NITROGEN ENGINEERS

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# PSA NITROGEN PLANTS

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# PRESSURE SWING ADSORPTION

Pressure swing adsorption (PSA) is a technology used to separate some gas species from a mixture of gases under pressure according to the species' molecular characteristics and affinity for an adsorbent material. It operates at near-ambient temperatures and differs significantly from cryogenic distillation techniques of gas separation. Specific adsorbent materials.) are used as a trap, preferentially adsorbing the target gas species at high pressure. The process then swings to low pressure to desorb the adsorbed material.

Pressure swing adsorption processes utilize the fact that under high pressure, gases tend to be attracted to solid surfaces, or "adsorbed". There is high adsorption at peak pressure. When the pressure is reduced, the gas is released, or desorbed. PSA processes can be used to separate gases in a mixture because different gases tend to be attracted to different solid surfaces more or less strongly.

Using two adsorbent vessels allows near-continuous production of the target gas. It also permits so-called pressure equalisation, where the gas leaving the vessel being depressurised is used to partially pressurise the second vessel. This results in significant energy savings, and is common industrial practice.

# HOW A PSA NITROGEN SYSTEM WORKS:

The adsorption separation is accomplished by the following process steps:

### FEED AIR AND CONDITIONING

The inlet compressed air is dried by an air dryer and filtered, before entering the process vessels.

### PRESSURIZATION/ADSORPTION

The cold, dried and filtered air is entered into a vessel filled with Carbon Molecular Sieve (CMS) where the oxygen is adsorbed preferentially in the pores of CMS. This allows concentrated nitrogen, with an adjustable purity, to remain in the gas stream and flow out of the vessel. Before the full adsorption capacity of the CMS is reached, the separation process changeover of adsorption towers takes place.

### DESORPTION/REGENERATION

The oxygen-saturated CMS is regenerated a pressure reduction, i.e. by venting off contents of the tower to atmosphere. This is achieved by a simple pressure release system where the exhaust gas stream is vented from the tower, usually through a silencer. The regenerated CMS is refreshed and can now be used again for the generation of nitrogen.

### ALTERNATION OF TOWERS

Adsorption and desorption should take place alternately at equal time intervals. This means that the continuous generation of nitrogen can be achieved by using two adsorbers; while one is adsorbing, the other is in regeneration mode; and switching back and forth, provides for a continuous and controlled flow of nitrogen.

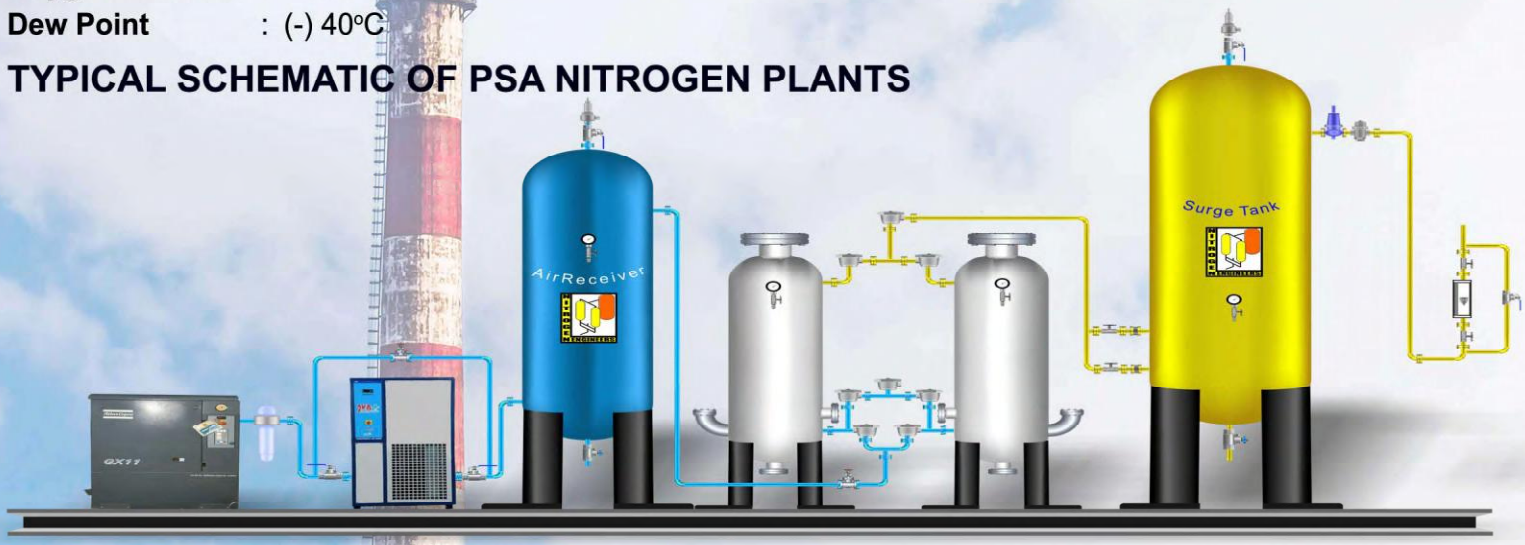
### SURGE TANK

Constant nitrogen product flow and purity is ensured by a connected surge tank that stores the nitrogen output. Surge tank is used to store PSA output nitrogen, to maintain constant pressure in PSA towers, and to quick refill of Adsorbing tower during startup of cycle. This can be designed for nitrogen purities up to 99.999% and pressures up to 10 bar.

# COMMERCIAL NITROGEN PLANTS

**Model Code** : CN
**Capacity** : 0.1 - 2000 $Nm^3$/Hr
**Purity** : 95 - 99.9%
**Oxygen Content** : < 5%
**Dew Point** : (-) 40°C

## TYPICAL SCHEMATIC OF PSA NITROGEN PLANTS




# HIGH PURITY PSA NITROGEN PLANTS

**Model Code** : HP
**Capacity** : 0.1 - 2000 $Nm^3$/Hr
**Purity** : 99.99%
**Oxygen Content** : < 100 PPM
**Dew Point** : (-) 50°C

In this system higher quantity of CMS and air is used to achieve this purity of Nitrogen in similar PSA Nitrogen plants

# ULTRA HIGH PURITY PSA NITROGEN PLANTS

**Model Code** : UHP
**Capacity** : 0.1 - 250 $Nm^3$/Hr
**Purity** : 99.999%
**Oxygen Content** : < 10 PPM
**Dew Point** : (-) 55°C

In this systems special grade of CMS with low temperature technology is used in PSA Nitrogen Plants.

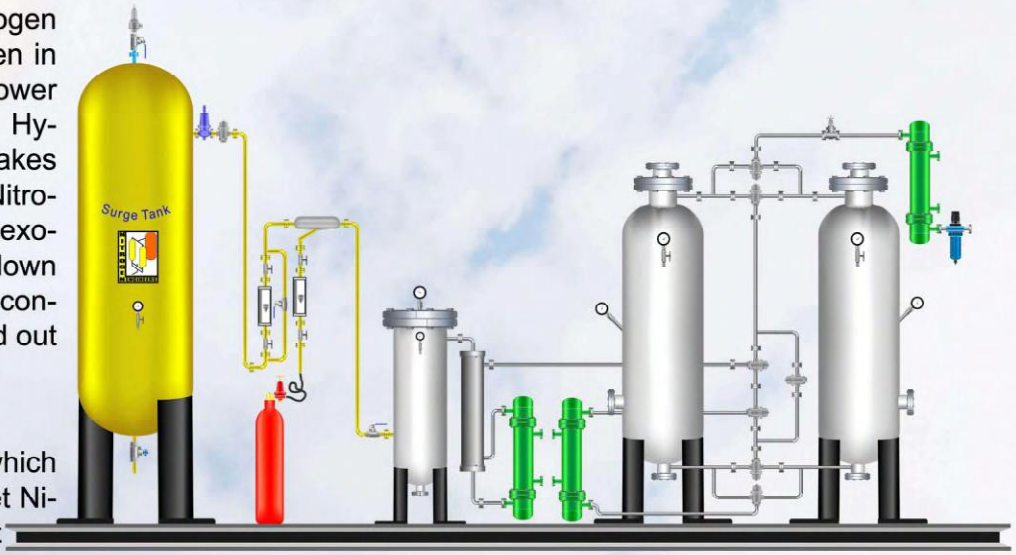
# Pd DEOXO PLANT

**Model Code** : DX
**Capacity** : 0.1 - 2000 $Nm^3$/Hr
**Purity** : 99.9999%
**Oxygen Content** : UPTO 1 PPM
**Hydrogen Content** : < 3 PPM
**Dew Point** : Can be achieved up to (-)80°C with help of Dryer

In this unit, the residual oxygen in Nitrogen From PSA Unit is mixed with Hydrogen in mixure and the mixture is passed to tower containing Palladium Catalyst where Hydrogen reacts with Oxygen and makes water. Thus we can achieve purity of Nitrogen up to 99.9999% The reaction is exothermic and the outlet gas is cooled down in After-Cooler where moisture vapour condenses and it is separated and drained out in moisture separator.

$$H_2 + ½\ O_2 \rightarrow H_2O$$

This nitrogen still contains moisture which is removed in Gas Dryer and the outlet Nitrogen can be achieved with dew point upto (-)80°C




# COPPER DEOXO BASED PSA NITROGEN PLANTS

| | | |
|---|---|---|
| **Model Code** | : | CDX |
| **Capacity** | : | 0.1 - 2000 $Nm^3$/Hr |
| **Purity** | : | 99.9999% |
| **Oxygen Content** | : | UPTO 1 PPM |
| **Dew Point** | : | Can be achieved up to (-)80°C with help of Dryer |

Nitrogen gas with less than 0.2% Oxygen, from your PSA Nitrogen Plant at around 6.0 kg/$cm^2$g pressure and at ambient temperature is heated by electric heater fitted in a shell inside the copper catalyst filled towers. The gas enters into one of the two catalyst beds and following reaction (Oxidation of copper) takes place

$$2Cu + O_2 \rightarrow 2Cuo$$

Thus all the oxygen in Nitrogen gas reacts with the copper and converts it into copper oxide and pure Nitrogen gas is received from the outlet and sent to receiver through water cooler.

Simultaneously, the second catalyst tower is under reduction of copper oxide.

Small quantity of pure and dry Nitrogen gas (from receiver) mixed with small Hydrogen is first heated up to 150oC and then enters the second catalyst bed and following reaction (reduction of copper oxide) takes place

$$CuO + H_2 \rightarrow Cu + H_2O$$

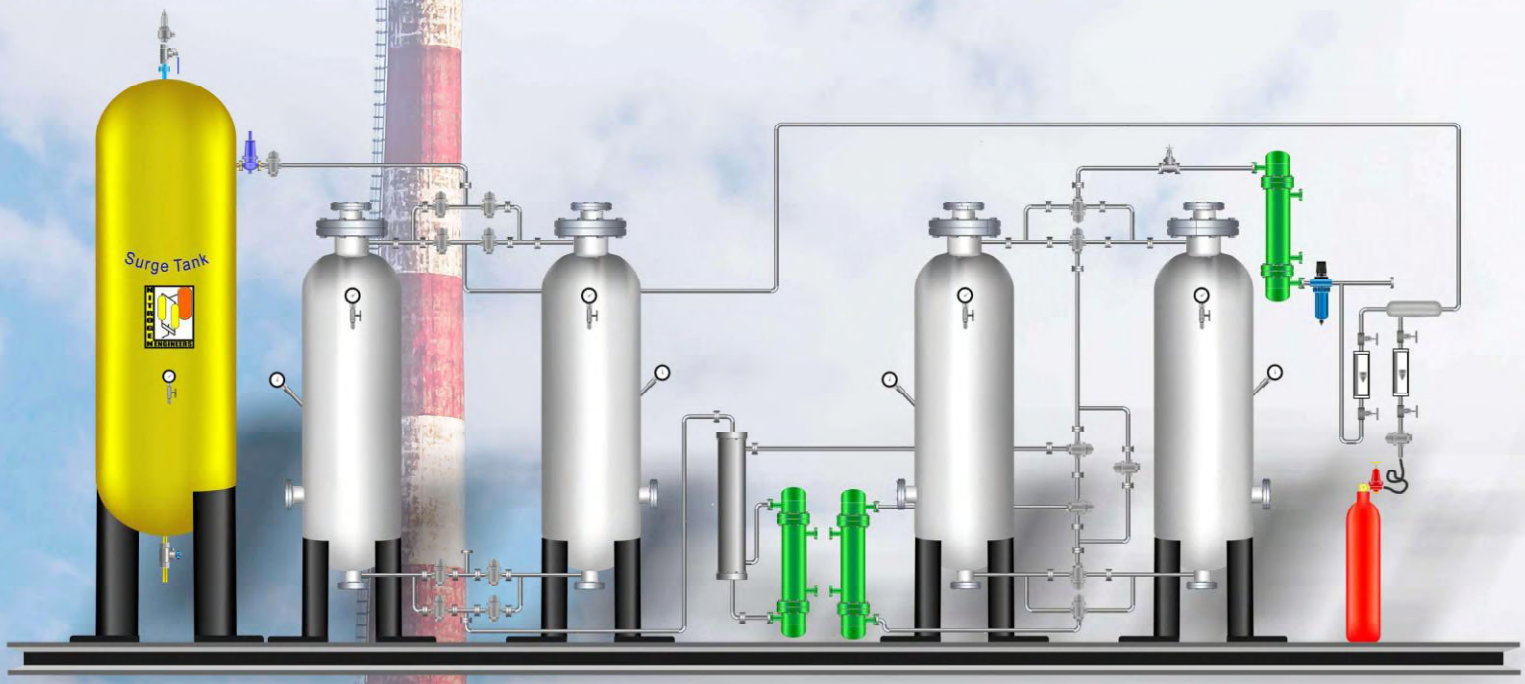
Thus the catalyst is reduced to copper and water is formed. This Nitrogen gas with water vapors is vented to atmosphere.

Both the above reaction are exothermic in nature, producing heat. The temperature of catalyst increases in proportion Oxygen/Hydrogen contents in Nitrogen gas.

The catalyst temperature is maintained below 250°C by controlling $O_2/H_2$ Contents.

The towers are interchanged after every fix cycle time by sequence programmer and same process is repeated. In this system we can achieve Hydrogen free Nitrogen upto purity of 99.9999%

## TYPICAL SCHEMATIC OF Cu-DEOXO WITH DRYER




## APPLICATIONS OF NITROGEN GENERATORS

**Food and beverage industries**: Aging of food grade material is caused by bacteria and other organisms. Generators are used to flood the products with N2 that displaces the oxygen and prolongs the product lifetime significantly because these organisms cannot develop in Nitrogen atmosphere. Furthermore, chemical degradation of food caused by oxidation is eliminated or stopped.

**Analytical chemistry**: Nitrogen generator is required for various forms of analytical chemistry such as liquid chromatography–mass spectrometry and gas chromatography where a stable and continuous supply of nitrogen is necessary.

**Aircraft & motor vehicle tires**: Most aircraft tires are filled with pure nitrogen. Also Nitrogen can be used for fill motor vehicles tires. The advantage of using nitrogen is that Nitrogen maintains a more stable pressure when heated and cooled as a result of being dry and doesn't permeate the tire as easily due to being a slightly larger molecule (155 pm) than $O_2$ (152 pm).

**Chemical and petrochemical industries**: The primary and very important application of nitrogen in chemical and petrochemical industries is the provision of inert environment ensuring general industrial safety during cleaning and protection of process vessels. In addition, nitrogen is used for pipelines pressure testing, chemical agents transportation, and regeneration of used catalysts in technological processes, Purging, Blanketing, Nitration reactions, Fertilizer Production.

**Electronics: In electronics**, Nitrogen serves to displace oxygen in the manufacture of semi-conductors and electric circuits, heat treatment of finished products, as well as in blowing and cleaning. The most common uses in electronics are in the soldering process. Specifically Selective, Reflow, and Wave Soldering equipment.

Fire Protection: The fire protection industry uses nitrogen gas for two different applications - fire suppression and corrosion prevention. Nitrogen generators are used in hypoxic air fire prevention systems to produce air with a low oxygen content which will suppress a fire. To prevent corrosion, nitrogen generators are used in place of or in conjunction with a compressed air system to provide supervisory nitrogen gas in place of air for dry pipe and pre-action fire sprinkler systems.

Glass industry: In glass production, nitrogen proves efficient as a cooling agent for electric arc furnace electrodes as well as to displace oxygen during process procedures.

Metallurgy: The metal industry generally utilizes nitrogen as a means of protecting ferrous and non-ferrous metals during annealing. Also, nitrogen is helpful in such standard industry processes as neutral tempering, cementing, hard brazing, stress relieving, cyanide hardening, metal-powder sintering, Aluminium degassing, laser cutting, and extrusion die cooling.

Paint-and-varnish industry: Paint and varnish production uses nitrogen for the creation of an inert environment in process vessels to ensure safety, as well as for oxygen displacement during packing in order to prevent polymerization of drying oils.

Petroleum industry: In the petroleum industry, nitrogen is an indispensable component in a number of processes. Most commonly, nitrogen is used to create an inert environment for preventing explosions and for fire safety and to support transportation and transfer of hydrocarbons. Additionally, nitrogen is used for pipeline testing and purging, cleaning technological vessels and cleaning liquefied gas carriers and hydrocarbon storage facilities.

Pharmaceutical industry: In the pharmaceutical industry, nitrogen finds application in pharmaceuticals packaging, and ensuring against explosion and fire safety in activities where fine dispersed substances are used.



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