Doctoral Thesis

Laborversuche zur instationären Ausbreitung isothermer Schwergaswolken

Author(s):
Billeter, Lukas

Publication Date:
1995

Permanent Link:
https://doi.org/10.3929/ethz-a-001511469

Rights / License:
In Copyright - Non-Commercial Use Permitted

This page was generated automatically upon download from the ETH Zurich Research Collection. For more information please consult the Terms of use.
Laborversuche
zur instationären Ausbreitung
isothermer Schwergaswolken

ABHANDLUNG
zur Erlangung des Titels
DOKTOR DER TECHNISCHEN WISSENSCHAFTEN
der
EIDGENÖSSISCHEN TECHNISCHEN HOCHSCHULE
ZÜRICH

vorgelegt von

Lukas Billeter
Dipl. Masch.-Ing. ETH
geboren am 29. Dezember 1961
von Männedorf (ZH) und Wallisellen (ZH)

angenommen auf Antrag von
Prof. Dr. T.K. Fanneløp, Referent
Prof. Dr. L. Reh, Korreferent

1995
Abstract

To determine the hazardous potential of accidental releases of heavy gases, it is important to understand the relevant spreading phenomena.

In the present study the behaviour of isothermal heavy gas clouds, instantaneously released, was investigated. The gases used were argon and argon-air mixtures. For these experiments a large scale laboratory test facility was used, i.e. a spreading channel with a length of 20m. Due to the large scale, the flow is comparable to full size radial releases. The repeatability in our experiments was found to be excellent also for the details of the cloud structure.

The concentrations were measured with a large number of fast-response concentration sensors (aspirated hot wires). They were designed to minimize the errors due to suction flow rate through the probes and the flow displacement due to the probe body.

By varying the relevant initial parameters, including the shape parameter aspect ratio (i.e. the height to length ratio of the initial gas volume), their influence on the spreading behaviour of the heavy gas cloud was determined.

Comparisons of the measured data with three different theoretical approaches to the description of heavy gas dispersion are given.

For the conventional box model with selfsimilar properties, i.e. rectangular cross section in the spreading direction and uniform density distribution, different scaling approaches for the air entrainment were investigated. The frontal velocity in this model is determined from dimensional arguments. The use of this velocity together with the frontal area of the cloud as scaling parameters, gave results in good agreement with the experiments.

Comparisons with theoretical solutions from a numerical shallow-layer model including a new air-entrainment hypothesis, were used to determine the empirical coefficients required in this model. The comparison between the experiments and the theory, using a fixed set of empirical coefficients, gave consistent and good agreement over the full range investigated.

A dynamic radial integral model, i.e. a refined box-model which includes the acceleration phase and a detailed energy budget was
adapted to the case of the spreading in a channel. In this model an entrainment hypothesis is considered, that is derived from a theoretical approach used to describe the atmospheric boundary layer.

By means of the box model with the usual simplifications, the measured concentrations were transferred to the case of radial spreading. Comparisons of these data with those from experiments for radial spreading, confirmed the universal validity of the entrainment parameters found in the present study.