STP-PT-066

# DESIGN GUIDELINES FOR CORROSION, EROSION AND STEAM OXIDATION OF BOILER TUBES IN PULVERIZED COAL-FIRED BOILERS



ASME STANDARDS TECHNOLOGY, LLC

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# FOREWORD

This report provides a development of design rules for advanced power plant boilers that pertain to fireside corrosion, erosion and steam oxidation of boiler tubes. These boilers will operate at advanced steam conditions, include discussion of $CO_2$ capture and contain co-firing of biomass or waste materials.

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# PART ONE - DESIGN GUIDELINES FOR PULVERIZED COAL BOILERS

# 1 GENERAL OVERVIEW

The purpose of this document is to provide a set of Design Guidelines for boiler design engineers and others aimed at the minimization of the effects of fireside corrosion, particle impact erosion and steam-side oxidation on boiler tubing and other components of large, pulverized coal-fired boilers. Particular emphasis is placed on the boiler components considered to be at highest risk in advanced supercritical and ultra-supercritical boilers, i.e. the superheater and reheater tubing operating at metal surface temperatures up to approximately 1350°F (730°C).

Modern coal-fired steam power plants are required to incorporate the relevant advances in technology to improve efficiency and maximize power generated per unit of coal burned, and hence reduce the overall emissions of $CO_2$. They should also be fitted with advanced combustion technologies and environmental control equipment to comply with mandated limits on the release levels of the prescribed pollutant species to air, land and water.

The pressure part materials are required to have the relevant high-temperature strength capabilities, and the heat transfer surfaces are exposed to increasingly aggressive hot flue gases. The available alloys are increasingly required to operate near to the limits of their capabilities. The boilers are also expected to have the capability of cyclic operation, and pressure parts are required to have the minimum possible wall thickness, to minimize thermal fatigue.

It is increasingly important, therefore, that the minimum tube dimensions, calculated according to the ASME Boiler & Pressure Vessel Code, are not overly conservative. This has implications for the accuracy of the input data used in the calculations and, for the first time, there is a requirement to provide estimates of the alloy thickness losses expected over the lifetime of the component, due to environmental factors, both on the fluid side and the fire side of the tubes.

In this report, the knowledge currently available on the modes of environmental degradation expected for pressure parts in advanced coal-fired boilers, and the expected metal loss rates have been examined. The available approaches for the quantification and mitigation of the associated metal loss have been analyzed to provide a set of guidelines for incorporation into ASME B&PV Code calculations.

The major factors considered are:

- Increasing final steam temperatures lead to increased rates of oxide growth on the internal surfaces of the pressure parts, and this can result in increased risks of premature component failure. The modes of failure include delamination and blistering of the oxide layers, and/or exfoliation with loss of oxide fragments capable of causing tube blockage. These can result in rapid local overheating. More generally, the increases in tube metal temperatures, associated with oxide growth, can have a significant effect on the overall rate of steam-side oxidation, and a negative impact on plant integrity.
- Fireside corrosion of the furnace wall tubes, superheater and reheater tubes, and other high-temperature components can be responsible for excessive rates of metal wastage and premature failure of boiler components. Conditions leading to acceleration of such wastage are directly related to the increased operating temperatures and to the changes to the fuels and combustion conditions and hence to the flue gas chemistry, which can combine to create increasingly corrosive environments.
- Erosive wear from ash particle impact wear of the fireside surfaces of the boiler tubes and other components can be a significant cause of metal loss. In addition to direct removal of metal, the erosion process may act to modify or accelerate fireside corrosion by removing ash deposit layers