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Design Principals of High Altitude Environmental Test Chamber

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ABSTRACT

This research is based on the altitude temperature, pressure and humidity, as defined by MIL-HDBK-310 standard and modifies this conditions to conform to the new standard MIL-STD-810F and test procedure given in AIAA-2466 from this fundamental guideline optimal design and sizing of test section, inlet, exhauster duct, temperature and humidity control was performed

초 록

본 연구는 MIL-HDBK-310을 기준으로 한 고도별 대기상태 즉, 온도, 습도 및 압력을 모사하여 고도에 따른 피시험물의 성능을 MIL-STD-810F 및 AIAA-2466에서 정한 시험 절차에 따라 평가하는 챔버를 개발하는 것이다. 이를 위한 대기차단 구조물, 시험부 및 공기순환유로, 고도모사 배기장치, 온도제어장치, 습도제어장치 및 설비제어장치 등을 설계하는데 고려하여야 할 사항을 기술하였다

Key Words: Altitude Test chamber, Temperature and humidity control, Exhauster system

1. Introduction

The main aim of performing this research is to demonstrate that our local industries can break away from the reliance on the monopoly of international cartel that produce test facilities, and has potential to locally develop low cost test facility capable of simulating high altitude test cell, and environmental test chamber. Included in this study is a comprehensive means of how to control air flow scheme, Temperature, humidity, and pressure

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2. High Altitude Chamber Prevailing Conditions

Design requirements specifies that the structure, air mass flow rate , altitude pressure temperature and humidity should at all times be identical to test input values desired. for this to be achieved then automated controlling intake parameters is of vital importance and was consider in this design features. The diagram below indicate environmental temperature and pressure lapse rate with increasing altitude pressure of up to 9.12kPa was considered inside the chamber caution was take on the structure frame for tests under partial vacuum (cave in) and pressure (explosion).

Structure was designed considering safety features that prevent pressure leak and chamber crush under high vacuum levels. while controlling pressure, temperature and humidity at different altitudes.

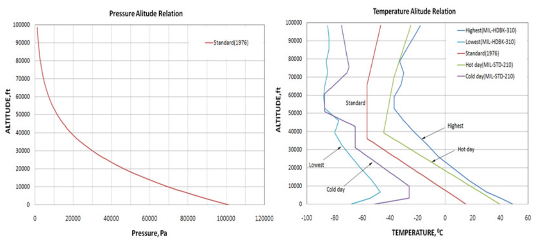

Fig. 1. U.S. Standard Atmosphere,1976, MIL-HDBK-310

Figure 1. above show environmental lapse rate with increasing altitude

2.1 Structural Frame

Design specifications are given as follows operating temperature of main frame and test section ranges from -60~150℃, humidity of 30~100 % RH, pressure 101.3~9.12 kPa. Because of a huge pressure differential skin reinforcement is done using H-Beam welded on the outside of the structural skin . The operational at an altitude of 100kft experience pressure of 1.09kPa outside the chamber giving differential pressure of up to 100kPa this difference justifies the use of support beams. Similarly all pressure lines, conduit cable lines air conditioning ducts that runs to the outside of the building require sealing.

Calculations show that pressure force of 59k impinges on the door during test. to prevent leakage seals are used around the door perimeters and doors opens from the inside out.

Since this design involves differential pressure ASME Boiler and Pressure Vessel Code section Ⅷ was used to calculate material strength in both tension and compression and in determining design pressure (MAWP).welding efficiency for calculation purposes was considered to be 0.85 and tensile strength of steel STS304 was selected for fabrication with thickness t=5.

Fig 2 represents the structural configuration of the chamber and test section.

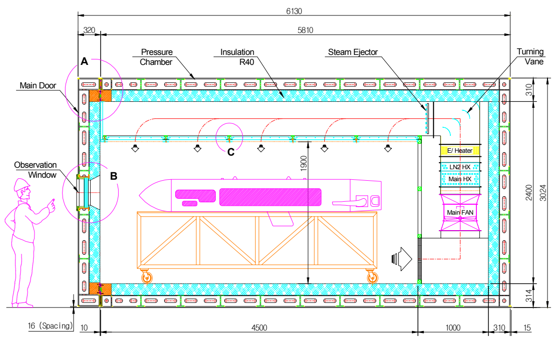

Fig. 2. Structural configuration of the Test Section

2.2 Test Section and Air Circulation

A separation panel that houses the test section is perforated from the top giving air rain effect. air exits the test section from below the test stand through the inlet side of the fan.

Air conditioning is achieved through main heat exchanger , cooling system and electrical heater that controls supply air temperature between -60~150℃.

The table below lists design specifications considered in designing control mechanism

Table 1. Test Section Specifications

Item	Performance	
Temp	Range	(-)60℃ ~ (+)150℃
	Accuracy	±2℃
	Operating Temp	Per Min 2℃ 이내
	Cooling Rate	5℃/min
	Heating Rate	5℃/min
Hum	Range	30% ~ 100%
	Accuracy	±5%
Alt	Range	0 ~ Max 55,000ft
	Accuracy	±5% or ± 200Pa
	Lapse Rate	7.6m/s ~ 10m/s

Turning vane were selected for use as shown on figure 4 to reduce turning and corner losses they also give a streamline flow

Temperature and humidity regulation devices are mounted aft the main fan position strategically selected for easy maintenance.

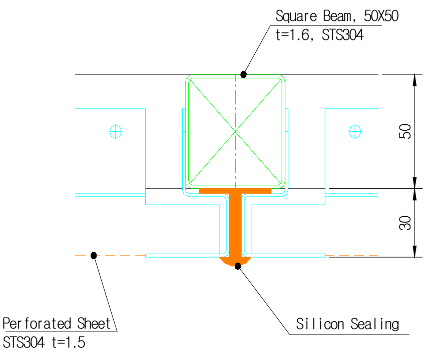

Fig. 3. Structural details and flow path

2.3 Altitude Control and Exhauster Valve

To achieve the set altitude vacuum sensors are installed along the exhaust duct to send control signal to dump valves and vacuum pump. control algorithm regulates dumping rate to an environmental lapse rate between 7.6m/s ~ 10m/s

To prevent ambient air rushing into the chamber during vacuum operation blockage door is mounted aft the vacuum pump.

Fig. 4 Describes the detailed operational theory and configuration of exhauster mechanism

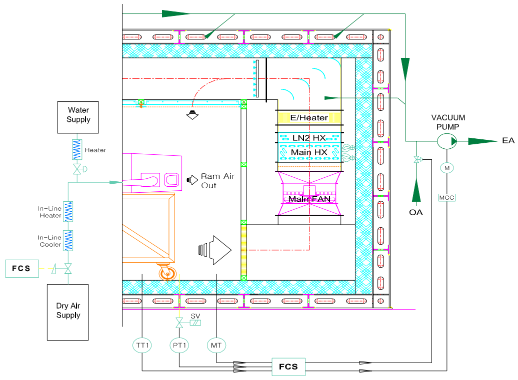

Fig. 4. Test Section and Back flow Prevention

2.4 Temperature Control

Temperature is regulated by a series of electric heater with DX coil direct pin tube cooling with liquid nitrogen notice that electric heater is installed after the cooling device this arrangement allows easy control of temperature and reduced power consumption. the latter would require a bigger cooling system.

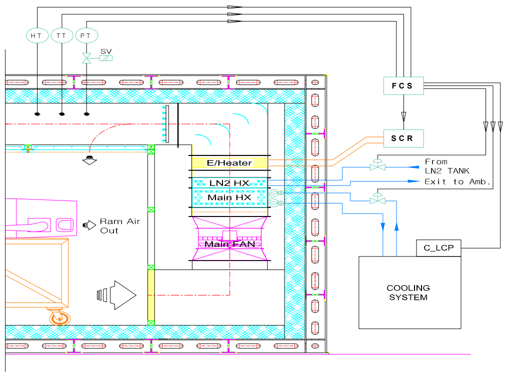

Fig. 5. Temperature Control Flow Diagram

Theory behind temperature control includes system (freezer) that applies the direct cooling system of pin tube single pass style through DX coils. The efficiency and that pressure loss at the coil was considered during selection of the main circulation fan motor.

2.5 Humidity Control

Chamber has a hydrometer sensor along the air duct working together with temperature sensor to calculate relative humidity giving moisture output signal as a percentage. for case where more humidity is required the control algorithm starts the steam ejector and regulates humidity as a function of the set temperature.

The figure below show humidity control schematics

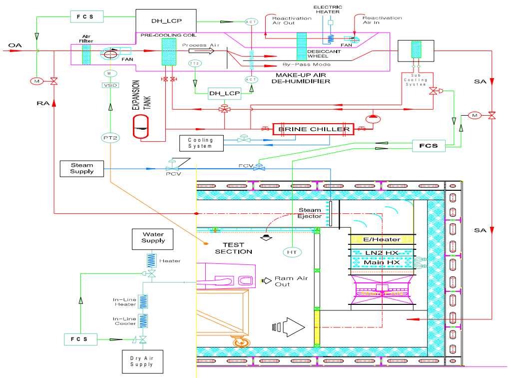

Fig. 6. Humidity Control Schematics

2.6 Equipment Control System

Important control parameters include temperature pressure ,and humidity are all centrally controlled through PLC PID control via network (100mbps) The signals are sent to DAQ module connected to PC with GUI interface window that allow operator to command the system both manually and automatically. The transmitted signal are passes through NI Measurement Studio driver for analysis and display on visual basic developed window in a mode easily understood and interpreted by operator

Functions of DAQ(Data acquisition system)

1) PID through PLC sends feedback signals
2) High speed acquisition and control of real time test data
3) Magnification of multiplex windows, tables and graphs/ abridgement function
4) Analyse 2D/3D graphical functions
5) Control all parameters related to equipment performance
6) Store test data for later reference

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