• Terry is a retired Senior Fellow from Solutia/Monsanto and presently provides contract engineering at ConocoPhillips Wood River refinery. He has 40+ years of experience in process control, simulation, operations, troubleshooting and optimization.

• Terry graduated from the Missouri University of Science and Technology with BS, MS & PhD ChE and was recently inducted into their Academy of Chemical Engineers in 2009. He was inducted into the CONTROL Automation Hall of Fame in 2002.

• He has received several ISA awards including the Distinguished Society Service Award in 1997, the E. G. Baily Award in 1993 and the Excellence in Documentation award in 1987.

• Terry has been an adjunct professor for Washington University from 2004-2008, a Lehigh University Biannual Lecturer from 1974-1986, an ISA Fellow in 1990, an AIChE Fellow in 2000 and a PE since 1974.
DISTILLATION CONTROL TOPICS

- Levels of control
- Classification and pairing of variables
- Control objectives and constraints
- Dynamic responses
- Material and energy balances
- Separation
- Pressure control
- Material balance control
- Temperature control
- References
DISTILLATION CONTROL

- **BASIC**
  - Inventory Control
  - Composition Control

- **SUBOPTIMIZING**
  - Feedforward Control
  - Two Point Composition Control

- **OPTIMIZING**
  - Floating Pressure
  - Maximum Profit
CLASSIFICATION and PAIRING of VARIABLES

CONTROLLED VARIABLES
distillate composition
bottom composition
accumulator level
sump level
column pressure

Y
X
La
Ls
P

La
Y
X
Ls
P
CLASSIFICATION and PAIRING of VARIABLES

MANIPULATED VARIABLES
    distillate flow  D
    bottom flow     B
    reflux flow     R
    reboiler duty   Qr
    condenser duty  Qc
CLASSIFICATION and PAIRING of VARIABLES

DISTURBANCE VARIABLES

- feed flow
- feed composition
- feed temperature
- reboiler heat supply
- condenser cooling
- supply and weather

Diagram of a distillation column with variables F, Z, q, S, W.
### CLASSIFICATION and PAIRING of VARIABLES

<table>
<thead>
<tr>
<th>CONTROLLED VARIABLES</th>
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<th>DISTURBANCE VARIABLES</th>
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<td>distillate flow</td>
<td>feed flow</td>
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<tr>
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<td>condenser cooling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>supply and weather</td>
</tr>
</tbody>
</table>
CONTROL OBJECTIVES

Chart showing:
- Total Operating Cost
- Cost of Energy
- Cost of Product Lost

Graph axes are:
- X-axis: Recovery
- Y-axis: $/F

Graph lines and labels indicate the relationship between recovery and the costs.
COLUMN INTERNALS

TRAYS
- SIEVE TRAYS
- VALVE TRAYS
- BUBBLE CAP TRAYS
- DUAL FLOW TRAYS

PACKING
- RANDOM PACKING
- STRUCTURED PACKING
- LIQUID & VAPOR DISTRIBUTORS
COLUMN DYNAMICS

RELATIVE RESPONSE TIMES

VAPOR - FAST
LIQUID - MEDIUM
COMPOSITION - SLOW

Response

time
MATERIAL & ENERGY BALANCES

MATERIAL BALANCE

\[ F = D + B \]
\[ zF = yD + xB \]
\[ \frac{D}{F} = \frac{z-x}{y-x} \]

ENERGY BALANCE

\[ hF + Q_{reb} = hD + hB + Q_{cond} \]
TOTAL REFLUX

\[ \alpha^n = \frac{y(1-x)}{x(1-y)} \]

NORMAL OPERATION

\[ S = f(\alpha, N, N_F, V/F, z, E) \]
MATERIAL BALANCE and SEPARATION EFFECTS

Increasing S

Light Key Mole Fraction

X

Y

Z

D/F

0 0.5 1.0
MATERIAL BALANCE CONTROL
SEPARATION CONTROL

NOT RECOMMENDED
PRESSURE CONTROL
CONDENSER DUTY

\[
Q_{\text{cond}} = UA(T_p - T_c)
\]
“BLOCK & BLEED” PRESSURE CONTROL
MATERIAL BALANCE CONTROL - TYPE 2
MATERIAL BALANCE CONTROL - TYPE 4
PROCESS SIMULATION

STeady State
- Parametric Cases
- Control Stage Location
- Sensitivity Analysis
- Disturbance Analysis

DYNAMIC
- Study Control Response
- Startup and Shutdown
CONTROL STAGE LOCATION

Benzene-Toluene Column Temperature Profiles

Stage Number vs Temperature, DegC

+1%D/F

-1%D/F
TEMPERATURE SENSITIVITY

CONTROL STAGE TEMPERATURE, degF

COMPOSITION, wt%

DISTILLATE PRODUCT

BOTTOM PRODUCT
REFERENCES


REFERENCES


