



Molsieve Designs Limited

CLIENT : ALKEM LABORATORIES LIMITED

LOCATION : BADDI, H.P.

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PSA NITROGEN PLANT : 5 NM³/HR; PURITY : 99.99%

TITLE : DESIGN QUALIFICATION PROTOCOL FOR NITROGEN PLANT

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Revision History

Revision	Revision Date	Reason for Revision/Change Request	Revised By



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The Technology

The technology for the generation of nitrogen from air by Pressure Swing Adsorption (PSA) on Carbon Molecular Sieves (CMS) presents a unique method of air separation from air at ambient temperature. The basis of the air separation is the pore structure of CMS, which is characterized by a high proportion of sub-micro and micro pores in the range of the critical diameters of permanent gases. The pore structure of the CMS is designed and generated so as to trap more number of smaller diameter (2.9 ⁰A) oxygen molecules than the bigger nitrogen (3.2 ⁰A) molecules.

The Principle

The principle of the separation process based on CMS is simple. Compressed air enters one of the two PSA Adsorbers filled with CMS. While air is passing through the CMS, oxygen and other gases are adsorbed and nitrogen and argon leaves the vessel. During adsorption in one vessel, the second vessel is regenerated by reducing the pressure to ambient pressure. After a certain adsorption time (60 seconds) the oxygen starts to break through the CMS bed at the top of the adsorption vessel. At this stage the adsorption step is stopped. Before starting the adsorption step in the second adsorber, a pressure equalization step equalizes the pressure between the two adsorbers. By this step part of the already produced nitrogen and part of the already pressurized air in the adsorption vessel will be pushed to the second adsorption vessel in order to minimize the loss of nitrogen and compressed air due to the pressure swing from one to the other vessel. After this pressure equalization step nitrogen flows back from the nitrogen buffer to the top of the adsorption vessel while compressed air enters the vessel from the bottom side to pressure up the vessel. After equalizing the pressure in the adsorption vessel and in the nitrogen buffer the nitrogen production starts. The pressure rises towards the end of cycle to the final adsorption pressure, of 7 Kg/cm²g, during majority of adsorption cycle.

Parts of PSA Plant

1. Compressed Air system with Filtration.

The compressed air system is with client's scope. The client shall ensure that the required amount of oil/dust free air for the PSA Plant is delivered at the PSA Towers at the required pressure and temperature.

2. Adsorptive Air Separation.

The adsorptive air separation system shall consist of two CMS adsorption vessels, nitrogen buffer, pipes, valves and a silencer for the exhaust gas. The system shall produce the required amount of nitrogen at the desired purity on continuous basis.

3. Control Panel

A control Panel is deployed housing the starters, sequence programmers, and other electrical components and devices so as to control the functioning of the PSA Nitrogen Plant. The panel shall be equipped with required interlocks, so as to automate the complete equipment.

4. Nitrogen Storage & Supply.

It shall consist of nitrogen storage tank, pressure and flow adjusting meters to store the nitrogen, to be used as and when required.



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Product Design Acceptance Parameters for Molsieve® Nitrogen Plant MN 5

The MN 5 PSA Nitrogen Plant shall be designed so as to produce nitrogen of following specifications, which are the basic acceptance parameters for the plant:

Product Nitrogen Plant Flow Rate	(Nm ³ /hr)	5
Oxygen in Product Nitrogen; max.	(% vol.)	0.01
Hydrogen in Product Nitrogen; max.	(%)	Nil
Physical Oil content in Product Nitrogen, max.	mg/M3	0.01
Oil Vapour in Product Nitrogen, max	mg/M3	0.01
Product Nitrogen + Argon	(% vol.)	99.99
Product Nitrogen Dew point at Atmospheric Pressure	(Deg C)	(-) 40
Product Nitrogen Temperature	(Deg C)	Ambient
Product Nitrogen Pressure	(Kg/cm ² g)	5.0
Suspended Particles	(microns)	<5

Plant Operational Design Parameters

Plant operation	Automatic
Plant Running	Continuous
Plant Mounting	Skid Mounted
Plant Location	Indoor



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Design Acceptance Parameters for Utilities Consumption in Molsieve® Nitrogen Plant MN 5

The MN 5 PSA Nitrogen Plant shall be designed so as to consume utilities not more than the following:

1. Power Supply

Voltage	:	220 V
Variation	:	+/- 10%
Frequency	:	50 Hz
Variation	:	+/- 10%
Combined Variation	:	10%
Phase	:	1
Consumption	:	1 KWH +/- 10%

2. Compressed Air

Flow	:	65 Nm ³ /hr
Pressure	:	7 Kg/cm ² g
Variation	:	+/- 0.25 Kg/cm ² g
Temperature	:	40 Deg C (Max)
Variation	:	- 2 Deg C
Quality	:	Oil Free



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General Working of Molsieve® Nitrogen Plant MN 5

Air Receiver

For regulating / minimizing surge in compressed air, an air receiver is installed, so as to a buffer of air before the PSA Module. Physical moisture is also removed in the receiver as the moisture is settled down in it and drained with the help of timer operated automatic drain valve.

Air Filtration

This wet air saturated with moisture enters the 2 stage filtration system. The First Stage shall be a Coalescent Filter of Borosilicate Glass Fibre with 3 microns rating. The second Stage shall also consist of borosilicate fibre with sponge with 0.01 microns rating.

PSA Module

The air now enters to the PSA Module, which shall consist of two PSA Towers with two different sections; the bottom one for Activated Alumina, and the top one for Carbon Molecular Sieves. Each section shall be independent of each other, with separate filling and desiccant removal openings. This module is known as PSA Module and interconnected with 8 nos. of automatic changeover valves & having a time cycle of 1+1 minute. For 1 minute one tower goes for adsorption i.e. under production of nitrogen of 99.5% purity whereas the other one goes under regeneration process to be prepared for the next cycle. The feed air has mainly a mixture of nitrogen (78%), Oxygen (20.9%), other gases like CO₂ & Argon and moisture present in atmosphere in suspended form. The alumina at the bottom has been used to remove all the physical moisture present in the air whereas the CMS is used for adsorption of Oxygen molecules present in air. After the adsorbers a nitrogen surge tank has been provided to provide saturated nitrogen gas with the required maximum oxygen content of 0.1%.

Nitrogen storage

The product nitrogen is now sent to the 2,000 Liters storage vessel, from where the product can be consumed for its consumption.



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Basic Design Qualification Criteria for the Molsieve® Nitrogen Plant MN 5

I Compressed Air before PSA Module

Air Required for Generating
5 Nm3/hr of Product Nitrogen
of 99.99% purity : 65 Nm3/hr
Pressure of Air Required : 7 Kg/cm2g (Minimum)
Temperature of Air : 40 Deg C
Quality of Air : Oil and Dust Free

Design Qualification Criteria for Compressed Air

Quality : Oil Free
Free Air Delivery : 65 Nm3/hr
Pressure : 7.0-7.5 Kg/cm2g
Temperature : 40 Deg C

Design Qualification Criteria for Filters

First Stage

Capacity : 35 CFM
MOC Element : Borosilicate sintered fiber
Make Element : Ultrafilter
End Connection : 1" BSP (F)
Rating : 3 Micron

Second Stage

Capacity : 35 CFM
MOC Element : Borosilicate sintered fiber
Make Element : Ultrafilter
End Connection : 1" BSP (F)
Rating : 0.01 Micron



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II Design Qualification Criteria for Air Receiver

Type	:	Pressure Vessel
General Design Code	:	GEP
Design Code for Fabrication	:	IS 2825
Material of Construction	:	IS 2002
Design Pressure	:	9.5 Kg/cm ² (g)
Design Temperature	:	55 °C
Geometrical Volume	:	175 Liters
Dimensions	:	As per Code and Design Pressure above;
Hydraulic Test	:	At 1.4 times the Design Pressure

III Design Qualification Criteria for PSA Towers

Total Activated Alumina		
Required	:	40 Kgs
Activated Alumina per tower	:	20 Kgs
	:	Approx 30 Liters
Total Carbon Molecular		
Sieves Required	:	276 Liters
CMS per tower	:	138 Liters
Type	:	Pressure Vessel
General Design Code	:	GEP
Design Code for Fabrication	:	IS 2825
Material of Construction	:	IS 2002
Design Pressure	:	9.5 Kg/cm ² (g)
Design Temperature	:	55 °C
Geometrical Volume	:	188 Liters
Dimensions	:	As per Code and Design Pressure above;
Hydraulic Test	:	At 1.4 times the Design Pressure

Design Qualification for PSA Module Silencer

Equipment	:	Silencer
Type	:	Honeycomb
General Design Code	:	GEP
Design Code for Fabrication	:	IS 2825
Material of Construction	:	IS 2002
Design Pressure	:	9.5 Kg/cm ² (g)
Design Temperature	:	55 °C
Sound Level	:	Less than 90 dB at 3 Meters
Dimensions	:	As per Code and Requirements above



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IV Design Qualification Criteria for Surge Vessel

Type	:	Pressure Vessel
General Design Code	:	GEP
Design Code for Fabrication	:	IS 2825
Material of Construction	:	IS 2002
Design Pressure	:	9.5 Kg/cm ² (g)
Design Temperature	:	55 °C
Geometrical Volume	:	800 Liters
Dimensions	:	As per Code and Design Pressure above; Height less than 3500 mm
Hydraulic Test	:	At 1.4 times the Design Pressure

V Design Qualification Criteria for Control Valves for PSA Module

Type	:	Control Valves; On-Off Type
Actuation	:	Pneumatic, through a Solenoid Valve
Duty	:	Robust, each valve to be operated in 1 minute
Working Cycles	:	About 100000
Pressure	:	Should not leak in back pressure of 8 Kg/cm ² g
Medium	:	Air/Nitrogen
Design Pressure	:	9.5 Kg/cm ² (g)
Design Temperature	:	55 °C
Size	:	As per Requirements
Pneumatic Test	:	At 1.25 times the Design Pressure

VI Design Qualification Criteria for Back Pressure Controller

Type	:	Pressure Holding Valve
Duty	:	Robust
Medium	:	Nitrogen
Design Pressure	:	9.5 Kg/cm ² (g)
Design Temperature	:	55 °C
Size	:	As per Requirements
Pneumatic Test	:	At 1.25 times the Design Pressure
Set Pressure	:	5 to 6 Kg/cm ² g.



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VII Design Qualification Criteria for Flowmeter

Type	:	Velocity based Flowmeter
Tube	:	Glass/Metal
Float	:	SS
Range	:	Should read 5 Nm ³ /hr Nitrogen of 99.95% in mid scale
Medium	:	Nitrogen
Design Pressure	:	9.5 Kg/cm ² (g)
Design Temperature	:	55 °C
Size	:	As per Requirements
Pneumatic Test	:	At 1.25 times the Design Pressure
Inlet/Outlet	:	Vertical

VIII Design Qualification Criteria for Storage Vessel

Type	:	Pressure Vessel
General Design Code	:	GEP
Design Code for Fabrication	:	IS 2825
Material of Construction	:	IS 2002
Design Pressure	:	9.5 Kg/cm ² (g)
Design Temperature	:	55 °C
Geometrical Volume	:	2000 Liters
Dimensions	:	As per Code and Design Pressure above; Height less than 3500 mm
Hydraulic Test	:	At 1.4 times the Design Pressure

IX List of Makes of Bought our components

CARBON MOLECULAR SIEVES :	CARBOTECH, GERMANY.
CHANGE OVER VALVES-PSA :	AIRMAX SS BODY
SOLENOID VALVES :	ROTEX
PRESSURE SWITCH :	DANFOSS, DENMARK
PRESSURE GAUGE :	MASS
PRESSURE REGULATOR :	SHAVO NORGREN
ACTIVATED ALUMINA :	I.P.C.L./ EQUIVALENT
ISOLATION VALVES :	LEGRIS, ITALY
ROTAMETER :	I.E.P.L, HYDERABAD
OXYGEN ANALYSER :	NUCON
BACK PR. CONTROLLER :	MOLSIEVE
VENT VALVE :	AIRMAX SS BODY
ELECTRICALS :	SIEMENS
PLC / SEQUENCER :	SIEMENS / GE FANUC / EAPL
SAFETY VALVE :	BRASSOMATIC
FILTERS :	ULTRA FILTER, USA



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Acceptance Criteria for Molsieve® Nitrogen Plant MSN 200

Parameter	Unit	Acceptance Parameter	Variation Measured	By Instrument
Product Nitrogen Plant Flow Rate	(Nm ³ /hr)	5	± 5%	Flowmeter
Impurity Oxygen in Product Nitrogen; max.	(% vol.)	0.01	± 0.03%	Oxygen Analyser
Product Nitrogen Dew point at Atmospheric Pressure	(Deg C)	(-) 40	± 5 Deg C	Dew Point Meter
Product Nitrogen Temperature	(Deg C)	Ambient	± 5 Deg C	Temperature Indicator
Product Nitrogen Pressure	(Kg/cm ² g)	5.0	± 0.5 Kg/cm ² g	Pressure Indicator
Compressed Air Consumption	kWh	65 Nm ³ /hr	± 10%	Air Flowmeter Readings

Performance Test

The acceptance criteria shall be demonstrated by a performance test by Molsieve. This performance test shall begin immediately after commissioning and after the plant has been operated under stable design conditions. The performance test shall be carried out by operating the plant for 48 consecutive hours according to the instructions of Molsieve. During the performance test, a period of 24 consecutive hours shall be selected and the average results obtained during the period shall form the basis of comparison between actual performance and the acceptance criteria of Molsieve.

If after 24 hours of the start of the performance test, during successful operation, the plant is shut down for any reasons for which Molsieve is not responsible, that portion of the performance test completed prior to shut down shall be the basis of calculating the performance guarantees.