APEX
INDUSTRIAL
SOLUTIONS

PRODUCTS & SERVICES

Boilers, Steam, & Condensate | Instrumentation | Valves & Actuators | Sanitary & High Purity | Dry Bulk Material Handling

Apex Industrial Solutions, Inc.
113 Chelsea Rd, Monticello, MN 55362
763-777-9525 | Sales@ApexSolutionsMN.com | www.ApexSolutionsMN.com

Who is Apex?

Apex was founded in **2009** with the idea that service in the industrial sector should be fast, accurate, and affordable. We are a hybrid manufacturer's representative and distributor of high quality, industrial engineered equipment for the food and beverage industry, agricultural processing, industrial manufacturing facilities, mechanical contractors and OEM's in the upper Midwest.

- Our experienced staff is able to simplify your job as a reliable and accessible partner.
- The equipment we provide enhances your operations by boosting uptime and optimizing energy efficiency.
- We take pride in keeping your projects on track, ensuring a smooth and timely execution, all while staying within your budget.

Our Core Values

1 — CHALLENGE
Our team isn't afraid to put our years of knowledge into practice. Bring us your complicated projects and the Apex team will work together to give you the best possible solution for your budget, your timeline, and your facility.

2 — STEWARDSHIP
We believe we have products that can help our planet, our people, and your organization. We see it as a duty to ensure we get these products out to market where our clients can benefit from using them.

3 — INTEGRITY
When things go wrong, we stand tall. We take responsibility when we make mistakes. We are human and humans screw up. But people with integrity face their mistakes. We are dedicated to learning and improving.

4 — MORALS & ETHICS
We don't take shortcuts, we do things the right way. Our team is comprised of honest Midwesterners who go above and beyond to build your trust in us through transparency, accountability, and compassion.

5 — DISCIPLINE
It takes discipline to constantly add massive value. We don't just say it and forget it. We live it and it takes constant practice. From the big things to the seemingly insignificant details, we are always seeking more ways to add value.

6 — CHARITABLE
We believe that giving back is essential. Because of this, our team regularly volunteers at several charities. We also donate a portion of our proceeds to St. Judes Hospital and other local organizations in our community.

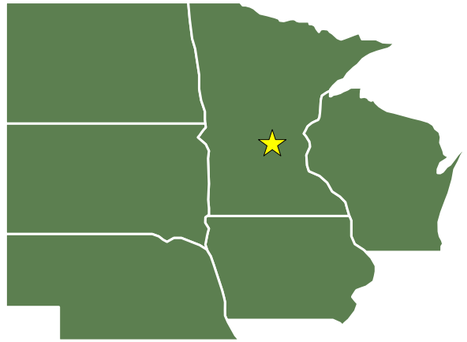
USA Made
We believe in carrying high-quality, American-made products that stand the test of time.

Attention & Speed
Don't wait days for a response. Our team always answers the phone and emails. We are not just fast, we also have a strong focus on accuracy.

Quality
We work with vendors that we trust to provide the best equipment with quick lead times and strong warranties.

Service
Our Midwestern values motivate us. We know doing things the right way is the only way.

Knowledge
The Apex team regularly attends training seminars and classes to keep up with new technology and trends in the industry.



Our local sales territory includes ND, SD, NE, MN, IA, WI.
Ask us about National distribution: 763-777-9525

Request a Quote

763-777-9525
Sales@ApexSolutionsMN.com
www.ApexSolutionsMN.com/contact-us/

BOILERS, STEAM, & CONDENSATE

For most manufacturers, energy isn't just another cost; it's a profit driver waiting to be optimized.
Apex helps you capture that opportunity by cutting energy waste, lowering operating costs, and increasing uptime.

The result: higher margins, fewer maintenance interruptions, and a stronger competitive edge in your market.
With Apex, your energy strategy becomes a profit strategy.

FEATURED PRODUCTS

Sellers Fire Tube Boilers

Sellers Manufacturing Company's rapid response boilers with patented multi-flame technology provide water tube response with fire tube durability in a simple to operate integral package.

- → 20-Year Pressure Vessel Warranty
- → No Thermal Shock
- → Single Pass Design
- → Low Cost of Ownership
- → 40% Smaller Footprint
- → 20 Minutes to Make Steam

Versaflex™ Control Valve Assembly

The Versaflex™ Control Valve Assembly, engineered by Apex, was created to solve several problems our team noticed that are created by using standard steam control valves.

- → Class 6 bubble-tight shut off for no steam leakage
- → No-leak stem and V-Ring combination
- → Orient your Versaflex™ valve in any direction to save space
- → Modulating with fail safe backup
- → 6 second operation speed

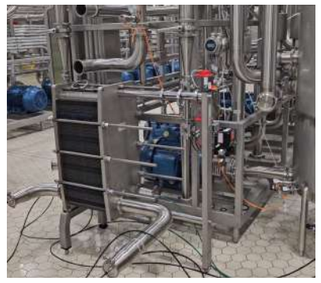
SERVICES

Steam Trap Audits

Did you know? A failed ¾" HP steam trap can cost $6,600 per year in lost steam! Apex will perform a steam trap audit on your facility to identify any failed traps. Most surveys yield 10 - 20 failed traps. Rebates available.

Steam 101 Training

Apex and Watson McDaniel currently offer a Steam 101 Class for your employees. This 6 hour course includes training on everything steam and safety. This is a great introduction or refresher class!



Tracer Gas Leak Testing & Heat Exchanger Audits

Apex will evaluate a heat exchanger's condition, performance, and integrity for efficiency, safety, and compliance. We also offer new Tracer Gas Leak Testing that allows us to test your plates for leaks and cracks without taking apart your heat exchanger!

Watson McDaniel

- Steam Traps
- Custom Tanks
- Regulators (PRVs)
- Control Valves
- Liquid Drainers
- Instantaneous Hot Water Heater

Thrush Co.Inc.

- Shell & Tube Heat Exchangers
- Air & Dirt Removal
- Hot-Pak Instantaneous Hot Water Heater
- Replacement Coil Bundles
- Pressure Booster Systems
- Pumps & Circulators

MARLO™ HEAT TRANSFER SOLUTIONS

- Fluid Coils
- Industrial Process Coils
- Air Handling Units
- Refrigerant Coils
- Steam Coils
- Specialty Coils
- Stratomizer Dampered Face & Bypass Coils
- Turbine Inlet Cooling & Heating Coils

Veotec Air Quality Solutions

- Water Removal Hatches
- HVAC Louvers
- HVAC Sound Control
- Dust Control Filters
- Heated & Cooled Louvers

WCR

- Plate & Frame Heat Exchangers
- Immersion Plates
- Replacement Plates & Gaskets
- 3-A Certified
- Cleaning, Regasketing, Dye Testing
- NEW! Tracer Gas Leak Testing

ENERQUIP THERMAL SOLUTIONS

- Shell & Tube Heat Exchangers
- Vapor Condensers
- Industrial Heaters
- Tank Heating & Cooling

Delta T Thermal Solutions
A Sharp Iron Group Company

- Plate Heat Exchangers
- Immersion Heat Exchangers
- Maxchangers

VERSAFLEX

- Control Valve Assembly for Boilers, Steam, & Condensate

KUNKLE Valve Division

- Safety & Relief Valves

Sellers MANUFACTURING CO

- Fire Tube Boilers
- Fire Tube Water Heaters
- Indirect Water Heaters
- Deaerators & Boiler Feed Systems

NLINE ENERGY

- Renewable Energy Turbines

CBW

- Boiler Economizers
- Shell & Tube Heat Exchangers
- Steam Accumulators
- Condensers

FABTEK

- Condensate Units
- Boiler Feeders
- Electric Condensate Pumps

V-AX®

- 5-Offset High Performance Butterfly Valves (Cryogenic & Control)

INSTRUMENTATION

You can't manage what you don't measure! And in manufacturing, that means every data point matters.
Apex delivers precision instrumentation that gives you the clarity to spot issues before they become costly problems.
With accurate, reliable data, you can keep your facility healthy, your processes optimized, and your production targets on track.
When your measurements are right, your decisions are right, and your operation runs at its best.

FEATURED PRODUCTS

Tek-Trol Coriolis Flow Meter

From clean to crude, a Tek-Trol Coriolis Flow Meter accurately measures it all! Built on the Coriolis principle, these meters measure the mass of the fluids directly rather than volume. This means they do not require compensations for factors such as temperature and pressure.

→ Suitable for clean to aggressive media; gas or liquid
→ No moving parts for easy maintenance
→ Measures mass flow, density, temperature, and volume flow

UWT Level Measurement & Monitoring

UWT's level measurement tools turn complex sensing challenges into simple, reliable control you can trust day after day. Bring together engineering excellence and user-friendly designs.

→ Designed to withstand extreme dust, moisture, temperature, and vibration
→ Plug-and-play setup minimizes commissioning time
→ Fast and helpful support for selection, installation, troubleshooting, and spare parts. Most instruments are easy to retrofit

SERVICES

Identifying Flow Needs
Apex can determine flow improvements that need to be made by using a non-invasive Ultrasonic Flow Meter in your process.

Installation Consultation
Our team can assist in selecting the best placement for your instrumentation for highest accuracy in measurement.

Compressed Air System Audits
Let Apex identify any inefficiencies, leaks, and wasted energy within your compressed air system to save you money and improve reliability.

FLOW | PRESSURE | LEVEL | TEMPERATURE | ENERGY | GAS

TEKTROL Technology Solutions

- Flow Measurement
- Temperature Measurement
- Pressure Measurement
- Level Measurement
- Steam Quality Measurement
- Indicators/Controllers

REOTEMP INSTRUMENTS

- Thermometers
- Thermocouples & RTDs
- Thermowells
- Temperature Transmitters
- Pressure Gauges
- Diaphragm Seals
- Pressure Transmitters & Switches

JOGLER PREMIER LEVEL PRODUCTS

- Magnetic Level Gauges
- Magnetrostrictive Level Gauges
- Point Level Switches
- Laser Level Transmitters
- Direct-Reading Liquid Level Indicators

bürkert FLUID CONTROL SYSTEMS

- Flow Meters
- Conductivity Meters

ifm electronic

- Pressure & Vacuum Sensors
- Level Sensors
- Flow Sensors & Meters
- Temperature Sensors
- Ultrasonic Sensors
- Capacitive Sensors

UWT LEVEL CONTROL

- Point Level Measurement
- Continuous Level Measurement
- Interface Measurement
- Level Monitoring & Visualization

SUPERLOK®

- Tube Fittings
- Compression Fittings
- General Use Valves

BRASCH ENVIRONMENTAL TECHNOLOGIES

- Multi-Zone Control Panel Gas Detectors
- Standalone Gas Detectors
- Remote Gas Detector Transmitters

VALVES & ACTUATORS

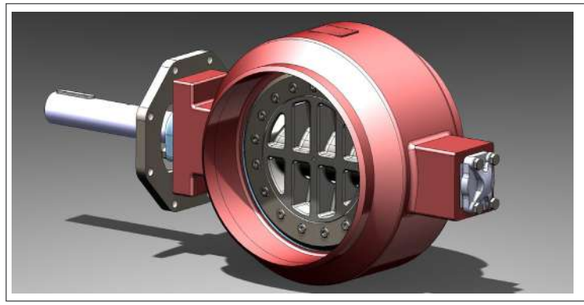
Valve automation done right. Every time.
Getting valve and actuator sizing right isn't simple. Torque variations, seat and seal differences, and process demands can turn a small error into costly downtime. Our experts ensure every valve and actuator combination is precisely sized and specified for your exact application. This saves you time, reducing rework, and keeping your operations running smoothly.
Get confidence that your automation will perform flawlessly from day one.

FEATURED PRODUCTS

Valve Solutions Inc. Segmented Ball Control Valve

One of the most versatile control valves on the market: it features a segmented ball design that is more similar to a globe valve. This allows for a very repeatable equal percent flow curve.

- → Trunnion mount allows for a very low torque requirement
- → Rotary motion means the stem never sees the process; allowing for longevity
- → V-Ring stem packing keeps a leak tight seal on stem at all times



V-AXX 5-Offset HP Butterfly Valves

This unique valve has the highest flow capacity (Kv/Cv) of any comparable torque-seated, butterfly valve. The higher the flow capacity, the lower the torque, size, and price.

- → Excellent flow control
- → No cavitation in liquids, no supersonic speed in gases
- → Lower noise levels for comfort
- → Built-in orifice plates allow for use as control valve
- → -454°F to 2552°F temperature range

SERVICES

Control Valve Selection & Sizing
A poorly sized control valve can negatively effect your entire steam system. Our team knows control valves and can size one that is engineered for your steam system.

Steam 101 Training
Apex and Watson McDaniel currently offer a Steam 101 Class for your employees. This 6 hour course includes training on everything steam and safety. This is a great introduction or refresher class!

In-House Valve Automation
Apex can assemble your valve & actuator assembly at our automation bench. You just plug and play!

VERSAFLEX

- Fast-Acting, Modulating Control Valve Assembly with Fail Safe Battery Back Up Electric Actuator

V-AXX®

- 5-Offset High Performance Butterfly Valves (Cryogenic & Control)

DELTA T
A Brand of Max-Air Technology.

- Resilient Seat, Double-Offset, Triple-Offset, & Control Butterfly Valves

A+R®

- Critical Service, Metal-Seated Ball Valves

SESTO VALVES

- Ball Valves

Max-Air TECHNOLOGY

- Electric Actuators
- Pneumatic Actuators

V-TORK

- Rack & Pinion Pneumatic Actuators
- Scotch Yoke Actuators
- Electric Actuators

AVCO

- High Pressure Valves
- Ball Valves
- Gate, Globe, & Check Valves
- Electric Actuators
- Pneumatic Actuators

SVF FLOW CONTROLS

- Flow Control Valves
- Actuators
- Controllers

BONOMI NORTH AMERICA

- Brass Ball Valves
- Grooved Butterfly Valves
- Check Valves
- Press Fittings

NAF

- Critical Service Ball Valves
- Critical Service Butterfly Valves
- Critical Service Check Valves
- Actuators

TITAN
TITAN FLOW CONTROL, INC

- Y Strainers
- Basket Strainers
- Duplex Strainers
- Check Valves

Chicago Valves & Controls

- Ball Valves
- Butterfly Valves
- Gate, Globe, & Check Valves

VSI

- Ball Valves
- Butterfly Valves
- Globe Valves
- Pressure Independent Valves
- V-Ball Valves
- Electric Actuators
- Pneumatic Actuators

DFT INC

- Check Valves
- Control Valves

ARROW UNITED INDUSTRIES

- Dampers
- Louvers
- Fire Dampers
- Smoke Dampers

SANITARY & HIGH PURITY

You're in the business of delivering purity. We're in the business of protecting it.
Apex high-purity systems safeguard your production from contamination; protecting your product quality, your equipment, and your reputation. With Apex, you can maintain the highest standards of cleanliness, extend equipment life, and strengthen the trust your customers place in your brand. **Because when your process stays pure, your promise to customers stays strong.**

FEATURED PRODUCTS

WCR Tracer Gas Leak Testing

The WCR predictive Hydrogen Plate Testing for food, beverage, and dairy industries allow you to detect flaws and schedule maintenance BEFORE an emergency shutdown occurs.

→ No need to take your plate & frame heat exchanger apart
→ No more struggling with gasket assembly
→ No downtime for dye testing (and the clean up afterward)
→ Detect cracks, micro-cracks, corrosion, and more

Mix-Proof Valves

The Definox Mixproof Valve is a high-performance hygienic valve designed to safely separate incompatible fluids, ensuring maximum process efficiency and product integrity.

→ Double-seat sealing prevents cross-contamination between product lines
→ Modular design with accessible components for easy cleaning
→ Long-lasting performance in demanding environments

SERVICES

Tracer Gas Leak Testing & Heat Exchanger Audits

Apex will evaluate a heat exchanger's condition, performance, and integrity for efficiency, safety, and compliance. We also offer new Tracer Gas Leak Testing that allows us to test your plates for leaks and cracks without taking apart your heat exchanger!

Connector Solutions

Is your facility still utilizing traditional-style connectors? Let Apex audit your process and offer solutions that eliminate dust leakage and offer better hygiene control.

Build-Your-Own Metal Detectors

Grow revenue, reduce waste, and protect your brand identity with a custom engineered Bunting Metal Detector. These tailored metal detection solutions are designed to meet your specific production requirements.

DEFINOX BOOST YOUR PERFORMANCE

- Isolation Valves
- Divert Valves
- Mixproof Valves
- Aseptic Valves
- Sampling Valves
- Protecting Devices
- Tank Equipment
- Regulating Valves
- Specific Valves
- Controlling & Signaling Tops
- Pigging Systems
- Injection Systems

Ace Sanitary

- Gaskets
- Single-Use Tube Assemblies
- Sanitary Hoses
- Instrumentation Hoses
- Fittings
- Data Center Cooling Hoses
- Washdown Stations
- Assembly Equipment

Watson McDaniel

- Sanitary Regulators (PRVs)
- Clean Steam Traps, Pumps, and More

GEA Tuchenhagen

- Pigging Systems
- Back-Pressure Valves
- Control Tops
- Air Jet Vacuum Pumps
- Containment Valves

BFM fitting

- Flexible Connectors
- Breather Bags & Covers
- Blanking Caps & Bins
- Bulk Bag Connectors
- Spigots
- Pneumatic Monitoring Systems

VMCR

- Sanitary Plate & Frame Heat Exchangers
- Replacement Plates & Gaskets
- 3-A Certified
- Cleaning, Regasketing, Dye Testing
- NEW! Tracer Gas Leak Testing

bürkert FLUID CONTROL SYSTEMS

- Solenoid Valves
- Process & Control Valves
- Electromotive Valves
- Pneumatics & Process Interfaces
- Sensors, Transmitters, & Controllers
- Microfluidics & Pumps
- Mass Flow Controllers
- Solenoid Control Valves
- Angle Seat Valves

WAYLAND The Right Way | The Fast Way | The Easy Way

- Tubing
- Fittings
- Ball Valves
- Butterfly Valves
- Spring Check Valves
- Y-Ball Check Valves

Q-Pumps

- Positive Displacement Pumps
- Centrifugal Pumps
- Mixers
- Drum Unloaders

BUNTING

- Magnets
- Metal Detectors

**Not all products meet listed certifications. Call Apex for proper product selection to meet your application needs. See page 18 for current definitions of certification symbols.*

DRY BULK MATERIAL HANDLING

Dry bulk handling done safely, efficiently, and right.
Handling dry bulk materials comes with real challenges. From sizing equipment correctly to managing combustible dust and staying NFPA compliant. Apex brings proven expertise to simplify that complexity. We design and specify the right equipment for your process, protect your people and assets, and keep your facility running safely and efficiently.
With Apex, you don't just meet compliance standards. You set the standard for reliability and safety in your industry.

FEATURED PRODUCTS

Meyer Industrial KLEAN-IN-PLACE II® Rotary Valve

The Meyer Industrial KIP II® rotary airlock valve is specifically engineered for applications that require frequent cleaning, sanitizing, or inspection of the bulk handling system, where minimizing downtime is essential.

→ Meets FDA, USDA, 3A Dairy, and NFPA standards
→ 2-RAIL construction allows easy access for cleaning
→ Available in five sizes from 6×6 through 16×16

EBRO ViDOS Metering Valve

The EBRO ViDOS Valve is a wafer-type process metering feeding device that features a vibrator on the lower shaft. Combine with a control panel for complete control across any desired feed range.

→ Low profile design for easy installation on dry bulk equipment
→ Go from a trickle to a full dump in seconds, and vice versa
→ Smart engineered for accuracy and repeatability
→ Low up-front cost and low maintenance

See it in action!

SERVICES

Magnet Audits

A certified technician will evaluate, test, and inspect the performance of your magnets' current strength. Notes regarding cleaning schedules, location of magnets, and magnet types will also be noted.

Dust Hazard Analysis (DHA)

Apex will identify and evaluate any potential fire and explosion risks within your facility and offer improvements and preventions.

Rotary Valve Selection & Sizing

Don't be stuck with an undersized or under-performing rotary valve! Our team can help you select a rotary valve that is made to work in your exact application.

MEYER INDUSTRIAL

- Sanitary Rotary Airlock Feeders & Valves
- Rotary Airlock Feeders & Valves
- Double Flapgate Airlock Valves
- Pneumatic Screw Pumps
- Slide Gates & Diverter Valves
- Blower Packages

Acrison

- Volumetric Feeders
- Bin Dischargers
- Continuous Blenders
- Loss-in-Weight Feeders
- Bin Vent Filters
- Bulk Bag Unloaders
- Dust Collectors
- Bag Dump Stations
- Water & Wastewater Treatment
- Controllers & Control Systems

UWT LEVEL CONTROL

- Point Level Measurement Instruments
- Continuous Level Measurement Instruments
- Interface Measurement Tools
- Visualization & Monitoring

Severfield

- Silo Discharger

VAC-U-MAX

- Pneumatic Conveying Systems
- Industrial Vacuum Cleaners
- Aero-Mechanical Conveyors
- Flexible Screw Conveyors
- Pulsonic Bin Activators

EBRO ARMATUREN®

- Inflatable Seat Valves
- Resilient Seated Valves
- PTFE Valves
- High-Performance Valves
- Actuators
- Controllers
- Ball Valves
- Knife Gate Valves
- Check Valves
- Vibrating Disc Valves

rembe®

Safety is for life.™

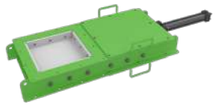
- Deflagration Venting
- Explosion Isolation
- Explosion Suppression
- Flameless Venting
- Explosion Prevention
- Rupture Discs

BUNTING

- Magnets
- Metal Detectors
- Industrial Conveyors

PEBCO®

- Slide Gates & Valves
- Diverters
- Dustless Loading Spouts, Chutes, & Positioners
- Fluidized Conveying (Air Slide) Equipment
- Dust Suppression
- Feeders
- Truck & Rail Car Loadout Systems
- Hydraulic Power Units
- Controls & Automation



JL Components

- Blower Packages
- Sound Enclosures
- Blowers
- Silencers

BFM fitting

- Flexible Connectors
- Breather Bags & Covers
- Blanking Caps & Bins
- Bulk Bag Connectors
- Spigots
- Pneumatic Monitoring Systems

ADDITIONAL BRANDS

Apex's network extends beyond our represented brands, allowing us to supply other trusted products when your needs call for them. Our goal is simple: to make sure you get the best solution, even if it falls outside our primary lines. **Get the right product without the hassle of multiple suppliers.**

- High Performance Butterfly Valves
- Sanitary Butterfly Valves

- Solenoid Valves for Fluid

- Pressure Transmitters
- Level Measurement
- Thermostats

- Pressure Transducers
- Thermostats
- Level Measurement
- Monitors

- HVAC Control Valves
- Damper Actuators
- Sensors/Meters

- Filter Housings
- Filters
- Strainers

- Ball Valves
- Butterfly Valves
- Control Valves
- Actuators

- Condensate Drains
- Level Controls
- Valves

- Valves for Gas, Sanitary, & Cryogenics
- Compact Actuators

- Tube Bends
- Central Vacuum

- Sensors & Monitors for Sanitary and Data Centers

- Butterfly Valves
- Ball Valves
- Control Valves
- Specialty Valves

- Butterfly Valves
- Actuators
- Gear Ops

- Brass & Lead Free Valves
- Brass & Lead Free Fittings

- Actuator Mounting Kits

- Couplings
- Tubing
- Piping
- Hoses

- Load Cells
- Weight Scales

- Electric Actuators

- Ball Valves
- Check Valves
- Triple Offset Butterfly Valves

- HVAC Control Valves
- Industrial Control Valves
- Level Controls

- Bucket Elevators
- Bulk Weighers
- Conveyor Belts
- Screeners

- Pressure Gauges
- Thermometers
- Thermowells

Request a Quote

763-777-9525
Sales@ApexSolutionsMN.com
www.ApexSolutionsMN.com/contact-us/

OUR CUSTOMERS & COMMUNITY

"We needed a flameless vent for a bag collector. It's a really specific application.

Apex worked with the supplier and got the right piece of equipment installed in a timely manner."

- Rich O. Senior Engineer

"Apex has consistently exceeded our expectations in serving our needs. They are knowledgeable and responsive in helping us solve challenging component issues."

- Brian P. Facilities Manager

"All of our project managers and engineers keep reaching back out to Apex because they help them do their job better. It takes a load off their back when they don't have to go and try to source a device or valve. They can work with Apex and they will help point them in the right direction."

- Alex Marcus OEM

"Serving our customers is always important. And getting things done when we say we are going to get them done is important. So having good partners that share the same values and dedication - Apex has done a great job of doing that since we started working with them.

When you have a vendor that you can work with that makes you look good to your customers, those are the people you want to surround yourselves with. My expectation and need is same day service. That's what I get when I go to Apex."

- Alex Ryan Mechanical Contractor

GIVING BACK

Apex is committed to giving back. We regularly support local charities and dedicate time each year to hands-on volunteer work. That community involvement keeps our team connected, energized, and focused on delivering the same care and commitment to our customers.

Feed My Starving Children
www.fmsc.org

Marici Dawn of Freedom
www.marici.org

Operation Underground Railroad
www.ourrescue.org

Marine Toys for Tots
www.toysfortots.org

St. Jude Children's Research Hospital
www.stjude.org

Properties Of Saturated Steam

Pressure (PSIG)	Temp. (°F)	Heat (BTU/hr)			Volume (ft^3/lb)	
		Sensible	Latent	Total	Condensate	Steam
0	212	180	970	1151	0.01672	26.8
1	215	184	968	1152	0.01674	25.21
2	219	187	966	1153	0.01676	23.79
3	222	190	964	1154	0.01679	22.53
4	224	193	962	1155	0.01681	21.4
5	227	195	961	1156	0.01683	20.38
6	230	198	959	1157	0.01685	19.46
7	232	201	957	1158	0.01687	18.62
8	235	203	956	1159	0.01689	17.85
9	237	206	954	1160	0.01690	17.14
10	239	208	953	1160	0.01692	16.49
12	244	212	950	1162	0.01696	15.33
14	248	216	947	1163	0.01699	14.33
16	252	220	944	1165	0.01702	13.45
18	255	224	942	1166	0.01705	12.68
20	259	228	940	1167	0.01708	11.99
22	262	231	937	1168	0.01711	11.38
24	265	234	935	1169	0.01713	10.83
25	267	236	934	1170	0.01715	10.57
26	268	237	933	1170	0.01716	10.33
28	271	240	931	1171	0.01719	9.874
30	274	243	929	1172	0.01721	9.459
32	277	246	927	1173	0.01723	9.078
34	279	249	925	1174	0.01726	8.728
35	281	250	924	1174	0.01727	8.563
36	282	251	923	1174	0.01728	8.404
38	284	254	922	1175	0.01730	8.104
40	287	256	920	1176	0.01733	7.826
42	289	258	918	1177	0.01735	7.566
44	291	261	916	1177	0.01737	7.323
45	292	262	916	1178	0.01738	7.208
46	294	263	915	1178	0.01739	7.096
48	296	265	913	1178	0.01741	6.883
50	298	267	912	1179	0.01743	6.683
55	303	272	908	1180	0.01748	6.230
60	307	277	905	1182	0.01753	5.837
65	312	282	901	1183	0.01757	5.491
70	316	286	898	1184	0.01761	5.184
75	320	291	895	1185	0.01766	4.911
80	324	295	892	1186	0.01770	4.665
85	328	298	889	1187	0.01774	4.444
90	331	302	886	1188	0.01778	4.242

Properties Of Saturated Steam

Pressure (PSIG)	Temp. (°F)	Heat (BTU/hr)			Volume (ft^3/lb)	
		Sensible	Latent	Total	Condensate	Steam
95	335	306	883	1189	0.01782	4.059
100	338	309	881	1190	0.01785	3.891
105	341	312	878	1190	0.01789	3.736
110	344	316	876	1191	0.01792	3.594
115	347	319	873	1192	0.01796	3.462
120	350	322	871	1192	0.01799	3.34
125	353	325	868	1193	0.01803	3.226
130	356	328	866	1194	0.01806	3.119
135	358	331	864	1194	0.01809	3.02
140	361	333	861	1195	0.01812	2.927
145	363	336	859	1195	0.01815	2.839
150	366	339	857	1196	0.01818	2.756
155	368	341	855	1196	0.01821	2.678
160	371	344	853	1196	0.01824	2.605
165	373	346	851	1197	0.01827	2.535
170	375	349	849	1197	0.01830	2.469
175	377	351	847	1198	0.01833	2.407
180	380	353	845	1198	0.01835	2.347
185	382	355	843	1198	0.01839	2.291
190	384	358	841	1199	0.01841	2.237
195	386	360	839	1199	0.01844	2.185
200	388	362	837	1199	0.01847	2.136
205	390	364	836	1200	0.01850	2.089
210	392	366	834	1200	0.01852	2.044
215	394	368	832	1200	0.01855	2.001
220	395	370	830	1200	0.01857	1.96
225	397	372	829	1201	0.01860	1.92
230	399	374	827	1201	0.01863	1.882
235	401	376	825	1201	0.01865	1.845
240	403	378	823	1201	0.01868	1.81
245	404	380	822	1202	0.0187	1.776
250	406	382	820	1202	0.01873	1.744
255	408	384	818	1202	0.01875	1.712
260	409	385	817	1202	0.01878	1.682
265	411	387	815	1202	0.0188	1.652
270	413	389	814	1203	0.01882	1.624
275	414	391	812	1203	0.01885	1.596
280	416	392	811	1203	0.01887	1.57
285	417	394	809	1203	0.01889	1.544
290	419	396	808	1203	0.01891	1.52
295	420	397	806	1203	0.01894	1.497
300	422	399	805	1203	0.01896	1.473

Draining Condensate from Steam Mains or Steam Supply Lines *(Charts Assume All Pipes are Insulated with 80% Efficiency)*

Warm Up Loads in pounds of Condensate Per Hour Per 100 Ft of Steam Main

Warm Up Loads are Based on a 1 Hour Warm Up Time. Outside Temperature at 70°F.
Based on Sch. 40 Pipe Up to 250 PSI; Sch. 80 Above 250 PSI; Sch. 120, 5" & Larger, Above 800 PSI

Steam Pressure (PSIG)	Pipe Size														0°F Correction Factor †
	2"	2½"	3"	4"	5"	6"	8"	10"	12"	14"	16"	18"	20"	24"	
0	6.2	9.7	12.8	18.2	24.6	31.9	48	68	90	107	140	176	207	308	1.50
5	6.9	11	14.4	20.4	27.7	35.9	48	77	101	120	157	198	233	324	1.44
10	7.5	11.8	15.5	22	29.9	38.8	58	83	109	130	169	213	251	350	1.41
20	8.4	13.4	17.5	24.9	33.8	44	66	93	124	146	191	241	284	396	1.37
40	9.9	15.8	20.6	29.3	39.7	52	78	110	145	172	225	284	334	465	1.32
60	11	17.5	22.9	32.6	44	57	86	122	162	192	250	316	372	518	1.29
80	12	19	24.9	35.3	48	62	93	132	175	208	271	342	403	561	1.27
100	12.8	20.3	26.6	37.8	51	67	100	142	188	222	290	366	431	600	1.26
125	13.7	21.7	28.4	40	55	71	107	152	200	238	310	391	461	642	1.25
150	14.5	23	30	43	58	75	113	160	212	251	328	414	487	679	1.24
175	15.3	24.2	31.7	45	61	79	119	169	224	265	347	437	514	716	1.23
200	16	25.3	33.1	47	64	83	125	177	234	277	362	456	537	748	1.22
250	17.2	27.3	35.8	51	69	89	134	191	252	299	390	492	579	807	1.21
300	25	38.3	51	75	104	143	217	322	443	531	682	854	1045	1182	1.20
400	27.8	43	57	83	116	159	241	358	493	590	759	971	1163	1650	1.18
500	30.2	46	62	91	126	173	262	389	535	642	825	1033	1263	1793	1.17
600	32.7	50	67	98	136	187	284	421	579	694	893	1118	1367	1939	1.16
800	38	58	77	113	203	274	455	670	943	1132	1445	1835	2227	3227	1.16
1000	45	64	86	126	227	305	508	748	1052	1263	1612	2047	2485	3601	1.15
1200	52	72	96	140	253	340	566	833	1172	1407	1796	2280	2767	4010	1.14
1400	62	79	106	155	280	376	626	922	1297	1558	1988	2524	3064	4440	1.13
1600	71	87	117	171	309	415	692	1018	1432	1720	2194	2786	3382	4901	1.13
1750	78	94	126	184	333	448	746	1098	1544	1855	2367	3006	3648	5285	1.13
1800	80	97	129	189	341	459	764	1125	1584	1902	2427	3082	3741	5420	1.13

Running Loads in Pounds of Condensate Per Hour Per 100 Ft of Steam Main

Outside Temperature at 70°F

Steam Pressure (PSIG)	Pipe Size														0°F Correction Factor †
	2"	2½"	3"	4"	5"	6"	8"	10"	12"	14"	16"	18"	20"	24"	
10	6	7	9	11	13	16	20	24	29	32	36	39	44	53	1.58
30	8	9	11	14	17	20	26	32	38	42	48	51	57	68	1.50
60	10	12	14	18	24	27	33	41	49	54	62	67	74	89	1.45
100	12	15	18	22	28	33	41	51	61	67	77	83	93	111	1.41
125	13	16	20	24	30	36	45	56	66	73	84	90	101	121	1.39
175	16	19	23	26	33	43	53	66	78	86	98	107	119	141	1.38
250	18	22	27	34	42	50	62	77	92	101	116	126	140	168	1.36
300	20	25	30	37	46	54	68	85	101	111	126	138	154	184	1.35
400	23	28	34	43	53	63	80	89	118	130	148	162	180	216	1.33
500	27	33	39	49	61	73	91	114	135	148	170	185	206	246	1.32
600	30	37	44	55	68	82	103	128	152	167	191	208	232	277	1.31
800	36	44	53	69	85	101	131	164	194	214	244	274	305	365	1.30
1000	43	52	63	82	101	120	156	195	231	254	290	326	363	435	1.27
1200	51	62	75	97	119	142	185	230	274	301	343	386	430	515	1.26
1400	60	73	89	114	141	168	219	273	324	356	407	457	509	610	1.25
1600	69	85	103	132	163	195	253	314	375	412	470	528	588	704	1.22
1750	76	93	113	145	179	213	278	347	411	452	516	580	645	773	1.22
1800	79	96	117	150	185	221	288	358	425	467	534	600	667	800	1.21

† **For Outside Temperatures of 0°F, Multiply Load Value Selected From Table by Correction Factor Shown.**

Steam Capacity Tables

This chart provides a simple method for sizing steam pipes with velocities in the range of 7,000 to 10,000 ft/min.

(Example: a 1" pipes with 100 PSIG steam pressure has a flow rate of 672 lbs/hr at a velocity of 7,250 ft/min.)

Steam Capacity - Flow in lbs/hr

Pressure (PSIG)	Temp (°F) (sat.)	Full-Port Valve *or* Pipe Size																
		¼	⅜	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12
		Velocity (FPM)																
		7062	7094	7125	7187	7250	7312	7375	7500	7625	7750	7875	8000	8250	8500	9000	9500	10000
250	406	176	324	518	916	1498	2615	3591	6018	8731	13700	18620	24360	39470	58730	107700	179200	267700
200	388	143	264	423	748	1223	2135	2932	4913	7128	11190	15200	19880	32230	47950	87910	146300	218500
175	378	127	235	375	664	1086	1895	2603	4361	6328	9931	13490	17650	28610	42560	78040	129800	194000
150	366	111	205	328	580	948	1655	2273	3810	5528	8675	11790	15420	24990	37180	68170	113400	169500
125	353	95	175	280	496	811	1415	1943	3256	4724	7414	10070	13180	21360	31780	58260	96940	144800
100	338	79	145	232	411	672	1173	1612	2701	3919	6150	8356	10930	17720	26360	48330	80410	120100
90	331	72	133	213	377	617	1076	1478	2477	3594	5641	7665	10030	16250	24180	44330	73760	110200
80	324	66	121	194	343	561	979	1345	2254	3270	5132	6973	9122	14780	22000	40330	67100	100300
70	316	59	109	175	309	505	881	1211	2029	2943	4619	6277	8211	13310	19800	36300	60400	90240
60	308	53	97	155	274	449	783	1076	1803	2616	4105	5577	7296	11820	17590	32260	53670	80190
50	298	46	85	136	240	392	684	940	1575	2286	3587	4874	6376	10330	15380	28190	46900	70080
40	287	39	72	116	205	335	585	803	1346	1953	3066	4166	5449	8831	13140	24090	40080	59890
30	274	33	60	96	170	278	485	666	1115	1618	2539	3451	4514	7315	10880	19960	33200	49610
25	267	29	54	86	152	249	434	596	999	1449	2274	3090	4042	6551	9747	17870	29730	44430
20	259	26	47	76	134	219	383	526	881	1279	2006	2726	3566	5780	8600	15770	26230	39200
15	250	22	41	66	116	190	331	455	763	1107	1737	2360	3087	5003	7444	13650	22710	33930
10	240	19	35	55	98	160	279	384	643	933	1464	1990	2603	4218	6276	11510	19150	28610
5	228	15	28	45	79	130	227	311	522	757	1188	1615	2112	3423	5093	9339	15540	23220
0	212	11	21	34	60	97	170	233	391	568	891	1210	1583	2566	3818	7000	11650	17400

This table represents steam loss through an orifice on a failed open steam trap, assuming that 25% of the flow consists of condensate.

Steam Flow - Through Various Orifice Diameters Discharging to Atmosphere (0 PSIG) in lbs/hr

Orifice Diameter (Inches)	Inlet Pressure (PSIG)												
	2	5	10	15	25	50	75	100	125	150	200	250	300
1/32	0.31	0.47	0.58	0.70	0.94	1.53	2.12	2.70	3.30	3.90	5.10	6.30	7.40
1/16	1.25	1.86	2.30	2.80	3.80	6.10	8.50	10.80	13.20	15.60	20.30	25.10	29.80
3/32	2.81	4.20	5.30	6.30	8.45	13.80	19.10	24.40	29.70	35.10	45.70	56.40	67.00
1/8	4.50	7.50	9.40	11.20	15.00	24.50	34.00	43.40	52.90	62.40	81.30	100.00	119.00
5/32	7.80	11.70	14.60	17.60	23.50	38.30	53.10	67.90	82.70	97.40	127.00	156.00	186.00
3/16	11.20	16.70	21.00	25.30	33.80	55.10	76.40	97.70	119.00	140.00	183.00	226.00	268.00
7/32	15.30	22.90	28.70	34.40	46.00	75.00	104.00	133.00	162.00	191.00	249.00	307.00	365.00
1/4	20.00	29.80	37.40	45.00	60.10	98.00	136.00	173.00	212.00	250.00	325.00	401.00	477.00
9/32	25.20	37.80	47.40	56.90	76.10	124.00	172.00	220.00	268.00	316.00	412.00	507.00	603.00
5/16	31.20	46.60	58.50	70.30	94.00	153.00	212.00	272.00	331.00	390.00	508.00	627.00	745.00
11/32	37.70	56.40	70.70	85.10	114.00	185.00	257.00	329.00	400.00	472.00	615.00	758.00	901.00
3/8	44.90	67.10	84.20	101.00	135.00	221.00	306.00	391.00	478.00	561.00	732.00	902.00	1073.00
13/32	52.70	78.80	98.80	119.00	159.00	259.00	359.00	459.00	559.00	659.00	859.00	1059.00	1259.00
7/16	61.10	91.40	115.00	138.00	184.00	300.00	416.00	532.00	648.00	764.00	996.00	1228.00	1460.00
15/32	70.20	105.00	131.00	158.00	211.00	344.00	478.00	611.00	744.00	877.00	1144.00	1410.00	1676.00
1/2	79.80	119.00	150.00	180.00	241.00	392.00	544.00	695.00	847.00	998.00	1301.00	1604.00	1907.00

Velocity to GPM Conversions

in standard wall pipes*
Flow Velocity (ft/sec) x Factor (1 ft/sec) = GPM
Typical HVAC Design Maximum Flow = 4 to 8 ft/sec

Nominal Pipe Size	GPM @ 1 Ft/Sec	GPM @ 4 Ft/Sec	GPM @ 8 Ft/Sec	GPM @ 12 Ft/Sec
0.5*	0.9	3.8	7.6	11.4
0.75*	1.7	6.6	13	20
1*	2.7	12	24	36
1.25*	4.7	19	37	56
1.5*	6.4	25	51	76
2*	11	42	84	126
2.5*	15	60	119	179
3*	23	92	184	279
4*	40	159	318	476
6*	90	360	720	1,080
8*	156	624	1,248	1,872
10*	246	984	1,968	2,952
12	353	1,412	2,824	4,236
14	430	1,720	3,440	5,160
16	569	2,276	4,552	6,828
18	728	2,912	5,824	8,736
20	907	3,628	7,256	10,884
24	1,323	5,292	10,584	15,876
30	2,094	8,378	16,755	25,133
36	3,042	12,168	24,336	36,504
42	4,165	16,660	33,320	49,980
48	5,465	21,861	43,722	65,583

*Standard wall and Schedule 40 are the same up to 10"

Formulas

$$GPM = \frac{BTU/hr}{500 \times \Delta T}$$

$$GPM = BHP \times 0.069$$

$$GPM = \frac{Tons \times 24}{\Delta T}$$

$$GPM = \frac{Steam(lbs/hr)}{500}$$

$$CFM = \frac{BTU/hr}{1.08 \times \Delta T}$$

$$BTU/hr = GPM \times \Delta T \times 500$$

$$BTU/hr = CFM \times \Delta T \times 1.08$$

$$BTU/hr = 500 \times Flow\ \ Rate(GPM) \times \Delta T(^{\circ}F)$$

Conversions	
1PSI	2.31 Ft of H_2O
1 Gallon H_2O	8.33 lbs
1 Ft^3 H_2O	7.48 Gallons
1 Ft^3 H_2O	62.3 lbs
1 Boiler Horsepower (BHP)	33,475 BTU/hr
1 PPH Steam	BTU/970
1 Ton	12,000 BTU
1 HP	746 Watts
1 Watt	3,413 BTU/hr
1 Therm	100,000 BTU/hr
°F	(°C x 1.8) + 32
°C	(°F - 32) /1.8

› Multiply	By	To Obtain
To Obtain	By	Divide ‹
BAR	14.697	Pounds per sq. in
Atmospheres	29.92	Inches of mercury
Barrels (petroleum)	42	Gallons
Barrels per day	0.0292	Gallons per minute
Bars-G	14.5	Pounds per sq. in
Cubic Feet per second	448.833	Gallons per minute
Cubic Inches	0.004329	Gallons
Feet	0.3048	Meters
Feet	0.3333	Yards
Feet	30.48	Centimeters
Feet of water	0.882	Water column
Gallons of water	8.328	Pounds (@ 70°F)
Gallons of liquid per minute	500 x Sp. Gr.	Pounds per hr liquid (@ 70°F)
Boiler Horsepower (BHP)	34.5	Pounds water per hour evaporation
Boiler Horsepower (BHP)	33479	BTU per hour
Inches	2.54	Centimeters
Kilograms	2.205	Pounds
KPAs	0.145	Pounds per sq. in
Pounds	0.4536	Kilograms
Pounds	16	Ounces
Pounds per sq. in	27.684	Inches of water
Pounds per sq. in	2.036	Inches of mercury
Specific Gravity (of gas or vapors)	28.97	Molecular Weight (of gas or vapors)

Definition Of Units	
C_V	Valve Flow Coefficient
Q	Volumetric Flow Rate of Liquid (US GPM)
P_1	Absolute Inlet Pressure (psia)
P_2	Absolute Outlet Pressure (psia)
ΔP	Pressure Drop (PSI) = P_1 - P_2
G	Specific Gravity of the Liquid
P_V	Vapor Pressure of the Liquid

Formulas for Control Valve Sizing for Liquids with Normal Flow

When: $\Delta P < K_c (P_1 - P_V)$:

$$Q = C_V \sqrt{\frac{\Delta P}{G}}$$ Flow rate based on C_V and ΔP

$$C_V = Q \sqrt{\frac{G}{\Delta P}}$$ C_V required based on Flow Rate & ΔP

$$\Delta P = \left[\frac{Q}{C_V}\right]^2 G$$ Pressure drop across valve based on Flow Rate and C_V

Valve Sizing Example:

A control valve is needed that will handle a maximum flow rate of 100 GPM of water @ 180°F. Since the temperature of the water is elevated, cavitation becomes a concern. Determine the maximum pressure drop across the control valve before cavitation will occur. Based on this maximum pressure drop, determine the required minimum C_V value of the control valve.

Conditions of Service:

- **Q =** 100GPM
- **T =** 180°F Water
- **P_1 =** 50 PSIG = 64.7PSIA

1. To determine the ΔP across the valve when cavitation could potentially occur, use the formula: **$\Delta P_C = K_C(P_1 - P_V)$**

$$\Delta P_C = K_C(P_1 - P_V)$$
$$= 0.53(64.7 - 7.51)$$
$$= 30 \text{ PSI}$$

$K_C = 0.65\ F_L^2 = 0.65\ (0.9)^2 = 0.53$

(For Globe Valve)

$P_V = 7.51$ @ 180°F for Water

(See Chart)

2. Determine the minimum C_V of the control valve at the maximum ΔP of 30 PSI.

$$C_V = Q\sqrt{\frac{G}{\Delta P}}$$
$$= 100\sqrt{\frac{0.972}{30}}$$
$$= 18$$

$G = 0.972$ @ 180°F for Water

(See Chart)

NOTE: Since a minimum C_V of 18 was calculated, we could choose a 1-½" HB Globe Style Control Valve which has a C_V = 22

Potential for Cavitation

Cavitation can occur when the pressure inside the control valve drops below the vapor pressure (Pv) of the liquid. Cavitation should be avoided because it restricts flow rate, generates noise, and may reduce life expectancy of internal components.

When ΔP < KC (P1 - PV), the Standard Flow Equation will predict performance. When ΔP ≥ KC (P1 - PV), cavitation may occur and the accuracy of the normal flow equation may be reduced.

Definition of Units	
F_L	The valve pressure recovery factor. For globe style control valve. F_L = 0.9
K_C	Based on when a 2% reduction of normal flow rate occurs. (0.65 proportionality constant is used for conservative determination of cavitation)
P_1	Vapor Pressure of the Liquid (psia)

Water Physical Properties		
Temp (°F)	G (Ref to 60°F)	P_V (PSIA)
32	1.001	0.09
40	1.001	0.12
50	1.001	0.18
60	1.000	0.26
70	0.999	0.36
80	0.998	0.51
90	0.996	0.70
100	0.994	0.95
120	0.990	1.69
140	0.985	2.89
160	0.979	4.74
180	0.972	7.51
200	0.964	11.5
212	0.959	14.7

Control Valve Sizing for Saturated Steam

The following formulas for Valve Sizing are based on ISA Standard 75.01.01-2007 (60534-2-1 Mod). The formulas assume pipe sizes equal to the size of the valve ports, with no attached fittings.

Definition Of Units			
Cv	Valve Flow Coefficient	γ	Heat Capacity Ratio for Steam = 1.3 (0 - 300 PSIG)
ΔP	Pressure Drop (PSI) = P_1 - P_2	Fγ	Heat Capacity Ratio Factor for Steam = γ/1.4 = 1.3/1.4 = 0.93
P_1	Absolute Inlet Pressure (PSIA)	x	Pressure Drop Ratio = ΔP/P_1
P_2	Absolute Outlet Pressure (PSIA)	ΔP_{CR}	Critical Pressure Drop
W	Saturated Steam Flow (lbs/hr)	x_T	Critical Pressure Drop Ratio for Air
T_1	Steam Inlet Temperature (°R) (see table)	x_{CR}	Critical Pressure Drop for Steam = ΔPCR/P1 = Fγ x_T = 0.93 x_T
Z_1	Steam Compressibility Factor (see table)		

For Sub-Critical Flow:

$$Cv = \frac{W}{82 \quad P_1(1 - x/3x_{cr})\sqrt{x/(T_1 Z_1)}}$$

When $\Delta P/P_1 < x_{cr}$: $x = \Delta P/P_1$

For Critical Flow:

$$Cv = \frac{W}{54.6 \quad P_1\sqrt{x_{cr}/(T_1 Z_1)}}$$

When $\Delta P/P_1 \geq x_{cr}$

For single-ported globe valve with flow-to-open seating arrangement:

$x_T = 0.72$ $\qquad$ $x_{cr} = 0.93 x_T = 0.67$

$$Cv = \frac{W}{82 \quad P_1(1 - x/2)\sqrt{x/(T_1 Z_1)}}$$

When $\Delta P/P_1 < 0.67$

$$Cv = \frac{W}{54.6 \quad P_1\sqrt{0.67/(T_1 Z_1)}}$$

When $\Delta P/P_1 \geq 0.67$

Saturated Steam Table			
P_1 PSIG	P_1 PSIA	T_1 (°R)	Z_1
0	14.7	672	0.985
10	24.7	699	0.978
20	34.7	718	0.973
30	44.7	734	0.968
40	54.7	746	0.963
50	64.7	757	0.959
60	74.7	767	0.955
70	84.7	776	0.951
80	94.7	784	0.947
90	104.7	791	0.943
100	114.7	798	0.940
110	124.7	804	0.936
120	134.7	810	0.933
130	144.7	815	0.930
140	154.7	821	0.927
150	164.7	826	0.923
160	174.7	830	0.920
170	184.7	835	0.917
180	194.7	839	0.915
190	204.7	843	0.912
200	214.7	848	0.909
210	224.7	851	0.906
220	234.7	855	0.903
230	244.7	859	0.901
240	254.7	862	0.898
250	264.7	866	0.895
260	274.7	869	0.893
270	284.7	872	0.890
280	294.7	875	0.888
290	304.7	879	0.885
300	314.7	882	0.883

Example:

Determine the Cv value for a Control Valve with a 60PSIG Inlet Steam Pressure, 30PSIG Outlet Pressure, and a Flow Rate of 4,000 lbs/hr.

- **W** = 4,000 lbs/hr
- **P_1** = 60 PSIG = 74.7 PSIA
- **P_2** = 30 PSIG = 44.7 PSIA
- **ΔP** = 30PSI
- x = ΔP/P1 = 30/0.72 = 0.67
- x_{CR} = 0.93x_T =0.93 x 0.72 x 0.67
- Since $x < x_{CR}$ flow is sub-critical
- **T_1** = 767 (from table)

$$Cv = \frac{W}{82 \quad P_1(1 - x/2)\sqrt{x/(T_1 Z_1)}}$$

When $\Delta P/P_1 < 0.67$

$$Cv = \frac{4{,}000}{82(74.7)(1 - 0.4/2)\sqrt{0.4(767 \times 0.955)}}$$

$$= \frac{4{,}000}{114.6} = 35$$

Coil Sizing

$$Q = \quad BTUs \ \ Required \ \ to \ \ Heat \ \ Air$$

$$Q = \quad 1.08 \times CFM \times \Delta T$$

Definition of Sanitary & High Purity Terms & Units		Temperature Ranges
Clean-In-Place (CIP)	Automated cleaning method that cleans the interiors of pipes, tanks, and equipment without disassembly	140°F - 185°F
Steam/Sterilize In Place (SIP)	An extension of the CIP method that involves the use of hot water or saturated steam at high temperatures to sterilize after the CIP process is completed	≥ 165°F
Clean & Sanitize In Place (CSIP)	The proposed updated term for CIP as of 2016. Offers more accuracy of the definition and is easier to say in conversation (pronounced "See-Sip"). CIP is still more commonly used in the industry.	140°F - 185°F
Pre-Rinse	The initial step where water is used to remove loose soil and debris from the equipment's surfaces before chemical cleaning begins	≤ 140°F
Detergent Wash	A cleaning stage using chemical solutions, such as high-pH (caustic) or enzymatic solutions, to break down and dissolve organic materials like fats and proteins.	≤ 140°F
Acid Wash	A wash using low-pH (acidic) solutions to remove mineral deposits and other scales	130°F - 150°F
Rinse	Steps of using water to remove any residual cleaning chemicals or contaminants from the equipment surfaces	≤ 140°F
Flow & Turbulence	CIP systems rely on creating turbulent flow of the cleaning solutions through pipes or spray balls in tanks to mechanically dislodge and remove residues	-
Circulation	The process of pumping cleaning solutions through the assembled equipment in a closed circuit	-
Validation	The process of ensuring and demonstrating that a CIP system consistently achieves a specified level of cleanliness and sanitation for product safety	-
Mechanical Action	The use of high-pressure sprays, turbulent flow, or ultrasonic technology as part of the cleaning process to provide physical removal of contaminants	-
Automation	The high degree of control and minimal operator involvement in the CIP process	-
Circuit	A closed loop system where the CIP cleaning solutions are connected to and circulated through the equipment to be cleaned	-
FPS	Feet per second (used to measure turbulent flow)	-

Definition of Sanitary & High Purity Symbols		Required
3-A	3-A Sanitary Standards are guidelines for the design and fabrication of equipment used in the food, dairy, and pharmaceutical industries to ensure it can be easily cleaned and maintained. These standards require equipment to have smooth surfaces, proper drainage, and durable, corrosion-resistant materials to prevent microbial growth and cross-contamination	Not by law, but most safety regulations encourage it
NSF	A public health standard developed and certified by NSF International, which is an accredited, independent organization. These standards are used to ensure that products like food equipment meet rigorous public health and safety requirements	Not by law, but most safety regulations require it
UL LISTED	UL Listed standards refer to safety and performance standards developed or recognized by UL (Underwriters Laboratories), a global safety certification organization. There are UL Standards that cover thousands of products, including: flammability of plastics, industrial control panels, and more	Not by law, but most safety regulations require it
PMO Pasteurized Milk Ordinance	The Pasteurized Milk Ordinance (PMO) is a set of federal guidelines in the United States that governs the production, processing, and distribution of Grade “A” milk and dairy products. It is issued and maintained by the U.S. Food and Drug Administration (FDA) in cooperation with state regulatory agencies	Yes, especially if milk is sold across state lines
ANSI	ANSI standards are technical standards developed or overseen by the American National Standards Institute (ANSI). These standards ensure products, services, processes, and systems are safe, reliable, and interoperable	Not by law, but most safety regulations require it
ETL	ETU regulations set limits on ethylene thiourea residues or migration in food, packaging, and occupational settings to protect human health from toxic exposure. Compliance involves testing, monitoring, and adhering to legal thresholds	Yes
CSA	CSA Certification refers to a safety and performance certification issued by CSA Group (formerly the Canadian Standards Association), which is an internationally recognized organization that develops standards and tests products to ensure they are safe and compliant	Not in the USA; but it is widely recognized in USA as UL and ANSI compliance

OSHA Combustible Dust List

- Egg White
- Milk, Powdered
- Milk, Non-Fat, Dry
- Soy Flour
- Starch, Corn
- Starch, Rice
- Starch, Wheat
- Sugar
- Sugar, Milk
- Sugar, Beet
- Tapioca
- Whey
- Wood Flour
- Alfalfa
- Apple
- Beet Root
- Carrageen
- Carrot
- Cocoa Bean Dust
- Cocoa Powder
- Coconut Shell Dust
- Coffee Dust
- Corn Meal
- Cornstarch
- Cotton
- Cottonseed
- Garlic Powder
- Gluten
- Grass Dust
- Green Coffee
- Hops (Malted)
- Lemon Peel Dust
- Lemon Pulp
- Linseed
- Locust Bean Gum
- Malt
- Oat Flour
- Oat Grain Dust
- Olive Pellets
- Onion Powder
- Parsley (Dehydrated)
- Peach
- Peanut Meal & Skins
- Peat
- Potato
- Potato Flour
- Potato Starch
- Raw Yucca Seed Dust
- Rice Dust
- Rice Flour
- Rice Starch
- Rye Flour
- Semolina
- Soybean Dust
- Spice Dust
- Spice Powder
- Sugar (10x)
- Sunflower
- Sunflower Seed Dust
- Tea
- Tobacco Blend
- Tomato
- Walnut Dust
- Wheat Flour
- Wheat Grain Dust
- Wheat Starch
- Xanthan Gum
- Charcoal, Activated
- Charcoal, Wood
- Coal, Bituminous
- Coke, Petroleum
- Lampblack
- Lignite
- Peat, 22% H_2O
- Soot, Pine
- Cellulose
- Cellulose Pulp
- Cork
- Corn
- Adipic Acid
- Anthraquinone
- Ascorbic Acid
- Calcium Acetate
- Calcium Stearate
- Carboxy-Methylcellulose
- Dextrin
- Lactose
- Lead Stearate
- Methyl-Cellulose
- Paraformaldehyde
- Sodium Ascorbate
- Sodium Stearate
- Sulfur
- Aluminum
- Bronze
- Iron Carbonyl
- Magnesium
- Zinc
- (Poly) Acrylamide
- (Poly) Acrylonitrile
- (Poly) Ethylene (low pressure process)
- Epoxy Resin
- Melamine Resin
- Melamine, Molded (Phenol-Cellulose)
- Melamine, Molded (Wood Flour & Mineral Filled Phenol-Formaldehyde)
- (Poly) Methyl Acrylate
- (Poly) Methyl Acrylate, Emulsion Powder
- Phenolic Resin
- (Poly) Propylene
- Terpene-Phenol Resin
- Urea-Formaldehyde/Cellulose, Molded
- (Poly) Vinyl Acetate/Ehylene Copolymer
- (Poly) Vinyl Alcohol
- (Poly) Vinyl Butyral
- (Poly) Vinyl Chloride/Ethylene/Vinyl Acetylene Suspension Copolymer
- (Poly) Vinyl Chloride/Vinyl Acetylene Emulsion Copolymer

Selecting Your Industrial Vacuum

A successful industrial vacuum application depends on finding the right balance between airflow and water lift for your specific material and conveying distance.

Material Type	Needs	Vacuum Type
Light, Find Powders (flour, dust, etc.)	High airflow to move large volume of particles	High CFM, moderate water lift
Heavy, Dense Materials (metal chips, blast media, etc.)	High suction power to overcome gravity	High water lift, moderate CFM
Long Conveying Distance (dust/powder settled on top of equipment, etc.)	System must overcome significant pressure drop from pipe friction	High water lift
Fine, Hazardous Dust (combustibles)	Required specialized filtration and explosion-proof certification	HEPA/ULPA filters and Class II ATEX certification

Sizing a Rotary Airlock Valve

To size a rotary airlock valve, calculate the material's volumetric flow rate and compare it to the valve's capacity per revolution.

Calculate Volumetric Capacity Needed:

1. Convert mass flow to volume:
   Mass Flow Rate/Density = Volume
2. Account for efficiency using the formula:

$$C = R \div D \div E \div S$$

Definition of Units	
D	Bulk density of material (lbs/ft³)
R	Conveying rate (PPH)
C	Required volumetric capacity per unit of time (ft³/hr)
E	Valve efficiency, typically 65 - 85%, expressed as a decimal (0.65 - 0.85)
S	Rotor speed

Other factors to consider:

- Frequency of use or duty cycle
- Bulk density of the material being handled
- Flowability of the material
- Rate of flow required
- Whether the rotary airlock valve also functions as metering device, feeds a pressure convey system, or sits under a head of material
- The average size of the material

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