AIAA
R-146-2020

Recommended Practice

Dual Flow Reference Nozzles for Verification of Sub-Scale Thrust and Airflow Test Rigs: Dual Separate Flow Reference (DSFR) and Dual Mixed Flow Reference (DMFR)

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Sponsored by

American Institute of Aeronautics and Astronautics

Approved 22 November 2019

Abstract

The AIAA Ground Test Technical Committee (GTTC) Dual Flow Reference Nozzle Working Group has developed recommended practices and aerodynamic definitions for two types of reference nozzles intended to verify thrust rigs measuring subscale exhaust nozzle system performance. Two different reference nozzles are defined: Dual Separate Flow Reference (DSFR) and Dual Mixed Flow Reference (DMFR). The recommended specifications focus on defining reference nozzle aerodynamic loft lines and features including flow conditioning, instrumentation, operational procedures, and data reduction procedures.

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Contents

Figures

Tables

Foreword

The American Institute of Aeronautics and Astronautics (AIAA) Ground Test Technical Committee (GTTC) began an effort to gather best practices in the area of sub-scale nozzle thrust and discharge verification testing to provide an industry-generated approach for establishing and monitoring a set of reference nozzle systems for turbofan engine development. The goal of the working group was to create a document of recommended practices to enable assessment of data level and quality for the various test rigs used in industry, government, and academia for turbofan nozzle development and compliance assessment.

The GTTC Dual Flow Reference Nozzle Working Group consisted of a diverse group of industry, government, and academia experts in the fields associated with turbine engine design, performance validation, and test verification. The core members of the AIAA GTTC Dual Flow Reference Nozzle Working Group were:

David Myren (Chair)	Aero Systems Engineering / FluiDyne
Kevin Mikkelsen (Vice Chair)	Aero Systems Engineering / FluiDyne
Morris Anderson	Honeywell Inc.
Keith Blodgett	GE Aviation
Guy Boyet	ONERA
Timothy Bressler	Boeing
Mark Cunningham	Pratt & Whitney Canada
Tedd Greku	Aero Systems Engineering / FluiDyne
Leonard Hebert	Boeing
Christopher Jorgens	Boeing
Mathieu Lallia	Safran Aircraft Engines
Matthieu Leyko	Safran Aircraft Engines
Randy Merchen	Aero Systems Engineering / FluiDyne
Jack Sokhey	Rolls-Royce North American Technologies
Thierry Surply	Airbus
Pawel Zakrzewski	Rolls-Royce plc

The working group would also like to acknowledge the technical contributions of the following participants who provided technical input in support of evaluating the reference nozzle systems defined by the groups work.

Thomas Dhervillez	Airbus
Nicholas Grech	Rolls-Royce plc
Mustafa Dindar	GE Aviation

Mark Zsurka	Pratt & Whitney

On the recommendation of the Dual Flow Reference Nozzle Working Group, the following knowledgeable individuals reviewed this document and provided valuable critiques.

Richard Brasket	Aero Systems Engineering / FluiDyne (Retired)
Christopher Sheaf	Rolls-Royce plc
Yogi Sheoran	Honeywell Inc.

The above consensus body unanimously approved this document in September 2019.

Other participants also contributed to this document during its development in support of the participating working group members. The GTTC Dual Flow Reference Nozzle Working Group acknowledges their interest in this effort and expresses gratitude for any inputs provided to the working group during the process of developing the DFRN reference configurations and the recommended practice.

The AIAA Standards Steering Committee (Michelle Bailey, Chairman) accepted the document for publication on 22 November 2019.

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1 Scope

The AIAA GTTC Dual Flow Reference Nozzle Working Group developed recommended practices and aerodynamic definitions for two types of reference nozzles used to verify the correct operation of thrust rigs measuring subscale exhaust nozzle system performance. The two nozzles defined are: Dual Separate Flow Reference (DSFR) and Dual Mixed Flow Reference (DMFR). The recommended specifications focus on defining reference nozzle aerodynamic loft lines (aero-lines) and features including flow conditioning, instrumentation, operational procedures, and data reduction procedures.

The intention of the work undertaken by the working group has been to collect the best practices in use within the sub-scale testing community to develop an agreed upon approach for the topics outlined above. It is hoped that the adoption of these recommended practices will lead to a consistent method that approaches a standard type basis for assessing the status of test rig functionality. The term “standard” and its use within this document is meant to define the method agreed upon by the working group.

2 Vocabulary

2.1 Units

This recommended practice and accompanying aero-lines were defined using U.S. Customary Units everywhere (except for some perforated plate metric drill sizes). Conversions to metric units are provided in parenthesis or on duplicate figures. These mathematical conversions to metric may be expressed using more than the significant number of decimal places.

2.2 Acronyms and Abbreviated Terms

Acronyms

AIAA	American Institute of Aeronautics and Astronautics
ASME	American Society of Mechanical Engineers
CAD	Computer Aided Design
CFD	Computational Fluid Dynamics
CMM	Coordinate Measuring Machine
DFRN	Dual Flow Reference Nozzle
DMFR	Dual Mixed Flow Reference
DSFR	Dual Separate Flow Reference

Parameters

A	Area, in^2 (mm^2)
C_D	Discharge coefficient
C_T	Thrust coefficient
Core	Engine core, or primary hot duct in engine