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Laboratory Memorandum

Mémoire de laboratoire

1988 / 08

LM-ENG-010

J85/79 CORRELATION TEST SUMMARY

M.F. Mulligan

**Division of
Mechanical Engineering**

**Division de
génie mécanique**



**National Research
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UN SOMMAIRE D'ESSAI DE CORRÉLATION DU J85/79

M.F. Mulligan

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Laboratory Memorandum

Mémoire de laboratoire

1988/08

LM-ENG-010

Engine Laboratory
Laboratoire des moteurs

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ABSTRACT

This report outlines a series of gas turbine tests that were carried out between the National Research Council of Canada and the Turkish Air Force. Inlet configurations, test problems, run numbers, as well as a number of general observations and recommendations are covered in this document.

ABSTRAIT

Ce rapport décrit une série d'essais d'un turbomoteur effectué entre le Conseil national de recherches du Canada et les forces aériennes de la Turquie. On y traite des configurations d'entrée de l'air, des problèmes rencontrés pendant les essais, des numéros d'essais, ainsi que de plusieurs observations générales. Le rapport se termine avec des recommandations.

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LIST OF SYMBOLS

Symbol

A	Inlet configuration number
B/M	Bellmouth
DND	Department of National Defense
Eff	Effective
GE	General Electric
Geo	Geometric
NRCC	National Research Council of Canada
PT1	Inlet Total Pressure Probes
SCN	Screen
SRCE	Bellmouth Type (TUAF or NRCC)
TUAF	Turkish Air Force

J85/79 CORRELATION TEST SUMMARY

1.0 INTRODUCTION

This document describes a series of gas turbine tests that were carried out during a test cell correlation program. Test run details, observations, and recommendations will be outlined. Review and validation of data will be discussed in a subsequent report.

The correlation was carried out between number four test cell of the National Research Council of Canada (NRCC) and a Turkish Air Force (TUAF) test facility at Eskiseher, Turkey. The correlation, sponsored by AGARD, was done to establish test cell correction factors that modify the performance of an engine. The engine used during the program was a Canadian J85-CAN-15 gas turbine of known performance, which was tested at NRCC before, and will be retested after, the test runs in Turkey. A TUAF J85-13, also tested during the program, will become the Turkish correlation engine for correlating other TUAF test facilities. Furthermore, a TUAF J79-17 gas turbine was run to determine its performance although this was not part of the original test plan. The J85 test runs were done at inlet temperatures ranging from 6 to 14 degrees Celsius.

2.0 DESCRIPTION OF TURKISH TEST CELL

The test building, which is shown in Figure 1 in side view and Figure 2 in plan view, consisted of several rooms, namely, an engine preparation area, a control room, a service room, and a test cell. The test cell contained an engine stand, a vertical air inlet and a horizontal exhaust detuner, all suitable for testing both J85 and J79 gas turbines. The cross sectional area of the cell measured about 38.5 square meters. The stand incorporated two rails for mounting the engines and two load sharing force cells (maximum combined load 222.4 kN) used for measuring scale thrust. The outputs from these cells were added electrically by a readout device located in the control room. The control room also contained a variety of instruments for monitoring speeds, fuel flows, vibrations, geometries and temperatures. An area for engine preparation and another for electrical services was also available in the building.

3.0 DESCRIPTION OF TEST EQUIPMENT

A Digital Equipment PDP 11/34 computer-based NEFF data acquisition system provided by NRCC was used during the engine tests. Several parameters, consisting of temperatures, pressures, speed and fuel flows were recorded. Thermocouples, as well as speed and fuel flow transmitter outputs, were connected to the data system directly. Pressures were mechanically multiplexed through a Scanivalve system and converted to electrical signals using high grade pressure transducers. An on-line calibration facility was also included for pressure transducers; calibration of each transducer at three values was thus possible for each data point.

Several steady state readout instruments, which included a precision voltmeter, temperature indicators, and digital counters were paralleled with the data system.

Data recorded during the tests were stored on removable rigid disks. The organization of the disk files is listed in Table 1. The file naming convention is shown in Figure 3.

4.0 DESCRIPTION OF TEST

Four inlet configurations, listed in Table 2 and shown in Figure 4 were investigated during the test series which consisted of nine runs. The J85-CAN-15 gas turbine was installed during runs 36 to 43, while a TUAJ J85 was used for runs 45 and 46. No test data were recorded for runs 37 and 44 as these runs were used to purge the fuel supply lines only. Furthermore, cell air flow was examined for two exhaust collector configurations (small collector was installed for runs 36 to 41 inclusive). Visual observations of cell flow streamlines were mapped (run number 36 and J79 run number 1) by introducing smoke throughout the test cell for different engine power levels.

Several load cell calibrations carried out before J85 run number 38 and J79 run number 1 were done during the program. A reference load cell (supplied by the TUAJ) was connected to the test bed which contained a hydraulic ram that was used to generate the applied load for the calibration. Cabled to the reference cell was a box that contained a power supply for excitation and a readout device. Load cell outputs (mV) were read in the control room along with their excitation voltage for each applied load. The ratio (mV/V) of the load cell's output to its excitation was curvefitted against load values obtained from the reference cell's readout. These curvefits were used to determine the scale thrust of the engines during test runs.

4.1 TEST COMMENTS

- RUN 36 - only one exhaust stack temperature was read. Two others were checked using an 'Analogic' thermocouple calibrator. It was found that all three thermocouples agreed.
 - thrust readings were entered by hand with values taken from a readout device located in the control room.
- RUN 38 - data scans 3 and 4 were lost because of low supply power in the building. Thrust excitation was entered by hand with values read from a HP3456A (SN 2201A11027) voltmeter.
- RUN 39 - inlet wall statics (4) were ganged together and read as one pressure.
- RUN 41 - a nozzle ejector was added.

- RUN 42 - probe P1A32 pressure connection was broken.
 - screen was reindexed to align the screen struts with the inlet total pressure rakes.
 - nozzle ejector was removed.
- RUN 43 - installed inlet total probes at 50 and 320 degrees.
- RUN 44 - entered new load cell coefficients
- RUN 45,46 - Turkish J85-13 was installed.

RUNS 39 to 42 - the 'MKS' barometer zero was offset -0.13 torr. This could not be detected by the data system. Therefore no data correction was made.

Specific gravity measurements made in Turkey were questionable. NRCC analysis will be carried out as a check before correcting recorded data.

5.0 CONCLUSIONS AND RECOMMENDATIONS

- a) A crane should be installed in the test cell to facilitate moving equipment and engines more rapidly.
- b) The test cell was large in cross-section and length and is suitable for engines of the J79 class.
- c) With the current collector size and placement of engine/thrust relative to the collector, the secondary airflow was found to be high. An approach velocity of 40 ft/s was measured with the J79 installed. Additionally, as a result of the large spacing between the engine and the collector, the radiated acoustic energy was extremely high.
- d) The vertical inlet, while undesirable from a flow distortion point of view, showed a low pressure loss. The inlet would be quite suitable if the engine was placed further back towards the exhaust detuner which would result in a reduction in the secondary cooling airflow.
- e) The thrust stand should be replaced with a rigid one because it was quite flexible and difficult to calibrate when external loads were applied. It also suffered from thermal growth, which altered the load cell tare values from the beginning to the end of a test sequence.

- f) The major portion, if not all, of the cell thrust correction factor term is the result of the induced secondary airflow around the engine. A lowering of this airflow consequently reduces the cell factor. This airflow can be controlled by installing a properly sized exhaust collector insert for each engine type. Insert cooling water would be required when an afterburner is operated. No water cooling would be required at other power settings.
- g) A reduction in the acoustic emissions was demonstrated using a collector insert placed approximately 0.5 meters from the tailpipe of the J85 engine.
- h) The existing collector should be moved back towards the rear of the test cell by 4 meters.
- i) The thrust stand incorporated two load sharing force cells with a combined capacity of 222.4 kN. These should be replaced with ones more closely matched to the engine on test, ie: 22 kN for the J85, and 90 kN for the J79.
- j) Thrust stand calibrations should be done using a center-line pull attachment. The particular type of engine under test should be mounted on the stand during the calibration.
- k) A system of redundant fuel meters should be installed by placing two meters in series and comparing their outputs at all times. They should also be sized to suit the engine fuel flow. The current meter used for the J79 was quite large. Radio frequency type pickoffs, which offer a 100:1 range vs. a 10:1 for magnetic pickoffs, are preferable.
- l) Regular calibrations of the entire measurement system should be done periodically. Installation effects must also be considered.
- m) A complete data acquisition and analysis system should be installed. This could offer on-line pressure and temperature calibrations, provide averaged measurements, reduce engine run time, and minimize operator readout errors.
- n) Manual readout instruments are still required but should be replaced with rugged high quality, digital and analog ones.
- o) A stable and reliable power source is required for computerized data acquisition. The current system caused occasional computer crashes.
- p) Fuel specific gravity, a vital requirement for measuring fuel flow which is used for trimming engines, was difficult to obtain with the current system. Fuel was frequently replenished, because it could only be drawn from the tank down to the 1/2 full level. It was not possible to sample fuel directly from the

tank; after purging, samples were taken from the fuel line in the test cell.

- q) Test data acquisition procedures need improvement. A reasonable engine stabilization time (typically 5 minutes) at each power setting was required to ensure thermal equilibrium before recording data.
- r) Instrument warm-up time is necessary to achieve published measurement accuracy. It was observed that two hours was required for the thrust cells to stabilize. Instrument life and reliability would also increase if they were powered up at all times.
- s) Data gathering with the present instrumentation suite was very difficult to accomplish as a result of unstable readings. Only an experienced test observer could achieve accurate results with the present system. Also, two data samples should be taken at each power setting to monitor engine instability.

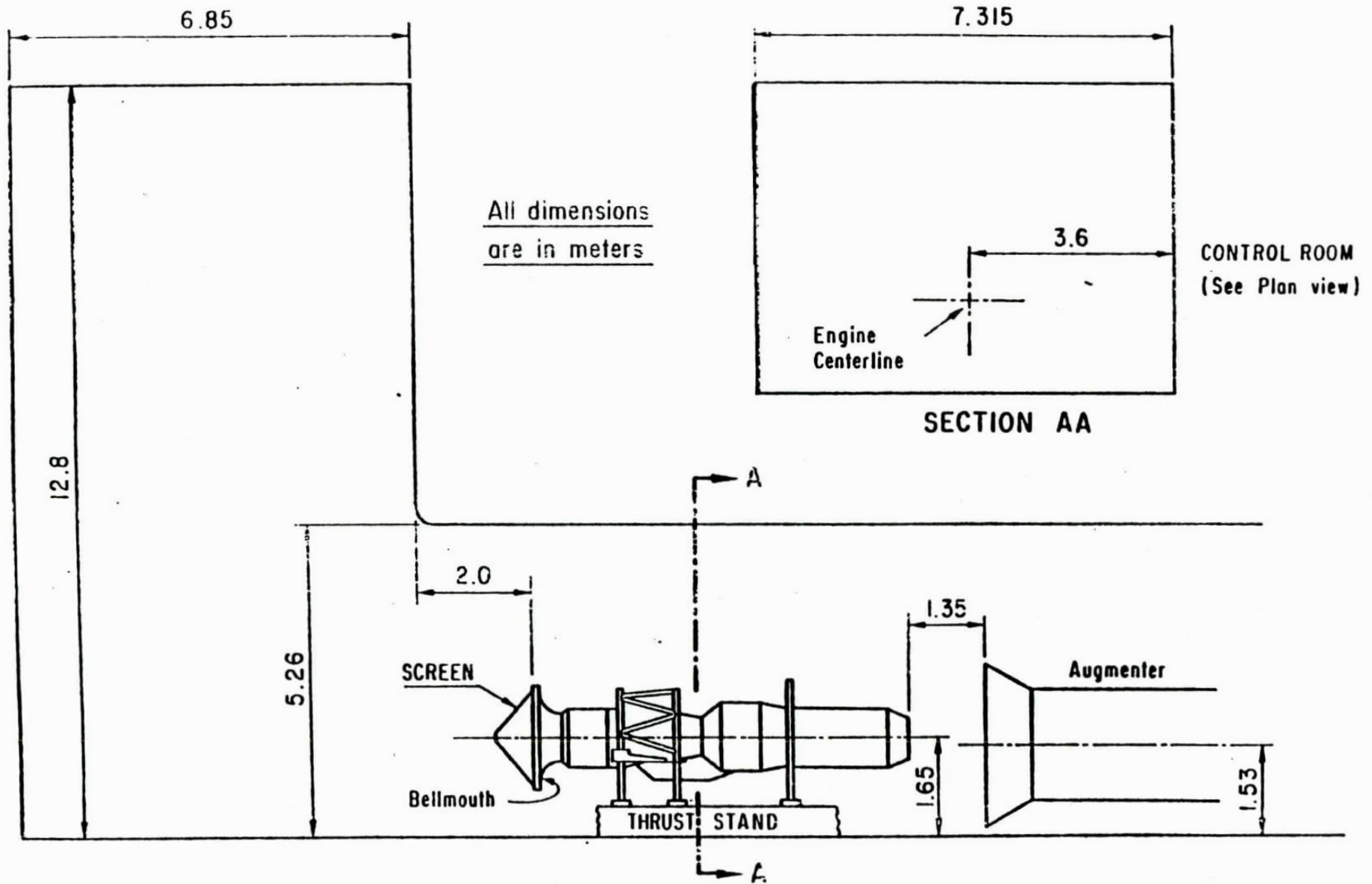


Figure I. Test Facility

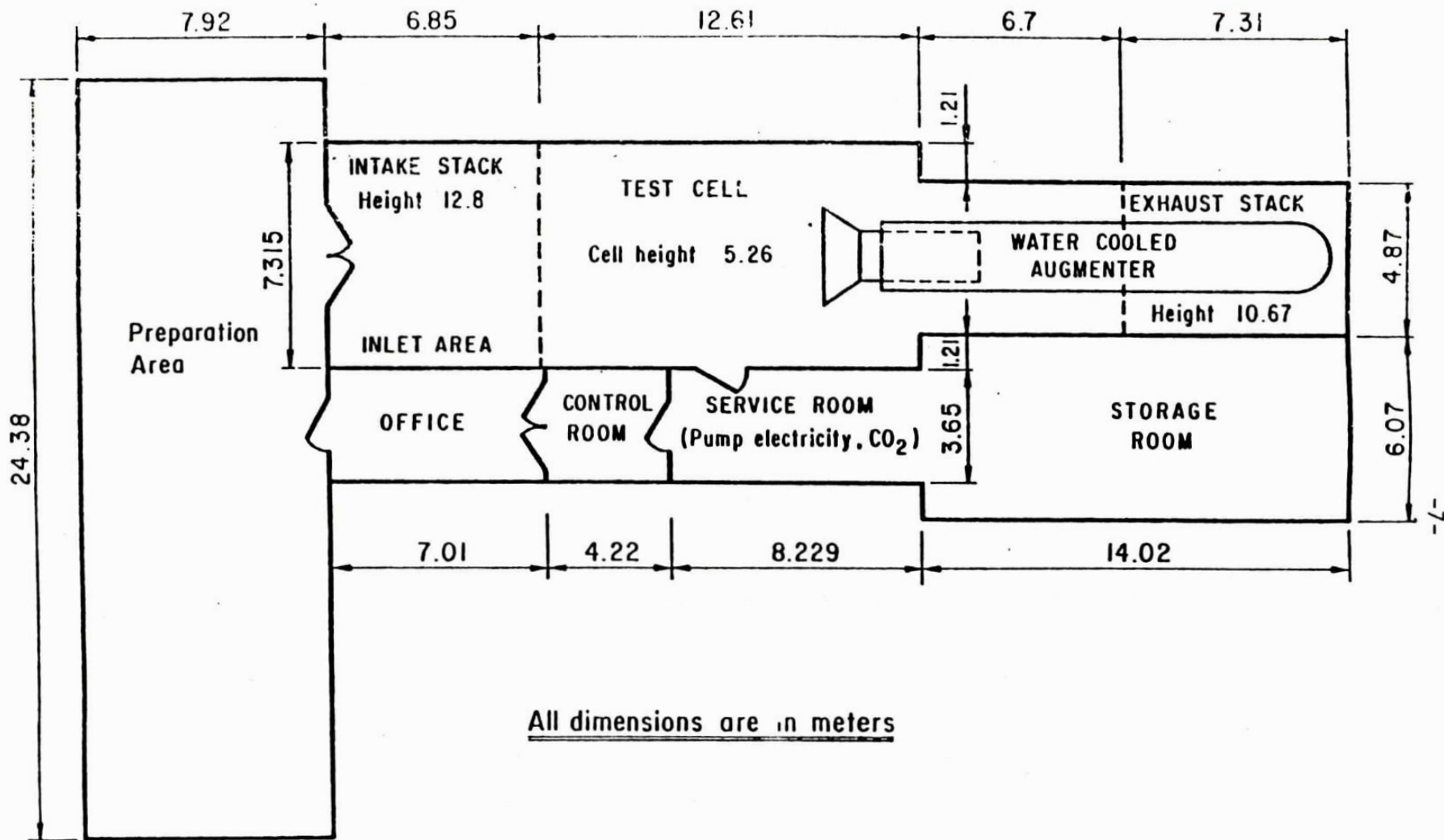


Figure 2. Plan view of the Facility.

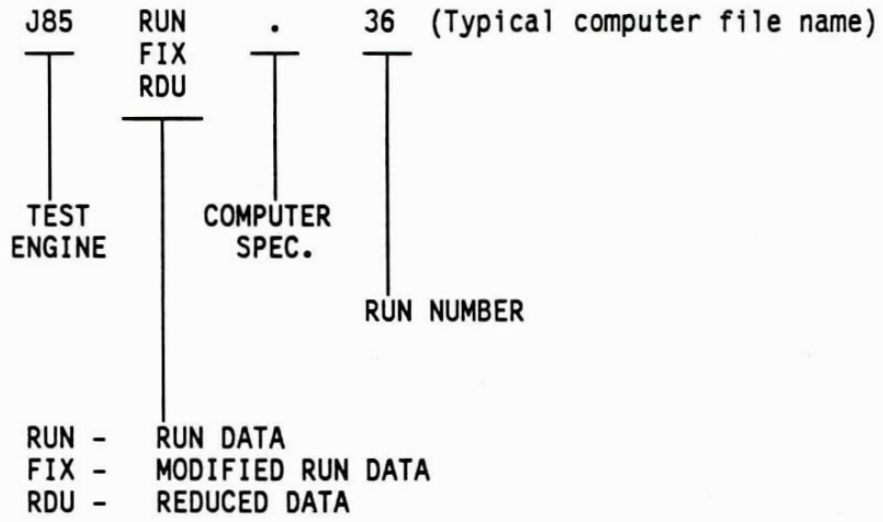
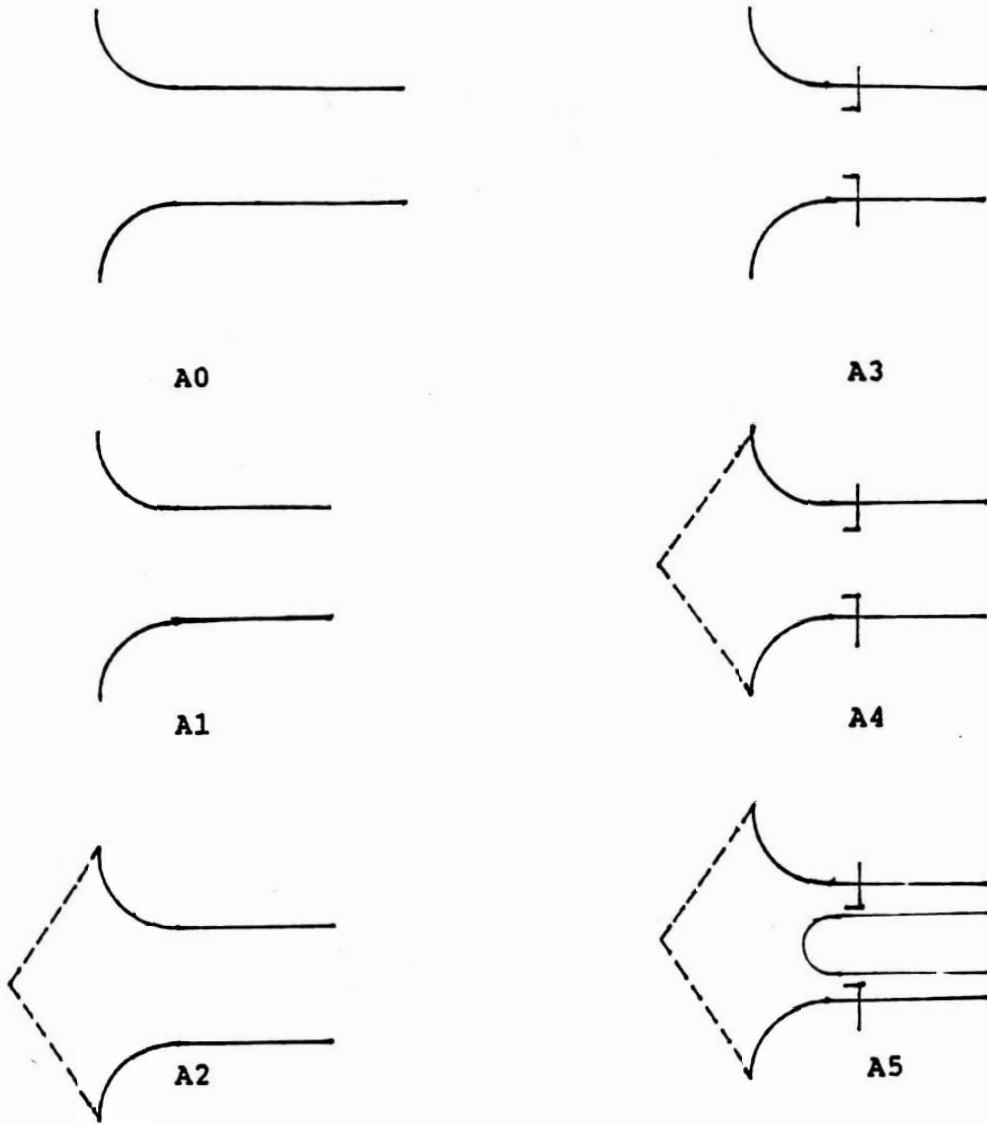


FIGURE 3 FILE NAMING CONVENTION



A0 - NRCC bellmouth-airmeter
A1 to A5 - General Electric 'field' bellmouth-airmeter

FIGURE 4 Inlet Configurations

DISK NO.	INFORMATION
6	RUN DISK TUAF
19	SOURCE CODE
22	RUN DATA
23	RUN DISK NRCC
49	FIXED DATA
50	REDUCED DATA

TABLE 1 DATA ORGANIZATION

RUN NO.	B/M	SRCE	GEO. AREA	EFF. AREA	PT1	SCN
			SQ-INS.	SQ-INS.	PSI	
36	A0	NRCC	203.286	200.847	NO	NO
38	A0	NRCC	203.286	200.847	NO	NO
39	A1	TUAF	200.982	188.923	NO	NO
40	A4	TUAF	200.982	187.918	YES	YES
41	A4	TUAF	200.982	187.918	YES	YES
42	A4	TUAF	200.982	188.722	YES	YES
43	A2	TUAF	200.982	TBD	NO	YES
45	A2	TUAF	200.982	TBD	NO	YES
46	A2	TUAF	200.982	TBD	NO	YES
*	A3	DND	200.982	193.747	NO	YES
**	A5	DND	185.288	181.768	YES	YES

* - Inlet configuration tested at NRCC only.

** - Inlet configuration, containing DND bulletnose, tested at NRCC only.

TABLE 2 INLET CONFIGURATIONS

REPORT DOCUMENTATION PAGE/PAGE DE DOCUMENTATION DE RAPPORT

REPORT/RAPPORT		REPORT/RAPPORT			
1a	LM-ENG-010	1b			
SECURITY CLASSIFICATION/ CLASSIFICATION DE SÉCURITÉ		DISTRIBUTION/DIFFUSION			
2	Unclassified	<input checked="" type="checkbox"/> Controlled/Contrôlé <input type="checkbox"/> Unlimited/Illimité			
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13					
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14					
Correlation, instrumentation, gas turbine					
SUMMARY/SOMMAIRE					
15					
This report outlines a series of gas turbine tests that were carried out to correlate an NRCC test cell and a Turkish Air Force test facility.					
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