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Evaluation standard of Zero Carbon Data Center

零碳数据中心评价标准

（*English Translation*）

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Contents

Foreword

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Evaluation standard of Zero Carbon Data Center

1 Scope

This document specifies the basic requirements, evaluation indicators and evaluation grades for Zero Carbon Data Center.

This document is applicable to the evaluation of Zero Carbon Data Center.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 384, *Determination of calorific value of petroleum products*

GB/T 11062, *Natural gas—Calculation of calorific values, density, relative density and Wobbe indices from composition*

GB 17167，*General principle for equipping and managing of the measuring instrument of energy in organization of energy using*

GB/T 32910.3—2016，*Data center—Resource utilization—Part 3：Electric energy usage effectiveness requirements and measuring methods*

3 Terms and definitions

For the purposes of this document，the following terms and definitions apply.

3.1
data center

Building site that provides an operating environment for centrally placed electronic information equipment，which may be a park，one or several buildings，or a part of a building，including a host room，auxiliary area，support area，and administrative management area

［Source：GB 50174—2017，2.1.1］

3.2
greenhouse gas

A gaseous component of the atmosphere that absorbs and emits radiation in the infrared spectrum from the earth's surface，atmosphere and clouds，both naturally occurring and generated by human activities

NOTE Unless otherwise specified, the greenhouse gases in this standard mainly include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC_s), perfluorocarbons (PFC_s), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

[Source: GB/T 32150—2015, 3.1]

3.3
carbon dioxide equivalent

CO_2e

Unit for comparing the radiative forcing of a greenhouse gas to that of carbon dioxide

NOTE The carbon dioxide equivalent is calculated using the mass of a given greenhouse gas multiplied by its global warming potential.

[Source: GB/T 32150—2015, 3.16]

3.4
global warming potential

GWP

Factor describing the radiative forcing impact of one mass-based unit of a given greenhouse gas relative to an equivalent unit of carbon dioxide over a given period of time

[Source: GB/T 32150—2015, 3.15]

3.5
data center accounting boundary

Range of greenhouse gas emissions related to the normal operation of infrastructure equipment and electronic information equipment in the data center

NOTE Infrastructure equipment includes but is not limited to the power supply and distribution system, HVAC system, water supply and drainage system, intelligent system, fire protection system, heating system, park public transportation system, etc. within the data center.

3.6
data center carbon emission

carbon emission

Sum of the CO_2 equivalent of range Ⅰ and range Ⅱ greenhouse gas emissions generated by the data center within the specified accounting boundary in a natural year

NOTE 1 Range Ⅰ in this document refers to carbon emissions from fossil fuel combustion and carbon emissions from the use of Freon refrigerants in the data center.

NOTE 2 Range Ⅱ in this document refers to the carbon emissions from electricity and heat consumed by the outsourcing of the data center.

3.7

data center carbon offset

carbon offset

Act of data centers conducting financial transactions or carbon emission reduction certification through domestic and foreign institutions recognized by the local government outside the accounting boundary to generate carbon sinks to offset the carbon dioxide equivalent of greenhouse gas emissions within the accounting boundary

3.8

data center carbon neutrality ratio

carbon neutrality ratio

CNR

Ratio of carbon offsetting to carbon emissions in data center

3.9

data center net carbon effectiveness

net carbon effectiveness

NCE

Ratio of carbon dioxide equivalent emitted by carbon in range Ⅰ and range Ⅱ within the data center accounting boundary to the

total electricity consumption of electronic information equipment

3.10
emission factor

Coefficient characterizing greenhouse gas emissions per unit volume of production or consumption activity

[Source: GB/T 32150—2015, 3.13]

3.11
carbon emission from fossil fuel combustion

Greenhouse gas emitted into the atmosphere during the combustion process of fossil fuel

3.12
carbon emission from electricity consumption

Greenhouse gas emitted into the atmosphere from the electricity production process corresponding to the consumption of purchased electricity

3.13
carbon emission from heat consumption

Greenhouse gas emitted into the atmosphere from the heat production process corresponding to the consumption of purchased heat

3.14

green electricity certificate

The electronic certificates with unique code identification issued by the National Renewable Energy Information Management Center to qualified renewable energy power generation companies based on the grid-connected renewable energy volume, in accordance with the relevant administrative regulations of the National Energy Administration, through the Renewable Energy Power Generation Project Information Management Platform of the National Energy Administration

[Source: Green power certificates issuance and voluntary subscription rules (Trial Implementation), Article 2]

3.15

green electricity consumption certificate

Document issued by organizations with certification qualifications, such as local power trading center and power grid block chain judicial authentication center, which record the whole process information such as user information, transaction electricity quantity, electricity quantity type, source power plant and equivalent carbon dioxide emission reduction

NOTE The green electricity consumption certificate can ensure the clarity and uniqueness of the ownership of green power attributes, and realize the traceability of the whole life cycle of green power. In carbon accounting, the carbon emissions of range Ⅱ are directly reduced.

3.16

carbon neutral management system

Systems and activities established within the data center to ensure the smooth progress of carbon and emission reduction

4 Basic requirements

The evaluation object shall be a compliance data center project that has been put into production for more than one year (inclusive), may clearly define the physical accounting boundary, may independently measure the energy consumption within the boundary, and belongs to the same legal entity, including:

a) Data center park with closed management;

b) Single or multiple buildings in the data center;

c) Data center computer room that shares buildings with other projects;

d) Individual data center computer room.

5 Evaluation indicators system

5.1 General

The evaluation indicators system of Zero Carbon Data Center

consists of four evaluation indicators: *CNR*, *NEC*, carbon neutral management system and carbon emission monitoring system. The scores for each of the evaluation Indicators for Zero Carbon Data Centers are shown in Table 1.

Table 1—Evaluation indicators scores

No.	Evaluation indicators	Indicators score code	Maximum score
1	*CNR*	S_{CNR}	10
2	*NEC*	S_{NCE}	75
3	Carbon neutral management system	S_{sys}	13
4	Carbon emission monitoring system	S_{mon}	2
5	Total score of zero carbon evaluation	S	100

5.2 *CNR*

5.2.1 The carbon neutrality ratio (*CNR*) is calculated using Formula (1):

$$CNR = E_{co} / E_{ce} \times 100\% \quad (1)$$

where

E_{co} is the carbon offset as carbon dioxide equivalent, in tons (t), with the value provided by carbon emission reduction certification or/and carbon trading voucher;

E_{ce} is the carbon emission as carbon dioxide equivalent, in tons (t);

E_{ce} is calculated according to Annex A, and the enthalpy of steam involved in the calculation is shown in Annex B.

5.2.2 The calculation of the score of *CNR* (S_{CNR}) is shown in Table 2.

Table 2—The calculation of the score of S_{CNR}

Evaluation indicators	Scoring rules	S_{CNR}
Carbon neutrality ratio *CNR*	$0 \leqslant CNR \leqslant 80\%$	$12.5CNR$
	$80\% < CNR$	10

5.3 ***NEC***

5.3.1 The net carbon effectiveness (*NCE*) is calculated using Formula (2):

$$NCE = E_{ce} / P_{IT} \times 1\,000 \qquad (2)$$

where

NCE is the net carbon effectiveness, in kg CO_2e/(kW·h);

P_{IT} is the electricity consumption of electronic information equipment, in kW·h;

P_{IT} is measured according to Clause 7 of GB/T 32910.3—2016.

5.3.2 The calculation of the score of net carbon effectiveness (S_{NCE}) is shown in Table 3.

Table 3—The calculation of S_{NCE}

Evaluation indicators	Scoring rules	S_{NCE}
Net carbon effectiveness (NCE)	NCE > 0.755 $kgCO_2e/(kW \cdot h)$	0
	0.151 $kgCO_2e/(kW \cdot h)$ ≤ NCE ≤ 0.755 $kgCO_2e/(kW \cdot h)$	(0.755 − NCE) × 75/0.604
	NCE < 0.151 $kgCO_2e/(kW \cdot h)$	75

5.4 Carbon neutral management system

5.4.1 The carbon neutral management system includes six secondary indicators: Establishment of carbon neutral management team, setting up special funds for carbon neutrality, development of annual energy consumption targets and implementation plans, regularly conducting carbon neutral publicity and training for all employees, obtaining low-carbon certification, and disclosing carbon emissions in range Ⅲ.

5.4.2 The calculation of the score of carbon neutral management system (S_{sys}) is shown in Table 4. Firstly, score the secondary indicators one by one according to the given scoring rules, and then calculate the sum of the scores of each secondary indicator

to obtain the carbon neutral management system score.

Table 4—The calculation of S_{sys}

Evaluation indicators	Secondary indicators	Scoring rules	S_{sys}
Carbon neutral management system	Establishment of carbon neutral management team	Provide a list of team leaders and members and a description of team responsibilities	0 to 2
	Establishment of special funds for carbon neutrality	Provide at least one application case of special funds for carbon neutrality	0 to 2
	Development of annual energy consumption targets and implementation plans	Compare carbon emission values before and after the implementation of the Energy Consumption Improvement Program	0 to 1
	Regularly conducting carbon neutral publicity and training for all employees	Provide carbon neutral course system and training sign-in records	0 to 1
	Obtaining low carbon certification	obtained Low-carbon or green certification of data center and related industries by the declared project within the last 3 years	0 to 2
	Disclosing carbon emissions in range Ⅲ	Provide at least one low-carbon emission certificate of data center supply chain, or disclose at least one carbon emission content and calculation method in range Ⅲ. Add 1 point for each additional item, with a maximum of 5 points	0 to 5

5.5 Carbon emission monitoring system

5.5.1 The carbon emission monitoring system shall measure and display the energy consumption and carbon emission of various systems in the data center.

5.5.2 The calculation of the score of carbon emission monitoring system（S_{mon}）is shown in Table 5. Firstly, score the secondary Indicators one by one according to the given scoring rules, and then calculate the sum of the scores of each secondary Indicator to obtain the carbon emission monitoring system Indicator score.

Table 5—The calculation of S_{mon}

Evaluation indicators	Secondary indicators	Scoring rules	S_{mon}
Carbon emission monitoring system	Itemized energy metering system	Have itemized energy metering system equipped with independent intelligent metering instruments for electricity, heat, fossil fuels and renewable energy e.g.. Metering instruments shall meet the requirements of GB 17167	0 to 1
	Integrated management system	Energy consumption data can be displayed as needed, and parameters such as electricity consumption, heat consumption, fossil fuel consumption, renewable energy consumption, and total carbon emissions within a certain period of time can be customized and extracted	0 to 1

6 Evaluation grades

The total score of zero carbon evaluation is calculated using Formula（3）：

$$S = S_{CNR} + S_{NCE} + S_{sys} + S_{mon} \quad (3)$$

where

S is the total score of zero carbon evaluation；

S_{CNR} is the score of CNR；

S_{NCE} is the score of NCE；

S_{sys} is the score of carbon neutral management system；

S_{mon} is the index score of carbon emission monitoring system.

According to the total score of zero carbon evaluation，the data center is classified into three grades，with zero carbon three-star as the highest grade and zero carbon one-star as the lowest grade. The grades of Zero Carbon Data Center grades are shown in Table 6.

Table 6—The grades of Zero Carbon Data Center

Evaluation grade	Grading indicators	Description
Zero carbon three-star（★★★）	$S \geqslant 95$	Zero carbon
Zero carbon two-star（★★）	$95 > S \geqslant 85$	Near zero carbon
Zero carbon one-star（★）	$85 > S \geqslant 70$	Low-carbon

Annex A
（Normative）
Data center carbon emissions calculation

A.1 Principle of calculation

The emission factor method shall be used to calculate the data center carbon emission, and the actual measurement method may be used by data center if conditions allow.

A.2 Selection and collection of greenhouse gas activity data

Select and collect greenhouse gas activity data according to the requirements of the selected calculation method, and the types of data shall be selected and collected in order of priority from high to low (see Table A.1).

Table A.1—Priority of data collection for greenhouse gas activities

Data type	Description	Priority
Original data	Data obtained by direct measurement and test	High
Secondary data	Data converted from raw data	Medium
Alternative data	Data from similar processes or activities	Low

The activity data of the main emission sources of the evaluation

object and data sources are shown in Table A.2.

Table A.2—Data and data sources of evaluation object

Greenhouse gas emission source	Data sources
Fixed combustion source	Energy balance sheet of data center
Mobile combustion source	Energy balance sheet of data center
Process emission source	Raw material consumption sheet, water balance sheet (wastewater discharge), wastewater testing report, raw material purchase certificate (purchase quantity/ purchase amount)
Fugitive emission source	Monitoring report
Purchased electricity, heat, or steam	Energy balance sheet of data center, purchase invoice or voucher
Information technology equipment	Reports of production, testing, logistics, warehousing and waste disposal

A.3 Selection or determination of greenhouse gas emission factors

The priority of obtaining greenhouse gas emission factors is shown in Table A.3.

Table A.3—Priority of obtaining greenhouse gas emission factors

Data type	Description	Priority
Measured or calculated values of emission factors	Obtain emission factors or related parameter values by direct measurement or energy balance of the evaluation object	High
Emission factor reference value	Use emission factors provided in relevant guidelines or documents	Low

The sources of greenhouse gas emission factors shall be explained in the evaluation report.

A.4 Calculating data center carbon emissions

A.4.1 Total carbon emissions as carbon dioxide equivalent

The total carbon emissions as carbon dioxide equivalent shall be calculated using Formula (A.1):

$$E_{ce} = E_{bur} + E_{pe} + E_{ph} + E_{r} \quad (A.1)$$

where

E_{ce} is the total carbon emissions as carbon dioxide equivalent, in tons (t);

E_{bur} is the total carbon emissions from fossil fuel combustion as carbon dioxide equivalent, in tons (t);

E_{pe} is the carbon emission from consumption of purchased electricity as carbon dioxide equivalent, in tons (t);

E_{ph} is the carbon emission from consumption of purchased heat as carbon dioxide equivalent, in tons (t);

E_{r} is the carbon emission from the use of refrigerants as carbon dioxide equivalent, in tons (t).

A.4.2 Carbon emissions from fossil fuel combustion as carbon dioxide equivalent (E_{bur})

A.4.2.1 Calculation Formula

E_{bur} is calculated using Formula (A.2):

$$E_{bur} = \sum_{i=1}^{n} (AD_i \times EF_i) \quad \text{(A.2)}$$

where

AD_i is the activity data of fossil fuel category i during the evaluation year, in GJ;

EF_i is the carbon dioxide emission factor of fossil fuel category i, in t/GJ;

i is the fossil fuel category code.

A.4.2.2 Activity data of fossil fuel category i during the evaluation year (AD_i)

A.4.2.2.1 Calculation Formula

AD_i is calculated using Formula (A.3):

$$AD_i = NCV_i \times FC_i \quad (A.3)$$

where

NCV_i is the average low calorific value of the fuel category i during the evaluation year under standard conditions, in GJ/t for solid and liquid fuels and in GJ/($10^4 m^3$) for gas fuels in standard state;

FC_i is the consumption of the fuel category i during the evaluation year, in tons (t) for solid and liquid fuels and in 10^4 m^3 for gas fuels in standard state.

A.4.2.2.2 Consumption of the fossil fuel category i during the evaluation year (FC_i)

FC_i is determined according to A.2.

The measurement device shall meet the requirements of GB 17167.

The fuel consumption of key emission facilities such as generator sets and direct-fired machines shall be measured and recorded separately.

A.4.2.2.3 Average low calorific value of fossil fuel category *i* during the evaluation year (NCV_i)

NCV_i may adopt the measured data provided by the supplier in accordance with GB/T 384 and GB/T 11062. If not, the default values given in Table A.4 shall be adopted.

Table A.4—Default values of parameters related to common fossil fuels

Energy	Unit of measurement	net calorific value	Carbon content per unit heating value (t/GJ)	Carbon oxidation rate (%)
Crude oil	t	41.816 GJ/t[a]	0.020 1[b]	98[b]
Fuel oil	t	41.816 GJ/t[a]	0.021 1[b]	
Gasoline	t	43.070 GJ/t[a]	0.018 9[b]	
Kerosene	t	43.070 GJ/t[a]	0.019 6[b]	
Diesel	t	42.652 GJ/t[a]	0.020 2[b]	
Liquefied petroleum gas	t	50.179 GJ/t[a]	0.017 2[c]	
Refinery dry gas	t	45.998 GJ/t[a]	0.018 2[b]	

Table A.4 (*continued*)

Energy	Unit of measurement	net calorific value	Carbon content per unit heating value (t/GJ)	Carbon oxidation rate (%)
Natural gas[d]	10^4 m^3	389.31 [GJ/(10^4 m^3)][a]	0.015 3[b]	99[b]
Coke oven gas[d]	10^4 m^3	173.54 [GJ/(10^4 m^3)][c]	0.012 1[c]	
Blast furnace gas[d]	10^4 m^3	33.00 [GJ/(10^4 m^3)][c]	0.070 8[c]	
Other gas[d]	10^4 m^3	52.27 [GJ/(10^4 m^3)][a]	0.012 2[c]	

[a] The data is sourced from *China Energy Statistical Yearbook* 2018.

[b] The data is sourced from *Guidelines for the Preparation of Provincial Greenhouse Gas Inventories* (*Trial*).

[c] The data is sourced from *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

[d] Under the standard state.

A.4.2.3 Carbon dioxide emission factor of the fossil fuel category i (EF_i)

A.4.2.3.1 EF_i shall be calculated using Formula (A.4):

$$EF_i = CC_i \times OF_i \times \frac{44}{12} \quad (A.4)$$

where

CC_i is the carbon content per unit calorific value of the

fossil fuel category i, in t/GJ;

OF_i is the carbon oxidation rate of the fossil fuel category i, in %;

$\frac{44}{12}$ is the ratio of the relative molecular mass of carbon dioxide to carbon.

A.4.2.3.2 The carbon content per unit calorific value is selected in accordance with those specified in Table A.4.

A.4.2.3.3 The carbon oxidation rate is selected in accordance with those specified in Table A.4.

A.4.3 Carbon emissions from purchased electricity consumption

The carbon dioxide equivalent from consumption of purchased electricity (E_{pe}) shall be calculated using Formula (A.5):

$$E_{pe} = AD_{pe} \times EF_{pe} \quad (A.5)$$

where

AD_{pe} is the purchased electricity quantity generated from fossil fuels consumed during the evaluation year, in MW·h;

EF_{pe} is the annual average emission factor of the power grid, in $tCO_2e/(MW \cdot h)$.

In case AD_{pe} cannot be measured independently, it shall be calculated using Formula (A.6):

$$AD_{pe} = PC_t - GE_{own} - GE_{pur} \quad (A.6)$$

PC_t is the total power consumption in data center (measured according to Clause 7 of GB/T 32910.3—2016), in MW · h;

GE_{own} is the renewable electricity (i.e., spontaneous green electricity) generated and directly consumed within the accounting boundary during the evaluation year, in MW · h;

GE_{pur} is the renewable electricity (i.e., self-purchased green electricity) generated outside the accounting boundary during the evaluation year and supplied through the power grid or dedicated line, and consumed within the data center accounting boundary, in MW · h.

EF_{pe} shall preferaly use the data provided by public energy suppliers to data centers. If it is not available, the latest annual emission factor of regional power grid (see Table A.5) issued by the competent department of the area where the data center is located shall be adopted.

Table A.5—Regional power grid coverage

Power grid	Coverage
Northeast regional power grid	Liaoning, Jilin, Heilongjiang, and the eastern part of Inner Mongolia Autonomous Region
Northwest regional power grid	Shaanxi, Gansu, Qinghai, Ningxia Hui Autonomous Region and the Xinjiang Uygur Autonomous Region
Central China regional power grid	Henan, Hubei, Hunan, Jiangxi, Sichuan and Chongqing
North China regional power grid	Beijing, Tianjin, Hebei, Shanxi, Shandong and western Inner Mongolia Autonomous Region
East China regional power grid	Shanghai, Jiangsu, Zhejiang, Anhui and Fujian
South regional power grid	Guangdong, Guangxi Zhuang Autonomous Region, Yunnan, Guizhou and Hainan

A.4.4 Carbon emissions from purchased heat consumption

A.4.4.1 Calculation Formula

The carbon emission from consumption of purchased heat as carbon dioxide equivalent (E_{pe}) shall be calculated using Formula (A.7):

$$E_{ph} = AD_{ph} \times EF_{ph} \quad (A.7)$$

where

AD_{ph} is the consumped heat from purchased heat during the evaluation year (the purchased heat at this time is the heat generated by consuming fossil fuels), in GJ;

EF_{ph} is the emission factor of heating, in tCO_2e/GJ.

A.4.4.2 The consumped heat from purchased heat during the evaluation year (AD_{ph})

The consumped heat from purchased heat during the evaluation year as well as the hot water heat and steam heat measured by mass shall be calculated using Formulas (A.8), (A.9) and (A.10), respectively.

$$AD_{ph} = AD_{w} + AD_{st} \quad (A.8)$$

where

AD_{w} is the heat contained in hot water, in GJ;

AD_{st} is the heat contained in steam, in GJ.

For hot water measured by mass, the heat (AD_{w}) contained in hot water is converted using Formula (A.9):

$$AD_{w} = Ma_{w} \times (T_{w} - 20) \times 4.186\ 8 \times 10^{-3} \quad (A.9)$$

where

Ma_w is the mass of hot water, in t;

T_w is the temperature of hot water, in ℃;

4.186 8 is the specific heat capacity of water at room temperature and normal pressure, in kJ/(kg • ℃).

For the steam measured by mass, the heat (AD_{st}) contained in steam is converted using Formula (A.10):

$$AD_{st} = Ma_{st} \times (En_{st} - 83.74) \times 10^{-3} \quad (A.10)$$

where

Ma_{st} is the mass of steam, in t;

En_{st} is the enthalpy per kilogram of steam at corresponding temperature and pressure (the enthalpy of saturated steam and superheated steam is shown in Annex B), in kJ/kg;

83.74 is the enthalpy of water at 20 ℃ under standard atmospheric pressure, in kJ/kg.

A.4.4.3 Emission factor for heat production (EF_{ph})

EF_{ph} shall use tthe latest data released by local authorities. If the data is missing, the recommended value 0.11 tCO_2e/GJ may be

adopted.

A.4.5 Emissions from the use of refrigerants

A.4.5.1 Calculation Formula

The carbon emissions generated by refrigerants in HVAC systems during the evaluation year as carbon dioxide equivalent (E_r) shall be calculated using Formula (A.11):

$$E_r = \frac{m_r}{y_e} \times N \times GWP_r / 1\,000 \qquad \text{(A.11)}$$

where

E_r is carbon emissions generated by refrigerants as carbon dioxide equivalent, in t;

m_r is the filling amount of refrigerants in device, in kg/unit;

y_e is the service life of device, in year (a);

N is the number of devices, in unit;

GWP_r is the global warming potential of refrigerants, see Table A.6 for values;

1 000 is the conversion factor, in kg/(t · a).

Table A.6—Global warming potential values of some greenhouse gases in 100-year time scale

Types of greenhouse gases	Global warming potential value	Types of greenhouse gases	Global warming potential value
CO_2	1	HFC－152a	140
CH_4	21	HFC－227ea	290
N_2O	310	HFC－236fa	6 300
HFC－23（CHF_3）	11 700	HFC－245fa	1 030
HFC－32	650	PFC－14（CF_4）	6 500
HFC－125	2 800	PFC－116（C_2F_6）	9 200
HFC－134a	1 300	SF_6	23 900
HFC－143a	3 800	—	—

NOTE The data are quoted from the *Second Biennial Update Report on Climate Change of the People's Republic of China*.

Annex B

(Informative)

Enthalpy of saturated steam and superheated steam

The enthalpy of saturated steam arranged by pressure is shown in Table B.1, that arranged by temperature is shown in Table B.2, and that of superheated steam is shown in Table B.3.

Table B.1—Enthalpy of saturated steam arranged by pressure

Pressure MPa	Temperature ℃	Enthalpy (kJ/kg)	Pressure MPa	Temperature ℃	Enthalpy (kJ/kg)
0.001	6.98	2 513.8	0.050	81.35	2 645.0
0.002	17.51	2 533.2	0.060	85.95	2 653.6
0.003	24.10	2 545.2	0.070	89.96	2 660.2
0.004	28.98	2 554.1	0.080	93.51	2 666.0
0.005	32.90	2 561.2	0.090	96.71	2 671.1
0.006	36.18	2 567.1	0.10	99.63	2 675.7
0.007	39.02	2 572.2	0.12	104.81	2 683.8
0.008	41.53	2 576.7	0.14	109.32	2 690.8
0.009	43.79	2 580.8	0.16	113.32	2 696.8
0.010	45.83	2 584.4	0.18	116.93	2 702.1
0.015	54.00	2 598.9	0.20	120.23	2 706.9
0.020	60.09	2 609.6	0.25	127.43	2 717.2
0.025	64.99	2 618.1	0.30	133.54	2 725.5
0.030	69.12	2 625.3	0.35	138.88	2 732.5
0.040	75.89	2 636.8	0.40	143.62	2 738.5

Table B.1（*continued*）

Pressure MPa	Temperature ℃	Enthalpy （kJ/kg）	Pressure MPa	Temperature ℃	Enthalpy （kJ/kg）
0.45	147.92	2 743.8	3.00	233.84	2 801.9
0.50	151.85	2 748.5	3.50	242.54	2 801.3
0.60	158.84	2 756.4	4.00	250.33	2 799.4
0.70	164.96	2 762.9	5.00	263.92	2 792.8
0.80	170.42	2 768.4	6.00	275.56	2 783.8
0.90	175.36	2 773.0	7.00	285.8	2 771.4
1.00	179.88	2 777.0	8.00	294.98	2 757.5
1.10	184.06	2 780.4	9.00	303.31	2 741.8
1.20	187.96	2 783.4	10.0	310.96	2 724.4
1.30	191.6	2 786.0	11.0	318.04	2 705.4
1.40	195.04	2 788.4	12.0	324.64	2 684.8
1.50	198.28	2 790.4	13.0	330.81	2 662.4
1.60	201.37	2 792.2	14.0	336.63	2 638.3
1.40	204.3	2 793.8	15.0	342.12	2 611.6
1.50	207.1	2 795.1	16.0	347.32	2 582.7
1.90	209.79	2 796.4	17.0	352.26	2 550.8
2.00	212.37	2 797.4	18.0	356.96	2 514.4
2.20	217.24	2 799.1	19.0	361.44	2 470.1
2.40	221.78	2 800.4	20.0	365.71	2 413.9
2.60	226.03	2 801.2	21.0	369.79	2 340.2
2.80	230.04	2 801.7	22.0	373.68	2 192.5

Table B.2—Enthalpy of saturated steam arranged by temperature

Pressure MPa	Temperature ℃	Enthalpy (kJ/kg)	Pressure MPa	Temperature ℃	Enthalpy (kJ/kg)
0	0.000 611	2 501.0	22	0.002 642	2 541.4
0.01	0.000 611	2 501.0	24	0.002 982	2 545.0
1	0.000 657	2 502.8	26	0.003 36	2 543.6
2	0.000 705	2 504.7	28	0.003 779	2 552.3
3	0.000 758	2 506.5	30	0.004 242	2 555.9
4	0.000 813	2 508.3	35	0.005 622	2 565.0
5	0.000 872	2 510.2	40	0.007 375	2 574.0
6	0.000 935	2 512.0	45	0.009 582	2 582.9
7	0.001 001	2 513.9	50	0.012 335	2 591.8
8	0.001 072	2 515.7	55	0.015 74	2 600.7
9	0.001 147	2 517.5	60	0.019 919	2 609.5
10	0.001 227	2 519.4	65	0.025 008	2 618.2
11	0.001 312	2 521.2	70	0.031 161	2 626.8
12	0.001 402	2 523.0	75	0.038 548	2 635.3
13	0.001 497	2 524.9	80	0.047 359	2 643.8
14	0.001 597	2 526.7	85	0.057 803	2 652.1
15	0.001 704	2 528.6	90	0.070 108	2 660.3
16	0.001 817	2 530.4	95	0.084 525	2 668.4
17	0.001 936	2 532.2	100	0.101 325	2 676.3
18	0.002 063	2 534.0	110	0.143 26	2 691.8
19	0.002 196	2 535.9	120	0.198 54	2 706.6
20	0.002 337	2 537.7	130	0.270 12	2 720.7

Table B.2（*continued*）

Pressure MPa	Temperature ℃	Enthalpy （kJ/kg）	Pressure MPa	Temperature ℃	Enthalpy （kJ/kg）
140	0.361 36	2 734	280	6.419 1	2 778.6
150	0.475 97	2 746.3	290	7.444 8	2 765.4
160	0.618 04	2 757.7	300	8.591 7	2 748.4
170	0.792 02	2 768	310	9.869 7	2 726.8
180	1.002 7	2 777.1	320	11.29	2 699.6
190	1.255 2	2 784.9	330	12.865	2 665.5
200	1.555 1	2 791.4	340	14.608	2 622.3
210	1.907 9	2 796.4	350	16.537	2 566.1
220	2.320 1	2 799.9	360	18.674	2 485.7
230	2.797 9	2 801.7	370	21.053	2 335.7
240	3.348	2 801.6	371	21.306	2 310.7
250	3.9776	2 799.5	372	21.562	2 280.1
260	4.694	2 795.2	373	21.821	2 238.3
270	5.505 1	2 788.3	374	22.084	2 150.7

Table B.3—Enthalpy of superheated steam

Temperature ℃	Pressure/MPa											
	0.01	0.1	0.5	1	3	5	7	10	14	20	25	30
0	0	0.1	0.5	1	3	5	7.10	10.1	14.1	20.1	25.1	30
10	42	42.1	42.5	43	44.9	46.9	48.80	51.7	55.6	61.3	66.1	70.8
20	83.9	84	84.3	84.8	86.7	88.6	90.40	93.2	97	102.5	107.1	111.7
40	167.4	167.5	167.9	168.3	170.1	171.9	173.60	176.3	179.8	185.1	189.4	193.8
60	2 611.3	251.2	251.2	251.9	253.6	255.3	256.90	259.4	262.8	267.8	272	276.1
80	2 649.3	335	335.3	335.7	337.3	338.8	340.40	342.8	346	350.8	354.8	358.7
100	2 687.3	2 676.5	419.4	419.7	421.2	422.7	424.20	426.5	429.5	434	437.8	441.6
120	2 725.4	2 716.8	503.9	504.3	505.7	507.1	508.50	510.6	513.5	517.7	521.3	524.9
140	2 763.6	2 756.6	589.2	589.5	590.8	592.1	593.40	595.4	598	602	605.4	603.1
160	2 802	2 796.2	2 767.3	675.7	676.9	678	679.20	681	683.4	687.1	690.2	693.3
180	2 840.6	2 835.7	2 812.1	2 777.3	764.1	765.2	766.20	767.8	769.9	773.1	775.9	778.7
200	2 879.3	2 875.2	2 855.5	2 827.5	853	853.8	854.63	855.9	857.7	860.4	862.8	856.2

Table B.3（*continued*）

Temperature ℃	Pressure/MPa											
	0.01	0.1	0.5	1	3	5	7	10	14	20	25	30
220	2 918.3	2 914.7	2 898	2 874.9	943.9	944.4	945.00	946	947.2	949.3	951.2	953.1
240	2 957.4	2 954.3	2 939.9	2 920.5	2 823	1 037.8	1 038.00	1 038.4	1 039.1	1 040.3	1 041.5	1 024.8
260	2 996.8	2 994.1	2 981.5	2 964.8	2 885.5	1 135	1 134.70	1 134.3	1 134.1	1 134	1 134.3	1 134.8
280	3 036.5	3 034	3 022.9	3 008.3	2 941.8	2 857	1 236.70	1 235.2	1 233.5	1 231.6	1 230.5	1 229.9
300	3 076.3	3 074.1	3 064.2	3 051.3	2 994.2	2 925.4	2 839.20	1 343.7	1 339.5	1 334.6	1 331.5	1 329
350	3 177	3 175.3	3 167.6	3 157.7	3 115.7	3 069.2	3 017.00	2 924.2	2 753.5	1 648.4	1 626.4	1 611.3
400	3 279.4	3 278	3 217.8	3 264	3 231.6	3 196.9	3 159.70	3 098.5	3 004	2 820.1	2 583.2	2 159.1
420	3 320.96	3 319.68	3 313.8	3 306.6	3 276.9	3 245.4	3 211.02	3 155.98	3 072.72	2 917.02	2 730.76	2 424.7
440	3 362.52	3 361.36	3 355.9	3 349.3	3 321.9	3 293.2	3 262.34	3 213.46	3 141.44	3 013.94	2 878.32	2 690.3
450	3 383.3	3 382.2	3 377.1	3 370.7	3 344.4	3 316.8	3 288.00	3 242.2	3 175.8	3 062.4	2 952.1	2 823.1
460	3 404.42	3 403.34	3 398.3	3 392.1	3 366.8	3 340.4	3 312.44	3 268.58	3 205.24	3 097.96	2 994.68	2 875.26
480	3 446.66	3 445.62	3 440.9	3 435.1	3 411.6	3 387.2	3 361.32	3 321.34	3 264.12	3 169.08	3 079.84	2 979.58

Table B.3（*continued*）

Temperature ℃	Pressure/MPa											
	0.01	0.1	0.5	1	3	5	7	10	14	20	25	30
500	3 488.9	3 487.9	3 483.7	3 478.3	3 456.4	3 433.8	3 410.20	3 374.1	3 323	3 240.2	3 165	3 083.9
520	3 531.82	3 530.9	3 526.9	3 521.86	3 501.28	3 480.12	3 458.60	3 425.1	3 378.4	3 303.7	3 237	3 166.1
540	3 574.74	3 573.9	3 570.1	3 565.42	3 546.16	3 526.44	3 506.40	3 475.4	3 432.5	3 364.6	3 304.7	3 241.7
550	3 593.2	3 595.4	3 591.7	3 587.2	3 568.6	3 549.6	3 530.20	3 500.4	3 459.2	3 394.3	3 337.3	3 277.7
560	3 618	3 617.22	3 613.64	3 609.24	3 591.18	3 572.76	3 554.10	3 525.4	3 485.8	3 423.6	3 369.2	3 312.6
580	3 661.6	3 660.86	3 657.52	3 653.32	3 636.34	3 619.08	3 601.60	3 574.9	3 538.2	3 480.9	3 431.2	3 379.8
600	3 705.2	3 704.5	3 701.4	3 697.4	3 681.5	3 665.4	3 649.00	3 624	3 589.8	3 536.9	3 491.2	3 444.2

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