Presenter:

Brian Fogg completed 50 years of involvement in the polyurethane industry in 2013. His extensive technical and market experience was obtained working in several countries, with involvement in every aspect of the industry. He holds degrees in Chemistry, Chemical Engineering and Micro-molecular Science. Following a 40 years career in the global PU industry, he now works as an international polyurethane consultant.

The course is divided into two parts:

Morning session – the Chemistry of Polyurethanes

9:00 – 9:30 Description of Polyurethane - a Brief History

Overview of PU market segments Rigid Foam, Flexible Foam and C.A.S.E.

9:30 – 10:30 Introduction to Polymer Chemistry focusing on Polyurethane

Polymerization Reactions

Reactant Functionality

Cross-linking

Polymer Properties

Crystalline and Amorphous behavior of Polymers

MORNING BREAK

10:45 – 12:15 Isocyanates and Polyols Explained - Polyether – Polyester etc - Pre-polymers – Reactions of Isocyanates - Terminology – Urethane Calculations

LUNCH BREAK 12:15 – 1:00
Afternoon session – Raw Materials and Formulating Techniques

1:00 – 2:30   Manufacture of Isocyanates – MDI/TDI/Aliphatic
             Manufacture of Polyols from Petroleum and Sustainable Resources

2:30 – 3:00  Additives used in PU Formulating – Explanation of Foam Formation
             Catalysts – Surfactants – Chain Extenders – Cross-linkers

AFTERNOON BREAK

3:15 – 4:00   Blowing Agents – Thermal conductivity – Flame Retardants
             Fillers and Reinforcement Agents
             Color – UV Stabilization – Anti-oxidants – Stabilizers – Anti-microbial Agents – Mold Release

4:00 – 4:30  Examples and Formulating Techniques for Rigid and Flexible Foams
             C.A.S.E. - Recycling
PDP-102- Introduction to Polyurethane Technology & Products

2013 Course Outline

Instructor: Paul Farkas
Duration: 6h: 30 min

Course Objective

Polyurethane Technology: Integration of polymer Chemistry knowledge with the potential of specific Equipment and manufacturing Process.

The Objective of PDP-102, by way of representative examples, is to elucidate the corroboration and interdependence required of these three technology aspects.

The course is equally useful to attendees who are just beginning their foray in the field of polyurethanes as those interested in a deeper understanding of its potential.

“Technology, a definition”: “The purposeful application of information in the design, production and utilization of goods and services and in the organization of human activities” (source: Internet, Business Dictionary).

1. The “World of Polyurethanes”. Scheduled time, ~ 5 minutes*
   * Scheduled presentation times are tentative only, allowing for presentation flexibility.
   - Polyurethanes in a changing world market.
   - The Complex Technology of the Polyurethanes: an Integration of Specialized Chemistry, Process and Equipment.

2. Flexible Polyurethane Foams. Scheduled time, 2 hours: 9-11AM*
   - Cellular Structure and Chemistry: open cell flexible foams
   - Mechanism of flexible foam cell formation
   - Types of flexible foams:
     o Conventional flexible foams,
     o High Resilience foams (HR)
     o Combustion Modified foams (CMHR)
     o High load Bearing foams
     o Soft/Supersoft foams
     o Viscoelastic foams
     o Renewable polyol based foams
   - Formulation Variables Effect on foam properties; critical factors for making quality foams. Recognizing specific foam quality issues.
   - Manufacturing technologies: slab, molded, spray; equipment specifics
   - Formulating for the diversity of Technologies and Equipment
   - Choosing proper starting raw materials for the required properties while managing costs
3. Rigid Polyurethane Foams. Scheduled time, 2 hours: 11AM-1PM *

- Cellular Structure and Chemistry: Closed cell, Open cell
- Mechanism of Rigid foam formation
- Types of Isocyanate chemistry based rigid foams:
  o PU Foams
  o PIR Foams
  o Modified PIR foams
- Effect of Chemical Constituents:
  o Isocyanates, Surfactants, Catalysts
  o Blowing agents; thermal conductivity, gas diffusion issues
  o Polyester, Polyether, NOP polyols
- Combustibility and Flame Retardants
- Energy Saving through thermal insulation: the role of Rigid PU
- Diversity in Manufacturing Technologies:
  o Pour in Place: Refrigeration, Appliances, Pipe insulation technology, variants.
  o Injection technology: some typical applications
  o Analysis: Pour in place vs. Injection technology
  o Discontinuous lines: Bunstock-Block vs. finished parts molding
  o Continuous lines; Slabstock; Double Band lamination and sandwich panels manufacturing technology
  o Spray foam, building industry, pipe insulation; specifics of formulations and process control; equipment issues
  o Structural Building elements. Formulation variables
- Formulating for the Technologies and Equipment available
- Choosing proper starting raw materials for the required properties while managing costs. Recognizing specific foam quality issues; bio-polyols and polyols based on CO2.
- Understanding Rigid Foams: Interactive Exercises # 3; # 4

4. Polyurethane Composites. Scheduled time, 2 hours: 2PM-4PM *

- What is a Polyurethane Composite? Why PU based Composites?
- Types of PU Composites: filled, reinforced, multiple layered structures
- About: Mineral fillers, Synthetic and Natural Fibers, Filaments, Metallic fibers, Reinforcements, Facing materials
- Composites Properties: mechanical, physical, chemical (CLTE, Flexural and Compression Modulus, Specific Gravity)
- Wetting by a liquid with time-dependent degree of polymerization and viscosity:
  o Air entrapment issues
  o Humidity concerns and its avoidance
  o Other adverse contaminants: oils, etc.
  o Release agents, Internal Mold Release
  o Adhesion to facings, inter-laid materials
- Coupling Agents: Titanates, Silanes
- Composites Manufacturing Technologies:
  o PU Injection technologies: RRIM, SRIM
  o PU Pouring in closed, open molds
  o PU Spray and Froth, lamination on thermoplastics
  o Pultrusion: Chemistry and System design, Process Control issues
  o Composite technologies are “alive”: New, Emerging technologies
- Shaping PU Composites: molds and dies
- Molds, dies: design issues for quality products
- Examples of Commercial Composites PU Technologies:
  CSM-Baypreg, Baypreg-NF/Nafpurtec (Bayer)
  LFI (Krauss Maffei)
  Intervert (Cannon)
  CSM-Baydur/ Fipurtec, CSM-Multitec (Bayer)
  Metal-PU-Metal Composites (BASF)
  PU Filament Winding (RS Technologies, Alberta)
  PU Vacuum Infusion (Huntsman)
  Agrifiber, Fulcrum (Dow)
- Formulating for the Technologies and Equipment available
- Choosing proper starting raw materials for the required properties while managing costs
- Some typical part quality problems
- The potential of PU Composites in today’s energy conscious world.
- Understanding Composites: Interactive Exercises # 5; # 6

5. Questions and Answers. Scheduled time, 30 minutes: 4-4:30PM *
Presenter:

Brian Fogg completed 50 years of involvement in the polyurethane industry in 2013. His extensive technical and market experience was obtained working in several countries, with involvement in every aspect of the industry. He holds degrees in Chemistry, Chemical Engineering and Micro-molecular Science. Following a 40 years career in the global PU industry, he now works as an international polyurethane consultant.

The course is divided into two parts:

Morning session – the Markets

9:00 – 10:00  Historical Overview of the PU Industry –What is Polyurethane?
   Polymers and the Polyurethanes - World, NAFTA, Latin America Market Statistics
   Raw Materials Manufacture and Demand – Isocyanates, Polyols, Additives

10:00 – 10:30  Rigid Foams, Flexible Foams and C.A.S.E. Markets – Consumption and Growth Trends

MORNING BREAK

10:45 – 12:15  Overview and Analysis of Market Segments
   Construction –Appliance – Decorative – Leisure
   Residential and Institutional Furniture – Bedding - Carpet Underlayment
   Transportation and Automotive – Seating and Acoustic Insulation
   Coatings – Adhesives –Sealants – Elastomers - (Integral Skin – Footwear –Synthetic Leather - Fibers - Binders)

LUNCH BREAK 12:15 – 1:00
Afternoon session – Applications

1:00 – 1:30   Equipment and Processing Techniques - Mixing PU – Metering Equipment

1:30 – 2:45  Rigid Foams

Explanation of Thermal Insulation Concept – Blowing Agents
Continuous and discontinuous panels – Slab-stock
Sprayed Foam - One Component Foam
Refrigerator and Appliance - In-situ foam - Insulated Pipe -Molded Foam

AFTERNOON BREAK

3:00 – 3:45   Flexible Foams

Concepts of Comfort and Energy and Sound Absorption explained
Slab Foam -Polyether – Polyester – Viscoelastic
Molded Foam for Furniture – Automotive Transportation

3:45 – 4:30  C.A.S.E.

Adhesives – Automotive, Packing, Footwear. Binders - Forest Products - Rubber Crumb, Foundry Core
Sealants - Construction, Automotive, Glazing
Elastomers – Cast, TPU, Fibers, Footwear, Synthetic Leather
PU 104A 104B Course Outlines

**PU104A - Polyurethane Sealants, Adhesives and Binders**

The CASE designation: Coatings, Adhesives, Sealants, Elastomers.

- The general differences among the CASE Polyurethanes
- What are the different types/forms of CASE?
- Different Types and uses: Solvent borne, water borne or 100% solids; One and two component; Moisture cure; Blocked Isocyanates
- Structure property effects, the effect of various components on polymer properties and polymer morphology

World Adhesive and Sealant Market and Uses

Overlapping classification between Sealants and Adhesives.

**Sealants**
- Defining a sealant and the different types (Chemistries and Uses).
- Urethane Sealant market and different market segments
- Advantages/Disadvantages of Polyurethane Sealants
- Properties versus Silicones
- Raw materials
- Different sealant types, how to formulate a sealant, some of the unique chemistries utilized in producing a polyurethane sealant
  - One and two component
  - Moisture cure
  - Hybrid sealants
- Testing of Sealants

**Adhesives**
- Defining an adhesive and the different types and failure modes.
- Adhesive Testing
- World Adhesives market and different market segments
- Advantages/Disadvantages of Polyurethane Adhesives
- Different adhesive types and Chemistries
  - Urethane vs. Silicone vs. epoxy vs. etc.
  - Reactive and Non-reactive
  - One or two component
- Raw materials
- How to formulate an adhesive
  - One and two component
  - Moisture cure
  - Thermal Cure
  - Reactive hot melts
  - Hybrid Adhesives
  - Polyurethane Dispersions
  - Latent Reactive
Urethane Binders

- Binder Market and Different Market Segments
  - Metal casting (foundry)
  - Carpet industry
  - Construction
  - Miscellaneous molded rubber products

**PU104B – Polyurethane Elastomers and Coatings**

The CASE designation: Coatings, Adhesives, Sealants, Elastomers.

- The general differences among the CASE Polyurethanes
- What are the different types / forms of CASE?
- Different Types and uses: Solvent borne, water borne or 100% solids; One and two component; Moisture cure; Blocked Isocyanates
- Structure/property relationships of Polyurethane Elastomers
  - Basic polymer morphology fundamentals (soft and hard segments).
  - \( T_g \) and \( T_m \), how to measure and the effect on physical properties
  - Dynamic Properties of Polyurethanes
  - The effect of the different formulation components on properties.

Polyurethane Elastomers (Solid and Microcellular)

- Comparison of urethanes versus non urethane elastomers
- Raw Materials
- Different Types of Polyurethane Elastomers and Market and Market Segments
- The different types of urethane elastomers, how they are formulated, and the different applications
  - Cast elastomers
    - Prepolymer and quasi prepolymer
  - One shot and RIM
  - Spray elastomers
  - TPU
  - Millable Polyurethane Elastomers
  - Microcellular elastomers
    - Different foaming techniques

Polyurethane Coatings

What is a coating and how is it applied?
- What is a Paint?
- Who are the top Coating Companies in the World?
- Different Coatings Resins - Urethane coatings versus other technologies
- Coatings market and different market segments and Industry trends
- VOC Considerations
• Coatings raw materials
  o The effects of various components on properties.
  o Effect of other constituents in the formulation

• How to formulate the different coatings types
  o One and two component
  o 100% solids
  o Moisture cure
  o UV/E beam
  o Blocked Isocyanates
  o Water borne

• Different testing methods
Presenters:

Christain Decker - Managing Director of Desma
Lutz Heidrich - Director of Sales for Hennecke Inc
Richard (Dick) Werner - Director of Foam & Plastics Technology for Cannon USA

Collectively these instructors have almost 70 years of experience in the polyurethanes industry. They have worked in the areas of product development, process design, turn-key plant design, polyurethane process equipment and mixing technologies, engineering, sales, and management. They offer a breadth of knowledge in a multitude of polyurethane applications including appliance, automotive, rigid foams, slab stock, insulation, elastomers, footwear, and molded foam.

**Morning Session 9:00 AM - 12:15 PM**

**Metering Machines**
- Overview of polyurethane and processing machines
- Basic Low pressure machine type and capability
- Low and high pressure machine comparisons
- Basic High pressure machine type and capability
- Basic operation via flow sheets (chemical & hydraulic)
- Basic components, parameters, and spare parts

**Morning Break – Approx. 9:30-9:45**

**Metering Machines (cont.)**
- Types and function of metering pumps and cylinders
- Output (flow) rate adjusment
- Shaft sealing and magnetic couplings
- Impacts of formulation changes

**Lunch Break – Approx. 12:15 – 1:00**
Afternoon Session 1:00 PM – 4:30 PM

**Metering Machines**
- Introduction to the variety of mixing heads
- Design & function of low-pressure mixing heads
- Design & function of high-pressure impingement heads
- Nozzle flow rates and adjusting the mixing pressure
- Specialty impingement mixing heads
- Spray foam mixing heads

**Electrical Control**
- Basic Metering Controls
- Process information and operator interface
- Open and closed loop control
- Chronological sequence of a shot cycle

Afternoon Break – Approx. 2:45-3:00

**Plant Design**
- Continuous and discontinuous production
- Injection, casting, & spray applications
- Single & Multiple Station applications
- Rotary table systems
- Gasketing plant design
- Racetrack, carousel, & conveyor systems
- Continuous & slab stock plant design
- Pultrusion plant design
PU 201 Course Outline


Introduction
- Presenters
- The Urethane Chemical Reaction

Isocyanates (-NCO)
- Isocyanate Content as % NCO

Polyols
- Hydroxyl Content (-OH)

Other Isocyanate Methods
- Acidity as %HCl
- Viscosity
- Monomer & Isomers in polymeric MDI
- TDI Isomers
- Color Methods

Other Polyol Methods
- Acid Number
- Basicity (Alkalinity)
- Basicity as % Nitrogen
- Water
- Blended and Formulated Polyol Methods

Relationship between Testing and Specifications

Applications or Performance Testing

Conclusions and Open Discussion
PU 204 Course Outline

PU 204 - Physical Testing of Polyurethane Foams

Introduction
  ○ Terminology
  ○ Sample Conditioning
  ○ Sample Orientation (Anisotropic Effects)

Rigid Foam Methods
  ○ Description and Discussion

Flexible Foam Methods
  ○ Description and Discussion

Miscellaneous Methods
  ○ Description and Discussion

Thermal Analysis
  ○ DMA, TGA, DSC

Data Use and Interpretation
  ○ Planning Experiments
  ○ Critical Properties
  ○ Understanding Method Precision

Standards
  ○ In-House Standards
  ○ Industry Standards
  ○ Regulatory Standards
  ○ National Standards
  ○ International Standards