Tissue Fabric Cleaning & Conditioning

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AN ACCENT ON INNOVATION

Objectives

- Introduction
  - What is cleaning & conditioning?
  - Theory & practical considerations
- Showers
  - Fan Jets
  - Needle Jets
- Felt Dewatering – Uhle Boxes
- Applications Specifics
- Questions

Why Clean Fabrics?

Maintain fabric properties over life of fabric – as "steady state" as possible

- remove contaminants
- combat compaction
- preserve permeability
- maintain surface
- retard wear (lubricate)

Showers

- Why Shower?
  - –Apply chemical
  - –Apply water
    - lubricate
    - CLEAN
      - –flushing
        - »direct/suction
        - »flooded nip
      - –kinetic energy

- Shower Types

  -Fan Jet

  even distribution

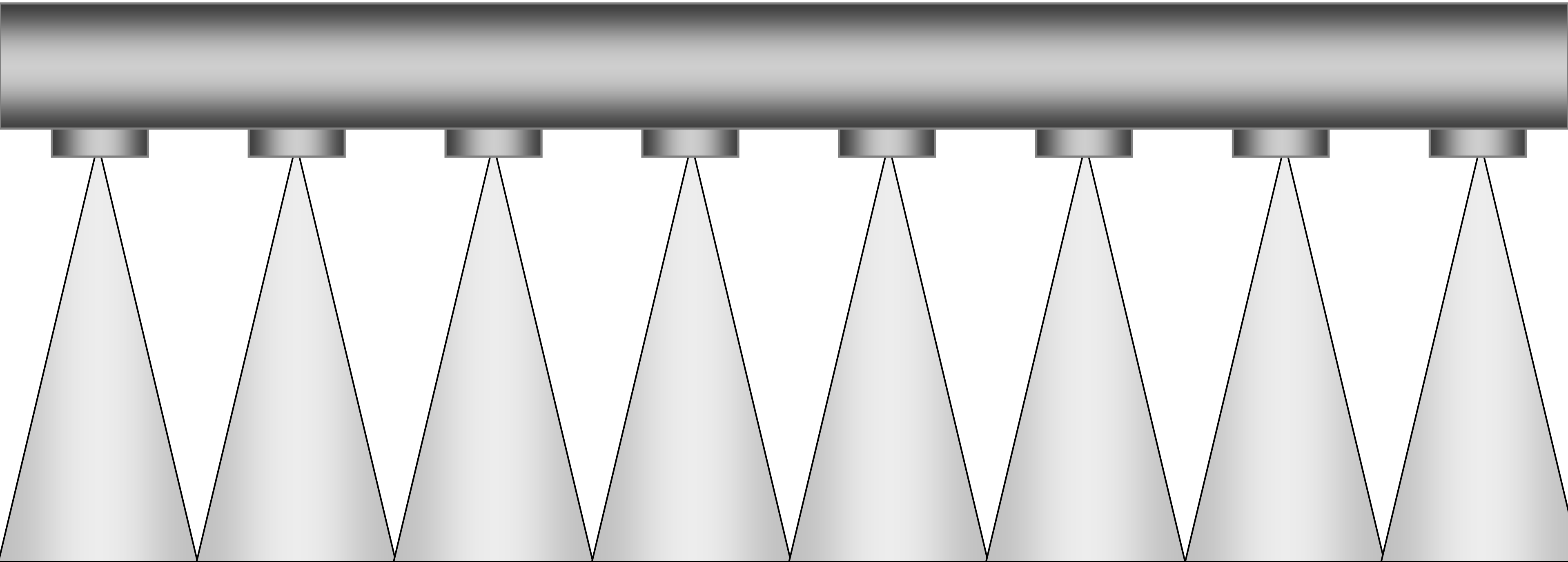
  -Needle Jet

  apply energy

  -Single Jet Scanning

•Tappi TIP 0404-61, "Paper Machine Shower Recommendations"

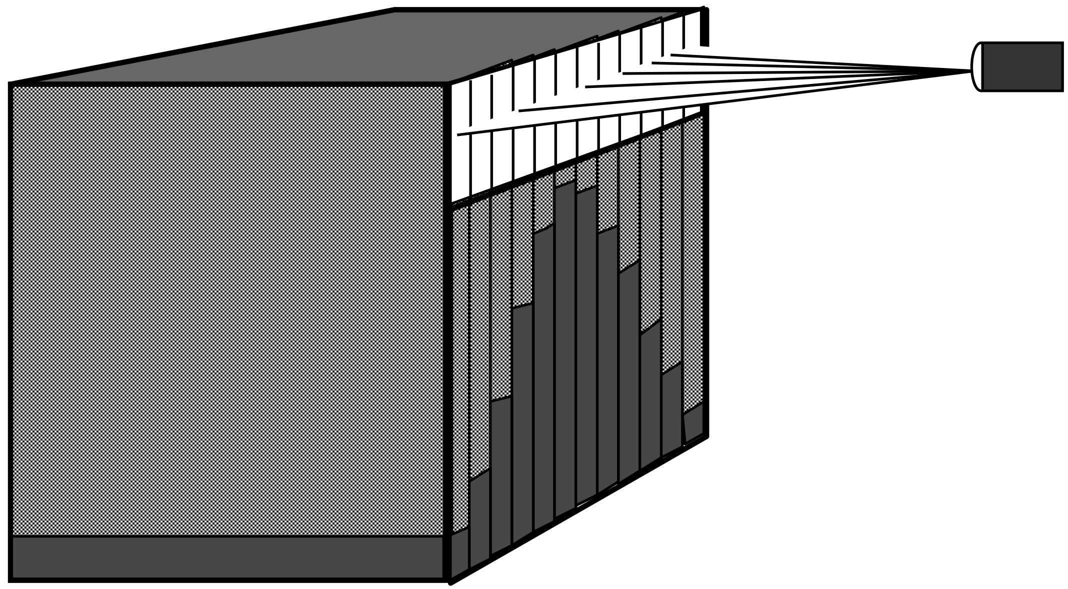
Fan Shower Profile Management



Fan Nozzle Variation:

- ***Flow Distribution***
- **Total Flow Volume**

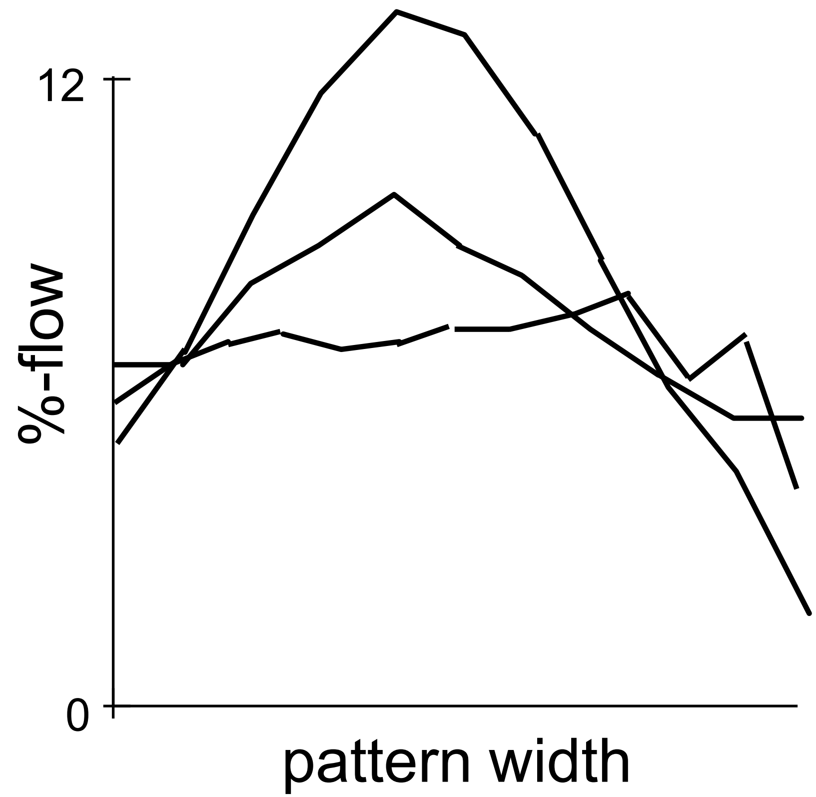
Nozzle Flow Distribution Tester



Nozzle Spray Distribution

40 - 45 degrees

.047 - .054 inch orifice



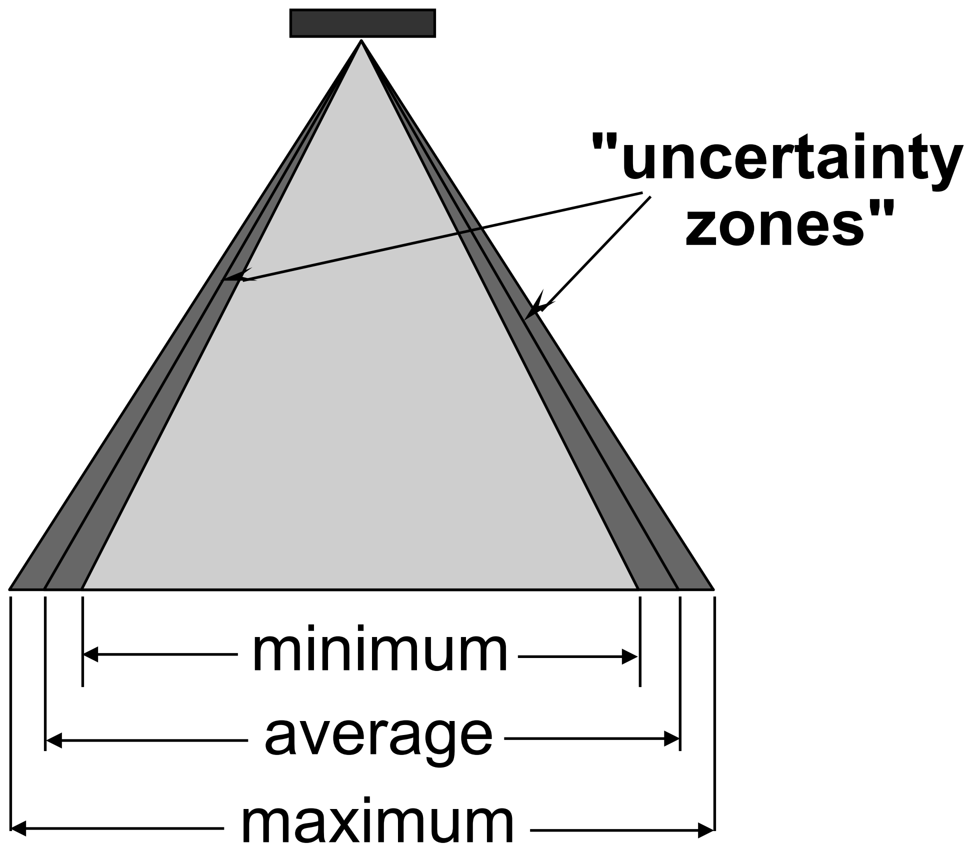
Total Flow Variations Nozzles of the Same Type

Standard Deviation/Average Flow

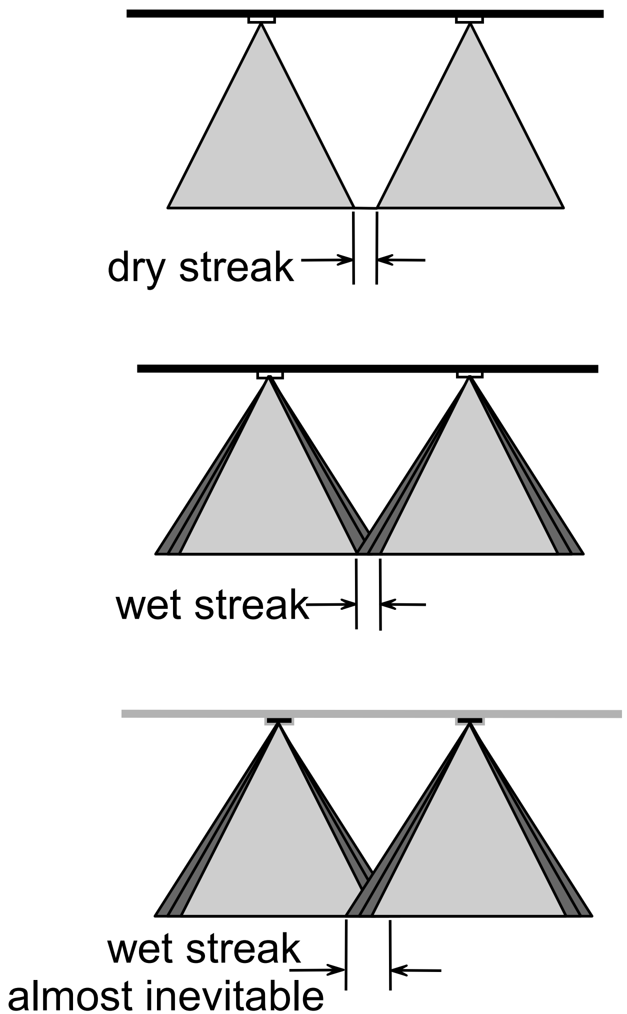
Nozzle	Type 1	Type 2	Type 3
25° - 30°	2%	4%	2%
30° - 35°	6%	3%	
40° - 45°	8%	3%	3%
55° - 60°	4%	3%	

Flow does not vary very much from nozzle to nozzle

Nozzle Spray Pattern Distribution



Nozzle Spacing



- Spaced for average pattern width
  - 50% chance of dry streak
  - 50% chance of wet streak
- Spaced for minimum width
  - Probable wet streak
  - ***No dry streaks***

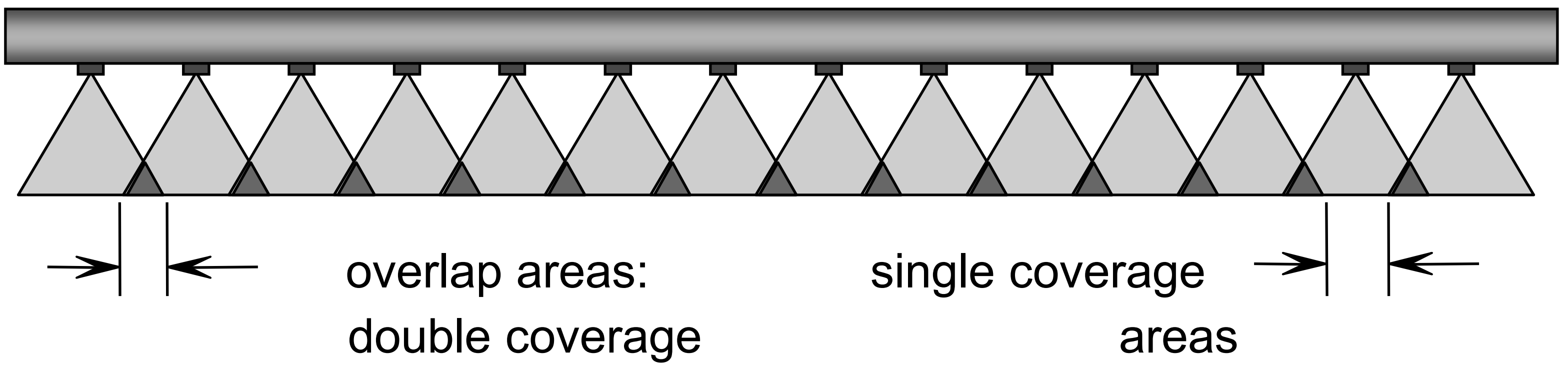
Overlapped Nozzles:

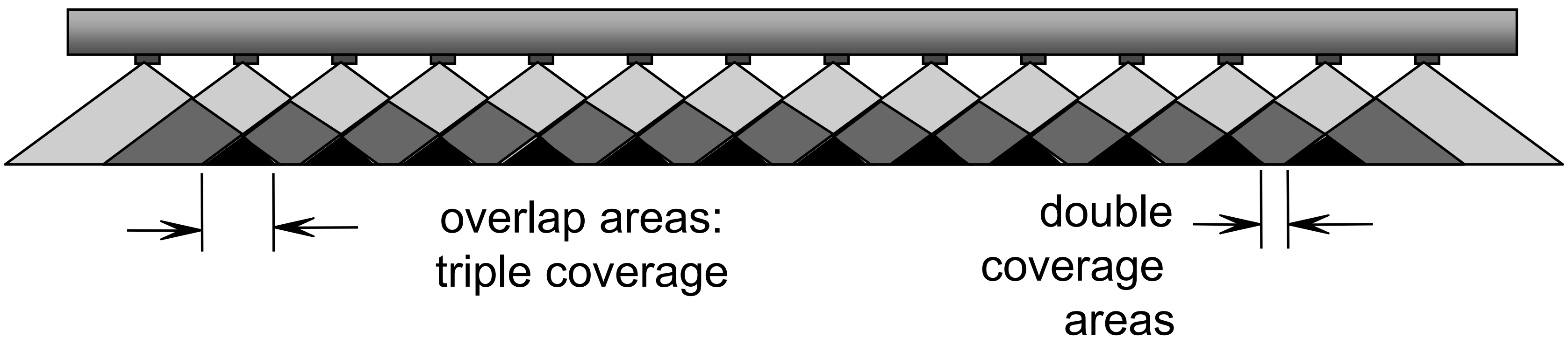
- Conservative Approach
- Precludes Dry Streaks
- Causes Wet Streaks

Typical Single Coverage Fan Shower Arrangement

- 1x coverage: each nozzle covers the same CD width
- Pattern edges overlap to prevent dry streaks

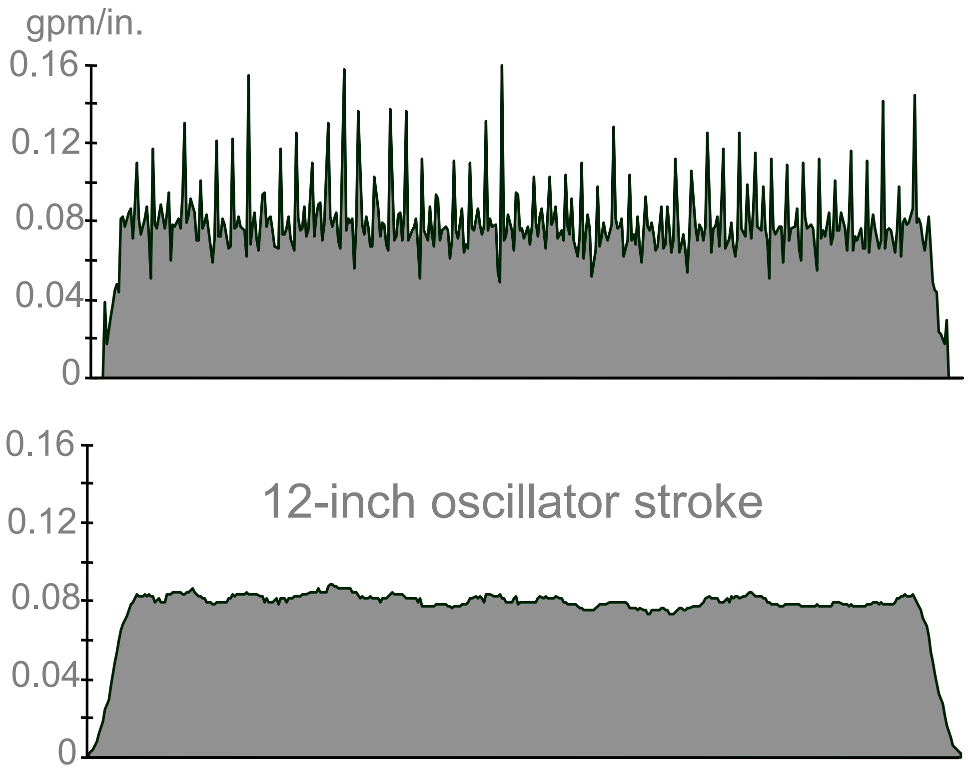
Shower Layout





- Single coverage is a must
- Multiple coverage is better
  - Attenuates variation (3:2 is better than 2:1)
  - “insurance” against plugged nozzles

Machine Width Shower Distribution

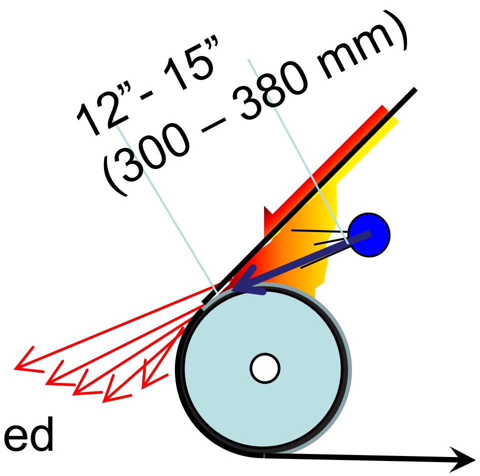


	Not Oscillated	Oscillated
Avg. flow (gpm/inch)	.079	.079
Standard Deviation	.019 (24%)	.003 (4%)

- 300 inches wide
- 45 degree nozzles
- 6 inch centers
- 1/2 inch pattern overlap

Flooded Nip Shower

- Full width flooded nip shower
  - Provides outstanding Knock-off & cleaning performance
- Excellent tool for cleaning inside surface & powering out voids with modest water volume
  - Helps debris off fabric, provides flushing water to clean fabric
  - Pointed just before nip, FORMS PUDDLE
    - ***Puddle*** insures even distribution, not nozzle-shower configuration
    - Allows roll's fluid mechanics to force contaminates out



- If it's the only full width fan shower, consider the applied energy
  - **Operation below RVV yields far less driving force for knock-off**
  - **RVV is VERY water intensive (high volume)**
  - Optimum cleaning occurs at RVV, BUT good cleaning can be achieved at lower volumes
- NOTE: the above is for flooded nip wire showers. For **felt** flooded nips, volume to achieve void volume (gpm) is

Fabric Width(in) x Fabric Wt.(oz/ft^2) x Speed(fpm) x C
– all other shower flows
Where C = 0.000063

Running Void Volume

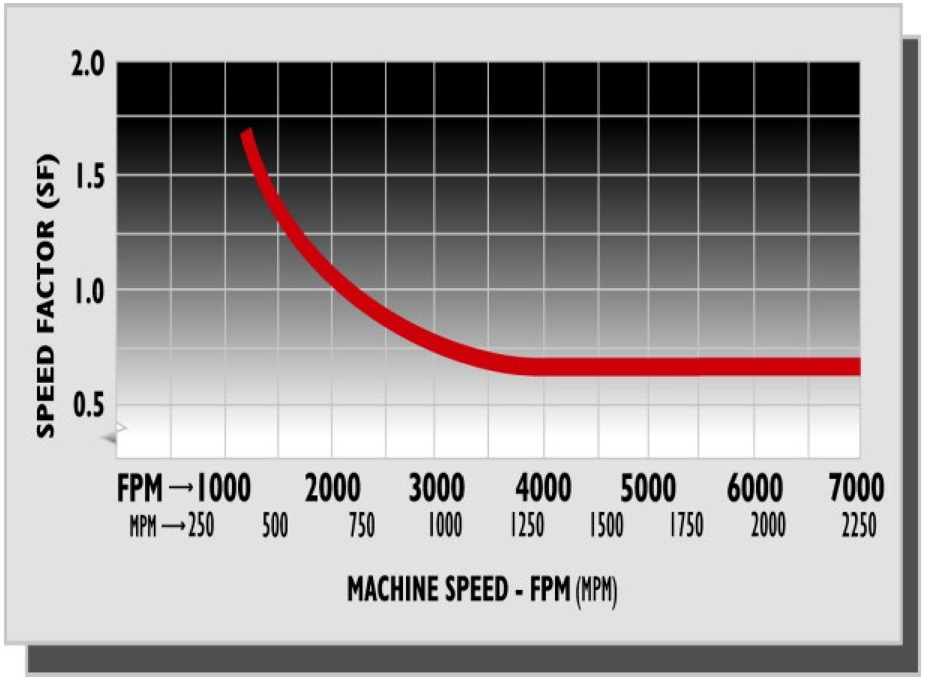
C= Caliper of Fabric in Inches
W= Fabric Width in Inches
S= Speed in FPM
V= Void Volume (use 0.6)
SF= Speed Factor for wires

R.V.V. (gpm)= $\mathbf{\dfrac{CxWxSxVxSF}{19.25}}$

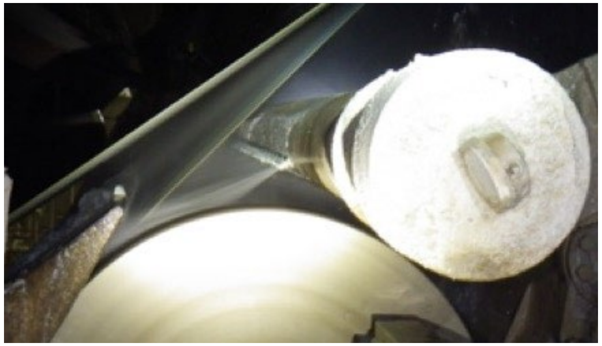
EXAMPLE flooded nip
1550 fpm-Speed factor = 1.3

Full coverage flow =
340 gpm on new wire

Re- calculate
Both S and SF for other
Machine speeds.
Note that void volume and
Speed factor are
Dimensionless.



Flooded Nip Showers



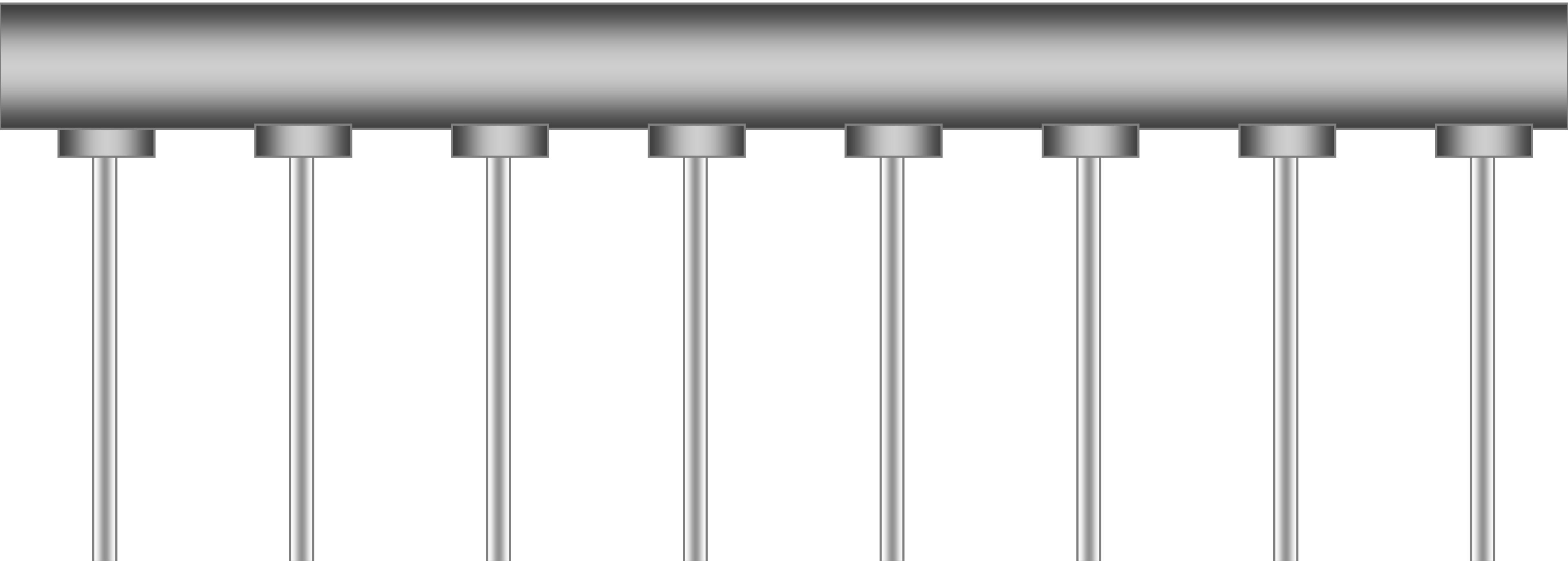
Flooded nip placement: note landing on roll before nip to form puddle

Tissue felt flooded nip

FNKO running at full (knock-off) volume

Flooded nip running at reduced volume sufficient for cleaning

Needle Jet Showers

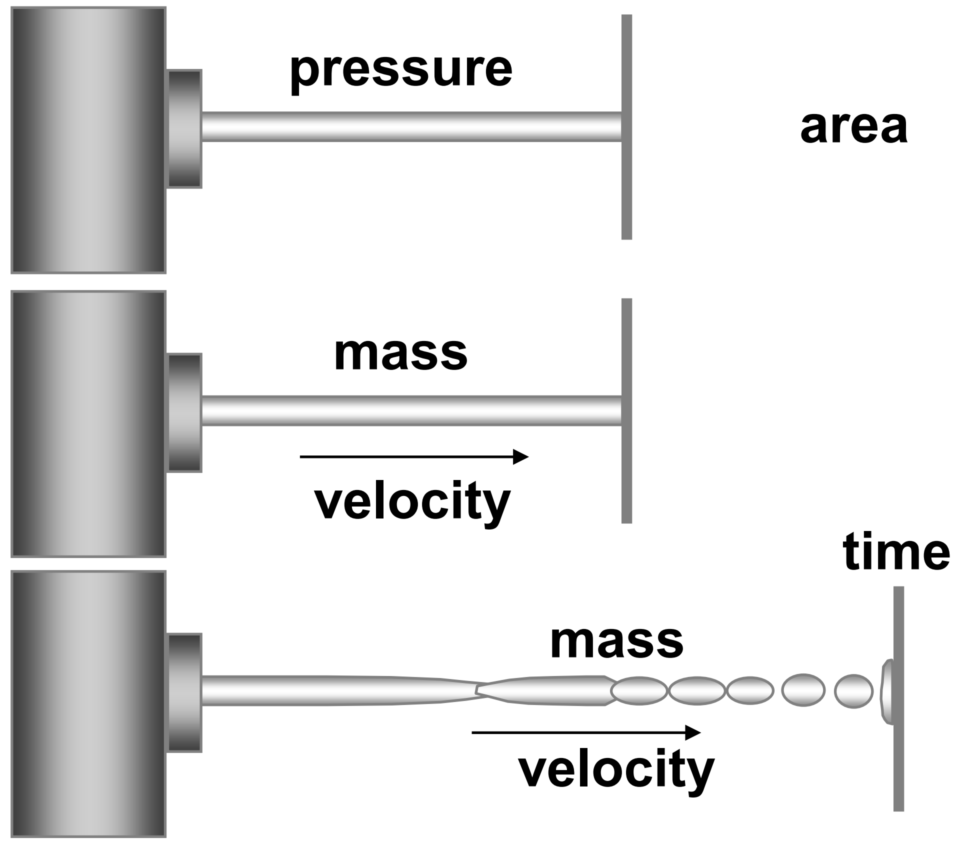


How Do Needle Showers Work?

1. Pressure, Force?

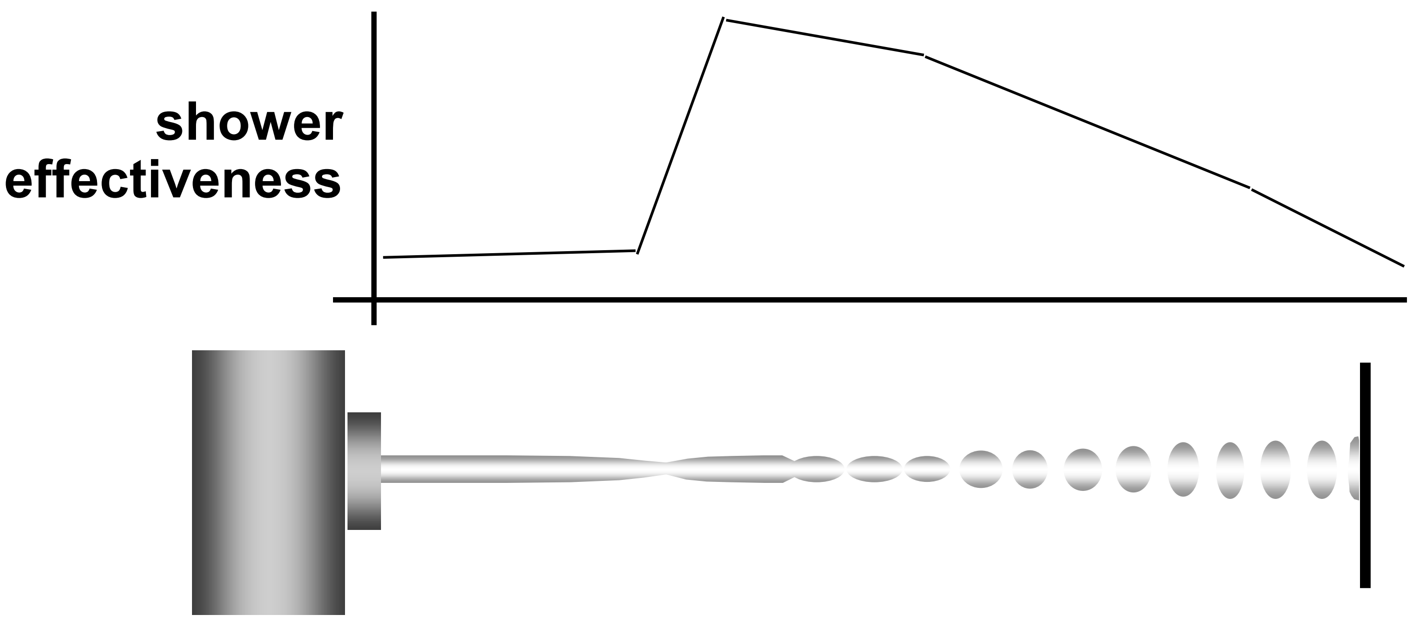
2. Energy, Momentum?

3. Impulse?



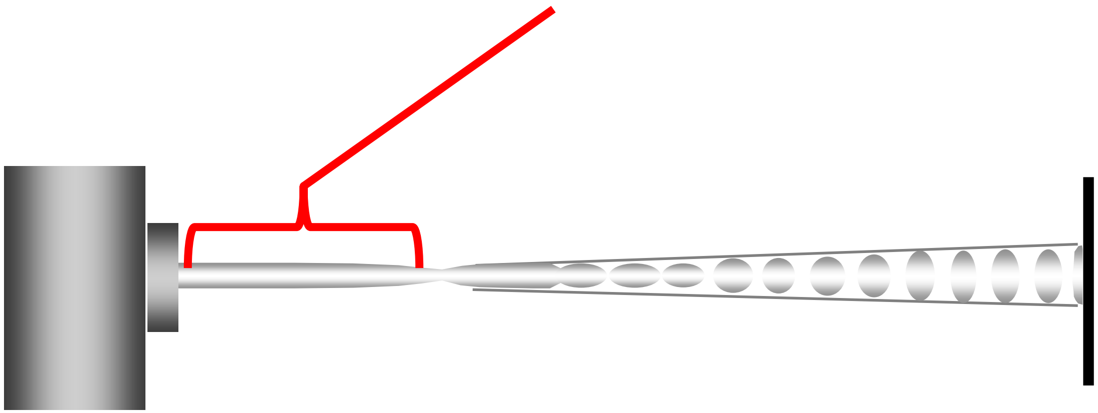
“Why’s” of Needle Jets

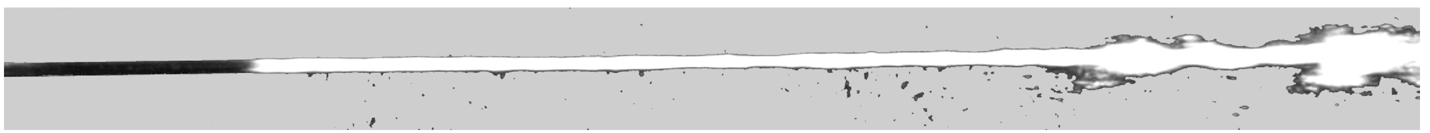
1. **Cleaning depends on distance from the fabric**
2. **Cleaning is proportional to energy Cleaning = f(energy/time) = f(power)**
3. **Energy** $= \frac{1}{2} mv^2$ $v \propto \sqrt{p}$ $m \propto a \propto d^2$



Inside HPS for through cleaning

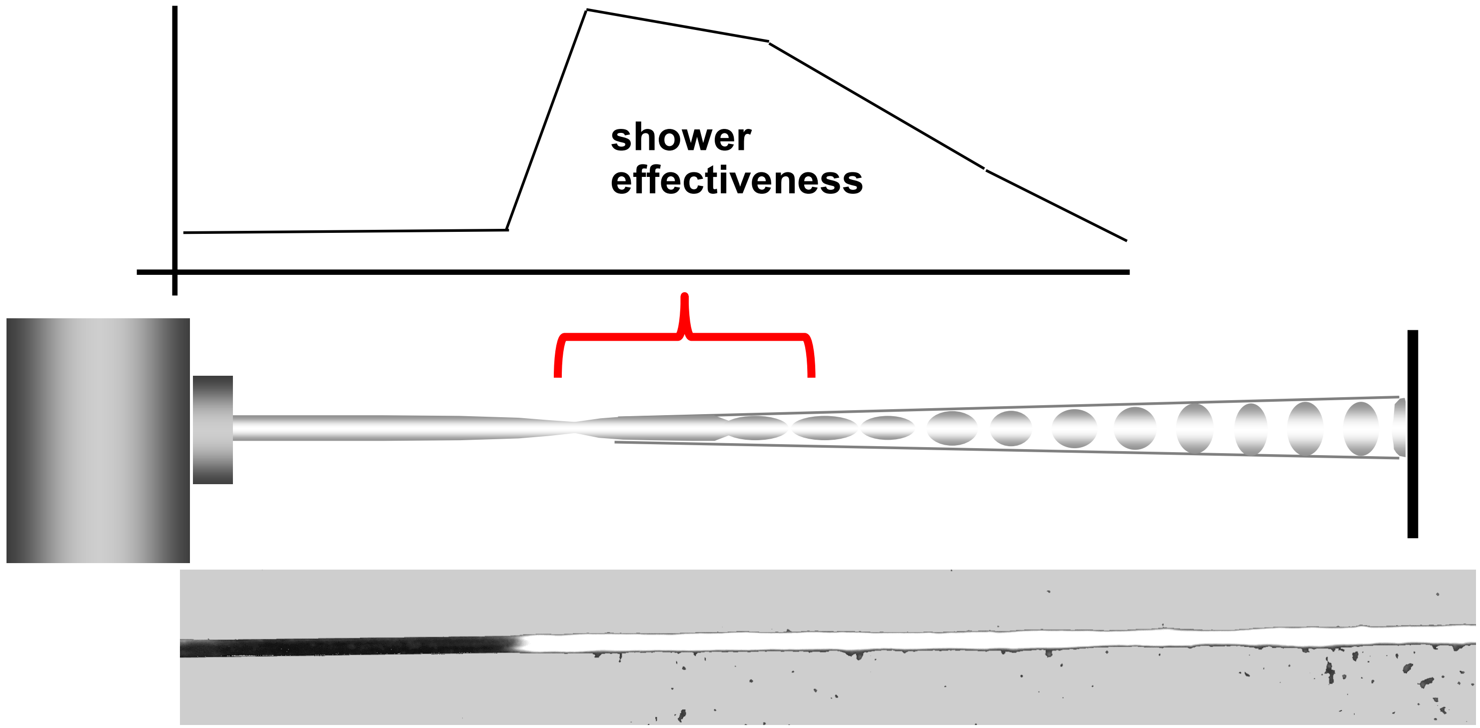
Laminar flow penetrates better, jet distance
< 4” for through cleaning



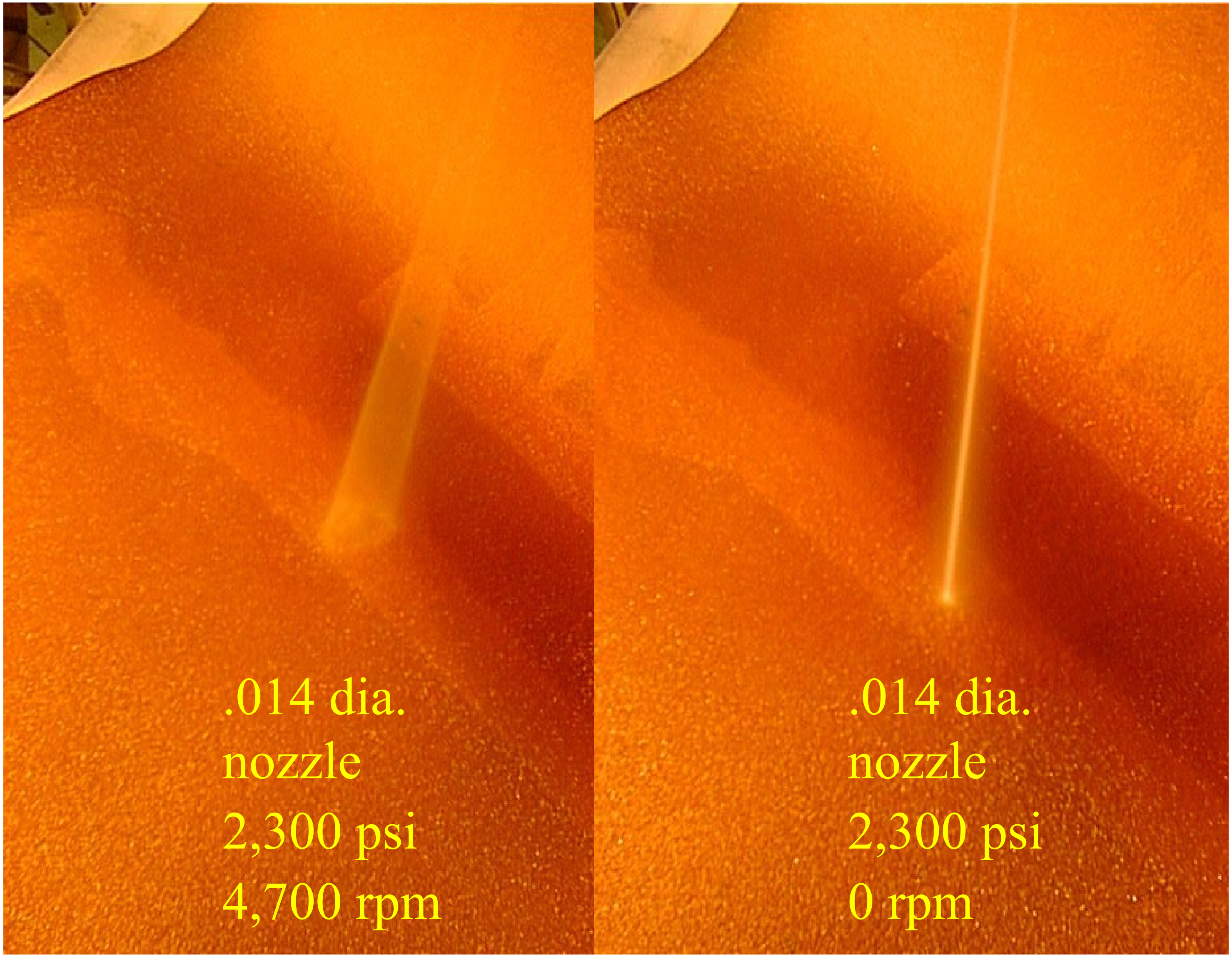


Sheet Side HPS for surface cleaning

Maximize surface cleaning effectiveness/pressure > 6 in.



How Important is Dispersal Area?



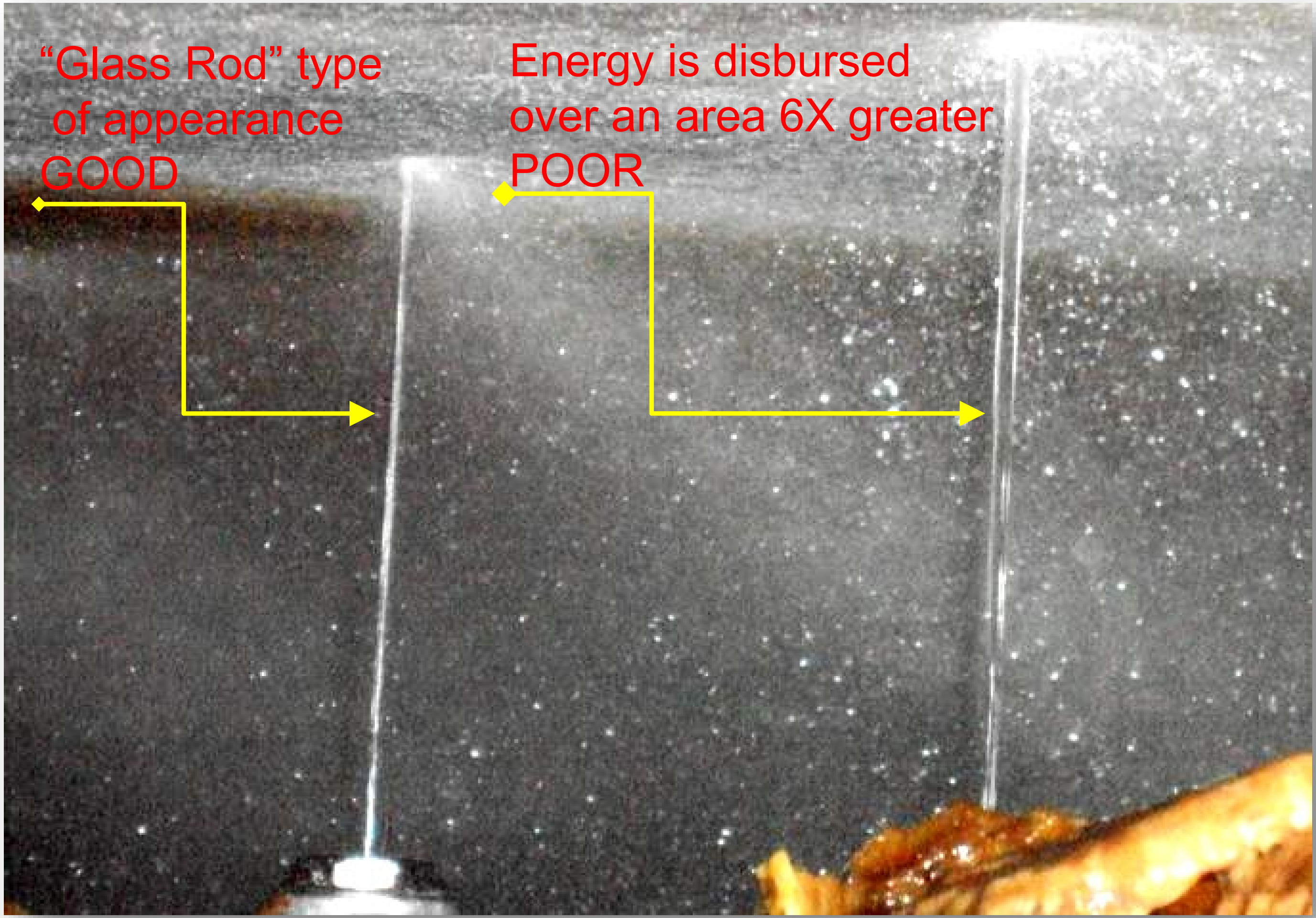
Power Application: Jet Vs. Fan

Typical Nozzle: .040 diameter, 150 psi

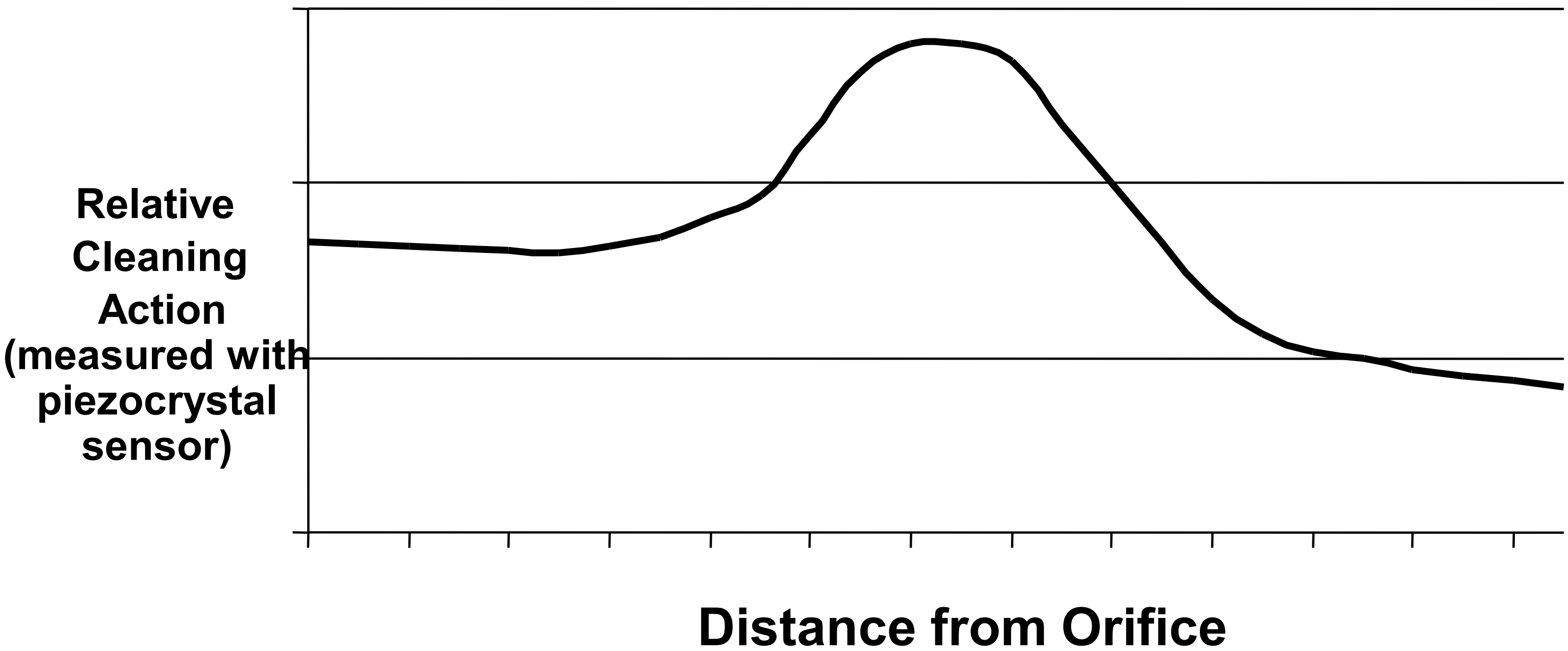
.040 Jet	.040 60^0 fan MD	.040 60^0 fan CD
.36 gpm	.46 gpm	.46 gpm
14 watts	19 watts	19 watts
11,000 watts/in^2	78 watts/in^2	78 watts/in^2
		467 watts/in^2 *effective*

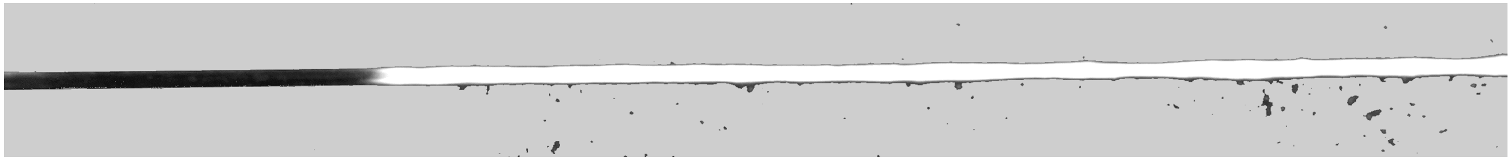
Felt HPN Jet Quality

- Jet Quality, significant impact on cleaning performance



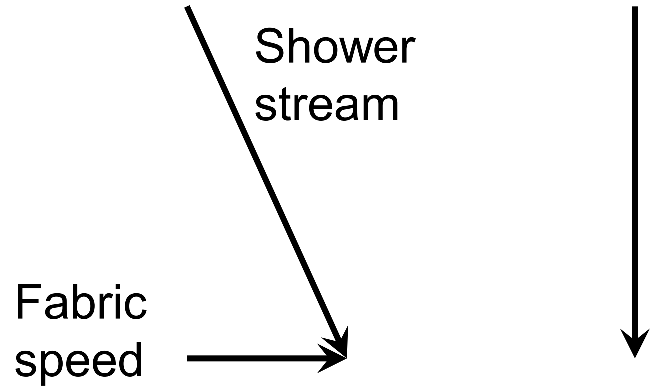
How Far From the Fabric?





Best Jet Angle

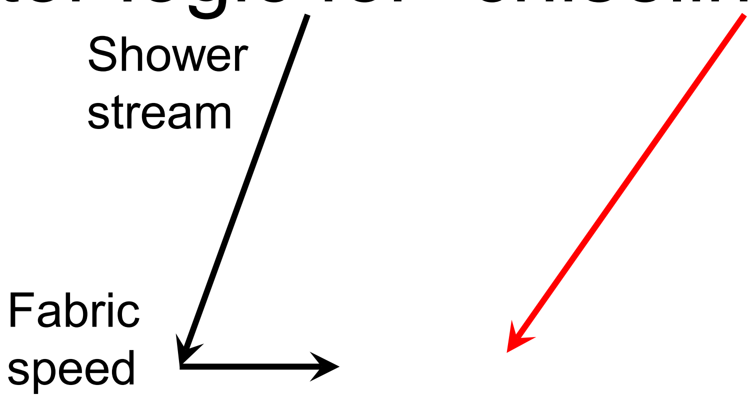
- Vector logic for “chasing” wire for **INSIDE**



Resultant vector (*from contaminant frame of reference*) into fabric depending on speed match

“through cleaning”

- Vector logic for “chiseling” wire for **OUTSIDE**



Resultant vectors apply energy to surface contaminants, and use some energy to get contaminants OFF fabric

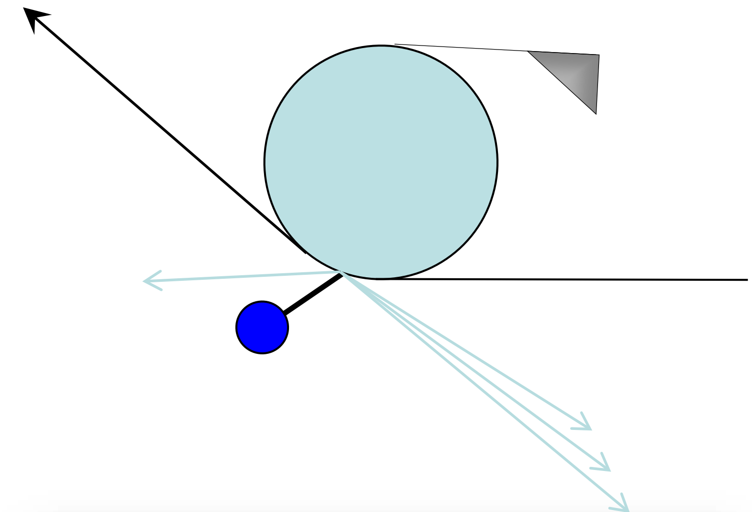
“surface cleaning”

Application to Fabric Conditioning

- For sheet side cleaning
  - Use region of peak dynamic power
  - Peak power occurs anywhere from ***6 to 10 inches***
  - Oscillation for even effect
- For inside cleaning
  - Use region of *optimum penetration*
  - Laminar flow penetrates better than 2 phase flow
  - Shower should be ***close to fabric (3-4 in.)***
- ***Replace nozzles regularly to maintain good patterns***

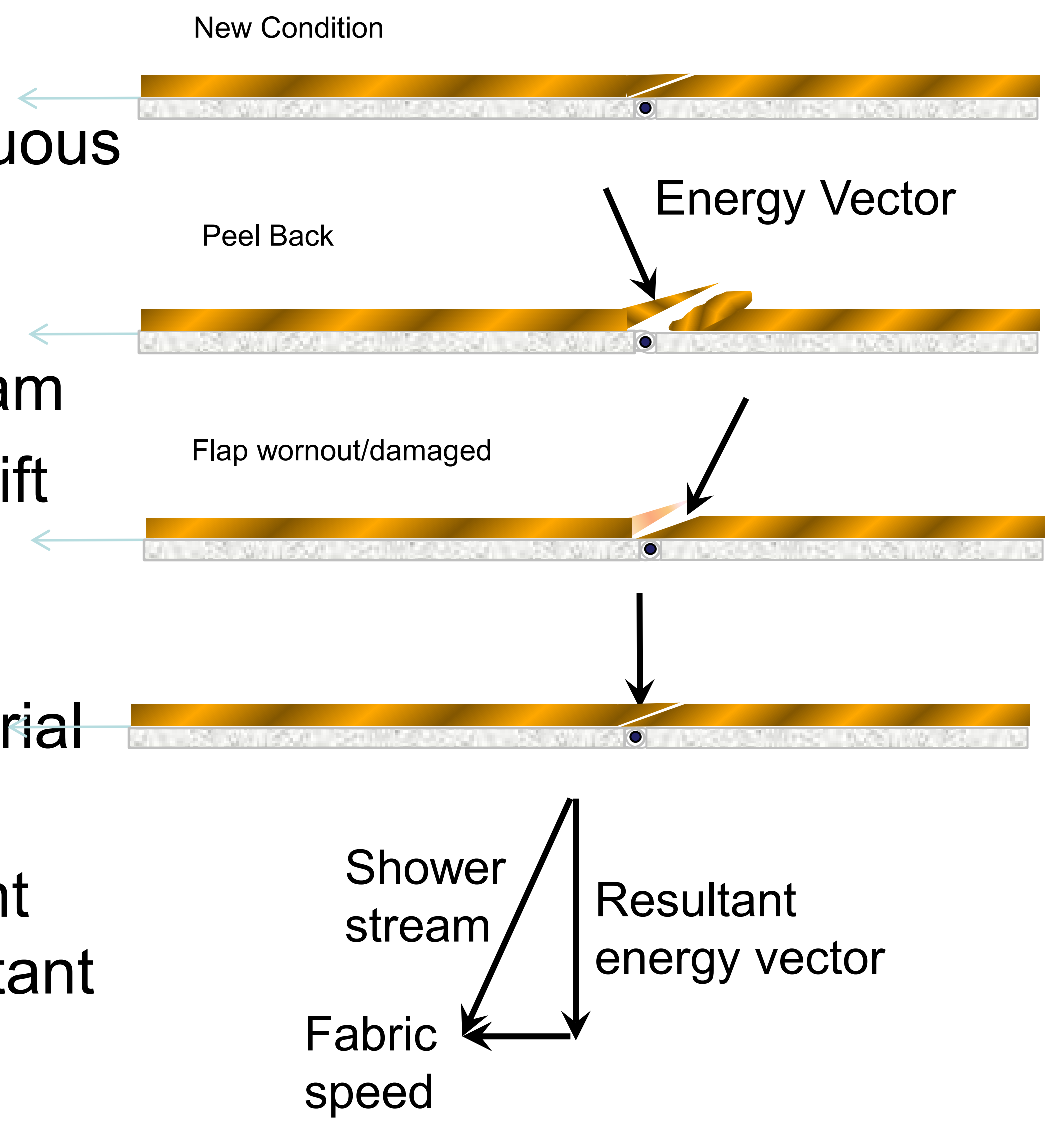
On Roll or In Space?

- Energy transfer
  - If wire cannot recoil on impact energy transfer is optimized → target shower on roll
- Mist control
  - If roll is behind wire, there is no through flow → no inside fabric run mess → target shower on roll
- Chisel or following angle?
  - Chisel is optimum for contaminant impact
  - Mist control is probably more important → point shower in direction for best mist control



What About Felt Seams?

- Clean vs. destroy
- Seam needs to be continuous with felt
- "Chiseling" angle tends to push seam batt out of seam
- Following angle tends to lift seam flap
- Ideal: resultant angle perpendicular, keep material in seam
- Best angle for seam: slight following angle with resultant perpendicular to felt

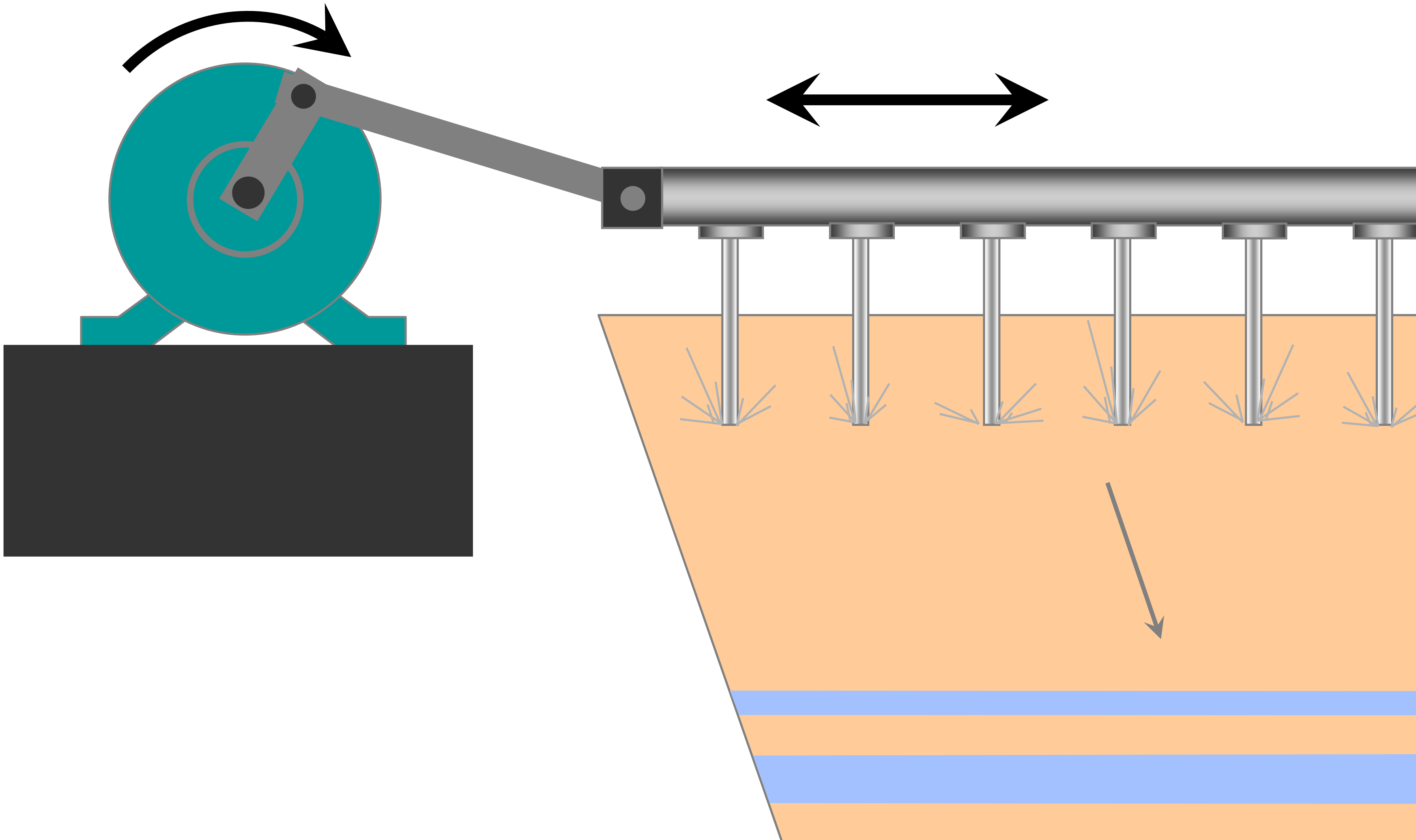


Oscillation of High Pressure Showers

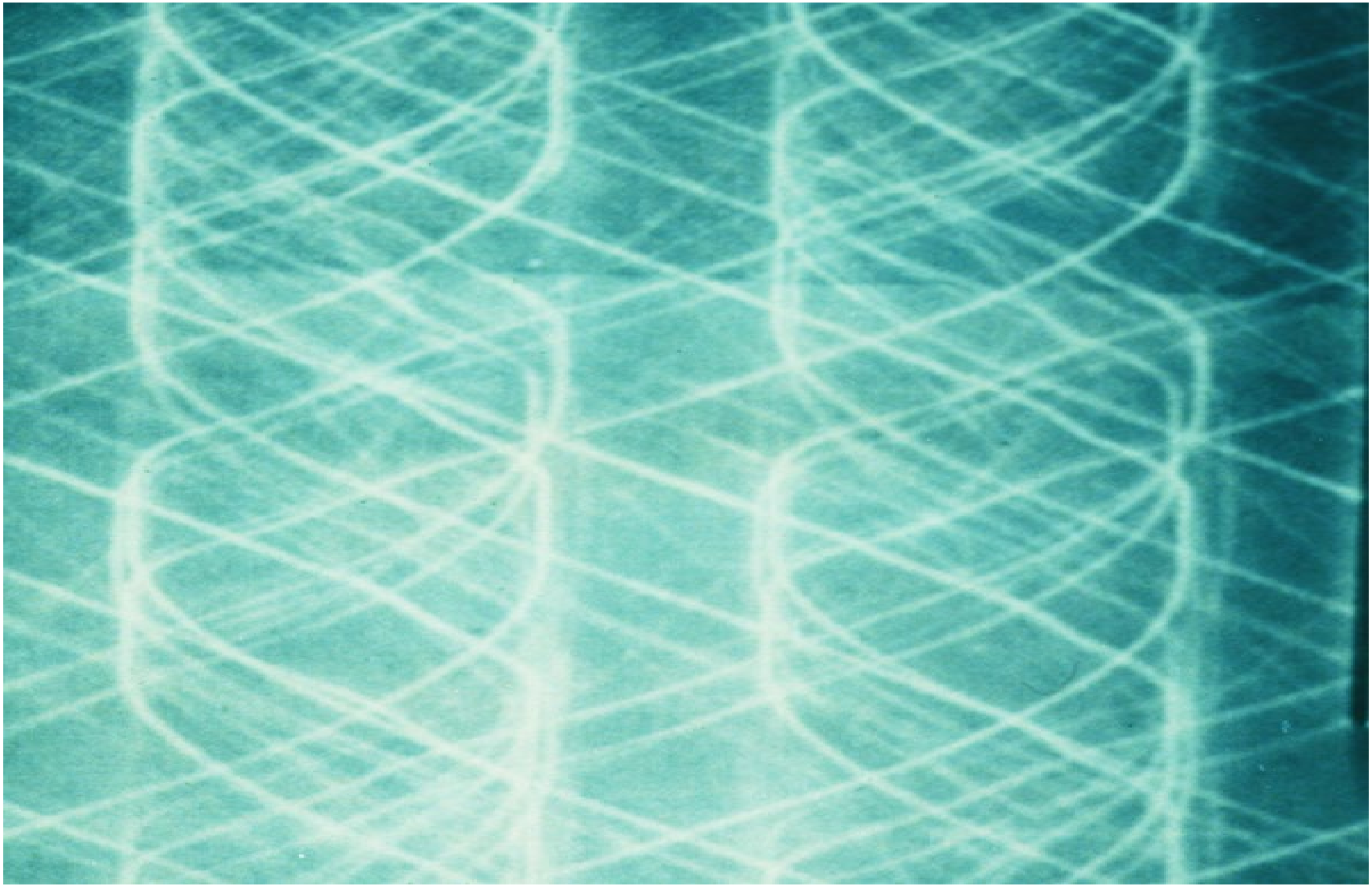
It’s not just a good idea,

It’s the law!

Crank Arm Oscillators

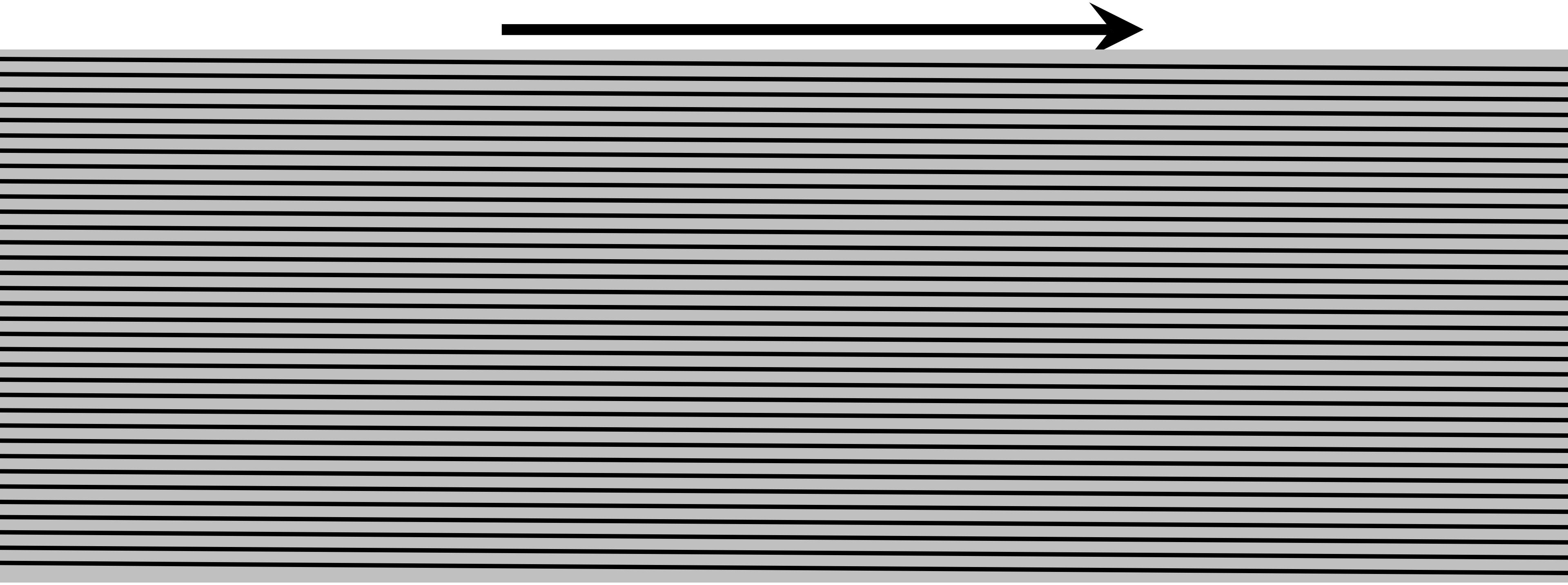


Importance of Proper Oscillation



Low Speed Oscillation

- Coordinate oscillator speed with fabric speed
- Perfect, even coverage



Even, Uniform Coverage

Oscillator Speed Calculations

$$\text{Traversing Speed} = \frac{\text{M/C speed x Noz. Dia.}}{\text{Fabric Length}}$$

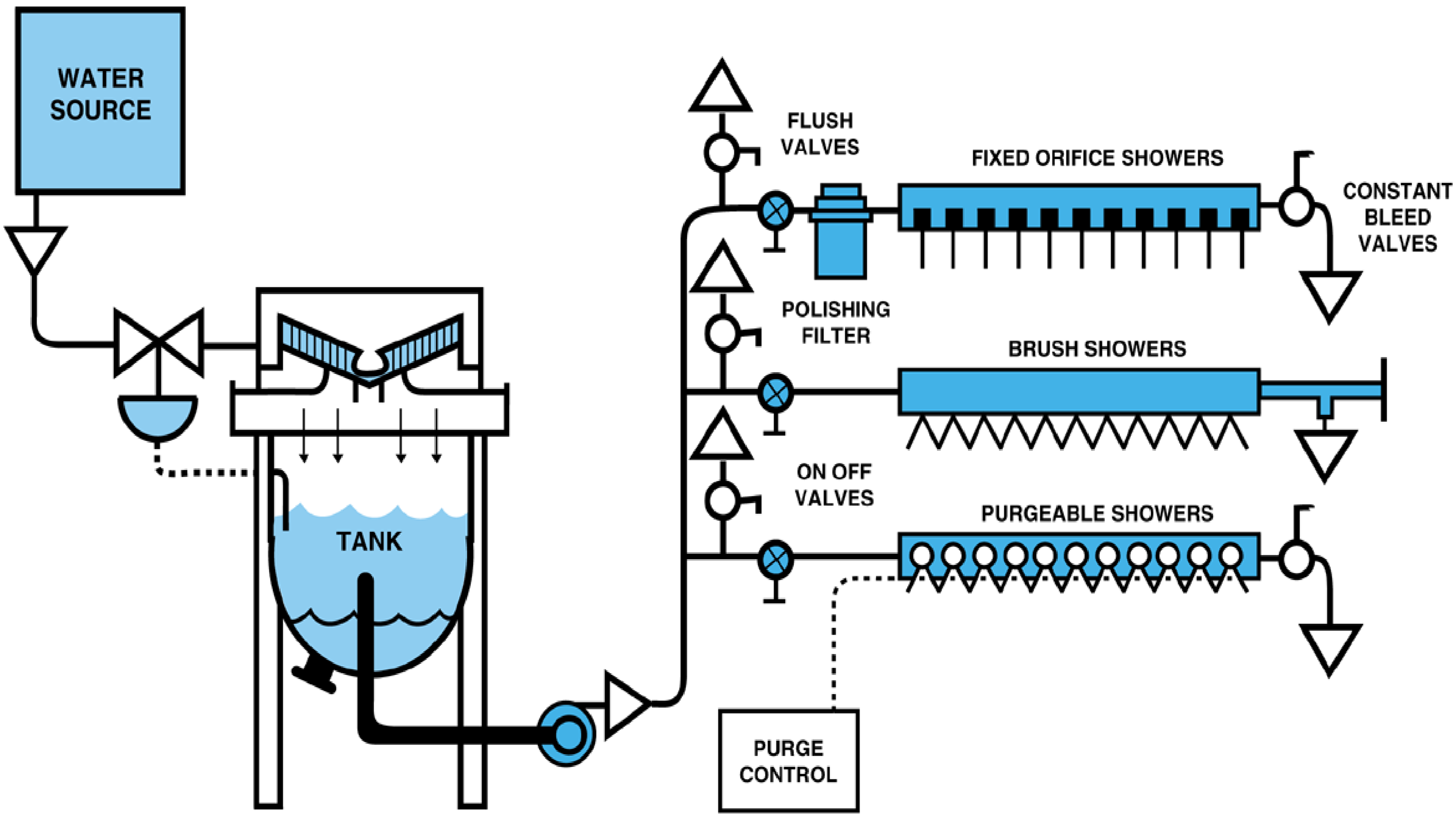
A Note on Scanning Jet Showers

- Continuous cleaning: STEADY STATE
- Treat Streaks
  - direct cleaning to area of greatest concern
  - maintain better profiles
- Reliability
  - Shower beam
  - High pressure supply system
  - *Maintenance program*

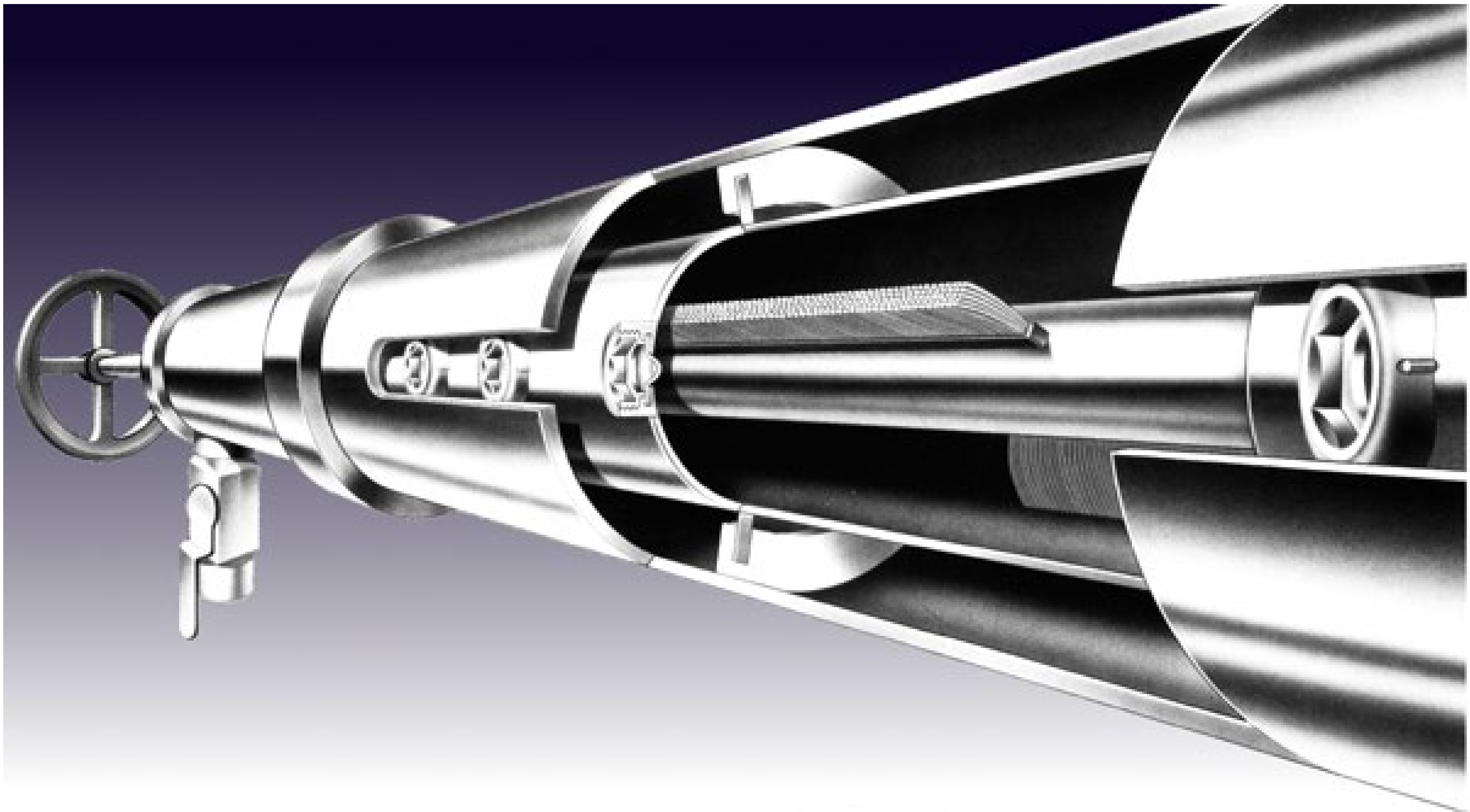
Other Profile Considerations

The Battle Against Nozzle Plugging

Filtration vs. Nozzle Plugging



Brush Showers



Filter media specification

- Nozzle orifice size defines the barrier dimension

Particle Retention Microns	Particle Retention Inches	Approximate Mesh Equivalent
2	0.0001	
5	0.0002	
10	0.0004	
15	0.0006	
20	0.0008	
25	0.0010	
32	0.0013	700
36	0.0014	400
44	0.0017	325
50	0.0020	
60	0.0024	250
75	0.0030	200
100	0.0039	150
104	0.0041	
140	0.0055	
150	0.0059	100
180	0.0071	80
250	0.0098	60
355	0.0140	45
425	0.0167	40
500	0.0197	35
600	0.0236	30
787	0.0310	
841	0.0331	20
1600	0.0630	12
4750	0.1870	4

Solids Loading ppm	Application
0-50	Equivalent to filtered fresh water
50-75	Usable in .040” (1mm) min fixed orifice
75-100	Usable in .055” (1.4mm) min fixed orifice
100-200	Usable in .125” (3.2mm) min fixed orifice
200-500	Brush type shower recommended
500+	Purgable showers recommended

- Loading defines the frequency of service
  - The filter’s total open area determines the ΔP

Felt Dewatering

- Uhle boxes
  - Remove water from the felt
  - Help keep felts clean
- Vacuum is applied to felts via stationary boxes to remove water from them
  - Called uhle boxes or suction boxes
  - Vacuum levels are conventionally up to 15 inHg, but can be as high as 20+ inHg (highly loaded presses, heavy felts)
  - New, more permeable felts have lower vacuums
- Conventionally, presses express water from the sheet to the felt, and water is then removed from the felt at the uhle box
  - Many modern machines depend on press **nip dewatering**; water is removed from the felt at the press making uhle dewatering less critical

Traditional Uhle Sizing

- Calculate dwell time for machine conditions, target moisture content.
  - First press: .8 - .7 lb H_2O/lb felt
  - Second press: .7 - .62 lb H_2O/lb felt
  - Third press: .6 - .54 lb H_2O/lb felt

  F2 = 1.23 • F1^(.819) • Q^(-.024) • dP^(-.124) • D^(-.096)

  NOTE: this equation was determined empirically and felts have changed radically. It can be used only for rough estimates of dewatering

- Calculate airflows with Decrosta equation. (still gives a reasonable estimate of airflow)

Decrosta Airflow Equation

$$\mathbf{V} = \frac{.069 \times \Delta P^{.476} \times t_d^{.11} \times \text{perm}^{.916}}{m_{p1}^{.628}}$$

$$\mathbf{V} = \frac{\Delta P \quad t_d \quad \textbf{perm}}{m_{p1}}$$

$$\left\{ \textbf{Just like} \;\; q = c_1 c_2 \sqrt{P} \right\}$$

Dwell Time

dwell time (seconds)

$$= \frac{5 \times \textit{no. of slots} \times \textit{slot width}\ \text{(inches)}}{\textit{speed}\ \text{(fpm)}}$$

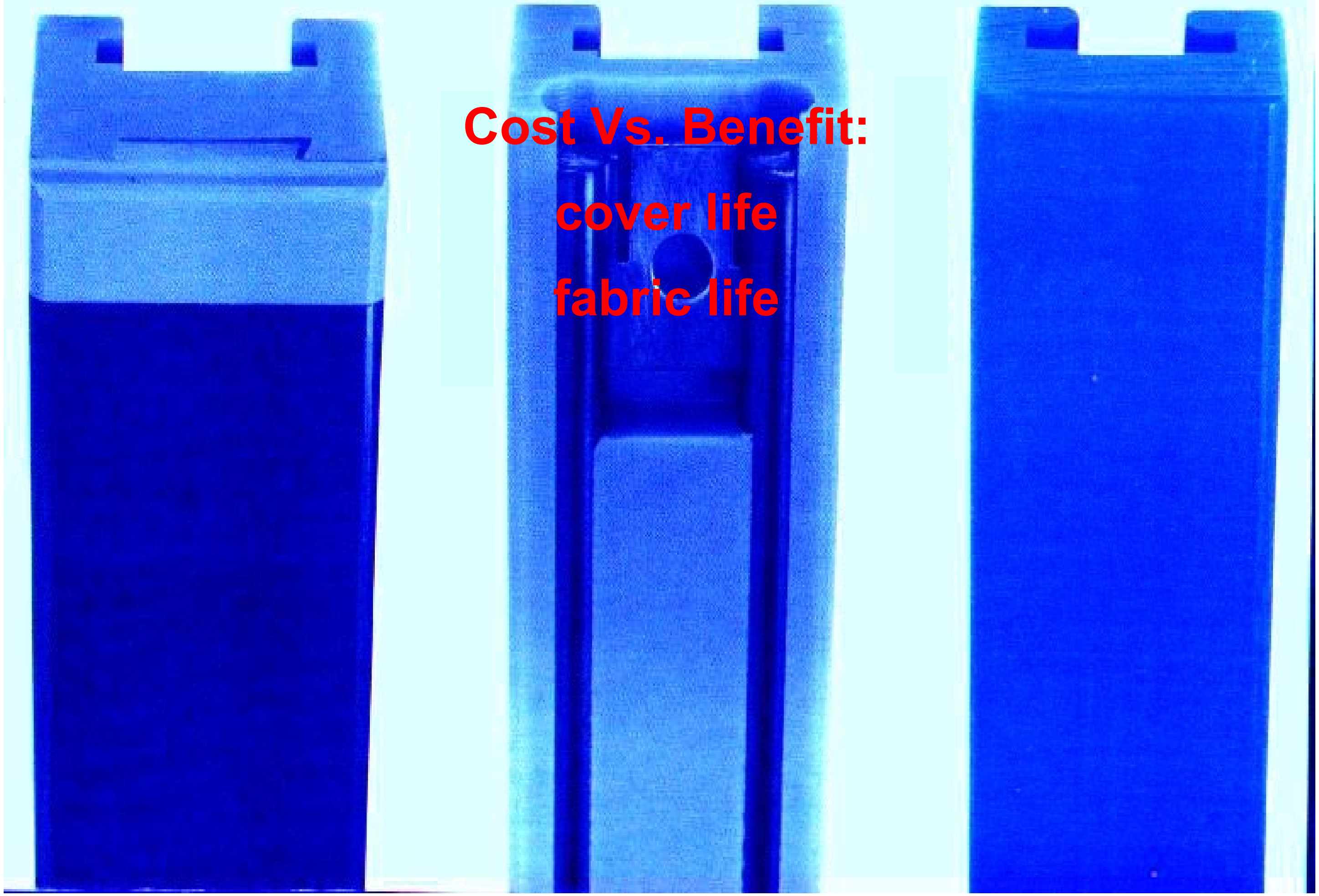
Pipe Sizing

- Air Velocity limit: pressure drop across pipe is less than 2 in.- H_2O
  - <3000 fpm before separator
  - <5000 fpm after separator
  - <500 fpm in separator
- Structure: maximum stress below 16,000 psi

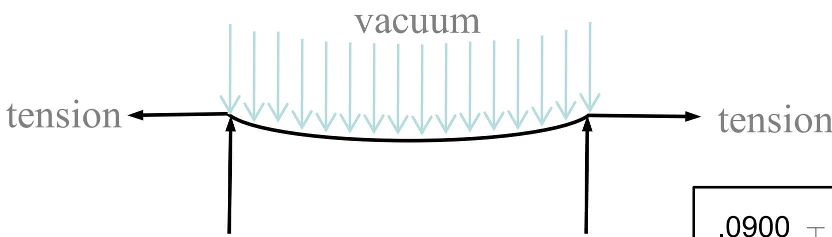
Slot Width

- Dwell time is the ONLY effect of slot width:
  - 1 x 1” = 2 x 1/2” *FOR DEWATERING*
- More narrow slots are better than fewer wide slots: felt wear
- Fewer wider slots are less likely to plug
- “Break to atmosphere” between slots doesn’t matter.

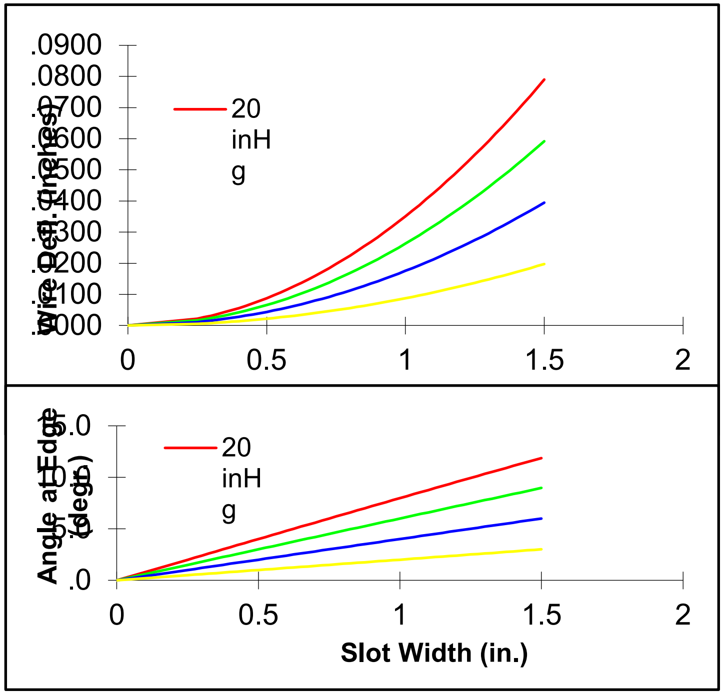
Wear Surface Materials



Slot Width, Fabric Penetration



Catenary Deflection



- Wide Slots
  - Provide high dwell time
  - Create high fabric wear
  - Create high seam stresses
- ¾ vs 1.5 inch slot width, 15 in-Hg
  - Fabric deflection: .035 vs .138 in.
  - Edge angle: 10^0 vs 20^0
  - At least twice the damage
- Multiple narrower slots are better
  - Less fabric wear
  - Less seam wear
- Slots that are too narrow can plug
  - About 3/8 inch width is a good practical lower limit

Seamed Fabrics

Herringbone Design

Zig Zag Design

Trapezoid Design

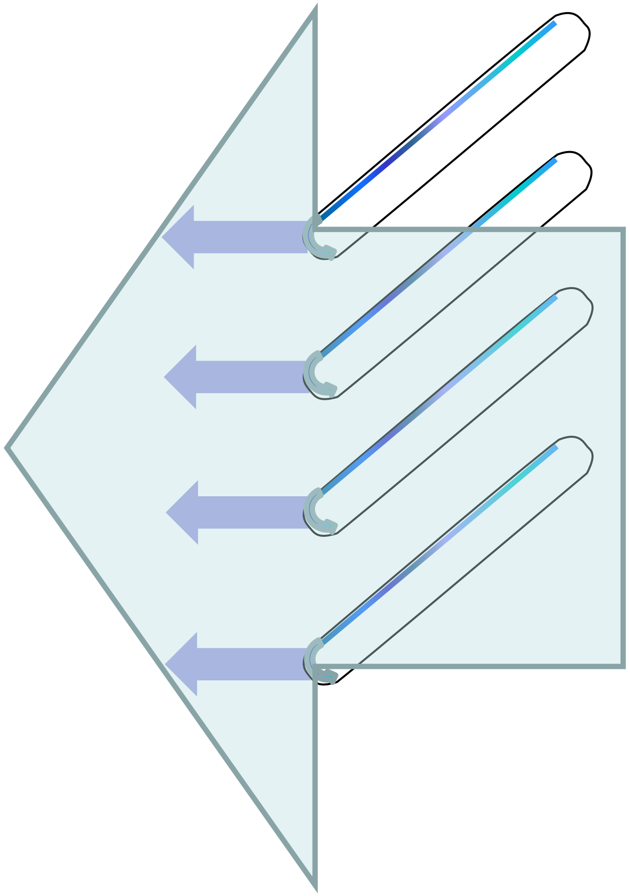
- Dwell time determines dewatering
- Make sure dwell time is even across width of fabric

Streaks from Herringbone Covers

- Worn covers are “re-injecting” water back into felt at the trailing edge of each slot

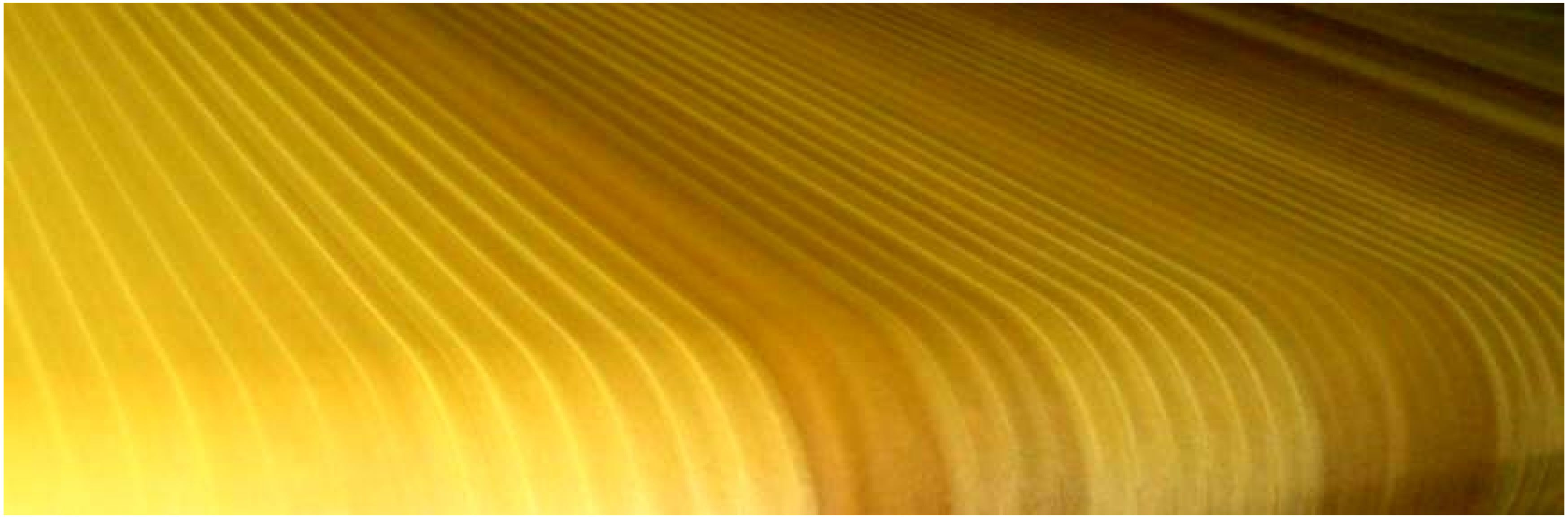
Herringbone Covers (continued)

- Worn covers
  - water is re-injected into the felt where the inside trailing edge has been worn away



Reading streaks

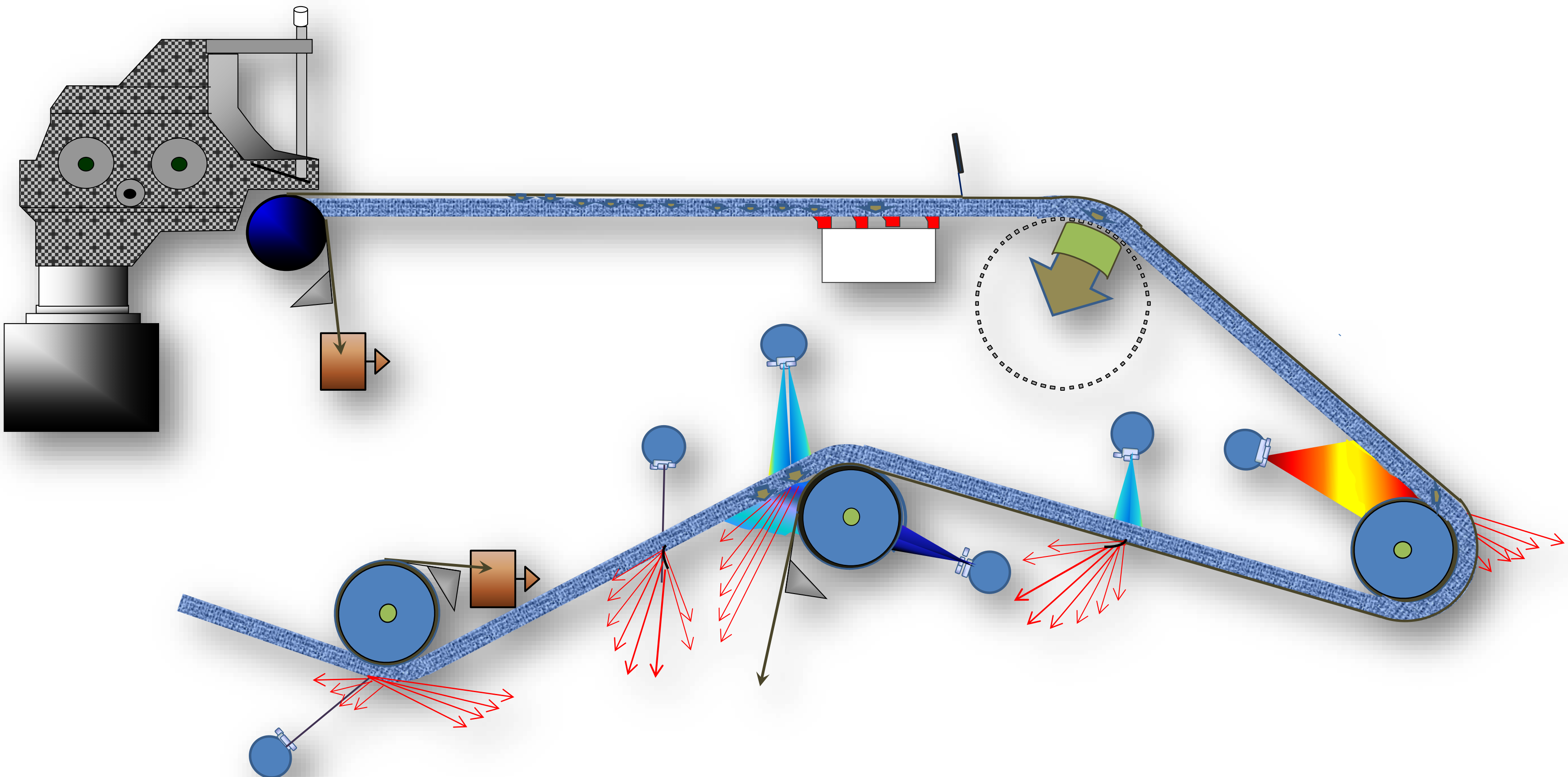
- Press fabric streaks (a mixed bag)
  - Narrow streaks every 2” – 3”……Herringbone cover geometry or worn
  - Narrow streaks every 6”…...……OPN oscillator reversal dwell
  - Dark 6” bands……………………Single plugged or poor nozzle
  - Very Dark 6” band………………..Adjacent nozzles plugged or poor
  - Bands after chemical wash……..Shower with plugged nozzles
  - Uneven batch shows up as diminished even color change across felt



Example of felt streaks (with typical 6” nozzle spacing & 12” oscillator)

Strategy
for
Ideal Cleaning
Applications

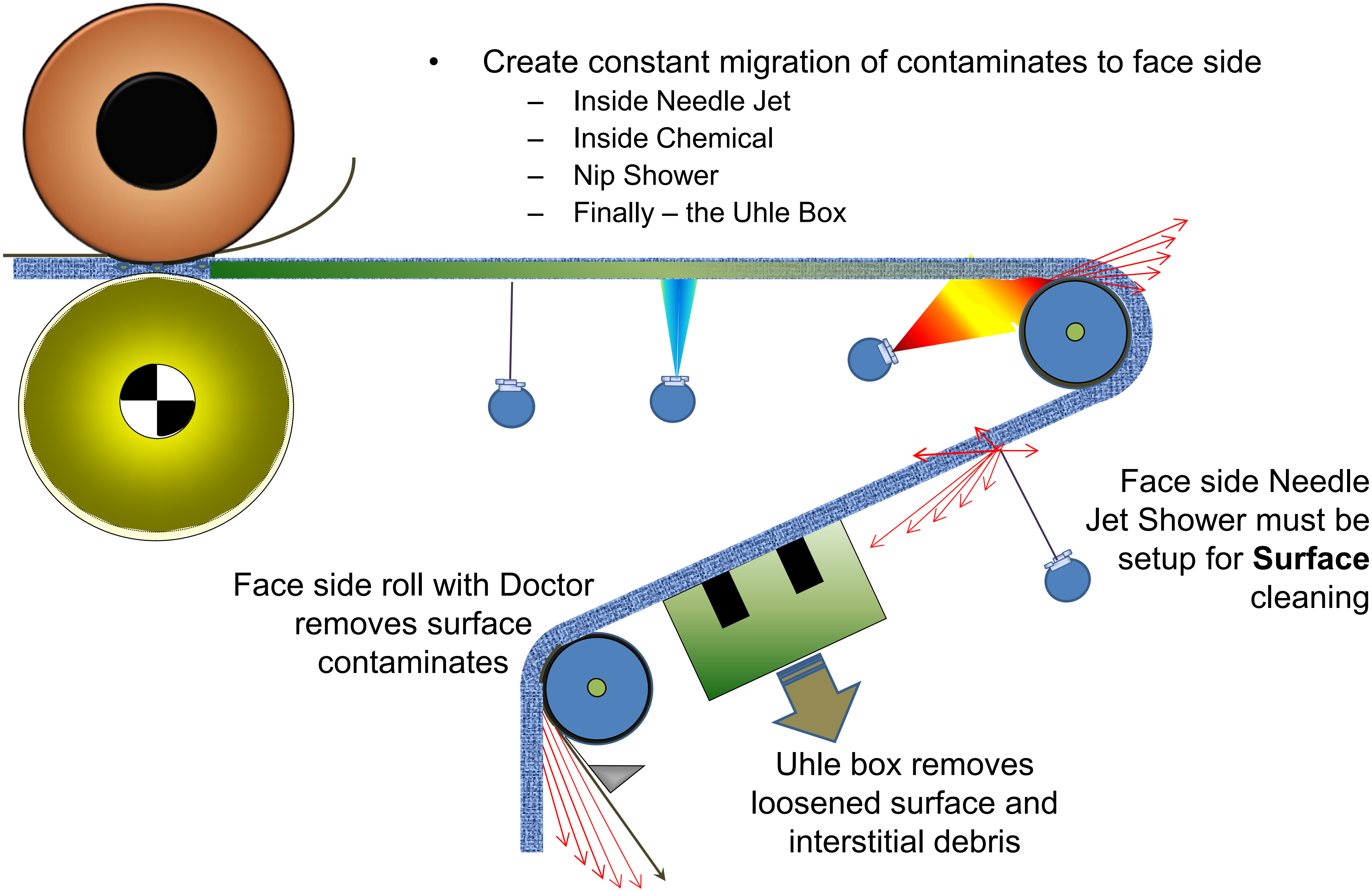
Wire Cleaning Strategy



Create constant fluid motion to the sheet side then, utilizing outside rolls with doctors and showers to flush wire. Inside rolls & catch pans for stapled fibers

Felt Cleaning Applications

- Create constant migration of contaminates to face side
  - Inside Needle Jet
  - Inside Chemical
  - Nip Shower
  - Finally – the Uhle Box



Some Relevant TAPPI TIPs

- 0404-27, Press Fabric Dewatering and Conditioning – Suction Box (Uhle Box) Design and Vacuum Requirements
- 0404-51, Paper Machine Clothing Cleaning and Conditioning for Recycled Fiber Use
- 0404-52, Press Section Optimization
- 0404-57, Troubleshooting Cross-Machine Direction Moisture Profile Problems
- 0404-61, Paper Machine Shower Recommendations
- 0404-67, Paper Machine Doctor Recommendations
- 0502-22, Paper Machine Water Efficiency

Summary

- Fan Showers – Even Distribution
  - Overlap nozzles, consider oscillating critical showers
  - Double or triple coverage nozzle spacing is best
  - Flooded Nip
    - Running Void Volume for knock off
    - Some volume less than RVV for some cleaning
    - For felts: RVV – other shower volume
- Needle Jets – Power Application
  - Use 6 inch stand-off on sheet side, 4 inches or less on inside
  - Use pressure as low as possible (400 psi max forming, 250 psi max felts)
  - Oscillate evenly @ twice nozzle spacing, 1 noz. diameter/fabric revolution
  - "Chisel" angle, 15^0 into fabric on sheet side showers
  - Perpendicular or 15^0 chasing angle for inside showers
- Change nozzles to maintain good patterns (rule of thumb, once/year)
- Basic fabric cleaning strategy: move contaminants out of fabric (flush), and then off (needle jets, wash rolls) in direction from which they came
- Uhle Boxes – Dewater and clean felts
  - Between 2 – 4 ms dwell
  - 15 inHg (or a little more) for broken-in felts

Thank you

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