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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)

Sponsored by

American Institute of Aeronautics and Astronautics

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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

Foreword 9

1 Scope 11

2 Vocabulary 11

2.1 Units 11

2.2 Acronyms and Abbreviated Terms 11

3 Reference Nozzle Concept Development 14

3.1 Reference Nozzle Concept and Types 14

3.2 Modular and Common Charging Station Concept 15

3.3 Concept General Features 17

3.4 Reference Nozzle Sizing 18

3.5 Future Test Model Areas Achievable on Reference Model Adapters 18

4 Dual Separate Flow Reference (DSFR) Nozzle Model 19

4.1 DSFR Configuration Features 19

4.1.1 Mechanical Design Conditions 19
4.1.2 Nozzles 19
4.1.3 Fan Duct Bifurcations 21
4.1.4 Pylon 21
4.1.5 Analytical External Nacelle 21
4.1.6 Charging Station Locations 21
4.1.7 Pressure Instrumentation 24
4.1.8 Temperature Instrumentation 33
4.1.9 Flow Conditioning 36
4.1.10 Leak Check Hardware 43

4.2 DSFR Aero-lines 44

4.2.1 DSFR Aero-lines Development 44
4.2.2 CFD Flow Quality Evaluation of DSFR Design 44

4.3 DSFR Mechanical Features 53

4.3.1 Materials 53
4.3.2 Joints and Seals 53
4.3.3 Hardware Aero-line Contour Tolerances 53
4.3.4 Weight and CG 54

4.4 DSFR Test Conditions 55

4.4.1 Pretest Procedures – Leak Test 55
4.4.2 Test Conditions for Checkouts (DSFR Data Set 1) 56
4.4.3 Additional Test Conditions (DSFR Data Set 2) 56

4.5 DSFR Experimental Results 57

4.5.1 Results Database and Statistical Statements 57
4.5.2 Data Reduction 58
4.5.3 Handling of Inoperative Measurements 60
4.5.4 Shared Database Parameters 61

4.6 DSFR Inspections and Nozzle Exit Throat Area Determination 62
4.6.1 Initial Geometry Verification and Commissioning Inspections 62
4.6.2 Routine Inspections 63
4.6.3 Event Log Including Damage and Repair Tracking 63
4.6.4 Nozzle Exit Throat Area Determination and Measurement Procedures 64
4.7 DSFR Handling and Storage 66
4.7.1 Storage Crate, Lifting Methods, and Guards 66
4.7.2 Two Person Handling Rule 67
5 Dual Mixed Flow Reference (DMFR) Nozzle Model 69
5.1 DMFR Configuration Features 69
5.1.1 Mechanical Design Conditions 71
5.1.2 Nozzle Tailpipe 71
5.1.3 Confluent Mixer 71
5.1.4 Fan Duct Bifurcators 71
5.1.5 Core Plug and Center-body 71
5.1.6 Charging Station Locations 72
5.1.7 Pressure Instrumentation 73
5.1.8 Temperature Instrumentation 81
5.1.9 Adapters and Thermal Growth Affecting Contours 87
5.1.10 Flow Conditioning 87
5.1.11 Leak Check Hardware 94
5.1.12 Analytical External Nacelle 95
5.1.13 Analytical Forced Mixer 95
5.2 DMFR Aero-lines 96
5.2.1 DMFR Aero-lines Development 96
5.2.2 CFD Flow Quality Evaluation of DMFR Design 96
5.2.3 Analytical Forced Mixer Aero-lines Development and CFD Evaluation 101
5.3 DMFR Mechanical Features 105
5.3.1 Thermal Growth 105
5.3.2 Materials 105
5.3.3 Joints and Seals 105
5.3.4 Hardware Aero-line Contour Tolerances 105
5.3.5 Weight and CG 107
5.4 DMFR Test Conditions 107
5.4.1 Pre-test Procedures – Leak Test 107
5.4.2 Test Conditions for Checkouts (DMFR Data Set 1) 108
5.4.3 Additional Test Conditions (DMFR Data Set 2) 109
5.5 DMFR Experimental Results 111
5.5.1 Results Database and Statistical Statements 111
5.5.2 Data Reduction 111
5.5.3 Handling of Inoperative Measurements 116
5.5.4 Shared Data Base Parameters 116
5.6 DMFR Inspections and Nozzle Throat Area Determination 117
5.6.1 Initial Geometry Verification and Commissioning Inspections 117
5.6.2 Routine Inspections 119

5.6.3 Event Log Including Damage and Repair Tracking....119
5.7 DMFR Handling and Storage....120
5.7.1 Storage Crate, Lifting Methods, and Guards....120
5.7.2 Two Person Handling Rule....121
6 Reference Nozzle Relationship to CFD....121
7 Concluding Remarks....121
8 Aero-lines Geometry Definition Files....122
9 Bibliography....123

Figures

Figure 1 - DSFR Model Cross Section Showing Modular Approach 16
Figure 2 - DSFR Features and Nomenclature 20
Figure 3 - DSFR Aerolines and Coordinate Origins 20
Figure 4 - DSFR Analytical External Nacelle (not part of DSFR hardware) 22
Figure 5 - DSFR Charging Station Instrumentation (area weighted locations, view looking downstream) 23
Figure 6 - DSFR Fan Charging Station Pressure and Temperature Instrumentation Schematic 23
Figure 7 - DSFR Core Charging Station Pressure and Temperature Instrumentation Schematic 24
Figure 8 - DSFR Fan Pt Rake 25
Figure 9 - DSFR Core Pt Rakes 28
Figure 10 - DSFR Fan Boundary Layer Pt Arrays 30
Figure 11 - DSFR Fan Tt Rake 33
Figure 12 - DSFR Core Tt Rakes 34
Figure 13 - DSFR Fan Tt Probe Detailed Design 35
Figure 14 - DSFR Core Tt Probe Detailed Design 35
Figure 15 - DSFR Fan Flow Conditioning 36
Figure 16 - DSFR Core Flow Conditioning 37
Figure 17 - DSFR Model Leak Check Tests 43
Figure 18 - DSFR Mach Contours (without instrumentation) 47
Figure 19 - DSFR Mach Contours (without instrumentation) 47
Figure 20 - DSFR Mach Contours (without instrumentation) 48
Figure 21 - DSFR Mach Contours (without instrumentation) 48
Figure 22 - DSFR Nozzle with Instrumentation Rakes for CFD Analysis 49
Figure 23 - DSFR Mach Contours, Without/With Instrumentation Rakes 49
Figure 24 - Total Pressure Deficit in the Wakes of Fan Duct Pressure and Temperature Rakes, Case 4 50
Figure 25 - Fan Duct Streamlines, Case 4 50
Figure 26 - Total Pressure Deficit in the Wakes of Core Duct Pressure and Temperature Rakes and Struts, Case 4 ..51
Figure 27 - Core Duct Streamlines, Case 4 51
Figure 28 - Assessment of Vertical Load on Plug 52
Figure 29 - DSFR Model Aerodynamic Surface Machining Tolerance Critical Zones 54
Figure 30 - DSFR Exit Area Definition (view at θ= 90 degrees) 64
Figure 31 - DSFR Minimum Inspection Locations of Assembled Model 66
Figure 32 - DSFR Support Cradle Concept for Transport and Storage Plus Separate Plexiglas Nozzle Guard for Model Protection On/Off Rig 68
Figure 33 - DMFR Model Cross Section Showing Modular Approach 69
Figure 34 - DMFR Features and Nomenclature 70

Figure 35 - DMFR Aero-lines and Coordinate Origins....70
Figure 36 - DMFR Charging Station Instrumentation....72
Figure 37 - DMFR Fan Pt Rakes....73
Figure 38 - DMFR Fan Charging Station Pressure and Temperature Instrumentation Schematic....74
Figure 39 - DMFR Core Pt rakes....77
Figure 40 - DMFR Core Charging Station Pressure and Temperature Instrumentation Schematic....77
Figure 41 - DMFR Fan Boundary Layer Pt Arrays....79
Figure 42 - DMFR Fan Tt Rakes....81
Figure 43 - DMFR Core Tt Rakes....83
Figure 44 - DMFR Fan Tt Probe Detailed Design....85
Figure 45 - DMFR Core Tt Probe Detailed Design....86
Figure 46 - DMFR Fan Flow Conditioning....88
Figure 47 - DMFR Core Flow Conditioning....88
Figure 48 - DMFR Model Leak Check Tests....94
Figure 49 - DMFR Analytical External Nacelle (not part of DMFR hardware)....95
Figure 50 - DMFR CFD Model....97
Figure 51 - DMFR CFD Model Mesh and Mach Number....98
Figure 52 - DMFR Wall Y+ Distribution Along Surfaces....98
Figure 53 - DMFR CFD Flow Results....99
Figure 54 - DMFR Static Pressure Variation at the Instrumentation Rake Location....100
Figure 55 - DMFR Boundary Layer Total Pressure Profile....100
Figure 56 - Analytical Forced Mixer....101
Figure 57 - Analytical Forced Mixer Nozzle Geometry....102
Figure 58 - Analytical Forced Mixer Mach Contours....103
Figure 59 - Confluent and Forced Mixer Temperature Contours at Ptfan/Ptcore=1.0....103
Figure 60 - Forced Mixer Temperature Contours at Pt fan/Pt core=0.9....104
Figure 61 - DMFR Model Aerodynamic Nominal Machining Tolerance Critical Zones....106
Figure 62 - DMFR Assembly Inspections....118
Figure 63 - DMFR Area Determination....120

Tables

Table 1 - DSFR Fan Duct Total Pressure Instrumentation 26
Table 2 - DSFR Fan Duct Static Pressure Instrumentation 27
Table 3 - DSFR Core Duct Total Pressure Instrumentation 29
Table 4 - DSFR Core Duct Static Pressure Instrumentation 30
Table 5 - DSFR Fan Duct Boundary Layer Total Pressure Instrumentation 32
Table 6 - DSFR Fan Duct Total Temperature Instrumentation 33
Table 7 - DSFR Core Duct Total Temperature Instrumentation 34
Table 8 - DSFR Fan Flow Conditioning Geometry 38
Table 9 - DSFR Fan Flow Conditioning Geometry (SI Units) 39
Table 10 - DSFR Core Flow Conditioning Geometry 40
Table 11 - DSFR Core Flow Conditioning Geometry (SI Units) 41
Table 12 - DSFR Flow Conditioning Estimated Upstream Pressures 42
Table 13 - DSFR CFD Analysis Cases 46
Table 14 - DSFR Data Set 1 Conditions 56
Table 15 - DSFR Data Set 2 Conditions 57
Table 16 – DSFR Minimum Instrumentation List 61
Table 17 - DMFR Fan Duct Total Pressure Instrumentation 75
Table 18 - DMFR Fan Duct Static Pressure Instrumentation 75
Table 19 - DMFR Core Duct Total Pressure Instrumentation 78
Table 20 - DMFR Core Duct Static Pressure Instrumentation 78
Table 21 - DMFR Fan Duct Boundary Layer Total Pressure Instrumentation 80
Table 22 - DMFR Fan Duct Total Temperature Instrumentation 82
Table 23 - DMFR Core Duct Total Temperature Instrumentation 84
Table 24 - DMFR Fan Flow Conditioning Geometry 89
Table 25 - DMFR Fan Flow Conditioning Geometry (SI Units) 90
Table 26 - DMFR Core Flow Conditioning Geometry 91
Table 27 - DMFR Core Flow Conditioning Geometry (SI Units) 92
Table 28 - DMFR Flow Conditioning Estimated Upstream Pressures 93
Table 29 - DMFR Data Set 1 Conditions 108
Table 30 - DMFR Data Set 2 Conditions 110
Table 31 - DMFR Minimum Instrumentation List 116
Table 32 - Aero-lines Geometry Files 122

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
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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