

Primary Beamline Target Hall RAW Exchange System Preliminary Design Review

Technical Design Aspects

Raina Wang

February 19, 2020



Purpose and Scope

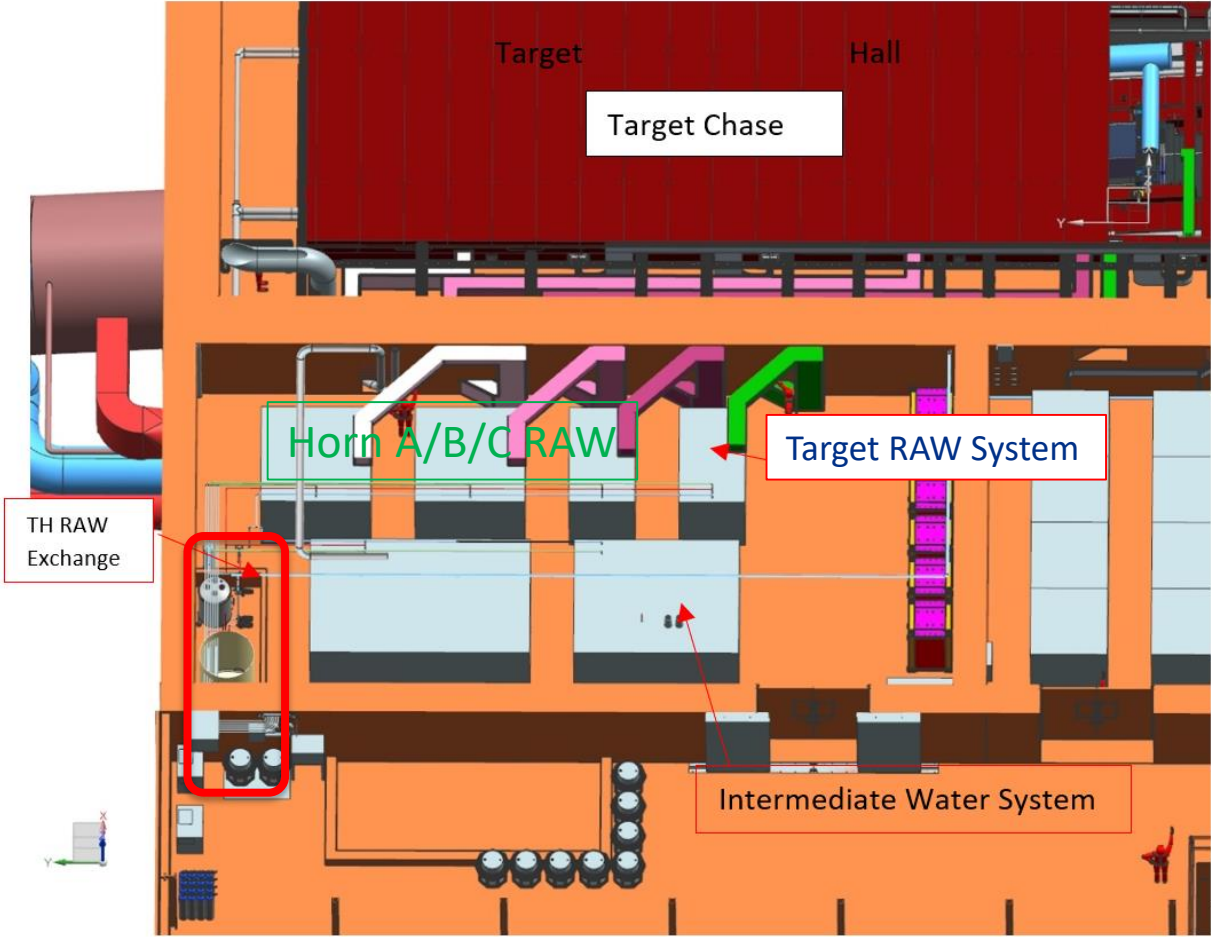
- Preliminary design of the Target Hall (TH) RAW Exchange System for the 2.4MW beamline radioactive cooling water (RAW) systems of LBNF project
- Includes four independent functional sections:
 - Make-up supply or Fill of low conductivity water (LCW) to all the five RAW and Intermediate Water Systems in the same RAW room of the Target Hall Complex :
 - Target RAW system – Target Mount, Hanger, Helium heat exchanger, and Baffle
 - Horn A RAW system
 - Horn B RAW system
 - Horn C RAW system
 - Target Shield Pile Cooling Panel RAW system
 - Intermediate Water System
 - Burping or periodically removing predetermined quantity of RAW from the 5 RAW systems during operation to reduce the contamination concentration of the RAW and thus maintain required cooling water quality.
 - Draining all 6 or any single RAW cooling system and intermediate water system completely during repair and maintenance modes
 - Transferring all the drained RAW or wastewater into radiation safe drums located outside of Target Hall for radioactive waste safe disposal – hauling offsite

Purpose and Scope – Cont.

- A stand along area in the RAW room: equipment, pipes, valves, fittings, and field installed instruments
- Piping and piping components between 6 pumps in this system and the 6 RAW skids and Intermediate Water system
 - except their first valve if there is one.
- Mechanical techniques for mitigating radiation risks
- All other EHS related radiation dose rate evaluations and control are excluded from this system
 - They are the work scope of ESH or Radiation Physicist Department

Purpose and Scope – Cont.

Picture 1: TH RAW System Skid Location in Target Hall Complex



Design Standards and Codes

In addition to comply with the following industrial and Fermilab standards and codes, the system design, particularly the system's operation modes, capacity, and valve regulating & controls, is mainly based on Numi/Nova systems' operational experience, lessons learned, and the latest feedback in operational input and upgrades.

- ASME B31.3 Code for Normal Fluid Service
- ASME BPVC Section IX for Welding Process Specifications (WPS's) and welders & pipefitters' Personal Weld Qualifications
- Both piping and vessels will adhere to FESHM Chapter 5031, as well as the Fermilab Engineering Manual
- ASTM-D-1998-15, Standard Specification for Polyethylene Upright Storage Tanks

Design Requirements - General

- Safe, Reliable, and Economic
- Convenient for maintenance
- Meet water quality and capacity of operational requirements for:
 - 1.2MW beamline – first phase
 - 2.4 MW beamline – 2nd phase as Designed phase
- Design depth – sufficient for cost estimating for Project Budget

Design Capacity

- depends on operation modes

- Operation Modes

Every functional section is required to be in operating one skid unit each time per Numi operation procedure

- meaning that no two systems will be running simultaneously,

- Capacity sizing: Thus, the equipment and piping header of every functional section is sized at the same flow rate of every single unit's flow rate

- Detailed design capacity and pressure of all sections are summarized in Table -1

Design Capacity

Table -1 Design Capacity - Provided By Fermilab Operation Engineers						
#	Functional Section	System Name	Fluid	Flow Rate (GPM)	Pressure (Psig)	
					Source	Destination
1	Make-up fill to storage tank	LCW Storage Tank	LCW	16	150	5
2	Fill - Fill only one skid each time	Target Baffle RAW System	LCW	8	5 LCW storage tank	5
		Horn A RAW System				0
		Horn B RAW System				0
		Horn C RAW System				0
		Target Chase Cooling Panel RAW System				5
3	Burp - burping only one skid each time	Target Baffle RAW System	RAW	12	80 120 120 120 60	0
		Horn A RAW System				0
		Horn B RAW System				0
		Horn C RAW System				0
		Target Chase Cooling Panel RAW System				0
4	Drain to RAW holding tank - drain only one skid each time	Target Baffle RAW System	RAW	40	8 3 3 3 10	0
		Horn A RAW System				
		Horn B RAW System				
		Horn C RAW System				
		Target Chase Cooling Panel RAW System				
	Drain LCW to waste capture tank or outdoor floor drain	Intermediate LCW system	LCW	14	0	0
5	Drain RAW transfer to disposal - transfer only one skid each time	From RAW holding tank		30	0 RAW holding tank	0 RAW waste capture drum

Detailed pump and piping sizing - see AFT Fathom simulation doc #:

Equipment Selection and Sizing

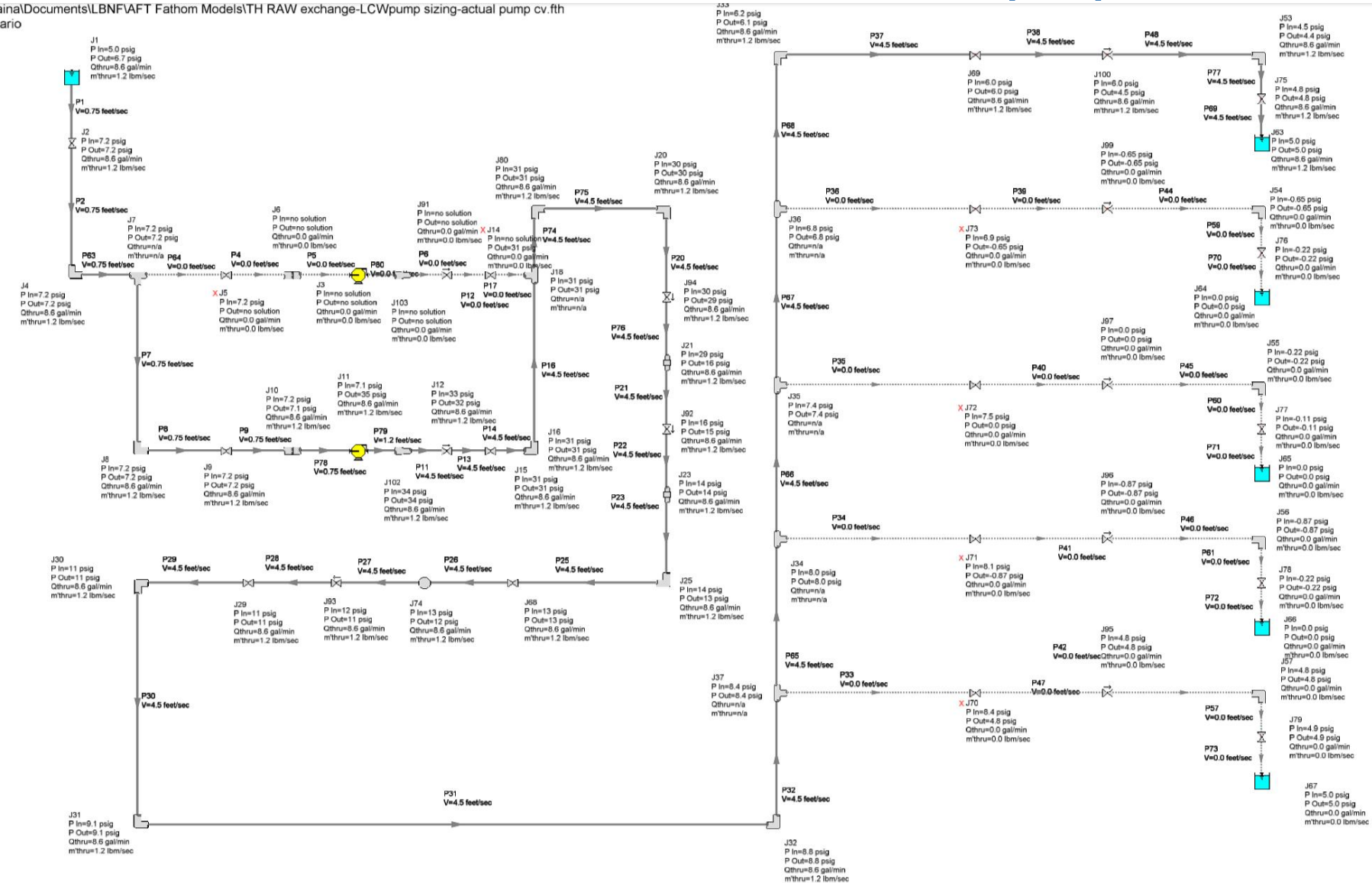
– Pumps, Piping, Pressure Regulators

- Sizing method: Hydraulic simulation
- Sizing technology: AFT Fathom software, version 9
- Multiple operation modes simulated:
 - LCW filling pump sizing
 - RAW skid drain Inline pump sizing
 - RAW transfer pump sizing
 - 5 RAW burping pressure regulator sizing
 - Burping pressure: 60 to 120 psig
 - Destination pressure at RAW holding tank: Atm. P

Equipment Selection and Sizing

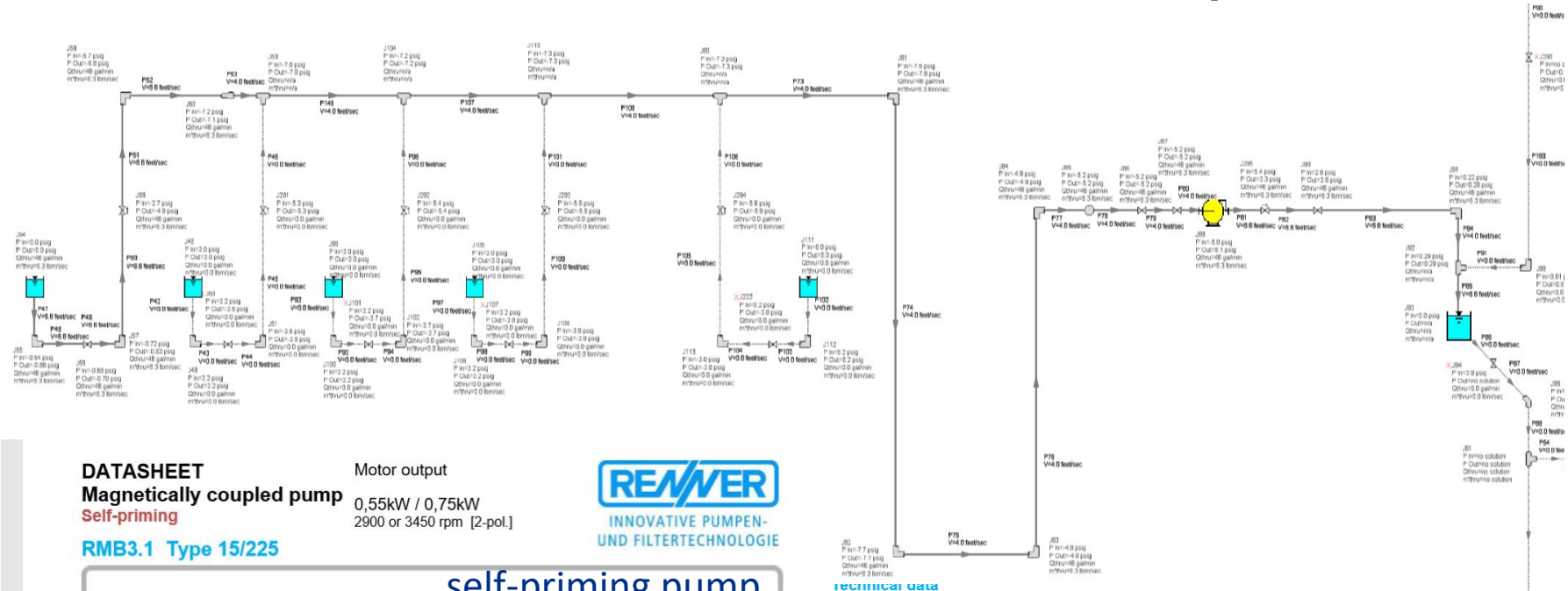
- AFT Fathom Simulation Results - LCW pumps

C:\Users\raina\Documents\LBNFAFT Fathom Models\TH RAW exchange-LCWpump sizing-actual pump cv.fth
Base Scenario



Equipment Selection and Sizing

- AFT Fathom Simulation Results - Inline Pump Selected



DATASHEET
Magnetically coupled pump
Self-priming
RMB3.1 Type 15/225

Motor output
0,55kW / 0,75kW
2900 or 3450 rpm [2-pol.]

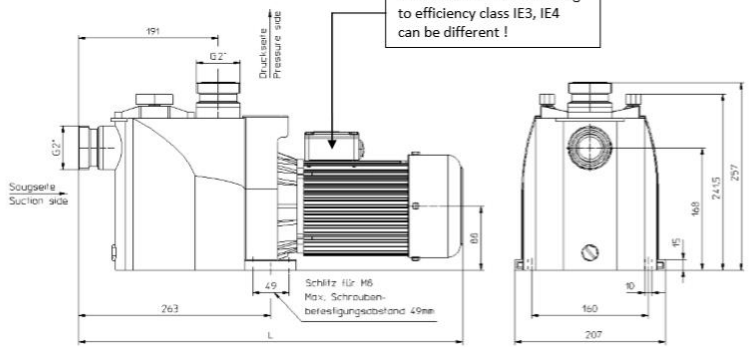


self-priming pump

Dimensional drawings [mm]

Motor output 0,55kW - 0,75kW IE2 (Material PP)

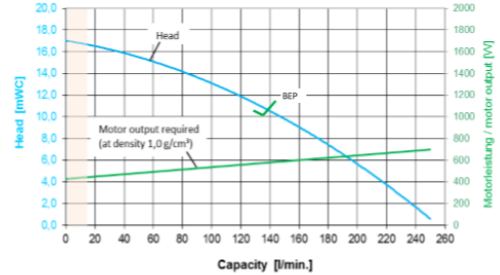
Motor dimensions according to efficiency class IE3, IE4 can be different!



technical data

Medium-temperature max.	PP PVDF	65 °C 85 °C
System-pressure max.	PP PVDF	2,5 bar 3,5 bar
Viscosity	< 160 Pa s	
Electrical motor	3-ph. motors, 50 and 60Hz, IE2, IE3 or IE4 Protection IP55, Isolationclass F, Chemical resistant 2K- painting RAL5011	
Options	Thermal protection, other voltages / frequencies, UL, CSA, Special paintings and colors	

Flow curves RMB3.1 - 15/225



Speed: 2900 rpm @ 50Hz or 3450 rpm @ 60Hz

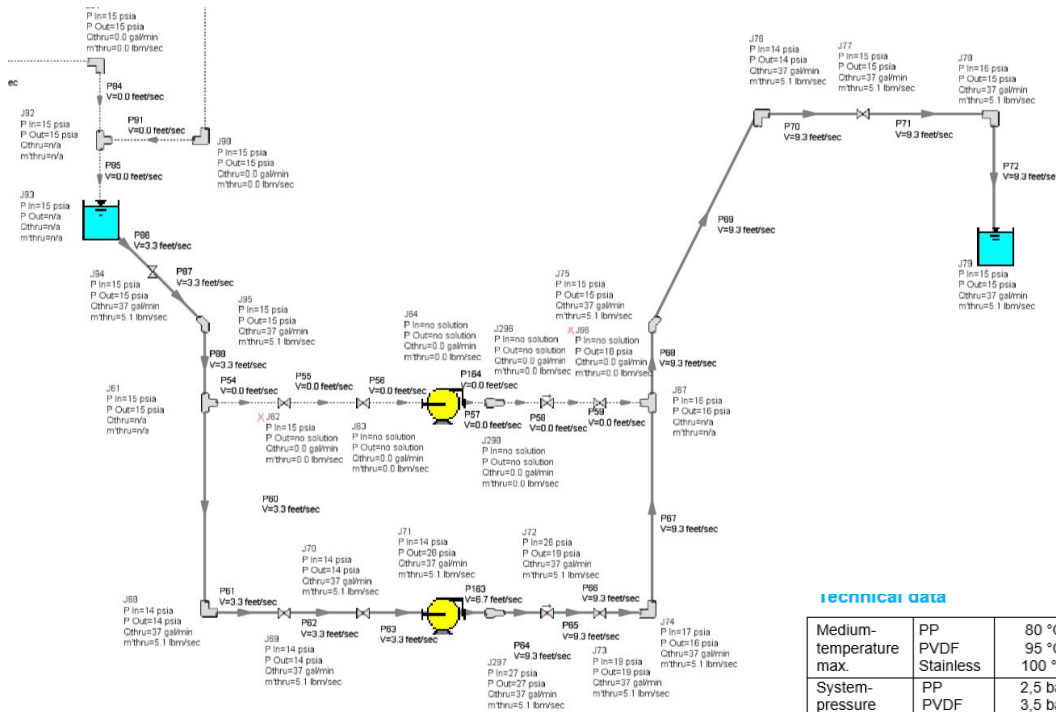
Values based on water at 20 °C (68 °F) / Measured value +/- 10%

Subject to technical alterations!



Equipment Selection and Sizing

- AFT Fathom Simulation Results - Transfer Pumps Selected



DATASHEET
Magnetically coupled pump

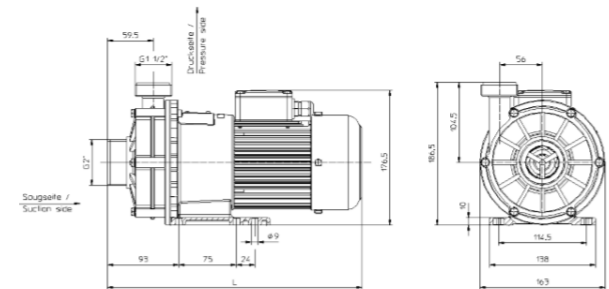
RM 3 - 16/200

Motor output
0,55kW ; 0,75kW ; 1,1kW
2900 or 3450 rpm [2-pol.]



Dimensional drawings [mm]

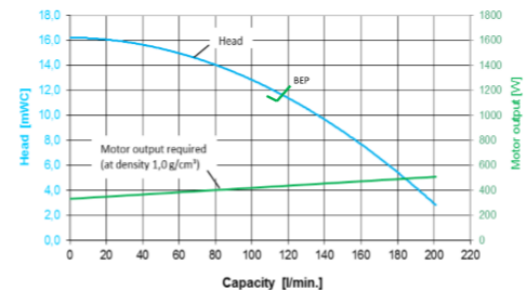
Motor output 0,55kW 2-pol.



Technical data

Medium-temperature max.	PP PVDF Stainless	80 °C 95 °C 100 °C
System-pressure max.	PP PVDF Stainless	2,5 bar 3,5 bar 8,0 bar
Viscosity	< 160 Pa s	
Electrical motor	3-ph. motors, 50 and 60Hz, IE2, IE3 or IE4 Protection IP55, Isolationclass F , Chemical resistant 2K- painting RAL5011	
Options	Thermal protection, other voltages / frequencies, UL, CSA, Special paintings and colors	

Flow curves RM3 - 16/200



Speed: 2900 rpm @ 50Hz or 3450 rpm @ 60Hz

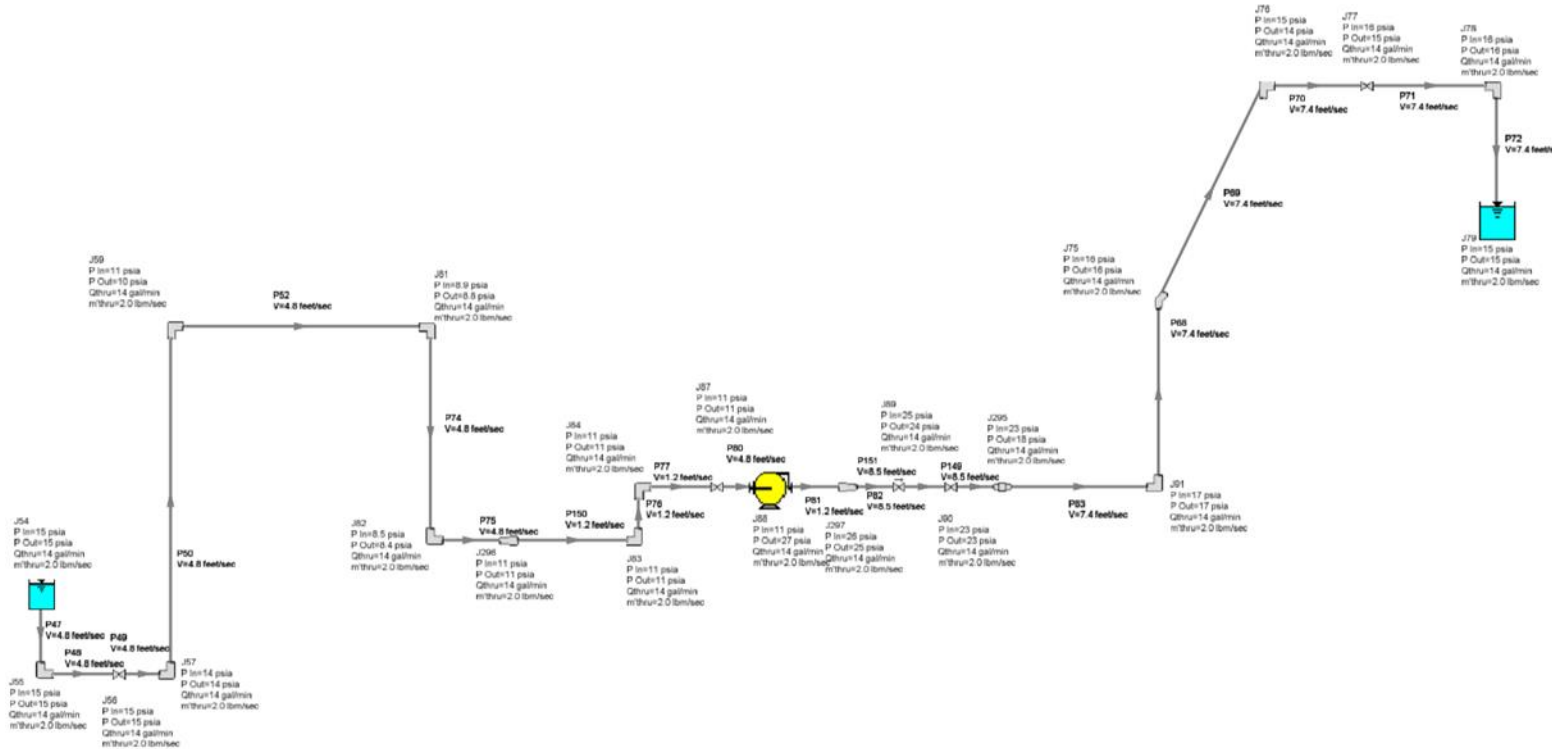
Values based on water at 20 °C (68 °F) / Measured value +/- 10%

Subject to technical alterations !



Equipment Selection and Sizing

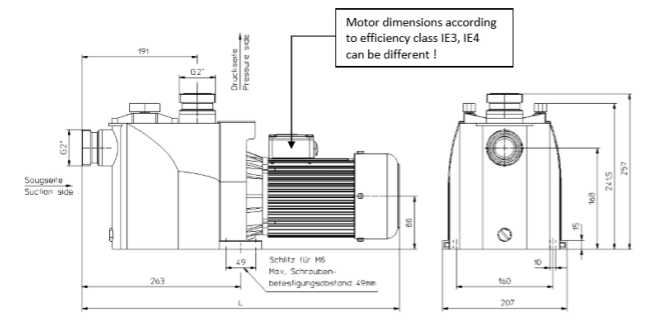
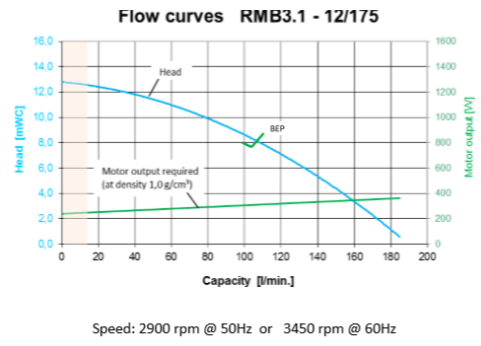
– AFT Fathom Simulation Results – Intermediate Water System Drain Pump Selected



Dimensional drawings [mm]

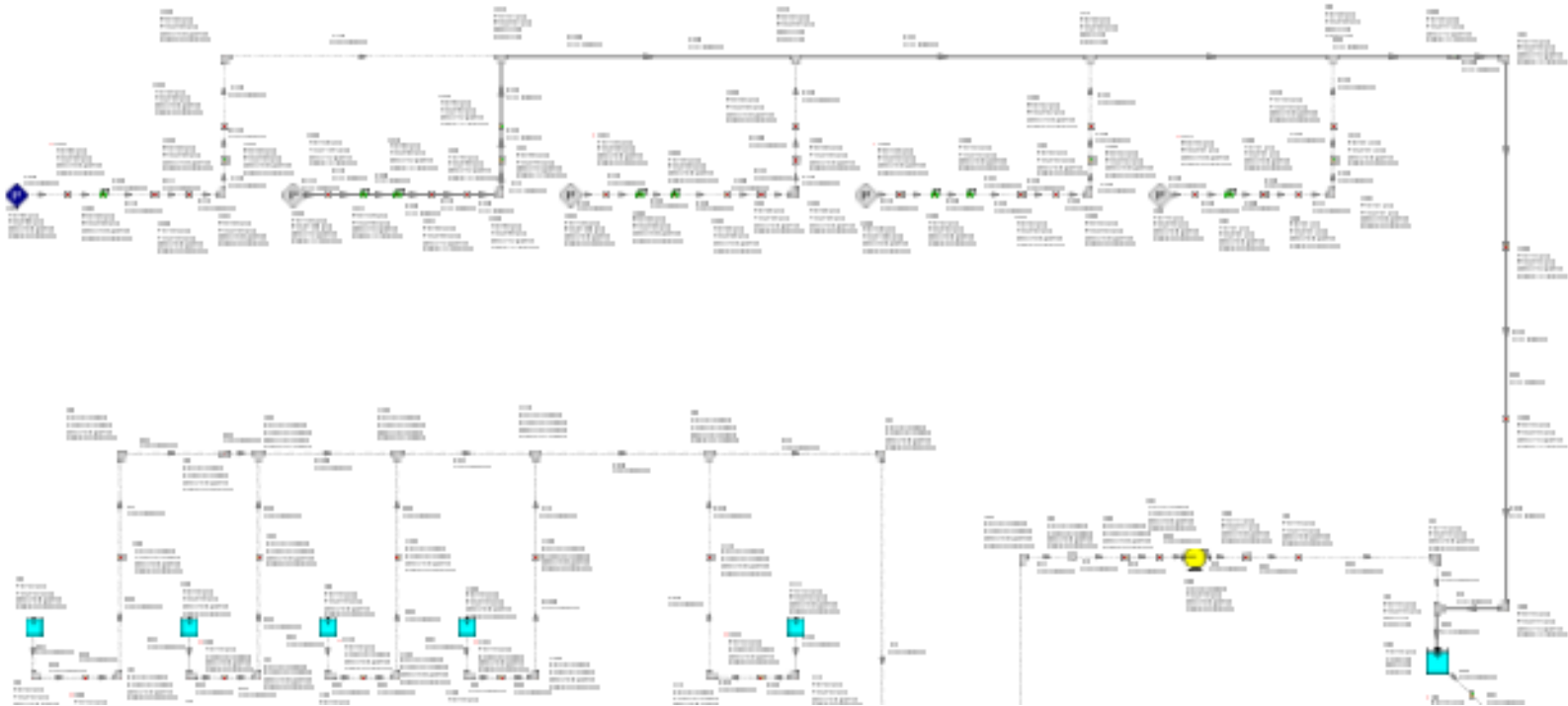
Motor output 0,55kW – 0,75kW IE2 (Material PP)

Temperature max.	100 °C	100 °C
System-pressure max.	PP PVDF	2,5 bar 3,5 bar
Viscosity	< 160 Pa s	
Electrical motor	3-ph. motors, 50 and 60Hz, IE2, IE3 or IE4 Protection IP55, Isolationclass F, Chemical resistant 2K-painting RAL5011	
Options	Thermal protection, other voltages / frequencies, UL, CSA, Special paintings and colors	



Equipment Selection and Sizing

– AFT Fathom Simulation Results – Horn A RAW Burping Regulator sizing



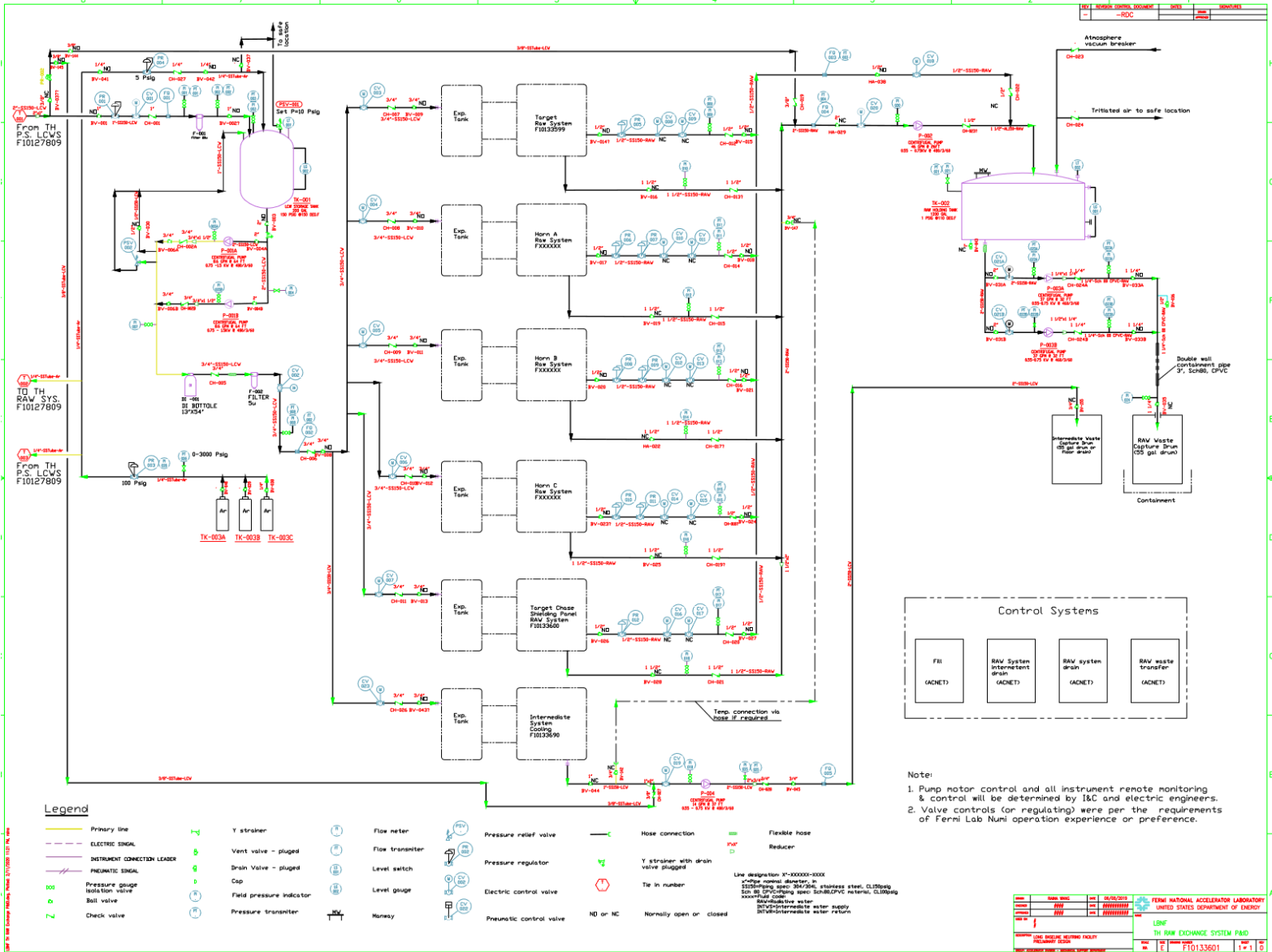
- RAW burping simulations of other 4 RAW skids is similar to Horn A's
- Results of 5 operation modes simulated:
 - Initial burping @ 80 and 120 psig – 2 Pressure regulators
 - Different setting pressure needed.

Equipment Selection and Sizing – Cont.

- Detailed Equipment List and Spec

LBNF Target Hall RAW Exchange System - Equipment List and Specification														
#	Tag #	Name	Quantity	Type or model number	Service Fluid	Operating / Design Condition						Materials	Manufacturer / Vendor	Notes
						Flow rate (GPM) or volume		Pressure (Psig)		Temperature (°F)				
						Operating	Design	Operating	Design	Operating	Design			
1	TK-001	LCW storage tank	1	SST-200 gallons vertical economy finish vessel 36" dia x 48" s/s x84" OAH w. nozzles per P&ID	Low conductivity water		200 Gallon	5	50 Psig internal / full vacuum external Per ASME BPVC VIII, Div. I	55 - 85	150	304L SS	BEFCO, Inc.	Price=cost quoted in Oct. 2018+5%
2	TK-002	RAW holding tank	1	POLYPROCESSING IMFO TANK Full-drain vertic. DIA: 5' / HT: 10' 17" threaded lid 2" reverse float level gauge assy 4" tall HDXLPE pad 6" VACUUM BREAKER ASSY w. nozzles per P&ID STDs & codes: ASTM D1998-15, B16.5, ASCE 7-16, and relevant plastic material STDs & codes	Low conductivity water		1200 Gallon	Amb.	Amb. + RAW height	55 - 85	120	High density XLPE, B16.5 CL150 flanges, SS bolts & nuts, EPDM gaskets	Poly Processing / Semler Industries, Inc.	30% quoted cost is considered for possible custom engineering
3	TK-003A/B/C	Ar storage tank	3	3AA2015	Ar		200 CF	2015		Amb.		CS		
4	P-001A/B	Centrigugal pump	2	RENNER RM-VA-EGKPE 8 GPM @ 58 TDH, 0.75 KW mag. motor @480V/3Phase/60Hz Inlet/outlet nozzle size: 1" / 3/4"	Radioactive water	8	8.6		64 FT W. TDH	55 - 85	140	SS316 body & PEEK neck ring	Renner / FLUX Pumps Corporation	
5	P-002	Inling self-priming centrigugal pump	1	RENNER RM-VA-EGKPE 40 GPM @ 23 TDH, 1.1 KW mag. motor @480V/3Phase/60Hz Inlet/outlet nozzle size: 2" / 1 1/2"	Radioactive water	40	40		23 FT W. TDH	55 - 85	140	PVDF	Renner / FLUX Pumps Corporation	
6	P-003A/B	Centrigugal pump	2	RENNER RM-VA-EGKPE 30 GPM @ 32 TDH, 0.75 KW mag. motor @480V/3Phase/60Hz Inlet/outlet nozzle size: 1 1/2" / 1"	Radioactive water	30	30		32 FT W. TDH	55 - 85	140	SS316 body & PEEK neck ring	Renner / FLUX Pumps Corporation	
7	P-004	Centrigugal pump	1	RENNER RMB-PVDF-VGKXK-12/175-30S(30S)-0.75/3-IE3 10 GPM @ 19 TDH, 0.55 - 0.75 KW mag. motor @480V/3Phase/60Hz Inlet/outlet nozzle size: 1" / 3/4"	Low conductivity water	10	10		18 FT W. TDH	70 - 85	150	SS316 body & PEEK neck ring	Renner / FLUX Pumps Corporation	
8	DI-101	Deionization bottles	1	SF-270- FER mixed bed PEDI 13"x54" Fiberglass tank 3.6 cubic feet of Dow IRN-150 mixed bed resin ¼ NPT in/Out with ¼" vent and ¼" riser	Low conductivity water	8	15	30	150	85	120	Fiberglass tank	Calco LTD	Price includes shipping
9	F-001	Signle cartridge filter - µ20	1	Full α® B5SB Filter Vessel B5SB-30-15D 1"NPT, VITON O-RINGS	Low conductivity water	16	16	125	150	70	140	316 SS	Parker / Instrument Associates	
10	F-002	Signle cartridge filter - µ5	1	Full α® B5SB Filter Vessel B5SB-30-15D 1"NPT, VITON O-RINGS	Low conductivity water	8	15	0 - 20	150	70	140	316 SS	Parker / Instrument Associates	
11	TK-004	CIP - spill containment tank	1	15.5' x 6' x 2' (tall) bottom plate thickness: 3/16" shell thickness: 1/4"	Radioactive water		1200 Gallon	Amb.	Amb.	55 - 85	140	A240M, Type 304	Field fabrication @ Fermi Lab	
		Total cost \$												

Process Flow – Piping & Instrumentation Diagram



Water Quality Control

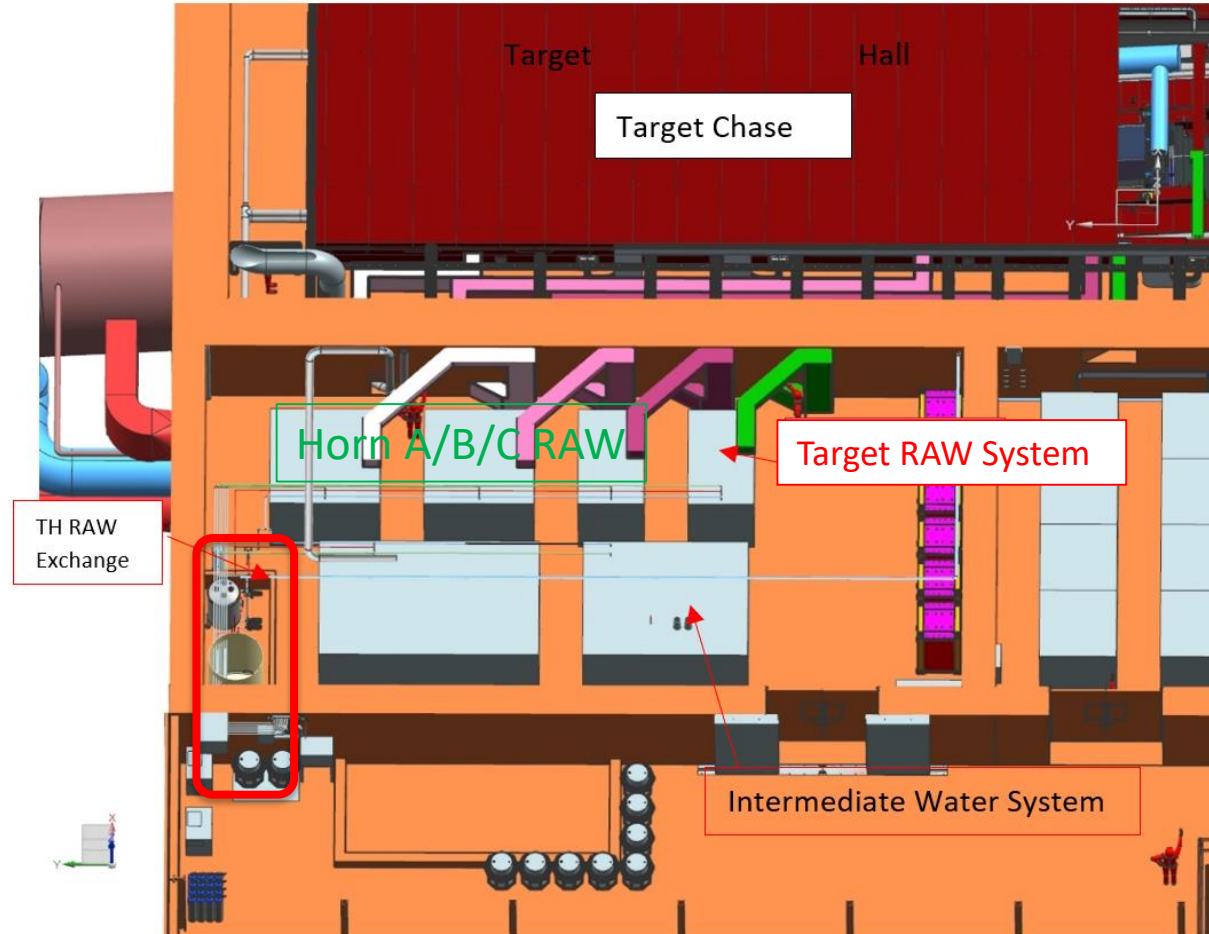
- The initial water supply for filling is pretreated city water from Fermilab LBNF Target Hall Power Supply Room (see P&ID drawing F10127809).
- It is then filtered by two stage cartridge filters:
 - one 20 μ m
 - one 5 μ m ultrafine
 - Control ultimate impurity particle size below 5 μ m for all the downstream users
- One Fermilab conventional DI bottles is used for controlling water resistivity within a range of 4 to 8 M Ω \times cm.
- Argon gas blanketing for the storage tank - To preventing contamination gas such as CO₂ from entering the system

ESH – Radiation Risk Control

- Risks:
 - Initial LCW - to be radioactivated after short running of those RAW cooling skids – becoming RAW
- The following mechanical techniques are used for mitigating RAW radiation risks and increase system reliability:
 - Radiation hardened materials are selected for all equipment and piping components
 - Clean in place containment tanks and warning alarms are designed to prevent spills and contamination of the soil and surface waters
 - Remotely controlled drainage and top up with fresh water will be used to keep the tritium concentrations at manageable levels. Wastewater will be disposed of as low-level radioactive waste after cooling-down
 - Electronic devices such as fluid measurement transmitters will be installed further away from the high radiation area to prevent radiation degradation

Equipment and Piping Layout - 3D Top View

Picture 1: TH RAW System Skid Location in Target Hall Complex

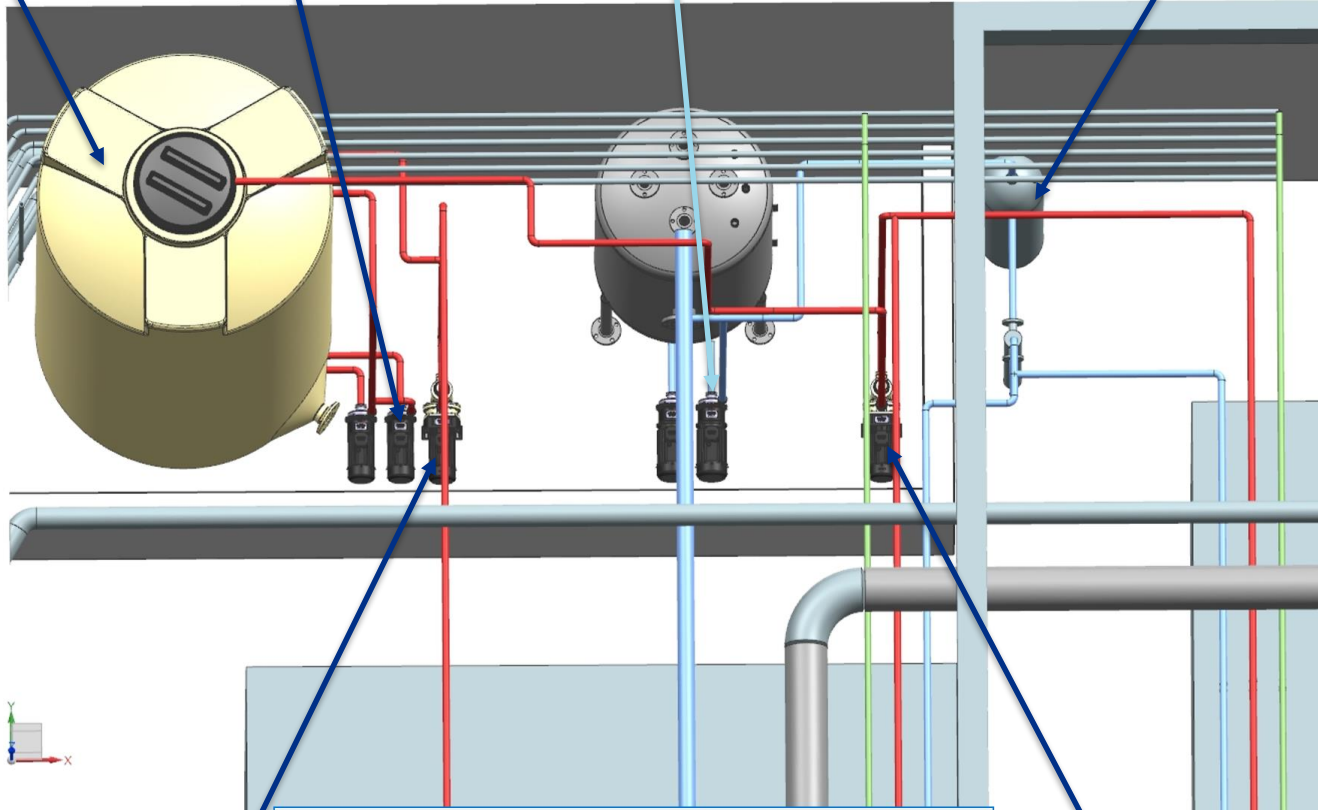


Equipment and Piping Layout - 3D View, area detail

RAW holding tank, 1200 Gal
Poly material & transfer pumps

LCW storage tank
200 Gal & pumps

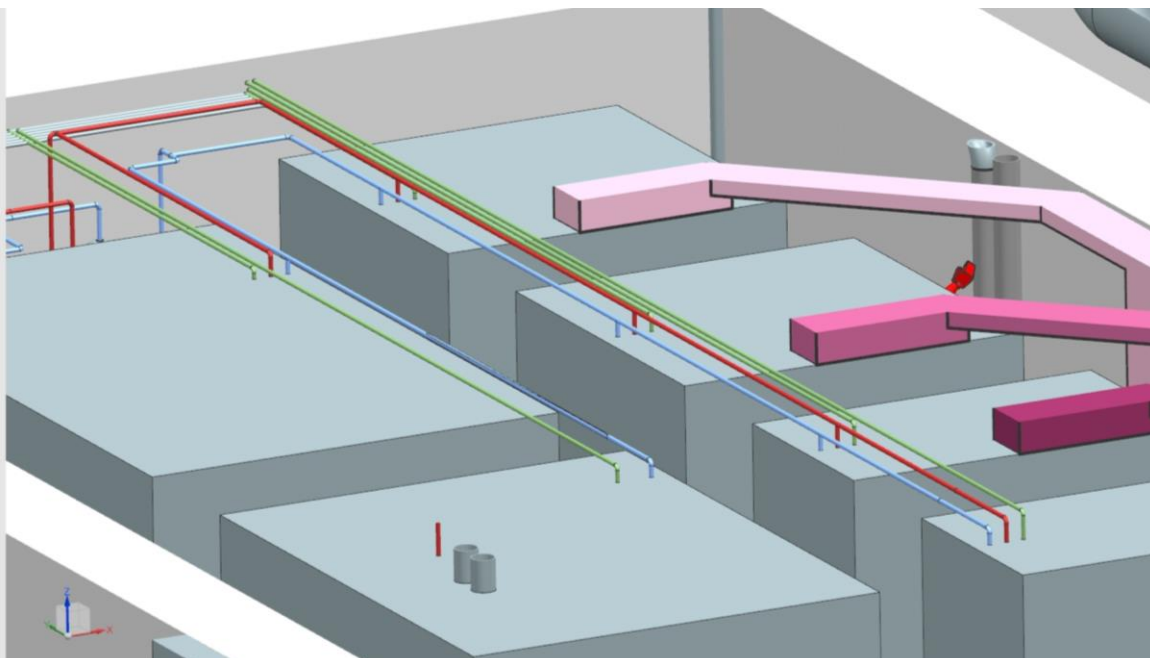
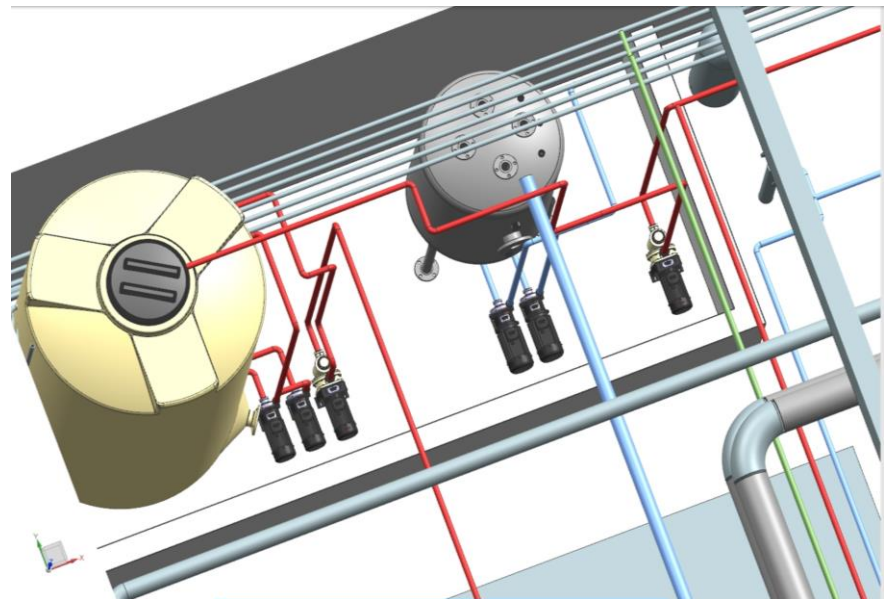
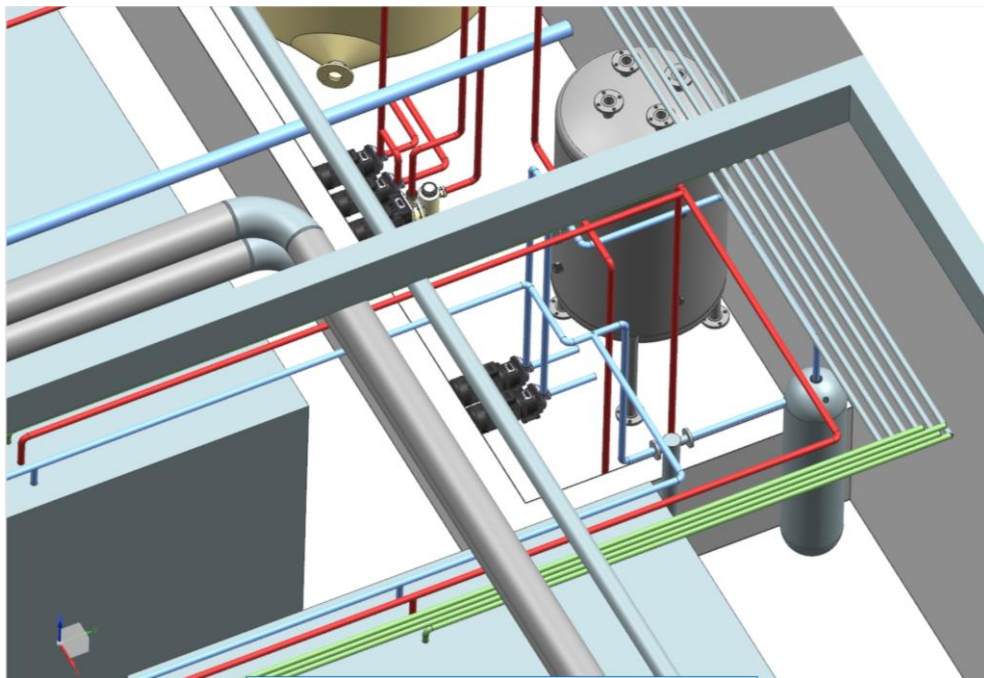
DI bottle & Filter



Intermediate water system
drain pump

Inline pump - burping

Equipment and Piping Layout - 3D View



Questions?

Thank You!

By Raina Wang

Mechanical Beamline Engineer

Feb. 19, 2020

Equipment Selection and Sizing

– 1200 Gal Holding Tank



NEXT LEVEL FULL DRAIN TANK SOLUTIONS

Sloped Bottom IMFO®: integrally molded outlet with sloped floor



Traditional tank maintenance can be a challenge with many chemicals – so Poly has designed and engineered a unique sloped bottom tank system that greatly minimizes the hazards associated with traditional vertical tank maintenance. With Poly Processing's Sloped Bottom Integrally Molded Flanged Outlet tank, or IMFO® system, the flange is molded while the tank is processing, making it a stress-free part of the tank. The floor of the tank is sloped towards the IMFO giving the user the greatest possible full drain system in a vertical tank design.

The Sloped Bottom IMFO's advantages are many:

- The flange is at the bottom of the tank and the tank floor is sloped, therefore complete full drainage is achieved below the tank knuckle radius, which eliminates the need to enter the tank for cleaning.
- One-piece construction enhances long-term performance of the tank, since it doesn't compromise the tank hoop's integrity or structural design.
- In aggressive applications, the complete flange face is protected by the antioxidant OR-1000™ system.
- The Sloped Bottom IMFO allows even heavier materials such as sludge, FOG, and thicker chemicals to discharge completely.

Equipment Selection and Sizing

– LCW Pumps Selected

DATASHEET Magnetically coupled pump

RM 3 – 20/200

Motor output
0,75kW ; 1,1kW ; 1,5kW
2900 or 3450 rpm [2-pol.]



DATASHEET Magnetically coupled pump

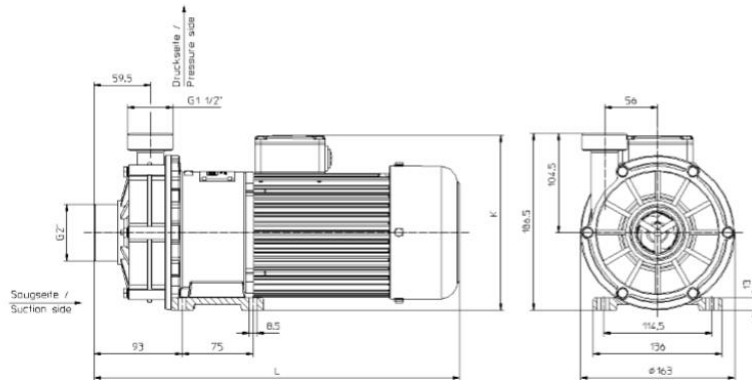
RM 3 – 20/200

Motor output
0,75kW ; 1,1kW ; 1,5kW
2900 or 3450 rpm [2-pol.]



Dimensional drawings [mm]

Motor output 0,75kW – 1,5kW 2-pol.



Magnetically coupled, centrifugal pumps, single-stage, horizontal, non self-priming, made in monobloc design.

		RM3 - 20/200		
		0,75	1,1	1,5
Motor output	[kW]	0,75	1,1	1,5
Rated current @ 400V 50Hz 3ph.	[A]	1,9	3,0	3,25
Rated current @ 230V 50Hz 1ph.	[A]	4,8	6,4	8,2
Head max.	[mWS]	20	20	20
Capacity max.	[l/min.]	200	200	200
Density max. @ Qmax	[g/cm³]	1,1	1,6	2,2
Length „L“	[mm]	387	400	400

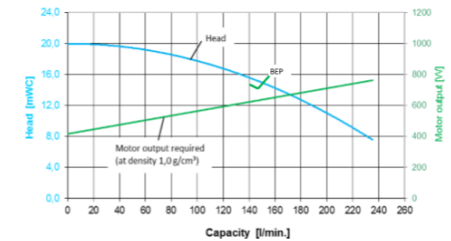
Materials:



Technical data

Medium-temperature max.	PP PVDF Stainless	80 °C 95 °C 100 °C
System-pressure max.	PP PVDF Stainless	2,5 bar 3,5 bar 8,0 bar
Viscosity	< 160 Pa s	
Electrical motor	3-ph. motors, 50 and 60Hz, IE2, IE3 or IE4 Protection IP55, Isolationclass F, Chemical resistant 2K- painting RAL5011	
Options	Thermal protection, other voltages / frequencies UL, CSA, Special paintings and colors	

Flow curves RM3 - 20/200



Speed: 2900 rpm @ 50Hz or 3450 rpm @ 60Hz

Values based on water at 20 °C (68 °F) / Measured value +/- 10%

Subject to technical alterations !

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Fermilab

Field Instruments and Valve List & Spec _ Page 1 of 3

Target Hall RAW Exchange System - Field Instruments and Valve List / Spec / Cost Estimate																
#	Tag #	Name	Pipe conn. Size (in)	Type / Model or Spec	Locations	Operating / Design Condition						Materials	Quantity	Reference Manufacturer / Vendor	Notes	
						Service Fluid	Flow rate (GPM) or volume		Pressure (Psig)		Temperature (°F)					
							Operating	Design	Operating	Design	Operating					Design
1	LG-001	Tank level indicator		SureSite® Standard Alloy Visual Level Gauge 316 SS housing 2 1/2" EPDM or Viton seal Mounting type DA 1" MNPT connection	TK-001 LCW tank side	LCW			5	100	55 - 110	150	316 SS	1	Sure Site / Gems Sensors & Controls	
2	LT-001	Tank level transmitter		Low temperature: 300 deg.F 4 - 20 mA Output	LG-001 level gauge top	LCW		Level range: 0-5 ft	5		55 - 85	150	Requires to be radiation hardened	1		
3	LT-002	Tank level transmitter		Centurion CGR Level Transmitter with 1" MNPT process connection, pushbuttons and display, non EX approvals, aluminum powder coated housing, IP66/IP68, 2-wire output with HART, -40°F to +176°F, 108x108" 316 stainless steel ROD Probe	TK-002 RAW holding tank top	RAW		Level range: 0-9 ft	Amb.	Amb.	55 - 85	150	Requires to be radiation hardened	1	Hawk Measurement	
4	PR-001	Pressure regulator	1	EB-25 SS, outlet pressure range 20-90 psi	TK-001 LCW tank inlet	RAW	16	20	Inlet 135-145 Outlet 45	150		150	ss body and trim EPDM seal	1	Cash ACME	
5	PR-002	Pressure regulator	1/2	EB-25 SS, outlet pressure range 20-50 psi	Priming line of inline pump	LCW			Inlet 135-145 Outlet 45	150		150	ss body and trim EPDM or Viton seal	1		
6	PR-003	Pressure regulator	1/4	Dual Stage Regulator: 0-100 Psig delivery - CGA 580 Part# Y12C445D580-AG	Ar tank outlet	Ar			Inlet 2105 / outlet 100	4000	Amb.	150	316 SS body and trim, PCTFE seat, Inconel spring	1	Airgas	
7	PR-004	Pressure regulator	1/4	Dual Stage Regulator - 0-30 PSI Delivery - CGA 580 Part# Y12C445A580-AG	TK-001 tank Ar blanket inlet	Ar			Inlet 100 / outlet 5	4000	Amb.	150	316 SS body and trim, PCTFE seat, Inconel spring	1	Airgas	
8	PR-005	Pressure regulator	1/2	SS-264AP, pressure adjustment range 3 to 50 psi	burping line - target RAW hanger & baffle	RAW	12	12	Inlet 94 Psia/ outlet 52 Psia	150	85 - 110	140	ss body and trim EPDM or Viton seal	1	Watts	
9	PR-006	Pressure regulator	1/2	SS-264AP, pressure adjustment range 3 to 50 psi	RAW burping line - horn A	RAW	12	12	Inlet 134 Psia/ outlet 92 Psia	150	85 - 110	140	ss body and trim EPDM or Viton seal	1	Watts	
10	PR-007	Pressure regulator	1/2	SS-264AP, pressure adjustment range 3 to 50 psi	RAW burping line - horn A	RAW	12	12	Inlet 92 Psia/ outlet 50 Psia	150	85 - 110	140	ss body and trim EPDM or Viton seal	1	Watts	
11	PR-008	Pressure regulator	1/2	SS-264AP, pressure adjustment range 3 to 50 psi	RAW burping line - horn B	RAW	12	12	Inlet 134 Psia/ outlet 90 Psia	150	85 - 110	140	ss body and trim EPDM or Viton seal	1	Watts	
12	PR-009	Pressure regulator	1/2	SS-264AP, pressure adjustment range 3 to 50 psi	RAW burping line - horn B	RAW	12	12	Inlet 90 Psia/ outlet 45 Psia	150	85 - 110	140	ss body and trim EPDM or Viton seal	1	Watts	
13	PR-010	Pressure regulator	1/2	SS-264AP, pressure adjustment range 3 to 50 psi	RAW burping line - horn C	RAW	12	12	Inlet 134 Psia/ outlet 87 Psia	150	85 - 110	140	ss body and trim EPDM or Viton seal	1	Watts	
14	PR-011	Pressure regulator	1/2	SS-264AP, pressure adjustment range 3 to 50 psi	RAW burping line - horn C	RAW	12	12	Inlet 87 Psia/ outlet 41 Psia	150	85 - 110	140	ss body and trim EPDM or Viton seal	1	Watts	
15	PR-012	Pressure regulator	1/2	SS-264AP, pressure adjustment range 3 to 50 psi	Burping line - cooling panel	RAW	12	12	Inlet 74 Psia/ outlet 40 Psia	150	85 - 110	140	ss body and trim EPDM or Viton seal	1	Watts	
16	PSV-001	Pressure Relief Valve	3/4	Spring type, 3/4" inlet size, set. P=10 Psig	tank blanket	LCW Fill			5 psig	150	70	150	ss body and trim EPDM or Viton seal / gaskets	1		FESHM / ASME code
17	PSV-002	Pressure Relief Valve	3/4	Spring type, 3/4" inlet size, set. P=10 Psig	tank blanket	LCW Fill			5 psig	150	70	150	ss body and trim EPDM or Viton seal / gaskets	1		
18	CH-024	Pressure Relief Check Valve		spring loaded Hy-lok. Tube X Tube	TK-002 RAW holding tank top	RAW								2		1 in w/ atmosphere, 1 out to TH vent
19	PI-001	Pressure Gauge	1/4	Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	LCW fill line	LCW Fill, before filter			6	100		150	SS case and bourdon tube /socket	1	Noshok	w/ ss plug valve
20	PT-001	Pressure transmitter	1/4	0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	LCW fill line	LCW Fill, before filter			6	100		150	SS	1	Noshok	
21	PI-002	Pressure Gauge	1/4	Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	LCW fill line	LCW Fill, after filter			5, 0 - 10 max.	50		150	SS case and bourdon tube /socket	1	Noshok	w/ ss plug valve
22	PT-002	Pressure transmitter	1/4	MNPT 1/4", 0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	LCW fill line	LCW Fill, after filter			5, 0 - 10 max.	50		150	SS	1	Noshok	

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25	PI-004	Pressure Gauge	1/4	Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	tank outlet header	LCW Fill		5, 0 - 10 max.	50	150	SS case and bourdon tube /socket	1		w/ plug valve
26	PI-005A&B	Pressure Gauge	1/4	Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	Pump outlets	LCW Fill		35	100	150	SS case and bourdon tube /socket	2		w/ plug valve
27	PI-007	Pressure Gauge	1/4	Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	Pump outlet header	LCW Fill		35	100	150	SS case and bourdon tube /socket	2		w/ plug valve
28	PI-008	Pressure Gauge	1/4	Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	LCW fill line after filter F-002	LCW Fill, after filter		5, 0 - 10 max.	50	150	SS case and bourdon tube /socket	1	Noshok	w/ ss plug valve
29	PT-008	Pressure transmitter	1/4	MNPT 1/4", 0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	LCW fill line after filter F-002	LCW Fill, after filter		0 - 13	50	150	SS	1	Noshok	
30	PI-009/011/013/015/017	Pressure Gauge		Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	burp line to RAW holding tank	RAW		0 - 120	200	150	SS case and bourdon tube /socket	5		w/ plug valve
31	PT-009/011/013/015/017	Pressure transmitter		MNPT 1/4", 0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	burp line to RAW holding tank	RAW		0 - 120	200	150	SS	5		w/ plug valve
32	PI-010/012/014/016/018	Pressure Gauge		Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	drain line to RAW holding tank	RAW		-0.7 - 5	-10 - 30	150	SS case and bourdon tube /socket	5		w/ plug valve
33	PI-019 / 020	Pressure Gauge		Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	Pump inlet to RAW or waste water holding tank	RAW		-1 - 5	-10 - 30	150	SS case and bourdon tube /socket	2		w/ plug valve
34	PI-021	Pressure Gauge		Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	tank blanket	RAW Capture		0	0 - 5	150	SS case and bourdon tube /socket	1		w/ plug valve
35	PT-021	Pressure transmitter		MNPT 1/4", 0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	tank blanket	RAW Capture		0	0 - 5	150	SS	1		w/ plug valve
36	PI-022A/B	Pressure Gauge		Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	RAW transfer pump inlet	RAW Capture		-1 - 5	-10 - 30	150	SS case and bourdon tube /socket	2		w/ plug valve
37	PT-022A/B	Pressure transmitter		MNPT 1/4", 0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	RAW transfer pump inlet	RAW Capture		-1 - 5	-10 - 30	150	SS	2		w/ plug valve
38	PI-023A, 023B, 0	Pressure Gauge		Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	RAW transfer pump outlet	RAW		0 - 6	0 - 30	150	SS case and bourdon tube /socket	2		w/ plug valve
39	PT-023A & B	Pressure transmitter		MNPT 1/4", 0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	RAW transfer	RAW		0 - 15	0 - 30	150	SS	2		w/ plug valve
40	PI-025	Pressure Gauge		Glycerin-filled, 2.5" SS dial, 1/4" NPT connection, lower mount, accuracy ±0.5%	P-004 outlet	Waste water Capture		0 - 6	0 - 30	150	SS case and bourdon tube /socket	1		w/ plug valve
41	PT-025	Pressure transmitter		MNPT 1/4", 0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	P-004 outlet	Waste water Capture		0 - 6	0 - 30	150	SS	1		w/ plug valve
42	PT-026	Pressure transmitter		MNPT 1/4", 0.5% Accuracy, 316 ss Welded Body and Wetted Parts , 4-20 mA or Voltage Output	Argon cylinders	LCW Fill		2105	4000	150	SS	1		w/ plug valve
43	FQ-Q01	Flow meter and transmitter	1	Yokogawa Vortex Flowmeter 1 inch (25 mm) Flowtube ◆ No Electronics - for use with DYA Converter ◆ ANSI 150 RF Flange Process Connection ◆ FM Explosion Proof for Cl I, Div 1, Grp A,B,C & D	LCW fill line to TK-001 LCW tank	LCW					CF8M Body Material Duplex Stainless Steel Shedder Bar	1		
44	FQ-Q02	Flow Meter	3/4	Yokogawa Vortex Flowmeter 3/4 inch (20 mm) Flowtube ◆ No Electronics - for use with DYA Converter ◆ ANSI 150 RF Flange Process Connection ◆ FM Explosion Proof for Cl I, Div 1, Grp A,B,C & D	LCW supply line	LCW					CF8M Body Material Duplex Stainless Steel Shedder Bar	1		
45	FQ-Q03	Flow Meter	1	Yokogawa Vortex Flowmeter 1 inch (25 mm) Flowtube ◆ No Electronics - for use with DYA Converter ◆ ANSI 150 RF Flange Process Connection ◆ FM Explosion Proof for Cl I, Div 1, Grp A,B,C & D	burp line to capture tank	RAW Burp					CF8M Body Material Duplex Stainless Steel Shedder Bar	1		
46	FQ-Q04	Flow Meter	2	Yokogawa Vortex Flowmeter: 2 inch (50 mm) Flowtube ◆ No Electronics - for use with DYA Converter ◆ ANSI 150 RF Flange Process Connection ◆ FM Explosion Proof for Cl I, Div 1, Grp A,B,C & D	drain line to capture tank	RAW Drain					CF8M Body Material Duplex Stainless Steel Shedder Bar	1	Yokogawa / JMI Instrument Co.	

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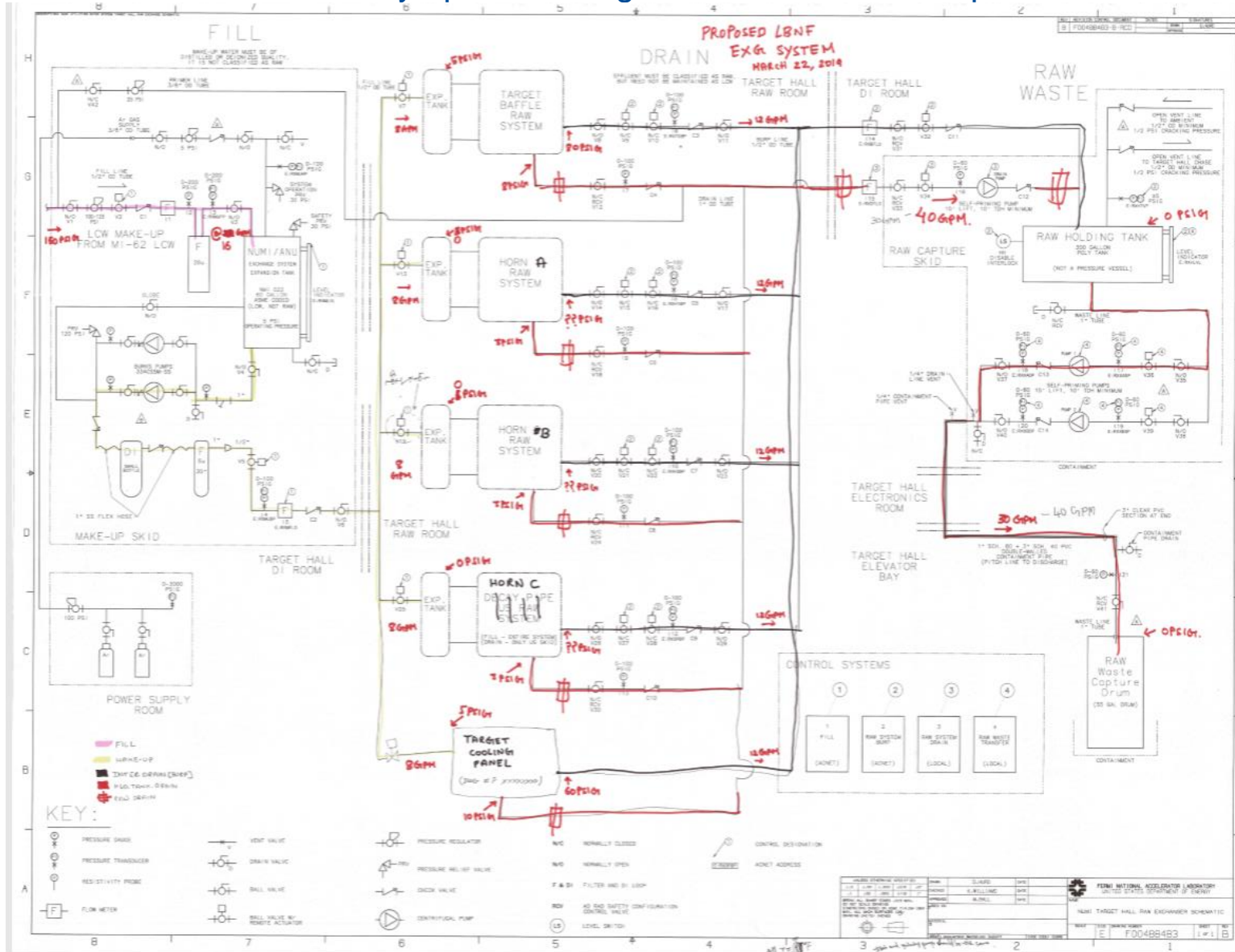
47	FT-001 to 004	Flow transmitter		Yokogawa Vortex Flowmeter Remote Converter Model DYA-D2D/FF1 ◆ 4-20 mA & Pulse Output with BRAIN Communications ◆ 1/2" NPT Female Electrical Connection ◆ 2-Line LCD Indicator with Setup Switches ◆ FM Explosion Proof for Cl I, Div 1, Grp A,B,C & D ◆ Includes 2" Pipe Mounting Bracket									Radiation hardened	4	
				Yokogawa DY Signal Cable (20') 5 4 Model DYC-1-2F									Radiation hardened	4	
48	FQ-005	Flow Meter	3/4		Drain line of intermediate system	LCW drain									
49	CV-001	Electric Actuated Valve	1	Type 2654 - 2/2-way ball valve 3-piece, electric actuator	lcw make-up tank and the RAW systems	LCW Fill		0 - 40	150	55 - 90	150		SS body and trim, Viton seal	1	connected to 1/2" tubing
50	CV-002 to 007, 023	Electric Actuated Valve	3/4	Type 2654 - 2/2-way ball valve 3-piece, electric actuator	lcw make-up tank and the RAW systems	LCW Fill		0 - 20	150	55 - 90	150		SS body and trim, Viton seal	7	connected to 1/2" tubing
51	CV-008 to 018	Electric Actuated Valve	1/2	Type 2654 - 2/2-way ball valve 3-piece, electric actuator	between the RAW systems and the RAW capture tank	RAW Burp		0 - 120	150	55 - 90	150		SS body and trim, Viton seal	11	Burkert
52	CV-019, 020, 021A&B	Electric Actuated Valve	2	Type 2654 - 2/2-way ball valve 3-piece, electric actuator	Intermediate Water Cooling Systems drain, inline & transfer pump inlet	INMTW, RAW		- 5 - 20	150	55 - 90	150		SS body and trim, Viton seal	4	connected to 1/2" tubing
53		Ball valves	1/2	3 piece, threaded ends					150		150		SS body and trim, Viton seal	12	
54		Ball valves	3/4	3 piece, threaded ends					150		150		SS body and trim, Viton seal	8	
55		Ball valves	1	3 piece, BW ends					150		150		SS body and trim, Viton seal	5	
56		Ball valves	1 1/4	3 piece, thread ends	Transfer lines				150		150		SS body and trim, Viton seal	3	
57		Ball valves	1 1/2	3 piece, BW ends					150		150		SS body and trim, Viton seal	7	
58		Ball valves	2	3 piece, threaded ends					150		150		SS body and trim, Viton seal	6	
59		Check Valves	1/2	Spring check valve, FNPT 8F-C8L-1/3-55	Burping lines				150		150		SS body and trim, Viton seal	6	Parker / Instrument Associates
60		Check Valves	3/4	Spring check valve, FNPT 12F-C12L-1/3-55	P-001A/B outlet and RAW skid supply				150		150		SS body and trim, Viton seal	10	Parker / Instrument Associates
61		Check Valves	1 1/4	Spring check valve, FNP	P-003A/B outlet				150		150		SS body and trim, Viton seal	52	Parker / Instrument Associates
62		Check Valves	1 1/2	CheckAll Valve model - spring check valve U3ISSV10.125SS	Drain lines				150		150		SS body and trim, Viton seal	6	CheckAll Valve / Instrument Associates
63		Y strainer 04-Y561S-10	2	Flanged Y strainer with drain valve plugged	P-001A /B pump inlet head line				150		150		SS body and trim, Viton seal	1	Titan / Pipingnow.com
64		Gauge isolation valve	1/2	1/2 NPT, 316SS, CL3000, UHMWPE seat or seal					150		150		SS body and trim, Viton seal	28	

Piping and Fitting Estimating

Target Hall RAW Exchange System - Piping and Fitting Estimate							
#	Name	Size (in)	Type / Model or Spec	Unit	Quantity	Reference Manufacturer / Vendor	Notes
1	Seamless ss pipe	2	Sch. 10S, A312, 304 / 304L, B36.19	ft	85		
2	Seamless ss pipe	1 1/2	Sch. 10S, A312, 304 / 304L, B36.19	ft	70		
3	Seamless ss pipe	1	Sch. 10S, A312, 304 / 304L, B36.19	ft	93		
4	Seamless ss pipe	3/4	Sch. 40S, A312, 304 / 304L, B36.19	ft	126		
5	Seamless ss pipe	1/2	Sch. 40S, A312, 304 / 304L, B36.19	ft	91		
6	Seamless ss pipe	1 1/2	Sch. 80, CPVC	ft	2		
7	Seamless ss pipe	1 1/4	Sch. 80, CPVC	ft	33		
8	Double containment pipe	1 1/4" carrier pipe 3" Containment pipe	Sch. 80, CPVC	ft	8	IPEX	
9	Double containment 150° elbow w. one side sealed end	1 1/4" carrier pipe 3" Containment pipe	Sch. 80, CPVC	unit	2	IPEX	
10	90° elbow, threaded	1 1/4	Sch. 80, CPVC	unit	2		
11	Tee, threaded	1 1/4	Sch. 80, CPVC	unit	1		
12	Reducer	1 1/2" x 1 1/4"	Sch. 80, CPVC	unit	2		
13	Flanges	1 1/2	Sch. 80, CPVC, CL125	unit	2		
14	Tube	1/4	316 SS, Sch. 10s	ft	45		
15	Butt welds on pipe	2		Unit	40		
16	Butt welds on pipe	1 1/2		Unit	35		
17	Butt welds on pipe	1		Unit	20		
18	Flanges	2	CL150, Sch. 10, WN, B16.5, ASTM A182 304/304L SS	Unit	10		
19	Flanges	1 1/2	CL150, Sch. 10, WN, B16.5, ASTM A182 304/304L SS	Unit	1		
20	Flanges	1	CL150, Sch. 10, WN, B16.5, ASTM A182 304/304L SS	Unit	40		
21	Flex hose	3/4	3/4" stainless steel braided flex hose, 150#, 3ft LG, threaded end	Unit	2		
22	Welded 90 deg. elbow	2	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	8		
23	Welded 90 deg. elbow	1 1/2	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	12		
24	Welded 90 deg. elbow	1	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	11		
25	threaded 90 deg. elbow	3/4	Sch.40, threaded, ASTM A182, ASME B16.11	Unit	16		
26	threaded 90 deg. elbow	1/2	Sch.40, threaded, ASTM A182, ASME B16.11	Unit	11		
27	Compression 90 deg. elbow	1/4	Sch. 10S, 316 SS	Unit			
28	45 deg. elbow	1 1/2	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	1		
29	30 deg. elbow	3/4	Sch.40, threaded, ASTM A182, ASME B16.11	Unit	1		
30	Welded Tee	2	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	1		
31	Welded Tee	1 1/2	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	1		
32	Welded Tee	2 x 1 1/2 x 2	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	4		
33	Welded Tee	1 1/2 x 1/2 x 1 1/2	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	1		
34	Threaded Tee	3/4	CL3000, ASTM A182, ASME B16.11	Unit	5		
35	Threaded Tee	1/2	CL3000, ASTM A182, ASME B16.11	Unit	4		
36	Threaded Tee	1/2 x 1/4 x 1/2	CL3000, ASTM A182, ASME B16.11	Unit	28		
37	Threaded Tee	1/4	1/4" Tee 304 Stainless Steel 150# Threaded Cast A351	Unit	3		
38	Threadflter	1/2	Threaded, CL3000, ASTM A182 Gr.304/304L, ASME B16.11	Unit	28	https://flexitallic.com	
39	Nipples	1/2	1/2" x 3"lg, CL3000, ASTM A182 Gr.304/304L, ASME B16.11	Unit	28	https://flexitallic.com	
40	Nipples	1/2	1/2" x 4"lg, CL3000, ASTM A182 Gr.304/304L, ASME B16.11	Unit	28		
41	Hex bushing	1/2 x 1/4	304/304L stainless steel, mnpt x fnpt	Unit	28		
42	Union	3/4	Stainless Steel 3000# Threaded A182 Gr. 304	Unit	20		
43	Union	1/2	Stainless Steel 3000# Threaded A182 Gr. 304	Unit	22		
44	Reducer	2 x 1 1/2	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	2		
45	Reducer	2 x 1	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit			
46	Reducer	2 x 3/4	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit			
47	Reducer	1 1/2 x 3/4	CL150, Sch. 10, BW, A403 Gr. 304/304L, ASME B16.9	Unit	2		
48	Gaskets	2	Spiral Wound Gasket Style CG with Internal ss ring, 150#	Unit	20	https://flexitallic.com	
49	Gaskets	1 1/2	Spiral Wound Gasket Style CG with Internal ss ring, 150#	Unit	40	https://flexitallic.com	
50	Gaskets	1	Spiral Wound Gasket Style CG with Internal ss ring, 150#	Unit	20	https://flexitallic.com	
51	Piping supports material	1 5/8" x 1 5/8" x 0.11"	Strut channel, 304/304L SS	ft	150	McMaster Carr	for 1" and below pipe
52		2" x 2" x 0.25"	Angle, 304 / 304L SS	ft	10		for 2" pipe
53		1"	Clevis Hanger, 304 Stainless Steel	set	40	McMaster Carr	1" NPD is the average size for cost estimate
54		5/16	5/16" Rod, 3ft LG with nuts	set	40	McMaster Carr	average size for cost estimate

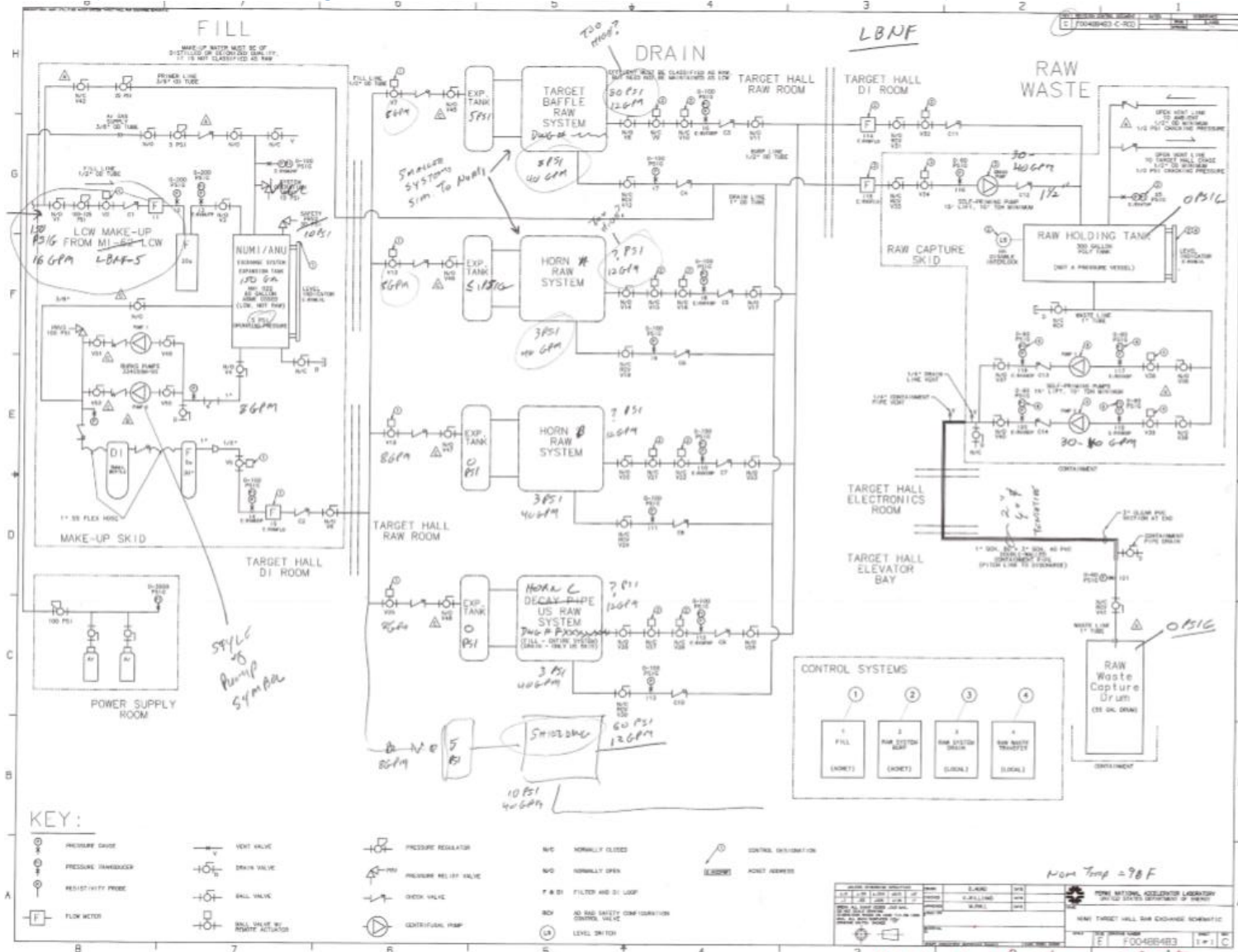
Design Requirements – Process Data

Provided by operation engineer - Abhishek Deshpande



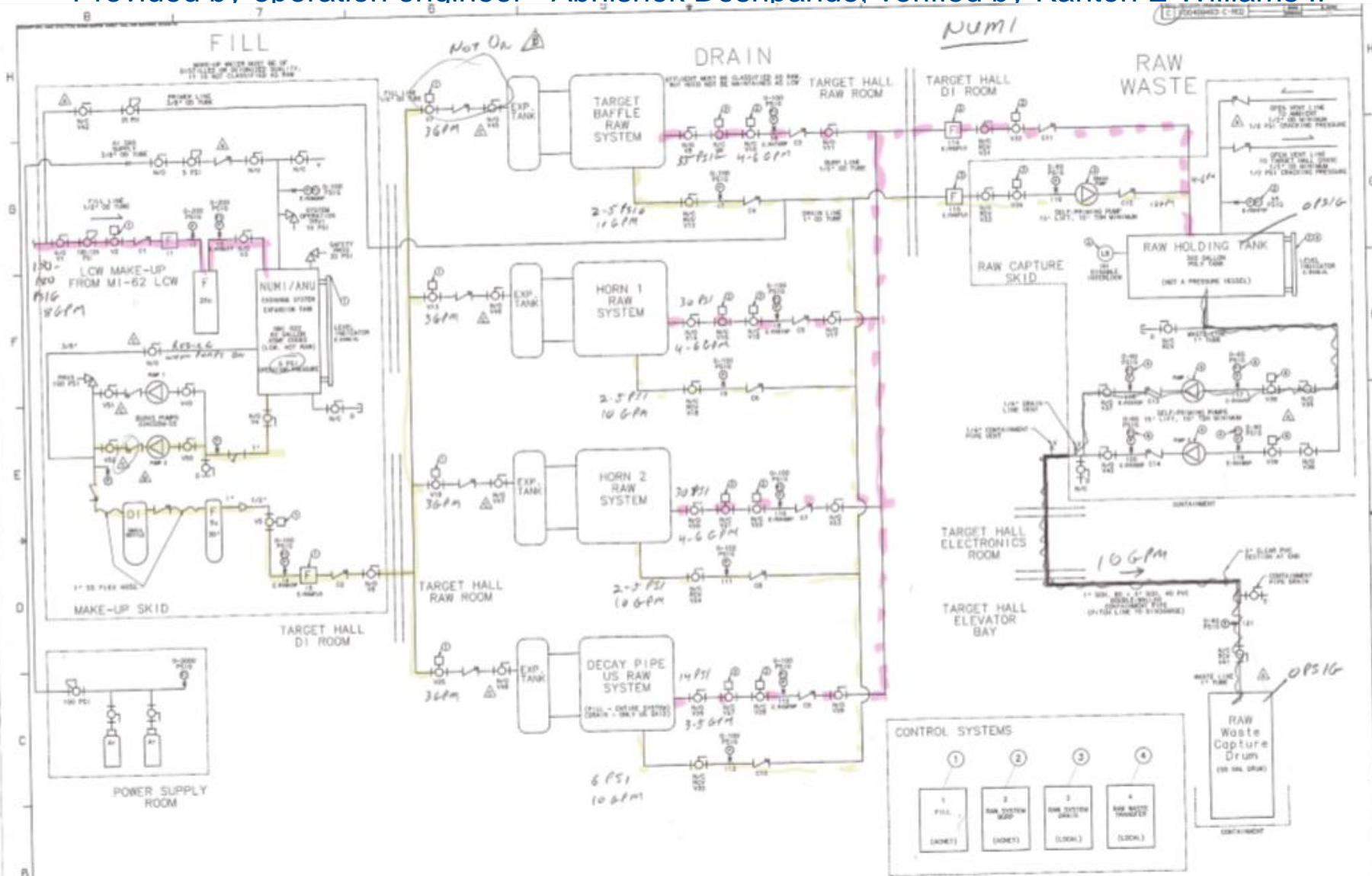
Design Requirements – Process Data

Provided by operation engineer - Abhishek Deshpande, verified by Karlton E Williams II



Design Requirements – NProcess Data

Provided by operation engineer - Abhishek Deshpande, verified by Karlton E Williams II



KEY:

- PRESSURE GAUGE
- HOT VALVE
- PRESSURE REGULATOR
- N/C NORMALLY CLOSED
- CONTROL DESIGNATION
- PRESSURE TRANSDUCER
- DRAIN VALVE
- PRESSURE RELIEF VALVE
- N/O NORMALLY OPEN
- ACID ADDRESS
- CHECK VALVE
- F & D FILTER AND DIP LOOP

NAME	DATE	CLASS	APP
DESIGNED BY			
CHECKED BY			
APPROVED BY			

PNL NATIONAL ACCELERATOR LABORATORY
 UNITED STATES DEPARTMENT OF ENERGY