Project/Program Name

**Test Title, (Phase #):**

**Test Plan for Facility ()**

**Nozzle Size**

**Initial Release: Date**

(THIS DOCUMENT IS A SAMPLE TEMPLATE. THIS FORMAT IS NOT REQUIRED. OTHER FORMATS ARE ACCEPTABLE. SOME TEXT INCLUDES INSTRUCTIONS; ALL OTHER TEXT IS FOR ILLUSTRATION PURPOSES ONLY)

Prepared by:

|  |  |
| --- | --- |
| \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| Name  Principal Investigator | Name  Test Lead |

Approvals:

|  |  |
| --- | --- |
| \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| Name  Title  Concurrence: |  |
| \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  *Print Name*  ARC Test Engineer | |

**Revision History**

|  |  |  |  |
| --- | --- | --- | --- |
| Version | Page(s) Affected | Description of Change | Date |
| - | - | Initial release |  |

**TABLE OF CONTENTS**

[1 SCOPE 6](#_Toc40275766)

[1.1 Roles and Responsibilities 6](#_Toc40275767)

[2 ACRONYMS (sample list) 6](#_Toc40275768)

[3 <NAME OF PROGRAM> 6](#_Toc40275769)

[3.1 Introduction 6](#_Toc40275770)

[4 TEST OBJECTIVES *<sample text>* 6](#_Toc40275771)

[5 TEST ARTICLES 7](#_Toc40275772)

[5.1 Model Design 7](#_Toc40275773)

[5.2 Model Availability 8](#_Toc40275774)

[6 TEST CONDITIONS 8](#_Toc40275775)

[6.1 Arc Jet Test Conditions 8](#_Toc40275776)

[6.2 Calibration of Test Conditions 9](#_Toc40275777)

[7 TEST PROCEDURES 9](#_Toc40275778)

[7.1 Pre- and Post-test Measurements 9](#_Toc40275779)

[7.2 Installation/Removal of Test Articles 9](#_Toc40275780)

[7.3 Day-to-Day Run Schedule 9](#_Toc40275781)

[7.4 Test Operation Logistics 9](#_Toc40275782)

[8 TEST FACILITY INSTRUMENTATION 10](#_Toc40275783)

[8.1 Facility Instrumentation Summary 10](#_Toc40275784)

[8.2 Pyrometers and IR Imagery 10](#_Toc40275785)

[8.3 Spectro-radiometer (non-standard instrument) 10](#_Toc40275786)

[8.4 Video 10](#_Toc40275787)

[8.5 Photographs 10](#_Toc40275788)

[8.6 Facility Data Acquisition System 11](#_Toc40275789)

[9 DATA ACQUISITION REQUIREMENTS 11](#_Toc40275790)

[9.1 Test Model Instrumentation 11](#_Toc40275791)

[9.2 Special Connection Requirement 11](#_Toc40275792)

[9.3 Output Range and Calibration 12](#_Toc40275793)

[9.4 Data Conversion 12](#_Toc40275794)

[9.5 PI-provided DAS 12](#_Toc40275795)

[10 TEST DATA PACKAGE 13](#_Toc40275796)

[10.1 Preliminary Test Data 13](#_Toc40275797)

[10.2 Final Test Data Package 13](#_Toc40275798)

[11 SAFETY CONSIDERATIONS 15](#_Toc40275799)

[12 Hardware Disposition 16](#_Toc40275800)

[13 Security 16](#_Toc40275801)

[14 REFERENCES 17](#_Toc40275802)

**List of tables**

Table 2: Proposed Test Conditions and Run Sequence 9

Table 3: Model Instrumentation Summary 11

Table 4: Measurement Range and Conversion Constants 12

**list of figures**

Figure 1. Test model design. 7

Figure 2. Wiring Schematic for (name) Output and Current Source Monitoring. 12

# SCOPE

This document describes the Arc Jet test that shall be performed at the NASA Ames Research Center (ARC) <Interaction Heating Facility (IHF)> in support of <Program/Name> test program. This document details the test models, technical requirements, facility instrumentation, and safety precautions to be followed during facility operations. Changes to this document that fall within the objectives of the test may be made with handwritten “redlines” and must be approved by both the Principal Investigator (PI), and the Test Engineer. The changes shall be documented by the Test Engineer, and the PI shall be responsible for subsequently updating this document to reflect the redline changes.

## Roles and Responsibilities

The principal roles and responsibilities of TSF branch personnel and of the PI are described in the test planning guide[[1]](#endnote-1) for the NASA Ames Arc Jet Complex. The actual facility operations and related procedures will be the responsibility of TSF branch personnel. <Name (affiliation)> is the Principal Investigator (PI) for this test series and serves as the primary point of contact to the Test Engineer. <Name (affiliation)> is the alternate point of contact in the event that the PI is unavailable. If neither of the two aforementioned individuals can be present during the test, a substitute shall be designated and communicated to the Test Engineer as soon as possible.

# ACRONYMS (sample list)

AHF Aerodynamic Heating Facility

ARC Ames Research Center

CFD Computational Fluid Dynamics

DAS Data Acquisition System

IHF Interaction Heating Facility

NASA National Aeronautics and Space Administration

PI Principal Investigator

RTV Room Temperature Vulcanizing silicone

TPS Thermal Protection System

# <NAME OF PROGRAM>

## Introduction

Background information on the project/program and how it relates to this test series

*Please list how many occupancy days are approved for test series; how many test samples, possibly how many runs/exposures. Any appropriate details. Also reference funding mechanism and task plan as appropriate*

# TEST OBJECTIVES *<sample text>*

The Arc Jet tests described in this document are intended primarily to investigate the response of <describe test samples> at <nominal heat flux conditions>. The target heating rates and enthalpies are obtained from expected aerothermal environments for <flight trajectory>. Past testing of <material> has demonstrated <…>. The proposed IHF tests are intended to measure and understand the <…> response at <\_\_\_ conditions. Please note thetargeted cold-wall heat flux and reference geometry for setting test conditions, as appropriate>. Specifically, the test objectives for this test series are as follows:

1. Determine the surface temperature at which something happens
2. Quantify some performance parameter
3. Etc.

# TEST ARTICLES

## Model Design

<Describe model geometry>. All test articles are (#inch, #cm) diameter <iso-q> stagnation models with a (#inch, #cm) corner radius, as seen in Figure 1. <Please include total model stack up length>.

Figure 1. Test model design. <drawing/figure with dimensions>

The <models> to be tested include a flight like design, consisting of <…>. There are a total of <number> test models. <Number> of the <total number> models will have <…>, while the remaining <number> will have <… >. The aluminum back plate (or shoulder) will have a marking and the word “Top” written on it to designate the 12 o’clock position of the model when mounted on the sting. <Please also provide 3 and 9 o’clock markings. When possible, include model ID on shoulder next to 3 o’clock marking so that the ID may be viewed remotely during alignment and stream insertion>

*Please include detailed engineering drawings of the test model assembly in an appendix*

Model weight: Click here to enter text.  
Model size and geometry**:** Click here to enter text.  
Model stack up length**:** Click here to enter text.  
Models marked at 12’O clock (top):Choose an item.  
Alignment datum: Click here to enter text.  
Alignment and target template**:** Choose an item.  
Number of model runs**:** Click here to enter text.SDS**:** Choose an item.

## Model Availability

All <number> test models have been assembled and will be available for delivery by <date>.

# TEST CONDITIONS

## Arc Jet Test Conditions

The desired Arc Jet test conditions are provided in Table 1

Table 1: Target Test Conditions <please indicate driving parameter>

|  |  |  |  |
| --- | --- | --- | --- |
| Condition ID | Cold-Wall Heat Flux on a <geometry> <sensor type> Calorimeter\*   ± <x%> | Stagnation Pressure\*\* ± <x%> | Centerline Enthalpy <or other simulation parameter as appropriate>\*\*\* |
| (W/cm2) | kPa | (MJ/kg) |
| 1 | 175 | 18 | 19 |
| 2 | 100 | 20 | 11 |
| 3 | 115 | 12 | 15 |
| 4 | 80 | 20 | 8 |

\*Primary simulation parameter

\*\*Match per best effort

\*\*\*Reference only

<Emphasis shall be placed on matching heat flux (include tolerance of driving parameter/s); the stagnation pressure achieved at the arc heater setting which best matches the target heat flux will be acceptable.> Table 2 presents the desired run sequence.

Table 2: Proposed Test Conditions and Run Sequence

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Run #** | **Condition** | **Sting** | **Test Model** | **Model ID** | **Exposure (sec)** | **Instrumentation** |
| 1 | Cond ID 1 | OH | 4" iso-q Slug Cal |  |  | Type K TC  Pressure |
| Cond ID 2 | East | 4" iso-q Slug Cal |  |  | Type K TC  Pressure |
| Cond ID 3 | West | 4" iso-q Slug Cal |  |  | Type K TC  Pressure |
| \* Repeat run if heat flux and enthalpy are not near the target condition | | | | | |  |
| 2\* |  | OH | 4" iso-q Slug Cal |  |  | Type K TC  Pressure |
|  | East | 4" iso-q Slug Cal |  |  | Type K TC  Pressure |
|  | West | 4" iso-q Slug Cal |  |  | Type K TC  Pressure |
| \*Repeat run if heat flux and enthalpy are not near the target condition | | | | | |  |
| 3\* |  | OH | Model Type 1 | A-1-1 | 60 | 4 type K TCs  2 type R TCs |
| East | Model Type 2 | A-2-1 | 80 | 4 type K TCs  2 type R TCs |
| West | Model Type 2 | A-2-2 | 90 | 4 type K TCs  2 type R TCs |
|  | | | | | |  |
| 4 |  | OH | Model Type 1 | A-1-2 | 100 | 4 type K TCs  2 type R TCs |
| East | Model Type 2 | A-2-3 | 110 | 4 type K TCs  2 type R TCs |
| West | Model Type 2 | A-2-4 | 120 | 4 type K TCs  2 type R TCs |

## Calibration of Test Conditions

At least one x” iso-q <Type of> calorimeter for each test condition is requested to verify flow conditions. The PI has final approval in deciding if a calibration run has met the target test condition, or if another run shall be made. The x” iso-q calorimeters are requested and shall be provided by the facility.

# TEST PROCEDURES

## Pre- and Post-test Measurements

Pre- and post-test mass measurements will be made of each test model. Topographical laser scans of all models are also planned to obtain a total surface recession map. The PI shall complete these tasks independently, and no involvement of test facility personnel is needed.

## Installation/Removal of Test Articles

Caution should be taken whenever transporting or handling the test articles to prevent damage. The PI will work with facility staff to install and remove the models as needed. <please include any special instructions if required> Models shall be installed and removed according to standard installation practices established at the facility. Facility personnel shall be responsible for making all electronic and cooling water connections.

## Day-to-Day Run Schedule

The Test Engineer shall notify the PI of the anticipated run start time before the close of business on the previous business day. Changes to the testing schedule shall be communicated to the PI through the Test Engineer. Additionally, the daily run schedules are posted on the status boards in the Arc Jet buildings.

## Test Operation Logistics

The PI shall be present for all test runs. Access to the guest wireless network will be required. A live video feed inside the control room is requested during the run along with real-time data monitoring of DAS channels selected by the PI. The channels to be monitored in real-time are indicated in the model traveler sheets.

# TEST FACILITY INSTRUMENTATION

## Facility Instrumentation Summary

* Pyrometers and IR imagery
* Video
* Photographs

## Pyrometers and IR Imagery

<Name/type> pyrometers are requested to cover a surface temperature measurement range of <X to Y degrees C and/or degree F>. The pyrometers shall be directed <at the center of the model> during its exposure to the Arc Jet flow.

Please include pointing directions/requirements for pyrometers, video cameras, and IR cameras. E.g., “An infrared (IR) camera is also requested; it should be focused to <view: e.g., the entire exposed face of the test article.> Quantitative IR temperature measurements are preferred, although a qualitative temperature map will be accepted. All pyrometers and the IR camera shall be calibrated to account for window and/or mirror losses by TSF staff with a blackbody source. Transfer standard instruments shall be traceable to NIST.”

(Please include full-scale alignment target and the expected temperature range)

## Spectro-radiometer (non-standard instrument)

Please provide details for non-standard requests and how these interface with the test.

## Video

<Please describe pointing requirements for cameras>. Video recording of all test runs is imperative. High definition video is preferred, if available. Video taken during the run shall view the front surface, side, and top of the model. During a particular run, the PI may request in real-time to zoom in on a particular area of the model (e.g., the surface of the model).

Video views and recording  
Top view**:** Choose an item.  
Stagnation/East view**:** Choose an item.  
Side/West (wide) view**:** Choose an item.  
Side/West (Close up) view**:** Choose an item.  
Live IR view**:** Choose an item.

## Photographs

Pre- and post-test color digital photographs taken at standard camera angles are required for all test models. The PI may also request additional views to focus on a particular feature of interest on the surface of the model. Still photographs during test runs are also requested if possible. The Test Engineer shall provide model labels. <please make sure to include IDs for test samples for photo labels. Please include pointing directions for cameras>.

Pre-test, Post-test, and in-stream photos  
Front View**:** Choose an item.  
3/4 view**:** Choose an item.  
Side view**:** Choose an item.  
Test Box**:** Choose an item.  
In-stream**:** Choose an item.  
Setups**:** Choose an item.

## Facility Data Acquisition System

The facility data acquisition system shall record the standard facility operating conditions and the readings from the model instrumentation. All of the measurement channels connected to the sensors within the model shall have standard electrical isolators at appropriate ranges to protect the facility data system and to reduce measurement noise.

# DATA ACQUISITION REQUIREMENTS

## Test Model Instrumentation

All models will have several Type x TCs and at least one <type sensor>. Table 3 summarizes the instrumentation requirements for each model. In addition, each and every model will be accompanied by a Model T/C traveler (a sample form will be provided to the PI).

Table 3: Model Instrumentation Summary

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model # | Thermocouples | | | | # of <name> Sensors |
| Type | Quantity | Lead Length | Connector Type |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

## Special Connection Requirement

Each <name sensor> requires an electrical excitation via a constant current source for measurement of resistance. Each current source, in turn, requires one 110 volt outlet for power through an AC/DC adaptor. A sample electrical connection schematic is provided in Figure 2. Constant current sources set to a 1 mA output via female banana connectors, AC/DC adaptors, and the reference resistor will all be supplied to the facility by the PI. A red box in Figure 2 indicates a mating interface with the facility data acquisition system.

Figure 2. Wiring Schematic for (name) Output and Current Source Monitoring.

<The PI will work with the Test Engineer to determine an appropriate termination for the lead wires of the model (e.g., TC miniature connector or DB-connector)—please specify here and in the table above what that is>. The facility should plan on accommodating up to <number of> thermocouple channels and one <name sensor> channels per sting in any given run.

## Output Range and Calibration

Sensor output range and calibration constants are given in Table 4.

Table 4: Measurement Range and Conversion Constants

|  |  |  |  |
| --- | --- | --- | --- |
| Sensor Type | Measurement Range (Physical Units) | Voltage Range | Conversion Constant |
| (Name) sensor | 0 - # mm | 0 - # mV | 1.492e-2 mm/mV |
| Type K thermocouple | # - # °C | # - # mV | Type K TC |

## Data Conversion

Test data shall be provided to the PI in engineering units for all facility data. *Unless requested otherwise, data will be provided in SI units.* *other special requirements*

## PI-provided DAS

<If necessary, describe the PI furnished DAS – what it is, what instruments are to be recorded, how it is operated and by whom, how it’s synchronized, how/if it interfaces with Arc Jet DAS, etc.>

# TEST DATA PACKAGE

## Preliminary Test Data

The PI requests transfer of preliminary test data on <CD, DVD, cloud storage site, etc> at <time, day, e.g at the end of the test day>. Slug calorimeter heat flux measurements, thermocouple output, and <sensor type> output are of greatest interest for this preliminary data transfer.

## Final Test Data Package

A final test data package is expected from the Test Engineer following the completion of the test series. The package may be delivered by <NASA issued external storage drive or cloud storage site. Please bear in mind that the data files will likely be large when specifying how to transfer data>. At a minimum, the data package should include the following:

* Description of the test setup: facility instrumentation locations and calibration information, mirror setup, material of viewport windows, and documentation of any anomalies.
* Run sheets
* Official test data including Arc Jet facility summary data and model instrumentation data

***Deliverables of calibration data***.eu files in ASCII**:** Choose an item.  
.eu files in**:** Choose an item.  
Quick-look plots and summary  
 in hardcopies**:** Choose an item.  
 in PDF files**:** Choose an item.

***Deliverables of model test data***.eu files in ASCII**:** Choose an item.

.eu files in**:** Choose an item.  
Quick-look plots and summary  
 in hardcopies**:** Choose an item.  
 in PDF files**:** Choose an item.

* Pre- and post-test photographs of the specimens

***Deliverables of high resolution tiffs & jpegs***Test model Photos**:** Choose an item.  
Setup Photos**:** Choose an item.  
Web Gallery**:** Choose an item.  
Contact Sheet**:** Choose an item.

Add Contact Sheet Hard Copy**:** Choose an item.

* Video and IR footage of each model run

***Deliverables of video***Calibration runs**:** Choose an item.  
One quad view recording of 4 above views**:** Choose an item.  
 ***OR***Calibration runs**:** Choose an item.  
One recording of Top view**:** Choose an item.  
One recording of East view**:** Choose an item.  
One recording of West view**:** Choose an item.  
One recording of quad view**:** Choose an item.

# 

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **INFRARED CAMERA DATA PROCESSING** | | | | |
| **Line Profiles** | | | | |
| **# of Line Profile Reports** | | 4 | | A picture containing device, orange, surfing, group  Description automatically generated |
| **Emissivity (0-1)**  1 | | | |
| **ROI (Region of Interest)** | | | |
| 1 | broken line | | green |
| 2 | line | | purple |
| 3 | circle | | red |
| 4 | Choose an item. | | Select color |
| **Comments**: *Line Profiles in our case refer to a specific type of data report given to customers as a portion of the Thermal Imaging packet. Line Profiles display temperature values along a specified line. Beside for the thickness, lines are fully customizable in terms of orientation or distance as long as it resides within the overall image being captured. Up to four lines may be created per report with additional lines possible if requested. Each Line Profile Report generated will contain an image of the model, a graph displaying the temperature as a function of the line, and tabulated temperature data corresponding to the line pixel distance for one specific frame. Typical reports contain 3 to 5 reports with each representing a single frame within the video sequence. Images may be attached in the right column with simple lines indicating the position and lengths.* | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time-Temperature Profiles** | | | | |
| **Time Temp Graph** | |  | | A picture containing device, orange, surfing, group  Description automatically generated |
| **Emissivity** | | 1 | |
| ROI Displayed | | | |
| # | shape | | Color |
| 1 | broken line | | green |
| 2 | line | | purple |
| 3 | circle | | red |
| 4 | Choose an item. | | Select color |
| Comments: *Time Temperature Reports refer to the second type of data given to customers as a portion of the Thermal Imaging packet. Time Temperature reports provide 3 types (Minimum, Average, and Maximum) of temperature data for individual ROIs as a function of the video sequence in frames. Generally, the report generated will contain an image of the model, graph displaying the ROI temperature as a function of the frames, and the ROI tabulated data. The user has the option of selecting multiple reports in either minimum, average, or maximum value. For example, if a maximum report is chosen and the shape (circle) above is chosen then the highest temperature within the circle will be displayed and recorded on the graph and data tables. A maximum of 4 ROIs may be selected for each report. Images may be attached in the right column with simple lines or circles.* | | | |

# SAFETY CONSIDERATIONS

Only qualified personnel are allowed to operate and maintain equipment that present potential hazards. The actual facility operations are thus the responsibility of NASA ARC personnel. The Test Engineer and the PI must approve all visitors, and visitors must read, sign, and adhere to the Building Emergency Action Plan (BEAP) for Building <N238>. Safety Data Sheets (SDS) for <any materials brought onto ARC> shall be on-hand at the facility throughout the entire test series.

Materials List

<include a list of the relevant SDSs and note particular hazards/cautions as appropriate, e.g.: There are no safety concerns or requirements that are not met by standard safety practices. Safety Data Sheets (SDS) are provided in Appendix <> for each material that comprise the test specific hardware and specimens.>

The following materials are present in this test:



Include comments about expected materials performance. e.g.

The <> coating is not expected to recess under these test conditions. However, if the coating has unexpected behavior, the coating and underlying <> could recess. The <> is not expected to degrade under these test conditions, but if unexpected behavior occurs, the <> and underlying <> could degrade. <> are underneath the test panel and are not in the flow. The <> are not expected to degrade under these test conditions.

It is anticipated that <> will melt. This is mitigated by <> to contain any material that may not burn away. IAW with the SDS of the material, this burning or melting does not pose any harmful threat to the test results or personnel.

# Hardware Disposition

Nitrile or similar powder-free lab gloves are required to be worn while handling the models, and, in particular, any contact with the top surface of the test article should be avoided. This is critical to the efforts made to preserve the integrity of any char layer produced during the test.

The PI is responsible for arranging the transfer of pre-test models to the arc-jet test area, where the Test Engineer will lock them in designated secure cabinets. Post-test models should be transferred immediately from the arc-jet test area to the post-test evaluation laboratory.

After Arc Jet testing is complete, all test articles shall be returned to <PI/company> for post-test evaluation. The PI shall provide a rigid, sealed container for shipping. Shipment shall be to the following:

***Shipping Address***

***Attention: < name (phone number and email)>***

# Security

The <this test> will be unclassified, but sensitive. <Please indicate how final test data shall be transferred – secure server, encrypted hard drive, etc. Please note restrictions for mailing/shipping test articles, and other security restrictions/markings>. Figure 6 shows the classification matrix in more detail. <Reference Security Plan if appropriate>.

Table 6: Security Classification Matrix

|  |  |
| --- | --- |
| **Type of Data** | **Highest Classification** |
| Facility Data | Unclassified |
| Flowfield Data | Unclassified |
| Thermocouple Data | Proprietary |
| Photographs | Proprietary |
| Video | Proprietary |
| Spectroscopy | Proprietary |
| Numerical Models | Proprietary |

# REFERENCES

1. Terrazas-Salinas, I., et. al., “Test Planning Guide for NASA Ames Research Center Arc Jet Complex and Range Complex.” A029-9701-XM3, Rev. C, April 2009.

   <project documents>

   <Security Plan> [↑](#endnote-ref-1)