TAPPICON
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RACING TOWARDS A SMART FUTURE

Troubleshooting Paper Machine Water Systems with a Portable Flowmeter

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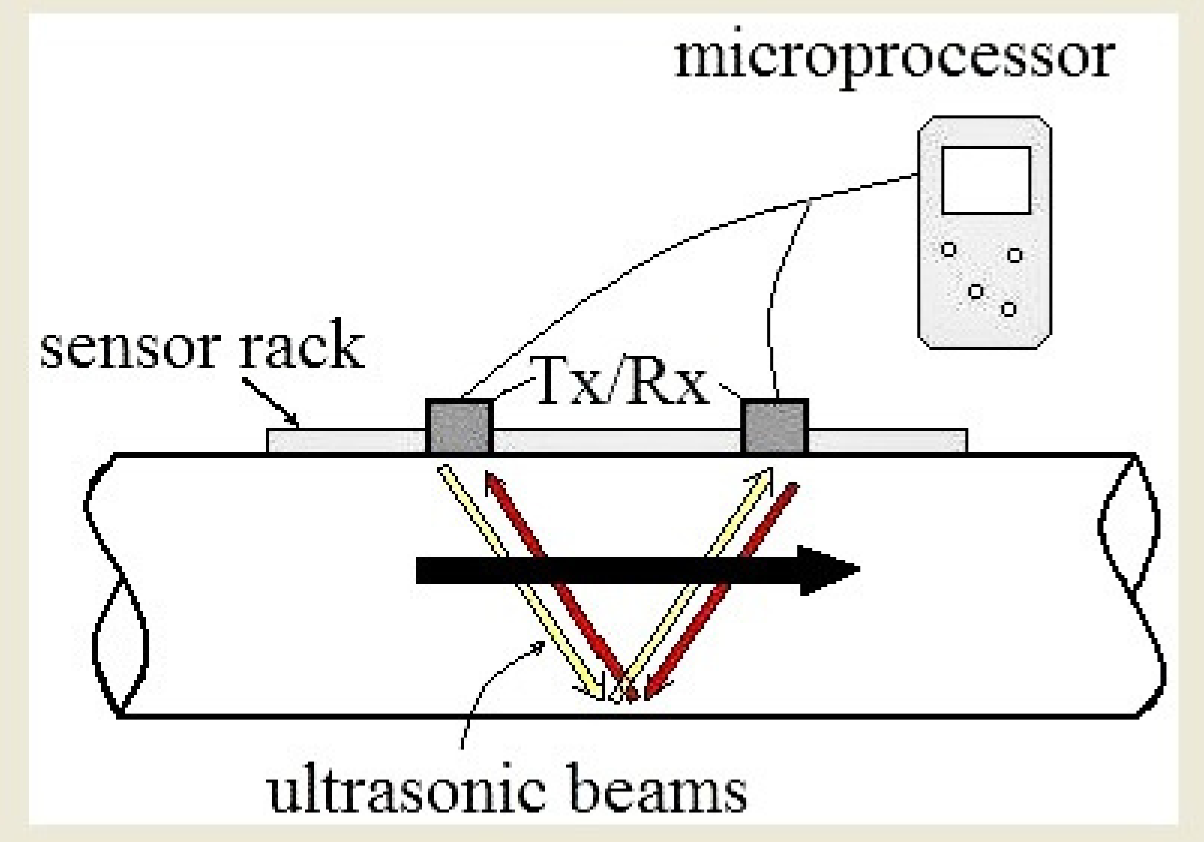
"If you don't measure it, you can't manage it."

In a mill setting, it is not practical to have permanent flow meters on everything. Some facilities have more complete instrumentation than others, but it is not reasonable to instrument everything.

- Utilize portable, ultrasonic flow measurement
- Transit time
- Doppler

Ultrasonic Transit Time Flow Meter

Ultrasonic Transit Time Flow Meter Configuration



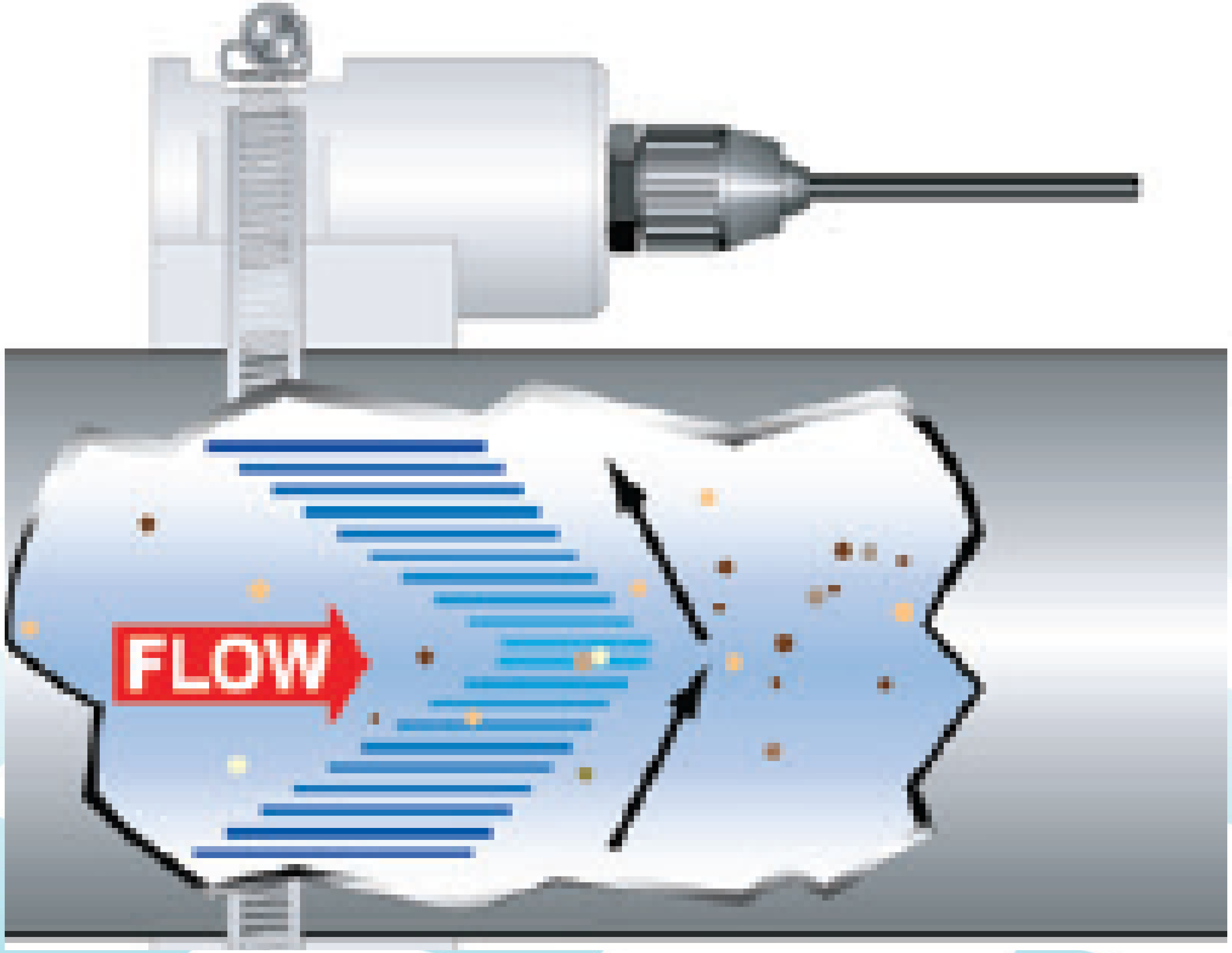
- Measures time it [illegible] upstream and downstream
- Calculates flow based on difference

Ultrasonic Transit Time Flow Meter

- Works well on water and other fluids
- Works on steel, stainless steel, copper, plastic, but not galvanized pipe
- Maximum temperature 375 degrees F. (GE Panametrics PT-878)
- Sound speed of pipe material and fluid must be known (or determined)
- May need to experimentally determine sound speed for unknown fluids
- Pipe must be full
- Recommended setup parameters are not unlike most flow meters (10 pipe diameters of straight pipe upstream and 5 downstream)
- Vibration may cause unstable operation
- Vapor bubbles may interfere with operation
- Does not work with high levels of suspended solids (typically > 1%)

Ultrasonic Doppler Flow Meter

Measures speed of particles or bubbles in fluid



Ultrasonic Doppler Flow Meter

- Does not require material sound speed information
- Requires particles or bubbles in fluid for operation
- Does not work with clear fluid
- May give erroneous readings if pipe is not full
- Velocity in pipe must be high enough that particles do not settle

Flow Measurement Surprises

- Paper machine dryer drainage condensers
- Paper machine warm water tank balance
- Paper machine showers (worn shower nozzles can double water consumption)
- Vacuum pump seal water management
- Rotating equipment seal or packing water (seals controlled with ball valve average 2.7 gpm)
- Fill valves (manual or controlled) on whitewater tanks, pulpers, etc. that appear to be shut
- Flows to heat exchangers (need to be in recommended range for good performance)
- Evaporator surface condensers

Dryer Drainage Condenser Troubleshooting

Condenser cooling water control valve is wide open, but not achieving desired vacuum.

How is vacuum created?

At a vacuum of 15” Hg, steam takes up ~3,200 times the volume of an equivalent mass of water. Collapsing steam to water creates a void, which in turn establishes vacuum. **Turning steam into water is the job of the condenser.**

Air is present in steam. In order to maintain vacuum, it must be removed from the condenser. **Removing air is the job of the vacuum pump** (or other air removal system).

Dryer Drainage Condenser Troubleshooting

Dryer Drainage Condenser Troubleshooting

The first step is to determine whether the condenser or air removal is limiting vacuum

- Measure temperature at condensate pump.
- Check condensate receiver vacuum
- Consult steam tables to determine if condensate is at saturation temperature

Inches Hg vacuum	Pressure PSIA	Pressure PSIG	Temperature ºF		Inches Hg vacuum	Pressure PSIA	Pressure PSIG	Temperature ºF
28	0.9	-13.8	99.7		12	8.8	-5.9	187.2
26	1.9	-12.8	124.6		10	9.8	-4.9	192.1
24	2.9	-11.8	140.3		8	10.8	-3.9	196.7
22	3.9	-10.8	151.7		6	11.8	-2.9	200.9
20	4.9	-9.8	161		4	12.7	-2	204.8
18	5.9	-8.8	168.9		2	13.7	-1	208.5
16	6.8	-7.9	175.8		0	14.7	0	212
14	7.8	-6.9	181.8					

Dryer Drainage Condenser Troubleshooting

If condensate is subcooled, vacuum is being limited by air removal system

- Vacuum pump may not have adequate seal water flow
- Vacuum pump may be in poor condition
- There may be excessive air leaking into system
- Air removal system may not be capable of providing desired vacuum (specific air volume gets larger with greater vacuum)

Dryer Drainage Condenser Troubleshooting

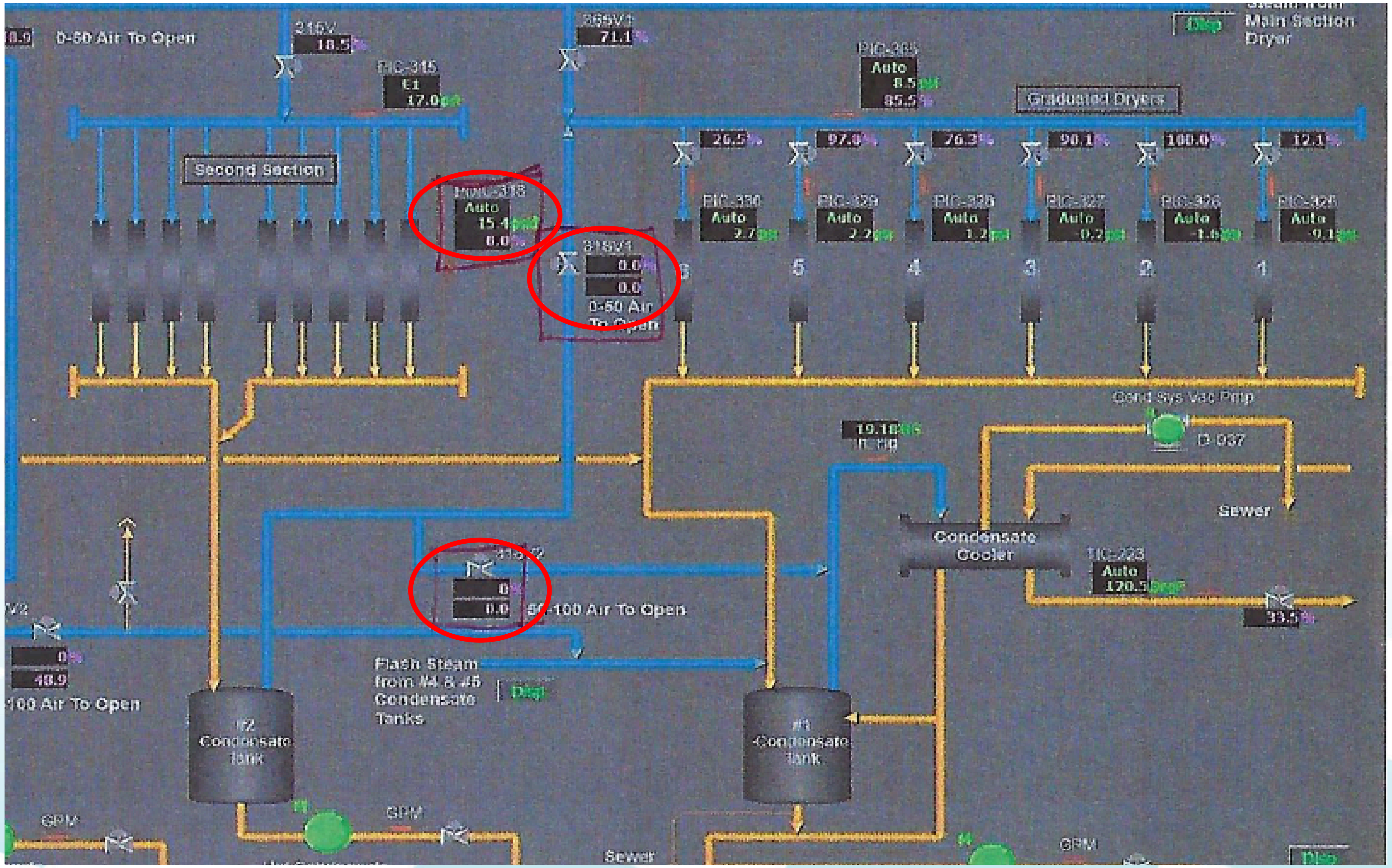
If condensate is at saturation temperature, vacuum is being limited by the action of condenser

- Condenser fouled
- Water flow inadequate
- The amount of steam reaching condenser may be greater than design flow (overloaded condenser)

Dryer Drainage Condenser Overloaded

- Weak or inappropriately designed thermocompressor
- Incorrect or damaged syphons
- Excessive dryer differential pressure
- Improper cascade pressures
- Vent valve(s) open or leaking through when shut

3rd Section Differential Pressure Out of Control



Both 3rd section differential pressure control valves are shut, but differential is much greater than set point – vent valve leaking

Hot Water Tank Out of Balance

/e is leaking through 152 gpm, while recirculating pump is sending 370 gpm b

Hot Water Tank Out of Balance

Pumps Operating in Parallel

Two (or more) pumps operating in parallel.
Are they all doing their fair share?

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Pumps Operating in Parallel

Plant operating (2) centrifugal pumps in parallel to provide raw water. Both pumps were designed for the same duty (10,000 gpm @ 92' head). One pump was an older, non-current model and the other was almost new.

- Portable flow measurements indicated the new pump was providing 5,200 gpm @ 112'head (correlated well with published curve)
- The old pump was not pumping at all!
- The old pump was using more electricity than the new one (265 vs. 255 hp)
- Casing on the old pump was 50 degrees warmer than raw water
- Pumps had been operating in this mode for several months
- Recommended replacing pump with a more appropriate design. Existing pumps 30 to 50% efficient, recommended unit >80%.

Pumps Operating in Parallel

- Operating below minimum flow can be harmful to pump (although the previous example did not seem to mind)
- Operating a pump below minimum flow can cause shaft breakage due to cavitation at the cutwater
- Multi-stage pumps are especially prone to failure due to low flow because heat can’t get away
- Most multi-stage pumps have some type of recirculation device to keep them above minimum flow
- Parallel pumps must be carefully designed for expected conditions
- In some cases, a smaller pump for winter conditions and larger pump for summer may be appropriate
- Installing a variable speed drive can save energy but is not a substitute for appropriately sized pumps

Excessive Seal Water Flow to Liquid Ring Vacuum Pumps

- Measured seal water flow to Nash CL2002 at 90 gpm (specification for applications up to 20" Hg is 20 gpm)
- Power usage with 90 gpm seal water flow was 104 hp.
- Slowly reduced seal water flow while also measuring power usage.
- Power usage continued to drop along with seal water flow.
- Ended up with 21.6 gpm seal water flow with power usage of 97 hp (reduction of ~7%)

Liquid Ring Vacuum Pump Seal Water Heat Recovery

- Flow and temperature measurements taken at several mills reveal the heat equivalent of ~70% of vacuum pump horsepower ends up in seal water.
- For a paper machine using 4,000 hp to drive vacuum pumps, this is over 7 MMBtu/hr (7,000 pph steam).
- In most mills, seal water heat is either sent to the outfall or a cooling tower.
- For mills that heat water or stock, heat from vacuum pump seal water can reduce mill steam usage.
- **There are three primary methods by which vacuum pump heat can be utilized**
    1. By use of heat exchanger for fresh or whitewater heating
    2. Direct usage of whitewater as vacuum pump seal water
    3. Utilize heated fresh water from vacuum pumps for showers, etc.

Heat Exchanger To Recover Heat From Seal Water

- Seal water delta T of 15 to 35 degrees F requires a large heat exchanger with low approach temperature to transfer useful heat.
- Plate and frame heat exchangers are lowest capital cost option but tend to foul quickly.
- Spiral heat exchangers have the highest capital cost but usually operate trouble free from an operations standpoint.
- Cascading seal water (first through high vacuum pumps, then pumps that operate at lower vacuum levels) can decrease total seal water flow and increase delta T which allows for better heat transfer and a smaller heat exchanger.

Direct Use Of Machine Whitewater For Vacuum Pump Seal Water

- No need for a heat exchanger
- All heat is used beneficially
- Whitewater chemistry may not be compatible with vacuum pump metallurgy
- Particulates in whitewater may plug seal water orifice plates or build up in vacuum pumps
- Whitewater at high temperature may reduce vacuum pump performance

Use Warm Vacuum Pump Seal Water For Showers

- Requires robust pre-separators to prevent contamination
- Machines that have an existing sump for vacuum pump seal water are good candidates
- Recommend turbidity monitor and/or separator high level interlocks
- Several mills have direct discharge permits for vacuum pump seal water (require reliable systems to ensure permit compliance)
- Very practical for mills that heat significant amounts of fresh water
- Warm water can also benefit rotating equipment (pumps, agitators, etc.) mechanical seals. Seal water infiltrating whitewater system will end up being heated to process temperature

Use Vacuum Pump Seal Water For Showers

Questions?

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