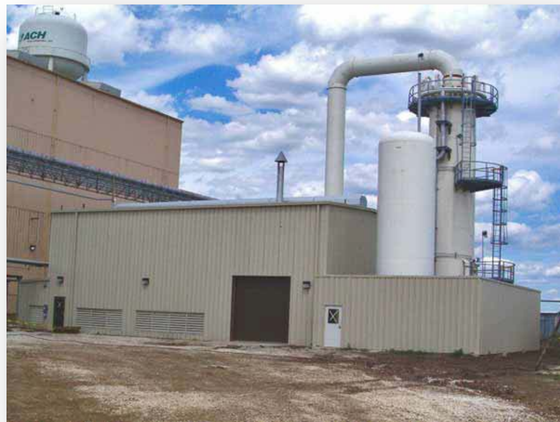
Fact Sheet

Hydro Chem Hydrogen Generating Plant
60,000 scfh at 200 psig   Purity 99.999%
Like New - Built in 2004

Marketed jointly by:

Solutions 4 Manufacturing	www.s4mequipment.com	217 245-2919
Schneider Industries	www.schneiderind.com	314 863-7711

Item C101. Complete hydrogen generating plant
Modular construction, manufactured by Hydro Chem. Capacity 60,000 scfh (1700 ncmh) at 200 psig gas. Built 2004. Reformer design with (4) pressure swing adsorbers for Hydrogen purity of 99.999%. Has waste heat reboiler for export steam at 270 psig back to process (replaced and reconditioned in 2007).



2.0 DESIGN BASIS AND UTILITIES

The plant is designed to produce hydrogen by steam reforming of natural gas.

2.1 PRODUCTS

The plant is designed to produce high purity gaseous hydrogen and steam as follows:

2.1.1 Hydrogen

Flow, (as pure H_2) SCFH	60,000	(design)
	57,000	(guaranteed)
Purity, vol % min (as H2)	99.999	
Impurities, ppmv max		
CO & CO_2	10	
H_2O	1	
Pressure, psig	200	
Temperature, ˚F max	100	

2.1.2 Export Steam

Capacity	See Section 2.4
Pressure, psig min	125
Temperature, ˚F	Saturated

Note: The export steam will have a maximum solids level of 5 ppm and contain trace levels of methanol and ammonia.

2.2 FEEDSTOCK

Natural Gas

Composition, mol%

Methane	91.960
Ethane	3.526
Propane	0.464
i -Butane	0.054
n-Butane	0.062
i-Pentane	0.019
n-Pentane•	0.014
n-Hexane	0.018
n-Heptane	0.013
n-Octane	0.006
Carbon dioxide	1.372
Nitrogen	2.491
Total	100.000

Sulfur, ppmv max as H_2S	5.0
LHV, BTU/SCF	911
HHV, BTU/SCF	1,010
Pressure, psig min	150
Temperature, °F	70

2.3 UTILITY SPECIFICATIONS

The hydrogen plant utility consumption is based on the following:

2.3.1 Fuel

Makeup fuel for the reformer is natural gas as shown in 2.2.
Fuel for the burner pilot is also natural gas.

2.3.2 Boiler Makeup Water

Treated boiler feed water, chloride and sulfate free, is supplied at:

Pressure, psig min		50
Temperature, °F	min	180
	max	210

2.3.3 Cooling Water

Quality: Treated, filtered, 100 ppmw CI' max

Pressure, psig min	50
Inlet Temperature, °F max	85
Return Temperature, °F max	100

2.3.4 Instrument Air

Quality: Filtered, oil-free, dry

Dew Point, °F	minus 40
Pressure, psig min	80

2.3.5 Electric Power

460/240 V, 3 Phase, 60 Hz
120 V, 1 Phase, 60 Hz

2.3.6 Nitrogen for Purging

Oxygen, ppmv max	10
Pressure, psig min	50
Temperature	Ambient

2.3.7 Steam

Steam required for startup and for building heaters:

Pressure, psig min	125
Temperature	sat

Note: Any steam pressure will be adequate for start-up requirements. If steam is not available, the plant start-up will take longer.

2.4 UTILITIES CONSUMPTION

The estimated utility consumption is as follows:

	Estimated	Guaranteed	
Feedstock, SCFH			
Feed	24,615		
Fuel	7,334		
Total	31,949	35,600	
Boiler Feed Water, lb/hr	8,274	9,350	
Export Steam, lb/hr	6,069	5,550	
Cooling Water (15°F rise), gpm	266	293	
Electric Power	KW		Motor **HP**
Feed Compressor	35		50
BFW Pumps	18		2 x 20
ID Fan	26		40
FD Fan	6		7.5
Instruments, Controls, & Misc.	5		
Total	90	100	
Instrument Air, SCFM	30		
Nitrogen, SCFH	7,500		

Note: Nitrogen is required only for 4 to 8 hours during startup and shut down for purging the equipment.

2.5 OTHER DESIGN PARAMETERS

2.5.1 Ambient Conditions

Site Elevation, feet above sea level	750
Average barometric pressure, psia	14.3
Temperature Range, °F	0 - 85
Design Conditions for Combustion	
Ambient Air Temperature, °F	70
Relative humidity, %	40
UBC Seismic Zone	2
Mechanical Design wind velocity, mph max	100
Soil Bearing Load for Foundation Design, psf	3,000

2.5.2 Meter Tolerances

Flow meters are subject to +/- 2% meter tolerance.

Power consumption is measured at the device and is subject to +/- 4% tolerance.

2.5.3 Noise

Maximum noise level during normal operation would not exceed 90 dBA when measured one meter from the device.

2.5.4 Turndown

Plant capacity may be varied from the control panel from 100% of design to 40% of design.

2.6 PROCESS DESCRIPTION

The following process description can be reviewed in conjunction with the attached process flow diagrams (Section 3).

2.6.1 Feed Heating

Natural gas for feed and fuel enters the plant at 150 psig and separates into two streams. One stream flows to the reformer burner manifold, the other as feed gas to the process.

The feed natural gas is compressed by the Feed Compressor (C-101). The compressed feed is heated to 725 ˚F in the Feed Heater (HX-101), using process heat upstream of the Shift Converter (V-102).

2.6.2 Hydrodesulfurization

Sulfur compounds are poisons to the reformer catalyst. The feedstock may contain hydrogen sulfide.

The heated natural gas is passed through the Hydrodesulfurizer (V-101). The zinc oxide bed adsorbs the hydrogen sulfide. The desulfurizer bed is designed for a minimum catalyst life of two years (based on 5 ppmv max sulfur in the feed).

Vessel MAWP 300 psig at 800F, ASME #709, serial #HC-1688. Built by Hydro Chem in 2004.

2.6.3 Reforming

The desulfurized feed is mixed with superheated steam and fed to the catalyst tubes in an upfired, upflow, circular reformer (R-101).

The reformer has catalyst tubes, filled with nickel catalyst. The following reactions occur:

$$C_n H_m + n H_2O = n CO + (m/2+n) H2 \quad (1)$$

$$CO + H2O = CO2 + H2 \quad (2)$$

Reaction (1) is reforming; reaction (2) is shift conversion. Both are equilibrium limited based on the outlet temperature and pressure.

The overall reaction is endothermic - requiring heat supplied by the burner. Most of the fuel requirement for the burner is met by the vent gas from the PSA system. The rest is supplied by natural gas.

The fluegas leaving the furnace is used to superheat the process steam, to generate steam, and to heat the boiler feed water before being sent to the atmosphere.

2.6.4 Shift Conversion

The reformer exit process gas is cooled to 650 °F in the Reformer Effluent Steam Generator (WH-104), and the Feed Heater (HX-101) and then fed to the Shift Converter (V-102). The shift converter contains chromium promoted iron oxide catalyst. Most of the carbon monoxide in the process gas is converted to carbon dioxide and hydrogen by the following reaction:

$$CO + H_2O = CO_2 + H_2$$

The reaction is exothermic and is favored by low temperature.

2.6.5 Process Gas Cooling

The shift exit process gas is cooled first by the Shift Effluent Steam Generator (WH-105) and the BFW Exchanger (HX-102). The process gas is then cooled to 100 °F by the Process Cooler (HX-104). The cold condensate is separated in the Cold Condensate Separator (V-104) and the gas is fed to the PSA System. Cold condensate mixed with BFW makeup and then sent to the Deaerator (V106).

2.6.6 PSA Hydrogen Purification System

The PSA purification system uses four vessels, each having a bed of activated alumina, carbon and molecular sieve. The system operates on a repeated cycle having two basic steps; adsorption and regeneration.

During the adsorption step the process gas flows through an adsorber vessel. Each adsorber runs for about four to six minutes. The adsorbents trap the impurities from the process gas. The pure hydrogen product is sent to the battery limits at 200 psig.

At the end of adsorption step, the adsorbent is loaded with impurities and is switched to the regeneration cycle. The regeneration consists of depressuring, purging and repressuring. The offgas from the regeneration step is collected in the Vent Gas Drum (V-105) and is used as primary fuel in the reformer.

2.6.7 Waste Heat Recovery

The waste heat in the process gas and the reformer flue gas is used to generate steam at 270 psig. Steam is generated in the Flue Gas Steam Generator (WH-102), the Reformer Effluent Steam Generator (WH-104), and the Shift Effluent Steam Generator (WH-105).

Treated BFW makeup water is mixed with the cold condensate, and deaerated in the Deaerator (V-106), using steam. The deaerated boiler feed water is pumped by the BFW Pumps (P-101 A&B), heated in the BFW Exchanger (HX-102 A&B) and the Economizer (WH-103) and fed to the Steam drum (V-107). The steam drum supplies water to the Fluegas Steam Generator (WH-102), the Reformer Effluent Steam Generator (WH-104), and the Shift Effluent Steam Generator (WH-105).

Most of the steam is superheated in the Steam Superheater (WH-101) and used as process steam for reforming. Some steam is used in the deaerator. The rest is exported on pressure control.

ACTUAL TEST RESULTS FOR COMPLETE PLANT follow on next 9 pages.