



# **Introduction to Process Diagnostic Division**

# **Traditional Methods of Unit Operation Troubleshooting**

- **Field Experience**

- **Past History**
- **Senior Personnel**

- **Quantitative Data**

- **Temperatures or Delta Ts**
- **Pressures or Delta Ps**
- **Flow Rates**
- **Liquid Levels**
- **Compositions**

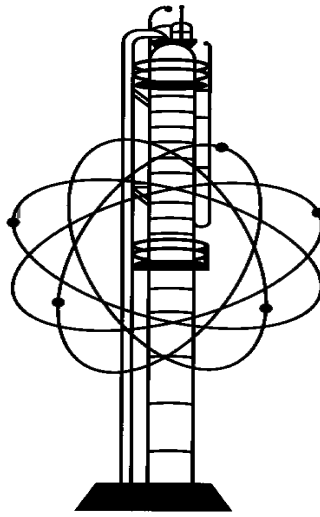
- **Trial-and-Error**

- **Cause and Effect Analysis**
- **Brainstorm**

- **“Rigorous” Analysis**

- **Computer Simulation**

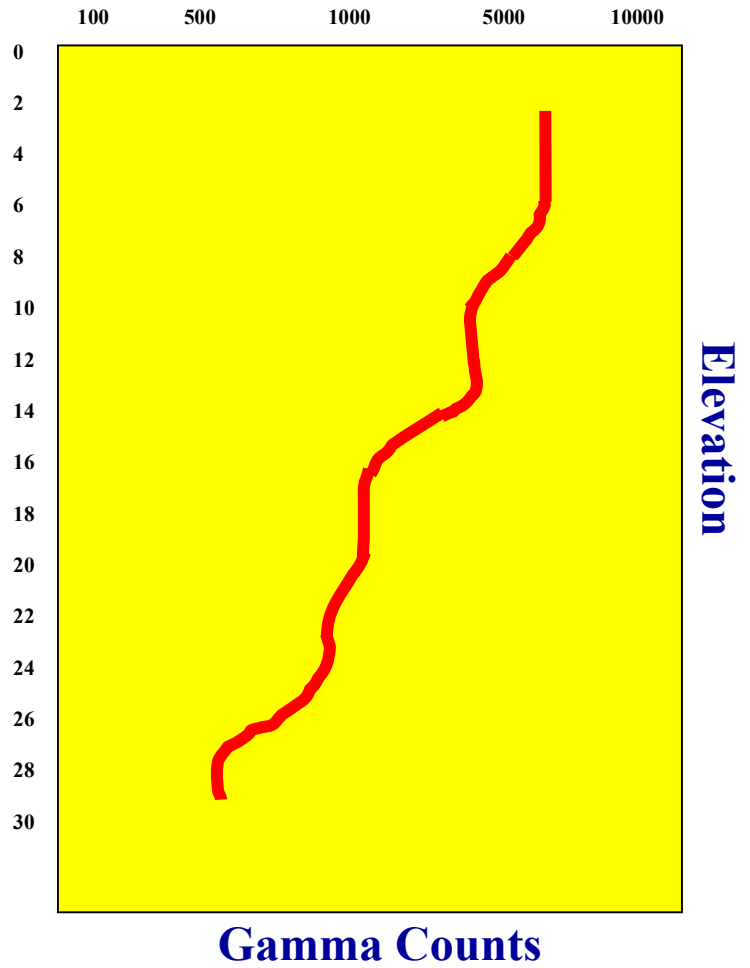
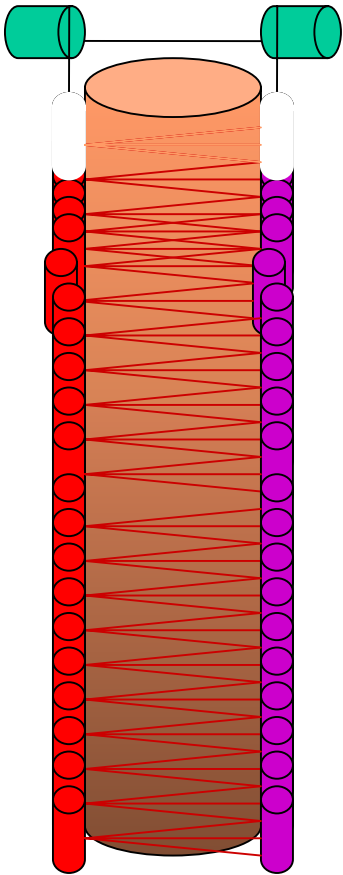
- **Shutdown Inspection**



- **On line Process Diagnostics**

- **Distillation Column Scanning**
- **Radioactive Tracing**
- **CAT-Scan**
- **FCC Reactor Diagnostics**
- **Neutron Backscatter**
- **Helium Leak Testing**
- **Scan/Simulation Integrated Diagnostics**
- **Knowledge Base**

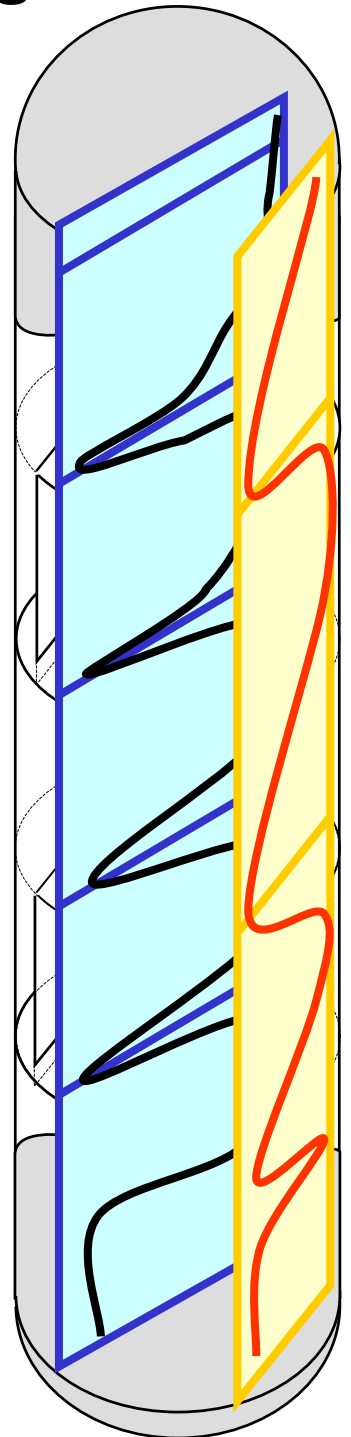
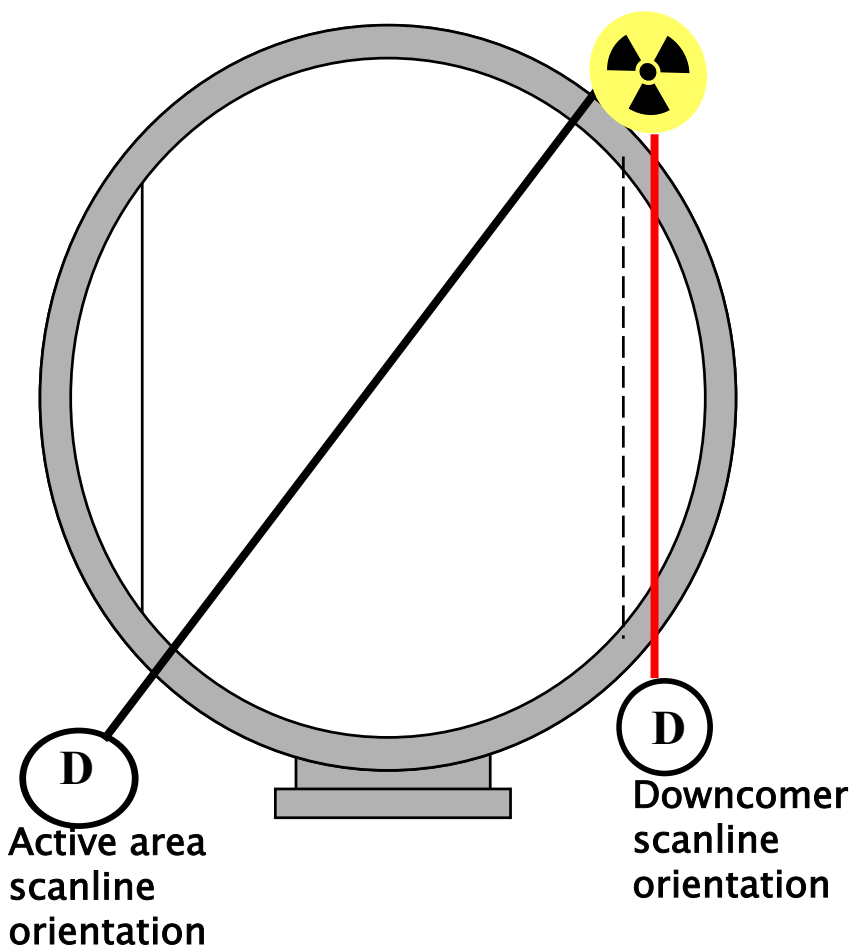
# Gamma Scan



$$\ln\left(\frac{I}{I_o}\right) = \sum \mu_i \rho_i x_i$$

# Gamma-Scan Experience

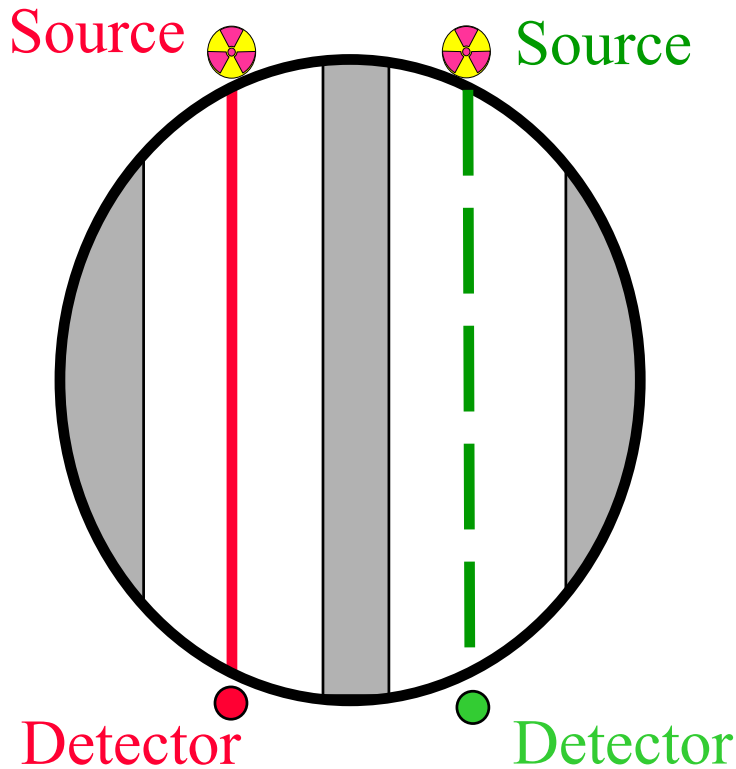
- **200 - 300 Scans per month Worldwide**
- **On-Site Presentation of Results**
- **Troubleshooting Experience**
- **In-House Experienced PE**
  - **Dr. Simon Xu**
- **Knowledge Base of Tower Case Histories**



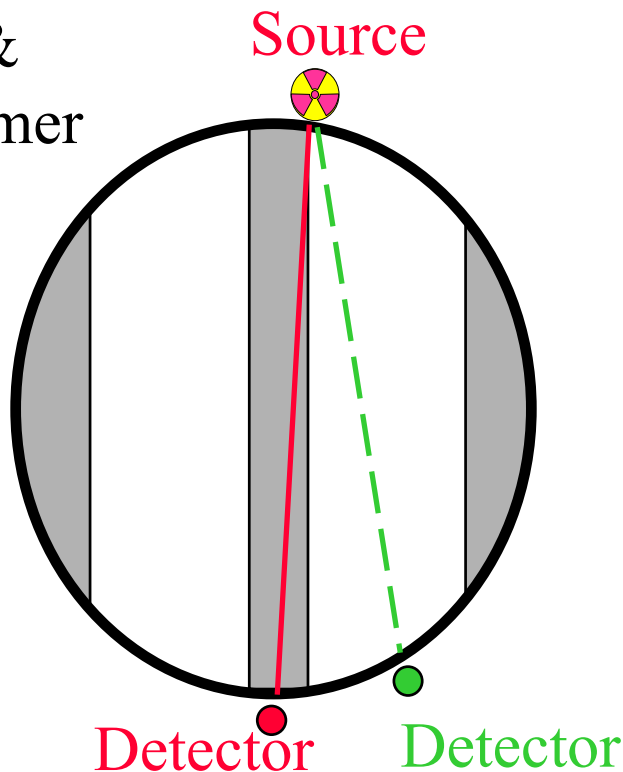
# Scanning Trayed Towers

## Active Areas & Downcomers

Two Pass Trays

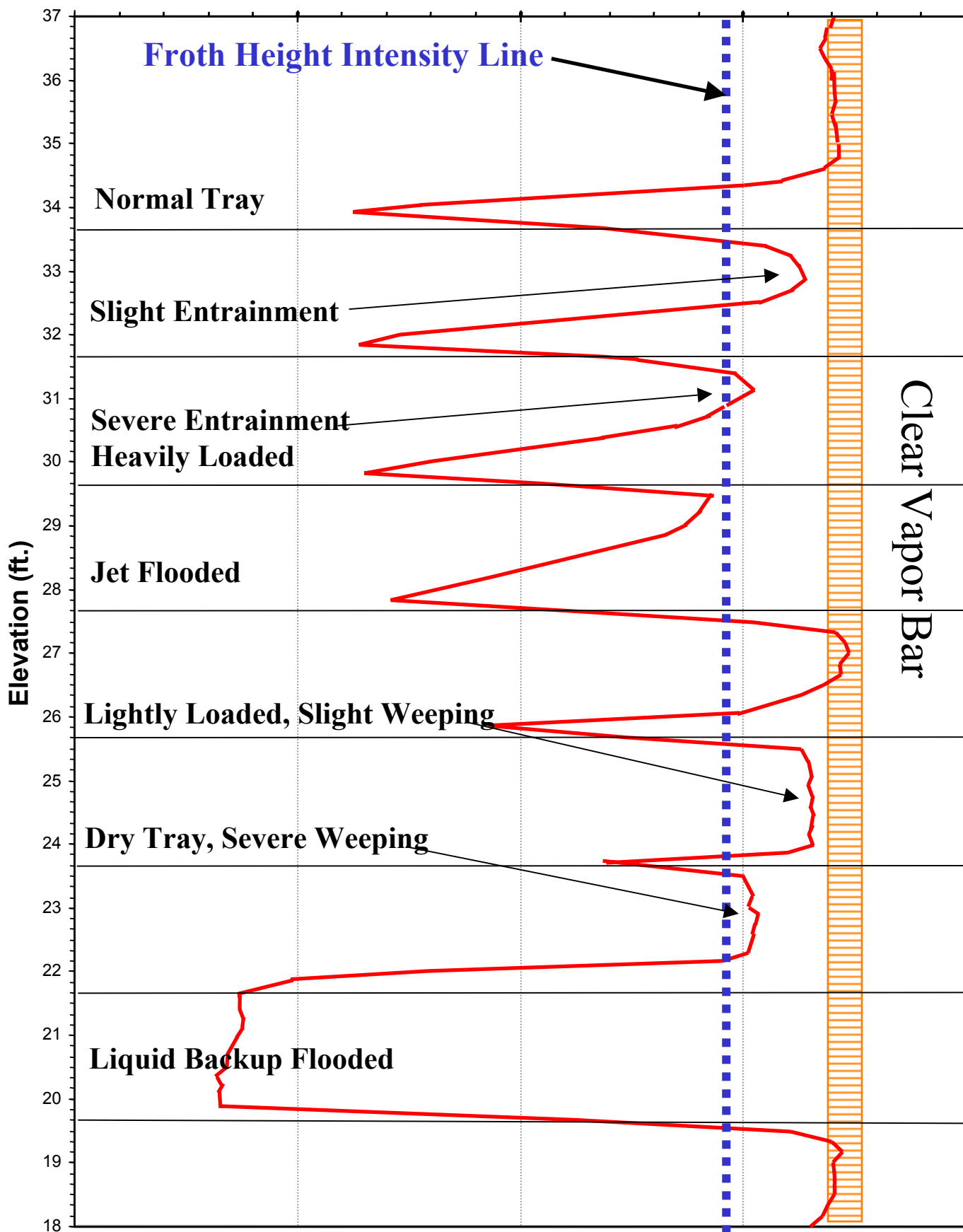


Concurrent  
Active Area &  
Center Downcomer



# Trayed Column Sample Scan Interpretation

# Radiation Intensity



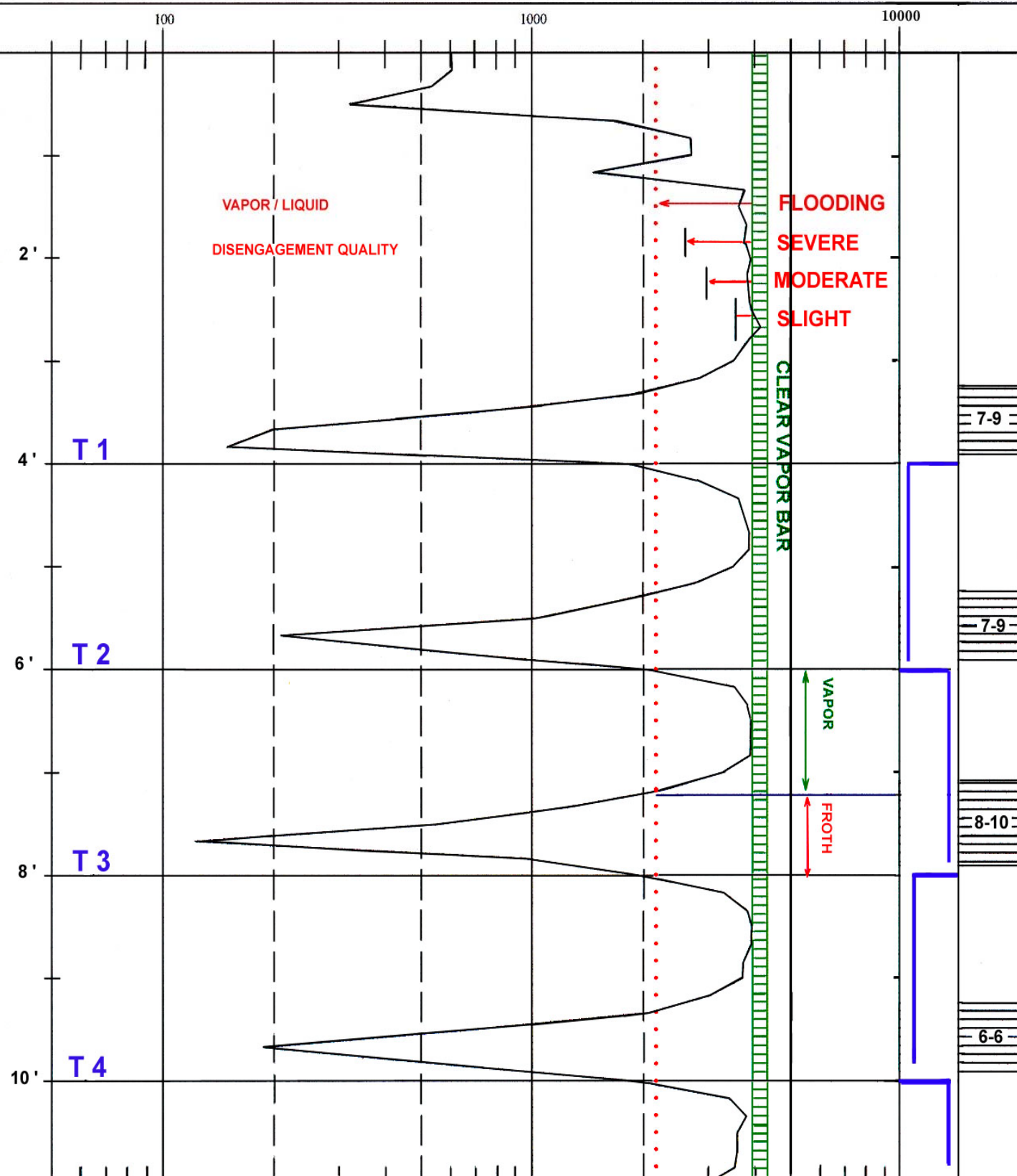
Sample Scan Figure 1  
SCAN INTERPRETATION

Scales: 50 - 10000



Tru-Tec Services, Inc.  
Process Diagnostics  
(800) 288-8970 toll free US & Canada  
(281) 471-8970 outside US  
<http://www.tru-tec.com/>

Clear Vapor Bar      Tray Active Area Scan Line  
Liquid Line

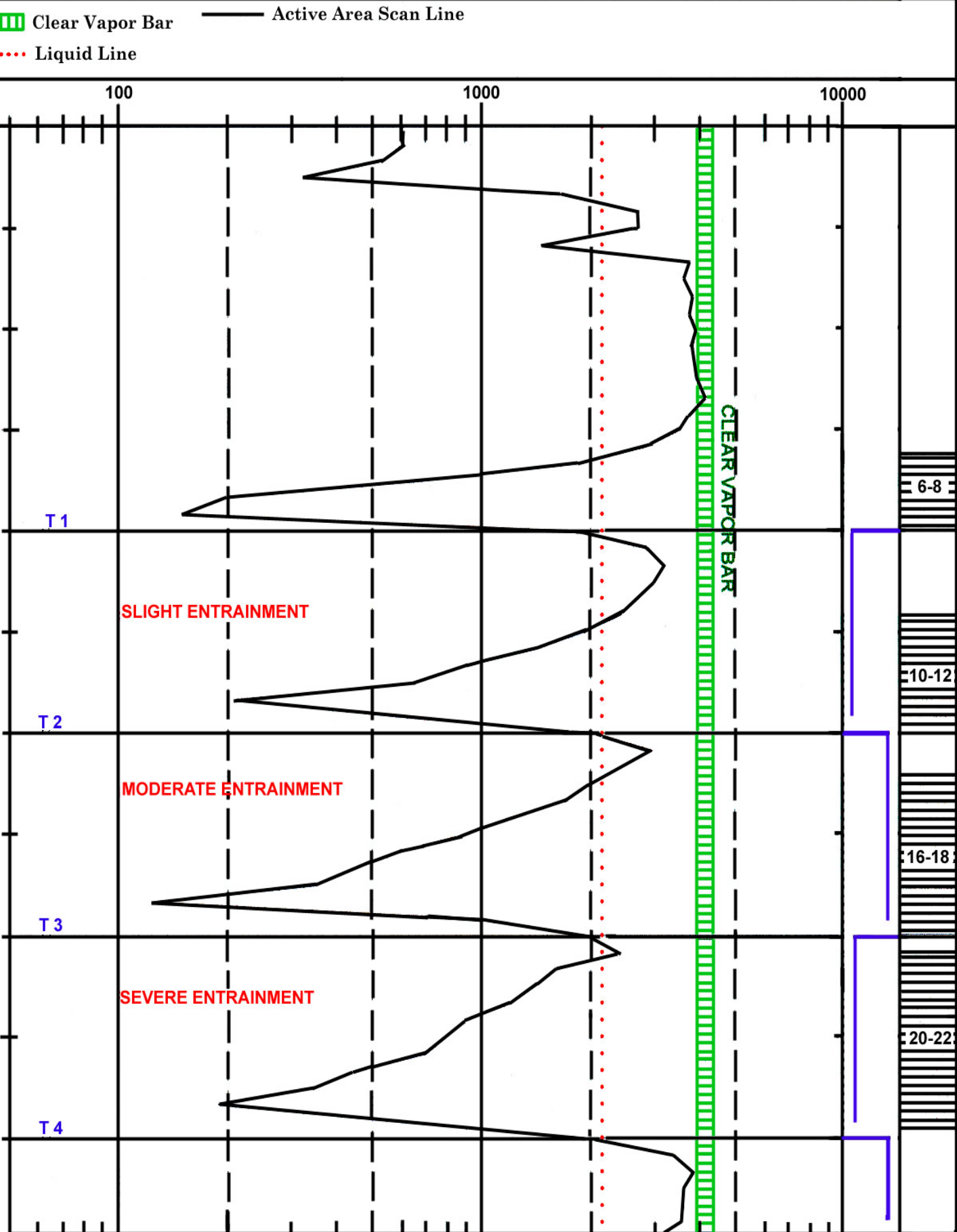


# Sample Scan Figure 2 RAY ENTRAINMENT

Scales: 50 - 10000



Tru-Tec Services, Inc.  
 Process Diagnostics  
 (800) 288-8970 toll free US & Canada  
 (281) 471-8970 outside US  
<http://www.tru-tec.com/>



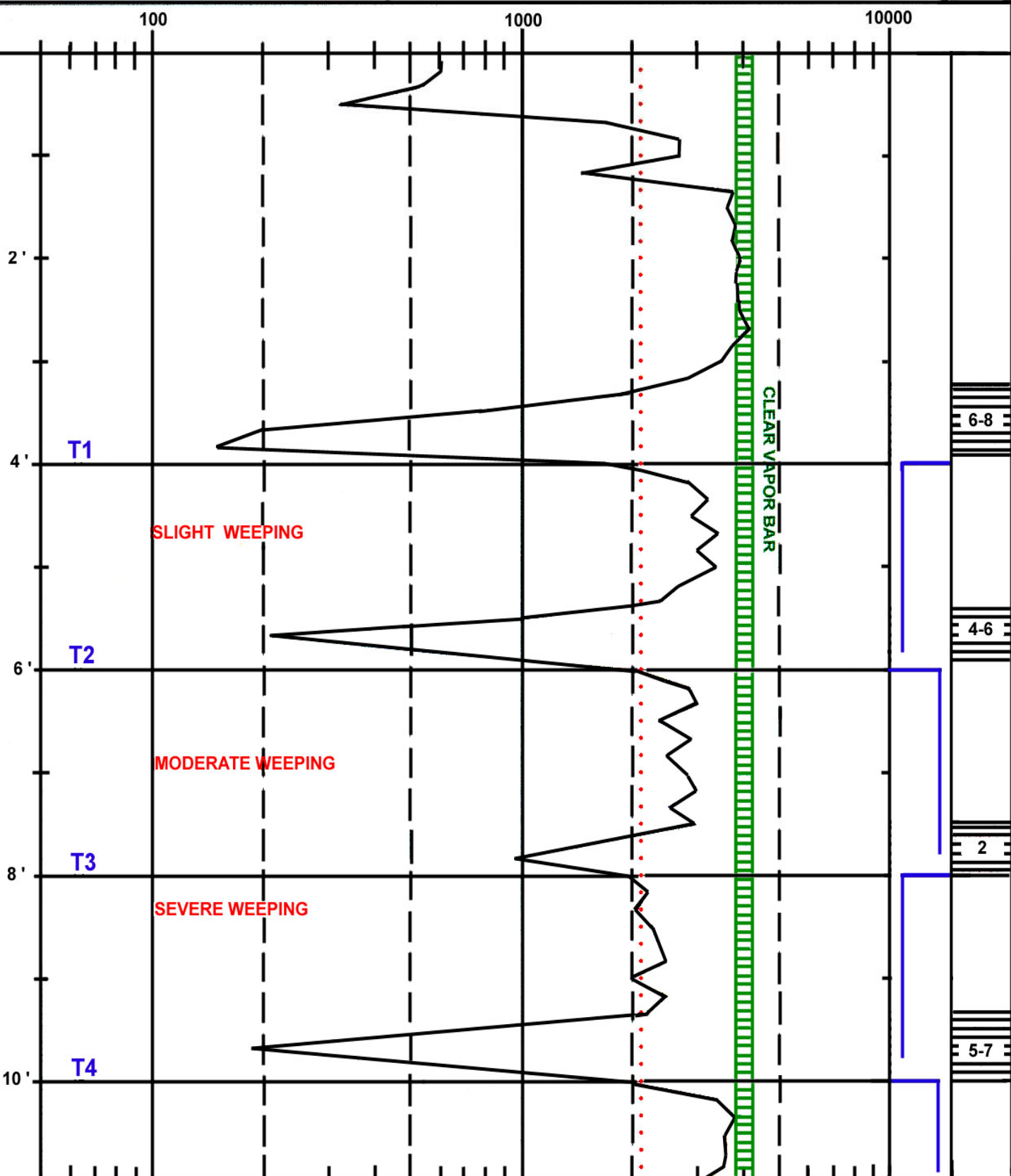
# Sample Scan Figure 3 WEEPING TRAYS



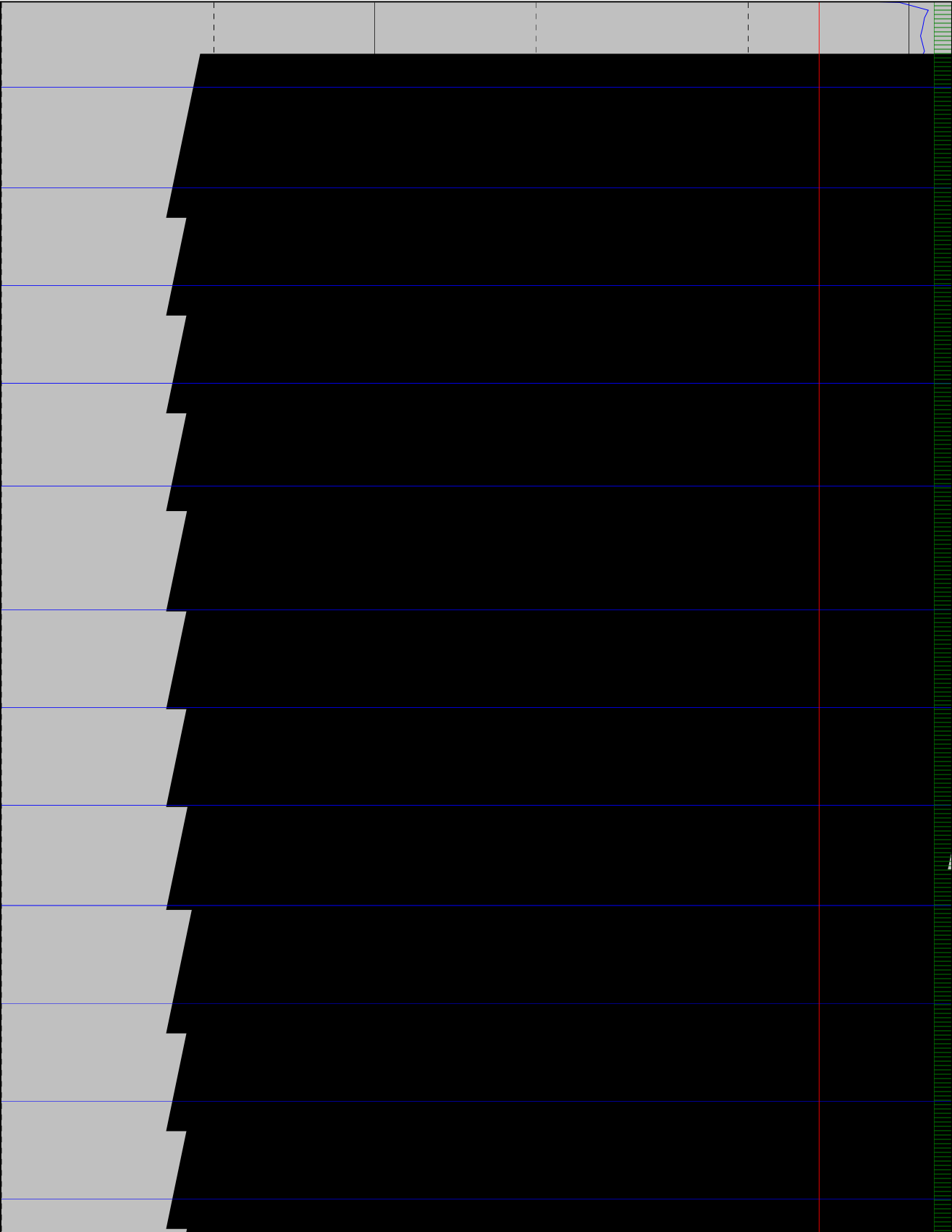
Tru-Tec Services, Inc.  
Process Diagnostics  
(800) 288-8970 toll free US & Canada  
(281) 471-8970 outside US  
<http://www.tru-tec.com/>

Scales: 500 - 10000

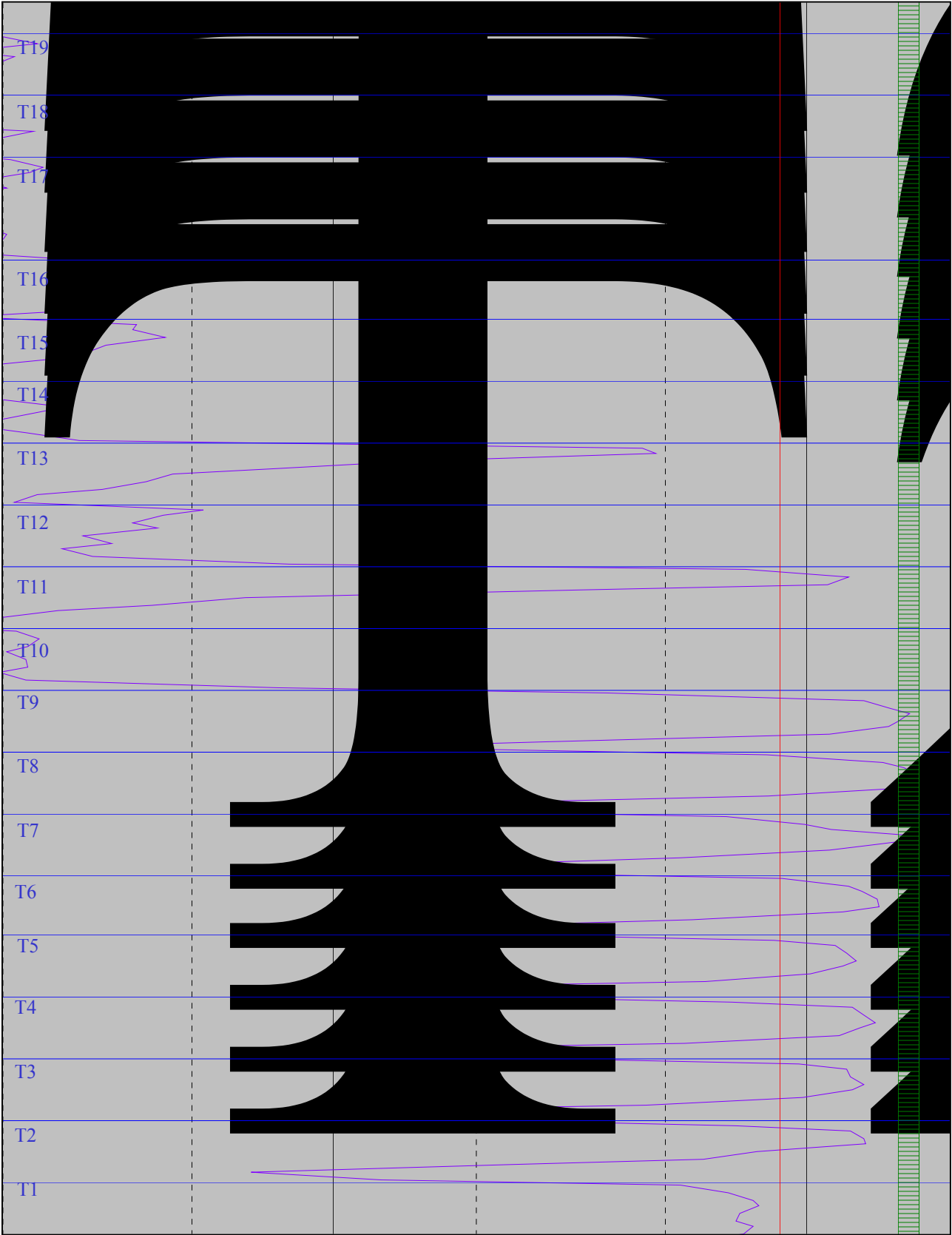
||||| Clear Vapor Bar      — Active Area Scan Line  
..... Liquid Line



# ***Damaged Trays***



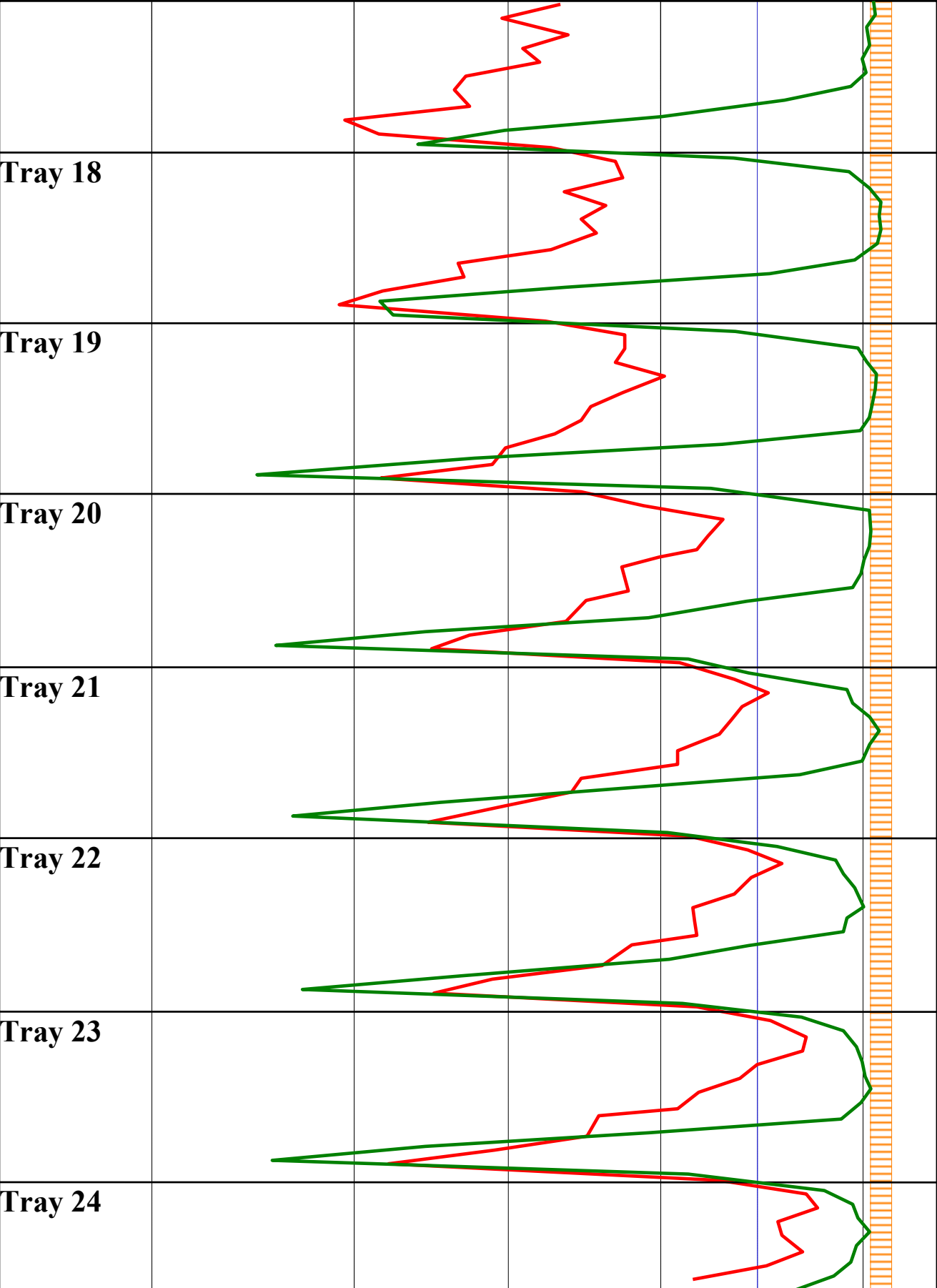
# Flooded Trays



# Example of Foaming Amine Regenerator Column

Red Curve: Initial Scan

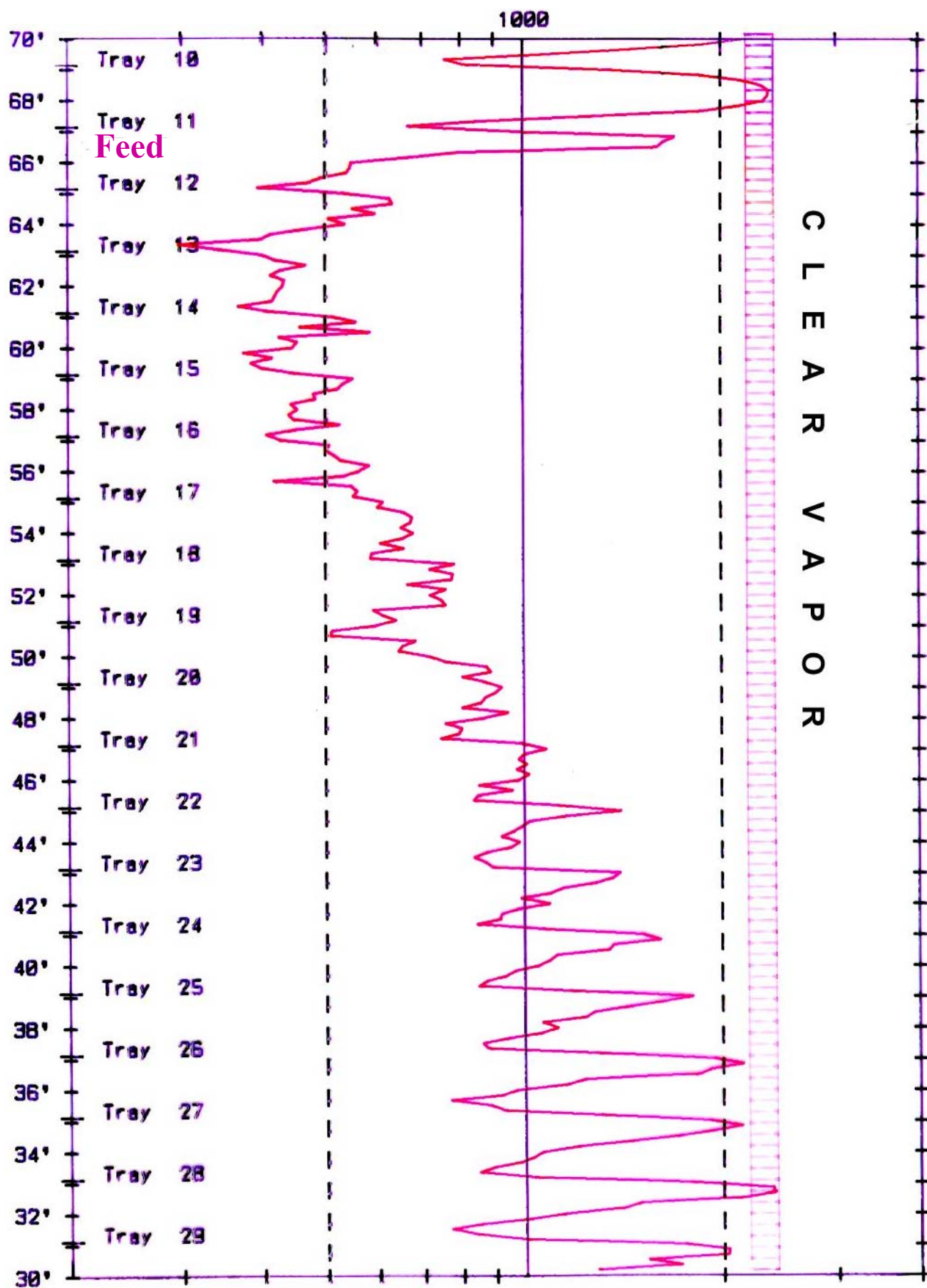
Green Curve: Second Scan following anti-foam injection



# Test Question

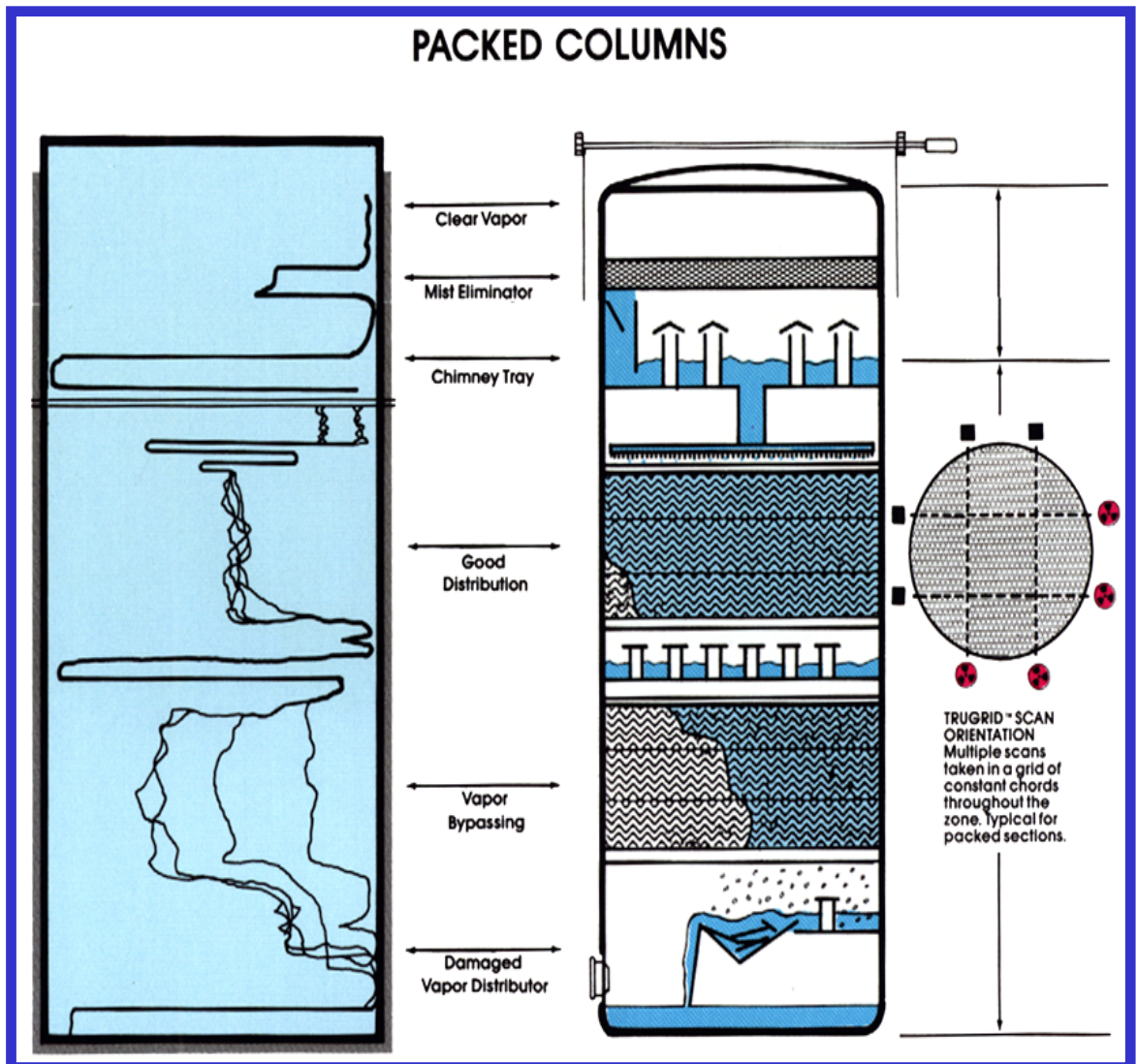
Tru-Tec Services, Inc.  
Process Diagnostic Division  
800-288-8970

SCALES: 200 - 4000



# *Tru-Grid™ Scan*

Scanning can identify a number of common malfunctions in columns



## **Mechanical**

- Damage to trays and packings
- Corrosion resulting in partial tray damage
- Missing tray manways
- Out-of-place liquid or vapor distributors
- Level control problems in the base of the column

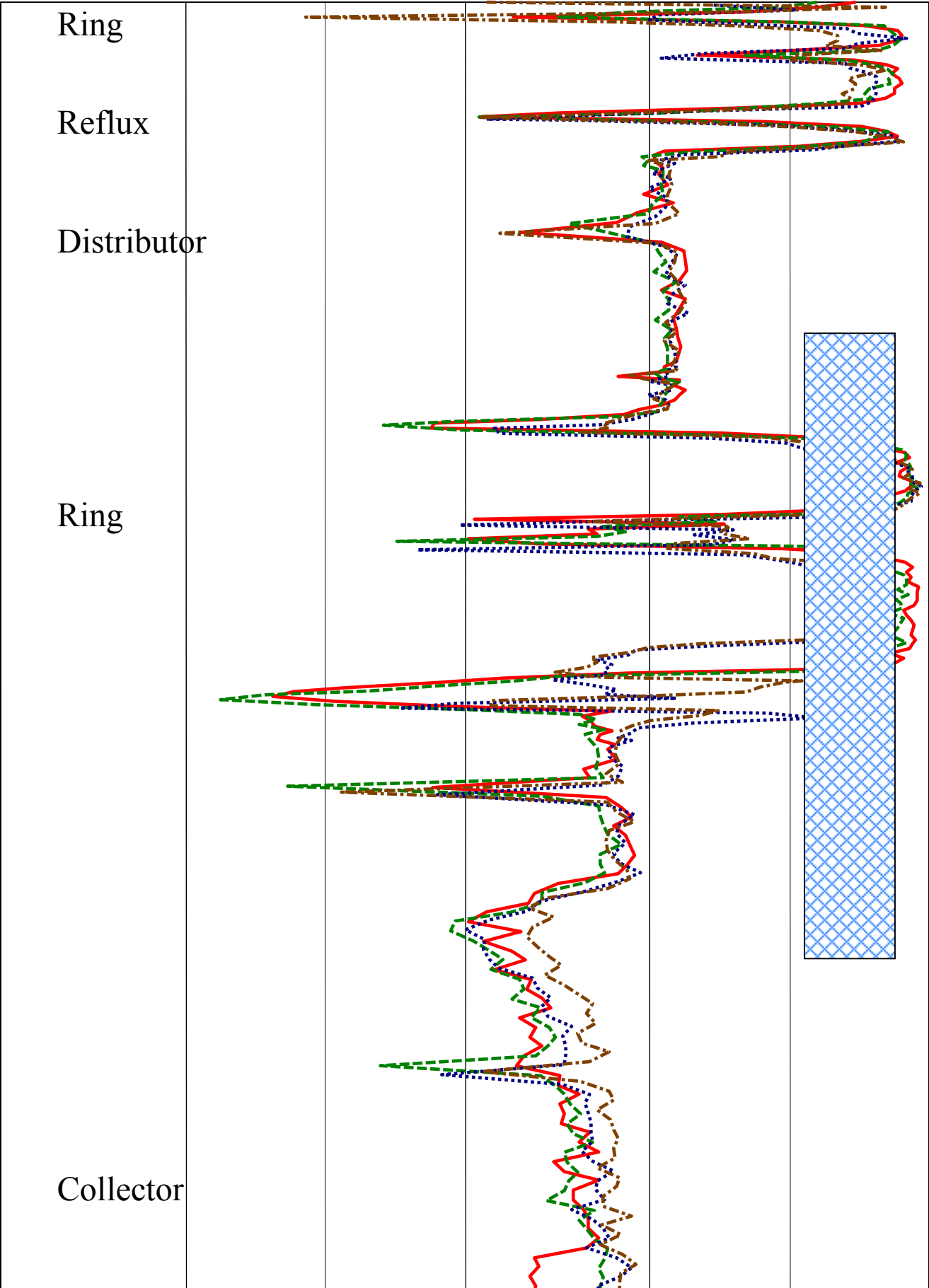
## **Rate Related**

- Entrainment (slight, moderate, severe, jet flooding)
- Weeping
- Dry or flooded trays due to loading conditions

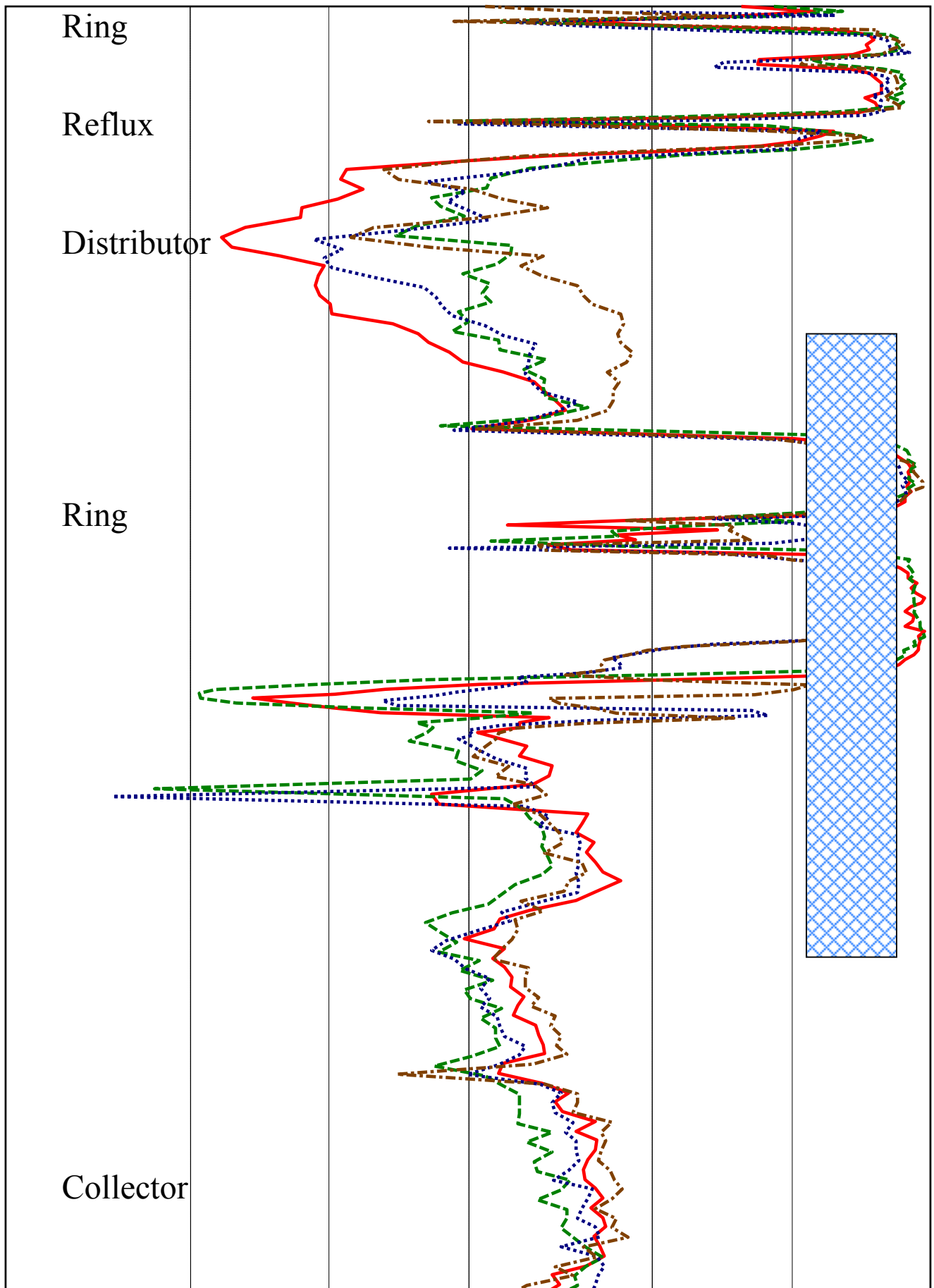
## **Process Related**

- Foaming
- Liquid holdup due to fouling or pluggage
- Superheated or subcooled feed or reflux

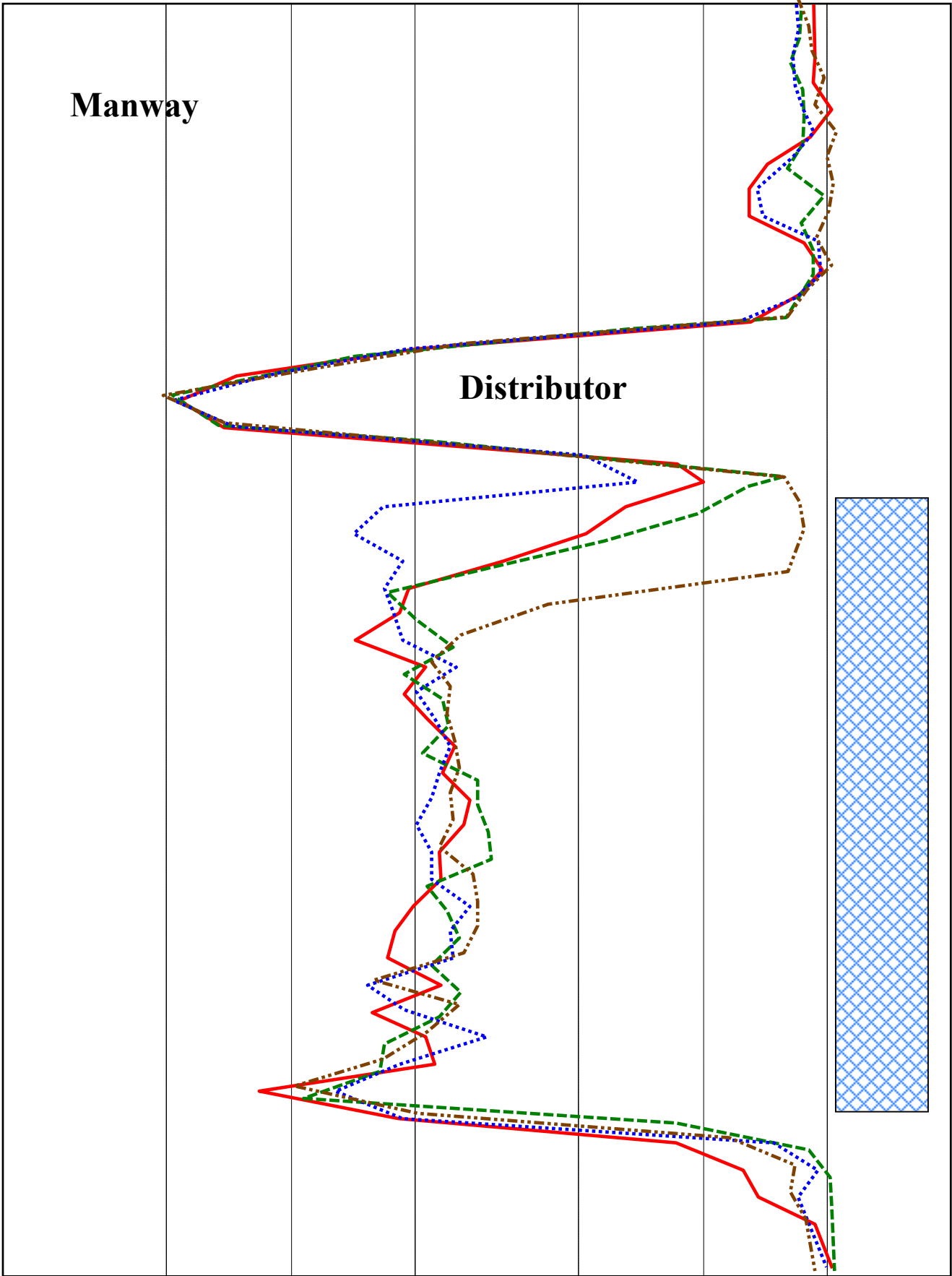
Example: Good Distribution  
Packed Stripper Column



# Example: Poor Distribution and Fouling Packed Stripper Column



# Example: Damaged Packing Stripper Column

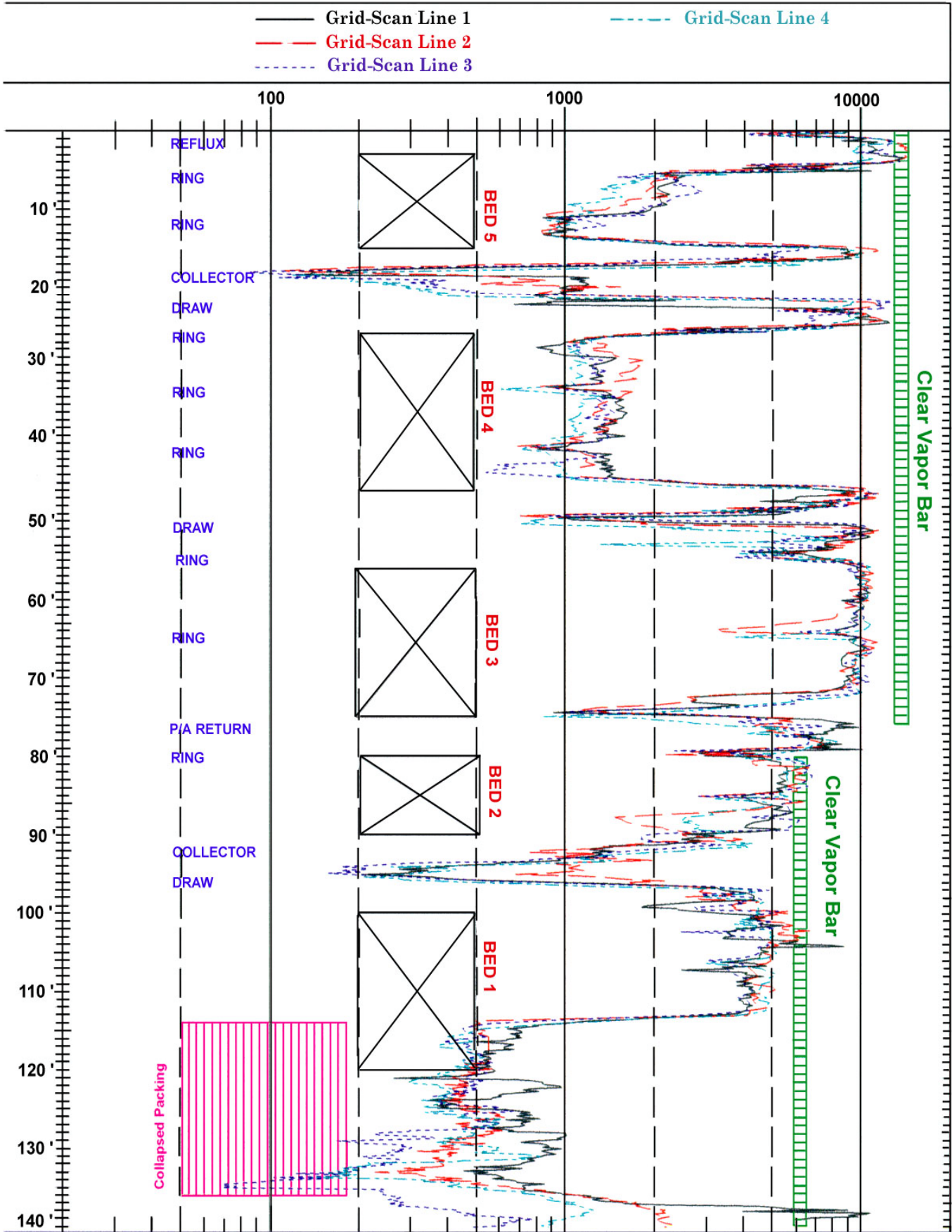


Sample Scan Figure 8  
COLLAPSED PACKING BEDS



Tru-Tec Services, Inc.  
Process Diagnostics  
(800) 288-8970 toll free US & Canada  
(281) 471-8970 outside US  
<http://www.tru-tec.com/>

Scales 20 - 20000



# Plugged Structured Packing

Sample Scan Figure 7

## PLUGGED STRUCTURE PACKING BED

Scales: 50 - 30000



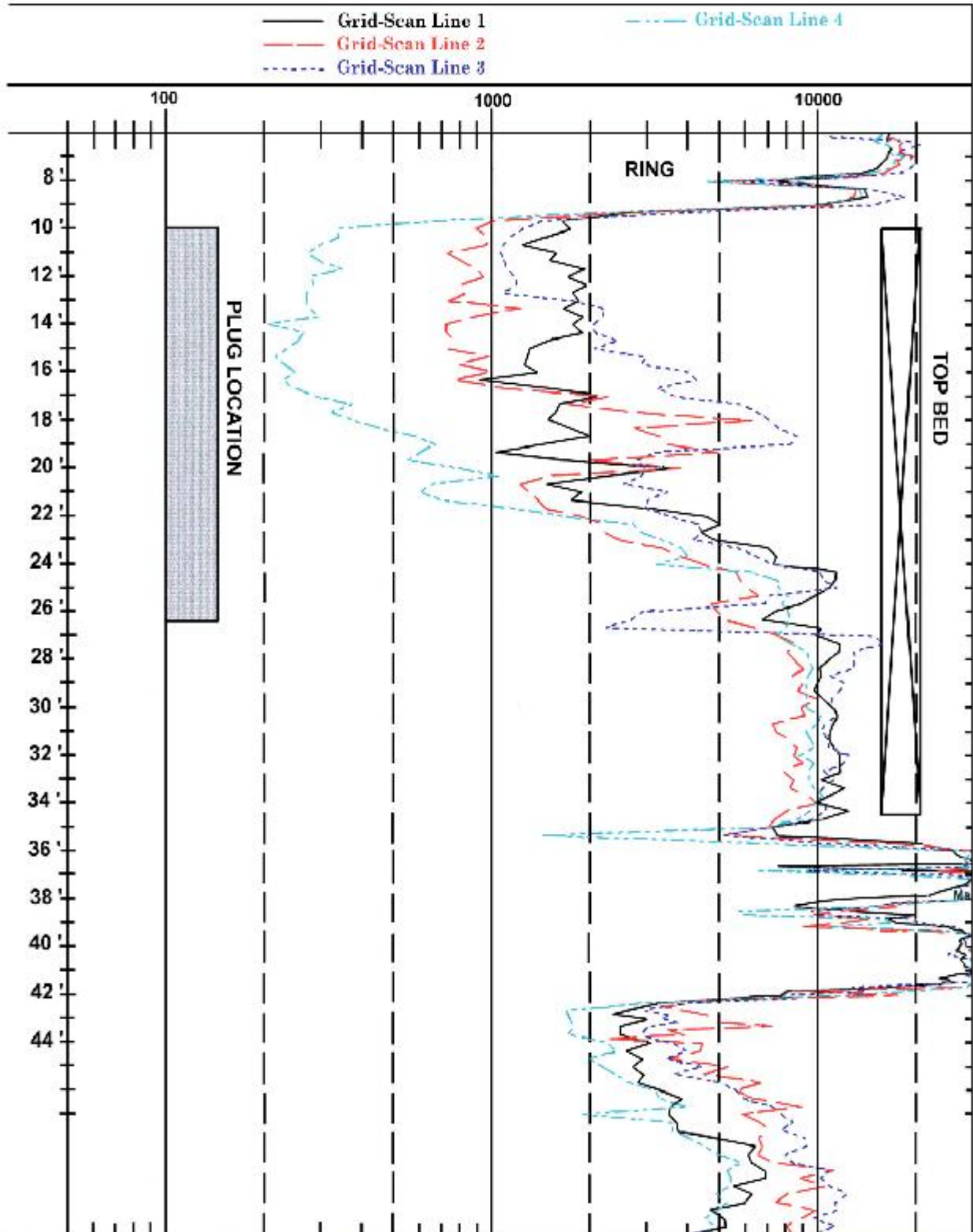
Tru-Tec Services, Inc.

Process Diagnostics

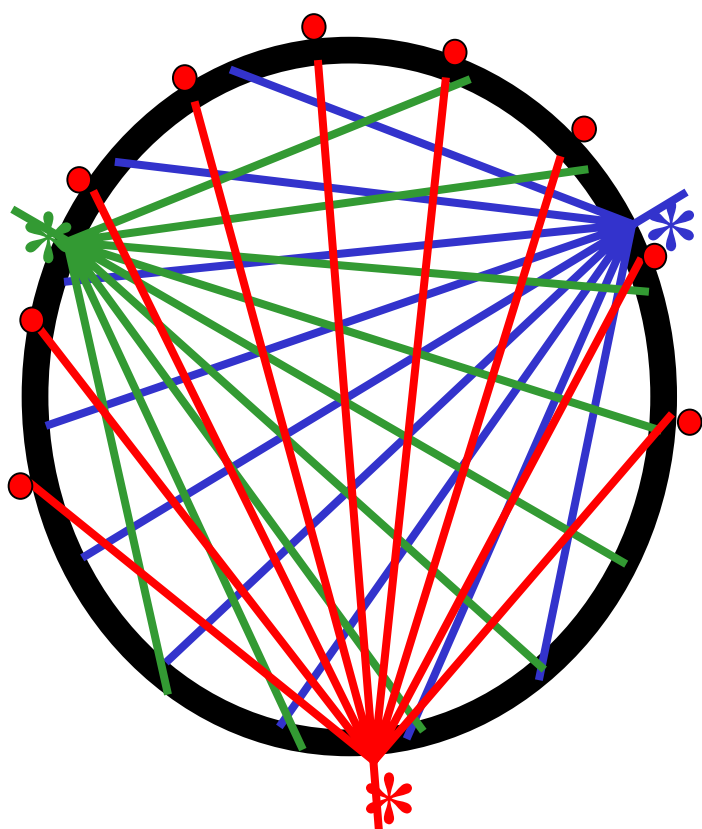
(800) 288-8970 toll free US & Canada

(281) 471-8970 outside US

<http://www.tru-tec.com/>

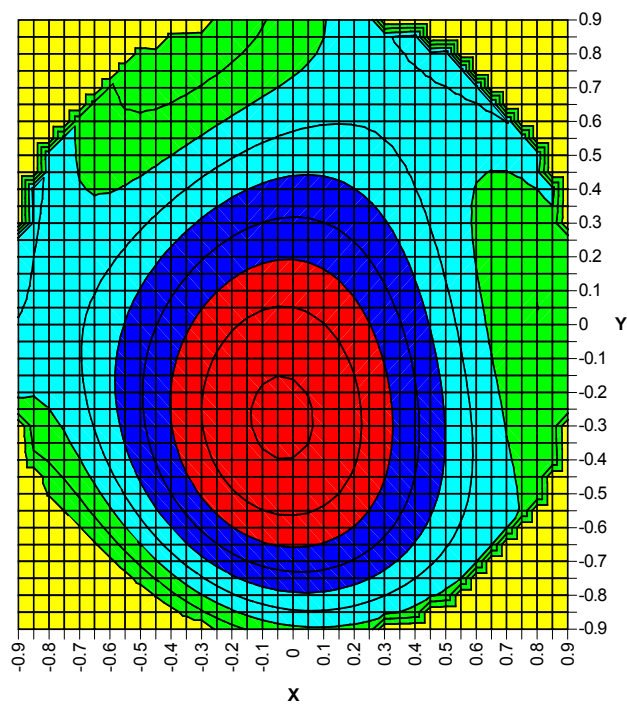


# CAT-Scan



**Source Placement**

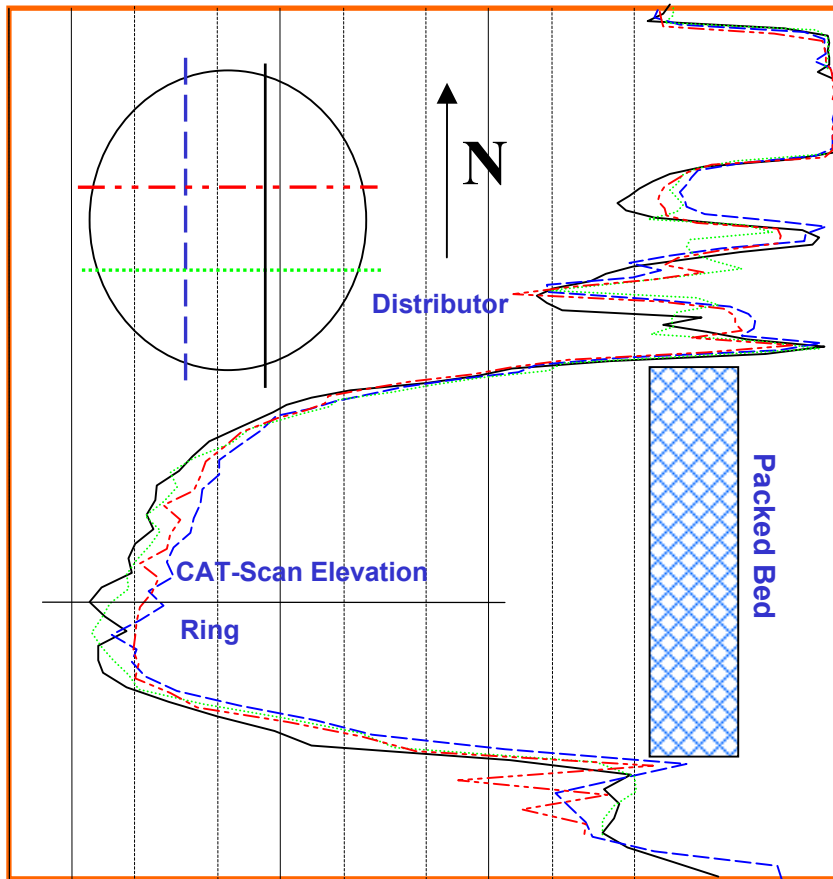
● **Detector Placement**



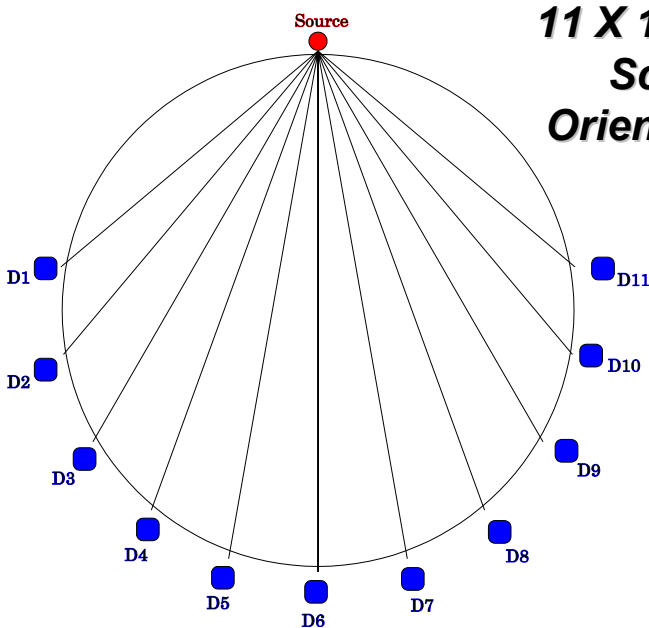
# CAT-Scanning Technology

(Computer Aided Tomography)

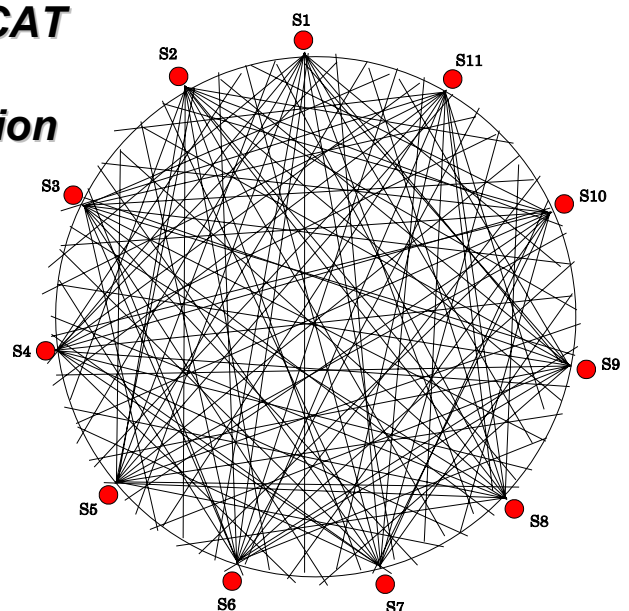
*Applied to Packed Beds*



**11 X 11 CAT  
Scan  
Orientation**

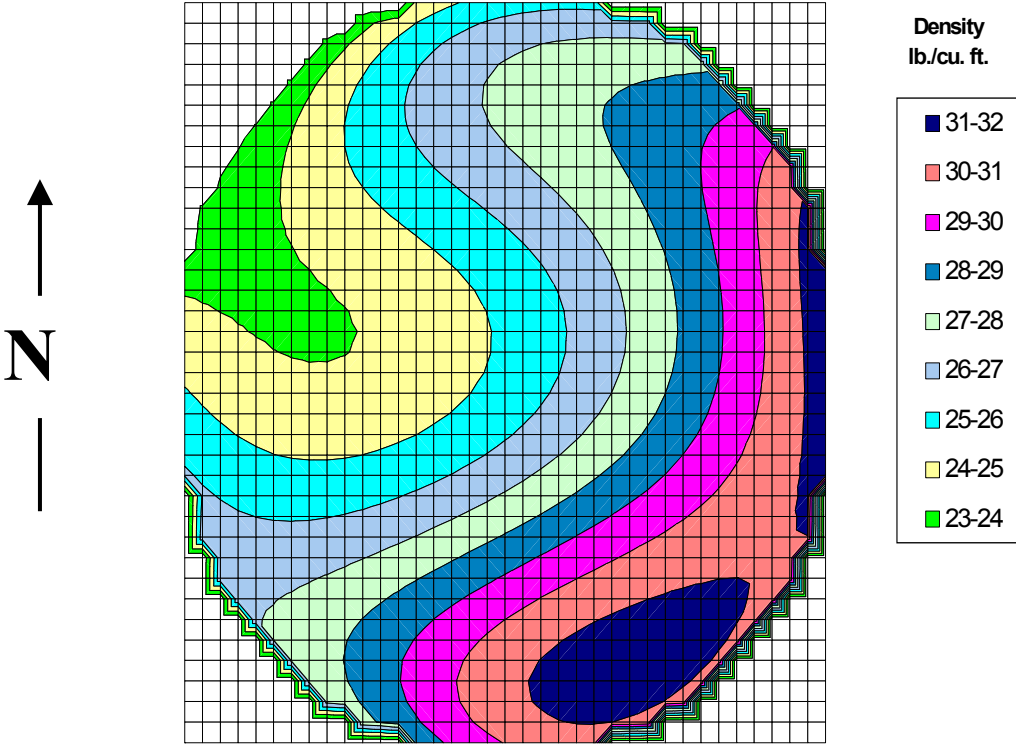


**11 detector chords  
per source fan  
beam**

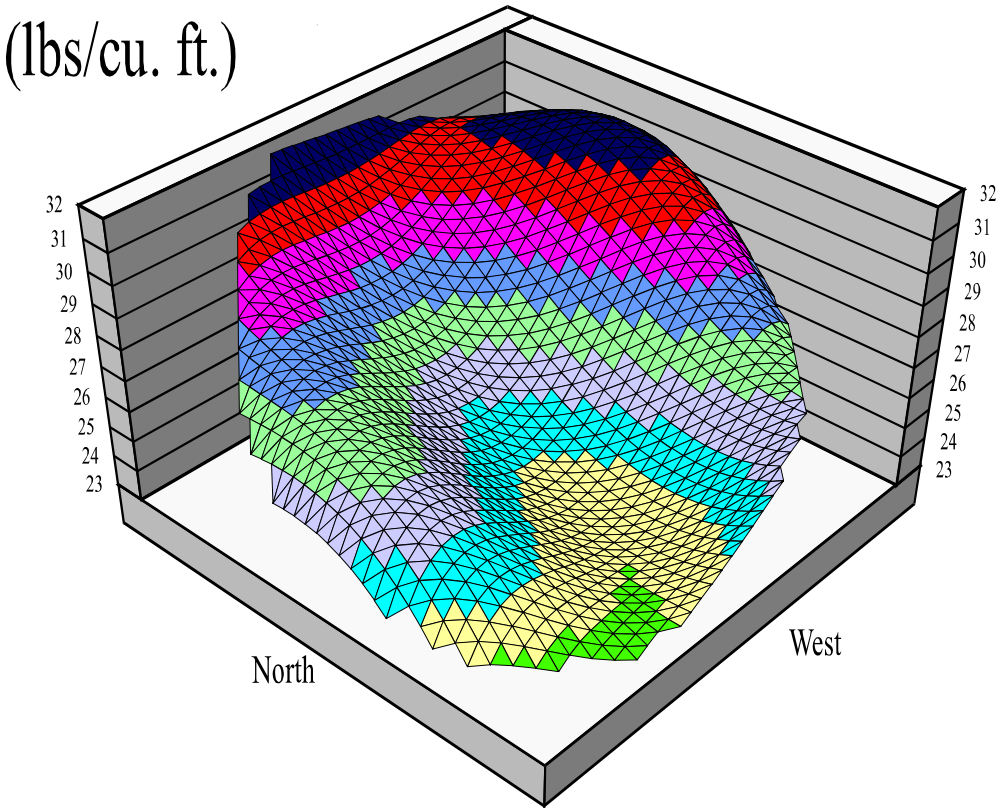


**11 source fan beams for a  
total of 121 scan chords**

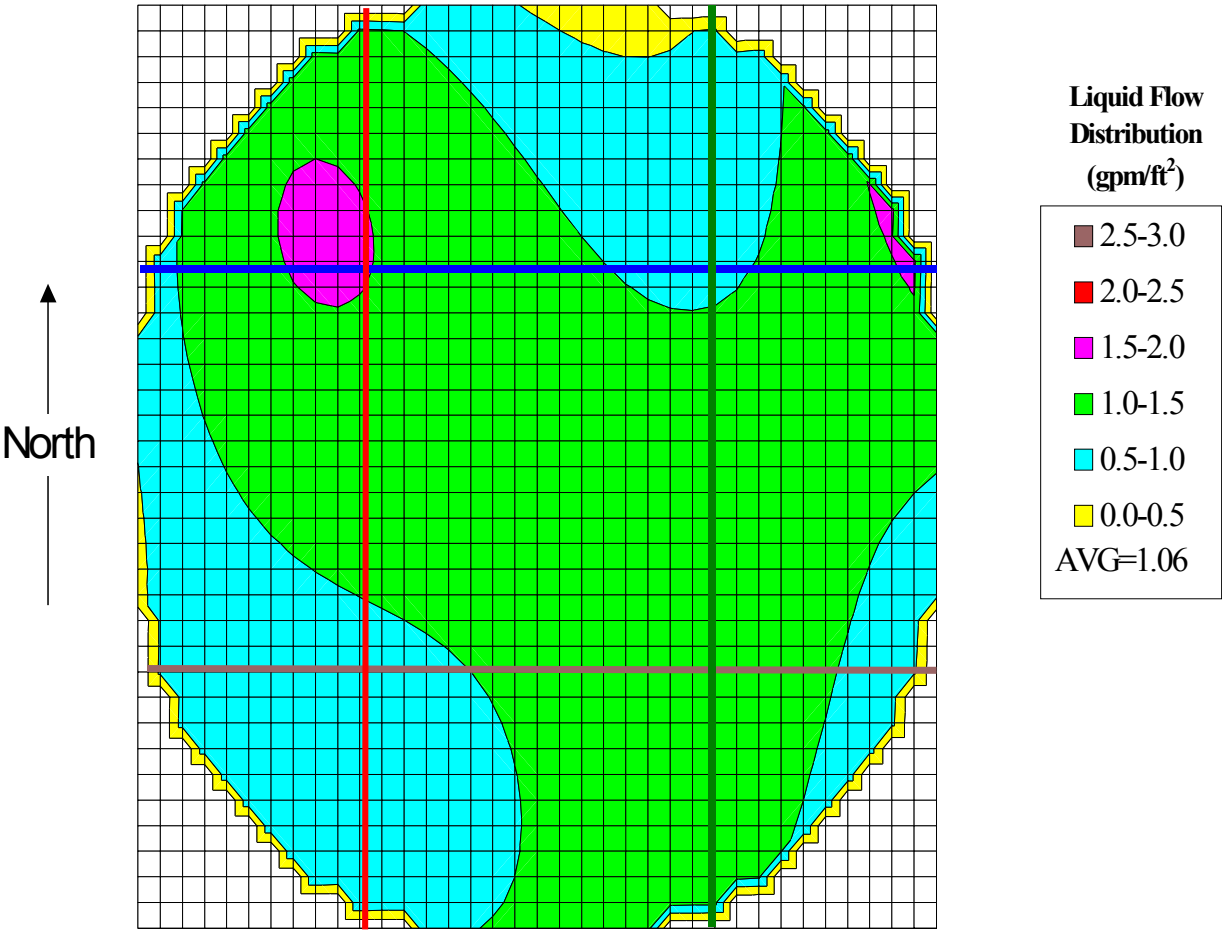
Packed Column  
Contour Plot



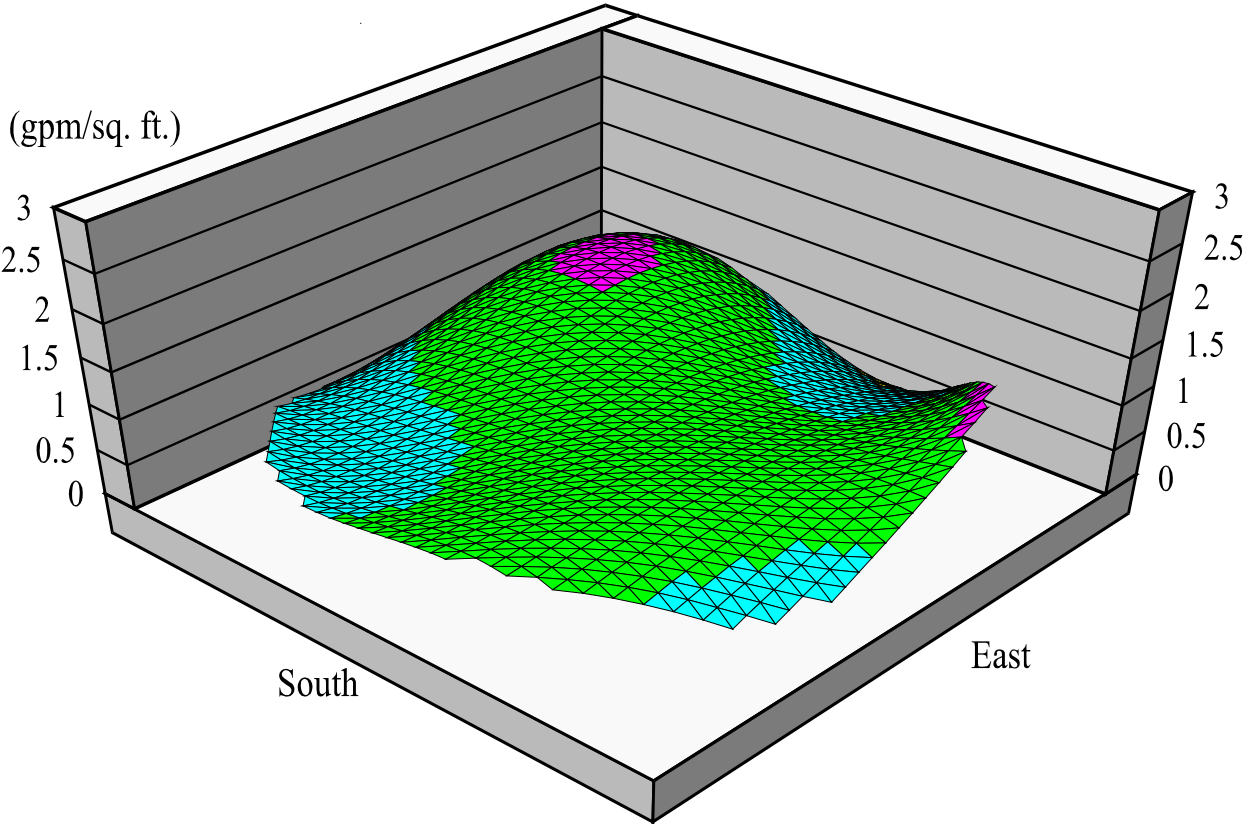
3-D Surface Plot



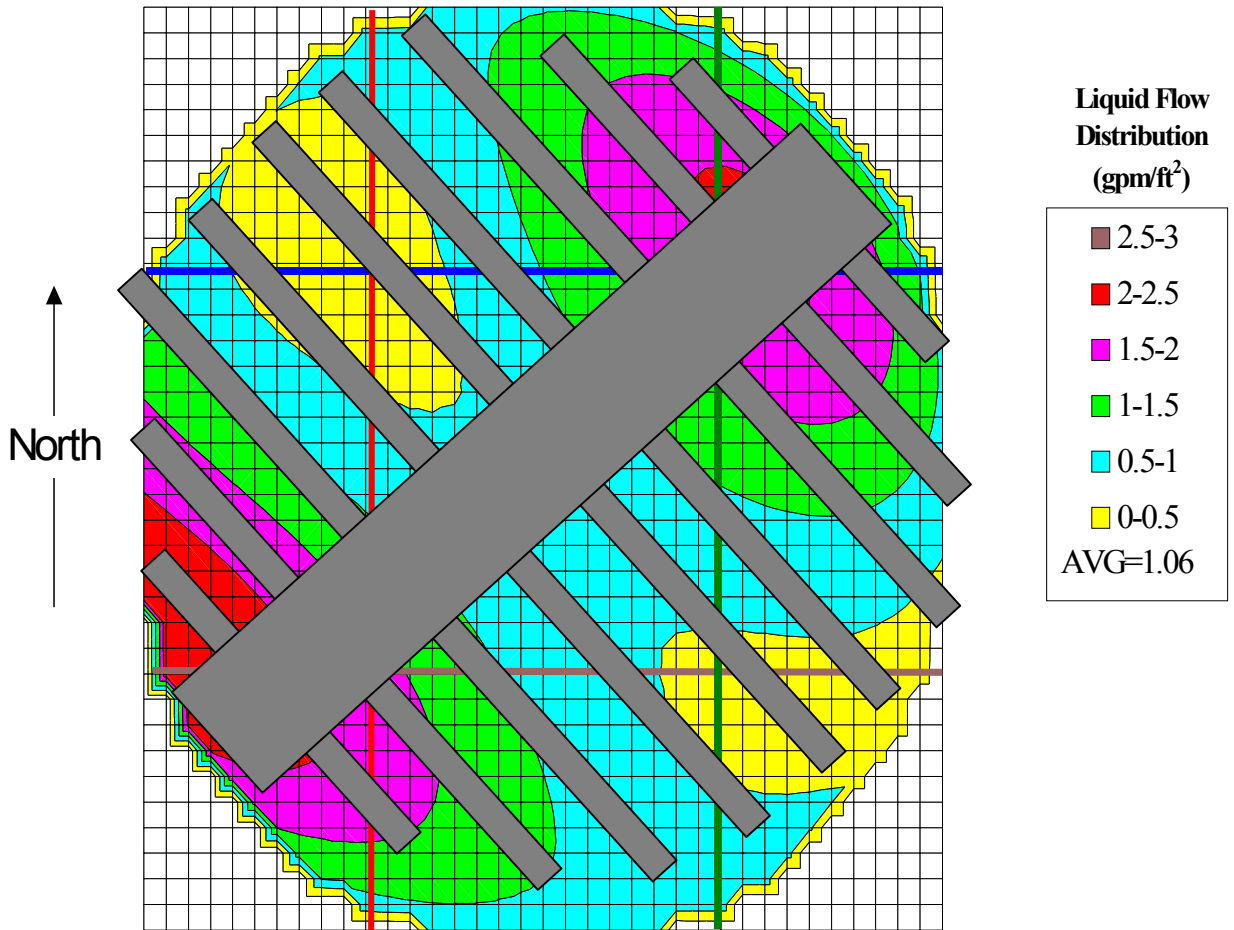
CAT-Scan Contour Plot  
Good Distribution



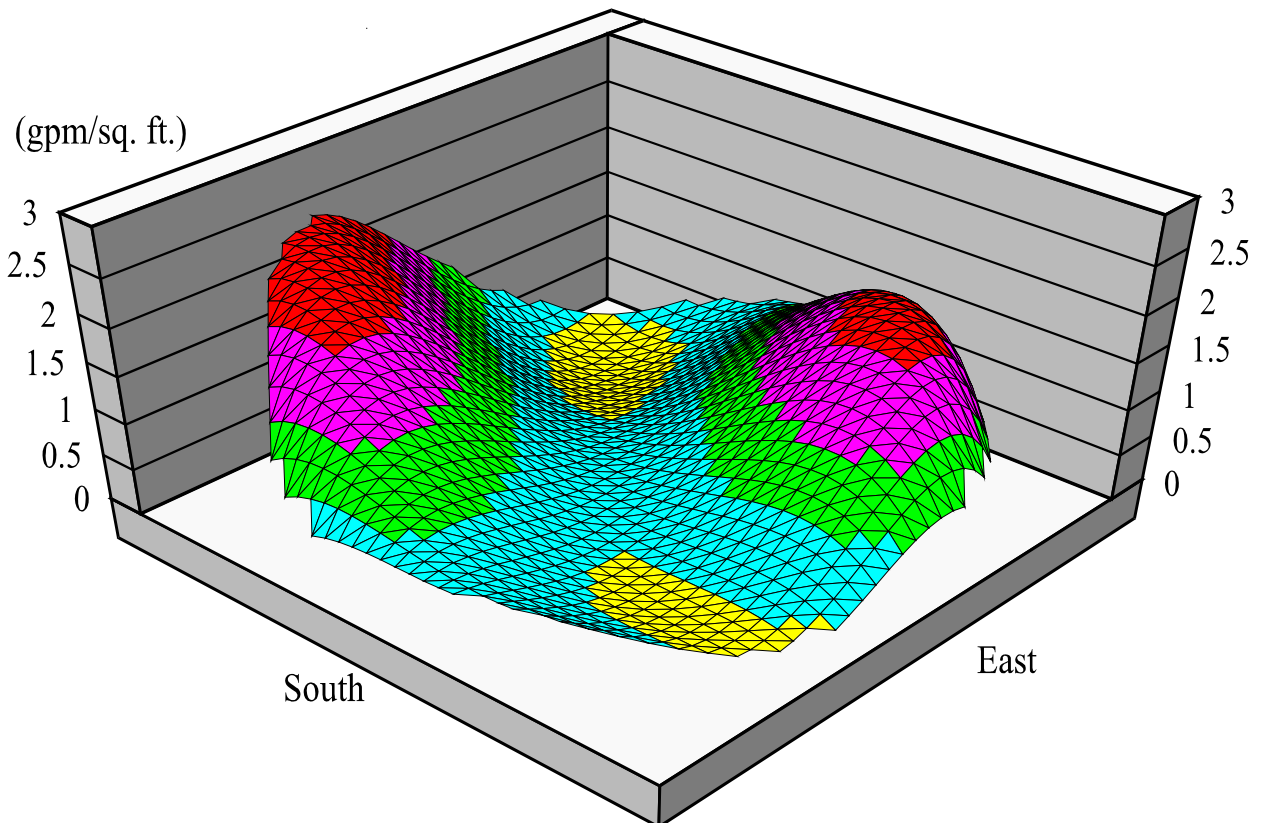
3-D Surface Plot



**CAT-Scan Contour Plot**  
**Poor Distribution**



**3-D Surface Plot**





# **Critical Path** **10' OD x 120' T/T** **Single Pass Trays**

- Safety Orientations - 28 men @ \$45/hr
- Supply/Install Isolation Blinds
- Clean Tower for Entry
- Open External Manway
- Erect Scaffold 6' from bottom tray
- Open & Tunnel internal manway's
- Sweep tray's
- Replace small amount of hardware
- Final inspection by client & contractor
- Close internals/tray manways
- Remove internal scaffolding
- De-blind column
- Close external manways
- De-mobilize

---

## **EQUIPMENT**

- 2 - Trucks
- 1 - Tool Trailer
- 1 - 650 CFM Air Compressor
- 1 - Air Tugger
- 12 - Low Volt Lights
- 4 - Radios
- 1 - Lot Fresh Air Equipment

---

Duration 3.5 Days (includes mobilization and demobilization)  
Manpower - 14 men per shift - work (2) elevations  
Total Man Hours - 1,232  
Total Cost - \$59,660.00

|                                                                         |
|-------------------------------------------------------------------------|
| <b>COST OF SCAN: &lt; \$5,000</b><br><b>TIME REQUIRED: &lt; 8 HOURS</b> |
|-------------------------------------------------------------------------|



# **Critical Path 10' OD x 120' T/T Replacement Single Pass Trays**

## **Scheduled Costs**

- (1) Single Pass Valve Tray 410 SS  
Normal Rate Price: ~ \$8,000  
Delivery Time - 4 Weeks

## **Emergency Costs**

- (1) Single Pass Valve Tray 410 SS  
Expedited Rate Price: ~ \$12,300  
Delivery Time - 24 Hrs Minimum

**COST OF SCAN: < \$5,000  
TIME REQUIRED: < 8 HOURS**

# Benefits of Pre-Turn-Around Scans

Mechanical Problem - Four Towers

Process Problems - Five Towers

No Problems Indicated - Ten Towers

(Entry can be eliminated if no history of fouling or corrosion)

## Crude Unit

Atmospheric Tower

All trays in place

Vacuum Tower

LVGO distributor plugged or damaged

HVGO draw tray leaking or wash

oil distributor damaged

## Crude Unit

Main Fractionator

Trays 21 and 22 damaged, all other internals in place

## Alky Unit

Isostripper

High reflux rate or subcooled reflux causing  
flooding on top four trays, lower  
accumulator leaking

Depropanizer

Severe liquid entrainment throughout the  
tower, no indications of mechanical damage

Acid stripper

No problems indicated

Acid regenerator

No problems indicated

## Unsat Gas Plant

Isobutane Absorber

Flooding present on top 32 trays

Amine Absorber

No Problems Indicated

Debutanizer

No Problems Indicated

Depropanizer

No Problems Indicated

Naptha Splitter

No Problems Indicated

## Sat Gas Plant

Stripper

No Problems Indicated

Amine Absorber

No Problems Indicated

Debutanizer

Severe flooding throughout the tower

Depropanizer Dryer

High reflux rate or subcooled reflux  
flooding top three trays, Tray 10 heavily  
loaded - possible downcomer restriction

Sponge Oil Absorber

No Problems Indicated

Main Absorber

All trays in place

## Delayed Coking Unit

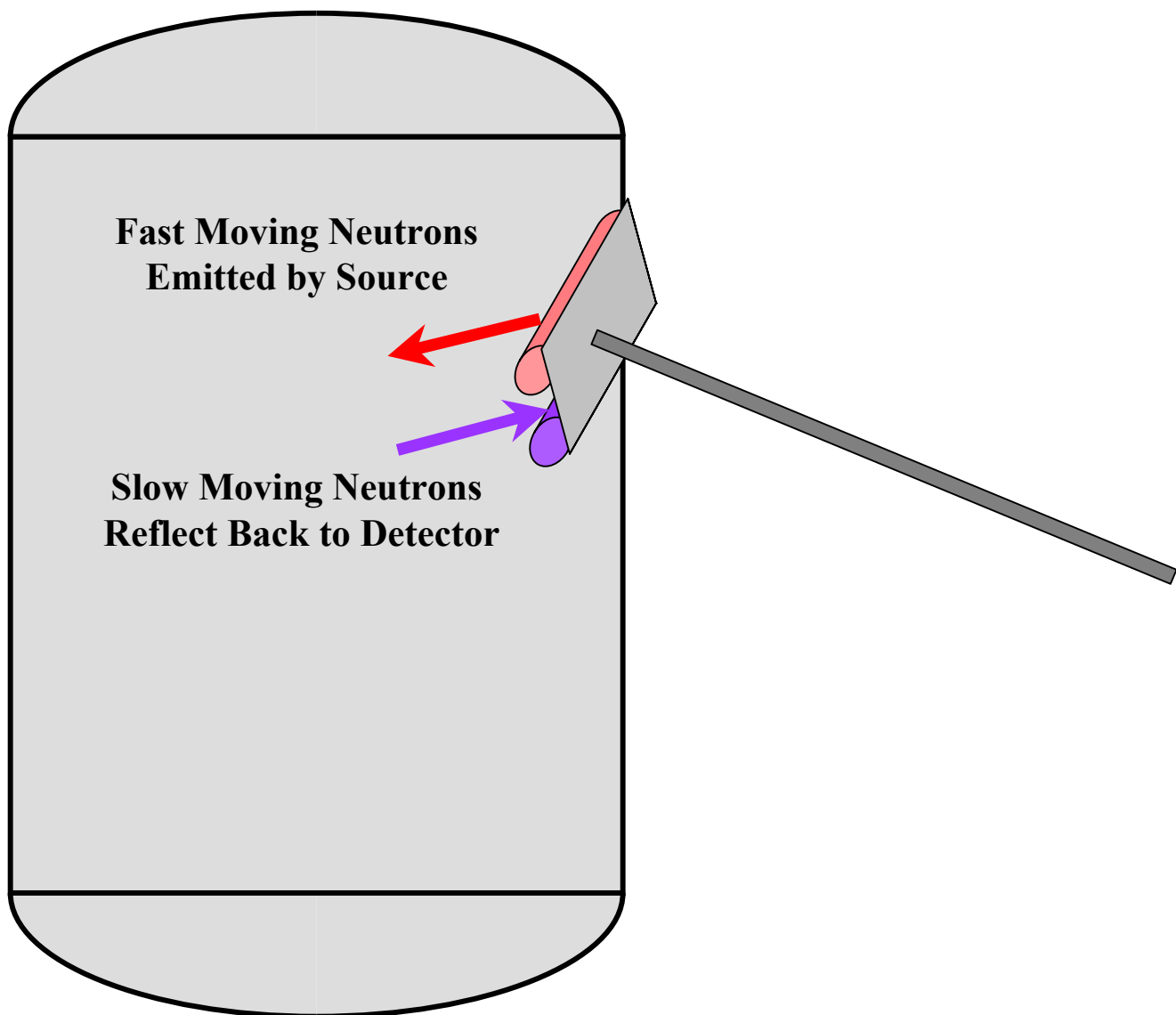
Coker Fractionator

No Problems Indicated

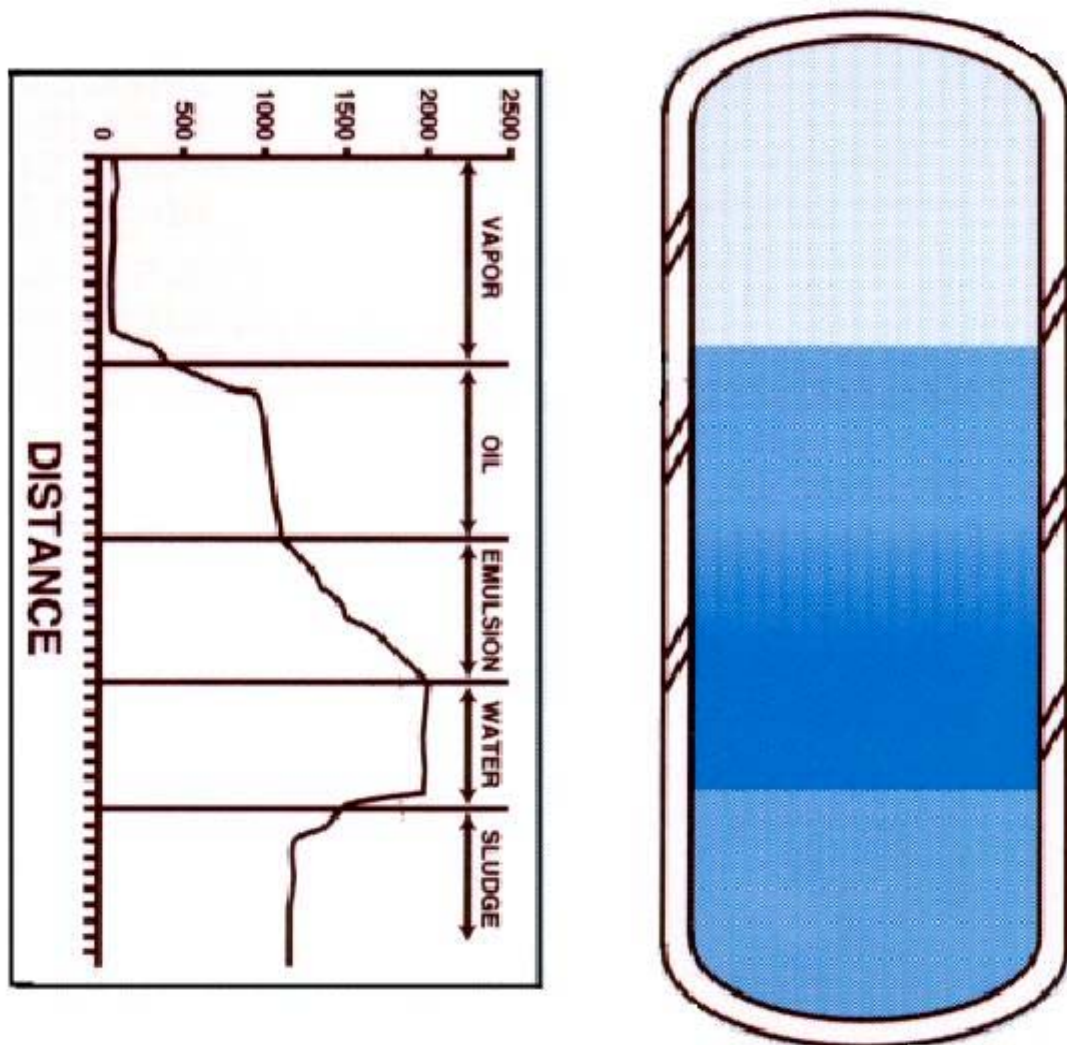
# Neutron Backscatter

## Neutron Backscatter

Measures The Interaction of Neutrons  
With The Hydrogen Nuclei In The  
Process

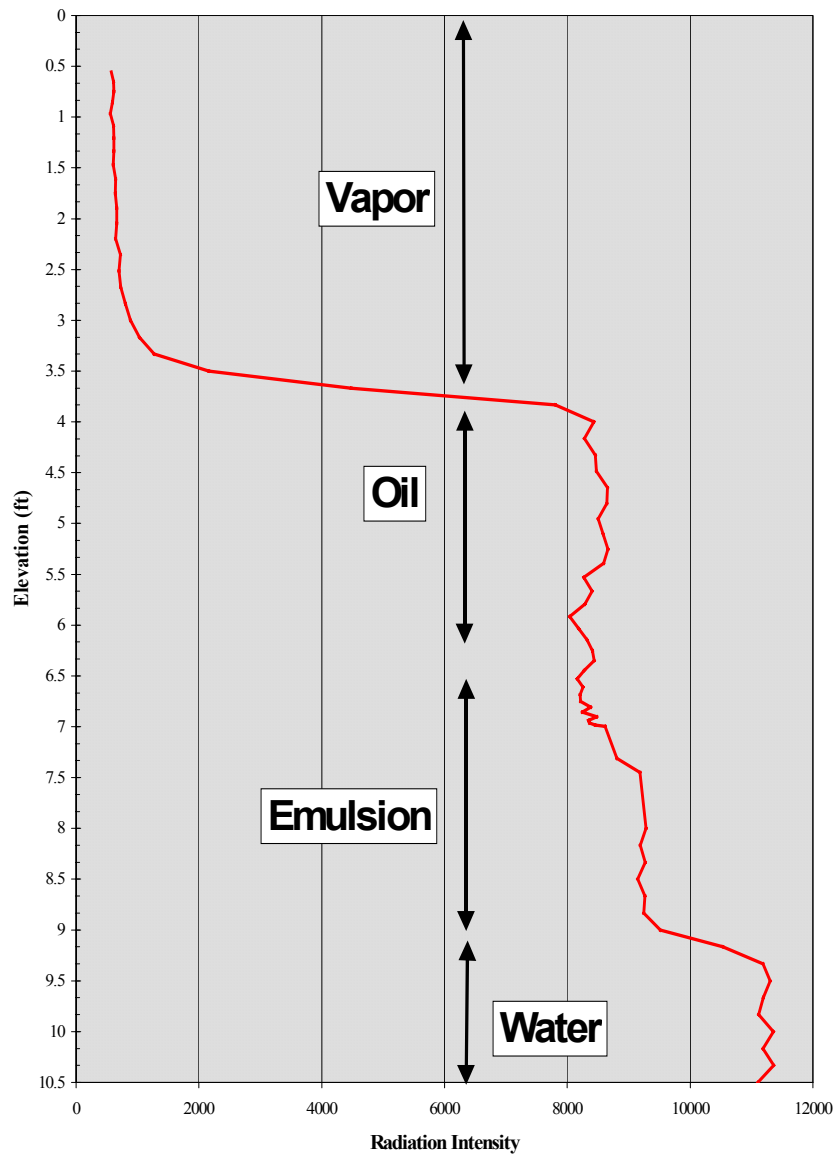
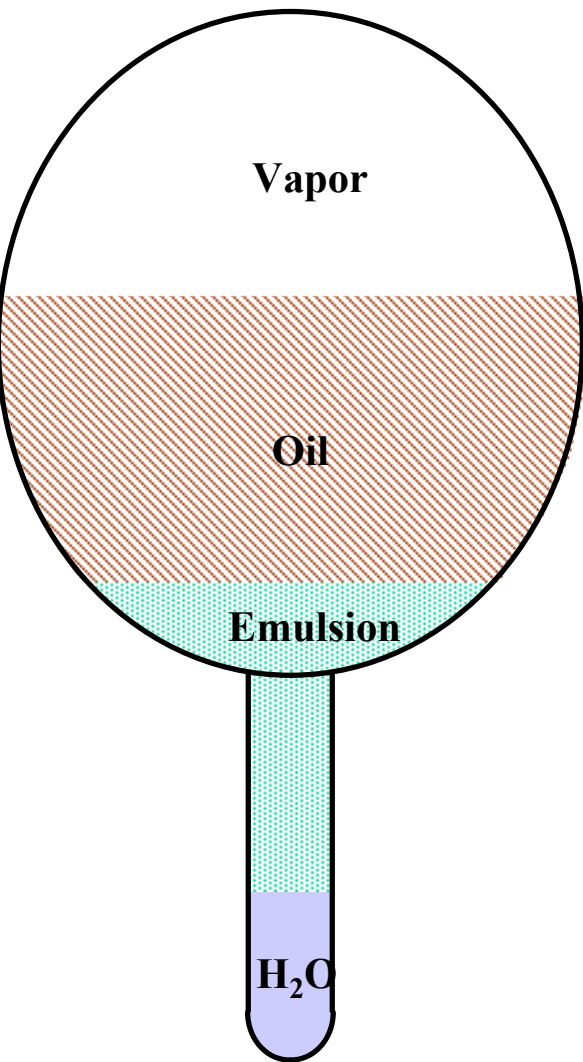


# NEUTRON RESPONSE OF VESSEL WITH FIVE DIFFERENT PHASES



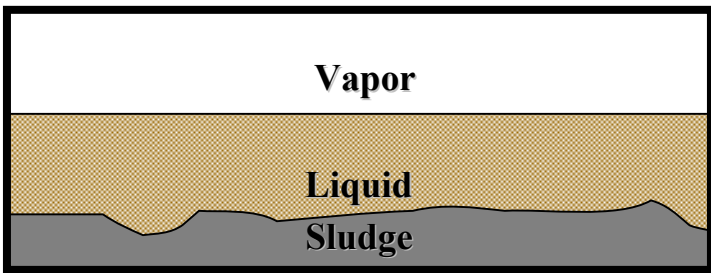
**This illustration shows a typical response for a neutron survey of a vessel with five different phases or materials with varying hydrogen concentrations. Unlike gamma scanning a neutron system response is a function of hydrogen concentration of the material inside the process.**

# Neutron Backscatter Survey Reflux Accumulator Drum

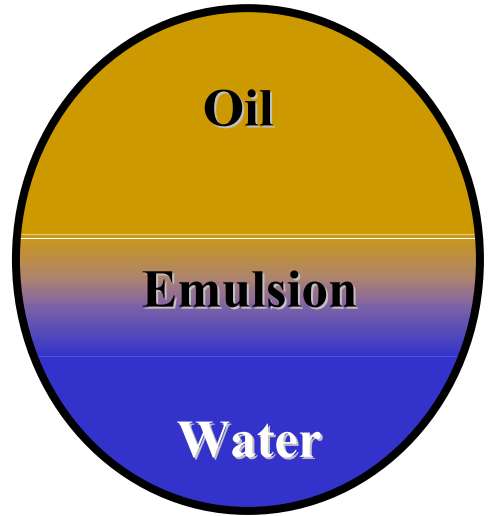


# Neutron Backscatter Survey Common Applications

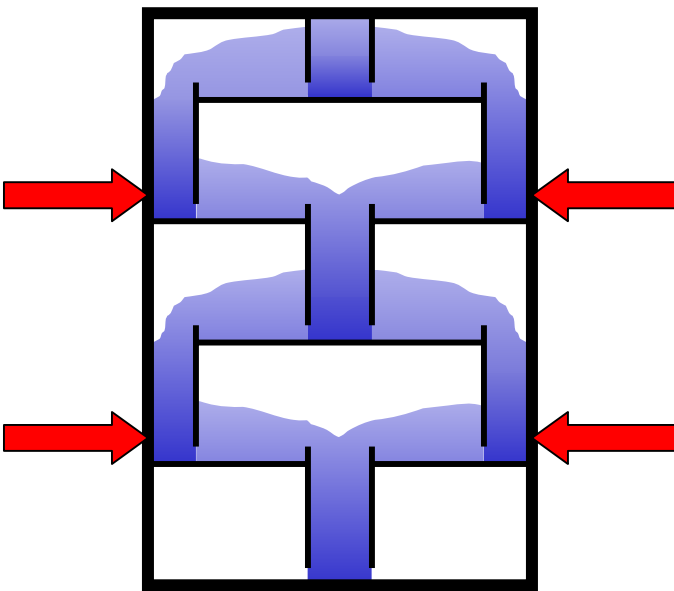
## Storage Tanks



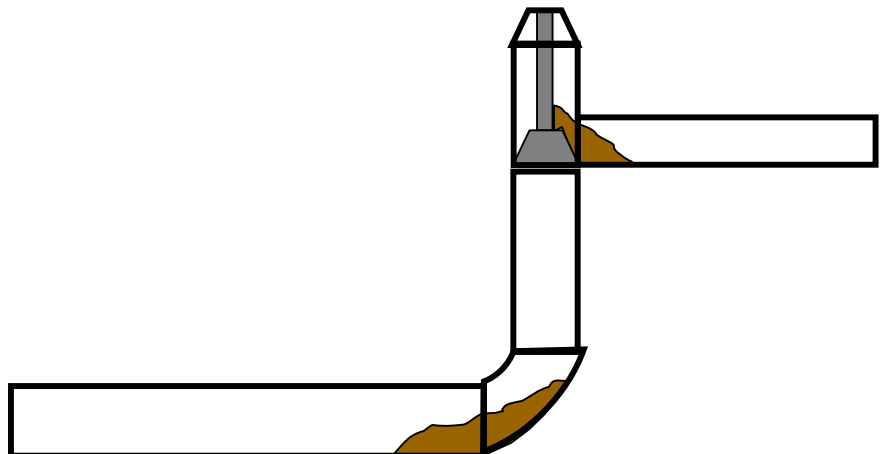
## Drums



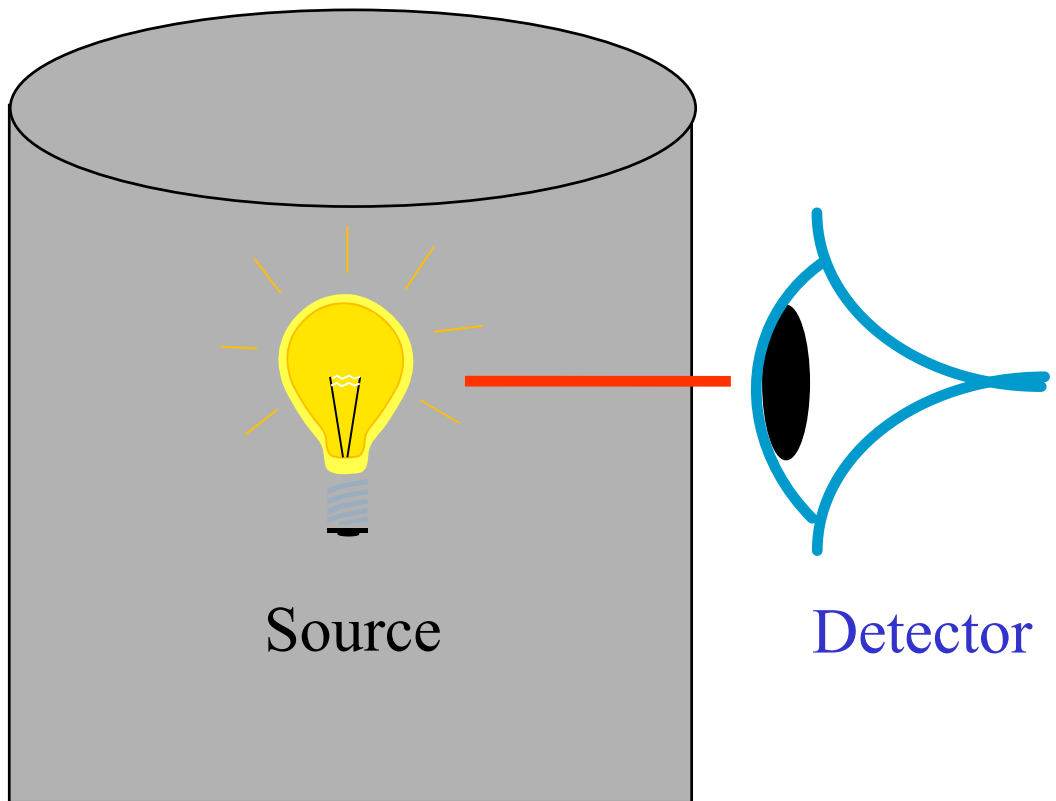
## Liquid Levels in Outside Downcomers & Sumps



## Plugs in Piping and Valves

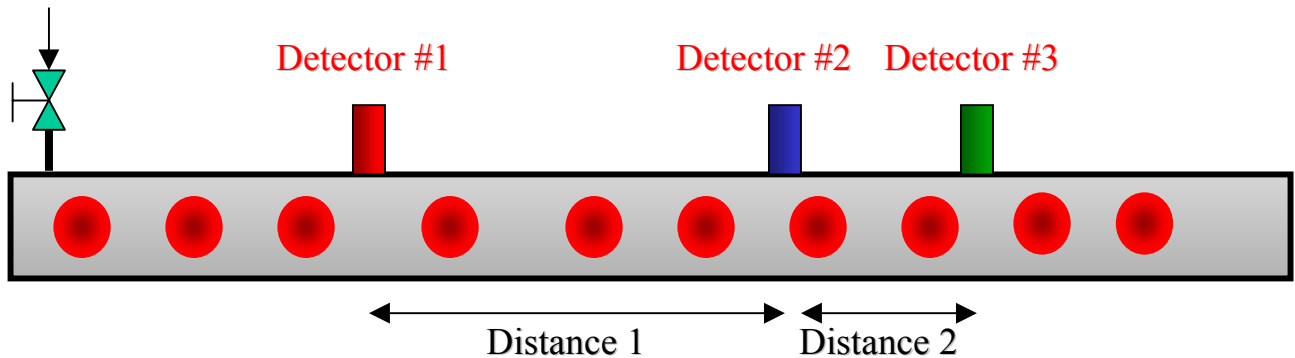


# Tracer

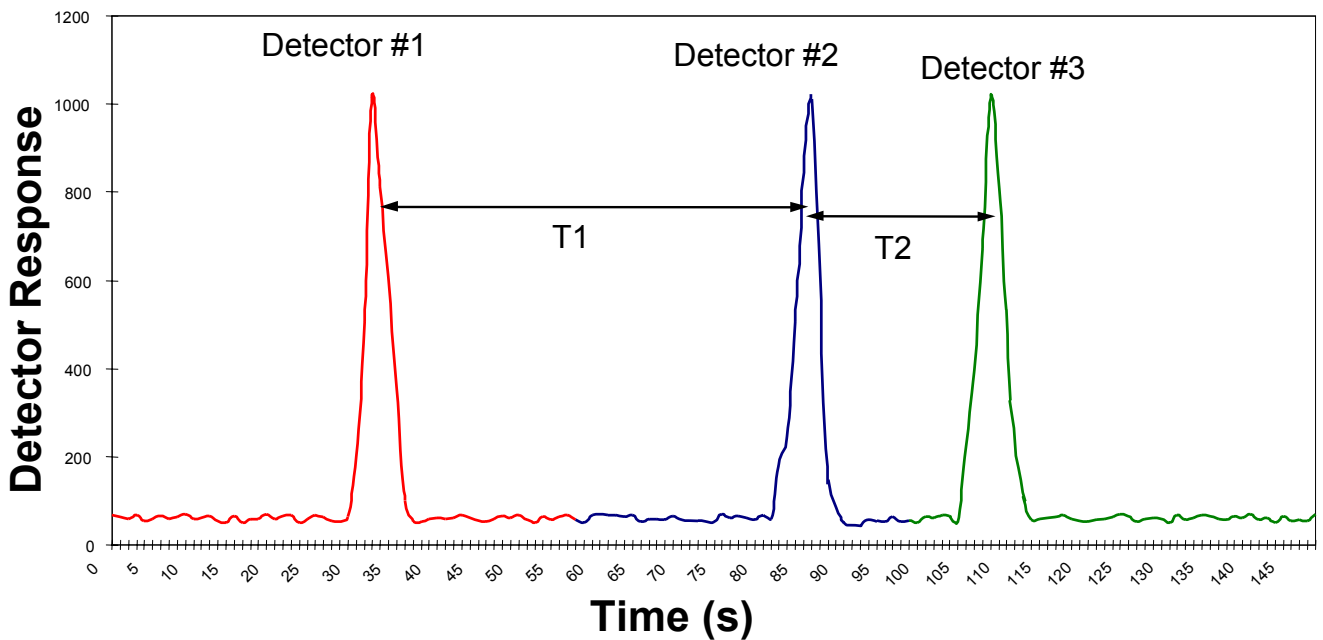


# Flow Rate Measurements

Injection

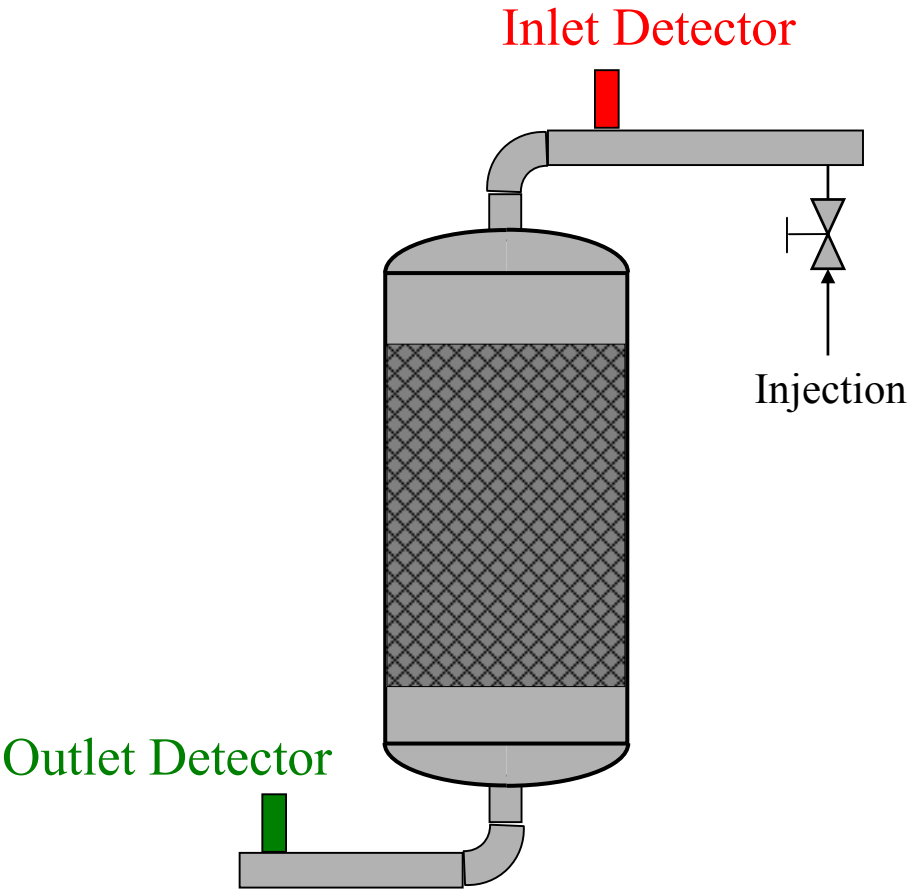


## Example Flow Rate

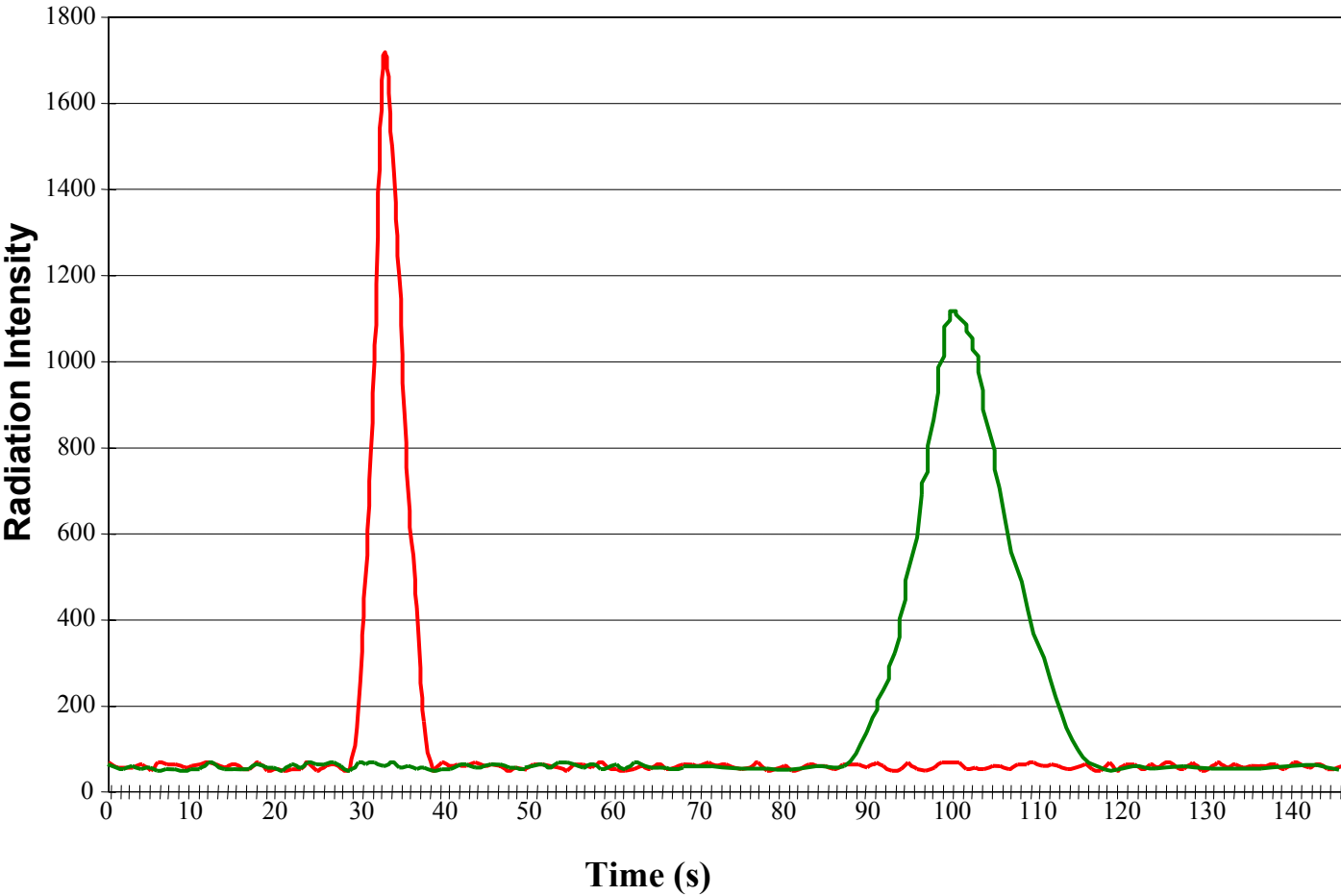


Tru-Flowrate™ measurements can be performed on virtually any type of process equipment including:  
**Pipes, Furnaces, Fin Fans, Reactors  
and Heat Exchangers**

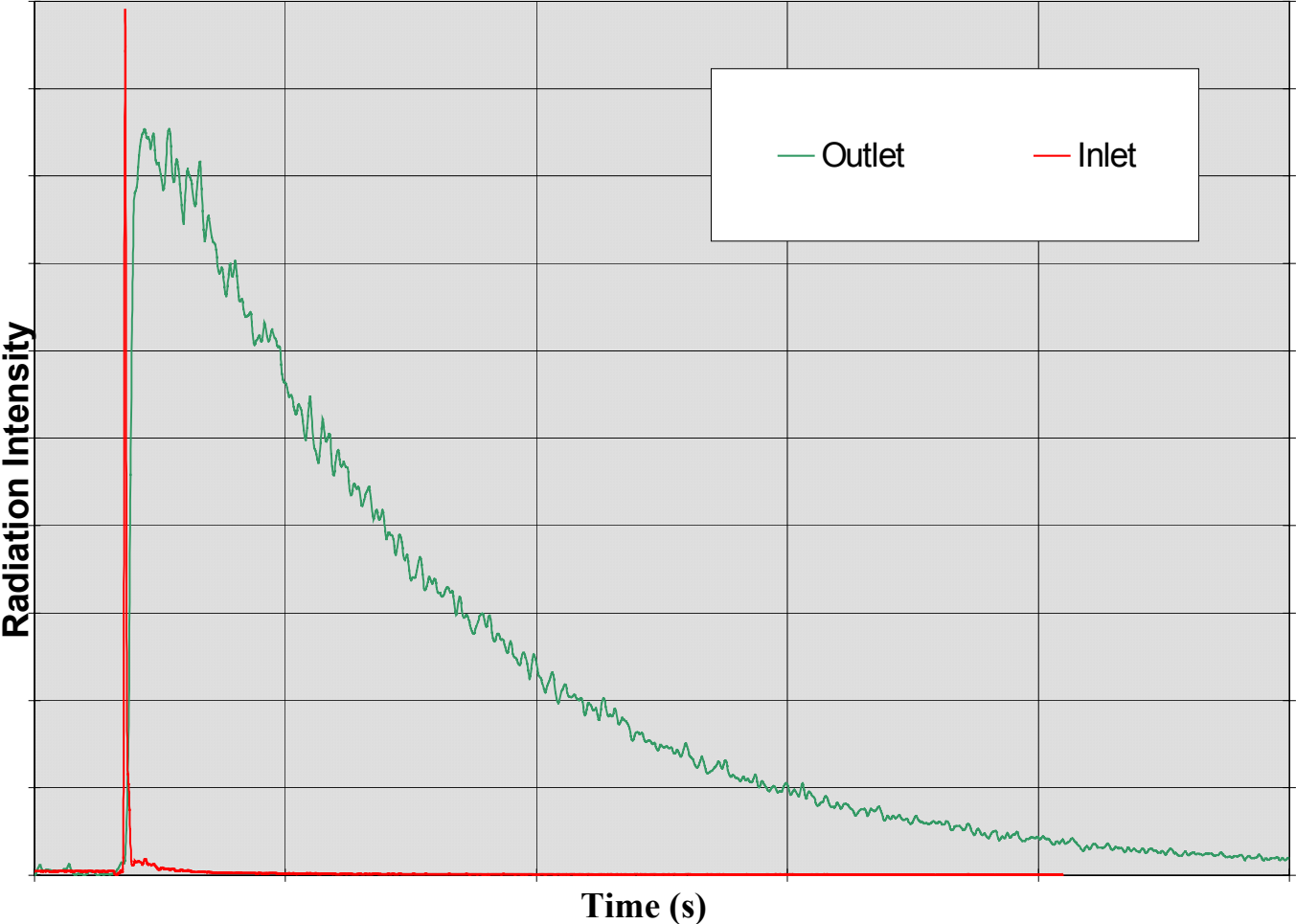
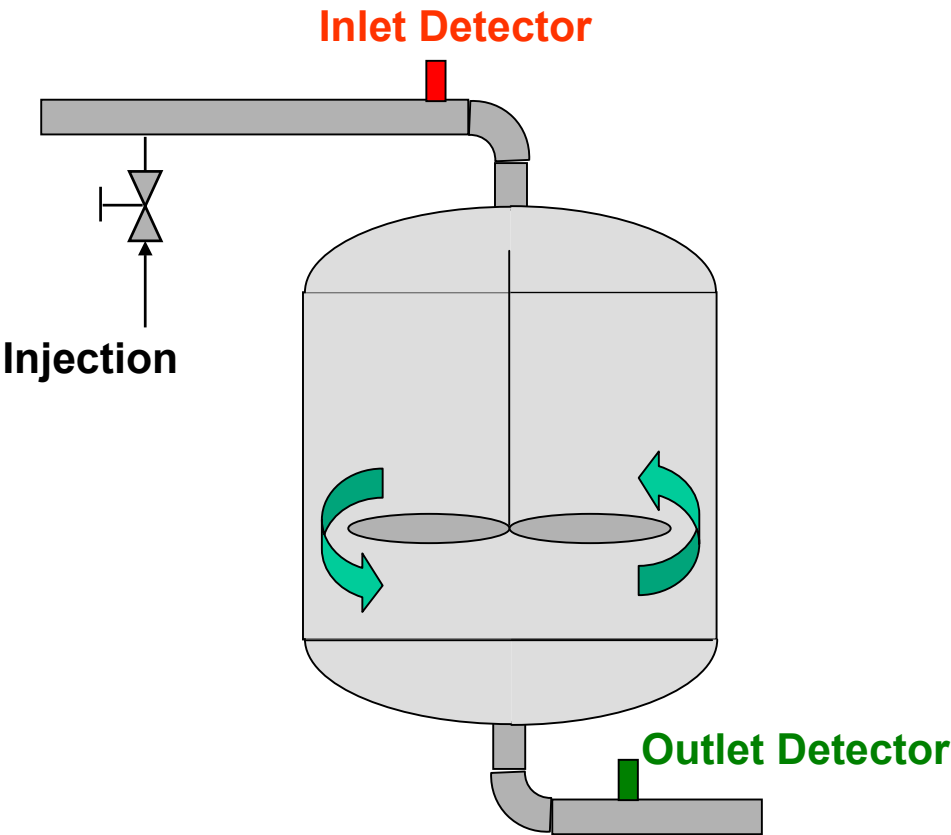
# MIXING AND RESIDENCE TIMES



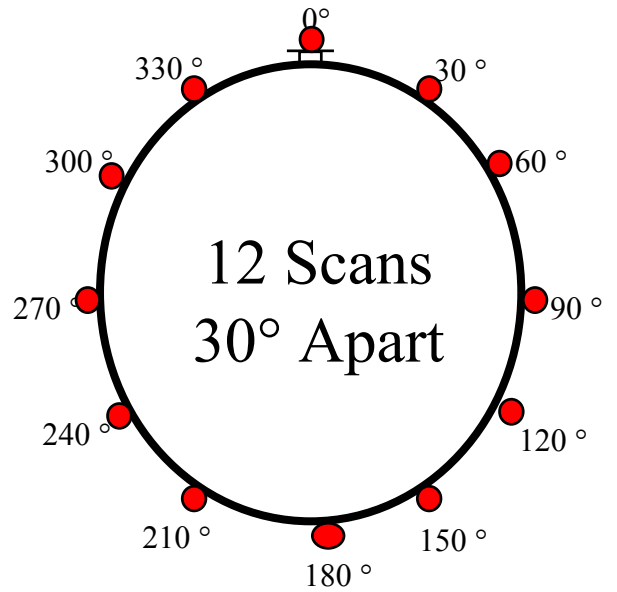
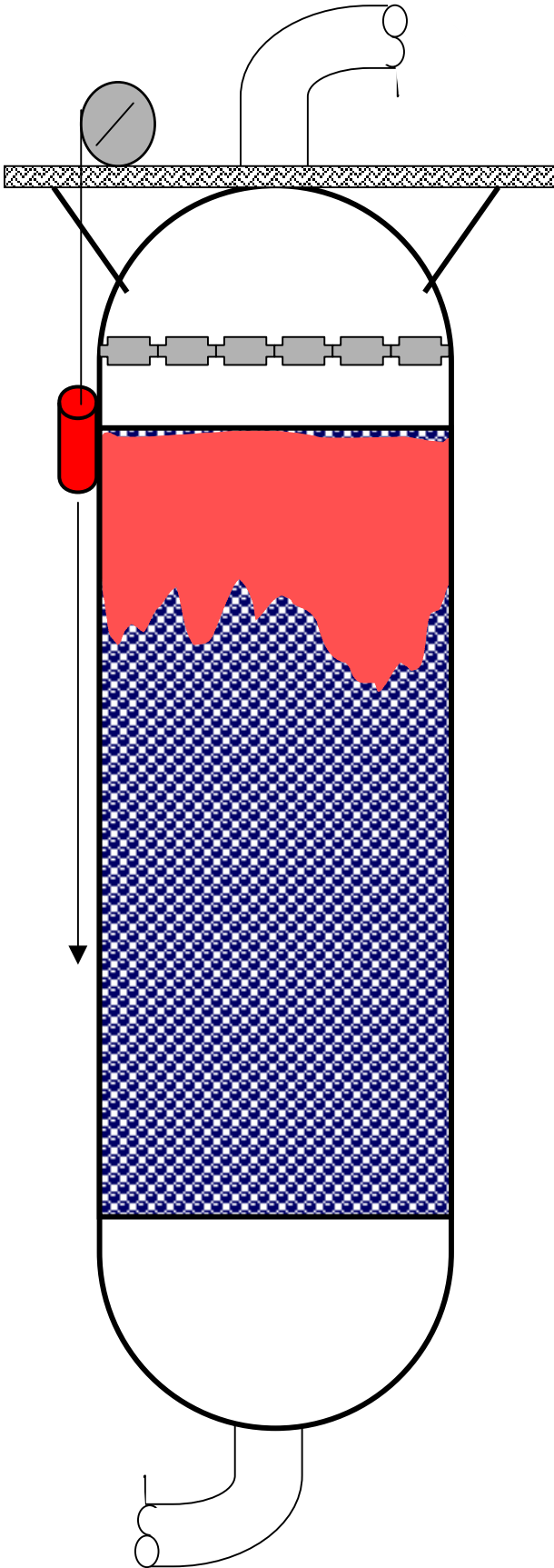
Example Plug Flow Reactor



# Stirred Tank Reactor

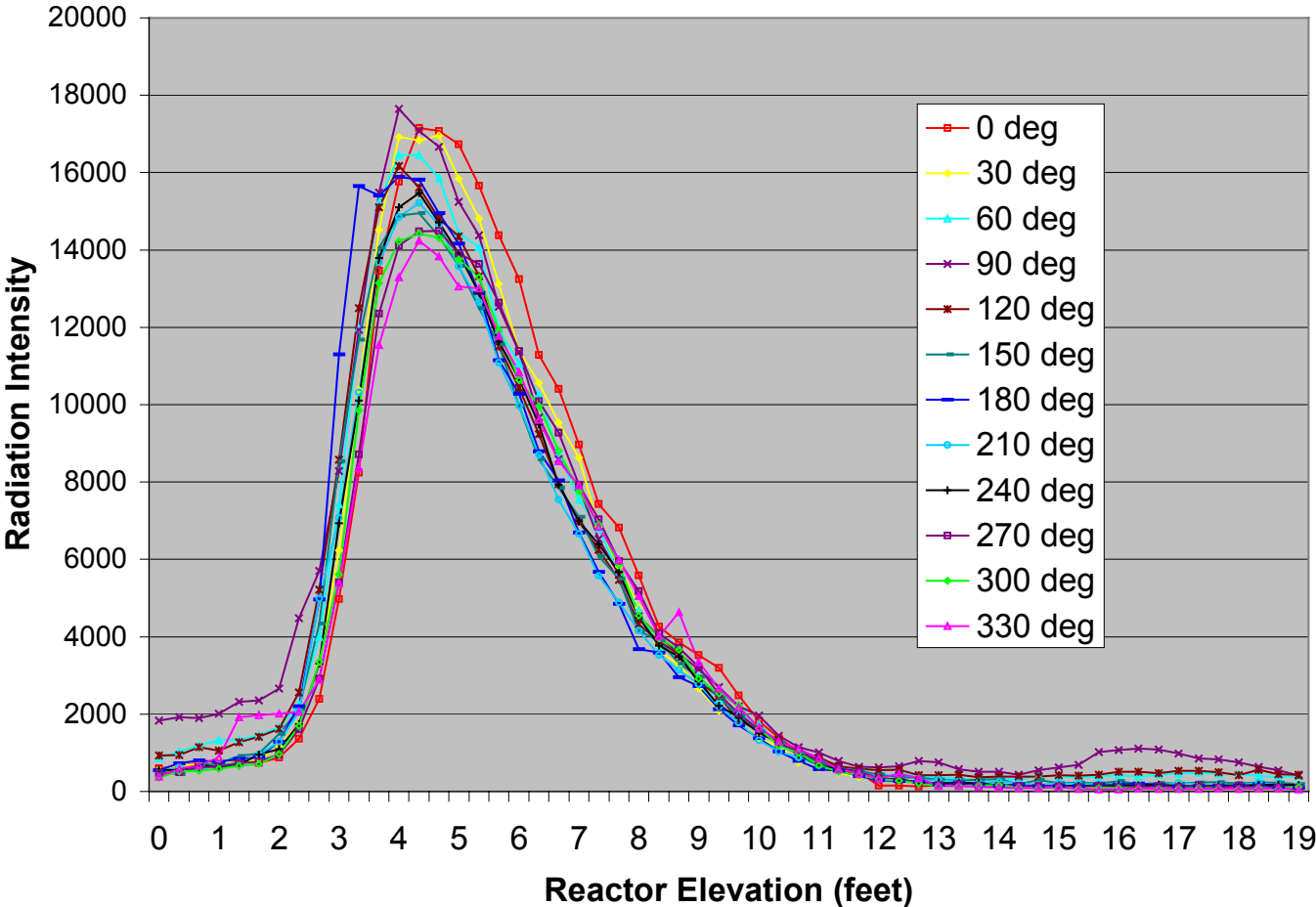


# *Spect Scan Orientation*

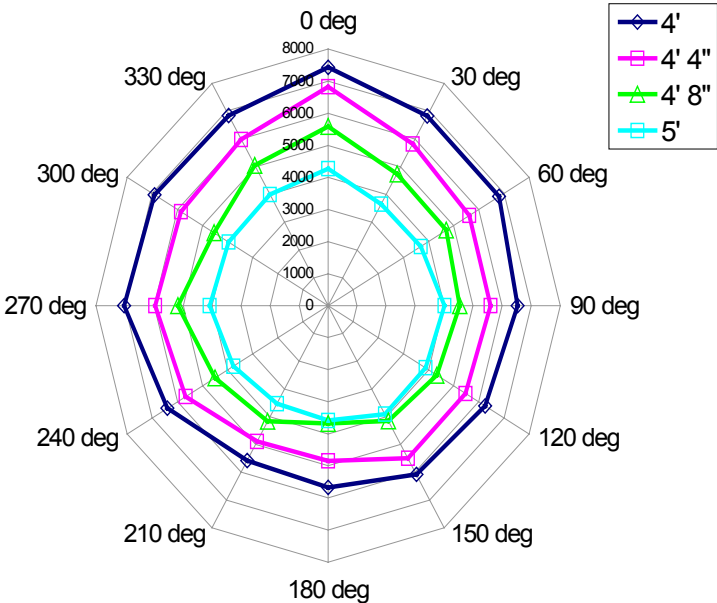


# *Spect Scan Example*

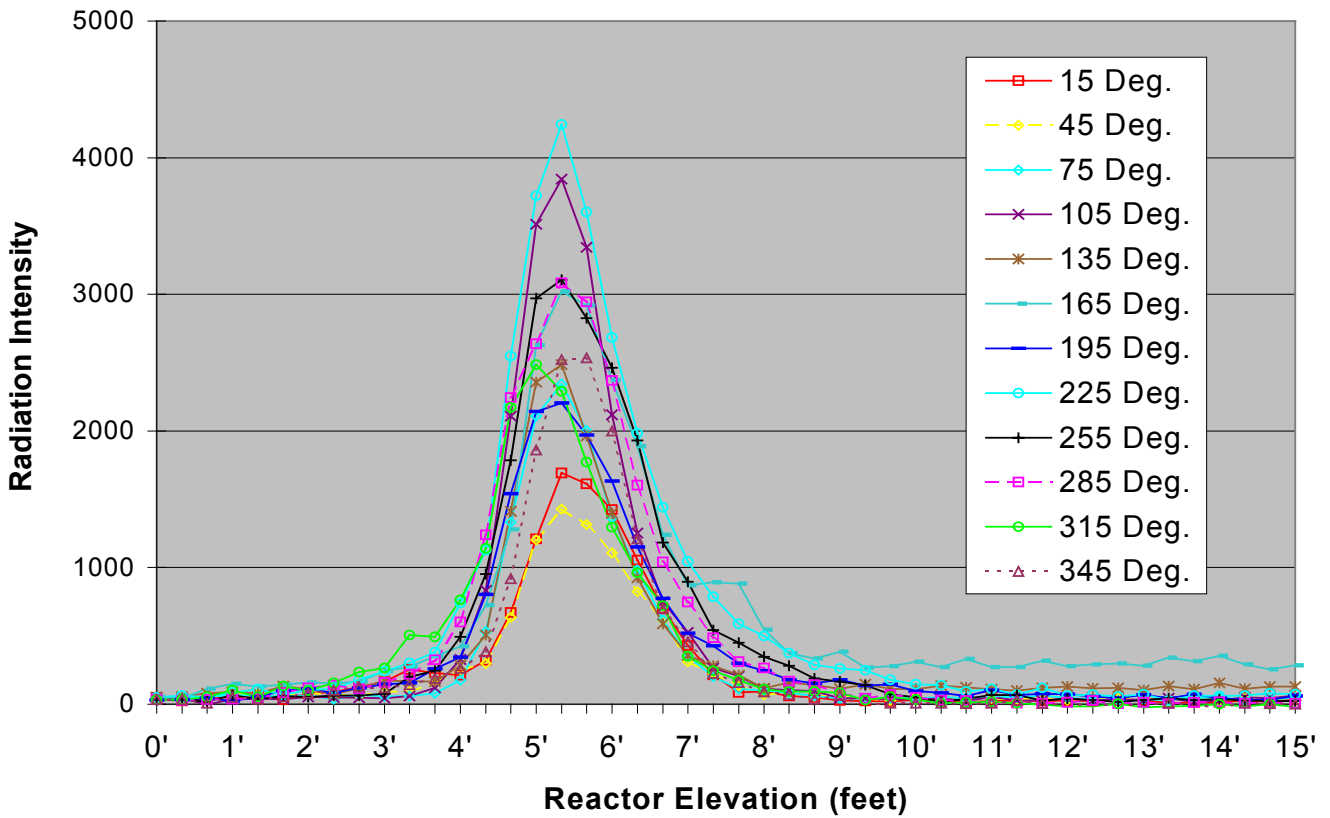
## *(Good Distribution)*



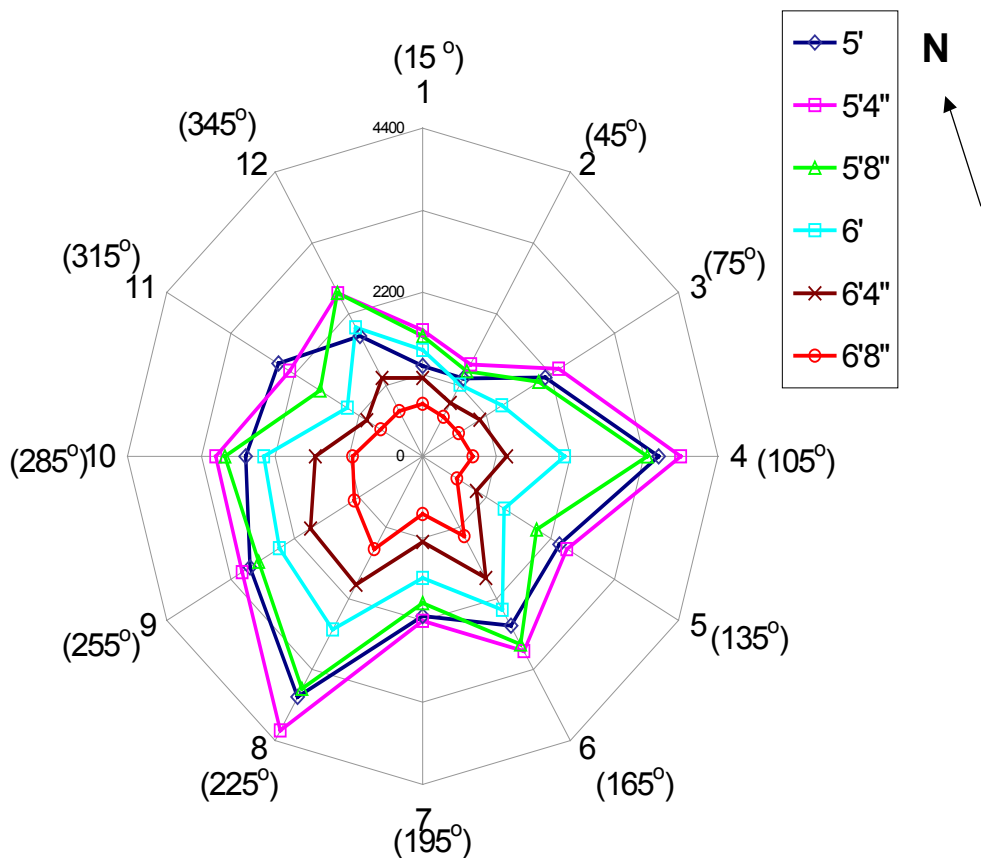
4 Feet to 5 Feet Reactor Elevation



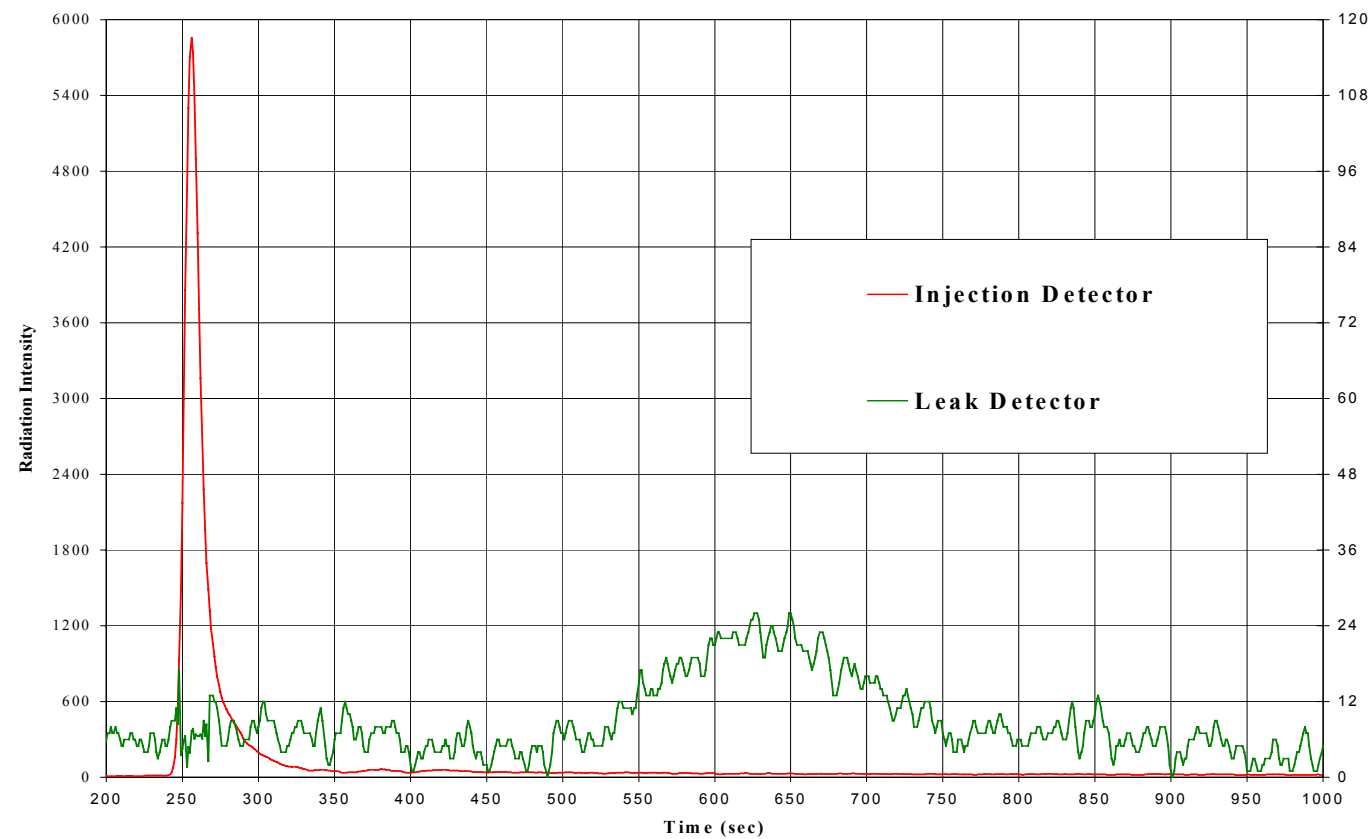
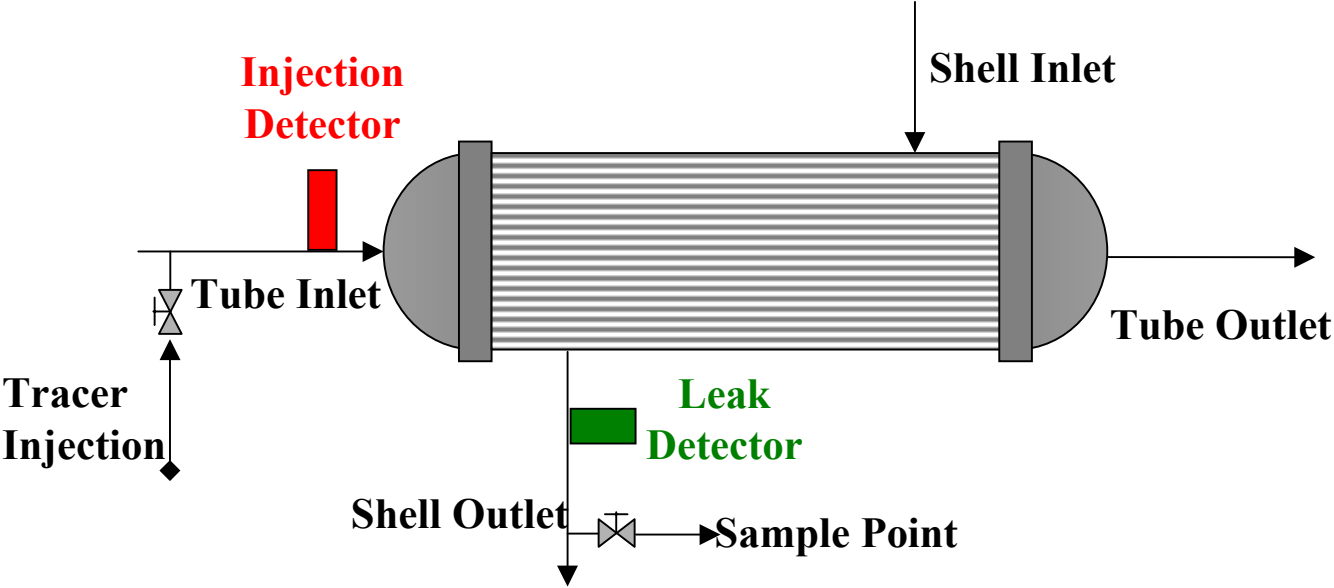
### *Spect Scan Example (Poor Distribution)*



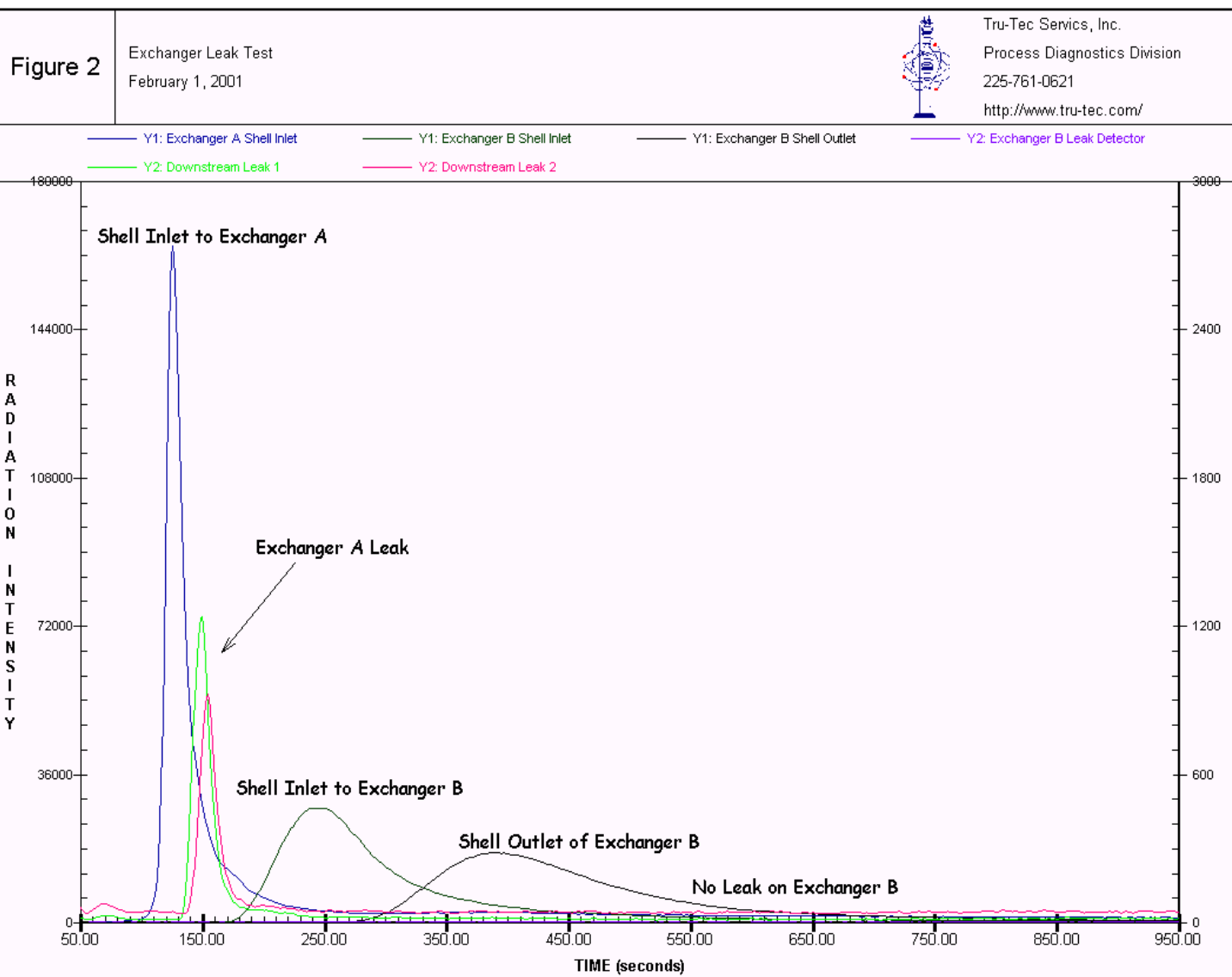
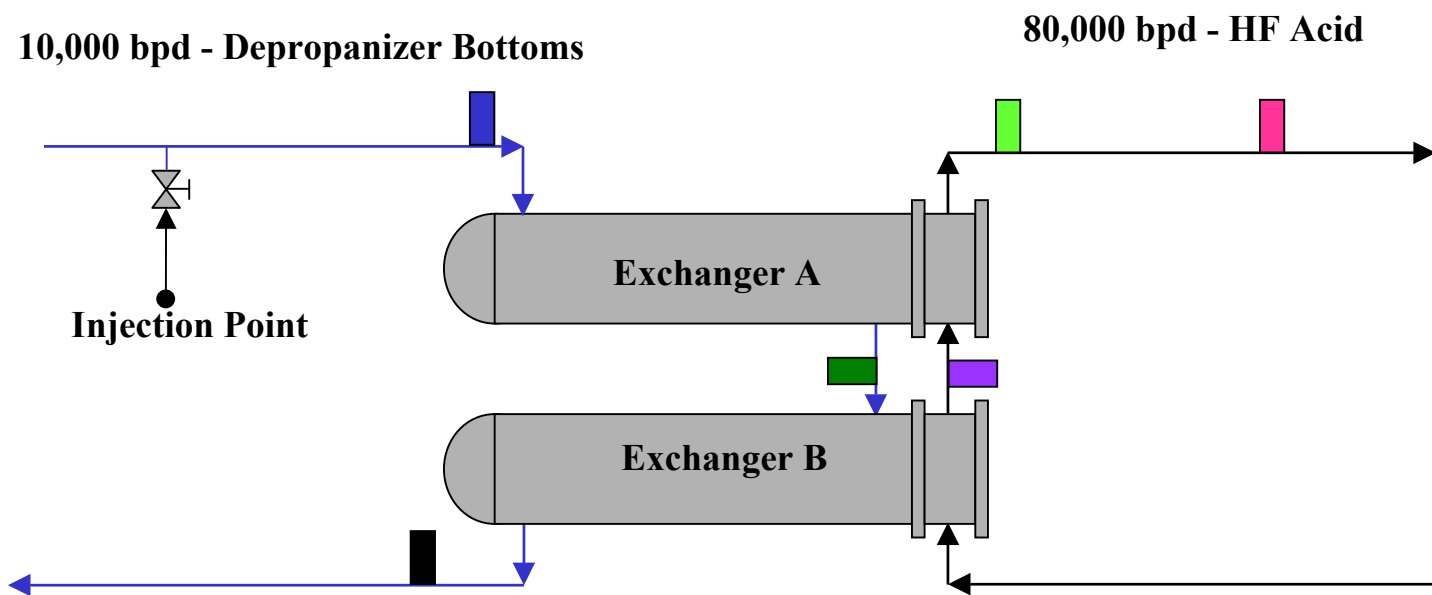
## 5 Feet to 6 Feet 8 Inches



# Example: Heat Exchanger Leak Test



# Leak Test on Exchanger Bank in Acid Unit





***How much of your  
profit \$\$\$\$'\$  
are going up in smoke?***

**Find the problem fast with Tru-Trace™ Diagnostics**  
***An on-line radioactive tracing procedure.***

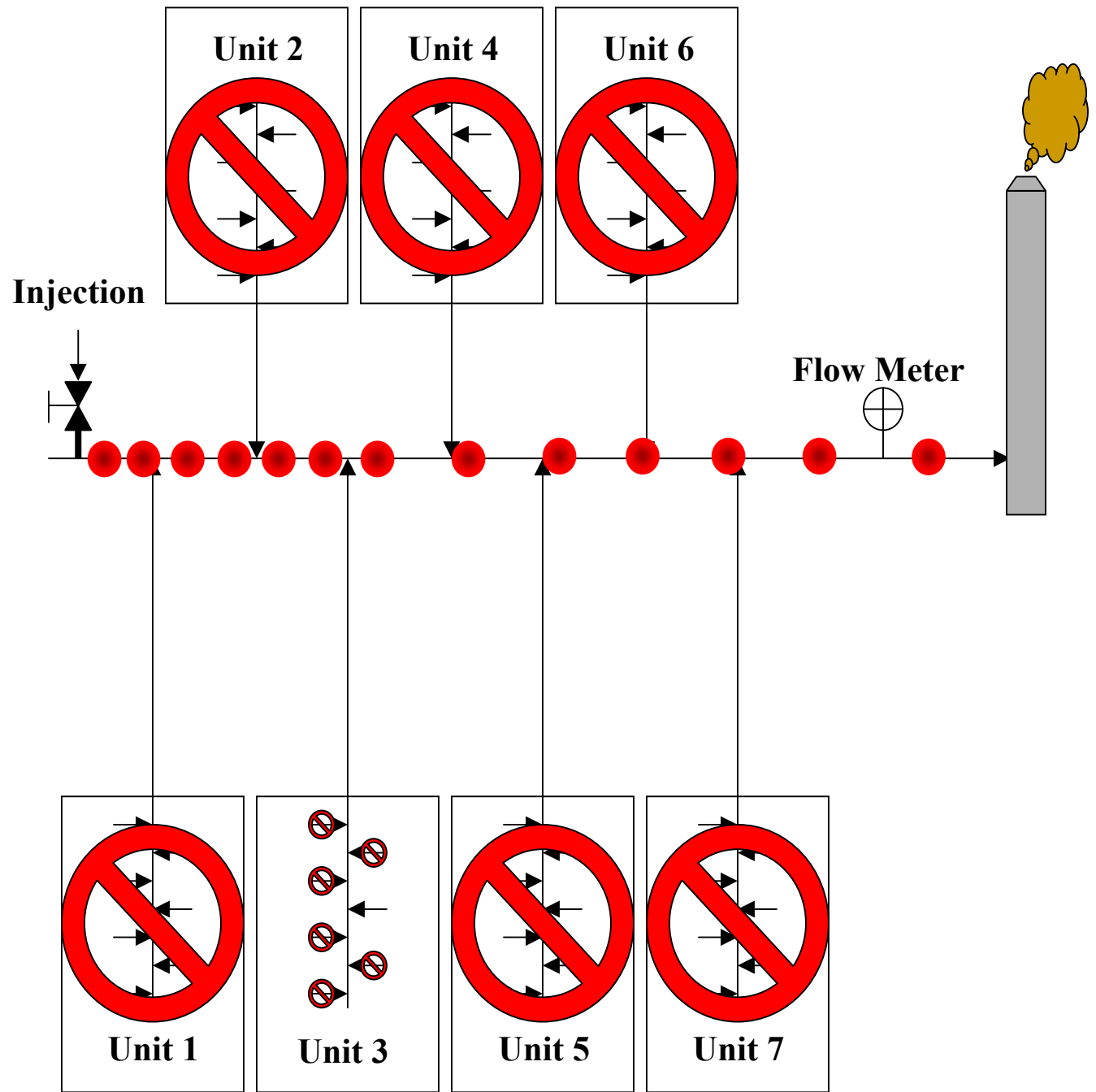
**Potential Problems Located Include**

- **Possible heat exchanger and valve leakage**
- **Less-than-ideal residence times and mixing**
- **Inaccurate flow rate measurement**

***Stay on-line and avoid unplanned shutdowns***

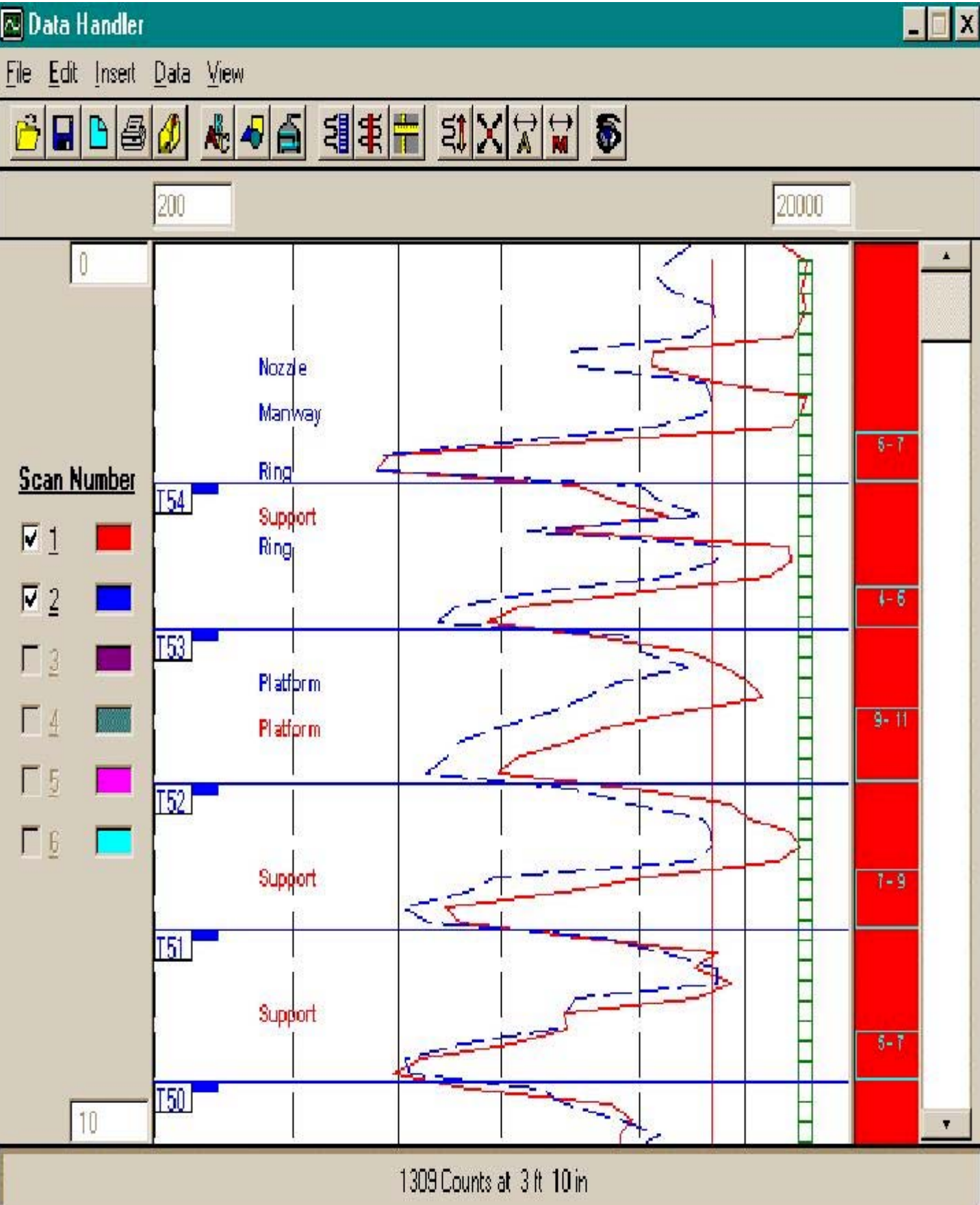
**Identify the source of process problems without a costly shutdown. Tru-Trace™ is used to “fine-tune” operations for maximum efficiency while meeting environmental standards.**

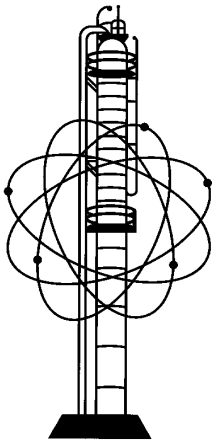
# Typical Procedure for Flare Leak Detection



**Measure where flow rate increases**  
**Eliminate Units that do not contribute**  
**Repeat steps in Unit sub-header**  
**Pinpoint leaking PSV**

# The Tru-Tec Knowledge Base - Data Handler Software





# ***Tru-Tec Process Diagnostic***

## ***“Outsource Your Troubleshooting Needs”***

---

### **Saves Time**

Most Efficient Use Of Engineers  
And Other Skilled Positions

### **Saves Money**

The Most Direct Approach Towards  
Solving Online Problems

### **Increase Production**

Optimize Online Production, Extended Run Times,  
Minimize Unscheduled Downtimes

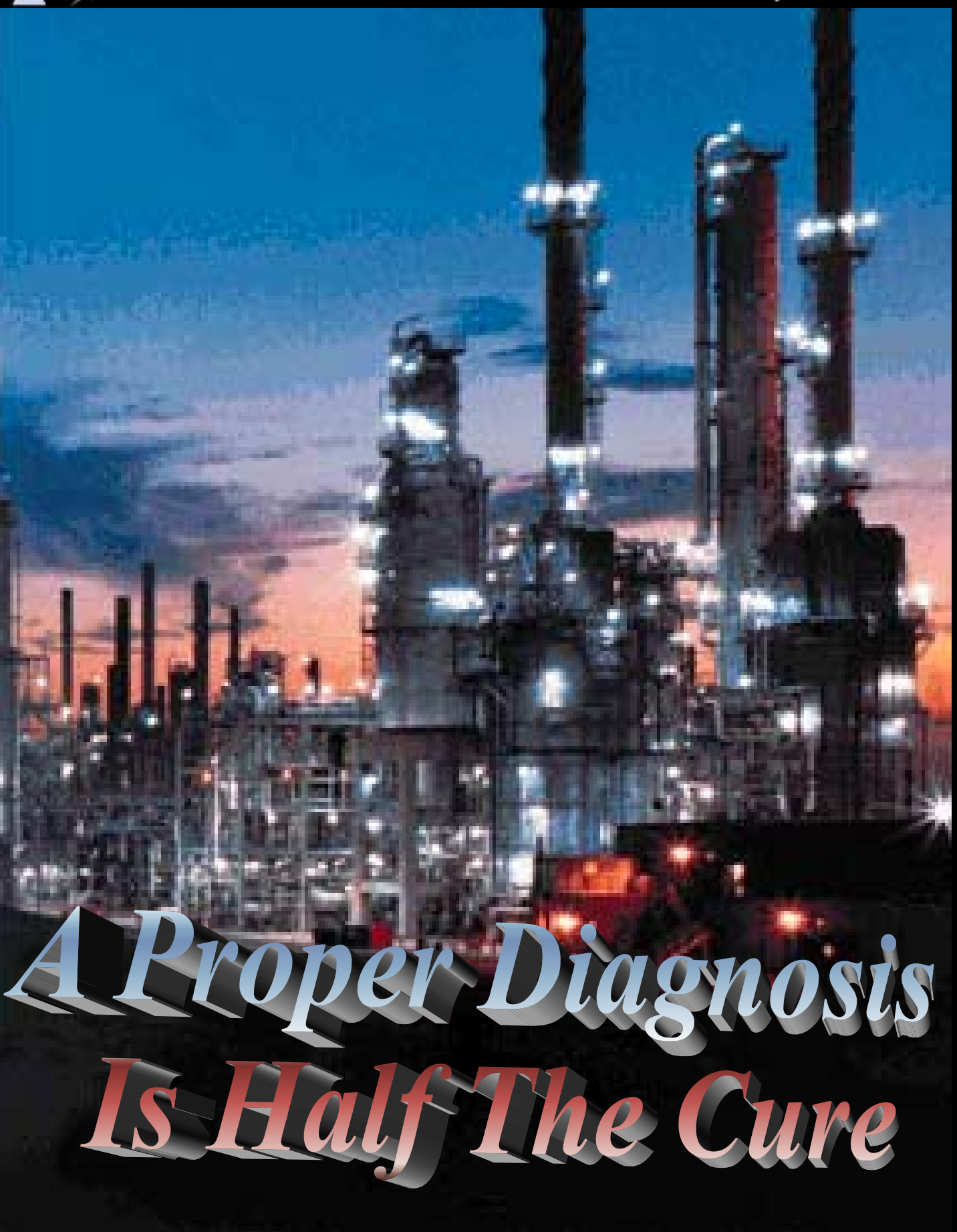
### **Avoid Surprises**

Anticipate Problems Before They Reach  
A Critical Point

---



Tru-Tec Services, Inc.



*A Proper Diagnosis  
Is Half The Cure*