Wear-resistant anticorrosive thermocouple specially designed for CFB

I.Brief introduction

Circulating fluid bed (CFB) boiler is provided with good environment-protective performance, it is also characterized by high fuel adaptability, strong capability in load regulation, and convenience in comprehensive utilization of clinker, and thus it has been increasingly regarded in many countries. In recent years, more and more power plants in China have adopted boilers that run as per the technology of circulating fluid bed, the capacity of generator sets has get higher and higher. In “Tenth Five-Year Plan”, it is put forward to further optimize the construction of thermal power generating units and to promote the popularization and application of circulating fluid bed boilers. The utility boilers 440t/h (CFB), which have been developed into mature products, are making giant strides as bamboo shoots after a spring rain. However, the problems such as corrosion resistance, wear resistance, and vibration resistance of thermocouple applied in detection of combustion system of a boiler always assail the operation of utility boilers, and these are the biggest difficulties to be solved by the thermal control personnel. Service life of most of the home-made wear-resistant thermocouples is 3~6 months, or even several hours. Service life of some high-quality thermocouples imported from foreign countries is usually approximately 10 months. Australian ECE Company has specialized in manufacturing of boiler temperature probes for 72 years; especially in the field of anticorrosive, wear-resistant and vibration-resistant thermocouple for temperature detection of circulating fluid bed boiler, it has several high-tech products that take the lead in the global industries. It adopts a type of specially processed wear-resistant materials that may solve the problem of service of temperature thermocouple for circulating fluid bed boiler, free of the lag in temperature detection; its protective sleeves are manufactured as per specific technologies that may ensure their wear resistance, high-temperature oxidation resistance, sulfuration resistance, resistance to cement materials such as liquid iron powder and lime stone, anti scour, and vibration resistance etc. such that the service life of thermocouple may reach 1 or 2 years or even 5 years in certain applications.

II.Main characteristics

・Wear-resistant material processing techniques: Apply high-tension electrical impulses onto the surface of alloy base material and generate local high heat that may have the base metal (for example: stainless steel 601) and tungsten-carbon molten and vaporized simultaneously; the both are rapidly merged and cooled down, and the whole process is finished momentarily. The processing technique may ensure that surface layer of the new alloy may be provided with extremely high hardness (C76), and the thickness of the alloy layer may reach 0.12" (3mm). As distinguished from metal coating techniques, this technique does not mean to coat metal onto the base material, but to generate a kind of new alloy on the surface of the base material; this metal layer is one piece with the base material, therefore the wear-resistant performance is significantly improved.

・Surface hardness of the processed tungsten-carbon alloy is up to Rockwell HRC76 (approximately equal to Vickers 1750, hardness level of ceramics), which is ten times the hardness of ordinary stainless steel. Hardness of most ordinary wear-resistant materials is lower than HRC60.

・Surface alloy layer and the base material of stainless steel belong to one piece, their heat expansion coefficient and brittle behavior are completely identical, and no cracking may take place in case of high heat.

・The wear-resistant alloy layer is provided with excellent resistance to high heat of up to 1800℃, and it allows long-term normal service in an environment of 1200℃.

・It is a type of tungsten-carbon compound, and its oxidation resistance is twice that of stainless steel 316.

It has a long service life, and its quality guarantee period is 12 months at the bed temperature of a coal fired boiler CFB.

III.Major technical parameters

1.Basic parameters

Insulation resistance > 100MÙ (at room temperature)

Test voltage: 500VDC

Electric outlet: M20*1.5 NPT1/2

Connection dimension: M27*2 NPT3/4

Level of protection: IP65

Accuracy class: Class 1

Flange standard:

US Standard: ASME/ANSIB116.5-88

German standard: DIN2628~2638-1975

2. Temperature range and permissible error

Graduation Number	Permission grade	
	Grade Ⅰ	
	Value of permissible error	Temperature detecting range (℃)
K	±1.5℃	-40~ +375
	±0.004t	375~1000
N	±1.0℃	-40~ +375
	±0.004t	375~800
S	±1.0℃	0~1100
	±[1+0.003(t-1100)]	1100~1600
B	±1.0℃	0~1100
	±[1+0.003(t-1100)]	600~1700

IV.References for type selection of temperature measuring-point thermocouple for CFB boiler

1.Recommended service temperature

Name	Graduation number	Manufacturing material of protective sleeve	Service temperature ℃		
			Long-term operating temperature	Short-term operating temperature	Instantaneous operating temperature
Vibration-resistant wear-resistant thermocouple	K	Metal	800	1100	1300
Vibration-resistant wear-resistant thermocouple	S	Metal	1200	1400	1600
High-temperature wear-resistant thermocouple	B	Nonmetal	1400	1600	1800
Note: The nonmetal thermocouple cannot be operated in an environment exposed to vibration.					

・Operating temperature for circulating fluid bed boiler shall be 950~1100℃.

・To select S-graduation thermocouple: Long-term measuring temperature for S-graduation thermocouple is 1200℃, and it may meet the requirements of safe operation of circulating fluid bed boiler. However, the S-graduation thermocouple is made of precious metal, and its operation is not very economical.

・To select K-graduation thermocouple: Long-term measuring temperature for K-graduation thermocouple is 800℃, its measuring temperature begins to drop after over-temperature application for 30 days, and oxidation damage may occur after over-temperature application for 90 days. Undamaged thermocouple may run still, but the measured values of temperature may be imprecise, the actual burner-hearth temperature it may endure shall drop for approximately 80℃, and it may not be applied in long-term detection of actual temperature of burner hearth. nevertheless it is possible to increase the diameter of thermocouple elements (maximum diameter of φ3.2mm) or adopt thermocouple core armored with alloy material to extend its service life; But the effect is still much more inferior to that of S-graduation thermocouple; however K-graduation thermocouple is made of low-priced metal, the long-term production cost is relatively low, so most users select K-graduation thermocouple still.

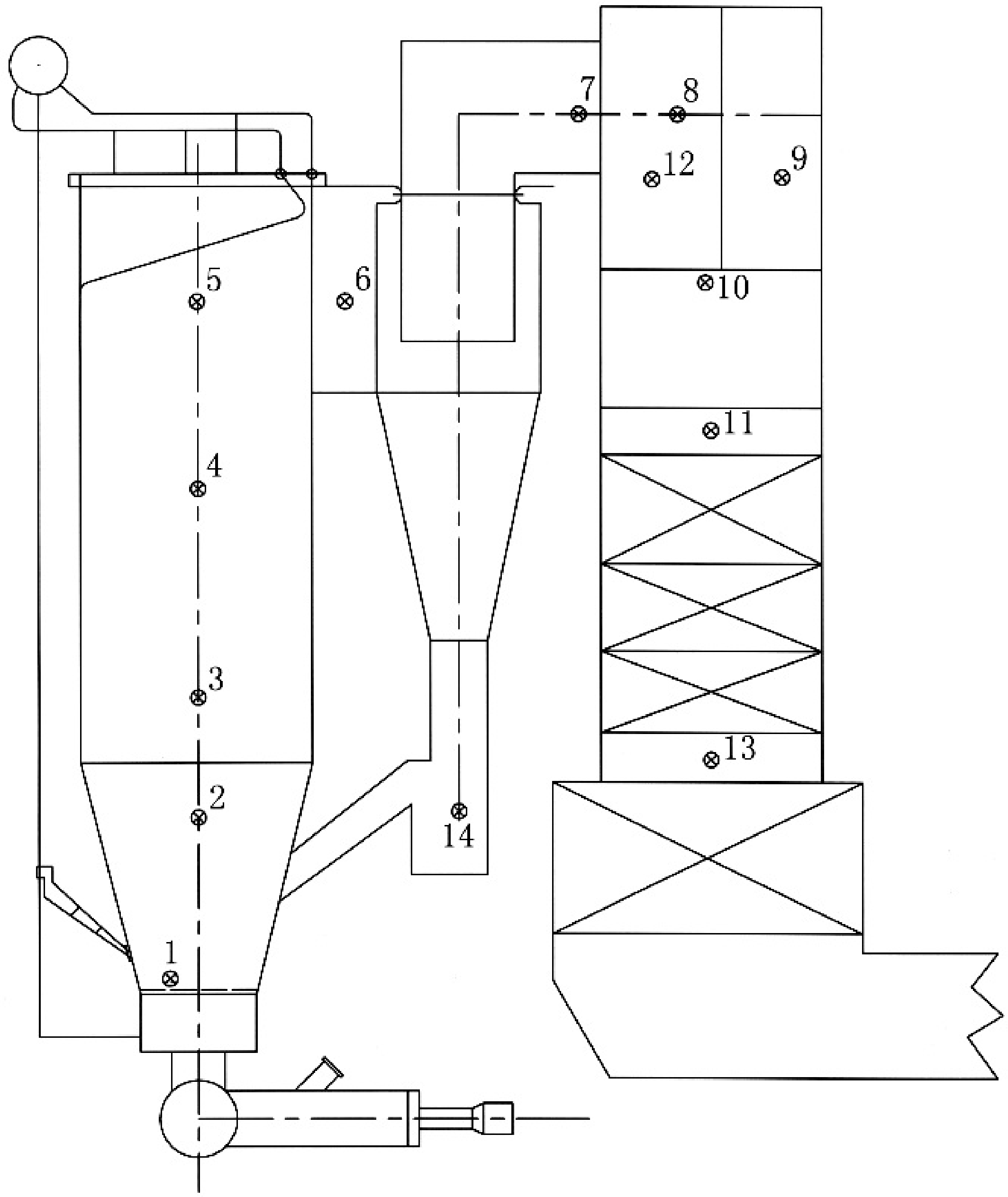
2.Recommended type selection as per temperature measuring point (temperature measuring point of boiler CFB 450t/h of a certain power plant is taken as example)

Temperature measuring	Normal operating temperature (℃)	Operation range (℃)	Quantity (pcs.)	Thermocouple		
				S graduation	K graduation	J graduation
Bed temperature of burner hearth	870	0~1100	24	√	O	
Burner hearth inside (left and right)	870~950	0~1000	8	√	O	
Burner hearth outlet (left and right)	883	0~950	2	√	O	
Cyclone inlet (left and right)	883	0~950	2	√	O	
Cyclone outlet (left and right)	871	0~930	2	√	O	
Temperature of charge returning device (left and right)	790	0~900	2	√	O	
Upper superheater inlet (left and right)	805	0~890	2	√	O	
Lower superheater inlet (left and right)	655	0~700	2	√	O	
Lower superheater outlet (left and right)	504	0~550	2	√	O	
Lower reheater inlet (left and right)	843	0~900	2	√	O	
Economizer outlet (left and right)	308	0~360	2		O	√ O
Air preheater outlet (left and right)	130	0~160	2		O	√ O

Note: Optimum type selection √, economy type selection O

(Temperature parameters and type selection of recommended temperature measuring point are for reference only; Actual measuring points shall be determined as per the technical parameters issued by the boiler manufacturer and the design organization)

3.Reference diagram for measuring points of CFB boiler



1.Bed temperature of burner hearth (24 points arranged in pairs)
2.Fluidized bed temperature (symmetrical arrangement)
3.Temperature of lower part of burner hearth (symmetrical arrangement)
4.Temperature of medium part of burner hearth (symmetrical arrangement)
5.Temperature of burner hearth outlet (symmetrical arrangement)
6.Temperature of cyclone inlet (symmetrical arrangement)
7.Temperature of cyclone outlet (symmetrical arrangement)
8.Temperature of upper superheater inlet (symmetrical arrangement)
9.Temperature of lower superheater inlet (symmetrical arrangement)
10.Temperature of lower superheater outlet (symmetrical arrangement)
11.Temperature of economizer outlet (symmetrical arrangement)
12.Temperature of lower reheater inlet (symmetrical arrangement)
13.Temperature of air preheater outlet (symmetrical arrangement)
14.Temperature of returned ash (symmetrical arrangement)

・For details of measuring point installation, see the installation drawing of high-temperature wall tube and wear-resistant thermocouplespecially designed for circulating fluid bed boiler.

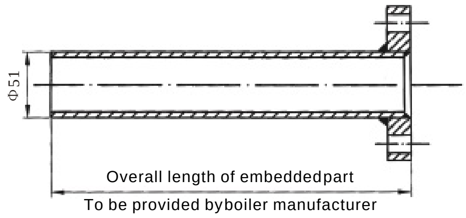
・The schematic diagram of vibration-resistant wear-resistant thermocouple (thermal resistor) is for reference only.

V.Table of type selection

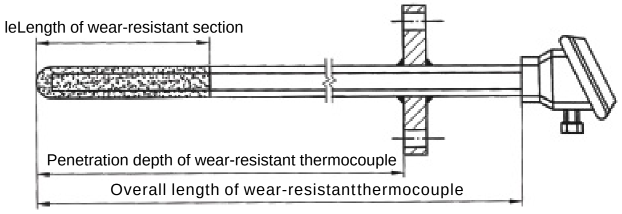
Item	Specification & Code	Description
Model	TS6……	Ruoduct code
Manufacturing material of protective sleeve	0……	301SS
	1……	253MA
	2……	Alloy 601
	3……	Alloy TC
	4……	Special manufacturing material
Installation mode	0……	No installation fittings
	1……	Thread
	2……	Adjustable flange
	3……	OEM
	4……	Customer design
Thermocouple element Category & Quantity	—K —N —S —B —J	
	0……	Single piece
	1……	Dual pieces
	2……	Three pieces
	3……	Four pieces
Element pattern	—A……	Porcelain-tube knockout core
	—B……	Armored knockout core
	—C……	Excalibur structure
Diameter of protective sleeve	—20……	mm
	—22……	mm
	—25……	mm
	—32……	mm
	—48……	mm
Length of protective sleeve	—□……	Optional less than 5000mm
Length of wear-resistant section	—SLT ……	Water-cooling jacket(See explanations in Page 7)
Auxiliary attachment	—CQT ……	Wall bushing(See type selection in Page 5)

VI.Drawings of auxiliary structures

1.Embedded part for wall bushing



2. Wear-resistant thermocoup



VII.Brief introduction to special-purpose high-temperature wall bushing

Over a long period of time, there is difficulty in replacement of thermocouple of circulating fluid bed boiler; the damaged thermocouple may hardly be withdrawn, and the renewals may hardly be inserted. It was said that the difficulty was caused by the ash accumulated inside the space between the wall bushing and protection tube of thermocouple; however it is not the truth. The major reasons are as follows: the wall bushing fabricated with stainless steel pipe or other steel pipes has poor temperature resistance only, creep deformation may take place in the bushing once the temperature gets higher than 800℃, the operating vibration may intensify the deformation of the wall bushing, and all these result in a seizure between the thermocouple and protection tube. The seizure leads to difficulty in replacement of damaged thermocouple. After operation for 3 months, deformation takes place in the wall bushing, it is very difficult to insert the thermocouple of original selected type, and people certainly will reduce the diameter of protection tube for the thermocouple, and the next renewals get smaller and smaller. As a result, the service life of the thermocouple may be reduced significantly.

High-temperature Wall Bushing CQT Series, which is specially designed for circulating fluid bed boiler, may eliminate the above-mentioned defects. Its major characteristics are as follows: Fabricated with high heat resistant material, provided with good high-temperature resistance, free of creep deformation at temperature of up to 1250℃, high strength, vibration resistant, free of bending, wear resistant, oxidation resistant, capable of limiting the burner-hearth penetration length of thermocouple, convenient replacement of thermocouple, and capable of good protection of thermocouple and lowering labor intensity.

1. Type and nomination of high-temperature alloy wall bushing

High-temperature alloy wall bushing CQT

- 1 Screw fixed type
- 2 Fixed thread M27 *2 or M33 *2
- 3 Loose flange D =70
- 4 Fixed flange D =95, 105, 115

- 1 Outer diameter ф40
- 2 Outer diameter ф45

- 1 Inner diameter ф28
- 2 Inner diameter ф33

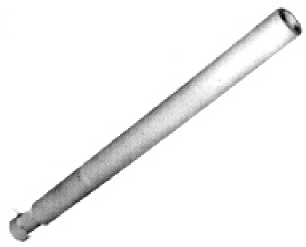
L Overall length (mm)

1 Facade (between diaphragm type walls) other positions omitted

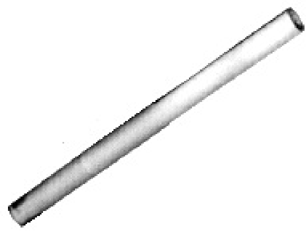
CQT □－□－□－□－□

Note:
1. Outer diameter ф40, inner diameter ф 28, applicable to thermocouple protection tubes with diameter less than ф25.
2. Outer diameter ф45, inner diameter ф33, applicable to thermocouple protection tubes with diameter less than ф32.
3. Facade indicates to install wall bushing between membrane type walls: 38mm

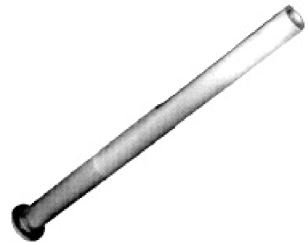
2. Outline drawing of high-temperature wall bushing



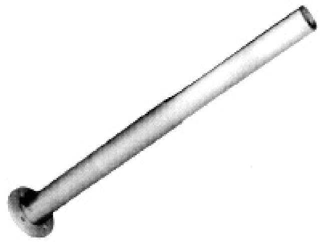
(1) Screw fixed type



(2) Fixed thread type

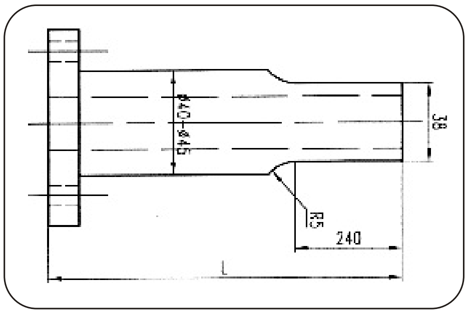


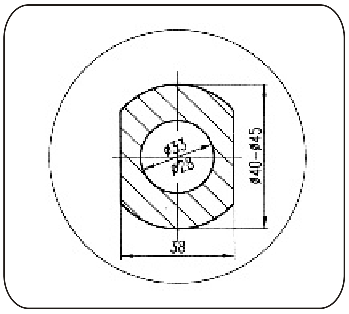
(3) Loose-flange fixed type

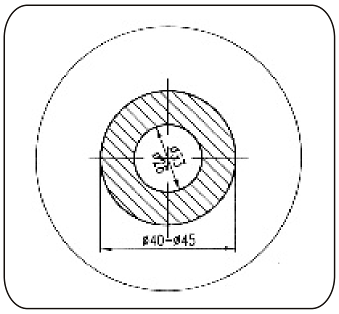


(4) Fixed flange type

3. Structure drawing of high-temperature wall bushing

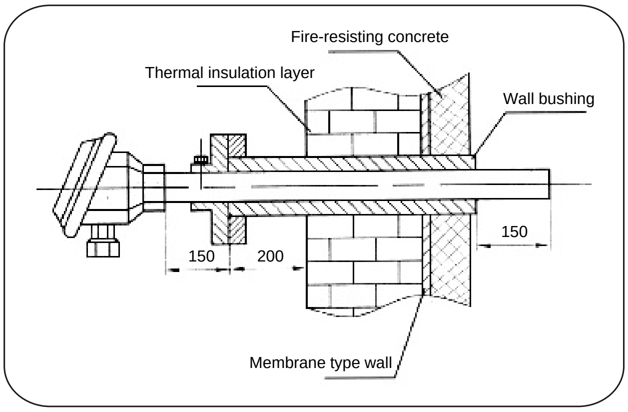




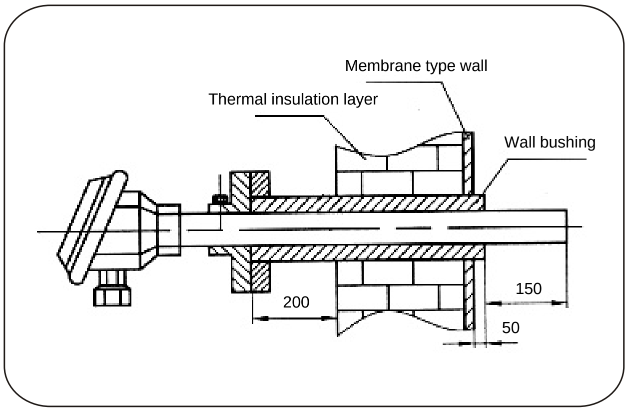


VIII.Installation drawing for mating applications

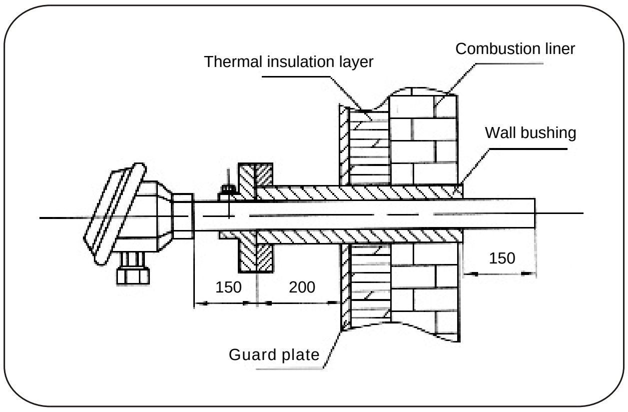
1. Upper part of charge layer and fluidized bed



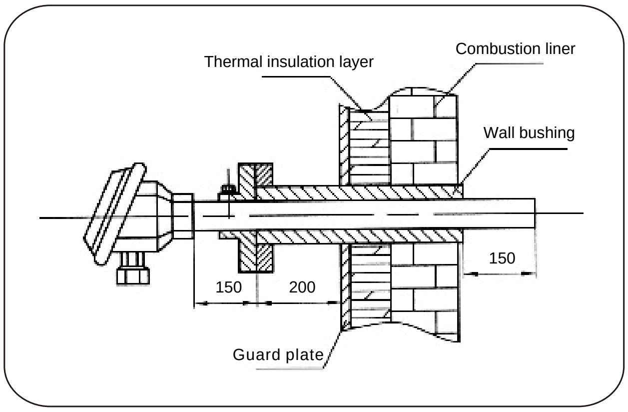
2. Medium/upper part of the burner hearth



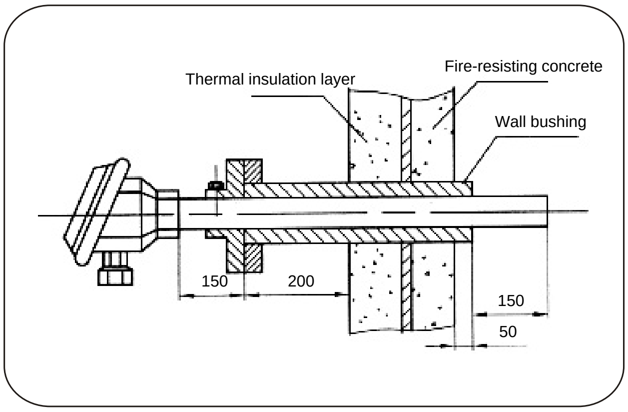
3. High/low-temperature superheater



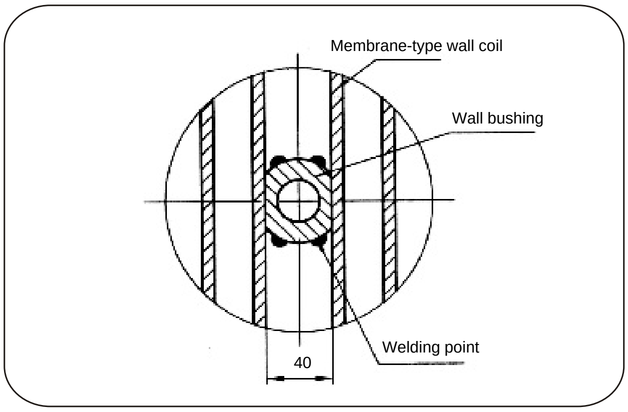
4. charge returning device, separator



5. Air chamber



6. Installation of membrane type wall

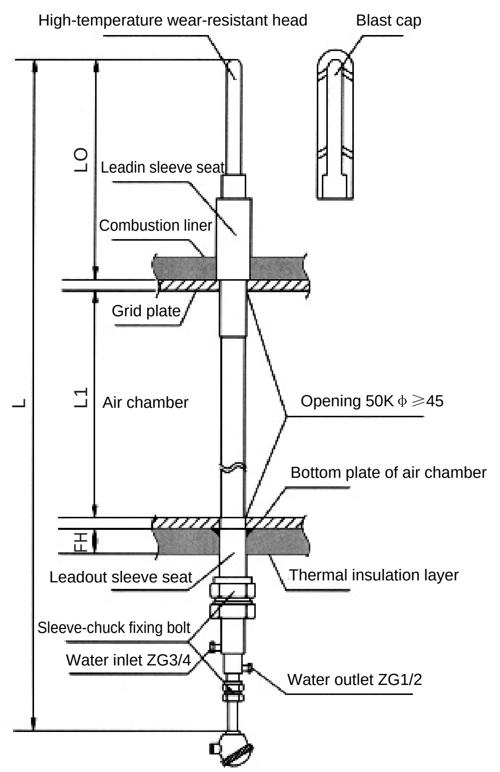


7. Vertical/oblique installation mode for thermocouple and water-cooled protective sleeve on grid plate

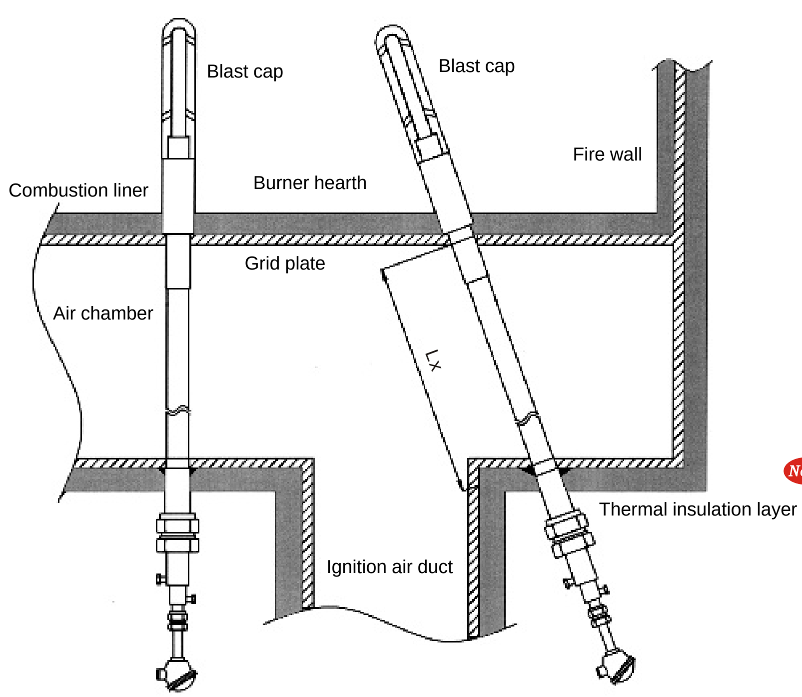
Protective sleeve is fixed to the grid plate at burner hearth, and the measuring-point openings in the grid plate at burner hearth and leadout openings in the bottom of air chamber are connected via straight pipe. Protective sleeve may be fixed to the burner-hearth grid plate as per two modes, namely welding fixation or implantation fixation into wear-resistant material on the hearth bottom. In case “welding fixation” is adopted, you have to remove the weld bond inside the air chamber before replacement of protective sleeve, so it is somewhat inconvenient. While, if you adopt the mode “ implantation fixation into wear-resistant material” , you may just demolish the surrounding wear-resistant material layer before pullout, and the replacement may be relatively convenient. The two fixation modes for protective sleeve may ensure the firmness and reliability of protective sleeve such that it may withstand the possible vibration due to the intense erosion of charge medium onto the sleeve, in addition, you may replace the thermocouple element when the boiler is in operation; it is important that the measuring-point opening and the leadout openings in the bottom of air chamber shall be mutually perpendicular or in one straight line; the installation sleeve inside the air chamber must be straight.

In case of large-size boiler with more measuring points, the feet of perpendicular axis of several points may be within the air intake duct of air chamber; if you allow it to pass trough the air intake duct and have it led out of the wall of expansion joint, the relative position of thermocouple may not be fixed due to the influence of the expansion joint, and installation will be fairly difficult. In such a case, a certain obliquity may be applied so as to avoid the air intake duct and make leadout opening in the bottom plate of the air chamber in correspondence with the oblique line. If this mode is applied, it is important that the central lines in the process of installation sleeve welding must be in one oblique line; otherwise it is impossible to install the connected straight pipe (To insert the protective sleeve with a certain obliquity into the burner hearth will have no influence upon the temperature measuring accuracy).

In service use, if you fix the protective sleeve onto the burner hearth and allow the installation sleeve to pass through the air chamber, the temperature inside the air chamber may get higher than 1200℃ in case of ignition, particularly long-term ignition for new-boiler boiling or boiler baking with improper control, any alloy material will be burnt, molten, or deformed seriously.. In such a case, water-cooling structure shall be fitted inside the installation sleeve and the problem may be solved thoroughly.



Schematic diagram for vertical installation of water-cooled sleeve



Installation with vertical insertion into air chamber

Installation with oblique insertion into air chamber

Schematic diagram for vertical installation on burner hearth

Form of ordering requirements

Installation mode	Penetration depth L0	Clear height of air chamber L1	Length of oblique line LXT	hickness of thermal insulation layer FH
Vertical installation	300	1.2m		
Oblique-line installation	300		1.3m	

Note: Instructions for installation and operation:

1. Thermocouple may be installed vertically or obliquely, and the tilt angle depends on the field condition.
2. The installation sleeve is welded onto the bottom plate of the air chamber; the penetration depth of water-cooled sleeve of the thermocouple into the burner hearth must not exceed the layer of fire-resisting placement material. The connection part between the wear-resistant head of thermocouple and water-cooled sleeve must be located inside the layer of fire-resisting placement material; the water-cooled sleeve and top plate of the air chamber may not be welded; the fire-resisting placement material shall be sealed.
3. When ignition of the boiler, water flow inside the water-cooled sleeve must be free of any clogging and any interruption. After the ignition oil gun is stopped for 30 minutes, it is allowed to turn off the water supply to the water-cooled sleeve, and this clause must be included into the regulations for operation of boilers. Case, water-cooling structure shall be fitted inside the installation sleeve and the problem may be solved thoroughly.

Installation site of water-cooled sleeve and thermocouple on grid plate of burner hearth

Installation drawing for water-cooled sleeve and thermocouple on grid plate of burner hearth (1)

Installation drawing for water-cooled sleeve and thermocouple on grid plate of burner hearth (2)

Installation drawing for water-cooled sleeve and thermocouple on grid plate of burner hearth (3)

Installation drawing for water-cooled sleeve and thermocouple on grid plate of burner hearth (4)

Installation drawing for water-cooled sleeve and thermocouple on grid plate of burner hearth (5)