

# **From Human Error Reduction to Operational Excellence: Human Reliability Assessment in Metal Casting Operations**

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## **Abstract**

This study presents a comprehensive Human Reliability Assessment (HRA) conducted at a major metal casting facility in Saudi Arabia. The objective was to minimize human error, enhance operational reliability, and improve product quality, while supporting national goals for industrial efficiency and sustainability. Established methodologies—including Hierarchical Task Analysis (HTA), the Human Error Assessment and Reduction Technique (HEART), and Failure Modes and Effects Analysis (FMEA)—were applied to identify error-prone tasks and error-producing conditions (EPCs) within the casting process. Findings showed that “Unreliable instrumentation” (EPC23) accounted for 19% of observed errors, contributing to increased defect rates and process variability. Additional inefficiencies included a 6.4% defect rate in gray cast iron production and a 27.71% silica sand waste rate, resulting in an estimated annual loss of nearly 400,000 SAR. Recommended interventions—such as improved instrumentation, standardized procedures, task checklists, and digital monitoring systems—yielded a 3.82% improvement in system reliability and projected annual savings exceeding 100,000 SAR. This assessment highlights the value of integrated HRA methodologies in enhancing safety, reducing defects, and optimizing resource utilization in metal manufacturing. The results demonstrate how human reliability engineering can advance operational excellence while aligning with strategic objectives for industrial sustainability and economic diversification.

## **Keywords**

Human Reliability Assessment, Hierarchical Task Analysis, Human Error Assessment and Reduction Technique, Failure Modes and Effects Analysis, Human Error.