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Novel Compression and Fueling Apparatus to Meet Hydrogen Vehicle Range Requirements

Merit Review and Peer Evaluation
May 19, 2003
Berkeley, CA

Phase I Program Goals

Central Issue:

There is no cost-effective, proven method for fast filling (10 minutes or less) vehicles to 700 barg

Investigate:

Novel “Isothermal” Compressor

High pressure automatic valves

900 barg storage vessels for cascade

Flowmeter and other instruments

Dispensing equipment

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Method

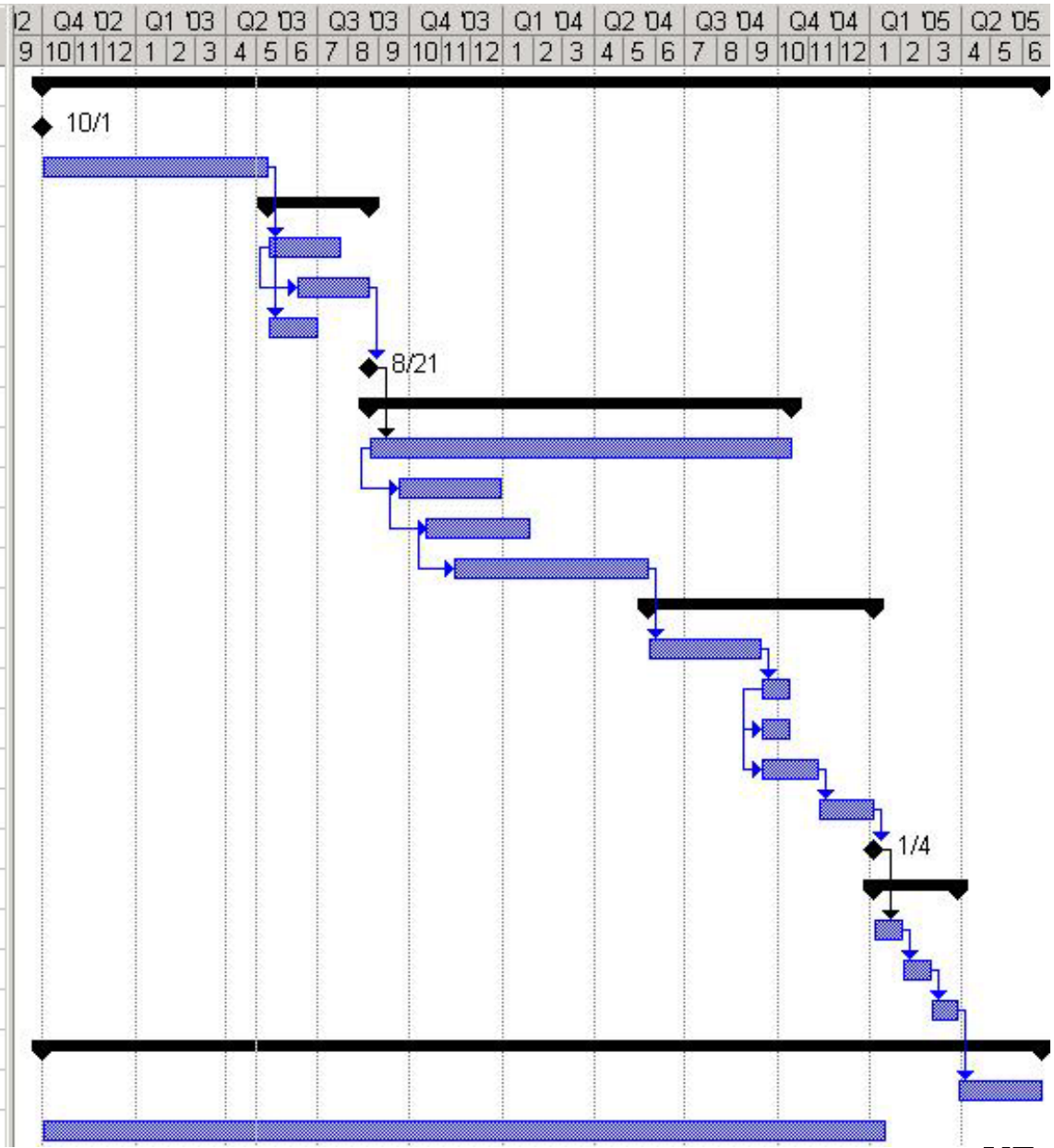
- Design, simulate, and test a novel compressor concept involving compression of hydrogen with a “liquid piston” with little temperature rise
  - ASPEN heat and material balance
  - ASPEN dynamics
  - Design spreadsheets for various system components
- Develop valves, instruments, storage systems, and dispensing components for 700 barg with industry partners

Technology Status

- Fast fill (<3 minutes) at 350 barg
  - Issues
    - Tank heating
    - Communications
    - Flow control and measurement
    - Codes not in place yet
    - Storage costs
- Systems up to 75 nm3/hr available, but most systems are 1-20 nm3/hr
- Automobile ranges are under 200 miles
- Industry moving to 700 barg to address range issues

Timeline

Task Name
Novel Hydrogen Compressor
Start Date
Contract Approval
1.0 Feasibility/System Design
1.1 System Pressure Analysis
1.2 Isothermal Compressor Analysis
1.3 Packless Valve Analysis
Program Review
2.0 System Design
2.1 Flow Lab Design
2.2 Dispenser Design
2.3 Isothermal Compressor Design
2.4 Packless Valve Design
3.0 Lab Installation and Testing
3.1 Compressor and Valves
3.2 Connectors and Flow Controls
3.3 Composite Vessels
3.4 Installation
3.5 Testing
Program Review
4.0 Field Installation and Operation
4.1 Penn State Review and Plan
4.2 Installation
4.3 Operational Field Tests
5.0 Program Management
5.1 Final Report
5.2 Management



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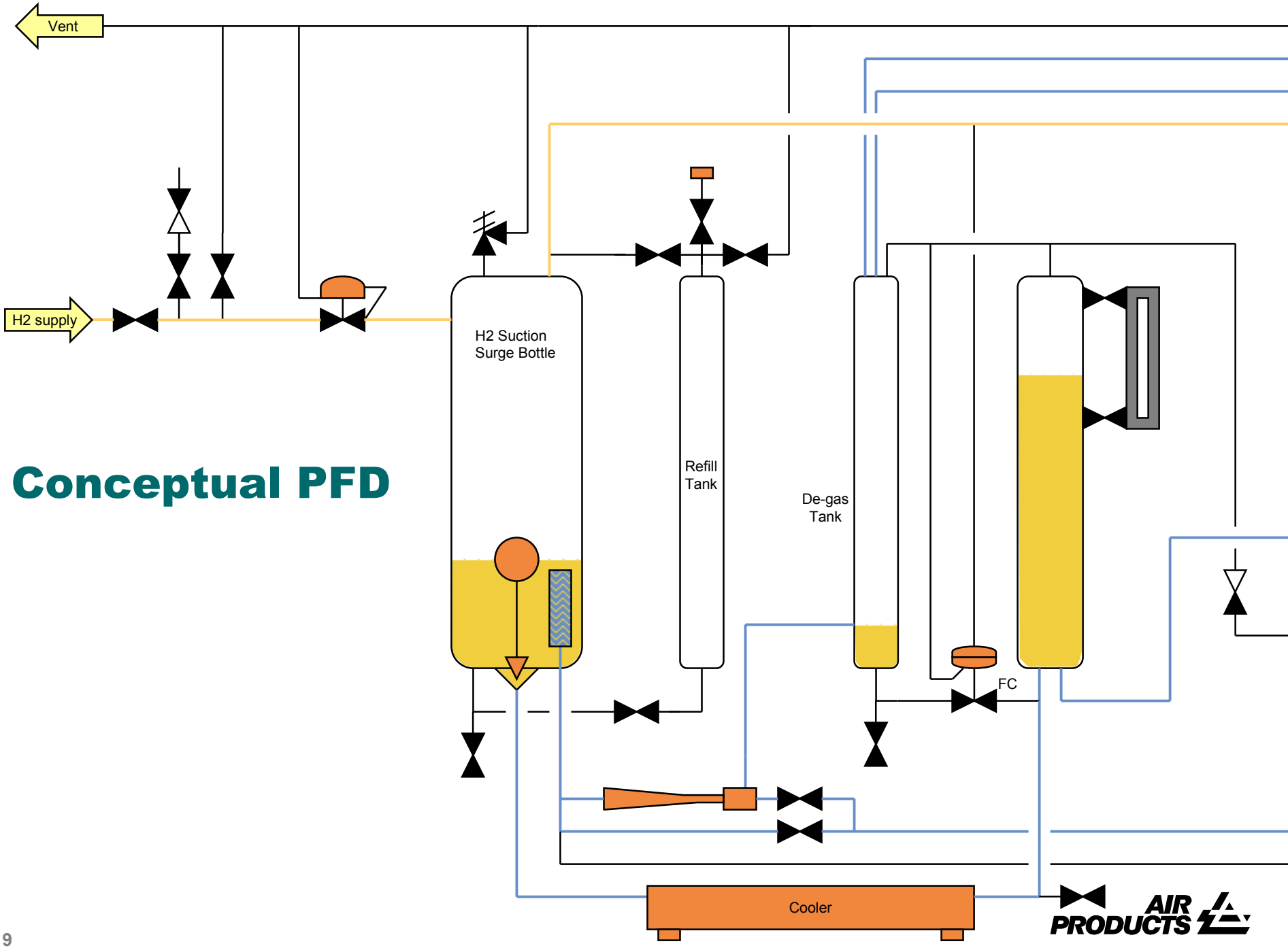
System Pressure Analysis

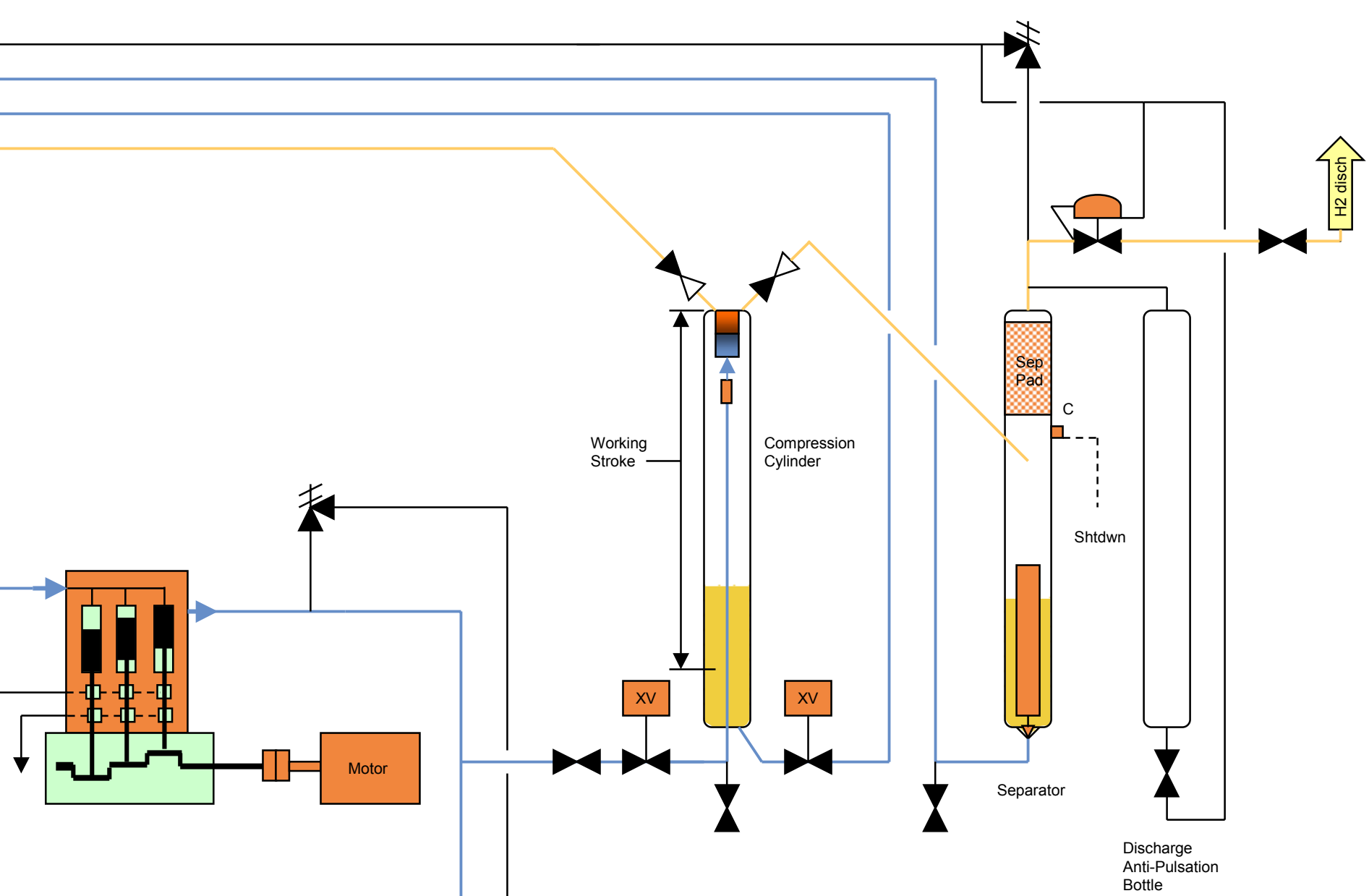
- Intermediate pressures will not meet the automotive range requirements, so 700 barg fill will be the system design basis
- Automotive companies are beginning to request 700 barg systems
- Most components have higher pressure alternatives that are available commercially
- Cost increases, but cost per kg of delivered hydrogen decreases slightly
- 700 barg delivers 71% more hydrogen for a similar sized vehicle tank

Novel Compressor

- Targets:
  - Prototype flow rate ~ 1 nm3/hr (2 kg/day)
  - Output pressure 12000-14000 psig
  - Cost < $15,000
  - Less than 5 Hp
- First pass
  - Water-based with pump and eductor set
  - Separation and surge volumes
  - Issues
    - Hydrogen solubility
    - High pressure water lubricity
- Further work - Other fluids

Conceptual PFD

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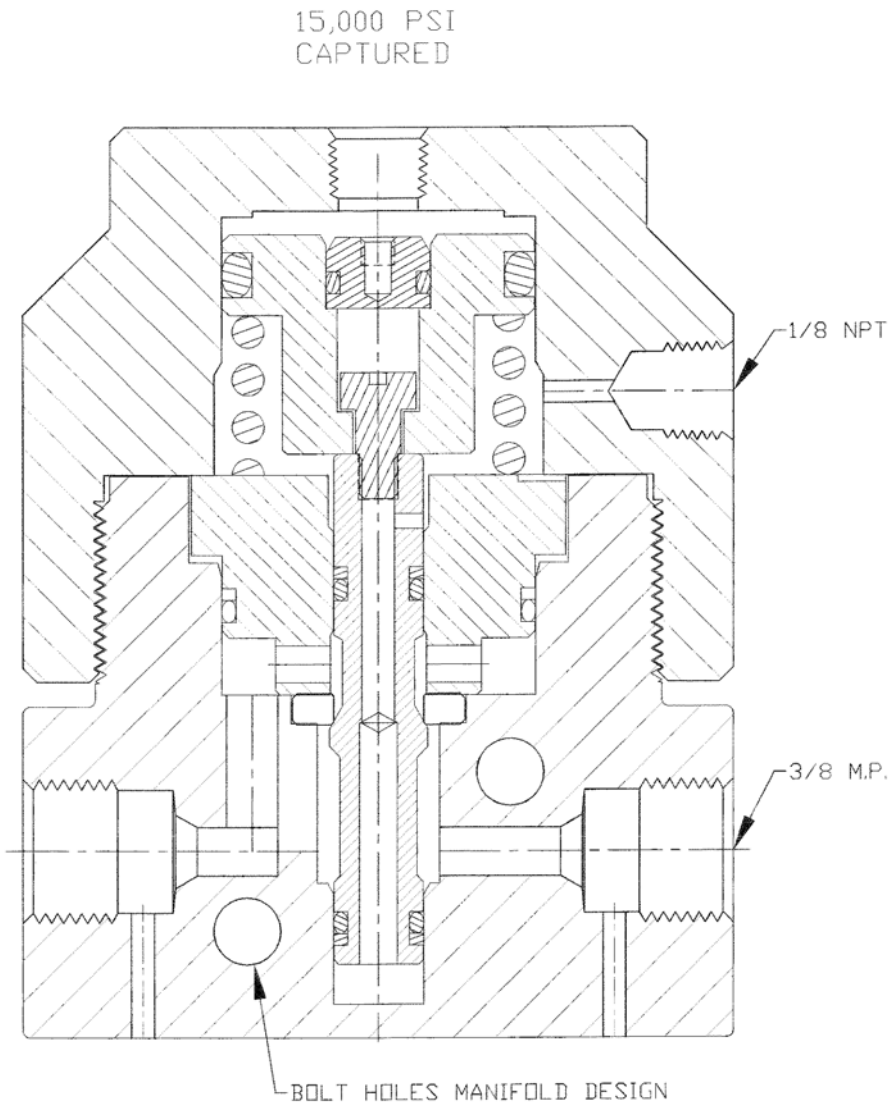
Compression
Cylinder
XV
XV
Motor
Separator
Discharge
Anti-Pulsation
Bottle

High Pressure Automatic Valves

- Developed with a valve supplier
- Unique, balanced-piston design
- Actuated with process gas
- Packless
- Captured vent
- Rated to 15,000 psig
- Small size and footprint (3” dia x 3.5” height)
- Able to manifold multiple valves together
- Cost can be reduced with moderate volumes to around 50% of single item cost today

High Pressure Automatic Valves



900 Barg Storage

- Investigating many options
  - Cascade to 350 barg and use booster to direct compress into vehicle at 700 barg
    - Upgrade to existing stations
  - Composite cylinders
    - Not ASME-approved
    - High cost
  - Steel cylinders at 900 barg
    - Not mass produced
    - Custom designed

Instrumentation and Flowmeter

- Flowmeter
  - Testing 350 barg flowmeter types in another DOE program
  - Work with successful vendors from the first program to increase the pressure capability to 900 barg
- Instruments
  - End connections must be robust and reliable
  - High pressure hydrogen concerns
  - Some devices are not currently available to 900 barg
  - Work with vendors to utilize appropriate end connections and raise pressure capability

Dispensing Equipment

- Working with fueling vendor (OPW) and other industry partners to develop a standard for nozzle and breakaway
  - Existing nozzles and breakaways are not SAE J2600 compliant
  - SAE and ISO standards are not approved yet
  - Communications even more important at higher pressures
  - No existing true nozzle or breakaway available at 700 barg
  - High pressure hose quick-connects typically used for 700 barg systems today

Progress and Milestones

- May 15, 2003 – Final Contract approved and in hand to allow material purchases
- June 1, 2003 – Testing of compressor subassemblies, Construction of 700 barg fueling system
- August 1, 2003 – Testing of custom compressor machined devices
- August 21, 2003 – Go/No Go decision for Phase II

350 Barg Fueling System

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Collaboration

- OPW/Shearex
- California Fuel Cell Partnership
- Major valve manufacturer
- Fluid manufacturer
- Pump manufacturer
- Custom machine shops
- A number of potential demonstration sites

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