مركز المستشار الوطني للتدريب
National Consultant Centre For Training

5-Day Cement Industry Training Course
In

CO AT KILN EXIT

Abu Dhabi - UAE, 27 Apr. – 01 May 2026

COURSE LEVEL: INTERMEDIATE TO ADVANCED

COURSE OVERVIEW:

The monitoring and control of Carbon Monoxide (CO) at the kiln exit is a critical factor for both operational safety and combustion efficiency. This course defines the chemical conditions that lead to the formation of CO and its significance as a marker for incomplete combustion. By mastering the relationship between fuel, air, and gas chemistry, participants will learn how to maintain a stable kiln environment while minimizing environmental impact.

The scope of this training focuses on the technical challenges of managing CO levels within the high-temperature environment of a rotary kiln. It covers the calibration of gas analyzers, the risks of CO-related explosions in downstream equipment, and the impact of CO on the overall heat balance. Furthermore, the course addresses the operational trade-offs between Nitrogen Oxide (NOx) reduction and CO control, which is essential for modern emissions management.

Coverage includes detailed modules on the "CO Trip" protocols for Electrostatic Precipitators (ESP), the impact of alternative fuels on gas composition, and the use of excess air to optimize combustion. Through technical simulations and case studies, participants will learn how to troubleshoot rising CO levels and prevent the formation of "reducing conditions" that can damage clinker quality and refractory life. Attendees will gain the expertise needed to operate the kiln at peak efficiency while ensuring the highest standards of industrial safety.

COURSE OBJECTIVES:

After completion of this course, the participants will be able to:

- Explain the chemical reactions leading to CO formation at the kiln exit.
- Identify the primary causes of incomplete combustion in the kiln and calciner.
- Analyze the relationship between CO levels and excess oxygen.
- Calibrate and maintain gas analyzers for accurate CO monitoring.
- Implement safety protocols to prevent CO-related explosions in the ESP.
- Understand the "CO Trip" logic and its impact on plant emissions.
- Manage the combustion of alternative fuels to minimize CO spikes.
- Detect "Reducing Conditions" in the kiln and their effect on clinker.
- Optimize the ID fan and primary air to control the kiln gas profile.
- Troubleshoot gas sampling system blockages and moisture interference.
- Correlate CO levels with specific fuel-to-air ratios and flame shapes.
- Prepare operational reports on combustion efficiency and gas emissions.

TARGET AUDIENCE:

This course is intended for Control Room Operators, Process Engineers, Environmental Technicians, and Kiln Supervisors.

TRAINING COURSE METHODOLOGY:

A highly interactive combination of lectures, discussion sessions, and case studies will be employed to maximize the transfer of information, knowledge, and experience. The course will be intensive, practical, and highly interactive. The sessions will start by raising the most relevant questions and motivating everybody to find the right answers. The attendants will also be encouraged to raise more of their questions and to share in developing the right answers using their analysis and experience. There will also be some indoor experiential activities to enhance the learning experience. Course material will be provided in PowerPoint, with necessary animations, learning videos, and general discussions.

The course participants shall be evaluated before, during, and at the end of the course.

COURSE CERTIFICATE:

National Consultant Centre for Training LLC (NCC) will issue an Attendance Certificate to all participants completing a minimum of 80% of the total attendance time requirement.

COURSE OUTLINE / COURSE CONTENT:

MODULE 1: COMBUSTION CHEMISTRY AND CO FORMATION

- Principles of oxidation: $C + O2 \rightarrow CO2$ vs. $2C + O2 \rightarrow 2CO$.
- The role of temperature and residence time in complete burnout.
- Why CO is a critical indicator of energy loss.
- Relationship between CO and O2 in kiln exit gases.
- Health and safety hazards of Carbon Monoxide gas.

MODULE 2: KILN EXIT GAS MONITORING SYSTEMS

- Types of gas analyzers: extractive versus in-situ.
- Maintenance of the sampling probe: cooling and cleaning.
- Dealing with high dust and temperature at the kiln inlet/exit.
- Calibration standards and frequency for gas sensors.
- Data integration into the DCS and trend analysis.

MODULE 3: REDUCING CONDITIONS AND CLINKER QUALITY

- Impact of CO and low O2 on the chemistry of Alite.
- How reducing conditions change clinker color and reactivity.
- Effects of CO on the sulfur cycle and "Sulfur Spikes."
- Refractory damage caused by carbon monoxide penetration.
- Testing clinker for "reducing cores."

MODULE 4: COMBUSTION OPTIMIZATION IN THE KILN

- Balancing primary, secondary, and tertiary air streams.
- Impact of burner momentum and flame shape on CO.
- Coal fineness and moisture: their role in rapid ignition.
- Managing "False Air" ingress and its effect on gas readings.
- ID fan control strategies for stable gas velocity.

MODULE 5: ALTERNATIVE FUELS AND CO MANAGEMENT

- Combustion kinetics of RDF, tires, and biomass.
- Managing CO spikes during the feeding of coarse alternative fuels.
- Impact of volatile matter in waste fuels on combustion stability.
- Optimization of the pre-calciner for high-substitution rates.
- Case studies of CO control with non-conventional fuels.

MODULE 6: SAFETY PROTOCOLS AND THE "CO TRIP"

- Explosive limits of CO in air and the risks for filter systems.
- Logic and settings for ESP high-CO safety trips.
- Managing bag filter safety and spark detection.
- Emergency procedures during a sudden CO surge.
- Restarting the kiln after a safety shutdown.

MODULE 7: NOx vs. CO: THE OPERATIONAL TRADE-OFF

- Understanding "Staged Combustion" for NOx reduction.
- Why lowering NOx can often lead to higher CO.
- SNCR and SCR systems and their interaction with kiln gases.
- Finding the "Sweet Spot" for environmental compliance.
- Multi-parameter emission control strategies.

MODULE 8: TROUBLESHOOTING GAS ANALYSIS ISSUES

- Identifying false readings: air leaks in the sampling line.
- Moisture condensation in gas analyzers and its prevention.
- Dealing with probe blockages and "Plugging" in the riser duct.
- Comparing manual gas testing with automated CEMS.
- Routine maintenance checklists for gas analysis technicians.

MODULE 9: THE PRE-CALCINER AND SECONDARY COMBUSTION

- Factors affecting CO burnout in the calciner.
- Impact of material-to-gas mixing on CO levels.
- Role of the "Goose Neck" and riser duct in gas chemistry.
- Tertiary air duct dampers and their use in CO control.
- Optimizing the calciner burner for zero CO.

MODULE 10: HEAT BALANCE AND FUEL ECONOMY

- Calculating energy losses due to unburned carbon (CO).
- Impact of CO on the kiln's specific heat consumption.

- Benefits of automated "Expert Systems" in minimizing CO.
- Economic impact of CO trips on plant productivity.
- Reporting CO levels as part of energy audits.

MODULE 11: ENVIRONMENTAL REGULATIONS AND REPORTING

- Local and international limits for CO emissions.
- Reporting "Excessive Emission" events to regulators.
- Role of CO in the total "Carbon Footprint" calculation.
- Continuous Emission Monitoring Systems (CEMS) certification.
- Public health aspects of industrial CO discharge.

MODULE 12: COURSE CONCLUSION AND FINAL WORKSHOP

- Final exam: interpreting kiln gas trends.
- Group discussion: solving a chronic high-CO problem.
- Summary of best practices for kiln combustion.
- Closing remarks and course feedback.