

**ILC VALUE ENGINEERING SESSION of
POWER & COOLING**

(Focus on Main Linac @ Shaft 7)

November 27, 2007

INFORMATION PHASE

Conventional Facility

Process Cooling Water Concept

Emil Huedem

FNAL

Outline

- Introduction
- Heat Loads (Total, Main Linac only)
- Conceptual Design
- Previous “Cost Reduction” Items
- Items going forward (criteria/heat load, delta T)
- Summary

Introduction

Some non-conventional abbreviations used

- RDR (Reference Design Report)
 - work done between ~Mar 2006 to Nov 2006

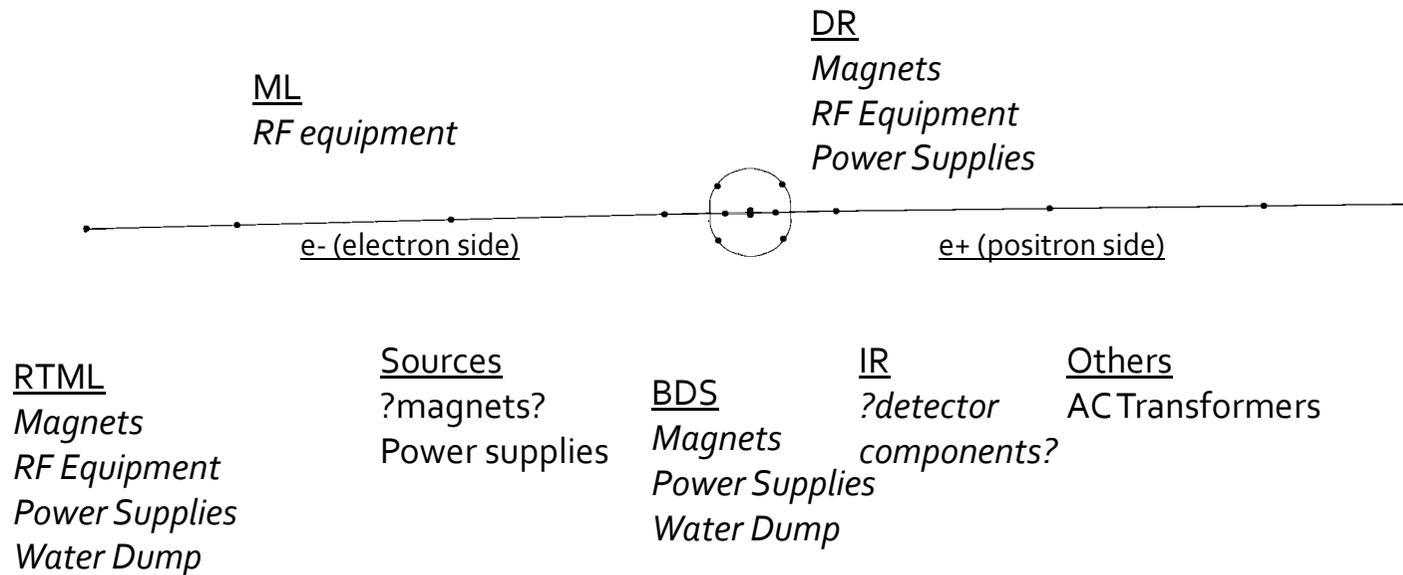
- EDR (Engineering Design Report)
 - work to be performed from Oct 2007 to Mid 2010?

- Various Area in the machine
 - BDS (Beam Delivery System)
 - DR (Damping Ring)
 - ML (Main Linac)
 - IR (Interaction Region)
 - RTML (Ring To Main Linac)

- CFS (Conventional Facility and Siting)
 - our group (civil, electrical, hvac, process water, safety, survey)

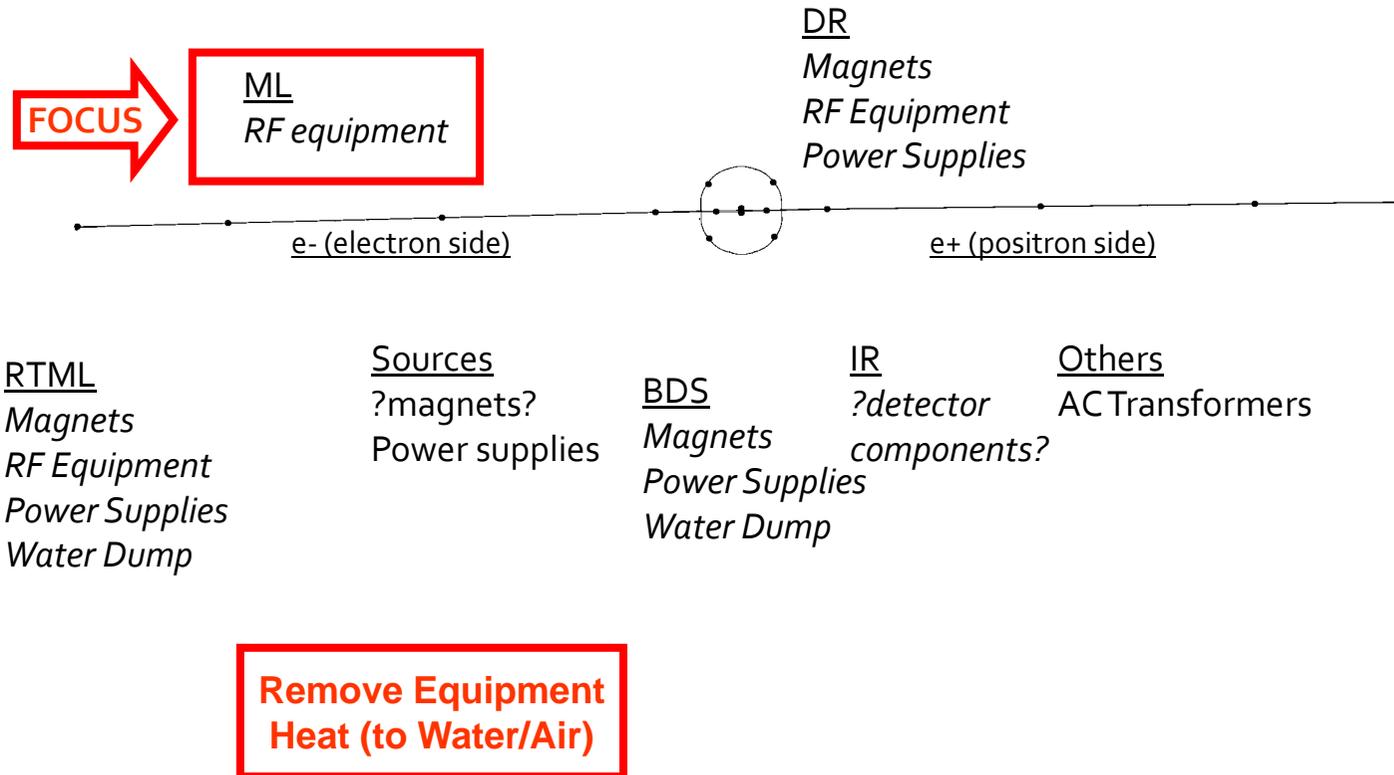
Introduction

- Machine is expected to run all season of the year
- What are the heat producing equipment to water/air?



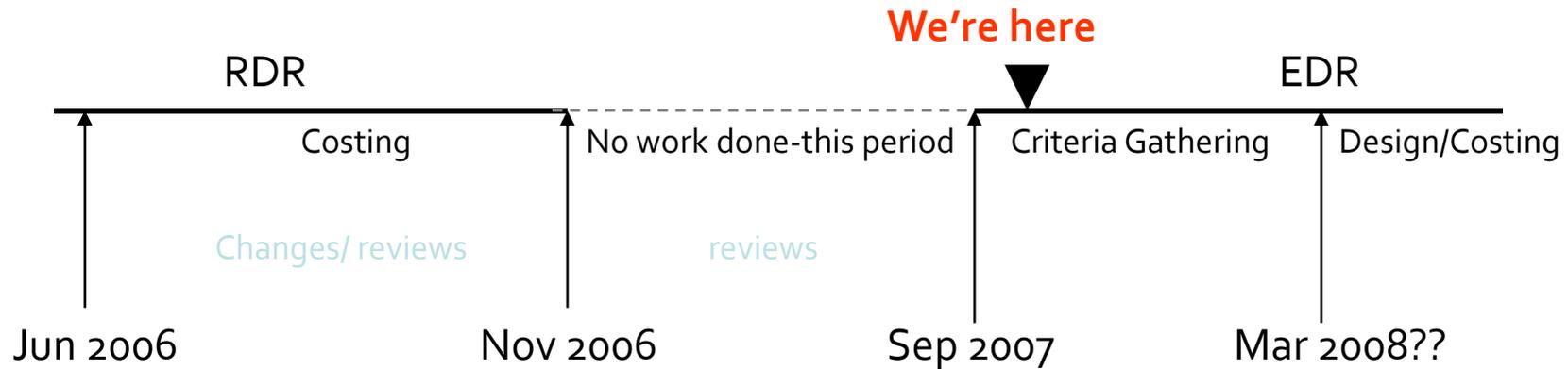
Introduction

- Machine is expected to run all season of the year
- What are the heat producing equipment to water/air?



Introduction

Perspective



Status

- Cooling infrastructure in RDR was conceptual, and very little on paper.
- Criteria and heat loads were incomplete. Most only have total KW (use scaling approach)
- Still need to layout/conceptualize LCW water system, establish other heat load components in service tunnel, get updated loads, firm up environmental criteria.
- Various Cost reduction sessions

Heat Loads

THERMAL LOAD USED (in MW) (..and still changing....)

Updated Nov 27 2006 CFS

Area System	LCW	Chilled Water	Total
SOURCES e-	2.88	1.42	4.300
SOURCES e+	17.48	5.33	22.810
DR e-	8.84	0.92	9.762
DR e+	8.84	0.92	9.762
RTML	9.25	1.34	10.589
MAIN LINAC	56.00	21.06	77.056
BDS	10.29	0.98	11.272
DUMPS	36	0	36.000

IR = None

150

32

182

SEE SEPARATE LARGE PRINTOUT

Heat Loads

These are the RF equipment

Nov 27b 2006
WATER AND AIR HEAT LOAD

Components	Quantity Per 36m	Location
Non-RF Components		
LCW Skid Pump 1 per 4 rf Motor/feeder Loss	0.25	Service Tunnel
P2R Loss and Motor Loss (misc)	1	Service Tunnel
Fancoils (5 ton Chilled Water) 1.5 Hp	2	Service Tunnel
Rack Water Skid	0.25	Service Tunnel
Lighting Heat Dissipation ~1.3W/sf		Service Tunnel
Lighting Heat Dissipation ~1.3W/sf		Accelerator-Tunnel
People Heat Dissipation 500btuh each	0	Accelerator-Tunnel
People Heat Dissipation 500btuh each	2	Service-Tunnel
AC Pwr Transformer 34.5- 48 kV	0.25	Service Tunnel
Emerg AC Pwr Transformer 34.5- 48 kV		Service Tunnel
RF Charging Supply 34.5 Kv AC-8KV DC	1/36 m	Service Tunnel
Switching power supply 4kV 50kW	1/36 m	
Modulator	1/36 m	Service Tunnel
Pulse Transformer	1/36 m	Service Tunnel
Klystron Socket Tank / Gun	1/36 m	Service Tunnel
Klystron Focusing Coil (Solenoid)	1/36 m	Service Tunnel
Klystron Collector	1/36 m	Service Tunnel
Klystron Body	1/36 m	Service Tunnel
Klystron Windows	1/36 m	Service Tunnel
Relay Racks (Instrument Racks)	1/36 m	Service Tunnel
Circulators, Attenuators & Dummy Load	1/36 m	Accelerator Tunnel
Waveguide	1/36 m	Accelerator Tunnel
Subtotal RF unit Only		
Total RF		

SEE SEPARATE LARGE PRINTOUT

Heat Table dated 11/27/06 – used in RDR

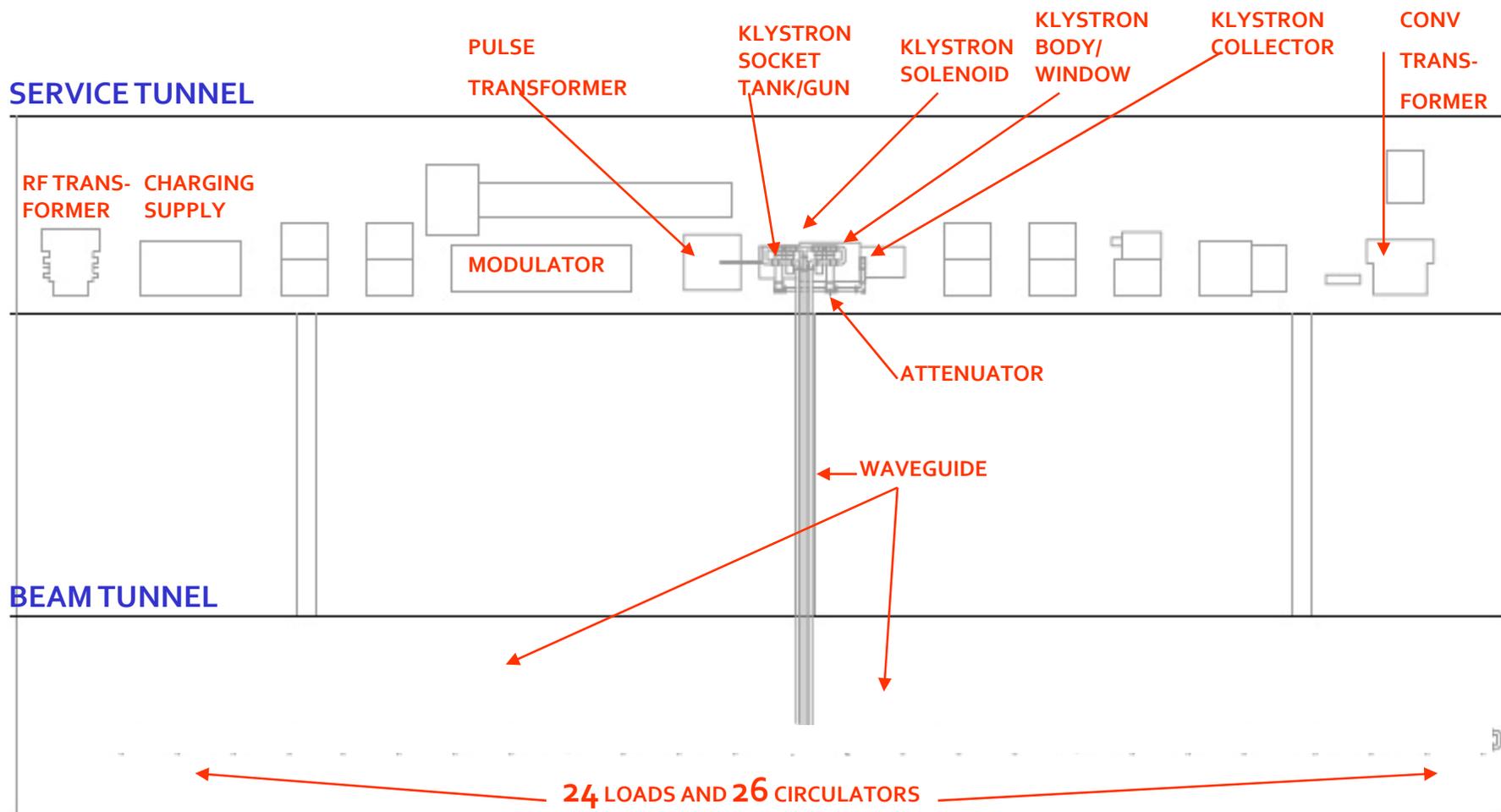
Current Heat Table (dated 10/31/07)- ongoing

Low Conductivity Water (LCW)

To Low Conductivity Water							to Chilled Water	Keith Jobe load to air Nov 22 06	Max Specie Temp (C)	Source	
Heat Load to Water (KW)	Supply Temp (variation) (C)	Delta Temperature (C delta)	Water Flow (l/min)	Maximum Allowable Pressure (Bar)	Typical (water) drop Bar	Acceptable Temp Variation delta C	Heat Load to Water (KW)	Power fraction to Tunnel Air (0-1)	Power to Tunnel Air (KW)		
0	N/A	N/A		N/A	N/A	None	0	1.00	0.60		
8	N/A	N/A		N/A	N/A	None	8	1.00	12.01	based on (1) 30 HP per 4 RF from Clay Table Email dated 9-15-06 Clay's Email Nov 22 2006	
0	N/A	N/A		N/A	N/A	None	0	1.00	0.20	(2) 15 HP per RF (Table 4 Ashrae Chap 28) placeholder based on (1) 5 HP per 4 rf (table4 Ashrae Chap 28) placeholder	
0	N/A	N/A		N/A	N/A	None	0	1.00	1.65	* Clay - 14 W per sq m	
0	N/A	N/A		N/A	N/A	None	0				
0	N/A	N/A		N/A	N/A	None	0				
1.50	N/A	N/A		N/A	N/A	None	0	0.25	0.50	* Clay email 3-14-06 typical 112 Kva oil xfmr *	
0	N/A	N/A		N/A	N/A	None	0	1.00	1.00	* Clay email 3-14-06 typical 112 Kva oil xfmr Keith J	
2.8	40	40	1.17	18	8	10	0	0.3	1.2	85 F (a) * C. Jensen email 2-27-06 183 kVa 0.84pf oil ps xfmr ** Shigeki Apr 18 2006 ** Clay 5-25-06 LRRF meeting ** Sep 18 move all to LCW per Marc Ross ** Move load to Dirty Water per RCassell Oct 20 2006, **Nov 22 2006 Keith Jobe Wag on load to Air** Nov 27 2006 C. Adolphsen Email	
4.5	35	13.6	7.6	13	8	10	0	0.4	3.0	** Move load to Dirty Water per Rcassell Oct 20 2006 LCW for now ** Nov 22 2006 Keith Jobe wag on load to air ** Chris Jensen Post meeting notes 11 16 06 ** Nov 27 2006 C. adolphsen Email	
4.5				28.823			0	0.4	3.0	* Shigeki Fukuda Email 3-1-06 ** Shigeki Apr 18 2006 ** Nov 22 2006 Keith Jobe wag on load to air ** 11-27-06 C. Adolphsen Email ** 12-1-06 Email from Chris Jensen	
0.7							0	0.3	0.3	** Shigeki Apr 18 2006 ** Nov 22 2006 Keith Jobe wag on load to air ** 11-27-06 C. Adolphsen Email	
0.8							0	0.2	0.2	** Shigeki Apr 18 2006 ** Marc & Keith - remove load to air/chilled - transfer all load to water ** Nov 22 2006 Keith Jobe wag on load to air ** 11-27-06 C. Adolphsen Email	
3.6							0	0.1	0.4	* Shigeki Fukuda Email 4-05-06 ** Nov 22 2006 Keith Jobe wag on load to air ** 11-27-06 C. Adolphsen Email	
45.8	*35>						0			* Shigeki Fukuda Email 3-1-06 ** Nov 22 2006 Keith Jobe wag on load to air ** 11-27-06 C. Adolphsen Email	
0.0	*35>					5	+ 2.5 C	0.0	1.4	* Shigeki Fukuda Email 3-1-06 ** Keith Jobe added stability Oct 20 2006 ** H LRF 11/16 /06 meeting ** 11-27-06 C. Adolphsen Email	
0.0	*35>					1		0.0		* Shigeki Fukuda Email 3-1-06 ** 11-27-06 C. Adolphsen Email	
0.0							11.5	-0.2	-1.5	* Shigeki Fukuda Email 3-30-06 ** Shigeki Apr 18 2006 (chilled water) *** Larsen email ** RayLarsen Email 9-15-06 except reduced by 40% per Marc * Ray H LRF Meeting 11/16/06 ** 11-27-06 C. Adolphsen Email	
0.0	N/A	N/A		N/A	N/A	None	0.0	N/A	N/A		
32.3								+ 2.5 C	0	0.1	1.7
3.5								+ 2.5 C	0	0.1	0.4
140.10											** Shigeki Email Apr 28 2006 ** H LRF 11/16/06 meeting update from 24.3 to 26.8 KW ** 11-27-06 C. Adolphsen Email
120.10											* Shigeki Fukuda Email 3-30-06 ** Keith Jobe added stability Oct 20 2006 ** H LRF 11/16/06 meeting from 4 KW to 5 KW ** 11-27-06 C. Adolphsen Email
162.8											(a) H LRF meeting Nov 16 2006
140.8											
0.00											
99.99											
11.50									26.07		

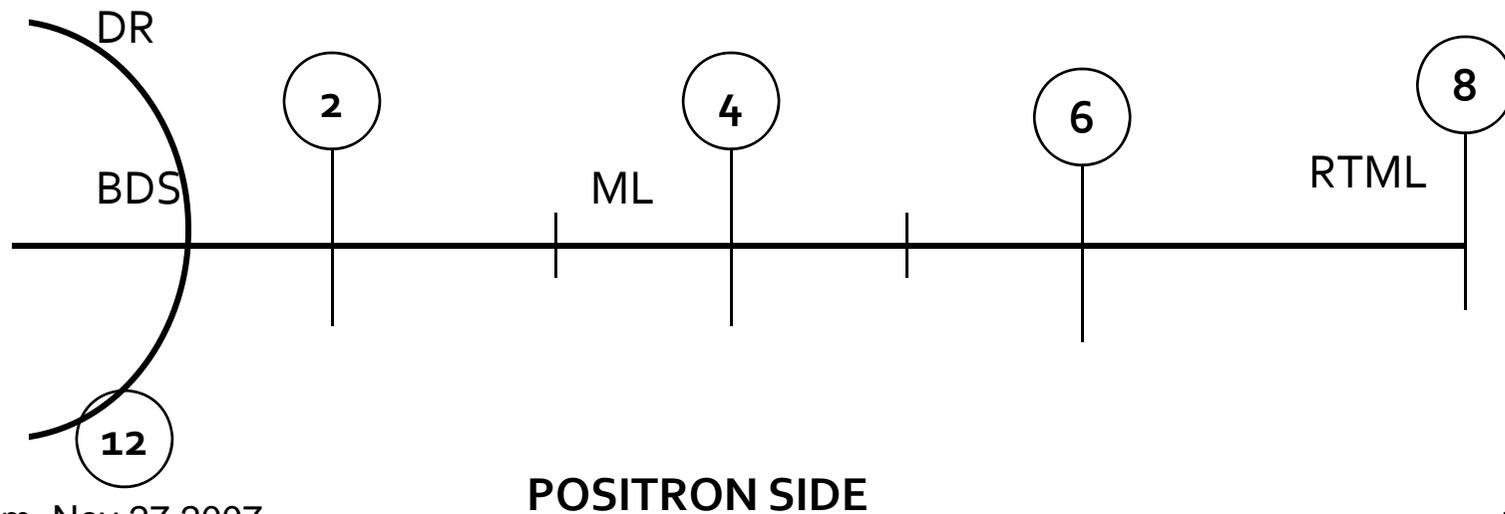
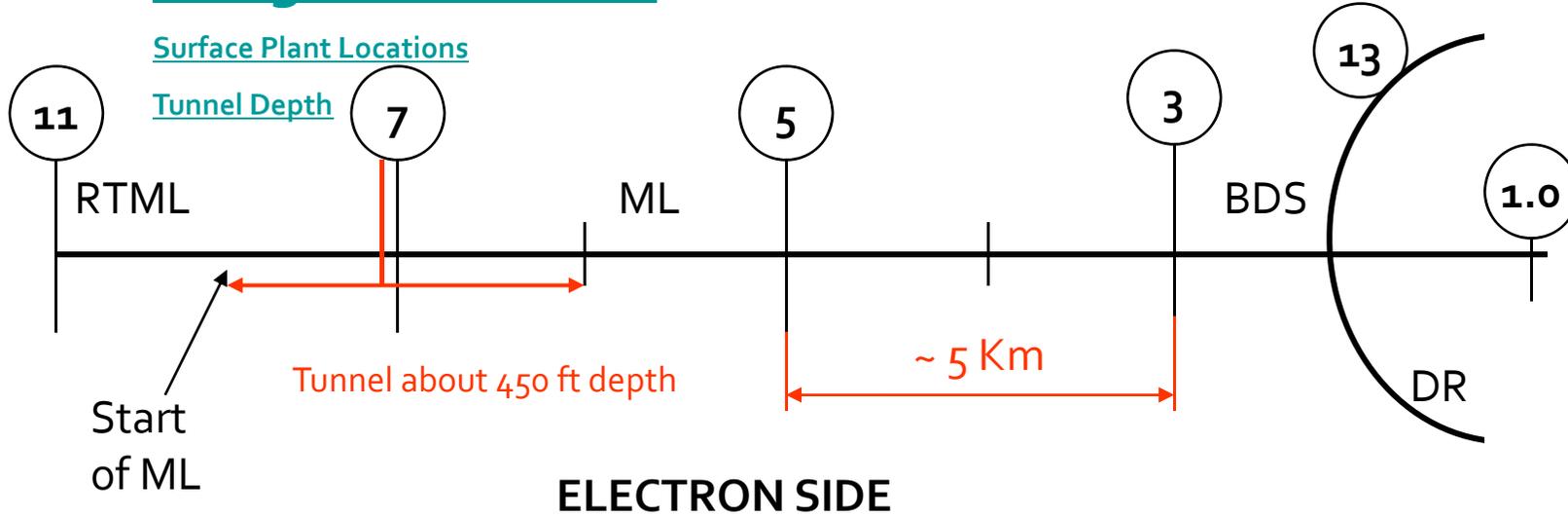
Total Heat load to Chilled water (per RF)	37.6 KW	cooled by process water with rust inhibitor
Total Heat load to LCW (per RF)	100.0 KW	cooled by low conductivity water

Racks require separate cold water system
LCW/Process Water Load is about 100 KW per RF (RDR)

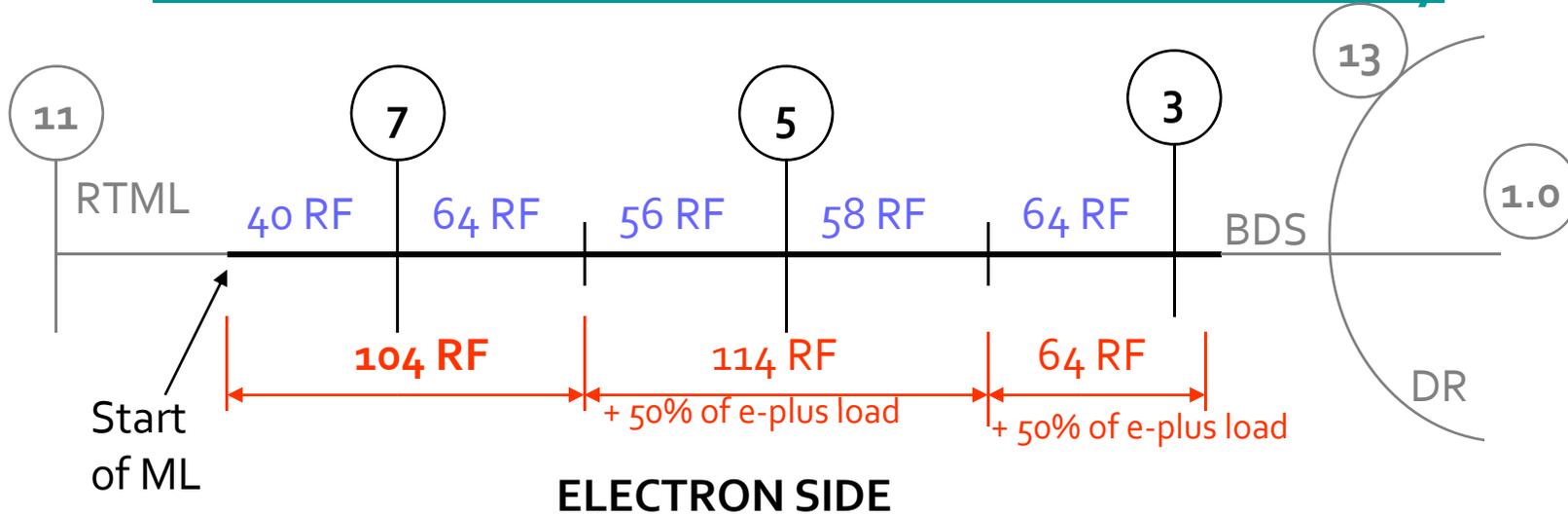


Plan View of ONE ML RF UNIT used in RDR

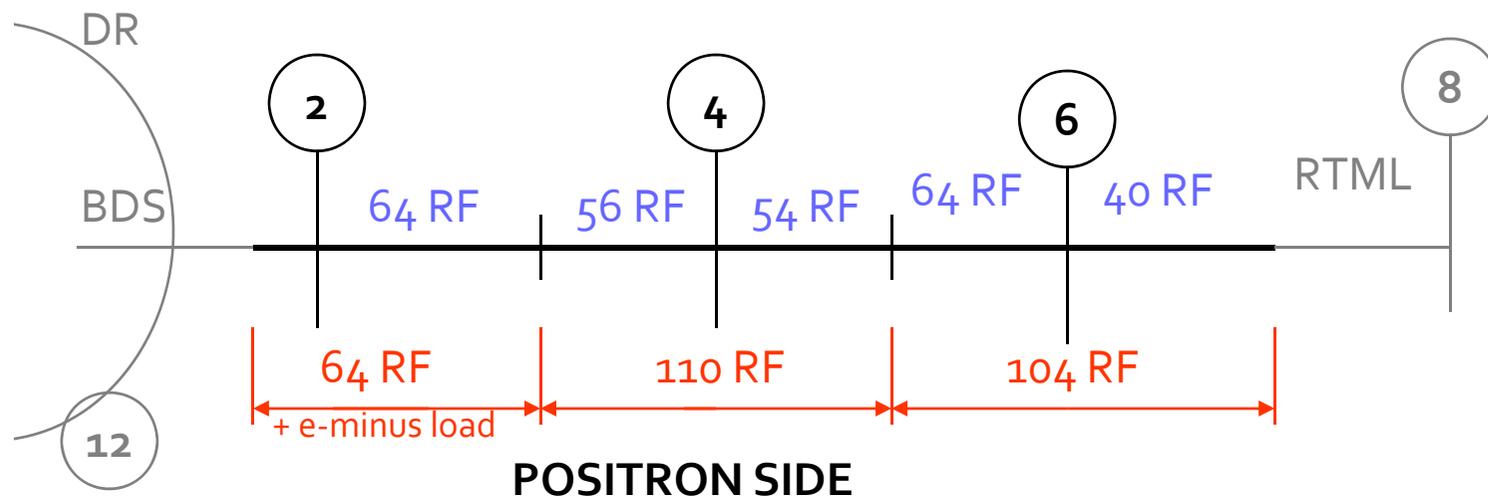
Design Constraints



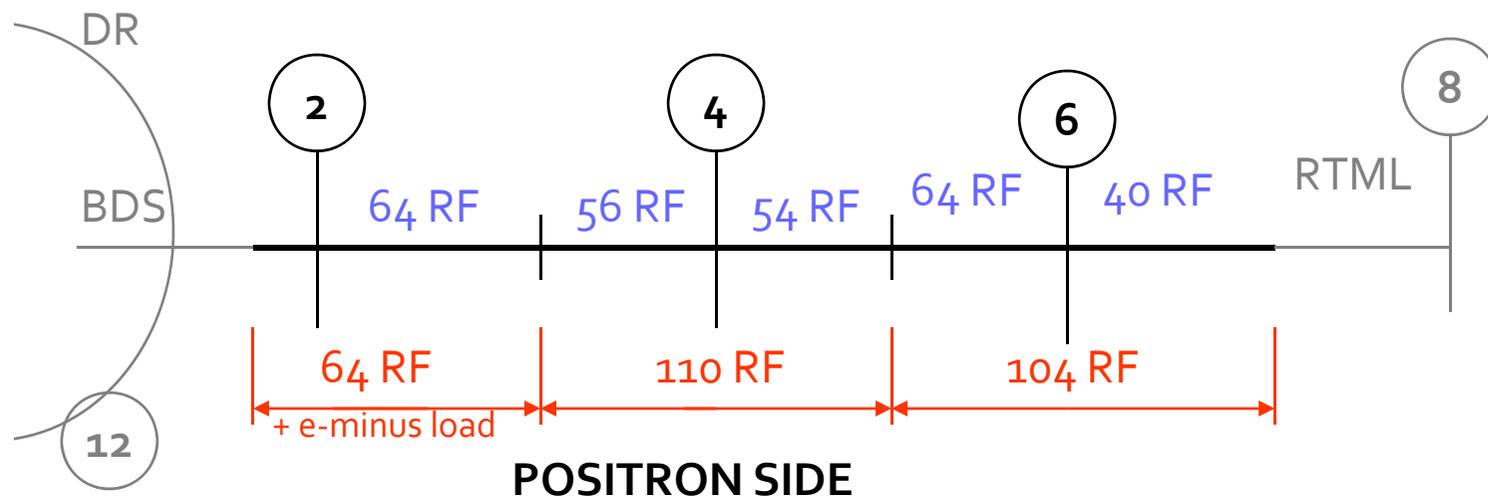
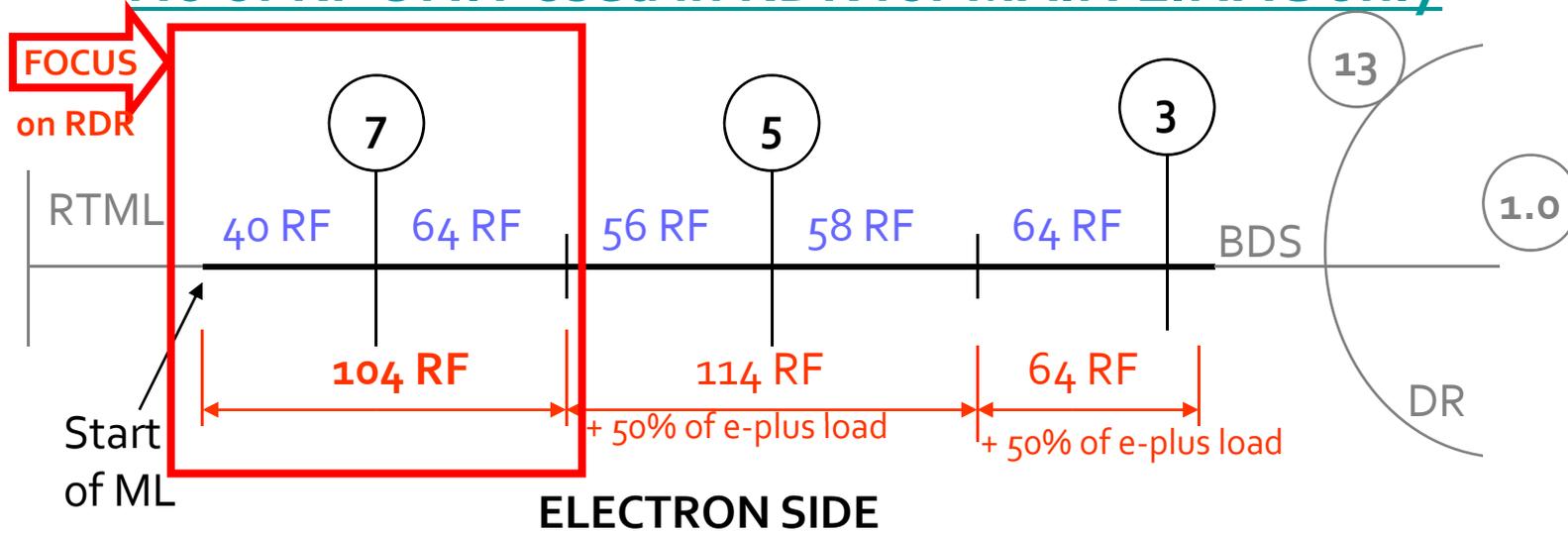
No of RF UNIT used in RDR for MAIN LINAC only



560 RF for ML !



No of RF UNIT used in RDR for MAIN LINAC only



Water Surface Plant Multiplier

Nov 27 2006

PLANT	Area System Served	How the loads are distributed	LOADS DISTRIBUTION (MW)		Multiplier	
			LCW/proce ss	AIR/Chw *	Process	Chw
12	DR	<u>DR</u> load total divided by 2 (no CHW in tunnel)	8.8	● 1.2	85%	24%
13	DR	<u>DR</u> load total divided by 2 (no CHW in tunnel)	8.8	● 1.2	85%	24%
11	RTML	Half of <u>RTML</u> total load	4.6	● 0.8	44%	17%
7 (BASIS)	ML	<u>Main Linac</u> Total Load x No fo ML RF at this shaft (104) divided by total no of ML RF (560)	10.4	4.9	100%	100%
5	ML & e+ source	<u>Main Linac</u> (with 114 total ML RF) plus half of <u>e+</u> source total load	18.4	8.0	177%	164%
3	ML & e+ source	<u>Main Linac</u> (with 64 total ML RF) plus half of <u>e+ source</u>	16.9	7.0	162%	143%
1.0	BDS	<u>BDS</u> total load	10.3	1.2	99%	25%
2	ML & e- source	<u>Main Linac</u> (same as Shaft 3 for ML) plus all of <u>e- source</u>	9.3	● 4.8	89%	98%
4	ML	<u>Main Linac</u> 110 total ML RF	11.0	5.2	106%	106%
6	ML	<u>Main Linac</u> (same as shaft 7)	10.4	4.9	100%	100%
8	RTML	Half of <u>RTML</u> total load	4.6	● 0.8	44%	17%
1.0 Dump	Dumps	BDS Tune up/Main <u>Dumps</u> mains (excl LCW skid)	36.0	0.0	346%	0%

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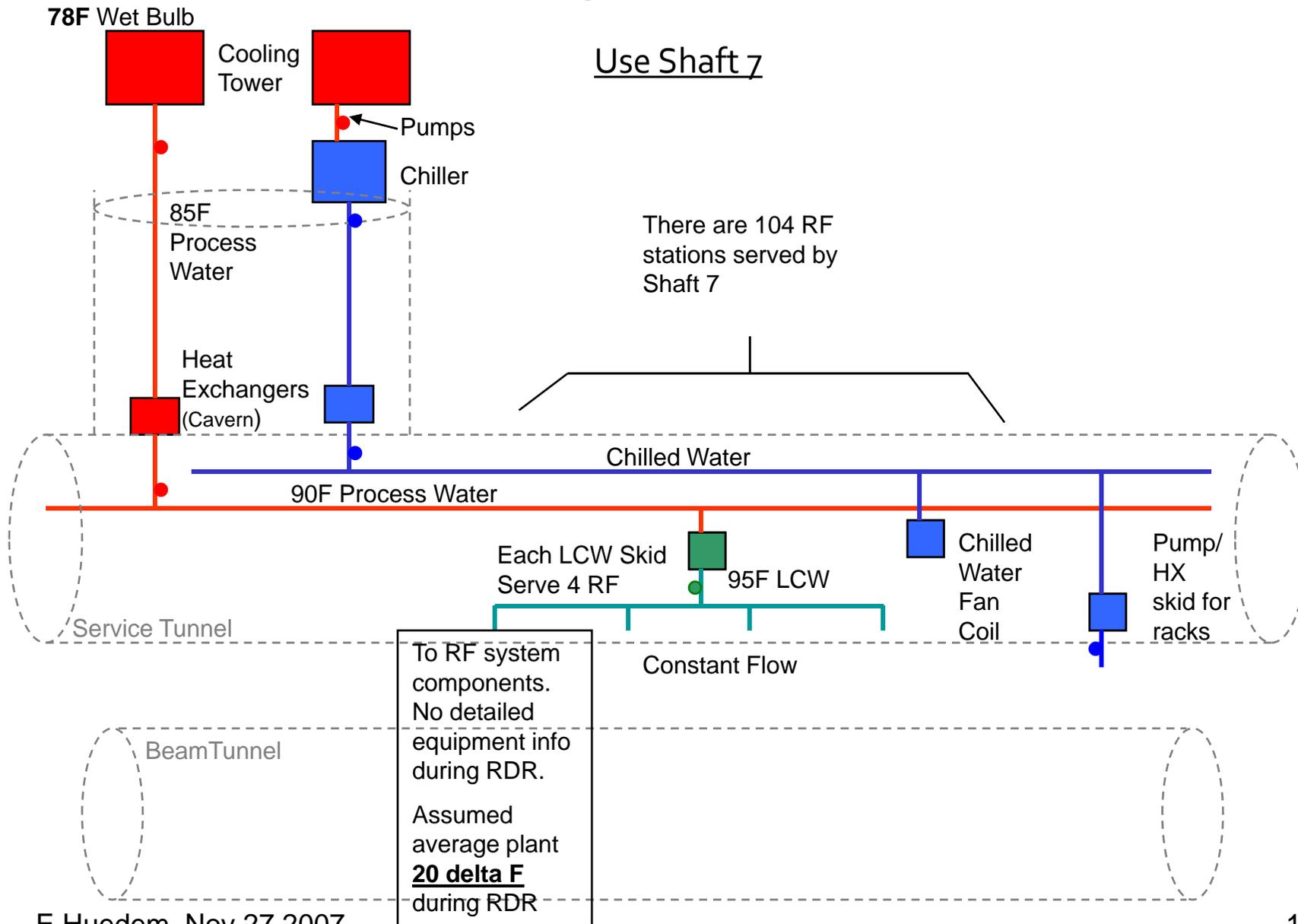
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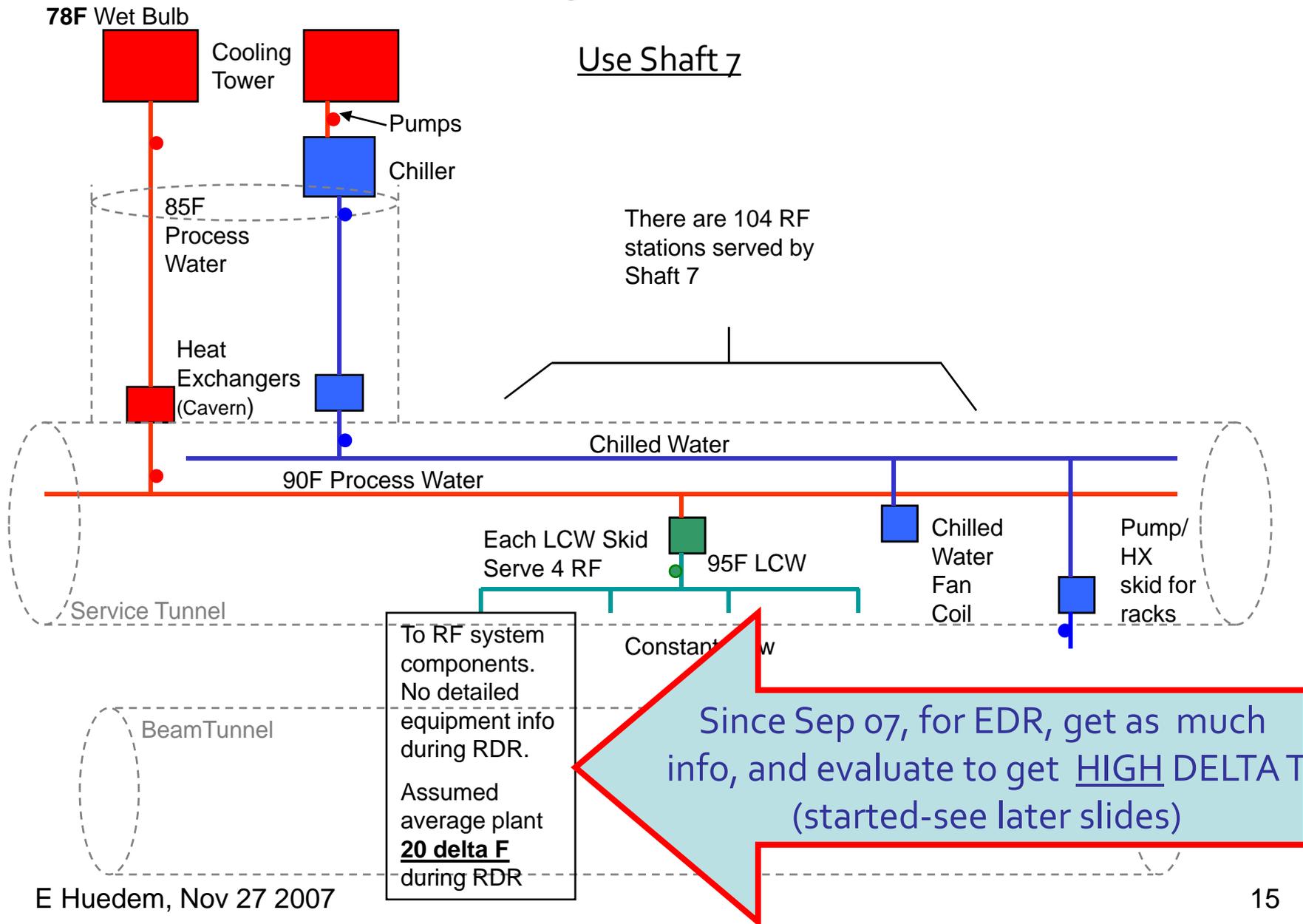
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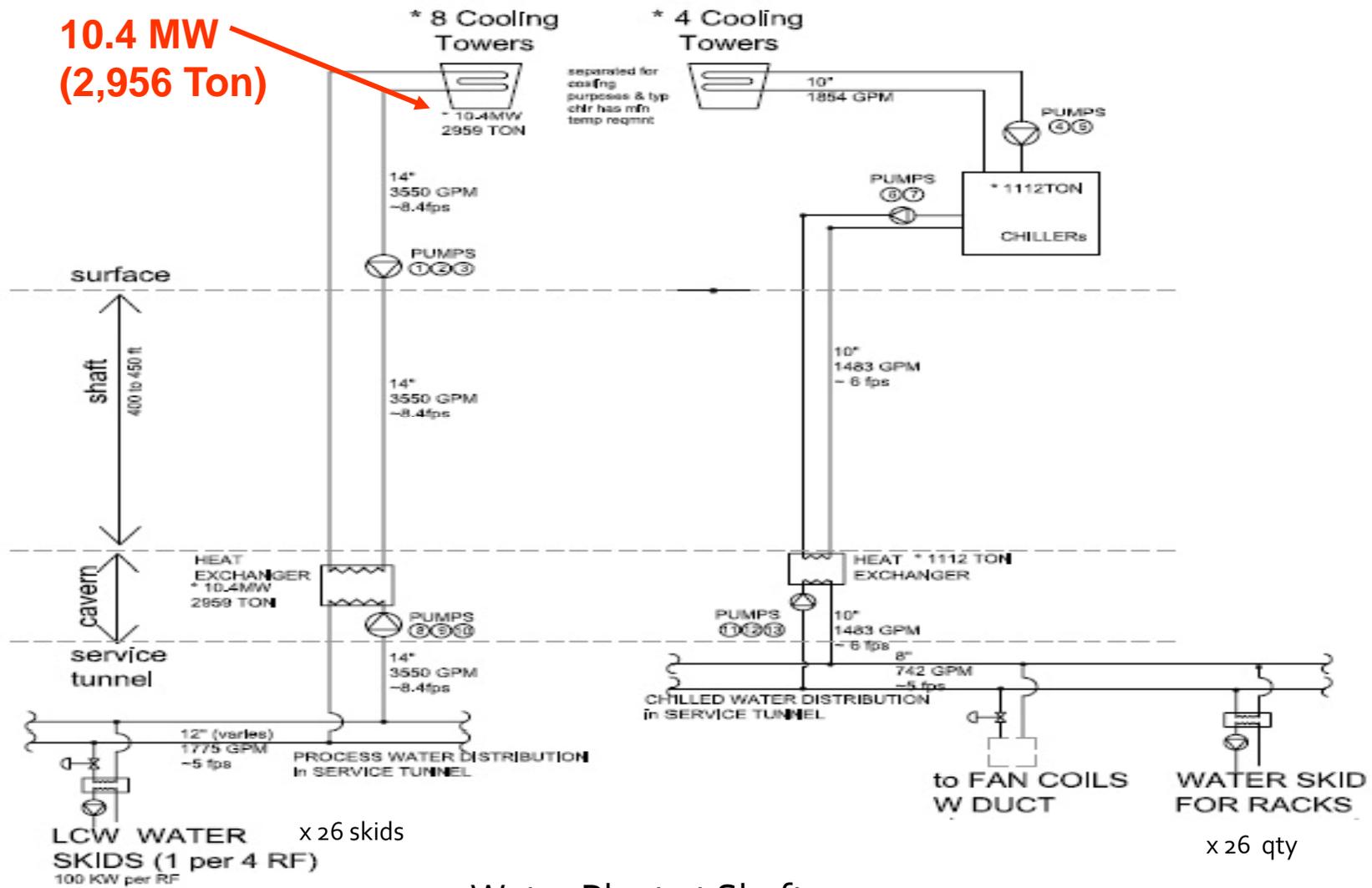
Basic Design Concept in RDR



Basic Design Concept in RDR



Basic Design Concept in RDR



Water Plant at Shaft 7

Cooling Tower

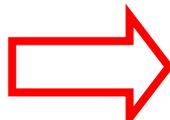
Used BAC (BaltimoreAircoil) HXV Closed Circuit Tower in RDR

	Ambi ent	Leaving Water	Approach	Fan HP per unit	Increase in Cost	Increase in Weight	Increase of HP per unit
 Used in RDR	78	85	7	25	0	0	0
	78	84	6	30	5%	9%	20%
	78	83	5	37.5	24%	30%	50%
	78	82	4	45	35%	43%	80%

Heat Exchanger

Approach Temperature F	Heat load MW	Hot			Cold		
		Inlet Temperature (F)	Outlet Temperature (F)	Pressure Drop (psi)	Inlet Temperature (F)	Outlet Temperature (F)	Pressure Drop (psi)
5	5.25	110	90	10	85	105	10
4	5.25	109	89	10	85	105	10
3	5.25	108	88	10	85	105	10

Approach Temperature F	Dimension Size	Volume (Cu ft)	Increase in Volume %	Increase in Cost %
5	92"H x 35"W x 118"L	220	0%	0%
4			?	16%
3	115"H x 35"W x 148"L	345	57%	58%



Used in RDR

Used Tranter Plate Heat Exchanger in RDR

About RDR Costs

- Approach: estimated cooling infrastructure at Shaft 7, and other areas were scaled (full & partial) depending on the total heat loads
- CFS cost is about ?? % of the whole ILC cost
- Process Water is about 15% of the total CFS cost (*less if chilled move to HVAC*)
- Cost Drivers in Process Water (% of Process Water Cost)
 - High Heat Load
 - LCW system 38%
 - Process Piping 12%
 - Chilled Water related items 28% (*will be part of HVAC in EDR*)

Examples of previous various "Cost-Reduction" (not VE) sessions

ML Meeting May 12 2006

Run both tunnel and electronics hotter using 85F tower water supply **X** *Can't due to HX & IL wetbulb, 85F amb was spec*

Increase all primary cooling pipe diameters to reduce shaft horsepower ✓

Reduce number of cooling skids ✓

Stack heat loads to reduce primary flow and increase delta T

Need Component Info

(ongoing)

July to Sep cost/power reduction exercises 2006

Evaluate power usage ✓

Cut number of skids ✓

Raise delta to klystron collector 2X ✓ *Need more Info (ongoing)*

Reduce or eliminate chilled water usage **X** *Ray has watercooled racks, tunnels has load to air*

Need watt per watt number ✓

Increase all primary cooling pipe diameters to reduce shaft horsepower requirements on water flows. The pumping costs for the primary cooling loops are larger than desired. ✓

Remove use of deionized water (LCW vs Non-LCW Water) **X** *Users against, 100% non-lcw not doable*

Examples of previous various "Cost-Reduction" (not VE) sessions

Caltech Review Oct 9 2007

Peter G Discussion of Dump arrangement and usage and the cooling needs for each dump. When dumps are not being used, water is circulating but heat is not being generated. This has resulted in a reduction of 60% of MW usage for the BDS down to 54.31 MW (for a 1 Tev scenario). *Water supply to the dumps needs to be revisited to optimize piping and cooling costs. Also piping sizes and configuration needs to be determined in the tunnel cross section. Emil – delta T for the water for the dump cooling is a larger number and perhaps scaling from the Main Linac example may not be appropriate.* ✓

Keith Jobe Marc and Keith still need to gather a spreadsheet of criteria and forward to Emil.

Tom Elioff Vibration from the water cooling pipes also needs to be considered. Tom L – Pumping configuration has been considered. Keith Jobe, the vibration from the water flow in the 14" – 16" pipe will be significant and needs to be considered. Wilhelm – the pumps are high frequency and have limited influence beyond a 20 m separation from the beam line. *Marc – placing the pumping system on the surface may be a viable alternative and will need to be reviewed. Local pumps for the RAW water secondary loops will still need to be in alcoves near the dumps.* ✗

Examples of previous various "Cost-Reduction" (not VE) sessions

Mac Meeting Review Jan 2007

The committee would like to remark that the process water return pipe might be a major source of heating of the tunnel air which then must be re-cooled at higher expense. The committee suggests investigating the benefit of an insulated process water return pipe, in particular the possibility of increasing the process water temperature rise which is expected to impact the diameters of water pipes the amount of pumping power which is needed to be installed, the coolant velocity and the corresponding dimensions of cooling channels of the components.

Pipe Velocity vs size vs HP

Orsay Cost Review May 2007

The Committee felt that some cost savings might be possible in the ILC conventional facilities. Among the items which it believes should be examined for further cost optimization are the following:

Water System Delta T

- The diameters of the Main Linac and Damping Ring tunnels
- The total number of vertical shafts
- The diameters of the vertical shafts
- The temperature rise of the tunnel component water cooling system
- The proposed 7 year construction schedule

Need Component Info (ongoing)

Cooling Plant watt* per watt** information (It VARIES!!)

Sep 2006

**electrical **heat removed*

Centrifugal chillers (only *no pump, no tower*) full load (~ 0.55 KW per ton

0.16 watt per watt

Data Centers typical (from Uptime Institute) =

0.55 watt per watt

Packaged Chilled water plant (from www.tas.com)

Superior (0.7KW/ton)

0.199 watt per watt

Above average (0.85 KW/ton)

TYPICAL



0.242 watt per watt

Below Average (1.3 KW/ton)

0.370 watt per watt

Inferior (1.6 KW/ton)

0.455 watt per watt

CUB installed (LCW & chilled)

0.242 watt per watt

Tevatron -installed(mostly LCW to pond from Maurice)

0.18 watt per watt

Main Injector -installed (mostly LCW to pond from Maurice)

0.16 watt per watt

Shaft 7 **COMBINED** Chilled & process *wag on equipment pressure drop*

using closed circuit towers (preliminary layout around Sep 2006)

0.17 watt per watt

Shaft 7 **process only** *wag on equipment pressure drop*

NO Chilled (preliminary layout around Sep 2006)

0.11 watt per watt

Shaft 7 **chilled only** *wag on equipment pressure drop*

NO process (preliminary layout around Sep 2006)

0.35 watt per watt

Udated Shaft 7 *wag on equipment pressure drop*

using closed circuit towers (RDR conceptt around Nov 2006)

TBD watt per watt

E Huedem, Nov 27 2007

To EDR

- Finish criteria / Heat Table
- VE
- Evaluate for High Water Delta T / Pipe Sizes
- Update concept design / Refine estimate

- Heat Table improvement! Oct 2007, but still incomplete

Oct 31 2007

WATER AND AIR HEAT LOAD (all LCW) and 9-8-9 ML

MAIN LINAC - ELECTRON & POSITRON																
Components	Quantity Per 36m	Location	To Low Conductivity Water									to Chilled Water	kerth Jobe load to air Nov 22 06		Max Space Temp (C)	
			Heat Load to Water (KW)	Max Allowable Temperature (C)	Supply Temp (variation) (C)	Supply Temp (C)	Delta Temperature (C delta)	Water Flow (l / min)	Maximum Allowable Pressure (Bar)	Typical (water) pressure drop Bar	Acceptable Temp Variation delta C	Heat Load to Water (KW)	Power fraction to Tunnel Air (0-1)	Power to Tunnel Air (KW)		
Non-RF Components																
AC Pwr Transformer 34.5-48 kV	0.25	Service Tunnel	1.50			35						None	0	0.25	0.50	
RF Components																
RF Charging Supply 34.5 Kv AC-8KV DC	1/36 m	Service Tunnel	2.8			40	40	1.17	18	5	10	0	0.3	1.2		85 F (a)
Switching power supply 4kV 50kW	1/36 m	Service Tunnel	4.5			35	8.50	7.6	13	5	10	0	0.4	3.0		
Modulator	1/36 m	Service Tunnel	4.5			35	3.23	20	10	5	n/a	0	0.4	3.0		
Pulse Transformer	1/36 m	Service Tunnel	0.7	60		35	0.50	20		1	n/a	0	0.3	0.3		
Klystron Socket Tank / Gun	1/36 m	Service Tunnel	0.8	60		35	1.15	10	15	1	n/a	0	0.2	0.2		
Klystron Focusing Coil (Solenoid)	1/36 m	Service Tunnel	5.5	80		55	8	10	15	1	n/a	0	0.1	0.4		
Klystron Collector	1/36 m	Service Tunnel	45.8	87		38 (inlet temp 25 to 63)	18	37	15	0.3	n/a	0	0.0	1.4		
Klystron Body & Windows	1/36 m	Service Tunnel	4.2	40		25 to 40C	6	10	15	4.5	+ - 2.5 C	0				
Relay Racks (Instrument Racks)	1/36 m	Service Tunnel	0	N/A		N/A	N/A		N/A	N/A	None	11.5	-0.2	-1.5		
Attenuators	2/36 m	Service Tunnel	0	N/A		N/A	N/A		N/A	N/A	None			0.0		
Waveguide (in service tunnel)	1/36 m	Service Tunnel	0											1.166		
Waveguide (in penetration)	1/36 m	Penetration	0.676													
Waveguide (in beam tunnel)	1/36 m	Beam Tunnel	0.0								+ - 2.5 C	0		5.9		
Circulators With loads (isolator)	26/36 m	Beam Tunnel	2.49			35	0.45 per load	3 per load			+ - 2.5 C	0		0.0		
Loads	24/36 m	Beam Tunnel	30.05			35	2.25 per load	8 per load			+ - 2.5 C			0.0		
Subtotal RF unit Only			102.0													
Total RF			103.5									11.5		21.4		

NOTE : Loads, Circulators and Klystron Body Supply Temperature is critical (should have very slow supply temp variat

Total Heat load to Air/Chilled water in service tunnel (per RF)	32.9 KW
Total Heat load to LCW (per RF)	103.5 KW
Total Heat load to air in beam tunnel (ignore rock contribution for now)	5.9 KW

cooled by chilled water
 cooled by low conductivity water
 pending

E Huedem, Nov 27 2007

• Heat Table improvement! Oct 2007, but still incomplete

Oct 31 2007

WATER AND AIR HEAT LOAD (all LCW) and 9-8-9 ML

Shigeki (check min Flow?)

MAIN LINAC - ELECTRON & POSITRON																	
Components	Quantity Per 36m	Location	To Low Conductivity Water									to Chilled Water	Keith Jobe load to air Nov 22 06		Max Space Temp (C)		
			Heat Load to Water (KW)	Max Allowable Temperature (C)	Supply Temp (variation) (C)	Supply Temp (C)	Delta Temperature (C delta)	Water Flow (l / min)	Maximum Allowable Pressure (Bar)	Typical (water) pressure drop Bar	Acceptable Temp Variation delta C	Heat Load to Water (KW)	Power fraction to Tunnel Air (0-1)	Power to Tunnel Air (KW)			
Non-RF Components																	
AC Pwr Transformer 34.5-48 kV	0.25	Service Tunnel	1.50			35							None	0	0.25	0.50	
RF Components																	
RF Charging Supply 34.5 Kv AC-8kV DC	1/36	Service Tunnel	2.8			40	40	1.17	18	5	10	0	0.3	1.2			85 F (a)
Switching power supply 4kV 50kW	1/36 m	Service Tunnel	4.5			35	8.50	7.6	18	5	10	0	0.4	3.0			
Modulator	1/36 m	Service Tunnel	4.5			35	3.23	20	10	5	n/a	0	0.4	3.0			
Pulse Transformer	1/36 m	Service Tunnel	0.7	60		35	0.50	20		1	n/a	0	0.3	0.3			
Klystron Socket Tank / Gun	1/36 m	Service Tunnel	0.8	60		35	1.15	10	15	1	n/a	0	0.2	0.2			
Klystron Focusing Coil (Solenoid)	1/36 m	Service Tunnel	5.5	80		55	8	10	15	1	n/a	0	0.1	0.4			
Klystron Collector	1/36 m	Service Tunnel	45.8	87		38 (inlet temp 25 to 63)	18	37	15	0.3	n/a	0	0.0	1.4			
Klystron Body & Windows	1/36 m	Service Tunnel	4.2	40		25 to 40C	6	10	15	4.5	+ - 2.5 C	0					
Relay Racks (Instrument Racks)	1/36 m	Service Tunnel	0	N/A		N/A	N/A		N/A	N/A	None	11.5	-0.2	-1.5			
Attenuators	2/36 m	Service Tunnel	0	N/A		N/A	N/A		N/A	N/A	None			0.0			
Waveguide (in service tunnel)	1/36 m	Service Tunnel	0											1.166			
Waveguide (in penetration)	1/36 m	Penetration	0.0														
Waveguide (in beam tunnel)	1/36 m	Beam Tunnel	0.0											5.0			
Circulators With loads (isolator)	26/36 m	Beam Tunnel	2.49			35	0.45 per load	3 per load				+ - 2.5 C	0	0.0			
Loads	24/36 m	Beam Tunnel	30.05			35	2.25 per load	8 per load				+ - 2.5 C		0.0			
Subtotal RF unit Only			102.0														
Total RF			103.5														
											11.5		21.4				

NOTE : Loads, Circulators and Klystron Body Supply Temperature is critical (should have very slow supply temp variat

Total Heat load to Air/Chilled water in service tunnel (per RF)	32.9 KW
Total Heat load to LCW (per RF)	103.5 KW
Total Heat load to air in beam tunnel (ignore rock contribution for now)	5.9 KW

Chris and Keith?

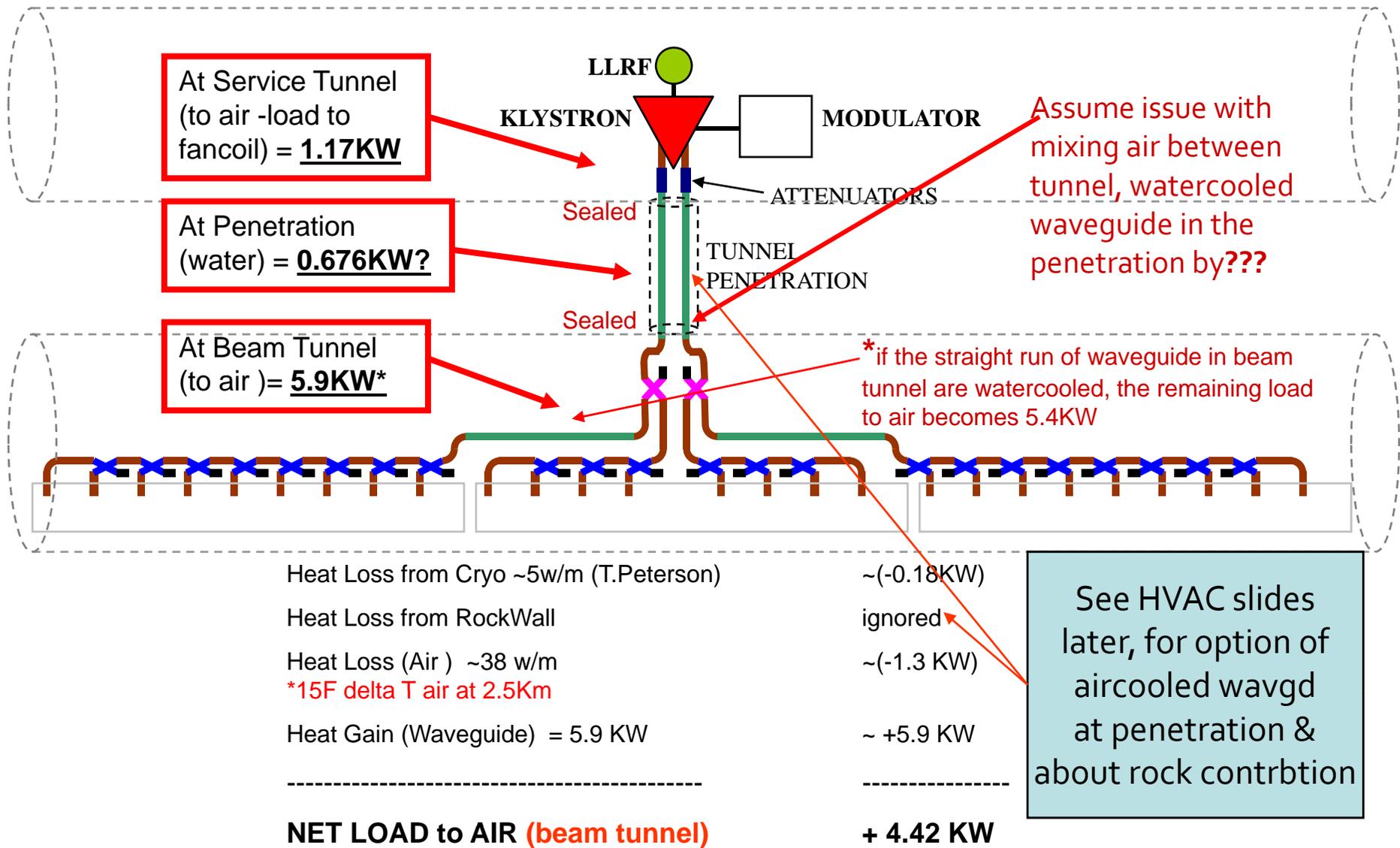
Chris Nantista

Beam Tunnel Temperature?

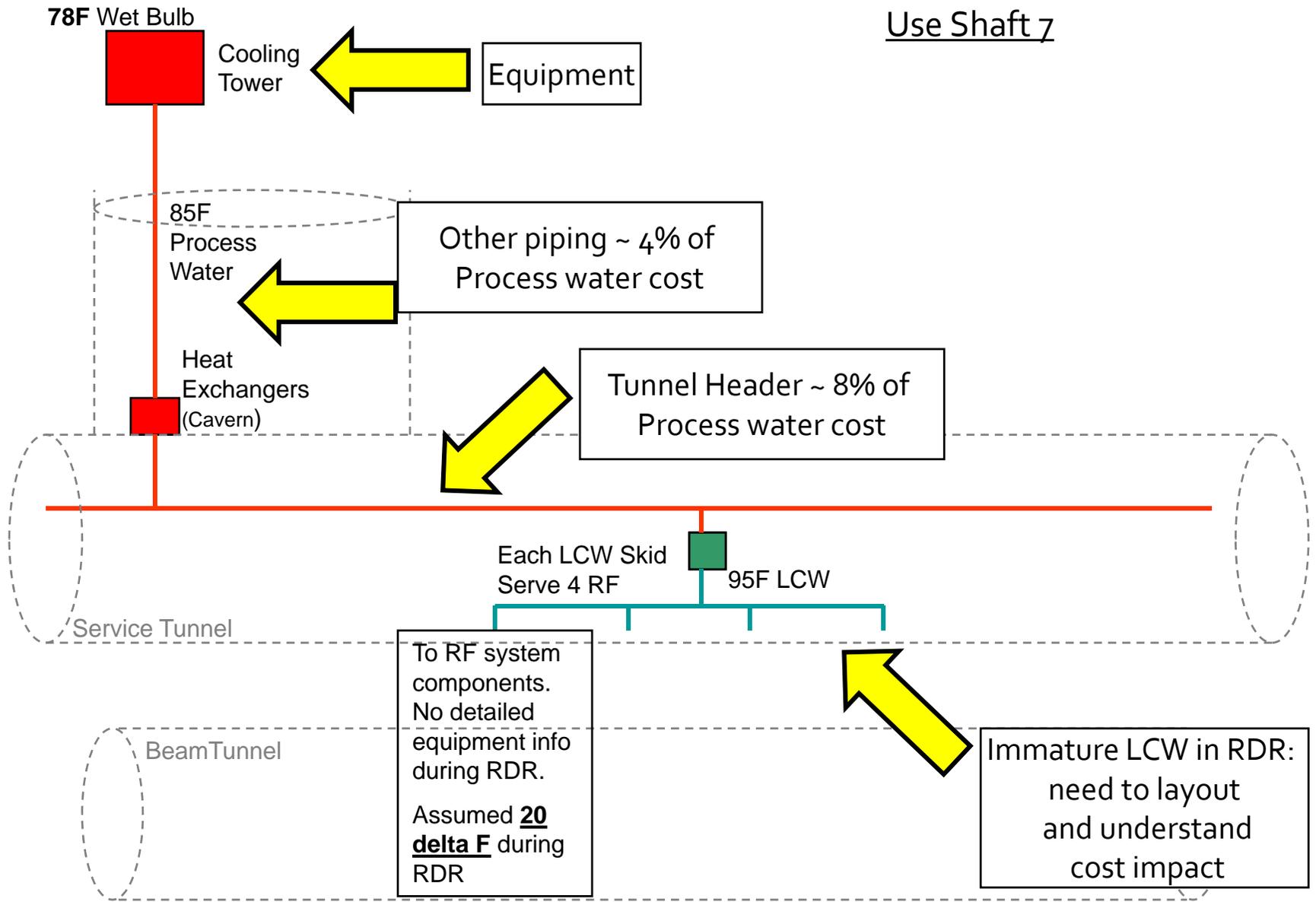
Loads Increasing

E Huedem, Nov 27 2007

Waveguide Heat of ONE RF UNIT (Oct 4 2007)

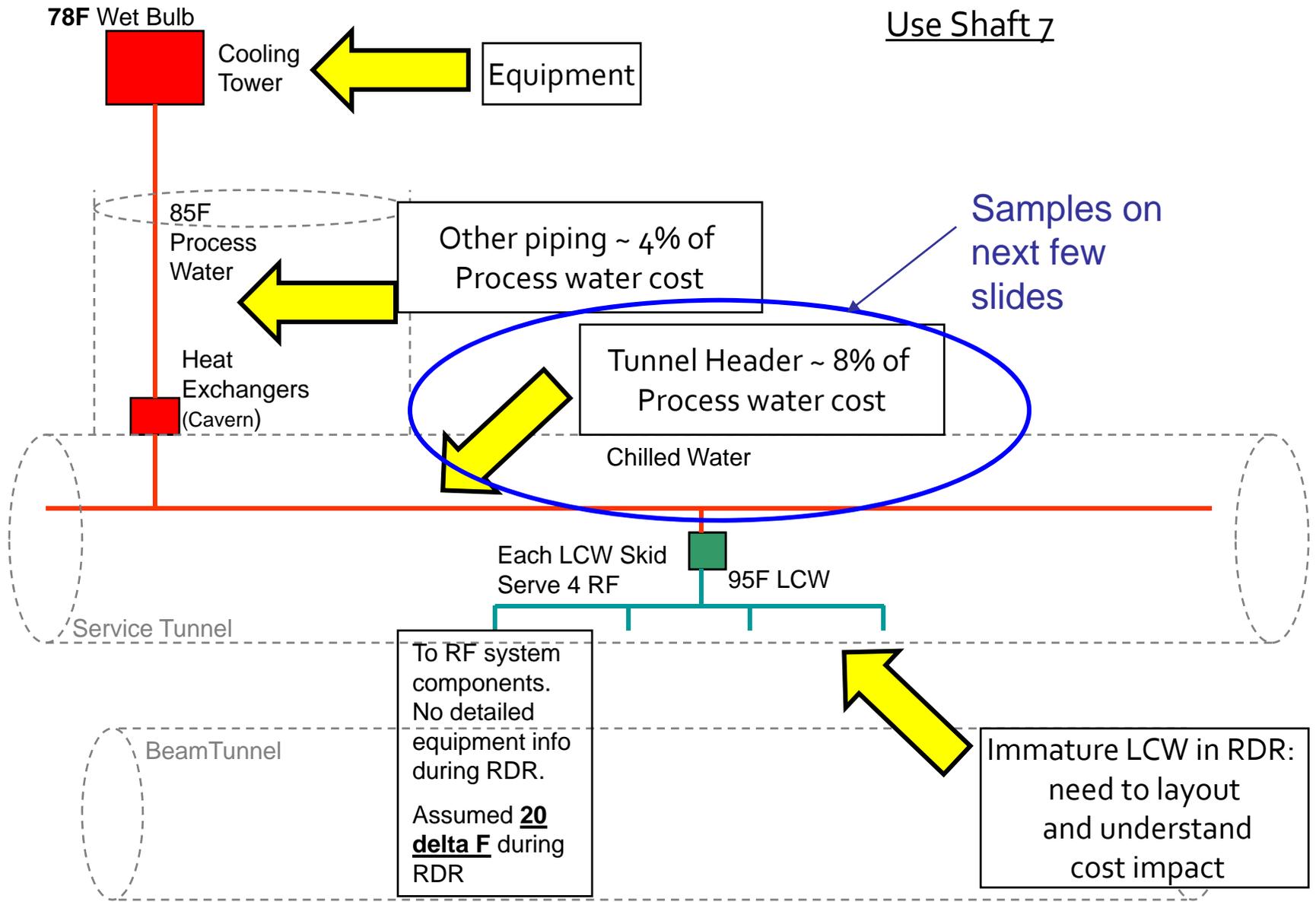


High Delta T Impact– Process Water only



Use Shaft 7

High Delta T Impact– Process Water only



- **Tunnel Pipe Sizes** Reasonable Balance between increased pumping hp, piping first cost, noise/vibration.

Process Water PIPE SIZE - SHAFT 7 Nov 27 2006 eh

No of RF water skid Per Plant **26**
 No of RF = 104, total KW per Skid **400** KW
 Supply Temp (process Water) **90** F
 Delta T (water) **20** F
 One Plant Serves **5** Km
 Flow per LCW skid Unit **137** gpm
 Plant Size (MW) **10.4** MW
 Plant Size (Ton) **2959** Ton



Pipe/Pump Sizing from Cavern to Skid at 20 delta F

Pipe Segment between Skid	FLOW gpm	Pipe SIZE	Velocity fps	press drop ft/100 ft	press drop	pipe length (ft) between skid
1	137	4"	3.45	1.12	5.577	37.95m x 4
2	273	6"	3.03	0.53	2.639	497.97
3	410	6"	4.55	1.14	5.677	497.97
4	546	6"	6.06	1.95	9.710	497.97
5	683	8"	4.36	0.75	3.735	497.97
6	819	8"	5.23	1.06	5.278	497.97
7	956	8"	6.1	1.43	7.121	497.97
8	1092	8"	7.01	1.84	9.163	497.97
9	1229	10"	4.97	0.73	3.635	497.97
10	1366	10"	5.53	0.89	4.432	497.97
11	1502	10"	6.08	1.07	5.328	497.97
12	1639	12"	4.67	0.53	2.639	497.97
13	1775	12"	5.06	0.69	3.436	497.97
14) Main Piping to HX cavern-supply/return	3550	14"	8.42	1.42	4.26	300

HX atCavern (pressure drop) **assume** ~ 10psid
 HX at Skid (pressure drop) **assume** ~ 10 psid
 Main Piping at HX cavern (supply & return)- item 14 above
 Control valve at skid (pressure drop) **assume**~6psid
 subtotal Supply pipe friction - item 1 to 13
 Subtotal Piping Supply & return pipe friction - double above item
 Add 20 elbows 14" (23 equiv ft each) - **wag**
 total supply & return pipe friction + 2 HXs + Valve+ Elbow press drop
 Add 10% **wag** for misc accessories
 Press Head pump in psi
 calculated BHP @ 65 effy for one pump
 calculated BHP @ 65 effy for two pumps

PIPING header only & INSULATION COST FOR ProcessWaterSTEEL PIPING (ignore fittings cost)

20 delta T F	Length	Unit	Steel Sch40	Means 2006
Pipe Header 14"	300	LF	\$ 174.00	\$ 52,200
Pipe Header 12"	3983.757	LF	\$ 200.00	\$ 796,751
Pipe Header 10"	5975.635	LF	\$ 165.00	\$ 985,980
Pipe Header 8"	7967.514	LF	\$ 109.00	\$ 868,459
Pipe Header 6"	5975.635	LF	\$ 80.00	\$ 478,051
Pipe Header 4"	1991.878	LF	\$ 48.00	\$ 95,610
Pipe Header 3"	0	LF	\$ 38.50	\$ -
Pipe Header 2-1/2"	0	LF	\$ 34.00	\$ -
Pipe Header 14" insulation return 1.5"	150	LF	\$ 20.00	\$ 3,000
Pipe Header 12" insulation return 1.5"	1991.878	LF	\$ 18.30	\$ 36,451
Pipe Header 10" insulation return 1.5"	2987.818	LF	\$ 16.75	\$ 50,046
Pipe Header 8" insulation return 1.5"	3983.757	LF	\$ 15.15	\$ 60,354
Pipe Header 6" insulation return 1.5"	2987.818	LF	\$ 11.85	\$ 35,406
Pipe Header 4" insulation retur 1.5"	995.9392	LF	\$ 9.50	\$ 9,461
Pipe Header 3" insulation return 1.5"	0	LF	\$ 8.05	\$ -
Pipe Header 2-1/2" insulation return 1.5"	0	LF	\$ 7.60	\$ -
piping main in tunnel=				\$ 3,471,769

• Tunnel Pipe Sizes Reasonable Balance between increased pumping hp, piping first cost, noise/vibration.

Process Water PIPE SIZE - SHAFT 7 Nov 27 2006 eh

No of RF water skid Per Plant 26
 No of RF = 104, total KW per Skid **400** kW
 Supply Temp (process Water) 90 F
 Delta T (water) **20** F
 One Plant Serves 5 Km
 Flow per LCW skid Unit 137 gpm
 Plant Size (MW) **10.4** MW
 Plant Size (Ton) **2959** Ton

RDR but higher pipe velocity

Pipe Segment between Skid	FLOW gpm	Pipe SIZE	Velocity fps	press drop ft/100 ft	press drop	37.95m x 4 pipe length (ft) between skid
1	137	2-1/2"	9.18	12.9	64.238	497.97
2	273	4"	6.88	4.08	20.317	497.97
3	410	4"	10.33	8.88	44.220	497.97
4	546	6"	6.06	1.95	9.710	497.97
5	683	6"	7.59	2.98	14.839	497.97
6	819	6"	9.1	4.22	21.014	497.97
7	956	8"	6.1	1.43	7.121	497.97
8	1092	8"	7.01	1.84	9.163	497.97
9	1229	8"	7.89	2.3	11.453	497.97
10	1366	8"	8.77	2.82	14.043	497.97
11	1502	8"	9.64	3.38	16.831	497.97
12	1639	10"	6.66	1.27	6.324	497.97
13	1775	10"	7.22	1.48	7.370	497.97
14) Main Piping to HX cavern-supply/return	3550	12"	10.18	2.31	6.93	300

HX at Cavern (pressure drop) **assume** ~ 10psid
 HX at Skid (pressure drop) **assume** ~ 10 psid
 Main Piping at HX cavern (supply & return)- item 14 above
 Control valve at skid (pressure drop) **assume** ~6psid
 subtotal Supply pipe friction - item 1 to 13
 Subtotal Piping Supply & return pipe friction - double above item
 Add 20 elbows **12"** (19 equiv ft each) - **wag**
 total supply & return pipe friction + 2 HXs + Valve+ Elbow press drop
 Add 10% **wag** for misc accessories
 Press Head pump in psi
 calculated BHP @ 65 effy for one pump
 calculated BHP @ 65 effy for two pumps

23.1	ft
23.1	ft
6.93	
13.9	ft
246.6	ft
493.3	ft
8.778	380.0
569.1	ft
626.0	ft
271.0	psi
863	BHP
432	BHP

PIPING header only & INSULATION COST FOR ProcessWaterSTEEL PIPING (ignore fittings cost) Means 2006

20 delta T F	Length	Unit	Steel Sch40	Total Stl
Pipe Header 14"	0	LF	\$ 174.00	\$ -
Pipe Header 12"	1200	LF	\$ 200.00	\$ 240,000
Pipe Header 10"	3983.757	LF	\$ 165.00	\$ 657,320
Pipe Header 8"	9959.392	LF	\$ 109.00	\$ 1,085,574
Pipe Header 6"	5975.635	LF	\$ 80.00	\$ 478,051
Pipe Header 4"	3983.757	LF	\$ 48.00	\$ 191,220
Pipe Header 3"	0	LF	\$ 38.50	\$ -
Pipe Header 2-1/2"	1991.878	LF	\$ 34.00	\$ 67,724
Pipe Header 14" insulation return 1.5"	0	LF	\$ 20.00	\$ -
Pipe Header 12" insulation return 1.5"	600	LF	\$ 18.30	\$ 10,980
Pipe Header 10" insulation return 1.5"	1991.878	LF	\$ 16.75	\$ 33,364
Pipe Header 8" insulation return 1.5"	4979.696	LF	\$ 15.15	\$ 75,442
Pipe Header 6" insulation return 1.5"	2987.818	LF	\$ 11.85	\$ 35,406
Pipe Header 4" insulation retur 1.5"	1991.878	LF	\$ 9.50	\$ 18,923
Pipe Header 3" insulation return 1.5"	0	LF	\$ 8.05	\$ -
Pipe Header 2" insulation return 1.5"	995.9392	LF	\$ 7.60	\$ 7,569

pipng main in tunnel= **\$ 2,901,573**

Means 2006 Schedule 40 Welded Steel Pipe Cost

T5 MECHANICAL

2000	Welded, sch. 40, on yoke & roll hangers, sized for covering,										
2010	10' O.C. (no hangers incl. for lines 2160 thru 2260)										
2040	Black, 1" diameter	Q-15	93	.172	L.F.	5.05	6.60	.74	12.39	16.30	
2050	1-1/4" diameter		84	.190		6.70	7.30	.82	14.82	19.25	
2060	1-1/2" diameter		76	.211		7.35	8.10	.91	16.36	21.50	
2070	2" diameter		61	.262		8.90	10.10	1.13	20.13	26	
2080	2-1/2" diameter		47	.340		11.60	13.10	1.47	26.17	34	
2090	3" diameter		43	.372		14	14.30	1.61	29.91	38.50	
2100	3-1/2" diameter		39	.410		18.35	15.75	1.77	35.87	45.50	
2110	4" diameter		37	.432		19.25	16.60	1.87	37.72	48	
2120	5" diameter		32	.500		25.50	19.20	2.16	46.86	59.50	
2130	6" diameter	Q-16	36	.667		34.50	26.50	1.92	62.92	80	
2140	8" diameter		29	.828		51.50	33	2.38	86.88	109	
2150	10" diameter		24	1		93	40	2.88	135.88	165	
2160	12" diameter		19	1.263		109	50.50	3.64	163.14	200	
2170	14" diameter		15	1.600		66	64	4.61	134.61	174	
2180	16" diameter		13	1.846		83	73.50	5.30	161.80	208	
2190	18" diameter		11	2.182		93	87	6.30	186.30	240	
2200	20" diameter		9	2.667		103	106	7.70	216.70	281	
2220	24" diameter		8	3		111	120	8.65	239.65	310	
2230	26" diameter		7.50	3.200		261	128	9.20	398.20	490	
2240	30" diameter		6	4		285	159	11.50	455.50	570	
2260	36" diameter		4.50	5.333		330	213	15.35	558.35	700	

- **Tunnel Pipe Sizes** Reasonable Balance between increased pumping hp, piping first cost, noise/vibration.

Process Water PIPE SIZE - SHAFT 7 NOV 21 2007 eh

No of RF water skid Per Plant 26
 No of RF = 104, total KW per Skid **400** KW
 Supply Temp (process Water) 90 F
 Delta T (water) **30** F
 One Plant Serves 5 Km
 Flow per LCW skid Unit 91 gpm
 Plant Size (MW) **10.4** MW
 Plant Size (Ton) 2959 Ton



Pipe/Pump Sizing from Cavern to Skid at 20 delta F

Pipe Segment between Skid	FLOW gpm	Pipe SIZE	Velocity fps	press drop ft/100 ft	press drop	37.95m x 4 pipe length (ft) between skid
1	91	3"	3.95	2.01	10.009	497.97
2	182	4"	4.59	1.9	9.461	497.97
3	273	6"	3.03	0.53	2.639	497.97
4	364	6"	4.04	0.91	4.532	497.97
5	455	6"	5.05	1.38	6.872	497.97
6	546	6"	6.03	1.93	9.611	497.97
7	637	8"	4.09	0.66	3.287	497.97
8	728	8"	4.67	0.85	4.233	497.97
9	819	8"	5.23	1.06	5.278	497.97
10	910	8"	5.84	1.3	6.474	497.97
11	1001	8"	6.42	1.56	7.768	497.97
12	1092	8"	7.01	1.84	9.163	497.97
13	1183	10"	4.81	0.69	3.436	497.97
14) Main Piping to HX cavern-supply/return	2367	10"	9.63	2.56	7.68	300

HX at Cavern (pressure drop) **assume** ~ 10psid
 HX at Skid (pressure drop) **assume** ~ 10 psid
 Main Piping at HX cavern (supply & return) - item 14 above
 Control valve at skid (pressure drop) **assume** -6psid
 subtotal Supply pipe friction - item 1 to 13
 Subtotal Piping Supply & return pipe friction - double above item
 Add 20 elbows **10"** (16 equiv ft each) - **wag**
 total supply & return pipe friction + 2 HXs + Valve+ Elbow press drop
 Add 10% **wag** for misc accessories
 Press Head pump in psi
 calculated BHP @ 65 effy for one pump
 calculated BHP @ 65 effy for two pumps

23.1	ft
23.1	ft
7.68	
13.9	ft
82.8	ft
165.5	ft
8.192	
241.5	ft
265.6	ft
115.0	psi
244	BHP
122	BHP

PIPING header only & INSULATION COST FOR ProcessWaterSTEEL PIPING (ignore fittings cost)

30 delta T F	Length	Unit	Steel Sch40	Total Stl
Pipe Header 14"	0	LF	\$ 174.00	\$ -
Pipe Header 12"	0	LF	\$ 200.00	\$ -
Pipe Header 10"	3191.878	LF	\$ 165.00	\$ 526,660
Pipe Header 8"	11951.27	LF	\$ 109.00	\$ 1,302,688
Pipe Header 6"	7967.514	LF	\$ 80.00	\$ 637,401
Pipe Header 4"	1991.878	LF	\$ 48.00	\$ 95,610
Pipe Header 3"	1991.878	LF	\$ 38.50	\$ 76,687
Pipe Header 2-1/2"	0	LF	\$ 34.00	\$ -
Pipe Header 14" insulation return 1.5"	0	LF	\$ 20.00	\$ -
Pipe Header 12" insulation return 1.5"	0	LF	\$ 18.30	\$ -
Pipe Header 10" insulation return 1.5"	1595.939	LF	\$ 16.75	\$ 26,732
Pipe Header 8" insulation return 1.5"	5975.635	LF	\$ 15.15	\$ 90,531
Pipe Header 6" insulation return 1.5"	3983.757	LF	\$ 11.85	\$ 47,208
Pipe Header 4" insulation return 1.5"	995.9392	LF	\$ 9.50	\$ 9,461
Pipe Header 3" insulation return 1.5"	995.9392	LF	\$ 8.05	\$ 8,017
Pipe Header 2" insulation return 1.5"	0	LF	\$ 7.60	\$ -

piping main in tunnel= **\$ 2,820,996**

- Tunnel Pipe Sizes Reasonable Balance between increased pumping hp, piping first cost, noise/vibration.

Process Water PIPE SIZE - SHAFT 7 NOV 21 2007 eh

No of RF water skid Per Plant: 26
 No of RF = 104, total KW per Skid: **400** kW
 Supply Temp (process Water): 90 F
 Delta T (water): **30** F
 One Plant Serves: 5 Km
 Flow per LCW skid Unit: 91 gpm
 Plant Size (MW): **10.4** MW
 Plant Size (Ton): **2959** Ton



Pipe/Pump Sizing from Cavern to Skid at 20 delta F

Pipe Segment between Skid	FLOW gpm	Pipe SIZE	Velocity fps	press drop ft/100 ft	press drop	pipe length (ft) between skid
1	91	2-1/2"	5.92	6.1	30.376	37.95m x 4
2	182	3"	7.9	7.41	36.900	497.97
3	273	4"	6.88	4.08	20.317	497.97
4	364	4"	9.17	7.07	35.206	497.97
5	455	6"	5.05	1.38	6.872	497.97
6	546	6"	6.06	1.95	9.710	497.97
7	637	6"	7.07	2.61	12.997	497.97
8	728	6"	8.09	3.37	16.782	497.97
9	819	6"	9.1	4.22	21.014	497.97
10	910	6"	10.11	5.16	25.695	497.97
11	1001	8"	6.42	1.56	7.768	497.97
12	1092	8"	7.01	1.84	9.163	497.97
13	1183	8"	7.59	2.14	10.657	497.97
14) Main Piping to HX cavern-supply/return	2367	10"	9.63	2.56	7.68	300

HX at Cavern (pressure drop) **assume** ~ 10psid
 HX at Skid (pressure drop) **assume** ~ 10 psid
 Main Piping at HX cavern (supply & return)- item 14 above
 Control valve at skid (pressure drop) **assume** ~6psid
 subtotal Supply pipe friction - item 1 to 13
 Subtotal Piping Supply & return pipe friction - double above item
 Add 20 elbows **10"** (16 equiv ft each) - **wag**
 total supply & return pipe friction + 2 HXs + Valve+ Elbow press drop
 Add 10% **wag** for misc accessories
 Press Head pump in psi
 calculated BHP @ 65 effy for one pump
 calculated BHP @ 65 effy for two pumps

PIPING header only & INSULATION COST FOR ProcessWaterSTEEL PIPING (ignore fittings cost)

30 delta T F	Length	Unit	Steel Sch40	Means 2006
				Total Stl
Pipe Header 14"	0	LF	\$ 174.00	\$ -
Pipe Header 12"	0	LF	\$ 200.00	\$ -
Pipe Header 10"	1200	LF	\$ 165.00	\$ 198,000
Pipe Header 8"	5975.635	LF	\$ 109.00	\$ 651,344
Pipe Header 6"	11951.27	LF	\$ 80.00	\$ 956,102
Pipe Header 4"	3983.757	LF	\$ 48.00	\$ 191,220
Pipe Header 3"	1991.878	LF	\$ 38.50	\$ 76,687
Pipe Header 2-1/2"	1991.878	LF	\$ 34.00	\$ 67,724
Pipe Header 14" insulation return 1.5"	0	LF	\$ 20.00	\$ -
Pipe Header 12" insulation return 1.5"	0	LF	\$ 18.30	\$ -
Pipe Header 10" insulation return 1.5"	600	LF	\$ 16.75	\$ 10,050
Pipe Header 8" insulation return 1.5"	2987.818	LF	\$ 15.15	\$ 45,265
Pipe Header 6" insulation return 1.5"	5975.635	LF	\$ 11.85	\$ 70,811
Pipe Header 4" insulation retur 1.5"	1991.878	LF	\$ 9.50	\$ 18,923
Pipe Header 3" insulation return 1.5"	995.9392	LF	\$ 8.05	\$ 8,017
Pipe Header 2" insulation return 1.5"	995.9392	LF	\$ 7.60	\$ 7,569
piping main in tunnel=				\$ 2,301,713

- **Tunnel Pipe Sizes** Reasonable Balance between increased pumping hp, piping first cost, noise/vibration.

Process Water PIPE SIZE - SHAFT 7 NOV 21 2007 eh

No of RF water skid Per Plant 26
 No of RF = 104, total KW per Skid **400** kW
 Supply Temp (process Water) 90 F
 Delta T (water) **40** F
 One Plant Serves 5 Km
 Flow per LCW skid Unit 68 gpm
 Plant Size (MW) **10.4** MW
 Plant Size (Ton) **2959** Ton



Pipe/Pump Sizing from Cavern to Skid at 20 delta F

Pipe Segment between Skid	FLOW gpm	Pipe SIZE	Velocity fps	press drop ft/100 ft	press drop	pipe length (ft) between skid
1	68	3"	3.42	4.56	22.707	497.97
2	137	4"	3.45	1.12	5.577	497.97
3	205	4"	5.17	2.37	11.802	497.97
4	273	6"	3.03	0.53	2.639	497.97
5	341	6"	3.79	0.8	3.984	497.97
6	410	6"	4.55	1.14	5.677	497.97
7	478	6"	5.31	1.52	7.569	497.97
8	546	6"	6.03	1.93	9.611	497.97
9	615	6"	6.83	2.44	12.150	497.97
10	683	8"	4.36	0.75	3.735	497.97
11	751	8"	4.82	0.9	4.482	497.97
12	819	8"	5.23	1.06	5.278	497.97
13	888	8"	5.70	1.24	6.175	497.97
14) Main Piping to HX cavern-supply/return	1775	10"	7.22	1.48	4.44	300

HX at Cavern (pressure drop) **assume** ~ 10psid
 HX at Skid (pressure drop) **assume** ~ 10 psid
 Main Piping at HX cavern (supply & return)- item 14 above
 Control valve at skid (pressure drop) **assume** ~6psid
 subtotal Supply pipe friction - item 1 to 13
 Subtotal Piping Supply & return pipe friction - double above item
 Add 20 elbows **12"** (19 equiv ft each) - **wag**
 total supply & return pipe friction + 2 HXs + Valve+ Elbow press drop
 Add 10% **wag** for misc accessories
 Press Head pump in psi
 calculated BHP @ 65 effy for one pump
 calculated BHP @ 65 effy for two pumps

PIPING header only & INSULATION COST FOR ProcessWaterSTEEL PIPING (ignore fittings cost)

40 delta T F	Length	Unit	Steel Sch40	Total Stl
Pipe Header 14"	0	LF	\$ 174.00	\$ -
Pipe Header 12"	0	LF	\$ 200.00	\$ -
Pipe Header 10"	1200	LF	\$ 165.00	\$ 198,000
Pipe Header 8"	7967.514	LF	\$ 109.00	\$ 868,459
Pipe Header 6"	11951.27	LF	\$ 80.00	\$ 956,102
Pipe Header 4"	3983.757	LF	\$ 48.00	\$ 191,220
Pipe Header 3"	1991.878	LF	\$ 38.50	\$ 76,687
Pipe Header 2-1/2"	0	LF	\$ 34.00	\$ -
Pipe Header 14" insulation return 1.5"	0	LF	\$ 20.00	\$ -
Pipe Header 12" insulation return 1.5"	0	LF	\$ 18.30	\$ -
Pipe Header 10" insulation return 1.5"	600	LF	\$ 16.75	\$ 10,050
Pipe Header 8" insulation return 1.5"	3983.757	LF	\$ 15.15	\$ 60,354
Pipe Header 6" insulation return 1.5"	5975.635	LF	\$ 11.85	\$ 70,811
Pipe Header 4" insulation retur 1.5"	1991.878	LF	\$ 9.50	\$ 18,923
Pipe Header 3" insulation return 1.5"	995.9392	LF	\$ 8.05	\$ 8,017
Pipe Header 2" insulation return 1.5"	0	LF	\$ 7.60	\$ -

pipng main in tunnel= **\$ 2,458,624**

- **Tunnel Pipe Sizes** Reasonable Balance between increased pumping hp, piping first cost, noise/vibration.

Process Water PIPE SIZE - SHAFT 7 NOV 21 2007 eh

No of RF water skid Per Plant **26**
 No of RF = 104, total KW per Skid **400** KW
 Supply Temp (process Water) **90** F
 Delta T (water) **40** F
 One Plant Serves **5** Km
 Flow per LCW skid Unit **68** gpm
 Plant Size (MW) **10.4** MW
 Plant Size (Ton) **2959** Ton



Pipe/Pump Sizing from Cavern to Skid at 20 delta F

Pipe Segment between Skid	FLOW gpm	Pipe SIZE	Velocity fps	press drop ft/100 ft	press drop	pipe length (ft) between skid
1	68	2-1/2"	4.56	3.41	16.981	497.97
2	137	2-1/2"	9.18	12.9	64.238	497.97
3	205	3"	9.31	8.9	44.319	497.97
4	273	4"	6.88	4.08	20.317	497.97
5	341	4"	8.59	6.24	31.073	497.97
6	410	4"	10.33	8.88	44.220	497.97
7	478	6"	5.31	1.52	7.569	497.97
8	546	6"	6.03	1.93	9.611	497.97
9	615	6"	6.83	2.44	12.150	497.97
10	683	6"	7.59	2.98	14.839	497.97
11	751	6"	8.34	3.57	17.778	497.97
12	819	6"	9.10	4.22	21.014	497.97
13	888	6"	9.86	4.93	24.550	497.97
14) Main Piping to HX cavern-supply/return	1775	10"	7.22	1.48	4.44	300

HX at Cavern (pressure drop) **assume** ~ 10psid
 HX at Skid (pressure drop) **assume** ~ 10 psid
 Main Piping at HX cavern (supply & return)- item 14 above
 Control valve at skid (pressure drop) **assume** ~6psid
 subtotal Supply pipe friction - item 1 to 13
 Subtotal Piping Supply & return pipe friction - double above item
 Add 20 elbows **12"** (16 equiv ft each) - **wag**
 total supply & return pipe friction + 2 HXs + Valve+ Elbow press drop
 Add 10% **wag** for misc accessories
 Press Head pump in psi
calculated BHP @ 65 effy for one pump
calculated BHP @ 65 effy for two pumps

PIPING header only & INSULATION COST FOR ProcessWaterSTEEL PIPING (ignore fittings cost)

40 delta T F	Length	Unit	Steel Sch40	Total Stl
Pipe Header 14"	0	LF	\$ 174.00	\$ -
Pipe Header 12"	0	LF	\$ 200.00	\$ -
Pipe Header 10"	1200	LF	\$ 165.00	\$ 198,000
Pipe Header 8"	0	LF	\$ 109.00	\$ -
Pipe Header 6"	13943.15	LF	\$ 80.00	\$ 1,115,452
Pipe Header 4"	5975.635	LF	\$ 48.00	\$ 286,830
Pipe Header 3"	1991.878	LF	\$ 38.50	\$ 76,687
Pipe Header 2-1/2"	3983.757	LF	\$ 34.00	\$ 135,448
Pipe Header 14" insulation return 1.5"	0	LF	\$ 20.00	\$ -
Pipe Header 12" insulation return 1.5"	0	LF	\$ 18.30	\$ -
Pipe Header 10" insulation return 1.5"	600	LF	\$ 16.75	\$ 10,050
Pipe Header 8" insulation return 1.5"	0	LF	\$ 15.15	\$ -
Pipe Header 6" insulation return 1.5"	6971.574	LF	\$ 11.85	\$ 82,613
Pipe Header 4" insulation retur 1.5"	2987.818	LF	\$ 9.50	\$ 28,384
Pipe Header 3" insulation return 1.5"	995.9392	LF	\$ 8.05	\$ 8,017
Pipe Header 2" insulation return 1.5"	1991.878	LF	\$ 7.60	\$ 15,138
piping main in tunnel=				\$ 1,956,620

Tunnel Pipe Header Only-shaft 7 (process water only)		
Delta T (low velocity)	cost reduction	bhp reduction
20		
30	19%	23%
40	29%	34%

Impact on others

Equipment =?

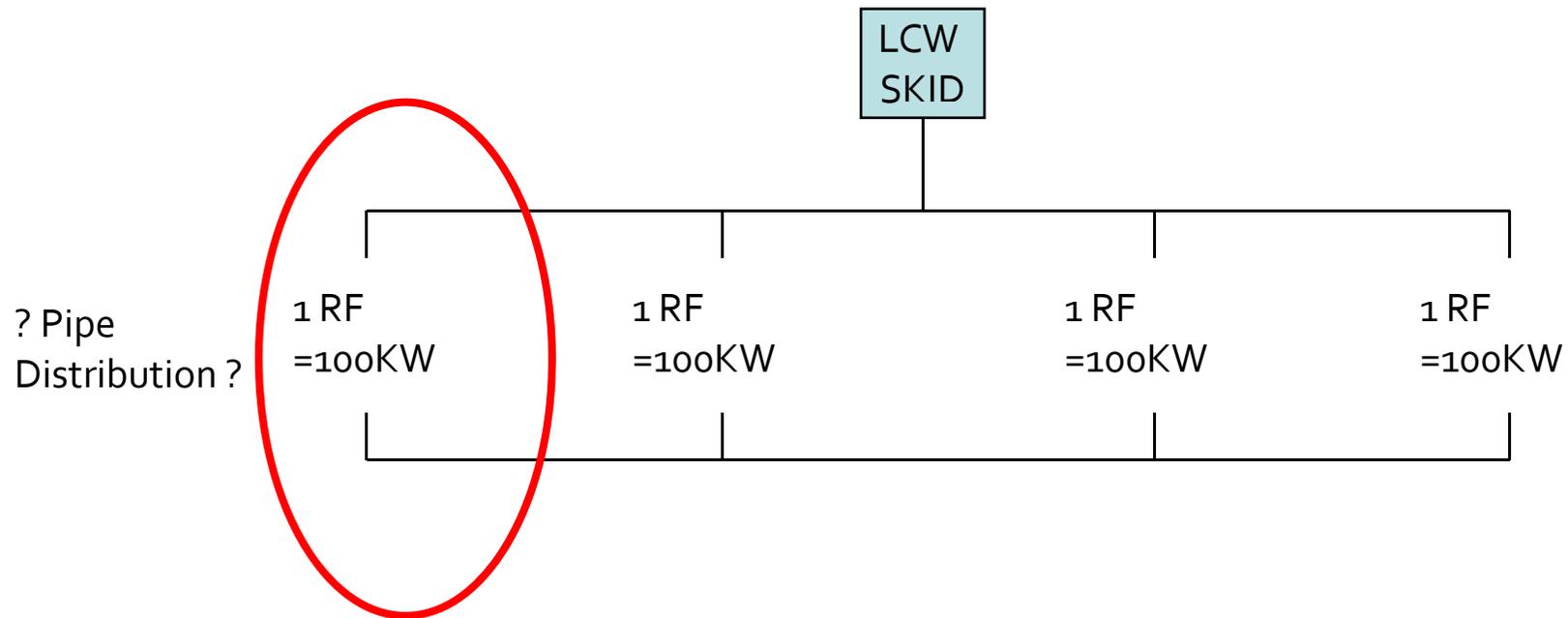
Other Piping =?

LCW =?

- High DELTA-T

RDR has incomplete component criteria to evaluate the delta T.

Used **20F**delta average for Shaft 7 plant.

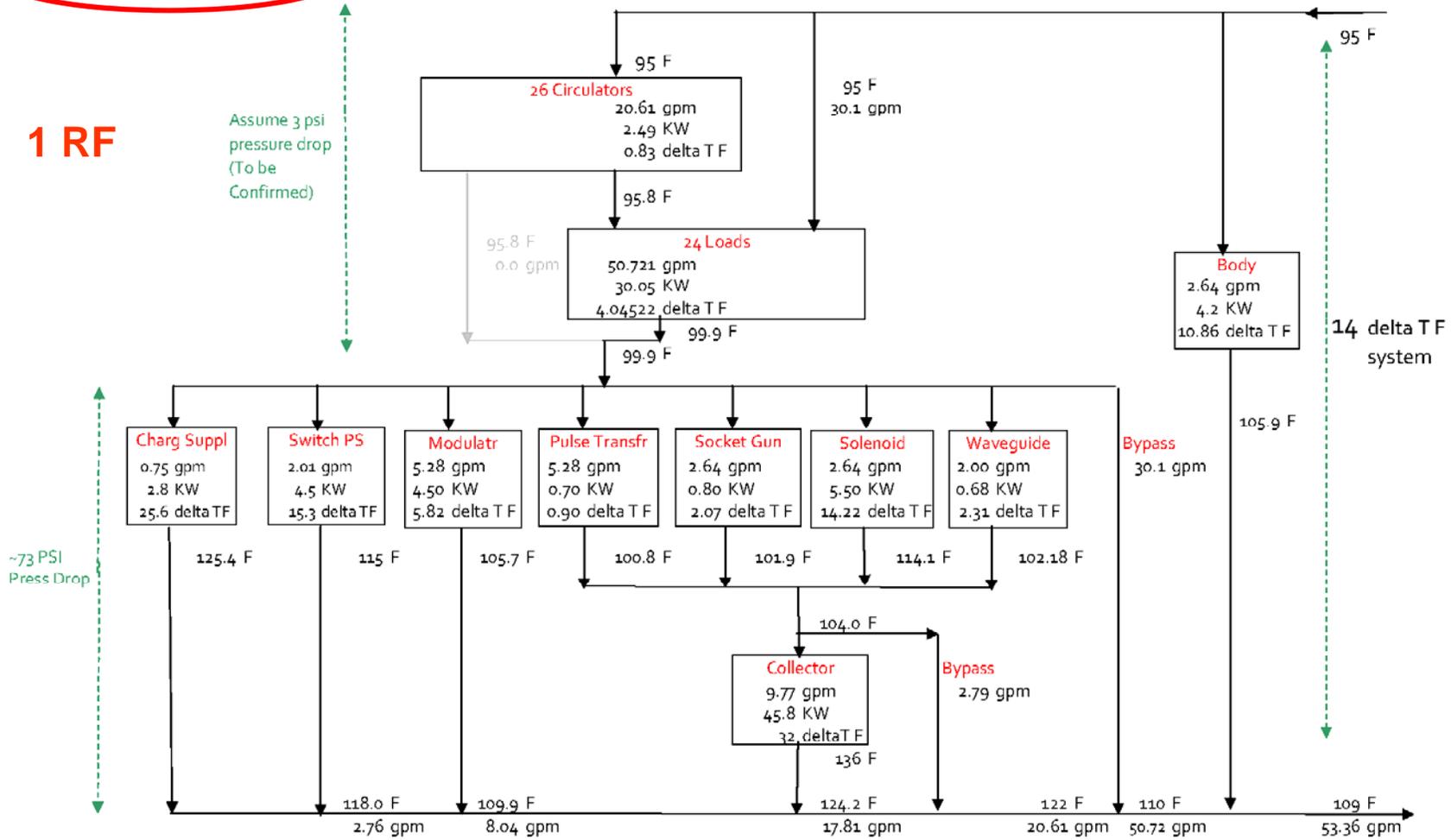


Stacking of Loads / High Delta T

MAIN LINAC RF WATER SYSTEM (based on incomplete heat table dated Oct 31 2007), excluding Transformer

8 liter /min per load flow

e. huedem 11/15/2007



Stacking of Loads / High Delta T

MAIN LINAC RF WATER SYSTEM (based on incomplete heat table dated Oct 31 2007), excluding Transformer

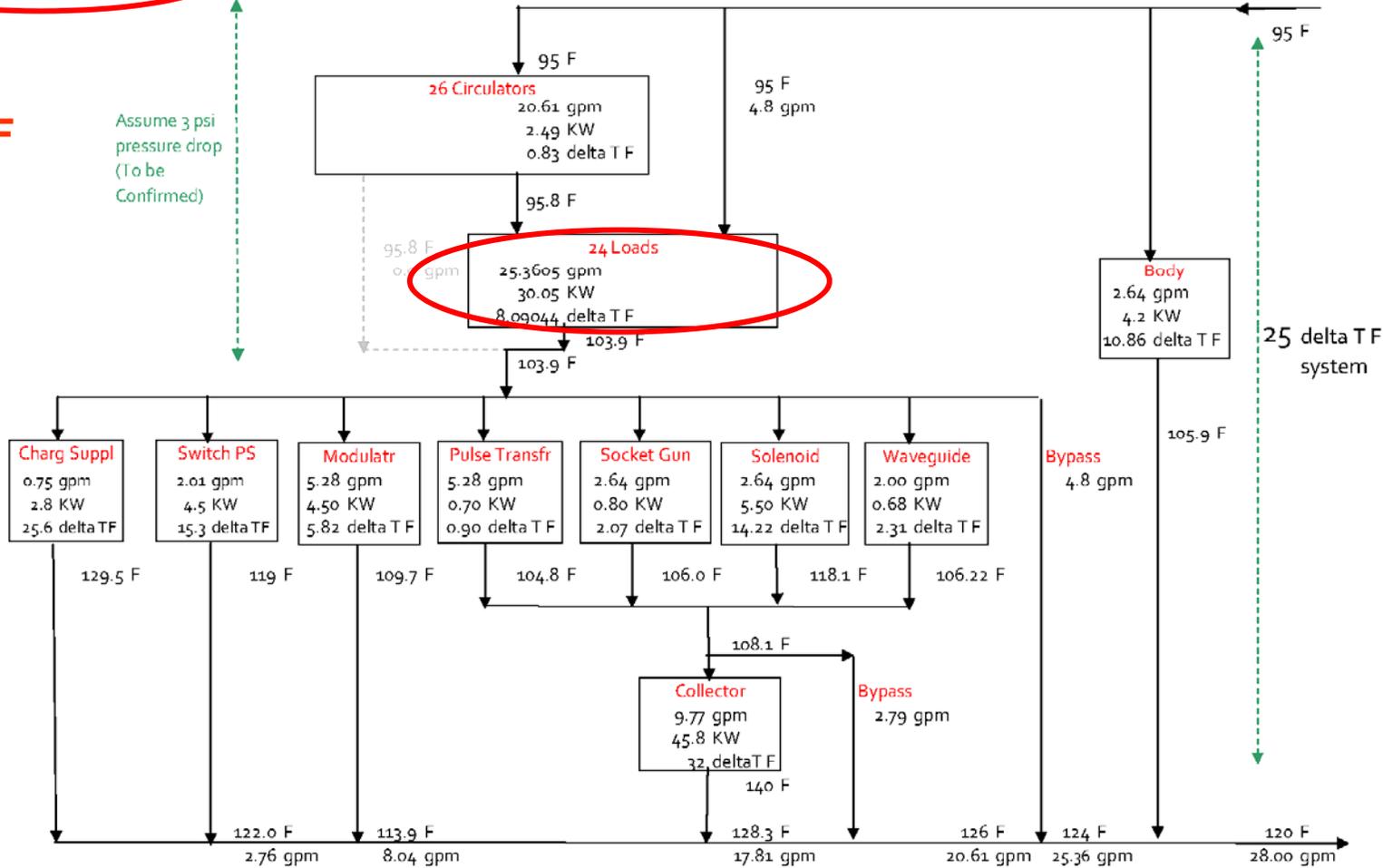
e. huedem 11/15/2007

4 liter / min per load flow

1 RF

Assume 3 psi
pressure drop
(To be
Confirmed)

~73 PSI
Press Drop



25 delta T F
system

Stacking of Loads / High Delta T

MAIN LINAC RE WATER SYSTEM (based on incomplete heat table dated Oct 31 2007), excluding Transformer

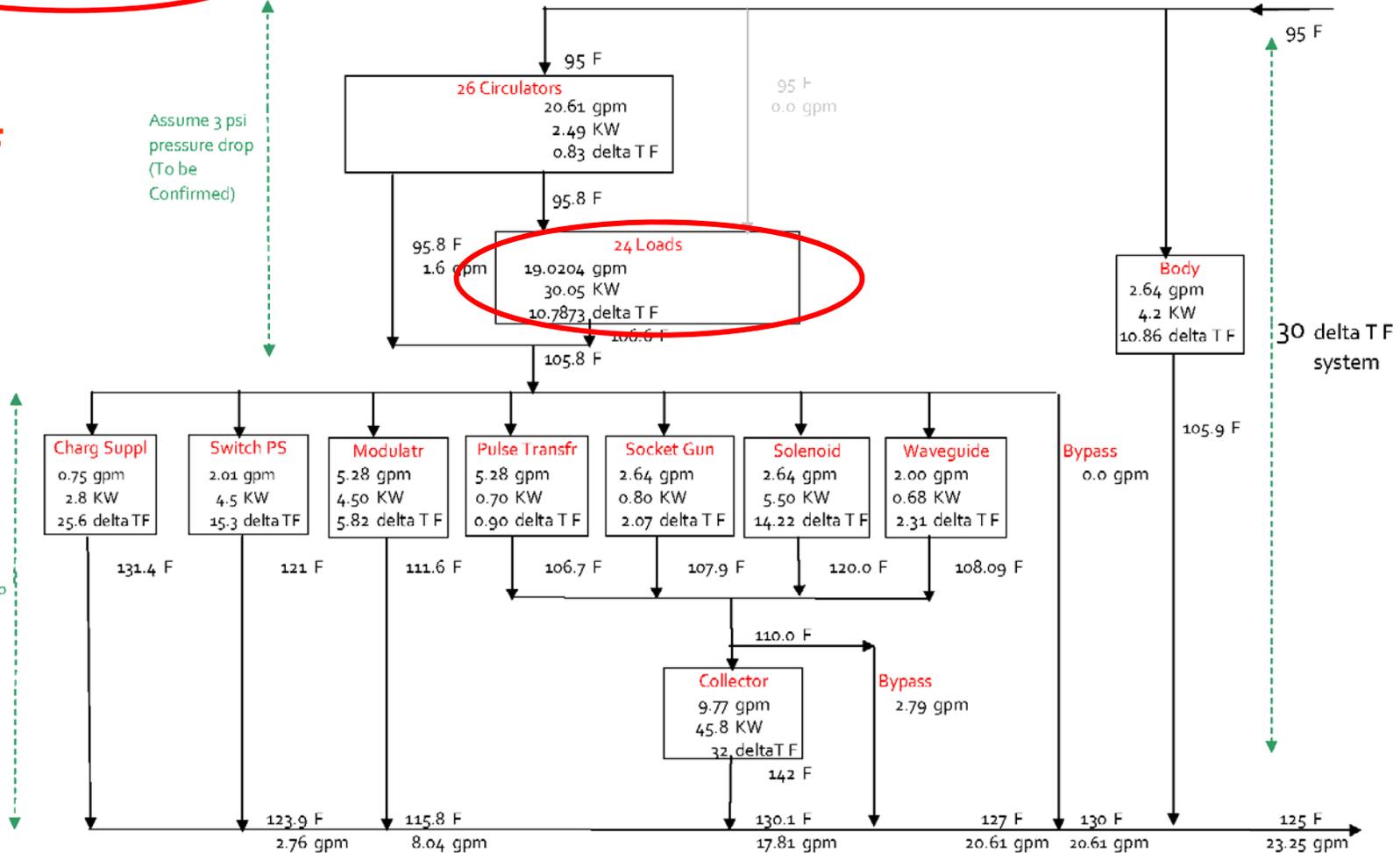
3 liter / min per load flow

e. huedem 11/15/2007

1 RF

Assume 3 psi pressure drop (To be Confirmed)

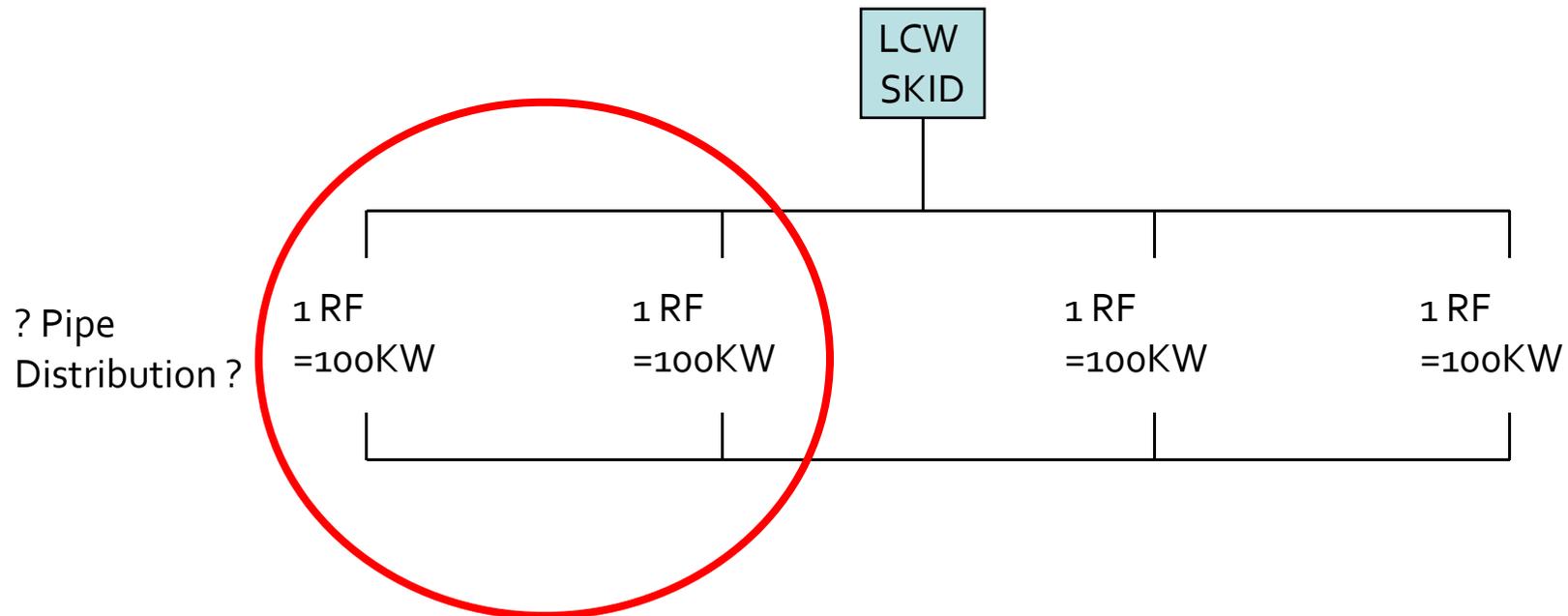
~73 PSI Press Drop



- High DELTA-T

RDR has incomplete component criteria to evaluate the delta T.

Used **20F**delta average for Shaft 7 plant.

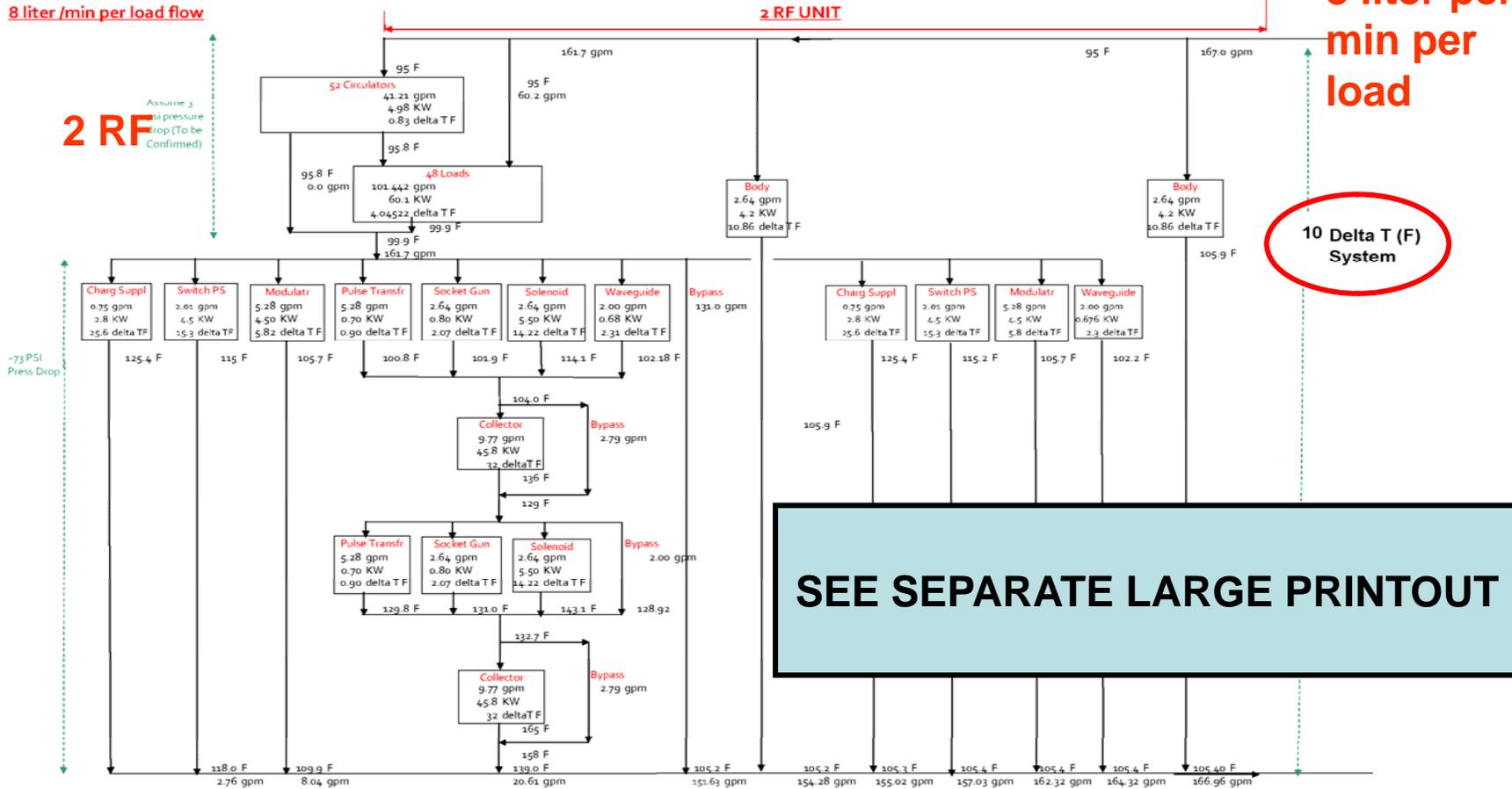


Stacking of Loads / High Delta T

MAIN LINAC 2RF WATER SYSTEM (based on incomplete heat table dated Oct 31 2007), excluding Transformer
 8 liter /min per load flow

e. huedem 11/15/2007

8 liter per min per load

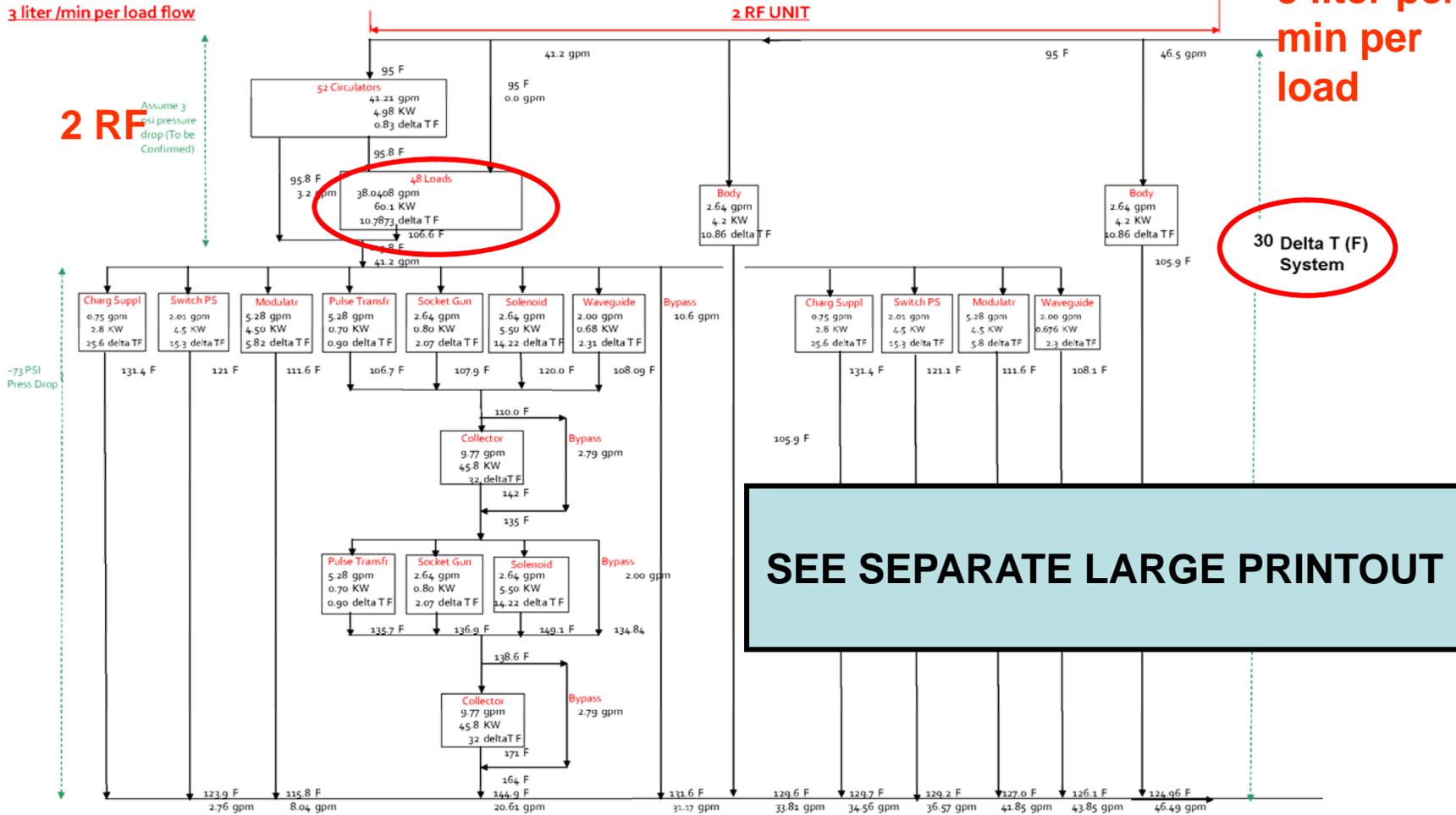


Stacking of Loads / High Delta T

MAIN LINAC 2RF WATER SYSTEM (based on incomplete heat table dated Oct 31 2007), excluding Transformer
 3 liter /min per load flow

e. huedem 11/15/2007

3 liter per min per load



- Piping implications /more piping?? (work for EDR)
- Flow at Loads/circulators can be reduced??(Help from Chris Nantista of Slac)
- Other missing info (Chris Nantista, Keith, etc)
- Change other low delta T components & compare value?? (Jensen? Maurice?)
- We assume the current numbers are right. How about minimum flow for Collector?? (Shigeki working on this with vendors) ..maybe more than what's currently specified (37 liter per min), maybe around ?100?, if so delta T reduced unless small pump dedicated to collector (power implication)??

Summary

Design concept presented (RDR) is preliminary, had *incomplete criteria*, BUT many cost reduction meetings

We're in the early EDR data/criteria gathering period, (*incomplete criteria*). Showed preliminary iteration with delta T, expect many meetings

Need criteria frozen (not a moving target), and time/resources to actually work on this (EDR), and whatever list this VE will generate

continue main focus on FIRST COST REDUCTION???

Hope to see lots of constructive discussions, and HOPE TO HAVE A PRODUCTIVE SESSION

Thank you for your attention.