

# JIS

**JAPANESE INDUSTRIAL STANDARD**

**Heat balancing of pottery and  
refractory firing tunnel kiln**

**JIS R 0301—1991**

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## JAPANESE INDUSTRIAL STANDARD

J I S

Heat balancing of pottery and refractory  
firing tunnel kiln

R 0301-1991

## 1. Scope

This Japanese Industrial Standard specifies the heat balancing of pottery and refractory firing tunnel kiln fired by liquid or gaseous fuel.

Remarks 1. This Standard may apply, besides the above scope, to carbon products, grinding wheels and other ceramic products.

2. Applicable Standards to this Standard are shown in the following:

JIS K 2249-Testing Methods for Density of Crude Oil and Petroleum Products, and Petroleum Measurement Tables Based on Reference Temperature of 15°C

JIS K 2251-Crude Petroleum and Petroleum Product - Sampling

JIS K 2270-Crude Petroleum and Petroleum Products - Determination of Carbon Residue

JIS K 2272-Testing Methods for Ash and Sulfated Ash of Crude Oil and Petroleum Products

JIS K 2275-Testing Methods for Water Content of Crude Oil and Petroleum Products

JIS K 2279-Testing Method for Heat of Combustion of Liquid Hydrocarbon Fuel by Bomb Calorimeter

JIS K 2301-Fuel Gases and Natural Gas- Methods for Chemical Analysis and Testing

JIS K 2541-Testing Methods for Sulfur in Crude Oil and Petroleum Products

3. In this Standard the units and numerical values shown in { } are in accordance with the traditional units and appended for informative reference.

## 2. Reference

2.1 Heat balancing shall be in accordance with the running results in normal running of kiln.

2.2 Heat balancing shall be performed per 1 t of fired wares drawn out of kiln.

2.3 For heat balancing take the ordinary temperature (outside atmospheric temperature) as the reference, and for heating value of fuel, use the lower heating value when in use.

### 3. Records and measurements

3.1 Records relating to kiln Records relating to kiln shall be as follows:

- (1) Classification and type
- (2) Size<sup>(1)</sup> (length, width and height)
- (3) Effective cross section
- (4) Surface area of each part (preheating zone, firing zone, cooling zone, doors at entrance and exit, air duct at outside of kiln and fan)
- (5) Number of cars in kiln and their total floor area
- (6) Type, capacity and number of burners
- (7) Ventilation system
- (8) Classification, type and capacity of waste heat utilization facility
- (9) History

Note <sup>(1)</sup> Length of kiln is the length of whole kiln except accessories, width is the inside width of kiln and height is the height from upper side of bricks of cars to inner top of kiln.

3.2 Items to be measured Items to be measured shall be as follows:

- (1) Date and time of measurement and name of measuring person
- (2) Weather, atmospheric pressure, temperature and humidity of outside air as well as temperature in room
- (3) Combustion equipment and ventilation equipment and their state
- (4) Name of fired ware
- (5) Load factor of kiln<sup>(2)</sup>
- (6) Firing time and cooling time
- (7) Atmosphere in firing zone
- (8) Classification, properties, composition, heating value, temperature and used amount of fuel
- (9) Volumes, temperatures and pressures of primary and secondary airs for combustion

- (10) Volume, temperature and pressure of cooling air and amount and temperature of cooling water.
- (11) Wares not yet fired<sup>(3)</sup>, classification of sheaths and tools, mass, moisture content, amounts of contained combustible components and temperature at entrance of kiln.
- (12) Mass of fired wares<sup>(4)</sup>, maximum temperature of firing and temperature at exit of kiln.
- (13) Number of cars running in the period of time of measurement, mass of one car (refractory part and iron part) and temperatures at entrance and exit of kiln.
- (14) Volume, temperature, pressure and composition of exhaust gas of combustion.
- (15) Volume and temperature of circulating combustion gas for waste heat utilization facility, or the like.
- (16) Surface temperature of each part of kiln (preheating zone, firing zone, cooling zone, doors of entrance and exit, air duct outside of kiln and fan)

Notes (<sup>2</sup>) The load factor of kiln means the ratio of actual carload in mass multiplied by the number of cars operated relative to the reference capacity calculated at the time of design or expressed by routine performance.

(<sup>3</sup>) Wares not yet fired means pottery, refractory, etc. set in kiln but not yet fired.

(<sup>4</sup>) Fired ware means the already fired pottery, refractory, etc.

#### 4. Measuring methods

4.1 Composition, heating value and used amount of fuel The measurement of the composition, heating value and used amount of fuel shall be as follows:

- (1) Composition of fuel shall be tested according to the following Japanese Industrial Standards.

- (a) JIS K 2251
- (b) JIS K 2270
- (c) JIS K 2272
- (d) JIS K 2275
- (e) JIS K 2301
- (f) JIS K 2541

- (2) Heating value of fuel shall be measured according to JIS K 2279. However, heating value of gaseous fuel may be obtained according to calculation from the results of gas analysis.
- (3) As to liquid fuel among fuels, the amount used shall be measured by volumetric flowmeter and be converted to mass with specific gravity<sup>(5)</sup> of liquid fuel.
- (4) As to gaseous fuel among fuels, the used amount shall be measured in main tube by using orifice, area flowmeter or Pitot tube.

Note <sup>(5)</sup> Specific gravity of liquid fuel is to be measured according to JIS K 2249.

4.2 Volume and temperature of air for combustion The volume and temperature of air for combustion shall be measured as follows:

- (1) As to total volume of air for combustion, calculate from compositions of fuel and combustion gas, and as to volume of preheating air among combustion airs measure according to orifice, area flowmeter, or Pitot tube, hot-wire anemometer, windmill anemometer.
- (2) Measure the temperature of preheating air at entrance and exit of preheating apparatus.

4.3 Volumes, temperatures and pressures of cooling air and cooling water Volumes, temperature and pressures of cooling air and cooling water shall be measured as follows:

- (1) Measure the volume of cooling air by means of orifice, area flowmeter or Pitot tube, hot-wire anemometer, windmill anemometer and measure the volume of cooling water with a volumetric flowmeter.
- (2) Measure the temperature of cooling air at blowing and outtake ports of kiln and measure the temperature of cooling water at intake and outtake ports.
- (3) Measure the pressure of cooling air by using water-column manometer, at exhaust port of blower and at blowing and outtake ports of kiln.

4.4 Masses of not yet fired wares, fired wares, sheaths and tools as well as moisture content, combustible components and temperature of not yet fired wares Masses of not yet fired wares, fired wares, sheaths and tools as well as moisture content, combustible components and temperature of not yet fired wares shall be measured as follows:

- (1) Measure the masses of not yet fired wares, fired wares, sheaths and tools relating to the total mass. However, in case where it is impossible to measure the total mass, measure the mass of sample taken at random and from the results it may be calculated.
- (2) As to the moisture content and combustible components of not yet fired wares, relating to the sample taken at random, measure the adhered water content, crystal water and combustible components.

- (3) Measure the temperature of not yet fired wares at entrance of kiln, and the temperature of fired wares, just after taking out of kiln.
- (4) As to the thermometer to measure firing temperature of not yet fired wares, use thermoelectric thermometer, radiation thermometer or optical pyrometer.

4.5 Temperature of car The temperature of car shall be measured relating to its refractory and iron parts at entrance of kiln and at its exit just after taking out of kiln.

4.6 Volume, temperature, pressure and composition of exhaust gas of combustion The volume, temperature, pressure and composition of exhaust gas of combustion shall be measured as follows:

- (1) Calculate the volume of exhaust gas of combustion from volume and composition of fuel and analytical values of exhaust gas of combustion or measured values by Pitot tube or the like.
- (2) Measure the temperature of exhaust gas of combustion at main gas flue near kiln.
- (3) Measure the pressure of exhaust gas of combustion by using a water-column pressure gauge at firing zone and preheating zone of kiln and at main gas flue near the kiln.
- (4) Make the taking position of sample for analyzing of composition of exhaust gas of combustion the main gas flue near the kiln, and make the sampling method in accordance with JIS K 2301.
- (5) As to analysis of composition of exhaust gas of combustion, use an Orsat analyzer, Hempel analyzer or instrumental analyzers of infrared type, magnetic type, etc.

4.7 Volume and temperature of circulating combustion gas for waste heat utilization facility or the like The measurement of volume and temperature of circulating combustion gas shall be performed as follows:

- (1) Measure the volume of circulating combustion gas by using orifice, area flowmeter or Pitot tube, hot-wire anemometer, or windmill anemometer.
- (2) Measure the temperature of circulating combustion gas near the outtake and blowing ports.

4.8 Surface temperature of kiln The surface temperature of kiln shall be measured by using surface thermometer at vertical and horizontal surfaces of preheating, firing and cooling zones of kiln and at doors of entrance and exit in three or more positions respectively.

## 5. Items of heat balance and calculation methods

The heat balance shall be performed, relating to the items given in left column of Table 1, according to calculation methods given in right column of the same table respectively.

Table 1

| Item                                                                                                                              | Calculation method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. <u>Heat input</u><br/><math>Q_1</math> (kJ/kcal))</p> <p>(1) Heat of combustion of fuel<br/><math>Q_d</math> (kJ/kcal))</p> | <p><math>Q_d = m_f \times H_i</math></p> <p>where, <math>m_f</math> : amount used of fuel per 1 t of fired wares (kg or <math>m^3</math>)</p> <p><math>H_i</math> : lower heating value of fuel (kJ/kg {kcal/kg} or <math>kJ/m^3</math> {kcal/<math>m^3</math>})</p> <p>Remarks: For example, in the case of gaseous fuel of a certain composition, the lower heating value of fuel <math>H_i</math> (kJ/<math>m^3</math> {kcal/<math>m^3</math>}) can be calculated from the following formula. However, in ( ) the volume percentage of component of gaseous fuel (%) is indicated.</p> $H_i = 30.5(CO) + 25.7(H_2) + 85.5(CH_4) + 153.7(C_2H_6) + 222.8(C_3H_8) + 292(C_4H_{10})$                             |
| <p>(2) Sensible heat of fuel<br/><math>Q_b</math> (kJ/kcal))</p>                                                                  | <p><math>Q_b = m_f \times C_f \times (t_f - t)</math></p> <p>where, <math>m_f</math> : amount used of fuel per 1 t of fired wares (kg or <math>m^3</math>)</p> <p><math>C_f</math> : specific heat of fuel (kJ/kg<math>^{\circ}C</math> {kcal/kg<math>^{\circ}C</math>}) or <math>kJ/m^3</math> {kcal/<math>m^3</math> <math>^{\circ}C</math>}</p> <p><math>t_f</math> : temperature of fuel (<math>^{\circ}C</math>)</p> <p><math>t</math> : ordinary temperature (<math>^{\circ}C</math>)</p> <p>Remarks: Specific heat of liquid fuel is to be taken as 1.88 kJ/kg<math>^{\circ}C</math> {0.45 kcal/kg<math>^{\circ}C</math>} and specific heat of gaseous fuel is to be calculated from its composition.</p> |

Table 1 (Continued)

|             | Item                                                                       | Calculation method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. (Cont'd) | (3) Heat carried in by not yet fired sheaths and tools<br>$Q_c$ (kJ{kcal}) | <p>(a) Heat carried in by not yet fired wares <math>Q_{ci}</math> (kJ{kcal})</p> $Q_{ci} = m_m \times C_m \times (t_m - t)$ <p>where, <math>m_m</math>: mass of not yet fired wares per 1 t of fired wares (kg)</p> <p><math>C_m</math>: average specific heat of not yet fired wares (kJ/kg°C{kcal/kg°C})</p> <p><math>t_m</math>: temperature of not yet fired wares at entrance of kiln (°C)</p> <p><math>t</math>: ordinary temperature (°C)</p> <p>(b) Heat carried in by sheaths and tools <math>Q_{cs}</math> (kJ{kcal})</p> $Q_{cs} = m_{st} \times C_{st} \times (t_{st} - t)$ <p>where, <math>m_{st}</math>: mass of sheaths and tools per 1 t of fired wares (kg)</p> <p><math>C_{st}</math>: specific heat of sheaths and tools (kJ/kg°C{kcal/kg°C})</p> <p><math>t_{st}</math>: temperature of sheaths and tools at entrance of kiln (°C)</p> <p><math>t</math>: ordinary temperature (°C)</p> <p>(c) Heat carried in by not yet fired wares, sheaths and tools <math>Q_c</math> (kJ{kcal})</p> $Q_c = Q_{ci} + Q_{cs}$ <p>where, <math>Q_{ci}</math>: heat carried in by not yet fired wares (kJ{kcal})</p> <p><math>Q_{cs}</math>: heat carried in by sheaths and tools (kJ{kcal})</p> |

Table 1 (Continued)

| Item        | Calculation method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. (Cont'd) | <p>(4) Heat carried in by cars<br/> <math>Q_a</math> (kJ{kcal})</p> <p>(a) Heat carried in by cars (refractory parts)<br/> <math>Q_{a1}</math> (kJ{kcal})<br/> <math>Q_{a1} = m_{co} \times C_{co} \times (t_{co} - t)</math><br/> where, <math>m_{co}</math> : mass of cars (refractory parts) per 1 t of fired wares (kg)<br/> <math>C_{co}</math> : specific heat of cars (refractory parts) (kJ/kg°C{kcal/kg°C})<br/> <math>t_{co}</math> : temperature of cars (refractory parts) at entrance of kiln (°C)<br/> <math>t</math> : ordinary temperature (°C)</p> <p>(b) Heat carried in by cars (iron parts) <math>Q_{a2}</math> (kJ{kcal})<br/> <math>Q_{a2} = m_{cs} \times C_{cs} \times (t_{cs} - t)</math><br/> where, <math>m_{cs}</math> : mass of cars (iron parts) per 1 t of fired wares (kg)<br/> <math>C_{cs}</math> : specific heat of cars (iron parts) (kJ/kg°C{kcal/kg°C})<br/> <math>t_{cs}</math> : temperature of cars (iron parts) at entrance of kiln (°C)<br/> <math>t</math> : ordinary temperature (°C)</p> <p>Remarks: Specific heat of iron is to be taken as 0.50 kJ/kg°C{0.12 kcal/kg°C}.</p> |

Table 1 (Continued)

| Item                                                                                                             | Calculation method                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. (Cont'd)                                                                                                      | <p>(c) Heat carried in by cars <math>Q_d</math> (kJ{kcal})</p> $Q_d = Q_{d1} + Q_{d2}$ <p>where, <math>Q_{d1}</math>: heat carried in by cars (refractory parts) (kJ{kcal})</p> <p><math>Q_{d2}</math>: heat carried in by cars (iron parts) (kJ{kcal})</p>                                                                                                                                                                               |
| (5) Heat of combustion carried in by combustible components contained in not yet fired wares<br>$Q_e$ (kJ{kcal}) | $Q_e = m_e \times H_{ib}$ <p>where, <math>m_e</math>: mass of combustible components contained in not yet fired wares per 1 t of fired wares (kg)</p> <p><math>H_{ib}</math>: effective heating value of combustible components (kJ/kg {kcal/kg})</p>                                                                                                                                                                                     |
| (6) Total heat input<br>$Q_i$ (kJ{kcal})                                                                         | $Q_i = Q_d + Q_b + Q_c + Q_e$ <p>where, <math>Q_d</math>: heat of combustion of fuel (kJ{kcal})</p> <p><math>Q_b</math>: sensible heat of fuel (kJ{kcal})</p> <p><math>Q_c</math>: heat carried in by not yet fired wares, sheaths and tools (kJ{kcal})</p> <p><math>Q_d</math>: heat carried in by cars (kJ{kcal})</p> <p><math>Q_e</math>: heat of combustion of combustible components contained in not yet fired wares (kJ{kcal})</p> |

Table 1 (Continued)

| Item                                      | Calculation method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2. <u>Heat output</u><br>$Q_2$ (kJ{kcal}) | <p>(1) Heat carried away by fired wares, sheaths and tools<br/> <math>Q_1</math> (kJ{kcal})</p> <p>(a) Heat carried away by fired wares <math>Q_n</math> (kJ{kcal})<br/> <math>Q_n = 1000 \times C' \times (t'_m - t)</math><br/>           where, <math>C'</math> : average specific heat of fired wares (kJ/kg°C{kcal/kg°C})<br/> <math>t'_m</math> : temperature of fired wares at exit of kiln (°C)<br/> <math>t</math> : ordinary temperature (°C)</p> <p>(b) Heat carried away by sheaths and tools <math>Q_2</math> (kJ{kcal})<br/> <math>Q_2 = m_{st} \times C'_{st} \times (t'_{st} - t)</math><br/>           where, <math>m_{st}</math> : mass of sheaths and tools per 1 t of fired wares (kg)<br/> <math>C'_{st}</math> : specific heat of sheaths and tools (kJ/kg°C{kcal/kg°C})<br/> <math>t'_{st}</math> : temperature of sheaths and tools at exit of kiln (°C)<br/> <math>t</math> : ordinary temperature (°C)</p> <p>(c) Heat carried away by fired wares, sheaths and tools <math>Q_1</math> (kJ{kcal})<br/> <math>Q_1 = Q_n + Q_2</math><br/>           where, <math>Q_n</math> : heat carried away by fired wares (kJ{kcal})<br/> <math>Q_2</math> : heat carried away by sheaths and tools (kJ{kcal})</p> |

Table 1 (Continued)

|             | Item                                             | Calculation method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2. (Cont'd) | (2) Heat carried away by cars<br>$Q_c$ (kJ/kcal) | <p>(a) Heat carried away by cars (refractory parts)<br/><math>Q_{c1}</math> (kJ/kcal)</p> <p><math>Q_{c1} = m_{cb} \times C'_{cb} \times (t'_{cb} - t)</math></p> <p>where, <math>m_{cb}</math> : mass of cars (refractory parts) per 1 t of fired wares (kg)</p> <p><math>C'_{cb}</math> : specific heat of cars (refractory parts) (kJ/kg°C {kcal/kg°C})</p> <p><math>t'_{cb}</math> : temperature of cars (refractory parts) at exit of kiln (°C)</p> <p><math>t</math> : ordinary temperature (°C)</p> <p>(b) Heat carried away by cars (iron parts) <math>Q_{c2}</math> (kJ/kcal)</p> <p><math>Q_{c2} = m_{cs} \times C'_{cs} \times (t'_{cs} - t)</math></p> <p>where, <math>m_{cs}</math> : mass of cars (iron parts) per 1 t of fired wares (kg)</p> <p><math>C'_{cs}</math> : specific heat of cars (iron parts) (kJ/kg°C {kcal/kg°C})</p> <p><math>t'_{cs}</math> : temperature of cars (iron parts) at exit of kiln (°C)</p> <p><math>t</math> : ordinary temperature (°C)</p> <p>Remarks: Specific heat of iron is to be 0.50 kJ/kg°C {0.12 kcal/kg°C}.</p> |

Table 1 (Continued)

| 2. (Cont'd)                                                            | Item | Calculation method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------------------------------------------------------------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                        |      | <p>(c) Heat carried away by cars <math>Q_g</math> (kJ{kcal})</p> <p style="text-align: center;"><math>Q_g = Q_{g1} + Q_{g2}</math></p> <p>where, <math>Q_{g1}</math> : heat carried away by cars (refractory parts) (kJ{kcal})</p> <p><math>Q_{g2}</math> : heat carried away by cars (iron parts) (kJ{kcal})</p>                                                                                                                                                                                                                                                  |
| (3) Heat carried away by cooling air<br>$Q_h$ (kJ{kcal})               |      | <p><math>Q_h = V_a \times C_a \times (t_a - t)</math></p> <p>where, <math>V_a</math> : volume of cooling air per 1 t of fired wares (<math>m^3_N</math>)</p> <p><math>C_a</math> : specific heat of air (kJ/<math>m^3_N</math> °C {kcal/<math>m^3_N</math> °C})</p> <p><math>t_a</math> : temperature of cooling air at outtake port of kiln (°C)</p> <p><math>t</math> : ordinary temperature (°C)</p> <p>Remarks: Specific heat of air is to be 1.30 kJ/<math>m^3_N</math> °C {0.31 kcal/<math>m^3_N</math> °C}.</p>                                             |
| (4) Heat carried away by exhaust gas of combustion<br>$Q_i$ (kJ{kcal}) |      | <p>(a) Sensible heat of dry exhaust gas of combustion<br/><math>Q_{i1}</math> (kJ{kcal})</p> <p style="text-align: center;"><math>Q_{i1} = m_f \times G' \times C_g \times (t_g - t)</math></p> <p>where, <math>m_f</math> : amount used of fuel per 1 t of fired wares (kg or <math>m^3_N</math>)</p> <p><math>G'</math> : amount of dry exhaust gas of combustion per 1 kg or 1 <math>m^3_N</math> of fuel (<math>m^3_N</math>)</p> <p><math>C_g</math> : specific heat of exhaust gas of combustion (kJ/<math>m^3_N</math> °C {kcal/<math>m^3_N</math> °C})</p> |

Table 1 (Continued)

| Item        | Calculation method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2. (Cont'd) | <p> <math>t_g</math> : temperature of exhaust gas of combustion (<math>^{\circ}\text{C}</math>)<br/> <math>t</math> : ordinary temperature (<math>^{\circ}\text{C}</math>) </p> <p>Remarks</p> <ol style="list-style-type: none"> <li>Specific heat of dry exhaust gas of combustion, in the case of approximate calculation is to be taken as <math>1.38 \text{ kJ/m}^3 \text{ } ^{\circ}\text{C}</math> <math>\{0.33 \text{ kcal/m}^3 \text{ } ^{\circ}\text{C}\}</math>.</li> <li>In case where combustible components exist in not yet fired wares, these must be added separately.</li> <li>In the case where amount of dry exhaust gas of combustion per <math>1 \text{ kg}</math> or <math>1 \text{ m}^3</math> of fuel <math>G'</math> (<math>\text{m}^3 \text{ } ^{\circ}\text{C}</math>) is to be obtained from compositions of exhaust gas of combustion and of fuel, the following formulae may be applied.           <p>(i) In the case of liquid fuel</p> <math display="block">G' = (m - 0.21) A_o + 1.867 \times \frac{c}{100} + 0.7 \times \frac{s}{100} + 0.8 \times \frac{n}{100}</math> <p>or <math>G' = \frac{1.867c + 0.7s}{(\text{CO}_2) + (\text{CO})}</math></p> <math display="block">m = \frac{(N_2) - 3.76[(O_2) - 0.5(\text{CO})]}{(N_2) - 3.76[(O_2) - 0.5(\text{CO})]}</math> <math display="block">A_o = \frac{1}{100} \left[ 8.89c + 26.7 \left( h - \frac{o}{8} \right) + 3.33s \right]</math> <p>where, <math>c</math> : mass percentage of carbon in fuel (%)<br/> <math>s</math> : mass percentage of combustible sulfur in fuel (%)<br/> <math>n</math> : mass percentage of nitrogen in fuel (%)</p> </li> </ol> |