power engineering
TRAINING SYSTEMS

Boiler Operator Training

- What Owners can expect in their new hires and is it enough? -

Bob Clarke, President and Chief Operating Officer
PanGlobal Training Systems Ltd
June 8, 2010

cibo

Agenda

1. Operator Training – Why the need?
2. Operator Training Overview
3. Operator Training – What should they know?
4. Operator Training – How to Create what they need.

Operator Training – Why the need?

Major Issues in the Profession

- Operating Efficiencies
- Staffing Concerns
- Safety Concerns
- Environmental Compliance

Operator Training
– Why the need?-

- FOR PLANT AND WORKER SAFETY
  - Ensuring that those responsible for day to day boiler operation, or overall management, are fully conversant with the risks, safe procedures and best practices.
- FOR OPERATIONAL EFFICIENCY
  - Ensuring that boilers run at peak performance at all times.
    - Design
    - Maintenance Costs
    - Combustion Efficiencies (Fuel to Steam – Fuel to Water - ASME PTC4, BTS2000)
- FOR COMPLIANCE WITH ENVIRONMENTAL LEGISLATION
  - Ensuring compliance with current legislation by learning the correct procedures to minimize emissions.
    - NOX, SO2, PM, Hg, CO2

Who are Power Engineers really?

- “It’s a job where, sometimes, you’ll be working on New Year’s Eve, on Christmas morning, on Sunday morning. It’s a job where someone’s got to be there 24-7-365. When customers turn on the light switch, someone’s got to be there to make sure the current flows and the bulb comes on, everytime.” **Brian Wilkins**, staff generation specialist with FirstEnergy Corp

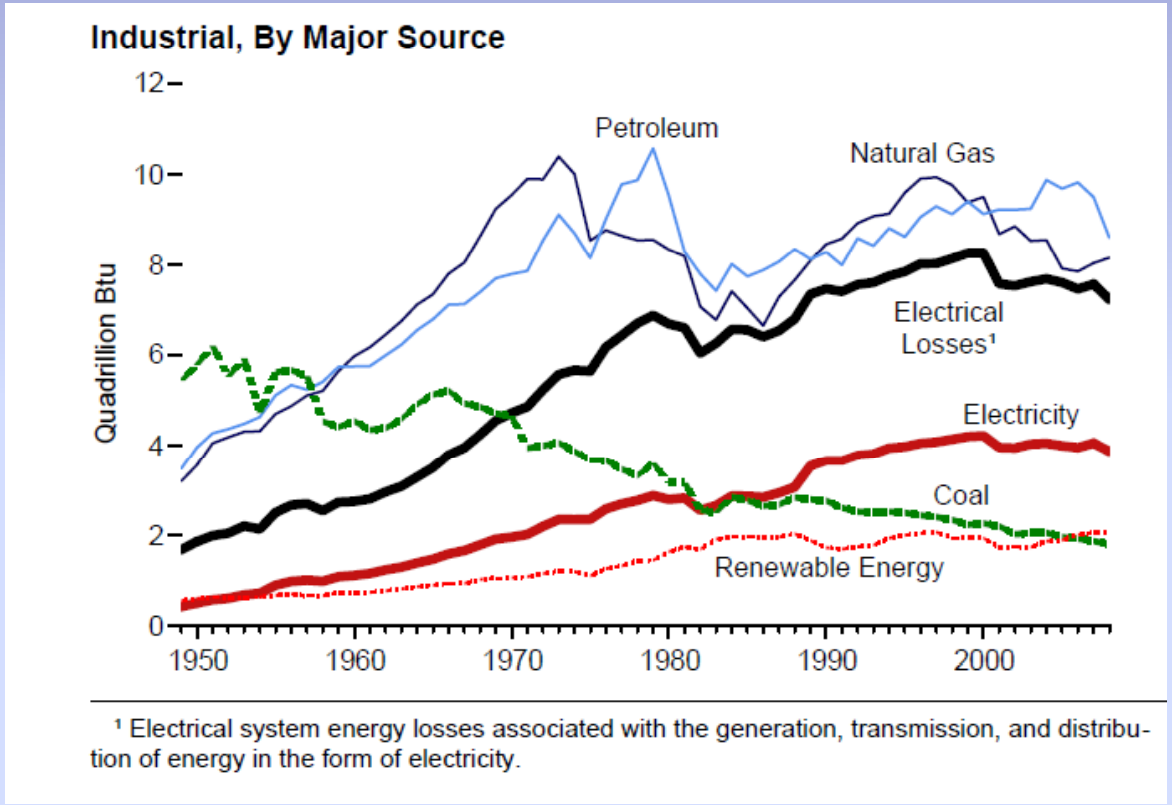
A Critical Job – Steam Generation – How Critical? - Today

US Consumption of Energy

- US Energy Demand (2008) – 95 Quads (10^{15} Btu) per year
- Manufacturing, Commercial, Power, Institutional and Military requirements for steam generation needs total 9 Quads

10% of Total US Energy demand is required to generate Steam

US Consumption of Energy - 2008



Energy Information Administration / Annual Energy Review 2008

Why are Corporations Investing in Operator Training?

The Need for Improved Safety, Operations and Maintenance Practices – The BP Experience

- **The explosion on March 23, 2005 explosion at BP's Texas City refinery:**
  - 15 Fatalities, 332 OSHA safety violations, BP Fined $21,361,500
  - As a result of infrastructure downtime and repairs following the explosion, BP has lost approximately $1 billion of business capital.
- **Surface Spill Response and Containment –**
  - June 1, Over 1,600 vessels involved recovering, in total, some 321,000 barrels (13.5 million gallons) of oily liquid out of between 20 and 43 million barrels released.
  - June 1, Approximately 30,000 claims have been submitted and more than 15,000 payments already have been made, totaling some $40 million. BP has received more than 110,000 calls into its help lines to date.
  - June 2 – Federal Fines – (minimum $1,000 per barrel) If the spill were contained today, the fines would add up to between $480 million and $1 billion.
  - June 3 – US Government submits 1st bill for cleanup - $47 million
  - Spill now much larger that Exxon Valdez which ultimately cost Exxon approximately $4.5 Billion over 20 years

Boiler Operator Training in North America
Historical Perspectives on Certification

Certification and Licensure

- **Equipment**
  - Boiler Explosion Act – 1882, England
  - Steam Boilers Ordinance – 1897, Canada
  - Boiler Design and Construction Codes, - 1907, Mass. US
  - Boiler Design Ordinance – 1911, Ohio
  - Boiler Construction Code – 1914, ASME
  - All North American Jurisdictions Align with ASME Code - 2006

- **Operators**
  - Steam Boilers Ordinance – 1897, Canada
  - Standardization of Power Engineers' Examination Committee – 1971, Canada
  - National Institute for the Uniform Licensing of Power Engineers – 1973, USA
  - Joint Certification Agreement SOPEEC/NIULPE - 2005

Power Engineering Training in North America
Historical Perspectives

Operator Education

- **Training**
  - Williamson Free School of Mechanical Trades, Media, Pa., 1894
  - Provincial Institute of Technology and Art (SAIT)- Can – 1920
  - Texas A&M University, College Station, Texas, 1940
  - Delcastle Technical High School, Wilmington, Del., 1969
  - Bismarck State College – 1976
  - Henry Ford Community College - 1978
  - Youngstown State University, Youngstown, Ohio, 2003
  - Centralia College, Centralia Wa - 2005
  - University of Cincinnati, Cincinnati, Ohio, September 2006
  - Houston Community College, Houston TX - 2009
- **Material Development**
  - Single School Efforts - 1920
  - Traditional Publishers – 1950
    - Numerous Reference Texts – ASME, Reeds, ATP, McGrawHill, B@W, Trane, Betz
  - PanGlobal Training Systems Ltd. - 2003

Opportunities for Power Engineering Training Available in North America

- Bachelors Degree delivered by Universities and Institutes
  - Continuous or Linked Four Year Programs
    - University of North Carolina A & T, University of Cincinnati, Bismarck State College, Houston Community College, Youngstown State University
- Associate Degree or Diploma delivered by Colleges and Universities
  - Three Year programs
    - Cambrian College
  - Two year programs
    - Youngstown State University, University of Cincinnati, Bismarck State College, Centralia College, Henry Ford Community College
    - SAIT, NAIT, BCIT, Keyano College, MHC, SIAST, RRC, NBCC, NSCC, CONA etc
- Certificate Programs using Qualified Educators
  - Two Year, One Year and 6 Month Programs
    - 45 Canadian Colleges in English and French
    - 1450 US Colleges and Vocational Centers
    - Other Learning providers
- Continuing Education Programs
  - Working Professionals requiring Upgrading/Updating
  - Evening and Online Programs (GPiLearn, CINet)
  - Private Trainers (American Trainco etc.)
- Staff Mentoring
  - Training to The Chief Engineer Level

Training Comparison Overview

- Preparing for the Job -

In the United States Power Engineering Skills are delivered by:

- Over 140 Colleges and Private Trainers providing
  - Licensure support (10 States, Numerous Cities - >300 Licenses)
  - Client specific training
  - Both Certified and Uncertified Training Experiences
  - Only a handful of recognized Centers of Excellence in Power Engineering Training
- On the job training
  - Manufacturer's training during startup (ABMA)
  - Mentoring
  - Process training
- Military sources (Navy)
- Apprentice Training through Trade Union initiatives

Training Comparison Overview

- Preparing for the Job -

In Canada Power Engineering Skills are delivered by:

- 5 National Licenses (5^{th} – 1^{st} Class)
- More than 50 community colleges and technical institutes in all 10 provinces and 3 territories
- Corporate and private trainers
- On the job training
  - Manufacturer's training during startup
  - Mentoring
  - Process training

All Educators use a single and consistent set of training materials as the basis of their training

Operator Training
What Should They Know?

Youngstown State University – Associate Degree in Power Plant Technology – leads to 4 Year Bachelors of Technology

Semester 1

- Personal & Social Responsibility - 3 Credits
- College Writing 1 - 3 Credits
- Technical Skills Development - 4 Credits
- Power Plant Fundamentals & Lab* - 4+2 Credits

Semester 2

- Electrical Fundamentals & Lab 3+1 Credits
- Power Plant Mechanical Equipment & Lab - 3+1 Credits
- Survey of Math - 3 Credits
- College Writing 2 - 3 Credits
- Societies & Institutions - 3 Credits

Summer Semester

- Electric Utility Co-op (Optional) - 2 Credits

Semester 3

- Power Plant Electrical Equipment & Lab - 3+1 Credits
- Intermediate Power Plant Systems & Lab - 3+1 Credits
- Power Plant Operator Practice & Lab - 3+1 Credits
- Communication Theory and Practice - 3 Credits

Semester 4

- Power Plant Inst and Control & Lab - 3+1 Credits
- Advanced Power Plant Systems & Lab - 3+1 Credits
- Power Plant Supervision & Lab - 3+1 Credits
- Options - 4 Credits

Bismarck State College – Associate Degree in Power Plant Technology

Recommended Sequence - 1st Semester

- Introduction to the Electric Industry – 3 Credits
- Applied Math – 3 Credits
- Safety – 3 Credits
- DC Fundamentals – 2 Credits
- AC Fundamentals - 3 Credits

Recommended Sequence - 2nd Semester

- Power Plant Equipment – 3 Credits
- Basic Print Reading – 2 Credits
- Instrumentation & Control – 4 Credits
- Thermodynamics – 3 Credits

Recommended Sequence - 3rd Semester

- Water Purification & Treatment – 2 Credits
- Energy Sources & Conversion – 2 Credits
- Boilers - 4 Credits
- Gas Turbines & Combined Cycle Operations – 4 Credits

Recommended Sequence - 4th Semester

- Steam Turbines & Auxiliaries – 3 Credits
- Power Generation – 2 Credits
- Electrical System Components & Protection – 4 Credits
- Plant Operations & Troubleshooting – 3 Credits
- Practical Applications – 2 Credits

SAIT Polytechnic (Alberta)Diploma in Power Engineering Technology

Semester 1 – 27 Credit Hours

- COMM-238 Technical Communications I 4.0 Credits
- COMP-200 PC Basics 2.0 Credits
- ENVS-243 Safety and Environment 2.0 Credits
- MATH-235 Mathematics for Technology I 5.0 Credits
- PWEN-226 Power Theory I 4.0 Credits
- PWEN-227 Power Lab I 5.0 Credits
- THRM-203 Thermodynamics I Theory 5.0 Credits

Semester 2 – 30 Credit Hours

- CHEM-228 Engineering Chemistry 3.0 Credits
- CNTR-260 Boiler Measurement and Ctrl. Sys 4.0 Credits
- ELEC-226 Electrical Principles 3.0 Credits
- PWEN-264 Unit Operations 2.0 Credits
- PWEN-276 Power Theory II 5.0 Credits
- PWEN-277 Power Lab II 8.0 Credits
- THRM-253 Thermodynamics II Theory 5.0 Credits

Summer Semester

- Optional Practicum (If Student has achieved a 4th Class Standing)

Semester 3 – 32 Credit Hours

- AMEC-310 Applied Power Eng. Mechanics I 5.0 Credits
- CNTR-340 Process Control I 4.0 Credits
- ELEC-325 Elec. AC/DC Machines 4.0 Credits
- ENGD-222 Flow Diagram Development & AutoCAD 3.0 Credits
- PWEN-326 Power Theory III 5.0 Credits
- THRM-326 Thermodynamics Theory III 5.0 Credits
- THRM-339 Thermodynamics Lab I 6.0 credits

Semester 4 – 31 Credit Hours

- AMEC-325 Applied Power Eng. Mechanics II 5.0 Credits
- CNTR-345 Process Control II 4.0 Credits
- ELEC-335 Electrical Power Generation 4.0 Credits
- OPMT-301 Technical Management 2.0 Credits
- PWEN-376 Power Theory IV 5.0 Credits
- THRM-343 Thermodynamics Lab II 6.0 Credits
- THRM-363 Thermodynamics IV 5.0 Credits

Determining Knowledge Expectations
What Do they Teach?

National Board Members Competency Levels

In a Large Industrial Plant

- Class 4 - New Operator, Helper
- Class 3 – Experienced Operator, Board Experience
- Class 2 Experienced Board Operator, Shift Engineer
- Class 1 – Senior Shift Engineer, Chief Engineer

National Board Competency Topics - 1st Class

National Board Competency Topics	Blooms Taxonomy Level 2 - 6 Achieved in School Curricula
Applied Thermodynamics and Plant Cycles	Self Directed Learning
Principles of Applied & Fluid Mechanics	Self Directed Learning
Applied Engineering Technologies (Metallurgy, Corrosion, combustion, water treatment)	Self Directed Learning
Power Plant Operations	Self Directed Learning
Legislation and Codes for Industrial Equipment	Self Directed Learning
Safety, Loss, and Environmental Program Management	Self Directed Learning
Inspection, Maintenance and Repair Practices	Self Directed Learning
Business & Workforce Management	Self Directed Learning

Blooms Taxonomy – A Hierarchy of Educational Objectives

Level	1	2	3	4	5	6
Objective	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating

National Board Competency Topics 2nd Class

National Board Competency Topics	Blooms Taxonomy Level 2 – 4 Achieved in School Curricula
A.S.M.E. Code, Sections 1 & 8, Calculations	Associate Degree/Diploma
Industrial Administration	Associate Degree/Diploma
Applied Mechanics	Associate Degree/Diploma
Thermodynamics	Associate Degree/Diploma
Metallurgy	Associate Degree/Diploma
Testing of Materials	Associate Degree/Diploma
Boilers	Associate Degree/Diploma
Pumps	Associate Degree/Diploma
Water Treatment	Associate Degree/Diploma
Heat Engines and Prime Movers	Bachelors
Lubrication	Bachelors
Piping	Bachelors
Mechanical Drawing	Bachelors
Power Plant Systems	Bachelors
Control Instrumentation	Bachelors
Fuels and Combustion	Bachelors
Environmental Protection	Bachelors
Electrotechnology	Bachelors
Principles of Air and Gas Compression	Bachelors
Industrial/Commercial Refrigeration	Bachelors

National Board Competency Topics 3rd Class

National Board Competency Topics	Blooms Taxonomy Level 1 – 3 Achieved in School Curricula
Applied Mathematics	Associate Degree/Diploma
Applied Mechanics	Associate Degree/Diploma
Thermodynamics	Associate Degree/Diploma
Applied Science (Chemistry, Metallurgy, Drawings)	Associate Degree/Diploma
Industrial Legislation and Codes	Associate Degree/Diploma
Code Calculations, ASME Section I	Associate Degree/Diploma
Fuels and Combustion	Associate Degree/Diploma
Piping	Associate Degree/Diploma
Electrotechnology	Associate Degree/Diploma
Electrical Calculations	Associate Degree/Diploma
Control Instrumentation	Associate Degree/Diploma
Industrial Safety and Fire Protection:	Associate Degree/Diploma
Boilers	Associate Degree/Diploma
Boiler Control Systems	Associate Degree/Diploma
Feedwater Treatment	Associate Degree/Diploma
Pumps	Associate Degree/Diploma
Welding Procedures and Inspection	Associate Degree/Diploma
Pressure Vessels	Associate Degree/Diploma
Prime Movers	Associate Degree/Diploma
Cogeneration	Associate Degree/Diploma
Compressors	Associate Degree/Diploma
Refrigeration	Associate Degree/Diploma
Special Industrial Equipment	Associate Degree/Diploma
Wastewater Treatment	Associate Degree/Diploma
Plant Maintenance and Administration	Associate Degree/Diploma

National Board Competency Topics 4th Class

National Board Competency Topics	Blooms Taxonomy Level 1 - 2 Achieved in School Curricula
Applied Mathematics	Associate/Diploma/Certificate
Elementary Mechanics and Dynamics	Associate/Diploma/Certificate
Elementary Thermodynamics	Associate/Diploma/Certificate
Mechanical Drawing, Administration	Associate/Diploma/Certificate
Industrial Legislation	Associate/Diploma/Certificate
Workplace Hazardous Materials	Associate/Diploma/Certificate
Plant Safety	Associate/Diploma/Certificate
Plant Fire Protection	Associate/Diploma/Certificate
Material and Welding	Associate/Diploma/Certificate
Environment	Associate/Diploma/Certificate
Piping and Valves	Associate/Diploma/Certificate
High Pressure Boiler Design	Associate/Diploma/Certificate
High Pressure Boiler Parts and Fittings	Associate/Diploma/Certificate
High Pressure Boiler Operation	Associate/Diploma/Certificate
Feedwater Treatment	Associate/Diploma/Certificate
Prime Movers and Engines	Associate/Diploma/Certificate
Pumps and Compressors	Associate/Diploma/Certificate
Lubrication	Associate/Diploma/Certificate
Electricity	Associate/Diploma/Certificate
Controls, instrumentation and computers	Associate/Diploma/Certificate
Heating Boilers	Associate/Diploma/Certificate
Heating Systems	Associate/Diploma/Certificate
Heating Boiler and Heating System Controls	Associate/Diploma/Certificate
Auxiliary Building Systems	Associate/Diploma/Certificate
Absorption Refrigeration	Associate/Diploma/Certificate
Vapour Compression Refrigeration	Associate/Diploma/Certificate
Air Conditioning	Associate/Diploma/Certificate
Air Conditioning Systems	Associate/Diploma/Certificate
Boiler Maintenance	Associate/Diploma/Certificate
Types of Plants	Associate/Diploma/Certificate

Comparing Environmental Topics

Class 4 – **Environment**

- Environmental terms and definitions
- Gas and noise pollution
- Solid and liquid pollution
- Potential environmental impact of liquids
- Potential environmental impact of vapours
- Potential environmental impact of operating facilities

Class 3 - **Fuels and Combustion**

- Flue gas analysis methods and devices; CO; CO2 and O2
- Control of emission standards: NOx, SO2, particulates.

Comparing Environmental Topics

Class 2 - **Environmental Protection**

- Monitoring equipment and troubleshooting procedures: continuous emissions monitoring systems; wastewater monitoring; data interpretation; troubleshooting
- Specific environmental controls and equipment: integrated environmental controls; technical knowledge and efficient operating practices and monitoring for the following:
  - flue gas desulphurization
  - selective catalytic reduction
  - NOx reduction
  - flue gas chemical conditioning
  - baghouses and precipitators
- Significance of measured parameters:
  - Air quality particulates, stack opacity, SO2 and NOx concentration and mass flow, mercury, O2, CO2, hydrocarbons
  - Wastewater - iron, phosphorous, biological oxygen demand, chemical oxygen demand, hydrocarbons, temperature, flow, pH, nitrogen

Comparing Environmental Topics

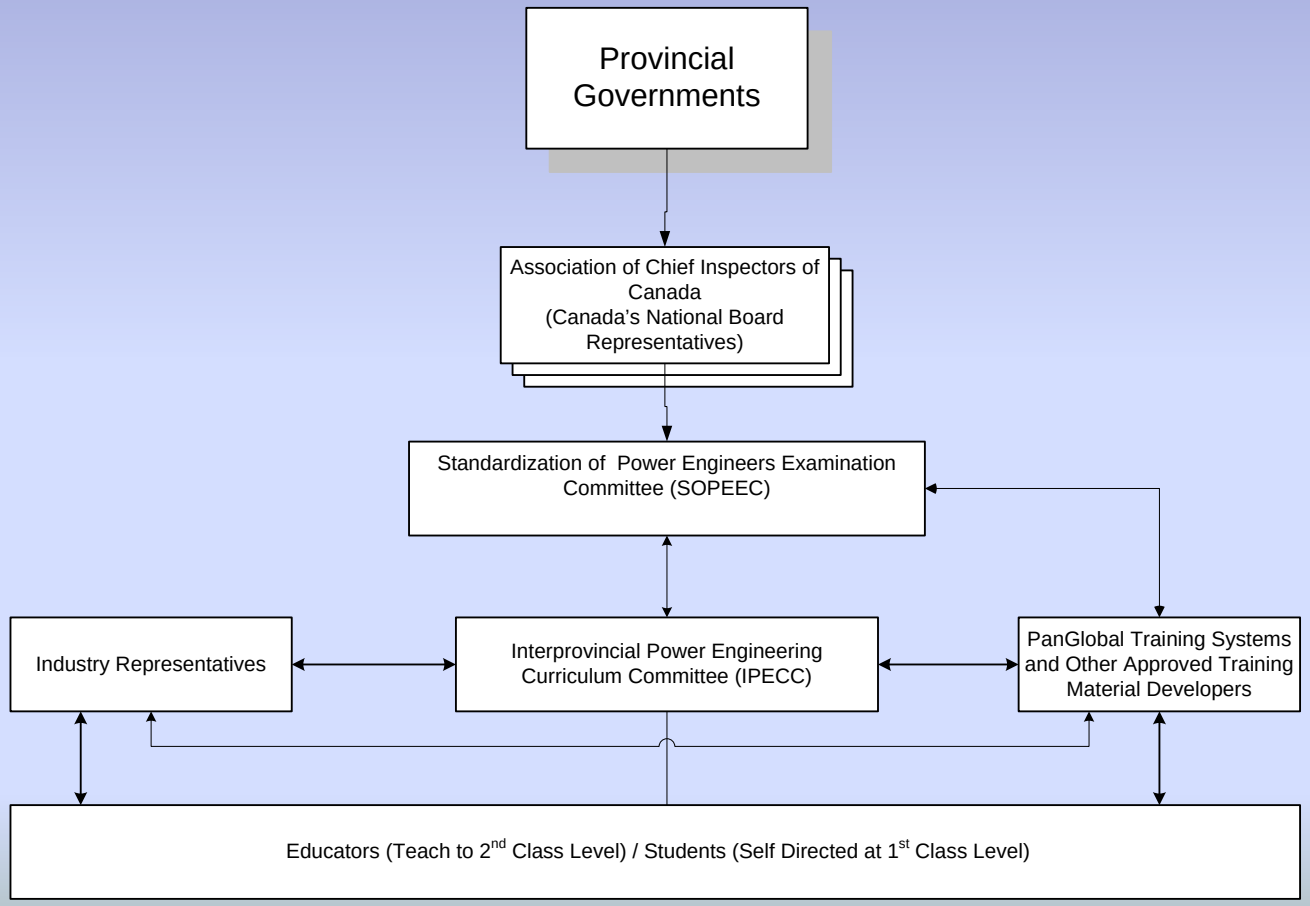
Class 1 - Environmental Program Management

- Components and administration of a loss control program; loss control standards.
- Implementation and management of a complete plant safety program: safety attitude and motivation techniques; incident investigation & reporting; emergency response programs; work with occupational health and safety committee; safe work permits, safe work procedures and planning.
- Safety Legislation in the workplace: identify legislation; legalities; responsibilities to enforce.
- Risk Assessment and Risk Management Techniques including; Safety Audits (components, procedures, analysis, follow-up; working with safety inspectors) and HAZOP (hazardous operability).
- Insurance programs; factors affecting insurance rates; insurance inspection procedures; working with insurance inspectors.
- Environmental Legislation: identify/explain all applicable legislation (provincial, state and federal); legalities, responsibilities.
- Environmental Permits: components of, including understanding of all terminology and units.
- Environmental Audits: components, procedures, analysis, follow-up; working with environmental inspectors.
- Environmental reporting procedures: routine reports and exceedences; spill clean up and containment.
- Environmental Management Systems, including ISO 14000 series; purpose, components and influence.
- Disposal and Reclamation: procedures and practices, including waste manifests.

Operator Training

How to Create what they need to know.

The Education and Certification of the Power Engineering Profession in Canada
Five Classes of Certification



Working Processes

- IPECC and SOPEEC in Partnership address the needs of the Knowledge Competency documents at each level
- “Volunteer” groups of stakeholders, Regulators, Educators and Industry Representatives from across North America
- Meet once per year as a full group
- Through the year subcommittees work to review the curriculum and validate appropriate updates
- Seven subcommittees:
  - 5th Class – 1st Class in SI and USCS
  - Refrigeration
  - Reference materials
  - All other courseware (Custom, French, Spanish derived from this process

Certification Product Development Process

- Principles of Development
  - Correct or update the material as soon as possible - Wrong information is (can be) the information students remember best
  - Be sensitive to educator needs for continuity and clarity
  - Add content providing additional value but make clear that content which addresses the Syllabus and Curriculum
  - Vet educational technologies through stakeholder group representatives
- Basic Development Process:
  - Authors are contracted based upon their subject matter expertise and educational background.
  - The Authoring process also includes input from PG staff including a Technical Editor, English/Grammar Editor and Media Specialist.
  - After Authoring, a content complete version of the module is sent to various educational partners and key stakeholders for review and comment.
  - A “pre-publication edition” of the courseware is produced and presented to the Certifying Body for comment and feedback.
  - A final Edit is performed and signoff by PG’s Director of Content Development
  - 1st Year of production creates a Field Testing period with educators only to identify material errors which are corrected through an errata process

Certified Product Examples

International Certification Standards – The 5 Core Programs

- **5th – 1st Class**
  - Variations
    - Canada (English & French)
    - United States
    - 4th - Australia
    - 4th and 3rd – Spanish
- **US Jurisdictional Licensure**
  - Minnesota Licensure Course Materials
    - Total of 7 Volumes approved towards the state's ten licenses
  - Massachusetts Licensure Course Materials
    - Total of 20 volumes approved towards the state's five licenses
  - Michigan Licensure Course Materials
    - Total of 15 volumes approved towards the state's four licenses
  - Ohio Licensure Course Materials
    - Total of 3 volumes approved towards the state's three licenses
  - City of Pittsburgh Licensure Course Materials
    - Total of 10 volumes approved towards the city's four licenses
    - - 40 Modules (Chapters) from US 4th Class for CE credit
  - Michigan Licensure Course Materials
    - Total of 15 volumes approved towards the state's four licenses
  - City of Erie PA
    - Total of 1 volume approved towards the cities Water Tender license

A Model For Effective Content Design, Development and Delivery

- Three Components:
  - Design Component
    - A Uniform Standard Knowledge Syllabus created through the contribution and partnership of all Stakeholder Groups
  - Development Component
    - Relevant Courseware developed according to the standard syllabus and endorsed by Stakeholders
    - Reviewed, Validated and Maintained through the partnership activities of Industry, Regulators, Educators and Content Developers
    - Required to respect both technological realities of industry and modern instructional design techniques
  - Delivery Component Emphasizing
    - Equal access to quality Power Engineering training using both in-class and distance methodologies
    - Effective use of demographically appropriate educational technologies

Current Status and Future Directions

- Professional Knowledge Sets identified
- Cognitive (Knowledge) Objective Levels Identified – Needs Validation
- Psychomotor (Skills) Objectives Proposed – Needs Approval and Validation
- Renewal of Standard Learning materials and delivery methodologies

The Future of Cooperation

- **Industry**
  - Define the Learning Needs for both Knowledge and Skills
- **SOPEEC / IPECC / NBBI**
  - Create the Assessment Standards
  - Establish the Profession's Curriculum
  - Validate and Recommend Appropriate Learning Materials
- **PanGlobal and other Publishers Produce Learning Materials and Supports**
  - Textbooks, multimedia, test banks, online delivery, workbooks, instructor guides
- **Educators Provide Training Support and Prior Learning Validation**
  - Prior Learning Evaluation and Validation
  - Program diversity
  - Continuing Education
  - Face to Face and Online Solutions

power engineering
TRAINING SYSTEMS

Thank You

Bob Clarke, BSc. MBA
President, COO
PanGlobal Training Systems Ltd.
Ph: 403-284-7176
Cell: 403-861-4309