BOILER DUTY

(Blowdown excluded)

(A) OEM @ 5% Overpressure 481 HB 784 (1967 Steam Tables)

Econ/evap/superheater

Main steam flow	=	6,449,000	lb/h	
Main steam enthalpy	=	1456.4	Btu/lb	(p= 2532.2, t= 1000)
Final feedwater enthalpy	=	550.6	Btu/lb	(p= 3200, t= 553.9)
Superheater spraywater flow	=	0	lb/h	

Heat added = 6,449,000 x (1456.4 – 550.6)
= 5841.5 x 10^6 Btu/h

Reheater

Reheater steam flow	=	5,191,655	lb/h
Cold reheat enthalpy	=	1306.7	Btu/lb
Hot reheat enthalpy	=	1519.1	Btu/lb

Heat added = 5,191,655 x (1519.1 – 1306.7)
= 1102.7 x 10^6 Btu/h

IP7010489

BOILER DUTY

(Blowdown excluded)

(B) **UNIT 1 BOILER MCR TEST FEBRUARY 1998** (1997 Steam Tables)
(ALSTOM CALCULATION)

Econ/evap/superheater

Main steam flow	=	6,756,500	lb/h	
enthalpy	=	1460.8	Btu/lb	(p= 2532.3, t= 1005.3)
Final feedwater enthalpy	=	557.8	Btu/lb	(p= 3000, t= 559.5)
Superheater spraywater flow	=	66,082	lb/h	
BFP discharge enthalpy	=	329.0	Btu/lb	(p= 3080, t= 352.4)

Heat added = 6,756,500 x (1460.8–557.8) + 66,082 x (557.8–329.0)
= 6116.2 x 10^6 Btu/h

Reheater

Reheater steam flow	=	5,451,270	lb/h	
Cold reheat enthalpy	=	1307.9	Btu/lb	(p= 605, t= 628.9)
Hot reheat enthalpy	=	1523.4	Btu/lb	(p= 564, t= 1007.8)

Heat added = 5,451,270 x (1523.4 – 1307.9)

= 1174.7 x 10^6 Btu/h

(C) **UNIT 2 BOILER MCR TEST MAY 1998** (1997 Steam Tables)
(ALSTOM CALCULATION)

Econ/evap/superheater

Main steam flow	=	6,794,000	lb/h	
enthalpy	=	1453.9	Btu/lb	(p= 2533.1, t= 995.4)
Final feedwater enthalpy	=	556.9	Btu/lb	(p= 3000, t= 558.6)
Superheater spraywater flow	=	101,615	lb/h	
BFP discharge enthalpy	=	331.5	Btu/lb	(p= 3070, t= 354.9)

Heat added = 6,794,000 x (1453.9–556.9) + 101,615 x (556.9–331.5)
= 6117.1 x 10^6 Btu/h

Reheater

Reheater steam flow	=	5,505,330	lb/h	
Cold reheat enthalpy	=	1305.6	Btu/lb	(p= 618, t= 626.9)
Hot reheat enthalpy	=	1524.2	Btu/lb	(p= 575, t= 1009.9)

Heat added = 5,505,330 x (1524.2 – 1305.6)

= 1203.5 x 10^6 Btu/h

IP7010490

BOILER DUTY

(Blowdown excluded)

(D) UNIT 1 – PROPOSED HP TURBINE UPGRADE (1997 Steam Tables)
(ALSTOM CALCULATION)

Econ/evap/superheater

Main steam flow	=	6,900,000	lb/h	
enthalpy	=	1461.2	Btu/lb	(p= 2412.2, t= 1000)
Final feedwater enthalpy	=	550	Btu/lb	(p= 2900, t= 553)
Superheater spraywater flow	=	0	lb/h	

Heat added = 6,900,000 x (1461.2–550)
= 6287.3 x 10^6 Btu/h

Reheater

Reheater steam flow	=	5,613,619	lb/h	
Cold reheat enthalpy	=	1306.6	Btu/lb	(p= 621, t= 629)
Hot reheat enthalpy	=	1518.6	Btu/lb	(p= 579, t= 1000)

Heat added = 5,613,619 x (1518.6 – 1306.6)

= 1190.0 x 10^6 Btu/h

(E) UNIT 2 – PROPOSED HP TURBINE UPGRADE (1997 Steam Tables)
(ALSTOM CALCULATION)

Econ/evap/superheater

Main steam flow	=	6,900,000	lb/h	
enthalpy	=	1461.2	Btu/lb	(p= 2412.2, t= 1000)
Final feedwater enthalpy	=	547.9	Btu/lb	(p= 2900, t= 551)
Superheater spraywater flow	=	0	lb/h	

Heat added = 6,900,000 x (1461.2–547.9)
= 6301.8 x 10^6 Btu/h

Reheater

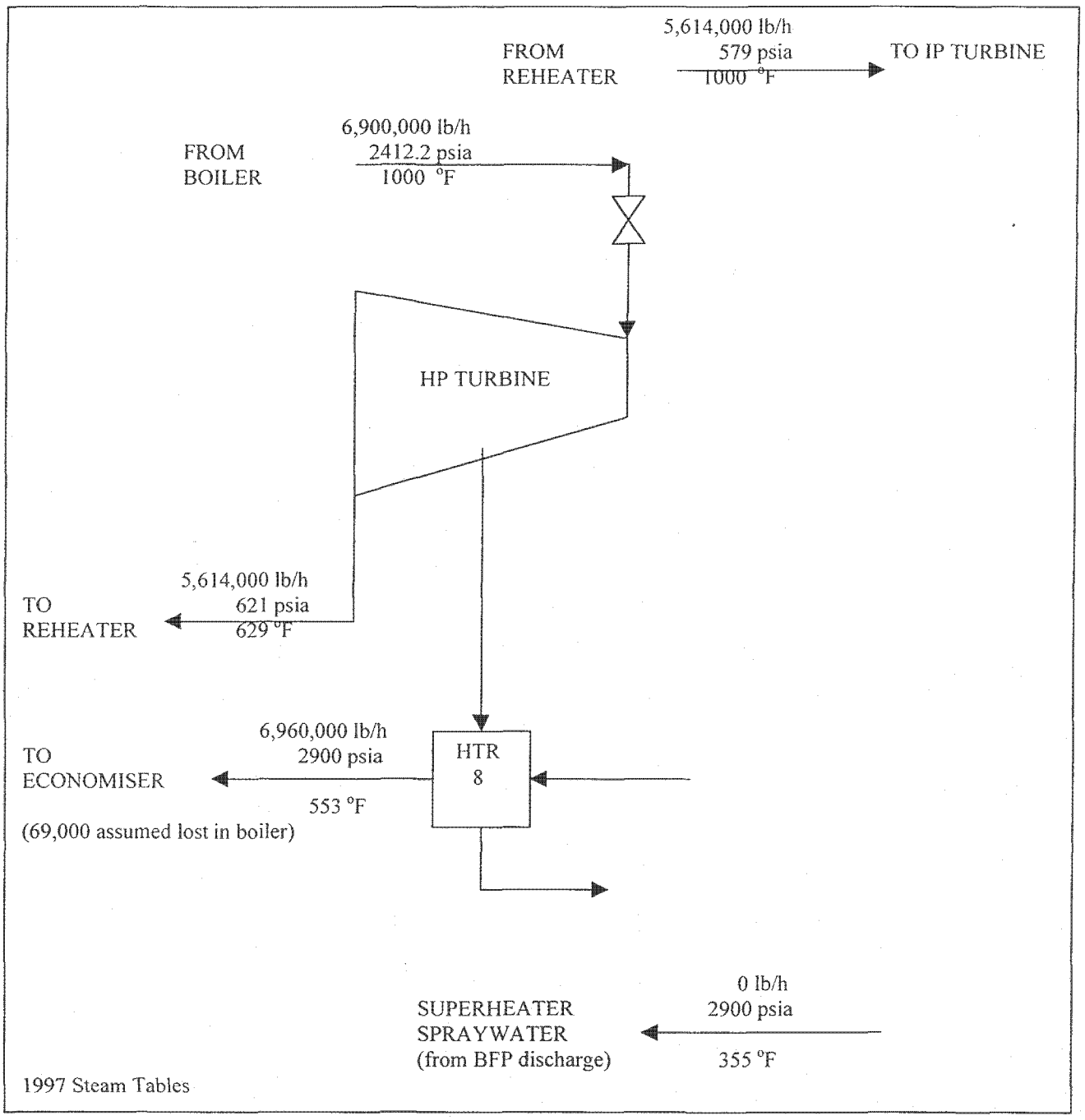
Reheater steam flow	=	5,627,815	lb/h	
Cold reheat enthalpy	=	1307.9	Btu/lb	(p= 629, t= 632)
Hot reheat enthalpy	=	1518.4	Btu/lb	(p= 585, t= 1000)

Heat added = 5,627,815 x (1518.4 – 1307.9)

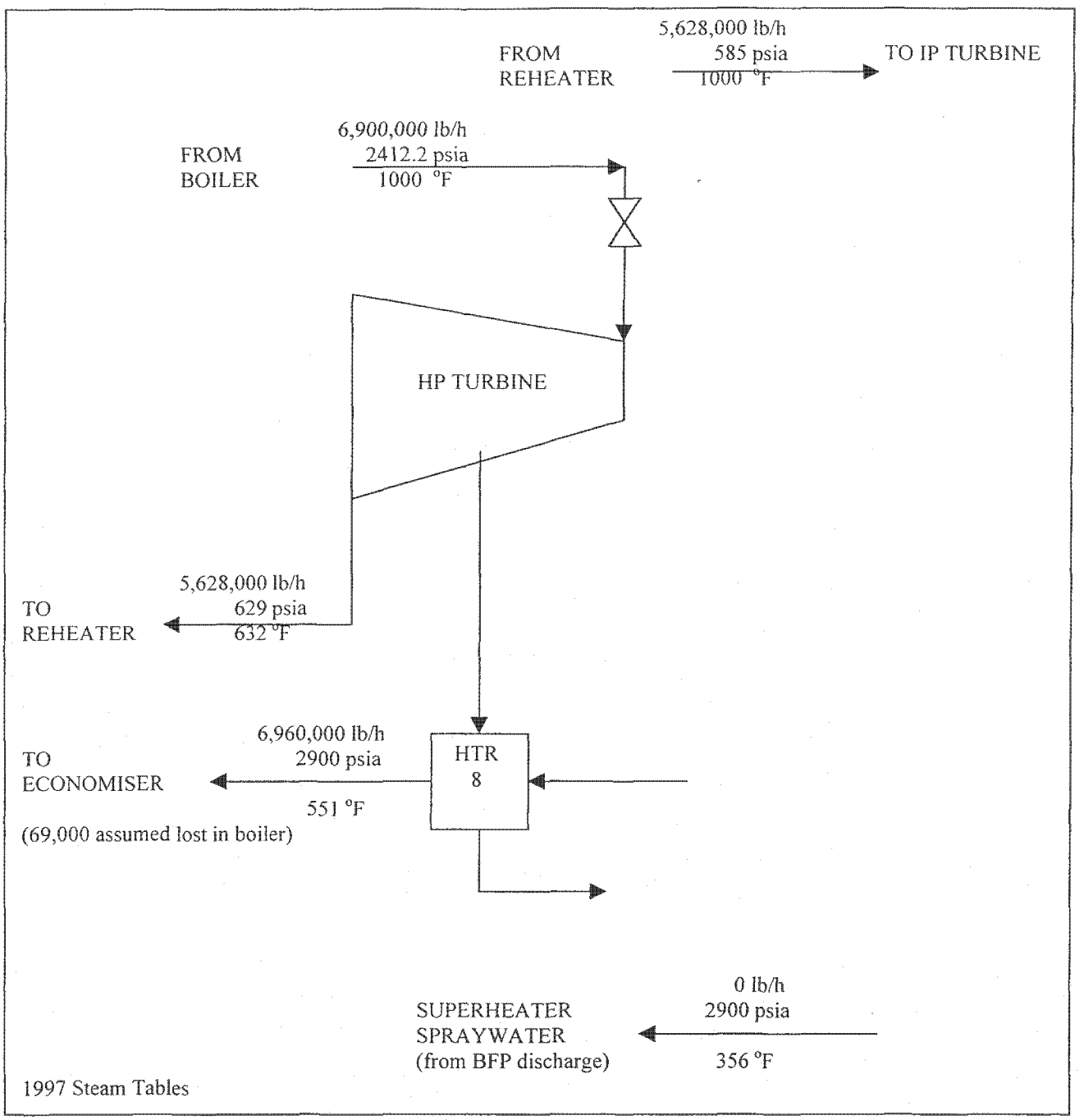
= 1184.7 x 10^6 Btu/h

IP7010491

BOILER INTERFACE CONDITIONS FOLLOWING HP TURBINE UPGRADE



BOILER INTERFACE CONDITIONS FOLLOWING HP TURBINE UPGRADE



February 2001

IP7010493

FEEDWATER HEATER DESIGN & OPERATING DATA

Heater No.	DESIGN		UNIT 1 OPERATION BMCR TEST 1998		UNIT 1 HP TURBINE UPGRADE PROPOSAL	
	psia	°F	psia	°F	psia	°F
8	1387	830	1112	801	1083	772
7	812	830	596	628	610	629
6	312	830	248	811*	255	803
5			132	632*	134	627
4	112	540	65	520*	71	515
3	87	430	42	422*	43	416
2	62	300	12	235*	12	229
1	62	300	5	-	5	165

* Reheat steam temperature = 1007°F

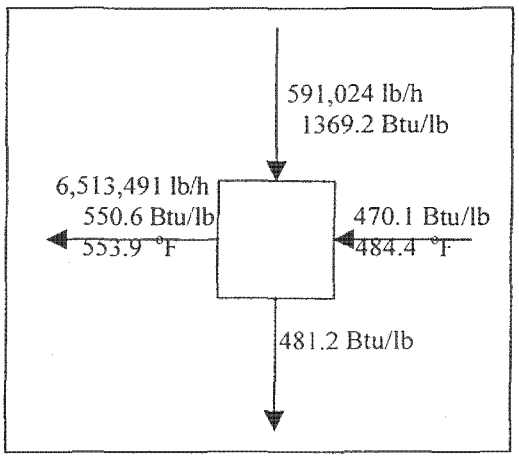
Heater No.	DESIGN		UNIT 2 OPERATION BMCR TEST 1998		UNIT 2 HP TURBINE UPGRADE PROPOSAL	
	psia	°F	psia	°F	psia	°F
8	1387	830	1112	792	1084	774
7	812	830	605	627	615	632
6	312	830	252	808**	258	799
5			133	634**	135	627
4	112	540	66	523**	71	511
3	87	430	42	423**	42	412
2	62	300	12	238**	12	227
1	62	300	5	-	5	165

** Reheat steam temperature = 1010°F

IP7010494

HEATER 8 DUTY

(A) OEM @ 5% Overpressure 481 HB 784

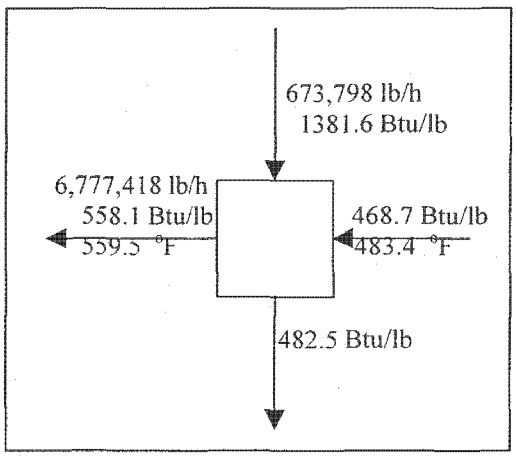


Feedwater: T = (553.9 – 484.4) = 69.5°F

Heat transferred = 591,024 x (1369.2 – 481.2)
= 524,829,312 Btu/h

Extraction steam vol. Flow = 370,655 ft^3/h

(B) UNIT 1 BMCR Test 1998 (ALSTOM Calculation)

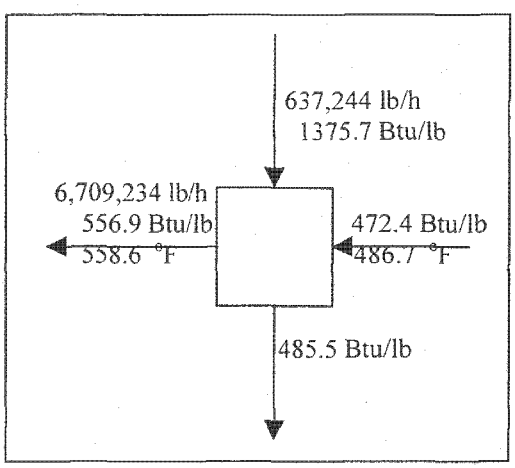


Feedwater: T = (559.5 – 483.4) = 76.1°F

Heat transferred = 673,798 x (1381.6 – 482.5)
= 605,811,782 Btu/h

Extraction steam vol. Flow = 397,810 ft^3/h

(C) UNIT 2 BMCR Test 1998 (ALSTOM Calculation)



Feedwater: T = (558.6 – 486.7) = 71.9°F

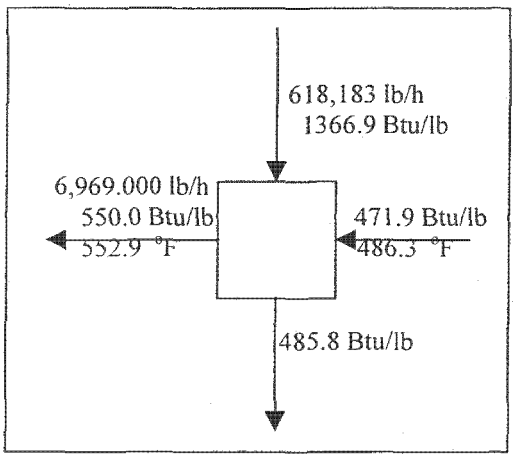
Heat transferred = 637,244 x (1375.7 – 485.5)
= 567,274,609 Btu/h

Extraction steam vol. Flow = 367,441 ft^3/h

IP7010495

HEATER 8 DUTY

(D) UNIT 1 HP UPGRADE PROPOSAL - Preliminary

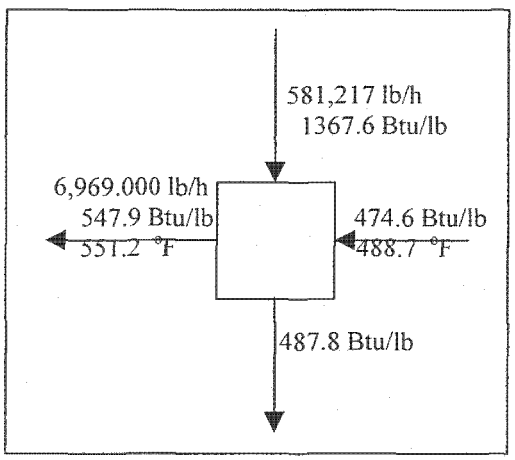


Feedwater: T = (552.9 – 486.3) = 69.6°F

Heat transferred = 618,183 x (1366.9 – 485.8)
= 544,681,041 Btu/h

Extraction steam vol. Flow = 374,743 ft^3/h

(E) UNIT 2 HP UPGRADE PROPOSAL - Preliminary



Feedwater: T = (551.2 – 488.7) = 62.5°F

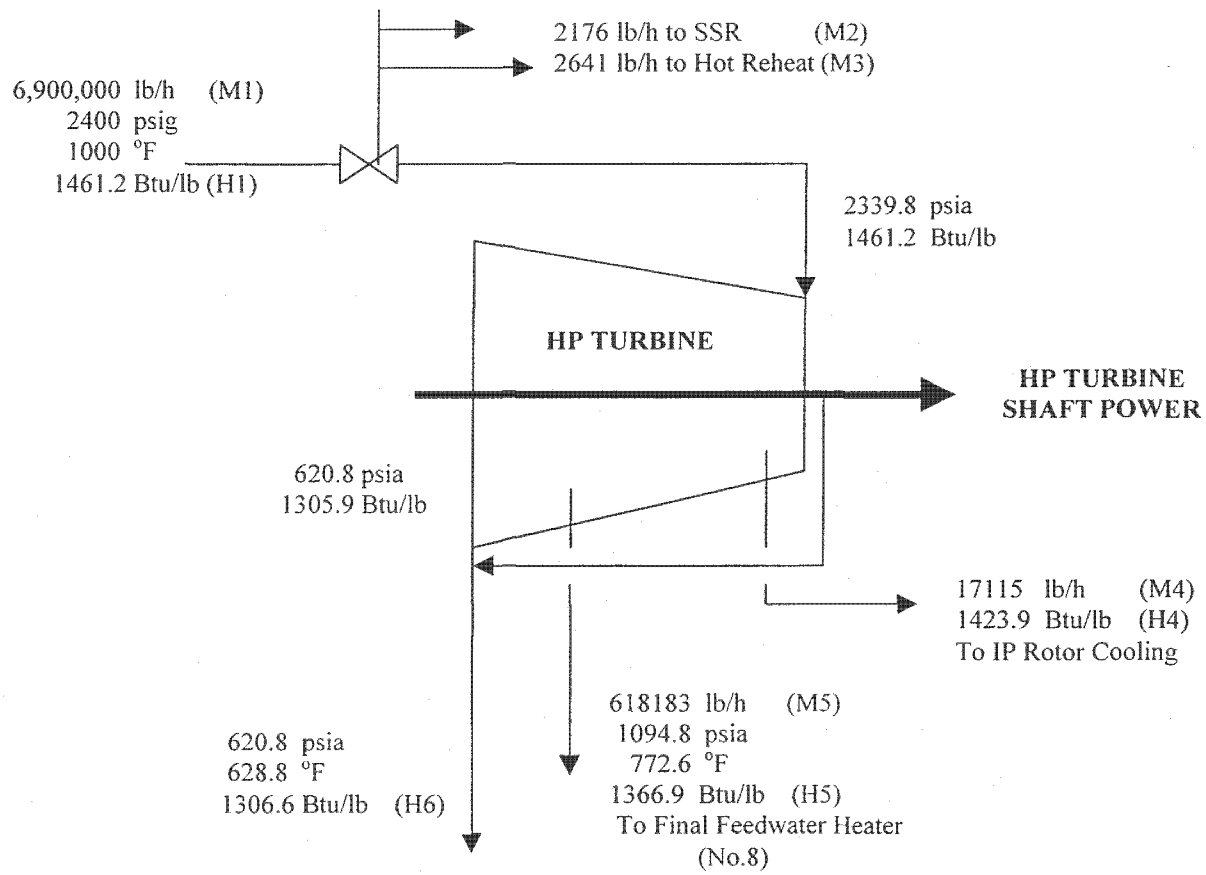
Heat transferred = 581,217 x (1367.6 – 487.8)
= 511,354,717 Btu/h

Extraction steam vol. Flow = 350,683 ft^3/h

IP7010496

HP TURBINE UPGRADE

HP POWER AND EFFICIENCY



HP TURBINE EFFICIENCY
including Valves
(1997 Steam Tables)

$$= \frac{H1 - H6}{H1 - H6'} \times 100 = 92.2\ \%$$

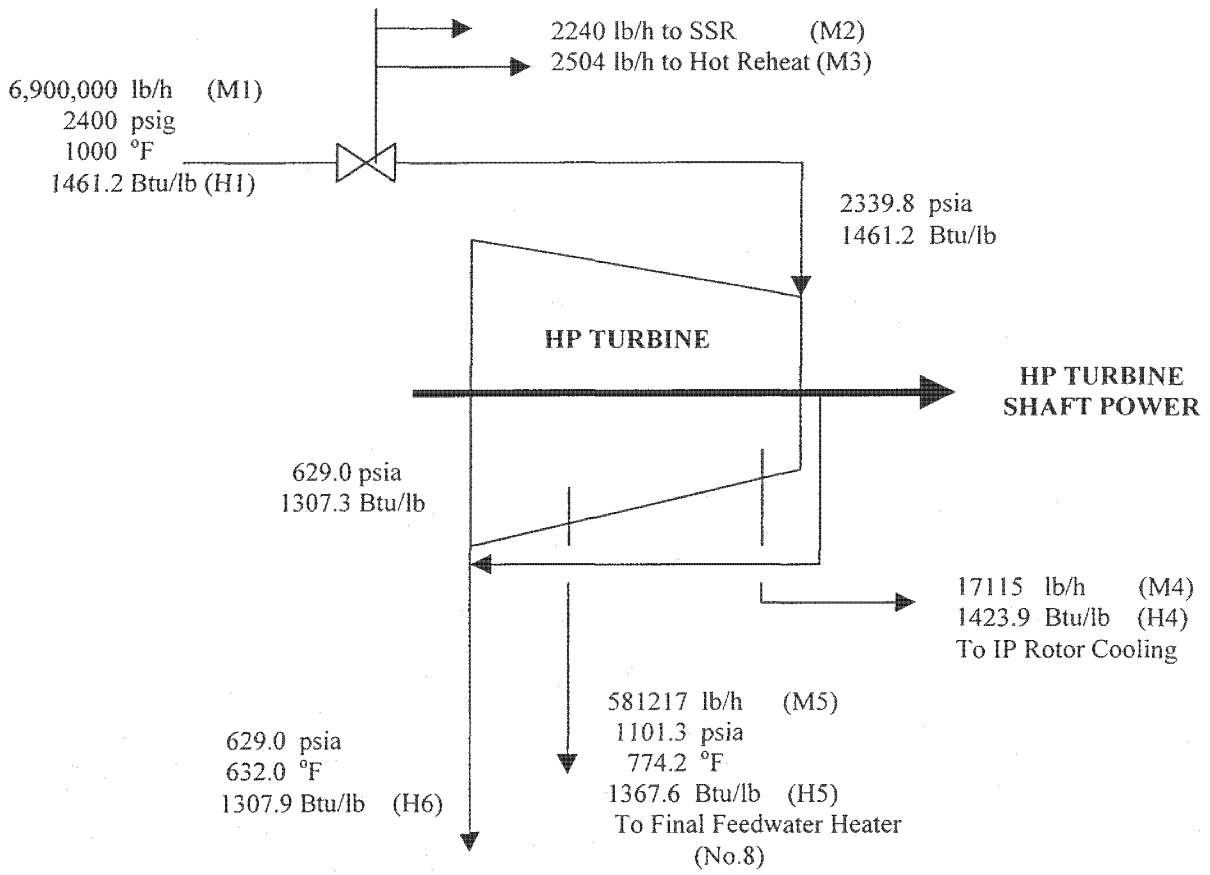
HP TURBINE SHAFT POWER
(1% Feedwater make-up assumed)

$$= \frac{(M1-M2-M3) \times (H1-H6) - M4 \times (H4-H6) - M5 \times (H5-H6)}{3412.14 \times 1000}$$

$$= 300.9\ MW$$

HP TURBINE UPGRADE

HP POWER AND EFFICIENCY



HP TURBINE EFFICIENCY
including Valves
(1997 Steam Tables)

$$= \frac{H1 - H6}{H1 - H6'} \times 100 = 92.2\ \%$$

HP TURBINE SHAFT POWER
(1% Feedwater make-up assumed)

$$= \frac{(M1-M2-M3) \times (H1-H6) - M4 \times (H4-H6) - M5 \times (H5-H6)}{3412.14 \times 1000}$$

$$= 299.0\ MW$$

HP TURBINE UPGRADE PERFORMANCE TESTING

(A) For Guarantees of HP Turbine Efficiency and HP Shaft Power

Measurements required

1. Main steam pressure at HP stop valve chest inlet.
2. Main steam temperature at HP stop valve chest inlet.
3. After throttle valve pressure at HP turbine inlet end of steam leads.
4. IP rotor cooling steam flow (and pressure, temperature).
5. HP extraction to heater 8 – pressure.
6. HP extraction to heater 8 – temperature.
7. HP exhaust pressure.
8. HP exhaust temperature.

9. Feedwater flow to economiser.
10. Heater 8A & 8B feedwater inlet temperatures.
11. Heater 8A & 8B drain temperatures.
12. Heater 8A & 8B feedwater outlet temperatures.
13. Final feedwater temperature (common).
14. HP valves spindle leakage flows.
15. Superheater spraywater flow.

Full cycle isolation required for determination of boiler flow losses.

Test Correction Factors Probably Required

Main steam pressure
Main steam temperature
HP valve pressure drop
Extraction flow to IP rotor cooling
Extraction flow to heater 8
HP exhaust pressure

} complex - all inter-related !

IP7010499

HP TURBINE UPGRADE PERFORMANCE TESTING

(B) For Guarantees of HP Turbine Efficiency and Swallowing Capacity

Measurements required

1. Main steam pressure at HP stop valve chest inlet.
2. Main steam temperature at HP stop valve chest inlet.
3. After throttle valve pressure at HP turbine inlet end of steam leads.
4. HP exhaust pressure.
5. HP exhaust temperature.

6. Feedwater flow to economiser.
7. HP valves spindle leakage flows.
8. Superheater spraywater flow

Full cycle isolation required for determination of boiler flow losses.

Test Correction Factors Probably Required

Main steam pressure
Main steam temperature
HP valve pressure drop
} for flow only – simple factors.

IP7010500