

PROCESS DESIGN BASIS

PSA Nitrogen Generation Unit

1.PROJECT DESCRIPTION

1.1 Objective

Design a Pressure Swing Adsorption (PSA) based Nitrogen Generation Unit to produce gaseous nitrogen from atmospheric air for industrial utility use.

1.2 Process Type

Technology: PSA using Carbon Molecular Sieve (CMS)

Separation Principle: Kinetic adsorption of oxygen

Operation Mode: Continuous cyclic dual-bed system

2. DESIGN CAPACITY

2.2 Nitrogen Production Rate

1000 Nm³/hr

2.2 Nitrogen Purity

99.5% N₂ (max 0.5% O₂)

This is:

Typical refinery utility nitrogen

Achievable by PSA

Commercially realistic

2.3 Nitrogen Delivery Pressure

6 bar(g) at battery limit

3. FEED AIR CONDITIONS

3.1 Air Composition (Standard Atmospheric)

Component	Volume%
Nitrogen	78.08
Oxygen	20.95
Argon	0.93
Others	<0.5

4. OPERATING CONDITIONS

4.1 Compressor Discharge Pressure

8 bar (g)

Reason:

PSA adsorption works efficiently at 6–8 bar

Allows margin for pressure drop across dryer and valves

4.2 PSA Bed Operating Pressure

Mode	Pressure
Adsorption	7 bar(g)
Equalization	~4 bar(g)
Regeneration	1.2 bar(a)

4.3 Product Tank Operating Pressure

6 bar(g)

5. DESIGN CONDITIONS

5.1 Air Receiver (V-102)

Operating: 8 bar(g)

Design: 10 bar(g)

5.2 PSA Beds (A-201 A/B)

Operating: 7 bar(g)

Design: 10 bar(g)

5.3 Product Tank (V-301)

Operating: 6 bar(g)

Design: 10 bar(g)

5.4 Design Temperature

Operating: 40–60°C

Design Temperature: 80°C

Reason:

Adsorption is exothermic → bed temperature rise possible.

6. PRODUCT SPECIFICATION

Parameter	Specification
Nitrogen Purity	$\geq 99.5\%$
Oxygen Content	$\leq 0.5\%$
Dew Point	$\leq -40^{\circ}\text{C}$
Oil Content	Nil detectable

7. RECOVERY & EFFICIENCY

Typical PSA recovery at 99.5% purity:

45–55%

Meaning:

For 1000 Nm³/hr nitrogen,
feed air requirement \approx 2000–2200 Nm³/hr.

8. OPERATING PHILOSOPHY SUMMARY

Dual-bed cyclic PSA

Automatic switching every 60 seconds

Continuous nitrogen production

Analyzer-based purity protection

Automatic diversion during low purity

9. SAFETY DESIGN PHILOSOPHY

All pressure vessels protected by PSV

Nitrogen vented to safe elevated location

Check valves to prevent backflow

Control valves fail-safe defined

Closed drains for all pressurized vessels

10. CONTROL PHILOSOPHY SUMMARY

Compressor maintains feed pressure

PSA switching via timer logic

Tank pressure controlled by PCV-302

Purity analyzer triggers diversion valve

11. BATTERY LIMIT CONDITIONS

At Battery Limit (OPC-302):

Nitrogen Flow: 1000 Nm³/hr

Pressure: 6 bar(g)

Temperature: 40–50°C

Purity: $\geq 99.5\%$

12. UTILITIES REQUIRED

Electrical Power: Compressor motor

Instrument Air: 6–7 bar

Cooling: Air-cooled exchanger (no CW required)