



License Agreement

for the CFD Test Case

IN-1: Droplet Characterization in Cryogenic Flash Boiling Liquid Nitrogen Sprays at High-altitude Conditions

The test data of this test case was generated by Andreas Rees during his doctorate project (2012 – 2020) under the scientific supervision of Univ.-Prof. Dr. rer.nat. M. Oschwald in the Combustion Chamber Technology Group of Dr. Dmitry Suslov at the DLR Institute of Space Propulsion in Lampoldshausen, Germany.

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The test case "IN-1" is open to everyone, who wants to use the data base for CFD validation. The provision of this test case is intended to be a contribution to the field of research on spray formation of superheated jets, especially the injection of propellants in rocket engines at high-altitude conditions. The provider of the test case highly appreciates to share results, experience and other useful information among the group of users and encourages all users to participate in that sense. Joint publications are welcome.

The test case consists of three documents:

- (1) the Test Case Description
- (2) the Test Case Data Set (figures)
- (3) the Test Case Raw Data Set (.xlsx data).

By signing this license agreement the user accepts:

- to not give access to anybody else to the contents of the test case description and test case data set
- to not distribute the contents of the test case and test case data set to third parties

- that he does not gain any rights on the obtained data or any other information on the test case.
- to cite in every publication (or in any other form of communication) the source and origin of his information, i.e. naming the authors and the institute. If the test case is used in any form of publication, the relevant publications below must be cited. Furthermore, the origin of the data base must be mentioned as follows: "The measurements on the test case "IN-1" were carried out at the Institute of Space Propulsion at the German Aerospace Center in Lampoldshausen, Germany".
- to give feedback to the Institute of Space Propulsion at the German Aerospace Center in Lampoldshausen about what he did with the provided information. Participation in the potential workshops and inclusion of these results in the data base are solicited and welcome.

After the signed License Agreement has been received by the contact at DLR listed below the detailed Test Case Description and the Test Case Data Set will be made available to the licensee.

Relevant publications of the test case:

- [1] C. Manfretti, "Laser Ignition of an Experimental 400N Cryogenic Reaction and Control Thruster: Pre-Ignition Condition," *Journal of Propulsion and Power*, vol. 30, no. 4, pp. 925-933, 2014.
- [2] A. Rees, H. Salzmänn, J. Sender und M. Oswald, „Investigation of flashing LN2-jets in terms of spray morphology, droplet size and velocity distributions,“ in *8th EUCASS*, Madrid, Spain, 2019
- [3] A. Rees, L. Araneo, H. Salzmänn, G. Lamanna, J. Sender, Oswald und Michael, „Droplet velocity and diameter distributions in flash boiling liquid nitrogen jets by means of phase Doppler diagnostics,“ *Experiments in Fluids*, 61:182, August 2020.
- [4] A. Rees, H. Salzmänn, J. Sender und M. Oswald, „About the morphology of flash boiling liquid nitrogen sprays,“ *At. Sprays*, accepted September 2020
- [5] V. Cleary, P. Bowen und H. Witlox, „Flashing liquid jets and two-phase droplet dispersion: I. Experiments for derivation of droplet atomisation correlations,“ *J. Hazard. Mater.*, Bd. 142, pp. 786-796, 2007
- [6] A. Rees, L. Araneo, H. Salzmänn, E. Kurudzija, D. Suslov, G. Lamanna, J. Sender, Oswald und Michael, „Investigation of Velocity and Droplet Size Distributions of Flash Boiling LN2-Jets With Phase Doppler Anemometry,“ in *29th ILASS-Europe*, Paris, France, 2019

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CFD Test Case

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at High-altitude Conditions
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User Details:

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With my signature I fully accept the license agreement on the test case IN-1 of DLR Institute of Space Propulsion :

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