BRAZILIAN AIR FORCE
AERONAUTICAL AND WARFARE MATERIAL DIRECTORATE
SÃO PAULO AERONAUTICAL MATERIEL DEPOT

TECHNICAL SPECIFICATIONS Nº 001/TMOT/2024

DATE: **February 05th, 2024**

I. PURPOSE

This Technical Specification (TS) has the purpose to present the collection of necessary and sufficient elements, with an adequate level of accuracy, to define the need to carry out a CFD (COMPUTATIONAL FLUID DYNAMICS) ANALYSIS to assess the feasibility of adapting the São Paulo Aeronautical Materiel Depot (PAMASP) test cell for testing the F414-GE-39E engine, which equips the F-39 (Gripen) aircraft in the Brazilian Air Force fleet.

The engine test cell at the PAMASP currently performs the test of the GE-J85-21C engine (Aircraft F-5M) and also has the capability for testing the MK 807 SPEY engine (Aircraft AMX A1).

II. OBJECT

PERFORMING CFD ANALYSIS, through a SITE VISIT TO THE PAMASP TEST CELL, in order to INSPECT the support systems (Electrical, Fuel and Preservation, Compressed Air and Starting, Instrumentation and Data Acquisition, Miscellaneous), INSPECT the facility infrastructure, COLLECT the data necessary to carry out the study and, finally, ISSUE a report with the results and recommendations of the CFD analysis.

The objective of carrying out the CFD analysis is to verify whether it is possible and what modifications will be necessary to, while maintaining the testing capabilities of the GE-J85-21C and MK 807 SPEY engines, also implement the test of the F414-GE-39E engine in our facilities.

III. TEST CELL FACILITY DATA

Annex A of this Technical Specification presents a Preliminary Assessment Report which details the resources and capabilities of the engine test cell facilities at PAMASP. Further information may be collected and/or provided by the PAMASP team at the time of the site visit.

IV. ESTIMATED COST

According to market estimates, the reference purchase price for performing this CFD ANALYSIS is USD 124,000.00 (one hundred twenty-four thousand Dollars).

V. TECHNICAL REQUIREMENTS

1. CFD Analysis must be provided by a General Electric Aerospace licensed test equipment supplier for the F414-GE-39E engine. It may be proved by a TAA (Technical Assistance Agreement) or other document issued by General Electric.

2. The site visit must last at least 2 days and must include a thorough inspection/investigation of all systems/subsystems and equipment relevant to the operation of the test cell, including:

   2.1. Test cell dimensions and condition (including the infrastructure of the air intake and gas exhaust, airflow and acoustics);

   2.2. Fuel system (tanks, pumps, meters, filters, piping, valves);

2.3. Start system (tanks, compressors, filters, piping valves);
2.4. Facility instrumentation and data acquisition system (weather station, fuel meters, thrust load cells, …);
2.5. Thrust stand condition;
2.6. Engine specific instrumentation;
2.7. Facility and engine control systems;
2.8. Exhaust gas cooling system;
2.9. Other relevant sub-systems.

3. In addition to the above, the following are features of the test cell that we require to be studied:
   3.1 To assess primary concerns about the size of the test cell, including:
      3.1.1. The engine center-line;
      3.1.2. Structural analysis of the test chamber and doors to make sure the building is structurally suitable for such high flow velocity;
      3.1.3. Flow across the engine needs to be analyzed to determine how it might affect thrust measurement.
   3.2. To evaluate the size of the augmentor and the interaction with the water injection system for cooling the engine exhaust gases.
   3.3. It must be determined if the thrust stand is suitable for normal and failure loading of the larger engine (F414-GE-39E).
   3.4 It is required the fuel system is studied for:
      3.4.1. Assess flow capacity at full A/B;
      3.4.2. Assess pressure regulation and response at full A/B flow and through transitions;
      3.4.3. Assess flow measurement at full A/B.
   3.5. It must be determined if the air supply system:
      3.5.1. Has sufficient flow and pressure capacity to start the F414;
      3.5.2. Has sufficient stored air capacity to support F414 in case additional starter use is needed for bad starts or to clear an engine fire.
   3.6. The inlet and exhaust systems must be inspected for:
      3.6.1. Structural integrity;
      3.6.2. Surface quality (absence of materials that can be drawn into the flow stream) that may cause FOD or external shedding of debris from the exhaust;
      3.6.3. Noise attenuation.
4. A report must be issued detailing the results and recommendations of the CFD analysis.
   4.1.Systems/Equipments/Infrastructure must be classified in one of the following categories:
      4.1.1. Good condition and appears suitable for use with F414 engine;
      4.1.2. Needs repairs but would be suitable for use with F414 engine, if repaired;
      4.1.3. Must be replaced due to condition or lack of suitability with F414 engine;
      4.1.4. Other upgrades required to run the F414 engine.
   4.2. The study must provide the costs of any facility modifications or special test equipment's needed for the project;
   4.3. The supplier must deliver all CFD analysis results (reports, simulation data, plans and drawings, and others) that are sufficient for the subsequent execution of the recommended modifications to adapt the test cell.

VI. DELIVERY

The dates of the site visit must be agreed between the CONTRACTED and the PAMASP team and must not exceed a period of 6 weeks from contracting.

The results report of the CFD analysis must be delivered within a maximum period of 90 calendar days after the completion of the site visit. The final report must include all the information requested in item V of this Technical Specification.

VII. TECHNICAL WARRANTY

The CONTRACTED must have a qualified engineer specialized in the design of test cells, who will be responsible for conducting the study and issuing the results. It must also have a specialized multidisciplinary team with the ability to evaluate the various aspects and complexities of the project.

The CONTRACTED must answer any issue related to the CFD ANALYSIS in less than 5 calendar days within 2 years after submission of the Final Report.

Prepared by:

Guilherme Nishisaky Bezerra Lins – 1st Lt. Eng Mech
Engine Engineer

Reviewed by:

Carlos César Minoru Imaniche – Lt. Col. Eng Mech
Head of Engines Subdivision

Approved by:

Claudomiro Feltran Junior – Col. Av
Head of Technical Division

MINISTÉRIO DA DEFESA
COMANDO DA AERONÁUTICA

CONTROLE DE ASSINATURAS ELETRÔNICAS DO DOCUMENTO

Documento:	Technical Specifications - CFD Analysis
Data/Hora de Criação:	06/02/2024 15:06:54
Páginas do Documento:	4
Páginas Totais (Doc. + Ass.)	5
Hash MD5:	c1db5b50dd0d54f4bccb86d072485f75
Verificação de Autenticidade:	https://autenticidade-documento.sti.fab.mil.br/assinatura

Este documento foi assinado e conferido eletronicamente com fundamento no artigo 6º, do Decreto nº 8.539 de 08/10/2015 da Presidência da República pelos assinantes abaixo:

Assinado via ASSINATURA CADASTRAL por 1º Ten GUILHERME NISHISAKY BEZERRA LINS no dia 06/02/2024 às 12:07:07 no horário oficial de Brasília.

Assinado via ASSINATURA CADASTRAL por Ten Cel Eng CARLOS CÉSAR MINORU IMANICHE no dia 14/02/2024 às 14:11:06 no horário oficial de Brasília.

Assinado via ASSINATURA CADASTRAL por Cel CLAUDOMIRO FELTRAN JUNIOR no dia 23/02/2024 às 12:11:49 no horário oficial de Brasília.

ANNEX A

PRELIMINARY ASSESSMENT REPORT - PAMASP'S ENGINE TEST CELL

PAMASP’s Engine Test Cell

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

Report – PAMASP's Engine Test Cell

Preliminary assessments of the resources and capabilities of the engine test cell facilities at the São Paulo Aeronautical Material Park (PAMASP) for testing the F414-GE-39E engine of the F-39 Project (Gripen NG).

São Paulo, August 1, 2023

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

Contact and Qualification of Appraisers

1st Lieutenant Guilherme Nishisaky Bezerra **Lins**
São Paulo Aeronautical Material Park (PAMASP)
Engines Subdivision (TMOT)
Phone: +55 (11) 2281-4109
Email: guilhermelinsgnbl@fab.mil.br
Head of Engine Maintenance Shops
Qualification: *Mechanical Engineer*

SubOfficer Veteran Antonio Luiz Dionizio
São Paulo Aeronautical Material Park (PAMASP)
Engines Subdivision (TMOT)
Phone: +55 (11) 2281-4121
Email: antonioald@fab.mil.br
Inspector and Supervisor of the Engine Test Shop
Qualification: *Basic Aircraft Maintenance Specialist (BMA)*

SubOfficer Fábio Henrique Pereira dos Santos
São Paulo Aeronautical Material Park (PAMASP)
Engines Subdivision (TMOT)
Phone: +55 (11) 2281-4121
Email: fabiofhps@fab.mil.br
Supervisor of the Engine Test Shop
Qualification: *Basic Aircraft Maintenance Specialist (BMA)*

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

1st Sergeant Marcio **Nogueira** da Silva

São Paulo Aeronautical Material Park (PAMASP)

Engines Subdivision (TMOT)

Phone: +55 (11) 2281-4121

Email: nogueiramns2@fab.mil.br

Instrumentation Inspector of the Engine Test Shop and Test Systems Developer

Qualification: *Basic Electricity and Instruments Specialist (BEI)*

3rd Sergeant André Luiz **Zangrandi** Zago de Castro

São Paulo Aeronautical Material Park (PAMASP)

Engines Subdivision (TMOT)

Phone: +55 (11) 2281-4121

Email: zangrandialzzc@fab.mil.br

Technician responsible for instrument calibration and maintenance

Qualification: *Basic Electronics Specialist (BET)*

3rd Sergeant Lucas Machado de **Sales**

São Paulo Aeronautical Material Park (PAMASP)

Engines Subdivision (TMOT)

Phone: +55 (11) 2281-4121

Email: saleslms@fab.mil.br

Technician responsible for operation, testing and adjustment of engines

Qualification: *Basic Aircraft Maintenance Specialist (BMA)*

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

1 - Goals

1.1 - Establish the operational conditions and capabilities of the PAMASP Test Cell in view of a possible adaptation of the system for testing the F414-GE-39E engine.

1.2 - Establish the needs for tests and adaptations regarding the air flow inside the test cell for the F414 engine resources, either with the current configuration, or with the removal of the blockage in the exhaust tower (exhaust stack flow blocker) or with the extension from the augmentor out of the exhaust tower.

This assessment is based on the following assumptions:

- **Technical and Economic Feasibility;**
- **Operational Feasibility;**
- **Project Deadline;**
- **Logistic Scenario.**

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

2 – Infrastructure and Systems

It is the set of fixed assets and permanent materials installed next to the buildings that make up the Test Cell.

The evaluation of the infrastructure and systems was based on the information obtained through the site-survey of the PAMASP test cell and the manuals of the ASE (construction originals), National Instruments, Focal Engenharia and Test Cell Maintenance Manuals of GE-J85-21C, MK 807 Spey and MK 540 Viper Engines.

In addition to the primary sources of information, catalogs and datasheets of equipment obtained from the websites of the respective manufacturers were used.

Characteristics:

- In operation since 1972;
- Preventive maintenance carried out periodically by the operators themselves;
- High robustness and upgradeability.

2 – Infrastructure and Systems

Regarding the infrastructure (Table 1), observe the good condition of the building (floors, walls and roof), metallic structures and doors of the Test Hall, piping, reservoirs, pumps, motors, compressors, electrical switchboards, lighting, against fire, collective protection equipment, technical furniture, grounding, lightning protection system (SPDA), data networks and supervision cameras. In addition to the general state of conservation, the quality of the materials and the strict observance of technical standards in the execution of the project can be noted.

Table 1 – Preliminary condition assessment and basic functional test

Infrastructure	Apparent Condition	reuse	tested / inspected?
Buildings	Good	Viable	Not applicable
Test Frame Metallic Structures	Good	Feasible with caveats (1)	No
Test Hall Doors	Good	Viable	Yes
Fuel pipes	Good	Feasible with caveats (2)	No
Reservoirs and Pressure Vessels	Moderada	Feasible with caveats (3)	Yes
Pumps	Good	Feasible with caveats (4)	Requires testing
Electric Motors	Good	Feasible with caveats (5)	Yes
Air compressor	Good	Viable	Yes
Compressed Air Reservoir	Moderate	Feasible with caveats (6)	Requires testing
Switchboards	Moderate	Feasible with caveats (7)	Not applicable
Lighting	Moderate	Feasible with caveats (8)	Yes
Fire Fighting Center	Good	Viable	Yes
Collective Protection Equipments	Good	Feasible with caveats (9)	No
Technical Furniture	Good	Viable	Not applicable
Instrumentation	Good	Feasible with caveats (10)	No
Automation Center	Good	Feasible with caveats (11)	No
IT	Good	Viable	No
DAS (Data Acquisition System)	Good	Viable	No
Grounding	Good	Viable	No
Protection system against atmospheric discharges	Good	Viable	No
Data Networks	Good	Viable	No
Supervision Cameras	Moderate	Viable	No

Caveats to be considered regarding infrastructure:

1 – Test Frame Adaptation

The current structure of the jet engine test cell presents characteristics that may be of vital importance for the future adaptation to the F414 systems, the whole structure presents high robustness and great adaptability. The jet engine cell can operate in different projects, having already been used for the MK 807 Spey, MK 540 Viper engines and, currently, for the GE-J85-21C engine, with a structural capacity for the operation of engines with up to 30,000 lb of thrust. The whole set can be divided into 3 basic parts, which are:

- <u>Intake Tower:</u> it consists of noise dampers installed in the intake and inlet turn vanes, it is important to highlight its modularity, something that allows adaptation to the multiple flow demands of different projects.

Figure 1: Inlet turn vane (left) and intake tower noise dampers (right)

- <u>*Test Stand* and Load Cell:</u> it has in its formation, the engine cradle (test stand) already equipped with a system for reading the engine thrust, currently with a capacity of up to 30,000 lb, with the engine lifting set by means of two electric hoists with a capacity of 2 ton each. Here, an inspection of Non-Destructive Tests is recommended, in addition to making a new cradle (test stand) for fixing the new engine. The engine with the largest dimensions and air flow tested in the PAMASP Test Cell is the engine that equips the AMX A-1 aircraft, the MK 807 Spey engine with approximately 11,000 lb of thrust.

Figure 2: Inside the test cell with Spey engine installed

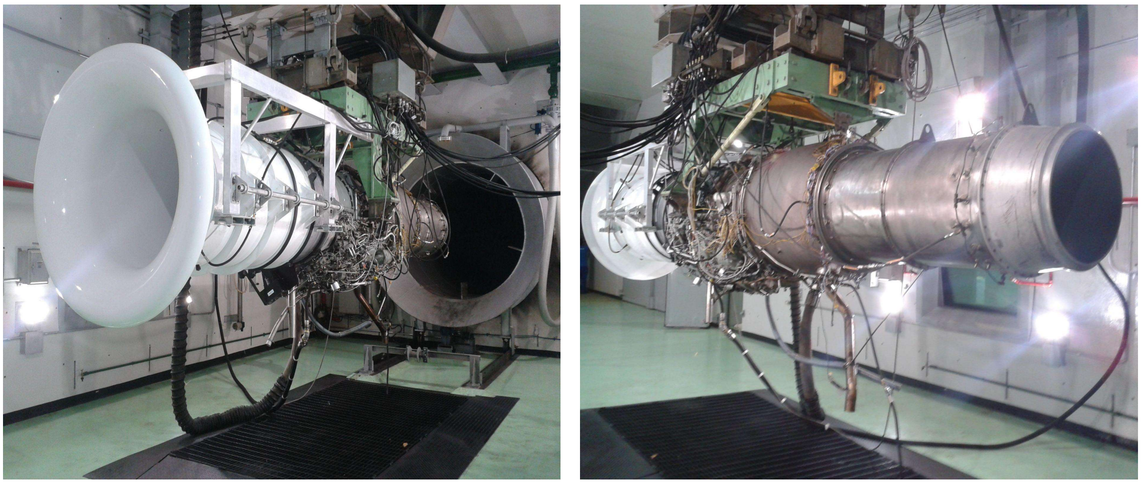


Figure 3: MK 807 Spey engine installed

- Exhaust Tower: The exhaust tower assembly consists of an exhaust gas collection tube (augmentor) which is telescopic in the part that is inside the test cell, an area at the top with an exhaust stack flow blocker, a water "sprinkler" system for exhaust gas cooling and 64 individual noise damper cells. Like the intake set, the exhaust tower allows adaptations for greater air flow, either by lengthening the exhaust duct (augmentor) by opening the final concrete wall of the exhaust tower, or by removing the exhaust stack flow blocker, if necessary, and the placement of turn vanes at the end of the augmentor.

Figure 4: Exhaust gas collection duct with the cooling sprinkler (on the left) and exhaust tower dampers (on the right)

Figure 5: Water tank used for cooling/emergency (capacity 100,000 liters). (In the background gas exhaust tower)

The topics below will be addressed again throughout this report:

2 - Fuel Pipes

The piping system and fuel filters must undergo analysis to verify the need for resizing and adequacy.

3 - Reservoirs and Pressure Vessels

It is recommended that existing reservoirs be treated or replaced, with improvements to the containment area.

4 - Pumps

This item addresses the fuel and fire system pumps.

a) Fuel Pumps: Resizing if necessary and testing;

b) Fire System Pumps: Resizing if necessary and testing.

5 – Electric Motors

Inspection and testing of electric motors are recommended.

6 - Compressed Air Reservoir

The current system is operational, however, in need of inspection/repair. Reservoir replacement is recommended.

7 - Switchboards

The current system is in operation with the need for detailed inspections, aiming at adapting to future test needs of the F414-GE-39E engine.

8 - Lighting

The test cell lighting system supports the need for tests, however, it is recommended to improve the set of reflectors in order to increase the resistance to vibration caused during the tests.

9 - Collective Protection Equipment

Need for inspection of the set of noise dampers and inspection windows.

10 – Instrumentation

The instrumentation appears to be viable as long as the needs of the F414-GE-39E engine are confirmed. For example, checking the pressures used for engine testing and their compatibility with the pressure transducers currently on the test cell.

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

2.1 – Electrical Systems

They comprise the set of components and devices responsible for supplying electrical energy for lighting, activating electrical machines, powering converters and computer equipment.

Characteristics:

- 500 KVA (Apparent Power) substation, with 630A general circuit breaker;
- Currently, only 80 KVA are used (last data survey done in 2019, by the Electrical Division of PAMASP);
- Electrical switchboards of the Motor Test Cell, despite being long-lived, are in good condition.

2.1 – Electrical Systems

The electrical system of the EnginesTest Cell comprises a substation with a capacity of 500 KVA (Apparent Power), with a general circuit breaker of 630A, being powered by circuit number 04 of PAMASP, as stated in the documentation of the area responsible for the infrastructure of PAMASP.

From this substation, distribution branches depart for five more switchboards, ranging from lighting, air conditioning equipment, to electrical machines and electronic systems, which will be shown in the following figures.

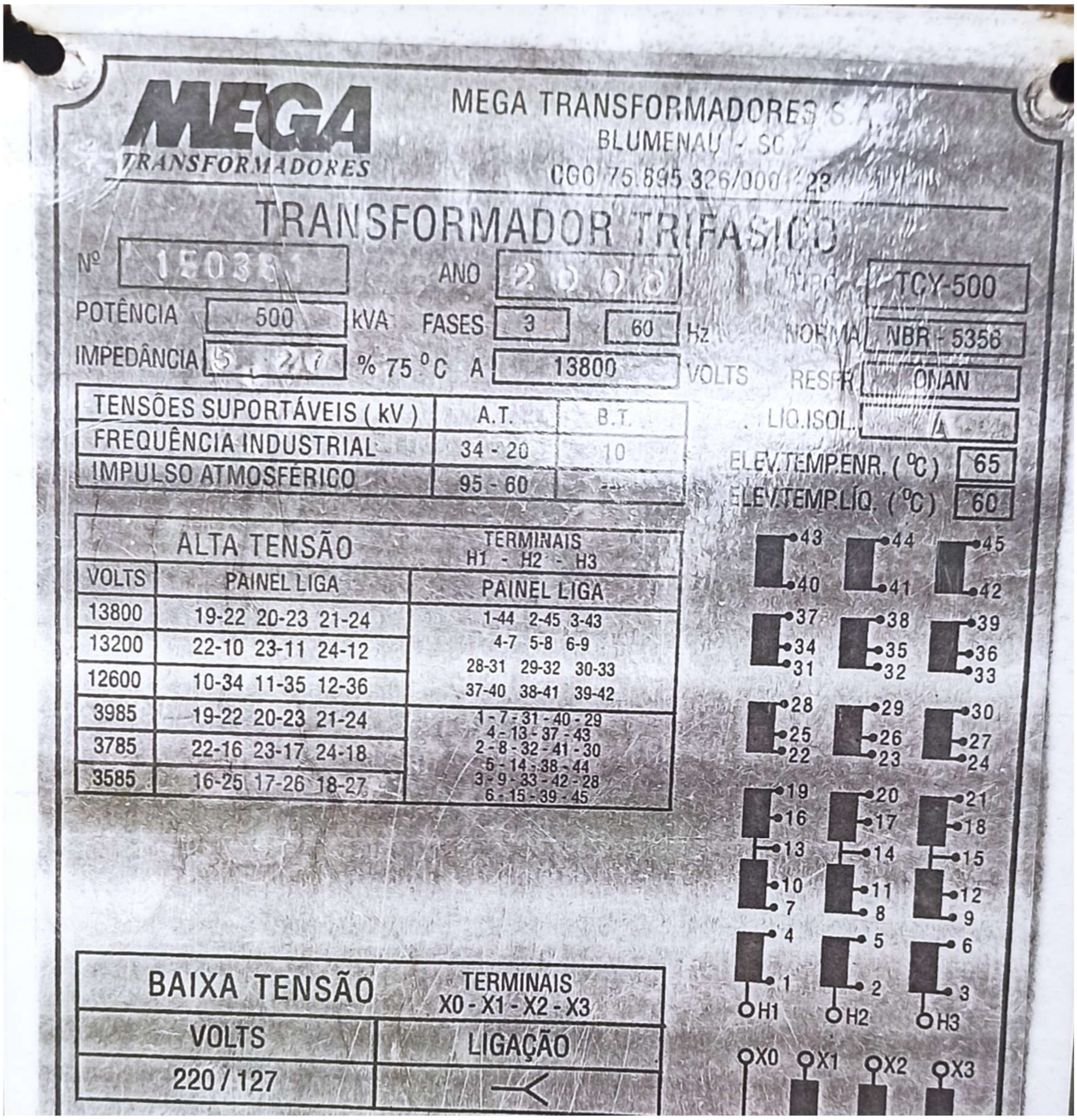


Figure 6: Substation electrical transformer specifications

During the inspection of the respective electrical panels, it was found that, despite their longevity, they are in good condition and in perfect working order. It would only be desirable to update the respective tables so that they would be in accordance with the current safety standards provided for in Brazilian Regulatory Standards (NBR).

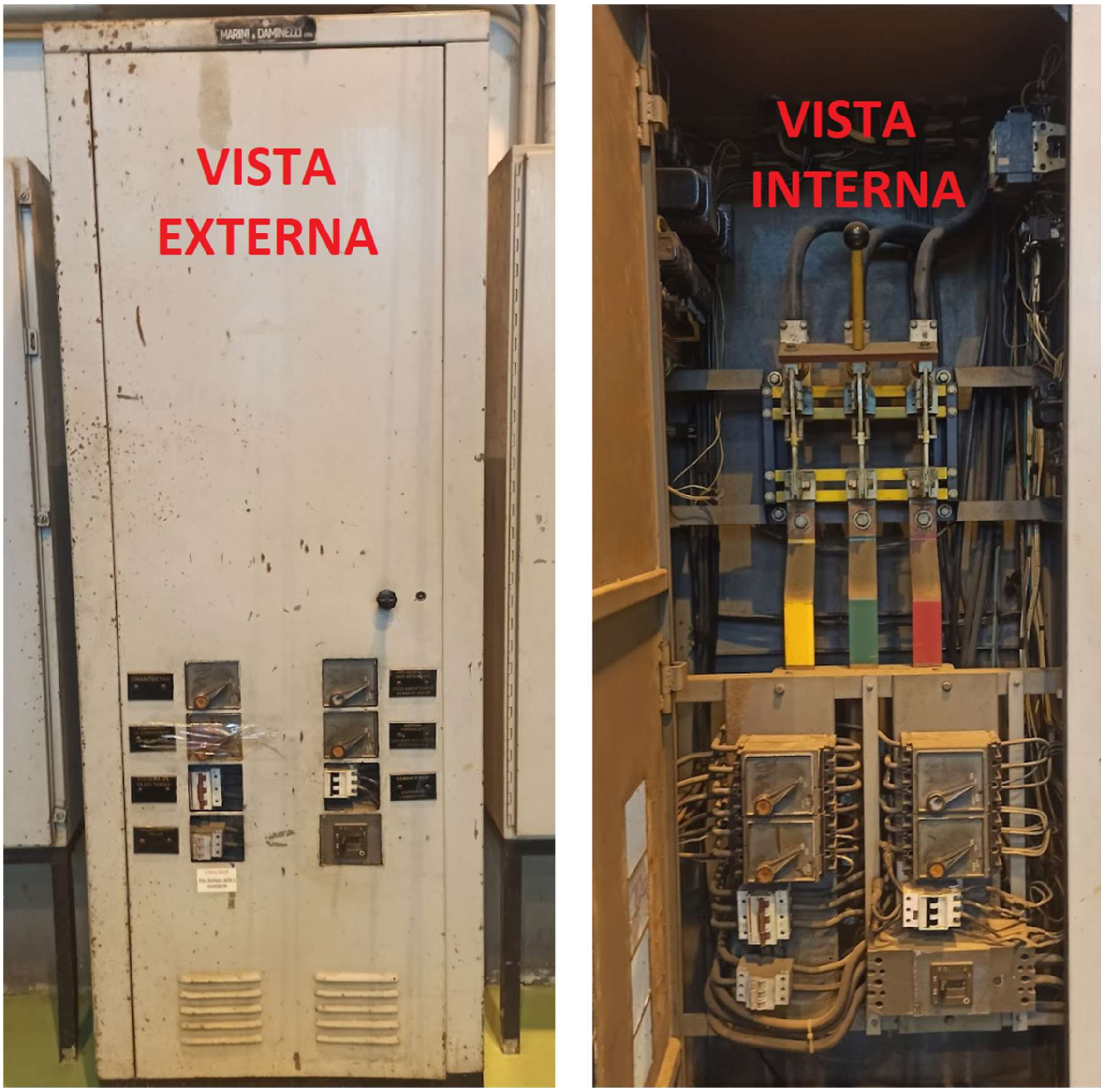


Figure 7: Internal and external views of the General Electrical Panel 1

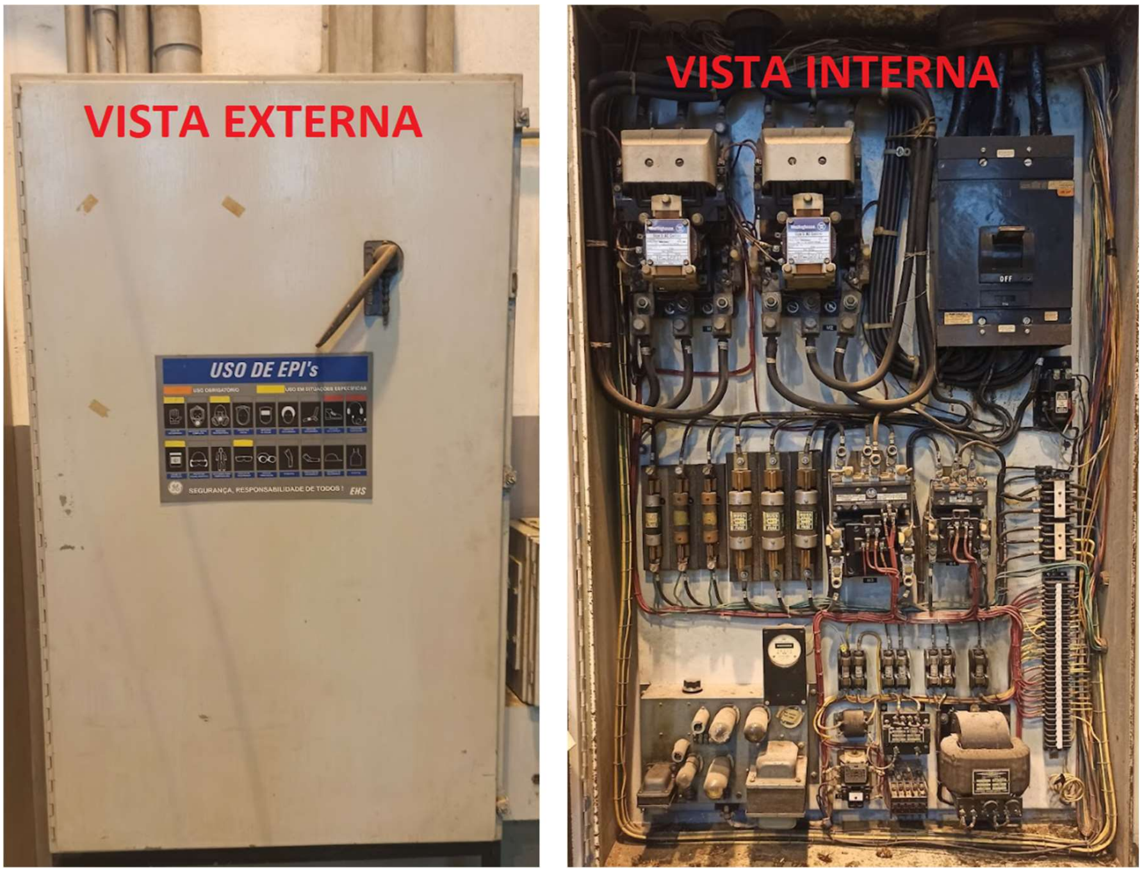


Figure 8: Internal and external views of the General Electrical Panel 2

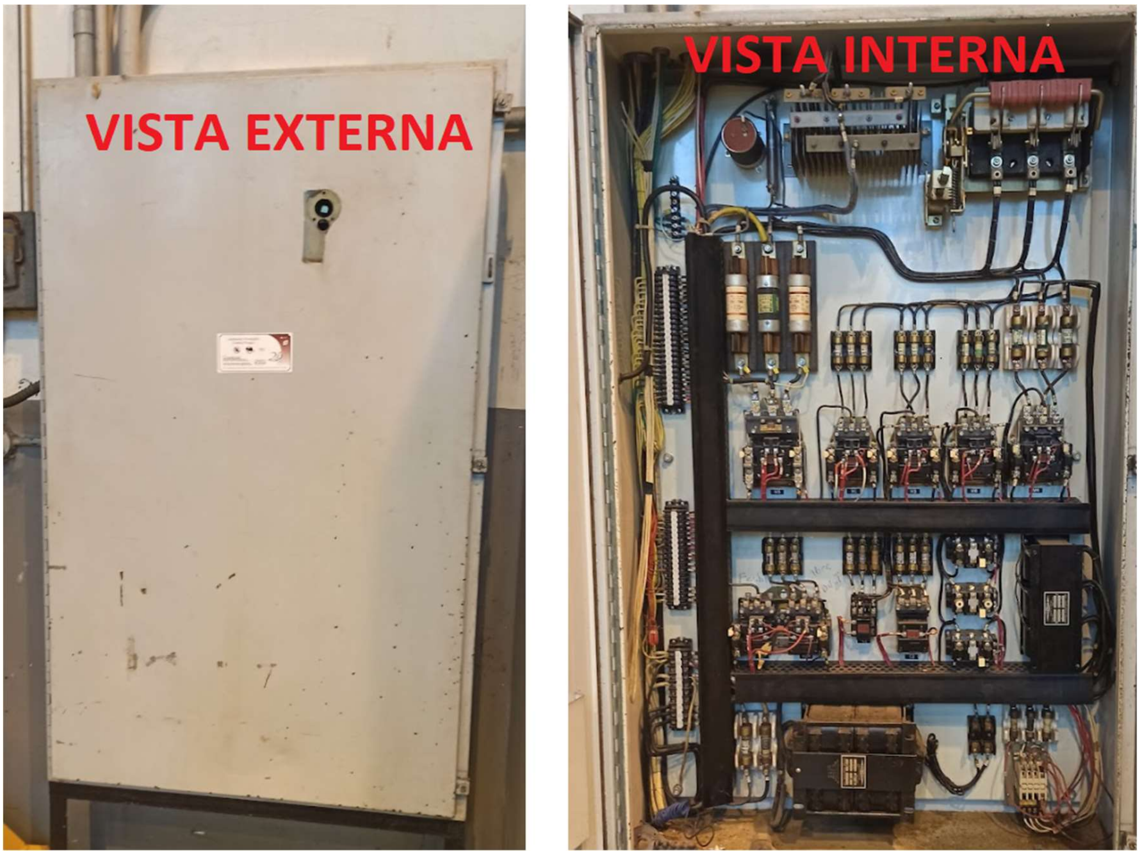


Figure 9(a): Internal and external views of the General Electrical Panel 3

Figure 9(b): Internal and external views of the General Electrical Panel 4

Figure 10: Views of the General Electrical Panel 5

Among the aforementioned panels, the most relevant is General Electric Panel number 5. This is responsible for supporting the entire electrical/electronic system of the bench and electric motors, used in the tests of jet engines.

The system also has a "no-break" (UPS) model FN10K2TXI, to protect the entire data acquisition system in any phase outage situation, which is in good condition and in full operation.

Figure 11: “nobreak” (UPS) model FN10K2TXI.

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

2.2 – Fuel Systems and Preservation

Receives, stores and supplies, under controlled conditions of pressure and flow, the fuel necessary for the engine to function in all operating regimes.

Characteristics:

- Set of three storage tanks with a capacity of 20 m³;
- A motor pump set;
- Network with dedicated filter.

2.2 – Fuel Systems and Preservation

The structure of the fuel system in operation of the test cell is formed by an external pressure pump set, the set of storage tanks and the pressure and return piping system.

The entire system is activated from inside the control room, through shut-off valves and electrical/pneumatic controls.

The set of pumps and tanks is located outside the test cell, in a separate and isolated location. As a recommendation, there is a need to build a shelter. Once activated, the system starts an electric pump that pressurizes and sends the fuel (JET A) through underground pipes to the engine test cell.

Currently, the system meets the demand for operating the GE-J85-21C and MK 807 Spey engines with peace of mind. The big Caveat, as already mentioned in this report, is the capacity of the tanks and pumps system, regarding the fuel of the F414-GE-39E (JP-8) and its pressure and flow needs.

Figure 12: Storage Tanks and Motor Pump Set

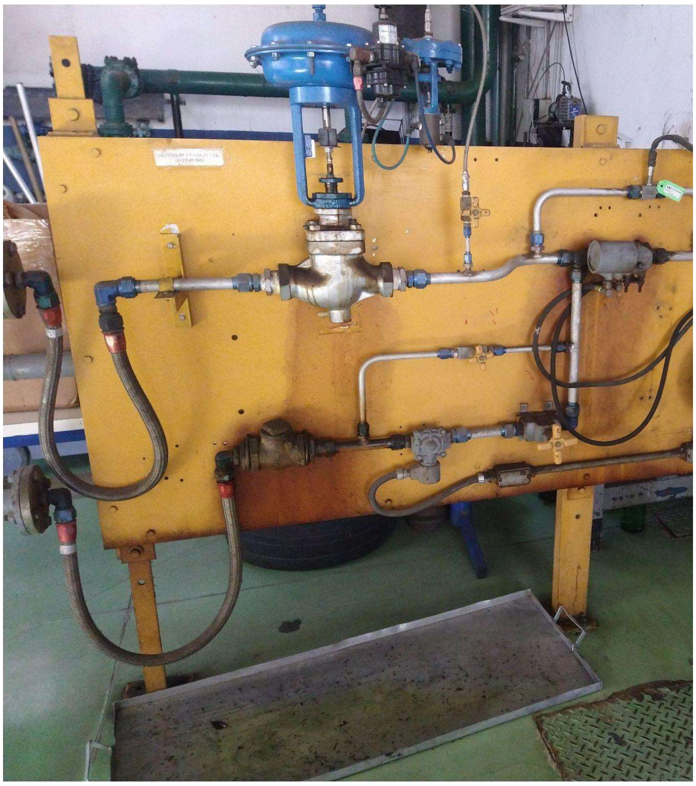


Figure 13: Filter and Fuel Control System

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

2.3 – Compressed Air and Starting System

Comprises the set of equipment responsible for compressing, drying, filtering, storing and releasing compressed air to drive the engine.

Characteristics:

- INGERSOLL RAND 30 HP Screw Compressor, Model UPS-30HP-125;
- Two reservoirs of 10.8 m³ each;
- Working pressure 8.5 kgf/cm²;
- Highly robust electro-pneumatic shut-off valves.

2.3 – Compressed Air and Starting System

The Compressed Air and Starting System comprises a 30 HP INGERSOLL RAND screw compressor model "UPS-30HP-125". This compressor delivers compressed air to a reservoir located next to the compressor room. The reservoir has two storage tanks with a capacity of 10.8 m³.

As the reservoir is located in an external area, unprotected from the weather, part of the standard painting (blue) has already been damaged, but apparently without major damage to the structure of the tank. The base for fixing the tank is in order, as well as the pipes and pressure outlet connections.

Mechanically there are no reservations regarding these equipment due to the great robustness of the materials. Both 10.8 m³ reservoirs have external power, so they are normally supplied by the central compressor of PAMASP itself.

Figure 14: Set of compressed air tanks and compressor

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

2.4 – Instrumentation and Data Acquisition (DAQ)

System responsible for measuring and interfacing the physical and electrical signals related to the operating parameters of the test plant and the engine.

Characteristics:

● Based on a set of computers and systems from the National Instruments (NI) company;
● Based on the PXI platform;
● Data sharing via Ethernet network;
● The data acquisition system is adaptable and can expand as needed;
● Currently it behaves according to the needs of the J85 and SPEY engine tests.

2.4 – Instrumentation and Data Acquisition (DAQ)

The Data Acquisition System (DAQ) is based on the concept of distributed architecture. In all, the system has 2 computers, one dedicated to data processing and user interface and another dedicated to camera monitoring, in addition to withdrawing and storing test reports, working together with an NI PXIe-1085.

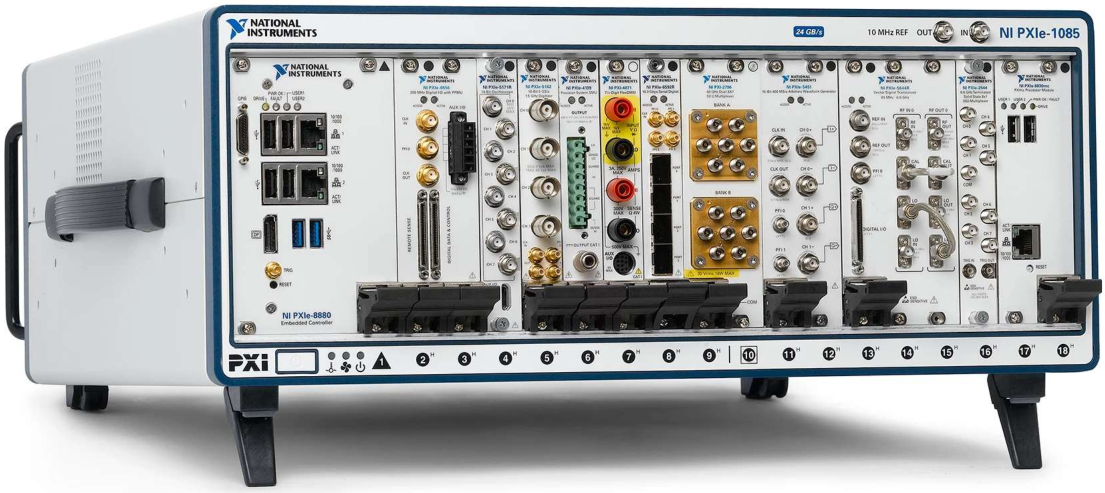


Figure 15: Illustrative figure of the NI PXIe-1085

Figure 16: Figure illustrating the acquisition card and the transducer, respectively

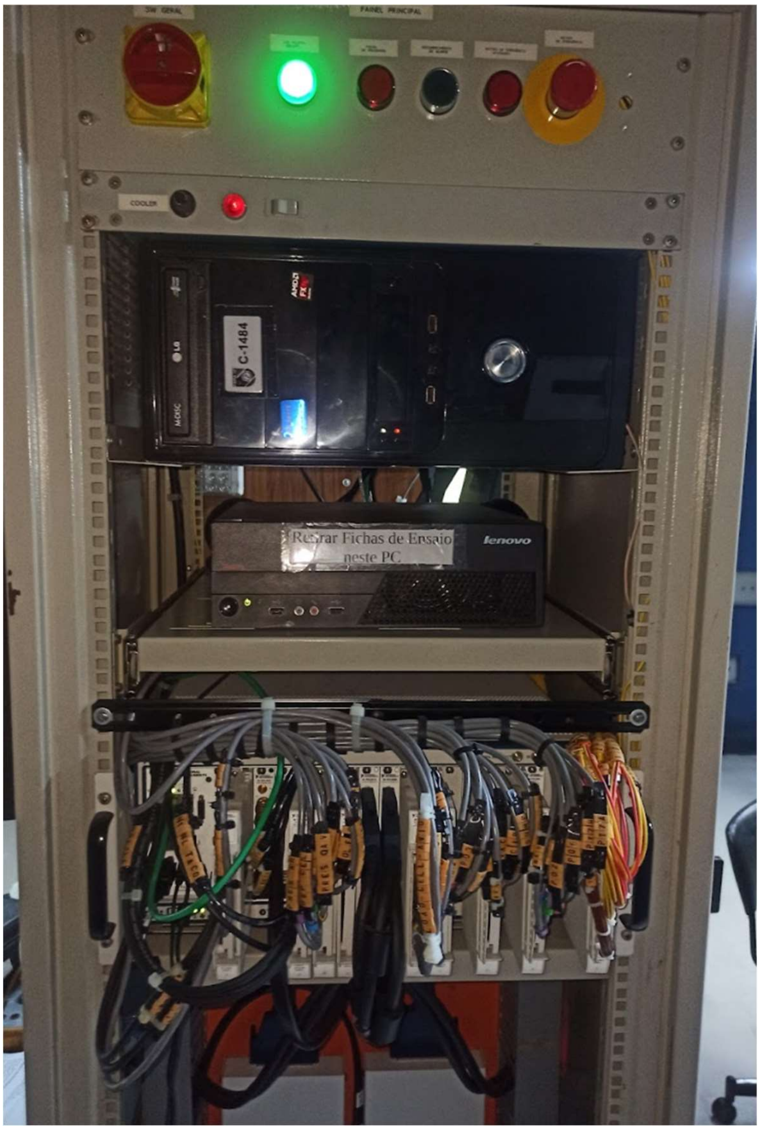


Figure 17: Figure of the GE-J85-21C and MK 807 Spey engine data acquisition system

The DAQ in question has 06 "slots" (compartments) for new data acquisition cards, which are responsible for the interpretation of the electrical information provided by the sensors. This fact makes it possible to implement another control system, requiring only the acquisition of new cards and sensors to meet the demands of the new tests to be carried out.

Summary

1 - Goals
2 - Infrastructure and Systems
2.1 - Electrical Systems
2.2 - Fuel Systems and Preservation
2.3 - Compressed Air and Starting Systems
2.4 - Instrumentation and Data Acquisition
2.5 - Miscellaneous
2.6 - MK 807 SPEY engine correlation
3 - Considerations and Analyzes
4 - Conclusion
5 - References

2.5 – Miscellaneous

It is responsible for the set of tasks related to the engine, such as hoists and operation/protection equipment.

Characteristics:

- Fire extinguishers in all sectors;
- Water fire extinguishing system;
- Reprogrammable Electronic Throttle (PLA);
- Electric hoists for lifting the motor.

2.5 – Miscellaneous

The currently system present in the Test Cell guarantees the operation a good margin of safety, with electric hoists with a capacity of 2 tons each, firefighting systems inside the test cell and internal insulation to prevent noise and vibrations.

The hoist assembly is quite robust and should be able to withstand the demands of the new engine.

The fire-fighting system is relatively simple and is activated from inside the control room. It consists of two motor pumps that, when activated, pressurize the system, and reach the sprinklers positioned laterally in the test cell, with the aim of extinguishing agent water from a test bench reservoir (Figure 5). All engine control is done from a “simple” electric lever.

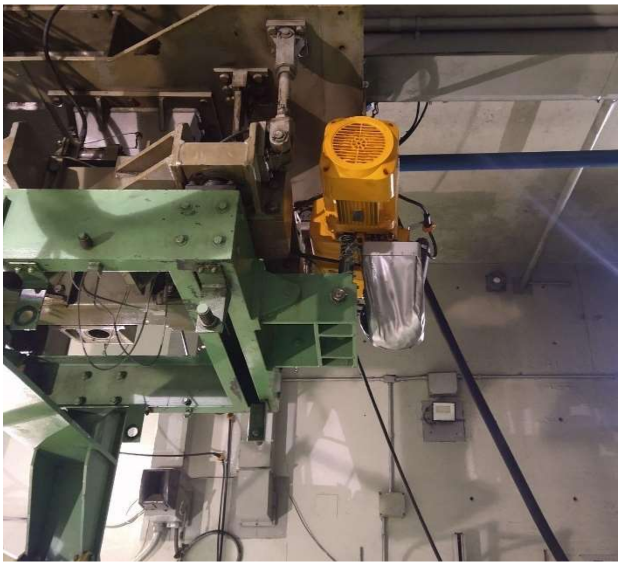


Figure 18: System operated by electric hoists

Figure 19: Test cell with the positioning of fire extinguishers

Figure 20: Motor-pump for the fire-fighting system

Figure 21: Acceleration lever (PLA)

Figure 22: Control panel

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

2.6 – SPEY MK 807 SPEY engine correlation

The data described below are part of the Site Survey developed on the engine test facility, with the aim of demonstrating the feasibility of carrying out the Spey tests on the PAMASP Engine Test Cell.

Características:

● Dimensions and technical data of the Test Cell according to the Survey carried out by the companies ROLLS-ROYCE ENGLAND, ROLLS-ROYCE BRAZIL and AVIO ITALIA, in partnership with PAMASP, in 2012.
● Documentary proof of approvals in the tests performed.

2.6 – SPEY MK 807 SPEY engine correlation

Certificate

Test Facility Calibration Re-validation

The Test Facility indicated on this certificate has been satisfactorily calibrated / re-validated in accordance with DEG136 & GQP.X.PS.12 for the engine/s listed below.

Test Facility Number	2	**RR Approval Status**	Approved
		Partner Co. Status	
Location		PAMA, Sao Paulo, Brazil	

Engine Types	Military Spey
Rating	11030 lbf
Mark Numbers	807
Date of Last Calibration Test	17th May 2013
Date of Re-validation	N/A
Approval Expiry Date	17th May 2016

Test Facility Calibration Reports	EDNS05000031627
Engine used for Calibration Test	16009
Calibrated against Test Facility Number	Cell 2, AVIO, Brindisi
Test Facility Configuration Report and / or GA	EDNS05000032043
Front shutter position during test	N/A
Rear Shutter position during test	N/A
Distance from exhaust nozzle to Detuner	0.62 m
Detuner blockage	N/A
Data acquisition system software	Manual Recording
Performance analysis software	PERF_SPEY_AVIO_PAMASP
Software Validation Report	Avio Co-ord Memo (FARR/005/13)

Test Facility Re-validation Report	N/A
Engine used for Re-validation Test	N/A

Restrictions:- None

Any alteration to the cell structure, its intake and exhaust configurations, or the position of the engine on test relative to these items automatically invalidates this certificate. No ancillary items of equipment to be left within the cell during performance testing, other than those permitted by the Test Cell Configuration Report or GA.

Wind-direction (Jan 2012 - Dec 2012)

N	10 %
NE	12 %
E	15 %
SE	27 %
S	18 %
SW	2 %
W	4 %
NW	12 %

Altitude

The altitude of the new facility is approximately 681m (2234ft) above sea level.

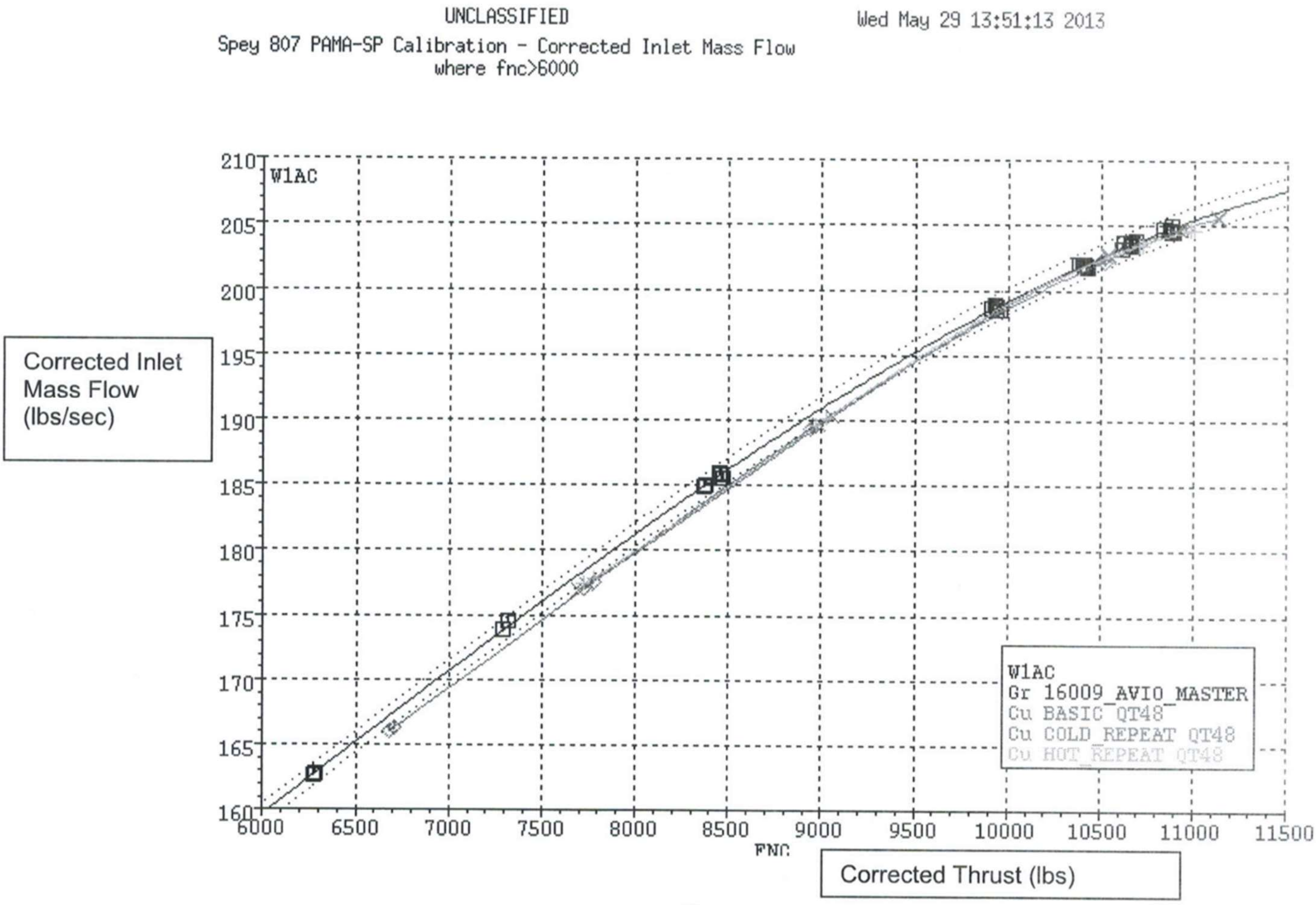
Attitude

The attitude of the facility is North – South (Exhaust - Inlet) which is conducive with the prevailing wind direction in the area.

DIMENSIONS

Description	Dimension
Overall External Facility Length	38.17m
Air Inlet Stack Height	12.67m
Exhaust Stack Height	15.09m
Exhaust Stack Distance From Air Inlet Stack	11.19m
Initial Air Inlet Area (top of Air Inlet Stack)	5.88m x 6.10m = 35.87m²
Air Inlet Area at entry to Test Cell	6.4m x 5.56 = 35.58m²
Air Inlet Blockage Area	Acoustic splitters 0.18m x 6.10m = 1.10m² x 20off = 22m²
Geometric Flow Area - Air Inlet	35.58m² – 22m² = 13.58m²
Test Cell Length (trailing edge of bottom Inlet turning vane) to rear wall	24.68m
Test Cell Width	6.40m
Height at front of Test Cell	5.56m
Height at rear of Test Cell above engine	4.80m
Distance from trailing edge of bottom Inlet turning vane to plane level with front face of Airmeter	16.09m
Installed Engine Horizontal Centreline from test cell port wall	3.08m
Installed Engine Vertical Centreline from Floor Level	2.03m
Minor Diameter of Telescopic Augmenter Tube	2.17m
Geometric Flow Area (Throat) – Telescopic Augmenter Tube	3.70m²
Length of Fixed Augmenter Tube/Blast Basket)	11.14m
Engine Jet Pipe Inner Diameter	0.57m
Spey Detuner Gap	0.62m

CORRECTED INLET MASS FLOW [M1K]



Comparator Load Cell and Display Details

Comparator Load Cell	
Supplier	Beowulf Corporation
Model	N-1
Capacity	20Kg
ID	4H3070/4H3069
Part No.	800260-202/800260-203
Serial No.	K524
Frequency of Calibration	Annually at qualified laboratory
Display	
Supplier	Beowulf Corporation
ID	9H0069
Part No.	800260-120
Serial No.	K524
Capacity	10Kg
Frequency of Calibration	Annually at qualified laboratory

During thrust calibrations load is applied to the floating frame via a hydraulically operated jack that is mounted on the engine centreline.

The output from the load cell is displayed on the thrust indicator display on the control console.

Exhaust System

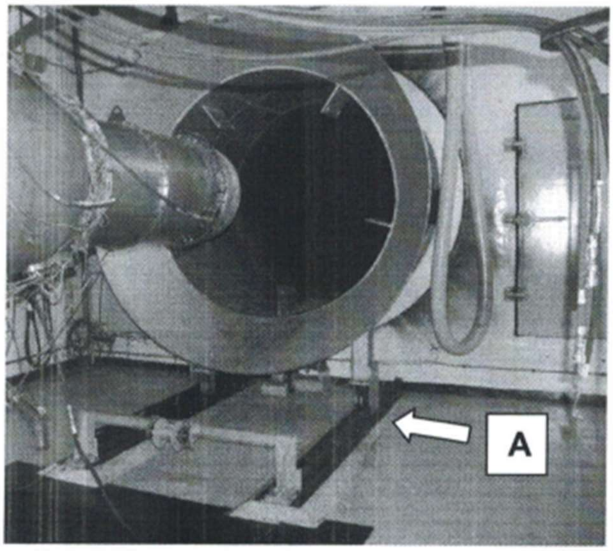


Figure 14 Telescopic Augmenter Tube

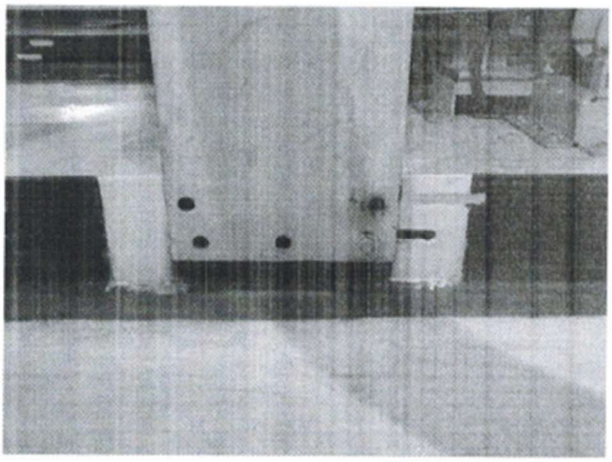


Figure 15 Telescopic Augmenter Tube - View on A

Telescopic Augmenter Tube

The Telescopic Augmenter Tube is installed to the inside of the Fixed Augmenter Tube which passes through the rear wall of the test cell into the Exhaust Stack. The Telescopic Augmenter Tube can be located in different positions to suit the engine type under test. This allows the engine exhaust exit plane to augmenter flare inlet plane distance to be optimised. The weight of the Telescopic Augmenter Tube is supported by two steel legs which run on two steel guide rails attached to the test cell floor. An electrical pulley system has recently been provided which is used to move the Telescopic Augmenter Tube. The control box for the electrical pulley system is located on the starboard wall at the rear of the test cell.

The correct position for each engine type has been established during the commissioning/aerodynamic survey to achieve the correct airflow through the test cell whilst minimising the chances of hot gas re-ingestion. This position is generally referred to as the 'detuner gap'. The Spey Mk807 detuner gap for this facility has been established as 0.62m (engine exhaust plane to augmenter initial inlet plane). The two guide rails on the test cell floor have been marked with white paint to identify the correct position for testing the Spey Mk807 engine.

The Telescopic Augmenter Tube has a maximum air inlet flare diameter of 2.94m subsequently leading to the Exhaust Augmenter Tube that has a diameter of 2.17m. This is the controlling flow area of the exhaust system. The minor diameter of the Augmenter Tube produces a throat area of $3.70m^2$ which is the effective flow control area of the facility. The centreline height of the Augmenter Tube is co-incident with the installed engine centreline height of 2.03m.

Fixed Augmenter Tube/Blast Basket

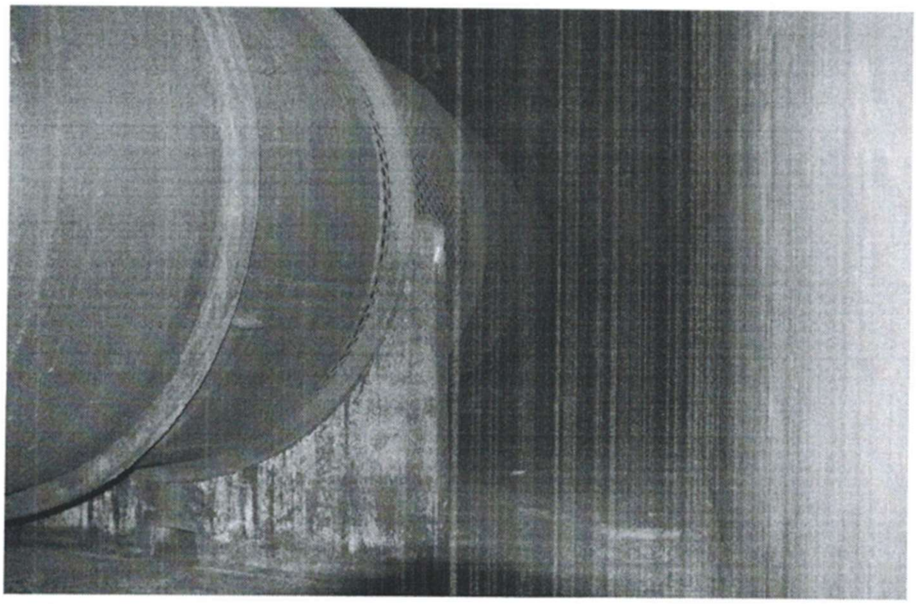


Figure 16 View inside Exhaust Stack

The Fixed Augmenter Tube passes through the rear wall of the test cell into the Exhaust Stack. The Fixed Augmenter Tube has a diameter of 2.51m x 5.59m long and is welded onto the blast basket which extends a further 5.55m to the rear of the Exhaust Stack. The blast basket section of the Fixed Augmenter Tube consists of a large perforated tube (diameter 2.51m) which includes a large fabricated end plate that is used to deflect the exhaust gases out of the structure.

The blast basket is designed to decelerate, deflect and distribute the engine gases into the Exhaust Stack prior to the exhaust stream leaving the facility via the Exhaust Splitters at the top of Stack. In this way the blast basket removes energy from the stream tube and assists with the acoustic attenuation of the facility.

Access to the bottom of the Exhaust Stack and the Fixed Augmenter Tube/Blast Basket is through a steel door (1.88m wide x 2.10m high) in the rear wall of the test cell.

Exhaust Stack Acoustic Splitters

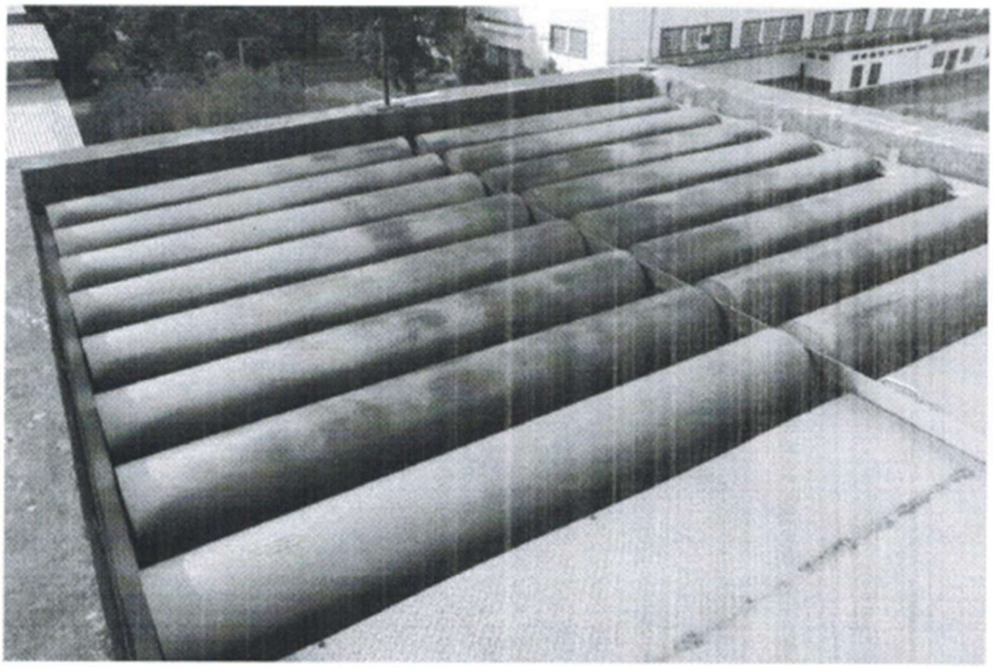


Figure 17 Acoustic Splitters at Top of the Exhaust Stack

To assist with the aerodynamics and acoustics of the facility the Exhaust Stack includes a set of 8off x 0.41m wide 'acoustic' splitters. The full area of the Exhaust Stack is used except for a 1.85m wide section at the front which is blocked off. A visual check of the acoustic splitters from inside the Exhaust Stack at ground level and on the top of the Stack confirmed that there is no witness of loose panels or exposed acoustic materials.

TEST FACILITY FUEL SUPPLY SYSTEM

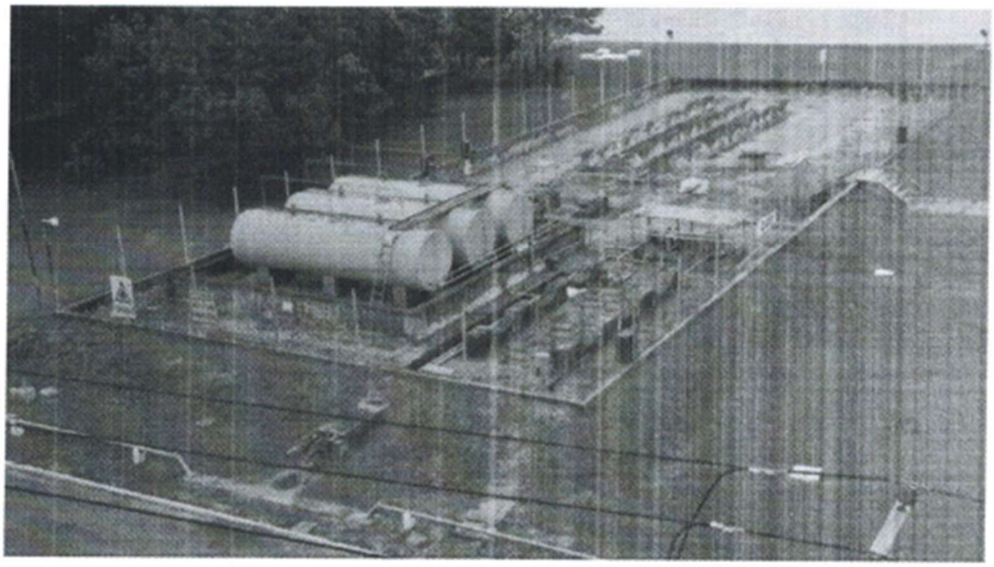


Figure 18 Bulk Fuel Storage Compound Viewed from the Exhaust Stack

Fuel Storage Compound

Fuel is supplied to the facility from a dedicated bulk fuel storage compound situated 50 meters north of the facility that includes three tanks each with a capacity of 20,000 litre (Jet A1 or QAV 1). The three tanks are bunded to prevent the escape of leaks or spills. Each tank has been provided with sighting glasses, inspection manholes, vents, lifting points and a suitable refilling point outside of the compound.

INLET AIR FLOWS

During the "A" leg running at Brindisi, Italy there was very little difference observed when testing with the PAMA-SP slave airmeter compared to the Avio Master airmeter (M45-1) and in the original analysis the associated Airmeter CoEfficient (K Factor) was left unchanged at 0.846 (effective area = 912.7in²).

For the initial analysis of data at PAMA-SP it was considered appropriate to attempt to adopt a similar approach so all coefficients and constants relating to slave hardware / instrumentation probes remained unchanged from the Brindisi "A" leg.

Unfortunately examination of the 1st engine run data at PAMA-SP showed a reduced Inlet airflow (M1) when compared to the Brindisi "A" leg results (circa -1.5%). This would be equivalent to a +0.1insHg shift in average S901 pressure reading and therefore prompted a series of investigative checks as follows.

- Confirmation that individual S901 static pressures at PAMA-SP were all consistent (±0.01ins Hg) and commensurate with Brindisi "A" leg runs in terms of profile.
- "End-End" leak checks of all 4 static pressure lines (confirmed as satisfactory with all results within -0.02ins Hg).

A 2nd set of calibration curve runs conducted after the checks above also produced very similar results.

Inlet mass flows are typically aligned by the use of individual airmeter "K" factors which are intended to compensate for any subtle changes in airmeter geometry despite all meters being made to the same basic design. The AVIO Brindisi airmeters have K factors of 0.846 (effective area = 912.7in²) for Airmeter ***M45-1*** and 0.851 (effective area = 918.1in²) for Airmeter ***M45-2***. Similarly the PAMA-SP Airmeter itself used to have a K factor of 0.846 (effective area 912.5in²) in its previous employment for Spey engine testing at GE, CELMA.

However, we now have several sets of performance curves from PAMA-SP supporting the use of a "K" factor for PAMA-SP Spey testing of 0.858 (effective area 926in²) almost 10in² larger than expected. This despite this very same airmeter, when used at AVIO Brindisi during the "A" leg running exhibiting very similar characteristics to the Master AVIO kit.

Having exhausted all obvious avenues of investigation regarding measurement errors the proposed way forward is to accept this significant change in Airmeter effective area to align with the Master test cell (albeit without sound technical justification). Accordingly everyone should be very vigilant in monitoring this parameter and mandate regular trending checks of PAMA-SP Inlet Airflows against the current AVIO Brindisi database.

CONCLUSIONS & RECOMMENDATIONS

Baring from some obvious data recording anomalies, analysis of data collected using Engine 16009 during the "B" leg running at PAMA-SP was very encouraging in terms of test bed correlation.

Accordingly the RR Performance Dept will recommend acceptance of the PAMA-SP facility as a RR certified test bed for Spey.807 performance testing subject to the following conditions.

- The Thrust correction at PAMA-SP is +2.5% at corrected thrusts up to 10000lbs, thereafter it is a fixed delta of +250lbs.

- The Airmeter effective area at PAMA-SP needs to be set at 926ins² to align Inlet Airflow with AVIO Brindisi. This needs to be closely monitored as it is significantly different to other Spey airmeter "K" factors.

- To support this correlation report which, in the absence of suitably validated software at the PAMA-SP facility has been conducted using the RR Spey Test Bed Analysis program [qt48], documented evidence is required comparing the Master AVIO Brindisi test cell analysis program [MAINCAL] with the AVIO Brazil spreadsheet tool intended for use at PAMA-SP.

For any RR approval to remain valid the test bed configuration is to be maintained in line with that documented in Reference 4. In the event of any changes to the configuration being necessary, the appropriate RR specialists should be consulted and the configuration control document must be updated accordingly.

Any RR approval is only valid for a maximum time period of 3 years from the date of the correlation testing (ie until 17th May 2016). After this time further re-approval can be considered by continuous statistical analysis of trended data (minimum 4 samples / year) or by a repeat of the correlation exercise.

The following are offered as recommendations

- The FAB calibration team should look to adopt the RR practice of conducting all thrust calibrations with a suitably installed engine. Ideally this should also include all ancillary equipment typically attached to the floating thrust frame (Airmeters, fuel pipes, air start lines etc).

- To prevent inadvertent manual data recording errors corrupting engine test results AVIO Brazil should consider including some simple data checking logic within the PAMA-SP analysis spreadsheet tool. This could be simple range comparison checks on multiple measurement parameters (T1, S901 etc) or more complex parameter expectation checks using curves and algorithms as defined in Ref 5.

- Incorporation of partially fixed derivative curve fits as used in the Avio, Brindisi [***MAINCAL***] program should also be considered to prevent excessive extrapolation errors when curve fitting / interpolating data. This is even more important for this test facility than Brindisi given its higher altitude environment, meaning greater extrapolation is likely and more often, and any methods to reduce the uncertainty from these data extrapolations should be pursued.

Summary

1 - Goals

2 - Infrastructure and Systems

2.1 - Electrical Systems

2.2 - Fuel Systems and Preservation

2.3 - Compressed Air and Starting Systems

2.4 - Instrumentation and Data Acquisition

2.5 - Miscellaneous

2.6 - MK 807 SPEY engine correlation

3 - Considerations and Analyzes

4 - Conclusion

5 - References

3 – Considerations and Analyzes

Rescues the initial assumptions and confronts them with the facts presented by the systems.

Question this thread seeks to answer:

- How feasible is the adaptation of the current system for testing the F414-GE-39E engine, in general infrastructure terms?

3 – Considerations and Analyzes

3.1 – Fuel and Compressed Air Systems

A “basic” analysis of the entire fuel storage and pressure set shows a need for improvements and adaptations to the new demands of the F414 engine. The compressed air system, due to its great robustness, presents interesting characteristics, mainly regarding the operating pressure.

3.2 – Operational and Logistics

The fact that the Test Cell Facilities are inserted in a large maintenance complex that has the most diverse shops, allows a high level of maintenance that can become highly efficient for the demands of the new engine. The location of PAMASP also allows for high fluidity and operability in the distribution of the engines tested, since it is located next to an airport (Campo de Marte) and has the possibility of transporting production via Guarulhos airport.

3.3 - Infrastructure

The entire test structure must be evaluated by a competent company in order to establish some important metrics, basically two stand out here, the study by means of CFD (Computer Fluid Dynamics) of the test installations regarding their air flow capacity, both exhaust how much intake, as well as the structural limits of the airframe to the required thrust for that engine.

As an auxiliary metric, the following graph can be evaluated, which correlates the thrust of the MK 807 Spey engine.

CORRECTED INLET MASS FLOW [M1K]

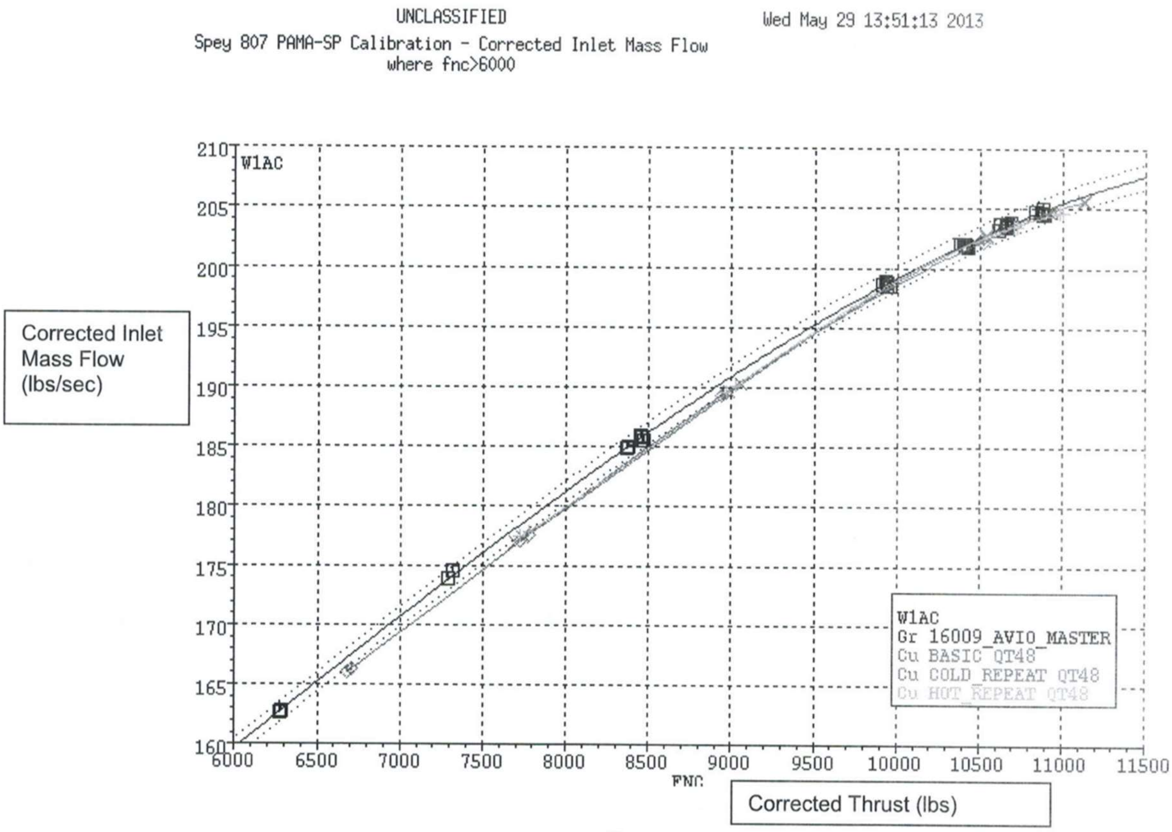


Figure 23: MK 807 Spey engine thrust graph

Note: The F414-GE-39E engine data sheet states the requirement for an airflow of 170 lb/s. As can be seen in the figure above, the test bench, in its current configuration, is already capable of supplying this inlet airflow demand.

Answer to the initial question:

- How feasible is the adaptation of the current system for testing the F414-GE-39E engine, in general infrastructure terms?

The Test Cell Facilities have all the basic conditions for adapting to the new engine, as long as the needs presented in this report are observed.

The entire general structure of the test cell, has great opportunities for improvement, as presented throughout this report, and the great differential is found in the team of technicians exclusively dedicated to the operation and maintenance of the Test Cell, which allows readiness and speed in the Troubleshooting, whether related to the specific engine or test facilities.

Summary

1 - Goals
2 - Infrastructure and Systems
2.1 - Electrical Systems
2.2 - Fuel Systems and Preservation
2.3 - Compressed Air and Starting Systems
2.4 - Instrumentation and Data Acquisition
2.5 - Miscellaneous
2.6 - MK 807 SPEY engine correlation
3 - Considerations and Analyzes
4 - Conclusion
5 - References

4 – Conclusion

Based on the preliminary assessments of the resources and capabilities of the PAMASP Test Cell, we can conclude that it is feasible to carry out the test of the F414-GE-39E engine, which equips the Gripen NG aircraft, of the F-39 Project, in the mentioned facilities. Although there are some caveats and necessary improvements, the general conditions of the infrastructure are extremely favorable.

The buildings, metal structures, pipes, reservoirs, pumps and electrical systems are in good condition, which demonstrates the possibility to adapt to the insertion of new projects (considering that, at the end of the project, the PAMASP test cell will be able to test, in addition to the engines it currently tests, Spey and J85, the F414 engine). All the improvements recommended here can be integrated quickly.

he instrumentation and data acquisition system based on the National Instruments PXI platform is highly flexible and expandable, allowing it to accommodate the demands of the F414 engine. Operability and logistics are also strengths.

The Test Cell is located in one of the largest aircraft maintenance complexes and close to two airports, which facilitates the flow of tested engines. In addition, the technical team dedicated to the operation and maintenance of the Test Cell demonstrated readiness and technical skills to deal with the challenges of engine testing.

Therefore, after carrying out the necessary analyses, we observed that it is technically feasible to test the F414-GE-39E engine at the PAMASP Test Cell facilities, with the necessary adjustments and suggested improvements.

Summary

1 - Goals
2 - Infrastructure and Systems
2.1 - Electrical Systems
2.2 - Fuel Systems and Preservation
2.3 - Compressed Air and Starting Systems
2.4 - Instrumentation and Data Acquisition
2.5 - Miscellaneous
2.6 - MK 807 SPEY engine correlation
3 - Considerations and Analyzes
4 - Conclusion
5 - References

5 – References

[1] F414-GE-39E Engine Data Sheet. Available in: https://www.geaerospace.com/propulsion/military/f414

[2] National Instruments (NI) Website. Available in: https://www.ni.com/pt-br/shop.html#pinned-nav-section2

WRITTEN BY

_______________(*electronically signed*)_______________

FÁBIO HENRIQUE PEREIRA DOS SANTOS **SO**

Supervisor of the Engine Test Shop and Test Systems Developer

(Representative of the PAMASP Engine Test Shop Team)

REVIEWED BY

_______________(*electronically signed*)_______________

GUILHERME NISHISAKY BEZERRA **LINS 1st Lt Eng**

Head of Engine Maintenance Shops

APPROVED BY

_______________(*electronically signed*)_______________

CARLOS CÉSAR MINORU **IMANICHE Lt Col Eng**

Head of the PAMASP Engines Subdivision

MINISTÉRIO DA DEFESA
COMANDO DA AERONÁUTICA

CONTROLE DE ASSINATURAS ELETRÔNICAS DO DOCUMENTO

Documento:	Preliminary Assessment Report
Data/Hora de Criação:	08/08/2023 11:34:54
Páginas do Documento:	45
Páginas Totais (Doc. + Ass.)	46
Hash MD5:	22c0793fe5b40b7392835a778a1ffaca
Verificação de Autenticidade:	https://autenticidade-documento.sti.fab.mil.br/assinatura

Este documento foi assinado e conferido eletronicamente com fundamento no artigo 6º, do Decreto nº 8.539 de 08/10/2015 da Presidência da República pelos assinantes abaixo:

Assinado via ASSINATURA CADASTRAL por Suboficial FABIO HENRIQUE PEREIRA DOS SANTOS no dia 08/08/2023 às 10:12:21 no horário oficial de Brasília.

Assinado via ASSINATURA CADASTRAL por 1º Ten GUILHERME NISHISAKY BEZERRA LINS no dia 08/08/2023 às 13:29:16 no horário oficial de Brasília.

Assinado via ASSINATURA CADASTRAL por Ten Cel Eng CARLOS CÉSAR MINORU IMANICHE no dia 08/08/2023 às 14:34:59 no horário oficial de Brasília.