APS Process Water Systems

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Mechanical Operations and Maintenance

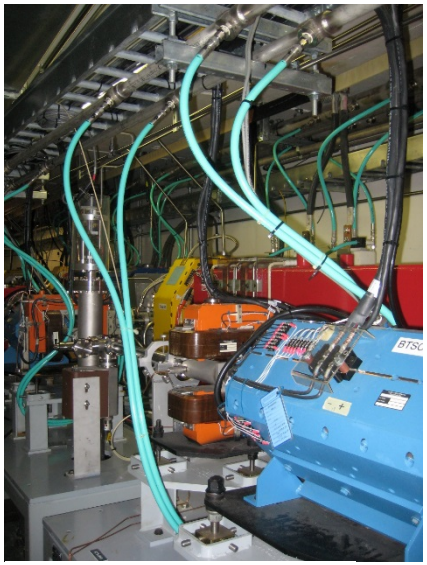
APS Process Water Systems

- Central Plant
- Dedicated Process Water Systems
- History
- Challenges and Lessons Learned
- Future

DI Water Systems

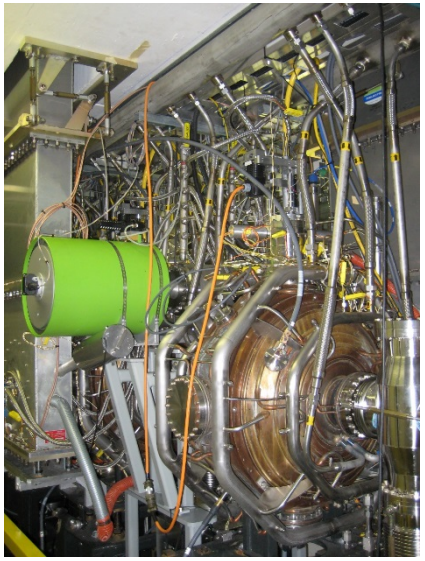
- Pumping of over 20000 GPM utilizing about 150 pumps.
  - 10gpm to 5000 gpm
  - 73 deg F to 120 deg F
  - 30 psig to 150 psi
- Cooling and/or conditioning thousands of accelerator and beamline components, affecting machine reliability, beam stability, beamline operation and carrying out RF tuning and bake-out for vacuum.
- Nearly a thousand flow meters, temperature and pressure sensors are interlocked to protect equipment and personnel.

DI Water Systems



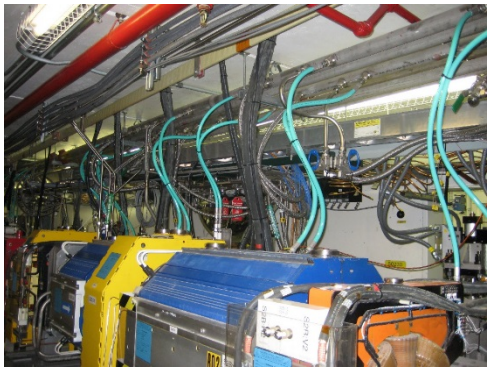
Storage Ring

Power Supplies



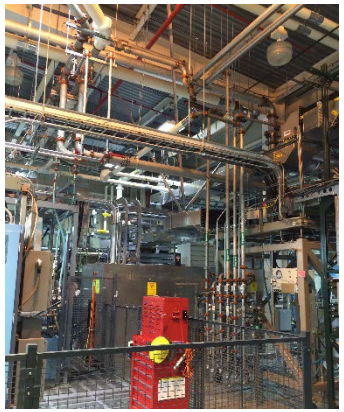
RF Cavities

Exp Hall Primary Water Mains



Storage Ring

Beamlines



RF Systems

Booster

Central Plant Systems

- Tower Water
- Chilled Water
- Primary Process Water System

Machine Dedicated Process Water Systems

- Secondary Water Systems (magnets, power supplies, absorbers, front-ends, RF systems…)
- Vacuum Chamber Cooling Skids
- Linac Skids
- Water for Beamlines
- Miscellaneous Water Systems

Tower Water System

Equipment

- Tower
  - 2 Three cell towers with common basin
  - 1 Two cell tower
- Pumps

Service

- Process Water Heat Exchangers
  - 3 Plate and frame HXs
- Chillers
  - 3 @ 2100 Ton
  - 1 @ 1700 Ton
  - 2 @ 1500 Ton
- Thermal Storage Refrigerant Package

Chilled Water System

Equipment

- Pumps (primary / secondary arrangement)
- Chillers
  - 3 @ 2100 Ton R-22
  - 1 @ 1700 Ton R-134a
  - 2 @ 1500 Ton R-134a
- Thermal Storage
  - 2 @ 600 ton screw compressors, R-22 ice on coil thermal storage. Capacity - 12000 Ton-hours

Service

- Process Water Heat Exchangers
  - 2 Plate and frame stainless HXs
- Air Conditioning and miscellaneous process loads
  - HVAC
  - Vacuum chamber cooling skids, User skids, beamlines, SCU compressors.

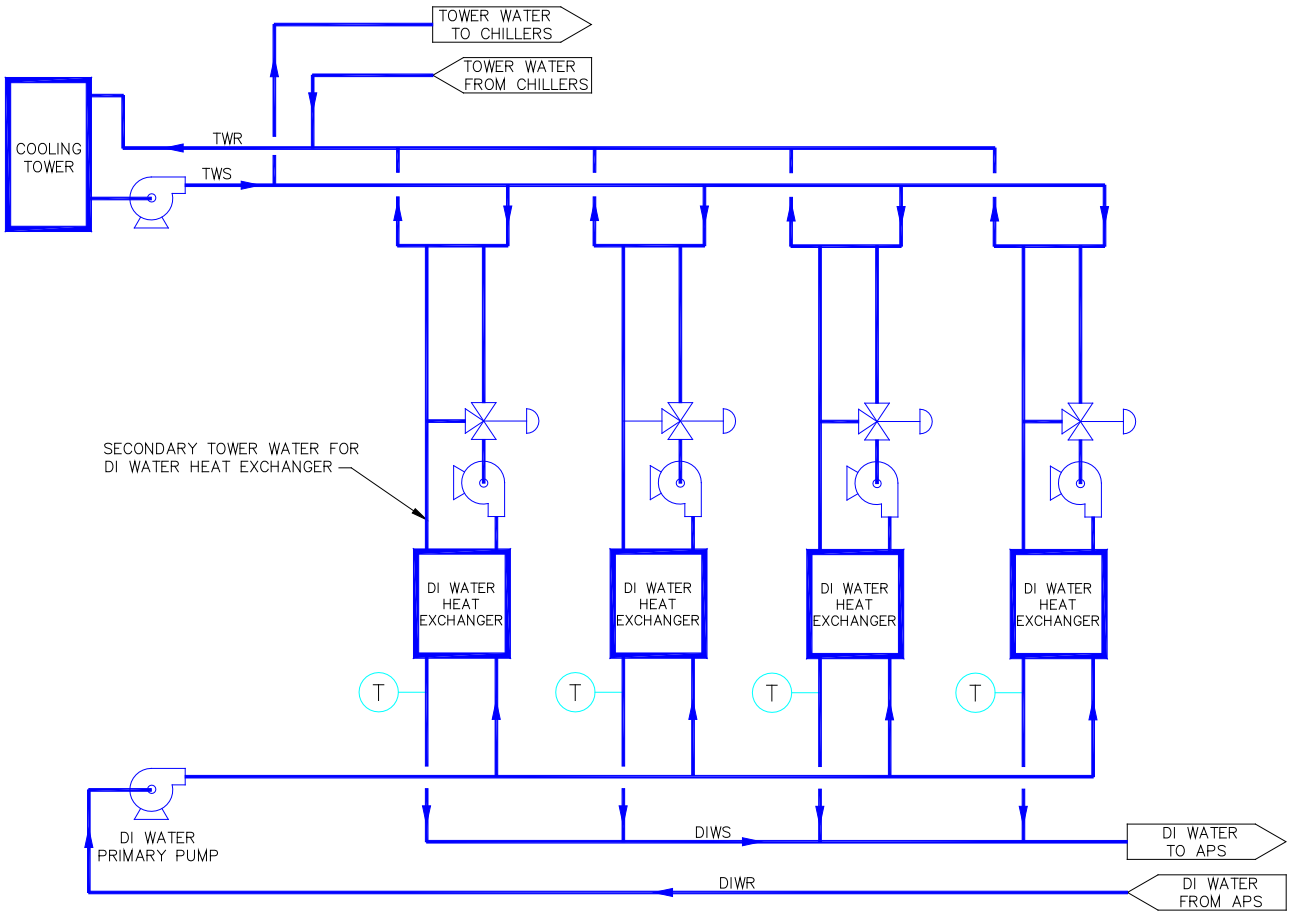
Chilled Water System

Used for cooling:
HVAC
Primary DI water
Aluminum water systems
Beamlines
SCU compressors

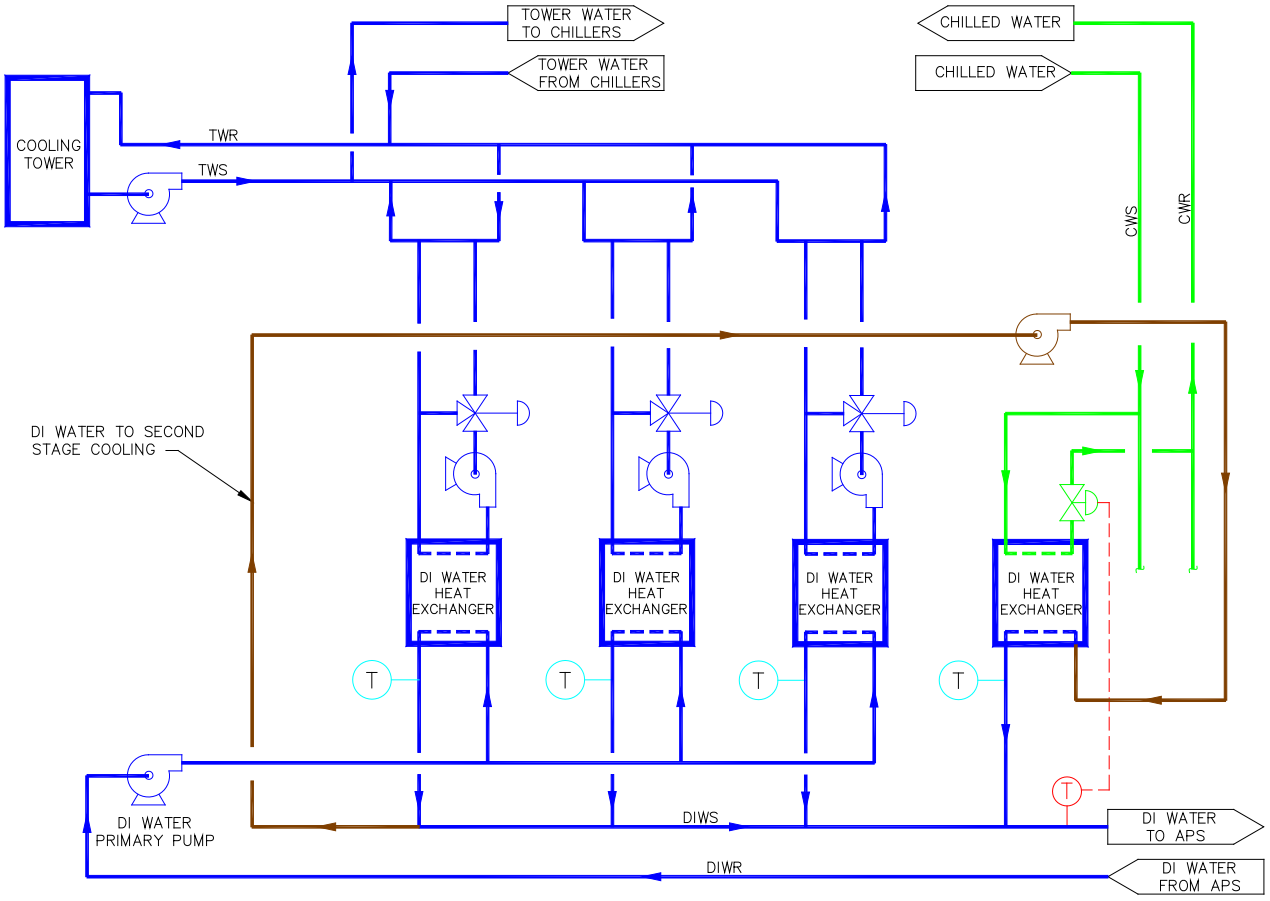
Primary Process Water System

- Pumps (two plus one standby)
  - 5500 gpm each
  - All with VFDs (variable frequency drives)
- Heat Exchangers
  - 3 Tower/Process Water
  - 2 Chilled/Process Water

Process Water Cooling
Original Concept (90 deg F)



Process Water Cooling
As Installed (73 deg F)



Primary Process Water System
Make-up, Polishing and Degasification

- Make up water
  - Combination of Charcoal, RO and Mixed bed resin system
  - Make-up water tank
- Polishing with mixed bed resin maintains system resistivity
- Gas removal with vacuum degasifier

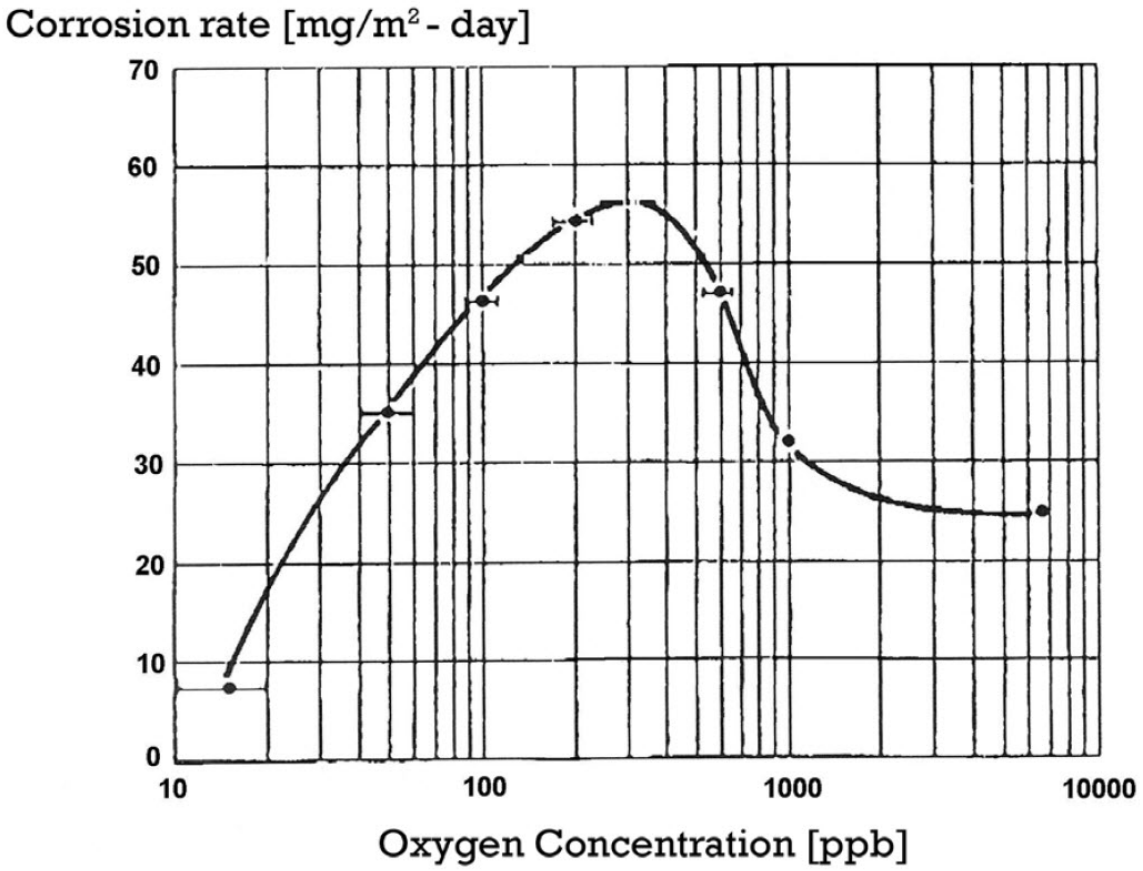
Primary DI Water Operating Parameters

- Flow rate: 10000 gpm
- Supply pressure: 30 psig
- Supply temperature: 73°F
- Temperature stability: ±0.5 °F

Make-up, polishing and degasification

- 5000 gallon storage tank
- Make-up water production capacity 2500 gal/day
- Dissolved oxygen (DO) content <10 ppb
- Resistivity 9-10 MΩ-cm
- UV treatment
- Filtration 0.5 micron

Effect of dissolved Oxygen on copper corrosion in DI water systems



- Guide on Stator Water Chemistry Management April 2010. Study committee A1, WG A1.15

Process Water Systems

- Secondary Water Systems
- Vacuum Chamber Cooling Skids
- Linac Skids
- Water for Beamlines
- Miscellaneous Water System
  - Bake-out skids
  - Citranox flushing skids
  - Gravity fed systems
  - Chillers

Secondary (copper) Water Systems

37 Pumping systems supplying pressure and temperature controlled water to most storage ring, booster, Linac, LEUTL and beamline equipment.

- 62 pumps
- 75 and 100 HP pump motors
- 350-600 GPM
- Supply pressure 135-150 psig
- Supply temperature
  75, 78, 85, 90 ± 0.2 °F
- Filtration 0.5 micron

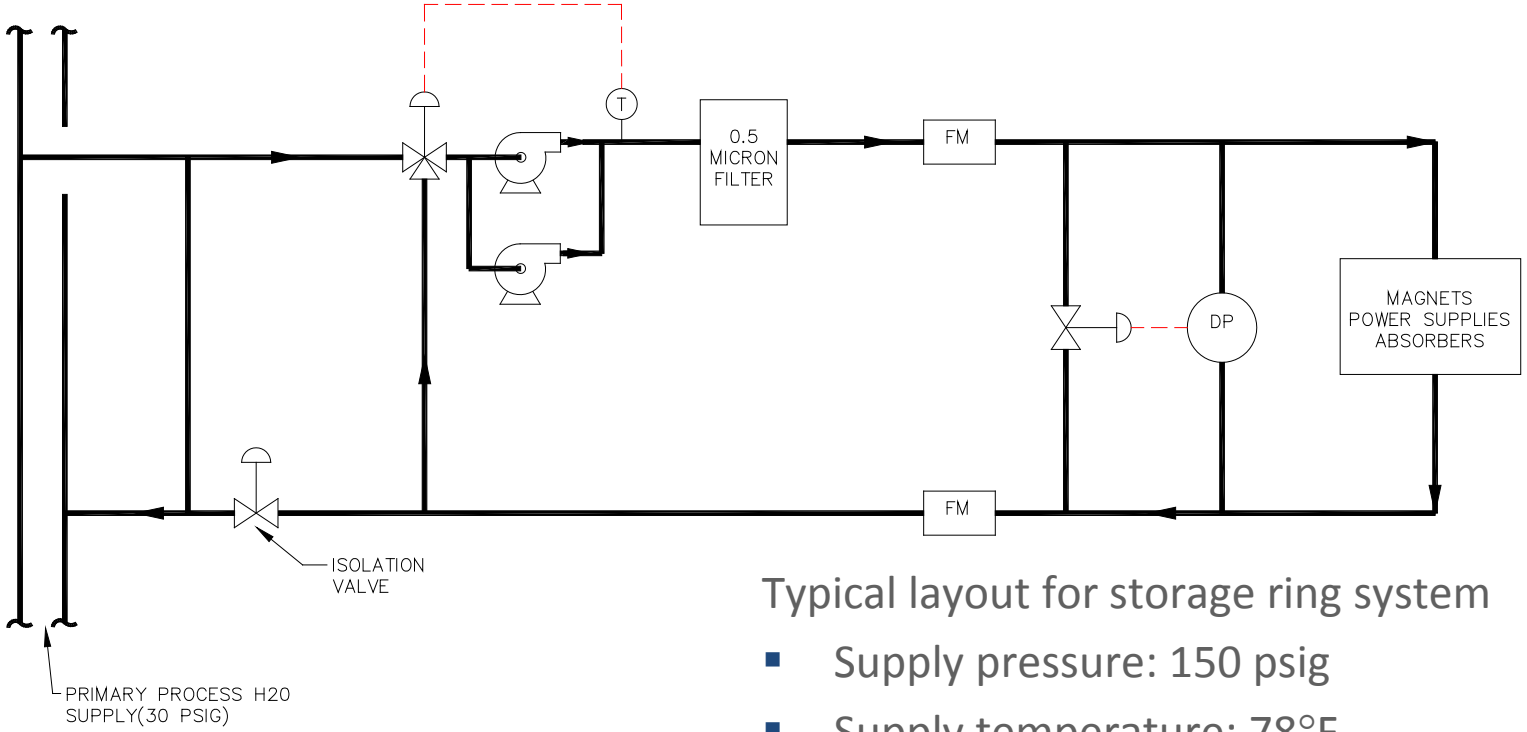
Storage Ring Secondary Pump System

Benefits of primary/secondary arrangement

- Centralized polishing, make-up and degasification
- Systems are hydraulically independent
- More efficient heat rejection
  - First Stage – Tower water
  - Second Stage – Chilled Water
- Smaller equipment room floor space required
  - No need for heat exchanger or polishing equipment
- Flexible for system modifications and new system addition

Typical *Original* APS Secondary System

Constant speed primary pumping
3-Way temperature control valve arrangement

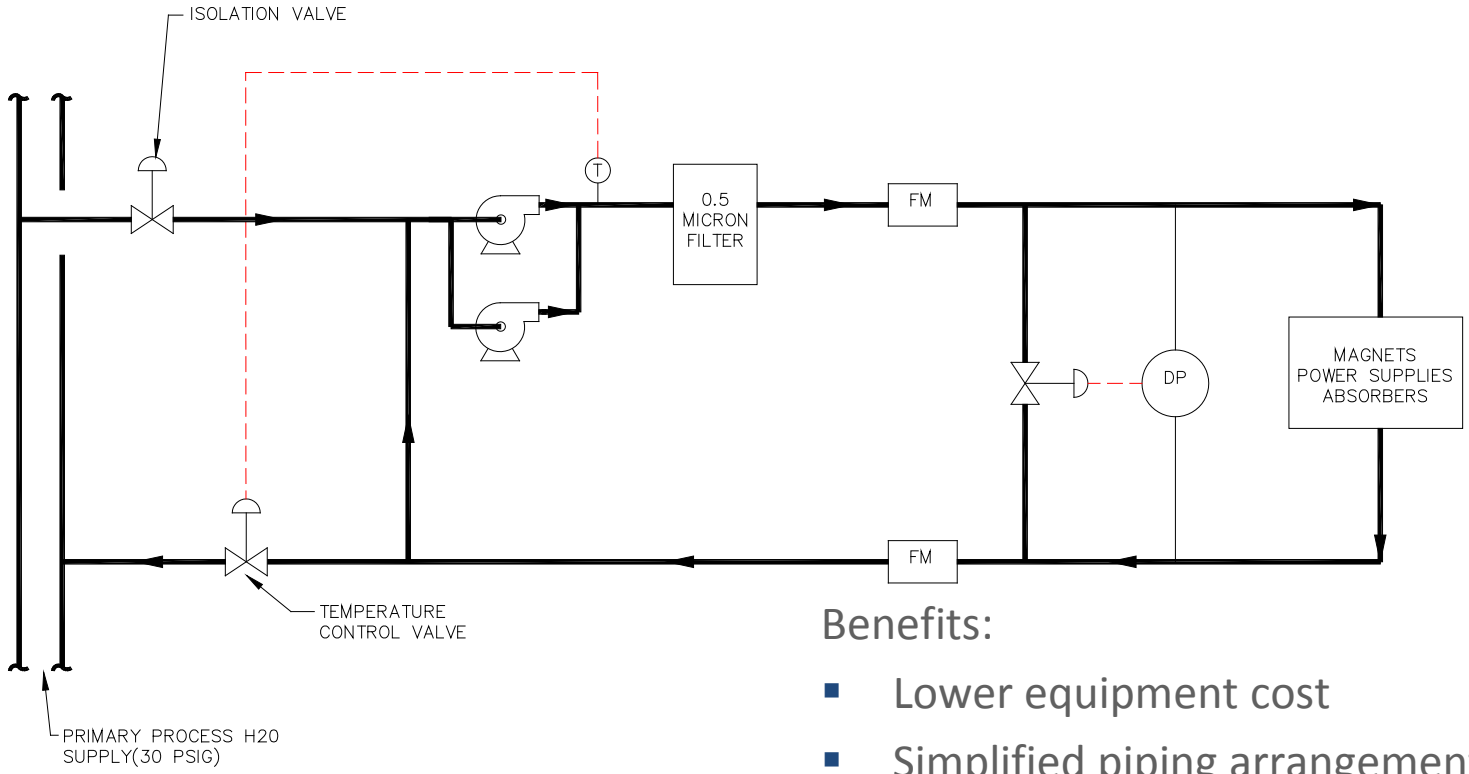


Typical layout for storage ring system

- Supply pressure: 150 psig
- Supply temperature: 78°F
- Temperature stability: ±0.2 °F
- Flow: 450 GPM

Typical Modified Secondary System

Variable Speed Primary Pumping
2-Way Temperature Control Valve arrangement

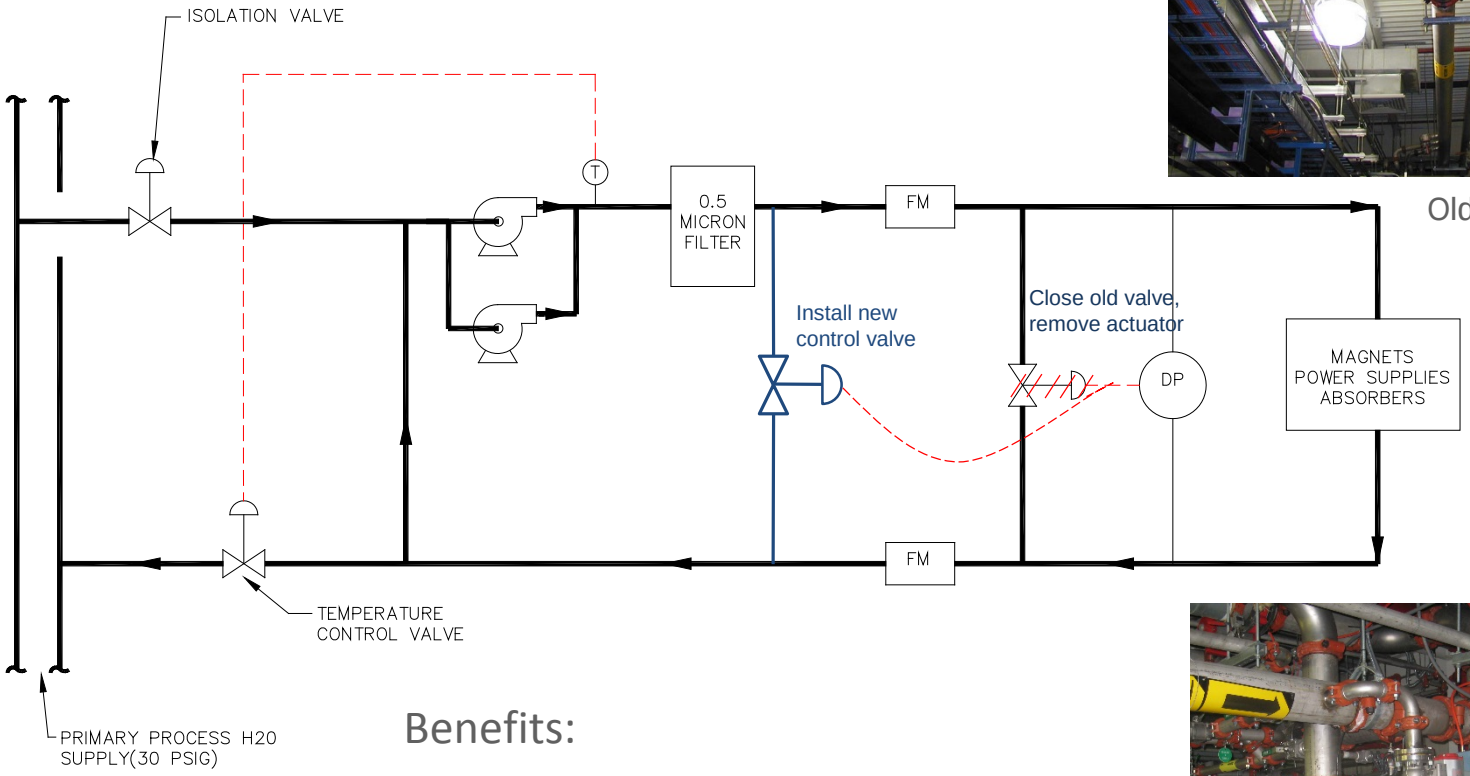


Benefits:

- Lower equipment cost
- Simplified piping arrangement
- Increased energy efficiency

Typical Modified Secondary System
New bypass valve location

Old location

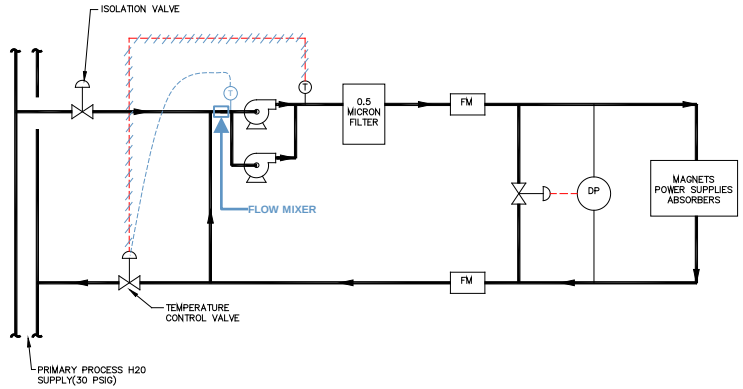


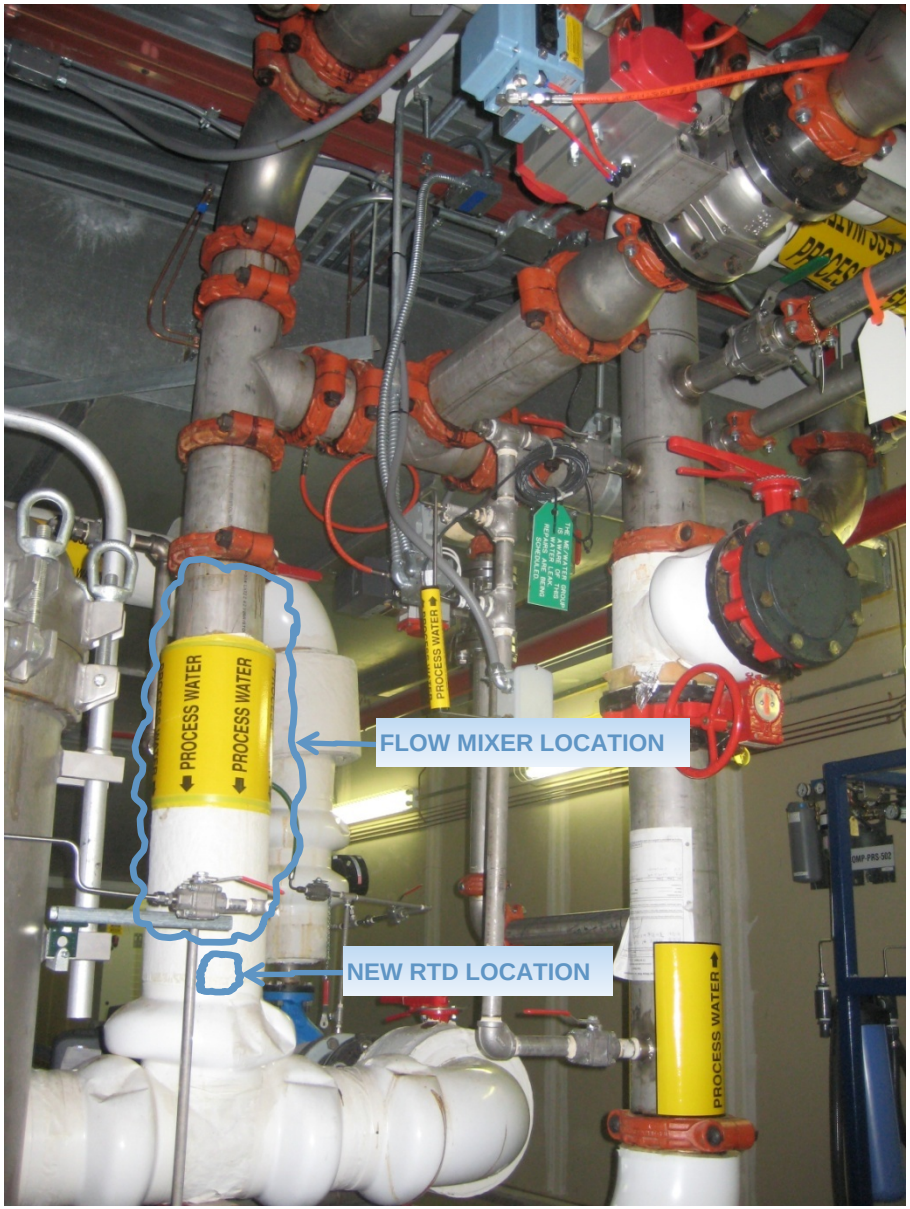
Benefits:

- Lower noise
- Ease of maintenance

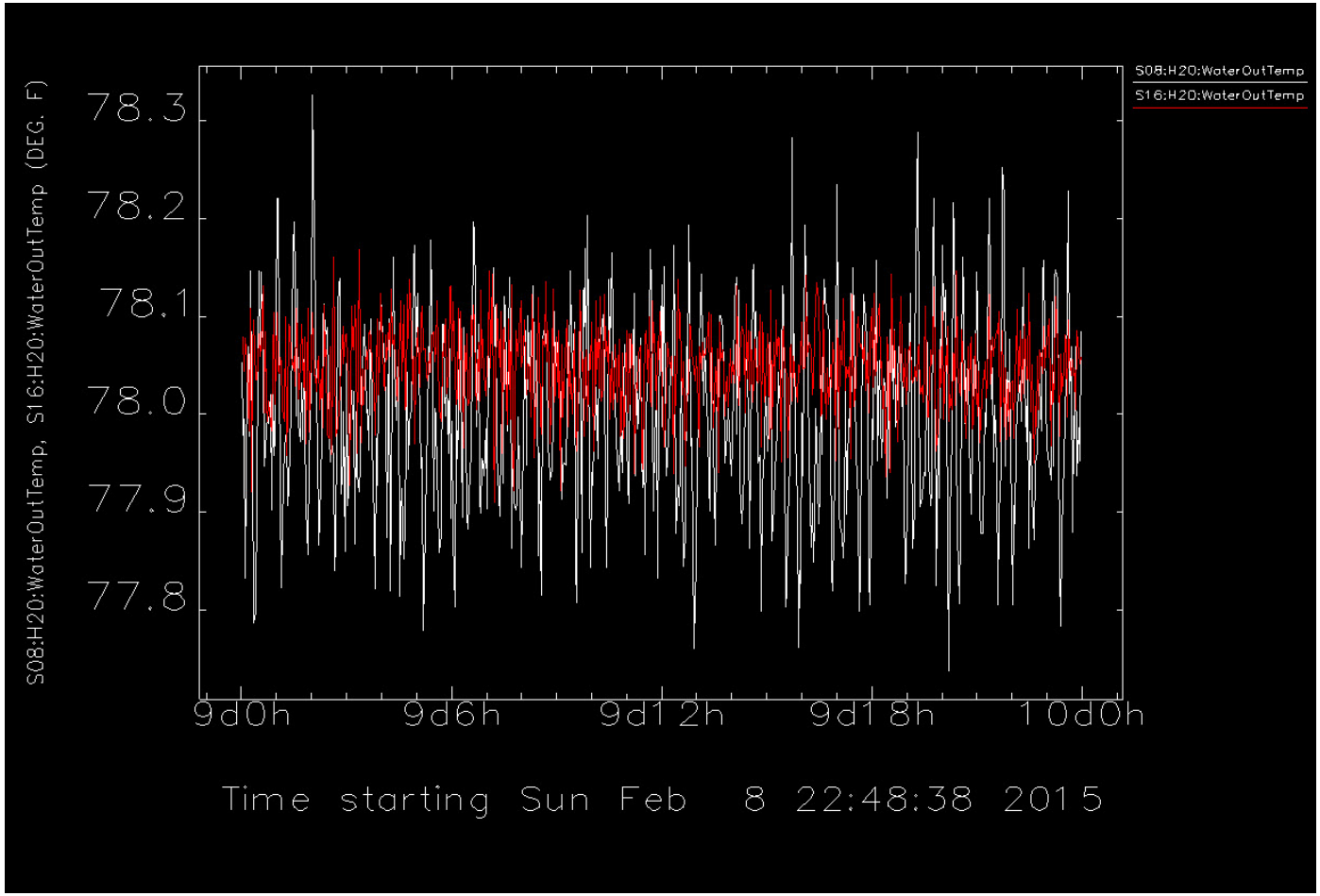
New location

Improved Temperature Control R&D



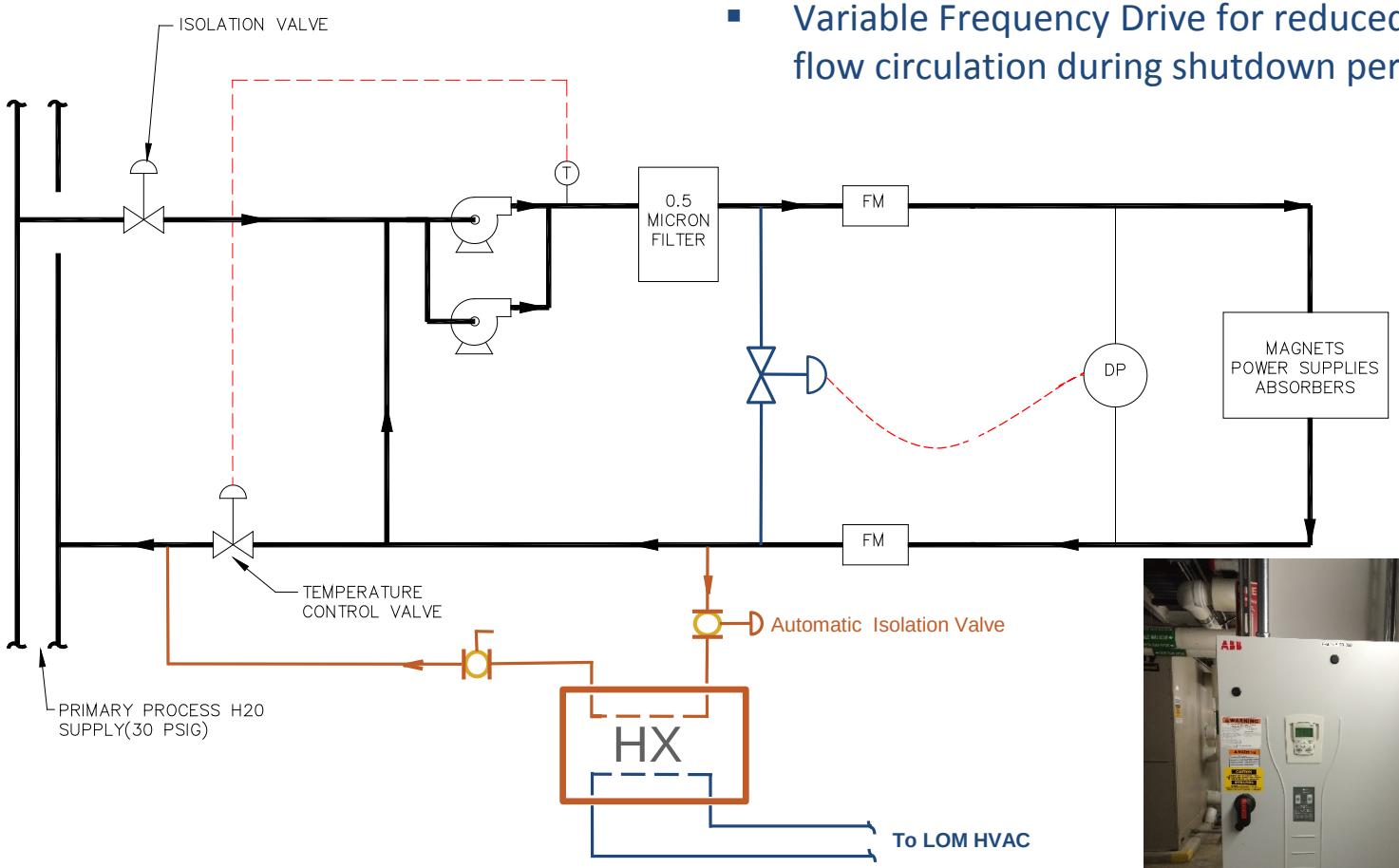


Secondary Water System
Improved Temperature Control



Secondary Systems – Energy Savings Projects

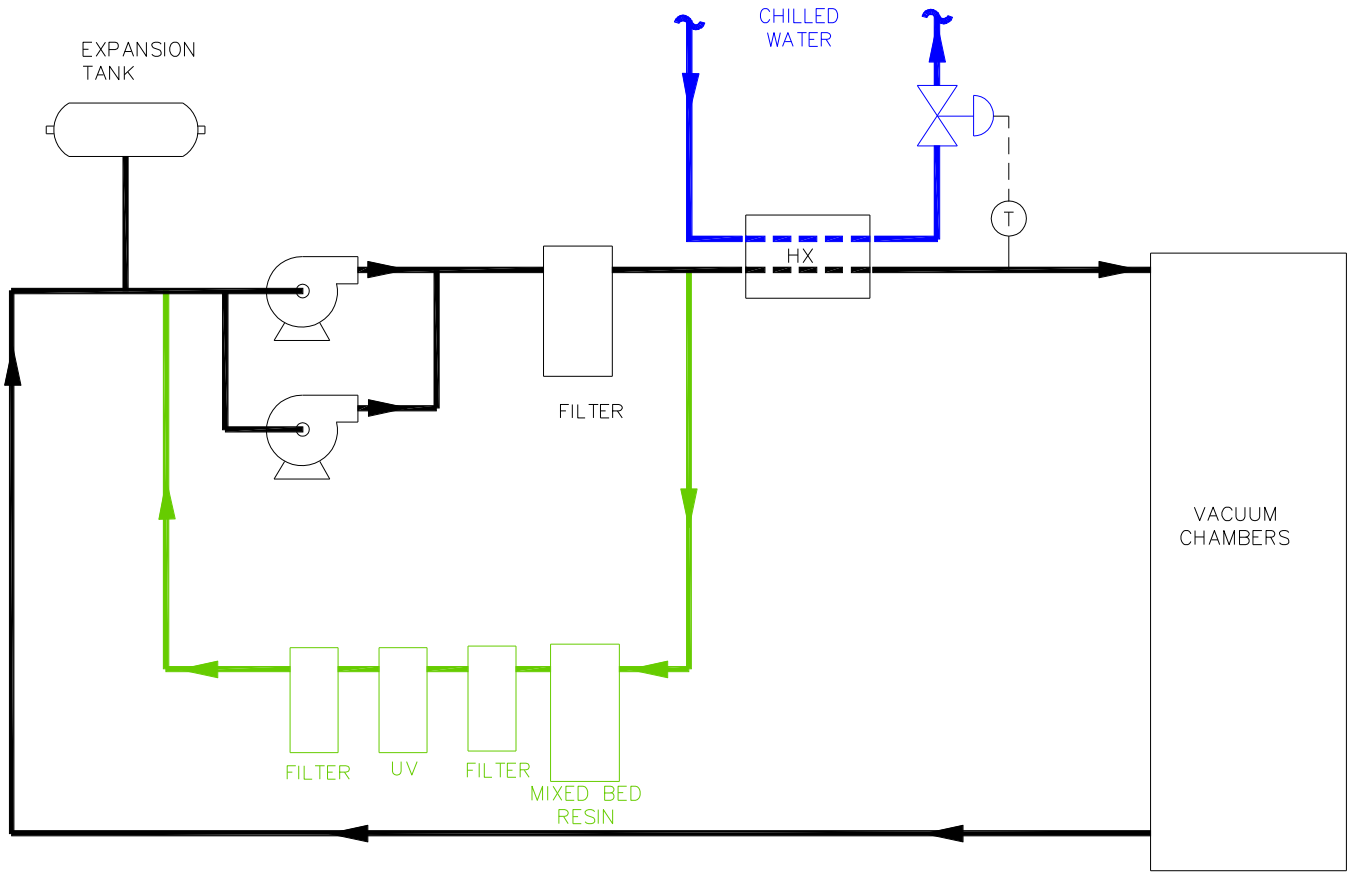
- Heat Recovery Heat Exchanger for outside air pre-heat
- Variable Frequency Drive for reduced flow circulation during shutdown periods



Vacuum Chambers Cooling Skids (aluminum)

- 20 2-pump systems
- 50 GPM / system
- Supply temperature 78 ± 0.1 °F
- 0.5 micron filtration
- 12-16 MΩ-cm resistivity
- UV lights for bacterial control

Vacuum Chambers Cooling Skids



Vacuum Chambers Cooling Skids
Heat Exchanger Replacement

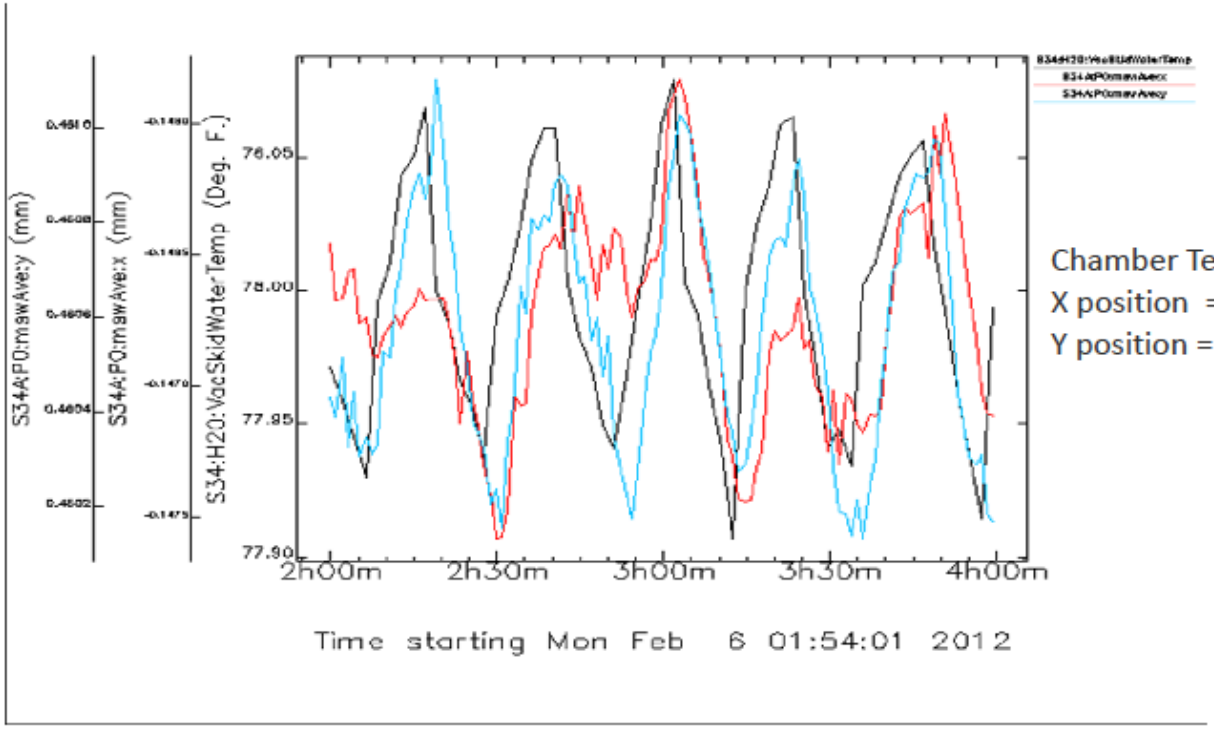
Heat Exchanger Corrosion

Old Plate and Frame Heat Exchanger and New Shell and Tube Type Heat Exchanger

Chilled Water Filter

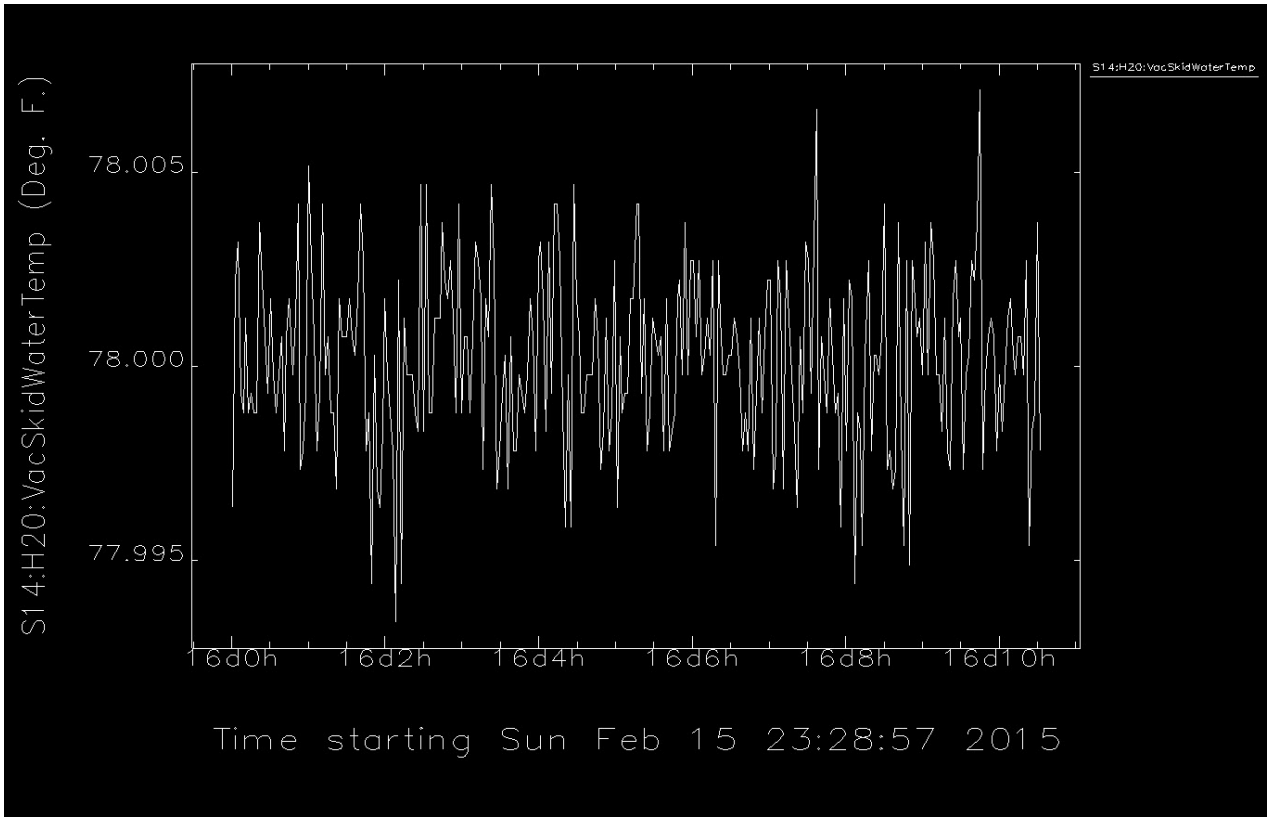
Vacuum Chambers Cooling Skids
Temperature Control R&D

Vacuum Chamber Temperature versus BPM Position
~1µm-1.5 µm /0.18 º F equals ~10-15 microns/ °C



Chamber Temp 0.2°F
X position = 1.5µm
Y position = 1 µm

Vacuum Chambers Cooling Skids
Temperature Control R&D



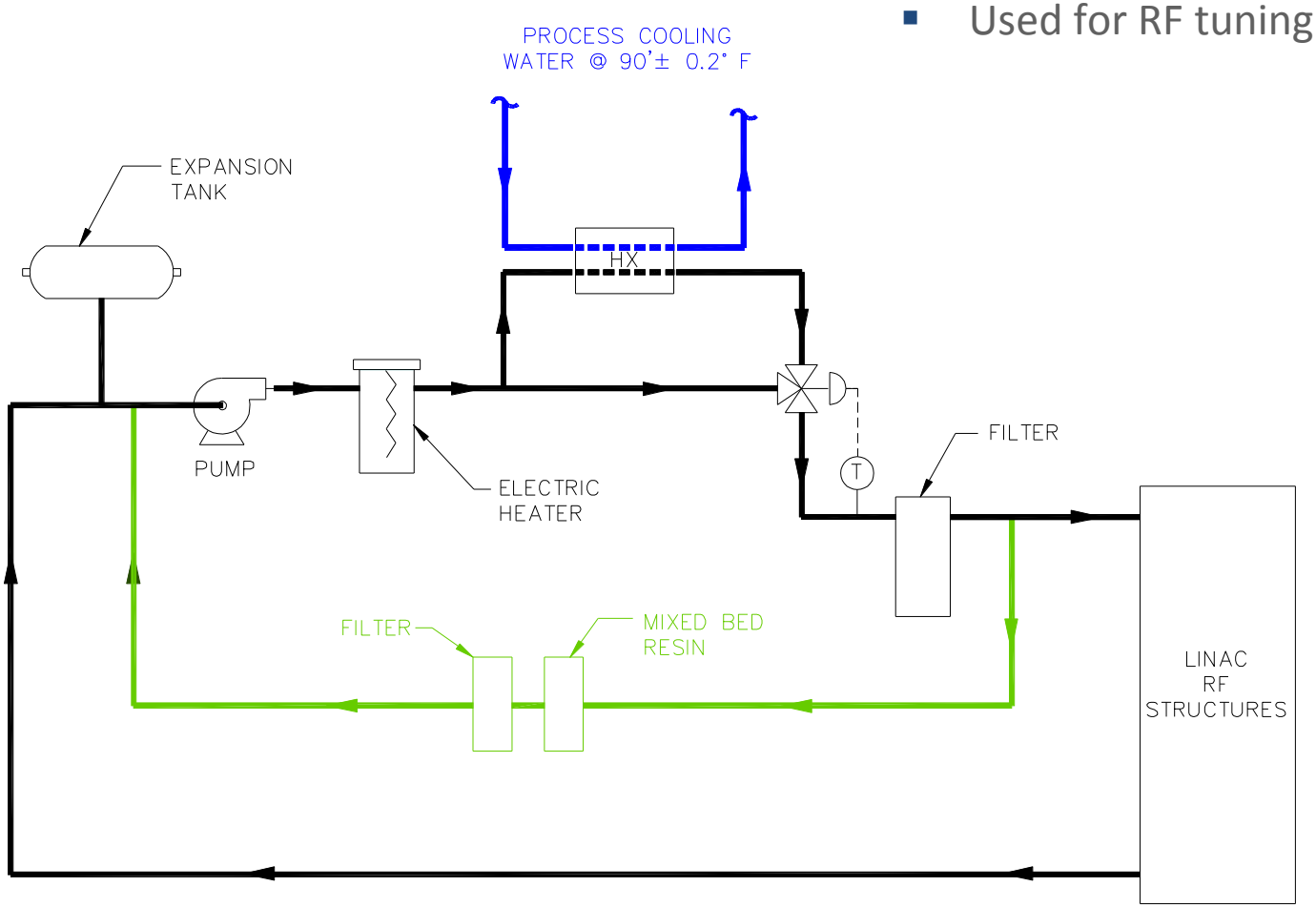
- New HX
- Characterized seat control valve
- Fast response RTD
- Narrow range temperature transmitter
- Improved PID tuning

Linac Skids

- 6 closed loop water skids
- Flow rate: 80 gpm
- Supply pressure: 90 psig
- Supply temperature:100 – 120 °F
- Temperature stability: ±0.05 °F
- Filtration 0.5 micron
- 12-14 MΩ-cm resistivity

Linac Skids

- Our first experience with precision temperature control
- Used for RF tuning



Water Systems
Monitoring and Controls

- Johnson Controls
- Allen-Bradley
- EPICS
- Vibration Monitoring
- Daily Rounds

Front-end flows interlock

Johnson Controls Panel

Beamline PSS flows interlock

Allen-Bradley chassis

Water for Beamlines

- History
- Present

Water for Beamline
History

May 20, 1994

APS TECHNICAL UPDATE - No. 3

Subject: Deionized water supply not available for beamline use

The APS facility deionized water supply provides the cooling for the entire accelerator system. In order to ensure the integrity of this supply, it will not be provided for cooling beamline components. (It had previously been indicated that a limited quantity would available for beamline use.)

Chilled water is supplied to the Experiment Hall for beamline use, refer to *APS Sector Layout Utilities, etc., ANL/APS/TB-9* for the specifications of this supply. When a deionized water cooling system is required for beamline components, a CAT may install a proprietary closed loop system which can reject heat to the chilled water through a heat exchanger.

Water for Beamlines
Original Installations

APS Designed Skid

APS Designed Skid with Modifications

Chiller

User Designed Skid

Connecting Beamlines to APS Water Advantages

- Benefit from system improvements made to APS water systems.
- Operational and maintenance expertise.
- System reliability equal to that of the accelerator water system (>99.5%).
- High quality water supply.
- Eliminate maintenance of pumps, filters, nitrogen, polishing, controls which are part of skids.
- Noise and vibration reduction.
- Improves space utilization.

Connecting Beamlines to APS Water

Concerns

- System modifications and operation shall not jeopardize reliability and operation of APS
  - Temperature and/or pressure fluctuations, contamination, air pockets as a result of

✓ Excessive leaks

✓ Closing and opening of valves

✓ Draining

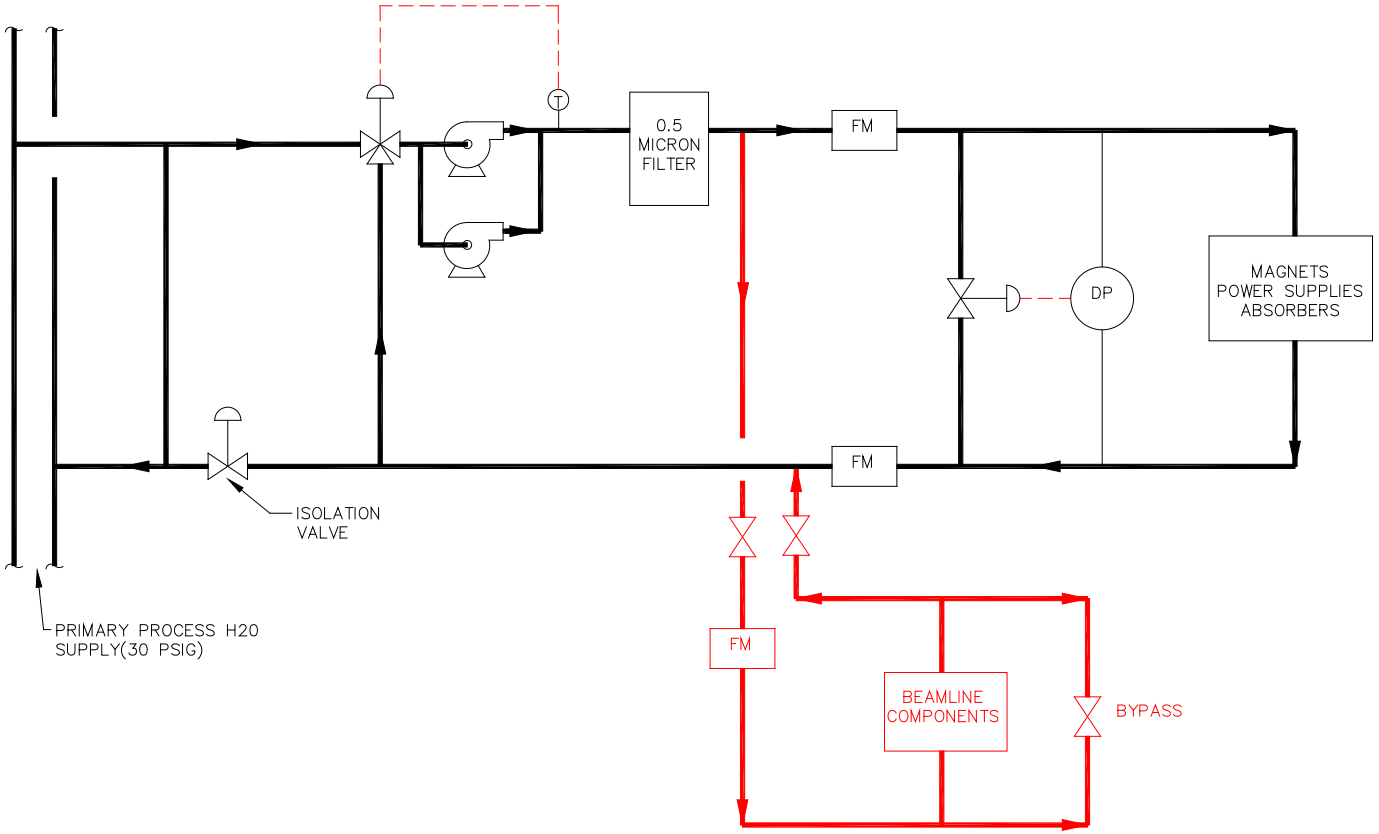
✓ Fill

✓ Contaminated Equipment

Administrative Controls

- APS will work with each CAT to determine water requirements and installation options for system optimization.
- APS will coordinate and complete all water system operation including taking equipment on and off line, draining, fill, new piping installation, existing piping modifications etc.

Connecting Beamlines to APS Water



Other Supported Water Systems

BAKEOUT SKIDS

CITRANOX FLUSHING CARTS

GRAVITY FED SYSTEMS

CHILLERS

Lessons Learned

- Troubleshooting is best done outside of controlled areas
  - Locate flow meters, temperature sensors, pressure transmitters… outside of tunnels if possible
- Minimize Instrumentation
  - Combine flow circuits where possible
  - Most of the faults are instrumentation related
- Use radiation resistant materials where applicable
- Leaks more often than not occur due to hoses
- Use high quality reliable equipment
- Noise bothers people
- Plan for future

Lessons Learned

- Recommended flow meters
  - V-cone/Yokogawa DPT

- Flow throttling

Current Challenges

- Equipment Obsolescence and Aging
- Budgets and manpower constraints
- Retiring Staff

Future (APS-U)

- Evolving Criteria
- Vibration Mitigation
- Temperature Control
- Capacity Adjustments
- Retaining current equipment