PNEUMATIC PRODUCTS
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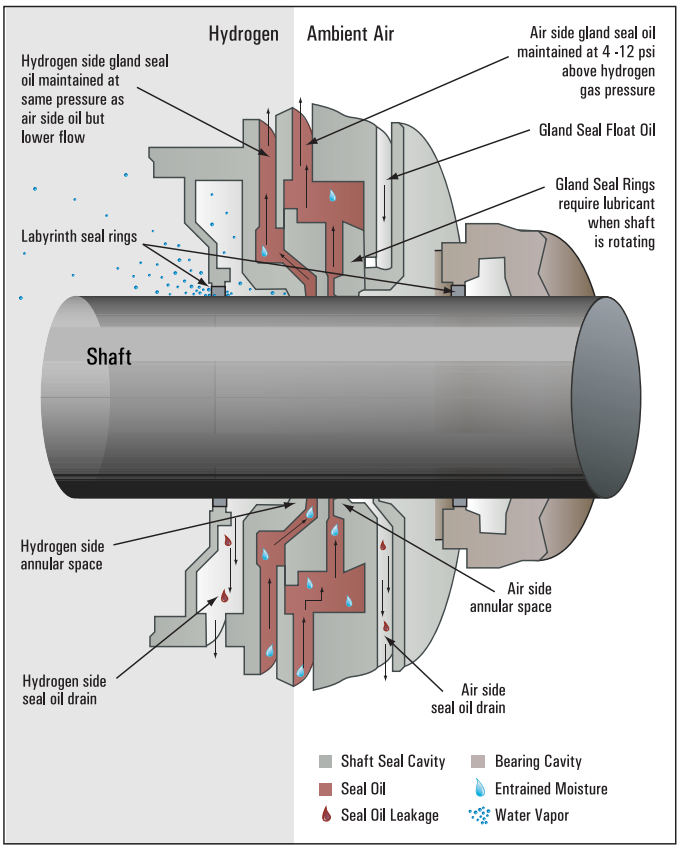
Legendary Hydrogen Gas Drying System

HCP Series

HCP Series - More Power to You

Since 1946, the world has turned to PNEUMATIC PRODUCTS for the quality and service demanded by the most critical of applications. Global leaders in the power industry demand maximum generator uptime. HCP Series ensures maximum electricity production by managing hydrogen gas composition. Constructed with durable components, HCP Series delivers unquestionable reliability and arrests Stress Corrosion Cracking (SCC) and winding deterioration to maximize MTBF (mean time between failure). Invest in our experience to extend generator service life and gain profitability. HCP Series - more power to you.

Typical Generator H_2 Gas Seal



Fick's Law (fiks) - the law of chemistry and physics stating that the diffusion of one material in another is proportional to the negative of the gradient of the concentration of the first material
[After Adolph Fick (1829-1901), G. Physiologist]

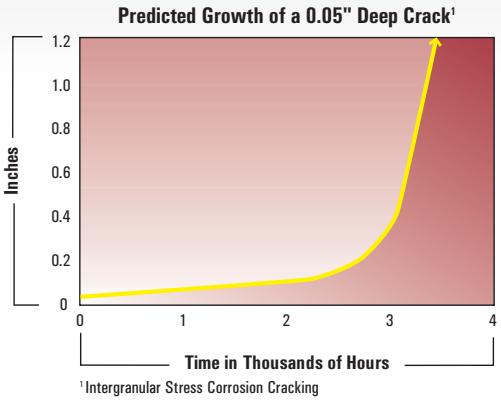
New Webster's Dictionary and Thesaurus

Sealing in the Moisture

SCC results from water vapor induced hydrogen ion formation. Water vapor enters the generator via the lubrication system or, through hydrogen gas leakage paths, through a phenomenon known as Fick's Law. Condensate forms inside the lubrication reservoir. Heavier than turbine oil, the condensed water settles to the bottom of the reservoir. Bearing lubrication and shaft seal oil are drawn from the same location. Seal oil enters the shaft seal cavity at about 4-12 psig above the hydrogen gas pressure inside the generator. Seal oil temperature rises about 30°F as it passes through the shaft seal cavity which vaporizes any entrained moisture that is present. As the Hydrogen side is drier than the ambient air side, the water vapor diffuses past the seal faces into the generator as water vapor seeks equilibrium. This cycle perpetuates as water vapor constantly enters or exits the gland seal rings as the seal oil moisture level seeks equilibrium with the ambient air.

Stress Corrosion Cracking (SCC) and Winding Failure

Retaining rings, (both 18-5 and 18-18 alloys) resist the centrifugal forces of the spinning rotor shaft to keep the copper windings in place. They are among the most highly stressed components in a power plant. Bottled hydrogen and on-site generation systems deliver high purity gas to improve efficiency through reduced windage losses. However, neither method is designed to address the ingress of water vapor that causes SCC and crack growth on the rotor zone and retaining rings. Hydrogen dew points below -20°F prevent hydrogen ion formation, arrest stress corrosion cracking and, prevent the lead carbonate formations that lead to electrical arcing and winding failure. Higher dew points virtually ensure future generator downtime and the $1mm price tag to rebuild it.



Windage Losses

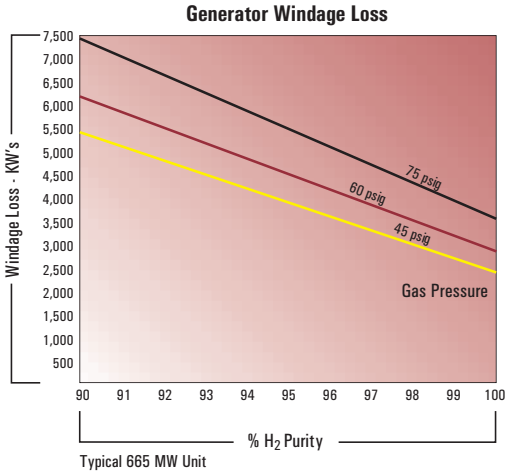
Hydrogen gas is used as a coolant for electric generators for two reasons. First, it has the best heat transfer properties of any gas, with a specific heat of 3.4 Btu/lb-F at standard conditions. On a mass basis, this makes it more than 14 times more efficient than dry air for removing heat. Second, it has the lowest atomic weight of any gas, which keeps windage losses to a minimum. Power production robbing water vapor is 8.9 times denser than hydrogen gas. HCP Series removes hydrocarbon and water vapor impurities to maximize the output of your generator.

Based on the adjacent Generator Windage Loss curve, purity improvement from 95-98% on a 665 MW generator operating at 60 psig results in a 1,100 kW decrease in windage losses.

Example: Annual Savings

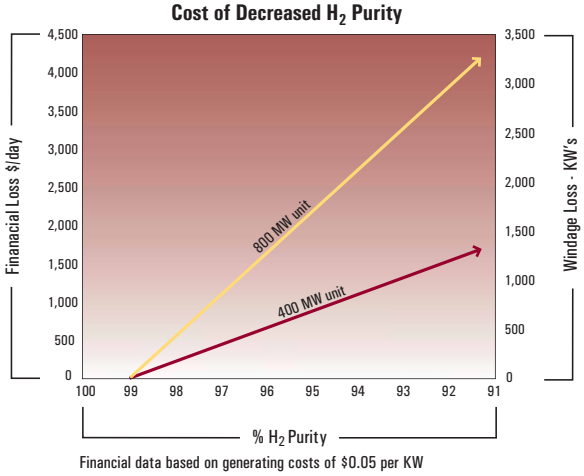
(1,100 kW) x ($.02/kWh[1]) x (8,760 Hr/Yr.) = $240,900

[1] Cost to Generate Power



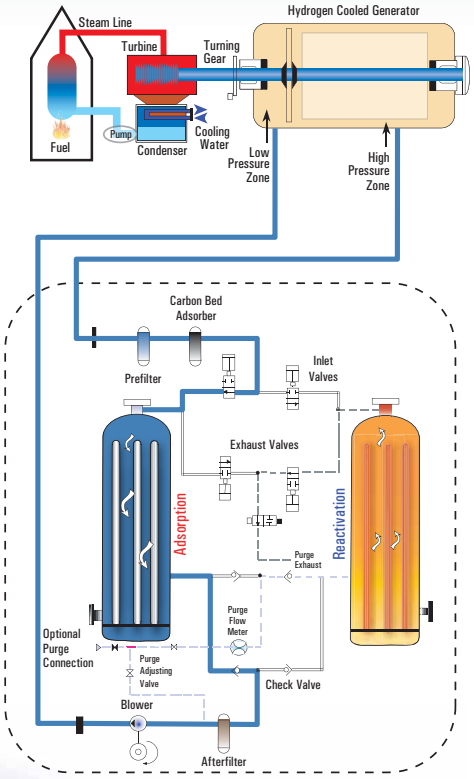
99% Pure Hydrogen - isn't

Operators need to be aware that a high purity reading does not mean the generator is dry. Purity analyzers operate on the premise that only hydrogen gas and "air" is present. This is evident as these sensitive instruments are protected from oil or water contamination by dedicated drying and filtration devices. Located upstream of the analyzer, they remove oil and water that infiltrated the system. Subsequently, the analyzer only displays the purity of "treated" gas and not the composition inside the generator. Typical hydrogen gas dew points range from +20°F to +70°F, while the analyzer shows 99 percent purity or more. Don't allow masked contaminants to decrease your utility revenues.



Superior Automatic Performance

Steam Turbine Generator System



HCP Series

Open Loop Regeneration

HCP Series provides continuous and effective hydrogen gas recirculation via an integral, positive displacement, magnetic drive blower. This accomplishes two critical goals. First, HCP Series ensures effective moisture removal during turning gear operation, during which the risk of moisture ingress is highest. Second, HCP Series compensates for flow resistance of the piping system that leads to and from the generator during operation. That allows our contaminant hungry molecular sieve desiccant and filtration components to efficiently remove water or oil (in both a liquid and gaseous state) and, fine abrasive particulate matter. Superior contaminant removal retards hydrogen purity level dilution. The end result? More power to you.

Competitive drying systems typically supplied with the generator prove ineffective as they rely on operational speed of the generator fan to create the differential pressure needed to circulate the gas. Sub-zero dew point control requires the removal of water as a vapor. HCP Series evacuates water from the system as a vapor to deliver automatic sub-zero dew point control through field adjustable NEMA design cycles of 24, 48 or 96 hours. Benefit from our design flexibility that can compensate for changes in moisture load as shaft seals wear and hydrogen/water vapor exchange rates increase. Increased purity levels reduce windage losses and keep labor intensive manual "Bleed and Feed" requirements to a minimum.

Hydrogen Replenishment

	H_2 Consumption (ACFM) cycle times (hours)		
	24	48	96
HCP Series (average over cycle)	0.500	0.250	0.125
Nominal shaft seal leakage (2.5 per)	5	5	5

Features	Benefits
Coalescing Pre-Filter	Removal of Liquid H_2O/Oil Contaminant
Carbon Bed Adsorber	Removal of Vapor Phase Oil Contaminant
DE-32 Molecular Sieve Desiccant Dryer	Removal of Vapor Phase H_2O/CO_2 Contaminant
Particulate Afterfilter	Removal of Particulates (dirt, rust, lead carbonate; desiccant fines)
Magnetic-Drive H_2 Gas Blower	Continuous Gas Circulation During Turning-Gear and Base Load Operation

HCP Series - Key Product Features

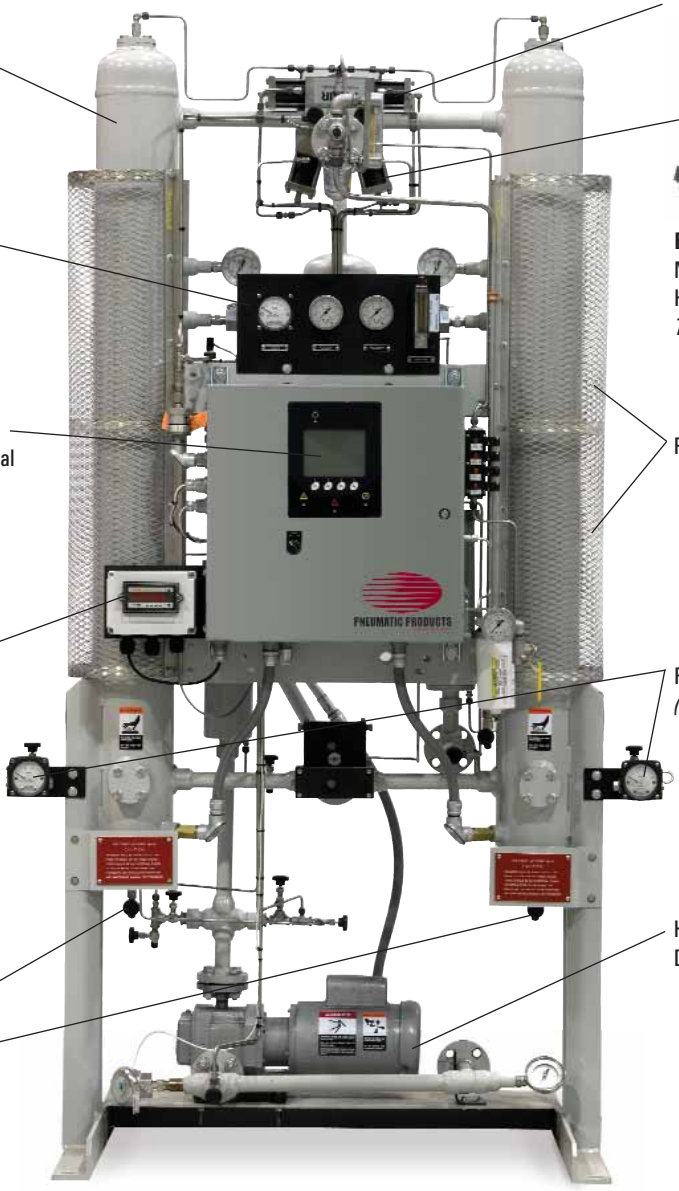
DE-32 Molecular Sieve
Desiccant (not shown)

Engineered Performance
Non-lubricated Select Series
Hydrogen Gas Duty Valves.
The ULTIMATE in reliability

High Quality Instrumentation

Communication and Control Center
NEMA 4, Selectable Cycles, Operational
Indicators and Text Display

Personnel Protection



Dew Point Monitor
(optional)

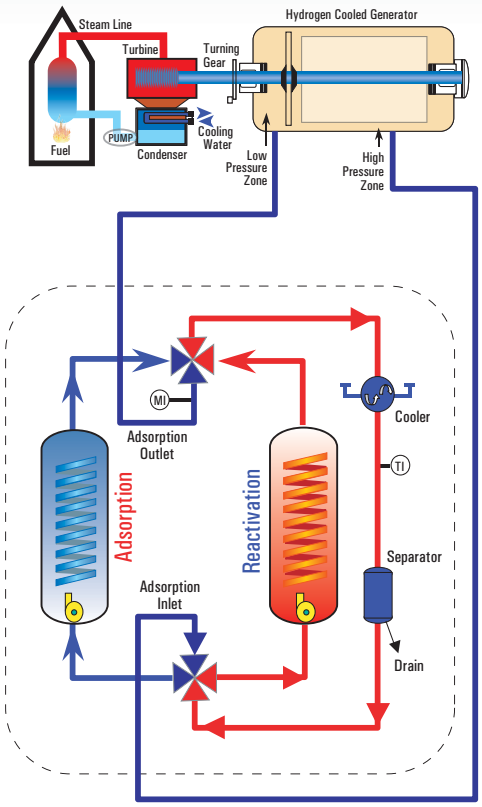
Filter Differential Pressure Gauges
(optional)

High-Efficiency Hydrogen Gas
Duty Magnetic-Drive Blower

Service Valves
to Purge CO_2, N_2, H_2

Inferior Automatic Performance

Steam Turbine Generator System



Typical Competitive Unit

Closed Loop Regeneration

Competitive closed loop regeneration systems rely on generator fan pressure to move the gas through the hydrogen dryer. This makes them susceptible to dew point erosion, particularly during turning gear mode. Low differential pressure during normal operation leads to low hydrogen circulation to and from the generator. This prevents effective operation, the use of filtration to protect the activated alumina desiccant from hydrocarbon contamination or, the generator from fine abrasive desiccant dust. Manual "bleed and feed" operations must continue to ensure high gas purity.

Moisture is removed as a liquid after passing through a water cooled heat exchanger that must use city or chilled water to drive down the dew point to something above +32°F. Latent moisture passes through to cause desiccant degradation/aging and, results in higher dew points than when removed as a vapor.

Manual Bleed and Feed

When hydrogen purity decreases, it is common practice to occasionally vent/purge off a portion of the contaminated gas then, replace it with pure hydrogen. While this elevates the purity, it does not control the relative humidity as noted previously. Remember, that to ensure accuracy, hydrogen gas analyzers pre-treat the gas stream to remove contaminants like oil and water to help ensure that the impurity being displayed is only air. This delivers a false sense of security as the contaminants still exist in the system gas.

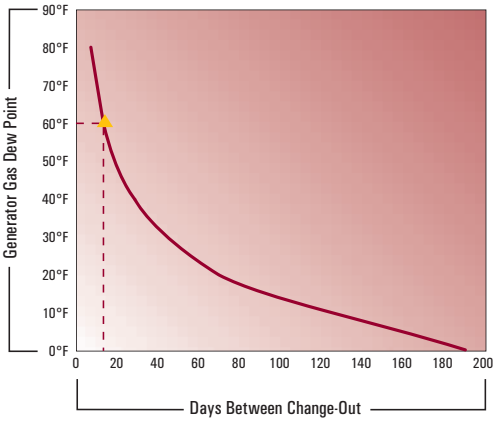
Also known as "bleed & feed" these scavenge systems are used to maintain hydrogen purity levels. At one Midwestern utility, rotometers indicated a feed rate of 2.5 ACFM at each end of the generator.

Example: Hydrogen Consumption Cost

5 cfm x 60 min/hr x 8,760 hrs/yr. x $2.50/100 ft^3 = $65,700

Estimating H_2 Gas Dew Points

Cartridge Life



▲ 13.2 days = 60°F Gas Dew Point

Estimate the Dew Point of your Hydrogen Gas

Most Purity Gas Analyzers have single canister, 13X molecular sieve dryers upstream to remove water and oil. With a capacity of 126 grams of water and, a Purity Gas Analyzer "volumetric" flow rate of 500 cc/minute one can estimate the generator system dew point by the life of the dryer cartridge.

Conditions:
Single canister, 13X molecular sieve dryer capacity:
126 grams of water = .278 lbs. = 1946 grains
Sample gas flow = 500 cc/min = .0177 CFM by volume (not mass flow)
At a 60°F dew point, gases hold 5.8 grains / ft^3

Calculation:

$$\frac{1946 \text{ grains (dryer)}}{5.8 \text{ grains}} \times \frac{1 \text{ ft.}^3}{.0177 \text{ ft.}^3} \times \frac{1 \text{ min}}{1440 \text{ min}} \times \frac{\text{day}}{} = 13.2 \text{ days}$$

Under the above conditions, changing this cartridge every 13.2 days means you only have a 60°F gas dew point.

HCP Series, Standard Features

Select Series Hydrogen Gas Duty Poppet Valves

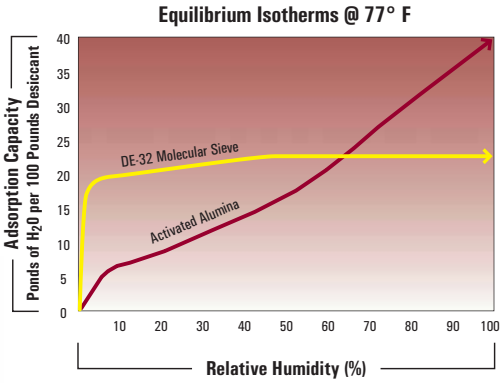
PNEUMATIC PRODUCTS' Poppet Valves are different. Our legendary self-powered designs are the model of simplicity with but one or two moving parts. Straddle-mounted bearing points provide balance and concentricity to the stainless steel motive shaft. Large diameter pistons smoothly deliver optimal force for sure openings and closings. Self-cleaning shaft and piston design wipes harmful dust away. Duplexed Hydrogen gas shaft seal designs are rated to 500,000 cycles and eliminate system complexity and premature sealing failures, through design simplicity and outstanding durability.

Molecular Sieve vs. Activated Alumina Desiccant

SPX Air Treatment purchases activated alumina for use in most desiccant products to the tune of 5.5 million pounds per year. One must ask, "why would the HCP Series use DE-32 Molecular Sieve when competitors use activated alumina?" After all, molecular sieve costs considerably more per pound. Well, inherent in its many fine qualities is the capacity to adsorb CO_2 gas and, greater affinity for removing moisture at decreasing levels. CO_2 gas is injected into the generator prior to charging it with hydrogen. During de-gassing, the lighter hydrogen gas rests on top of the heavier CO_2 to displace it out the bottom. Inevitably, traces of CO_2 are left in the system at commissioning. As water and CO_2 combine to form lead carbonate powder, a leading promoter of electrical arcing and winding failure, the use of molecular sieve further ensures maximum MTBF for your generator.

DE-32 Molecular Sieve

Activated Alumina



Functions, Features, and Specifications

Product Features

Desiccant	Instrumentation											
DE-32 Premium Grade Molecular Sieve	Chamber Pressure & Temperature Gauges	Blower Differential Pressure Gauge	Blower Outlet Temperature Gauge	Purge Flow Rotometer	**Indications;** Switching Failure, Blower Over Temperature, Low Pilot Air Pressure, Heater Trouble	Pilot Air Pressure Gauge	On/Off Switch	Cycle Time Selection via Interface	Vent Flow Rotometer	Locking Purge Valve	Dew Point Monitor	Filter Differential Pressure Gauges
S	S	S	S	S	S	S	S	S	S	S	O	O

S = Standard O = Option

Engineering Data

Model	Inlet Flow ACFM	Blower hp	Heater Rated Output watt	Full Load amps	Dimensions inches W	D	H	Approx. Weight lbs.	Inlet /Outlet Connections inches	Mounted Filtration Prefilter	Afterfilter
25HCP	8-12	1	600	21	56	39	94	1,500	1"-150#	PCS11001G16SW	PCS11001G16SW

Design Operating Conditions

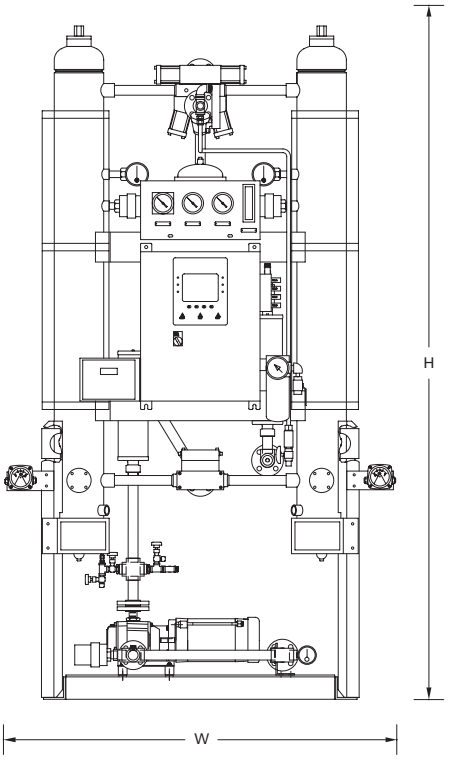
Fluid	Hydrogen Gas
System Flow Rate (ACFM)	8-12
Operating Pressure Min/Max (psig)	10/75
Inlet Temperature Max (°F)	120
Outlet Moisture Content (°F D.P.@ pressure)	-40

Detail Specifications

Complete NEMA Design Cycle (hrs)	24, 48 or 96
Adsorbent - (lbs/chamber)	30
Activated Carbon (lbs)	10
Heat Cycle Purge Flow (scfm)	2
Purge Source	Dryer Outlet or Separate Source
System Conn. Size, 150 lb RF flange (in.)	1
Prefilter Rating (µm)	.6
Afterfilter Rating (µm)	.9
Pilot Air Filter Rating (µm)	.9
Vessel Corrosion Allowance (in.)	0.0625

Utilities

Electrical Classification	NEMA 4
Electrical Service (V/Hz/Ph)	120/1/60
Heater Size (watt/chamber)	600
Motor Size (hp)	1
Pilot Air, separate source (min. psig)	60



SPX PNEUMATIC PRODUCTS

Improvements and research are continuous at SPX Pneumatic Products. Specifications may change without notice.

Bulletin PIS-114_b

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