Vacuum System Efficiency

Andy Smiltneek

Keynote Speaker

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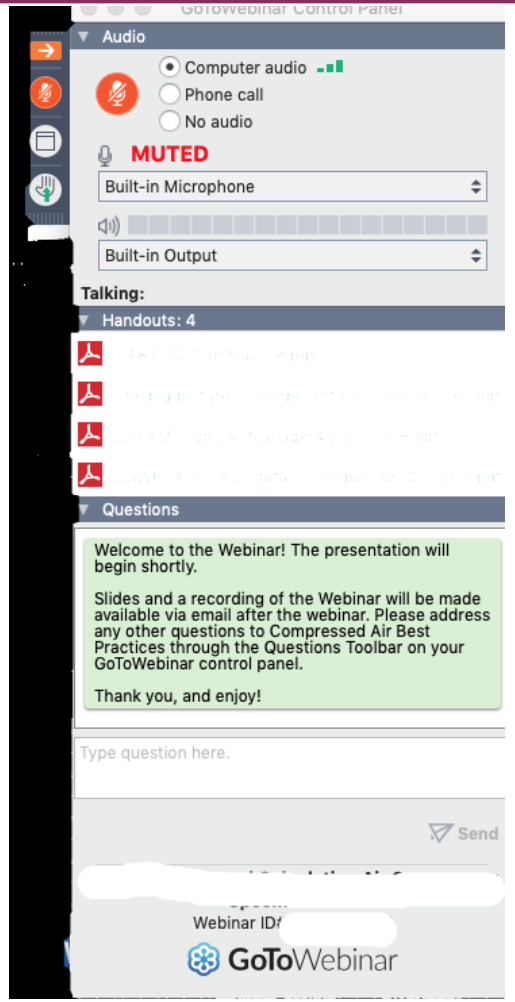
Q&A Format



- Panelists will answer your questions during the Q&A session at the end of the Webinar.

- Please post your questions in the Questions Window in your GoToWebinar interface.

- Direct all questions to Blower & Vacuum Best Practices® Magazine

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Handouts

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Employees are the heart of your organization. Growth Solutions Consultants' Heart Analyzer© charts the process of finding, hiring, developing and losing employees. It is presented on one sheet of paper and particularly well received and understood by technical employees.

Vacuum Pumps and Vacuum Systems Consulting – Troubleshooting and Design
On a paper machine the vacuum system is the second most expensive to install and the second most expensive to run, yet is largely uncontrolled or wastefully controlled and unmanaged. Many systems were designed for the clothing technology and process control technology available decades ago. The clothing technology in particular continues to improve, yet the vacuum system is untouched. Growth Solutions Consultants provides vacuum system surveys, troubleshooting and design change recommendation to optimize the energy consumption of the machine. Capabilities include borescopic examination and orifice plate capacity checking of the pump; system mapping, and process troubleshooting.

Tissue Machine Troubleshooting
We have extensive experience with troubleshooting process problems on tissue machines.

Presentations and Training
Andy Smiltneek has presented at both Papercon and Tissue World conventions with the subjects of Liquid Ring Vacuum Pump Basics, Vacuum System Energy Savings and Press Section Water Balance. He is a co-author of the TAPPI standard for liquid ring vacuum pump testing. GSC has one hour, four hour and two day training sessions available on both management and vacuum systems; and has customized this training for corporate clients and their specific needs.

Industries:
Pulp and Paper; Heavy Industrial; Mining

Customers:
Our customers include Georgia Pacific, SCA (now Essity), Clearwater, Irving Tissue, USG, Greif, Midwest Paper and Domtar.
References are available upon request.

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Disclaimer

All materials presented are educational. Each system is unique and must be evaluated on its own merits.

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Vacuum System Efficiency

Introduction

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About the Speaker

Andy Smiltneek
Growth Solutions Consultants

- President, Growth Solutions Consultants
- Spent 30 Years at Kimberly-Clark
- Prior Director of Tissue Machine Design with Asia Pulp and Paper in China
- Prior Technical Director at Somarakis.

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Vacuum Systems Energy Savings
Lessons from my Grandfather

November 30, 2023

Andy Smiltneek
President
Growth Solutions Consultants LLC

Objective

The objective of this presentation is to provide a method for analyzing a vacuum system to discover energy savings opportunities

Vacuum and Vacuum Pump Definition

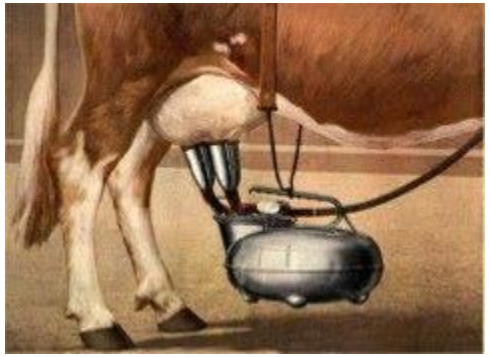
- Any pressure lower than the local atmospheric pressure is called a vacuum.
- A machine capable of evacuating some of the air from an enclosure so the enclosure is at a lower pressure than local atmospheric is called a vacuum pump.
- The vacuum pump takes air at a low pressure and delivers it to a higher pressure.
- By definition, a “vacuum pump” is a compressor.

Usual Energy Wasters

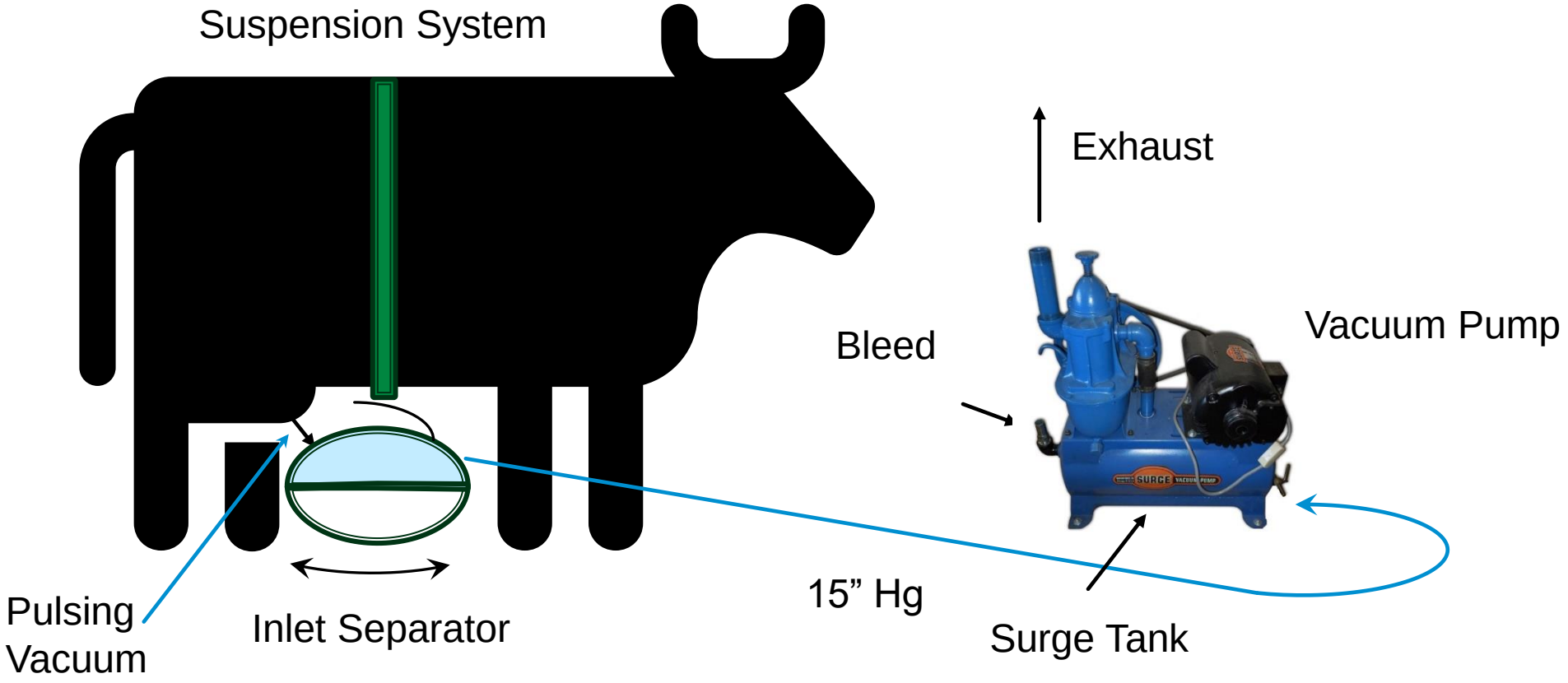
- Wrong type of pump
- Misunderstanding of the process
- Too many or too few vacuum pumps
- Backpressure on the discharge
- Improper inlet separation
- Vacuum Leaks
- Poor System Design
- Worn Pumps
- Running at the wrong speed
- Liquid Ring Pumps:
  - Too much seal water
  - Hot seal water

What I wish I had asked my Grandpa

- My Grandfather – Henry Jasper – was born in 1888 on a dairy farm in Upper Michigan
- The pulsator milker was invented in 1895, prior to that the attempts to automate the milking process were with continuous vacuum, which harmed the cows.
- The Surge Milking machine was invented in 1921, this was the first practical milker and was universally used in the dairy industry - and on the Jasper farm
- I saw the milker, the vacuum pump, the valves, hoses and pipes and really wish I had asked my Grandpa “How does it work, when did you get it, do the cows mind ……?”



The Jasper Milking System in 1961



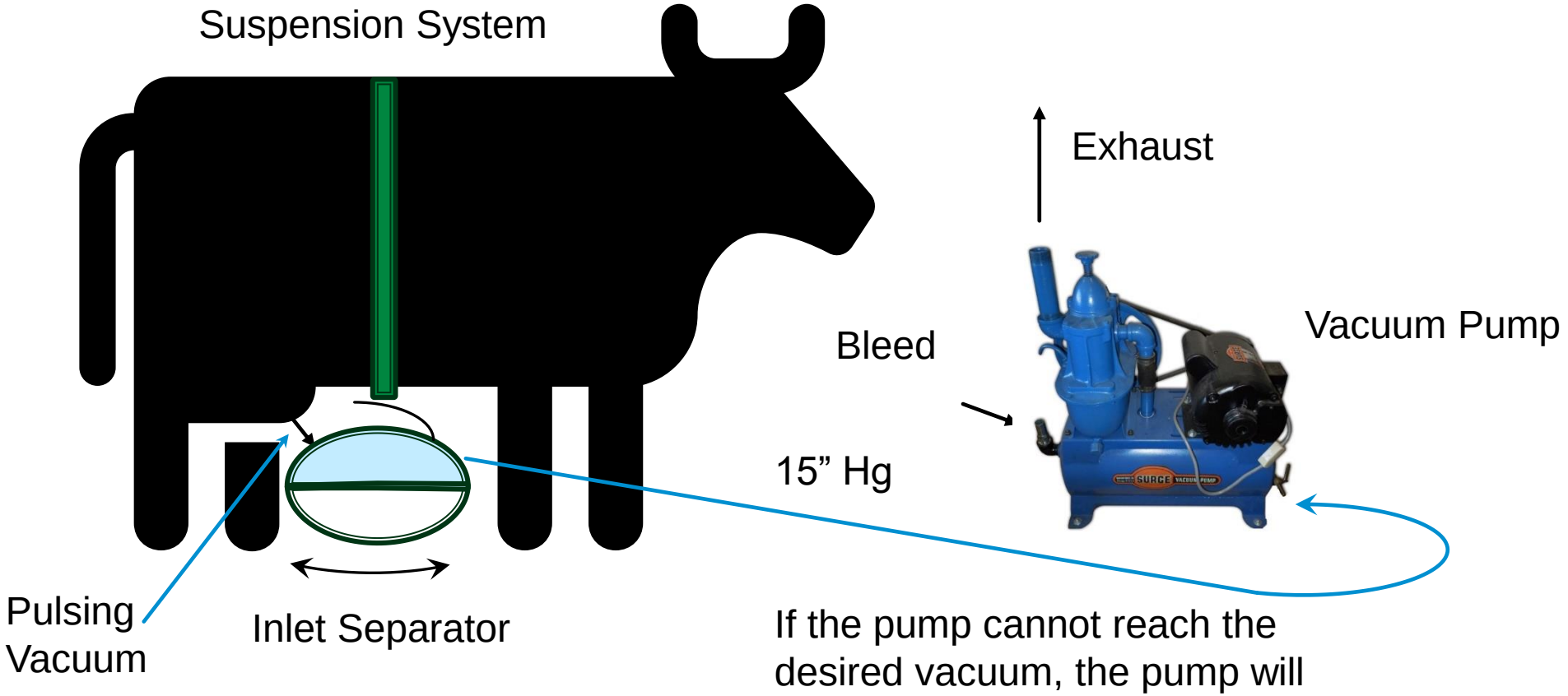
Very little air flow-basically an evacuation problem

- The Surge SP11 was ½ Hp and 5 CFM
- The total volume of the piping and the milker was about 2.5 cubic feet
- The leakage when attaching the cups to the cow was about 2.5 cubic feet
- The total volume needed to reach 15” Hg was 1.32X(2.5+2.5)=6.6 cu^3
- Thus, the time needed for the system to reach 15”Hg was 6.6/5=1.32 minutes
- If the bleed was opened to control the vacuum the time would be longer

Optimization

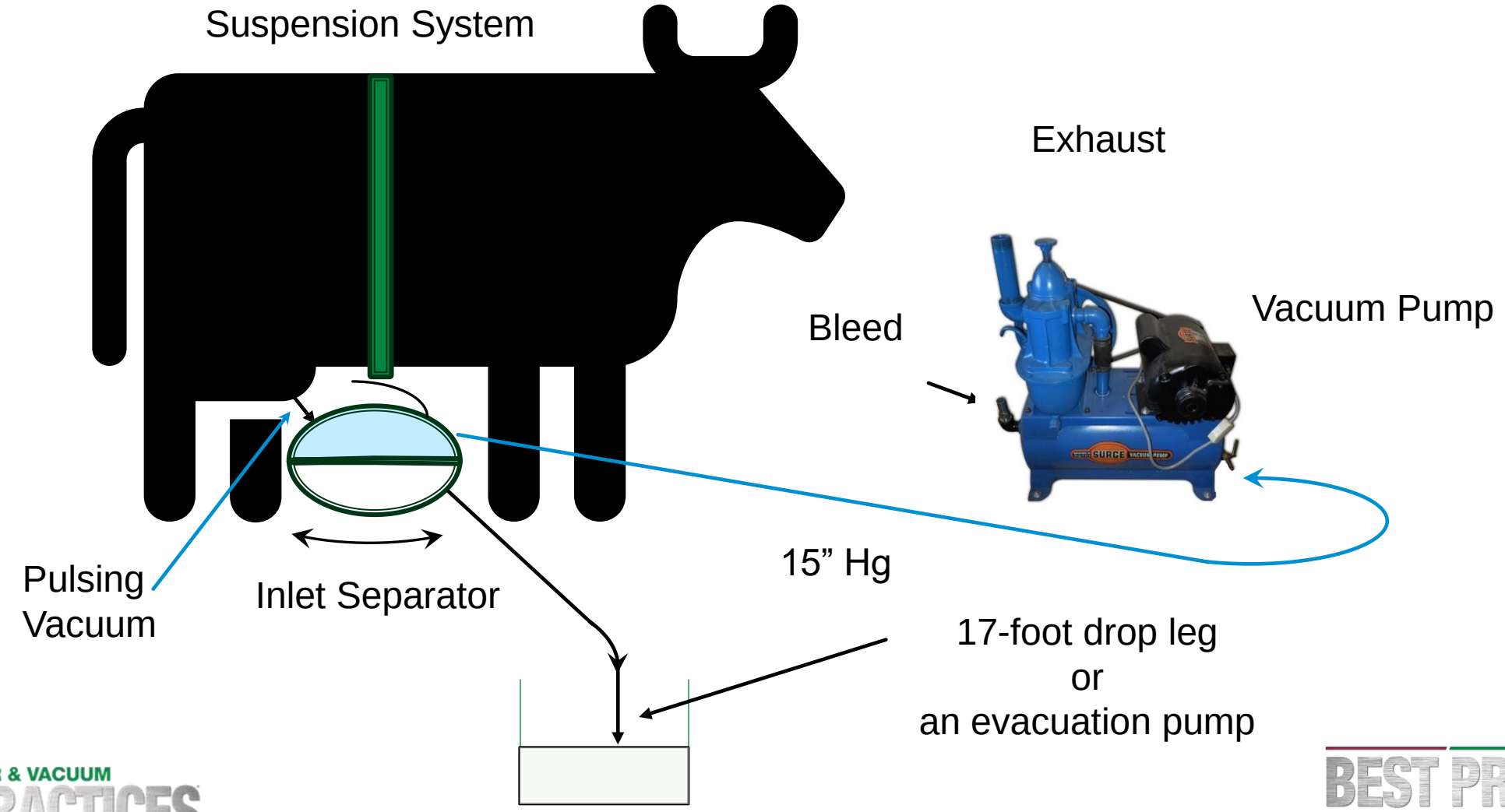
- The time for a cow to milk out varies, but is around 5 to 10 minutes
- Modern milking parlors can do 8.5 minutes per cow
- The farmer has other things to do while to cow is milking, like prepping the next cow, so speeding up the actual milking time may not speed up the process, but too slow will slow it down
- If you have 32 cows and two milking machines you will milk for 2 1/4 hours; milking twice a day is 4 1/2 hours
- You can optimize the process by speeding up the vacuum pump to decrease the time to optimum vacuum, and then slow it to maintain the optimum level
- This optimization will save energy, but not necessarily decrease the milking time

Worn Pump

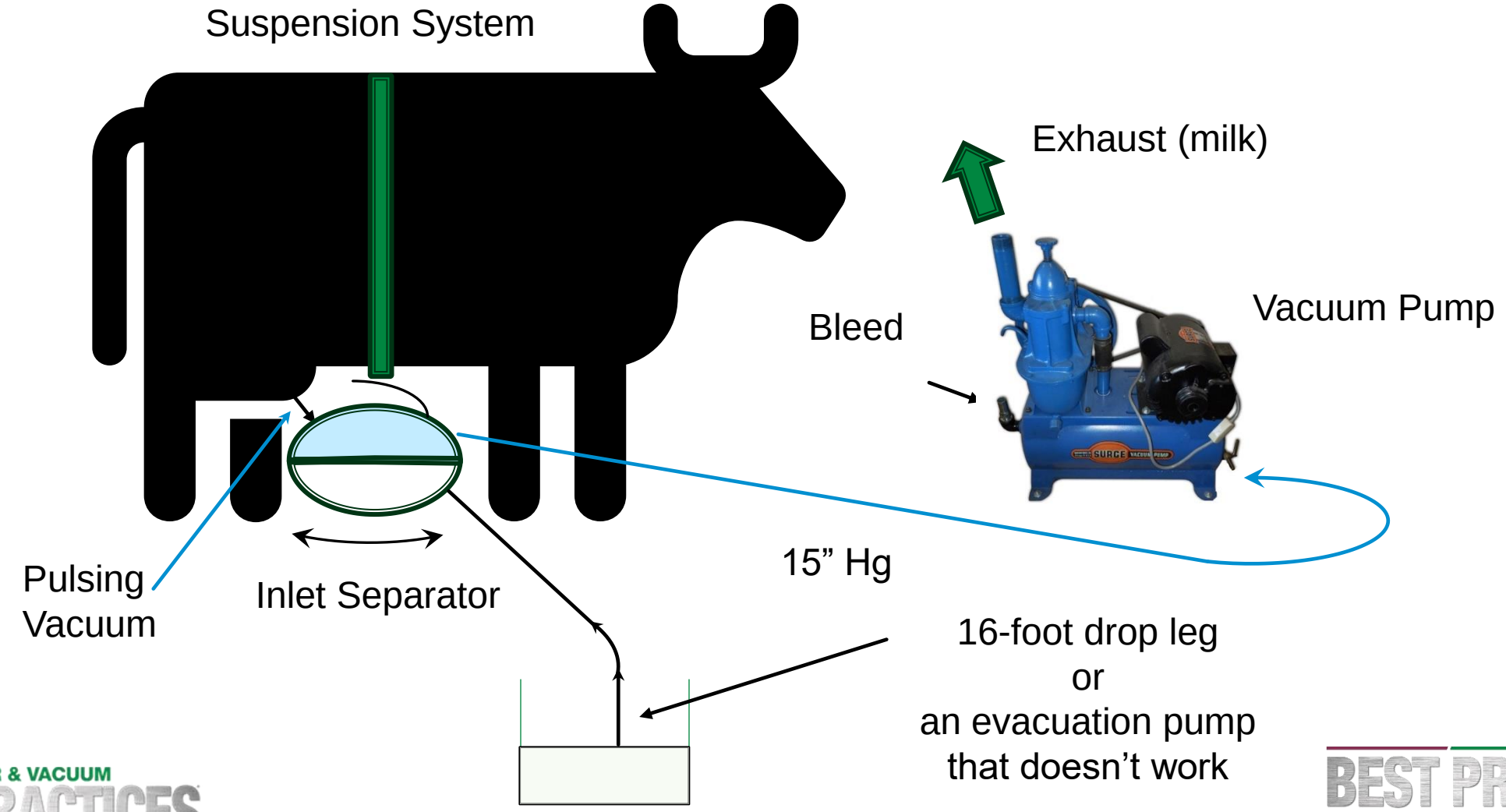


If the pump cannot reach the desired vacuum, the pump will need to be rebuilt or replaced. If the bleed is just less open, you are still wasting energy but not affecting production.

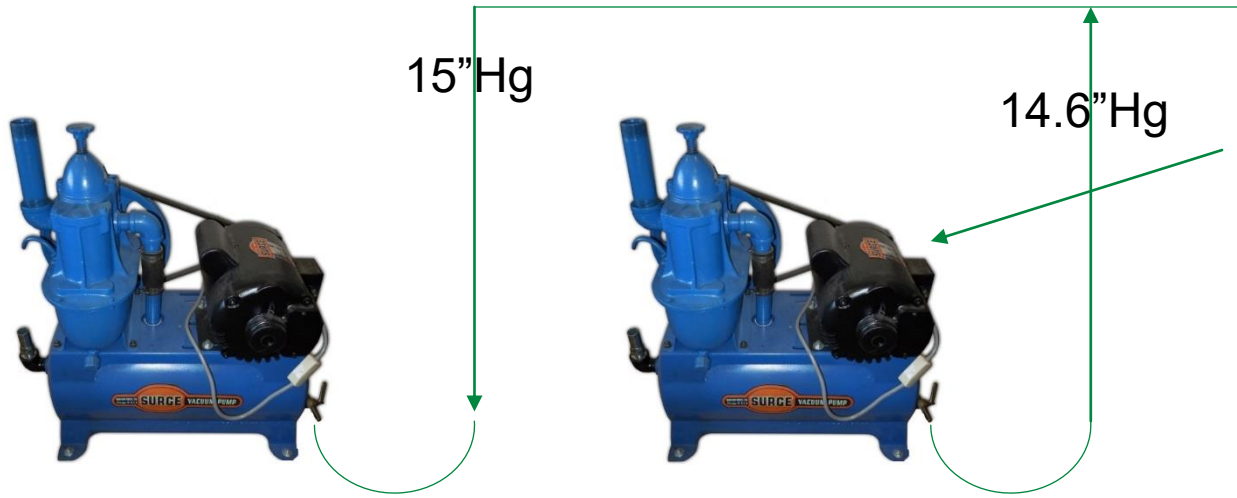
Hauling milk and a pipeline



Hauling milk and a pipeline



Parallel Vacuum Pumps



Capable of 2:1 compression (15”Hg)

Capable of 1.95:1 compression (14.6”Hg)

This pump looks like a bleed, and the vacuum in the entire system goes down, and you lose all the HP of the second pump, and some of the first as well

Parallel Vacuum Pump Solution

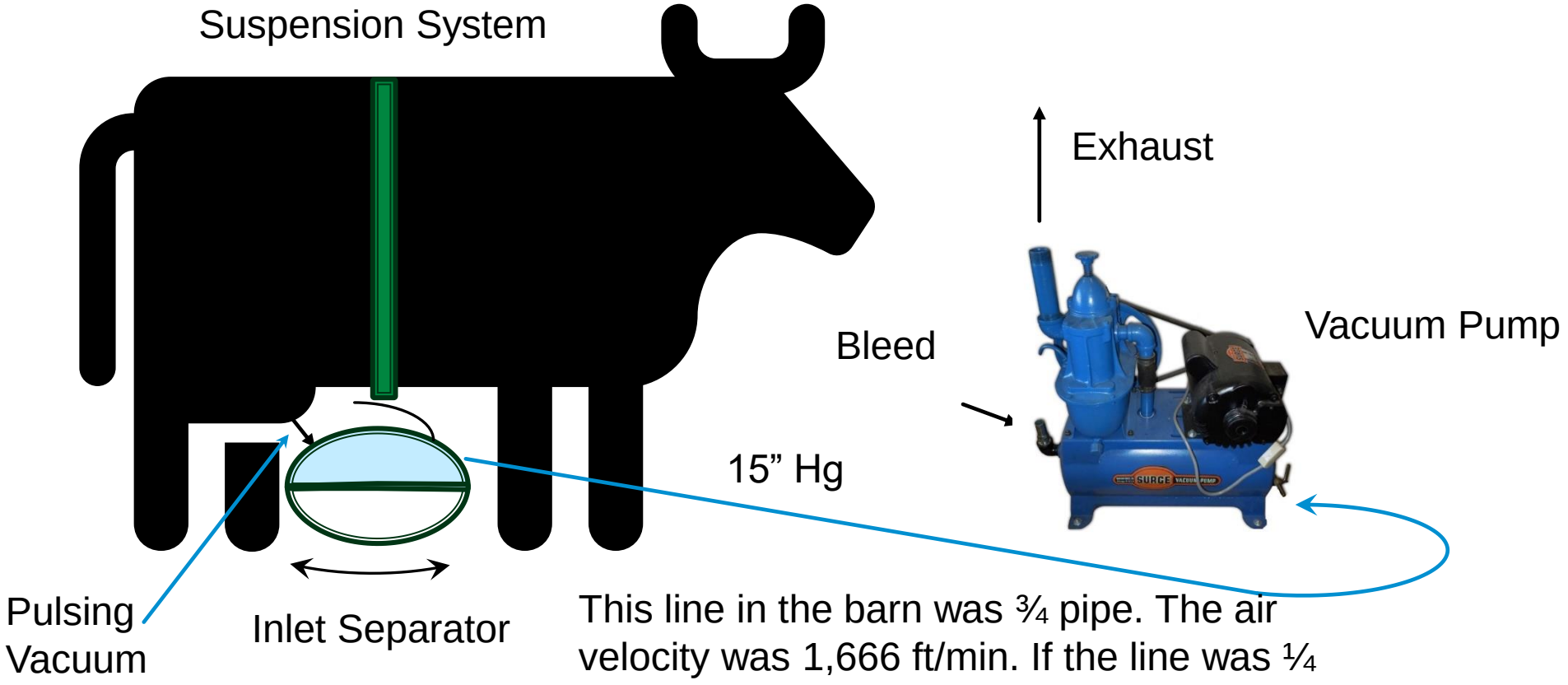
Half the barn

Capable of 2:1 compression
(15”Hg)

Capable of 1.95:1 compression
(14.6”Hg)

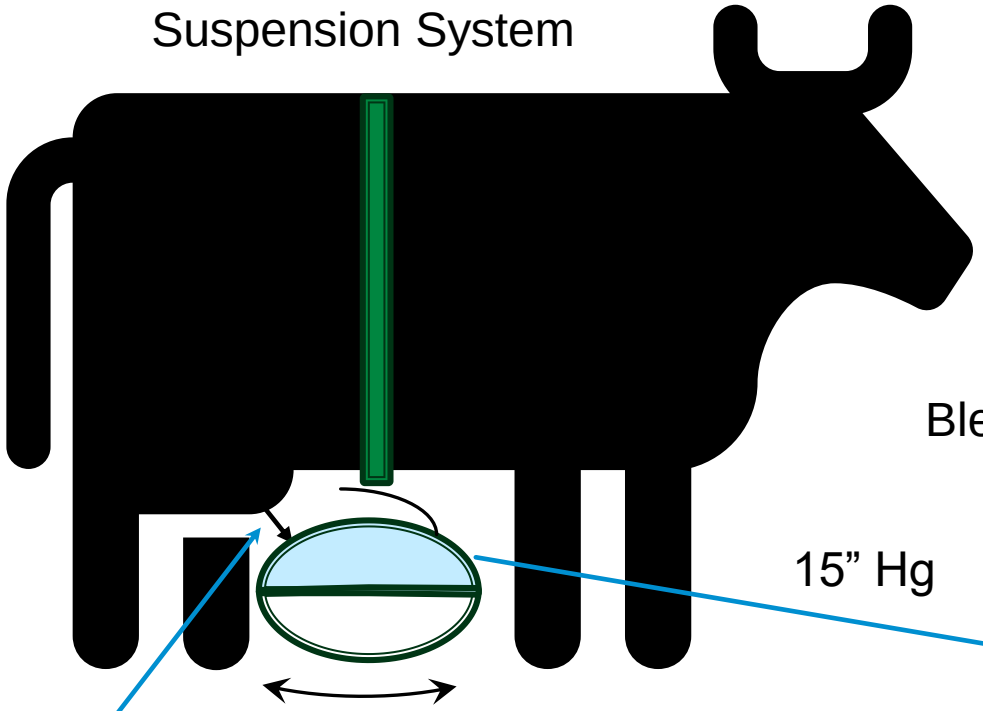
The other half of
the barn

System Design



This line in the barn was ¾ pipe. The air velocity was 1,666 ft/min. If the line was ¼ tubing, the velocity would be 14000 fpm with significant pressure loss.

System Design



Exhaust

Bleed

Vacuum Pump

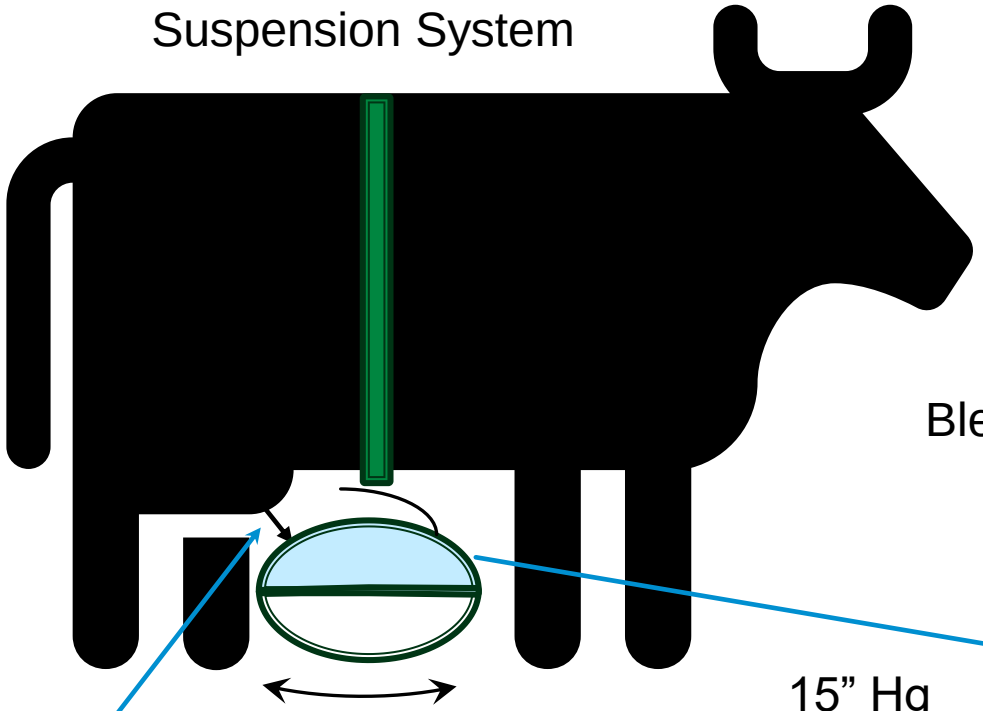
15” Hg

Pulsing Vacuum

Inlet Separator

The rules are 6000 fpm dry air, 3000 fpm with entrained air and 500 fpm in the separator

Condensation Effect



Exhaust

Bleed

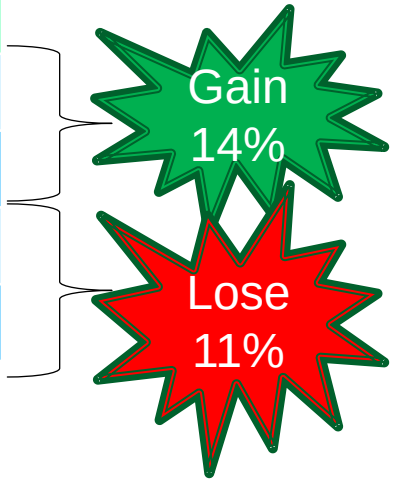
Vacuum Pump

15” Hg

If the air is hot and humid, spray water colder than the air into the air line and increase the CFM

Condensation Factor – 100% Humidity

	Temp (°F)	Saturation Pressure ("Hg)	Vacuum Level ("Hg)	Absolute Pressure ("Hg)	% Water Vapor of Gas Mixture
	212	30	0	30	100%
	140	5.88	24.1	5.9	99.66%
Air In	100	1.926	20	10	19.26%
Air at Seal Water Temp	60	.52	20	10	5.22%
Air In	90	1.417	20	10	14.17%
Air at Seal Water Temp	110	2.589	20	10	25.89%



Choosing a vacuum pump type

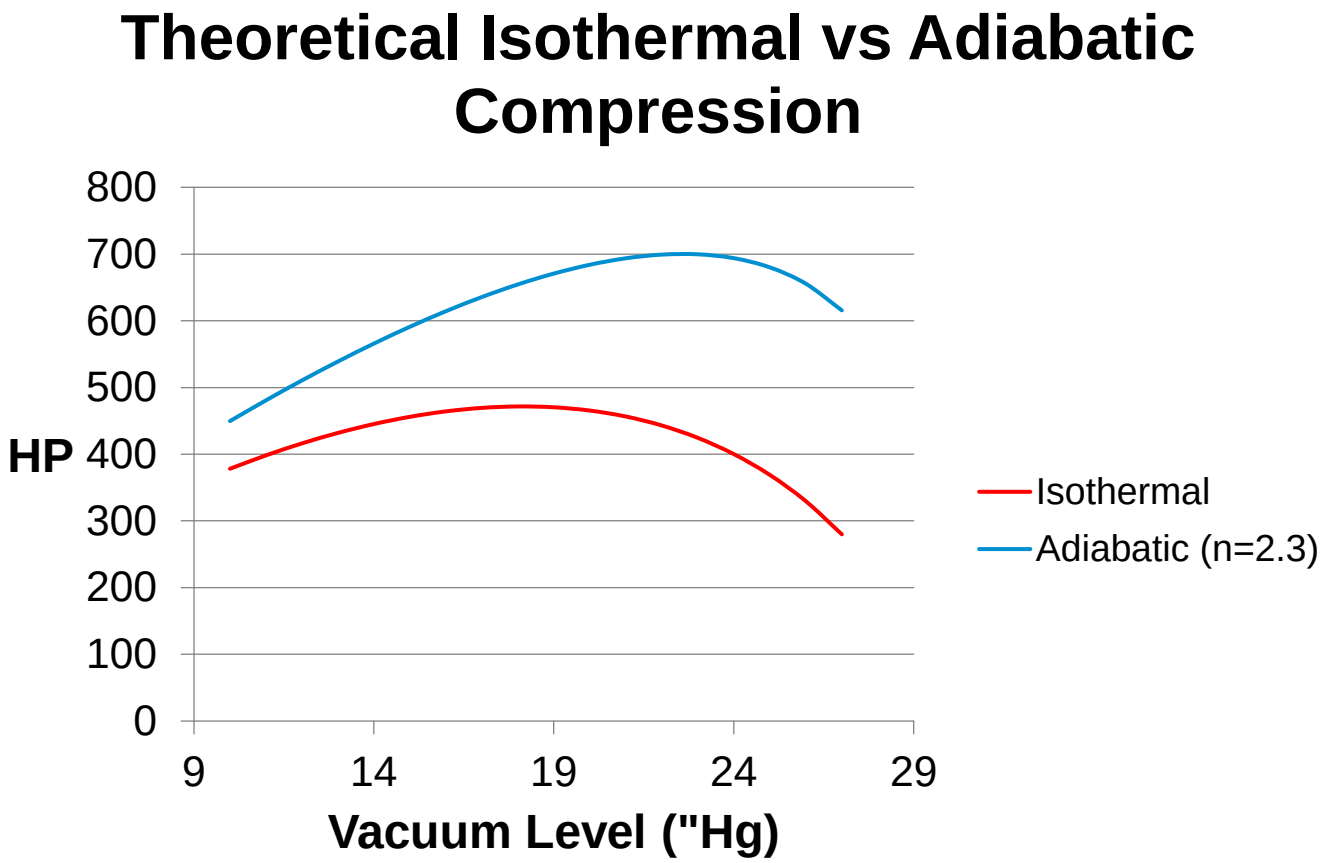
Gentlemen,
This is the bible….I wrote it…… and I taught your fathers, and I taught your grandfathers, and you will do the same thing they did to get any kind of grade in this class.

Edward F. Obert

$$\triangle W_{\text{rev of isothermal}} = mRT \ln(p_1/p_2)$$

$$\triangle W_{\text{rev of polytropic}} = m[(nRT_1/(1-n)]*[(p_2/p_1)^{(n-1)/n}-1)]$$

Power to Compress Air



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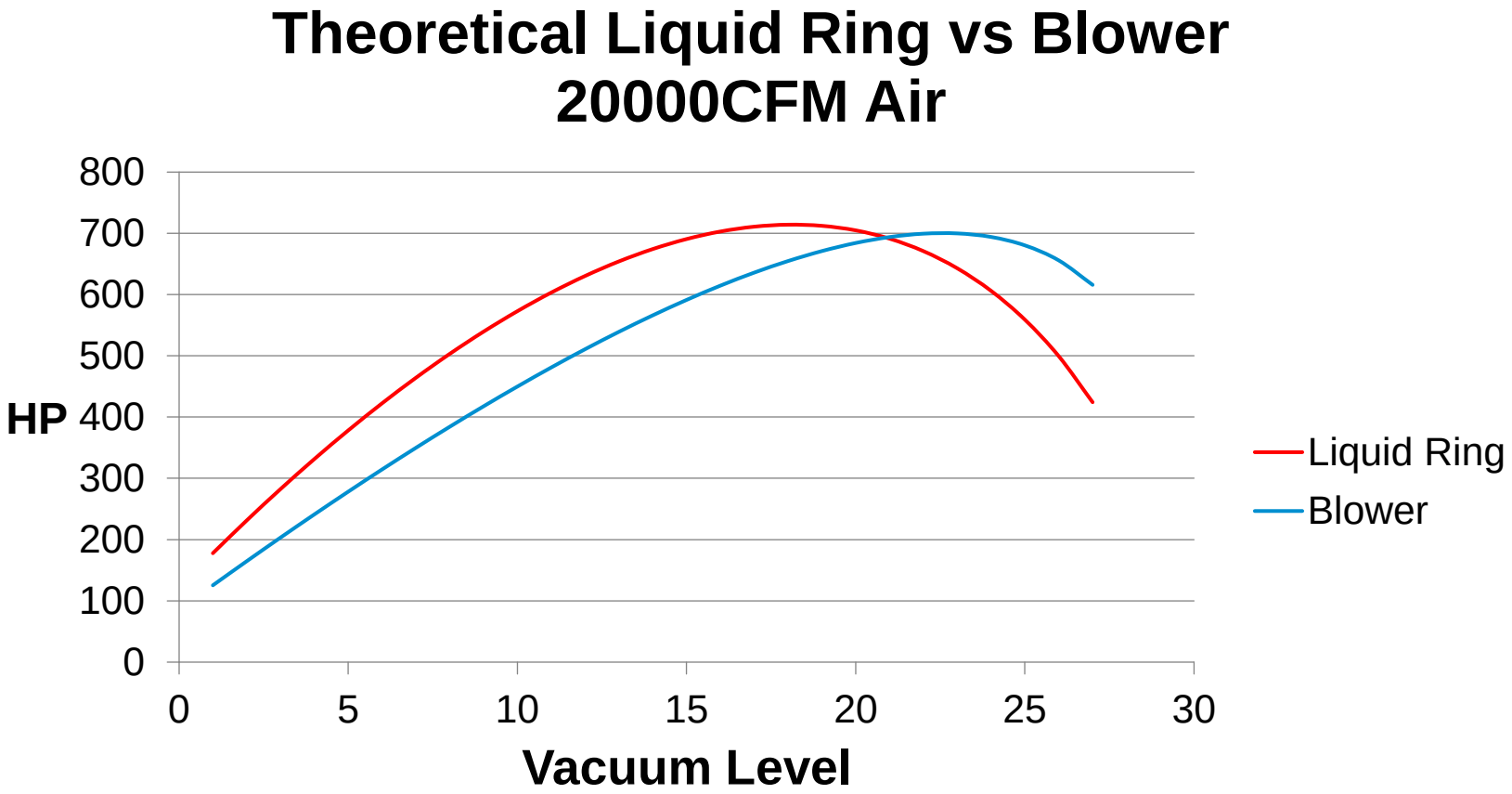
Power Consumption of Liquid Ring vs Blower



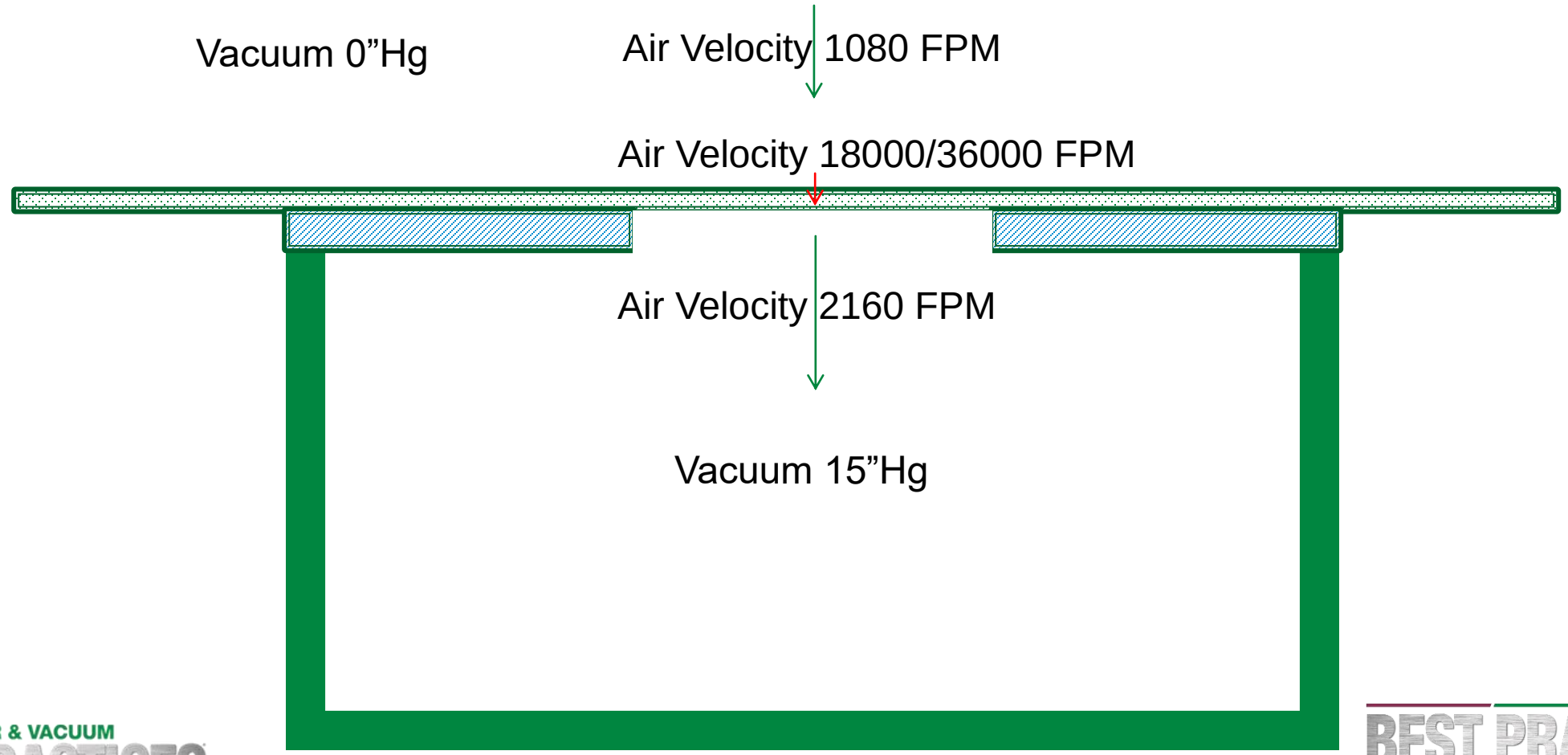
Type of Vacuum Pump – Paper Industry

- Fans are good and energy efficient to about 3”Hg
- Turboblowers are good and efficient to 15” Hg, but make sure the inlet separation is good
- Liquid Ring pumps are good in a single stage to 27”Hg and in a multistage to 29”Hg.
- Bryan will cover the other common types of vacuum pumps

Understanding the process of water removal

- Many vacuum applications are to remove water from a substrate
- The natural assumption is that the vacuum creates high velocity air stream that entrains the water and/or the water evaporates
- The usual actual application moves the water to an interface from where it is mechanically removed
- Here are a couple of examples
- If you do not understand this process, you can keep adding vacuum and using energy with no results

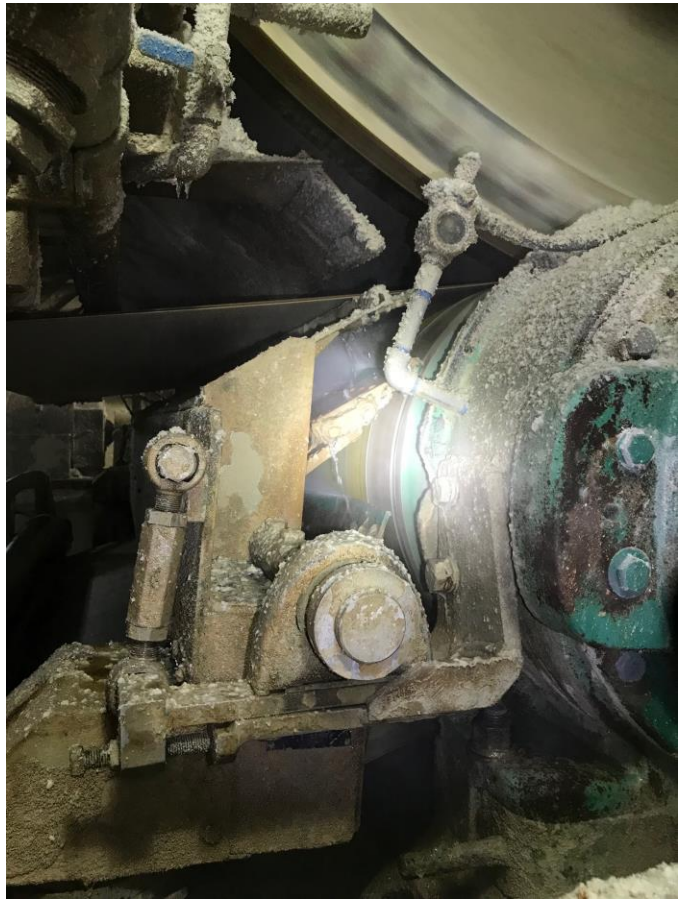
Typical Uhle Box Air Flows



Inside of the Uhle box

Felt Direction

Dual doctor on pressure roll



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Capacity Test

Liquid Ring Vacum Pump Field Test

Growth Solutions Consultants LLC

Tested By:	Andrew Smiltneek
Date:	Tuesday, May 28, 2019
Witnessed:	
Certified:	Andrew Smiltneek
Customer :	
Customer Location:	
Pump Number:	3
Pump Manufacturer/Model:	Nash 904P2
Barometric Pressure ("Hg)	29.74
Air Temperature (°F)	91

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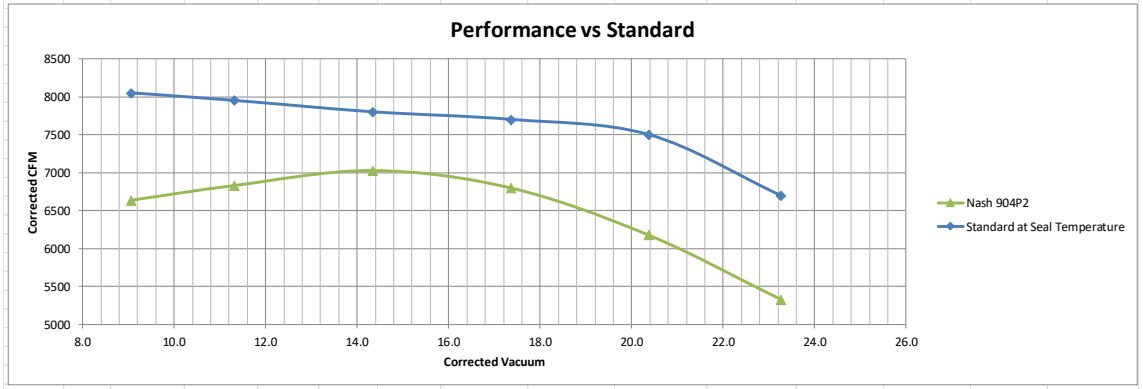
Test Point	RPM	Idle End Vacuum ("Hg)	Drive End Vacuum ("Hg)	Orifice Size	Holes Open	Seal Water Temp	Corrected Idle End Vacuum ("Hg)	Corrected Drive End Vacuum ("Hg)	Corrected Idle End Capacity (CFM)	Corrected Drive End Capacity (CFM)	Total Corrected Capacity (CFM)	Average Corrected Vacuum ("Hg)	New Pump Capacity (CFM)	% of Standard New Capacity
1	400	8.5	9.5	1.250	12	56	8.6	9.6	3143	3496	6639	9.1	8050	82.5%
2	400	11	11.5	1.250	10	56	11.1	11.6	3336	3498	6834	11.3	7950	86.0%
3	400	14	14.5	1.250	8	56	14.1	14.6	3440	3592	7032	14.3	7800	90.2%
4	400	17	17.5	1.250	6	56	17.1	17.6	3330	3473	6803	17.4	7700	88.3%
5	400	20	20.5	1.250	4	56	20.1	20.6	2994	3186	6180	20.4	7500	82.4%
6	400	23	24.5	1.250	2	56	23.0	23.5	2227	3105	5332	23.3	6700	79.6%
7	400	25	26	1.250	1	56	26.0	25.0	1734	#VALUE!	#VALUE!	25.5		#VALUE!

Note: This pump tested at an average of 84.8% of new capacity. It is the southernmost pump in the train.

84.8%

Average: 84.8%



Review of Usual Energy Wasters

- Wrong type of pump
- Misunderstanding of the process
- Too many vacuum pumps
- Backpressure on the discharge
- Improper inlet separation
- Vacuum Leaks
- Poor System Design
- Worn Pumps
- Running at the wrong speed
- Liquid Ring Pumps:
  - Too much seal water
  - Hot seal water

Questions and Critique

- And Thanks for your time
- For more information, follow my blog on the growthsolutionsconsultants.com website, much of this information is explained in more depth
- Contact me at:
- andys@growthsolutionsconsultants.com
- +1 920 470 9432

About the Speaker

Bryan Jensen
Rogers Machinery

- Engineered System Solutions Manager, Rogers Machinery
- 21+ years with Rogers Machinery
- Responsible for Rogers' Engineered System Solutions internationally
- Former NASA materials researcher

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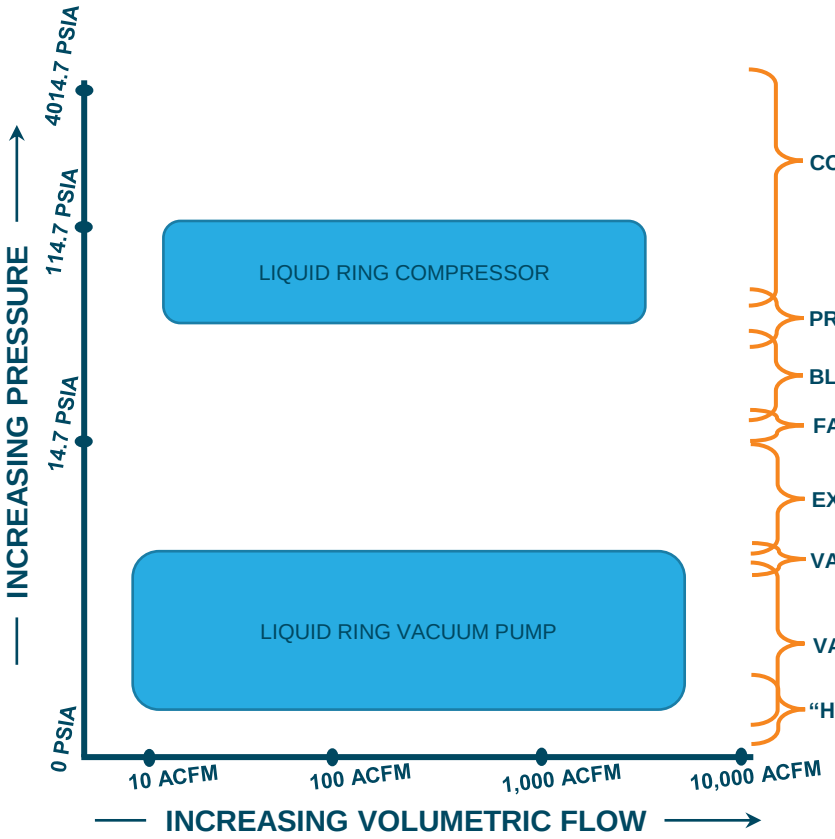
Power Efficiency in Vacuum Systems

Application Considerations

November 30, 2023

Liquid Ring



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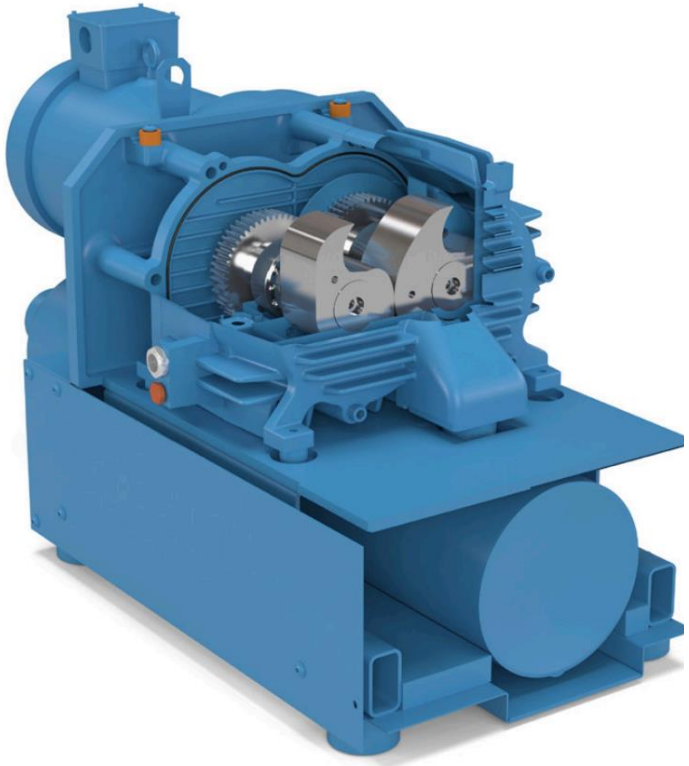
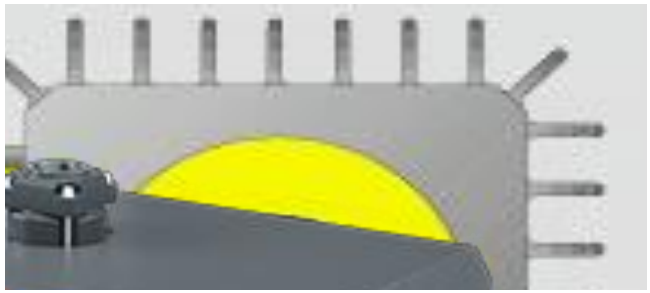
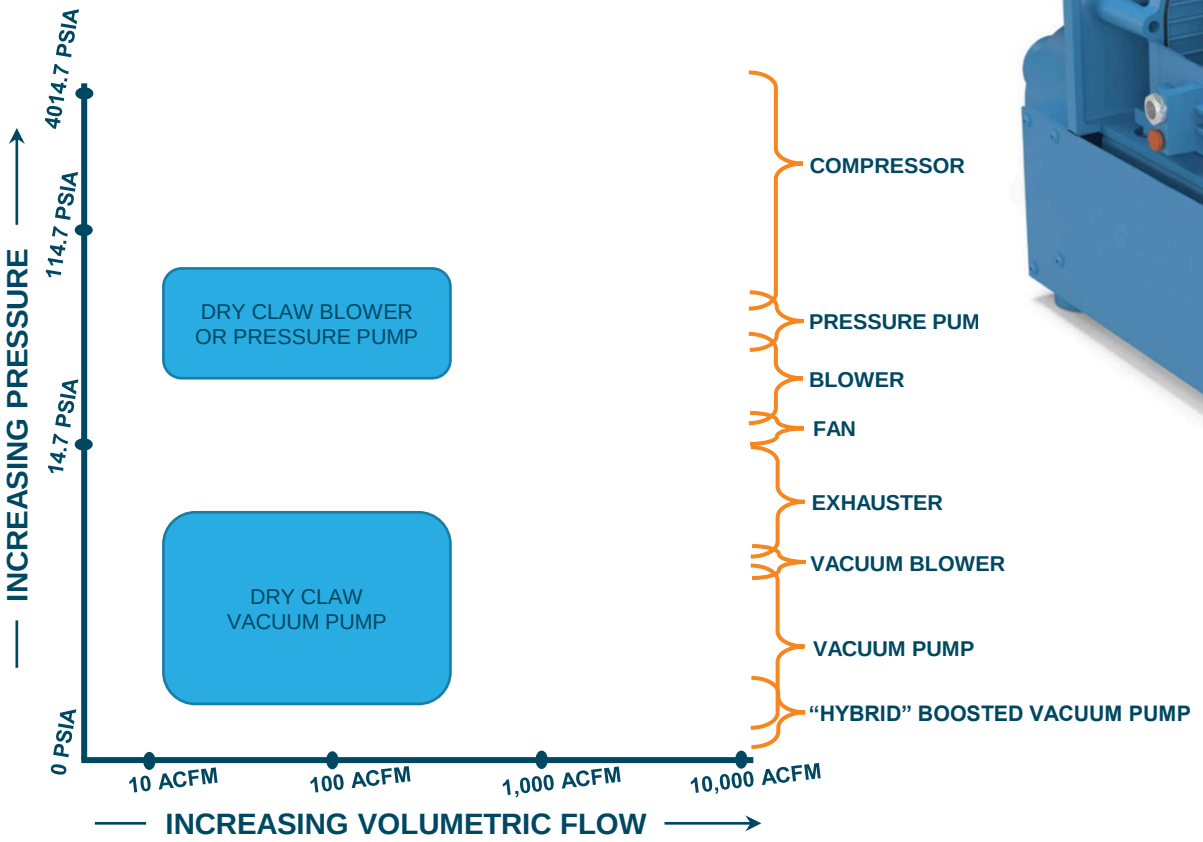
Dry Claw







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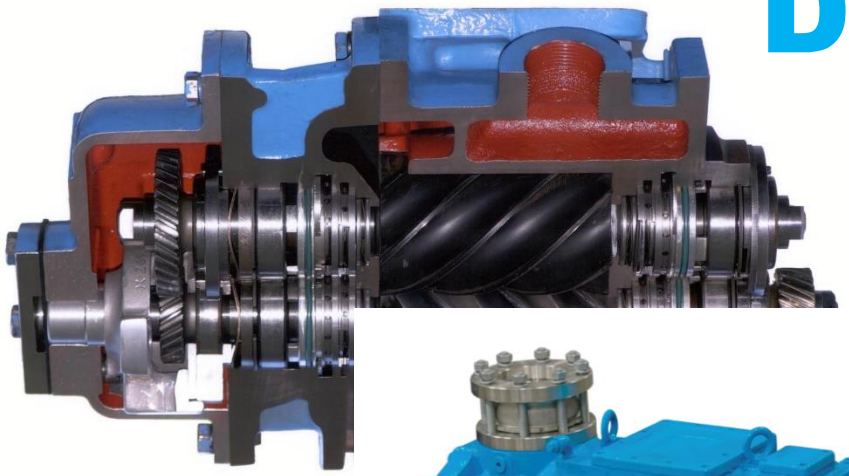
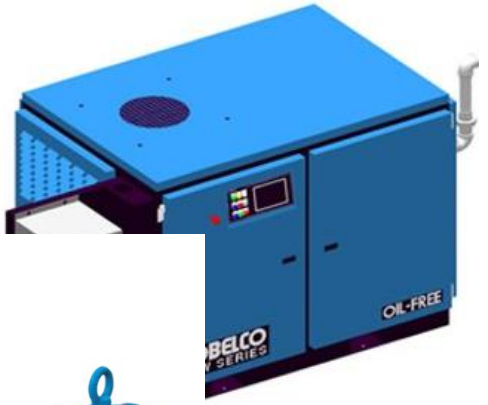
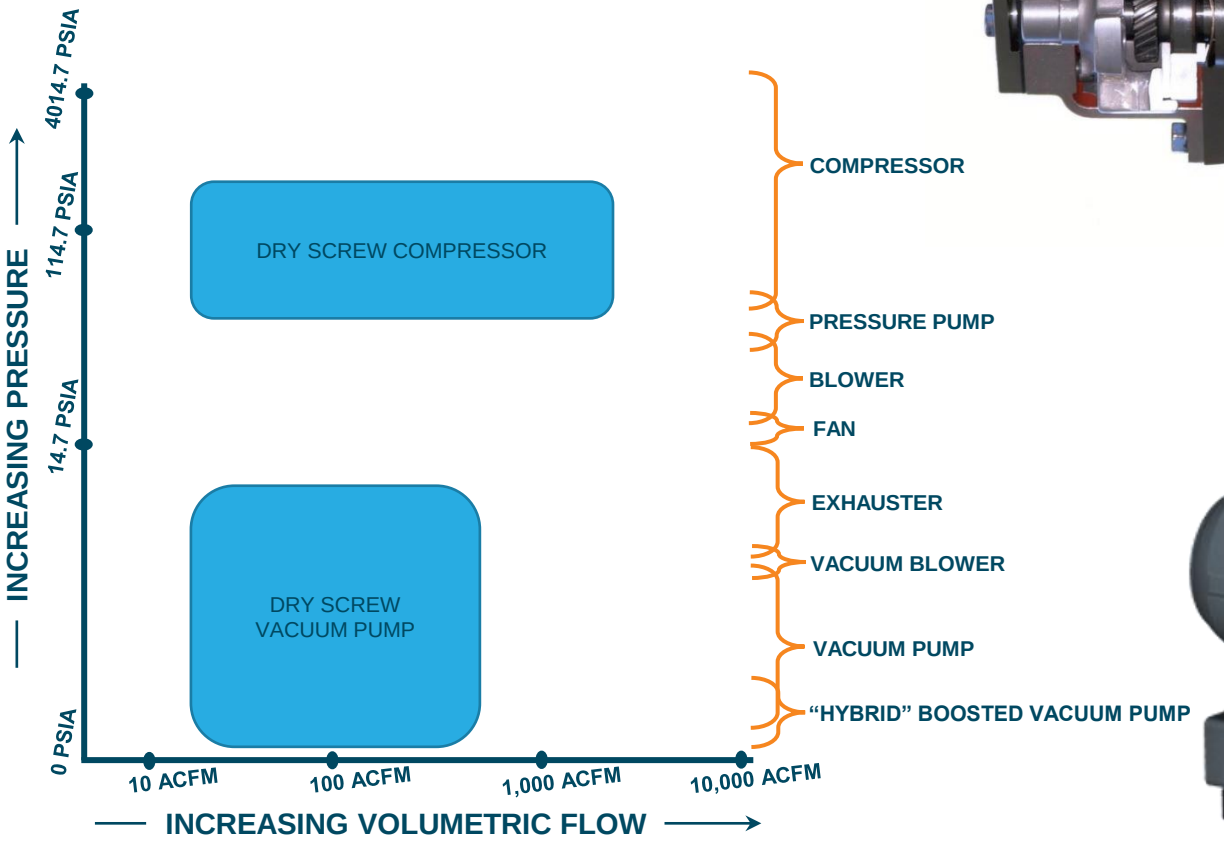
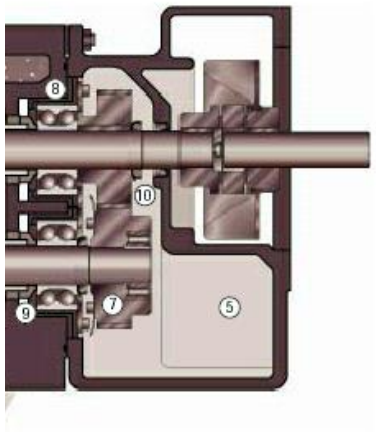
Dry Screw









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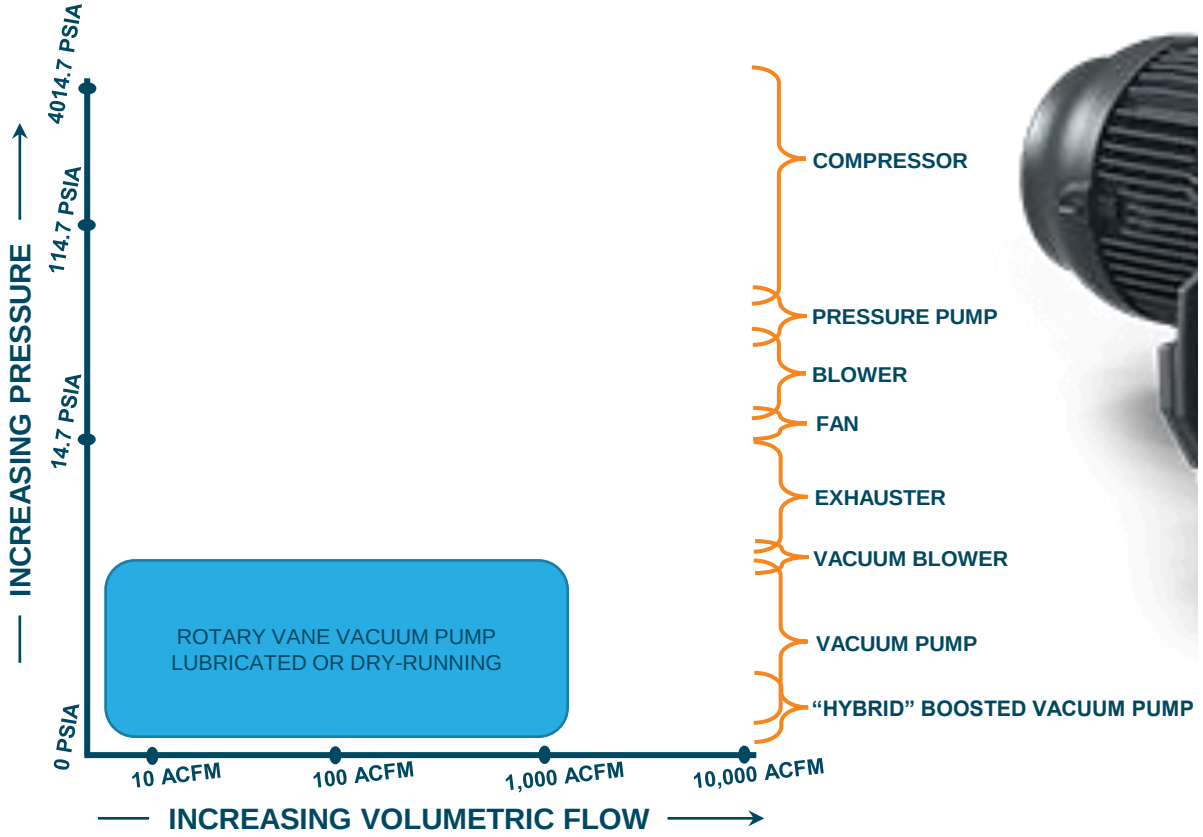
Rotary Vane



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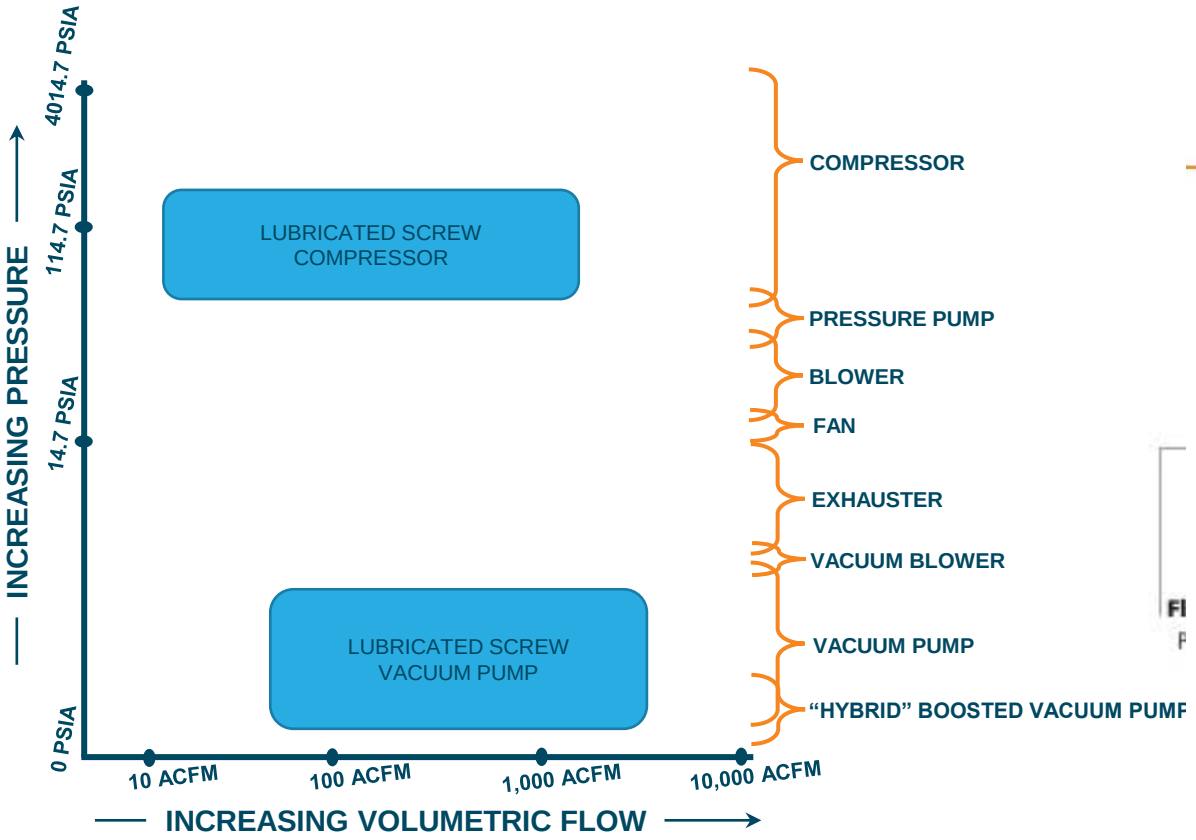
Lubricated Screw



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and during startup.

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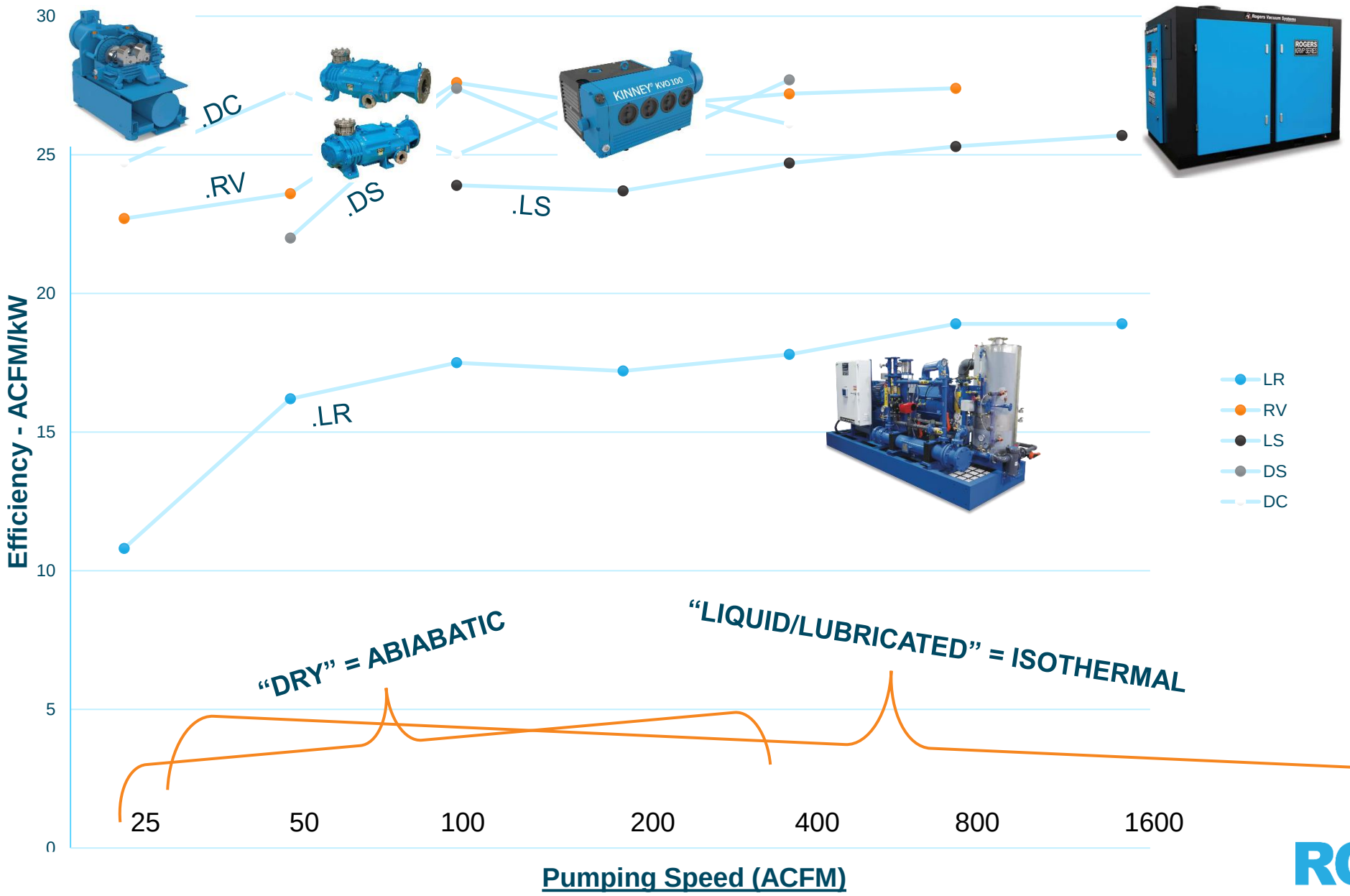
Generic Look at Pumping Speed (ACFM) vs Power Efficiency by Vacuum Technology



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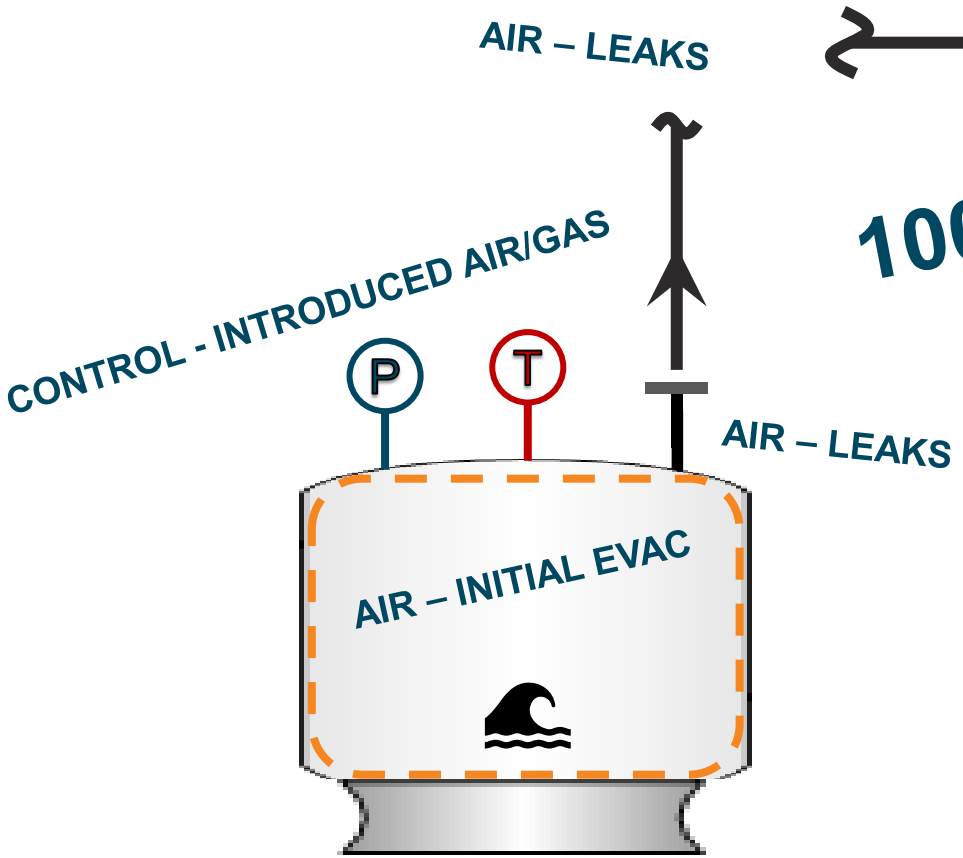

100% NON-CONDENSABLE LOAD

NON-CONDENSABLE LOAD

\+ CONDENSABLE LOAD

TOTAL LOAD

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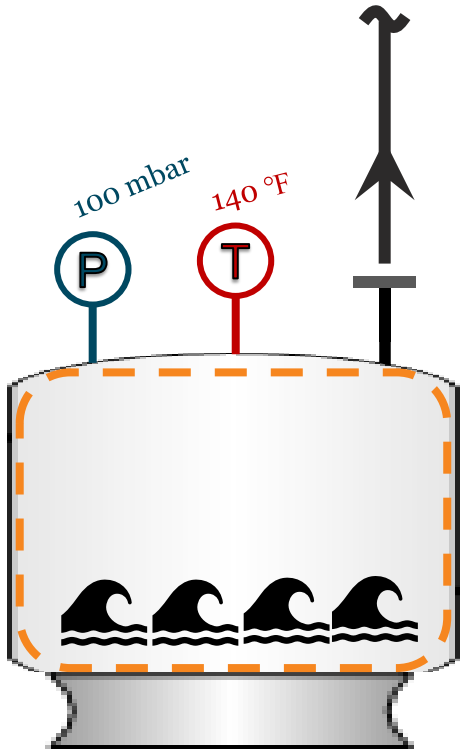
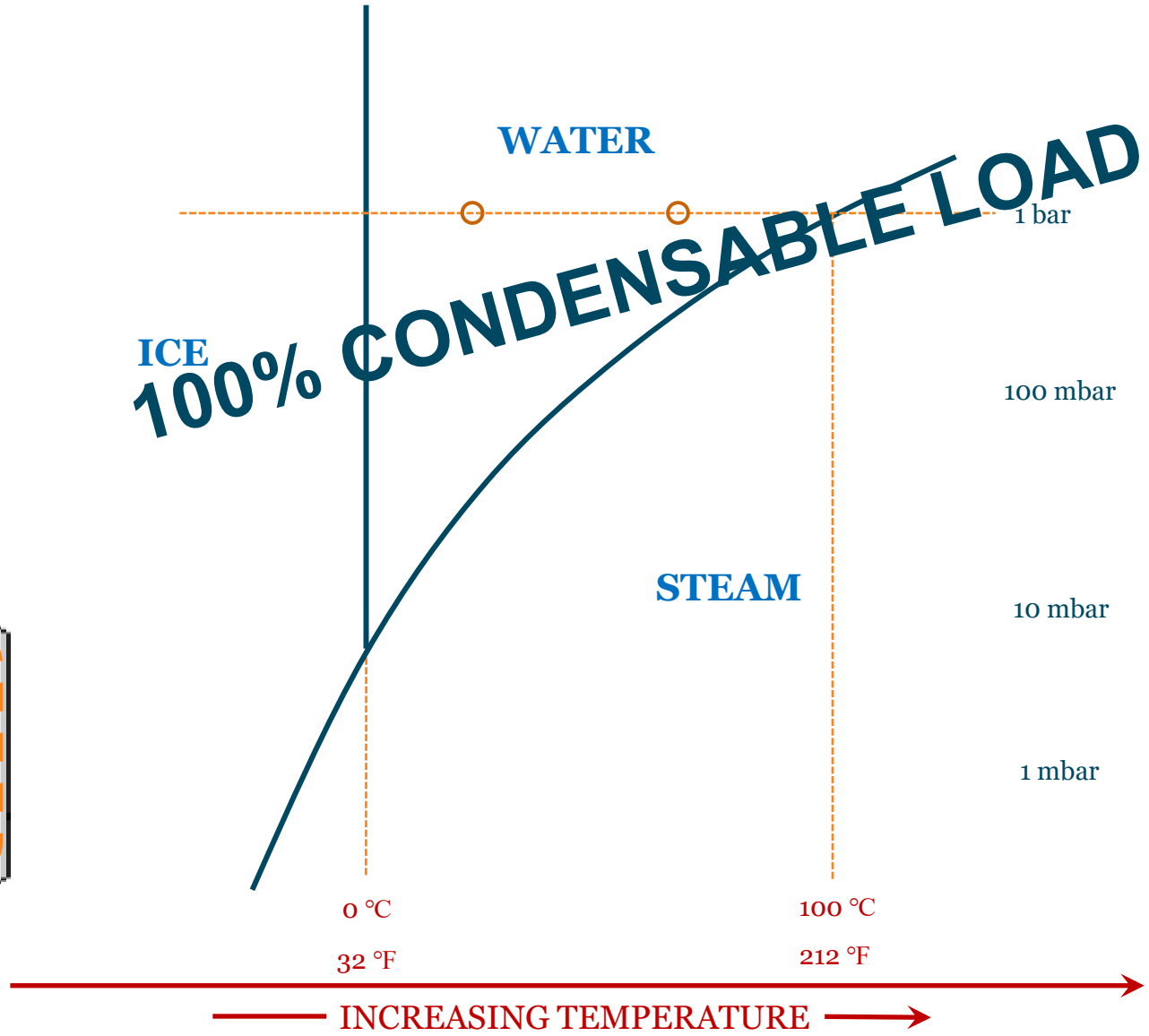
Boiling Water under Reduced Pressure





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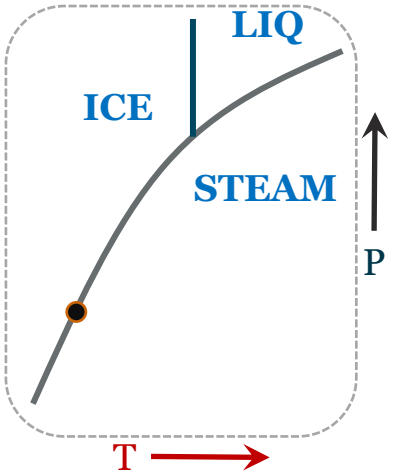
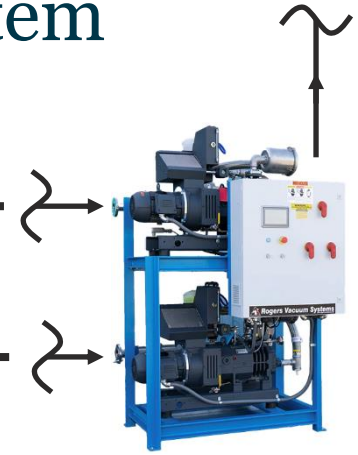
Freeze-Drying COLD TRAP – inlet condenser for vacuum system





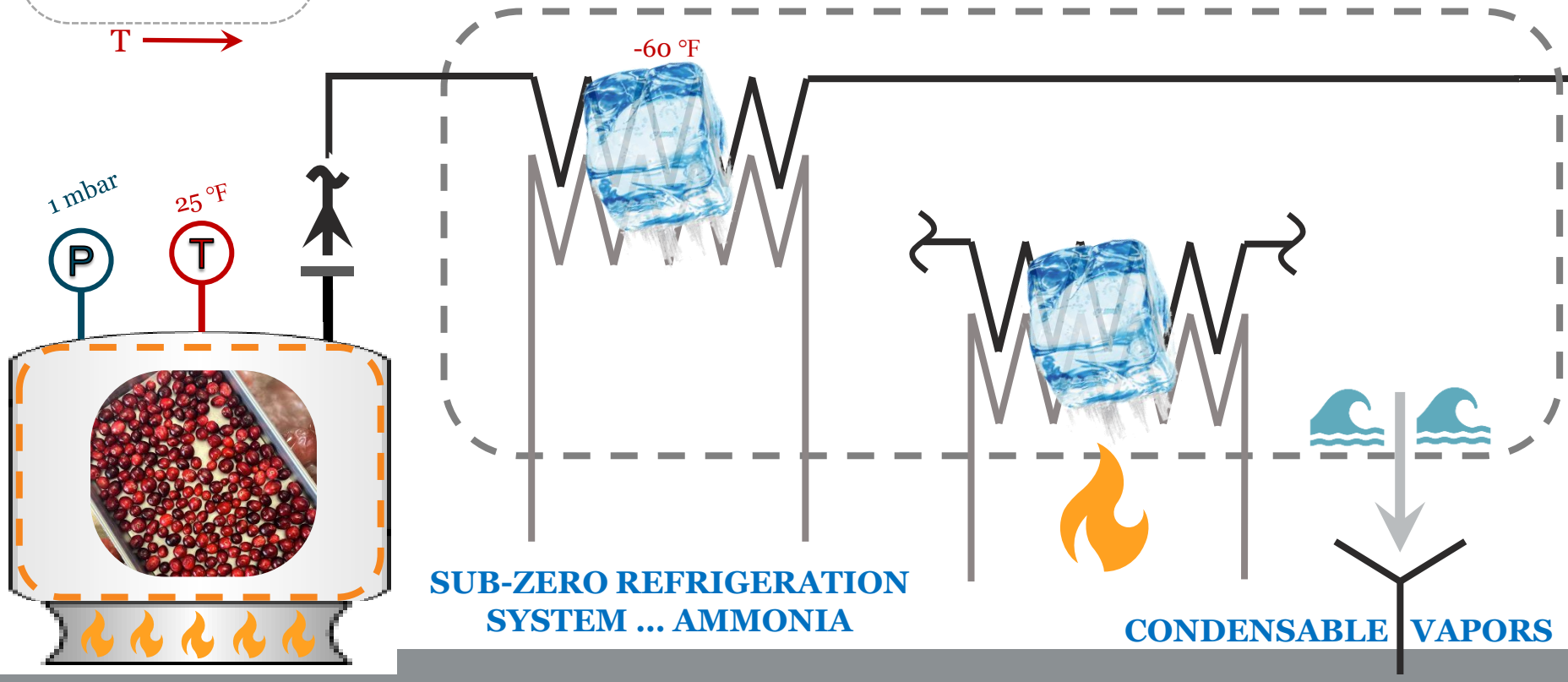
NON-CONDENSABLE VAPORS (GASSES)

Nitrogen (N_2)

Oxygen (O_2)

Helium (He)

+ leftover CONDENSABLE VAPORS



SUB-ZERO REFRIGERATION SYSTEM … AMMONIA

CONDENSABLE VAPORS

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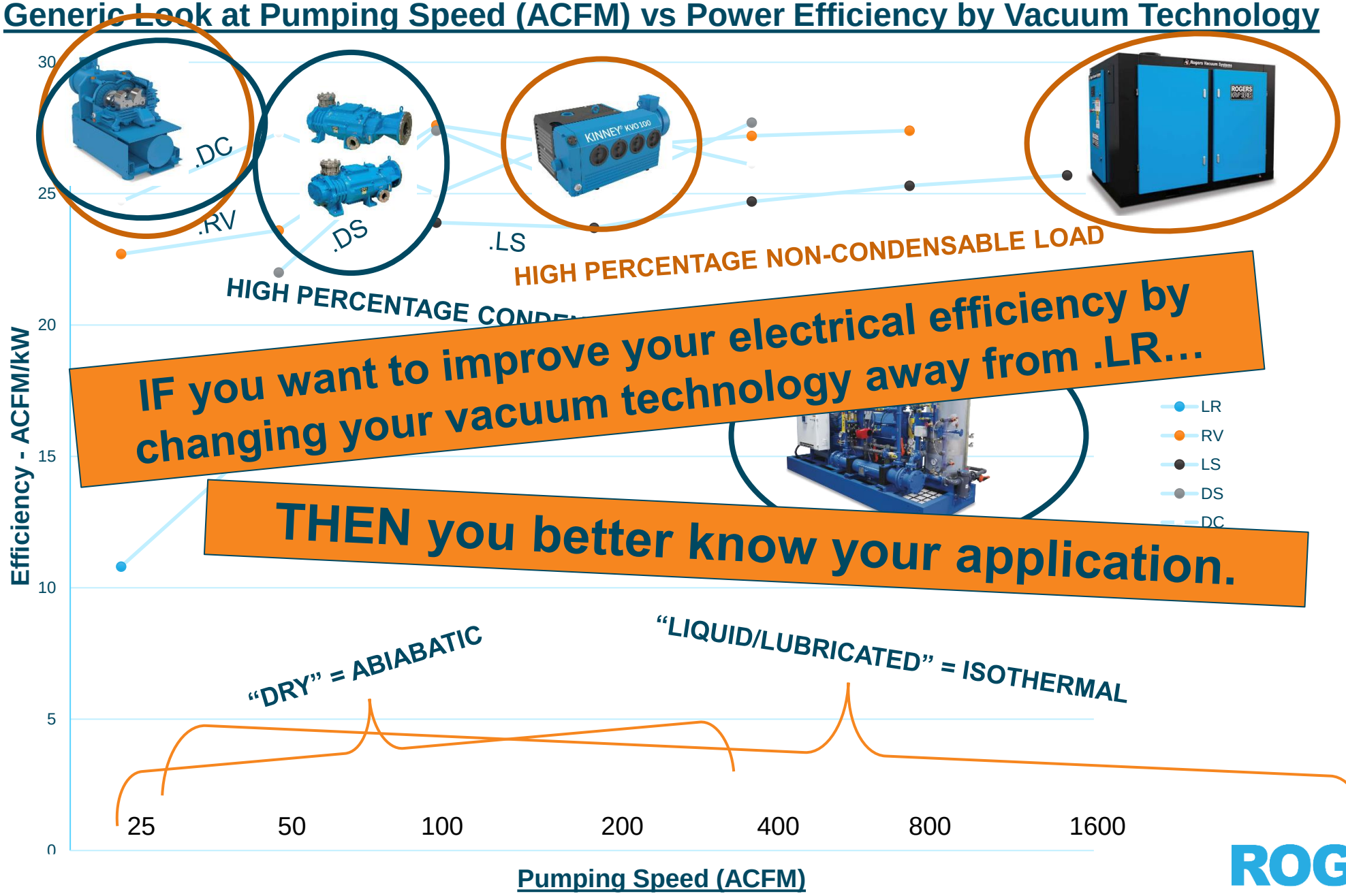

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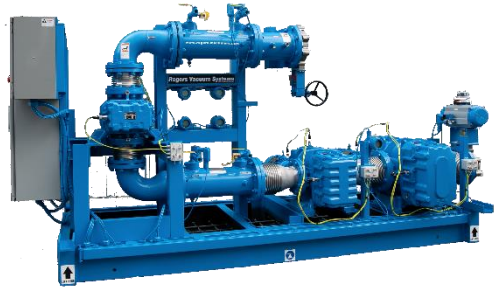

SCAN ME

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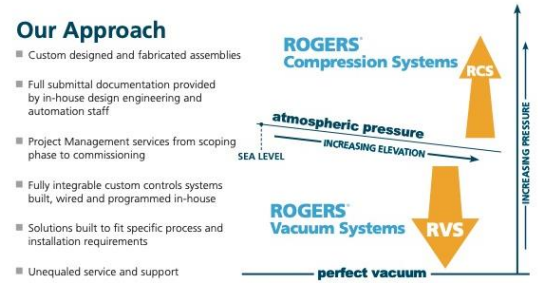
ROGERS Engineered System Solutions



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Thank you!

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Vacuum System Efficiency

Q&A

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Loran Circle
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