NATIONAL EXAMINATIONS

December 2016

07-MEC-B3 ENERGY CONVERSION AND POWER GENERATION

Three hours duration

Notes to Candidates

1. This is a **Closed Book** examination.
2. Examination paper consists of two Sections. **Section A is Calculative** with four (4) questions and **Section B is Descriptive** with two (2) questions.
3. Note that Question 4 is on two pages.
4. **Do three (3) questions (including all parts of each question) from Section A (Calculative) and one (1) question from Section B (Descriptive).**
5. **Four questions constitute a complete paper.** (Total 60 marks).
6. **All questions are of equal value.** (Each 15 marks).
7. If doubt exists as to the interpretation of any question or in the event of missing data, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.
8. If any initial parts of a multi-part question cannot be solved the remaining parts may be worked by making appropriate assumptions for the first parts from the technical data given.
9. **Read the entire question before commencing the calculations** and take note of any hints or recommendations given.
10. Candidates may use one of the approved **Casio** or **Sharp** calculators.
11. **Reference data** for particular questions are given on pages 9 to 14. **All pages used are to be returned with the answer booklet showing where data has been obtained.**
12. **Reference formulae and constants** are given on pages 15 to 18.
13. **Steam Tables** from "Thermodynamics and Heat Power" are provided.

SECTION A CALCULATIVE QUESTIONS

Show all steps in the calculations and state the units for all intermediate and final answers.

QUESTION 1 REGENERATIVE GAS TURBINE

The initial part of this question is to determine the efficiency of a simple cycle gas turbine. The latter part is to determine the efficiency of a regenerative cycle gas turbine operating within the same boundary conditions. These conditions are as follows:

Compressor inlet air pressure	0.1 MPa	(atmospheric)
Compressor inlet air temperature	15°C	(ambient)
Turbine inlet gas pressure	0.6 MPa	(pressure ratio = 6)
Turbine inlet gas temperature	760°C	(maximum permitted)
Air mass flow rate	1 Mg/s	
Compressor efficiency	86%	
Turbine efficiency	89%	
Regenerator effectiveness	75%	
Fuel heating value	40 MJ/kg	

Assume that the gas mass flow rate is the same as that of the air (neglect fuel mass flow rate). Assume also cold air standard conditions ($k = 1.4$).

(a) Sketch the simple cycle on a T-s diagram and label all key points in the cycle that will be used to identify calculated values. Allow space to show regenerative cycle conditions. (1)

(b) Calculate the temperatures (ideal and actual) at the compressor and turbine inlets and outlets. (6)

(c) Calculate the net power produced by the machine and the efficiency of the simple cycle. (3)

(d) Consider the addition of a regenerative heat exchanger to the simple cycle with the effectiveness (actual heat transfer / maximum possible heat transfer) as given. Show the transfer of heat on the T-s diagram in (a) above.

(e) Calculate the rate of heat transfer in the regenerative heat exchanger. (1)

(f) Calculate the cycle efficiency with the regenerative heat exchanger and comment on its usefulness as an addition to the simple cycle. (2)

(g) Calculate the air/fuel ratio for both the simple cycle and the regenerative cycle. (2)

[15 marks]

QUESTION 2 COMBINED CYCLE PLANT

This question follows from Question 1 but can be completed without having solved any parts of Question 1.

The question considers the addition of a steam cycle (bottoming cycle) to the simple cycle gas turbine in Question 1. Exhaust gas from the gas turbine is used in a heat recovery boiler to generate steam for a steam turbine. Cycle conditions are as follows:

Gas turbine exhaust temperature	392°C	(regenerator inlet)
Regenerator outlet temperature	177°C	
Gas mass flow rate	1 Mg/s	
Fuel mass flow rate	13 kg/s	(gas turbine)
Fuel heating value	40 MJ/kg	
Gas cycle efficiency	28%	(simple cycle)
Steam pressure	1.6 MPa	
Feedwater inlet temperature	40°C	
Steam outlet temperature	350°C	
Steam turbine efficiency	88%	

Assume cold air standard conditions for exhaust gas. Assume also no heat loss in the heat recovery boiler. Use steam tables for steam conditions.

(a) Sketch the temperature profiles of the gas and steam on a temperature versus path length diagram and label all key points in the cycle that will be used to identify calculated values. Sketch also the turbine expansion line on an h-s diagram and label all key points to identify calculated values (2)

(b) Determine all enthalpies at key points in the steam cycle. (4)

(c) Calculate gas turbine power output and steam turbine power output and hence the combined cycle efficiency. (6)

(d) Calculate the temperature difference between the exhaust gas and the steam circuit at the pinch point. (1)

(e) Explain the significance of the pinch point with respect to the design of the heat recovery boiler. Consider primarily heat transfer and capital cost.

OR

Explain how the steam cycle could be modified to improve the thermodynamic performance of the heat recovery boiler and hence efficiency of the cycle. (2)

[15 marks]

QUESTION 3 INTERNAL COMBUSTION ENGINE

Refer to the Examination Paper Attachments **Volkswagen Jetta 2003 Model** on Page 9.

Following the steps given below, estimate the power output of the 2.0 L Four Cylinder In-line Engine as used on the Volkswagen Jetta when running at 2 600 rpm (maximum torque) corresponding to normal highway driving. Technical parameters for this engine are given on Page 9.

Consider a fuel-air cycle with modified specific heats and assume the inlet conditions to be ambient and atmospheric. Note that the mass of fuel must be included with the air (and gas) when calculating the cycle conditions. Use the following air-fuel characteristics:

Air-Fuel Ratio	r_f	=	15	
Calorific Value	CV	=	45 MJ/kg	
Specific Heat	c_p	=	1.42 kJ/kg°C	(air + fuel)
Specific Heat	c_v	=	1.14 kJ/kg°C	(air + fuel)
Inlet Pressure	p_1	=	100 kPa	
Inlet Temperature	t_1	=	30°C	

Note that only the temperatures at each point in the cycle need be calculated to determine the theoretical power.

(a) Sketch the cycle on a p-V diagram and label all key points in the cycle that will be used to identify calculated values. (1)

(b) Calculate the cylinder volume at the beginning and end of the compression stroke. (2)

(c) Calculate the mass of air and fuel ($m_{air} + m_{fuel}$) in the cylinder during the cycle and the mass of fuel (m_{fuel}) available for heat release. (2)

(d) Calculate the temperatures at all key points in the cycle. (3)

(e) Calculate the net work out from the cycle (kJ) (one cylinder only). (3)

(f) Calculate the ideal cycle power output (kW) for the whole engine at 2 600 rpm (1)

(g) Calculate the actual cycle power output (kW) taking account of process losses (time loss 6%, blowdown loss 2%, heat loss 12%) of 20%. (1)

(h) Calculate the useful power output (kW) taking account of mechanical losses (pumping loss 2%, friction loss 16%) of 18%. (1)

(i) Calculate the specified power (kW) at 2 600 rpm from the given specifications. Compare this with the power calculated in (h) and comment on the result. (1)

[15 marks]

QUESTION 4 STEAM PLANT HEAT REJECTION

PART I CONDENSER PERFORMANCE

Refer to the Examination Paper Attachments Page 10 **Koeberg Condenser** and Page 11 **Temperature Profiles.** Note that 1 bar = 0.1 MPa.

Consider the condenser to be operating under the given conditions. Sketch, in dotted lines on each of the given axes, the design temperature profile, with specified temperatures for both cooling water and steam, along the condenser tubes (from inlet to outlet). Show clearly the change in cooling water temperature ΔT and the difference between the average cooling water temperature and the condensing steam temperature θ.

For the following no detailed calculations are required and temperatures should be rounded to the nearest 1°C. The estimates should be based on average temperature differences (not log mean temperature differences) and in each case the new values for ΔT and θ should be stated.

If the conditions are changed as indicated below, sketch, in solid lines on the given axes, the anticipated temperature profiles, with numerical values for both cooling water and steam, across the condenser for each of the following conditions:

(a) Cooling water inlet temperature increased to 18°C. (1½)

(b) Turbine load reduced to one quarter of its original value. (2½)

(c) Cooling water flow reduced to one half of its original value which also results in the overall heat transfer coefficient being reduced **to** 70% of its original value. (2½)

(d) Overall heat transfer coefficient reduced **by** 20% due to fouling of tubes. (2½)

(9 marks)

Question 4 continued on next page

Question 4 continued.

PART II COOLING TOWER

Refer to the Examination Paper Attachments Page 12 **Cooling Tower Evaporative Loss**.

A coal fired power plant with an electrical output of 600 MW rejects 1500 MJ/s of heat to the atmosphere via a steam condenser and a wet natural draught cooling tower. Operating conditions are as follows:

Steam inlet (turbine exhaust) temperature	30°C
Cooling water inlet temperature	15°C
Cooling water outlet temperature	25°C
Ambient air temperature	30°C.
Relative air humidity	40%

Determine the following:

(a) Flow rate of cooling water (m^3/s). (2)

(b) Evaporative loss in cooling tower (m^3/GJ). (1)

(c) Evaporative loss in cooling tower (m^3/s). (1)

(d) Percentage loss of cooling water (%). (1)

(e) Consumption of water by cooling tower (L/kWh generated) (litres/unit generated). (1)

(6 marks)

[15 marks]

SECTION B DESCRIPTIVE QUESTIONS

Descriptive questions (but not graphical questions done on attachments) should be answered in essay form, with sketches if appropriate, and taking approximately one full page for every 5 marks. A full page means approximately 250 words unless diagrams take the place of some words.

QUESTION 5 BRAYTON CYCLE MODIFICATIONS

Refer to the Examination Paper Attachments Pages 13 and 14 **Brayton Cycle Modifications.**

Part (a) must be done on the attachments which must be returned with the examination booklet.

(a) For each of the following modifications to the basic cycle sketch, on a T-s diagram, the basic cycle and the modified cycle.

- (i) increased pressure ratio
- (ii) regenerative heating
- (iii) compressor intercooling
- (iv) turbine reheating
- (v) exhaust afterburning

In each case assume that the turbine inlet temperature is at its limiting (maximum) value (before and after the modification) and that the atmospheric air inlet temperature is constant.

(10 marks)

(b) State with reasons what the advantages and disadvantages are of each modified cycle and how the efficiency and power output is likely to be affected. Where appropriate give examples of practical applications of the cycles to support the choice of particular modifications

(5 marks)

[15 marks]

QUESTION 6 FUEL CHARACTERISTICS

PART I FOSSIL FUEL

(a) State what is meant by heating value and clarify the difference between higher heating value and lower heating value. State which one is commonly used.

(b) Compare and state the characteristics (constituents and heating value) of coals of different grade or rank. Indicate how and why these characteristics change according to the degree of transformation from vegetal matter to coal.

(c) With regard to coal, state what constitutes a Proximate Analysis and what constitutes an Ultimate Analysis. Clarify the usefulness of each.

(9 marks)

PART II NUCLEAR FUEL

For a nuclear reactor of your choice:

(a) Describe the nuclear fission process. Clarify what fuel is used, how fission is initiated and what components are produced. State the necessary characteristics of a nuclear fuel and describe the properties of a typical fuel.

(b) Explain the design requirements of a nuclear reactor. Describe the main internal components and clarify what purpose they serve. Emphasis should be on how the chain reaction is maintained and how energy is produced and removed from the reactor core.

(6 marks)

[15 marks]

EXAMINATION PAPER ATTACHMENTS

QUESTION 3 VOLKSWAGEN JETTA 2003 MODEL

2.0 L GASOLINE ENGINE

Description	Specification
Engine	
Type	2.0 L, 4 cylinder, in-line
Bore	82.5 mm
Stroke	92.8 mm
Displacement	1,984 cm^3
Compression Ratio	10.0:1
Horsepower (SAE) @ rpm	115 @ 5,200 (85 kW @ 5,200)
Maximum torque, lbs - ft @ rpm	122 @ 2,600 (165 Nm @ 2,600)
Fuel Requirement	Regular unleaded
Firing Order	1-3-4-2
Engine Design	
Arrangement	Front mounted, transverse
Cylinder Block	Cast iron
Crank Shaft	Cast iron, five main bearings
Cylinder Head	Aluminum alloy, cross flow
Valve Train	Single overhead camshaft, spur belt driven with semi-automatic belt tensioner, two valves per cylinder, maintenance free hydraulic lifters, single coil valve springs
Cooling System	Water cooled, water pump, cross flow radiator, double thermostatically controlled electric 2-speed radiator fan
Lubrication	Rotary internal gear pump, intermediate shaft driven, oil cooler
Fuel / Air Supply	Sequential multi-point fuel injection (Motronic)
Emissions	Bin 3 EPA Federal Emissions Concept, ORVR (On-board Refuelling Vapor Recovery), EVAP (enhanced evaporation system) standards for USA, 3-way catalytic converter with two oxygen sensors (up - and downstream)

QUESTION 4 PART I KOEBERG CONDENSER

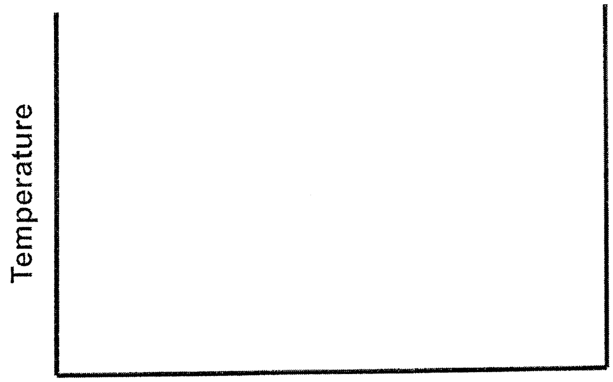
NAME ....

Steam flow rate	2996 t/h
Water make-up flow rate	9 t/h
Cooling water flow rate	141 000 t/h
Cooling water inlet temperature	13°C
Cooling water outlet temperature	24°C
Cooling water density	1.025
Cooling water friction head loss	4.7 m
Mean steam velocity at tube bank	92 m/s
Cooling water velocity inside tubes	2 m/s
Number of tubes	76968
Number of support plates	14 (per bundle)
Tube material	titanium
Cooling surface area	57 426 m^2
Tube overall length	12.84 m
Tube effective length	12.50 m
Tube diameter (OD)	19 mm
Tube wall thickness (normal tubes)	0.5 mm
Tube wall thickness (impact tubes)	0.6 mm
Tube configuration	diagonal array
Tube pitch across array	26 mm
Tube pitch along array	45 mm
Tube fixing method	expanding
Tube mass	132 t
Total volume under vacuum	7500 m^3
Steam inlet pressure	0.043 bar abs
Steam inlet temperature	30°C
Terminal temperature difference	6°C
Condenser hotwell capacity	700 m^3 (approx.)
Number of water boxes (inlet and outlet)	12
Water box internal lining	neoprene
Condenser shell thickness	18 mm
Tube plate thickness	25 mm
Support plate thickness	12 mm
Condenser length	43 m (approx.)
Condenser width	25 m (approx.)
Condenser mass without LP Heaters	1267 t

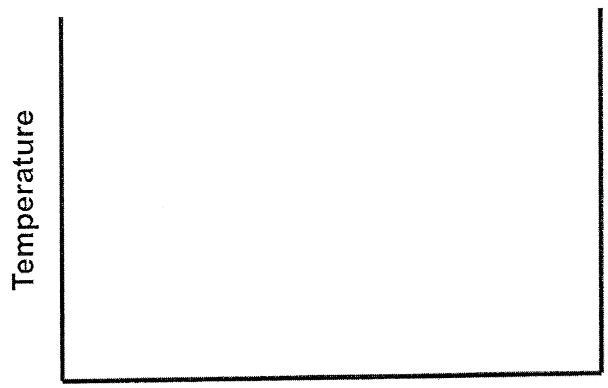
QUESTION 4 PART I TEMPERATURE PROFILES NAME ....

Show initial conditions as dotted lines on each diagram
Show new conditions for each case as solid lines
Give temperatures on axes
Show basic calculations and new values for ΔT and θ below each diagram

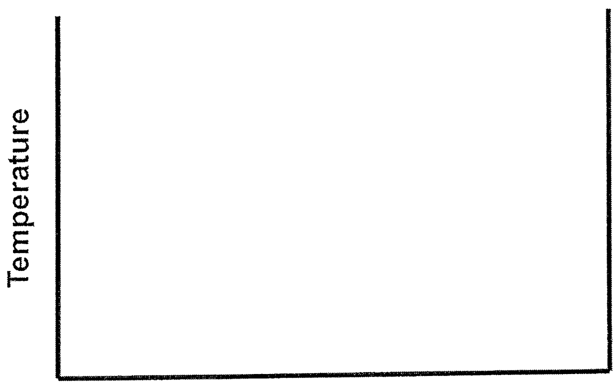
(a) Increase in cooling water temperature



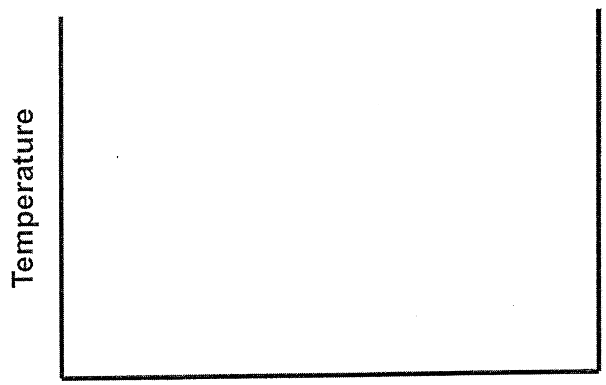
(b) Reduction in turbine load



(c) Reduction in cooling water flow



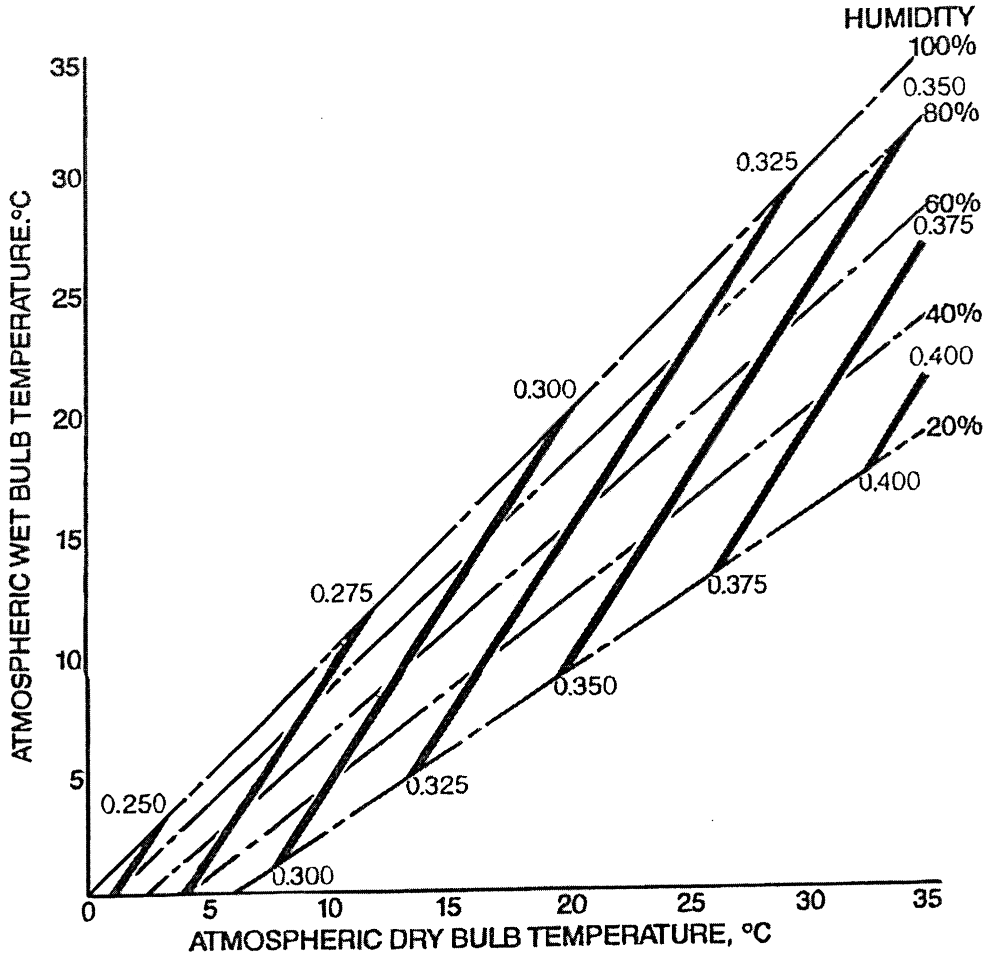
(d) Reduction in heat transfer coefficient



EXAMINATION PAPER ATTACHMENTS

NAME ....

QUESTION 4 PART II COOLING TOWER EVAPORATION LOSS



EVAPORATIVE LOSS IN m³/GJ REJECTED

Evaporative loss from natural draught
cooling towers
The chart is used to estimate the evaporative loss in
m^3/GJ of heat rejected.

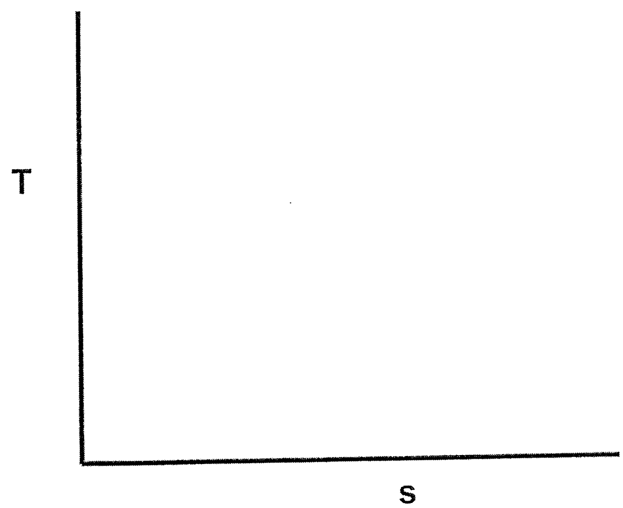
EXAMINATION PAPER ATTACHMENTS

NAME ....

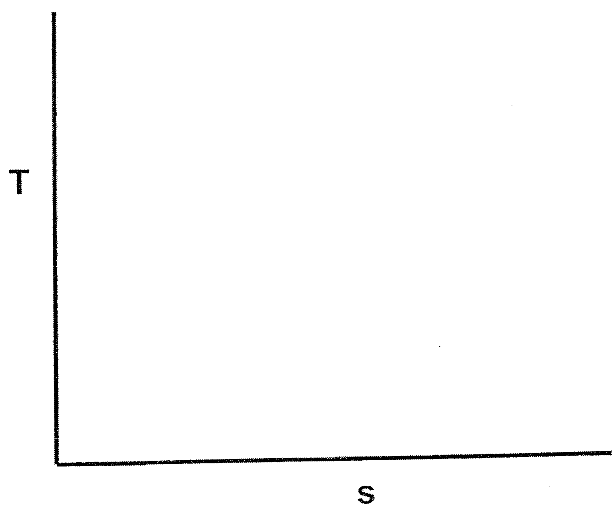
QUESTION 5 BRAYTON CYCLE MODIFICATIONS

(a) On each T-s diagram sketch a basic Brayton Cycle and show how it is modified in each case (with fixed compressor and turbine inlet temperatures).

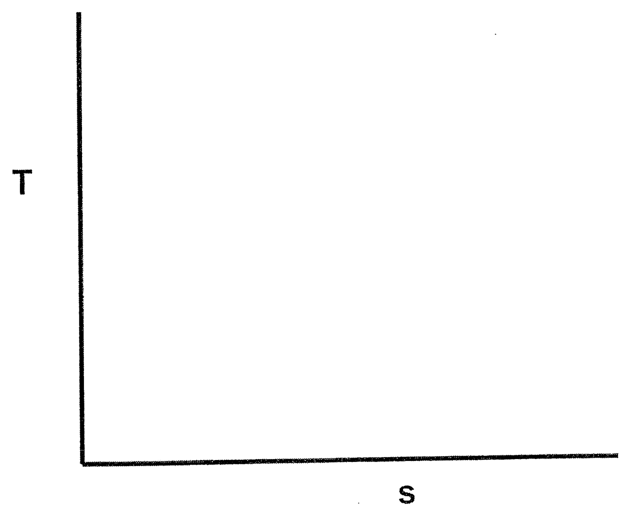
(i) Increased Pressure Ratio



(ii) Regenerative Heating



(iii) Compressor Intercooling



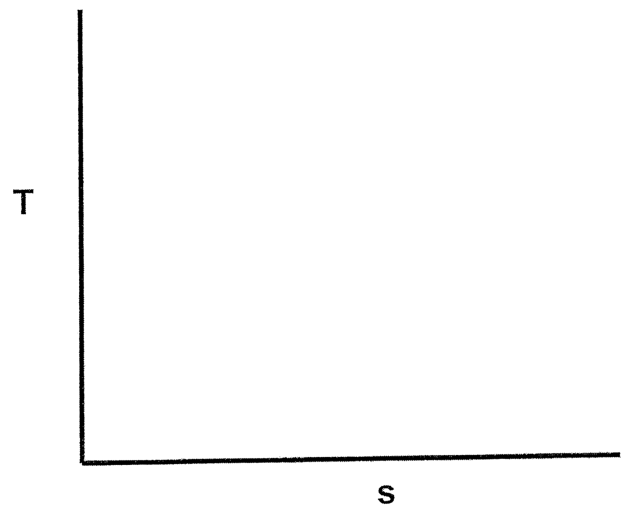
EXAMINATION PAPER ATTACHMENTS

NAME ....

QUESTION 4 CONTINUED

(iv) Turbine Reheating

(v) Exhaust Afterburning



EXAMINATION REFERENCE MATERIAL

NOMENCLATURE FOR REFERENCE EQUATIONS (SI UNITS)

a	Acceleration	m/s^2
A	Flow area, Surface area	m^2
c_p	Specific heat at constant pressure	J/kg°C
c_v	Specific heat at constant volume	J/kg°C
D	Diameter	m
E	Energy	J
E_f	Energy release per fission of one atom	
h	Specific enthalpy	J/kg
H	Enthalpy	J
F	Force	N
g	Gravitational acceleration	m/s^2
k	Ratio of specific heats	
L	Length	m
m	Mass	kg
m	Fractional mass flow rate	
M	Mass flow rate	kg/s
M	Molecular weight	
N	Number of nuclei	number/g
N_A	Avogadro's Number	
N_f	Number of fissile nuclei	$number/cm^3$
n	Gas expansion index	
p	Pressure	Pa
P	Power	W
q	Heat transferred	J/kg
q*	Heat release rate	J/cm^3
Q	Heat	J
Q	Volume flow rate	m^3/s
R	Specific gas constant	J/kg°K
R_0	Universal gas constant	J/kg-mole°K
s	Specific entropy	J/kg°K
S	Entropy	J/°K
t	Time	s
t	Temperature	°C
T	Absolute temperature	°K
u	Specific internal energy	J/kg
U	Internal energy	J
v	Specific volume	m^3/kg
V	Volume	m^3
V	Velocity	m/s
w	Specific work	J/kg
W	Work	J

x	Length	m
z	Elevation	m
γ	Fuel enrichment	
η	Efficiency	
ϕ	Neutron flux	neutrons/cm^{2}s
σ_f	Cross section	barn
μ	Dynamic viscosity	Ns/m^2
ν	Kinematic viscosity	m^2/s
ρ	Density	kg/m^3
T	Thrust	N
τ	Torque	Nm
Ω	Heat transfer rate	J/s

CONSTANTS

For consistency in calculations the following constants should be used:

Gravitational Acceleration	$g = 9.81$ m/s
Atmospheric Pressure	$p = 100$ kPa
Universal Gas Constant	$R_o = 8.314$ kJ/kg mole°K
Density of Water	$\rho = 1000$ kg/m^3
Specific Heat of Water	$c_p = 4.19$ kJ/kg°C
Specific Heat of Air	$c_p = 1.005$ kJ/kg°C
Specific Heat of Air	$c_v = 0.718$ kJ/kg°C
Specific Heat of Helium	$c_p = 5.193$ kJ/kg°C
Specific Heat of Helium	$c_v = 3.116$ kJ/kg°C
Specific Gas Constant for Air	$R = 0.287$ kJ/kg°K
Avogadro's Number	$N_A = 0.602 \times 10^{24}$ atoms/mole
Nuclear Cross Section	1 barn = 10^{-24} cm^2

GENERAL REFERENCE EQUATIONS

Ideal Gas Relationships

Gas Law:	$pv = RT$
Gas Law:	$pV = mRT$
Specific Heat at Constant Pressure:	$c_p = \Delta h/\Delta T$
Specific Heat at Constant Volume:	$c_v = \Delta u/\Delta T$
Gas Constant:	$R = c_p - c_v$
Specific Heat Ratio:	$k = c_p/c_v$

Constant Volume:	$T_1/T_2 = p_1/p_2$
Constant Pressure:	$T_1/T_2 = v_1/v_2$
Constant Temperature:	$p_1v_1 = p_2v_2$
Constant Entropy:	$p_1v_1^k = p_2v_2^k$
Isentropic Relations:	$p_1/p_2 = (v_2/v_1)^k = (T_1/T_2)^{k/(k-1)}$
	$T_1/T_2 = (v_2/v_1)^{k-1} = (p_1/p_2)^{(k-1)/k}$

Work in Non-Flow Processes

Constant Pressure:	$w = p\ (v_2 - v_1)$
Constant Temperature:	$w = p_1v_1 \ln(v_2/v_1)$
Constant Entropy:	$w = (p_2v_2 - p_1v_1) / (1 - k)$
	$w = (T_2 - T_1)\ R / (1 - k)$

Work in Flow Processes

Constant Temperature:	$w = p_1v_1 \ln(v_2v_1)$
Constant Volume:	$w = (p_2 - p_1)\ v$
Constant Entropy:	$w = (p_1v_1 - p_2v_2)\ k / (k - 1)$

Thermodynamics

First Law:	$dE = \delta Q - \delta W$
Enthalpy:	$h = u + pv$
Enthalpy Change	$\Delta h = \Delta u + \Delta(pv)$
Continuity:	$\rho VA = \text{constant}$
Flow Work:	$w = \Delta(pv)$
Energy Equation:	$zg + V^2/2 + u + pv + \Delta w + \Delta q = \text{constant}$
Entropy:	$\Delta s = q/T$ (reversible conditions)

Fluid Mechanics

Continuity Equation:	$\rho_1V_1A_1 = \rho_2V_2A_2 = M$
Energy Equation:	$z_1g + V_1^2/2 + u_1 + p_1v_1 + w_{in} + q_{in}$
	$= z_2g + V_2^2/2 + u_2 + p_2\ v_2 + w_{out} + q_{out}$
Bernoulli's Equation:	$p_1/\rho g + z_1 + V_1^2/2g = p_2/\rho g + z_2 + V_2^2/2g$
Momentum Equation:	$F = p_1A_1 - p_2A_2 - \rho VA(V_2 - V_1)$
	(one dimensional)

Internal Combustion Engines

Power Output	$P = 2\pi N\tau / 60$
Engine Capacity	$V_{total} = 1000\ (\pi D^2/4)\ LN_{cylinders}$
Mean Effective Pressure	$MEP = Work / (V_1 - V_2)$

Steam Turbines

Nozzle Equation: $h_1 - h_2 = (V_2^2 - V_1^2) / 2$

Work: $w = [(V_{1\,absolute}^2 - V_{2\,absolute}^2) + (V_{2\,relative}^2 - V_{1\,relative}^2)] / 2$

Gas Turbines

Isentropic Equation: $(T_2/T_1) = (p_2/p_1)^{(k-1)/k}$

Enthalpy Change: $h_1 - h_2 = c_p(T_1 - T_2)$ (ideal gas)

Nozzle Equation: $h_1 - h_2 = (V_2^2 - V_1^2) / 2$

Jet Propulsion

Thrust: $\tau = M(V_{jet} - V_{aircraft})$

Thrust Power: $\tau V_{aircraft} = M(V_{jet} - V_{aircraft})V_{aircraft}$

Jet Power: $P = M(V_{jet}^2 - V_{aircraft}^2) / 2$

Propulsion Efficiency: $\eta_p = 2V_{aircraft}/(V_{jet} + V_{aircraft})$

Wind Turbines

Maximum Ideal Power: $P_{max} = 8\,\rho\, AV_1^3 / 27$

Nuclear Energy

Number of nuclei per gram of material: $N = N_A / M$

Number of fissile nuclei per cm^3 of material: $N_f = \gamma\,(N_A / M)\,\rho$

Heat release rate in nuclear fuel: $q^* = \phi\, N_f\, \sigma_f\, E_f$

Cycle Efficiencies

$\eta_{cycle} = w_{out} / q_{in} = W_{out} / Q_{in} = P_{out} / \Omega_{in}$

$\eta_{Carnot} = (T_{hot} - T_{cold}) / T_{hot}$

$\eta_{Rankine} = (\Delta h_{turbine} - \Delta h_{pump}) / \Delta h_{boiler}$

$\eta_{Brayton} = (\Delta T_{turbine} - \Delta T_{Compressor}) / \Delta T_{combustion}$

Component Efficiencies

$\eta_{boiler} = \Omega_{out} / \Omega_{in}$

$\eta_{boiler} = (\Omega_{in} / \Omega_{lost}) / \Omega_{in}$

$\eta_{turbine} = \Delta h_{actual} / \Delta h_{isentropic}$

$\eta_{nozzle} = \Delta h_{actual} / \Delta h_{isentropic}$

$\eta_{gas\ turbine} = \Delta T_{actual} / \Delta T_{isentropic}$

$\eta_{pump} = \Delta h_{isentropic} / \Delta h_{actual}$

$\eta_{compressor} = \Delta T_{isentropic} / \Delta T_{actual}$

Thermodynamics and Heat Power

SIXTH EDITION

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late, Queensborough Community College of City University of New York

Maurice Bluestein, Ph.D.

Indiana University–Purdue University, Indianapolis

PRENTICE HALL

Upper Saddle River, New Jersey   Columbus, Ohio

TABLE A.1 (SI)
Saturation: Temperature (Steam)

Temp. °C T	Press. kPa P	Specific Volume (m³/kg) Sat. Liquid v_f	Specific Volume Sat. Vapor v_g	Internal Energy (kJ/kg) Sat. Liquid u_f	Internal Energy Evap. u_{fg}	Internal Energy Sat. Vapor u_g	Enthalpy (kJ/kg) Sat. Liquid h_f	Enthalpy Evap. h_{fg}	Enthalpy Sat. Vapor h_g	Entropy (kJ/kg · °k) Sat. Liquid s_f	Entropy Evap. s_{fg}	Entropy Sat. Vapor s_g
0.01	0.6113	0.001 000	206.14	.00	2375.3	2375.3	.01	2501.3	2501.4	.0000	9.1562	9.1562
5	0.8721	0.001 000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	.0761	8.9496	9.0257
10	1.2276	0.001 000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	.1510	8.7498	8.9008
15	1.7051	0.001 001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	.2245	8.5569	8.7814
20	2.339	0.001 002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	.2966	8.3706	8.6672
25	3.169	0.001 003	43.36	104.88	2304.9	2409.8	104.89	2442.3	2547.2	.3674	8.1905	8.5580
30	4.246	0.001 004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	.4369	8.0164	8.4533
35	5.628	0.001 006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	.5053	7.8478	8.3531
40	7.384	0.001 008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	.5725	7.6845	8.2570
45	9.593	0.001 010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	.6387	7.5261	8.1648
50	12.349	0.001 012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	.7038	7.3725	8.0763
55	15.758	0.001 015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	.7679	7.2234	7.9913
60	19.940	0.001 017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	.8312	7.0784	7.9096
65	25.03	0.001 020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	.8935	6.9375	7.8310
70	31.19	0.001 023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	.9549	6.8004	7.7553
75	38.58	0.001 026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	7.6824
80	47.39	0.001 029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	7.6122
85	57.83	0.001 033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	7.5445
90	70.14	0.001 036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	7.4791
95	84.55	0.001 040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	7.4159

TABLE A.1 (SI) (cont'd.)

		Specific Volume (m³/kg)		Internal Energy (kJ/kg)			Enthalpy (kJ/kg)			Entropy (kJ/kg · °k)		
Temp. °C T	Press. kPa P	Sat. Liquid v_f	Sat. Vapor v_g	Sat. Liquid u_f	Evap. u_{fg}	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Evap. s_{fg}	Sat. Vapor s_g
	MPa											
100	0.101 35	0.001 044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3549
105	0.120 82	0.001 048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2958
110	0.143 27	0.001 052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2387
115	0.169 06	0.001 056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1833
120	0.198 53	0.001 060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1296
125	0.2321	0.001 065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0775
130	0.2701	0.001 070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0269
135	0.3130	0.001 075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9777
140	0.3613	0.001 080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9299
145	0.4154	0.001 085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8833
150	0.4758	0.001 091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8379
155	0.5431	0.001 096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.7935
160	0.6178	0.001 102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.7502
165	0.7005	0.001 108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.7078
170	0.7917	0.001 114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.6663
175	0.8920	0.001 121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.6256
180	1.0021	0.001 127	0.194 05	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.5857
185	1.1227	0.001 134	0.174 09	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.5465
190	1.2544	0.001 141	0.156 54	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.5079
195	1.3978	0.001 149	0.141 05	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.4698
200	1.5538	0.001 157	0.127 36	850.65	1744.7	2595.3	852.45	1940.7	2793.2	2.3309	4.1014	6.4323
205	1.7230	0.001 164	0.115 21	873.04	1724.5	2597.5	875.04	1921.0	2796.0	2.3780	4.0172	6.3952
210	1.9062	0.001 173	0.104 41	895.53	1703.9	2599.5	897.76	1900.7	2798.5	2.4248	3.9337	6.3585
215	2.104	0.001 181	0.094 79	918.14	1682.9	2601.1	920.62	1879.9	2800.5	2.4714	3.8507	6.3221
220	2.318	0.001 190	0.086 19	940.87	1661.5	2602.4	943.62	1858.5	2802.1	2.5178	3.7683	6.2861
225	2.548	0.001 199	0.078 49	963.73	1639.6	2603.3	966.78	1836.5	2803.3	2.5639	3.6863	6.2503
230	2.795	0.001 209	0.071 58	986.74	1617.2	2603.9	990.12	1813.8	2804.0	2.6099	3.6047	6.2146
235	3.060	0.001 219	0.065 37	1009.89	1594.2	2604.1	1013.62	1790.5	2804.2	2.6558	3.5233	6.1791
240	3.344	0.001 229	0.059 76	1033.21	1570.8	2604.0	1037.32	1766.5	2803.8	2.7015	3.4422	6.1437
245	3.648	0.001 240	0.054 71	1056.71	1546.7	2603.4	1061.23	1741.7	2803.0	2.7472	3.3612	6.1083

TABLE A.1 (SI) (cont'd.)

Temp. °C T	Press. MPa P	Specific Volume (m³/kg) Sat. Liquid v_f	Sat. Vapor v_g	Internal Energy (kJ/kg) Sat. Liquid u_f	Evap. u_{fg}	Sat. Vapor u_g	Enthalpy (kJ/kg) Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Entropy (kJ/kg · °k) Sat. Liquid s_f	Evap. s_{fg}	Sat. Vapor s_g
250	3.973	0.001 251	0.050 13	1080.39	1522.0	2602.4	1085.36	1716.2	2801.5	2.7927	3.2802	6.0730
255	4.319	0.001 263	0.045 98	1104.28	1496.7	2600.9	1109.73	1689.8	2799.5	2.8383	3.1992	6.0375
260	4.688	0.001 276	0.042 21	1128.39	1470.6	2599.0	1134.37	1662.5	2796.9	2.8838	3.1181	6.0019
265	5.081	0.001 289	0.038 77	1152.74	1443.9	2596.6	1159.28	1634.4	2793.6	2.9294	3.0368	5.9662
270	5.499	0.001 302	0.035 64	1177.36	1416.3	2593.7	1184.51	1605.2	2789.7	2.9751	2.9551	5.9301
275	5.942	0.001 317	0.032 79	1202.25	1387.9	2590.2	1210.07	1574.9	2785.0	3.0208	2.8730	5.8938
280	6.412	0.001 332	0.030 17	1227.46	1358.7	2586.1	1235.99	1543.6	2779.6	3.0668	2.7903	5.8571
285	6.909	0.001 348	0.027 77	1253.00	1328.4	2581.4	1262.31	1511.0	2773.3	3.1130	2.7070	5.8199
290	7.436	0.001 366	0.025 57	1278.92	1297.1	2576.0	1289.07	1477.1	2766.2	3.1594	2.6227	5.7821
295	7.993	0.001 384	0.023 54	1305.2	1264.7	2569.9	1316.3	1441.8	2758.1	3.2062	2.5375	5.7437
300	8.581	0.001 404	0.021 67	1332.0	1231.0	2563.0	1344.0	1404.9	2749.0	3.2534	2.4511	5.7045
305	9.202	0.001 425	0.019 948	1359.3	1195.9	2555.2	1372.4	1366.4	2738.7	3.3010	2.3633	5.6643
310	9.856	0.001 447	0.018 350	1387.1	1159.4	2546.4	1401.3	1326.0	2727.3	3.3493	2.2737	5.6230
315	10.547	0.001 472	0.016 867	1415.5	1121.1	2536.6	1431.0	1283.5	2714.5	3.3982	2.1821	5.5804
320	11.274	0.001 499	0.015 488	1444.6	1080.9	2525.5	1461.5	1238.6	2700.1	3.4480	2.0882	5.5362
330	12.845	0.001 561	0.012 996	1505.3	993.7	2498.9	1525.3	1140.6	2665.9	3.5507	1.8909	5.4417
340	14.586	0.001 638	0.010 797	1570.3	894.3	2464.6	1594.2	1027.9	2622.0	3.6594	1.6763	5.3357
350	16.513	0.001 740	0.008 813	1641.9	776.6	2418.4	1670.6	893.4	2563.9	3.7777	1.4335	5.2112
360	18.651	0.001 893	0.006 945	1725.2	626.3	2351.5	1760.5	720.5	2481.0	3.9147	1.1379	5.0526
370	21.03	0.002 213	0.004 925	1844.0	384.5	2228.5	1890.5	441.6	2332.1	4.1106	.6865	4.7971
374.14	22.09	0.003 155	0.003 155	2029.6	0	2029.6	2099.3	0	2099.3	4.4298	0	4.4298

TABLE A.2 (SI)

Saturation Pressures (Steam)

Press. kPa P	Temp. °C T	Specific Volume (m³/kg) Sat. Liquid v_f	Specific Volume (m³/kg) Sat. Vapor v_g	Internal Energy (kJ/kg) Sat. Liquid u_f	Internal Energy (kJ/kg) Evap. u_{fg}	Internal Energy (kJ/kg) Sat. Vapor u_g	Enthalpy (kJ/kg) Sat. Liquid h_f	Enthalpy (kJ/kg) Evap. h_{fg}	Enthalpy (kJ/kg) Sat. Vapor h_g	Entropy (kJ/kg · °K) Sat. Liquid s_f	Entropy (kJ/kg · °K) Evap. s_{fg}	Entropy (kJ/kg · °K) Sat. Vapor s_g
0.6113	0.01	0.001 000	206.14	.00	2375.3	2375.3	.01	2501.3	2501.4	.0000	9.1562	9.1562
1.0	6.98	0.001 000	129.21	29.30	2355.7	2385.0	29.30	2484.9	2514.2	.1059	8.8697	8.9756
1.5	13.03	0.001 001	87.98	54.71	2338.6	2393.3	54.71	2470.6	2525.3	.1957	8.6322	8.8279
2.0	17.50	0.001 001	67.00	73.48	2326.0	2399.5	73.48	2460.0	2533.5	.2607	8.4629	8.7237
2.5	21.08	0.001 002	54.25	88.48	2315.9	2404.4	88.49	2451.6	2540.0	.3120	8.3311	8.6432
3.0	24.08	0.001 003	45.67	101.04	2307.5	2408.5	101.05	2444.5	2545.5	.3545	8.2231	8.5776
4.0	28.96	0.001 004	34.80	121.45	2293.7	2415.2	121.46	2432.9	2554.4	.4226	8.0520	8.4746
5.0	32.88	0.001 005	28.19	137.81	2282.7	2420.5	137.82	2423.7	2561.5	.4764	7.9187	8.3951
7.5	40.29	0.001 008	19.24	168.78	2261.7	2430.5	168.79	2406.0	2574.8	.5764	7.6750	8.2515
10	45.81	0.001 010	14.67	191.82	2246.1	2437.9	191.83	2392.8	2584.7	.6493	7.5009	8.1502
15	53.97	0.001 014	10.02	225.92	2222.8	2448.7	225.94	2373.1	2599.1	.7549	7.2536	8.0085
20	60.06	0.001 017	7.649	251.38	2205.4	2456.7	251.40	2358.3	2609.7	.8320	7.0766	7.9085
25	64.97	0.001 020	6.204	271.90	2191.2	2463.1	271.93	2346.3	2618.2	.8931	6.9383	7.8314
30	69.10	0.001 022	5.229	289.20	2179.2	2468.4	289.23	2336.1	2625.3	.9439	6.8247	7.7686
40	75.87	0.001 027	3.993	317.53	2159.5	2477.0	317.58	2319.2	2636.8	1.0259	6.6441	7.6700
50	81.33	0.001 030	3.240	340.44	2143.4	2483.9	340.49	2305.4	2645.9	1.0910	6.5029	7.5939
75	91.78	0.001 037	2.217	384.31	2112.4	2496.7	384.39	2278.6	2663.0	1.2130	6.2434	7.4564
MPa												
0.100	99.63	0.001 043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001 048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001 053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001 057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001 061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001 064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878

TABLE A.2 (SI) (cont'd.)

Press. MPa P	Temp. °C T	Specific Volume: Sat. Liquid v_f	Specific Volume: Sat. Vapor v_g	Internal Energy: Sat. Liquid u_f	Internal Energy: Evap. u_{fg}	Internal Energy: Sat. Vapor u_g	Enthalpy: Sat. Liquid h_f	Enthalpy: Evap. h_{fg}	Enthalpy: Sat. Vapor h_g	Entropy: Sat. Liquid s_f	Entropy: Evap. s_{fg}	Entropy: Sat. Vapor s_g
0.250	127.44	0.001 067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001 070	0.6573	548.59	1991.9	2540.5	548.89	2172.4	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001 073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001 076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001 079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001 081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001 084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001 088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001 093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001 097	0.3427	655.32	1909.2	2564.5	655.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001 101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001 104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001 108	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001 112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001 115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001 118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001 121	0.2150	741.83	1838.6	2580.5	742.83	2031.1	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001 124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001 127	0.194 44	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001 133	0.177 53	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001 139	0.163 33	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001 144	0.151 25	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001 149	0.140 84	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693

TABLE A.2 (SI) (cont'd.)

Press. MPa P	Temp. °C T	Specific Volume (m³/kg) Sat. Liquid v_f	Sat. Vapor v_g	Internal Energy (kJ/kg) Sat. Liquid u_f	Evap. u_{fg}	Sat. Vapor u_g	Enthalpy (kJ/kg) Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Entropy (kJ/kg · °k) Sat. Liquid s_f	Evap. s_{fg}	Sat. Vapor s_g
1.50	198.32	0.001 154	0.131 77	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001 166	0.113 49	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001 177	0.099 63	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001 187	0.088 75	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001 197	0.079 98	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001 217	0.066 68	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001 235	0.057 07	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001 252	0.049 78	1082.31	1520.0	2602.3	1087.31	1714.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001 286	0.039 44	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001 319	0.032 44	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001 351	0.027 37	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001 384	0.023 52	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001 418	0.020 48	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6772
10	311.06	0.001 452	0.018 026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141
11	318.15	0.001 489	0.015 987	1433.7	1096.0	2529.8	1450.1	1255.5	2705.6	3.4295	2.1233	5.5527
12	324.75	0.001 527	0.014 263	1473.0	1040.7	2513.7	1491.3	1193.6	2684.9	3.4962	1.9962	5.4924
13	330.93	0.001 567	0.012 780	1511.1	985.0	2496.1	1531.5	1130.7	2662.2	3.5606	1.8718	5.4323
14	336.75	0.001 611	0.011 485	1548.6	928.2	2476.8	1571.1	1066.5	2637.6	3.6232	1.7485	5.3717
15	342.24	0.001 658	0.010 337	1585.6	869.8	2455.5	1610.5	1000.0	2610.5	3.6848	1.6249	5.3098
16	347.44	0.001 711	0.009 306	1622.7	809.0	2431.7	1650.1	930.6	2580.6	3,7461	1.4994	5.2455
17	352.37	0.001 770	0.008 364	1660.2	744.8	2405.0	1690.3	856.9	2547.2	3.8079	1.3698	5.1777
18	357.06	0.001 840	0.007 489	1698.9	675.4	2374.3	1732.0	777.1	2509.1	3.8715	1.2329	5.1044
19	361.54	0.001 924	0.006 657	1739.9	598.1	2338.1	1776.5	688.0	2464.5	3.9388	1.0839	5.0228
20	365.81	0.002 036	0.005 834	1785.6	507.5	2293.0	1826.3	583.4	2409.7	4.0139	.9130	4.9269
21	369.89	0.002 207	0.004 952	1842.1	388.5	2230.6	1888.4	446.2	2334.6	4.1075	.6938	4.8013
22	373.80	0.002 742	0.003 568	1961.9	125.2	2087.1	2022.2	143.4	2165.6	4.3110	.2216	4.5327
22.09	374.14	0.003 155	0.003 155	2029.6	0	2029.6	2099.3	0	2099.3	4.4298	0	4.4298

TABLE A.3 (SI)
Properties of Superheated Steam

T	P = .010 MPa (45.81)				P = .050 MPa (81.33)				P = .10 MPa (99.63)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	14.674	2437.9	2584.7	8.1502	3.240	2483.9	2645.9	7.5939	1.6940	2506.1	2675.5	7.3594
50	14.869	2443.9	2592.6	8.1749								
100	17.196	2515.5	2687.5	8.4479	3.418	2511.6	2682.5	7.6947	1.6958	2506.7	2676.2	7.3614
150	19.512	2587.9	2783.0	8.6882	3.889	2585.6	2780.1	7.9401	1.9364	2582.8	2776.4	7.6134
200	21.825	2661.3	2879.5	8.9038	4.356	2659.9	2877.7	8.1580	2.172	2658.1	2875.3	7.8343
250	24.136	2736.0	2977.3	9.1002	4.820	2735.0	2976.0	8.3556	2.406	2733.7	2974.3	8.0333
300	26.445	2812.1	3076.5	9.2813	5.284	2811.3	3075.5	8.5373	2.639	2810.4	3074.3	8.2158
400	31.063	2968.9	3279.6	9.6077	6.209	2968.5	3278.9	8.8642	3.103	2967.9	3278.2	8.5435
500	35.679	3132.3	3489.1	9.8978	7.134	3132.0	3488.7	9.1546	3.565	3131.6	3488.1	8.8342
600	40.295	3302.5	3705.4	10.1608	8.057	3302.2	3705.1	9.4178	4.028	3301.9	3704.7	9.0976
700	44.911	3479.6	3928.7	10.4028	8.981	3479.4	3928.5	9.6599	4.490	3479.2	3928.2	9.3398
800	49.526	3663.8	4159.0	10.6281	9.904	3663.6	4158.9	9.8852	4.952	3663.5	4158.6	9.5652
900	54.141	3855.0	4396.4	10.8396	10.828	3854.9	4396.3	10.0967	5.414	3854.8	4396.1	9.7767
1000	58.757	4053.0	4640.6	11.0393	11.751	4052.9	4640.5	10.2964	5.875	4052.8	4640.3	9.9764
1100	63.372	4257.5	4891.2	11.2287	12.674	4257.4	4891.1	10.4859	6.337	4257.3	4891.0	10.1659
1200	67.987	4467.9	5147.8	11.4091	13.597	4467.8	5147.7	10.6662	6.799	4467.7	5147.6	10.3463
1300	72.602	4683.7	5409.7	11.5811	14.521	4683.6	5409.6	10.8382	7.260	4683.5	5409.5	10.5183
	P = .20 MPa (120.23)				P = .30 MPa (133.55)				P = .40 MPa (143.63)			
Sat.	.8857	2529.5	2706.7	7.1272	.6058	2543.6	2725.3	6.9919	.4625	2553.6	2738.6	6.8959
150	.9596	2576.9	2768.8	7.2795	.6339	2570.8	2761.0	7.0778	.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	.7163	2650.7	2865.6	7.3115	.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	.7964	2728.7	2967.6	7.5166	.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	.8753	2806.7	3069.3	7.7022	.6548	2804.8	3066.8	7.5662
400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	.7726	2964.4	3273.4	7.8985

TABLE A.3 (SI) (cont'd.)

T	v	u	h	s	v	u	h	s	v	u	h	s
	$P = .20$ MPa (120.23)				$P = .30$ MPa (133.55)				$P = .40$ MPa (143.63)			
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2372	3662.4	4157.3	8.9244
900	2.706	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.6563	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.3	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780
	$P = .50$ MPa (151.86)				$P = .60$ MPa (158.85)				$P = .80$ MPa (170.43)			
Sat.	.3749	2561.2	2748.7	6.8213	.3157	2567.4	2756.8	6.7600	.2404	2576.8	2769.1	6.6628
200	.4249	2642.9	2855.4	7.0592	.3520	2638.9	2850.1	6.9665	.2608	2630.6	2839.3	6.8158
250	.4744	2723.5	2960.7	7.2709	.3938	2720.9	2957.2	7.1816	.2931	2715.5	2950.0	7.0384
300	.5226	2802.9	3064.2	7.4599	.4344	2801.0	3061.6	7.3724	.3241	2797.2	3056.5	7.2328
350	.5701	2882.6	3167.7	7.6329	.4742	2881.2	3165.7	7.5464	.3544	2878.2	3161.7	7.4089
400	.6173	2963.2	3271.9	7.7938	.5137	2962.1	3270.3	7.7079	.3843	2959.7	3267.1	7.5716
500	.7109	3128.4	3483.9	8.0873	.5920	3127.6	3482.8	8.0021	.4433	3126.0	3480.6	7.8673
600	.8041	3299.6	3701.7	7.3522	.6697	3299.1	3700.9	8.2674	.5018	3297.9	3699.4	8.1333
700	.8969	3477.5	3925.9	8.5952	.7472	3477.0	3925.3	8.5107	.5601	3476.2	3924.2	8.3770
800	.9896	3662.1	4156.9	8.8211	.8245	3661.8	4156.5	8.7367	.6181	3661.1	4155.6	8.6033
900	1.0822	3853.6	4394.7	9.0329	.9017	3853.4	4394.4	8.9486	.6761	3852.8	4393.7	8.8153
1000	1.1747	4051.8	4639.1	9.2328	.9788	4051.5	4638.8	9.1485	.7340	4051.0	4638.2	9.0153
1100	1.2672	4256.3	4889.9	9.4224	1.0559	4256.1	4889.6	9.3381	.7919	4255.6	4889.1	9.2050
1200	1.3596	4466.8	5146.6	9.6029	1.1330	4466.5	5146.3	9.5185	.8497	4466.1	5145.9	9.3855
1300	1.4521	4682.5	5408.6	9.7749	1.2101	4682.3	5408.3	9.6906	.9076	4681.8	5407.9	9.5575

TABLE A.3 (SI) (cont'd.)

T	v	u	h	s	v	u	h	s	v	u	h	s
	P = 1.00 MPa (179.91)				P = 1.20 MPa (187.99)				P = 1.40 MPa (195.07)			
Sat.	.194 44	2583.6	2778.1	6.5865	.163 33	2588.8	2784.8	6.5233	.140 84	2592.8	2790.0	6.4693
200	.2060	2621.9	2827.9	6.6940	.169 30	2612.8	2815.9	6.5898	.143 02	2603.1	2803.3	6.4975
250	.2327	2709.9	2942.6	6.9247	.192 34	2704.2	2935.0	6.8294	.163 50	2698.3	2927.2	6.7467
300	.2579	2793.2	3051.2	7.1229	.2138	2789.2	3045.8	7.0317	.182 28	2785.2	3040.4	6.9534
350	.2825	2875.2	3157.7	7.3011	.2345	2872.2	3153.6	7.2121	.2003	2869.2	3149.5	7.1360
400	.3066	2957.3	3263.9	7.4651	.2548	2954.9	3260.7	7.3774	.2178	2952.5	3257.5	7.3026
500	.3541	3124.4	3478.5	7.7622	.2946	3122.8	3476.3	7.6759	.2521	3121.1	3474.1	7.6027
600	.4011	3296.8	3697.9	8.0290	.3339	3295.6	3696.3	7.9435	.2860	3294.4	3694.8	7.8710
700	.4478	3475.3	3923.1	8.2731	.3729	3474.4	3922.0	8.1881	.3195	3473.6	3920.8	8.1160
800	.4943	3660.4	4154.7	8.4996	.4118	3659.7	4153.8	8.4148	.3528	3659.0	4153.0	8.3431
900	.5407	3852.2	4392.9	8.7118	.4505	3851.6	4392.2	8.6272	.3861	3851.1	4391.5	8.5556
1000	.5871	4050.5	4637.6	8.9119	.4892	4050.0	4637.0	8.8274	.4192	4049.5	4636.4	8.7559
1100	.6335	4255.1	4888.6	9.1017	.5278	4254.6	4888.0	9.0172	.4524	4254.1	4887.5	8.9457
1200	.6798	4465.6	5145.4	9.2822	.5665	4465.1	5144.9	9.1977	.4855	4464.7	5144.4	9.1262
1300	.7261	4681.3	5407.4	9.4543	.6051	4680.9	5407.0	9.3698	.5186	4680.4	5406.5	9.2984
	P = 1.60 MPa (201.41)				P = 1.80 MPa (207.15)				P = 2.00 MPa (212.42)			
Sat.	.123 80	2596.0	2794.0	6.4218	.110 42	2598.4	2797.1	6.3794	.099 63	2600.3	2799.5	6.3409
225	.132 87	2644.7	2857.3	6.5518	.116 73	2636.6	2846.7	6.4808	.103 77	2628.3	2835.8	6.4147
250	.141 84	2692.3	2919.2	6.6732	.124 97	2686.0	2911.0	6.6066	.111 44	2679.6	2902.5	6.5453
300	.158 62	2781.1	3034.8	6.8844	.140 21	2776.9	3029.2	6.8226	.125 47	2772.6	3023.5	6.7664
350	.174 56	2866.1	3145.4	7.0694	.154 57	2863.0	3141.2	7.0100	.138 57	2859.8	3137.0	6.9563
400	.190 05	2950.1	3254.2	7.2374	.168 47	2947.7	3250.9	7.1794	.151 20	2945.2	3247.6	7.1271
500	.2203	3119.5	3472.0	7.5390	.195 50	3117.9	3469.8	7.4825	.175 68	3116 2	3467.6	7.4317
600	.2500	3293.3	3693.2	7.8080	.2220	3292.1	3691.7	7.7523	.199 60	3290.9	3690.1	7.7024
700	.2794	3472.7	3919.7	8.0535	.2482	3471.8	3918.5	7.9983	.2232	3470.9	3917.4	7.9487

TABLE A.3 (SI) (cont'd.)

T	v	u	h	s	v	u	h	s	v	u	h	s
	P = 1.60 MPa (201.41)				P = 1.80 MPa (207.15)				P = 2.00 MPa (212.42)			
800	.3086	3658.3	4152.1	8.2808	.2742	3657.6	4151.2	8.2258	.2467	3657.0	4150.3	8.1765
900	.3377	3850.5	4390.8	8.4935	.3001	3849.9	4390.1	8.4386	.2700	3849.3	4389.4	8.3895
1000	.3668	4049.0	4635.8	8.6938	.3260	4048.5	4635.2	8.6391	.2933	4048.0	4634.6	8.5901
1100	.3958	4253.7	4887.0	8.8837	.3518	4253.2	4886.4	8.8290	.3166	4252.7	4885.9	8.7800
1200	.4248	4464.2	5143.9	9.0643	.3776	4463.7	5143.4	9.0096	.3398	4463.3	5142.9	8.9607
1300	.4538	4679.9	5406.0	9.2364	.4034	4679.5	5405.6	9.1818	.3631	4679.0	5405.1	9.1329
	P = 2.50 MPa (223.99)				P = 3.00 MPa (233.90)				P = 3.50 MPa (242.60)			
Sat.	.079 98	2603.1	2803.1	6.2575	.066 68	2604.1	2804.2	6.1869	.057 07	2603.7	2803.4	6.1253
225	.080 27	2605.6	2806.3	6.2639								
250	.087 00	2662.6	2880.1	6.4085	.070 58	2644.0	2855.8	6.2872	.058 72	2623.7	2829.2	6.1749
300	.098 90	2761.6	3008.8	6.6438	.081 14	2750.1	2993.5	6.5390	.068 42	2738.0	2977.5	6.4461
350	.109 76	2851.9	3126.3	6.8403	.090 53	2843.7	3115.3	6.7428	.076 78	2835.3	3104.0	6.6579
400	.120 10	2939.1	3239.3	7.0148	.099 36	2932.8	3230.9	6.9212	.084 53	2926.4	3222.3	6.8405
450	.130 14	3025.5	3350.8	7.1746	.107 87	3020.4	3344.0	7.0834	.091 96	3015.3	3337.2	7.0052
500	.139 98	3112.1	3462.1	7.3234	.116 19	3108.0	3456.5	7.2338	.099 18	3103.0	3450.9	7.1572
600	.159 30	3288.0	3686.3	7.5960	.132 43	3285.0	3682.3	7.5085	.113 24	3282.1	3678.4	7.4339
700	.178 32	3468.7	3914.5	7.8435	.148 38	3466.5	3911.7	7.7571	.126 99	3464.3	3908.8	7.6837
800	.197 16	3655.3	4148.2	8.0720	.164 14	3653.5	4145.9	7.9862	.140 56	3651.8	4143.7	7.9134
900	.215 90	3847.9	4387.6	8.2853	.179 80	3846.5	4385.9	8.1999	.154 02	3845.0	4384.1	8.1276
1000	.2346	4046.7	4633.1	8.4861	.195 41	4045.4	4631.6	8.4009	.167 43	4044.1	4630.1	8.3288
1100	.2532	4251.5	4884.6	8.6762	.210 98	4250.3	4883.3	8.5912	.180 80	4249.2	4881.9	8.5192
1200	.2718	4462.1	5141.7	8.8569	.226 52	4460.9	5140.5	8.7720	.194 15	4459.8	5139.3	8.7000
1300	.2905	4677.8	5404.0	9.0291	.242 06	4676.6	5402.8	8.9442	.207 49	4675.5	5401.7	8.8723

TABLE A.3 (SI) (cont'd.)

T	v	u	h	s	v	u	h	s	v	u	h	s
	$P = 4.0$ MPa (250.40)				$P = 4.5$ MPa (257.49)				$P = 5.0$ MPa (263.99)			
Sat.	.049 78	2602.3	2801.4	6.0701	.044 06	2600.1	2798.3	6.0198	.039 44	2597.1	2794.3	5.9734
275	.054 57	2667.9	2886.2	6.2285	.047 30	2650.3	2863.2	6.1401	.041 41	2631.3	2838.3	6.0544
300	.058 84	2725.3	2960.7	6.3615	.051 35	2712.0	2943.1	6.2828	.045 32	2698.0	2924.5	6.2084
350	.066 45	2826.7	3092.5	6.5821	.058 40	2817.8	3080.6	6.5131	.051 94	2808.7	3068.4	6.4493
400	.073 41	2919.9	3213.6	6.7690	.064 75	2913.3	3204.7	6.7047	.057 81	2906.6	3195.7	6.6459
450	.080 02	3010.2	3330.3	6.9363	.070 74	3005.0	3323.3	6.8746	.063 30	2999.7	3316.2	6.8186
500	.086 43	3099.5	3445.3	7.0901	.076 51	3095.3	3439.6	7.0301	.068 57	3091.0	3433.8	6.9759
600	.098 85	3279.1	3674.4	7.3688	.087 65	3276.0	3670.5	7.3110	.078 69	3273.0	3666.5	7.2589
700	.110 95	3462.1	3905.9	7.6198	.098 47	3459.9	3903.0	7.5631	.088 49	3457.6	3900.1	7.5122
800	.122 87	3650.0	4141.5	7.8502	.109 11	3648.3	4139.3	7.7942	.098 11	3646.6	4137.1	7.7440
900	.134 69	3843.6	4382.3	8.0647	.119 65	3842.2	4380.6	8.0091	.107 62	3840.7	4378.8	7.9593
1000	.146 45	4042.9	4628.7	8.2662	.130 13	4041.6	4627.2	8.2108	.117 07	4040.4	4625.7	8.1612
1100	.158 17	4248.0	4880.6	8.4567	.140 56	4246.8	4879.3	8.4015	.126 48	4245.6	4878.0	8.3520
1200	.169 87	4458.6	5138.1	8.6376	.150 98	4457.5	5136.9	8.5825	.135 87	4456.3	5135.7	8.5331
1300	.181 56	4674.3	5400.5	8.8100	.161 39	4673.1	5399.4	8.7549	.145 26	4672.0	5398.2	8.7055
	$P = 6.0$ MPa (275.64)				$P = 7.0$ MPa (285.88)				$P = 8.0$ MPa (295.06)			
Sat.	.032 44	2589.7	2784.3	5.8892	.027 37	2580.5	2772.1	5.8133	.023 52	2569.8	2758.0	5.7432
300	.036 16	2667.2	2884.2	6.0674	.029 47	2632.2	2838.4	5.9305	.024 26	2590.9	2785.0	5.7906
350	.042 93	2789.6	3043.0	6.3335	.035 24	2769.4	3016.0	6.2283	.029 95	2747.7	2987.3	6.1301
400	.047 39	2892.9	3177.2	6.5408	.039 93	2878.6	3158.1	6.4478	.034 32	2863.8	3138.3	6.3634
450	.052 14	2988.9	3301.8	6.7193	.044 16	2978.0	3287.1	6.6327	.038 17	2966.7	3272.0	6.5551
500	.056 65	3082.2	3422.2	6.8803	.048 14	3073.4	3410.3	6.7975	.041 75	3064.3	3398.3	6.7240
550	.061 01	3174.6	3540.6	7.0288	.051 95	3167.2	3530.9	6.9486	.045 16	3159.8	3521.0	6.8778
600	.065 25	3266.9	3658.4	7.1677	.055 65	3260.7	3650.3	7.0894	.048 45	3254.4	3642.0	7.0206

TABLE A.3 (SI) (cont'd.)

T	v	u	h	s	v	u	h	s	v	u	h	s
	$P = 6.0$ MPa (275.64)				$P = 7.0$ MPa (285.88)				$P = 8.0$ MPa (295.06)			
700	.073 52	3453.1	3894.2	7.4234	.062 83	3448.5	3888.3	7.3476	.054 81	3443.9	3882.4	7.2812
800	.081 60	3643.1	4132.7	7.6566	.069 81	3639.5	4128.2	7.5822	.060 97	3636.0	4123.8	7.5173
900	.089 58	3837.8	4375.3	7.8727	.076 69	3835.0	4371.8	7.7991	.067 02	3832.1	4368.3	7.7351
1000	.097 49	4037.8	4622.7	8.0751	.083 50	4035.3	4619.8	8.0020	.073 01	4032.8	4616.9	7.9384
1100	.105 36	4243.3	4875.4	8.2661	.090 27	4240.9	4872.8	8.1933	.078 96	4238.6	4870.3	8.1300
1200	.113 21	4454.0	5133.3	8.4474	.097 03	4451.7	5130.9	8.3747	.084 89	4449.5	5128.5	8.3115
1300	.121 06	4669.6	5396.0	8.6199	.103 77	4667.3	5393.7	8.5473	.090 80	4665.0	5391.5	8.4842
	$P = 9.0$ MPa (303.40)				$P = 10.0$ MPa (311.06)				$P = 12.5$ MPa (327.89)			
Sat.	.020 48	2557.8	2742.1	5.6772	.018 026	2544.4	2724.7	5.6141	.013 495	2505.1	2673.8	5.4624
325	.023 27	2646.6	2856.0	5.8712	.019 861	2610.4	2809.1	5.7568				
350	.025 80	2724.4	2956.6	6.0361	.022 42	2699.2	2923.4	5.9443	.016 126	2624.6	2826.2	5.7118
400	.029 93	2848.4	3117.8	6.2854	.026 41	2832.4	3096.5	6.2120	.020 00	2789.3	3039.3	6.0417
450	.033 50	2955.2	3256.6	6.4844	.029 75	2943.4	3240.9	6.4190	.022 99	2912.5	3199.8	6.2719
500	.036 77	3055.2	3386.1	6.6576	.032 79	3045.8	3373.7	6.5966	.025 60	3021.7	3341.8	6.4618
550	.039 87	3152.2	3511.0	6.8142	.035 64	3144.6	3500.9	6.7561	.028 01	3125.0	3475.2	6.6290
600	.042 85	3248.1	3633.7	6.9589	.038 37	3241.7	3625.3	6.9029	.030 29	3225.4	3604.0	6.7810
650	.045 74	3343.6	3755.3	7.0943	.041 01	3338.2	3748.2	7.0398	.032 48	3324.4	3730.4	6.9218
700	.048 57	3439.3	3876.5	7.2221	.043 58	3434.7	3870.5	7.1687	.034 60	3422.9	3855.3	7.0536
800	.054 09	3632.5	4119.3	7.4596	.048 59	3628.9	4114.8	7.4077	.038 69	3620.0	4103.6	7.2965
900	.059 50	3829.2	4364.8	7.6783	.053 49	3826.3	4361.2	7.6272	.042 67	3819.1	4352.5	7.5182
1000	.064 85	4030.3	4614.0	7.8821	.058 32	4027.8	4611.0	7.8315	.046 58	4021.6	4603.8	7.7237
1100	.070 16	4236.3	4867.7	8.0740	.063 12	4234.0	4865.1	8.0237	.050 45	4228.2	4858.8	7.9165
1200	.075 44	4447.2	5126.2	8.2556	.067 89	4444.9	5123.8	8.2055	.054 30	4439.3	5118.0	8.0987
1300	.080 72	4662.7	5389.2	8.4284	.072 65	4460.5	5387.0	8.3783	.058 13	4654.8	5381.4	8.2717

TABLE A.3 (SI) (cont'd.)

T	v	u	h	s	v	u	h	s	v	u	h	s
	$P = 15.0$ MPa (342.24)				$P = 17.5$ MPa (354.75)				$P = 20.0$ MPa (365.81)			
Sat.	.010 337	2455.5	2610.5	5.3098	.007 920	2390.2	2528.8	5.1419	.005 834	2293.0	2409.7	4.9269
350	.011 470	2520.4	2692.4	5.4421								
400	.015 649	2740.7	2975.5	5.8811	.012 447	2685.0	2902.9	5.7213	.009 942	2619.3	2818.1	5.5540
450	.018 445	2879.5	3156.2	6.1404	.015 174	2844.2	3109.7	6.0184	.012 695	2806.2	3060.1	5.9017
500	.020 80	2996.6	3308.6	6.3443	.017 358	2970.3	3274.1	6.2383	.014 768	2942.9	3238.2	6.1401
550	.022 93	3104.7	3448.6	6.5199	.019 288	3083.9	3421.4	6.4230	.016 555	3062.4	3393.5	6.3348
600	.024 91	3208.6	3582.3	6.6776	.021 06	3191.5	3560.1	6.5866	.018 178	3174.0	3537.6	6.5048
650	.026 80	3310.3	3712.3	6.8224	.022 74	3296.0	3693.9	6.7357	.019 693	3281.4	3675.3	6.6582
700	.028 61	3410.9	3840.1	6.9572	.024 34	3398.7	3824.6	6.8736	.021 13	3386.4	3809.0	6.7993
800	.032 10	3610.9	4092.4	7.2040	.027 38	3601.8	4081.1	7.1244	.023 85	3592.7	4069.7	7.0544
900	.035 46	3811.9	4343.8	7.4279	.030 31	3804.7	4335.1	7.3507	.026 45	3797.5	4326.4	7.2830
1000	.038 75	4015.4	4596.6	7.6348	.033 16	4009.3	4589.5	7.5589	.028 97	4003.1	4582.5	7.4925
1100	.042 00	4222.6	4852.6	7.8283	.035 97	4216.9	4846.4	7.7531	.031 45	4211.3	4840.2	7.6874
1200	.045 23	4433.8	5112.3	8.0108	.038 76	4428.3	5106.6	7.9360	.033 91	4422.8	5101.0	7.8707
1300	.048 45	4649.1	5376.0	8.1840	.041 54	4643.5	5370.5	8.1093	.036 36	4638.0	5365.1	8.0442
	$P = 25.0$ MPa				$P = 30.0$ MPa				$P = 35.0$ MPa			
375	.001 973 1	1798.7	1848.0	4.0320	.001 789 2	1737.8	1791.5	3.9305	.001 700 3	1702.9	1762.4	3.8722
400	.006 004	2430.1	2580.2	5.1418	.002 790	2067.4	2151.1	4.4728	.002 100	1914.1	1987.6	4.2126
425	.007 881	2609.2	2806.3	5.4723	.005 303	2455.1	2614.2	5.1504	.003 428	2253.4	2373.4	4.7747
450	.009 162	2720.7	2949.7	5.6744	.006 735	2619.3	2821.4	5.4424	.004 961	2498.7	2672.4	5.1962
500	.011 123	2884.3	3162.4	5.9592	.008 678	2820.7	3081.1	5.7905	.006 927	2751.9	2994.4	5.6282
550	.012 724	3017.5	3335.6	6.1765	.010 168	2970.3	3275.4	6.0342	.008 345	2921.0	3213.0	5.9026
600	.014 137	3137.9	3491.4	6.3602	.011 446	3100.5	3443.9	6.2331	.009 527	3062.0	3395.5	6.1179
650	.015 433	3251.6	3637.4	6.5229	.012 596	3221.0	3598.9	6.4058	.010 575	3189.8	3559.9	6.3010

TABLE A.3 (SI) (cont'd.)

T	v	u	h	s	v	u	h	s	v	u	h	s
	$P = 25.0$ MPa				$P = 30.0$ MPa				$P = 35.0$ MPa			
700	.016 646	3361.3	3777.5	6.6707	.013 661	3335.8	3745.6	6.5606	.011 533	3309.8	3713.5	6.4631
800	.018 912	3574.3	4047.1	6.9345	.015 623	3555.5	4024.2	6.8332	.013 278	3536.7	4001.5	6.7450
900	.021 045	3783.0	4309.1	7.1680	.017 448	3768.5	4291.9	7.0718	.014 883	3754.0	4274.9	6.9886
1000	.023 10	3990.9	4568.5	7.3802	.019 196	3978.8	4554.7	7.2867	.016 410	3966.7	4541.1	7.2064
1100	.025 12	4200.2	4828.2	7.5765	.020 903	4189.2	4816.3	7.4845	.017 895	4178.3	4804.6	7.4057
1200	.027 11	4412.0	5089.9	7.7605	.022 589	4401.3	5079.0	7.6692	.019 360	4390.7	5068.3	7.5910
1300	.029 10	4626.9	5354.4	7.9342	.024 266	4616.0	5344.0	7.8432	.020 815	4605.1	5333.6	7.7653
	$P = 40.0$ MPa				$P = 50.0$ MPa				$P = 60.0$ MPa			
375	.001 640 7	1677.1	1742.8	3.8290	.001 559 4	1638.6	1716.6	3.7639	.001 502 8	1609.4	1699.5	3.7141
400	.001 907 7	1854.6	1930.9	4.1135	.001 730 9	1788.1	1874.6	4.0031	.001 633 5	1745.4	1843.4	3.9318
425	.002 532	2096.9	2198.1	4.5029	.002 007	1959.7	2060.0	4.2734	.001 816 5	1892.7	2001.7	4.1626
450	.003 693	2365.1	2512.8	4.9459	.002 486	2159.6	2284.0	4.5884	.002 085	2053.9	2179.0	4.4121
500	.005 622	2678.4	2903.3	5.4700	.003 892	2525.5	2720.1	5.1726	.002 956	2390.6	2567.9	4.9321
550	.006 984	2869.7	3149.1	5.7785	.005 118	2763.6	3019.5	5.5485	.003 956	2658.8	2896.2	5.3441
600	.008 094	3022.6	3346.4	6.0114	.006 112	2942.0	3247.6	5.8178	.004 834	2861.1	3151.2	5.6452
650	.009 063	3158.0	3520.6	6.2054	.006 966	3093.5	3441.8	6.0342	.005 595	3028.8	3364.5	5.8829
700	.009 941	3283.6	3681.2	6.3750	.007 727	3230.5	3616.8	6.2189	.006 272	3177.2	3553.5	6.0824
800	.011 523	3517.8	3978.7	6.6662	.009 076	3479.8	3933.6	6.5290	.007 459	3441.5	3889.1	6.4109
900	.012 962	3739.4	4257.9	6.9150	.010 283	3710.3	4224.4	6.7882	.008 508	3681.0	4191.5	6.6805
1000	.014 324	3954.6	4527.6	7.1356	.011 411	3930.5	4501.1	7.0146	.009 480	3906.4	4475.2	6.9127
1100	.015 642	4167.4	4793.1	7.3364	.012 496	4145.7	4770.5	7.2184	.010 409	4124.1	4748.6	7.1195
1200	.016 940	4380.1	5057.7	7.5224	.013 561	4359.1	5037.2	7.4058	.011 317	4338.2	5017.2	7.3083
1300	.018 229	4594.3	5323.5	7.6969	.014 616	4572.8	5303.6	7.5808	.012 215	4551.4	5284.3	7.4837

TABLE 4

Liquid												
p (t Sat.) MPa	0				2.5 (223.99)				5.0 (263.99)			
t	10^3v	u	h	s	10^3v	u	h	s	10^3v	u	h	s
Sat.					1.1973	959.1	962.1	2.5546	1.2859	1147.8	1154.2	2.9202
0	1.0002	−0.03	−0.03	−0.0001	0.9990	−0.00	2.50	−0.0000	0.9977	0.04	5.04	0.0001
20	1.0018	83.95	83.95	0.2966	1.0006	83.80	86.30	0.2961	0.9995	83.65	88.65	0.2956
40	1.0078	167.56	167.56	0.5725	1.0067	167.25	169.77	0.5715	1.0056	166.95	171.97	0.5705
60	1.0172	251.12	251.12	0.8312	1.0160	250.67	253.21	0.8298	1.0149	250.23	255.30	0.8285
80	1.1291	334.87	334.87	1.0753	1.0280	334.29	336.86	1.0737	1.0268	333.72	338.85	1.0720
100	1.0436	418.96	418.96	1.3069	1.0423	418.24	420.85	1.3050	1.0410	417.52	422.72	1.3030
120	1.0604	503.57	503.57	1.5278	1.0590	502.68	505.33	1.5255	1.0576	501.80	507.09	1.5233
140	1.0800	588.89	588.89	1.7395	1.0784	587.82	590.52	1.7369	1.0768	586.76	592.15	1.7343
160	1.1024	675.19	675.19	1.9434	1.1006	673.90	676.65	1.9404	1.0988	672.62	678.12	1.9375
180	1.1283	762.72	762.72	2.1410	1.1261	761.16	763.97	2.1375	1.1240	759.63	765.25	2.1341
200	1.1581	851.8	851.8	2.3334	1.1555	849.9	852.8	2.3294	1.1530	848.1	853.9	2.3255
210	1.1749	897.1	897.1	2.4281	1.1720	895.0	898.0	2.4238	1.1691	893.0	898.8	2.4195
220	1.1930	943.0	943.0	2.5221	1.1898	940.7	943.7	2.5174	1.1866	938.4	944.4	2.5128
230	1.2129	989.6	989.6	2.6157	1.2092	987.0	990.1	2.6105	1.2056	984.5	990.6	2.6055
240	1.2347	1037.1	1037.1	2.7091	1.2305	1034.2	1037.2	2.7034	1.2264	1031.4	1037.5	2.6979
250	1.2590	1085.6	1085.6	2.8027	1.2540	1082.3	1085.4	2.7964	1.2493	1079.1	1085.3	2.7902
260	1.2862	1135.4	1135.4	2.8970	1.2804	1131.6	1134.8	2.8898	1.2749	1127.9	1134.3	2.8830
270	1.3173	1186.8	1186.8	2.9926	1.3102	1182.4	1185.7	2.9844	1.3036	1178.2	1184.3	2.9766
280	1.3535	1240.4	1240.4	3.0904	1.3447	1235.1	1238.5	3.0808	1.3365	1230.2	1236.8	3.0717
290	1.3971	1297.0	1297.0	3.1918	1.3855	1290.5	1294.0	3.1801	1.3750	1284.4	1291.3	3.1693
300	1.4520	1358.1	1358.1	3.2992	1.4357	1349.6	1353.2	3.2843	1.4214	1341.9	1349.0	3.2708
310									1.4803	1404.1	1411.5	3.3789

FIGURE 5.11a Extract from subcooled table (SI units).

TABLE A.4 (SI)
Properties of Compressed Liquid (Steam)

	$P = 5$ MPa (263.99)				$P = 10$ MPa (311.06)				$P = 15$ MPa (342.24)			
T	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	.001 285 9	1147.8	1154.2	2.9202	.001 452 4	1393.0	1407.6	3.3596	.001 658 1	1585.6	1610.5	3.6848
0	.000 997 7	.04	5.04	.0001	.000 995 2	.09	10.04	.0002	.000 992 8	.15	15.05	.0004
20	.000 999 5	83.65	88.65	.2956	.000 997 2	83.36	93.33	.2945	.000 995 0	83.06	97.99	.2934
40	.001 005 6	166.95	171.97	.5705	.001 003 4	166.35	176.38	.5686	.001 001 3	165.76	180.78	.5666
60	.001 014 9	250.23	255.30	.8285	.001 012 7	249.36	259.49	.8258	.001 010 5	248.51	263.67	.8232
80	.001 026 8	333.72	338.85	1.0720	.001 024 5	332.59	342.83	1.0688	.001 022 2	331.48	346.81	1.0656
100	.001 041 0	417.52	422.72	1.3030	.001 038 5	416.12	426.50	1.2992	.001 036 1	414.74	430.28	1.2955
120	.001 057 6	501.80	507.09	1.5233	.001 054 9	500.08	510.64	1.5189	.001 052 2	498.40	514.19	1.5145
140	.001 076 8	586.76	592.15	1.7343	.001 073 7	584.68	595.42	1.7292	.001 070 7	582.66	598.72	1.7242
160	.001 098 8	672.62	678.12	1.9375	.001 095 3	670.13	681.08	1.9317	.001 091 8	667.71	684.09	1.9260
180	.001 124 0	759.63	765.25	2.1341	.001 119 9	756.65	767.84	2.1275	.001 115 9	753.76	770.50	2.1210
200	.001 153 0	848.1	853.9	2.3255	.001 148 0	844.5	856.0	2.3178	.001 143 3	841.0	858.2	2.3104
220	.001 186 6	938.4	944.4	2.5128	.001 180 5	934.1	945.9	2.5039	.001 174 8	929.9	947.5	2.4953
240	.001 226 4	1031.4	1037.5	2.6979	.001 218 7	1026.0	1038.1	2.6872	.001 211 4	1020.8	1039.0	2.6771
260	.001 274 9	1127.9	1134.3	2.8830	.001 264 5	1121.1	1133.7	2.8699	.001 255 0	1114.6	1133.4	2.8576
280					.001 321 6	1220.9	1234.1	3.0548	.001 308 4	1212.5	1232.1	3.0393
300					.001 397 2	1328.4	1342.3	3.2469	.001 377 0	1316.6	1337.3	3.2260
320									.001 472 4	1431.1	1453.2	3.4247
340									.001 631 1	1567.5	1591.9	3.6546

TABLE A.4 (SI) (cont'd.)

	$P = 20$ MPa (365.81)				$P = 30$ MPa				$P = 50$ MPa			
T	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	.002 036	1785.6	1826.3	4.0139								
0	.000 990 4	.19	20.01	.0004	.000 985 6	.25	29.82	.0001	.000 976 6	.20	49.03	.0014
20	.000 992 8	82.77	102.62	.2923	.000 988 6	82.17	111.84	.2899	.000 980 4	81.00	130.02	.2848
40	.000 999 2	165.17	185.16	.5646	.000 995 1	164.04	193.89	.5607	.000 987 2	161.86	211.21	.5527
60	.001 008 4	247.68	267.85	.8206	.001 004 2	246.06	276.19	.8154	.000 996 2	242.98	292.79	.8052
80	.001 019 9	330.40	350.80	1.0624	.001 015 6	328.30	358.77	1.0561	.001 007 3	324.34	374.70	1.0440
100	.001 033 7	413.39	434.06	1.2917	.001 029 0	410.78	441.66	1.2844	.001 020 1	405.88	456.89	1.2703
120	.001 049 6	496.76	517.76	1.5102	.001 044 5	493.59	524.93	1.5018	.001 034 8	487.65	539.39	1.4857
140	.001 067 8	580.69	602.04	1.7193	.001 062 1	576.88	608.75	1.7098	.001 051 5	569.77	622.35	1.6915
160	.001 088 5	665.35	687.12	1.9204	.001 082 1	660.82	693.28	1.9096	.001 070 3	652.41	705.92	1.8891
180	.001 112 0	750.95	773.20	2.1147	.001 104 7	745.59	778.73	2.1024	.001 091 2	735.69	790.25	2.0794
200	.001 138 8	837.7	860.5	2.3031	.001 130 2	831.4	865.3	2.2893	.001 114 6	819.7	875.5	2.2634
220	.001 169 3	925.9	949.3	2.4870	.001 159 0	918.3	953.1	2.4711	.001 140 8	904.7	961.7	2.4419
240	.001 204 6	1016.0	1040.0	2.6674	.001 192 0	1006.9	1042.6	2.6490	.001 170 2	990.7	1049.2	2.6158
260	.001 246 2	1108.6	1133.5	2.8459	.001 230 3	1097.4	1134.3	2.8243	.001 203 4	1078.1	1138.2	2.7860
280	.001 296 5	1204.7	1230.6	3.0248	.001 275 5	1190.7	1229.0	2.9986	.001 241 5	1167.2	1229.3	2.9537
300	.001 359 6	1306.1	1333.3	3.2071	.001 330 4	1287.9	1327.8	3.1741	.001 286 0	1258.7	1323.0	3.1200
320	.001 443 7	1415.7	1444.6	3.3979	.001 399 7	1390.7	1432.7	3.3539	.001 338 8	1353.3	1420.2	3.2868
340	.001 568 4	1539.7	1571.0	3.6075	.001 492 0	1501.7	1546.5	3.5426	.001 403 2	1452.0	1522.1	3.4557
360	.001 822 6	1702.8	1739.3	3.8772	.001 626 5	1626.6	1675.4	3.7494	.001 483 8	1556.0	1630.2	3.6291
380					.001 869 1	1781.4	1837.5	4.0012	.001 588 4	1667.2	1746.6	3.8101