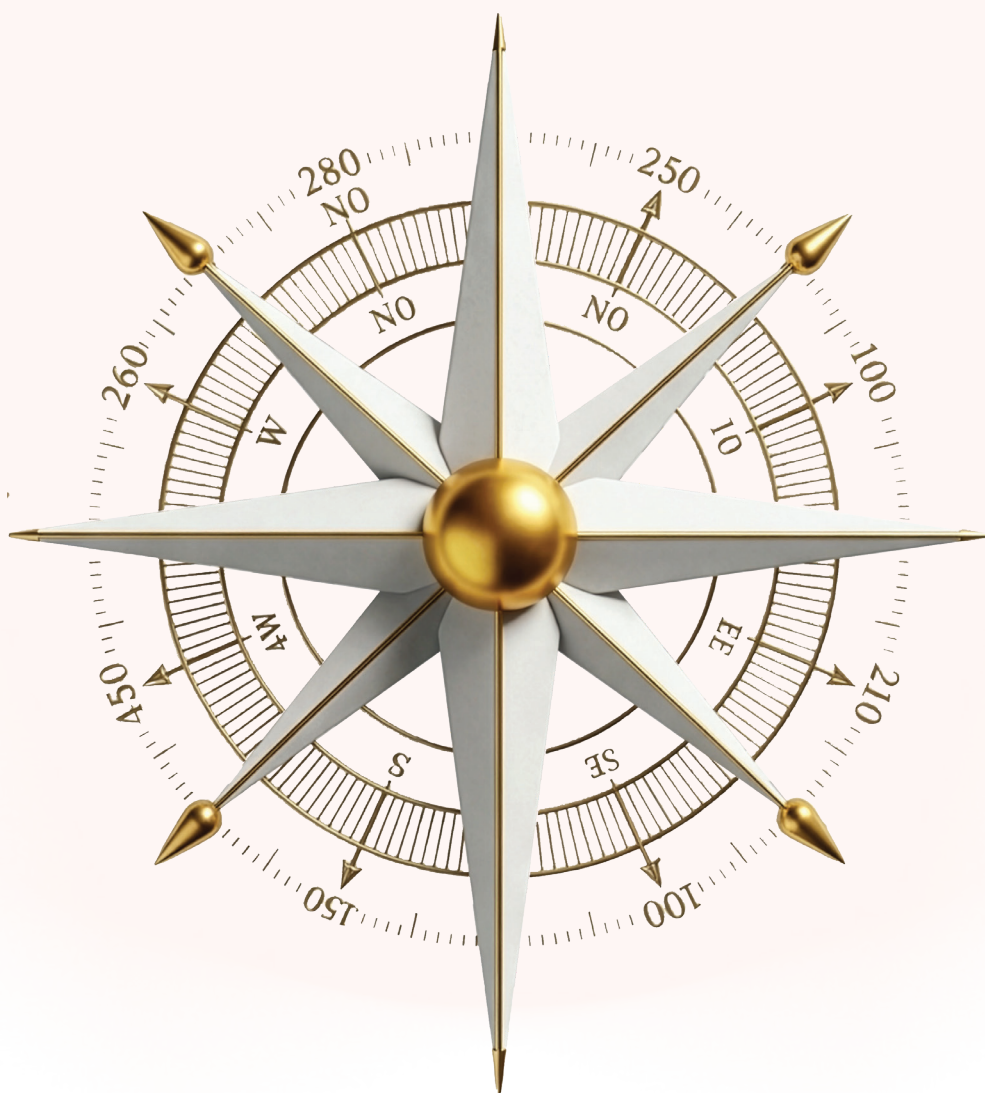




Chemical Reaction Hazards Course: Thermal Runaway, Calorimetry and Safe Scale-Up



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Introduction:

Chemical reaction hazards, covering thermal runaway, calorimetry and safe scale-up, is a 10-day course for process safety, development and batch production engineers that ends with a Reaction Hazard Assessment and Safe Scale-Up Plan for a case process. Syntheses that behave in a laboratory flask can self-heat in a plant vessel, because heat release grows faster than cooling area and accumulated reagent or a cooling failure then drives a runaway. Nominees already develop, run or review batch reactions and work through case studies built on calorimetry test data. CoreConcept Training Center delivers this chemical reaction hazards course.

Course Objectives:

- Screen reactants, intermediates and mixtures for reactivity using structural alerts, hazard data compilations and differential scanning calorimetry results
- Interpret adiabatic and reaction calorimetry data to derive heat of reaction, adiabatic temperature rise, accumulation and gas generation rates
- Assess runaway scenarios with MTSR, TMRad, TD24 and the Stoessel criticality classes, and rank the severity and probability of loss of control
- Build incompatibility matrices that capture unintended mixing, contamination and wrong-charge cases for a reaction step
- Specify the emergency relief basis for tempered, gassy and hybrid systems using DIERS two-phase concepts
- Define safe operating limits, dosing control and scale-up rules that move a batch or semi-batch process from laboratory to plant

Target Audience:

- Staff responsible for process safety studies and reaction hazard reviews on batch and semi-batch units
 - Staff responsible for developing new syntheses and transferring recipes from laboratory to pilot plant
 - Staff responsible for running and supervising reactor campaigns in production
 - Staff responsible for thermal stability and calorimetry testing in hazard laboratories
 - Staff responsible for relief system sizing and change approval on reaction equipment
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Course Outline:

Day 1: Reaction Hazard Fundamentals and Runaway Mechanisms

- Heat Generation Versus Heat Removal Semenov Diagram Reading
- Desired Reaction and Secondary Decomposition Energy Release Comparison
- Volume to Cooling Area Ratio Effect During Scale-Up
- Runaway Incident Timelines From Cooling and Agitator Failure
- Reaction Step Inventory and Hazard Baseline Questionnaire

Day 2: Reactivity Screening Methods and Hazard Data Sources

- Structural Alert Groups for Energetic and Unstable Molecules
- Bretherick Type Reactive Hazard Data Compilation Searches
- Oxygen Balance and Calculated Reaction Enthalpy Estimates
- Differential Scanning Calorimetry Screening Curve Interpretation
- Onset Temperature Safety Margin Rules for Screening Data

Day 3: Calorimetry Techniques and Thermal Stability Data

- Accelerating Rate Calorimetry Heat Wait Search Procedure
- Phi Factor Correction of Adiabatic Test Results
- Heat Flow Reaction Calorimeter Calibration and UA Determination
- Heat Balance and Power Compensation Calorimeter Principles
- Gas Evolution Measurement and Pressure Rate Data Logging

Day 4: Thermal Risk Assessment Criteria and Criticality Classes

- Adiabatic Temperature Rise From Measured Reaction Enthalpy
- MTSR Calculation From Unreacted Reagent Accumulation Profiles
- TMRad and TD24 Estimation From Kinetic Parameters
- Stoessel Criticality Class Assignment for Batch Scenarios
- Severity and Probability Ranking Matrix for Loss Control

Day 5: Case Study on Week-One Thermal Risk Assessment

- Case Nitration Step Screening and Calorimetry Data Pack
 - Case Accumulation Profile and MTSR Worksheet Completion
 - Case Criticality Class Decision and Peer Defence
 - Case Cooling Failure Scenario Timeline Reconstruction
 - Week-One Thermal Risk Summary Sheet Review
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Day 6: Incompatibility Analysis, Autocatalysis and Gassy Systems

- Chemical Reactivity Worksheet Style Binary Incompatibility Matrix
- Contamination, Wrong Charge and Reverse Addition Scenarios
- Autocatalytic Decomposition Detection With Isothermal Ageing Tests
- Tempered, Gassy and Hybrid Runaway System Classification
- Solvent Boiling Barrier and Pressure Containment Checks

Day 7: Protection Layers, Emergency Relief and Safe Operating Limits

- DIERS Two-Phase Flow Relief Sizing Concepts
- Vent Line Disposal, Catch Tanks and Quench Systems
- Dosing Interlocks, Temperature Trips and Agitation Monitoring
- Layer of Protection Analysis for Runaway Scenarios
- Safe Operating Envelope Document and Critical Limit Register

Day 8: Scale-Up Strategy, Technology Transfer and Change Control

- Semi-Batch Feed Rate Matched to Cooling Capacity
- Pilot Plant Trial Plan and Hold Point Criteria
- Process Description Handover Pack From Development to Production
- Management of Change Review for Recipe and Equipment Changes
- Operator Briefing Sheet for Exotherm Warning Signs

Day 9: Reaction Hazard Metrics, Audits and Learning From Incidents

- Reaction Hazard Review Coverage and Overdue Testing Indicators
- Temperature Excursion and Near Miss Trend Analysis
- Calorimetry Laboratory Data Quality and Repeat Test Rules
- Runaway Incident Root Cause Mapping Against Assessment Gaps
- Periodic Revalidation Schedule for Established Reaction Steps

Day 10: Case Study Capstone on the Reaction Hazard Assessment and Safe Scale-Up Plan

- Case Process Screening and Calorimetry Data Consolidation
 - Case Incompatibility Matrix and Gassy System Verdict
 - Case Relief Basis and Protection Layer Selection
 - Case Semi-Batch Dosing Limits and Pilot Hold Points
 - Reaction Hazard Assessment and Safe Scale-Up Plan Completion
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Skills You Will Gain:

- Reactivity Screening
- Calorimetry Data Interpretation
- Thermal Risk Classification
- Accumulation Analysis
- Incompatibility Matrix Development
- Runaway Relief Basis Definition
- Semi-Batch Dosing Control
- Reaction Hazard Review Leadership

Why Attend This Course:

- Deliver a Reaction Hazard Assessment and Safe Scale-Up Plan for a case process to the plant manager and the process safety lead
- Decide whether a reaction step can move to pilot or plant scale, and under which dosing rate, temperature limit and relief basis
- Prevent runaway reactions, undersized vents and unplanned recipe changes that cause injuries, lost batches and plant damage
- Coach development chemists and shift teams with the screening checklist, accumulation worksheet and incompatibility matrix

Conclusion:

Back at work, the participant presents the Reaction Hazard Assessment and Safe Scale-Up Plan to the plant manager, the process safety lead and the development chemist who owns the recipe. They use it to approve or hold a scale-up, fix the dosing rate and temperature limits, request further calorimetry tests and confirm the relief basis for the reactor. After the first pilot or production campaign under the plan, the unit should compare recorded temperature profiles, dosing times and excursions with the predicted values and update the criticality class and limits.

Frequently Asked Questions FAQ:

What should participants know before a chemical reaction hazards and thermal runaway course?

Participants should understand basic chemistry, heat balances and how batch or semi-batch reactors are run. Prior calorimetry experience is not needed, but bringing anonymised screening reports, calorimetry printouts or a recipe for a reaction step helps them apply the methods to their own process.

How does a chemical reaction hazards course differ from a chemical storage safety or reactor design course?

It concentrates on the energy and gas a reaction can release and how to keep it under control during scale-up. Storage safety courses cover labelling, segregation and spills, while reactor design courses cover kinetics, sizing and catalysts for yield rather than runaway prevention.

Why does reagent accumulation matter in chemical reaction hazards and thermal runaway?

Unreacted reagent stores energy. If dosing continues while the reaction is slow or stalled, a cooling failure can release that stored heat at once, raising the temperature to the MTSR and possibly triggering a secondary decomposition that ordinary cooling cannot stop.

What do participants take back from chemical reaction hazards and safe scale-up training?

Participants take back a Reaction Hazard Assessment and Safe Scale-Up Plan for a case process, with screening results, calorimetry interpretation, criticality class, incompatibility matrix, relief basis and dosing limits, plus worksheets they can reuse on their own reaction steps.
