MANAGING RISK

2 October 2012

Technical eNewsletter

Oil contamination of marine boilers

This newsletter focuses on the immediate and consequential impact of oil contamination on auxiliary boilers and DNV classification perspectives on managing the associated risks to the safety of people on board, the boiler plant and the vessel. Needless to say, the adverse effects of oil contamination on boiler steel and the plant can never be deemed overemphasised.

Notwithstanding the protective devices fitted on steam plants exposed to the risk of oil contamination, it is still not rare for DNV to experience various degrees of contamination of boilers and associated systems. Cracks and an associated loss of integrity at high heat transfer areas are also encountered in some cases. Most of them result in expensive and time-consuming repairs involving the replacement of pressure parts, chemical-mechanical cleaning and downtime.

SOURCES OF OIL CONTAMINATION

The most common sources of oil contamination observed on boilers originate from leaking heating coils fitted in fuel oil tanks, fuel/lub oil heaters, cylinder lub oil from reciprocating steam engines for pumps and heating coils in DB tanks dedicated for sludge/waste oil tanks. It is also not rare for cargo tank heating coils and tank cleaning heaters fitted on the cargo side to contribute to the contamination in some cases.

However, main propulsion boiler plants with a segregated saturated steam system as the main source of heating medium are least likely to be contaminated by oil.

IMMEDIATE EFFECTS

The immediate effects of oil contamination range from foaming and carry over in oil-fired boilers due to increased tension at the water surface to the malfunction of boiler water level controls and even protective shutdown devices. In the worst cases, the carry-over of water and moisture with the steam may even reach the intensity of priming, causing havoc to consumers, eg: turbines, super heaters, steam piping and associated gaskets.

CONSEQUENTIAL EFFECTS

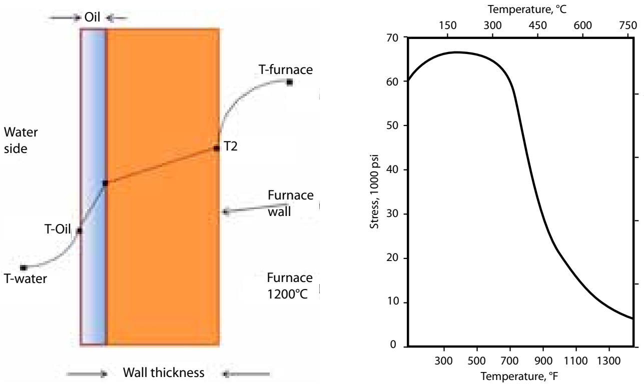
Severe oil contamination leads to a collapse of the heat transfer rate through the boiler steel, contributing to a higher metal temperature than the design value.

With reference to the illustrations (next page), even an oil film or deposit as thin as 0.5 mm on the water side can easily increase the metal temperature on the furnace side (T2) from the design value of 250 deg C to well above 600 deg C under normal operating conditions on an auxiliary boiler rated at 7 bar (g). This has a domino effect of exponentially reducing

For more information, please contact DNV Machinery and Systems:
TGCNO894@dnv.com

More newsletters from DNV:
www.dnv.com/newsletters

the yield strength of the material until the pressure parts subjected to active heat transfer fail.



Temperature gradient across the material thickness

In cases where the reduction in the strength does not lead to immediate failure, the boiler steel can still be subjected to a time-dependent creep zone that is hard to evaluate (if above 380 deg C) unless catered to at the design stage by alloying.

In the case of exhaust gas water tube boilers with an extended surface area that forms part of the steam generation system by forced circulation, this may in the worst cases lead to soot fires due to a lack of heat transfer from the gas side and rise in the metal temperatures due to the uncooled boundaries. Smoke tube exhaust gas boilers are prone to cracks on the tube terminations (see image below) due to differential expansion of the overheated tubes with respect to the shell.

It is also prudent to be aware that other long-term effects are local corrosion of the area subjected to exposure to the acidic nature of oil deposits. Hydrocarbon deposits have a tendency to turn acidic when exposed to high temperatures in the presence of water.

CLASSIFICATION FOLLOW UP

Observations of any degree of oil contamination on boilers lead to a requirement of the permanent restoration of the heat-transfer surfaces on the water and steam side prior to the boiler being put back into service.

In exceptional cases and in order to support main functions, the short-term use of the boilers may be conditionally considered by DNV after careful assessment of the heat-transfer surfaces on the water and steam side and satisfactory isolation of the source of the contamination. Compensatory and precautionary measures include derating the boiler's steam generating capacity by reducing the firing rate/heat input in conjunction with the design working pressure.

Boiling out the water side of the boiler using recommended chemicals and/or mechanical cleaning are normal procedures undertaken to facilitate satisfactory cleaning. This may be additionally supported by hardness checks and a hydrostatic pressure test at 1.5 times the design working pressure to ensure the expected safety factor at the design temperature.

In view of the oil deposits on the water side, it is also imperative that the impulse piping to the level transmitters is blown through and safety functions verified for satisfactory operation.

ASPECTS OF DERATING

A reduction in the design pressure is deemed necessary when the stress levels are expected to exceed the acceptable limits at the design pressure and temperature conditions with the required safety factor. Some of the common reasons range from local/general corrosion, the adverse impact of contaminants on the boiler pressure parts and conditional temporary repairs.

However, the reduction in the design pressure has an impact on the specific volume of steam and subsequently the relieving capacity of the safety valves, the attachment to the boiler shell and the waste steam piping. DNV Rules do not permit an accumulation pressure exceeding 10% above the boiler's design working pressure at the rated evaporation rate (with the safety valves set at the design working pressure).

The specific volume of saturated steam, for instance, shows an increase of 31% when reduced from 7 bar (g) to 5 bar (g). Unless the safety valve and attachment design cater for the satisfactory relieving capacity of the design steam evaporation rate at 5 bar, the compatibility is deemed lost if the boiler is derated from 7 bar to 5 bar using a reduced setting on the safety valves.

The derating of design pressure must always be compensated by a corresponding reduction in the firing rate to limit the evaporation rates for the satisfactory operation of the safety valves at an increased specific volume of steam. This can be verified by either design calculations or an accumulation test at the revised evaporation rate and derated pressure testing.

In most cases involving the conditional short-term acceptance of contaminated boilers, a reduction in firing rate serves the purpose of reducing the metal temperatures.