Threading Technical Theory into PTEC Courses (how/why)

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Aim of this workshop

- Benefits of teaching theory
- Impact in PTEC courses
- Impact in Industry Training
- Examples
  - Centrifugal Pump theory
  - Crude flow speed in pipeline
  - More if we have time

What is ‘technical theory’?

- Technical theory involves the science, engineering design, and function of equipment and processes
- Industry best practices

Benefits of teaching theory

- Saves Money
- Improves safety performance
- Improves environmental compliance
- Improves efficiency
- Improves operator performance

Impact in PTEC courses

- Context:
  - Better student understanding
  - More tools for troubleshooting
  - More awareness of safety/operating concerns
- Continuity: ideas carry through multiple courses
- Communication: Technicians have more tools to communicate with engineering/maintenance

Impact in Industry Training

- Safety
  - 24-hour focus on the process
  - Technicians provide more thorough review of new projects/procedures
  - Environmental releases can be reduced
- Efficiency
  - More specific work orders - efficient use of Maintenance time
  - Reduce ‘emergency’ work orders – lower costs
  - Better communication between Operations and Engineering/Maintenance

Examples of Theory Topics

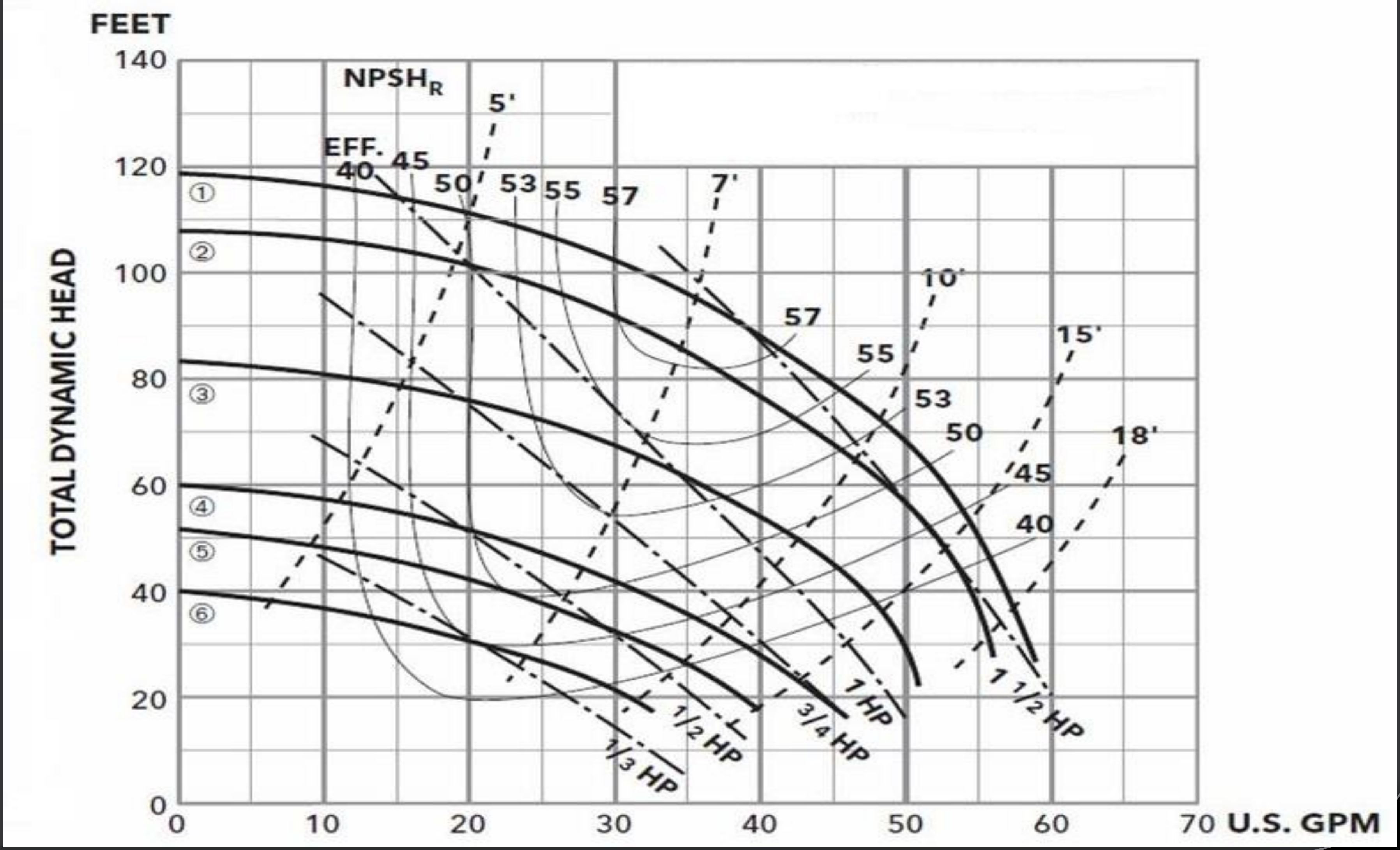
- Pumps
- Pipeline Flow Speed
- Separators
- Heat Exchangers
- Instrument scaling and tuning
- Conversion factors
- Etc.

Examples

- Flow calculations –
  - Pipeline issues with low and high flow (corrosion/erosion issues)
  - Flow vs. dP
  - Flow vs. static electricity generation
- Pump curve analysis -
  - pump performance vs. design
  - Pump cavitation vs. NPSH
- Heat exchanger design vs. actual performance

Pumps – mechanical devices that transfer energy to move materials through piping systems….

Pump Curves


FEET
TOTAL DYNAMIC HEAD
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70 U.S. GPM
NPSHR
5'
7'
10'
15'
18'
EFF.
40
45
50
53
55
57
57
55
53
50
45
40
①
②
③
④
⑤
⑥
1/3 HP
1/2 HP
3/4 HP
1 HP
1 1/2 HP

Pump Curve information

- Flow vs. differential pressure
  - (Discharge P – Suction P)

- Can a pump handle a new target flow?
- What happens if 1 of 2 pumps shuts down?
- Maintenance issue vs. wrong pump?
  - Operators can check operating data vs. pump curve to determine if pump is working correctly.

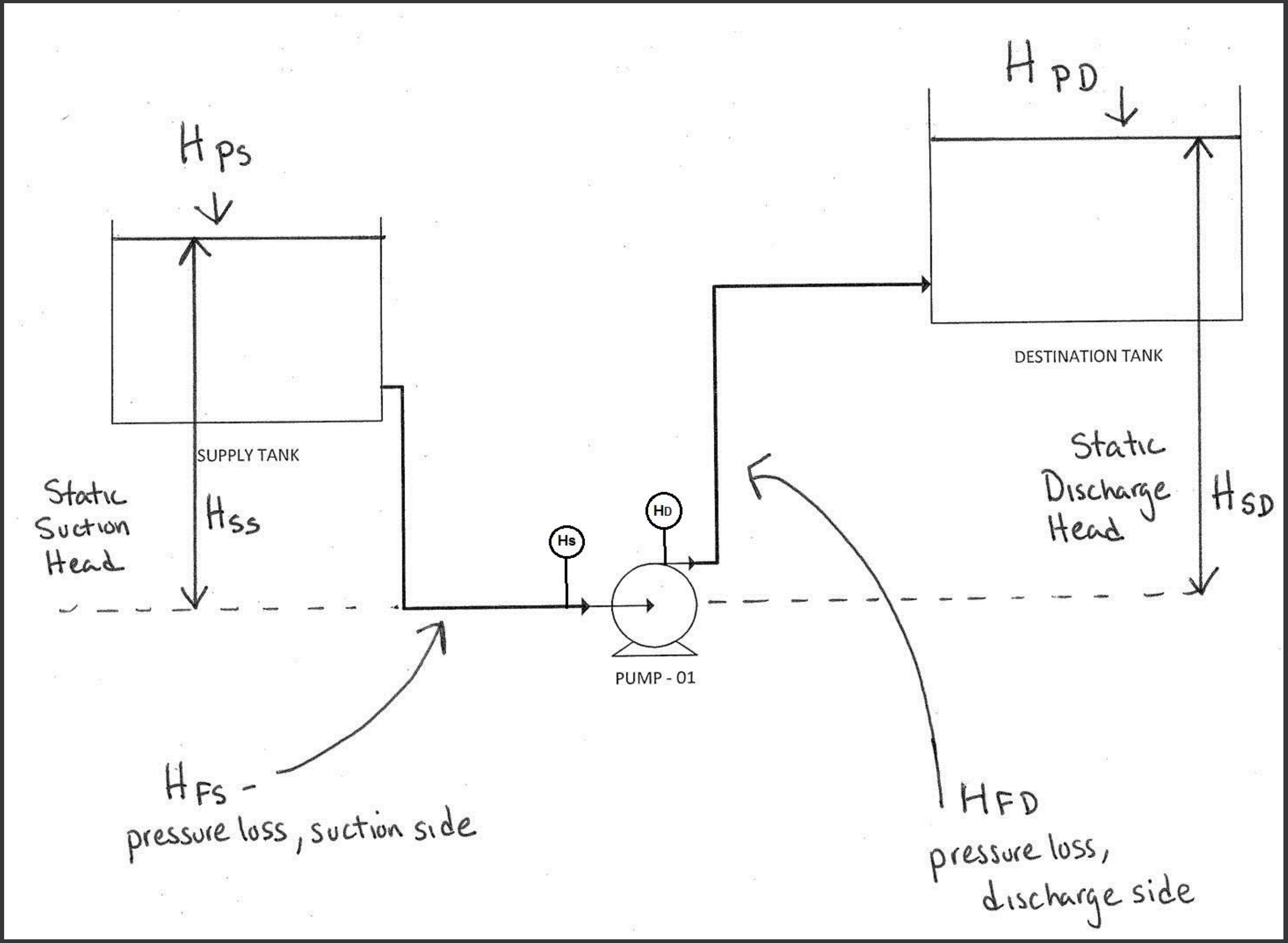
How to feed into PTEC classes or training

- Teach students how to read the curve, take data from a curve.
  - Note: lots of unit conversions, good experience for the students
- Hands-on: With an operating pump, take pressure data at different flow rates to build the pump curve and illustrate the relationship.

Pump NPSH:
Complicated theory, practical application

- NPSH = Net Positive Suction Head
- $NPSH = H_{SS} + H_{PS} - H_{FS} - VP$
  - If NPSH available (actual) is < NPSH required, then pump will cavitate
  - Cavitation – vaporization of fluid inside the pump
  - Cavitation – damages pump, interrupts flow

NPSH – visual explanation



NPSH – how to incorporate in training

- Explain all 4 terms in class
- Hands-on – lab activities that measure and/or calculate each factor
- Hands-on – demonstrate pump cavitation with a trainer (or a cheap pump!)

- Complex theory becomes practical as soon as a pump cavitates in the field:

Cavitation response: Change factors in the NPSH equation – some are operational

- Static Height –
  - add more liquid,
  - hold supply tanks at higher level
- System Pressure –
  - adjust pressure if possible
- Friction Loss –
  - change fittings or pipe size
  - change flow
- Vapor pressure –
  - change temperature

Industry Scenario: Jet Fuel Truck Rack

- Expansion at truck rack doubled jet fuel flow rate
- Shipping pumps began to cavitate: NPSH problem
- Operational fix – increase minimum working level in tank to increase static suction head
- Design fix – upgrade shipping header size to reduce friction loss

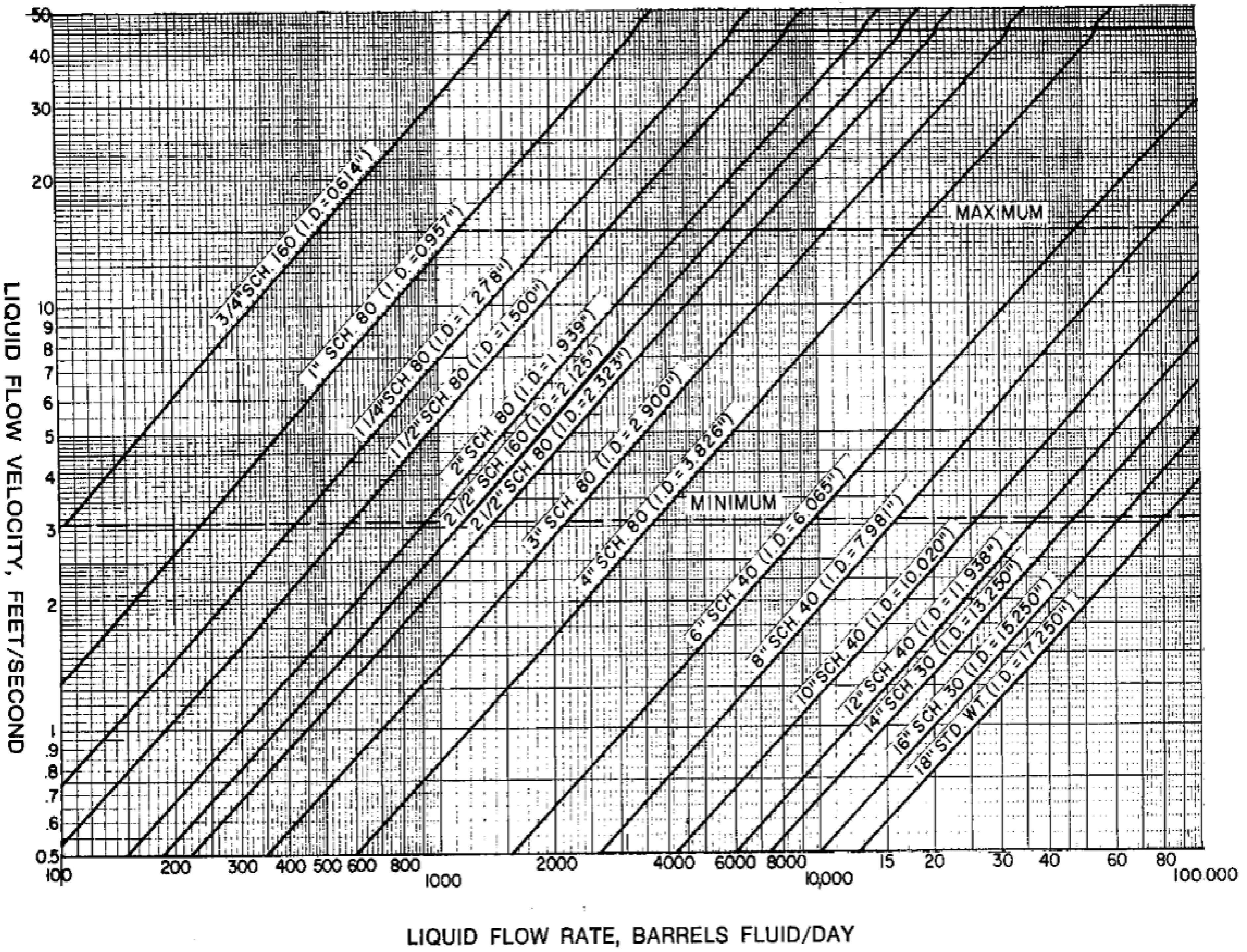
News Headlines about the - North Slope 2006 leak

- Because Of North Slope Oil Spill In 2006, AK Oil Co. Ordered To Pay Alaska $255 Million
- AK Oil Co. must face shareholder suit over 2006 Alaska oil spill
- AK Oil Co.: Learning from oil spill lessons
  - …relatively low flow rate in the facility-2 transit line

Solve

- Before the leak
  - Flow 166,000 Bbl/day
  - Transit Line 31" dia
- After leak
  - Flow 166,000 Bbl/day
  - New transit line 17"

- Rules:
- Max flow rate 15 ft/sec
- Min flow rate 3 ft/sec
- V= ft^3/sec/ft^2



LIQUID FLOW VELOCITY, FEET/SECOND
LIQUID FLOW RATE, BARRELS FLUID/DAY
50
40
30
20
10
9
8
7
6
5
4
3
2
1
.9
.8
.7
.6
0.5
100
200
300
400
500
600
800
1000
2000
4000
6000
8000
10,000
15
20
30
40
60
80
100.000
MAXIMUM
MINIMUM
3/4" SCH. 160 (I.D.=0.614")
1" SCH. 80 (I.D.=0.957")
1 1/4" SCH. 80 (I.D.=1.278")
1 1/2" SCH. 80 (I.D.=1.500")
2" SCH. 80 (I.D.=1.939")
2 1/2" SCH. 160 (I.D.=2.125")
2 1/2" SCH. 80 (I.D.=2.323")
3" SCH. 80 (I.D.=2.900")
4" SCH. 80 (I.D.=3.826")
6" SCH. 40 (I.D.=6.065")
8" SCH. 40 (I.D.=7.981")
10" SCH. 40 (I.D.=10.020")
12" SCH. 40 (I.D.=11.938")
14" SCH. 30 (I.D.=13.250")
16" SCH. 30 (I.D.=15.250")
18" STD. WT. (I.D.=17.250")

Pipeline velocity: The Math

$$\frac{166000\ \text{BBL}}{1\ \text{DAY}} \times \frac{1\ \text{Day}}{24\ \text{HR}} \times \frac{1\ \text{HR}}{60\ \text{min}} \times \frac{1\ \text{min}}{60\ \text{Sec}} \times \frac{42\ \text{Gal}}{1\ \text{BBL}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}}$$

$$= \frac{10.7880\ \text{Ft}^3}{\text{Sec}}$$

$$\pi\left(\frac{31\ \text{in}}{2} \times \frac{\text{ft}}{12\ \text{in}}\right)^2 = 5.2415\ \text{ft}^2$$

$$\frac{\frac{10.7880\ \text{ft}^3}{\text{sec}}}{5.2415\ \text{ft}^2} = 2.06\ \text{ft}/\text{sec}$$

Pipeline velocity: The Math

Replace Pipeline with 17" pipe

$$\pi \left(\frac{17\text{ in}}{2} \times \frac{\text{ft}}{12\text{ in}} \right)^2 = 1.5763\ \text{ft}^2$$

$$\frac{\dfrac{10.7880\ \text{ft}^3}{\text{sec}}}{1.5763\ \text{ft}^2} = 6.84\ \text{ft}/\text{sec}$$

How to incorporate into classes

- Focus on common principles
  - Hydraulics
  - Pumps
- Include industry-specific practices
  - Static prevention
  - Flow vs. corrosion prevention
- Focus on principles that apply to more than one course
  - Pressure/level data
  - Flow data
  - Equipment monitoring
- Include practical examples to illustrate
  - Hands-on equipment, if possible
  - Instructor experience in industry

Survey

- Can you think of theory that you would incorporate in your training?
- What are some ways that you can incorporate theory into your training?

Discussion: How to Incorporate Theory into PTEC Courses

- Use external resources – videos, etc.
- Include calculations in student activities
- Look for case studies on the internet
- Expert speakers on specific topics
- Encourage student research on topics
- Review courses for consistency from class-to-class
- Opportunities for Instructors to use common information

Discussion: How to Include Theory into Industry Training

- Training with other departments
- Informal review sessions with Engineering dept.
- Vendor presentations
- Case studies of incident investigations
- Review maintenance work orders – look for patterns where more initial information would make make requests more efficient

Questions

- Learning Journal
  - What is the one most important thing you learned in this session?
  - What are three things you will do differently as a result of this session?
  - Who else would benefit from what you learned today?
  - What do you want to tell them?
- Reminder:
  - sign-in sheet
  - evaluations

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Example: Flow Rate vs. dP

- Differential pressure will change with the square of the flow
- If flow doubles, then dP will quadruple

- PTEC class example: Use pump trainer to illustrate change in dP across an orifice or globe valve as flow changes

Industry Scenario: Pressure drop through a filter

- dP is monitored to determine when filter elements are saturated
- If dP suddenly spikes upward, what is the correct response?
  - A: Immediately write work order to shut down filter and change elements
  - B: Check current operating conditions – has flow or temperature changed significantly?
- If B is done first, you can avoid unnecessary filter element changes

Example: Static Electricity vs. Flow

- API 2003 recommended practice for filling empty tanks (for certain petroleum products)
- Initial fill rate = 3.2 ft/sec line velocity, until fill pipe covered or floating roof floating
- Reduces risk of static electricity ignitions of flammable vapors

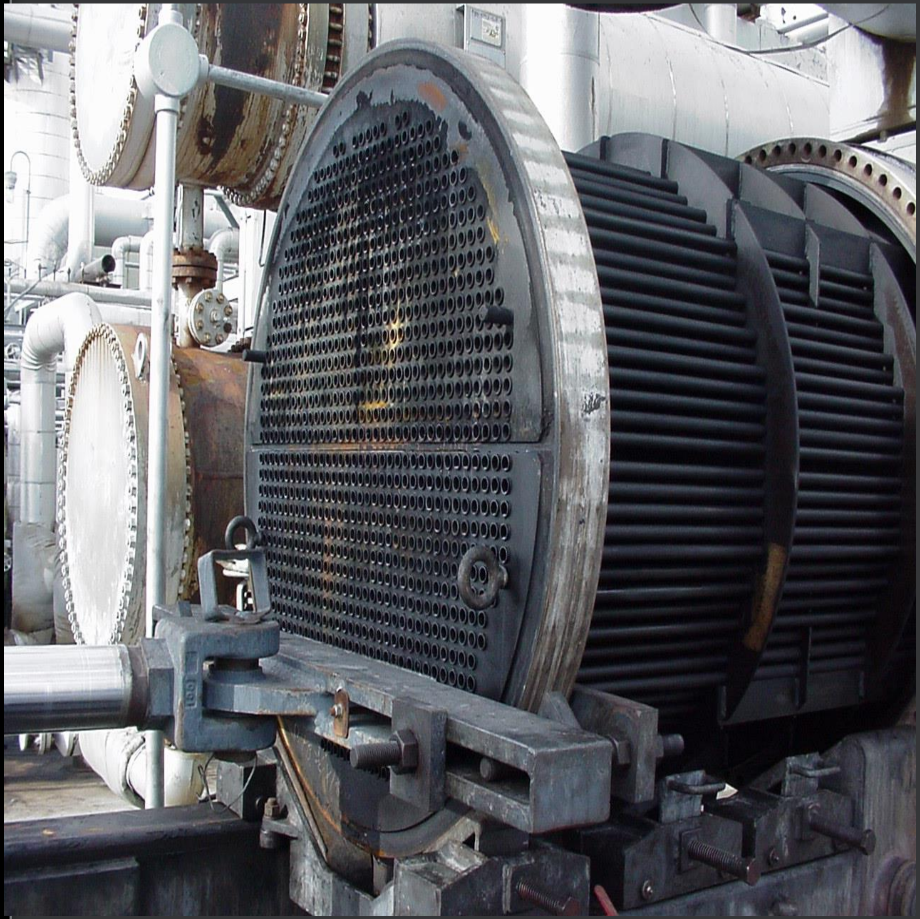
Industry Scenario: Static Electricity

- Compare two industry procedure statements
  - "initial flow rate through the 4" fill line will be 130 gpm"
  - "Initial flow velocity will be less than 3.2 ft/sec to prevent static ignition"

Industry Scenario: Temporary Operation

- Need to use a 2" fill line for temporary operation after a tank cleaning procedure. Normal pipe size is 4".
- SOP that includes the 'why' of the initial flow rate will give technicians the tools to identify that they must use a lower initial fill rate with a smaller fill line.
- Gives technicians more tools to incorporate safety – on the front lines.

Heat Exchangers



Example: Heat Exchanger Theory

- Basics of heat transfer
  - Conduction, Convection, Radiation
- Heat exchanger design –
  - BTU transfer, Inlet/Outlet temperatures
  - pressure drop through exchanger
  - pressure ratings (shell & tube)
  - flow direction and profile
- Heat exchanger performance
  - current conditions vs. design

Scenario: Heat Exchanger

- Applications for theory:
  - New pumps in system, possibly exceeding design pressure
  - Outlet temperature dropping
    - Technicians can check pressure drop/flow against design case
    - Determine whether exchanger is fouling, short-circuiting
    - Note that dP vs. Flow considerations apply here, too