



*Carmagen Course No. 1305*

## SAFETY IN PROCESS DESIGN AND RELIEF SYSTEM DESIGN

### Course Objective

Upon completion of this course, Participants will have a comprehensive understanding of the issues associated with the process design of a facility, developing “inherently safer” designs, an understanding of the Code requirements for relief valves, the types of relief devices and the methodology for determining the relief flows, sizing relief devices, and handling the relief streams. Extensive case studies are offered that discuss incidents in the process industry that demonstrate how process design, management of change and inadequate safeguards have all contributed to major accidents. Examples are also provided for determining relief loads and sizing single and two-phase relief devices.

### Who Should Attend?

- New graduates who wish to gain an understanding of practical process design issues
- Individuals who are managing and performing process design and process hazard evaluations or risk assessments for operating facilities, or are coordinating project activities
- Individuals who require an understanding of relief system design

### Course Description

- Introduction
- Process Safety Management
  - Risk
  - Process Safety Management Systems
  - Corporate Systems

### *Part 1 – Fundamentals*

- Flammability
  - Fire
  - Explosion
  - Flammability
  - Sources of Ignition
  - Controlling Oxygen Concentration Effects
  - Codes
- Materials of Construction
  - Metal Structure
  - Properties
  - Brittle Fracture

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- Creep
- Thermal Expansion
- Fatigue
- Erosion
- Codes
- Corrosion
  - General Corrosion
  - Hydrogen Effects
  - Galvanic Corrosion
  - Stress Related Corrosion
  - Leaching
  - Corrosion Fatigue
  - Pitting/Crevice Corrosion
  - External “Sweating” Corrosion
  - Erosion/Corrosion
- Health Hazards Awareness
  - Industrial Health Concepts
  - Industrial Toxicology
  - Chemical Hazards/Effects
  - Occupational Exposure Limits
  - Noise, Radiation
  - Thermal Stress
  - Ergonomics
- Evaluating Reactive Chemical Hazards
  - Polymerization
  - Peroxides
  - Decomposition Reaction
  - Reaction Hazard Index
  - Experimental Methodologies (ARC, etc.)
  - Thermal Explosions
  - Maximum Stable Reactor Temperature

### ***Part 2 – Equipment Design and Operation***

- Process Equipment
  - General Hazards
  - Loss of Containment

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- Reactors
- Adsorption
- Distillation Columns
- Heat Exchangers
- Vacuum Equipment
- Gas/Liquid Separators
- Filters, Centrifuges
- Pumps and Compressors
- Furnaces and Boilers
- Strategies to Prevent Fires and Explosions
  - Inerting
  - Purging
  - Static Electricity
  - Explosion Proof Instrument and Electrical Housing
  - Area Classification
  - Ventilation
  - Isolation Systems
- Piping Systems
  - Piping Integrity
  - Potential Weak Points
  - Thermal Displacement
  - Two-Phase Flow
  - Velocity Criteria
  - Flanges
  - Gaskets
  - Codes

### ***Part 3 – Relief Systems***

- Fundamentals
  - Function of Relief Systems
  - Causes of Overpressure
  - Systems Assessment
  - Relief Device Service Identification
  - Sizing
  - Specification
  - Safety Review
  - Installation
  - Documentation, Inspection, Maintenance, Management of Change

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- Codes, Laws, Standards and Practices
  - ASME Codes (Sections I and VIII)
  - Laws (e.g., OSHA 1910)
  - Company Standards
  - Industry Practices (e.g., API-RP 520 and Standard 2000, NFPA 30 and 58, National Board NP-65)
- Design Pressure and Temperature, and Maximum Allowable Working Pressure
- Basic Pressure Relief System Requirements
  - ASME Sections I and VIII
  - API 2000
  - Set Pressure
  - Accumulation
  - Overpressure
  - Blow-Down
  - Cold Differential Test Pressure
  - Interconnected Vessels
  - Isolation from Source of Overpressure
  - Block Valves
  - Pressure Profiles
  - Non-ASME Equipment
  - Piping
  - Vacuum Protection
  - Sparing
  - Administrative Procedures
- Determination of Relief Loads
  - Basis for Calculations
  - Causes of Over-Pressure
  - Distillation
  - Fire Loading
  - Liquid-Filled Systems
  - Tube Rupture
  - Mechanical Equipment
  - Exothermic Reactions
  - Two-Phase Flow
- Storage Tanks
  - Types of Tanks
  - Design Codes and Standards
  - Over-Pressure Protection

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- Tank Design Standards
- Vacuum Design
- Frangible Roof Design
- Tank Venting Requirements
- Selection of Venting and Pressure Relief Devices
- Installation of Venting Devices
- Pressure Relief Device Selection
  - Pressure Relief Devices
  - Conventional Spring-Opposed Relief Valves
  - Balanced Spring-Opposed Pressure Relief Valves
  - Liquid Trim Relief Valves
  - Accessories
  - Pilot Operated Pressure Relief Devices
  - Rupture Discs
  - Concerns
  - Pressure Relief Valve/Rupture Disc Combinations
  - Other Types of Pressure Relief Device
- Pressure Relief Device Sizing
  - ASME, API and Manufacturer's Equations
  - Multiple-Phase/Flashing Flow Service
  - Pilot Operated Pressure Relief Valves
  - Safety Valves
  - Sizing Procedures
  - Orifice Selection
  - Existing Valve Evaluation
  - Rupture Disc Sizing
  - Physical Specification
- Installation
  - General
  - Inlet Piping
  - Outlet Piping
  - Pilot Operated Pressure Relief Valves
  - Rupture Discs
  - Flare Headers
  - Associated Equipment

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- Pressure Loss Calculations
  - Types of Service
  - Sizing Basis
  - Piping Resistance Factors
- Discharge Systems
  - Disposal Options
  - Hazard and Risk Assessment
  - Environmental Factors
  - Vapor Release Criteria
  - Liquid Release Criteria
  - Disposal into a Process
  - Closed Disposal Systems
  - Design Considerations
- Documentation
  - Relief Load Analysis and Calculations
  - Pressure Relief Device Specifications
  - Pressure Relief Device Installation Details
  - Reference Drawings and Data
  - Engineering File Maintenance
  - Operating Procedures and Limitations
  - Inspection and Maintenance Records
- Inspection
  - Inspection Intervals
  - Inspection Items
  - Testing
  - Installation Inspection
  - Locked Block Valves
  - Rupture Disc Inspection
  - Records
- Maintenance
  - General Responsibilities
  - National Board VR Program
  - Training and QC
  - Test Stands
  - Maintenance Practices

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- Design Tools – Spreadsheets
  - Manufacturer-Supplied Sizing Programs
  - Compressible Flow Calculations
  - Equivalent Length Calculations for Fittings in Piping Systems
  - Venting Calculations for Tanks
  - Supercritical Fluid Calculations
  - Two-Phase Calculations

**Supplementary Workshops** - To be included as time permits and depending on the interests of course attendees

- Typical Distillation Column Relief Load Calculation – 1
- Typical Distillation Column Relief Load Calculation – 2
- Heat Exchanger Tube Rupture
- Thermal Relief (Liquid/Vapor/Supercritical)
- Thermal Relief – Short-Cut

#### ***Part 4 – Plant Design and Operation***

- Elimination of Hazards Through Process Design
  - Inherently Safe/Safer Concepts
  - Reduction in Inventory
  - Substitution
  - Attenuation
  - Limitation of Effects
  - Simplification
- The Human Error
  - Unintentional Errors
  - Intentional Errors
  - Communication
  - Training
  - Conflicting Requirements
- Misleading Information
- Poor Design
- Procedures
- Training
- Human Capabilities

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### *Part 5 – Modifications*

- Hardware Modifications
  - Control of Change
  - Design Changes
  - Maintenance Issues
  - Temporary Modifications
  - Removing Equipment
- Other Modifications Affecting Plant Integrity: Case Studies
  - Scale-Up
  - Change of Duty for Tank
  - Change of Specification for Adsorbent Carbon
  - Analytical Method/Testing Changes
  - Materials of Construction
  - Computer Software
  - Staffing
  - Personnel
- Prevention of Incidents
  - Manage Change
  - Procedure
  - Definition of Change
  - Assessment
  - Personnel
  - Authorization
  - Records
  - Training

### *Part 6 – Overview of Risk Assessment*

- Risk Identification
  - What-If
  - Checklist
  - HAZOP
  - LOPA
  - Event Tree
- Fault Tree
- QRA
- Risk Classification/Tolerance Criteria
  - Qualitative
  - Quantitative

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**Supplementary Workshops** - To be included as time permits and depending on the interests of course attendees

Case Study 1 - "Waste Water Tank" Explosion

Case Study 2 - Issues Surrounding Potential Phosgene Plant Acquisition

Case Study 3 - Bhopal

Case Study 4 - Flixborough

Case Study 5 - Feyzin

Case Study 6 - CO<sub>2</sub> Storage Tank Incident

**Course Duration**

5 Days

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