CARLISLE
FLUID TECHNOLOGIES

FINISHING EDUCATION UNIVERSITY

Paint Circulation Design & Equipment

October 2021

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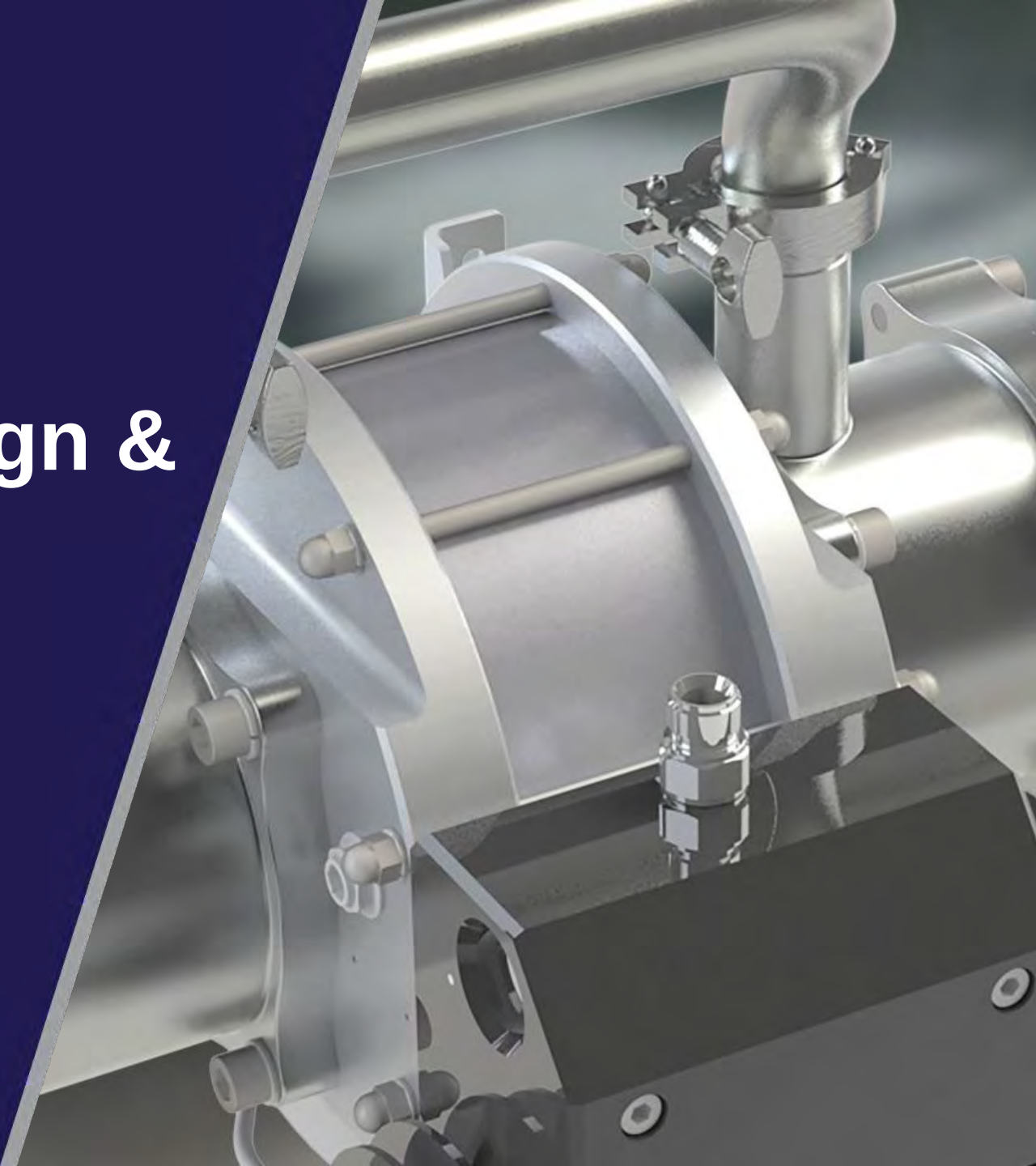
Pump Product Specialist



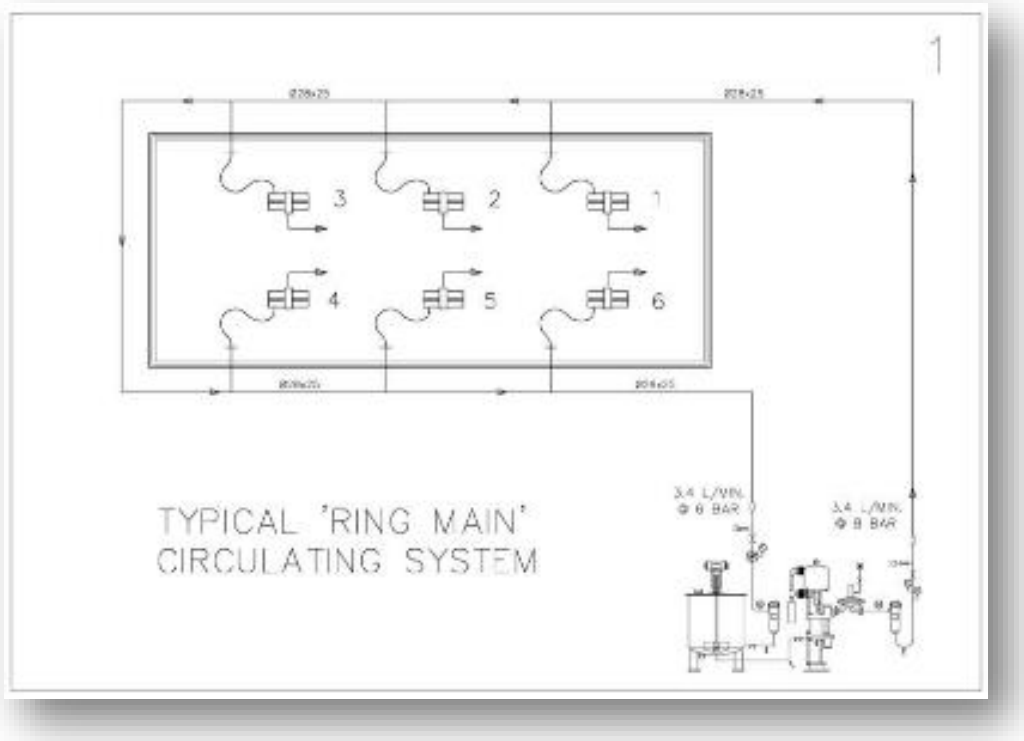
Paint Circulation

Goal:

Provide attendees with ability to differentiate themselves from competitors!

Paint Circulating System - Purpose/Function

- **MOVE** liquid material from point A to B
- Supply consistent **PRESSURE** at point B (when material is in demand)
- Supply consistent **FLOW** at point B (when material is in demand)
- Maintain **MATERIAL INTEGRITY** 24/7/365



Move

Circulation systems provide a more efficient method of moving material as opposed to manual transportation

“ IF ” :

- Numerous colors are required
- Numerous application points exist
- Volume of material usage is high

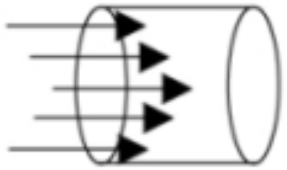
Pressure

Pressure Drop: As material flows through piping there is a pressure loss caused by friction.

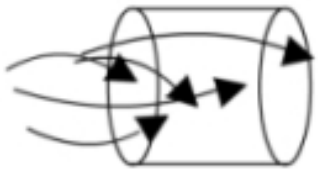
- We can provide value by calculating pressure drop and line sizes for customer.
- Yes we can charge for this!
- Be careful as this increase's liability and responsibility.
- Differentiator?

Pressure Drop

How to calculate!

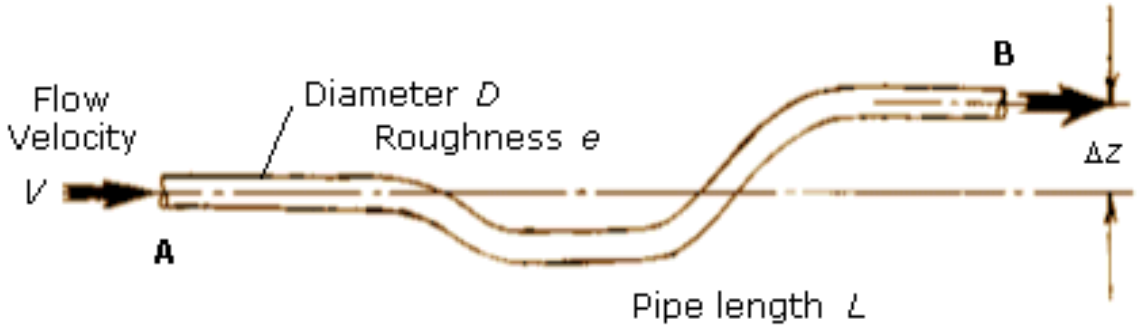


R<2300
laminar rate



R>3000
rate of turbulence

R=d X w/v
d: ID of the pipe (ft or m)
w: average speed (ft/min or m/s)
v: kinematic viscosity (ft²/min or m²/s)



Bernoulli Equation…Poiseuille Law…Continuity Equation…

Pressure Drop

Pressure Drop Formula: **Delta P Formula**

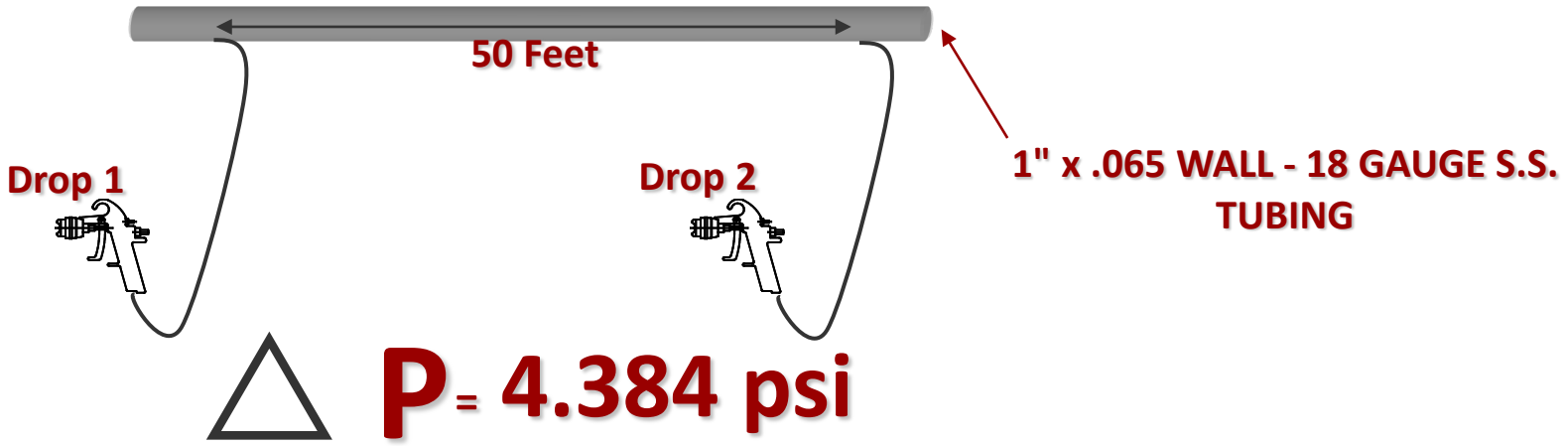
- $\Delta P = \frac{0.0273\ QVL}{ID^4}$
- Q Flow Rate GPM
- V Viscosity in Poise
- L Length of Pipe
- ID Internal Diameter of Pipe
- 0.0273 is a constant based on the mass flow characteristics for typical pipe / hose used for installation

Delta P Formula

Substitute numbers into formula

FORMULA ~ $\triangle P = .0273 \dfrac{Q\ V\ L}{ID\ \ 4}$

FORMULA ~ $\triangle P = .0273 \dfrac{1.84 * 1 * 50}{.87\ \ 4}$



$\triangle P = 4.384$ psi

Delta P Formula

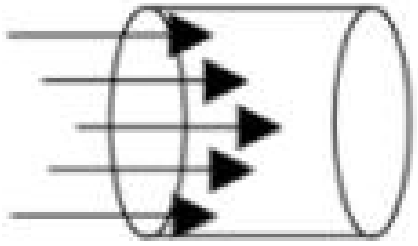
Pressure Line Drop Calculations

Flow Rate (GPM)	Viscosity (poise)	Pipe/Hose Length (feet)	Pipe/Hose ID (inches)	Pressure Drop
1.84	1	50	0.87	4.4
1.84	1	**100**	0.87	**8.8**
1.84	1	100	**0.62**	**34.0**
1.1	1	100	**0.62**	**20.3**

$$\Delta P = \frac{0.0273\ QVL}{ID^4}$$

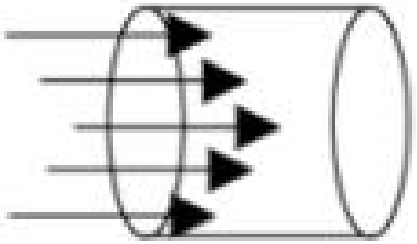
Material Integrity

This is the #1 concern for paint circulating system design. Issues include:



R<2300
laminar rate

- Material velocity
  - Settling
  - Shear



R<2300
laminar rate

Material Integrity

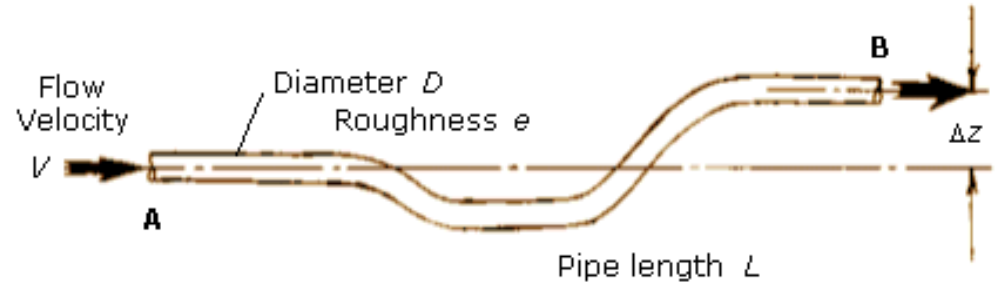
Material must maintain a certain velocity through all piping and drop hoses (think agitator).

"Velocity" is measured via ft/sec of material flow through piping.

General rule is WB material must maintain 0.5'/sec and SB 1'/sec.

Most users do not know their required velocity!

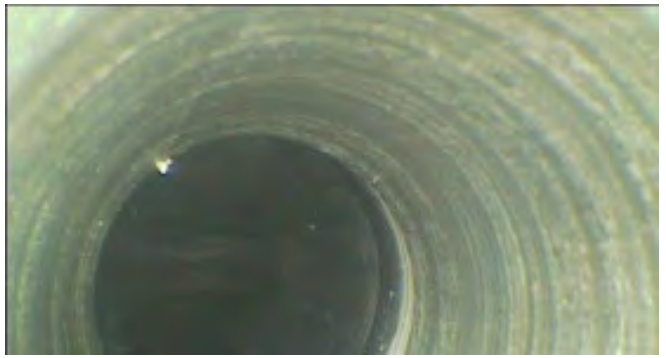
Chart 1: Material Velocity Chart			
Pipe OD Dia.	Material Velocity		
	1.5'/sec	1'/sec	0.5'/sec
1/2" Line (0.049)	0.6 GPM	0.4 GPM	0.2 GPM
5/8" Line (0.049)	1.05 GPM	0.7 GPM	0.35 GPM
3/4" Line (0.65)	1.4 GPM	1 GPM	0.48 GPM
1" Line (0.65)	2.8 GPM	1.85 GPM	0.94 GPM
1.25" Line (0.65)	4.6 GPM	3.05 GPM	1.55 GPM
1.5" Line (0.65)	6.9 GPM	4.6 GPM	2.3 GPM

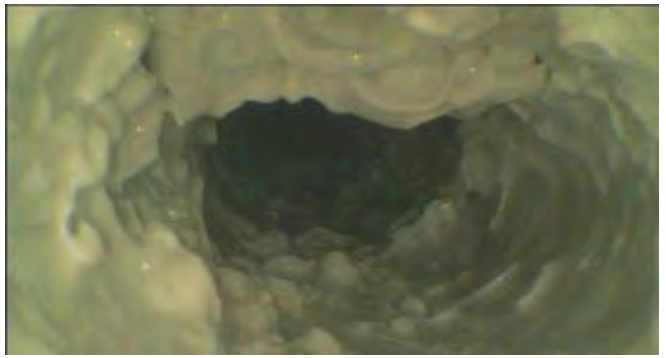


Material Integrity

Material Velocity

- If velocity is too low, then material can settle.
- If material settles finished product can have the “appearance” of dirt when in fact it is a settling issue.
- Over time this can also lead to restricted or clogged lines (usually return lines).





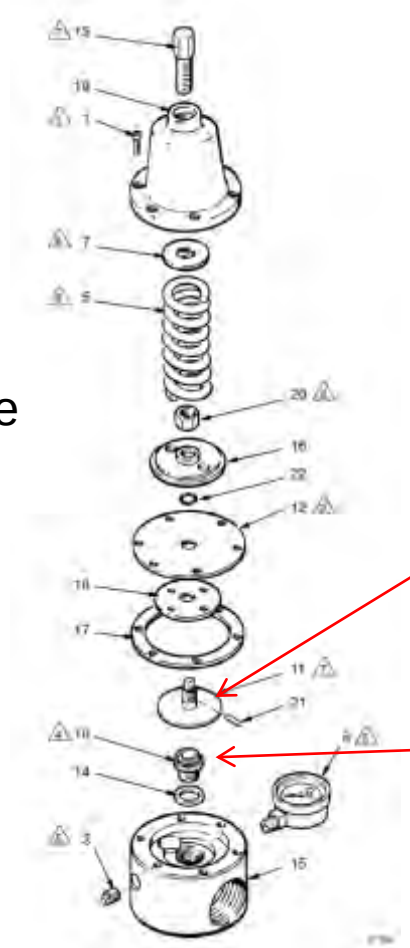
Material Integrity: Shear

Circulation Points That Attribute to Shear?

- Style of Pump.
  - Positive Displacement Pumps good
  - Plunger Pump medium
  - Rotary & Turbine Pumps bad
- BPR (Back Pressure Regulator)

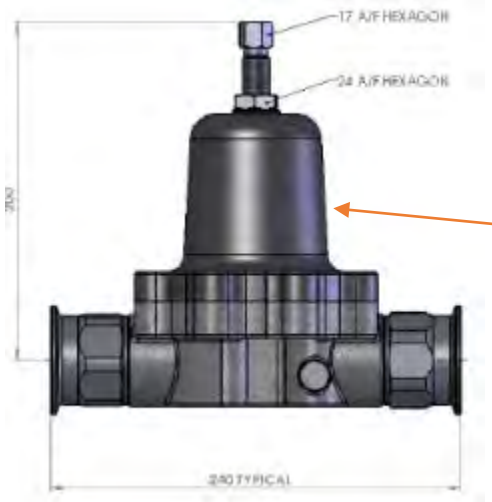
Valve/Seat Style vs. Low Shear BPR

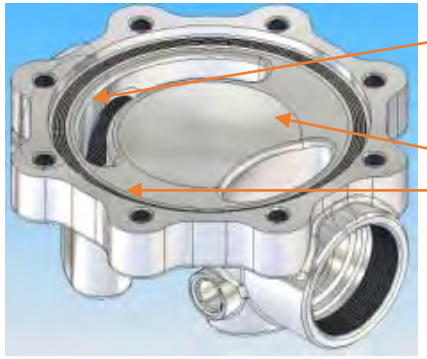
High Shear Valve Seat Style BPR



- Standard high shear valve/seat style BPRs have a small area where material flow is impinged.
- This small area increases material velocity thus increasing shear force.
- Wear on set area also reduces overall efficiency.

Valve/Seat Style vs. Low Shear BPR

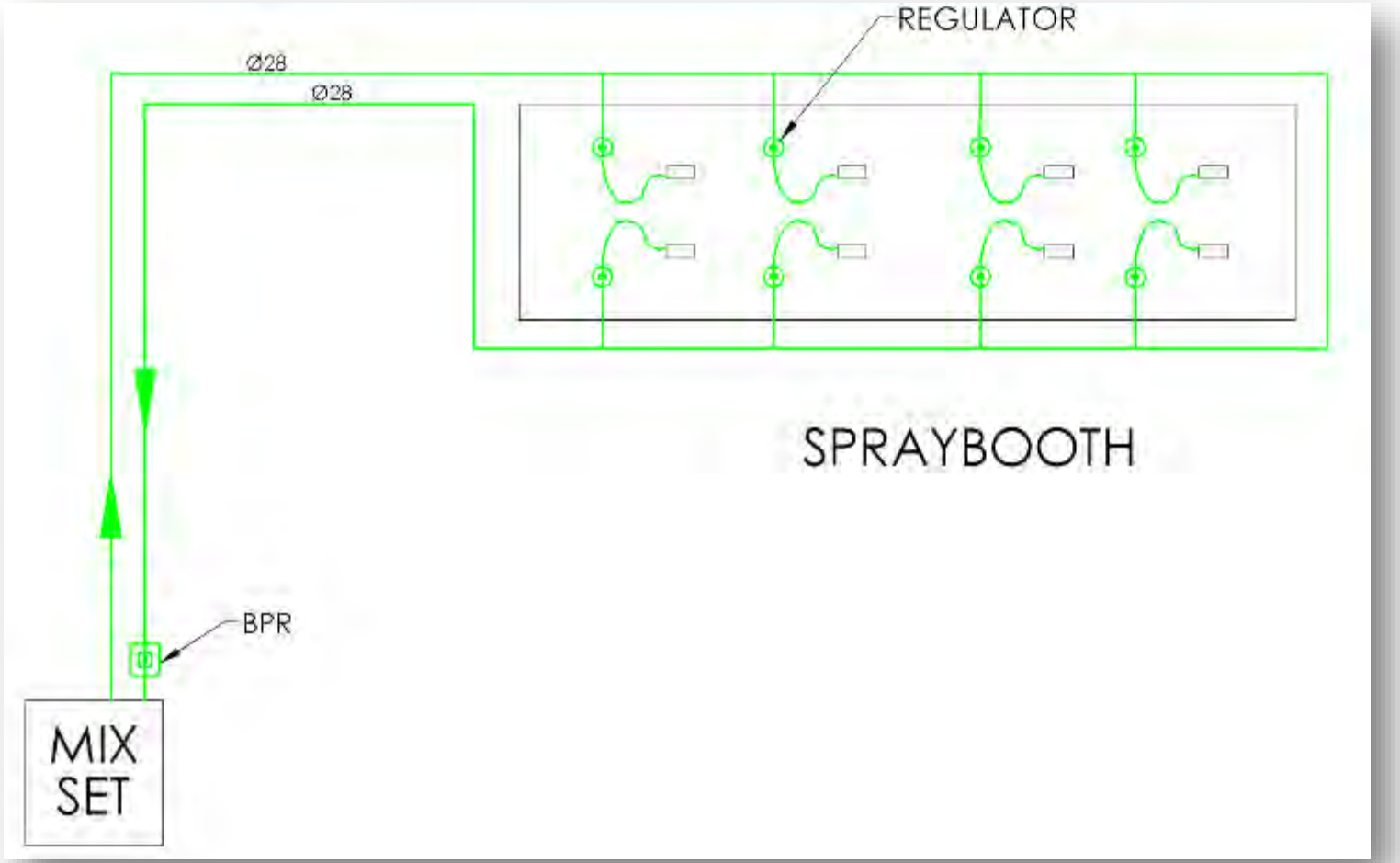




- Diaphragm style BPRs have a large fluid area at the point of material impingement.
- By increasing fluid exit cavity dimension, a lower fluid velocity is also achieved.
- This larger area reduces material velocity thus lowering shear force.

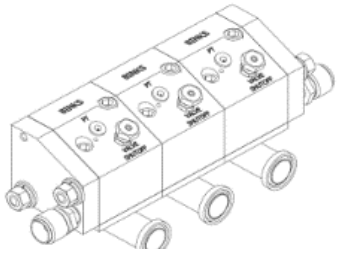
Types of Paint Circulations Systems

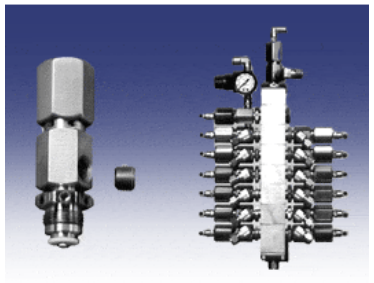
Typical “1-Pipe” Dead-End Drops

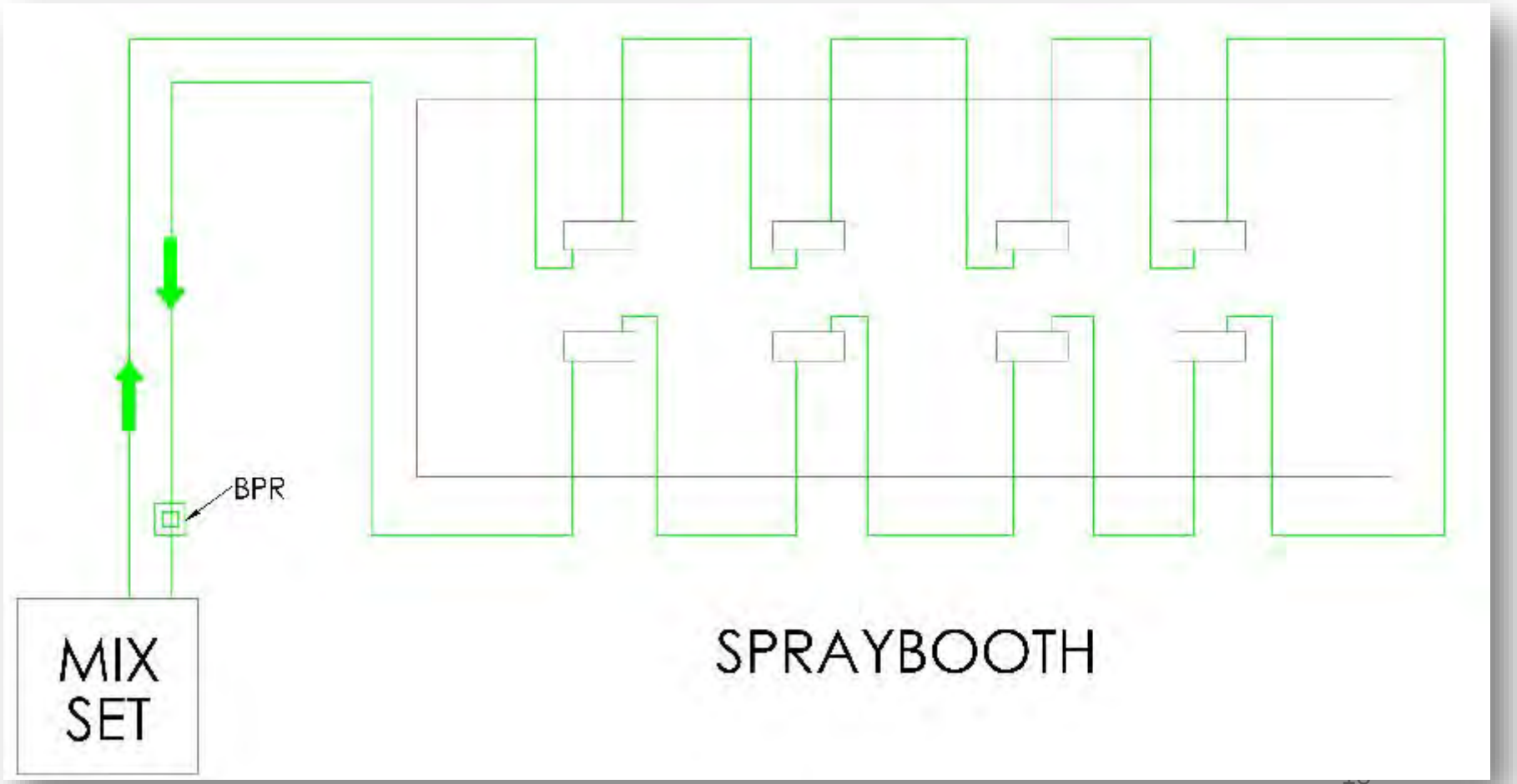


Types of Paint Circulations Systems

Typical “1-Pipe” Daisy Chained CCV

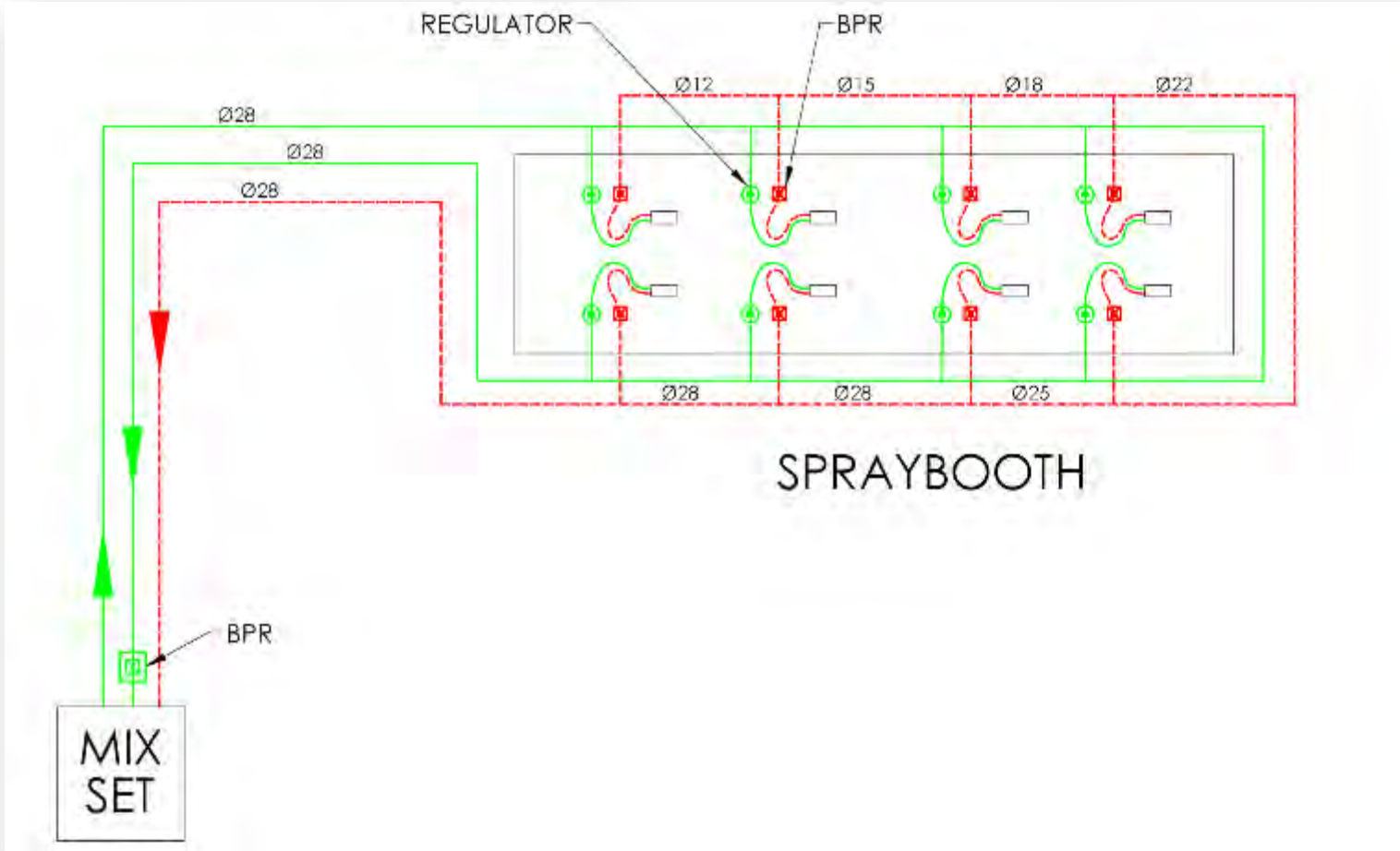






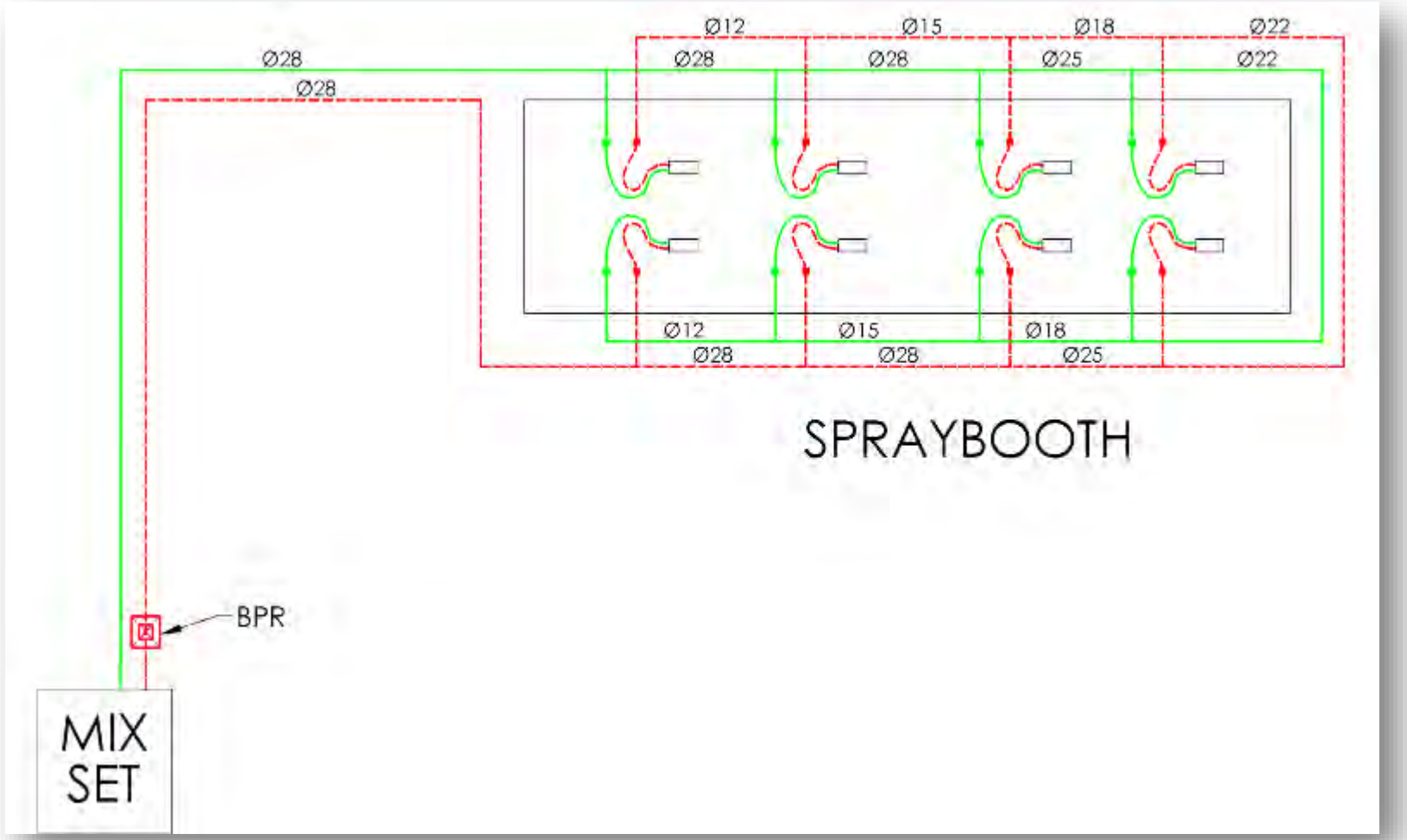
Types of Paint Circulations Systems

Typical “3-Pipe” System



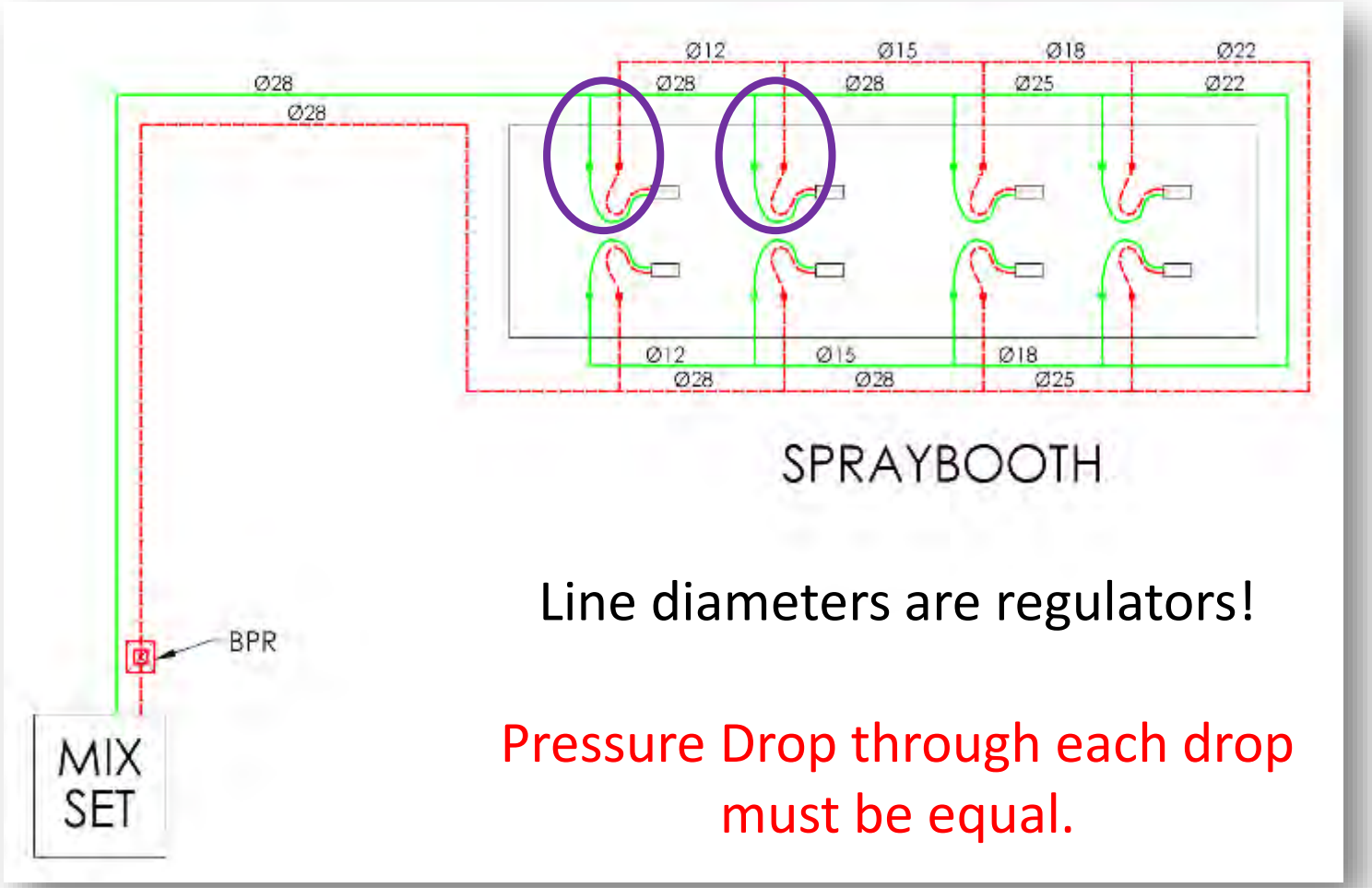
Types of Paint Circulations Systems

Typical “2-Pipe” System



Types of Paint Circulations Systems

2-Pipe System: How does it work?



Line diameters are regulators!

Pressure Drop through each drop must be equal.

Circ System Design Review

What Do We Need To Know?

- Viscosity
- Booth and Paint Kitchen Location (dimensions)
- Required Material Velocity
- Special Material Concerns (i.e. shear sensitive)
- Max Required Flow at Applicators
- Pressure Required at Drop

Answer These Questions and We Are Good To Go!

BINKS PCE SMART*PUMP FAMILY*

CARLISLE FLUID TECHNOLOGIES

Electric Positive Displacement Piston Pumps

E2-7 / E2-15

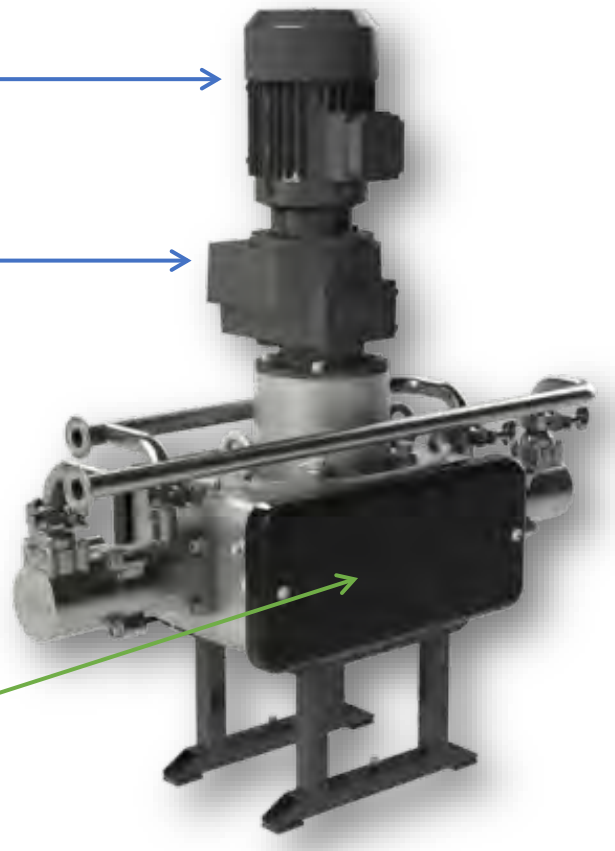
E2-30 / E2-40

E2-60 / E4-60 / E4-100

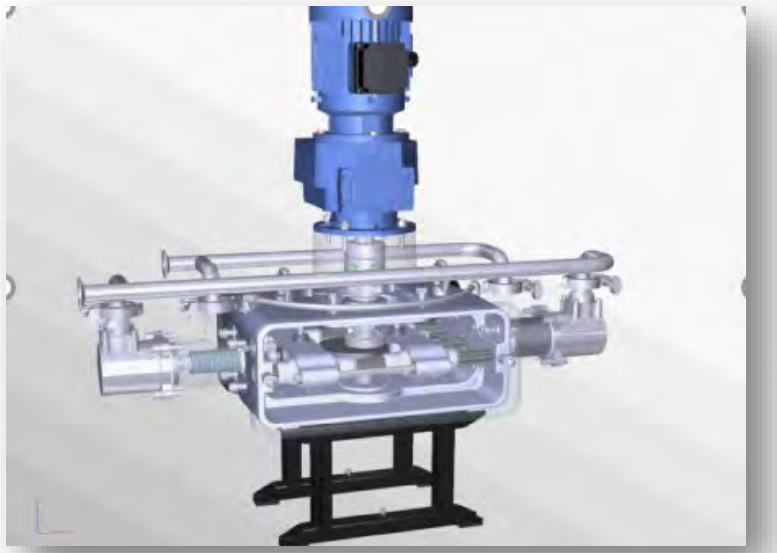
Smart Pump

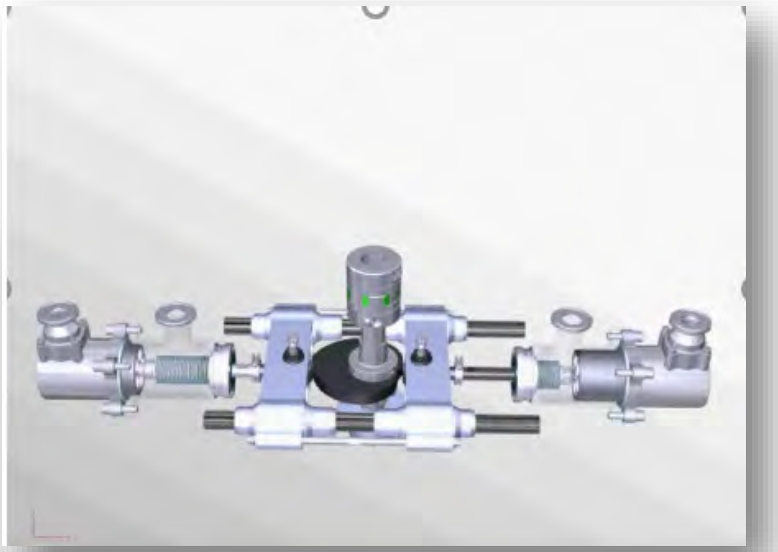
Consists of:

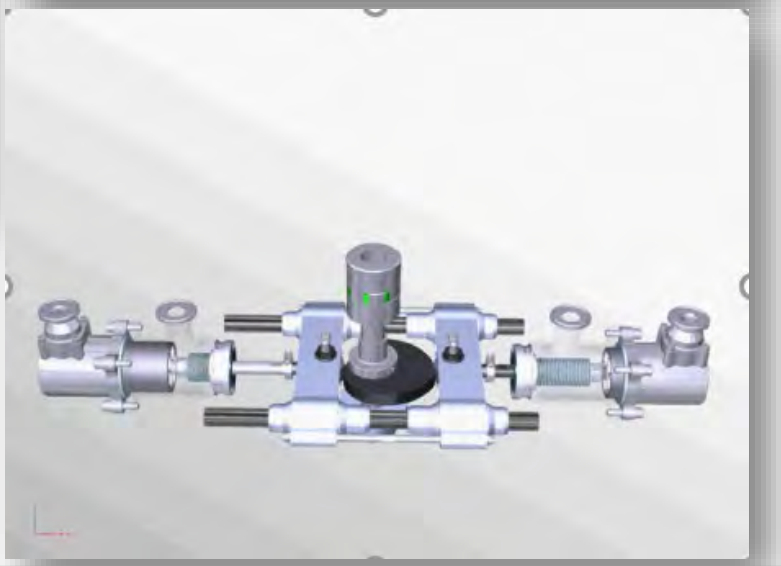
- Ex-Proof Motor
- Standard Gearbox
- Positive Displacement Fluid Sections
- CV “constant velocity” cam drive area

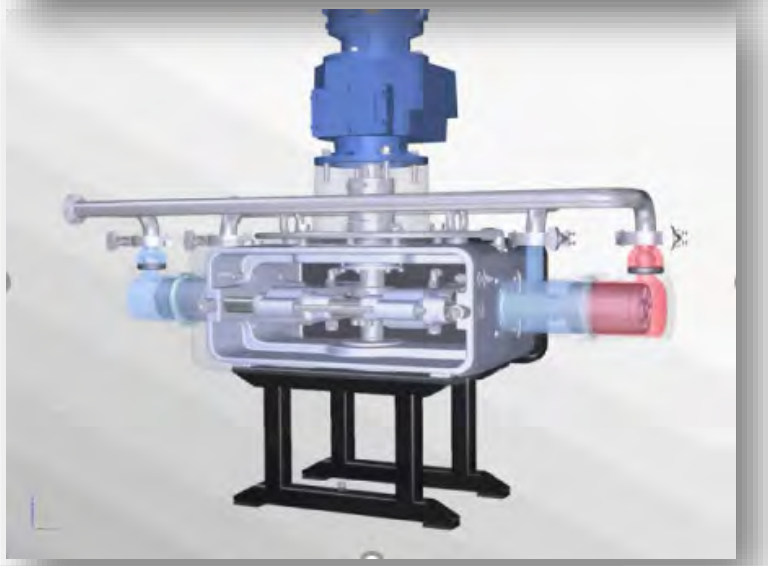


Smart Pump









Smart Pump CV Cam Drive

Pressure Drop on Pump Change Over

NO SURGE CHAMBER

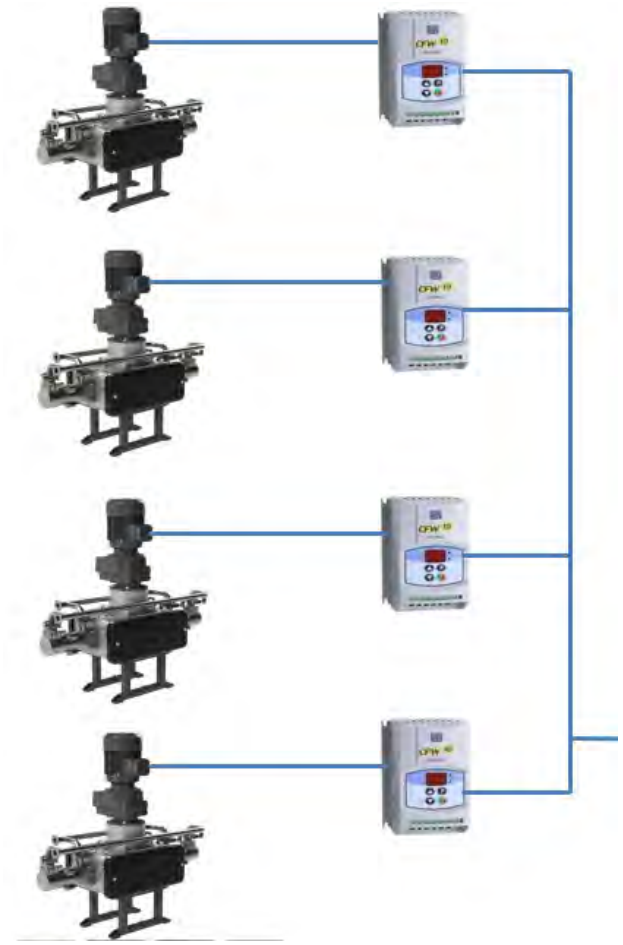
IntelliControls: Smart Pump Process

- Smart Pump can operate in open or closed loop process.
- Open loop is Flow Control.
- Closed loop is pressure control.
- Smart Pump controls can switch between open and closed loop controls in real time thus can adapt to applicator requirements as production flow demands change.
- During nonproduction times Smart Pump can switch to **automated sleep mode** thus lowering energy, material wear, pump and system component wear.
- Ability to control flow rate via Hz input to motor provides more process control.
- Any brand VFD or PLC can be used to control Smart Pump. No black box technology or special motor requirements.

Motor Speed Fluid Output Table			
Motor Speed HZ	Pump Speed Cycles/min	Fluid Flow Rate Litres/min	Fluid Flow Rate US Gall./min
20	10.0	15.00	4
25	12.5	18.75	5
30	15.0	22.50	5
35	17.5	26.25	7
40	20.0	30.00	8
45	22.5	33.75	9
50	25.0	37.50	10
55	27.5	41.25	11
60	30.0	45.00	12
65	32.5	48.75	13
70	35.0	56.25	14
75	37.5	56.25	15
80	40.0	60.00	16

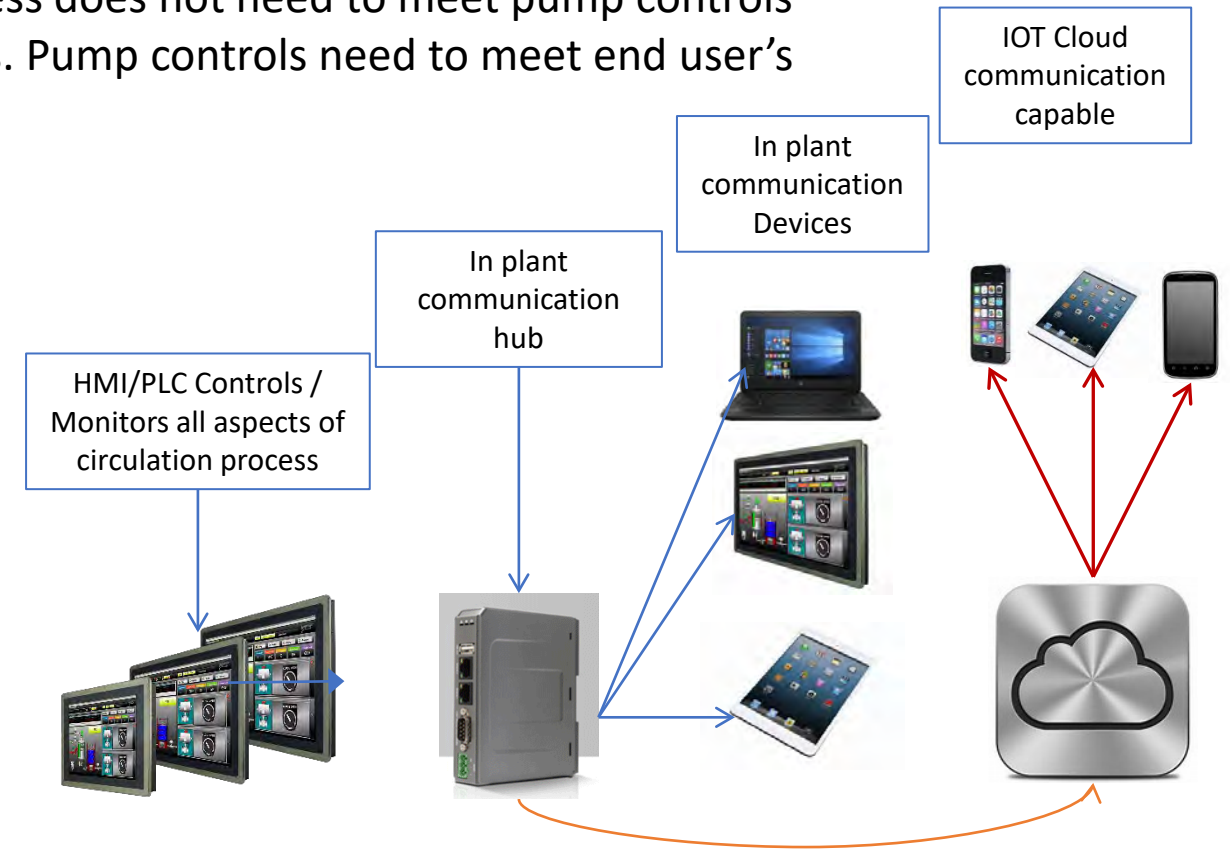
IntelliControls: Smart Pump Process

Smart Pump / VFD

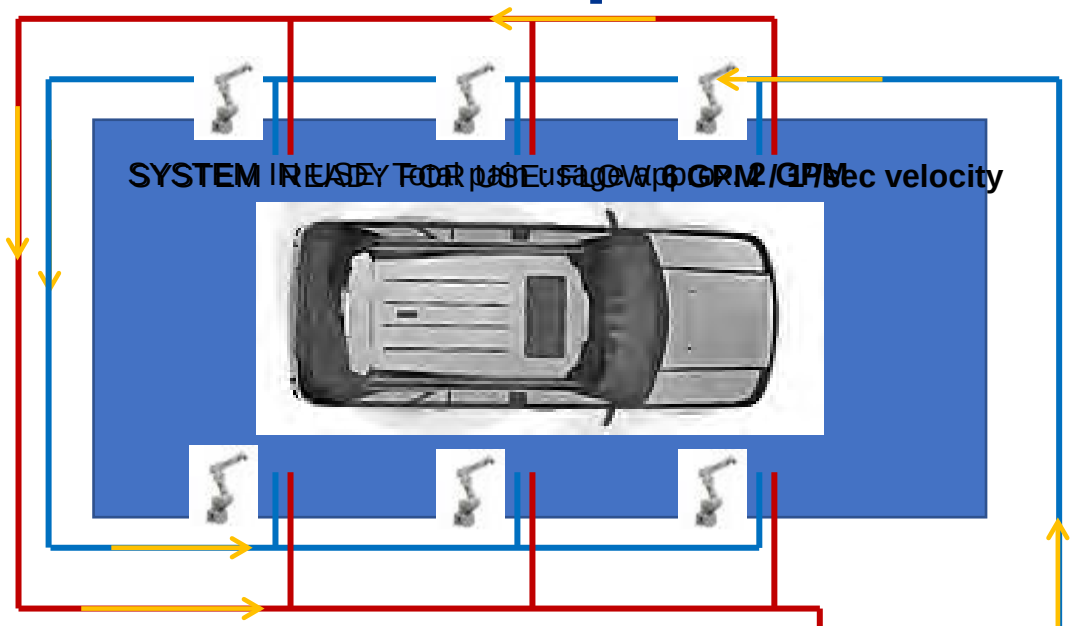


Users needs are all slightly different. Smart Pump control options allow for customization to user's process.

Their process does not need to meet pump controls capabilities. Pump controls need to meet end user's process!



IntelliControls: Smart Pump Process



"Smart Circ" Process

Return line OPEN LOOP:
System not in use
Flow 6 GPM (1'/sec) @ 0 PSI

Pump OPEN LOOP:
System not in use
Flow 6 GPM (1'/sec) @ 90 PSI

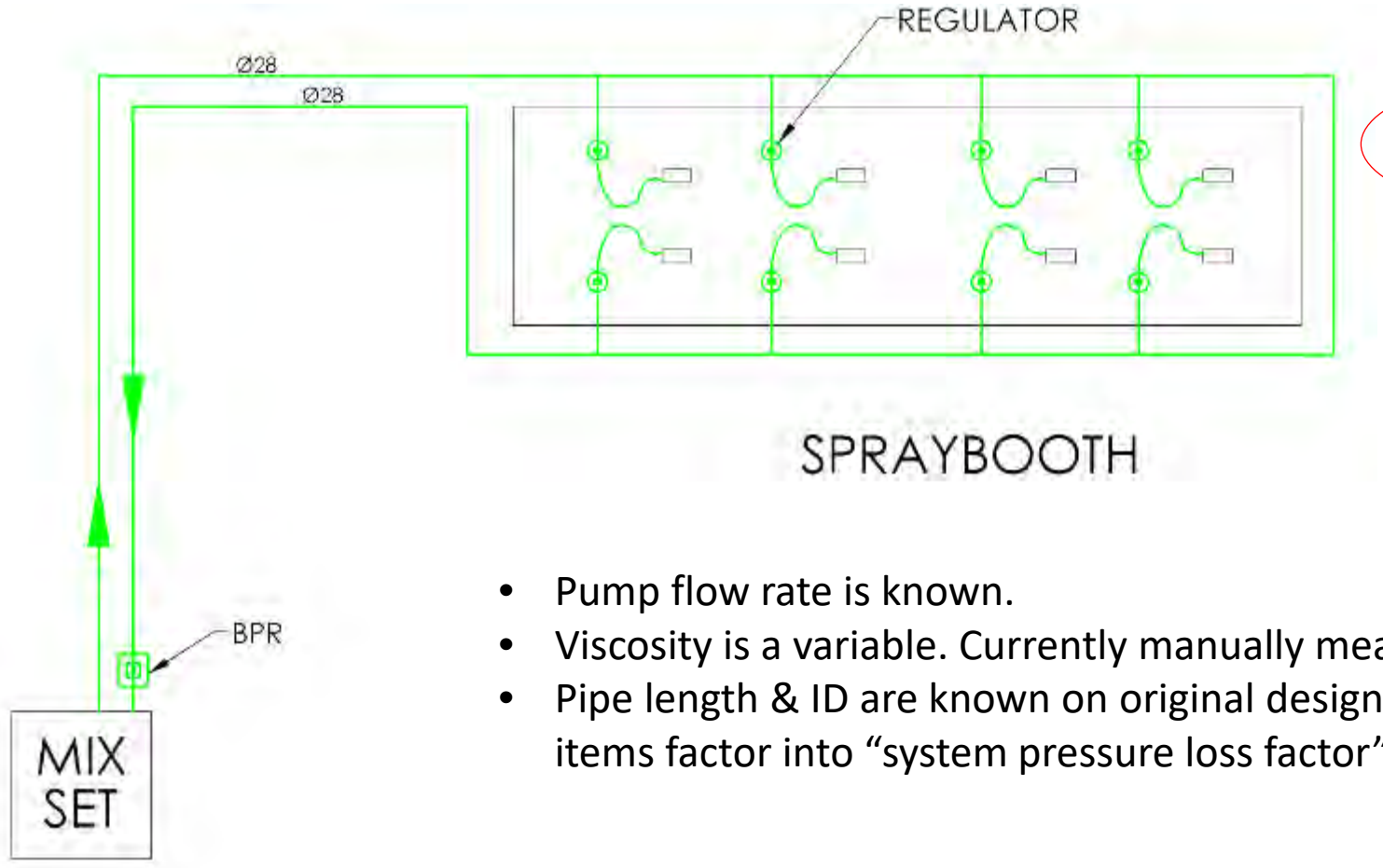
Air piloted back pressure regulator

E2-30 SMART Pump

Return line CLOSED LOOP:
System ready for use
(max spray)
Flow 6 GPM @ 100 PSI

Pump CLOSED LOOP:
System IN use (max spray)
Flow 6 GPM @ 190 PSI

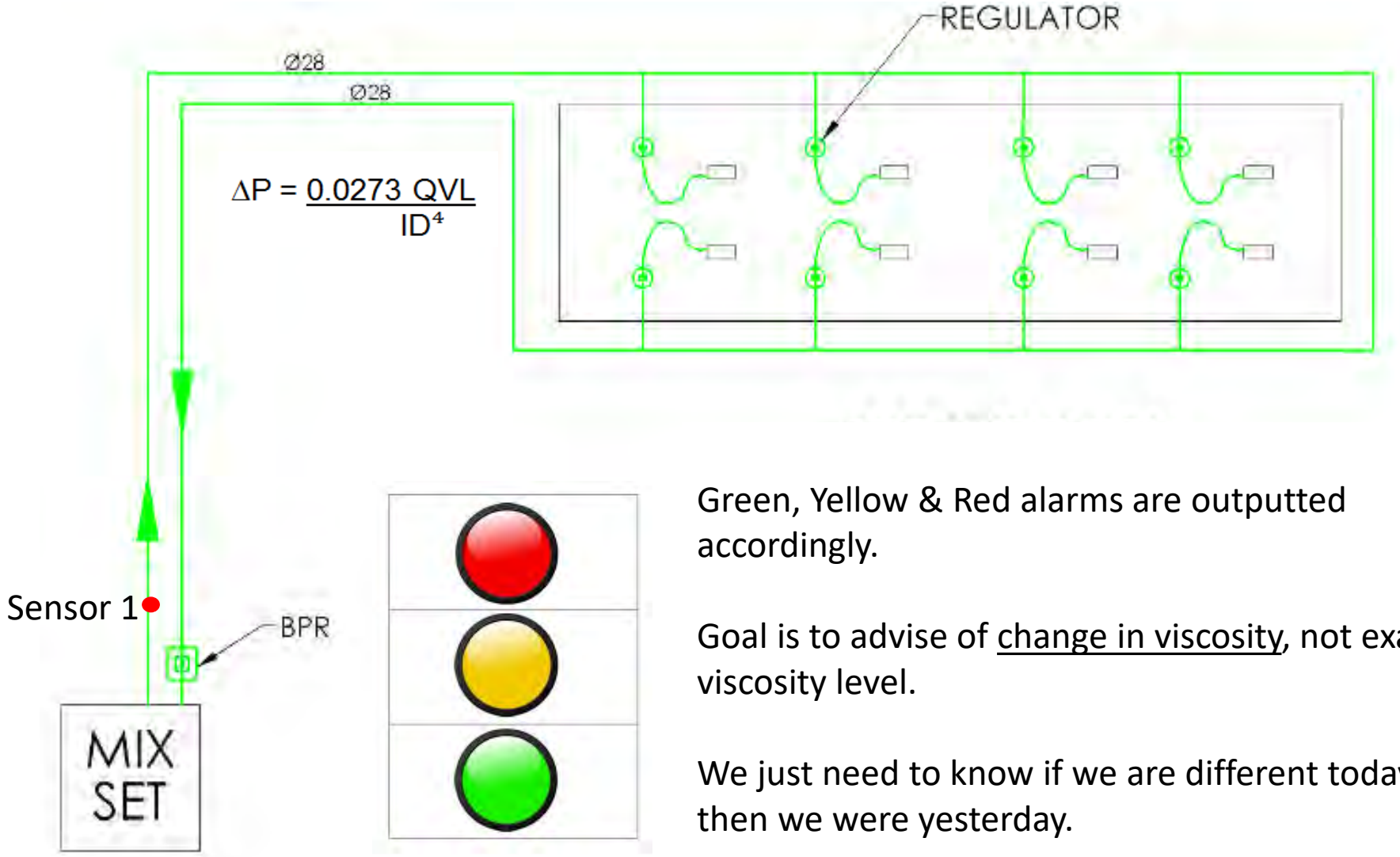
Material Integrity Monitor



$$\Delta P = \frac{0.0273\ QVL}{ID^4}$$

- Pump flow rate is known.
- Viscosity is a variable. Currently manually measured.
- Pipe length & ID are known on original design. Both items factor into “system pressure loss factor”.

Material Integrity Monitor: Viscosity



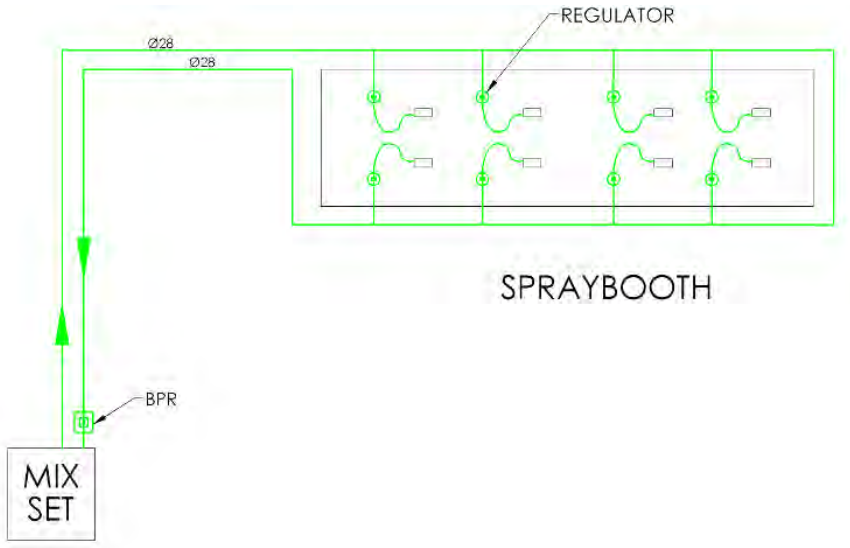
Green, Yellow & Red alarms are outputted accordingly.

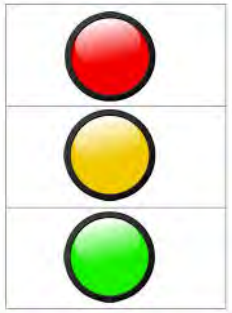
Goal is to advise of change in viscosity, not exact viscosity level.

We just need to know if we are different today then we were yesterday.

Material Integrity Monitor: Velocity

Pump Cycle = Flow Rate = Paint Velocity





>10%

>5% <10%

<5%

High level user inputs pump flow rate required to maintain material velocity through pipe.

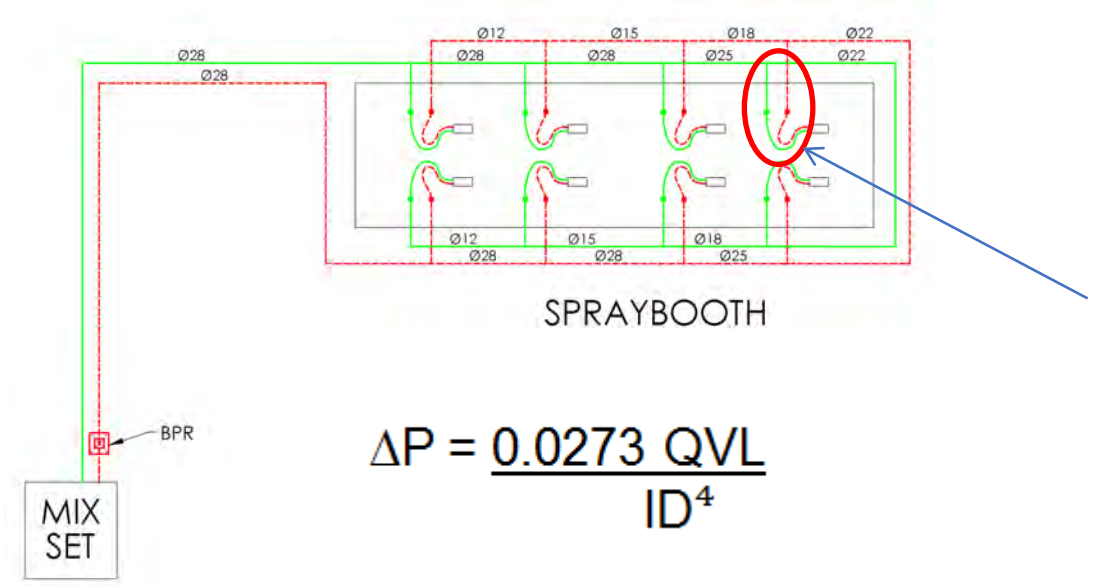
System will monitor set point via pump cycles and provide soft alarms if material velocity is to high or low.

Data is collected for any future warranty concerns.

Chart 1: Material Velocity Chart			
Pipe OD Dia.	Material Velocity		
	1.5'/sec	1'/sec	0.5'/sec
1/2" Line (0.049)	0.6 GPM	0.4 GPM	0.2 GPM
5/8" Line (0.049)	1.05 GPM	0.7 GPM	0.35 GPM
3/4" Line (0.65)	1.4 GPM	1 GPM	0.48 GPM
1" Line (0.65)	2.8 GPM	1.85 GPM	0.94 GPM
1.25" Line (0.65)	4.6 GPM	3.05 GPM	1.55 GPM
1.5" Line (0.65)	6.9 GPM	4.6 GPM	2.3 GPM

Circulation Line Status: Balance

What We Know…



$$\Delta P = \frac{0.0273\ QVL}{ID^4}$$

What We Want To Know…

System Balancing

A properly balanced system has equal pressure loss through all drops.

Equal pressure loss equates to equal flow.

With known viscosity & flow, a hose pressure loss factor can also be communicated.

Pump Status: Real Time Maintenance/Diagnosis

Real-Time Maintenance & Pump Diagnosis:

By utilizing pump cycle counter and pump outlet pressure sensors real-time pump operation or system diagnosis can be determined.

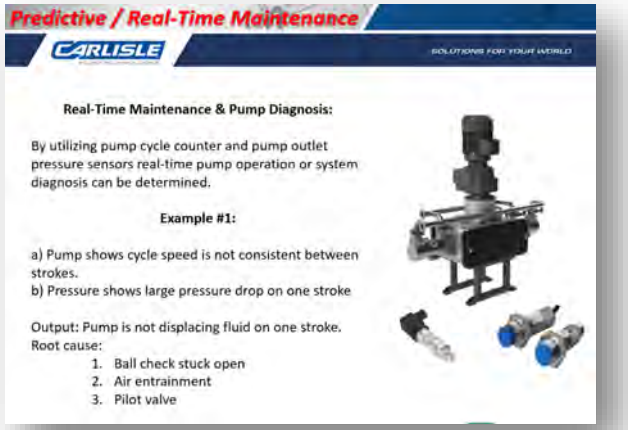
Example #1:

a) Pump shows cycle speed is not consistent between strokes.
b) Pressure shows large pressure drop on one stroke

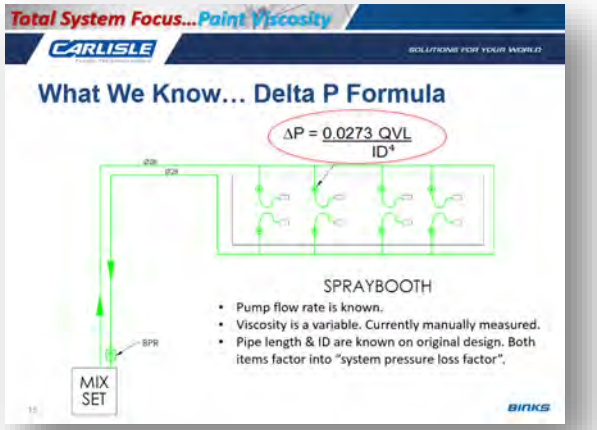
Output: Pump is not displacing fluid on one stroke. Root cause:

1. Ball check stuck open
2. Air entrainment
3. Pilot valve

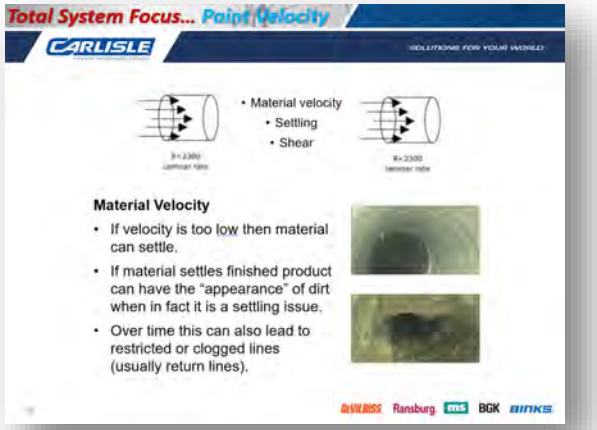
Options:



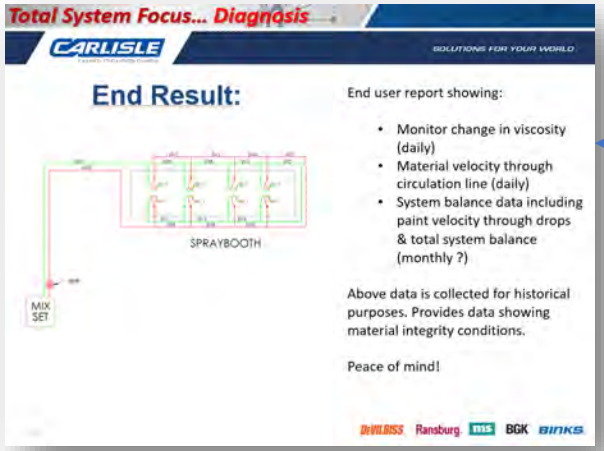
Predictive/ Realtime Maintenance



Material Viscosity Monitor



Material Velocity / Integrity Monitor



Circulation System Realtime Diagnosis.

Control, Communicate and monitor other circulation products

IntelliControls: Smart Pump Process

End Result

- User Provided following data:
  - Material Viscosity (monitoring change)
  - Material Temperature (real-time)
  - System Flow Rate (real-time)
  - Material Velocity (real-time)
  - Operating Pressure (real-time)
  - System Balance (diagnoses process)
  - Pump Operation (diagnoses process)
  - Data Collection / Storage
  - Tank level & total material usage (requires level sensor & data log)
  - Automated sleep mode during non production times.

Real-time data available at users finger tips…

Can be in plant communication hub only or if IoT is allowed data can be forwarded to cell phone apps, corporate offices…

Goal is user can locate and diagnose system issues prior to production issues (i.e. process vision).

The process does not need to meet pump controls capabilities. Pump controls need to meet end user's process!

BGK A CARLISLE BRAND

BINKS A CARLISLE BRAND

DEVILBISS A CARLISLE BRAND

HOSCO A CARLISLE BRAND

MS A CARLISLE BRAND

RANSBURG A CARLISLE BRAND

CARLISLE FLUID TECHNOLOGIES

Questions?