For a better view of the experiments available in the database, a brief summary of the experiments are provided in this section.

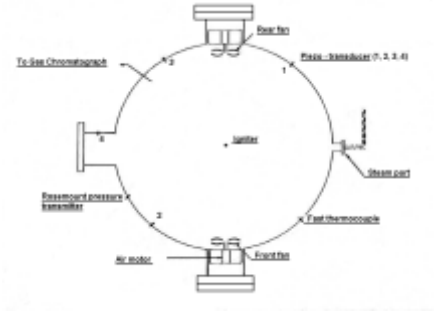
FZK hydrogen distribution tests in free turbulent jet

Experiment Type	Hydrogen Dispersion
Keywords	Dispersion, High Pressure Release, Jet,
Draft drawing or simple description for the facility	
Short description	Hydrogen distribution tests in horizontal free turbulent jet have been carried out in a compartment with an internal volume of 160 m3. Experimental facility consisted of high pressure gas system to provide hydrogen release at pressures in the range 20 – 260 bar through the nozzle. Experiments were made in order to evaluate amount of burnable hydrogen – air mixture (above the lower flammability limit) in free turbulent jet at different pressures.

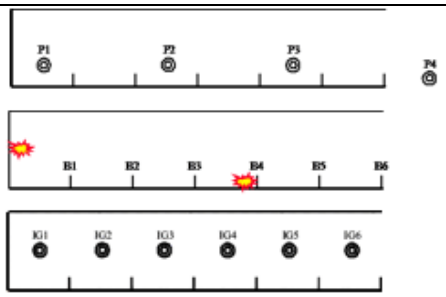
HSL Un-ignited High-Pressure Hydrogen Releases in the Atmosphere – Experiment no7

Experiment Type	Dispersion
Keywords	Dispersion, High Pressure Jet, Large-scale, Open Environment,
Draft drawing or simple description for the facility	 
Short description	A set of experiments involving horizontal high-pressure hydrogen jet releases was conducted at HSL. Different release pressures and nozzle diameters were used.

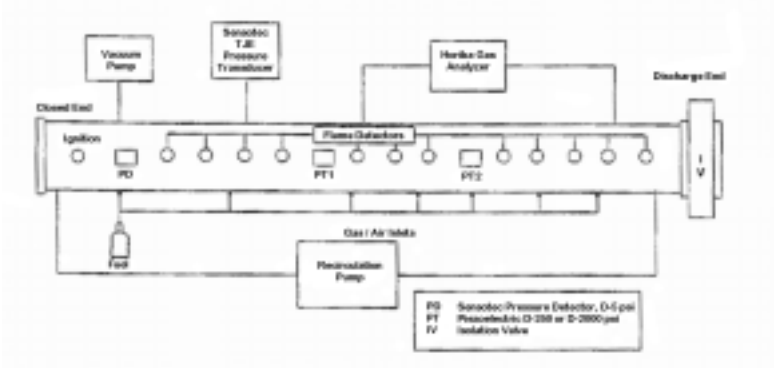
Deflagration in a Sphere UU 01

Experiment Type	Deflagration
Keywords	Deflagration, Large-scale Vessel, Premixed, Closed Environment
Draft drawing or simple description for the facility	
Short description	Deflagration of 29.5% (by vol.) hydrogen-air quiescent mixture in the 6.37 m3 closed spherical vessel (diameter 2.3 m). Central point ignition source. Initial temperature is 373 K, initial pressure 97 kPa.

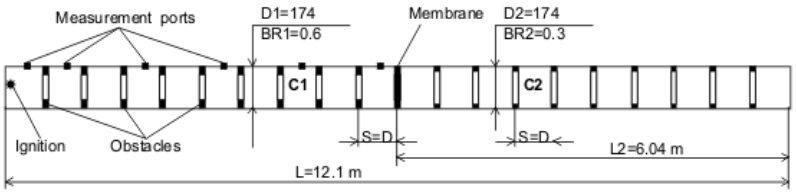
GexCon MOGELEG channel

Experiment Type	Deflagration
Keywords	Deflagration, Vented Channel, Obstacles
Draft drawing or simple description for the facility	
Short description	Vented hydrogen explosions in a channel on a table without or with 2 baffles from inner wall; ignition centrally at the inner end; concentration variation provided for the empty channel.

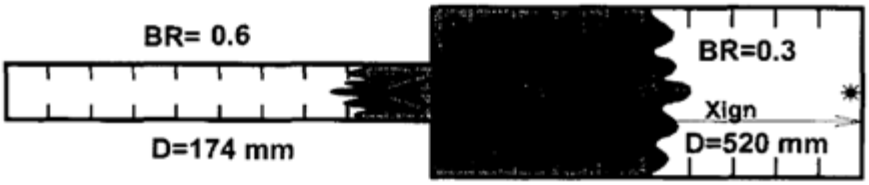
FIKE Experiments

Experiment Type	DDT
Keywords	DDT, Tube, Flame Acceleration, Different Hydrogen Concentration, Different Diameter
Draft drawing or simple description for the facility	 Pipe Diameters - 6" (0.1524 m), 10" (0.254 m), 16" (0.4064 m) The 6" I.D. pipe was 15 m long. The 10" I.D. pipe was 25 m long. The 16" I.D. pipe was 40 m long.
Short description	Explosion experiments with hydrogen in straight pipes of 3 different diameters (All with L/D = 98) were carried out, for the 6”/15m pipe 6 different gas concentrations were applied.

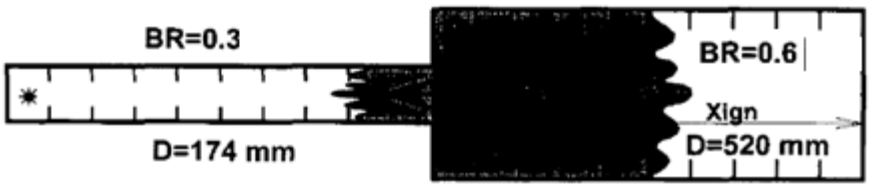
HYCOM-MC043

Experiment Type	Deflagration
Keywords	Deflagration, Obstacles, None Uniform Hydrogen, Flame Acceleration
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in obstructed tube of 174 mm in diameter and 12.1 m in length. Repeatable obstacles at distances equal to diameter. The experimental tube was divided in two equal parts by thin polyethylene membrane with different blockage ratios and hydrogen concentrations.

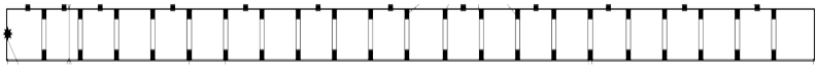
HYCOM-HC020

Experiment Type	Deflagration
Keywords	Deflagration, Non-uniform Obstructed Tube,
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in non-uniform obstructed tube of 12.4 m long combined of two parts with diameter of 174 and 520 mm in diameter. Combustion of uniform test mixture with 10% of H2 in air was investigated.

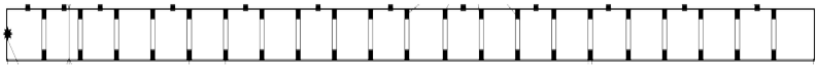
HYCOM-HC027

Experiment Type	Deflagration
Keywords	Deflagration, Non-uniform Obstructed Tube,
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in non-uniform obstructed tube of 12.4 m long combined of two parts with diameter of 174 and 520 mm in diameter. Combustion of uniform test mixture with 10% of H2 in air was investigated.

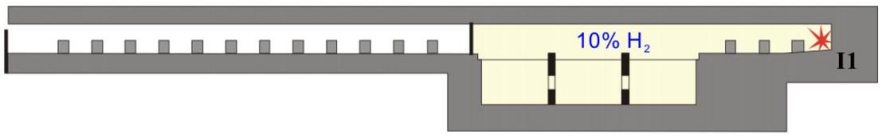
HYCOM-MC003

Experiment Type	Deflagration
Keywords	Deflagration, Obstacles, Quenching, Closed Tube
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in obstructed tube of 174 mm in diameter and 12.2 m in length (DRIVER facility). Repeatable obstacles with blockage ratio BR=0.6 at distances equal to diameter. Hydrogen/air mixture with concentration of 10% H_2 was tested.

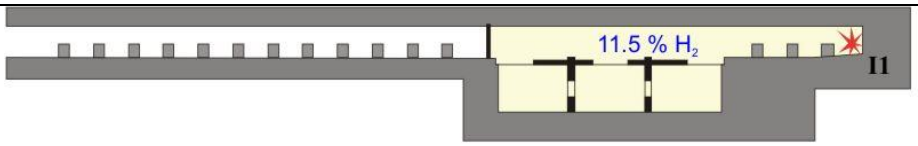
HYCOM-MC012

Experiment Type	Deflagration
Keywords	Deflagration, Obstacles, Flame Acceleration, Closed Tube
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in obstructed tube of 174 mm in diameter and 12.2 m in length (DRIVER facility). Repeatable obstacles with blockage ratio BR=0.6 at distances equal to diameter. Hydrogen/air mixture with concentration of 13% H_2 was tested.

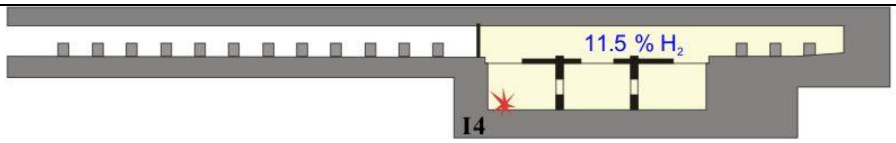
HYCOM-HYC01

Experiment Type	Deflagration
Keywords	Deflagration, Large-scale Complex Geometry, Obstacles, Flame Acceleration
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in large scale multi-compartment geometry consisted of curved channel and canyon. Four repeatable obstacles with blockage ratio BR=0.3 installed in the channel and two obstacles in bottom part of canyon. Uniform hydrogen/air mixture with concentration of 10% H_2 was tested.

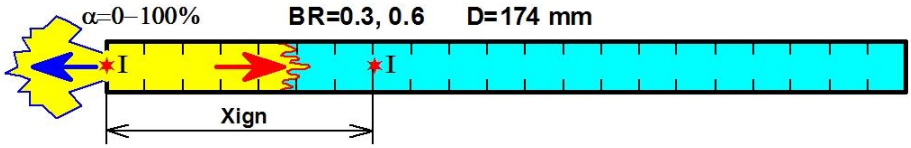
HYCOM-HYC12

Experiment Type	Deflagration
Keywords	Deflagration, Large-scale Complex Geometry, Obstacles, Flame Acceleration
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in large scale multi-compartment geometry consisted of curved channel and canyon. Four repeatable obstacles with blockage ratio BR=0.3 installed in the channel. Canyon has been divided in four separate rooms connected with orifices. Uniform hydrogen/air mixture with concentration of 11.5% H_2 was tested.

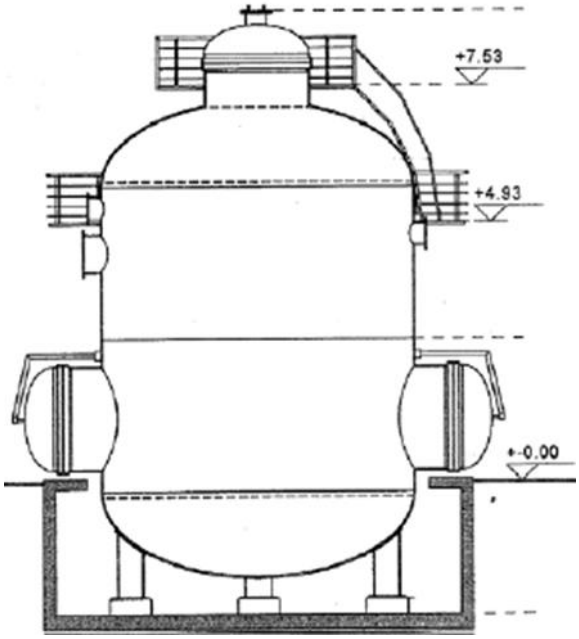
HYCOM-HYC14

Experiment Type	Deflagration
Keywords	Deflagration, Large-scale Complex Geometry, Obstacles, Flame Acceleration
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in large scale multi-compartment geometry consisted of curved channel and canyon. Four repeatable obstacles with blockage ratio BR=0.3 installed in the channel. Canyon has been divided in four separate rooms connected with orifices. Uniform hydrogen/air mixture with concentration of 11.5% H_2 was tested.

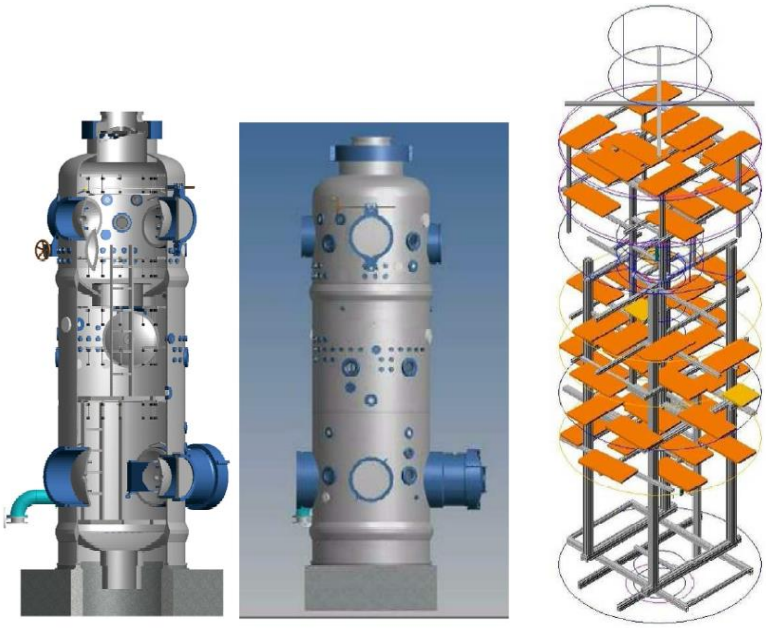
HYCOM experiments on flame acceleration in vented tube

Experiment Type	Deflagration
Keywords	Deflagration, Obstacles, Venting, Flame Acceleration
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in obstructed tube. Repeatable obstacles with 2 different blockage ratios at distances equal to diameter were installed. Two typical hydrogen-air mixtures with concentrations of 10% H_2 (for subsonic deflagration) and 13% H_2 (for sonic deflagration) have been tested in a tube with different end venting. Ignition at various distances from the open tube.

LACOMECO deflagration in A2

Experiment Type	Deflagration
Keywords	Deflagration, Homogeneous mixture, Large-scale experiment, Ignition,
Draft drawing or simple description for the facility	Draft drawing of experiment facility HYKA A2:  Description: The volume of the facility is 220 m^3. The inner height is 9.1 m. The inner diameter is 6.0 m.
Short description	The experiment was performed in the HYKA A2 experimental facility. A homogeneous mixture of hydrogen (10 vol.%), steam (25 vol.%) and air was established in the vessel. The initial pressure was 1.49 bar, and the average initial temperature was about 90.0 ºC. The mixture was ignited at the bottom of the vessel and the ensuing axial and radial flame propagation were observed. Pressure and temperature were measured at different axial and radial locations.

LACOMECO deflagration in A3

Experiment Type	Deflagration
Keywords	Deflagration, Hydrogen Gradient, Large-scale Vessel, Ignition
Draft drawing or simple description for the facility	Experiments are performed inside the A3 cylindrical vessel of 8 m total height and 2.35 m of internal diameter. The facility, having total volume of 32.8 m3, consists of two chambers, lower (21.6 m3) and upper (11.2 m3), separated by round duplex door of 1 m diameter. Internal structures comprise the supporting metal frame and the obstacles made of plywood. There are six layers of obstacles of BR (block ratio) = 40 % and the annular compartments separating surface of BR = 80 %. 
Short description	Ten experiments performed in the framework of HYGRADE project is devoted to flame propagation in an obstructed large scale facility A3 with initially vertical hydrogen concentration gradients: three tests with homogeneous hydrogen concentration, three tests with hydrogen concentrations having negative slopes and lower ignition (at 1.2 m), two tests with hydrogen concentration having positive slopes and lower ignition (at 0.2m and at 0.02 m), and two tests with hydrogen concentrations having positive slopes and upper ignition (at 7.078 m).

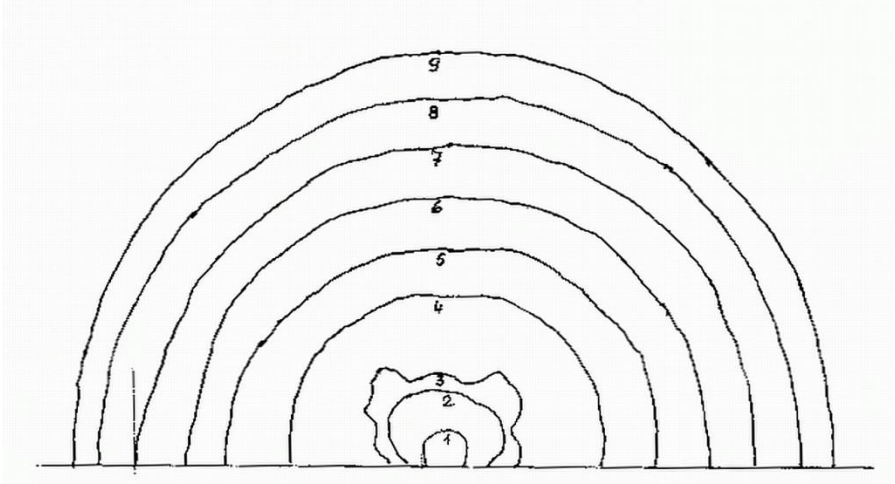
Shell Hydrogen Refuelling Station (HRS-1)

Experiment Type	Deflagration
Keywords	Deflagration, Large-scale, Homogeneous Mixture, Complex Geometry
Draft drawing or simple description for the facility	
Short description	A mock-up of a Hydrogen Refuelling Station, which includes a brick wall, two dispensers and simplified steel structure representing a vehicle, was designed. Polythene film is wrapped around the rig, which is then filled with a homogeneous stoichiometric hydrogen-air mixture. The ignition source is spark plug generating ignition energy of ca. 50 mJ.

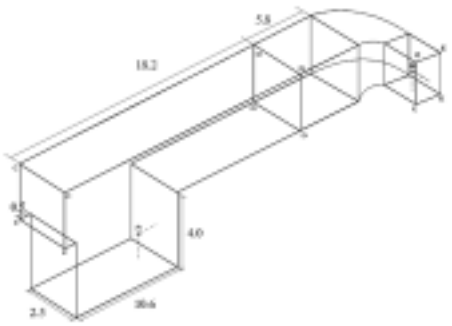
FZK-R0498_09

Experiment Type	DDT
Keywords	DDT, Flame Acceleration, Obstacles, Closed Tube
Draft drawing or simple description for the facility	
Short description	Combustion experiments have been carried out in obstructed tube of 350 mm in diameter and 12 m in length. Repeatable obstacles with blockage ratio BR=0.3 at distances 500mm. Hydrogen/air mixture with concentration of 15% H_2 was tested.

Open atmosphere detonation

Experiment Type	Detonation
Keywords	Detonation, Large-Scale, Open Environment
Draft drawing or simple description for the facility	
Short description	Detonation of 29.05% (by vol.) hydrogen-air quiescent mixture in the 53 m^3 hemispherical balloon (diameter 2.93 m). Central point ignition source.

KI RUT hyd5

Experiment Type	Detonation
Keywords	Detonation, Large-scale, Complex Geometry
Draft drawing or simple description for the facility	
Short description	Detonation experiments have been carried out in large scale confined complex geometry (263 m^3). Uniform hydrogen/air mixture with concentration of 20.0% H_2 was tested.