

**NATIONAL EXAMINATIONS**

**DECEMBER 2017**

**16-MEC-B3 ENERGY CONVERSION AND POWER GENERATION**

**Three hours duration**

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**Notes to Candidates**

1. This is a **Closed Book** examination.
2. Examination paper consists of two Sections. **Section A is Calculative** with five (5) questions and **Section B is Descriptive** with three (3) questions.
3. **Do four (4) questions (including all parts of each question) from Section A (Calculative) and two (2) questions from Section B (Descriptive).**
4. **Six questions constitute a complete paper.** (Total 60 marks).
5. **All questions are of equal value.** (Each 10 marks).
6. 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.
7. 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.
8. **Read the entire question before commencing the calculations** and take note of any hints or recommendations given. Note that **Question 4 and Question 5** are each on **two pages**.
9. Candidates may use one of the approved **Casio** or **Sharp** calculators.
10. **Reference data** for particular questions are given on pages 10 to 13. **All pages used are to be returned with the answer booklet showing where data has been obtained.**
11. **Reference formulae and constants** are given on pages 14 to 17.
12. **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 GAS TURBINE**

An aircraft gas turbine engine of the turbojet type has the following technical and operating data when stationary on the ground:

Air flow	G	=	70 kg/s
Fuel flow	f	=	1 kg/s
Pressure ratio	r	=	16
Compressor efficiency	$\eta_c$	=	0.80
Turbine efficiency	$\eta_t$	=	0.85
Nozzle efficiency	$\eta_n$	=	0.95
Fuel calorific value	CV	=	40 000 kJ/kg

- (a) Sketch a T-s diagram of the system and identify by number all points to be calculated. (1)
- (b) Calculate the temperatures and pressures at the five key points (actual conditions) in the engine and nozzle assuming that the ambient air temperature and pressure are 27°C and 100 kPa respectively. Assume an air standard cycle, that is,  $k = 1.4$  and  $R = 0.287 \text{ kJ/kg}^\circ\text{C}$ . (9)

Note that all the turbine work is used to drive the compressor and that the remaining energy in the turbine exhaust gases is used to accelerate the exhaust gas to a high velocity in the nozzle. The nozzle exhausts at 100 kPa.

[ 10 marks ]

**QUESTION 2 STEAM TURBINE**

Refer to the Examination Paper Attachments Page 10 **Mollier Chart**.

Steam is supplied to a steam turbine at 16 MPa and 540°C. Since full power is not required, it is throttled to 8 MPa before entering the high pressure turbine. It then expands with frictional heating to 2 MPa. After this it is reheated to 500°C before entering the low pressure turbine. Here it expands to 0.004 MPa. The internal efficiency of the high pressure turbine is 90% and that of the low pressure turbine is 80%.

- (a) Plot the process on the attached Mollier Chart (h-s diagram) and read all necessary values from the chart. (4)
- (b) Determine the outlet conditions of the high pressure turbine (pressure and temperature). (2)
- (c) Determine the outlet conditions of the low pressure turbine (moisture and temperature). (2)
- (d) If, at this load, the steam flow rate is 75 kg/s, determine the power output assuming no extraction steam for feedwater heating. (2)

[ 10 marks ]

**QUESTION 3 STEAM CYCLE**

Refer to the Examination Paper Attachments Page 11 **Heat Balance Diagram**.

Using the data given in the Heat Balance Diagram, calculate the following:

- (a) Overall steam cycle efficiency based on heat input and electrical output. (3)
- (b) Power output of the high pressure (HP) turbine. (3)
- (c) Power output of the intermediate pressure (IP) turbine. (4)

*Note that all parameters have been converted to SI units and temperatures and pressures in particular have been rounded to reduce the number of significant figures. Enthalpies therefore will not agree exactly with those in steam tables should these be referred to.*

[ 10 marks ]

## QUESTION 4 WIND AND WATER POWER

### PART I WIND TURBINE

Refer to the Examination Paper Attachments Page 12 **Vestas Wind Turbine** and Page 13 **Wind Power Efficiencies**.

The tables and graphs give information for the Vestas V80 1.8 MW Wind Turbine, as well as efficiencies, for ideal and actual wind turbines. Determine the following for a wind speed of 10 m/s and compare with the specified output.

- (a) Maximum theoretical power and efficiency that can be obtained based on energy and momentum theoretical equations for any wind speed. (1)
- (b) Ideal efficiency and power based on ratio of blade tip speed to wind speed as given (from graph of efficiency on page 13). (2)
- (c) Actual efficiency and power based on ratio of blade tip speed to wind speed as given (from graph of efficiency on Page 13). (1)
- (d) Actual power output at the given wind speed as specified by the manufacturer (from graph on page 12). (1)

( 5 marks )

*This question is continued on the next page .....*

**Question 4 Continued**

## PART II MACTAQUAC EFFICIENCY

Hydro turbines of the Kaplan type are installed at Mactaquac on the Saint John River in New Brunswick. In order to determine the efficiency of the Mactaquac turbines the following hypothetical measurements are considered:

Turbine-Generator speed	112.5 rev/min
Generator electrical output	110 MW
Water flow rate	354 m <sup>3</sup> /s
Inlet pipe diameter	6.4 m
Outlet pipe diameter	7.0 m
Inlet water pressure	226 kPa gauge
Outlet water pressure	-4.5 m H <sub>2</sub> O

The elevation of the outlet pressure measuring point is 5.0 m below that of the inlet pressure measuring point.

Determine the efficiency of the turbine.

( 5 marks )

[ 10 marks ]

**QUESTION 5 POWER PLANT EFFLUENTS****PART I CARBON DIOXIDE EMISSIONS**

In the context of reducing carbon dioxide emissions, consider the replacement of a coal fired power plant by a natural gas fired combined cycle (gas-steam) power plant. Assume that coal is primarily pure carbon and that natural gas is primarily methane.

- (a) Determine the amount of carbon dioxide produced (as a percentage of that produced when burning coal) when burning natural gas instead of coal to produce the same amount of electricity. (5)

For consistency assume that the electrical output of each system is 100 MW. Use the following data:

Fuel	Formula	Higher Heating Value (kJ/kg)	Lower Heating Value (kJ/kg)
Carbon	C	32 800	32 800
Methane	CH <sub>4</sub>	55 530	50 050

Coal fired plant overall thermal efficiency = 40%

Combined cycle plant overall thermal efficiency = 50%

- (b) Comment on the validity of the assumption that coal is primarily carbon and that natural gas is primarily methane. If this assumption is not valid, indicate how the answer would be affected. (1)

( 6 marks )

*This question is continued on the next page .....*

**Question 5 Continued**

## PART II COAL FIRED PLANT

A coal fired power plant with an electrical output of 600 MW has the following operating parameters:

Steam cycle efficiency	41%
Boiler thermal efficiency	94%
Electrical generation efficiency	96%
Coal calorific value (as received)	35 000 kJ/kg
Coal ash content	6%
Cooling water inlet temperature	13°C
Cooling water temperature rise	11°C (maximum)
Cooling water specific heat	4.19 kJ/kg°C
Cooling water density	1025 kg/m <sup>3</sup>

Under full load conditions determine the following:

- (a) Required mass flow rate and volume flow rate of cooling water so as not to exceed the maximum permitted cooling water temperature rise.  
(2)
- (b) Required mass flow rate of coal per second and amount of ash produced per day.  
(2)

( 4 marks )

[ 10 marks ]

## SECTION B DESCRIPTIVE QUESTIONS

*Descriptive questions 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 6 SOLAR ENERGY

(a) Describe the configuration and operation of either (ONE only) of the following types of solar-thermal electrical generating systems.

- Central-receiver system with heliostats
- Distributed system with trough concentrators

Clarify in a sketch how the heat from the sun is concentrated and transferred to the working fluid. Show also, in a flow diagram of the system, where heat is received and rejected and where power is produced. Give an indication of the overall efficiency of the whole system when receiving optimal solar radiation.

(5)

(b) Describe the configuration of a typical photovoltaic electrical generating system and explain the basic principles of energy conversion in solar cells. Clarify how sufficiently high voltages and power for grid system requirements can be obtained from such small cells. Give an indication of the overall efficiency of the whole system when receiving optimal solar radiation.

(5)

[ 10 marks ]



### QUESTION 7 FUEL CHARACTERISTICS

(a) State what is meant by heating value and clarify the difference between higher heating value (HHV or HCV) and lower heating value (LHV or LCV) of a fossil fuel. State which one is commonly used and why it is used.

(3)

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

(3)

(b) Explain the transformation of coal from vegetal matter (such as peat) to a high grade coal (such as anthracite). Clarify what constituents change during this transformation and how these affect the characteristics and type of the coal.

(4)

[ 10 marks ]

### QUESTION 8 ENVIRONMENTAL PROTECTION

Exhaust gases from fossil fuel fired power plants (especially coal fired plants) emit particulates and gases that are detrimental to the environment. These can be reduced substantially by various devices and methods.

Explain in detail how TWO of the following methods work giving appropriate theory (physical or chemical) and describe the configuration of the equipment and how it operates. Use sketches where appropriate.

- Collection and handling of fly ash in exhaust gas.
- Capture and extraction of sulphur dioxide from exhaust gas.
- Reduction of nitrogen oxide in fuel burners and exhaust gas.
- Capture and disposal of carbon dioxide in exhaust gas.

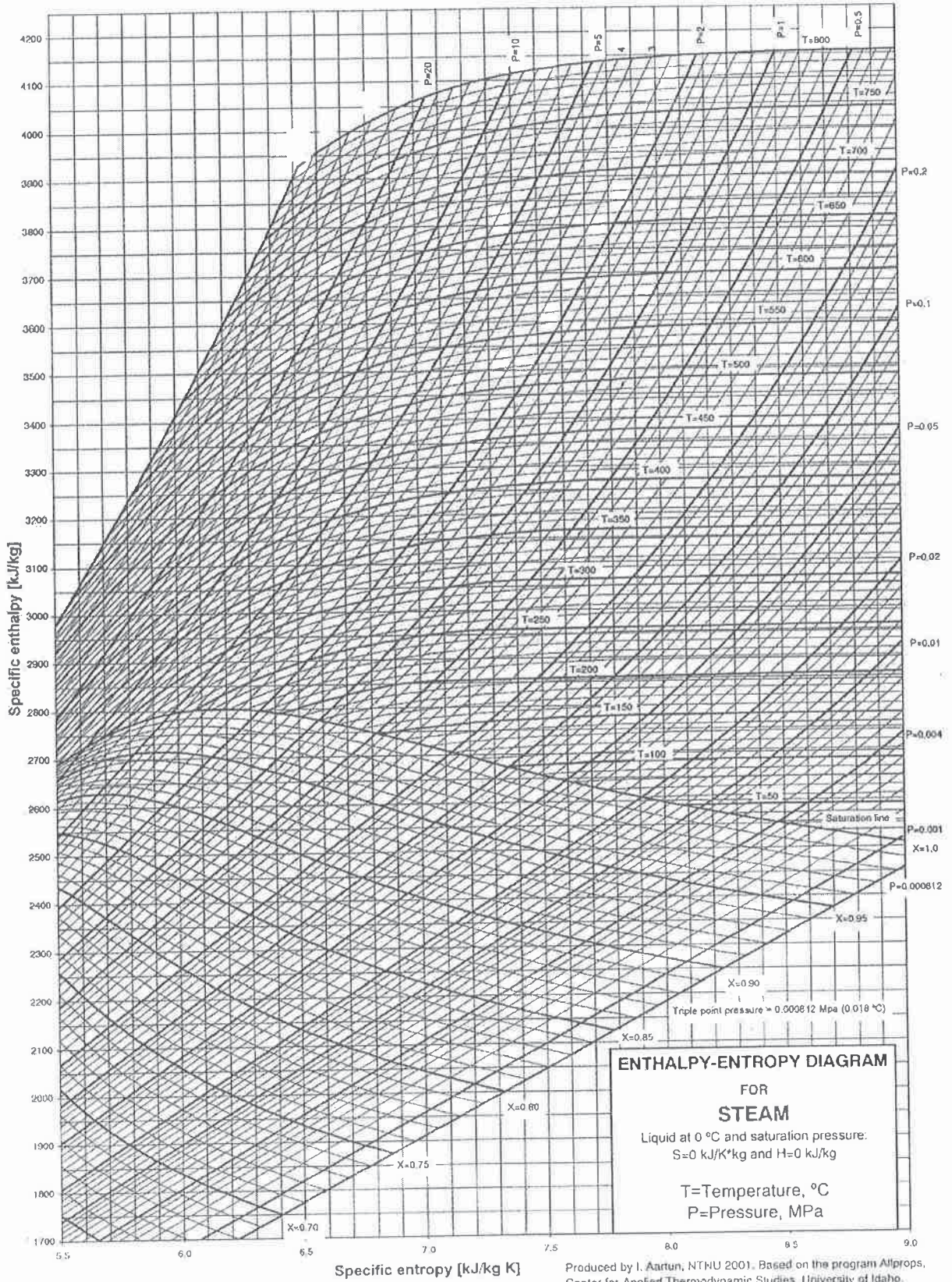
Descriptions of only TWO are required. Each will be worth 5 marks.

(2 x 5 marks)

[ 10 marks ]

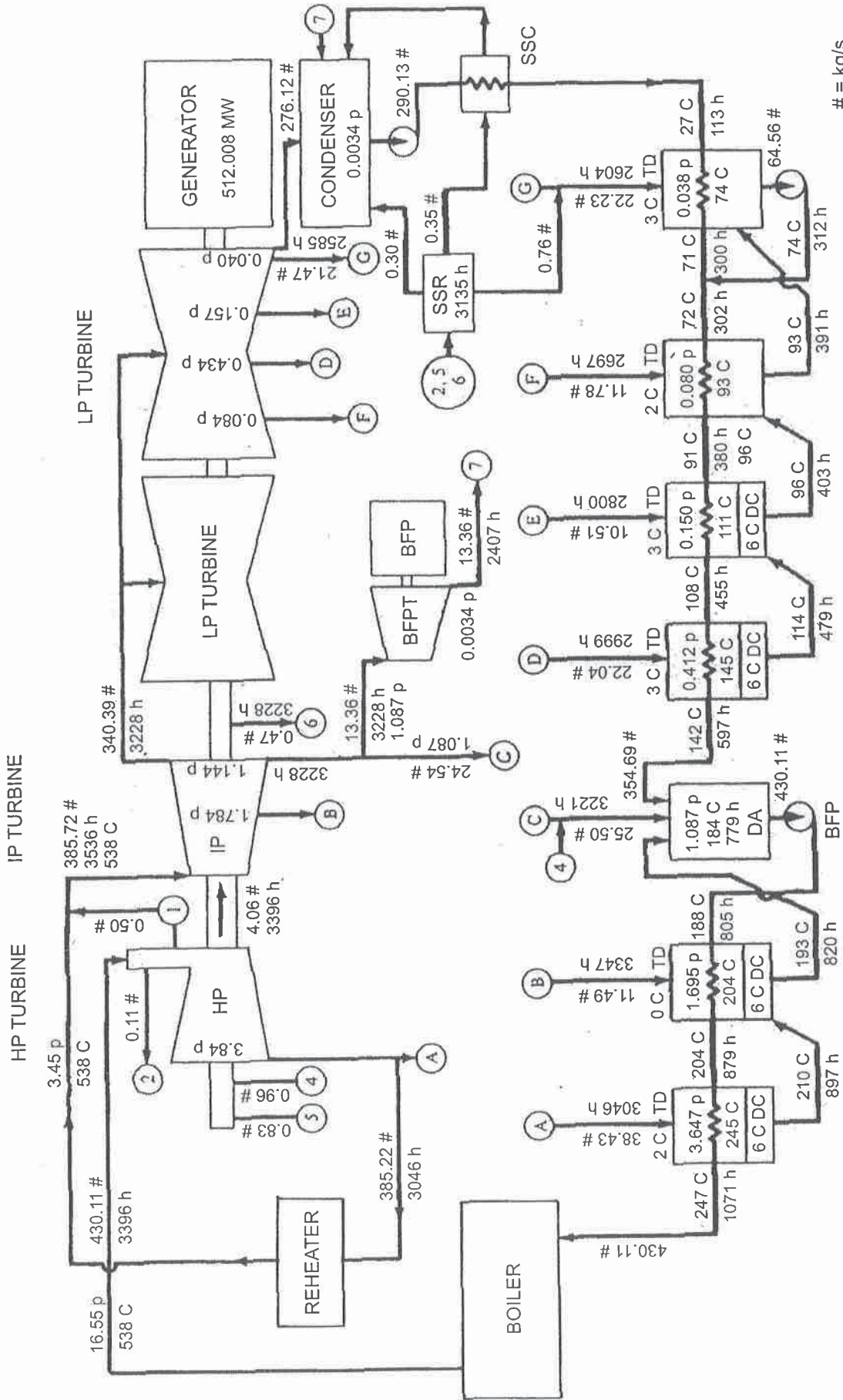
QUESTION 2 MOLLIER CHART

NAME .....





QUESTION 3 HEAT BALANCE DIAGRAM (512 MW REHEAT STEAM POWER PLANT)



# = kg/s  
 h = kJ/kg  
 p = Mpa  
 C = °C

# = kg/s  
 h = kJ/kg  
 p = Mpa  
 C = °C

HP FEEDWATER HEATERS  
 BFP = BOILER FEED PUMP  
 BFPPT = BOILER FEED PUMP TURBINE  
 DA = DEAERATOR  
 DC = DRAIN COOLER  
 LP FEEDWATER HEATERS  
 SSR = SEALING STEAM REGULATOR  
 SSC = SEALING STEAM CONDENSER

QUESTION 4 PART I VESTAS WIND TURBINE



# V80 – 1.8 MW

Pitch regulated wind turbine with OptiSlip® and OptiTip®

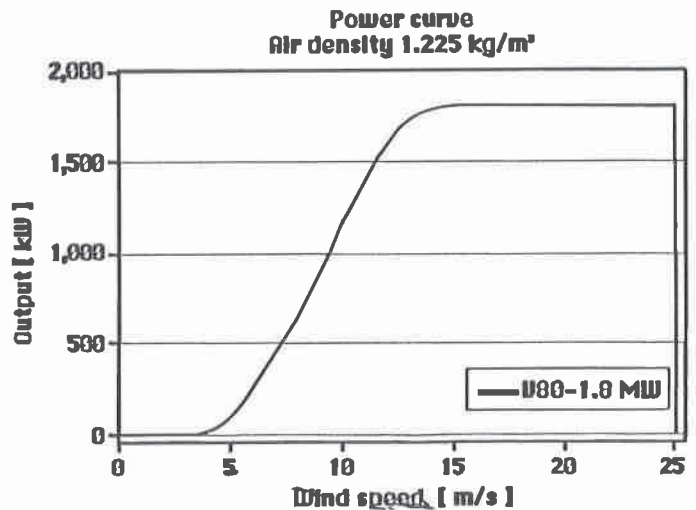
ROTOR			
Diameter:	80 m		
Swept area:	5,027 m <sup>2</sup>		
Speed of revolution:	15.7 RPM		
Number of blades:	3		
Power regulation:	Pitch + OptiSlip®		
Air brake:	3 separate pitch settings		
TOWER:			
Hub height (approx.):	60 - 67 - 70 m		
OPERATIONAL DATA:			
Cut-in wind speed:	4 m/s		
Nominal wind speed:	16 m/s		
Stop wind speed:	25 m/s		
GENERATOR:			
Type:	Asynchronous with OptiSlip®		
Nominal output:	1.8 MW		
Operational data:	60 Hz 690V 1,000 - 1,900 RPM		
GEARBOX:			
Type:	Planet/parallel gear		
CONTROL:			
Type:	Microprocessor-based control of all turbine functions with the option of remote monitoring. OptiSlip® output regulation and OptiTip® pitch regulation of the blades.		
WEIGHT: (APPROX.)			
	(60 m)	(67 m)	(70 m)
Nacelle:	63 t	63 t	63 t
Rotor:	30 t	30 t	30 t

## Ideal for moderate wind conditions

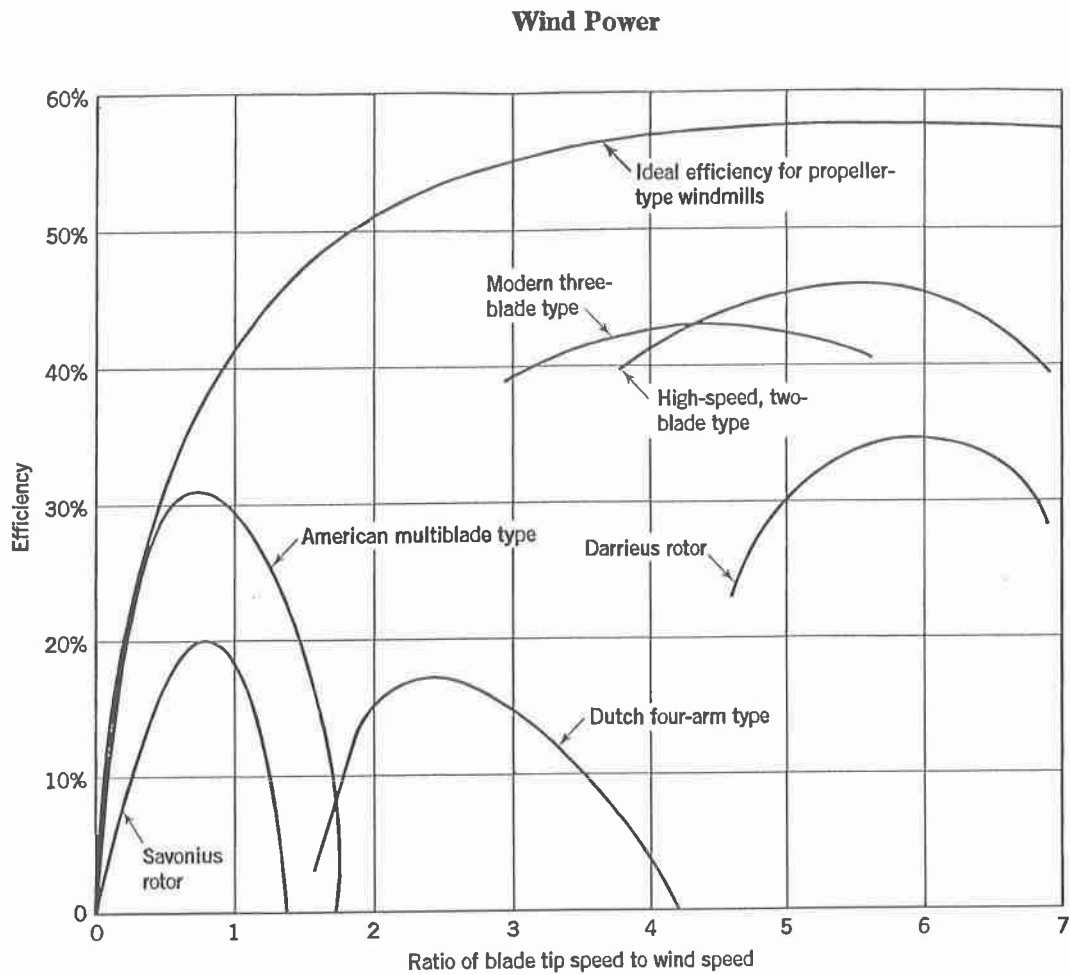
The V80-1.8 MW is particularly well suited for installation in areas with moderate to high wind conditions, and thanks to OptiSlip®, the turbine can adapt to wind conditions in almost any location. In this way, Vestas continues to strive for excellence by taking firm steps towards the full exploitation of wind energy.

## Advanced Vestas technology

The Vestas V80-1.8 MW is based on the well-known technology from the V66-1.65 MW turbine. The turbine is a three blade 60 Hz pitch-regulated wind turbine with OptiSlip® and OptiTip®. The turbine's rotor diameter is 80 meters – and the turbine can be delivered with tower heights of up to 70 meters.



**QUESTION 4 PART I WIND POWER EFFICIENCIES**



Typical efficiencies of several types of windmills plotted against their tip-speed ratio. The maximum efficiencies are seen to vary from about 16 to 46%. The ideal efficiency shown is a mathematical ideal, never to be achieved in practice. (Source: Basic data from R. Wilson and P. Lissaman, *Applied Aerodynamics of Wind Power Machines*, Oregon State University.)

## 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	$J/kg^\circ C$
$c_v$	Specific heat at constant volume	$J/kg^\circ C$
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
$\dot{m}$	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 <sup>3</sup>
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	$J/kgEK$
$R_0$	Universal gas constant	$J/kg-moleEK$
s	Specific entropy	$J/kgEK$
S	Entropy	$J/EK$
t	Time	s
t	Temperature	EC
T	Absolute temperature	$^\circ K$
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
$\gamma$	Fuel enrichment	
$\eta$	Efficiency	
$\phi$	Neutron flux	neutrons/cm <sup>2</sup> s
$\sigma_f$	Cross section	barn
$\mu$	Dynamic viscosity	Ns/m <sup>2</sup>
$\nu$	Kinematic viscosity	m <sup>2</sup> /s
$\rho$	Density	kg/m <sup>3</sup>
$\tau$	Thrust	N
$\tau$	Torque	Nm
$\Omega$	Heat transfer rate	J/s

## CONSTANTS

For consistency in calculations the following constants should be used:

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

## 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:	$w = p_1v_1 \ln(v_2/v_1)$
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:	$z_1g + V_1^2/2 + u_1 + p_1v_1 + w_{in} + q_{in}$
	$= z_2g + V_2^2/2 + u_2 + p_2v_2 + w_{out} + q_{out}$
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	$MEP = \text{Work} / (V_1 - V_2)$



**Steam Turbines**

Nozzle Equation:  $h_1 - h_2 = (V_2^2 - V_1^2) / 2$   
 Work:  $W = [(V_1^2_{\text{absolute}} - V_2^2_{\text{absolute}}) + (V_2^2_{\text{relative}} - V_1^2_{\text{relative}})] / 2$

**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:  $T = M(V_{\text{jet}} - V_{\text{aircraft}})$   
 Thrust Power:  $T V_{\text{aircraft}} = M(V_{\text{jet}} - V_{\text{aircraft}}) V_{\text{aircraft}}$   
 Jet Power:  $P = M(V_{\text{jet}}^2 - V_{\text{aircraft}}^2) / 2$   
 Propulsion Efficiency:  $\eta_p = 2V_{\text{aircraft}} / (V_{\text{jet}} + V_{\text{aircraft}})$

**Wind Turbines**

Maximum Ideal Power:  $P_{\text{max}} = 8 \rho A V_1^3 / 27$

**Nuclear Energy**

Number of nuclei per gram of material:  $N = N_A / M$   
 Number of fissile nuclei per cm<sup>3</sup> 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**

$\eta_{\text{cycle}} = W_{\text{out}} / q_{\text{in}} = W_{\text{out}} / Q_{\text{in}} = P_{\text{out}} / \Omega_{\text{in}}$   
 $\eta_{\text{Carnot}} = (T_{\text{hot}} - T_{\text{cold}}) / T_{\text{hot}}$   
 $\eta_{\text{Rankine}} = (\Delta h_{\text{turbine}} - \Delta h_{\text{pump}}) / \Delta h_{\text{boiler}}$   
 $\eta_{\text{Brayton}} = (\Delta T_{\text{turbine}} - \Delta T_{\text{Compressor}}) / \Delta T_{\text{combustion}}$

**Component Efficiencies**

$\eta_{\text{boiler}} = \Omega_{\text{out}} / \Omega_{\text{in}}$   
 $\eta_{\text{boiler}} = (\Omega_{\text{in}} / \Omega_{\text{lost}}) / \Omega_{\text{in}}$   
 $\eta_{\text{turbine}} = \Delta h_{\text{actual}} / \Delta h_{\text{isentropic}}$   
 $\eta_{\text{nozzle}} = \Delta h_{\text{actual}} / \Delta h_{\text{isentropic}}$   
 $\eta_{\text{gas turbine}} = \Delta T_{\text{actual}} / \Delta T_{\text{isentropic}}$   
 $\eta_{\text{pump}} = \Delta h_{\text{isentropic}} / \Delta h_{\text{actual}}$   
 $\eta_{\text{compressor}} = \Delta T_{\text{isentropic}} / \Delta T_{\text{actual}}$

# Thermodynamics and Heat Power

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SIXTH EDITION

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PRENTICE HALL

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

Temp. °C <i>T</i>	Press. kPa <i>P</i>	Specific Volume (m <sup>3</sup> /kg)						Internal Energy (kJ/kg)						Enthalpy (kJ/kg)						Entropy (kJ/kg · °K)					
		Sat. Liquid		Sat. Vapor		Sat. Liquid		Sat. Vapor		Sat. Liquid		Sat. Vapor		Sat. Liquid		Sat. Vapor		Sat. Liquid		Sat. Vapor					
		<i>v<sub>f</sub></i>	<i>v<sub>g</sub></i>	<i>u<sub>f</sub></i>	<i>u<sub>g</sub></i>	<i>u<sub>fg</sub></i>	<i>u<sub>g</sub></i>	<i>h<sub>f</sub></i>	<i>h<sub>g</sub></i>	<i>h<sub>fg</sub></i>	<i>h<sub>g</sub></i>	<i>s<sub>f</sub></i>	<i>s<sub>g</sub></i>	<i>s<sub>fg</sub></i>	<i>s<sub>g</sub></i>										
0.01	0.6113	0.001 000	206.14	.00	2375.3	2375.3	2375.3	.01	2501.3	2501.3	.0000	9.1562	9.1562	0.0000	9.1562	9.1562									
5	0.8721	0.001 000	147.12	20.97	2361.3	2382.3	2382.3	20.98	2489.6	2489.6	.0761	8.9496	8.9496	.0761	8.9496	9.0257									
10	1.2276	0.001 000	106.38	42.00	2347.2	2389.2	2389.2	42.01	2477.7	2477.7	.1510	8.7498	8.7498	.1510	8.7498	8.9008									
15	1.7051	0.001 001	77.93	62.99	2333.1	2396.1	2396.1	62.99	2465.9	2465.9	.2245	8.5569	8.5569	.2245	8.5569	8.7814									
20	2.339	0.001 002	57.79	83.95	2319.0	2402.9	2402.9	83.96	2454.1	2454.1	.2966	8.3706	8.3706	.2966	8.3706	8.6672									
25	3.169	0.001 003	43.36	104.88	2304.9	2409.8	2409.8	104.89	2442.3	2442.3	.3674	8.1905	8.1905	.3674	8.1905	8.5580									
30	4.246	0.001 004	32.89	125.78	2290.8	2416.6	2416.6	125.79	2430.5	2430.5	.4369	8.0164	8.0164	.4369	8.0164	8.4533									
35	5.628	0.001 006	25.22	146.67	2276.7	2423.4	2423.4	146.68	2418.6	2418.6	.5053	7.8478	7.8478	.5053	7.8478	8.3531									
40	7.384	0.001 008	19.52	167.56	2262.6	2430.1	2430.1	167.57	2406.7	2406.7	.5725	7.6845	7.6845	.5725	7.6845	8.2570									
45	9.593	0.001 010	15.26	188.44	2248.4	2436.8	2436.8	188.45	2394.8	2394.8	.6387	7.5261	7.5261	.6387	7.5261	8.1648									
50	12.349	0.001 012	12.03	209.32	2234.2	2443.5	2443.5	209.33	2382.7	2382.7	.7038	7.3725	7.3725	.7038	7.3725	8.0763									
55	15.758	0.001 015	9.568	230.21	2219.9	2450.1	2450.1	230.23	2370.7	2370.7	.7679	7.2234	7.2234	.7679	7.2234	7.9913									
60	19.940	0.001 017	7.671	251.11	2205.5	2456.6	2456.6	251.13	2358.5	2358.5	.8312	7.0784	7.0784	.8312	7.0784	7.9096									
65	25.03	0.001 020	6.197	272.02	2191.1	2463.1	2463.1	272.06	2346.2	2346.2	.8935	6.9375	6.9375	.8935	6.9375	7.8310									
70	31.19	0.001 023	5.042	292.95	2176.6	2469.6	2469.6	292.98	2333.8	2333.8	.9549	6.8004	6.8004	.9549	6.8004	7.7553									
75	38.58	0.001 026	4.131	313.90	2162.0	2475.9	2475.9	313.93	2321.4	2321.4	1.0155	6.6669	6.6669	1.0155	6.6669	7.6824									
80	47.39	0.001 029	3.407	334.86	2147.4	2482.2	2482.2	334.91	2308.8	2308.8	1.0753	6.5369	6.5369	1.0753	6.5369	7.6122									
85	57.83	0.001 033	2.828	355.84	2132.6	2488.4	2488.4	355.90	2296.0	2296.0	1.1343	6.4102	6.4102	1.1343	6.4102	7.5445									
90	70.14	0.001 036	2.361	376.85	2117.7	2494.5	2494.5	376.92	2283.2	2283.2	1.1925	6.2866	6.2866	1.1925	6.2866	7.4791									
95	84.55	0.001 040	1.982	397.88	2102.7	2500.6	2500.6	397.96	2270.2	2270.2	1.2500	6.1659	6.1659	1.2500	6.1659	7.4159									

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

Temp. °C <i>T</i>	Press. kPa <i>P</i>	Specific Volume (m <sup>3</sup> /kg)		Internal Energy (kJ/kg)			Enthalpy (kJ/kg)			Entropy (kJ/kg·°K)		
		Sat. Liquid <i>v<sub>f</sub></i>	Sat. Vapor <i>v<sub>g</sub></i>	Sat. Liquid <i>u<sub>f</sub></i>	Evap. <i>u<sub>fg</sub></i>	Sat. Vapor <i>u<sub>g</sub></i>	Sat. Liquid <i>h<sub>f</sub></i>	Evap. <i>h<sub>fg</sub></i>	Sat. Vapor <i>h<sub>g</sub></i>	Sat. Liquid <i>s<sub>f</sub></i>	Evap. <i>s<sub>fg</sub></i>	Sat. Vapor <i>s<sub>g</sub></i>
		MPa										
100	0.10135	0.001044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3549
105	0.12082	0.001048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2958
110	0.14327	0.001052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2387
115	0.16906	0.001056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1833
120	0.19853	0.001060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1296
125	0.2321	0.001065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0775
130	0.2701	0.001070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0269
135	0.3130	0.001075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9777
140	0.3613	0.001080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9299
145	0.4154	0.001085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8833
150	0.4758	0.001091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8379
155	0.5431	0.001096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.7935
160	0.6178	0.001102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.7502
165	0.7005	0.001108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.7078
170	0.7917	0.001114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.6663
175	0.8920	0.001121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.6256
180	1.0021	0.001127	0.19405	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.5857
185	1.1227	0.001134	0.17409	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.5465
190	1.2544	0.001141	0.15654	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.5079
195	1.3978	0.001149	0.14105	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.4698
200	1.5538	0.001157	0.12736	850.65	1744.7	2595.3	852.45	1940.7	2793.2	2.3309	4.1014	6.4323
205	1.7230	0.001164	0.11521	873.04	1724.5	2597.5	875.04	1921.0	2796.0	2.3780	4.0172	6.3952
210	1.9062	0.001173	0.10441	895.53	1703.9	2599.5	897.76	1900.7	2798.5	2.4248	3.9337	6.3585
215	2.104	0.001181	0.09479	918.14	1682.9	2601.1	920.62	1879.9	2800.5	2.4714	3.8507	6.3221
220	2.318	0.001190	0.08619	940.87	1661.5	2602.4	943.62	1858.5	2802.1	2.5178	3.7683	6.2861
225	2.548	0.001199	0.07849	963.73	1639.6	2603.3	966.78	1836.5	2803.3	2.5639	3.6863	6.2503
230	2.795	0.001209	0.07158	986.74	1617.2	2603.9	990.12	1813.8	2804.0	2.6099	3.6047	6.2146
235	3.060	0.001219	0.06537	1009.89	1594.2	2604.1	1013.62	1790.5	2804.2	2.6558	3.5233	6.1791
240	3.344	0.001229	0.05976	1033.21	1570.8	2604.0	1037.32	1766.5	2803.8	2.7015	3.4422	6.1437
245	3.648	0.001240	0.05471	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 <i>T</i>	Press. MPa <i>P</i>	Specific Volume (m³/kg)						Internal Energy (kJ/kg)						Enthalpy (kJ/kg)						Entropy (kJ/kg · °K)					
		Sat. Liquid		Sat. Vapor		Sat. Liquid		Sat. Vapor		Sat. Liquid		Sat. Vapor		Sat. Liquid		Sat. Vapor		Sat. Liquid		Sat. Vapor					
		<i>v<sub>f</sub></i>	<i>v<sub>g</sub></i>	<i>u<sub>f</sub></i>	<i>u<sub>g</sub></i>	<i>h<sub>f</sub></i>	<i>h<sub>g</sub></i>	<i>u<sub>f</sub></i>	<i>u<sub>g</sub></i>	<i>h<sub>f</sub></i>	<i>h<sub>g</sub></i>	<i>s<sub>f</sub></i>	<i>s<sub>g</sub></i>	<i>h<sub>f</sub></i>	<i>h<sub>g</sub></i>	<i>s<sub>f</sub></i>	<i>s<sub>g</sub></i>	<i>h<sub>f</sub></i>	<i>h<sub>g</sub></i>	<i>s<sub>f</sub></i>	<i>s<sub>g</sub></i>				
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 <i>P</i>	Temp. °C <i>T</i>	Specific Volume (m <sup>3</sup> /kg)			Internal Energy (kJ/kg)			Enthalpy (kJ/kg)			Entropy (kJ/kg · °K)		
		Sat. Liquid <i>v<sub>f</sub></i>	Sat. Vapor <i>v<sub>g</sub></i>	Sat. Liquid <i>u<sub>f</sub></i>	Sat. Liquid <i>u<sub>f</sub></i>	Evap. <i>u<sub>fg</sub></i>	Sat. Vapor <i>u<sub>g</sub></i>	Sat. Liquid <i>h<sub>f</sub></i>	Evap. <i>h<sub>fg</sub></i>	Sat. Vapor <i>h<sub>g</sub></i>	Sat. Liquid <i>s<sub>f</sub></i>	Evap. <i>s<sub>fg</sub></i>	Sat. Vapor <i>s<sub>g</sub></i>
0.6113	0.01	0.001 000	206.14	.00	2375.3	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878

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

Press. MPa <i>P</i>	Temp. °C <i>T</i>	Specific Volume		Internal Energy			Enthalpy			Entropy		
		Sat. Liquid <i>v<sub>f</sub></i>	Sat. Vapor <i>v<sub>g</sub></i>	Sat. Liquid <i>u<sub>f</sub></i>	Evap. <i>u<sub>fg</sub></i>	Sat. Vapor <i>u<sub>g</sub></i>	Sat. Liquid <i>h<sub>f</sub></i>	Evap. <i>h<sub>fg</sub></i>	Sat. Vapor <i>h<sub>g</sub></i>	Sat. Liquid <i>s<sub>f</sub></i>	Evap. <i>s<sub>fg</sub></i>	Sat. Vapor <i>s<sub>g</sub></i>
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	0.1944	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	0.1775	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	0.1633	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	0.1512	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	0.1408	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 <i>P</i>	Temp. °C <i>T</i>	Specific Volume (m <sup>3</sup> /kg)				Internal Energy (kJ/kg)				Enthalpy (kJ/kg)				Entropy (kJ/kg · °K)			
		Sat. Liquid <i>v<sub>f</sub></i>	Sat. Vapor <i>v<sub>g</sub></i>	Sat. Liquid <i>u<sub>f</sub></i>	Sat. Vapor <i>u<sub>g</sub></i>	Sat. Vapor <i>u<sub>g</sub></i>	Evap. <i>u<sub>fg</sub></i>	Sat. Liquid <i>h<sub>f</sub></i>	Sat. Vapor <i>h<sub>g</sub></i>	Evap. <i>h<sub>fg</sub></i>	Sat. Vapor <i>h<sub>g</sub></i>	Sat. Liquid <i>s<sub>f</sub></i>	Sat. Vapor <i>s<sub>g</sub></i>	Evap. <i>s<sub>fg</sub></i>	Sat. Vapor <i>s<sub>g</sub></i>		
1.50	198.32	0.001 154	0.131 77	843.16	1751.3	2594.5	844.89	2792.2	1947.3	2.3150	4.1298	6.4448					
1.75	205.76	0.001 166	0.113 49	876.46	1721.4	2597.8	878.50	2796.4	1917.9	2.3851	4.0044	6.3896					
2.00	212.42	0.001 177	0.099 63	906.44	1693.8	2600.3	908.79	2799.5	1890.7	2.4474	3.8935	6.3409					
2.25	218.45	0.001 187	0.088 75	933.83	1668.2	2602.0	936.49	2801.7	1865.2	2.5035	3.7937	6.2972					
2.5	223.99	0.001 197	0.079 98	959.11	1644.0	2603.1	962.11	2803.1	1841.0	2.5547	3.7028	6.2575					
3.0	233.90	0.001 217	0.066 68	1004.78	1599.3	2604.1	1008.42	2804.2	1795.7	2.6457	3.5412	6.1869					
3.5	242.60	0.001 235	0.057 07	1045.43	1558.3	2603.7	1049.75	2803.4	1753.7	2.7253	3.4000	6.1253					
4	250.40	0.001 252	0.049 78	1082.31	1520.0	2602.3	1087.31	2801.4	1714.1	2.7964	3.2737	6.0701					
5	263.99	0.001 286	0.039 44	1147.81	1449.3	2597.1	1154.23	2794.3	1640.1	2.9202	3.0532	5.9734					
6	275.64	0.001 319	0.032 44	1205.44	1384.3	2589.7	1213.35	2784.3	1571.0	3.0267	2.8625	5.8892					
7	285.88	0.001 351	0.027 37	1257.55	1323.0	2580.5	1267.00	2772.1	1505.1	3.1211	2.6922	5.8133					
8	295.06	0.001 384	0.023 52	1305.57	1264.2	2569.8	1316.64	2758.0	1441.3	3.2068	2.5364	5.7432					
9	303.40	0.001 418	0.020 48	1350.51	1207.3	2557.8	1363.26	2742.1	1378.9	3.2858	2.3915	5.6772					
10	311.06	0.001 452	0.018 026	1393.04	1151.4	2544.4	1407.56	2724.7	1317.1	3.3596	2.2544	5.6141					
11	318.15	0.001 489	0.015 987	1433.7	1096.0	2529.8	1450.1	2705.6	1255.5	3.4295	2.1233	5.5527					
12	324.75	0.001 527	0.014 263	1473.0	1040.7	2513.7	1491.3	2684.9	1193.6	3.4962	1.9962	5.4924					
13	330.93	0.001 567	0.012 780	1511.1	985.0	2496.1	1531.5	2662.2	1130.7	3.5606	1.8718	5.4323					
14	336.75	0.001 611	0.011 485	1548.6	928.2	2476.8	1571.1	2637.6	1066.5	3.6232	1.7485	5.3717					
15	342.24	0.001 658	0.010 337	1585.6	869.8	2455.5	1610.5	2610.5	1000.0	3.6848	1.6249	5.3098					
16	347.44	0.001 711	0.009 306	1622.7	809.0	2431.7	1650.1	2580.6	930.6	3.7461	1.4994	5.2455					
17	352.37	0.001 770	0.008 364	1660.2	744.8	2405.0	1690.3	2547.2	856.9	3.8079	1.3698	5.1777					
18	357.06	0.001 840	0.007 489	1698.9	675.4	2374.3	1732.0	2509.1	777.1	3.8715	1.2329	5.1044					
19	361.54	0.001 924	0.006 657	1739.9	598.1	2338.1	1776.5	2464.5	688.0	3.9388	1.0839	5.0228					
20	365.81	0.002 036	0.005 834	1785.6	507.5	2293.0	1826.3	2409.7	583.4	4.0139	.9130	4.9269					
21	369.89	0.002 207	0.004 952	1842.1	388.5	2230.6	1888.4	2334.6	446.2	4.1075	.6938	4.8013					
22	373.80	0.002 742	0.003 568	1961.9	125.2	2087.1	2022.2	2165.6	143.4	4.3110	.2216	4.5327					
22.09	374.14	0.003 155	0.003 155	2029.6	0	2029.6	2099.3	2099.3	0	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	s	v	u	h	s	s	v	u	h	s	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	3.418	2511.6	2682.5	7.6947	1.6958	2506.7	2676.2	7.3614							
100	17.196	2515.5	2687.5	8.4479	3.889	2585.6	2780.1	7.9401	1.9364	2582.8	2776.4	7.6134							
150	19.512	2587.9	2783.0	8.6882	4.356	2659.9	2877.7	8.1580	2.172	2658.1	2875.3	7.8343							
200	21.825	2661.3	2879.5	8.9038	4.820	2735.0	2976.0	8.3556	2.406	2733.7	2974.3	8.0333							
250	24.136	2736.0	2977.3	9.1002	5.284	2811.3	3075.5	8.5373	2.639	2810.4	3074.3	8.2158							
300	26.445	2812.1	3076.5	9.2813	6.209	2968.5	3278.9	8.8642	3.103	2967.9	3278.2	8.5435							
400	31.063	2968.9	3279.6	9.6077	7.134	3132.0	3488.7	9.1546	3.565	3131.6	3488.1	8.8342							
500	35.679	3132.3	3489.1	9.8978	8.057	3302.2	3705.1	9.4178	4.028	3301.9	3704.7	9.0976							
600	40.295	3302.5	3705.4	10.1608	8.981	3479.4	3928.5	9.6599	4.490	3479.2	3928.2	9.3398							
700	44.911	3479.6	3928.7	10.4028	9.904	3663.6	4158.9	9.8852	4.952	3663.5	4158.6	9.5652							
800	49.526	3663.8	4159.0	10.6281	10.828	3854.9	4396.3	10.0967	5.414	3854.8	4396.1	9.7767							
900	54.141	3855.0	4396.4	10.8396	11.751	4052.9	4640.5	10.2964	5.875	4052.8	4640.3	9.9764							
1000	58.757	4053.0	4640.6	11.0393	12.674	4257.4	4891.1	10.4859	6.337	4257.3	4891.0	10.1659							
1100	63.372	4257.5	4891.2	11.2287	13.597	4467.8	5147.7	10.6662	6.799	4467.7	5147.6	10.3463							
1200	67.987	4467.9	5147.8	11.4091	14.521	4683.6	5409.6	10.8382	7.260	4683.5	5409.5	10.5183							
1300	72.602	4683.7	5409.7	11.5811															
					P = .20 MPa (120.23)					P = .30 MPa (133.55)					P = .40 MPa (143.63)				
					v	u	h	s	s	v	u	h	s	s	v	u	h	s	s
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	P = .20 MPa (120.23)					P = .30 MPa (133.55)					P = .40 MPa (143.63)				
	v	u	h	s	s	v	u	h	s	s	v	u	h	s	s
500	1.7814	3130.8	3487.1	8.5133	8.5133	1.1867	3130.0	3486.0	8.3251	8.3251	.8893	3129.2	3484.9	8.1913	8.1913
600	2.013	3301.4	3704.0	8.7770	8.7770	1.3414	3300.8	3703.2	8.5892	8.5892	1.0055	3300.2	3702.4	8.4558	8.4558
700	2.244	3478.8	3927.6	9.0194	9.0194	1.4957	3478.4	3927.1	8.8319	8.8319	1.1215	3477.9	3926.5	8.6987	8.6987
800	2.475	3663.1	4158.2	9.2449	9.2449	1.6499	3662.9	4157.8	9.0576	9.0576	1.2372	3662.4	4157.3	8.9244	8.9244
900	2.706	3854.5	4395.8	9.4566	9.4566	1.8041	3854.2	4395.4	9.2692	9.2692	1.3529	3853.9	4395.1	9.1362	9.1362
1000	2.937	4052.5	4640.0	9.6563	9.6563	1.9581	4052.3	4639.7	9.4690	9.4690	1.4685	4052.0	4639.4	9.3360	9.3360
1100	3.168	4257.0	4890.7	9.8458	9.8458	2.1121	4256.8	4890.4	9.6585	9.6585	1.5840	4256.5	4890.2	9.5256	9.5256
1200	3.399	4467.5	5147.3	10.0262	10.0262	2.2661	4467.2	5147.1	9.8389	9.8389	1.6996	4467.0	5146.8	9.7060	9.7060
1300	3.630	4683.2	5409.3	10.1982	10.1982	2.4201	4683.0	5409.0	10.0110	10.0110	1.8151	4682.8	5408.8	9.8780	9.8780
P = .50 MPa (151.86)															
Sat.	.3749	2561.2	2748.7	6.8213	6.8213	.3157	2567.4	2756.8	6.7600	6.7600	.2404	2576.8	2769.1	6.6628	6.6628
200	.4249	2642.9	2855.4	7.0592	7.0592	.3520	2638.9	2850.1	6.9665	6.9665	.2608	2630.6	2839.3	6.8158	6.8158
250	.4744	2723.5	2960.7	7.2709	7.2709	.3938	2720.9	2957.2	7.1816	7.1816	.2931	2715.5	2950.0	7.0384	7.0384
300	.5226	2802.9	3064.2	7.4599	7.4599	.4344	2801.0	3061.6	7.3724	7.3724	.3241	2797.2	3056.5	7.2328	7.2328
350	.5701	2882.6	3167.7	7.6329	7.6329	.4742	2881.2	3165.7	7.5464	7.5464	.3544	2878.2	3161.7	7.4089	7.4089
400	.6173	2963.2	3271.9	7.7938	7.7938	.5137	2962.1	3270.3	7.7079	7.7079	.3843	2959.7	3267.1	7.5716	7.5716
500	.7109	3128.4	3483.9	8.0873	8.0873	.5920	3127.6	3482.8	8.0021	8.0021	.4433	3126.0	3480.6	7.8673	7.8673
600	.8041	3299.6	3701.7	7.3522	7.3522	.6697	3299.1	3700.9	8.2674	8.2674	.5018	3297.9	3699.4	8.1333	8.1333
700	.8969	3477.5	3925.9	8.5952	8.5952	.7472	3477.0	3925.3	8.5107	8.5107	.5601	3476.2	3924.2	8.3770	8.3770
800	.9896	3662.1	4156.9	8.8211	8.8211	.8245	3661.8	4156.5	8.7367	8.7367	.6181	3661.1	4155.6	8.6033	8.6033
900	1.0822	3853.6	4394.7	9.0329	9.0329	.9017	3853.4	4394.4	8.9486	8.9486	.6761	3852.8	4393.7	8.8153	8.8153
1000	1.1747	4051.8	4639.1	9.2328	9.2328	.9788	4051.5	4638.8	9.1485	9.1485	.7340	4051.0	4638.2	9.0153	9.0153
1100	1.2672	4256.3	4889.9	9.4224	9.4224	1.0559	4256.1	4889.6	9.3381	9.3381	.7919	4255.6	4889.1	9.2050	9.2050
1200	1.3596	4466.8	5146.6	9.6029	9.6029	1.1330	4466.5	5146.3	9.5185	9.5185	.8497	4466.1	5145.9	9.3855	9.3855
1300	1.4521	4682.5	5408.6	9.7749	9.7749	1.2101	4682.3	5408.3	9.6906	9.6906	.9076	4681.8	5407.9	9.5575	9.5575
P = .80 MPa (170.43)															

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

T	P = 1.00 MPa (179.91)			P = 1.20 MPa (187.99)			P = 1.40 MPa (195.07)					
	v	u	h	s	v	u	h	s	v	u	h	s
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)												
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	7.9933	.2232	3470.9	3917.4	7.9487
P = 2.00 MPa (212.42)												

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

T	P = 1.60 MPa (201.41)					P = 1.80 MPa (207.15)					P = 2.00 MPa (212.42)				
	v	u	h	s	s	v	u	h	s	s	v	u	h	s	s
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 = 3.00 MPa (233.90)															
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		.070 58	2644.0	2855.8	6.2872		.058 72	2623.7	2829.2	6.1749	
250	.087 00	2662.6	2880.1	6.4085		.081 14	2750.1	2993.5	6.5390		.068 42	2738.0	2977.5	6.4461	
300	.098 90	2761.6	3008.8	6.6438		.090 53	2843.7	3115.3	6.7428		.076 78	2835.3	3104.0	6.6579	
350	.109 76	2851.9	3126.3	6.8403		.099 36	2932.8	3230.9	6.9212		.084 53	2926.4	3222.3	6.8405	
400	.120 10	2939.1	3239.3	7.0148		.107 87	3020.4	3344.0	7.0834		.091 96	3015.3	3337.2	7.0052	
450	.130 14	3025.5	3350.8	7.1746		.116 19	3108.0	3456.5	7.2338		.099 18	3103.0	3450.9	7.1572	
500	.139 98	3112.1	3462.1	7.3234		.132 43	3285.0	3682.3	7.5085		.113 24	3282.1	3678.4	7.4339	
600	.159 30	3288.0	3686.3	7.5960		.148 38	3466.5	3911.7	7.7571		.126 99	3464.3	3908.8	7.6837	
700	.178 32	3468.7	3914.5	7.8435		.164 14	3653.5	4145.9	7.9862		.140 56	3651.8	4143.7	7.9134	
800	.197 16	3655.3	4148.2	8.0720		.179 80	3846.5	4385.9	8.1999		.154 02	3845.0	4384.1	8.1276	
900	.215 90	3847.9	4387.6	8.2853		.195 41	4045.4	4631.6	8.4009		.167 43	4044.1	4630.1	8.3288	
1000	.2346	4046.7	4633.1	8.4861		.210 98	4250.3	4883.3	8.5912		.180 80	4249.2	4881.9	8.5192	
1100	.2532	4251.5	4884.6	8.6762		.226 52	4460.9	5140.5	8.7720		.194 15	4459.8	5139.3	8.7000	
1200	.2718	4462.1	5141.7	8.8569		.242 06	4676.6	5402.8	8.9442		.207 49	4675.5	5401.7	8.8723	
1300	.2905	4677.8	5404.0	9.0291											



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

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

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

T	P = 6.0 MPa (275.64)					P = 7.0 MPa (285.88)					P = 8.0 MPa (295.06)				
	v	u	h	s	s	v	u	h	s	s	v	u	h	s	s
700	.073 52	3453.1	3894.2	7.4234	7.3476	.062 83	3448.5	3888.3	7.3476	7.3476	.054 81	3443.9	3882.4	7.2812	7.2812
800	.081 60	3643.1	4132.7	7.6566	7.5822	.069 81	3639.5	4128.2	7.5822	7.5822	.060 97	3636.0	4123.8	7.5173	7.5173
900	.089 58	3837.8	4375.3	7.8727	7.7991	.076 69	3835.0	4371.8	7.7991	7.7991	.067 02	3832.1	4368.3	7.7351	7.7351
1000	.097 49	4037.8	4622.7	8.0751	8.0020	.083 50	4035.3	4619.8	8.0020	8.0020	.073 01	4032.8	4616.9	7.9384	7.9384
1100	.105 36	4243.3	4875.4	8.2661	8.1933	.090 27	4240.9	4872.8	8.1933	8.1933	.078 96	4238.6	4870.3	8.1300	8.1300
1200	.113 21	4454.0	5133.3	8.4474	8.3747	.097 03	4451.7	5130.9	8.3747	8.3747	.084 89	4449.5	5128.5	8.3115	8.3115
1300	.121 06	4669.6	5396.0	8.6199	8.5473	.103 77	4667.3	5393.7	8.5473	8.5473	.090 80	4665.0	5391.5	8.4842	8.4842
P = 10.0 MPa (311.06)															
Sal.	.020 48	2557.8	2742.1	5.6772	5.6141	.018 026	2544.4	2724.7	5.6141	5.6141	.013 495	2505.1	2673.8	5.4624	5.4624
325	.023 27	2646.6	2856.0	5.8712	5.7568	.019 861	2610.4	2809.1	5.7568	5.7568	.016 126	2624.6	2826.2	5.7118	5.7118
350	.025 80	2724.4	2956.6	6.0361	5.9443	.022 42	2699.2	2923.4	5.9443	5.9443	.020 00	2789.3	3039.3	6.0417	6.0417
400	.029 93	2848.4	3117.8	6.2854	6.2120	.026 41	2832.4	3096.5	6.2120	6.2120	.022 99	2912.5	3199.8	6.2719	6.2719
450	.033 50	2955.2	3256.6	6.4844	6.4190	.029 75	2943.4	3240.9	6.4190	6.4190	.025 60	3021.7	3341.8	6.4618	6.4618
500	.036 77	3055.2	3386.1	6.6576	6.5966	.032 79	3045.8	3373.7	6.5966	6.5966	.028 01	3125.0	3475.2	6.6290	6.6290
550	.039 87	3152.2	3511.0	6.8142	6.7561	.035 64	3144.6	3500.9	6.7561	6.7561	.030 29	3225.4	3604.0	6.7810	6.7810
600	.042 85	3248.1	3633.7	6.9589	6.9029	.038 37	3241.7	3625.3	6.9029	6.9029	.032 48	3324.4	3730.4	6.9218	6.9218
650	.045 74	3343.6	3755.3	7.0943	7.0398	.041 01	3338.2	3748.2	7.0398	7.0398	.034 60	3422.9	3855.3	7.0536	7.0536
700	.048 57	3439.3	3876.5	7.2221	7.1687	.043 58	3434.7	3870.5	7.1687	7.1687	.036 69	3520.0	4103.6	7.2965	7.2965
800	.054 09	3632.5	4119.3	7.4596	7.4077	.048 59	3628.9	4114.8	7.4077	7.4077	.042 67	3819.1	4352.5	7.5182	7.5182
900	.059 50	3829.2	4364.8	7.6783	7.6272	.053 49	3826.3	4361.2	7.6272	7.6272	.046 58	4021.6	4603.8	7.7237	7.7237
1000	.064 85	4030.3	4614.0	7.8821	7.8315	.058 32	4027.8	4611.0	7.8315	7.8315	.050 45	4228.2	4858.8	7.9165	7.9165
1100	.070 16	4236.3	4867.7	8.0740	8.0237	.063 12	4234.0	4865.1	8.0237	8.0237	.054 30	4439.3	5118.0	8.0987	8.0987
1200	.075 44	4447.2	5126.2	8.2556	8.2055	.067 89	4444.9	5123.8	8.2055	8.2055	.058 13	4654.8	5381.4	8.2717	8.2717
1300	.080 72	4662.7	5389.2	8.4284	8.3783	.072 65	4460.5	5387.0	8.3783	8.3783					

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

<i>T</i>	<i>P</i> = 15.0 MPa (342.24)					<i>P</i> = 17.5 MPa (354.75)					<i>P</i> = 20.0 MPa (365.81)				
	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>	<i>s</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>	<i>s</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>	<i>s</i>
Sat.	.010 337	2455.5	2610.5	5.3098	5.1419	.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		
<i>P</i> = 25.0 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	P = 25.0 MPa					P = 30.0 MPa					P = 35.0 MPa					
	v	u	h	s	v	u	h	s	v	u	h	s	v	u	h	s
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	.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	.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	.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	.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	.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	.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	.020 815	4605.1	5333.6	7.7653

T	P = 40.0 MPa					P = 50.0 MPa					P = 60.0 MPa					
	v	u	h	s	v	u	h	s	v	u	h	s	v	u	h	s
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	.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	.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	.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	.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	.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	.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	.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	.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	.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	.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	.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	.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	.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	.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	.012 215	4551.4	5284.3	7.4837



TABLE 4

<i>p</i> ( <i>t</i> Sat.) MPa		Liquid											
		0				2.5 (223.99)				5.0 (263.99)			
<i>t</i>	Sat.	$10^3v$	<i>u</i>	<i>h</i>	<i>s</i>	$10^3v$	<i>u</i>	<i>h</i>	<i>s</i>	$10^3v$	<i>u</i>	<i>h</i>	<i>s</i>
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		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)

T	P = 5 MPa (263.99)					P = 10 MPa (311.06)					P = 15 MPa (342.24)				
	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.)

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