Item 6530. Hydrogen Gas Plant

Hydro-Chem Hydrogen Generating Plant—90,000 scfh @ 200 psig. Purity 99.99%

Hydrogen generating plant engineered by Hydro-Chem built in 1980. Design capacity is 90,000 scfh at 200 psig with a purity of 99.99% pure hydrogen - was running on 10 of its 20 tubes for 45,000 scfh capacity. Reformer can be fired on natural gas or propane - same burner. Waste heat boiler generating 3,000 to 5,000 #/hr export steam at 250 psig. PSA plant (4 psa vessels replaced in 1998) with Jamesbury valves kept up to date, Quench pot design. Plant completely intact except for small natural gas compressor. Has new tubes, new reformer and shift converter catalyst. Five (5) spare tubes available. Plant has just recently shut down in mid 2012, and proper shutdown procedures were followed - still under nitrogen blanket.

Reformer can be fired on natural gas or propane—same burner

Feedwater system

PSA plant with Jamesbury valves kept up to date (4 PSA vessels replaced in 1998).

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SOLUTIONS 4 MANUFACTURING

Pertinent Points

- Plant was in operation until mid-2012
- Was shut down properly using guidelines developed by Richard Daniel – plant still under nitrogen
- Waste heat boiler was drained and dried – has desiccant packs in it
- Boiler water treatment system is part of this sale
- The small natural gas compressor is gone since they were using their own high pressure gas – all the rest of the plant is intact
- Control system is AB series 5. All the instruments are intact and installed and come with the sale as does the plc program and ladder logic. The AB5 plc and I/O's do not since they are a part of the ongoing operation
- Plant running on 10 tubes for 45,000 scfh. Other tubes removed and burner changed out for efficiency
- Five spare tubes come with this sale
- H_2 plant is enclosed in building and reformer/vent gas drum behind a wind wall – and in good shape. Building is not part of the sale price but can be negotiated
- All Fisher & Jamesbury valves have been kept up to date and changed as necessary – all in excellent shape
- All 4 PSA units changed out in August 1998
- Gas plant is modular skid construction
- Burner fired on propane once a year to test it as a standby backup fuel – main fuel was natural gas.

Hydrodesulfurizers

Fact Sheet

Hydro Chem Hydrogen Generating Plant
90,000 scfh at 200 psig   Purity 99.99%
Built in 1980

Marketed by:
Solutions 4 Manufacturing   www.s4mequipment.com   217 245-2919

Item 6530. Complete hydrogen generating plant
Modular construction, manufactured by Hydro-Chem. Capacity 90,000 scfh (2500 ncmh) at 200 psig gas. Built 1980. Reformer design with (4) pressure swing adsorbers for Hydrogen purity of 99.99%. Has waste heat reboiler for export steam at 250 psig back to process (PSA adsorbers replaced in 1998).

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	90,000	(design)
Currently modified flow SCFH	45,000	
Purity, vol % min (as H2)	99.99	
Impurities, ppmv max		
CO & CO_2	10	
H_2O	1	
Pressure, psig	200	
Temperature, ˚F max	100	

2.1.2 Export Steam

Capacity	3,000 to 5,000 pph
Pressure, psig min	250
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

Burner is dual fuel: Natural Gas or Propane.

2.3.2 Boiler Makeup Water

Feedwater chemical addition system, ss tanks includes as part of sale.
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 Cl' 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.
Note: Export steam is at 250 psig.

2.4 UTILITIES CONSUMPTION

The estimated utility consumption is as follows:

	Natural Gas	Propane	
Feedstock, SCFH			
Feed	34,845	14,700	
Fuel	7,390	3,750	
Total	42,235	18,450	
Boiler Feed Water, lb/hr (approx.)	8,274		
Export Steam, lb/hr	5,000		
Cooling Water (15°F rise), gpm	266	293	
Electric Power (Approximate)	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 PROCESS DESCRIPTION

See Process Schematic attached.

The following process description can be reviewed in conjunction with the attached process flow diagrams.

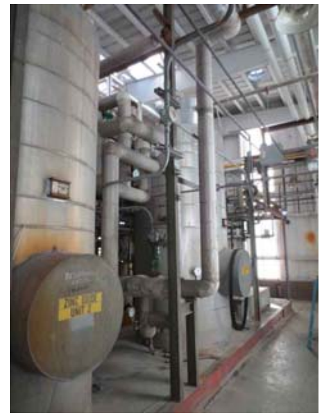
2.5.1 Feed Heating

Natural gas for feed and fuel enters the plant at 180 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. {This compressor is missing from the system.} The compressed feed is heated to 700˚F in the Feed Heater, using process heat upstream of the Shift Converter.

2.5.2 Hydrodesulfurization

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



The heated natural gas is passed through two Hydrodesulfurizers (C-101 & C-102). 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).

Vessels are ASME design. Built by Hydro Chem.

2.5.3 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.

2.5.4 Shift Conversion

The reformer exit process gas goes to the Quench pot (V-202). Condensate is sprayed into the gas cooling it from 1500°F to 700°F, and the Feed Heater (HX-101), and then fed to the Shift Converter (C-103). 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:

$$CO + H2O = CO2 + H2$$

The reaction is exothermic and is favored by low temperature.

2.5.5 Process Gas Cooling

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 and the gas is fed to the PSA System.
Cold condensate mixed with BFW makeup and then sent to the Deaerator.

2.5.6 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 and is used as primary fuel in the reformer.

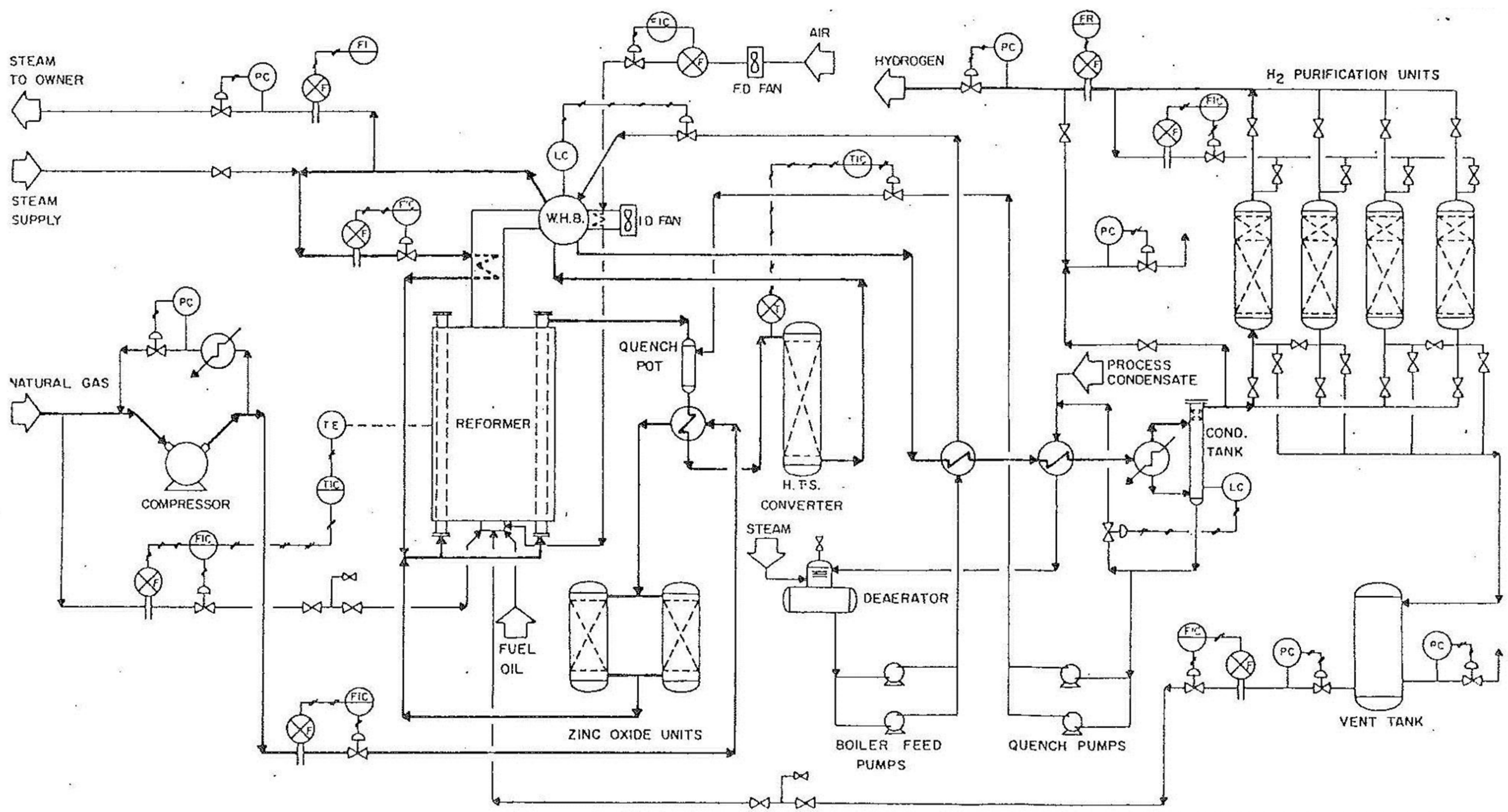
2.5.7 Waste Heat Recovery

The waste heat in the process gas and the reformer flue gas is used to generate steam at 250 psig. Steam is generated in the Flue Gas Steam Generator, the Reformer Effluent Steam Generator, and the Shift Effluent Steam Generator.

Treated BFW makeup water is mixed with the cold condensate, and deaerated in the Deaerator, using steam. The deaerated boiler feed water is pumped by the BFW Pumps, heated in the BFW Exchanger and the Economizer and fed to the Steam drum. The steam drum supplies water to the Fluegas Steam Generator, the Reformer Effluent Steam Generator, and the Shift Effluent Steam Generator.

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

Item 6530. Hydrogen Gas Plant
Hydro-Chem: Capacity 90,000 scfh at 200 psig with purity to 99.99%



- Reformer design: Fuel gas can be either natural gas or propane; feed is natural gas
- Export steam boiler at 5,000 to 6,000 pph at 250 psig out of this plant back to Process
- Currently configured with 10 tubes (half) for capacity of 45,000 scfh with 5 spare tubes in storage
- Was in operation until mid 2012 – still under power, heat, and nitrogen blanket. Stored correctly

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