Process Water VE Updates

(Main Linac Only)

Emil Huedem
FNAL

ILC Meeting - CHICAGO
Nov 17 2008

Brief History - Process Water cooling

•Dec 2006 RDR Cost finished

•Oct 2007 Update ML heat table – (evaluate DT)

•Nov 2007 Value Engineering. PM select VE items (Dec 07 stop work)

•Aug 2008 Cost Kly Cluster

•Sep & Oct 08 VE Costing exercise

Re-visit VE, & Performed a comparative cost estimate to understand the delta and impacts on selected VE/ PM items, for the goal of First-Cost reduction only. Focus on costing rather than design

(Specific VE selected is for Main Linac only RDR-twin-tunnel)

Oct 31 2007

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

Main Linac HLRF Heat Load Table

Data from a number of people

MAIN LINAC - ELECTRON & POSITRON		To Low Conductivity Water									to Chilled Water	keith Jobe load to air Nov 22 06			
Components	Quantity Per 36m	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)		Max Space Temp (C)
Non-RF Components															
LCW Skid Pump 1 per 4 rf -Motor/Feeder Loss	0.25	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	None	0	1.00	0.60		
I^2R Loss and Motor Loss (misc)	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	None	0	1.00	8.22		
Fancoils (5 ton Chilled Water) 1.5 Hp	2	**0**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**None**	**0**				
Rack Water Skid	0.25	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	None	0	1.00	0.20		
Lighting Heat Dissipation ~1.3W/sf		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	None	0	1.00	1.65		
AC Pwr Transformer 34.5-.48 kV	0.25	1.50			35					None	0	0.25	0.50		
Emerg. AC Pwr Transformer 34.5-.48 kV		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	None	0	1.00	1.00		
RF Components															
RF Charging Supply 34.5 Kv AC-8KV DC	1/36 m	2.8			40	40	1.2	18	5	10	0	0.3	1.2		
Switching power supply 4kV 50kW	1/36 m	4.5			35	8.50	7.6	13	5	10	0	0.4	3.0		
Modulator	1/36 m	4.5			35	3.23	20	10	5	n/a	0	0.4	3.0		
Pulse Transformer	1/36 m	0.7	60		35	0.50	20		1	n/a	0	0.3	0.3		
Klystron Socket Tank / Gun	1/36 m	0.8	60		35	1.15	10	15	1	n/a	0	0.2	0.2		
Klystron Focusing Coil (Solenoid)	1/36 m	5.5	80		55	8	10	15	1	n/a	0	0.1	0.4		85 F (a)
Klystron Collector	1/36 m	45.8	37		38 (inlet temp 25 to 63)	18	37	15	0.3	n/a	0	0.0	1.4		
Klystron Body & Windows	1/36 m	4.2	40		25 to 40C	6	10	15	4.5	+ - 2.5 C	0				
Relay Racks (Instrument Racks)	1/36 m	0	N/A		N/A	N/A		N/A	N/A	None	11.5	-0.2	-1.5		
Attenuators	2/36 m	0	N/A		N/A	N/A		N/A	N/A	None			0.0		
Waveguide (in service tunnel)	1/36 m	0											1.166		
Waveguide (in penetration)	1/36 m	0.676													
Waveguide (in beam tunnel)	**1/36 m**	**0.0**								+ - 2.5 C	0		5.9		
Circulators With loads (isolator)	**26/36 m**	**2.49**			35	0.45 per load	3 per load			+ - 2.5 C	0		0.0		
Loads	**24/36 m**	**30.05**			35	2.25 per load	8 per load			+ - 2.5 C			0.0		
Subtotal RF unit Only		102.0													
Total RF		103.									11.5		21.4		

NOTE : Loads, Circulators and Klystron Body Supply Temperature is critical (should have very slow supply temp variation) **Oct 25 2007 Jensen,Oleg & Shigeki

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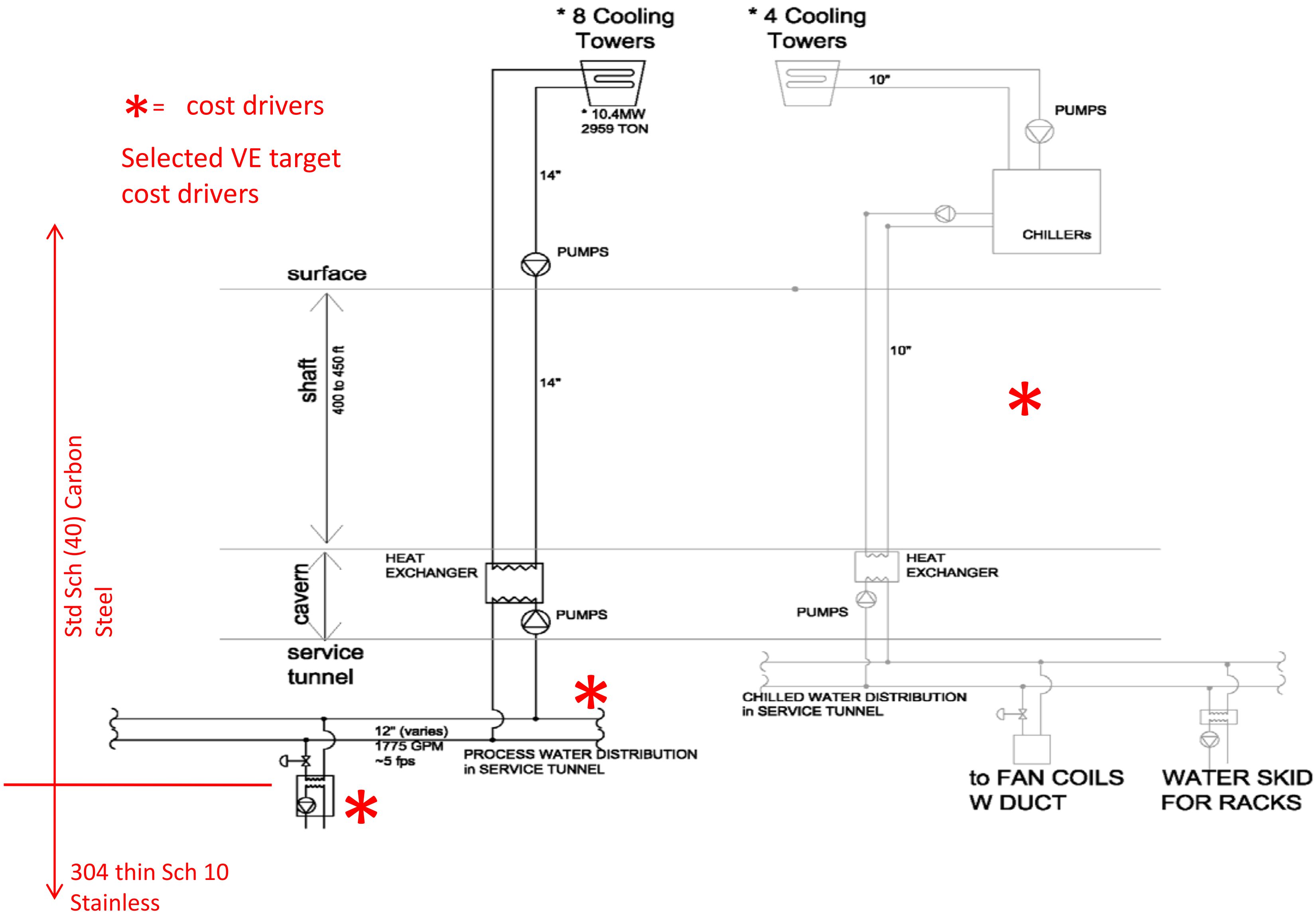
Reduced by 50% (Mar 2008)

RDR Process Water System
Basis: Shaft 7

*= cost drivers

Selected VE target cost drivers



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VE ITEMS – Nov 2007

Additional PM items- Mar 2008

		DESCRIPTIONs & "color" legend	
		(Gut-Feel) may not result to large savings	
		(Gut-Feel) may result to savings. Will be evaluated? (potential cost	
		MARC ROSS DEC 04, 2007 DIRECTION (LIST TO BE EVALUATE	
		Will be evaluated By Others(HLRF), not CFS, whether high cost sa	
		(not shaded) = Items that im Not Sure	
1	1	Provide one high efficiency cogen power / cooling plant on site and distribute power and 33 degree F chilled water throughout the facility, remove the power generation and chilling cost from the project cost	Steve
	4	Eliminate one piping system by using process water as primary rejection for chilled water system w/#1 (using	
	4b		
	5		

1 Eliminate chilled water system. Use process water as the primary rejection,

2 Use process fancoils, warmer tunnel temperature 104 F (**up to ~113F/ 45C**) during normal operation, and portable cooling for workers

3 Increase water system Delta T = 30 D F (16.7 D C) **up to 72 F DT (40 D K)**

5	10	Centralize the HVAC and reconfigure air flow from the ends	Lee
	13		
	15		

4 Consider using low mineral content water instead of LCW (pipe material)

5 Allow different type of pipe materials (CPVC)

8	16	Redesign the RF loads for more optimal process water flow	Mike
9	21	Modify top shaft HVAC to only process make up air, add blowers down shaft for recirculation	Lee
10	24	Reduce lighting level to egress limits	Tom
11	25	Reduce water pressure drop across components, minimize head pressure	Mike

6 Use localized cooling unit

7 **Remove LCW Skid**

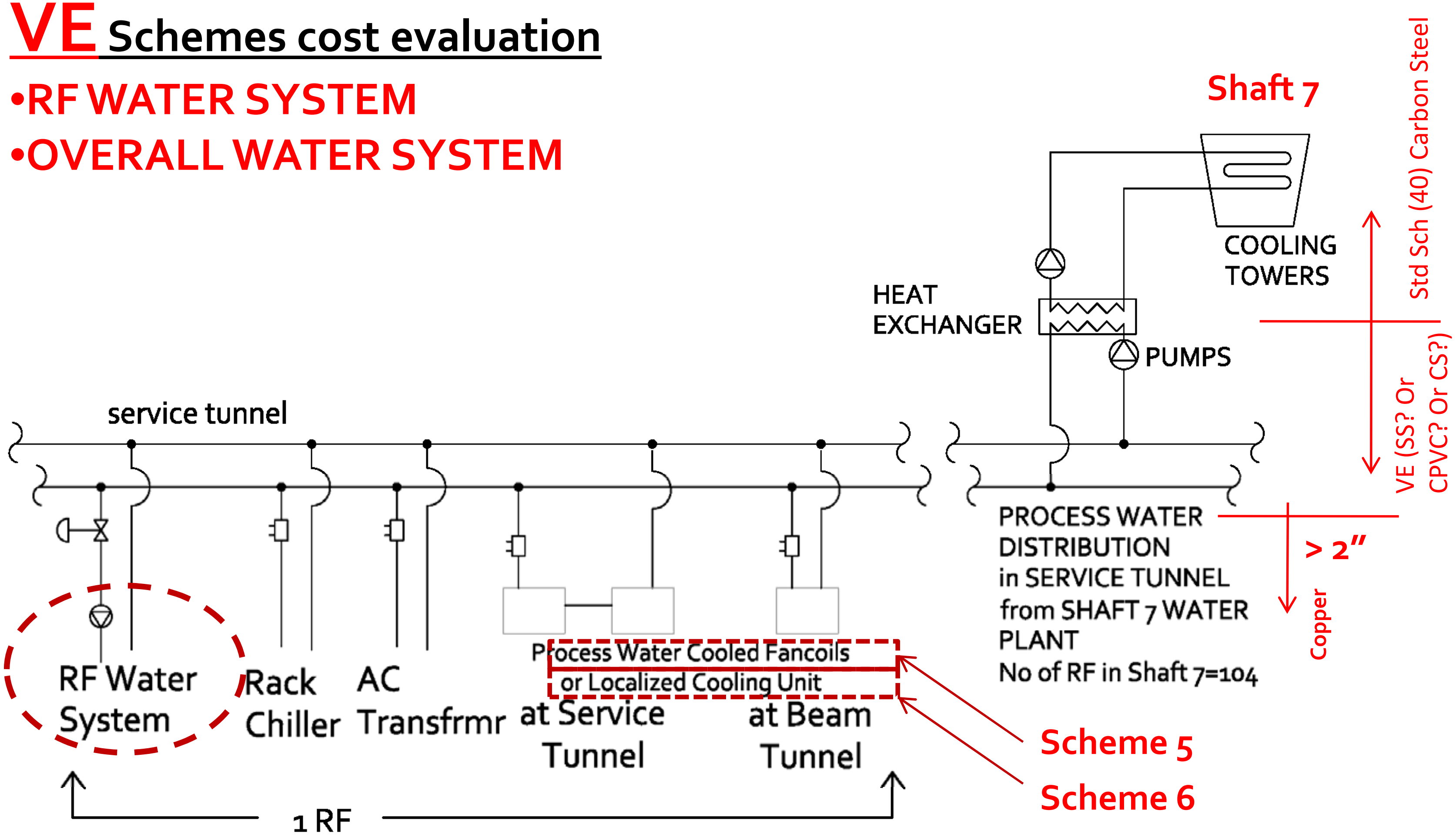
8 **Restore rack cooling only to less than ½ of the rack power load (50% reduction rack load)**

19	50	Develop loads that do not require low conductivity water	Fukuda
20	54	Use the waveguide pressurization system for cooling the waveguide (flow cooled gas inside the waveguide)	Mike
2	8	Define the maximum hydrostatic pressure for the collectors	Mike
4	27	Reexamine the hot changeout of modulator power supplies	Keith
8	41	Use a dessicant to dehumidify ventilation air	Lee
9	51	Evaluate each load individually to determine requirements	Keith / Mike
10	52	Establish power budgets for the relay racks (400 W / RF + 10% of power supplies)	Keith
11	53	Provide power supply that will work with warm water if necessary (quasi militarized)	Keith
NEW	NEW1	Eliminate Rack Skid and replace with just pump	Tom/Emil
NEW	NEW2	*Eliminate one piping system by using chilled water only as primary rejection, eliminate process water distribution*	Tom/Emil

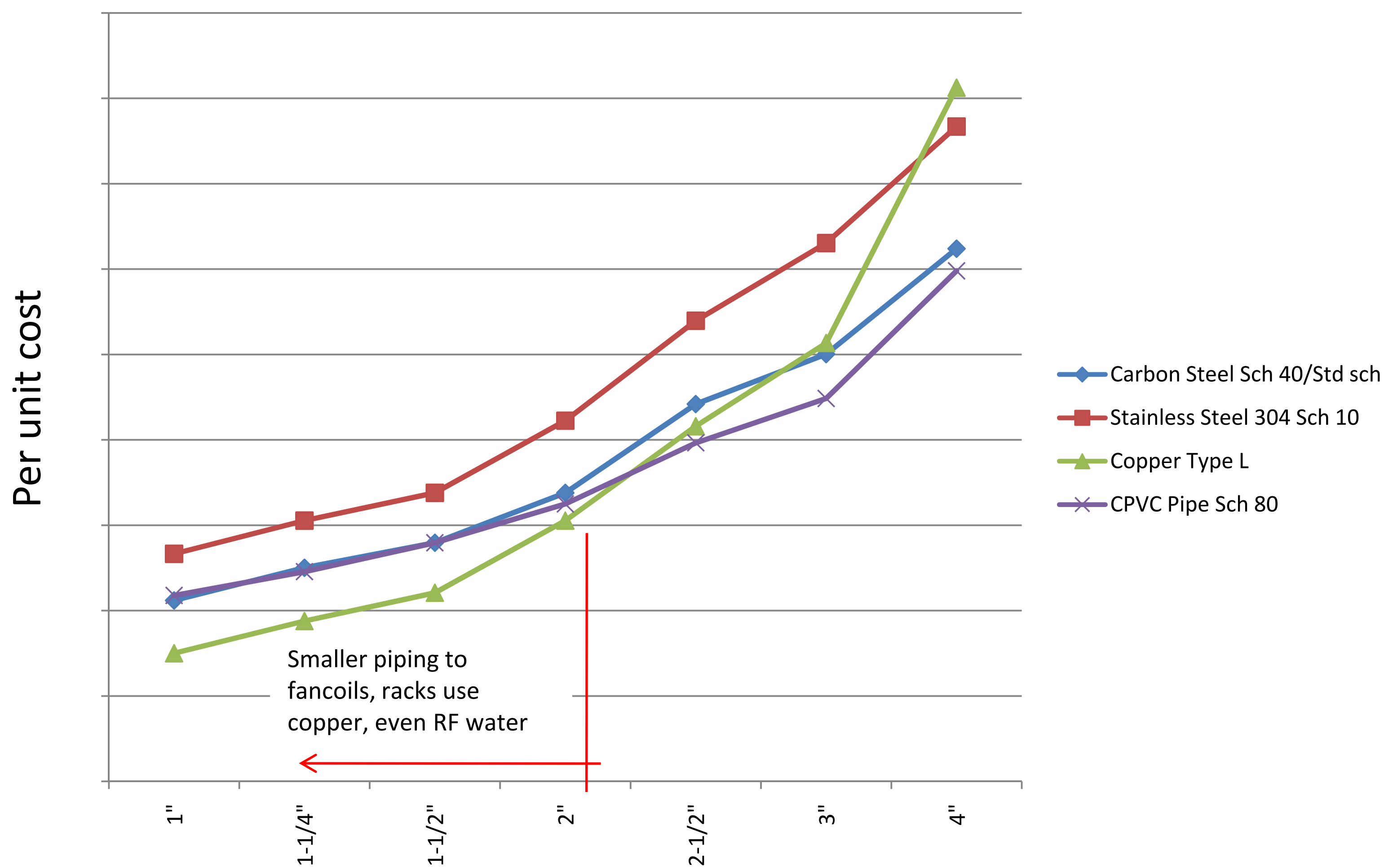
Process Water Only for

VE Schemes cost evaluation

- •RF WATER SYSTEM
- •OVERALL WATER SYSTEM



MEANS BOOK SAMPLE PIPE COST
1" (25DN) to 4" (100DN)



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VE Item. PIPE MATERIAL in tunnel ??

	Resisitivity M-Ohms	Conductivity microsiemens	ppm TDS	
	18	0.056	0.027	Ultra Pure
Main Injector & TeV LCW	10	0.1	0.05	
	8	0.125	0.06	Pure
	5	0.2	0.1	
	4	0.25	0.12	
Tesla CPI notes/ Thales	1	1	0.5	
VE	0.1	10	5	
	0.02	50	25	
	0.002	500	245	Tap water
	0.0002	5,000	2450	
	0.0001	10,000	4900	Sea water
	0.00002	50,000	24500	

Stainless /Copper/ plastic

Means Cost Book has cost for limited size steel, stainless, copper, iron, some plastic. Used

Stainless 304 sch 10,

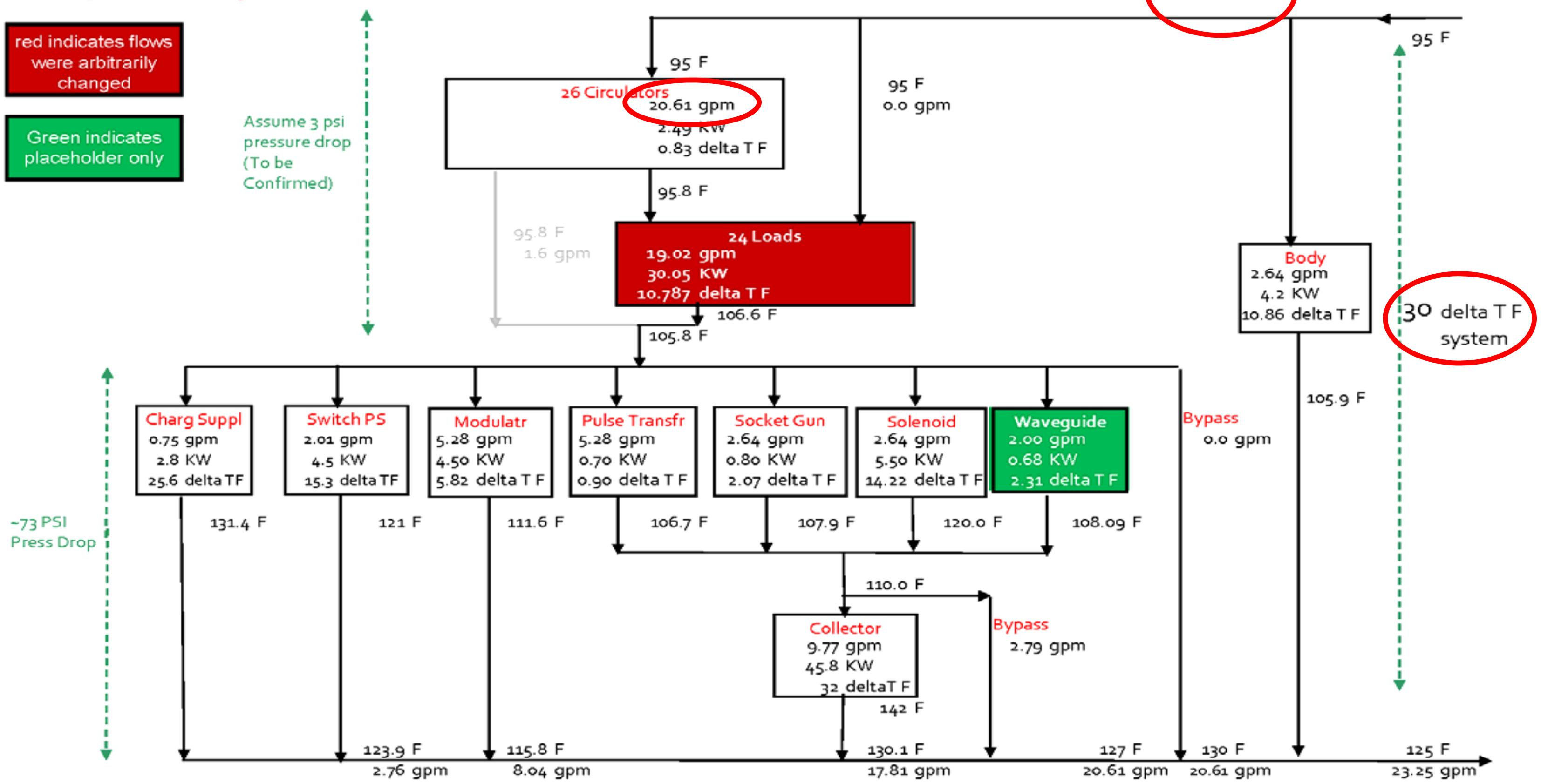
CPVC sch 80,

carbon steel ?

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

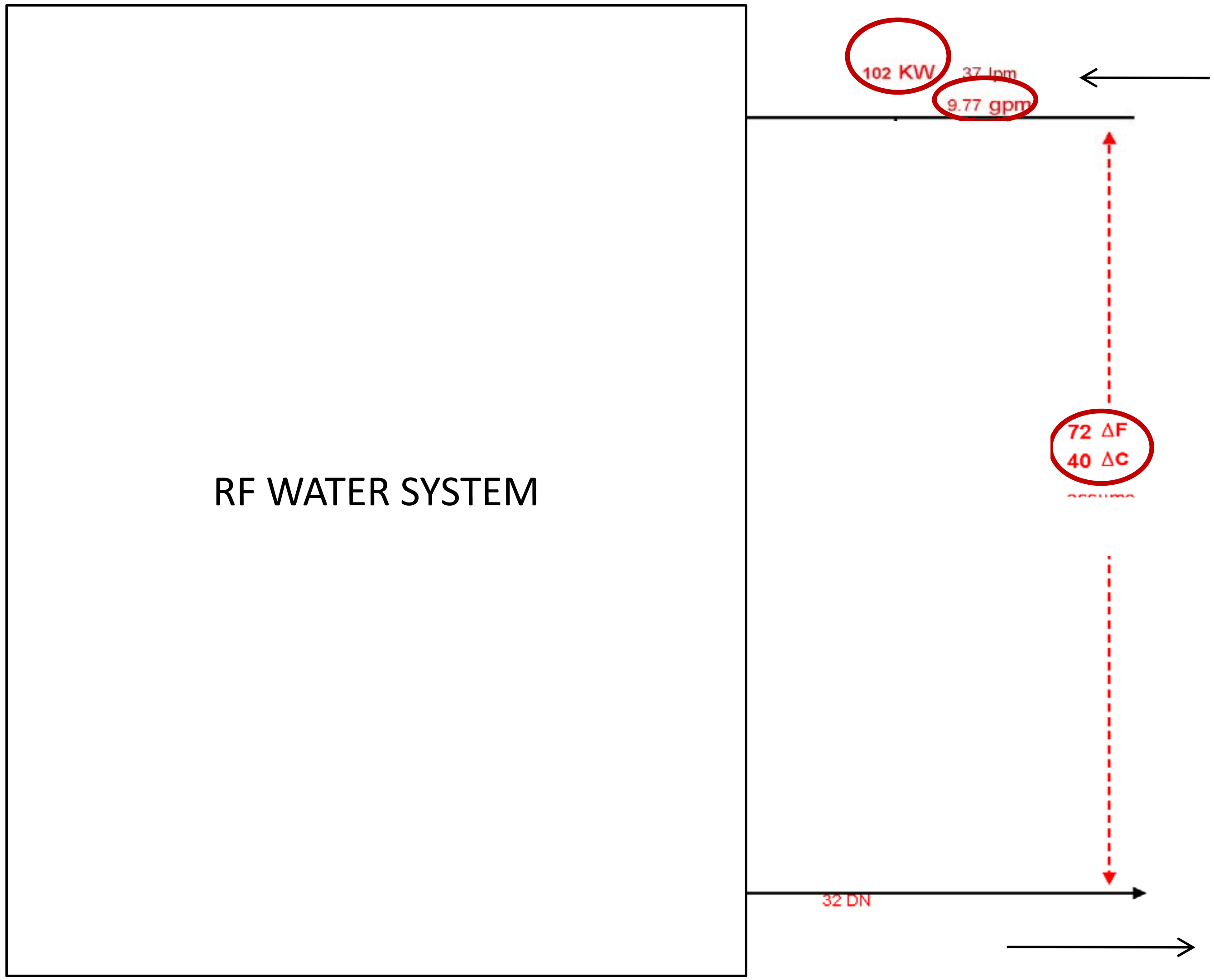
3 liter /min per load flow

e. huedem 11/15/2007



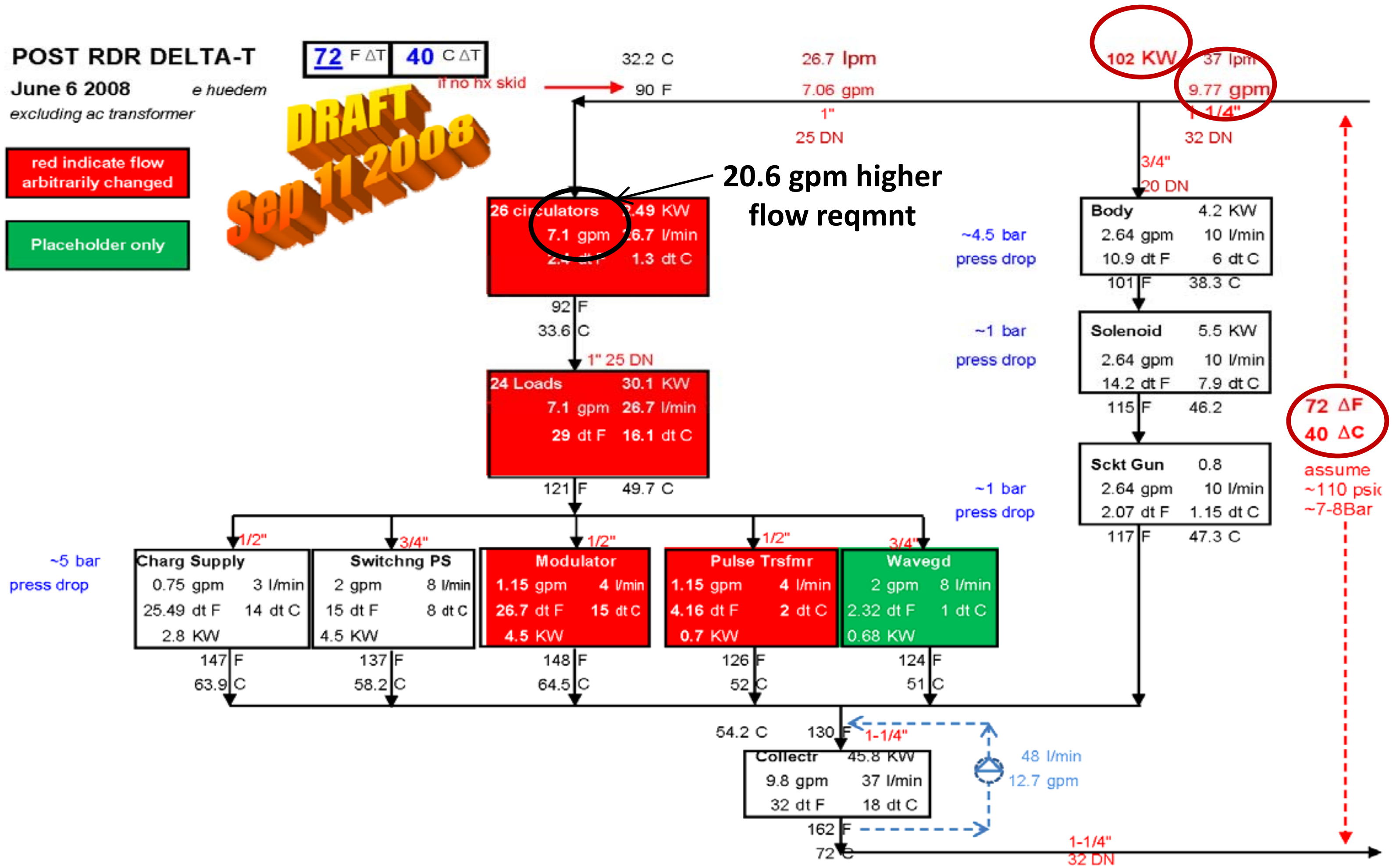
gpm= BtuH/ (500 x ΔT F)

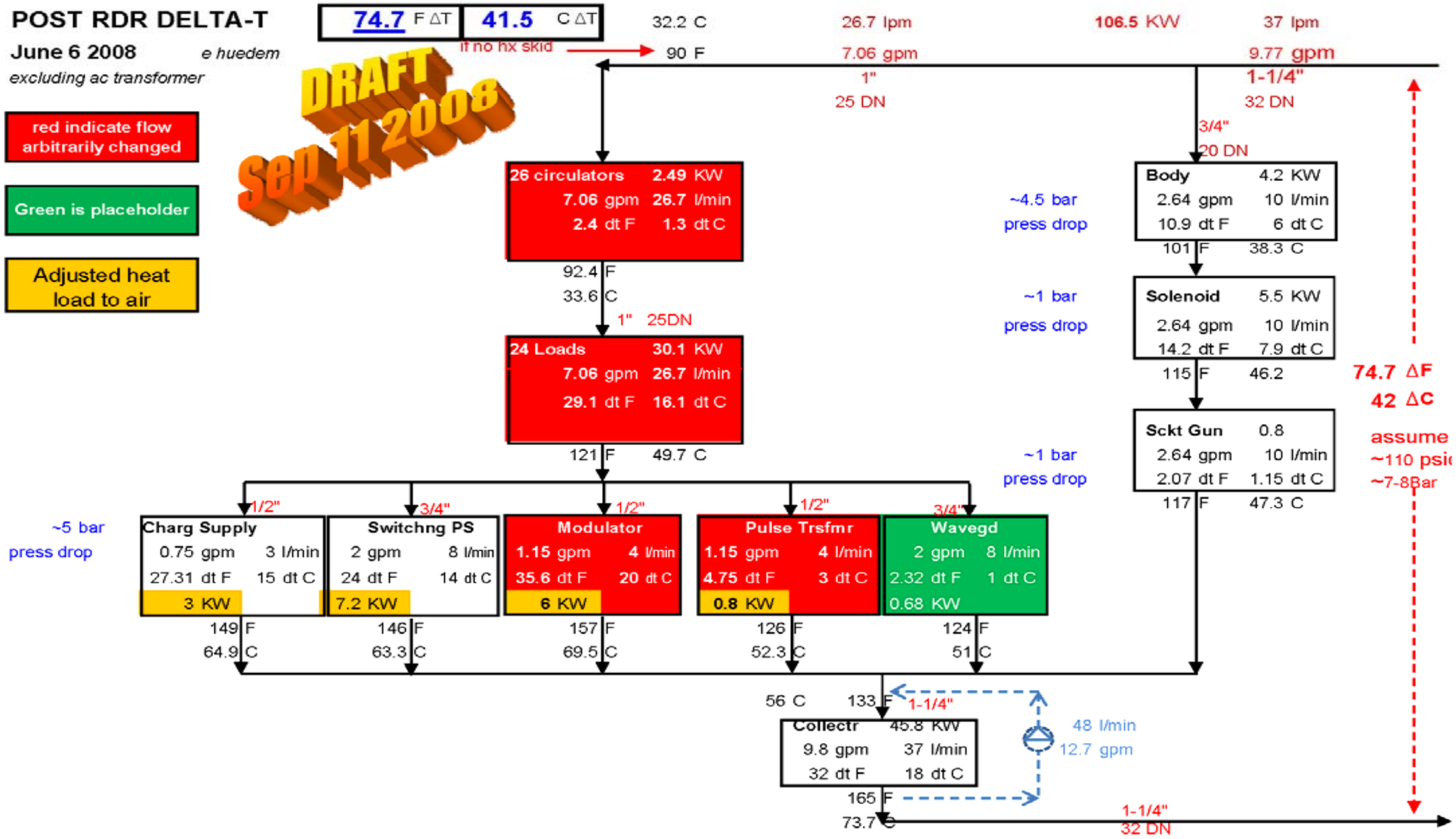
lpm =14.375 KW / ΔT K

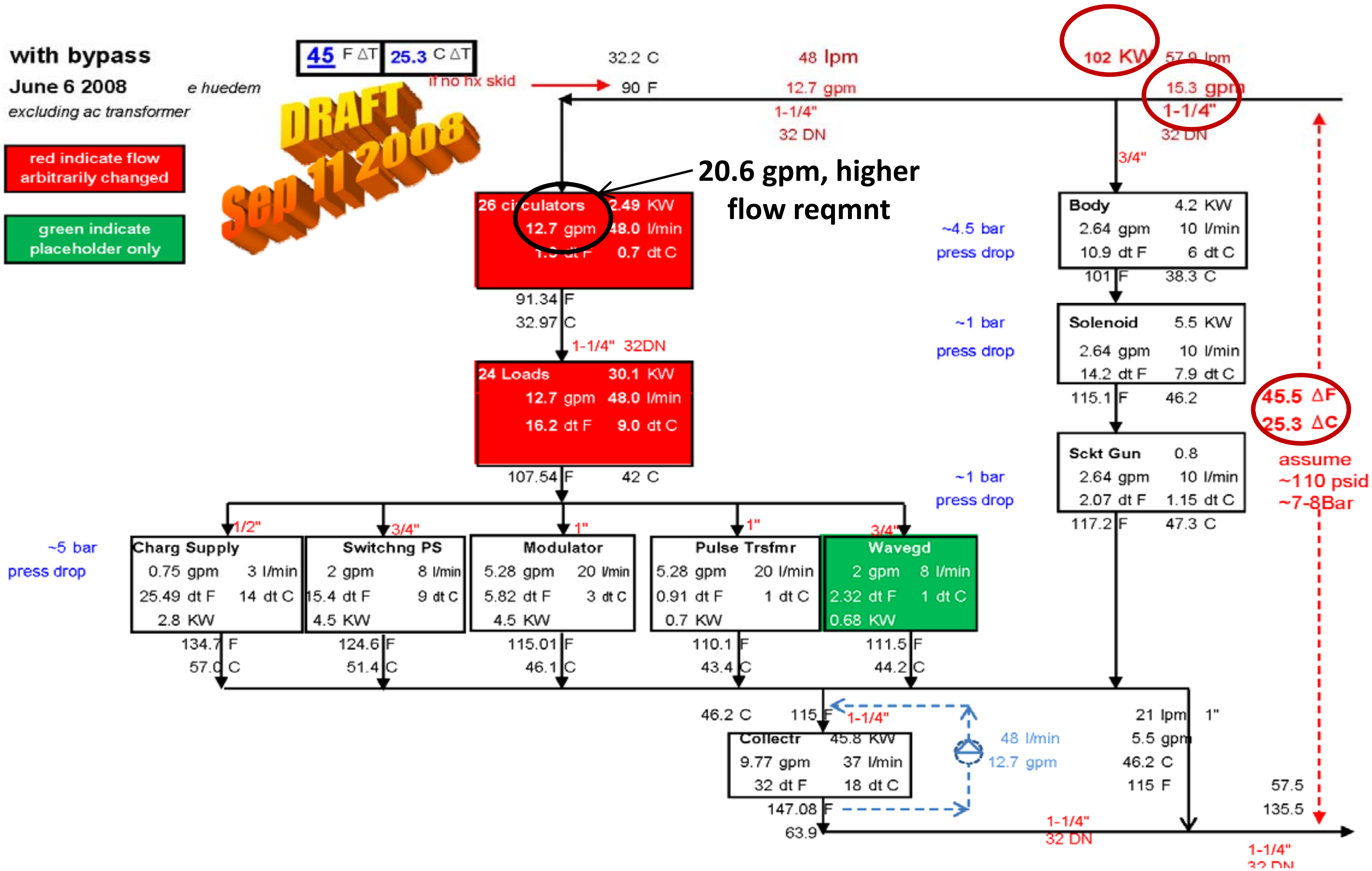


gpm= BtuH/ (500 x DT F)

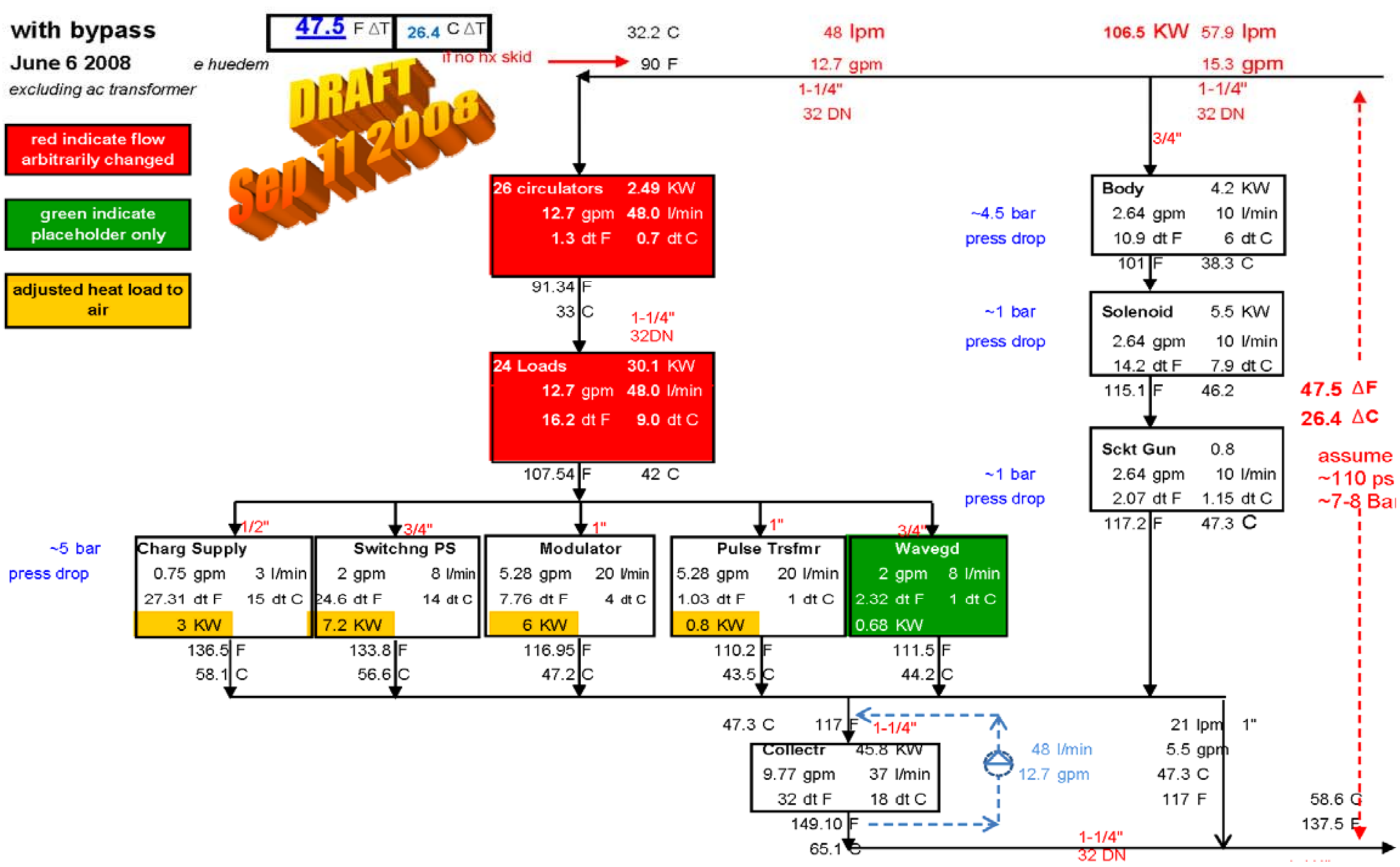
lpm =14.375 KW / DT K




POST RDR DELTA-T
June 6 2008
e huedem
excluding ac transformer
red indicate flow arbitrarily changed
Green is placeholder
Adjusted heat load to air
74.7 F ΔT
41.5 C ΔT
if no hx skid
DRAFT
Sep 11 2008
32.2 C
90 F
26.7 lpm
7.06 gpm
1"
25 DN
106.5 KW
37 lpm
9.77 gpm
1-1/4"
32 DN
3/4"
20 DN
26 circulators 2.49 KW
7.06 gpm 26.7 l/min
2.4 dt F 1.3 dt C
92.4 F
33.6 C
1" 25DN
24 Loads 30.1 KW
7.06 gpm 26.7 l/min
29.1 dt F 16.1 dt C
121 F 49.7 C
Body 4.2 KW
2.64 gpm 10 l/min
10.9 dt F 6 dt C
101 F 38.3 C
~4.5 bar
press drop
Solenoid 5.5 KW
2.64 gpm 10 l/min
14.2 dt F 7.9 dt C
115 F 46.2
~1 bar
press drop
Sckt Gun 0.8
2.64 gpm 10 l/min
2.07 dt F 1.15 dt C
117 F 47.3 C
~1 bar
press drop
74.7 ΔF
42 ΔC
assume
~110 psi
~7-8Bar
~5 bar
press drop
1/2"
3/4"
1/2"
1/2"
3/4"
Charg Supply
0.75 gpm 3 l/min
27.31 dt F 15 dt C
3 KW
149 F
64.9 C
Switching PS
2 gpm 8 l/min
24 dt F 14 dt C
7.2 KW
146 F
63.3 C
Modulator
1.15 gpm 4 l/min
35.6 dt F 20 dt C
6 KW
157 F
69.5 C
Pulse Trsfmr
1.15 gpm 4 l/min
4.75 dt F 3 dt C
0.8 KW
126 F
52.3 C
Wavegd
2 gpm 8 l/min
2.32 dt F 1 dt C
0.68 KW
124 F
51 C
56 C
133 F
1-1/4"
Collectr 45.8 KW
9.8 gpm 37 l/min
32 dt F 18 dt C
48 l/min
12.7 gpm
165 F
73.7 C
1-1/4"
32 DN



with bypass
June 6 2008
e huedem
excluding ac transformer
red indicate flow arbitrarily changed
green indicate placeholder only
45 F ΔT
25.3 C ΔT
DRAFT
Sep 11 2008
if no hx skid
32.2 C
90 F
48 lpm
12.7 gpm
1-1/4"
32 DN
102 KW
57.9 lpm
15.3 gpm
1-1/4"
32 DN
3/4"
20.6 gpm, higher flow reqmnt
26 circulators 2.49 KW
12.7 gpm 48.0 l/min
0.7 dt C
91.34 F
32.97 C
1-1/4" 32DN
24 Loads 30.1 KW
12.7 gpm 48.0 l/min
16.2 dt F 9.0 dt C
107.54 F 42 C
~4.5 bar press drop
~1 bar press drop
~1 bar press drop
Body 4.2 KW
2.64 gpm 10 l/min
10.9 dt F 6 dt C
101 F 38.3 C
Solenoid 5.5 KW
2.64 gpm 10 l/min
14.2 dt F 7.9 dt C
115.1 F 46.2
Sckt Gun 0.8
2.64 gpm 10 l/min
2.07 dt F 1.15 dt C
117.2 F 47.3 C
45.5 ΔF
25.3 ΔC
assume
~110 psid
~7-8Bar
~5 bar press drop
1/2"
3/4"
1"
1"
3/4"
Charg Supply
0.75 gpm 3 l/min
25.49 dt F 14 dt C
2.8 KW
134.7 F
57.0 C
Switchng PS
2 gpm 8 l/min
15.4 dt F 9 dt C
4.5 KW
124.6 F
51.4 C
Modulator
5.28 gpm 20 l/min
5.82 dt F 3 dt C
4.5 KW
115.01 F
46.1 C
Pulse Trsfmr
5.28 gpm 20 l/min
0.91 dt F 1 dt C
0.7 KW
110.1 F
43.4 C
Wavegd
2 gpm 8 l/min
2.32 dt F 1 dt C
0.68 KW
111.5 F
44.2 C
46.2 C
115 F
1-1/4"
Collectr 45.8 KW
9.77 gpm 37 l/min
32 dt F 18 dt C
147.08 F
63.9
48 l/min
12.7 gpm
21 lpm 1"
5.5 gpm
46.2 C
115 F
57.5
135.5
1-1/4"
32 DN
1-1/4"
32 DN



with bypass
June 6 2008
e huedem
excluding ac transformer
47.5 F ΔT
26.4 C ΔT
DRAFT Sep 11 2008
red indicate flow arbitrarily changed
green indicate placeholder only
adjusted heat load to air
if no hx skid
32.2 C
90 F
48 lpm
12.7 gpm
1-1/4"
32 DN
106.5 KW
57.9 lpm
15.3 gpm
1-1/4"
32 DN
3/4"
26 circulators 2.49 KW
12.7 gpm 48.0 l/min
1.3 dt F 0.7 dt C
91.34 F
33 C
1-1/4"
32DN
24 Loads 30.1 KW
12.7 gpm 48.0 l/min
16.2 dt F 9.0 dt C
107.54 F
42 C
Body 4.2 KW
2.64 gpm 10 l/min
10.9 dt F 6 dt C
101 F
38.3 C
~4.5 bar
press drop
Solenoid 5.5 KW
2.64 gpm 10 l/min
14.2 dt F 7.9 dt C
115.1 F
46.2
~1 bar
press drop
47.5 ΔF
26.4 ΔC
Sckt Gun 0.8
2.64 gpm 10 l/min
2.07 dt F 1.15 dt C
117.2 F
47.3 C
~1 bar
press drop
assume
~110 ps
~7-8 Ba
~5 bar
press drop
1/2"
3/4"
1"
1"
3/4"
Charg Supply
0.75 gpm 3 l/min
27.31 dt F 15 dt C
3 KW
136.5 F
58.1 C
Switchng PS
2 gpm 8 l/min
24.6 dt F 14 dt C
7.2 KW
133.8 F
56.6 C
Modulator
5.28 gpm 20 l/min
7.76 dt F 4 dt C
6 KW
116.95 F
47.2 C
Pulse Trsfmr
5.28 gpm 20 l/min
1.03 dt F 1 dt C
0.8 KW
110.2 F
43.5 C
Wavegd
2 gpm 8 l/min
2.32 dt F 1 dt C
0.68 KW
111.5 F
44.2 C
47.3 C
117 F
1-1/4"
Collectr 45.8 KW
9.77 gpm 37 l/min
32 dt F 18 dt C
149.10 F
65.1 C
48 l/min
12.7 gpm
21 lpm
5.5 gpm
47.3 C
117 F
1"
58.6 C
137.5 F
1-1/4"
32 DN

PROCESS WATER AND AIR TREATMENT *(SI Unit)* *e.huedem*

CFS POST-RDR Evaluations - MAIN LINAC ONLY

DRAFT Oct 08 2008

			RDR	POST-RDR							
			Dec 2006	Nov 2007			Jun&Sep 2008		Sep 2008		Aug 2008
RF watercooled component			RDR	Using Numbers given as is	Changed the "circulator" & "rf load" flow, to increase delta T	Changed the "circulator" & "rf load" flow, to increase delta T further	quick sketch evaluation at last day of Dubna-Changed the "circulator" & "rf load" flow,		Changed the "circulator", "rf load" & <u>other component flows further</u>, to increase delta T further		One-Tunnel Kly-cluster scheme from C.A.Jul 07 email
Klystron Body Windows *(max allowable temp 40 C)*	heat load to water per RF	KW	none	4.2							
	flow	lpm	none	10					8	7.4	10
	water delta T	ΔC	None	6.0					7.6	8.2	6
	Resultant outlet water temperature	C					38		40	41	
Klystron Solenoid *(max allowable temp 80 C)*	heat load to waterper RF	KW	3.6	5.5							
	flow	lpm	none	10					8	7.4	10
	water delta T	ΔC	None	7.9					9.9	10.7	7.9
	Resultant outlet water temperature	C					46		49	51	
Klystron Gun *(max allowable temp 60 C)*	heat load to water per RF	KW	0.8								
	flow	lpm	none	10					8	7.4	10.0
	water delta T	ΔC	None	1.15					1.4	1.6	1.15
	Resultant outlet water temperature	C					47		51	53	
Circulators	heat load to water per RF	KW	None	2.49							Use rough numbers from C.A. email Jul 21 2008 for a <u>quick</u> high-level cost evaluation
	quantity per rf		None	26							
	heat load to water each	KW	None	0.096							
	flow per circulator	lpm	None	3			1.85	1.03	0.8	0.77	
	water delta T	ΔC	None	0.5			0.74	1.34	1.66	1.8	
RF load	heat load to water per RF	KW	None	30.1							
	quantity per rf		None	24							
	heat load to water each	KW	None	1.25							
	flow per loads	lpm	None	8	4	3	2	1.11	0.9	0.83	
	water delta T	ΔC	None	2.3	4.5	6	9	16.15	20	21.7	
Watercooled Waveguide	heat load to water per RF	KW	none	0.68 (placeholder)							
RF charging Supply	heat load to water per RF	KW	2.8								
Switching Power Supply	heat load to water per RF	KW	4.5								
Modulator *(max allowable temp 60 C ?)*	heat load	KW	4.5	4.5							
	flow	lpm	None	20				4.4	3.0	1.6	
	water delta T	ΔC	None	3.2				14.8	21	40	
	Resultant outlet water temperature	C					46	64	75	96	
Pulse Transformer *(max allowable temp 60 C)*	heat load	KW	0.7	0.7							
	flow	lpm	None	20				4.4	0.49	0.3	
	water delta T	ΔC	None	0.5				2.3	20	38	
	Resultant outlet water temperature	C					43	52	74	94	
Collector *(max allowable temp 87 C)*	heat load	KW	45.8	45.8							
	flow	lpm	none	37					30	27	
	water delta T	ΔC	None	18					22	24	
	Resultant outlet water temperature	C					64	72	82	86	
	RF water system delta T (delta F)		**20**	**14**	**25**	**30**	**45.5**	**72**	**89**	**97**	Varies
	RF water system delta T (delta C)		**11.1**	**7.8**	**13.9**	**16.7**	**25**	**40**	**49**	**54**	

Arbitrarily changed numbers, *Marc noted from Shigeki's dubna report that this is doable*

Placeholders

Numbers that were arbitrarily changed further to increase system delta T (*impact whether doable to be checked by ??)

Used this for costing evaluation

ASSUMPTION WITH RACK COOLING

Revisit Pre-RDR (Aug 2006) scheme of <u>self contained cooling unit</u>

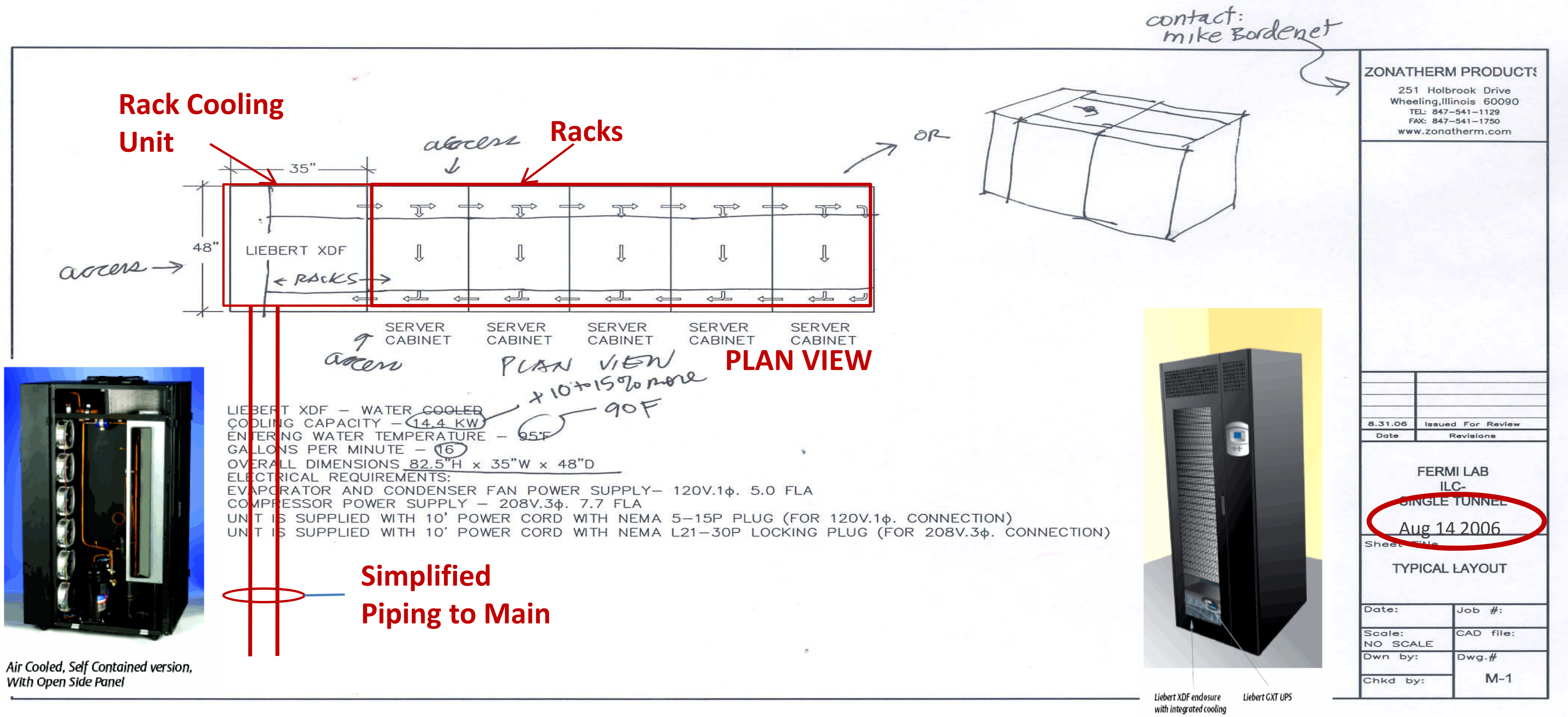
Discussion with Vendor ,Mike Bordenet, VP of Zonatherm, (Liebert& Knurr Equipment)

-suggest XDF version, no specific off-the-shelf that match the size, but can provide to whatever size you want

-BUT this typically comes/purchased with racks

-This simplify the CFS piping, but impact the rack arrangement,

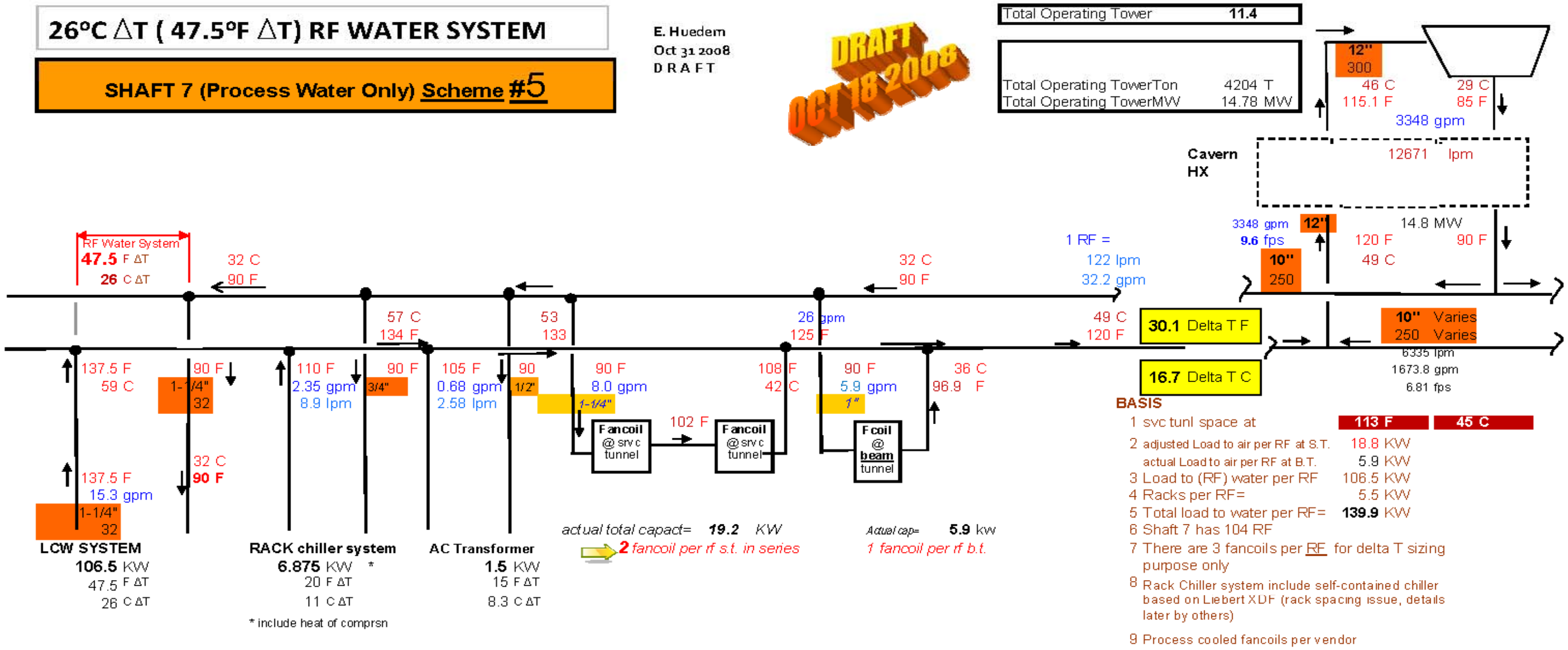
-similar to localized coolng unit, less efficient than centralized chilled water system



26°C ΔT (47.5°F ΔT) RF WATER SYSTEM

SHAFT 7 (Process Water Only) Scheme #5

E. Huedem
Oct 31 2008
DRAFT



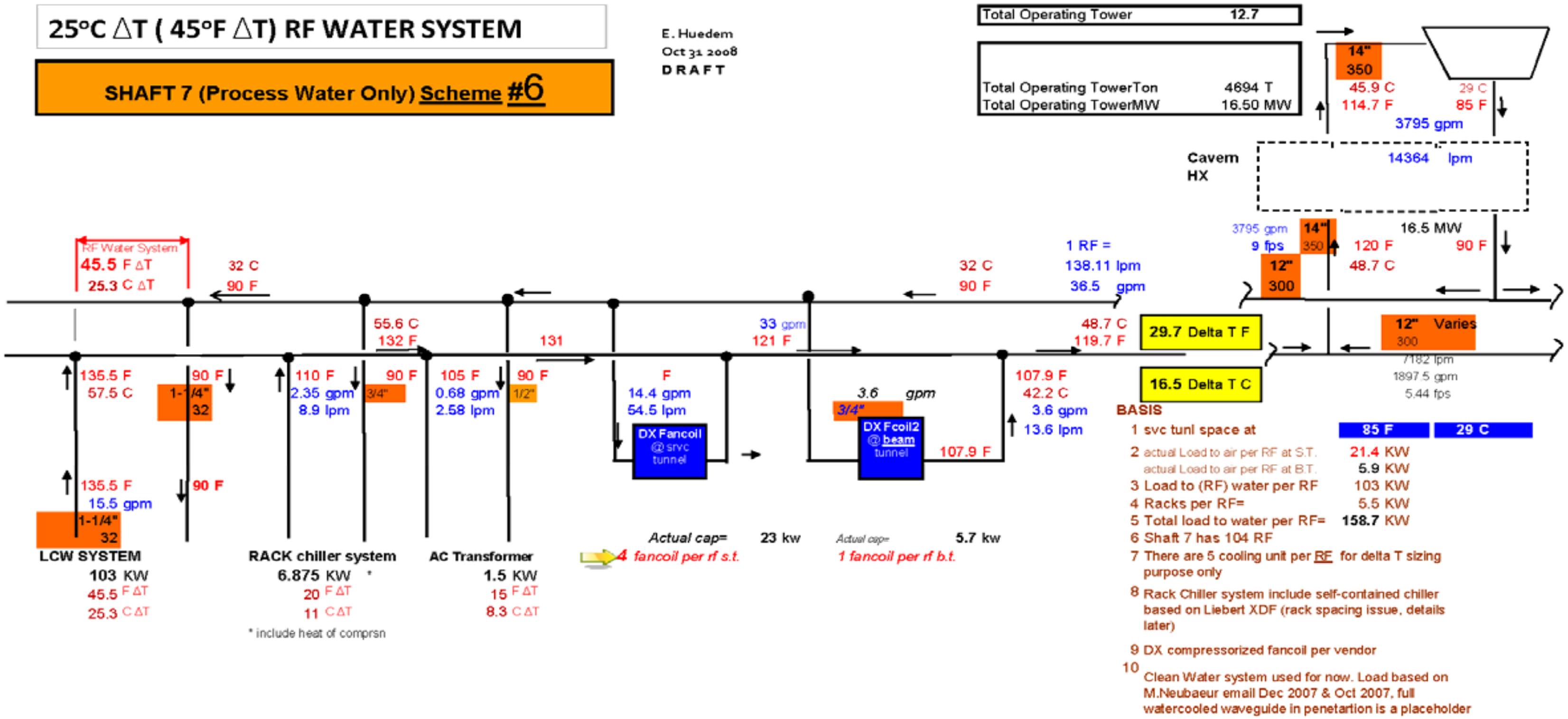
BASIS

1 svc tunl space at 113 F 45 C
2 adjusted Load to air per RF at S.T. 18.8 KW
actual Load to air per RF at B.T. 5.9 KW
3 Load to (RF) water per RF 106.5 KW
4 Racks per RF= 5.5 KW
5 Total load to water per RF= 139.9 KW
6 Shaft 7 has 104 RF
7 There are 3 fancoils per RF for delta T sizing purpose only
8 Rack Chiller system include self-contained chiller based on Liebert XDF (rack spacing issue, details later by others)
9 Process cooled fancoils per vendor
10 Clean Water system used for now. Load based on M.Neubaeur email Dec 2007 & Oct 2007, full watercooled waveguide in penetration is a placeholder

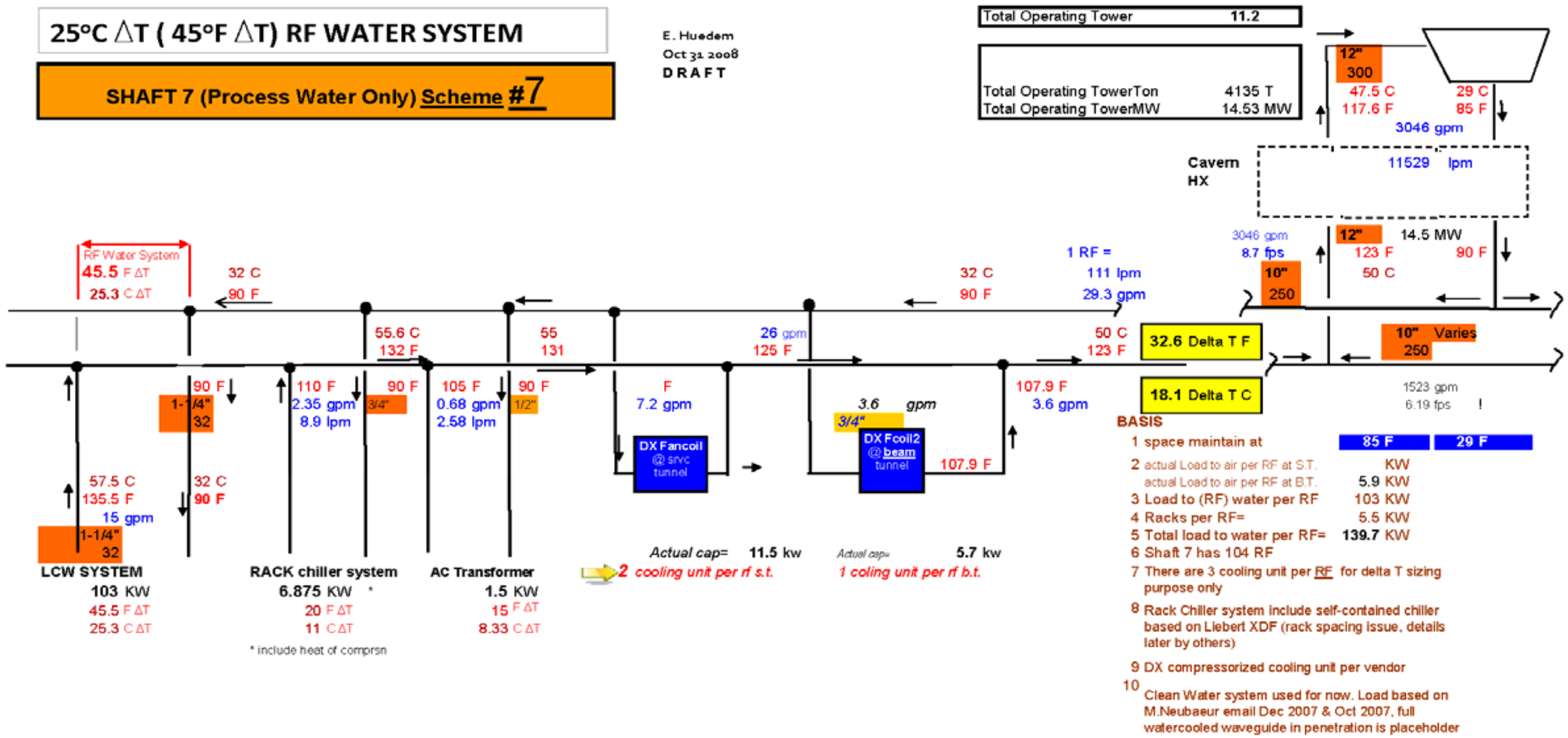
25°C ΔT (45°F ΔT) RF WATER SYSTEM

SHAFT 7 (Process Water Only) Scheme #6

E. Huedem
Oct 31 2008
DRAFT



Scheme to consider effect of
reduction of heat load to air by 50%



	25°C DT (45°F **D**T) RF Water model			**40°C DT** (72°F **D**T) RF Water model		
	Scheme 5	**Scheme 6**	**Scheme 7**	**Scheme 5**	**Scheme 6**	**Scheme 7**
Actual RF Water delta T	26.4°C (47.5°F)	25.3°C (45.5°F)	25.3°C (45.5°F)	41.5°C (74.7°F)	40°C (72°F)	40°C (72°F)
Overall Water delta T	16.7°C (30.1°F)	16.5°C (29.7°F)	18.1°C (32.6°F)	20.3°C (36.5°F)	19.6°C (35.2°F)	22.4°C (40.4°F)

DIFFERENCES BETWEEN SCHEMES

process cooled fancoils	Yes	NO	NO	Yes	NO	NO
localized compressorized cooling unit	NO	Yes	Yes	NO	Yes	Yes
service tunnel space temperature	45 C (113 F)	29 C (85 F)	29 C (85 F)	45 C (113 F)	29 C (85 F)	29 C (85 F)
available from cooling unit in service tunnel KW	19.2	23	11.5	19.2	23	11.5

MATRIX SUMMARY (as of Nov 14 2008 4:30pm) – Cost Savings vs Impact/Issues

RF Water Delta T		25C DT (45F DT)									40C DT (72F DT)							Kly Cluster-Aug 2008
Impact / Issues (by others) Cost to be added (could be by others?) Major IMPACT/ Issues?		Scheme 5			Scheme 6			Scheme 7			Scheme 5			Scheme 6			Scheme 7	
SS=Sch 10 304 Stainless in Tunnel only ; **CPVC**=Sch 80 CPVC plastic pipe; **CS**= Std Sch (40) Carbon Steel		SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	SS
Overall Water Delta T	°C		16.7			16.5			18.1			20.3			19.6		22.4	22.1
	°F		30.1			29.7			32.6			36.5			35.2		40.4	39.8
"First-Cost" Savings in % - Process/Air Treatment WBS 1.7.3. & 1.7.5		28%	30% X	31% X	23%	25% X	26% X	30%	32% X	33% X	31%	33% X	32% X	26%	28% X	27% X	35%	47%
RF Loads and Circulators reduced flow																		
RF Modltrs and Plse Transfm-flow/temp																		
Watercooled wvgde cooling design (by others)																		
Kly Clstr's RF Pipe Cooling by others																		
High Space Temperature ok?		~45°C (113°F)									~45°C (113°F)							
Equipment Insulations??																		
50% reduction in air heat load possible?																		
Finalize HLRF Heat Load table? Collector issue?																		
Rack chiller impact ok? / Rework rack arrngmt??																		
Confirm reduced Heat load from racks?																		
Cost for increased maintenance due high space																		
Cost of portable cooling for maintenance																		
Pump Recirc loop at Collector~ **$2M??**																		
Pump Recircloop (modul/P.Transfmr)~ **$2M ??**																		
Electrical Reduction		~ (- 2.3 MW)									~ (- 2.3 MW)							
Operational cost reduction		~ (- ??)									~ (- ??)							
Electrical addition					~ + 3 MW			~ + 1 MW						~ + 3 MW			~ + 1 MW	??
Operational cost addition					+ ??			+ ??						+ ??			+ ??	
Pipe Press & Temp limit issues																		
"Clean Water" Compatibility Issue																		

Savings % still need to be checked !

Cost savings comparison

note that the resultant overall cost savings were result from a number of VE items (not just one item), but following is an attempt to shows various delta between some VE items

COST SAVINGS COMPARISON

(basic schemes) **5% D**

RF Water Delta T

Impact / Issues (by others)

Cost to be added (could be by others?)

Major IMPACT/ Issues?

SS=Sch 10 304 Stainless in Tunnel only ; **CPVC**=Sch 80 CPVC plastic pipe; **CS**= Std Sch (40) Carbon Steel

RF Water Delta T		25C DT (45F DT)									40C DT (72F DT)							Kly Cluster-Aug 2008
		Scheme 5			Scheme 6			Scheme 7			Scheme 5			Scheme 6			Scheme 7	
		SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	SS
Overall Water Delta T	ºDC	16.7			16.5			18.1			20.3			19.6			22.4	22.1
	ºDF	30.1			29.7			32.6			36.5			35.2			40.4	39.8
"First-Cost" Savings in % - Process/Air Treatment WBS 1.7.3. & 1.7.5		28%	30% X	31% X	23%	25% X	26% X	30%	32% X	33% X	31%	33% X	32% X	26%	28% X	27% X	35%	-47%
RF Loads and Circulators reduced flow																		
RF Modltrs and Plse Transfm-flow/temp																		
Watercooled wvgde cooling design (by others)																		
Kly Clstr's RF Pipe Cooling by others																		
High Space Temperature ok?		~45°C (113°F)									~45°C (113°F)							
Equipment Insulations??																		
50% reduction in air heat load possible?																		
Finalize HLRF Heat Load table? Collector issue?																		
Rack chiller impact ok? / Rework rack arrngmt??																		
Confirm reduced Heat load from racks?																		
Cost for increased maintenance due high space																		
Cost of portable cooling for maintenance																		
Pump Recirc loop at Collector~ **$2M??**																		
Pump Recircloop (modul/P.Transfmr)~ **$2M ??**																		
Electrical Reduction		~ (- 2.3 MW)									~ (- 2.3 MW)							
Operational cost reduction		~ (- ??)									~ (- ??)							
Electrical addition					~ + 3 MW			~ + 1 MW						~ + 3 MW			~ + 1 MW	??
Operational cost addition					+ ??			+ ??						+ ??			+ ??	
Pipe Press & Temp limit issues																		
"Clean Water" Compatibility Issue																		

COST SAVINGS COMPARISON

(reduction of heat load to air by 50%) **7 to 8% D**

RF Water Delta T		25C DT (45F DT)									40C DT (72F DT)							**Kly Cluster-Aug 2008**
Impact / Issues (by others) Cost to be added (could be by others?) Major IMPACT/ Issues?		Scheme 5			Scheme 6			Scheme 7			Scheme 5			Scheme 6			Scheme 7	
SS=Sch 10 304 Stainless in Tunnel only ; **CPVC**=Sch 80 CPVC plastic pipe; **CS**= Std Sch (40) Carbon Steel		SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	SS
Overall Water Delta T	°C		**16.7**			**16.5**			**18.1**			**20.3**			**19.6**		**22.4**	**22.1**
	°F		**30.1**			**29.7**			**32.6**			**36.5**			**35.2**		**40.4**	**39.8**
"First-Cost" Savings in % - Process/Air Treatment WBS 1.7.3. & 1.7.5		28%	30% X	31% X	23%	25% X	26% X	30%	32% X	33% X	31%	33% X	32% X	26%	28% X	27% X	35%	47%
RF Loads and Circulators reduced flow																		
RF Modltrs and Plse Transfm-flow/temp																		
Watercooled wvgde cooling design (by others)																		
Kly Clstr's RF Pipe Cooling by others																		
High Space Temperature ok?			~45°C (113°F)									~45°C (113°F)						
Equipment Insulations??																		
50% reduction in air heat load possible?																		
Finalize HLRF Heat Load table? Collector issue?																		
Rack chiller impact ok? / Rework rack arrngmt??																		
Confirm reduced Heat load from racks?																		
Cost for increased maintenance due high space																		
Cost of portable cooling for maintenance																		
Pump Recirc loop at Collector~ **$2M??**																		
Pump Recircloop (modul/P.Transfmr)~ **$2M ??**																		
Electrical Reduction			~ (- 2.3 MW)									~ (- 2.3 MW)						
Operational cost reduction			~ (- ??)									~ (- ??)						
Electrical addition						~ + 3 MW			~ + 1 MW						~ + 3 MW		~ + 1 MW	??
Operational cost addition						+ ??			+ ??						+ ??		+ ??	
Pipe Press & Temp limit issues																		
"Clean Water" Compatibility Issue																		

COST SAVINGS COMPARISON

(by Pipe material) **2% D**

RF Water Delta T

Impact / Issues (by others)

Cost to be added (could be by others?)

Major IMPACT/ Issues?

SS=Sch 10 304 Stainless in Tunnel only ; **CPVC**=Sch 80 CPVC plastic pipe; **CS**= Std Sch (40) Carbon Steel

		25C DT (45F DT)									40C DT (72F DT)							Kly Cluster-Aug 2008
		Scheme 5			Scheme 6			Scheme 7			Scheme 5			Scheme 6			Scheme 7	
		SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	CPVC	CS	SS	SS
Overall Water Delta T	°DC	16.7			16.5			18.1			20.3			19.6			22.4	22.1
	°DF	30.1			29.7			32.6			36.5			35.2			40.4	39.8
"First-Cost" Savings in % - Process/Air Treatment WBS 1.7.3. & 1.7.5		28%	30% X	31% X	23%	25% X	26% X	30%	32% X	33% X	31%	33% X	32% X	26%	28% X	27% X	35%	47%
RF Loads and Circulators reduced flow																		
RF Modltrs and Plse Transfm-flow/temp																		
Watercooled wvgde cooling design (by others)																		
Kly Clstr's RF Pipe Cooling by others																		
High Space Temperature ok?		~45°C (113°F)									~45°C (113°F)							
Equipment Insulations??																		
50% reduction in air heat load possible?																		
Finalize HLRF Heat Load table? Collector issue?																		
Rack chiller impact ok? / Rework rack arrngmt??																		
Confirm reduced Heat load from racks?																		
Cost for increased maintenance due high space																		
Cost of portable cooling for maintenance																		
Pump Recirc loop at Collector~ **$2M??**																		
Pump Recircloop (modul/P.Transfmr)~ **$2M ??**																		
Electrical Reduction		~ (-2.3 MW)									~ (-2.3 MW)							
Operational cost reduction		~ (-??)									~ (-??)							
Electrical addition					~ +3 MW			~ + 1 MW						~ +3 MW			~ + 1 MW	??
Operational cost addition					+ ??			+ ??						+ ??			+ ??	
Pipe Press & Temp limit issues																		
"Clean Water" Compatibility Issue																		

Plastic Pipe ratings

Schedule 80 CPVC: Water Pressure Rating (psi)

130 F to 140 F return water

~140 psi system

Pipe Size	70°F	80°F	90°F	100°F	120°F	140°F	160°F	180°F	200°F
¼"	1,130	1,130	1,028	927	735	565	452	283	226
⅜"	920	920	837	754	598	460	368	230	184
½"	850	850	774	697	553	425	340	213	170
¾"	690	690	628	566	449	345	276	173	138
1"	630	630	573	517	410	315	252	158	126
1¼"	520	520	473	426	338	260	208	130	104
1½"	470	470	428	385	306	235	188	118	94
2"	400	400	364	328	260	200	160	100	80
2½"	420	420	382	344	273	210	168	105	84
3"	370	370	337	303	241	185	148	93	74
4"	320	320	291	262	208	160	128	80	64
5"	290	290	264	238	189	145	116	73	58
6"	280	280	255	230	182	140	112	70	56
8"	250	250	228	205	163	125	100	63	50
10"	230	230	209	189	150	115	92	58	46
12"	230	230	209	189	150	115	92	58	46
14"	220	220	200	180	143	110	88	55	44
16"	220	220	200	180	143	110	88	55	44

Schedule 40 CPVC: Water Pressure Rating (psi)

Pipe Size	70°F	80°F	90°F	100°F	120°F	140°F	160°F	180°F	200°F
¼"	780	780	710	640	507	390	312	195	156
⅜"	620	620	564	508	403	310	248	155	124
½"	590	590	537	484	384	295	236	148	118
¾"	480	480	437	394	312	240	192	120	96
1"	450	450	410	369	293	225	180	113	90
1¼"	365	365	322	299	237	183	146	91	73
1½"	330	330	300	271	215	165	132	83	66
2"	275	275	250	226	179	138	110	69	55
2½"	300	300	273	246	195	150	120	75	60
3"	260	260	237	213	169	130	104	65	52
4"	220	220	200	180	143	110	88	55	44
6"	180	180	164	148	117	90	72	45	36
8"	160	160	146	131	104	80	64	40	32
10"	140	140	127	115	91	70	56	35	28
12"	130	130	118	107	85	65	52	33	26
14"	130	130	118	107	85	65	52	33	26

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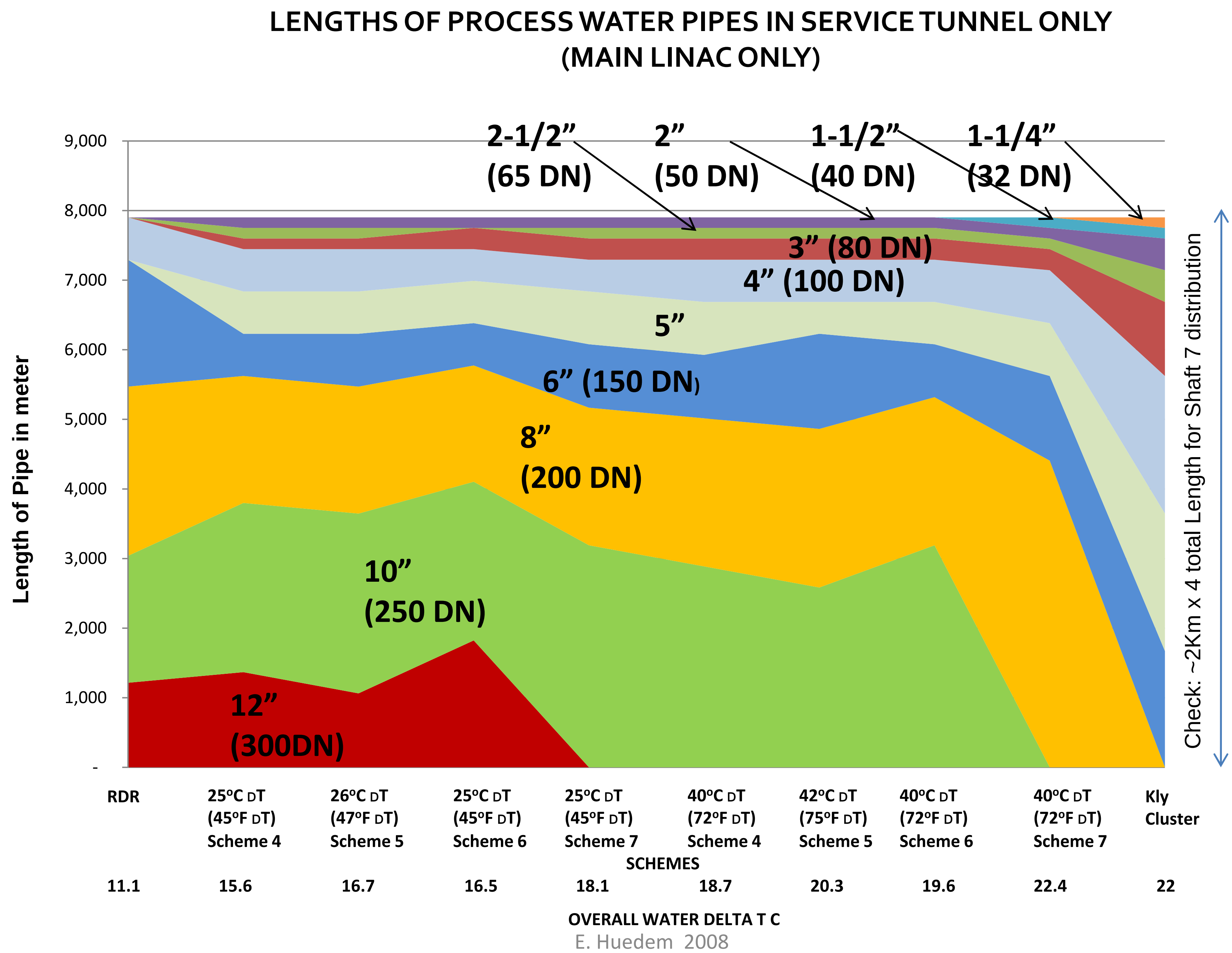


LENGTHS OF PROCESS WATER PIPES IN SERVICE TUNNEL ONLY
(MAIN LINAC ONLY)
Length of Pipe in meter
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
2-1/2" (65 DN)
2" (50 DN)
1-1/2" (40 DN)
1-1/4" (32 DN)
3" (80 DN)
4" (100 DN)
5"
6" (150 DN)
8" (200 DN)
10" (250 DN)
12" (300DN)
Check: ~2Km x 4 total Length for Shaft 7 distribution
RDR
25°C DT (45°F DT) Scheme 4
26°C DT (47°F DT) Scheme 5
25°C DT (45°F DT) Scheme 6
25°C DT (45°F DT) Scheme 7
40°C DT (72°F DT) Scheme 4
42°C DT (75°F DT) Scheme 5
40°C DT (72°F DT) Scheme 6
40°C DT (72°F DT) Scheme 7
Kly Cluster
SCHEMES
11.1
15.6
16.7
16.5
18.1
18.7
20.3
19.6
22.4
22
OVERALL WATER DELTA T C
E. Huedem 2008

Pipe Size – Overall Water System

	RDR	25C DT (45F DT)			40C DT (72F DT)			Kly Cluster Aug 2008
		Scheme 5	Scheme 6	Scheme 7	Scheme 5	Scheme 6	Scheme 7	Kly Cluster
Process Water Delta T (F)	11	16.7	16.5	18.1	20.3	19.6	22	22
Process Water Delta T (F)	20	30.1	29.7	32.6	36.5	35.2	40	40
Pipe Main Size	**350 DN (14")**	**300 DN (12")**	**350 DN (14")**	**300 DN (12")**	**300 DN (12")**	**300 DN (12")**	**300 DN (12")**	200 DN (8") (less surface RF Load)
Largest Pipe size in Tunnel	**300 DN (12")**	**300 DN (12")**	**300 DN (12")**	250 DN (10")	250 DN (10")	250 DN (10")	200 DN (8")	150 DN (6")
Chilled Water Delta T (F)	18	none	none	none	none	none	none	none
Pipe Main Size	250 DN (10")	none	none	none	none	none	none	none
Largest Pipe size in Tunnel	200 DN (8")	none	none	none	none	none	none	none

E. Huedem 2008

Summary

•A Matrix (cost savings vs issues) resulted from the VE cost evaluation, showing the corresponding issues and impact. This will be check and updated and the effort will be documented. Close the loop on the VE items from Dec 06.

•Cost savings comes from a combined number of VE items not just from single one, mainly from removal of Centralized Chilled Water Loop & LCW skid , & reduced heat loads BUT has impacts that need to be investigated. Only considered first-cost savings.

•Placeholders and Impacts can affect cost later. (such as watercooled waveguide placeholder, heat loads, etc).

•This VE cost evaluation is only for selected VE items. Other VE (Cogeneration) may be worth pursuing by experts in those fields.

•The VE is only for Main Linac. Other heat loads/ water system for other area system remain immature (nothing done since RDR).

THE END

BACKUP SLIDES

To account for all VE items=2 basic schemes for overall water system	Scheme 5	Scheme 6

COMMON TO BOTH SCHEMES

Eliminate chilled Water. Use only process water	Yes	Yes
Remove LCW Skid	Yes	Yes
Reduce Rack Heat load by 50%	Yes	Yes

DIFFERENCES BETWEEN SCHEMES

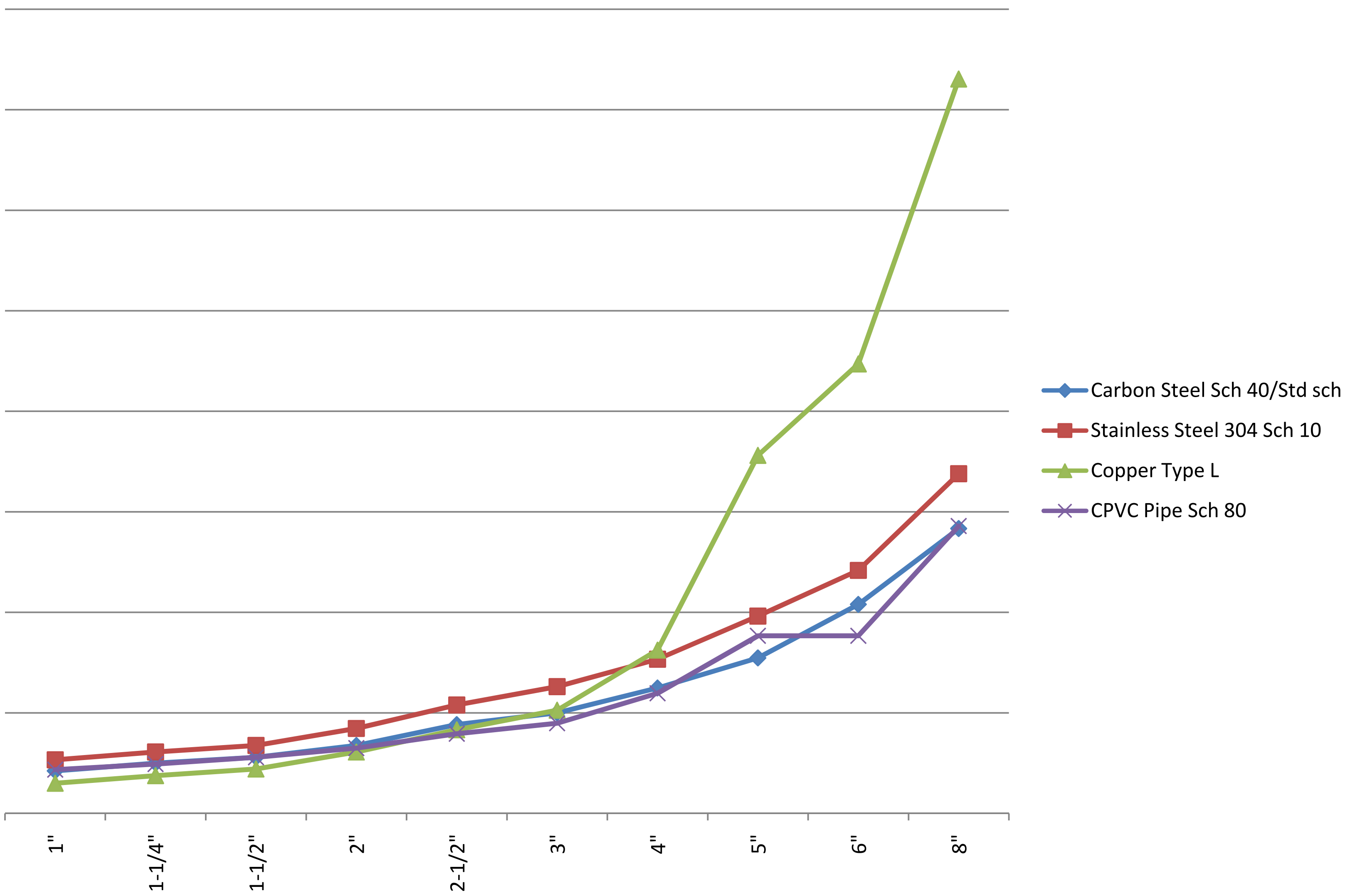
process cooled fancoils	Yes	NO
localized compressorized cooling unit	NO	Yes
service tunnel space temperature	45 C (113 F)	29 C (85 F)

Where did we get this data?

based on (1) 30 HP per 4 RF from Clay Table Email dated 9-15-06
Clay's Email Nov 22 2006
(2) 1.5 HP per RF (Table 4 Ashrae Chap 28) placeholder
based on (1) 5 HP per 4 rf (table4 Ashrae Chap 28) placeholder
* Clay - 14 W per sq m**Nov 22 2006 Keith Added Value
* Clay email 3-14-06 typical 112.Kva oil xfmr *** Nov 22 2006 Keith Added Value**
* Clay email 3-14-06 typical 112.Kva oil xfmrKeith J

* C.Jensen email 2-27-06 183 kVa 0.84pf oil ps xfmr **Shigeki Apr 18 2006 ** Clay 5-25-06 LLRF 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 **** RCassell email Oct 3 2007**
** 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 ** Rcassell email Oct 3 2007 ****Oct 25 2007 fix delta T**
* 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 ******supply temp, water flow, press drop from Chris Jensen mtg 10-24-07**
Shigeki Apr 18 2006 Nov 22 2006 Keith Jobe wag on load to air**11-27-06 C.Adolphsen Email******supply temp, water flow, press drop from Chris Jensen mtg 10-24-07**
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****supply temp, water flow, press drop from Chris Jensen mtg 10-24-07**
* Shigeki Fukuda Email 4-05-06 **Nov 22 2006 Keith Jobe wag on load to air** 11-27-06 C. Adolphsen Email ***Shigeki Oct 18 2007**
* Shigeki Fukuda Email 3-1-06 **Nov 22 2006 Keith Jobe wag on load to air** 11-27-06 C. Adolphsen Email*** Shigeki Oct 18 2007**
* Shigeki Fukuda Email 3-1-06** Keith Jobe added stability Oct 20 2006 * * HLRF 11/16 /06 meeting** 11-27-06 C. Adolphsen Email*Shigeki Oct 18 2007 **Oct 25 2007 Fix Supply temp ***Shigeki Email Oct 26 2007**
* Shigeki Fukuda Email 3-30-06 **Shigeki Apr 18 2006 (chilled water) ***Rlarsen email** RayLarsen Email 9-15-06 except reduced by 40% per Marc * Ray HLRF Meeting 11/16/06**11-27-06 C. Adolphsen Email
***C. Nantista Oct 1 2007**
*** C. Nantista Oct 3 2007**
*** C. Nantista Oct 3 2007**
*** C. Nantista Oct 3 2007**
Shigeki Email Apr 28 2006HLRF 11/16/06 meeting update from 24.3 to 29.8 KW** 11-27-06 C. Adolphsen Email ****C. Nantista Oct 1 2007** ** Oct 24 2007 Flow, Supply Temp per Oleg, NO Press drop ***Chris Nantista Oct 26 2007 8 liter per min per load, 10 bar press, no press drop, but 30 C for circulator?**
Shigeki Email Apr 28 2006HLRF 11/16/06 meeting update from 24.3 to 29.8 KW** 11-27-06 C. Adolphsen Email ****C. Nantista Oct 1 2007** ** Oct 24 2007 Flow, Supply Temp per Oleg, NO Press drop ***Chris Nantista Oct 26 2007 8 liter per min per load, 10 bar press, no press drop, but 30 C for circulator?**
(a) HLRF meeting Nov 16 2006

MEANS BOOK SAMPLE PIPE COST
1″ (25DN) to 8″ (200DN)

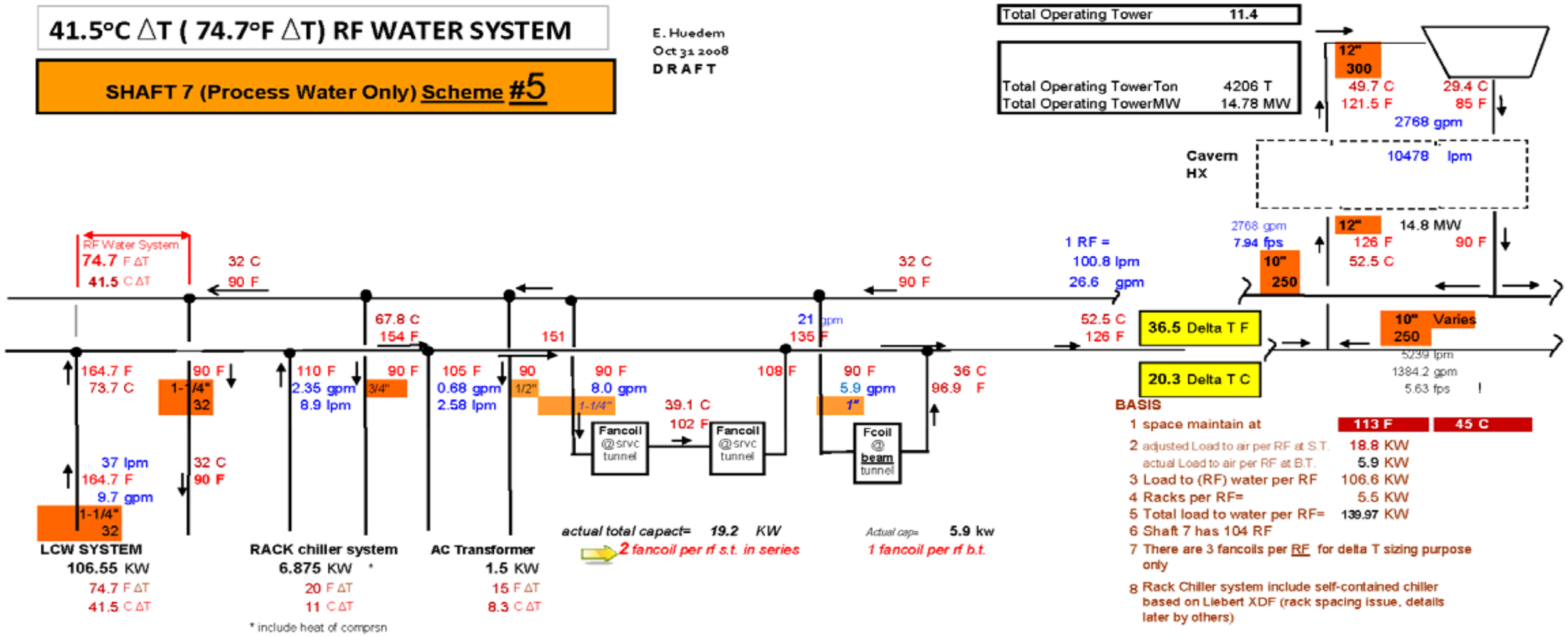


E. Huedem 2008

41.5°C ΔT (74.7°F ΔT) RF WATER SYSTEM

SHAFT 7 (Process Water Only) Scheme #5

E. Huedem
Oct 31 2008
DRAFT



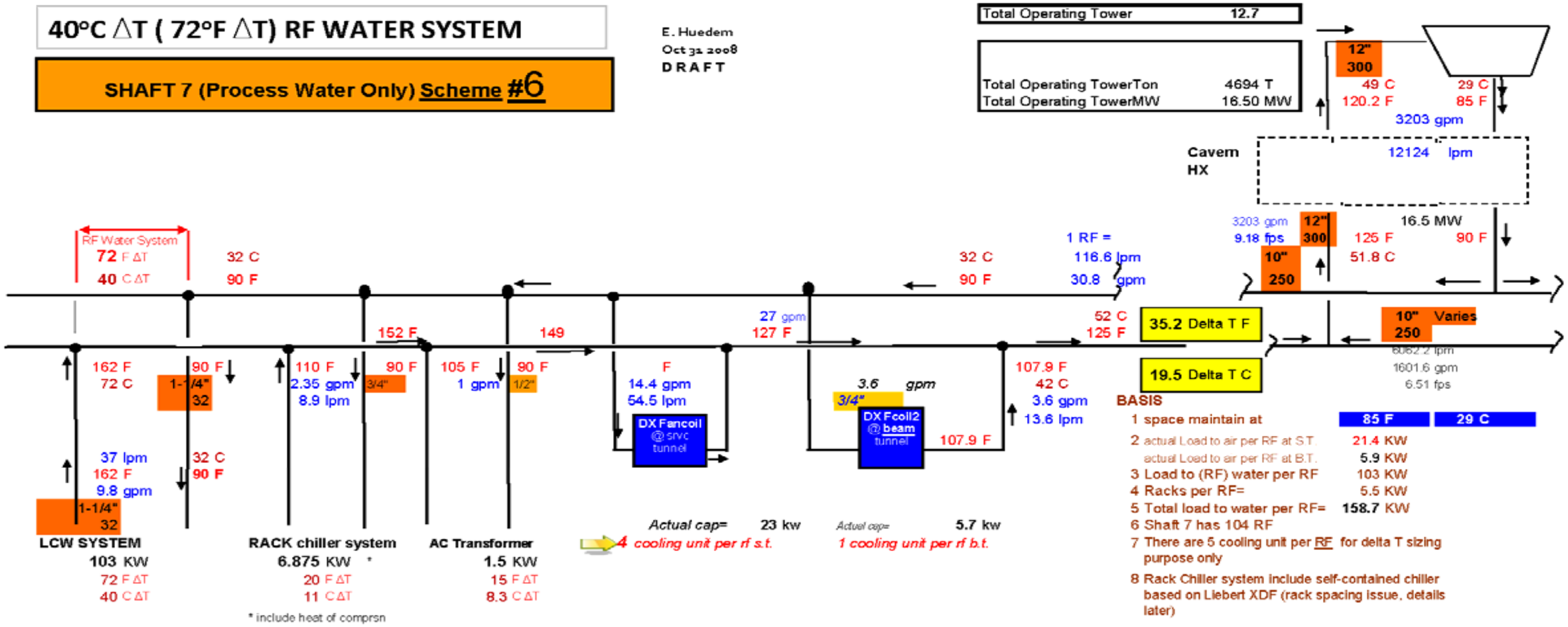
BASIS

1	space maintain at	113 F	45 C
2	adjusted Load to air per RF at S.T.	18.8 KW	
	actual Load to air per RF at B.T.	5.9 KW	
3	Load to (RF) water per RF	106.6 KW	
4	Racks per RF=	5.5 KW	
5	Total load to water per RF=	139.97 KW	
6	Shaft 7 has 104 RF		
7	There are 3 fancoils per RF for delta T sizing purpose only		
8	Rack Chiller system include self-contained chiller based on Liebert XDF (rack spacing issue, details later by others)		
9	Process Cooled Fancoils based on vendor		
10	Clean Water system used for now. Load based on M.Neubaeur email Dec 2007 & Oct 2007, full watercooled waveguide in penetration (by others) is placeholder		

40°C ΔT (72°F ΔT) RF WATER SYSTEM

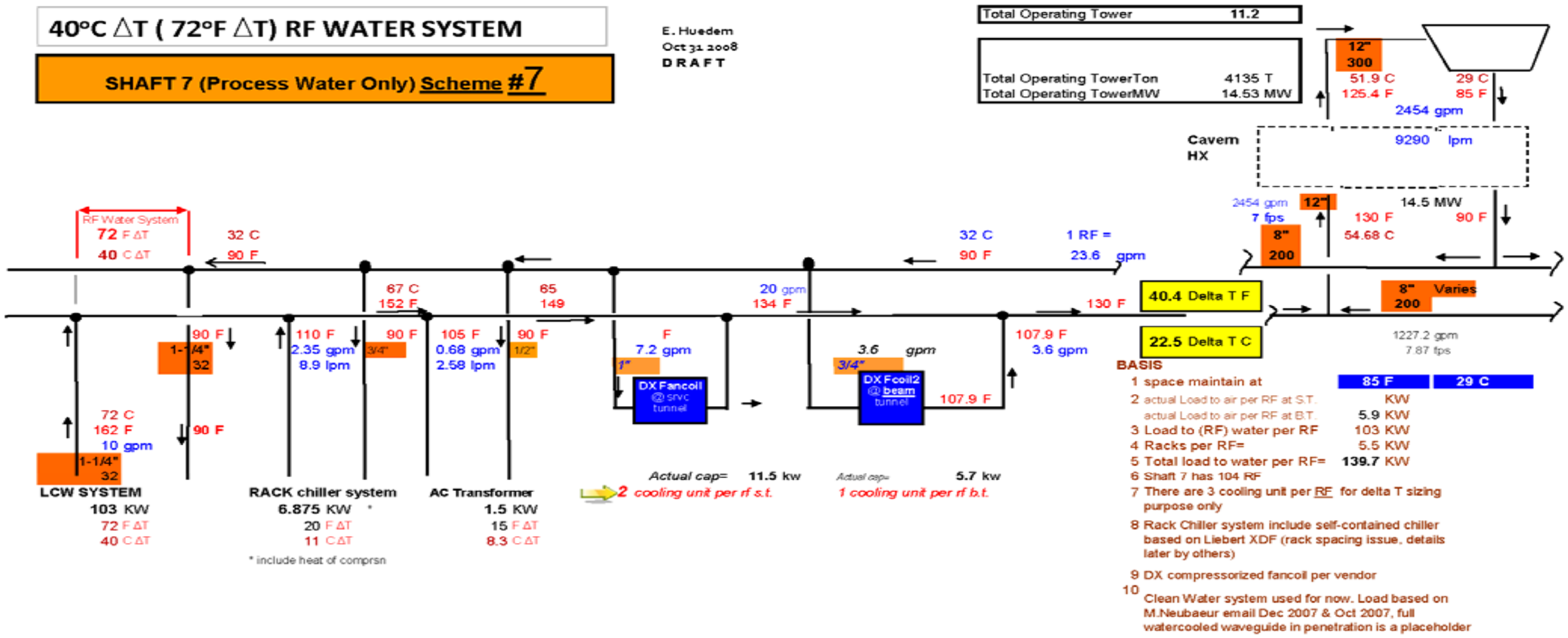
SHAFT 7 (Process Water Only) Scheme #6

E. Huedem
Oct 31 2008
DRAFT



BASIS

1. space maintain at — 85 F — 29 C
2. actual Load to air per RF at S.T — 21.4 KW
   actual Load to air per RF at B.T. — 5.9 KW
3. Load to (RF) water per RF — 103 KW
4. Racks per RF= — 5.5 KW
5. Total load to water per RF= — 158.7 KW
6. Shaft 7 has 104 RF
7. There are 5 cooling unit per RF for delta T sizing purpose only
8. Rack Chiller system include self-contained chiller based on Liebert XDF (rack spacing issue, details later)
9. DX compressorized fancoil per vendor
10. Clean Water system used for now. Load based on M.Neubaeur email Dec 2007 & Oct 2007, full watercooled waveguide in penetration is a placeholder



40°C ΔT (72°F ΔT) RF WATER SYSTEM
SHAFT 7 (Process Water Only) Scheme #7
E. Huedem
Oct 31 2008
DRAFT
Total Operating Tower 11.2
Total Operating TowerTon 4135 T
Total Operating TowerMW 14.53 MW
12" 300
51.9 C
125.4 F
29 C
85 F
2454 gpm
Cavern HX
9290 lpm
2454 gpm
7 fps
12"
8" 200
14.5 MW
130 F
54.68 C
90 F
RF Water System
72 F ΔT
40 C ΔT
32 C
90 F
32 C
90 F
1 RF =
23.6 gpm
67 C
152 F
65
149
20 gpm
134 F
130 F
40.4 Delta T F
22.5 Delta T C
8" Varies 200
1227.2 gpm
7.87 fps
90 F
1-1/4" 32
110 F
2.35 gpm
8.9 lpm
90 F
3/4"
105 F
0.68 gpm
2.58 lpm
90 F
1/2"
F
7.2 gpm
1"
DX Fancoil @ srvc tunnel
3.6 gpm
3/4"
DX Fcoil2 @ beam tunnel
107.9 F
107.9 F
3.6 gpm
72 C
162 F
10 gpm
90 F
1-1/4" 32
LCW SYSTEM
103 KW
72 F ΔT
40 C ΔT
RACK chiller system
6.875 KW *
20 F ΔT
11 C ΔT
* include heat of comprsn
AC Transformer
1.5 KW
15 F ΔT
8.3 C ΔT
Actual cap= 11.5 kw
2 cooling unit per rf s.t.
Actual cap= 5.7 kw
1 cooling unit per rf b.t.
BASIS
1 space maintain at 85 F 29 C
2 actual Load to air per RF at S.T. KW
actual Load to air per RF at B.T. 5.9 KW
3 Load to (RF) water per RF 103 KW
4 Racks per RF= 5.5 KW
5 Total load to water per RF= 139.7 KW
6 Shaft 7 has 104 RF
7 There are 3 cooling unit per RF for delta T sizing purpose only
8 Rack Chiller system include self-contained chiller based on Liebert XDF (rack spacing issue, details later by others)
9 DX compressorized fancoil per vendor
10 Clean Water system used for now. Load based on M.Neubaeur email Dec 2007 & Oct 2007, full watercooled waveguide in penetration is a placeholder

Pipe Size – RF Water System

RF Water Delta T	RDR RDR	25C DT (45F DT)	40C DT (72F DT)	Kly Cluster Aug 2008
RF Water Main Flow	128 lpm (34 gpm)	58 lpm (15.3 gpm)	37 lpm (9.77 gpm)	
RF Water Pipe Main	50 DN (2")	32 DN (1-1/4")