ICS 27.100
K 54
Record No. J926—2009

DL

Electric Power Industry Standard of the People's Republic of China

P

DL / T 5428 — 2009

Technical Code for Design of I&C Protection System in Fossil Fuel Power Plant

Issue Date: July 22, 2009 Implementation Date: December 1, 2009

Issued by the National Energy Administration of the People's Republic of China

Electric Power Industry Standard of the People's Republic of China

P DL / T 5428 — 2009

Technical Code for Design of I&C Protection System in Fossil Fuel Power Plant

CHINA ELECTRIC POWER PRESS
BEIJING, 2011

Contents

Foreword

This code is revised according to *Circular of the General Office of National Development and Reform Commission on the Issuance of 2006 Industrial Standard Program* (FGBGY [2006] No. 1093).

This code is put forward by China Electricity Council.

This code is interpreted and under jurisdiction by Electrical Planning and Design Standardization Technical Committee of Power Industry.

This code is drafted by CPECC Southwest Electric Power Design Institute.

This code is mainly drafted by Zhang Jinbin, Xu Huiqiang, Yu Haiping, Song Chun, Zhang Yu and Du Shaomao.

This code comes into effect since the implementation date, in lieu of the complete contents of DLGJ 116—1993 *Technical Regulations on Design of Furnace Safe Supervisory System in Fossil Fuel Power Plant* and "Chapter Ⅵ Protection" of NDGJ 16—1989 *Technical Regulations on I&C Automation Design in Fossil Fuel Power Plant*.

Suggestions and comments during application of this code shall be fed back to the Standardization Center of China Electric Council (No.1, 2nd Lane, Baiguang Road, Beijing, 100761).

This code is translated by SUNTHER Translation & Solutions under the authority of China Electric Power Planning & Engineering Association.

1 Scope

This code specifies the design principles and design methods that shall be followed in power supply, logic and protection system configuration as well as equipment part of protection system in fossil fuel power plant.

This code is applicable to the design of new construction, expansion and betterment projects for condensing fossil fuel power plants with steam turbine generator unit rated 125MW– 1000MW, as well as the design of thermal power plants with capacity of 50MW and above.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this code. For dated references, subsequent amendments (excluding the contents of errata) to, or revision of, any of these publications do not apply. However, parties to agreements based on this code are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

GB/T 5578—2007 *Fixed Power Plant Turbine Specifications*

GB/T 13399—1992 *Specification for Steam Turbine Safety Monitoring Devices*

GB/T 13983—1992 *Instruments—Vocabulary—Basic Terms*

GB/T 17626.2—2006 *Electromagnetic Compatibility—Testing and Measurement Techniques—Electrostatic Discharge Immunity Test*

GB/T 17626.3—2006 *Electromagnetic Compatibility—Testing and Measurement Techniques—Radiated Radio-Frequency Electromagnetic Field Immunity Test*

GB/T 17626.4—2008 *Electromagnetic Compatibility—Testing and Measurement Techniques—Electrical Fast Transient/Burst Immunity Test*

GB/T 17626.5—2008 *Electromagnetic Compatibility—Testing and Measurement Techniques—Surge Immunity Test*

GB/T 17626.6—2008 *Electromagnetic Compatibility—Testing and Measurement Techniques—Immunity to Conducted Disturbances Induced by Radio-Frequency Fields*

GB/T 17626.8—2006 *Electromagnetic Compatibility—Testing and Measurement Techniques—Power Frequency Magnetic Field Immunity Test*

GB/T 17626.9—1998 *Electromagnetic Compatibility—Testing and Measurement Techniques—Pulse Magnetic Field Immunity Test*

GB/T 17626.10—1998 *Electromagnetic Compatibility—Testing and Measurement Techniques—Damped Oscillatory Magnetic Field Immunity Test*

GB/T 17626.11—2008 *Electro*magnetic *Compatibility—Testing and Measurement Techniques—Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests*

GB/T 17626.12—1998 Electro*magnetic Compatibility—Testing and Measurement Techniques—Oscillatory Waves Immunity Test*

GB/T 20438.1—2006 *Functional Safety of Electrical/Electronic/ Programmable Electronic Safety-related Systems—Part 1: General Requirements*

GB/T 20438.2—2006 *Functional Safety of Electrical/Electronic/ Programmable Electronic Safety-related Systems—Part 2: Requirements for Electrical/Electronic/Programmable Electronic Safety-related Systems*

GB/T 20438.3—2006 *Functional Safety of Electrical/Electronic/ Programmable Electronic Safety-related Systems—Part 3: Software Requirements*

GB/T 21109.1—2007 *Functional Safety—Safety Instrumented Systems for the Process Industry Sector—Part 1: Framework Definitions System Hardware and Software Requirements*

GB 50217—2007 *Code for Design of Cables of Electric Engineering*

GB 50229—2006 *Code for Design of Fire Protection for Fossil*

Fuel Power Plants and Substations

DL/T 435—2004 *Code for the Prevention of Pulverized Coal Firing Furnace Explosions/Implosions in Power Plant Boilers*

DL/T 589—1996 *Directives of Thermal Instrumentation and Control for Coal Fired Boiler in Power Plant*

DL/T 590—1996 *Directives of Thermal Instrumentation and Control for Condensation Type Turbine in Power Plant*

DL/T 591—1996 *Directives of Thermal Instrumentation and Control for Turbo-Generator in Power Plant*

DL/T 592—1996 *Directives of Thermal Instrumentation and Control for Boiler Feedwater Pump in Power Plant*

DL/T 641—2005 *Electric Valve Actuators for Power Plant*

DL/T 701—1999 *Thermopower Automation–Vocabulary for Fossil Fired Power Plant*

DL/T 711—1999 *Test Guide of Steam Turbine Governing System*

DL/T 834—2003 *Guide for the Prevention of Water and Cool Steam Damage to Steam Turbines in Fossil Power Plant*

DL/T 892—2004 *Specification of Steam Turbine for Power Plant*

DL 5000—2000 *Technical Code for Designing Fossil Fuel Power Plant*

DL/T 5182—2004 *Technical Rule for Designing of Local Equipment Installation, Pipeline and Cables of I&C in Power Plant*

SD 268—1988 *Specification for Power Station Coal Fired Boiler*

NFPA 85—2004 *Boiler and Combustion Systems Hazards Code*

ASME TDP-1 — 1998 *Recommended Practices for the Prevention of Water Damage to Steam Turbines Used for Electric Power Generation*

3 Terms and Definitions, Abbreviations

In addition to the terms and definitions specified in GB/T 13983 and DL/T 701, the following terms and definitions, as well as abbreviations are applicable to this code.

3.1 Terms and Definitions

3.1.1

One out of two for binary variable

Logic consisting of two binary variables reflecting the same event. When any variable is “true”, the logic output is “true”.

3.1.2

Two out of three for binary variable

Logic consisting of three binary variables reflecting the same event. When any two variables are “true”, the logic output is “true”.

3.1.3

Dual redundancy for analog variable

One variable is measured simultaneously by two analog variable transmitters or sensors for mutual standby.

3.1.4

Triple redundancy for analog variable

One variable is measured simultaneously by three analog variable transmitters or sensors for mutual standby.

3.1.5

Multiple redundancy for analog variable

One variable is measured simultaneously by more than three analog variable transmitters or sensors, for mutual standby.

3.1.6

Programmable electronic

Based on computer technology, programmable electronic can be composed of hardware, software, and their input and (or) output units.

3.1.7

Logic system

The part used to perform the decision and transition for functional logic in this system. A logic system provides output in particular sequence to respond to external input and internal logic. Logic system includes:

1 Hardwired system: devices and their interconnecting wiring.

2 The system based on microprocessor.

1) Computer hardware, power supply, I/O device and their interconnecting parts.

2) Operating system and logic software.

3.1.8

Programmable electronic logic system

Logic system based on one or more programmable electronic devices, used for control, protection or monitoring, which includes all elements in the system, such as power supply, input device, data highway, other communication channels, and output device, etc.. For example: PLC, DCS, etc..

3.1.9

Safety function

The function realized by safety-related programmable electronic system, other technical safety-related systems or external risk reduction facilities in respect of certain hazardous events, in order to achieve or maintain the safety state of controlled equipment.

3.1.10

Safety-related system

The specified system must be capable of realizing the required safety function to achieve or maintain the safety state of equipment controlled; the system alone or together with other safety-related programmable electronic systems, other technical systems or external risk reduction facilities can achieve the safety integrity required by the necessary safety function.

3.1.11

Safety integrity

The probability that safety-related system successfully achieves the safety function required under conditions specified and within the time specified.

3.1.12

Safety integrity level; SIL

A discrete level (one of the four possible levels), used to specify the safety integrity requirements of safety function assigned to safety-related programmable electronic system. SIL 4 herein is the highest, and SIL 1 is the lowest. See Table 3.1.12.

Table 3.1.12 Safety Integrity Level: Target Failure Variable for Safety Function Assigned to a Programmable Safety-Related System in Demanding or Continuous Operation Mode

Safety Integrity Level	Demanding or Continuous Operation Mode (Dangerous Failure Probability per Hour)
SIL 4	$\geqslant 10^{-9}$ and $< 10^{-8}$
SIL 3	$\geqslant 10^{-8}$ and $< 10^{-7}$
SIL 2	$\geqslant 10^{-7}$ and $< 10^{-6}$
SIL 1	$\geqslant 10^{-6}$ and $< 10^{-5}$
Note: see Para. 7.6.2.9 in GB/T 20438.1—2006 for detailed explanation	

3.1.13

Burner pair

The two diagonal burners on the same layer of tangentially fired furnace consist of one “burner pair”.

3.1.14

Pulverized coal feeder pair

In case that coal pulverizing system with storage bin and tangentially fired furnace are used, the pulverized coal feeders corresponding to the “burner pair” consist of one “pulverized coal feeder pair”.

3.1.15

Mass airflow

The value of airflow stated with mass as equivalent.

3.1.16

Local ignition

Performing ignition for burners one by one locally.

3.1.17

Remote ignition

Performing ignition for burners one by one in control room.

3.1.18

Automatic ignition

Performing ignition for burners automatically as per the stipulated ignition logic.

3.1.19

Environmental condition

The physical, chemical and biological conditions around instrumentation and protection and control equipment, including ambient temperature, relative ambient humidity, ambient pressure, electromagnetic field, gravity, inclination, power supply voltage and

frequency changes, harmonic wave, radiation, impact, vibration, corrosion, erosion, and flammable and combustible conditions.

3.2 Abbreviations

DCS: Distributed Control System

PLC: Programmable Logic Controller

UPS: Uninterrupted Power Supply

SOE: Sequence of Event

SIL: Safety Integrity Level

MFT: Master Fuel Trip

OFT: Oil Fuel Trip

FCB: Fast Cut Back

RB: Run Back

FSSS: Furnace Safety Supervisory System, composed of FSS and BCS

FSS: Furnace Safety System

BCS: Burner Control System

I/O: Input/Output

ETS: Emergency Trip System

DEH: Digital Electro-Hydraulic Control System

MCS: Modulation Control System

SCS: Sequence Control System

PCV: Pressure Control Valve

CPU: Central Processing Unit

SPDT: Single-Pole Double-Throw

DPDT: Double-Pole Double-Throw

4 General

4.0.1 Design of the protection system is an important part of I&C automation design in power plant, which shall be conducted according to the features of the unit, using equipment and components of advanced technology and reliable quality. New products and new technologies can only be adopted after successful tests and verification or other applicable evaluations.

4.0.2 Approved Standard design, typical design and reference design shall be adopted actively for design of the protection system in power plant.

4.0.3 In designing the protection system, regulations of DL 5000 and the current related national standards and industrial standards shall be implemented, and the requirements of this code shall be met.

4.0.4 In design of the protection system, integrated coordination shall be made with related control system, interlocking device, operation and process equipment and system.

5 Design Principles of Protection System

5.1 Design Principles of Power Supply

5.1.1 AC single-phase protection power supply shall be of voltage 220V, with allowable voltage fluctuation range 176V–264V, and allowable frequency fluctuation range 47.5Hz–52.5Hz; DC power supply can be either of voltage 220V with allowable fluctuation range 176V–286V, or of voltage 110V with allowable fluctuation range 88V–143V.

5.1.2 All protection devices shall be equipped with two AC 220V power supplies, one of which shall be AC uninterruped power supply (UPS), while the other of which shall be led from auxiliary emergency power supply or auxiliary low-voltage busbar. Where redundant UPS power supply system is provided, the two incoming lines can be powered by the UPS power supply, but shall be connected to different supply busbars. Two DC 220V (or 110V) power supplies can also be used, with DC current led from DC panel of battery. The two power supplies shall be in mutual standby and be transferred from one to the other automatically, with the transfer time interval not affecting normal functions of protection system.

5.1.3 When DC protection trip circuit is used, bipolar control shall be adopted, that is, the positive and negative sides are activated simultaneously.

5.1.4 The hardwired protection logic circuit and the independent protection drive circuit shall be equipped with power fuses or trippers respectively, and power supply monitoring shall be arranged for

important circuits.

5.1.5 For fault of main protection power supply, alarm independent from the programmable electronic logic system should be set up in the control room.

5.2 Logic Design Principles

5.2.1 During design of the protection system, measures to prevent malfunction shall be provided. Fault of single part in the system shall not cause malfunction of the protection. In case of interruption or recovery of power supply of protection system, action instruction will not be sent in error.

5.2.2 When programmable electronic logic system is used to realize main I&C protection logic, the following requirements shall be met:

1 Failure modes of components shall be evaluated, and effects of at least the following faults shall be evaluated and addressed.

1) Effects of changes in power supply conditions, including power supply interruption, fluctuation, steep drop, recovery, transient variation, and partial power loss, etc.;
2) Error and loss of memory;
3) Error of information transmission and information loss;
4) Input/output error (fault opening and breaking);
5) Signal error or failure to recognize signal;
6) Failure to address error;
7) Processor fault;
8) Fault of relay coil, and fault of relay contact (fault opening and breaking);
9) Timer fault.

2 Diagnosis means with function of monitoring processor logic shall be configured.

3 Fault of logic system shall not prevent the normal operation of operator.

4 Protection means to prevent unauthorized logic change shall be designed. During operation of the equipment, the relevant logic shall not be changed.

5 System response time (total time from inputting to outputting of information) shall be very short, so as not to cause negative effect.

6 Strong anti-interference capacity shall be provided, to prevent false action.

7 Fault of any individual part in logic system shall not hinder forced trip of steam turbine and boiler.

8 External watchdog timer for monitoring controller shall be configured.

5.2.3 Important I&C protection circuit of the unit with capacity of 300MW and above should be capable of conducting action test during unit operation, without disabling the protection function and affecting normal operation of the unit.

5.2.4 For important protection circuit to stop operation of boiler or steam turbine, dedicated manual trip button (duplicate or provided with cover) shall be disposed on the console, which shall be independent and directly connected to drive circuits for boiler and turbine shutdown.

5.2.5 Event review function shall be set up for unit of 125MW and above, with review span not less than 5min before and after trip, review interval time not more than 3s–5s, and review interval time for rapidly changing parameters such as speed and furnace pressure not more than 1s. The sequence of events logs shall be established for the causes of operations of boiler and turbine shutdown protection.

5.2.6 The principle of “protection first” shall be implemented.

Operation instructions of the protection system output shall have priority over any other instructions and shall be executed by the control circuit of the drive device of controlled object.

5.2.7 Contact signal input to the protection system should be passive dry contact and shall generally be taken from the terminal contacts of field binary variable instruments or controlled equipment.

5.2.8 After the controlled object has its state changed due to acceptance of protection action, it will not restore to the state before accepting the protection action automatically. After input conditions are met, protection logic can be reset automatically. Any measures for operator to switch on/off and reset logic protection manually shall not be set up.

5.3 Configuration Principles of Protection System

5.3.1 The boiler and turbine protection systems (i.e., FSS and ETS) may employ either safety-related systems or programmable electronic logic systems (DCS or PLC) that are implemented using soft logics or relay-forming hard logics. Where safety-related systems are used, they should be of certified systems in compliance with GB/T 20438.1—2006, GB/T 20438.2—2006, GB/T 20438.3—2006 and GB/T 21109.1—2007 that are applicable to high standard applications or have a safety integrity level of SIL3 under continuous operation mode. Where safety-related systems or other programmable electronic logic systems independent of unit control systems are used, they should have communication interfaces to unit control systems to transmit the monitoring information to the latter.

5.3.2 The protection systems except for boiler and turbine protection system should be implemented by programmable electronic logic systems (DCS or PLC) through the use of soft logics. The

programmable electronic logic systems adopted independent of unit control system should have communication interfaces with unit control system, to send monitoring information into unit control system.

5.3.3 When DCS or PLC programmable electronic logic system is used to implement the protection logic, the following requirements in addition to 5.2.2 shall be met as well.

1 At least the following requirements for electromagnetic compatibility shall be satisfied, namely, the system performance shall be normal under corresponding test conditions:

1) Level 3 for electrostatic discharge immunity test specified in GB/T 17626.2—2006;
2) General test level 3 for radiated radio-frequency electromagnetic field immunity and test level 4 for protection (equipment)'s resistance to radio-frequency radiation of digital cordless phones, specified in GB/T 17626.3—2006;
3) Level 3 for electrical fast transient test specified in GB/T 17626.4—2008;
4) Level 4 for surge immunity test specified in GB/T 17626.5—2008;
5) Test level 3 for immunity to conducted disturbances induced by radio-frequency fields, specified in GB/T 17626.6—2008;
6) Level 4 for stable and short-time acting magnetic field test specified in GB/T 17626.8—2008;
7) Level 4 for pulse magnetic field test specified in GB/T 17626.9—1998;
8) Level 4 for damped oscillatory magnetic field test

specified in GB/T 17626.10—1998;

9) All test levels for voltage dips and short interruptions (i.e., test level 0, 40 and 70) and voltage test level 40 and 0 for voltage variations, specified in GB/T 17626.11—2008;

10) Level 3 for ring wave test and level 3 for damped oscillatory wave test specified in GB/T 17626.12—1998.

2 Logic controller for protection system must be with redundancy, and output relay must be reliable.

3 Response time of protection action shall meet the requirements of the controlled object.

4 I/O channel shall have electric isolation.

5.3.4 DC relays should be adopted for protection logic; if power supply is from UPS, AC relays may be used.

5.3.5 Unless otherwise specially indicated, the protection system shall comply with the following “independence” principles:

1 Protection logic system for turbine shutdown and boiler shutdown shall be equipped with independent logic and independent redundancy controllers, independent input/output systems and independent power supply, functionally and physically independent of other logic systems, and shall not be in combination with any other logic systems (such as MCS and SCS).

2 One set of protection logic system shall be restricted to single unit and shall not be shared by multiple units.

3 Redundant I/O signals shall be input or output through different I/O modules and channels.

4 The binary variable instrument and analog variable transmitter/ sensor triggering protection signals for turbine shutdown and boiler shutdown shall be set up separately; when they are required to be

used in combination with other systems due to difficulties, their signals shall be first input into the protection system, and then led into other systems through isolation facilities.

5 The sampling systems of the binary variable instrument and analog variable transmitter/sensor triggering protection signals for unit shutdown and boiler shutdown shall not be used in combination with the transmitters of other systems, and the binary variable instrument and analog variable transmitter/sensor with redundancy shall not share one sampling system.

6 Action commands for steam shutdown and boiler shutdown shall not be transmitted through communication bus. Signals triggering turbine shutdown and boiler shutdown shall be hardwired.

5.3.6 The binary variable instrument with redundancy shall be set up according to the actual situation of unit equipment, which shall at least comply with the following requirements.

1 One out of two: differential between primary air pressure and furnace pressure (if required by the manufacturer).

2 Two out of three: positive furnace pressure, negative furnace pressure, differential between the flame scanner cooling air pressure and furnace pressure (or flame scanner cooling air pressure), condenser vacuum, lubricating oil pressure, fire-resistant oil pressure, and generator cooling water flow.

5.3.7 The analog variable instrument with redundancy shall be set up according to the actual situation of unit equipment, which shall at least comply with the following requirements.

1 Dual redundancy: reheated steam temperature, axial displacement, feed pump turbine speed, drum pressure, total forced draft air flow, differential pressure of inlet and outlet of boiler water circulating pump, outlet temperature of atmospheric fluidized bed cyclone

separator, and fuel pressure.

2 Triple redundancy: drum level of drum boiler, feed water flow of once-through boiler, furnace pressure, atmospheric fluidized bed pressure and fluidized airflow, turbine speed, main steam pressure, reheated steam pressure, and mill outlet temperature.

3 Multiple redundancy: atmospheric fluidized bed temperature.

5.4 Others

5.4.1 The measuring instrument and devices required for the protection system provided along with boiler shall at least be in conformity with the requirements of DL/T 589—1996 and SD 268—1998; the measuring instrument and devices required for the protection system provided along with the steam turbine shall at least be in conformity with the requirements of GB/T 5578—2007, DL/T 590—1996 and DL/T 892—2004; the measuring instrument and devices required for the protection system provided along with steam turbine generator shall at least be in conformity with the requirements of DL/T 591—1996; the measuring instrument and devices required for the protection system provided along with boiler feed pump shall at least be in conformity with the requirements of DL/T 592—1996.

5.4.2 Design of local equipment and pipeline shall meet the requirements of DL/T 5182—2004.

5.4.3 Cable design shall be in conformity with the regulations of GB 50217—2007 and 6.7 of GB 50229—2006.

6 Boiler Protection

6.1 Partial Protection for Boiler

6.1.1 Main steam pressure high protection

Protection against high main steam pressure shall include the following:

1 When main steam pressure exceeds the specified value Ⅰ, alarm shall be issued; if bypass systems with quick open function are provided, high pressure bypass valve shall be opened automatically and quickly.

2 When main steam pressure exceeds the specified value Ⅱ, pressure control valve (PCV) shall be opened automatically.

3 When main steam pressure exceeds the specified value Ⅲ, corresponding safety valve shall be opened automatically.

4 When saturated steam pressure of boiler exceeds the specified value, drum safety valve shall be opened automatically.

6.1.2 Protection against high reheated steam pressure

Protection against high reheated steam pressure shall include the following:

1 When reheater outlet pressure exceeds value Ⅰ specified, alarm shall be given; if bypass system with quick open function are provided, low pressure bypass valve shall be opened automatically.

2 When reheater outlet pressure exceeds value Ⅱ specified, hot reheater safety valve shall be opened automatically, and alarm shall be given.

6.1.3 High and low pressure bypass protection.

See 8.5.

6.1.4 Protection against high reheated steam temperature.

When temperature of hot reheated steam section exceeds the specified value, emergency water spray valve shall be opened with override.

6.1.5 Drum level protection.

Drum level protection shall include the following:

1 When drum level reaches the specified value Ⅰ, alarm shall be given; when it reaches the specified value Ⅱ, emergency drum drain valve shall be opened automatically and alarm shall be given; when it reaches the specified value Ⅲ specified, emergency boiler shutdown (MFT) shall be done automatically.

2 When drum level drops to the specified value Ⅰ, alarm shall be given; when it drops to the specified value Ⅱ, alarm shall be given; when it drops to the specified value Ⅲ specified, emergency boiler shutdown (MFT) shall be done automatically.

6.1.6 Water supply failure protection for forced circulation boilers

When differential inlet and outlet pressure of boiler water circulating pump in operation drops to the specified value Ⅰ, alarm shall be given; when it drops to the specified value Ⅱ, such pump shall be removed out of service, and the standby boiler water circulating pump shall be started automatically. In case of trip of all boiler water circulating pumps, or small differential pressure or flow loss before and after all boiler water circulating pumps, emergency boiler shutdown (MFT) shall be done automatically.

6.1.7 Water supply failure protection for once-through boiler.

Water supply failure protection for once-through boiler shall include the following:

1 When feed water flow drops to the specified value Ⅰ, alarm shall be given;

2 When feed water flow drops to the specified value Ⅱ, emergency boiler shutdown (MFT) shall be done automatically;

3 When all boiler feed water pumps trip, emergency boiler shutdown (MFT) shall be done automatically.

6.1.8 Boiler partial flame loss protection.

Boiler partial flame loss protection of boilers shall include the following:

1 For tangentially fired boiler with capacity of 1000t/h and above, in case of flame loss of a single burner, alarm signal shall be given, and the operator shall judge whether to stop corresponding burner pair, or to stop the pulverized coal feeders or coal mills corresponding to all burners at the layer.

2 For wall or arch fired boiler with capacity of 1000t/h and above, in case of flame loss of single burner, alarm shall be given; When the number of flame-out burners that are served by the same coal mill or pulverized coal feeder exceeds the specified value, the associated coal mill or pulverized coal feeder shall be stopped automatically.

3 For tangentially fired boiler for direct-fired pulverizing system of fan mill with capacity of 1000t/h and above, in case of flame loss of a single burner, alarm shall be issued, and the operator shall judge whether to stop the corresponding coal mill; when the quantity of flameout burners at a corner is more than the specified value, corresponding fan mill shall be stopped automatically.

6.1.9 The design for other partial protections of boilers should comply with the requirements for boilers and their process system features.

6.2 Boiler Furnace Safety Protection

6.2.1 Explosion-proof design for furnace of pulverized coal fired

boiler shall be in conformity with the regulations of DL/T 435—2004.

6.2.2 Boiler purging.

1 For atmospheric fluidized bed boiler, when bed fluidization and bed temperature are more than the limit values for ignition and there is no boiler trip mode, the purging logic can be bypassed. In addition, the furnace (including flue ducts) must be purged before boiler ignition, and all purging conditions must be met at the beginning and during the process of purging. When any of the purging conditions is not met, purging timing shall be stopped immediately. When purging conditions are met again, purging program shall be restarted.

2 Purging sequence control function for single oil gun should also be provided for boilers with a capacity of 670t/h and above.

3 Purging time for boiler furnace shall not be less than five minutes, or shall be equivalent to the time required for five times of air changes in volume of the furnace and its rear pressure-bearing member, whichever is the greater.

4 Basic purging conditions for boiler furnace shall be determined according to boiler capacity and type of coal pulverizing system, in accordance with the conditions listed in Table 6.2.2. Certain conditions can also be added according to the requirements of boiler manufacturer, such as:

1) All auxiliary air dampers shall be opened to purging positions;
2) All hot air dampers shall be closed;
3) Others.

5 Indication shall be available after purging is completed, and MFT logic shall be reset automatically through purging completion

signal.

Table 6.2.2 Purging Conditions for Boiler Furnace

S/N	Purging Conditions	Storage Bin Pulverizing System		Direct-Fired Pulverizing System	
		220t/h–670t/h	1000t/h–3000t/h	220t/h–670t/h	1000t/h–3000t/h
1	No MFT trip conditions exist	√	√	√	√
2	At least one forced draft fan (FDF) is operating, with corresponding air damper open	√	√	√	√
3	At least one induced draft fan (IDF) is running, with corresponding air damper open	√	√	√	√
4	Both rotary air preheaters are put into operation	√	√	√	√
5	Both electrostatic precipitators trip	√	√	√	√
6	Furnace air flow is within the range of 25%–40% of rated load mass airflow (or determined by test)	△	√	△	√
7	Main fuel (or gas) shut-off valve or quick closing valves are closed, and main gas vent valve is open	√	√	√	√
8	All oil gun (or gas gun) shut-off valves or quick closing valves are closed, and all gas vent valves of gas guns are open	○	√	○	√
9	All primary air fans trip	√	√	√	√

Table 6.2.2 (continued)

S/N	Purging Conditions	Storage Bin Pulverizing System		Direct-Fired Pulverizing System	
		220t/h–670t/h	1000t/h–3000t/h	220t/h–670t/h	1000t/h–3000t/h
10	All pulverized coal exhausters and feeders trip	√	√		
11	All coal feeders and mills trip			√	√
12	Water level of drum or steam-water separator is normal (up to the level required for ignition)	√	√	√	√
13	No flame is detected by flame scanners	√	√	√	√
14	Power supply of boiler furnace safe supervisory system is normal	√	√	√	√
15	"Purging" instruction is started	√	√	√	√
16	Oil leakage test is passed	△	√	△	√
Note: mark "√" in the table means strict requirement, showing that it shall be done under normal circumstances; mark "△" means slightly optional requirement, showing that it shall be done first under the permitted conditions; mark "○" means optional requirement, showing that it can be done under certain conditions					

6.2.3 Leakage test for oil system.

It shall be implemented in accordance with the special regulations of boiler manufacturer, if any. Unless otherwise specially specified, the following requirements shall be met:

1 Before furnace purging program is started, leakage test for oil system should be conducted, which can also be bypassed through

keyboard or program controller.

2 Each safety shut-off valve and oil return valve of oil burner shall be closed, and quick-closing valves and control valve of main oil pipe shall be opened, then the system oil pressure shall reach the specified value within one minute, otherwise it may be determined that leakage test fails; afterwards, the quick-closing valves of main oil pipe shall be closed, the oil pressure shall maintain for more than three minutes, otherwise it may also be determined that leakage test fails. Acoustic and optical alarm signal shall be given if leakage test fails.

3 After the aforesaid test is completed, oil return valve shall be opened, and then closed when oil pressure is less than the specified valve, which shall still be less than the specified value after 3min, otherwise it may be determined that leakage test fails. Acoustic and optical alarm signal shall be given if leakage test fails.

4 Indication shall be given for leakage test meeting requirements, and furnace purging program shall be started automatically.

6.2.4 Flame detection and flame loss protection.

1 Flame monitoring shall be conducted respectively for each coal, oil, and gas burner to facilitate the use of flame monitoring and flame loss protection based on single burner.

2 Where there is “critical flame” monitoring logic in boiler furnace safe supervisory system, it can only be used as alarm signal before verified.

3 The pulverized coal fired boiler with a capacity of 410t/h and above should be equipped with industrial television(s) for monitoring furnace flame.

4 Flame scanner system shall have self-check function. In case of fault of detection system, the signal indicating faulty flame

detection system shall be given.

5 Reliable cooling air system for flame scanners must be provided, such as dedicated flame scanners in mutual standby for cooling fans. If proved reasonable technically and economically, other reliable air source can also be used as cleaning air and cooling air for flame detection.

6.2.5 Furnace pressure protection.

1 High and low furnace pressure must be measured near the measuring point of conventional furnace pressure gauge or pressure transmitter at the same level.

2 High and low furnace pressure alarm signals should be given by pressure switches.

3 High and low furnace pressure trip signals shall be given by pressure switches, using “two out of three” logic, with separate sampling of three pressure switches. After a short delay, master fuel trip (MFT) signal shall be sent.

6.3 Boiler Trip Protection

6.3.1 In case of any of the following situations for boiler in operation, a MFT instruction shall be sent to realize emergency shutdown protection:

1 Manual shutdown instruction.

2 Loss of all flame (delay).

3 Furnace pressure excessively high (as high as value Ⅲ, delay).

4 Furnace pressure excessively low (as low as value Ⅲ, delay).

5 Drum level excessively high (as high as value Ⅲ, delay).

6 Drum level excessively low (as low as value Ⅲ, delay).

7 All forced draft fans trip.

8 All induced draft fans trip.

9 All primary air fans trip when only pulverized coal burners are put into operation.

10 All fuel is cut off.

1) Atmospheric fluidized bed boiler: all fuel is cut off, and the bed temperature is unsuitable for any fuel feeding.
2) Direct-fired pulverizing system: all coal mills trip or all coal feeders trip, and the main fuel (gas) valve or all branch fuel (gas) valves are closed.
3) Storage bin pulverizing system: all coal feeders trip and all pulverized coal exhausters (primary air fans) trip, and the main fuel (gas) valve or all branch fuel (gas) valves are closed.

11 Total airflow is less than purging airflow by 5% of full load airflow.

12 Reheater is overheated (should trip).

13 Unit system steam turbine trips (when bypass for operation is not set up, or capacity of bypass for operation is not applicable).

14 Protection system power supply is lost.

15 Cooling air for flame detection of pulverized coal fired boiler is lost.

In addition, the following MFT conditions shall be added for boiler with different characteristics:

1) All boiler water circulating pumps trip, or differential pressure before and after all boiler water circulating pumps is small or flow is lost (for forced circulation boilers);
2) Bed temperature is too high or flue gas temperature of

furnace outlet is too high (for atmospheric fluidized bed boilers);

3) Bed temperature is lower than the temperature at which it is allowed to feed main fuel, and flame of start-up burner is not confirmed (for atmospheric fluidized bed boilers);
4) All fluidized fans trip or fluidized airflow is too small (for atmospheric fluidized bed boilers);
5) Cooling water flow of fluidized bed system components is too small (for atmospheric fluidized bed boiler);
6) Feed water flow is too small (for once-through boilers);
7) All feed water pumps trip (for once-through boilers);
8) Other protection items provided by boiler manufacturer.

6.3.2 When a pulverized coal boiler operates on fuel oil, an OFT instruction shall be issued if any of the following conditions occur:

1 Item 1 to Item 8, Item 11 and Item 15 of MFT conditions;

2 Main fuel valve or the final safety shut-off valve of oil burner is closed;

3 Fuel oil pressure is too low;

4 Pressure of atomizing medium for oil burner is too low (for non-mechanical atomization).

6.3.3 The alarm values of furnace pressure, drum level, reheated steam temperature, fluidized bed temperature and fluidized airflow, and feed water flow of once-through boiler, the actuation value and delay of MFT shall be designed based on the data provided by the boiler manufacturer.

6.3.4 FDFs and IDFs shall not trip in case of MFT that is not caused by tripping of FDFs and IDFs. At this time, if the airflow is larger than the purging airflow, the airflow may be slowly decreased

to the purging airflow; if the airflow is lower than the purging airflow, it shall be maintained unchanged for 5 minutes and then increased to the purging airflow gradually at which purging is conducted after flame loss.

6.3.5 When the interlocking used is for startup, shutdown and tripping of FDFs and IDFs in pairs, if only one FDF trips, the corresponding IDF shall be tripped, and dampers associated with both fans shall be closed. If it is the last FDF in operation that trips, the IDFs shall be maintained in operation under controlled condition, and dampers associated with the FDF shall be maintained in open position.

6.3.6 When all FDFs trip, master fuel trip (MFT) instruction shall be given, and the override of control device for IDF shall be actuated. After a certain delay, all FDF dampers shall be opened and kept in open state. The dampers of flue gas recirculating fan system shall be closed. If the manufacturer of atmospheric fluidized bed boiler has special requirements, these requirements shall be followed.

6.3.7 When the interlocking used is for startup, shutdown and trip of FDFs and IDFs in pairs, if only IDF trips, the corresponding FDF shall be tripped, and the dampers associated the both fans shall be closed. If it is the last IDF in operation that trips, the dampers associated with the both fans shall be maintained in open position.

6.3.8 When all IDFs trip, the master fuel trip (MFT) instruction shall be given, and all the FDFs shall be tripped. After a certain delay, all IDF dampers shall be opened and kept in open state. The dampers of flue gas recirculating fan system shall be closed. If the manufacturer of atmospheric fluidized bed boiler has special requirements, these requirements shall be followed.

6.3.9 If emergency shutdown is due to loss of all FDFs or IDFs, or

all the FDFs or IDFs have been tripped, all dampers on flue gas and air ducts shall be opened slowly to the fully open position to establish natural ventilation as practical as possible. The process of opening fan dampers shall be timed or controlled in order to avoid excessive positive pressure or negative pressure generated in furnace during inertial motion of fans. Such natural ventilation state shall be kept for at least 15min. After that, if fans can be restarted, fans shall be started and airflow shall be adjusted to purging airflow slowly to complete post-flame loss furnace purging according to corresponding regulations. If the manufacturer of atmospheric fluidized bed boiler has placed special requirements, these requirements shall be followed.

6.3.10 When positive furnace pressure exceeds normal operation pressure and reaches the limit value specified by boiler manufacturer, MFT shall be triggered. After trip, if fans are still in operation, operation shall be continued, but the air flow shall not be increased manually or automatically. Following MFT and subsequent furnace purging, if furnace pressure is still more than the specified value of boiler manufacturer before main fuel ignition, all FDFs shall trip.

6.3.11 When negative furnace pressure exceeds the negative pressure for normal operation and reaches the limit value specified by boiler manufacturer, MFT shall be triggered. After trip, if fans are still in operation, operation shall be continued, but the air flow shall not be increased manually or automatically. After MFT and subsequent furnace purging, if negative furnace pressure is still more than the specified value of boiler manufacturer before main fuel ignition, all IDFs shall trip.

6.3.12 It is not allowed to scavenger oil pipes immediately after master fuel trip (MFT) or fuel oil trip (OFT).

6.3.13 In case of master fuel trip (MFT) or fuel oil trip (OFT), indication signal of "cause for trip" must be given.

6.3.14 When master fuel trip (MFT) occurs, the following commands shall be executed automatically:

1 All coal mills shall be stopped and all outlet dampers of coal mills shall be fully closed (for direct-fired pulverizing system);

2 All coal feeders shall be stopped (for direct-fired pulverizing system);

3 All pulverized coal feeders shall be stopped (for storage bin pulverizing system);

4 All pulverized coal exhausters shall be stopped (for storage bin pulverizing system);

5 All primary air fans shall be stopped and primary air dampers shall be closed;

6 The main oil (gas) fuel safety shut-off valve and quick-closing valve shall be closed, and the main gas vent valve shall be opened;

7 All oil (gas) fuel safety shut-off valves and quick-closing valves shall be closed, and all gas vent valves of gas gun shall be opened;

8 Spraying water control valves and shut-off valves of superheater and reheater shall be closed;

9 All igniters shall be switched off, and ignition gun and oil (gas) gun shall be retracted;

10 Electrostatic precipitator shall be stopped;

11 Operation of soot blower shall be blocked, the soot blower in operation shall be removed out of service automatically;

12 Flue gas desulfurization and de-NO_x devices shall be stopped;