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Technical Code for Stress Calculating of Steam/Water Piping in Fossil Fuel Power Plant

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Foreword

This code is prepared as required by *Notice on Issuance of Plan for Development of Electric Power Industry Standards in 2006* issued by the General Office of National Development and Reform Commission (FGBGY [2006] Document No. 1093).

Appendices A and C to this code are normative; Appendix B is informative.

This code will be effective upon implementation and replace SDGJ 6-1990 *Technical Rule for Stress Calculating of Steam/Water Piping in Fossil Fuel Power Plant*.

This code is proposed by China Electricity Council.

This code is managed and interpreted by Technical Committee on Electric Power Planning and Engineering of Standardization Administration of Power Industry.

This code is drafted by East China Electric Power Design Institute.

The leading authors of this code: Gu Jin and Shen Qinfeng.

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

1 Scope

This code specifies the basic technical requirements for the calculation of stress in steam/water piping in fossil fuel power plants.

This code applies to the calculation of stress in steam/water piping made of low carbon steel, low alloy steel and high chrome steel in newly built, expanded or modified fossil fuel power plants.

This code may provide reference for the calculation of stress in oil and gas piping and non-nuclear related piping in nuclear stations.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments (excluding the contents of errata) to, or revisions of, any of these publications do not apply. However parties to agreements based on this standard 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.

DL/T 5054 *Code for Design of Thermal Power Plant Steam/Water Piping*

SY/T 5037 *Spiral Submerged Arc-Welded Steel Pipe for Pipelines for Low Pressure Fluid Service*

ASME B31.1—2004 *Power Piping*

3 General

3.0.1 The calculation of piping stress mainly addresses the primary stress that occurs under internal pressure, dead weight and other external loads, and the secondary stress that occurs in constrained displacement arising from thermal expansion and contraction. It also deals with the judgment and calculation of piping safety, economy and rationality, as well as that the thrust and moment created by piping on equipment shall be within the affordable range of the equipment.

3.0.2 The thermal expansion stress of piping shall be checked for stress range within cold and hot change range. The thrust and moment acting on equipment by piping shall be checked respectively according to the maximum possible values under cold and operating conditions.

3.0.3 Proper cold spring may reduce the hot state stress and hot state thrust of piping on ends during initial piping operation, as well as reduce the local overstrain of piping system. Cold spring is irrelevant to the checked stress range.

3.0.4 An entire piping system may be assumed as an elastomer in analyzing its flexibility.

3.0.5 The units and meanings of the symbols used in this code are given in Appendix A.

4 Allowable Stress of Steel

4.0.1 The allowable stress of steel shall be determined according to the relevant strength characteristics as one of the following three values, the minimum of which shall apply:

$$\sigma_b^{20}/3\,;\quad \sigma_s^t/1.5 \text{ or } \sigma_{s(0.2\%)}^t/1.5\,;\quad \sigma_D^t/1.5$$

Where:

σ_b^{20} —minimum tensile strength of steel at 20℃, MPa;

σ_s^t —minimum yield strength of steel at design temperature, MPa;

$\sigma_{s(0.2\%)}^t$ —minimum yield limit of steel at design temperature with 0.2% residual deformation, MPa;

σ_D^t —10^5 h average creep strength of steel at design temperature, MPa.

4.0.2 The properties of common steels are given in Appendix B.

4.0.3 In the case of steels not included in Appendix B, their allowable stresses shall be calculated as set forth herein if they are in line with relevant technical specifications to serve as steam/water piping system materials.

5 Piping Design Parameters

5.1 Determination of Design Pressure

The piping design pressure (gauge pressure) refers to the maximum operating pressure of the medium within pipe during operation. In determining the design pressure of water piping, the effect of static pressure of water column shall be considered, which can be omitted as it is lower than 3% of the rated pressure. The design pressure of main piping shall be determined as follows:

5.1.1 Main Steam Piping

For boilers installed on the unit system (i.e., one boiler and one turbine or other prime mover) and provided with automatic combustion control equipment responsive to steam header pressure, the design pressure for the steam piping shall be no less than the design pressure at the throttle inlet plus 5%, or no less than 85% of the lowest pressure at which any drum safety valve is set to blow, or no less than the expected maximum sustained operating pressure at any point in the piping system, whichever is greater. For once-through boilers, the design pressure of the main steam piping shall be no less than the expected maximum continuous pressure either.

For main steam piping that is connected to superheater outlet header, in addition to the foregoing provisions, the design pressure shall be no less than 85% of the lower limit of superheater safety valve setting pressure or that of any drum safety valve, whichever is greater.

5.1.2 Reheat Steam Piping

This will be determined as 1.15 times the HP turbine exhaust

pressure in the heat-balance diagram under maximum calculated output condition (Valve Wide Open, VWO in short). As for the section from the reheater outlet header to the turbine, the design pressure may be reduced to the lowest setting pressure at which the reheater outlet safety valve is able to operate.

5.1.3 Extraction Piping for Steam Turbine

The design pressure for non-adjustable extraction piping shall be determined as 1.1 times the extraction pressure of the steam turbine under the maximum calculated output condition, and no less than 0.1 MPa. The design pressure for adjustable extraction piping shall be determined as its maximum operating pressure.

5.1.4 Back Pressure Steam Turbine Exhaust Piping

The design pressure shall be determined as its maximum operating pressure.

5.1.5 Steam Piping Downstream Pressure Reducing Device

The design pressure of piping after pressure reducing device equipped with safety valve shall be determined as the lowest setting pressure of the safety valve.

5.1.6 Steam/Water Piping Connected with Once-through Boiler Startup Separator

The design pressure shall be determined as the maximum possible operating pressure of the separator under various conditions.

5.1.7 High Pressure Feedwater Piping

1 For the outlet piping section of the constant speed feedwater pump from the booster pump to the main feedwater pump or from the main feedwater pump to the boiler economizer inlet, the design pressure shall be the sum of the pressure corresponding to the highest point on the booster pump or the main feedwater pump characteristic curve and the pressure at the inlet side.

2 For the outlet piping section of variable speed feedwater pump from the feedwater pump outlet to the first shut-off valve, the design pressure shall be the sum of the pressure corresponding to the highest point on the characteristic curve under the rated pump speed and the pressure at the inlet side; for the section from the first pump outlet shut-off valve to the boiler economizer inlet, the design pressure shall be the sum of 1.1 times the pressure lift of the pump under the rated speed and design flow and the pressure at the inlet side.

3 For the above high pressure feedwater piping pressures, the correction of the inlet water temperature on pressure shall be taken into consideration.

5.1.8 Low Pressure Feedwater Piping

1 For a constant pressure deaeration system, the design pressure shall be the sum of the rated pressure of deaerator and the static pressure of water column corresponding to the highest water level of the deaerator.

2 For a sliding pressure deaeration system, the design pressure shall be the sum of 1.1 times the deaerator heating extraction pressure under the maximum calculated output condition of the steam turbine and the static pressure of water column corresponding to the highest water level of the deaerator.

5.1.9 Condensate Piping

1 For the piping at the inlet side of the condensate pump, the design pressure shall be determined as the static pressure of water column between the pump inlet center line and the steam turbine exhausting casing port (at which point the pressure inside condenser is to be considered as atmospheric pressure), and no less than 0.35 MPa.

2 For the outlet side piping of single stage pump system, the design pressure shall be the sum of the pump lift when the pump outlet

valve is shut off and the inlet side pressure (the foregoing water static pressure).

3 For the condensate pump outlet side piping of two stage pump system, the design pressure shall be determined following the same principle as single stage pump.

4 For the outlet side piping of the condensate booster pump in two stage pump system, the design pressure shall be the sum of the lifts of the two pumps (condensate pump and condensate booster pump) when the outlet valve is shut off.

5.1.10 Heater Drainage Piping

The design pressure shall be determined as 1.1 times the extraction pressure of steam turbine under the maximum calculated output condition, and no less than 0.1 MPa. Where the pressure increment as a result of the drainage static pressure in the piping is above 3% of the extraction pressure, the static pressure shall also be taken into account.

5.1.11 Boiler Blowdown Piping

At upstream of the blowdown valve, or its downstream where a valve or blocking plate is installed which might cause the piping pressure to rise, the design pressure for periodic blowdown pipes shall be no less than the sum of the lowest setting pressure among all the safety valves on the boiler drum and the static pressure of water column of the highest water level of the boiler drum in relation to the lowest point of piping; for continuous blowdown pipe, it shall be no less than the minimum pressure setting among all safety valves on the boiler drum. Where nothing downstream the blowdown valve may cause a rise in piping pressure, the design pressure of the blowdown pipes (periodic or continuous blowdown) shall be determined according to Table 5.1.11.

Table 5.1.11 Design Pressure for Piping Downstream Boiler Blowdown Valve MPa

Boiler pressure	1.750–4.150	4.151–6.200	6.201–10.300	⩾10.301
Design pressure of piping	1.750	2.750	4.150	6.200

5.1.12 Feedwater Recirculation Piping

1 Where the unit system is used, the final shut-off valve and its upstream piping shall have the same design pressure as that of the corresponding high pressure feedwater piping. For the piping downstream the shut-off valve, its design pressure shall be determined as either the rated pressure of the deaerator in case of deaerator operating under constant pressure, or 1.1 times the deaerator heating extraction pressure under maximum calculated output of the steam turbine in case of deaerator operating under sliding pressure.

2 Where the header system is used, the design pressure for throttling orifice plate and its upstream piping shall be determined as that of the corresponding high pressure feedwater piping; and the design pressure for the piping downstream throttling orifice plate shall be determined as the rated pressure of the deaerator in cases where no valve is installed or it is impossible to shut off the valve on medium outlet.

5.1.13 Exhaust Piping Downstream Safety Valve

The design pressure shall be determined based on the hydraulic calculation results of steam exhausting pipe.

5.2 Determination of Design Temperature

Design temperature refers to the highest operating temperature of the medium within the piping.

The design temperature of the main piping shall be determined as follows:

5.2.1 Main Steam Piping

The design temperature shall be determined as the rated steam operating temperature at boiler superheater outlet plus the allowable temperature deviation during boiler normal operation. The temperature deviation may be taken as 5℃.

5.2.2 Reheat Steam Piping

1 The design temperature for the hot reheat steam piping shall be determined as the rated steam operating temperature at boiler reheater outlet plus the allowable temperature deviation during normal boiler operation, which may be taken as 5℃.

2 The design temperature for the cold reheat steam piping shall be determined as the corresponding temperature derived from isoentropic analysis by using the steam exhaust parameters of high pressure cylinder under the maximum calculated output condition of turbine and design pressure. If the manufacturer has special requirements, the design temperature shall be determined as the highest possible operating temperature.

5.2.3 Extraction Piping for Steam Turbine

1 The design temperature for non-adjustable extraction piping shall be determined as the corresponding temperature derived from isoentropic analysis by using the steam extraction parameters under the maximum calculated output condition of turbine and design pressure.

2 The design temperature for adjustable extraction piping shall be determined as the highest operating temperature of extraction steam.

5.2.4 Back Pressure Steam Turbine Exhaust Piping

The design temperature shall be determined as the highest

operating temperature.

5.2.5 **Steam Piping Downstream Attemperator**

The design temperature shall be determined as the highest operating temperature of the outlet of the attemperator.

5.2.6 **Steam/Water Piping Connected with Once-through Boiler Startup Separator**

The design temperature shall be determined as the highest possible operating temperature of steam and water in piping under various conditions of the separator.

5.2.7 **High Pressure Feedwater Piping**

The design temperature shall be determined as the highest operating temperature of the high pressure feedwater downstream the high pressure heater.

5.2.8 **Low Pressure Feedwater Piping**

1 For the deaerator operating under constant pressure, the design temperature shall be determined as the saturation temperature corresponding to the deaerator rated pressure.

2 For the deaerator operating under sliding pressure, the design temperature shall be determined as the saturation temperature corresponding to 1.1 times the deaerator heating extraction pressure under maximum calculated output condition of the steam turbine.

5.2.9 **Condensate Piping**

The design temperature shall be determined as the highest operating temperature of the condensate downstream the low pressure heater.

5.2.10 **Heater Drainage Piping**

The design temperature shall be determined as the saturation temperature corresponding to the design pressure of heater extraction pipe.

5.2.11 Boiler Blowdown Piping

At upstream of the blowdown valve, or its downstream where a valve or blocking plate is installed which might cause the piping pressure to rise, the design temperature of blowdown piping (periodic or continuous blowdown) shall be determined as the saturation temperature corresponding to the lowest setting pressure among all safety valves on the boiler drum.

Where nothing downstream the blowdown valve may cause a rise in piping pressure, the design temperature of blowdown piping (periodic or continuous blowdown) will be determined according to Table 5.2.11.

Table 5.2.11 Piping Design Temperature

Downstream Boiler Blowdown Valve

Boiler pressure MPa	1.750–4.150	4.151–6.200	6.201–10.300	⩾10.301
Design temperature of piping ℃	210	230	255	280

5.2.12 Feedwater Recirculation Piping

The design temperature for constant pressure deaeration system shall be determined as the saturation temperature corresponding to the rated pressure of deaerator, and for sliding pressure deaeration system, it shall be determined as the saturation temperature corresponding to 1.1 times the heating extraction steam of deaerator.

5.2.13 Exhaust Piping Downstream Safety Valve

The design temperature for steam exhausting pipe shall be determined based on the corresponding data in the hydraulic calculation of exhausting pipe.