

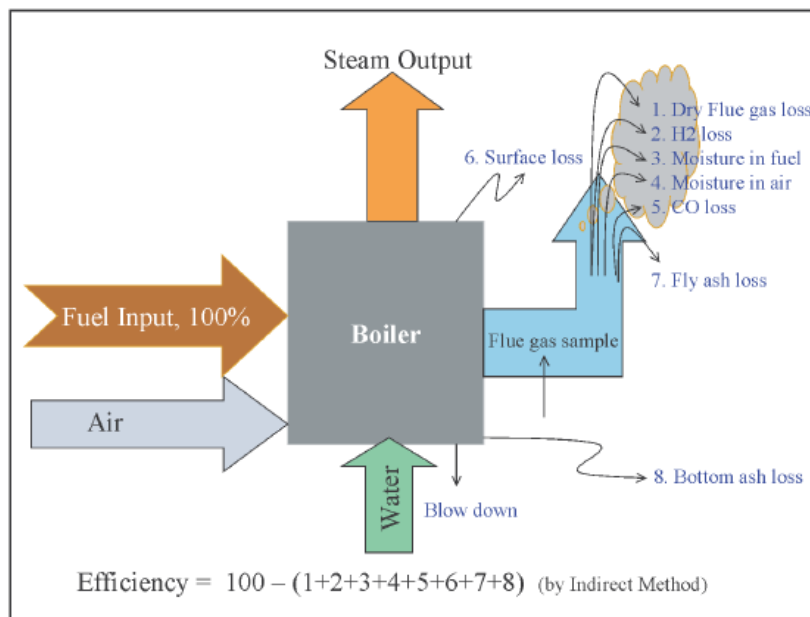
White Paper: Key Performance Indicators (KPIs) for Auxiliary Marine Boiler Optimization

Executive Summary

Auxiliary marine boilers are critical components of a vessel's operational reliability and energy efficiency. Effective monitoring through Key Performance Indicators (KPIs) enables maritime stakeholders to optimize performance, reduce fuel consumption, ensure safety, and extend equipment lifespan. This white paper outlines key operational and efficiency metrics, introduces the value of condition audits, and proposes methods for digital integration to improve boiler monitoring and management.

Introduction

Auxiliary boilers support vital onboard functions, including power generation, heating, and propulsion support. However, without effective monitoring, these systems are prone to inefficiencies, failures, and environmental non-compliance. A structured KPI framework offers insights into system performance, reliability, and fuel usage, enabling data-driven decisions for maintenance and upgrades.



Performance and Reliability KPIs

1. Boiler Availability (%): $(\text{Actual Operating Hours} / \text{Planned Operating Hours}) \times 100$ | Goal: >95%
2. Unplanned Downtime (hrs/month): Goal: Minimize
3. Number of Boiler Trips / Alarms per Month: Goal: Reduce frequency
4. Time to Reach Operating Pressure/Temperature: Goal: Meet design ramp-up times
5. Blowdown Frequency and Water Quality Compliance: Goal: Optimize balance between blowdown and water treatment

Advanced Performance Metrics

1. Fuel-to-Steam Ratio: Tracks efficiency trends and detects gradual degradation.
2. Efficiency Deviation from Design Baseline: Flags deviations from OEM specifications.

Fuel Efficiency KPIs

1. Fuel Consumption per Ton of Steam: $\text{Fuel Used (kg)} / \text{Steam Generated (tons)}$ | Goal: Minimize.
2. Boiler Thermal Efficiency (%): $(\text{Useful Heat Output} / \text{Total Heat Input}) \times 100$ | Goal: $\geq 80\%$

Heat Loss Analysis (Indirect Method)

Losses:

- L1: Dry flue gas
- L2–L4: Moisture-related losses
- L5: Carbon monoxide loss
- L6: Surface radiation & unaccounted losses

$$\text{Efficiency} = 100 - (L1 + L2 + L3 + L4 + L5 + L6)$$

Boiler Water Conditioning KPIs

1. Blowdown Rate (%): Typical Range: 2–5% of feedwater
2. Boiler Efficiency Deviation ($\Delta\%$): Detects fouling and maintenance needs.

Environmental KPIs

1. Boiler Specific Fuel Consumption (BSFC): Lower = better efficiency
2. Emissions per Ton of Steam: CO₂, NO_x, SO_x, PM - monitored against IMO limits

TABLE 1.1 TYPICAL INSTRUMENTS USED FOR BOILER PERFORMANCE ASSESSMENT.		
Instrument	Type	Measurements
Flue gas analyzer	Portable or fixed	% CO ₂ , O ₂ and CO
Temperature indicator	Thermocouple, liquid in glass	Fuel temperature, flue gas temperature, combustion air temperature, boiler surface temperature, steam temperature
Draft gauge	Manometer, differential pressure	Amount of draft used or available
TDS meter	Conductivity	Boiler water TDS, feed water TDS, make-up water TDS.
Flow meter	As applicable	Steam flow, water flow, fuel flow, air flow

Condition Audit: Justification and Benefits

Benefits:

- Reduced breakdowns
- Planned maintenance
- Upgrade insights
- Crew training
- Maintenance optimization

KPI Dashboard Proposal for Shipboard Analytics

Features:

- Real-time monitoring
- Trend analysis
- Alerts for key deviations

Suggested Improvements

1. Digital Integration
2. Data-Driven Maintenance
3. Combustion Optimization
4. Heat Recovery Enhancements

Conclusion

Integrating a robust KPI framework for auxiliary marine boilers is essential for efficiency, compliance, and operational resilience. With real-time analytics and condition-based maintenance, vessel operators can significantly lower operational costs while supporting sustainability goals.