SMC CORPORATION OF AMERICA

Energy Saving in Pneumatic Systems

Ecologically Responsible Pneumatic Systems

Solutions That Save

Objectives

At the end of this course, the student should be able to:

- Formulate an energy saving program
- Quantify the benefits of energy saving
- Identify areas for energy savings
- Implement energy saving opportunities

What is Energy Saving?

- **Energy Saving** is the practice of decreasing the quantity of energy used. It may be achieved through efficient energy use, in which case energy use is decreased while achieving a similar outcome, or by reduced consumption of energy services.

Source: http://en.wikipedia.org/wiki/Energy_conservation

Energy Saving Opportunities

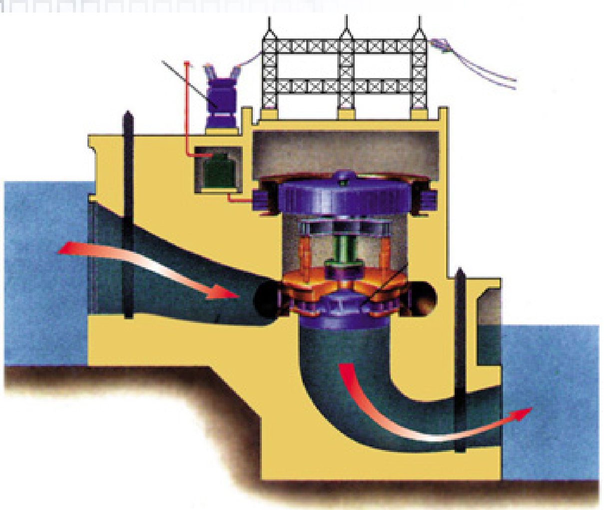
Over 95 percent of compressed air systems have low-cost energy saving opportunities.

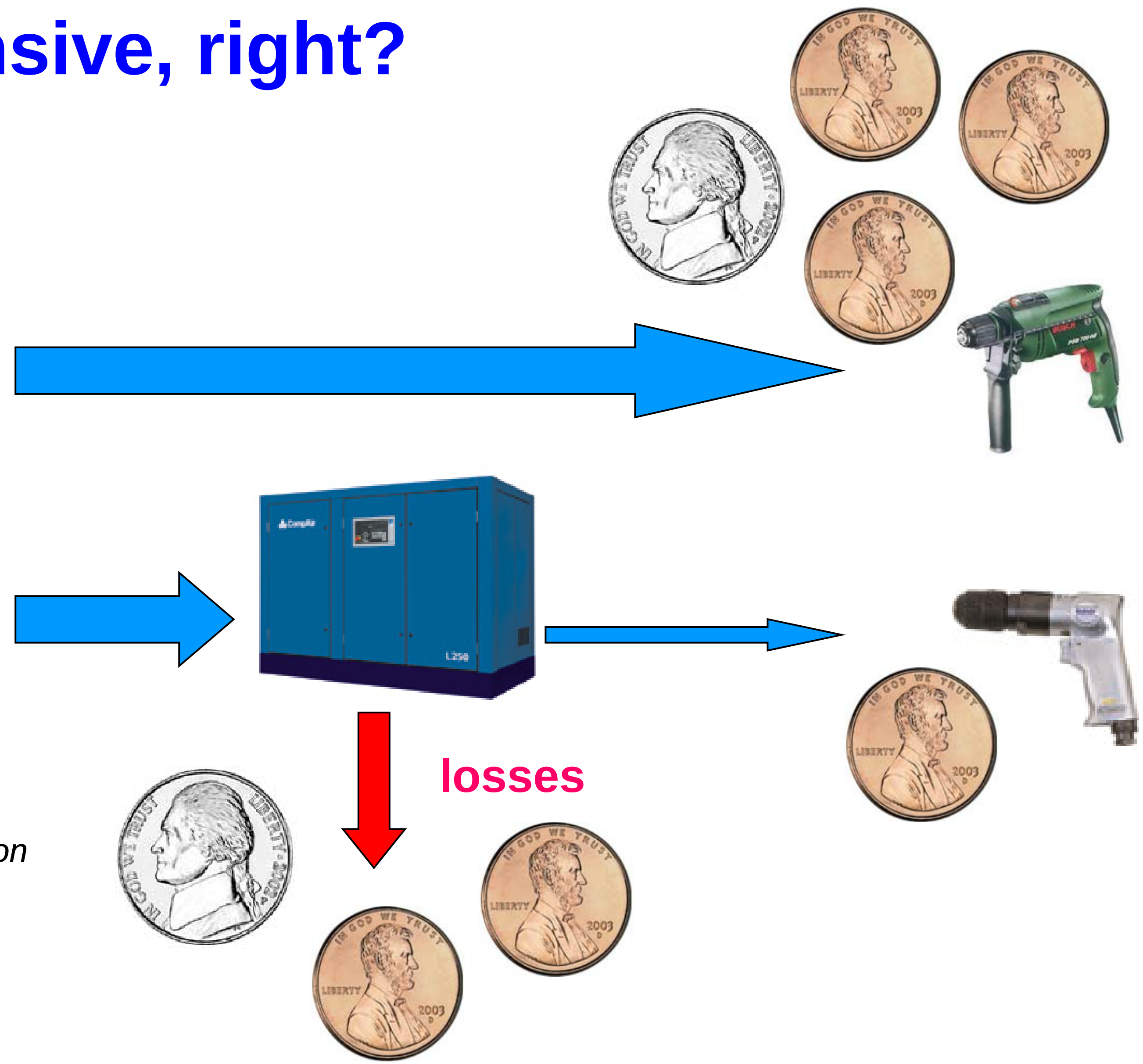
- Based on audits conducted by the U.S. Department of Energy

Energy Saving Opportunities

Why don't we stop using compressed air?

- It's expensive, right?





1 Kwh. ~ $0.08

Source: Energy Information Administration

Cost of Electricity

Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, September 2009

(Cents per kilowatthour)	Residential	Commercial	Industrial
Census Division	Sep-2009	Sep-2009	Sep-2009
New England	17.68	15.23	13.3
Middle Atlantic	16.22	14.09	8.42
East North Central	11.44	9.14	6.59
West North Central	9.74	7.66	5.96
South Atlantic	11.66	9.7	6.65
East South Central	9.55	9.04	5.7
West South Central	11.29	8.94	5.99
Mountain	10.81	8.96	6.65
Pacific Contiguous	13.74	13.43	9.25
Pacific Noncontiguous	22.53	19.43	18.2

Source: Energy Information Administration

http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html

Cost of Compressed Air

Calculations will typically use these values:

- **8,760 hours of operation**
  - **(24 hours/day X 365 days/year = theoretical maximum)**
- **90% electrical motor efficiency (0.90)**
- **4 SCFM per BHP (Brake Horsepower)**
- **$0.10 per Kw hour (varies per location, see page 6).**

The power-cost formula is:

$$Annual\ Cost = \frac{BHP \times 0.746 \times Hours\ of\ Operation \times Cost\ per\ kWh}{Motor\ Efficiency}$$

For example: The annual cost of running a 200 HP compressor:

$$Annual\ Cost = \frac{200 \times 0.746 \times 8760 \times \$0.10}{0.90} = \$145{,}221.33$$

Cost of Compressed Air

Let's look at this another way. . .

What is the annual cost of an air leak?

We have a leak in our system and we're losing 5 SCFM.

- **Convert SCFM to BHP** 5 SCFM / 4 SCFM per BHP = 1.25 BHP
- **Apply the formula** 1.25 x 0.746 x 8,760 x 0.10 / 0.90 = **$908/year**

For another example. . .

What is our air blow application costing us?

- **We use 9 SCFM in the application.** 9 SCFM / 4 SCFM per BHP = 2.25 BHP
- **The annual cost** 2.25 x 0.746 x 8,760 x 0.10 / 0.90 = **$1,634/year**

Why do we use compressed air?

- **When managed properly, compressed air is still the best power transmission system!**

Energy cost	Low	High
Installation	Complex	Simple
Initial cost	High	Low
Replacement Cost	High	Low
Service Life	Short	Long

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Why do we use compressed air?

- **Compressed air is frequently used in industry because of its favorable features, however it can be <u>expensive when not properly managed!</u>**

Hole Size	Leakage	Annual Cost
1/16 inch	6 SCFM	$1,089
1/8 inch	26 SCFM	$3577
1/4 inch	104 SCFM	$14,308

At $0.08/kWh, 8760 hours/year

Why save energy?

The decision to implement an energy savings program in a compressed air and pneumatic system is usually based on two main factors:

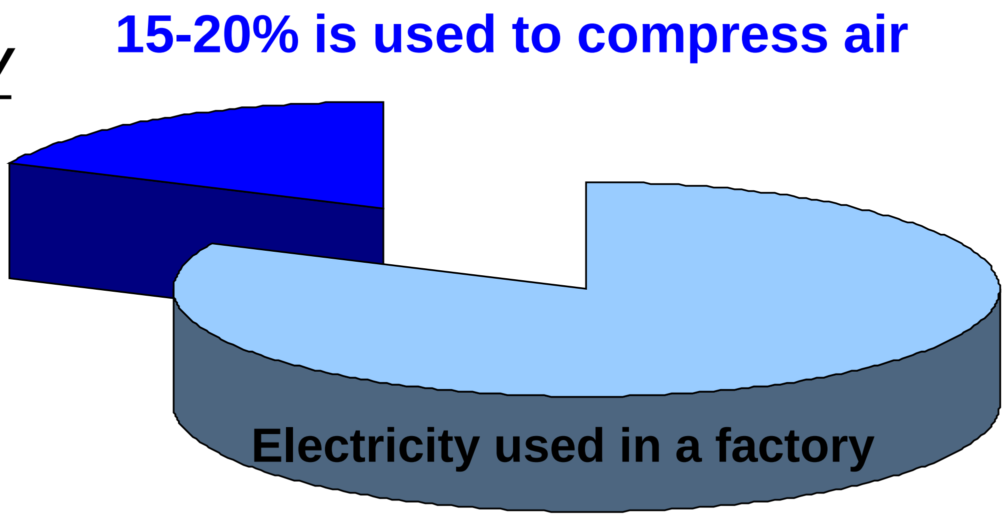
<u>Operational cost savings</u>

($ directly into your pocket!)

<u>Environmental Responsibility</u>

Reducing energy consumption

(Reducing carbon footprint)



Why save energy?

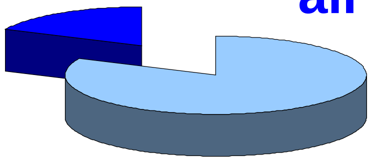
The following benefits occur after energy savings measures are implemented:

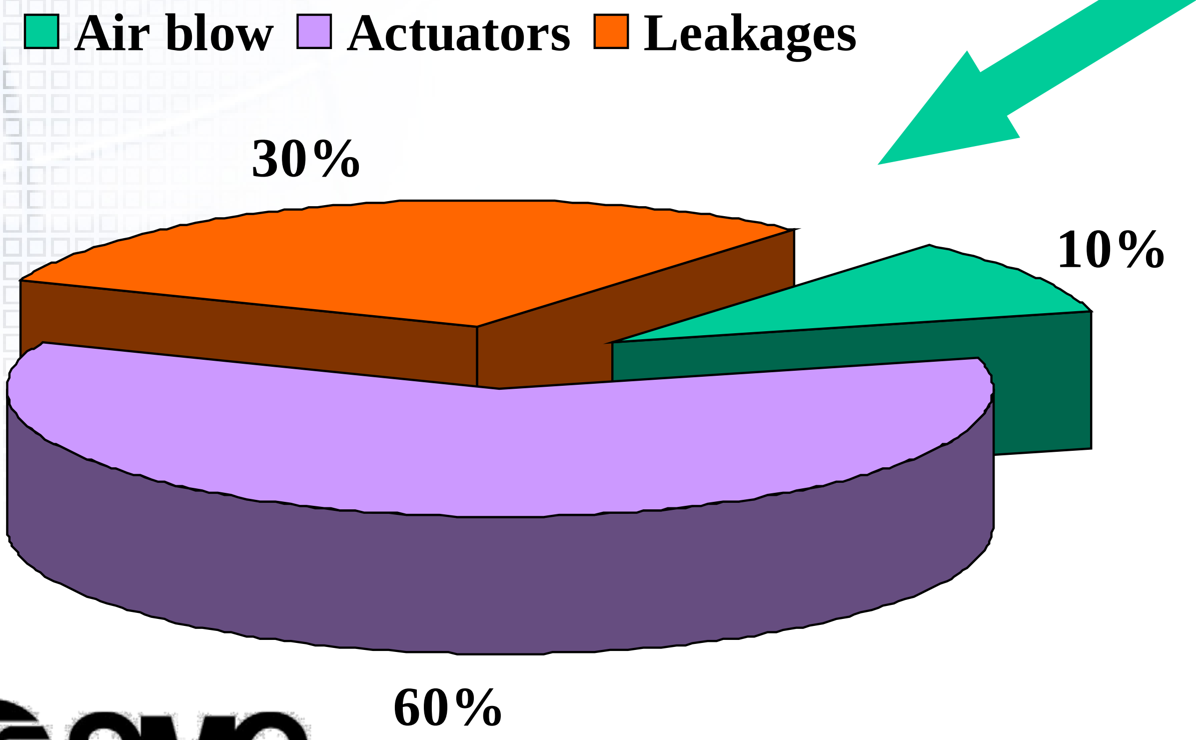
- Reduction in maintenance
- Decreased downtime
- Increased production
- Decreased scrap rate
- Decreased number of compressors in operation

Where is the energy used?

Compressed air consumption by application

15-20% of electricity used in a factory is used to compress air

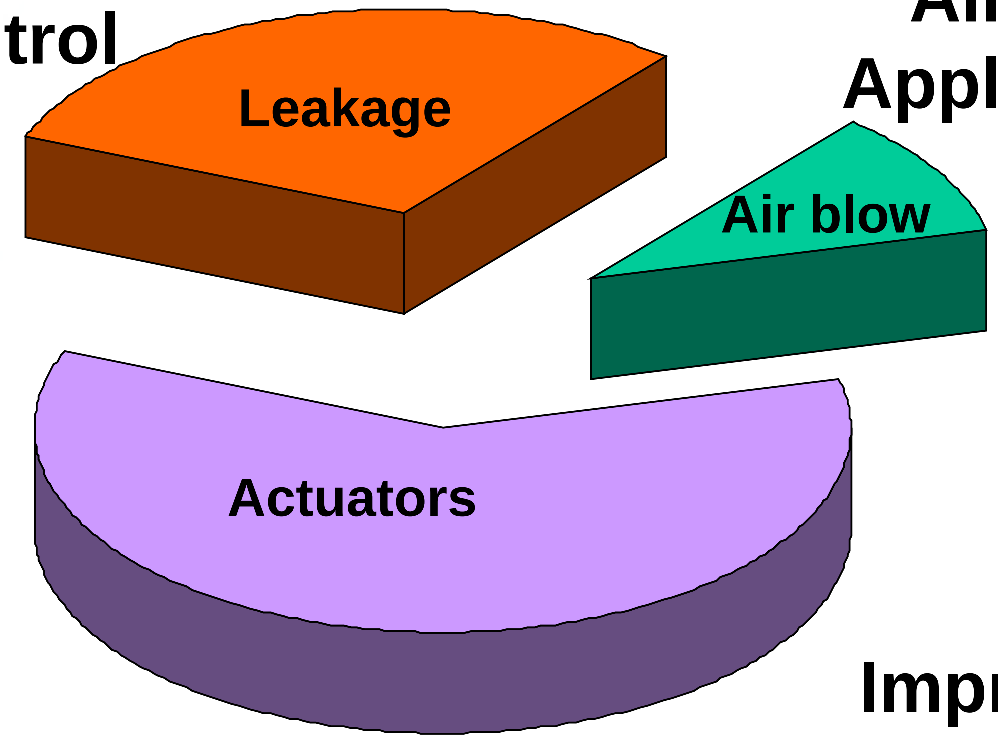




How can we save energy in each of these areas?

System monitoring and leakage control

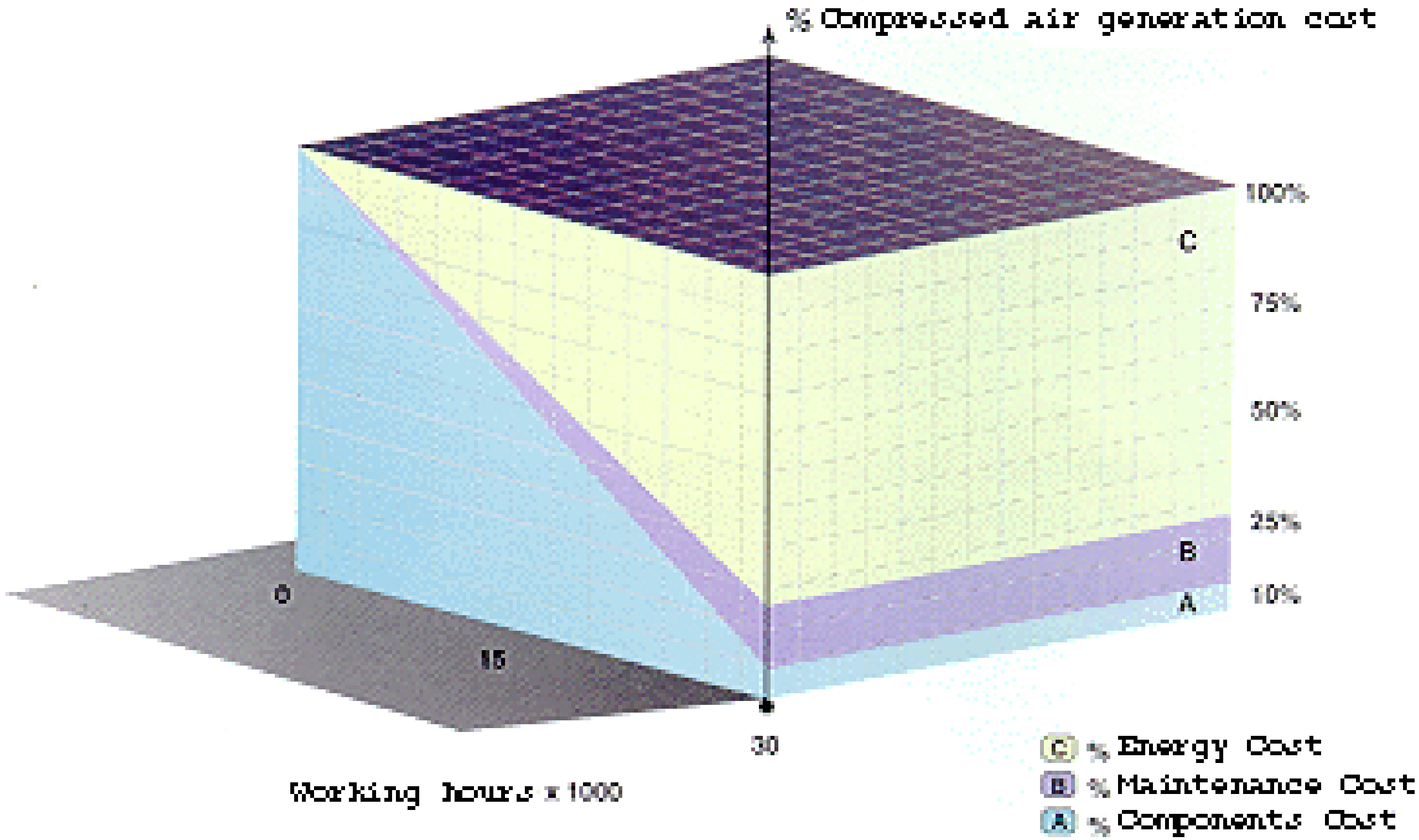
Optimization of Air-Blow Applications



Improvement of actuator systems

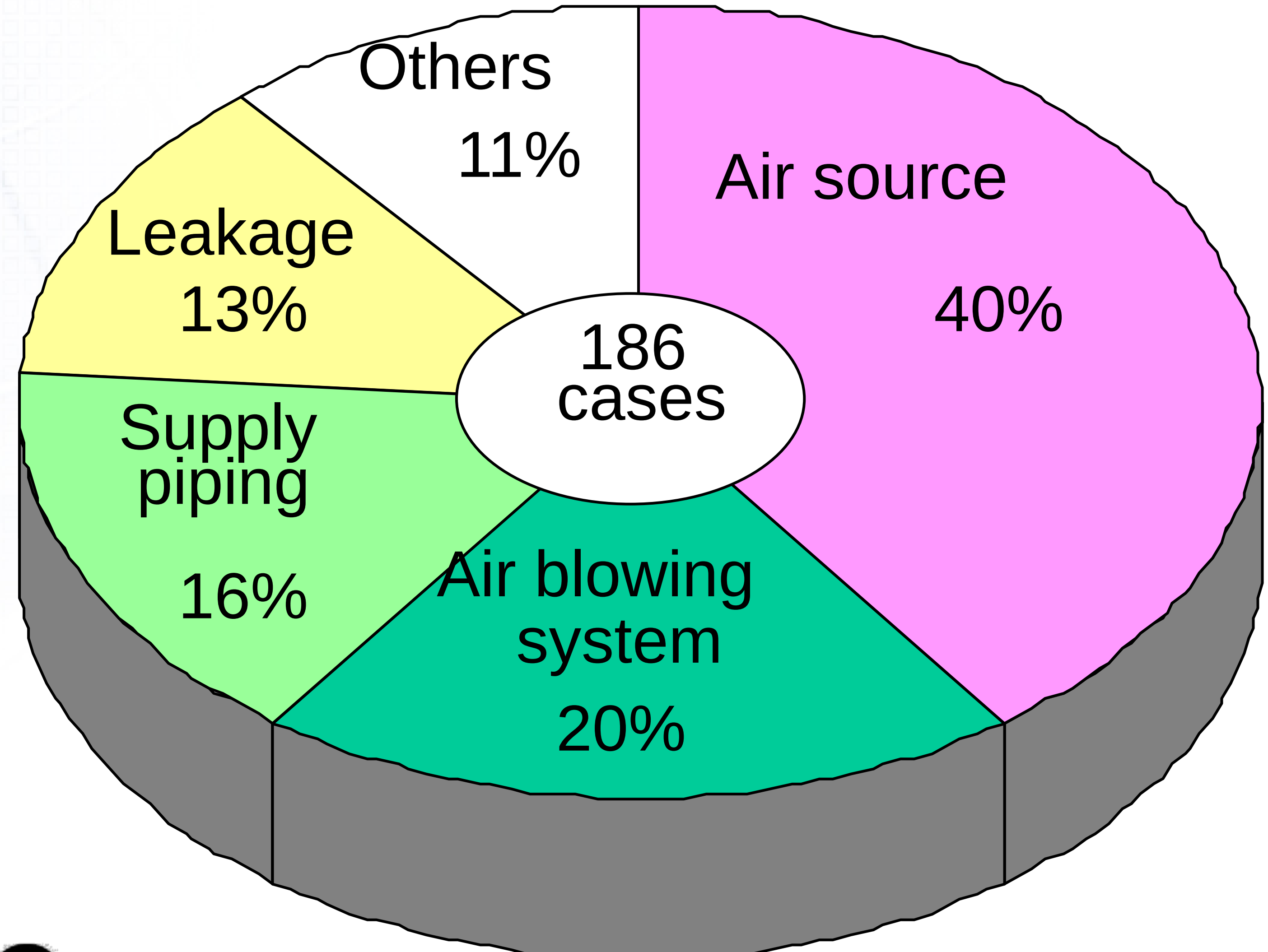
How can we save money?

- **Electricity accounts for approximately 80% of the total cost of operating a pneumatic system. A small increase in the amount spent on maintenance will considerably reduce the electricity cost.**

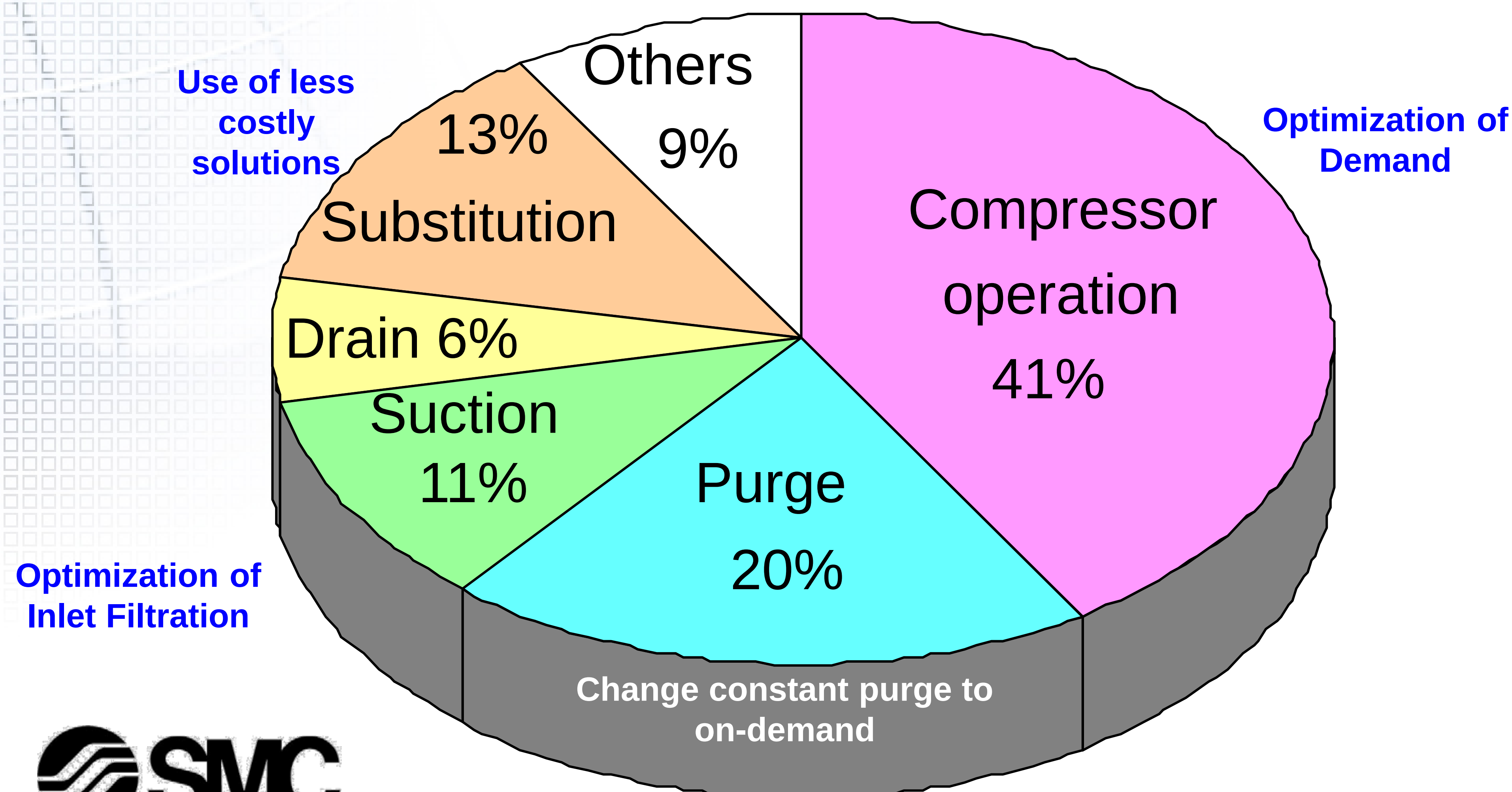


Where can we save energy?

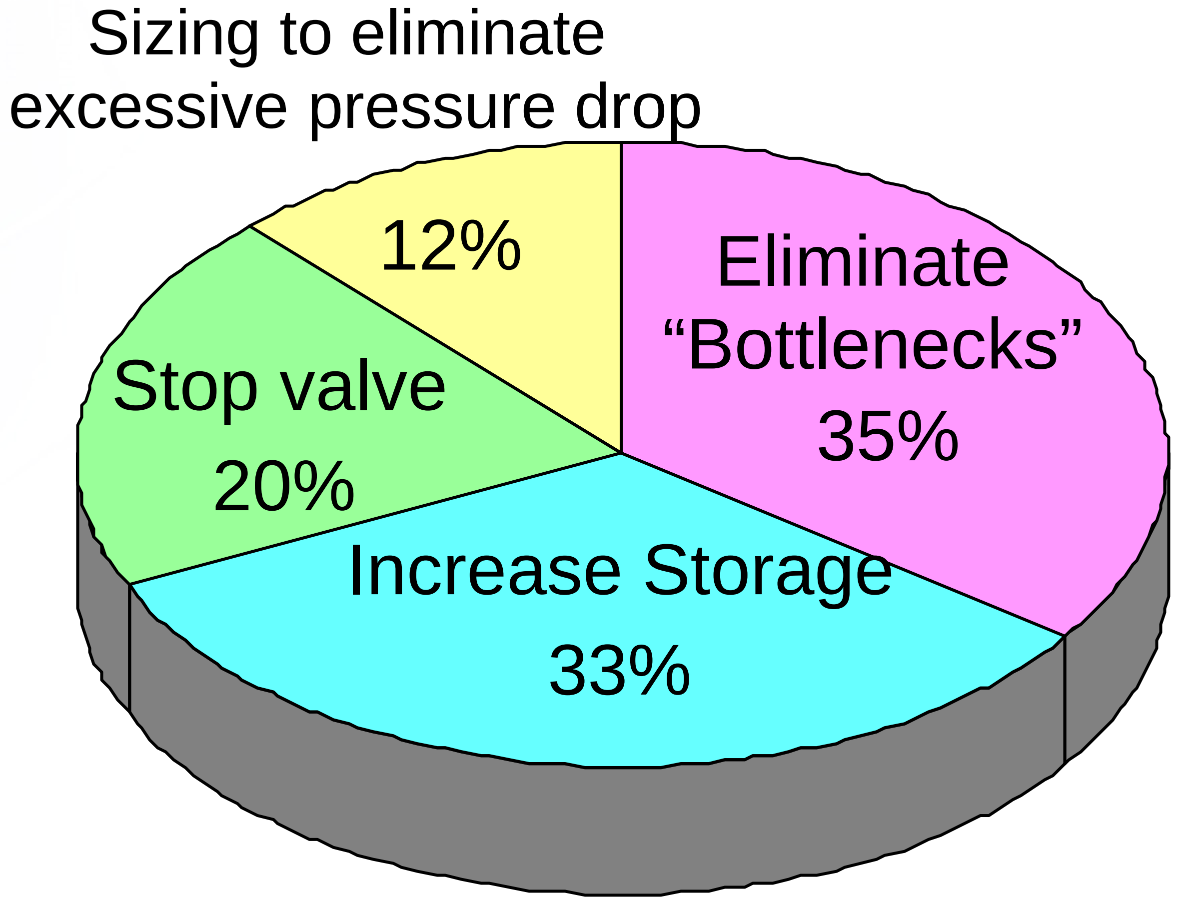
Statistics based on 186 case studies performed by SMC



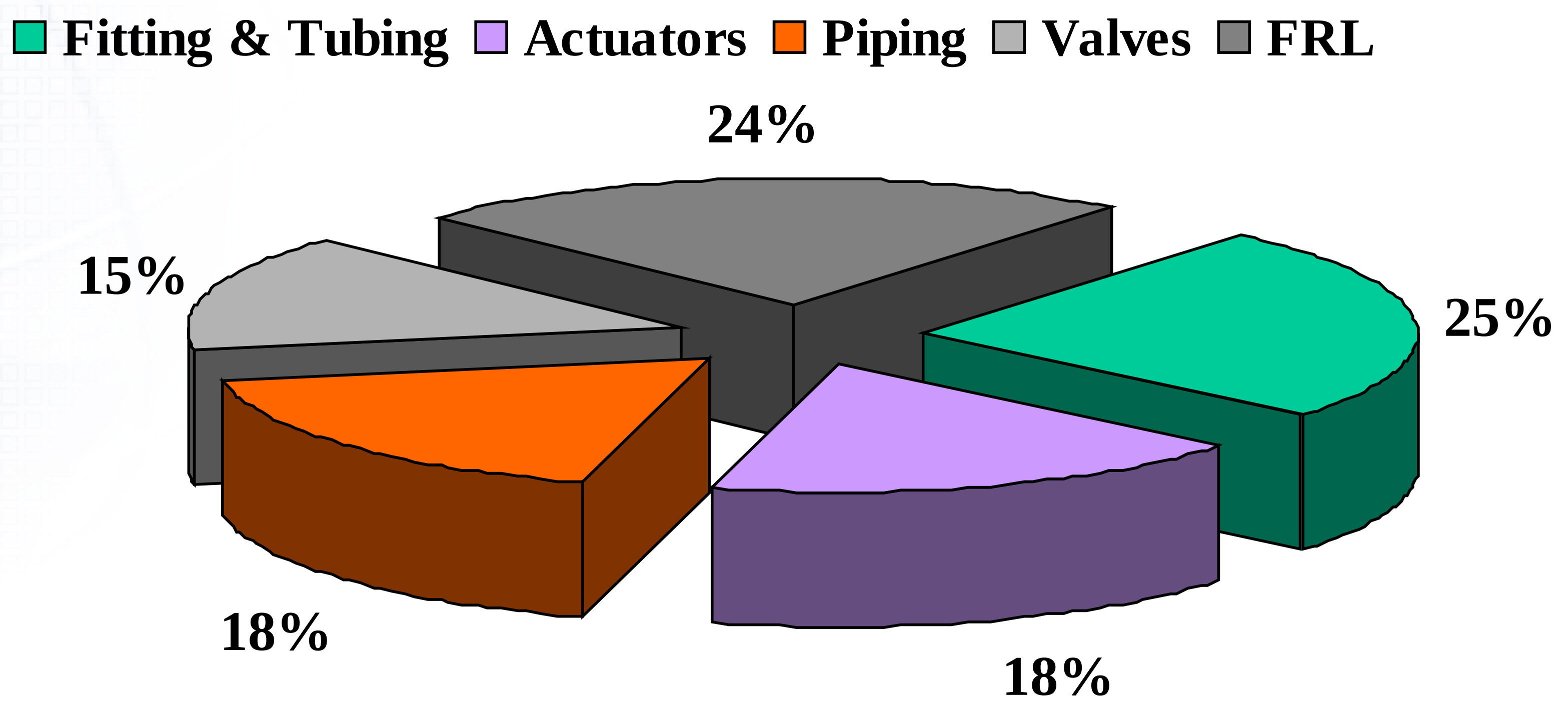
Savings Related to the Air Source



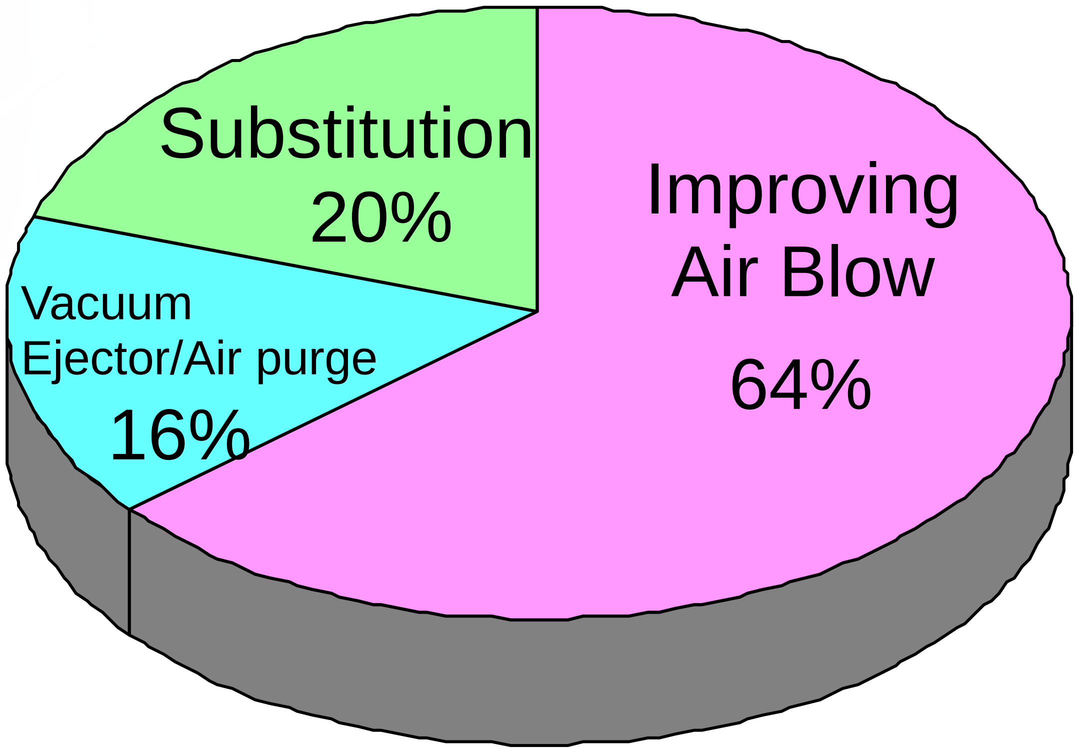
Savings Related to the Supply System



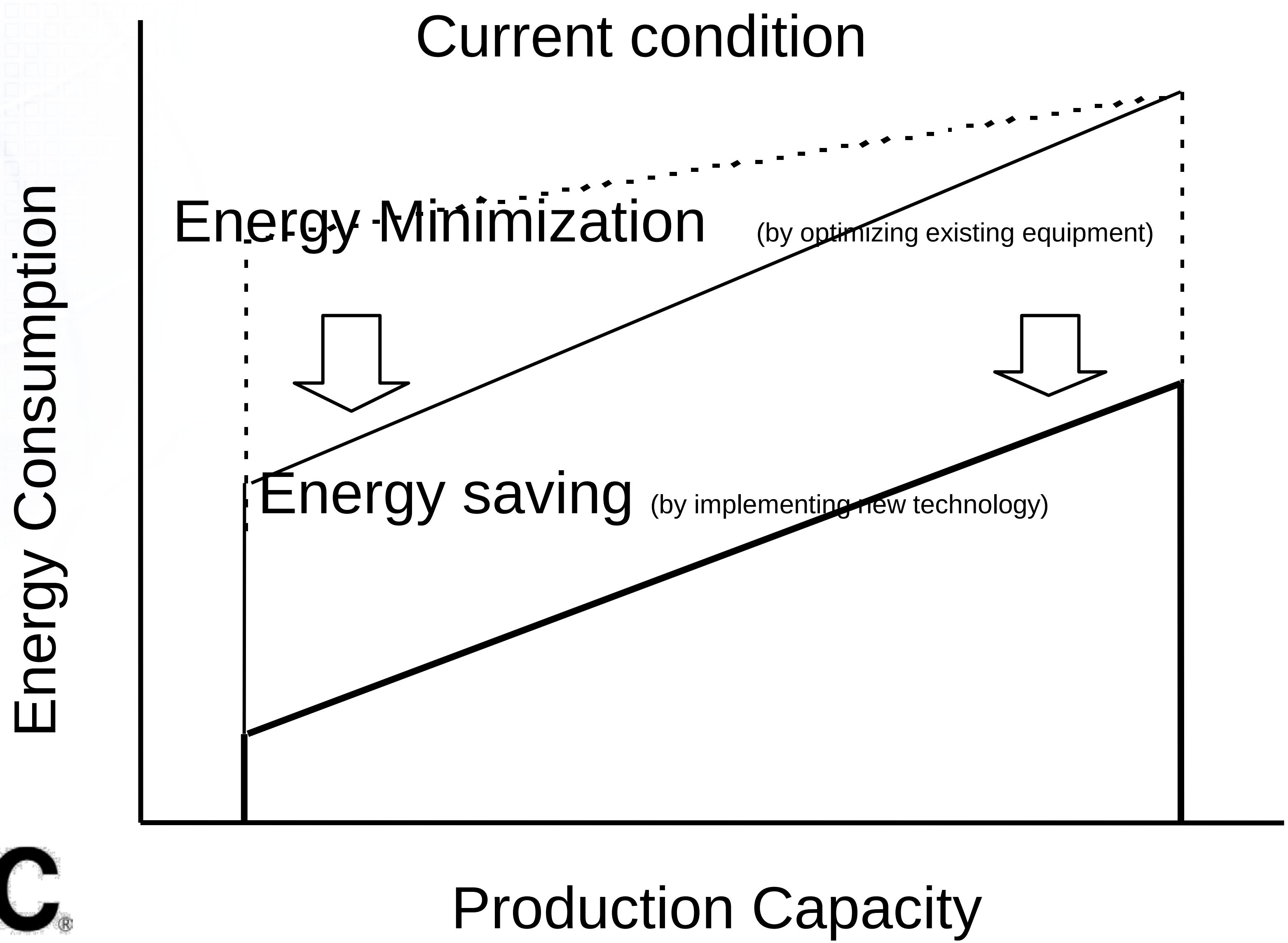
Savings Related to Air Leakage



Savings Related to Air Blowing



Two Steps to Energy Saving



Where to Start? . . .

. . . "Lean Thinking"

We suggest using a holistic approach and Six Sigma principles to develop an Energy saving program.

- Define: How much energy is consumed to produce compressed air?
  - Calculate: How much compressed air is used?
- Measure: How much compressed air is wasted?
  - Calculate: The potential savings?
- Analyze: Identify causes of waste.
- Improve: Remedy causes of waste.
- Control: Continue to measure, analyze and improve.

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Define and Measure

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

- A baseline needs to be established.
- Temperature and dew point are useful air system measurements…However, the key metrics are:
  - **Pressure**
  - **Rate of air flow**
  - **Electrical consumption**
- This trio helps to determine the cost, monitor system operation and establishes a baseline for evaluating future modifications.

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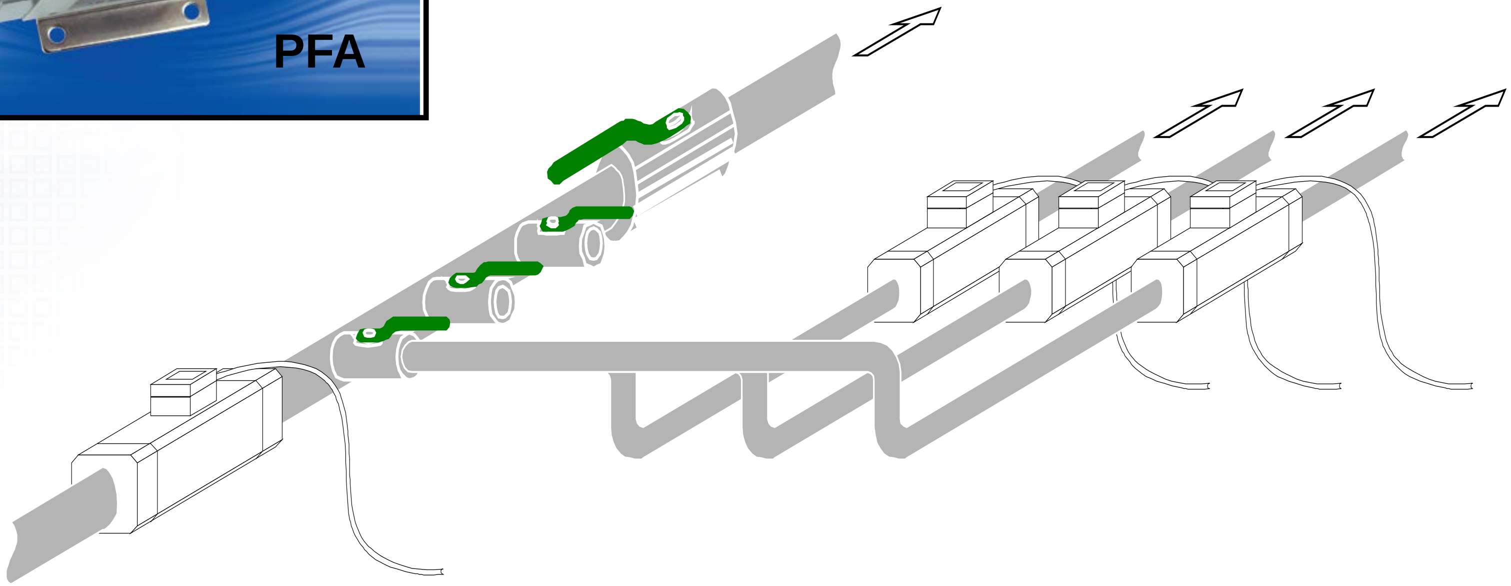
Define and Measure *Solutions*

Monitor flow and establish a baseline to measure and control improvements.



Define and Measure *Solutions*

- How do we measure flow?
  - CFM at stated Pressure (Actual volume of flow & Actual pressure)
  - CFM Free Air Delivery (14.7psia, 70^0 F, 0% Relative Humidity)
  - SCFM (14.7psia, 68^0 F, 36% Relative Humidity)
  - Liters per minute ANR (14.7psia, 68^0 F, 65% Relative Humidity)
  - Normal Liters per minute (14.7psia, 32^0 F, 0% Relative Humidity)

  - **SCFM = L/min * 28**
    - **Which version of Liters per minute? See next slide…**

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Flow Rate Settings

Specifying Air flow capacity or air consumption

Reference	Temperature	Pressure	RH
ANR **Atmosphere Normale de Reference. The metric measurement of flow:** **l/min ANR , m^3/min ANR**	**20°C (68°F)**	**101.3 KPa (14.7 psia)**	**65%**
Nl/min (Normal liter) **Normal l/min , that is related back to normal inlet conditions.**	**0°C (32°F)**	**101.3 KPa (14.7 psia)**	**0%**

<u>Example</u>

Assume a flow of 10 N l/min. What does this looks like in ANR?

General Gas Equation: $$\frac{P1*V1}{T1} = \frac{P2*V2}{T2}$$

<u>Normal Condition:</u> T1 = 0°C (273°K) , P1 = 101.3 KPa (14.7 psia)

volume V1 = 10 l/min

<u>ANR:</u> T2= 20°C (293°K), P2 = 101.3 KPa (14.7 psia), V2= unknown

V2= (P1*V1*T2)/P2*T1

V2= 101.3 * 10 * 293/ 101.3 * 273

V2= 10.7 l/min ANR

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Define & Measure *Solutions*

Monitor Pressure

Develop a pressure profile. Take readings at the following points:

1. **Main supply components**
2. **Beginning and end of the main piping system**
3. **Points of use**

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Analyze:
Identify Energy Saving Opportunities

- The following steps have been created to locate energy savings improvement opportunities in any manufacturing environment.

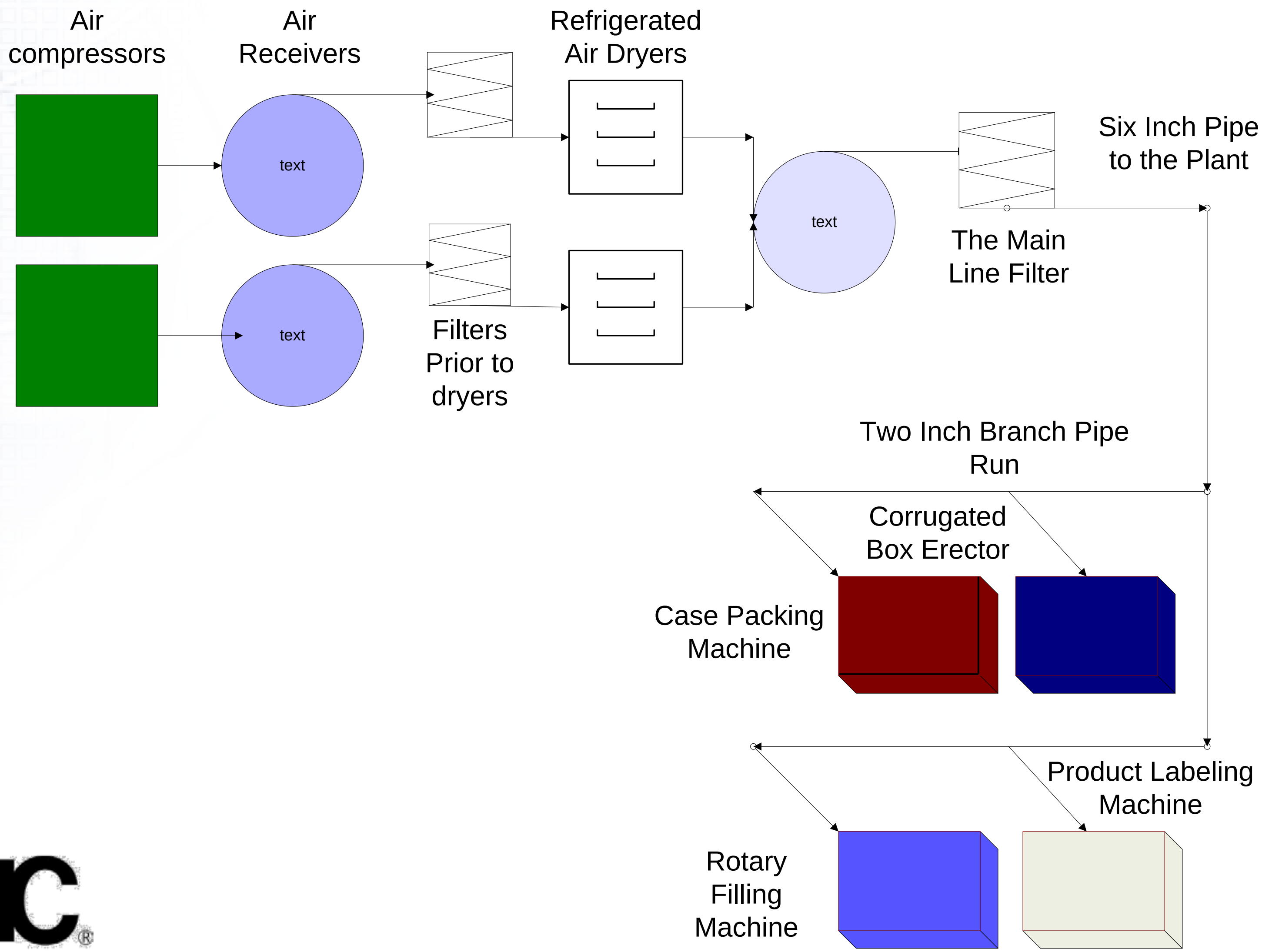
- Observing the following steps will provide simple and effective measures to corrective action in any compressed air and pneumatics system.

Analyze:
Identify Energy Saving Opportunities

1) Develop your system diagram
2) Identify OEM specified pressure & flow settings
3) Select a compressed air quality standard
4) Determine system pressure and flow requirements
5) Take corrective actions

Step One

Develop a basic diagram of your system.



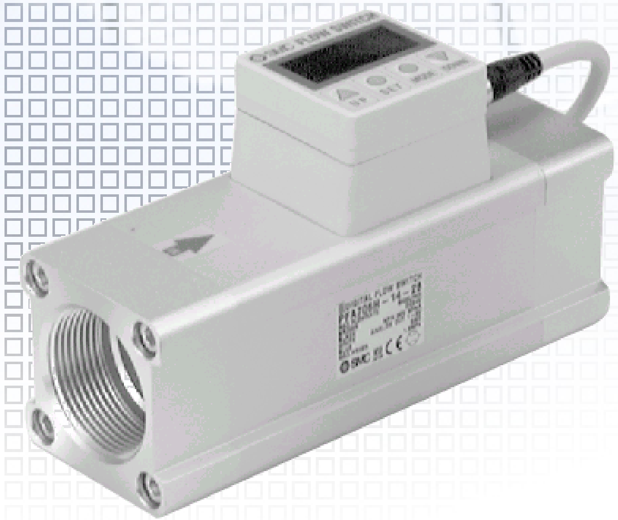
Step Two

Identify OEM specifications for:

Flow (SCFM)

Pressure (psi)

Digital Flow Switch



Digital Pressure Switch

Step Two Continued

- A digital flow switch allows you to baseline the flow requirements of critical equipment running 24/7 and monitor it for deviation from the baseline.

- A digital pressure switch can be installed to monitor overall system pressure, branch runs or individual drops. High, low and current pressures are available to assess pressure needs.

Step Two Example

Verify pressure & flow profiles:

Tank Pressure
120 PSI

Sand Blaster

Requires: 84 PSI

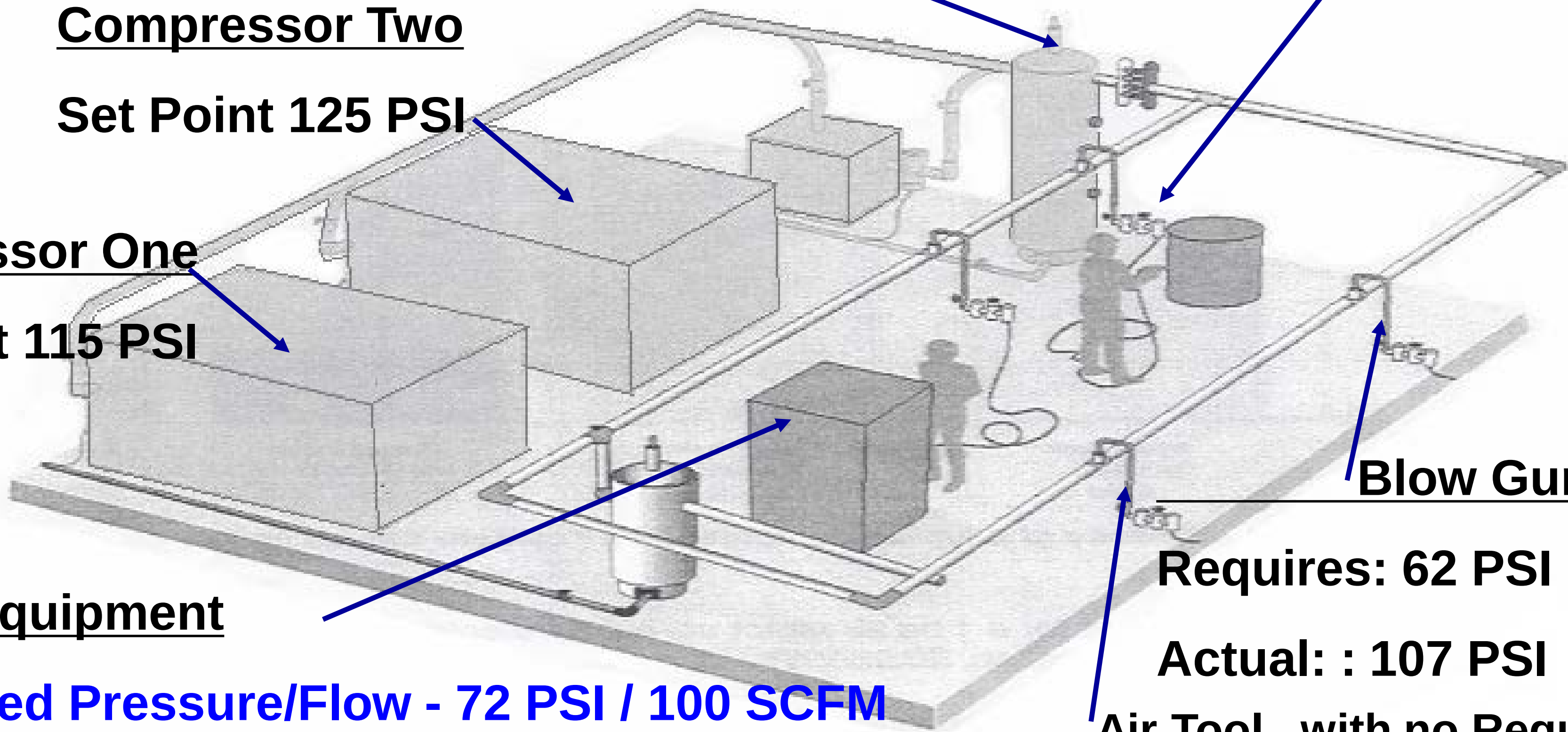
Actual: : 108 PSI

Compressor Two

Set Point 125 PSI

Compressor One

Set Point 115 PSI



Blow Gun

Requires: 62 PSI

Actual: : 107 PSI

OEM Equipment

Required Pressure/Flow - 72 PSI / 100 SCFM

Actual Pressure/Flow – 93 PSI / 250 SCFM

Air Tool with no Regulator
Requires: 70 PSI

Actual: 116 PSI

Step Three

Select an ISO compressed air quality standard and verify that your equipment consistently delivers the compressed air quality required.

ISO 2001: 8573 Air Quality Standards

Quality Class	Pressure Dewpoint (100 PSI)	Oil Mist & Particulate (mg/m^3)
1	-94 ºF	0.01
2	-40 ºF	0.1
3	-4 ºF	1.0
4	37.4 ºF	5
5	44.6 ºF	--
6	50 ºF	--

Step Three Continued

Consider appropriate levels of filtration at the main-line, branch, and for specific equipment. **Monitor filtration**.

Air Quality Classes for Typical Applications

Application	Suggest Air Quality			Additional Requirements
	Solids	Water	Oil	
Air bearings, Tubing, Gauging	2	3	2	-
Instrumentation	2	3	2	-
Abrasive Blasting	3	3	-	-
Pharmaceuticals, Food & Beverage	3	1	2	Odor removal

Step Three Continued

Filters are available to provide air suitable for virtually all applications.

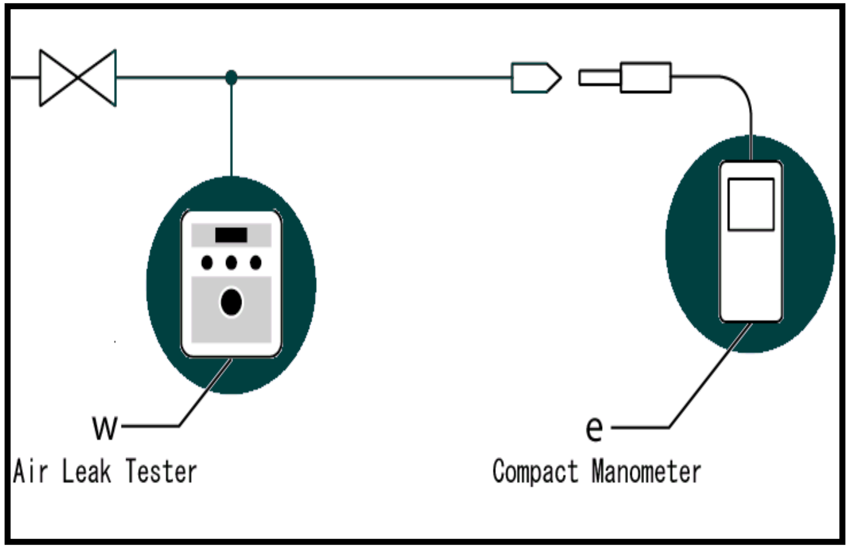
Filter Model	AMG	AFF	AM	AMD	AMH	AME	AMF
Filter type	Water separator	Main line filter	Mist separator	Micro-mist separator	Micro-mist separator with pre-filter	Super mist separator	Odor removal filter
Element type	Resin mesh	Cotton paper	Glass fiber	Glass fiber	Glass fiber	Glass fiber	Adsorbent activated carbon
Particle size	6	3	3	1	1	1	1
Oil Content class	6	4	3	2	2	2	2

Use filters that perform to ISO 8573-1

Step Four

Determine demand-side issues including pressure loss, excessive pressure, inappropriate use and intermittent demand.

Find, measure & verify air leakage on each line.



Left to right: Air Leakage Tester and compact manometer

Step Five

Take corrective action.

Re-evaluate compressor and dryer controls and see the effect improvements have made on the energy bill.

SMC's IDFB
Refrigerated Air Dryers

Pneumatic System Savings

The top target areas of energy savings in pneumatic systems that need to be "Analyzed and Improved" are:

1. *Leaks*
2. *Air Blow & Inappropriate Usage*
3. *Excessive Pressure*
4. *Intermittent Demand*
5. *Design Alternatives*

Leaks

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Where to look for leakage?

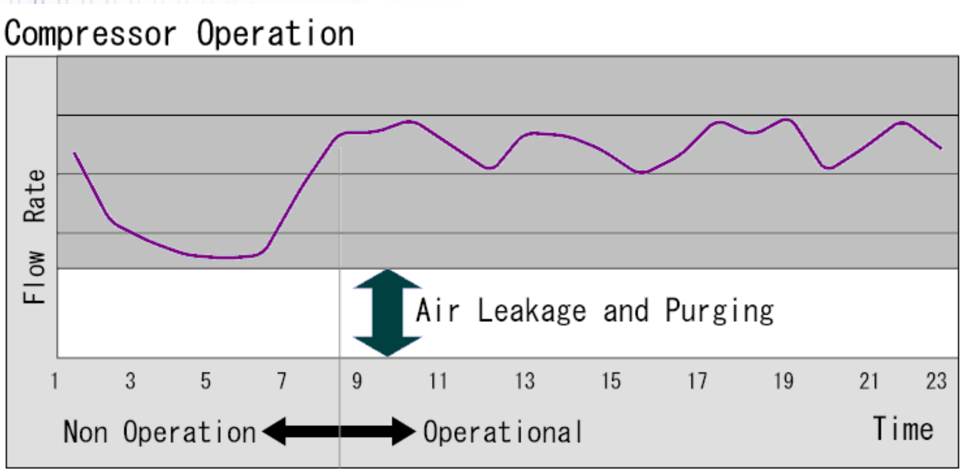
- Frequent leaks
  - Cylinder rod seals
  - Connections
  - Hoses and tubing
  - Other components

Remedies for leakage?

- Leak Detection
- Repair or Replace
- Preventative Maintenance
- Fitting and Tubing “Crash Cart”
- Consolidate / Match fitting and tubing sizes
- Universal Fittings

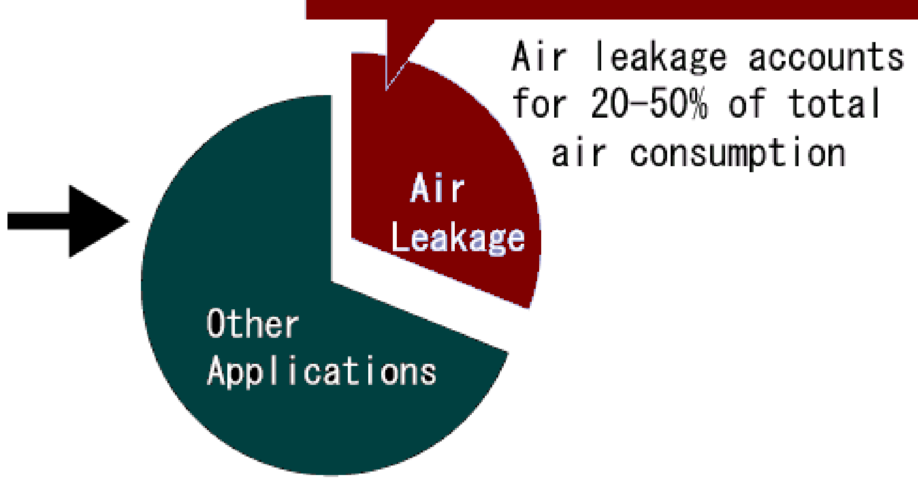
Air Leakage

Leaks are the thieves in any compressed air system, causing the compressor to operate even during machine stoppage.



Air Consumption

Tubing / Fittings	20%
Couplers	25%
Rubber Hosing	30%
Others	25%



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Actuator Example/Solutions

<u>Actuators</u>

Low quality cylinders begin to leak around the rod-seal after 1 million cycles or less and fail after 7 million cycles. This leaking cylinder costs **$73** more per year compared to a non-leaking cylinder .

SMC #2 Bushing

Cylinders are available which last 5x longer!

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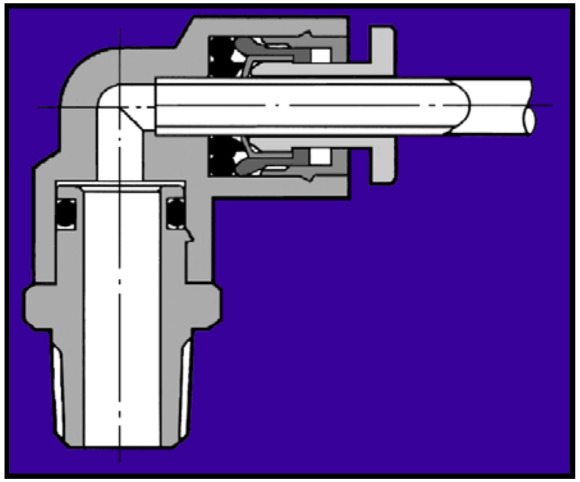
Fitting Example/Solutions

70% of tubing and fitting leaks are caused by improperly cut tubing!

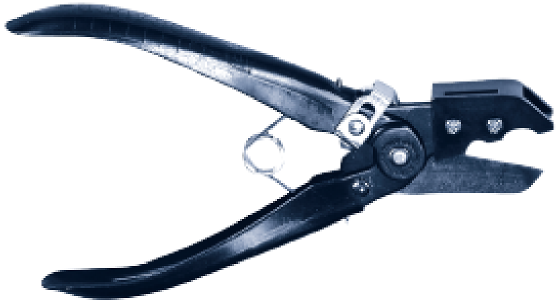
Use of tubing cutters ensures a 90 degree cut 100% of the time.

Use fittings which do not require a perfectly straight cut



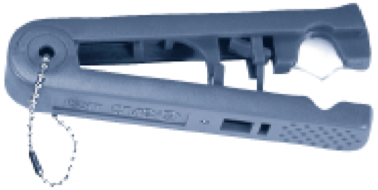
Tubing Cutters

TK-1
Applicable tubing O.D.: 13mm or less.



TK-2
Applicable tubing O.D.: 18mm or less.

TK-3 (Simple type)
Applicable tubing O.D.: 12mm or less.



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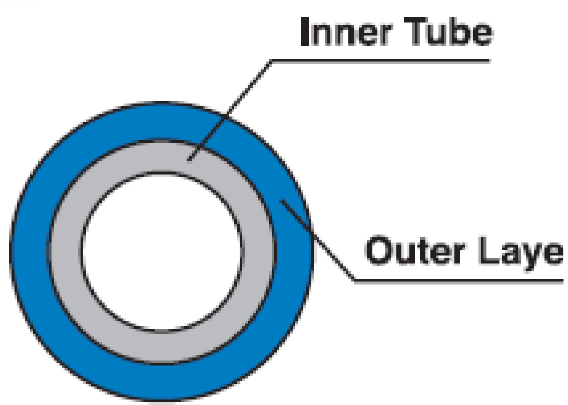
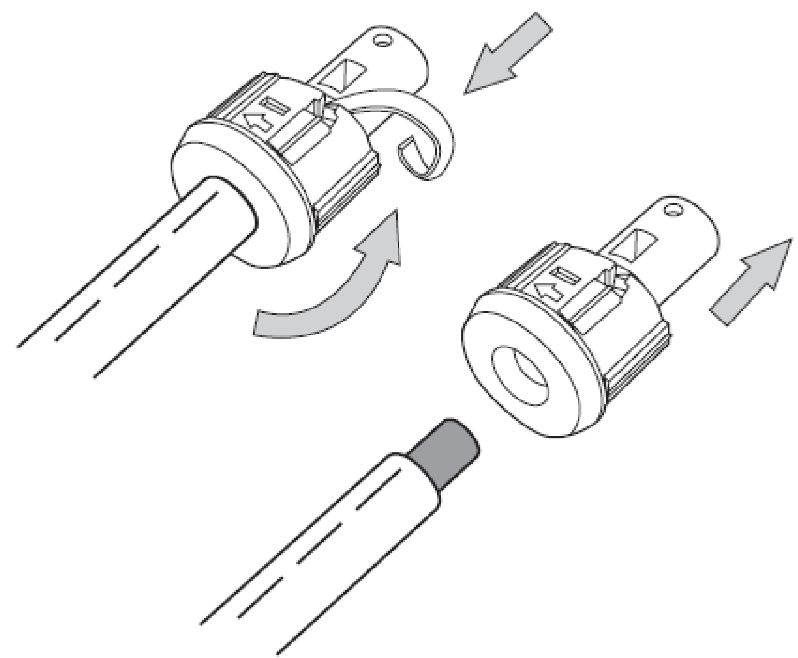
Tubing Example/Solutions

Leaks due to worn Leaks due to worn tubing can be solved by using double layer tubing.

To simplify cutting and stripping of the tubing, SMC offers the TKS line of stripping tools.



FR Double Layer Tubing
Sectional View



Leak Detection

Flow Meters

Air leak tester

PARABOLIC DISH AND ULTRASONIC LEAK DETECTOR

Cost of Air Leaks & Potential Savings

DISCHARGE THROUGH AN ORIFICE						
DIAMETER OF ORIFICE, INCHES						
	1/16	1/8	1/4	1/2	3/4	*1 INCH*
PRESSURE	DISCHARGE IN CUBIC FEET OF AIR PER MINUTE					
70 PSI	4.79	19.2	76.7	307	690	1227
Annual Cost To Operate	$590	$2,269	$9,062	$36,281	$81,545	$145,009
100 PSI	6.49	26	104	415	934	1661
Annual Cost To Operate	$765	$3,072	$12,290	$49,045	$110,382	$196,300
125 PSI	7.90	31.6	126	506	1138	2023
Annual Cost of Leak	$931	$3,734	$14,890	$59,800	$134,491	$239,082

Case Study

A recent leak detection exercise during an energy audit at a large plant found 276 leaks!

642.5 SCFM

Annual cost = $ 40,410

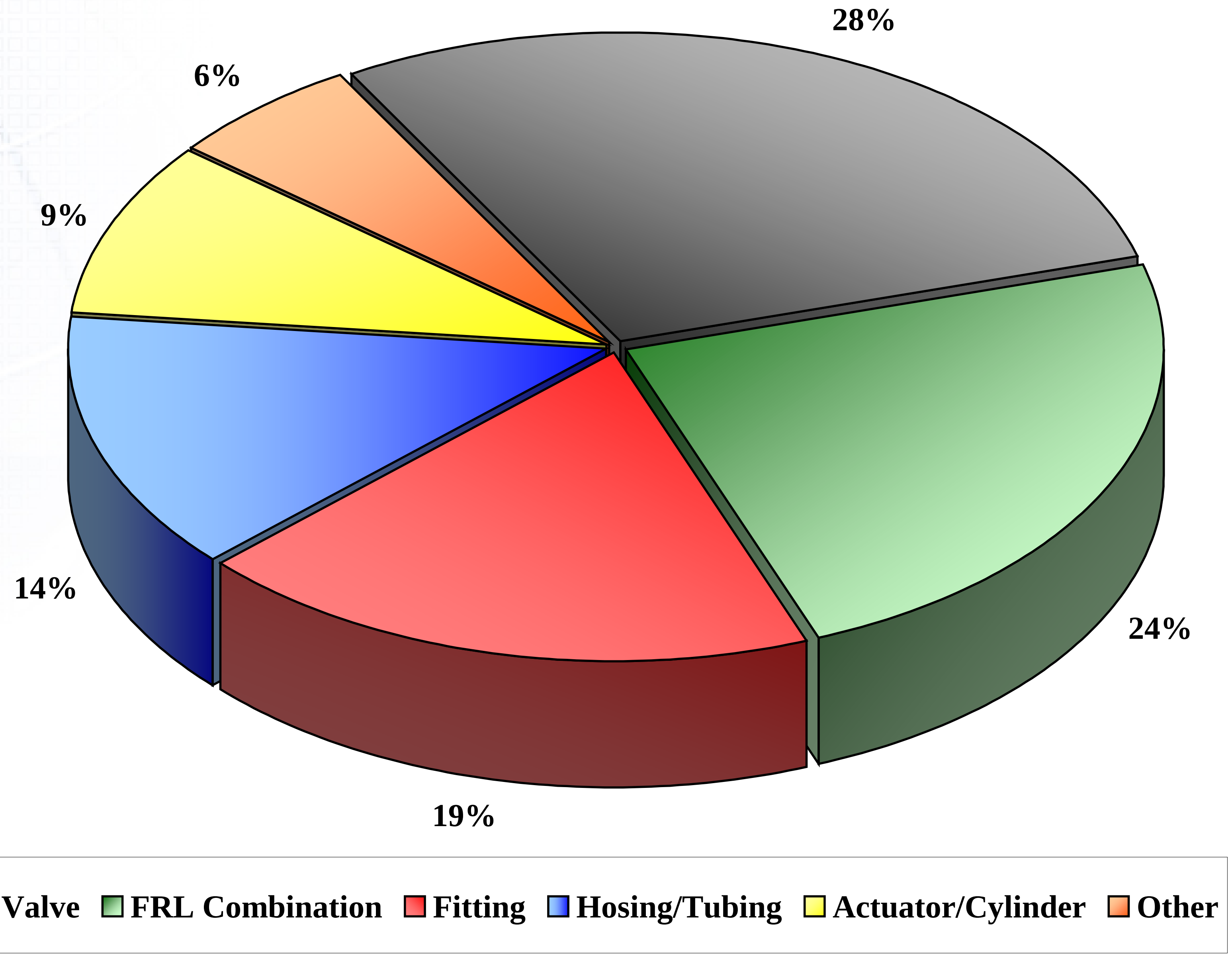
All of these leaks were documented and tagged, so the entire cost can be eliminated by replacing these components.

Case Study

Tag #	Location in Plant	Component	Port Size	Leak Description	SCFM	COST
410	Coater #1, start of line.	Fitting	3/8"	Copper fitting leak.	3	$188.72
411	Coater #1, FF belt #2.	Valve	1/2"	Manual valve leak.	2	$125.81
412	Coater #1, reject chute.	Valve	3/8"	Pneumatic valve leak. Pic #6646.	3	$188.72
413	CTR #2, finished, #1 conveyor.	Valve	3/8"	Pneumatic valve leak. Pic #6647.	2.00	$125.81
414	#2 CTR cooler, FEG machine inlet.	Filter-Regulator	1/2"	Filter/regulator leak. Pic #6648.	1	$62.91
415	Behind and above #3 CTR weigh off chute, at inlet.	Regulator	1/4"	Regulator leak, pic #6650.	1	$62.91
416	#3 CTR, Dryer #3.	Filter	1/2"	Filter leak. SN: F602048BJ/MS. Pic #6652.	0.5	$31.45
417	Under stage C conveyor, discharge screw.	Filter	3/4"	Filter leak. Pic #6657.	1	$62.91
418	Under stage C conveyor, discharge screw.	Valve	1"	Ball valve leak. Pic #6658.	10	$629.06

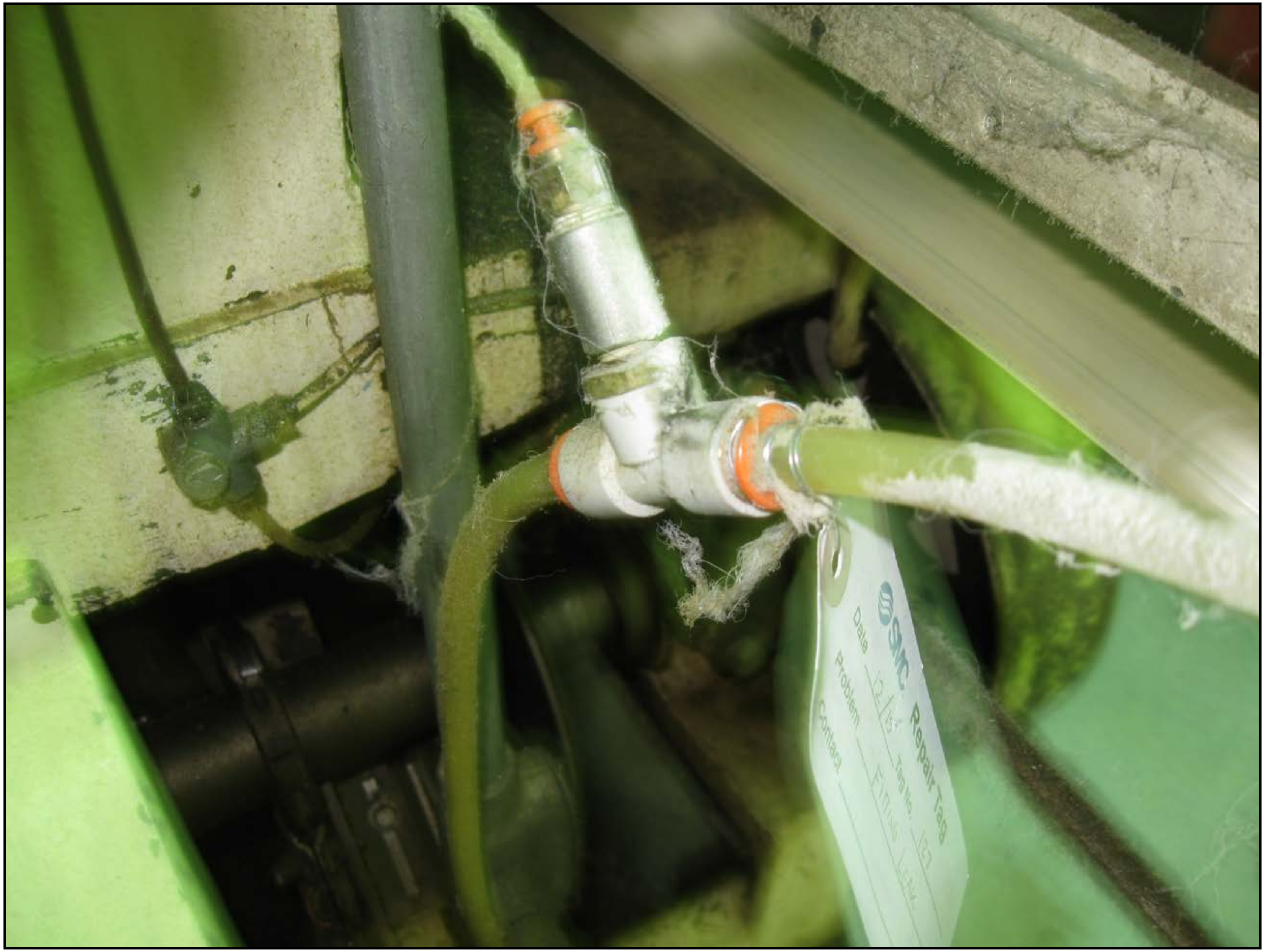
Case Study

Leaks by % of total SCFM



Case Study – Examples of Leaks

Case Study – Examples of Leaks



Case Study – Examples of Leaks

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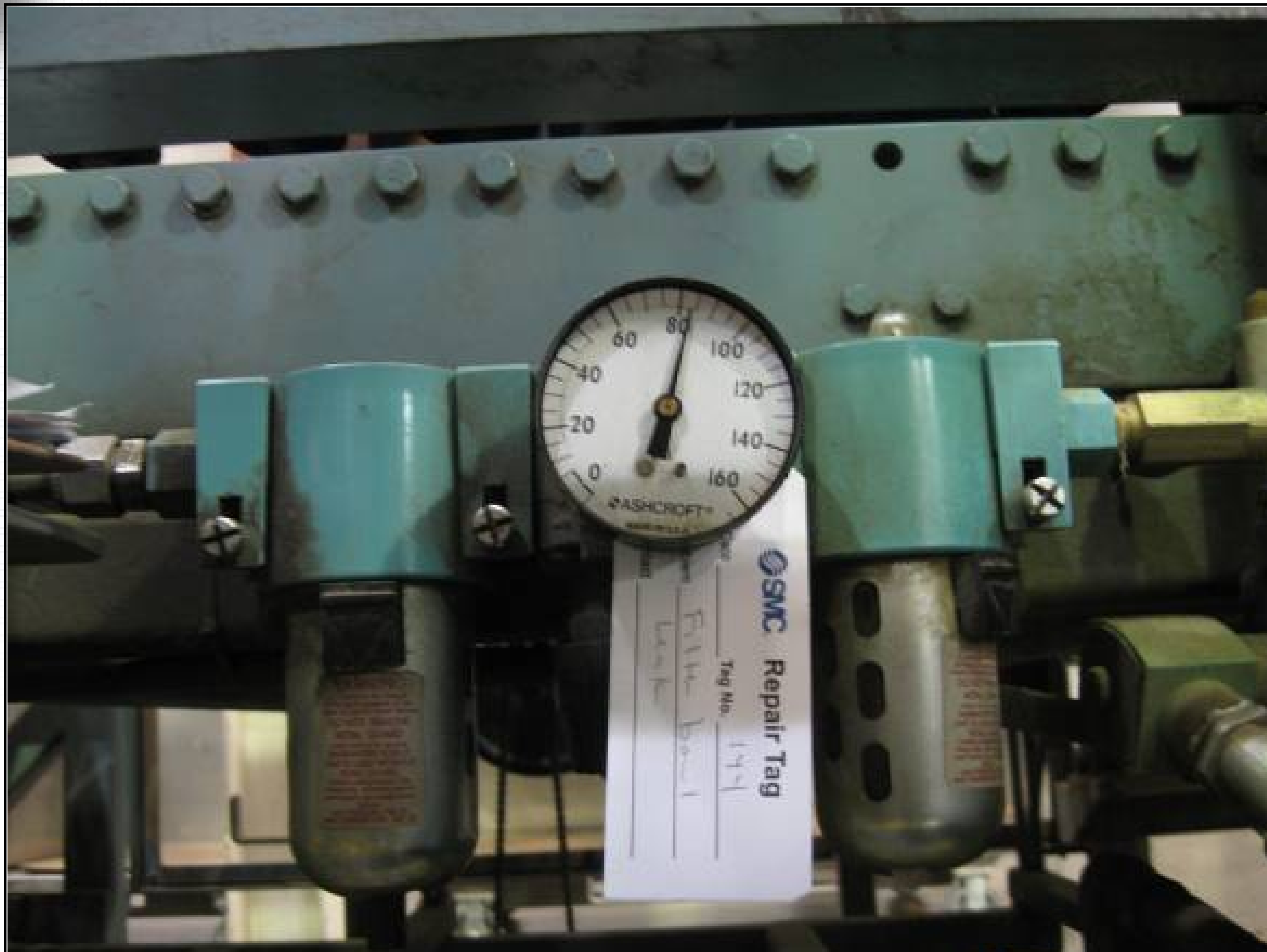


Case Study – Examples of Leaks

Case Study – Examples of Leaks

Case Study – Remediation

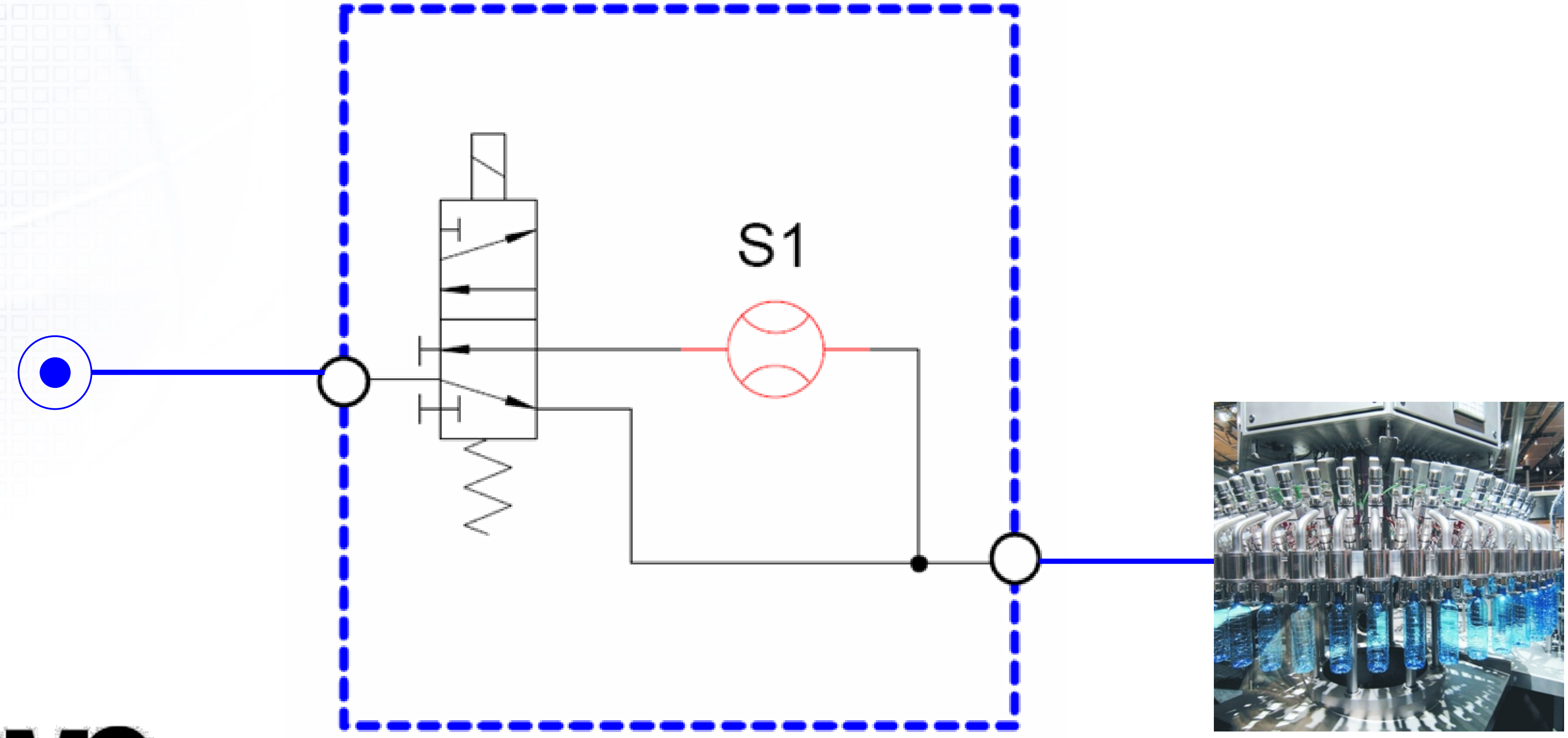
- Fixing the leaks discovered at this plant will save **$** 40,410 per year.
- **To realize long-term savings, launch a Leak Remediation Campaign**
  - Tag audible leaks as they develop
  - Notify maintenance.
  - Perform ultrasonic leak detection quarterly
  - Assemble a leak repair crash cart to ensure that replacement components are in stock
  - Consider Automatic Leak Detection Systems (more…)

Solution – Automatic Leak Detection System

- SMC has developed an **ALDS** (automatic leak detection system – patent pending) aimed to make **leak detection totally automatic.**
- With **ALDS,** it is possible to achieve the following **goals** with more accuracy :
  - ✓ **Leakage value:** The system is able to detect and report the leakage rate in Nl/min.
  - ✓ **Position**: we can define which valve, tubing or cylinder is leaking.

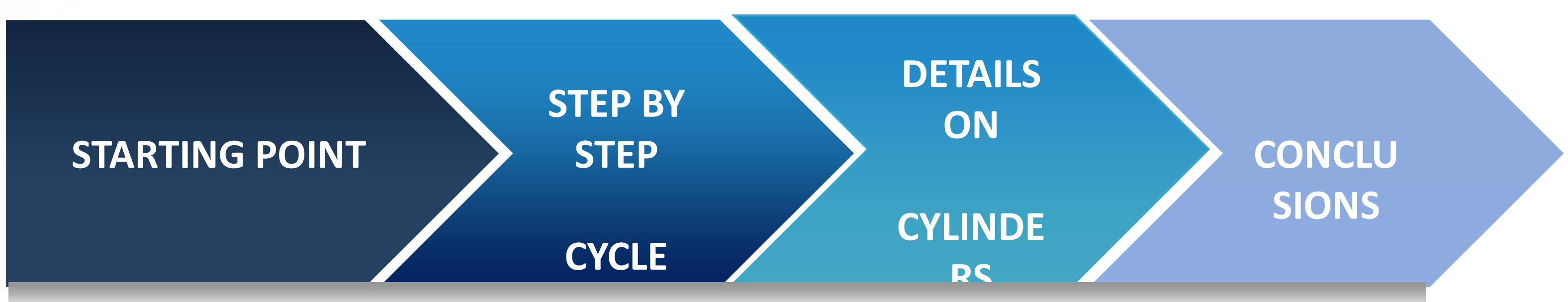
ALDS – Basic Concept

- **ALDS** is based on a block consisting of a **Flow Meter and a diverting valve** installed on the **main air supply line** of the machine, which **interacts** with the machine **through software** (sequence instructions) **integrated** in the machine software (**PLC**)



ALDS – Practical Example – Definition

- **Starting Point**
  - Define the machine, circuit and other variables
  - Section branches / determine baseline flow rate
- **Step by Step Leakage Detection Test**
  - Establish the machine’s working flow rate
  - Each actuator will be moved sequentially and flow recorded
- **Details on the Cylinders**
  - Leakage value defined mathematically for each branch of circuit
- **Conclusions**
  - Leakage report



Air Blow

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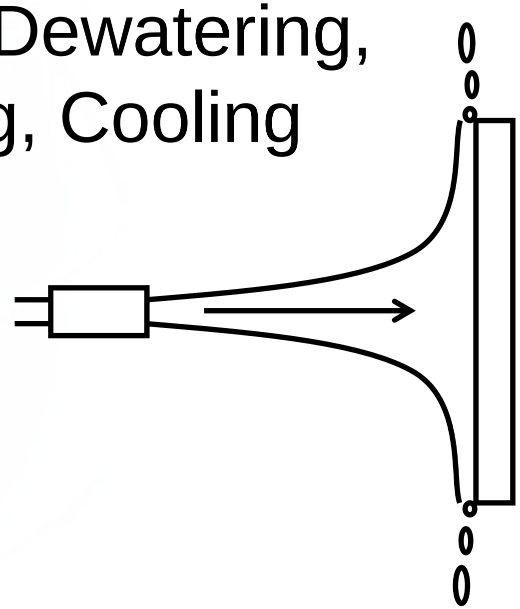
Topics in Air Blowing

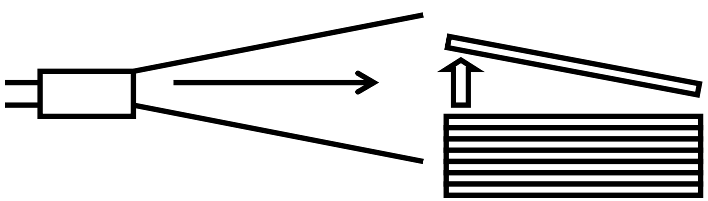
- Examples/Solutions
  - Turn off when not needed!
  - Properly size nozzles and piping
  - Inappropriate Usage
    - Other solutions may exist!
- Potential Savings
- Case Studies

Air Blow Applications

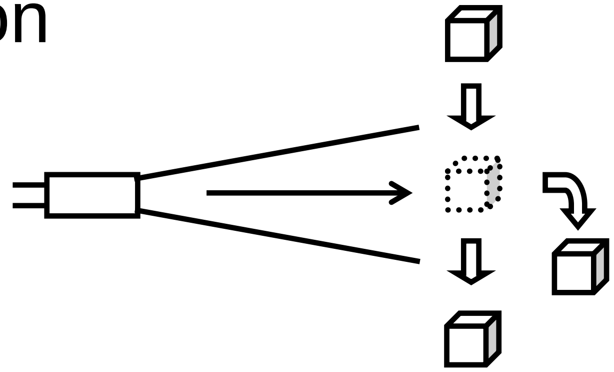
Duster, Dewatering, Drying, Cooling



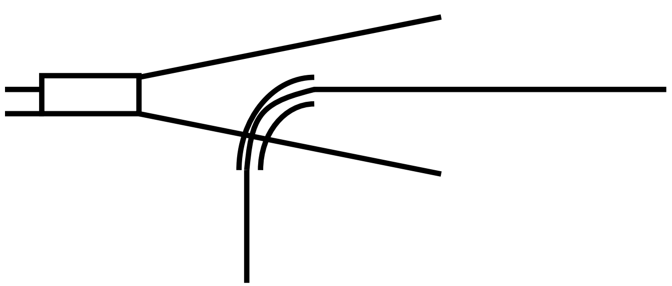
Detachment of film



Rejection

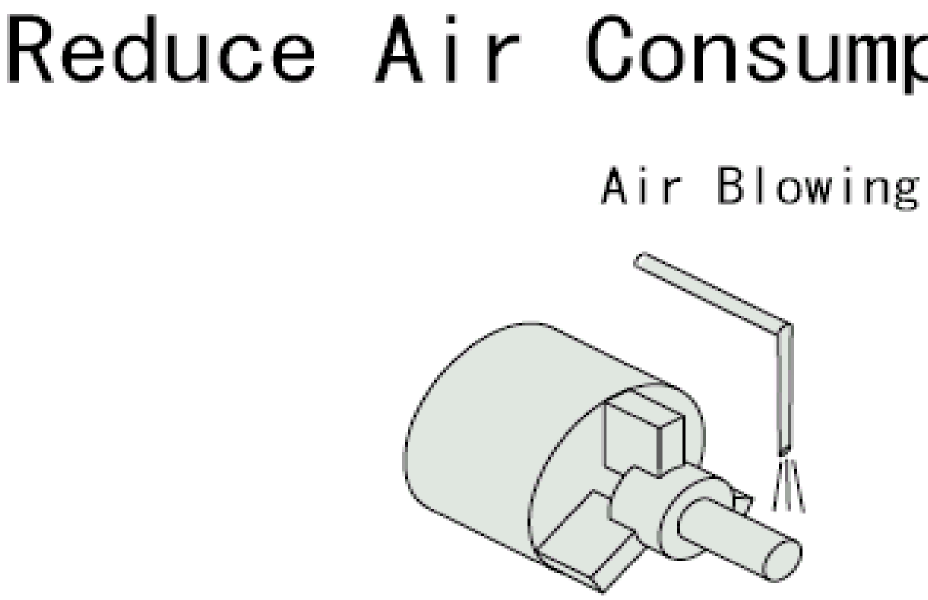


Attracting



Air Blow

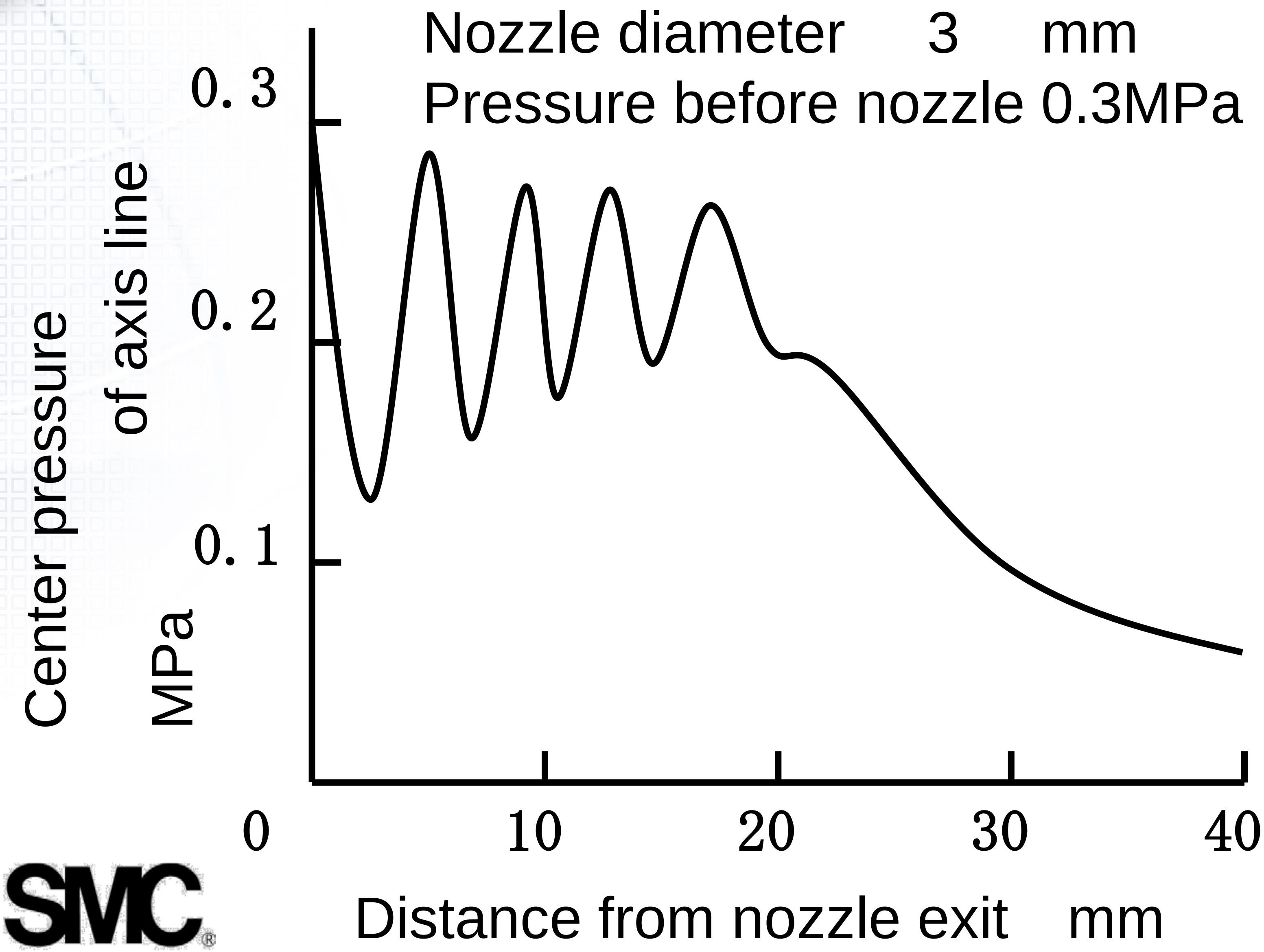
Many factories do not regulate air pressure to air blow applications or blow guns. OSHA Directive 100-1 states that air should be regulated below 30 PSI for cleaning applications.



VMG Blow Gun

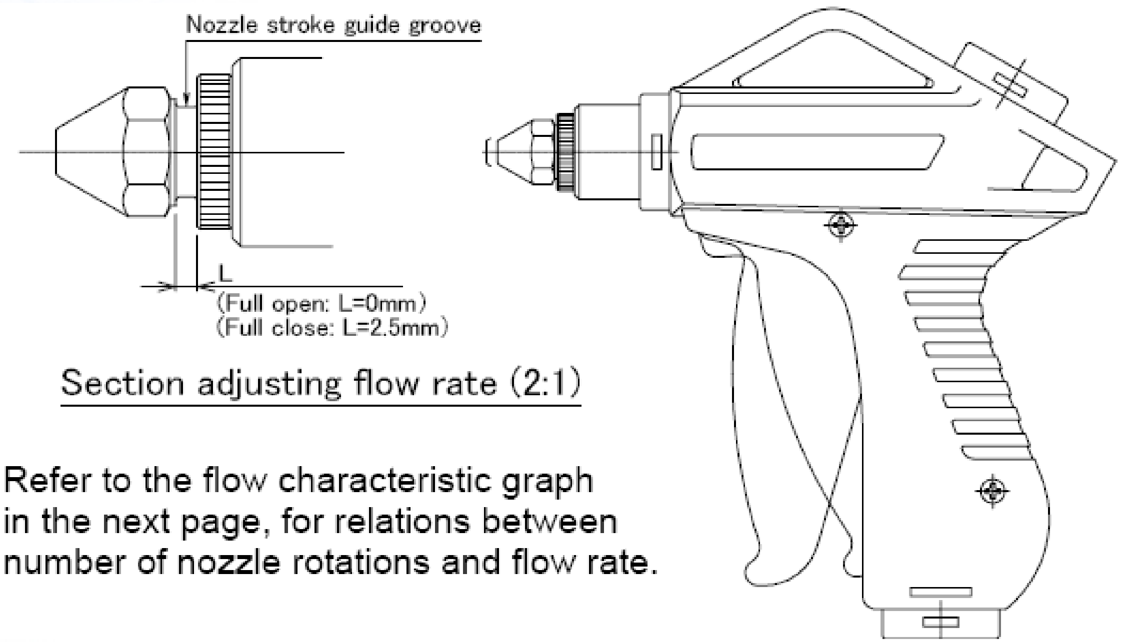
Air Blow Applications

Pressure Along the Jet Axis

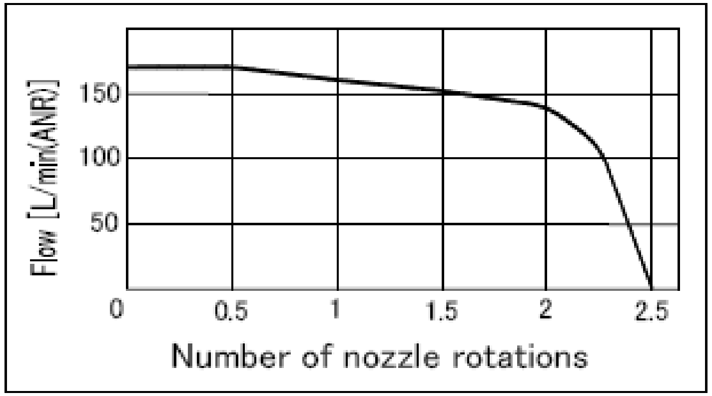


Air Blow *Solutions*

Measures such as high efficiency nozzles and adjustable blow guns can reduce air consumption by 50 – 75% and *increase* impact pressure!



Refer to the flow characteristic graph in the next page, for relations between number of nozzle rotations and flow rate.



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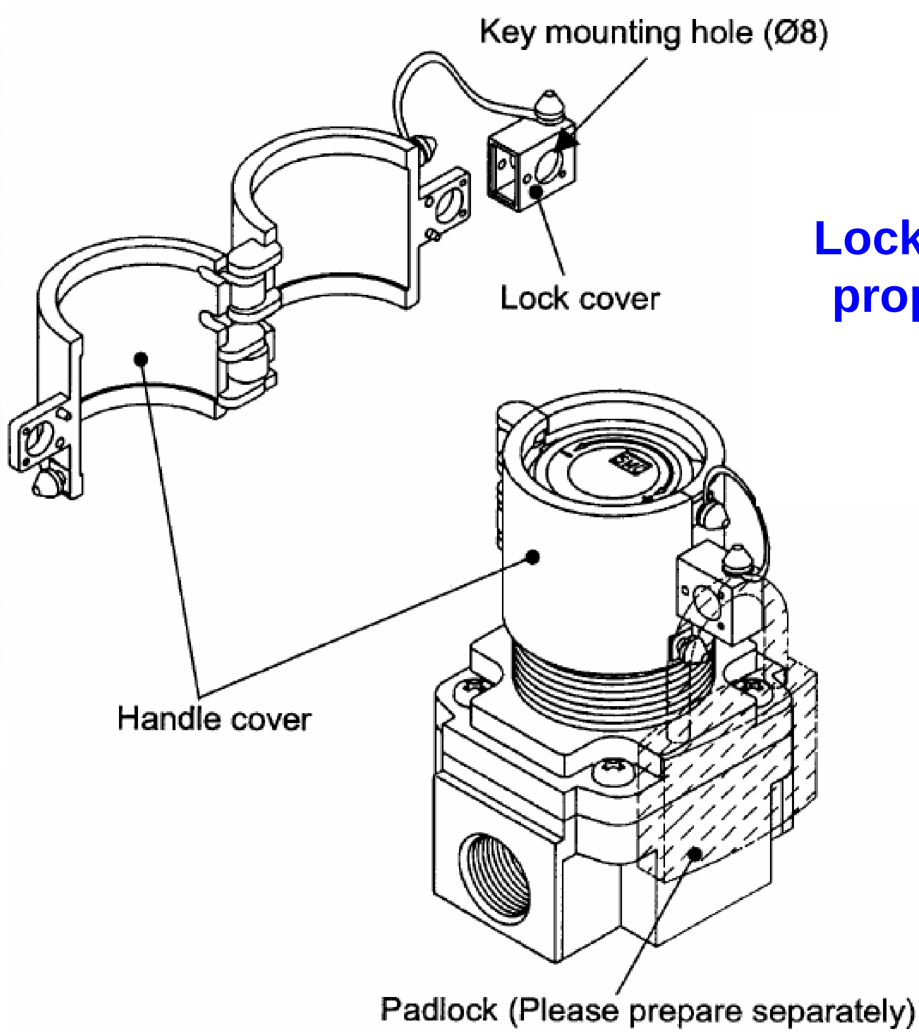
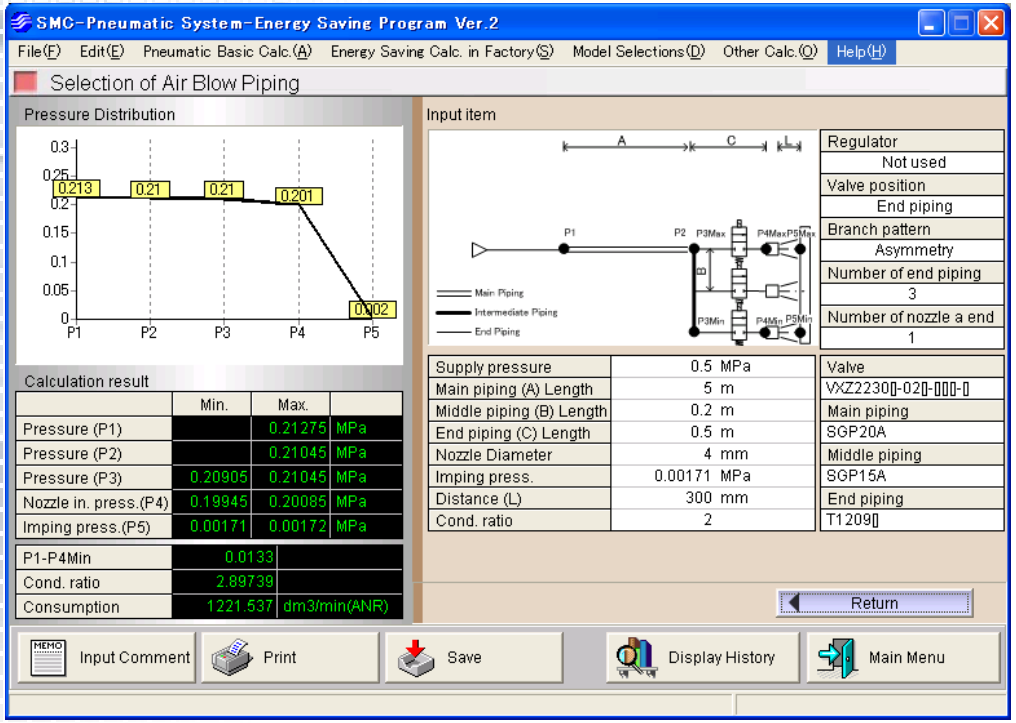
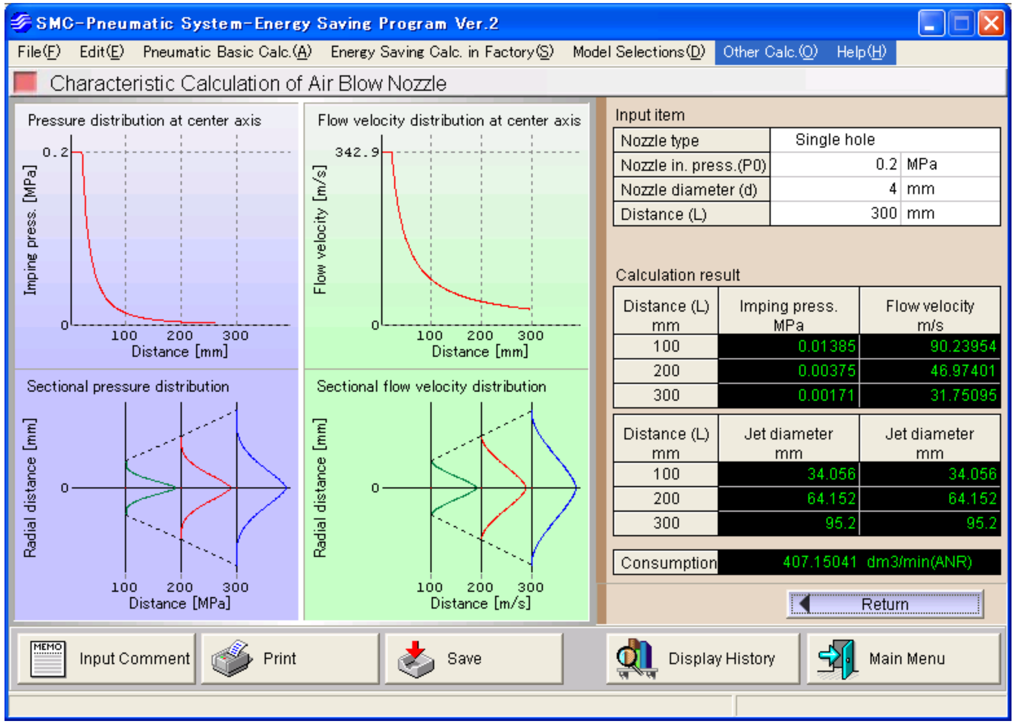
Air Blow Solutions



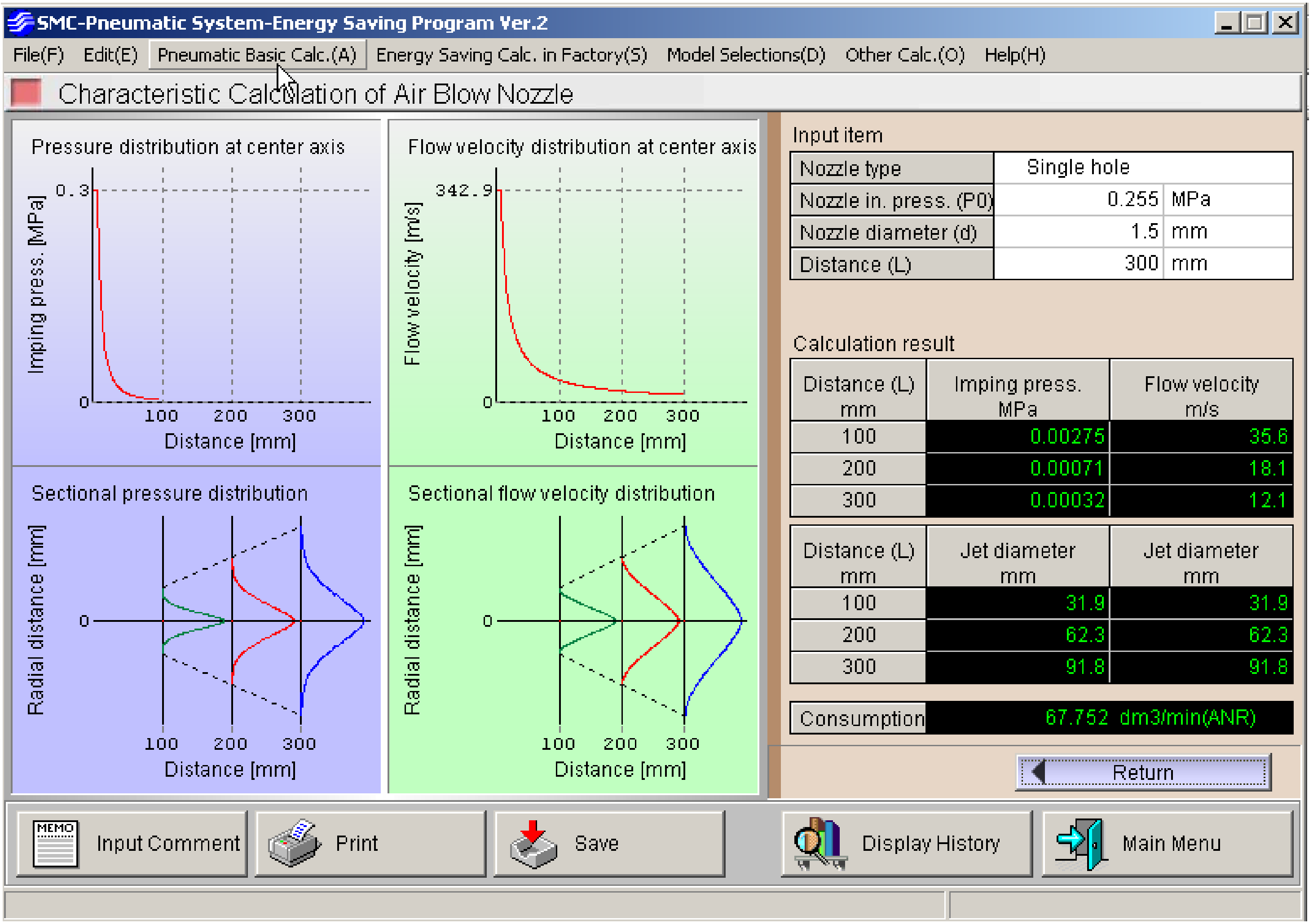
Locking regulators ensure proper pressure settings.

Air Blow Solutions





Energy Savings Program



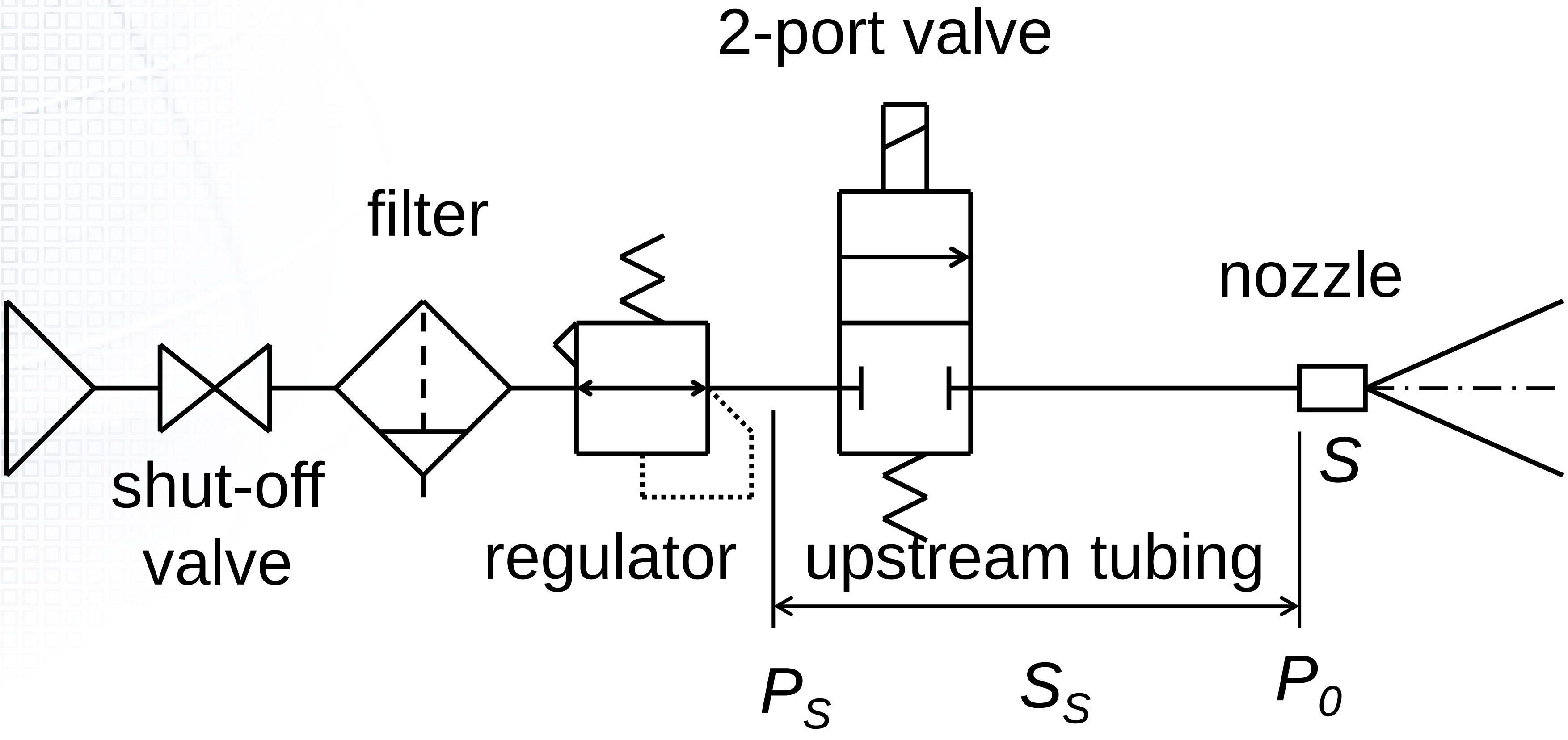
Air blow characteristics calculated with Energy Savings Program

Air Blow *Solutions*

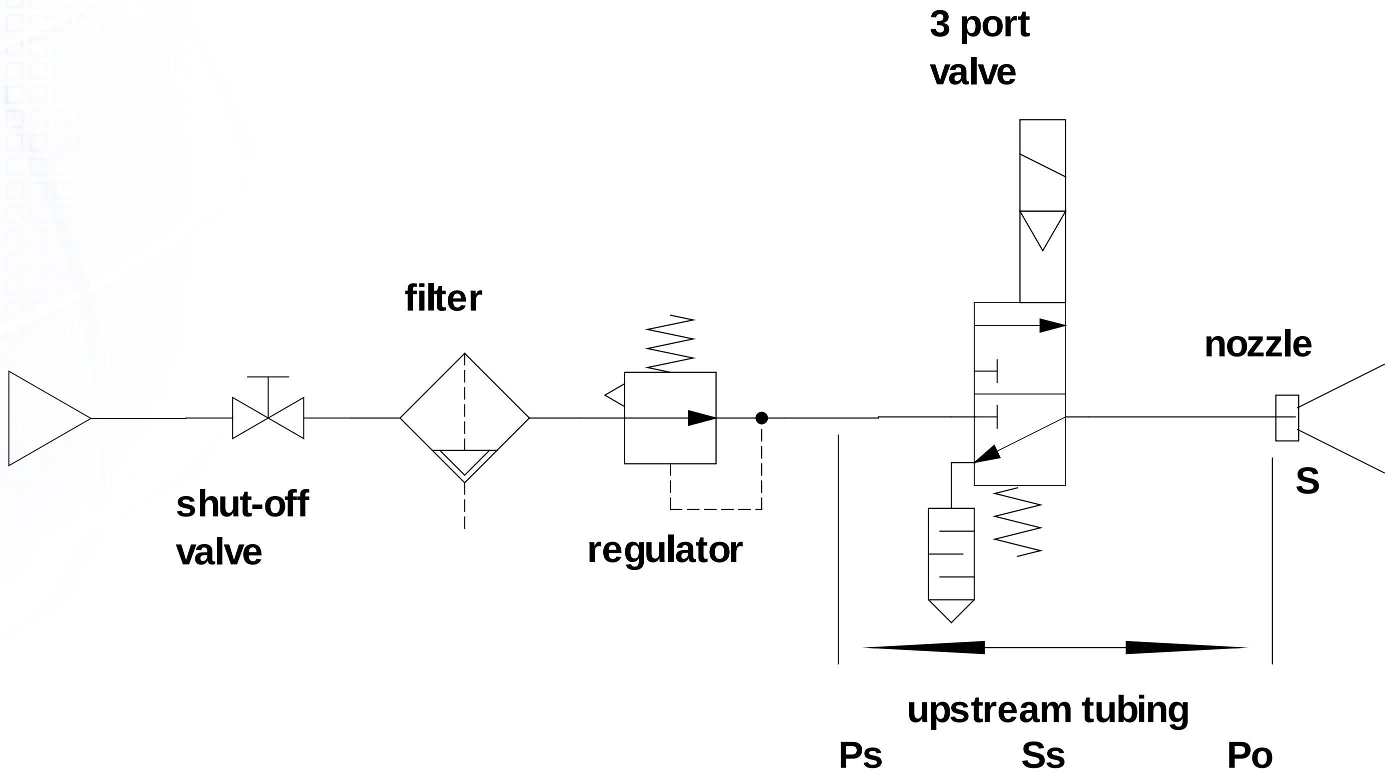
	Nozzle Diameter mm	Pressure before nozzle MPa	Distance of work mm	Impact Pressure MPa	Air flow rate dm^3/min (ANR)
Current	4.0	0.02	100	0.0014	120
Improvement	1.8	0.09	100	0.0014	52
	1.0	0.29	100	0.0014	33

Air Blow Solutions

Recommended Circuits for Air-blow

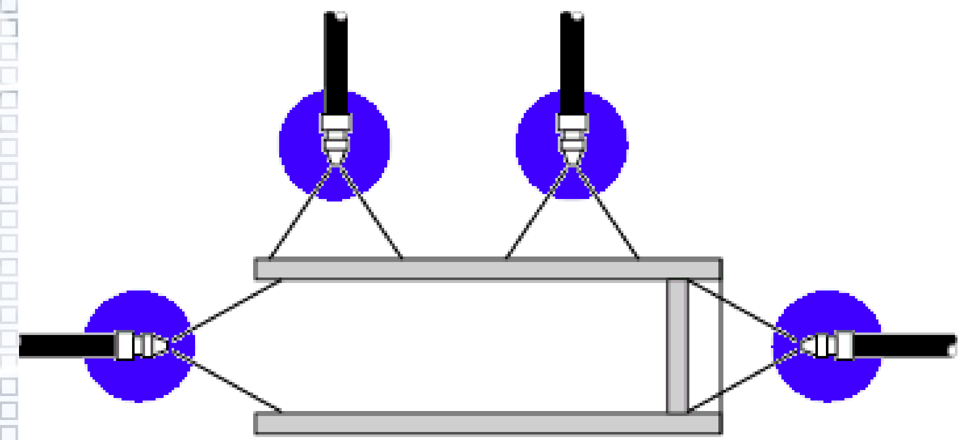


Air Blow Solutions
Recommended Solutions for Air-Blow



Air Blow Solutions

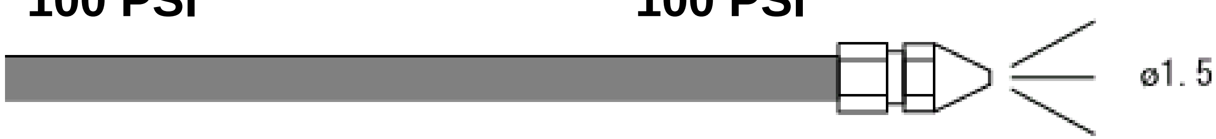
Reduce pressure loss and air consumption while increasing work surface impact.



High-efficiency nozzle

With Nozzle

100 PSI 100 PSI



Pressure Loss is minimal

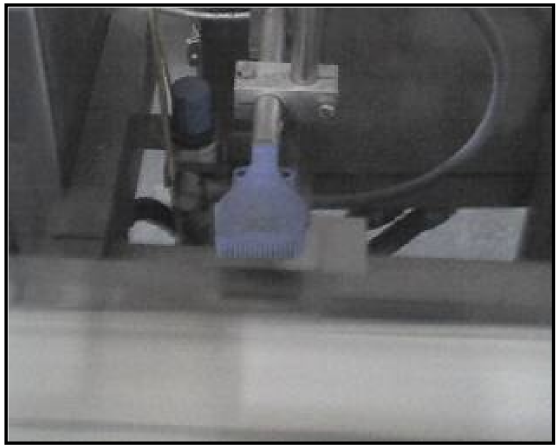
Without Nozzle

100 PSI 60 PSI 20 PSI

Pressure loss is great

Case Study - Examples

- Our example plant currently uses air blow to:
  - Move, cool, or guide product
  - Dry and clean conveyor belts.



While some of the uses were efficient and practical, there were also applications where air blow was used quite inefficiently.

Case Study - Examples

- No Regulator
- No Nozzle
- Too Far
- Misdirected

Air Consumption = 7 SCFM or $440 per year

Case Study - Examples

- No Regulator
- High Pressure

Air Consumption = 13 SCFM or $818 per year

Case Study - Examples

- Air Knives
- High Consumption
- High Pressure
- Necessary?

Air Consumption = 25 SCFM or $1,572 per year

Case Study - Examples

- 45 PSIG
- Continuous
- Ineffective?

Statistics			
	Min.	Avg.	Max.
Flow (SCFM)	21.90	22.50	23.00
Pressure (psi)	43.30	44.61	45.20

Air Consumption = 22.5 SCFM or $1,415 per year

Case Study - Solutions

Air Blow Applications before Improvements	
Location	**SCFM**
1. Packaging Baggers 1 & 2 - Windjet air knife (24 SCFM each)	48 SCFM
2. Packaging LL107 Baggers 1 & 2 - air knife (19 SCFM each)	38 SCFM
3. Packaging BIB 128 Baggers 1 & 2 - air knife (5 SCFM each)	10 SCFM
4. Packaging BIB 202 - 5 air knives	40 SCFM
5. Packaging Line 9 Bottom Maker Infeed - 1/4" orifice	10 SCFM
6. #3 CTR Supply Bin - 2 broken/missing air knives	30 SCFM
7. Processing Cutter - Exair Super Air Knives (2)	29 SCFM
8. Processing West - crimped copper tubing	13 SCFM
9. Processing East - 1/4" open tube	7 SCFM
10. Processing - 4 Windjet air knives	23 SCFM
11. Packaging 4 & 3 - Air bars (2)	25 SCFM
12. Packaging CV0404 - Windjet - no regulator	24 SCFM

Total Air Blow Compressed Air Consumption 297.00 SCFM

Case Study - Solutions

CURRENT ANNUAL CONSUMPTION AND COST		
Total Air Blow Compressed Air Consumption		297.00 SCFM
Total bhp to Produce that Air		58.67 bhp
Total kWh to Produce that bhp		43.77 kW
TOTAL ANNUAL COST TO RUN AIR BLOW		$18,305

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Case Study - Solutions

Air Blow Applications after Improvements	
Location	**SCFM**
1. Packaging Baggers 1 & 2 - KNH nozzles regulated to 50 psi	10 SCFM
2. Packaging LL107 Baggers 1 & 2 - KNH nozzles reg. to 50 psi	10 SCFM
4. Packaging BIB 128 Baggers 1 & 2 - KNH nozzles reg. to 30 psi	6 SCFM
5. Packaging BIB 202 - 5 KNH nozzles regulated to 30 psi	15 SCFM
11. Packaging Line 9 Bottom – KNH nozzle regulated to 30 psi	3 SCFM
12. #3 CTR Supply Bin - 2 KNH nozzles regulated to 30 psi	6 SCFM
19. Processing West - use KNH nozzle regulated at 30 psi	13 SCFM
20. Processing East - add KNH nozzle/regulator at 30 psi	3 SCFM
21. Processing - Remove air knives - use guide arm	0 SCFM
22. Packaging 4 & 3 - Remove air bars - use guide rails	0 SCFM
23. Packaging Mezzanine - use KNH/add regulator at 50 psi	5 SCFM

Case Study - Solutions

POTENTIAL ANNUAL CONSUMPTION AND COST		
Initial air blow consumption		297.00 SCFM
Total air blow after improvements		71.00 SCFM
Total savings		226.00 SCFM
Total savings in bhp		45.56 bhp
Total annual savings after improvements		$14,216

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Case Study – Other Findings

- No Regulator
- No Nozzle
- 55 SCFM

Statistics			
	Min.	Avg.	Max.
Flow (SCFM)	54.50	54.81	55.30
Pressure (psi)	1.51	2.81	3.47

Air Consumption = 55 SCFM or $3,460 per year

Case Study - Solution

- Regulator
- High Efficiency Gun
- High Efficiency Nozzle
- Reduced Consumption

Statistics			
	Min.	Avg.	Max.
Flow (SCFM)	7.55	7.79	8.32
Pressure (psi)	75.40	76.66	78.20

Air Consumption = **8 SCFM** or $503 per year

Savings ~ 85%

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Air Blow - Savings

- **To improve the efficiency of the current state of air blow:**
- Remove air blow unnecessary to production
- Move air blow as close to the work surface as possible
- Regulate pressure to the lowest level of effectiveness
- Observe OSHA standards regarding orifice pressure
- Maintain supply pressure with a locking or fixed regulator
- Size supply tubing correctly
- Replace existing nozzles with high-efficiency models
- Shut off circuits when not needed in the production process
- Consider installing centrifugal blowers as an alternative to air blow

Air Blow - Summary

- Typical areas of concern are unregulated air blow applications, continually running air blow, open orifices and large blow guns.
- Simple solutions such as installing regulators, nozzles, and valves are quick, cost-effective approaches to solving these problems and operating much more efficiently.

Excessive Pressure

Ecologically Conscious Pneumatic Systems

Solutions That Save

Topics in Excessive Pressure

- Examples
  - Increased pressure to compensate for wear
  - Variations in quality of regulators
  - Locking Regulators are necessary
- Solutions
  - Show difference in energy usage at lower pressures
- Potential Savings
- Case Studies

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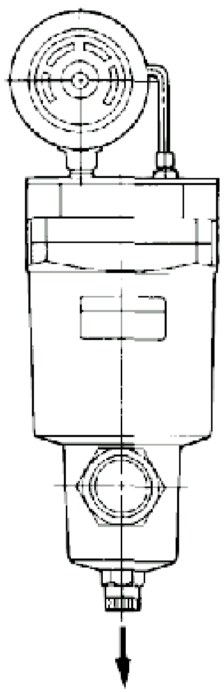
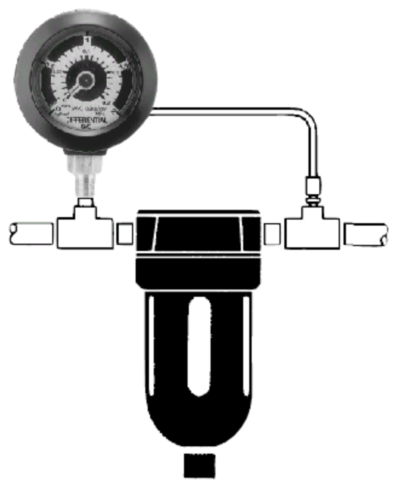
Excessive Pressure

- **Clogged filters are a main cause of pressure loss.**





DIFERENTIAL
PRESSURE GAUGE

ELEMENT
SERVICE INDICATOR

PRESSURE
SWITCH

Excessive Pressure Solutions

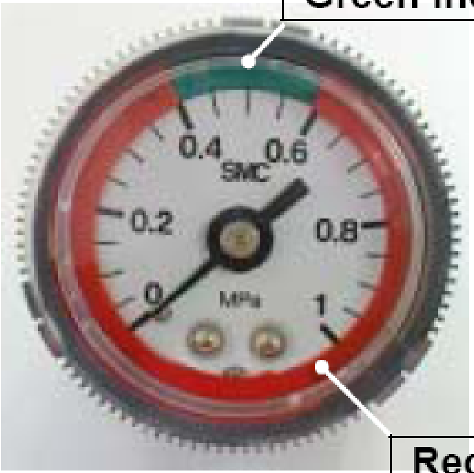
Use filters with metal bowls, locking regulators, embedded gauges and differential pop-up indicators or gauges.

Excessive Pressure Solutions

Use Gauges with a differential pressure display.

Feature : Red and green zones offer improved visibility of pressure control range.

Green indicator

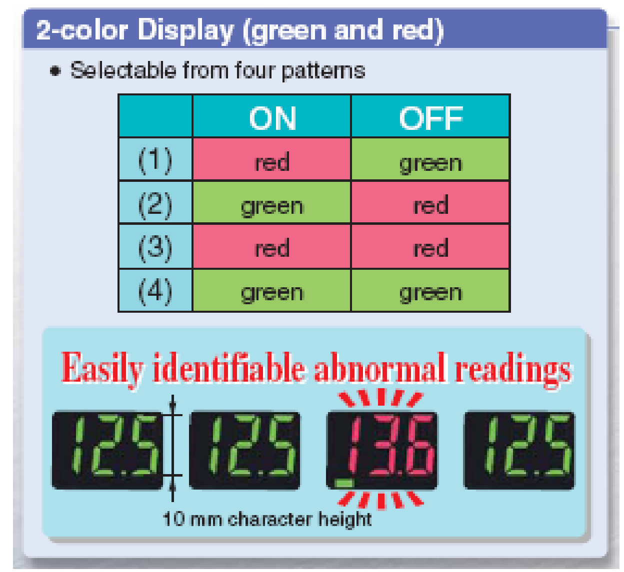


Red indicator

Indicator adjusts to highlight preferred range

Excessive Pressure Solutions

Use Gauges with visual pressure range display.


2-color Display (green and red)

• Selectable from four patterns

	ON	OFF
(1)	red	green
(2)	green	red
(3)	red	red
(4)	green	green

Or a gauge which will monitor differential pressures (PSE200)

Excessive Pressure Solutions

Section 1: Use products that allow you to recognize maintenance needs.

Example: As pressure builds before a clogged filter, flow is sacrificed downstream. The compressor must work harder to overcome this pressure differential, which costs you money.

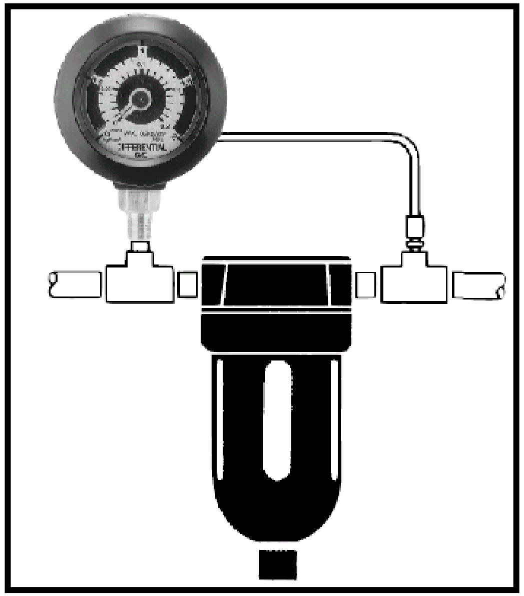
Use a Filter with Element Service Indicator to indicate excessive pressure drop

Excessive Pressure Solutions

Section 2: Pressure monitoring devices allow you to detect pressure loss issues before they become a problem.

<u>Example:</u> To prevent excessive filter clogging, the differential pressure gauge is put in line. Use a pressure switch which shows current system pressure, and stores high and low pressures.

From left to right: Differential Pressure gauge; Digital Pressure Switch



Excessive Pressure Solutions

Regulating pressure to air tools allows tools to generate the appropriate amount of torque to do work without damaging the tool.

50-75% of air consumption can be saved. .

A regulator with locking cap prevents setting adjustment

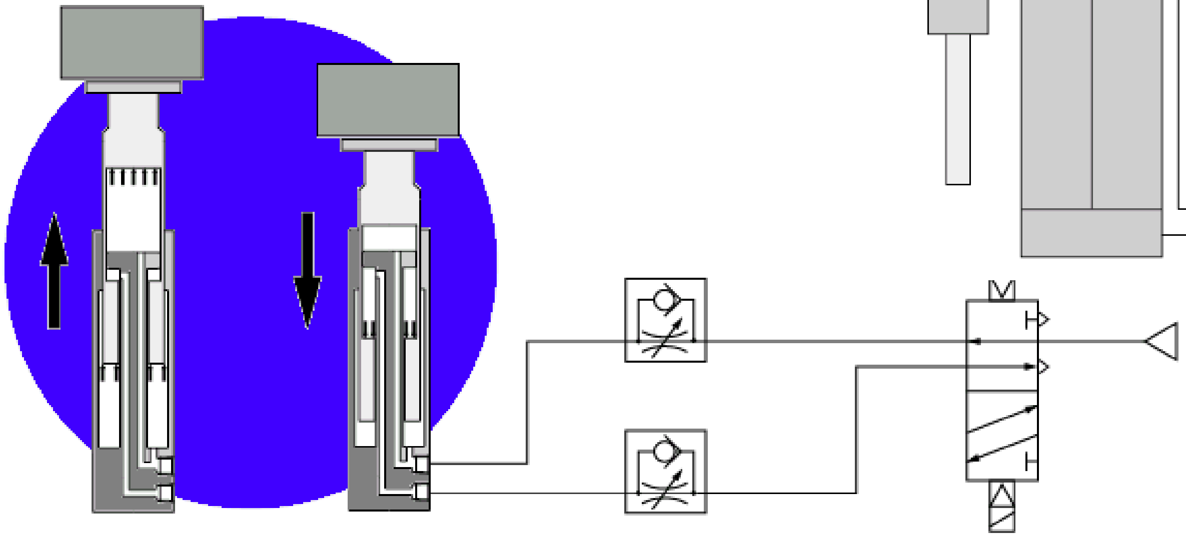
Use couplers designed not to leak or restrict flow.

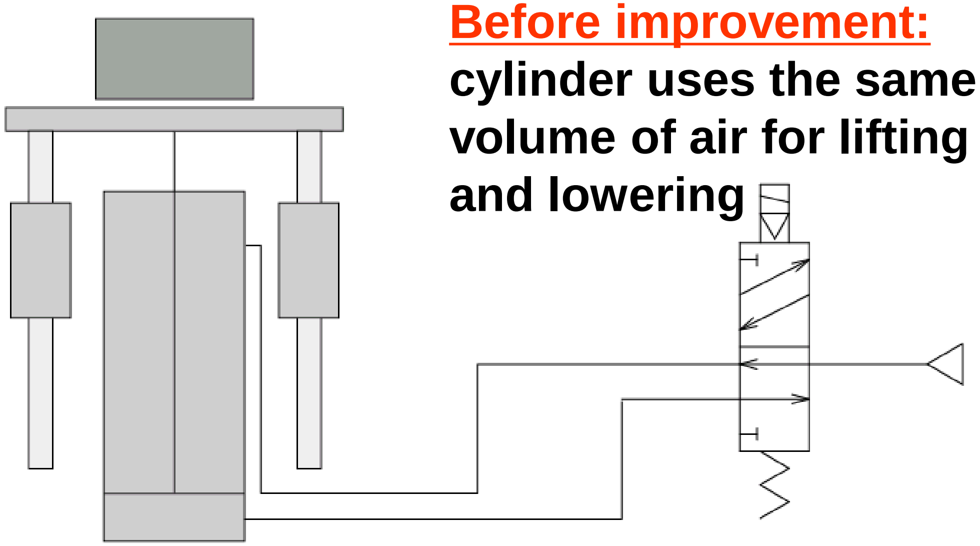
Excessive Pressure Solutions

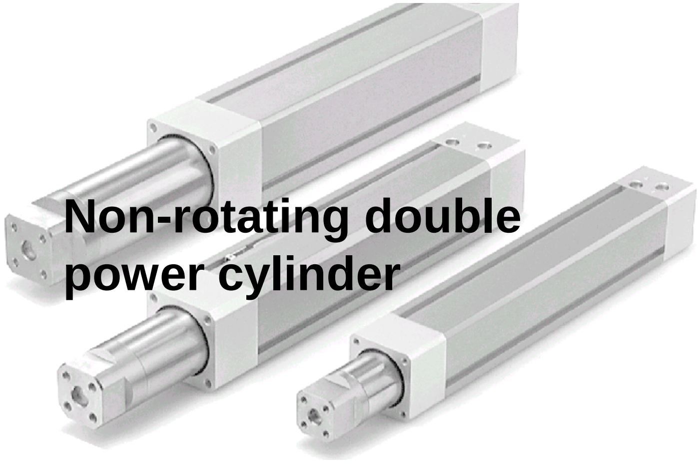
A double-force guided cylinder can decrease the dimensions and air consumption of a circuit.

After improvement: **Double power extension cylinder consumes 35% less air.**

Before improvement: **cylinder uses the same volume of air for lifting and lowering**



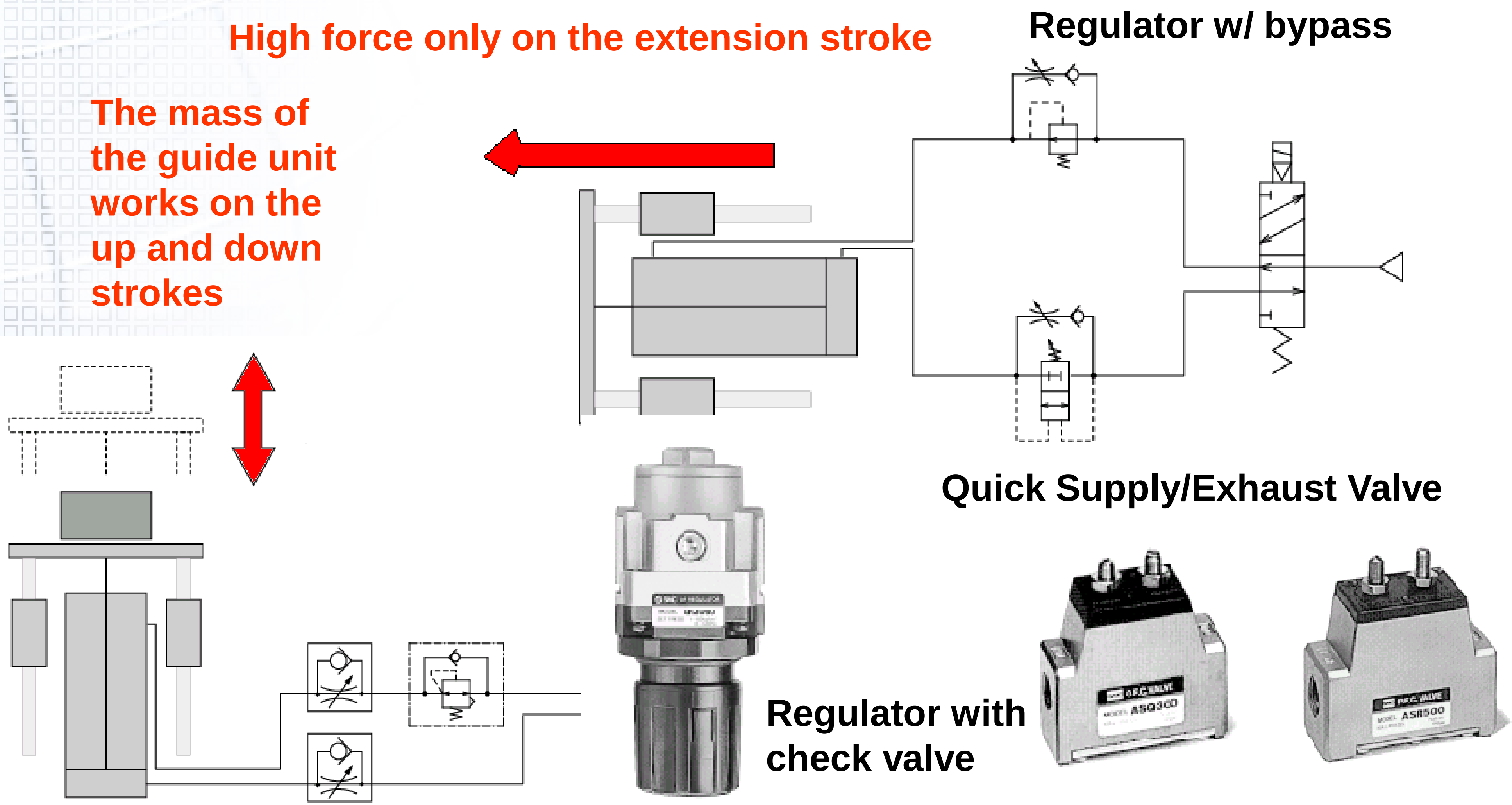




Non-rotating double power cylinder

Solutions for Excessive Pressure

Pressure on the return stroke can be lower, since large forces are not generally required on many applications.



Case Study – Excessive Pressure

- There were four main causes of excessive pressure in our example plant:
  - Broken, unreadable or missing pressure gauges
  - FRL components
  - Inappropriate settings.
  - Dot Matrix LASER



Case Study – Pressure Gauges

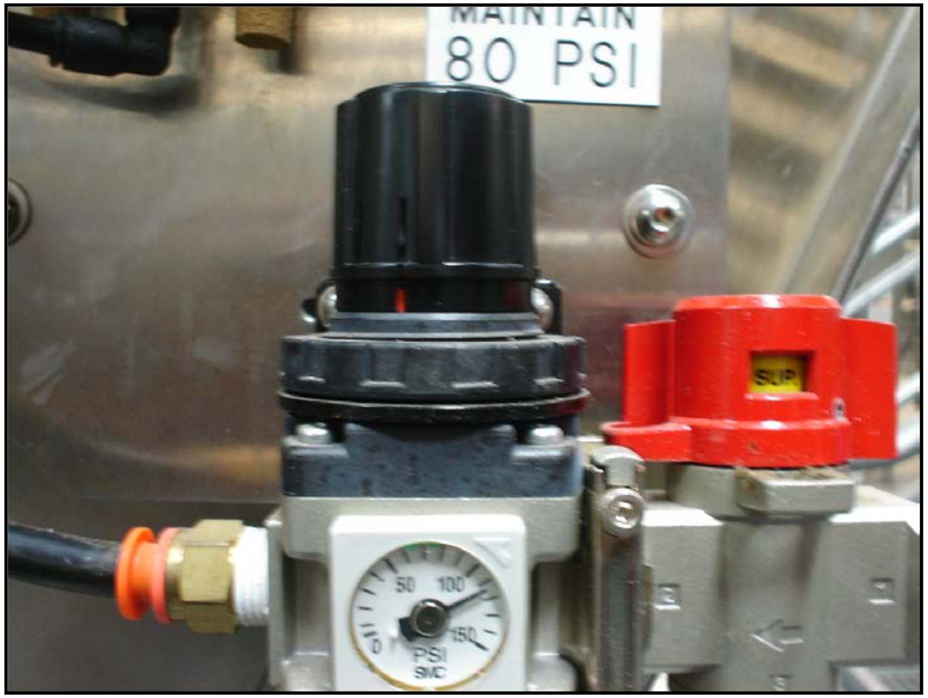
- Broken or unreadable gauges
  - Unable to confirm correct setting
  - Operator may adjust pressure too high to be "sure"

Case Study – FRL Components

- Clogged filter elements
  - More pressure is required to flow through clogged filter elements
- Leaking FRL components

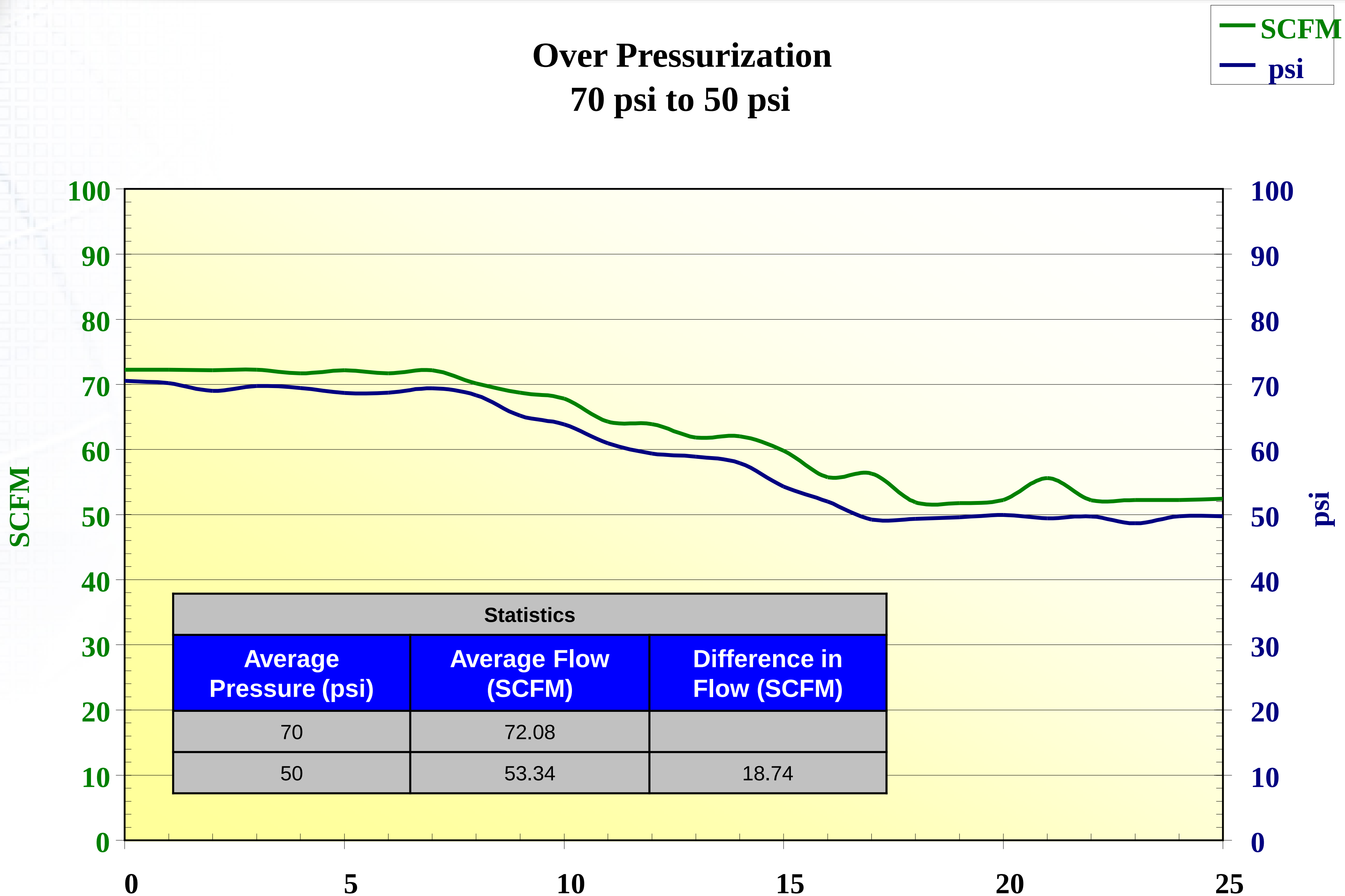
Case Study – Inappropriate Settings

- Required pressure is labeled for many applications
  - – Pressure gauges show higher setting than label
- Higher pressure consumes more air



Regulator is set for 112 PSI even though label states 80 PSI

Case Study - Example



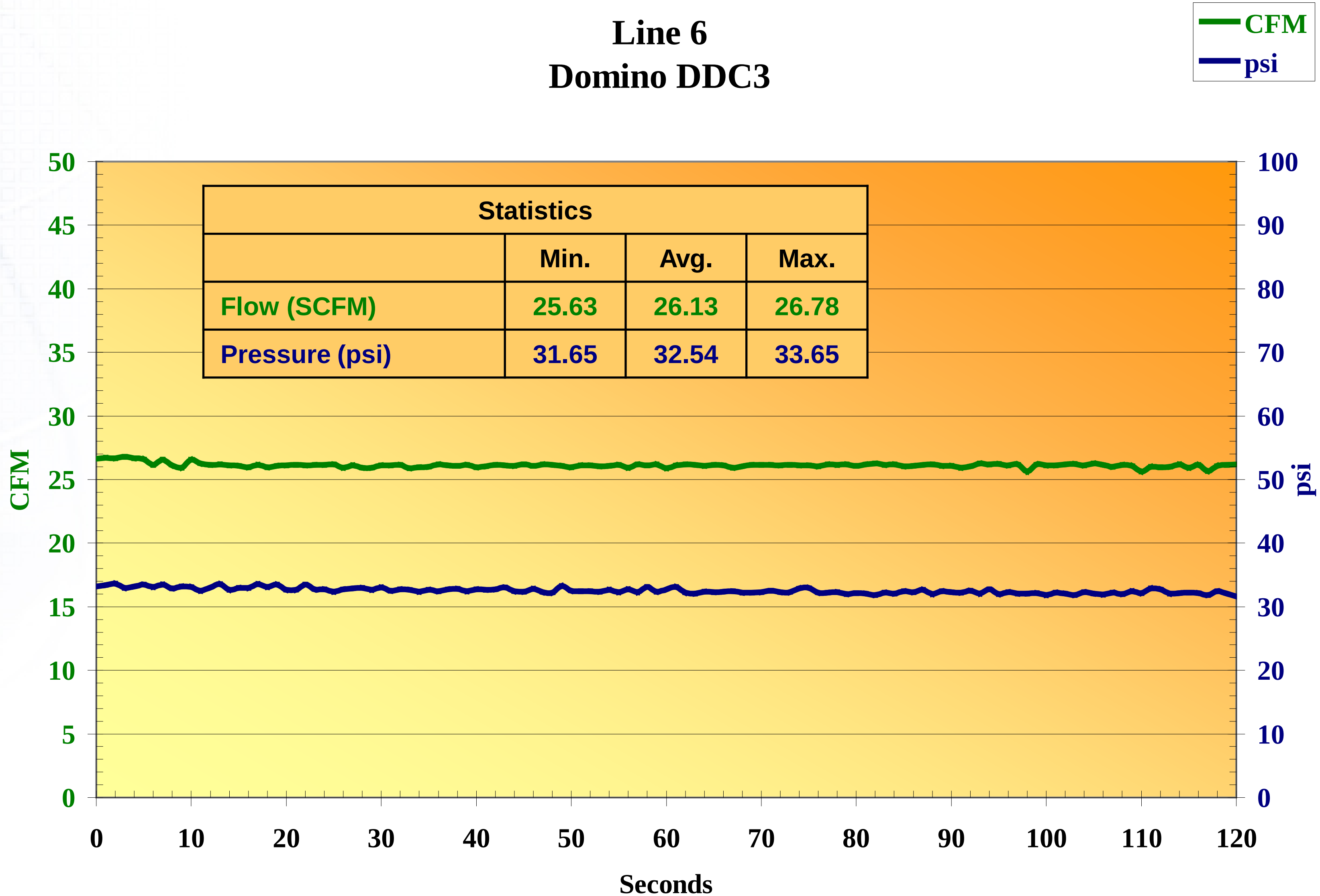
Statistics		
Average Pressure (psi)	Average Flow (SCFM)	Difference in Flow (SCFM)
70	72.08	
50	53.34	18.74

Difference in average flow = 18.74 SCFM = $3,152 annually!

Case Study – Domino DDC3

- DDC3 used for LASER marking
  - Air used for cooling & cleaning
  - Unit requires 4 ~ 7 SCFM air flow
  - no pressure requirement
  - Actual flow averaging 26.13 SCFM

Case Study – Domino DDC3



Statistics			
	Min.	Avg.	Max.
Flow (SCFM)	25.63	26.13	26.78
Pressure (psi)	31.65	32.54	33.65

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Annual Air Consumption Beyond Requirement = 19 SCFM

Intermittent Demand

Ecologically
Conscious
Pneumatic
Systems

Solutions That Save

SMC®

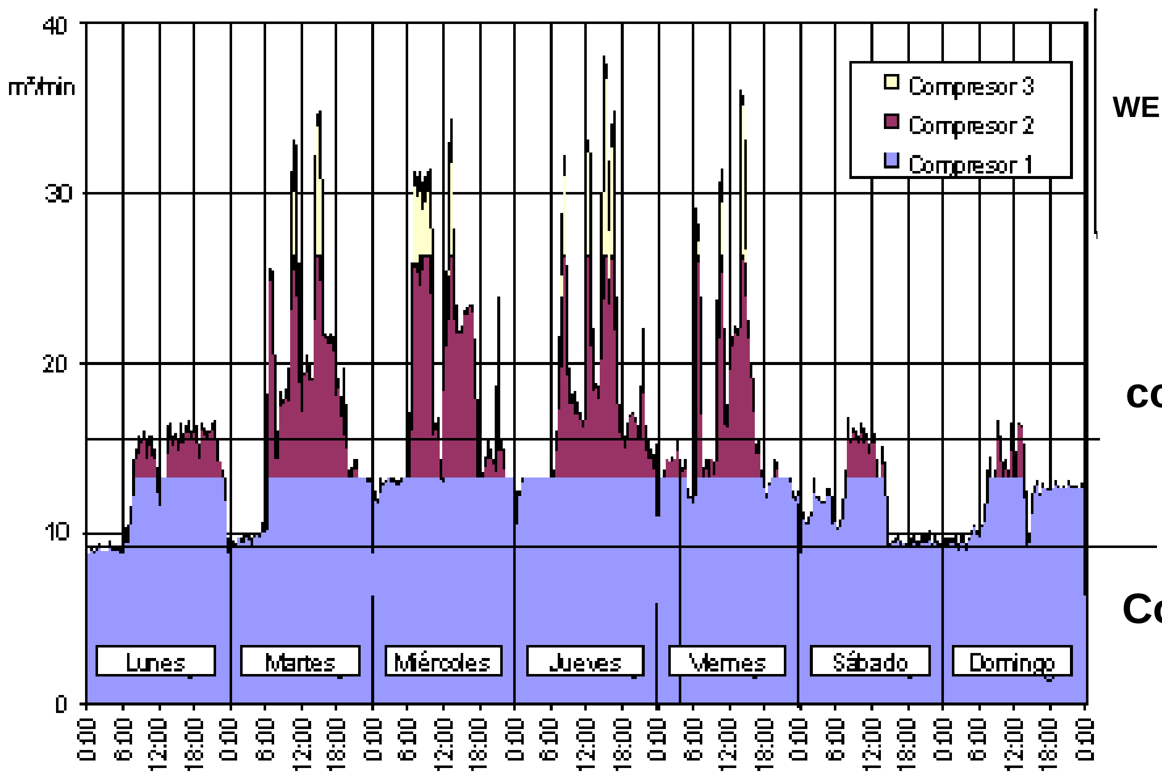
Topics in Intermittent Demand

- Examples
  - Machines need to shut off when not in use
  - Isolate during breaks, maintenance, etc.
  - Most machines operate 60% of the time
- Solutions
  - 3-port valves
- Potential Savings
- Case Studies

Intermittent Demand Testing

ISOLATION OF CIRCUIT AREAS

The compressor may be operating continuously due to leakage.



WEEKLY CONSUMPTION

Average consumption

Consumption due to Leakage.

Intermittent Demand Testing

Test to determine the leakage in your pneumatic system:

- Measure the average flow rate when equipment is in production

- Measure the average flow rate when equipment is not in production

- The difference between the two will indicate usage of compressed air due to leakage!

How can we fix Intermittent Demand?

- Ø Intermittent demand is an issue in every facility.
- Ø In most cases, if OEM equipment is not running, then compressed air should not be supplied.
- Ø There are simple, cost-effective ways to solve common intermittent demand issues:
    - Use a three-way valve that shuts air off to equipment when no work piece is present.
    - Use a mechanical valve that actuates when a work piece is present.

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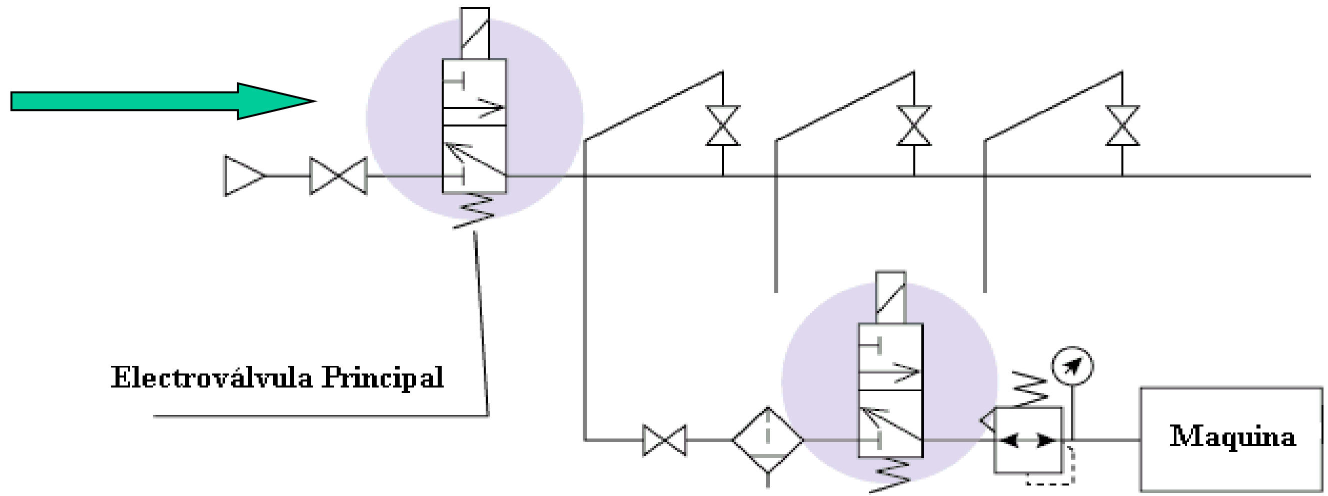
Intermittent Demand Solutions

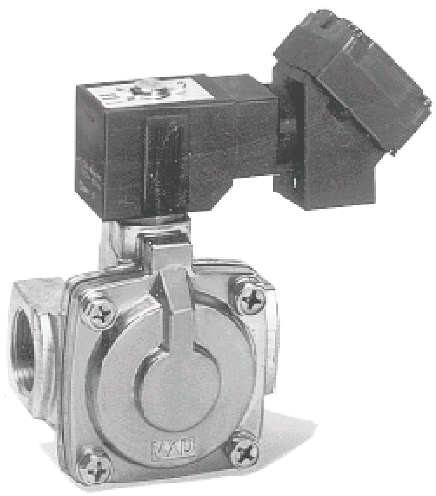
- Air supply to the equipment should be stopped when it is not operating.

MASTER SOLENOID VALVE

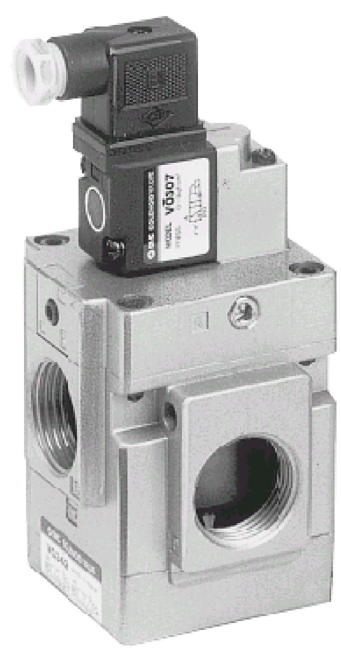


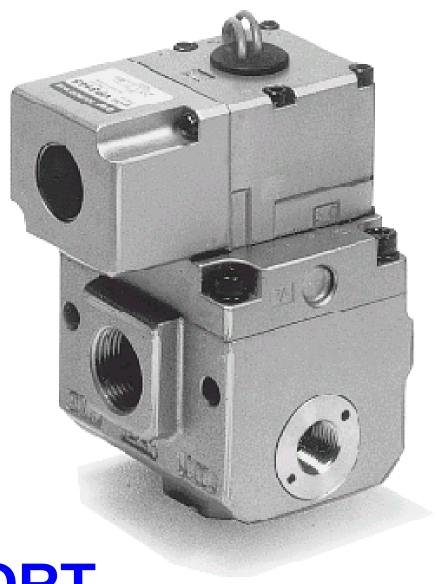
Intermittent Demand Solutions

- REDUCE AIR CONSUMPTION by 100% DURING PERIODS OF NON-OPERATION (EVENINGS, WEEKENDS, ETC…) BY INSTALLING SOLENOID VALVES ON EACH AIR-LINE.



2 PORT





3 PORT

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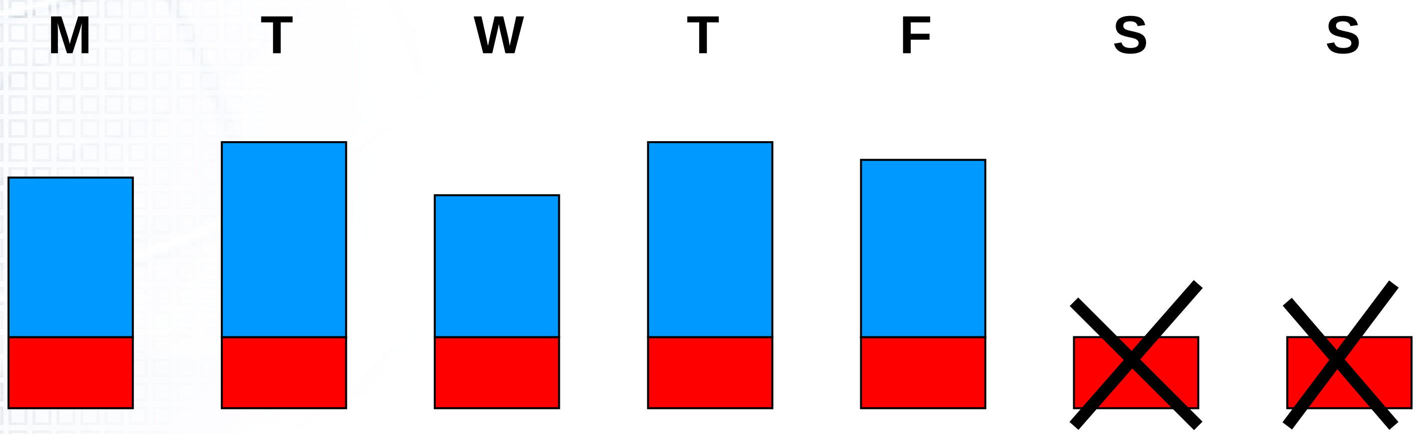
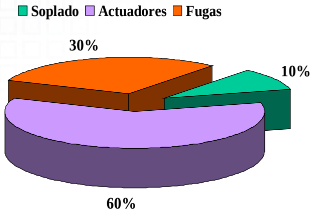
Intermittent Demand Solutions

Consumption during weekends



30% LEAKAGE

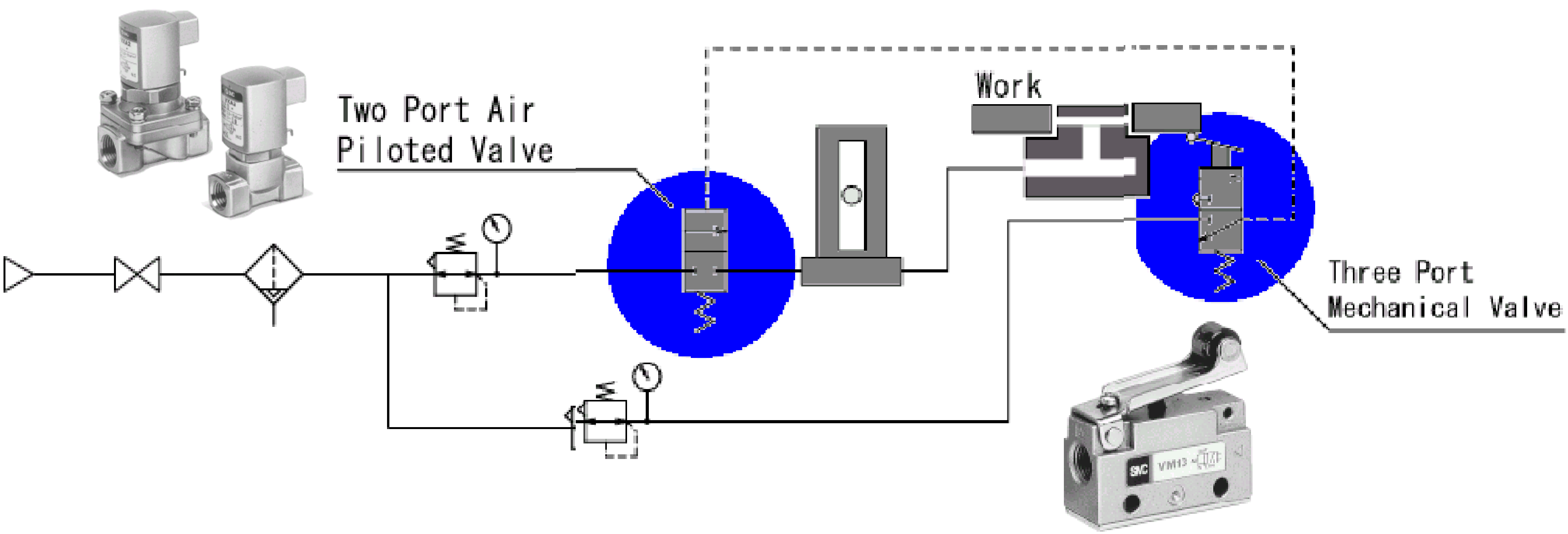


20% LEAKAGE

2% REDUCTION IN THE TOTAL ELECTRIC CONSUMPTION OF THE PLANT

Intermittent Demand Solutions

Work precision is often measured using an air micro gauge that purges air whether work is present or not.



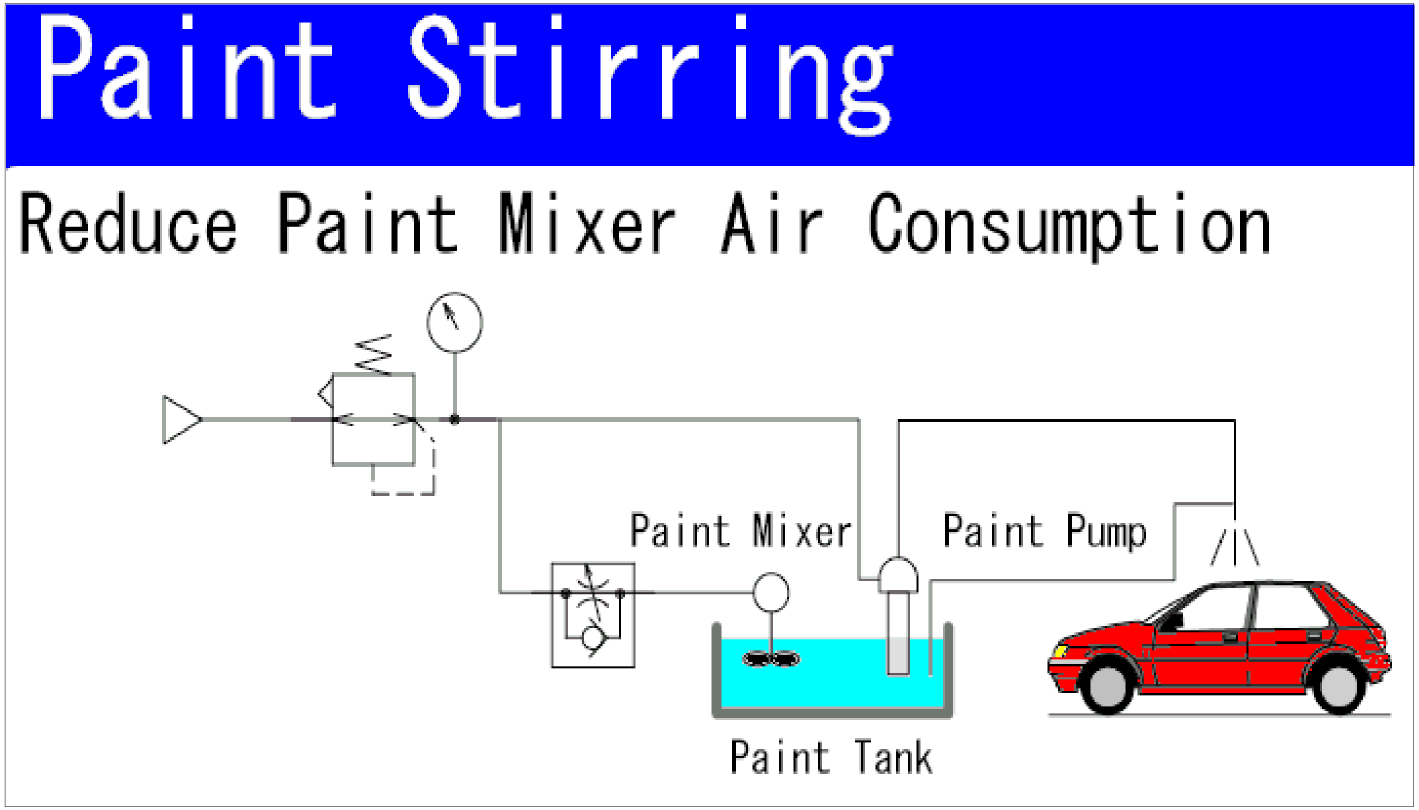
Up to 95% of purging air can be conserved using a three port mechanical valve circuit.

Intermittent Demand Solutions

- STOP costly air purging when there is no work to be done.
- One solution includes using a simple 3 port mechanical valve.

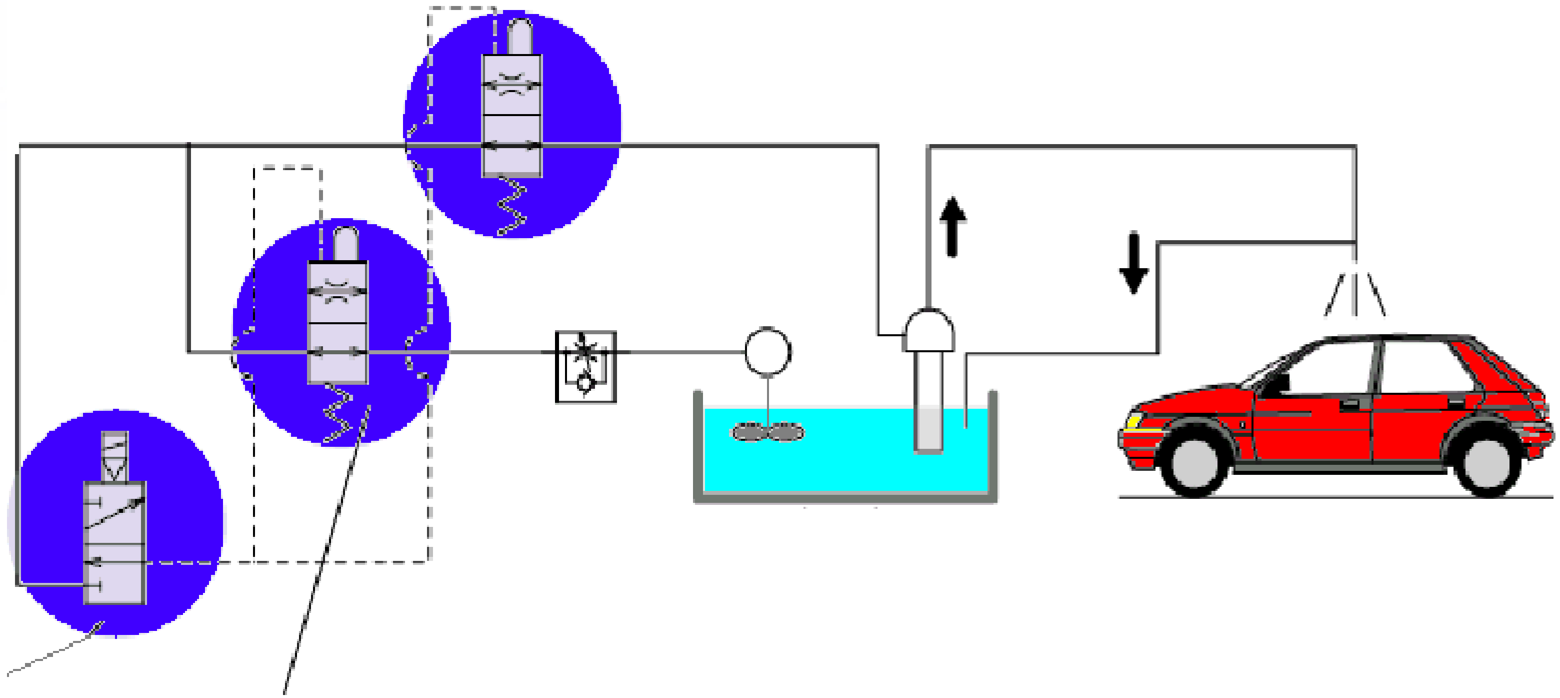
Intermittent Demand Solutions

Paint must be continually stirred so that it does not harden. This means that air is consumed by the paint mixer even during line stoppage.



Intermittent Demand Solutions

In this case, it was not feasible to stop the mixing operation, but it was determined that the mixing could slow during times when painting operations were halted.



3 port, pilot type solenoid valve

A 2-port air operated metering valve makes this possible.

Intermittent Demand Solutions

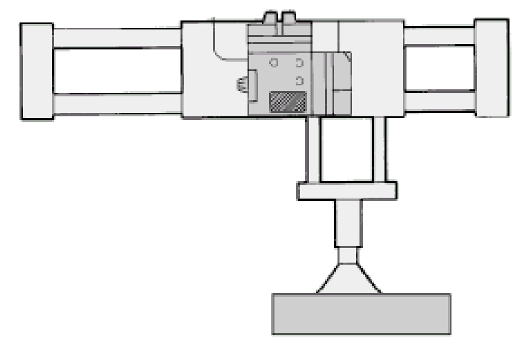
✓Turn vacuum on only when it is needed.

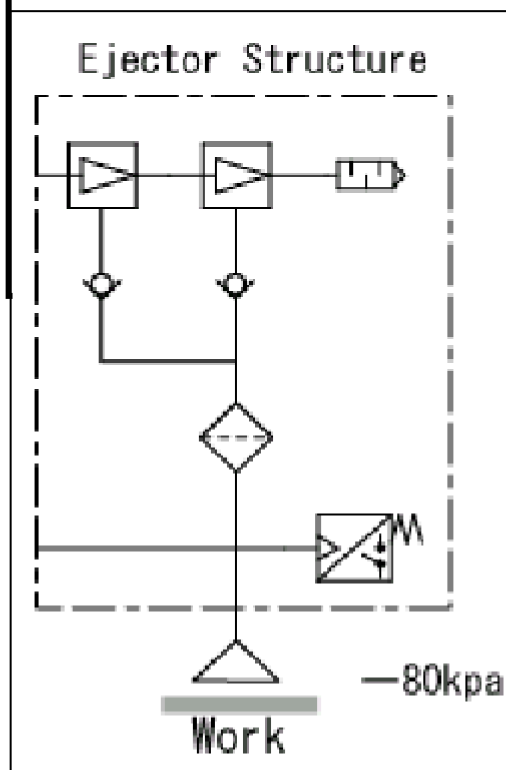
✓In some applications, a check valve ejector may be used to hold work while the air source is off.

✓50-75% of air can be conserved.

Vacuum

Reduce air consumption of ejectors with transfer vacuum





Case Study – Bottling Line

- On a bottling line, multiple air-blow jets are used on cap feeders to assist in feeding the caps into a capper. When the capper stops, the air blow continues to run, consuming 20 SCFM.
- A high level sensor could send a signal to a valve that would shut the air off when the capper stops.
- Suppose the line stops for 5 minutes every hour or 730 hours per year on 10 different cappers throughout the plant.
- This equates to $303 per year per capper, **$3,030** per year for all cappers in the plant!

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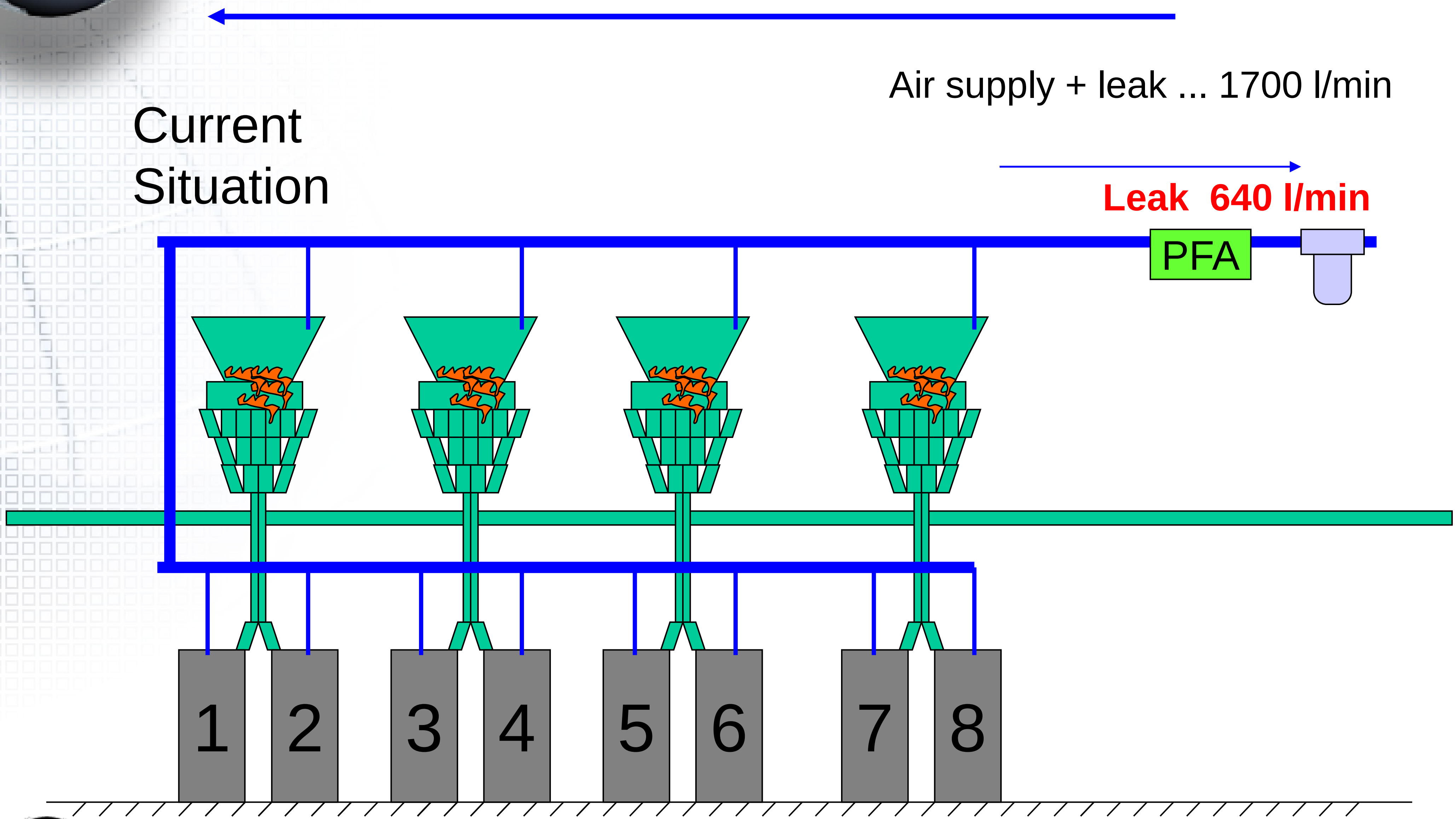
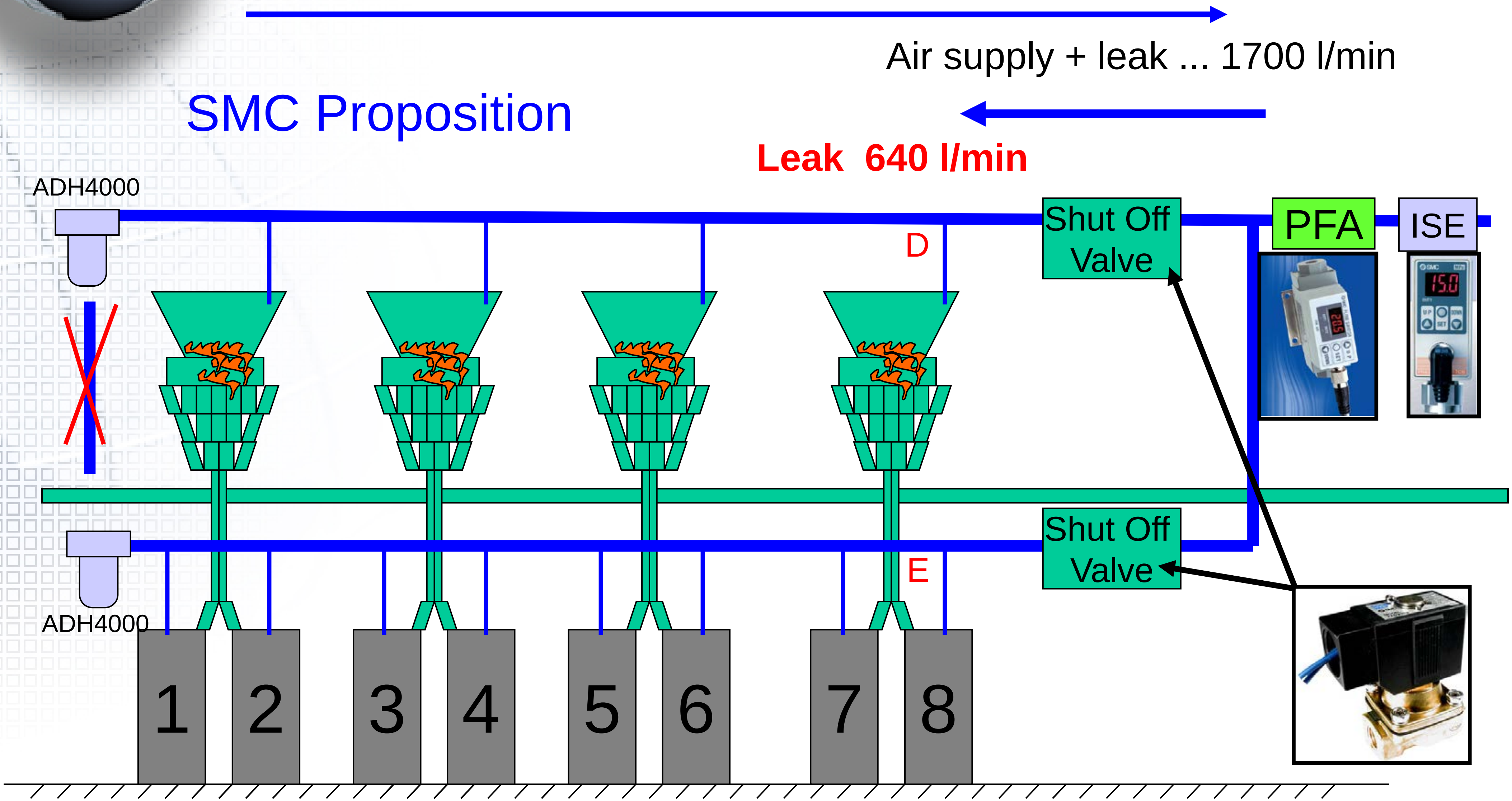
Case Study –Snack Line

Current Situation



Snack Chip Packaging Line

Case Study –Snack Line



Snack Chip Packaging Line

Case Study –Snack Line

- 640 liter/min is 22.60 SCFM.
- To convert to HP we need to divide by 4.5, which equals: 5.02 HP.
- Using a cost per Kwh of $0.14 and annual hours of operation at 8760 (24/7/365) the cost is $5,103 for just the leaks on each packaging line.
- 8 packaging lines in this plant equates to **$40,824** per year for all packaging lines in the plant!
- Without fixing any leaks and just shutting off the air during shut-down, the savings equals: **$13,607**

Case Study – Air Knife

4th Floor Line F Cutters

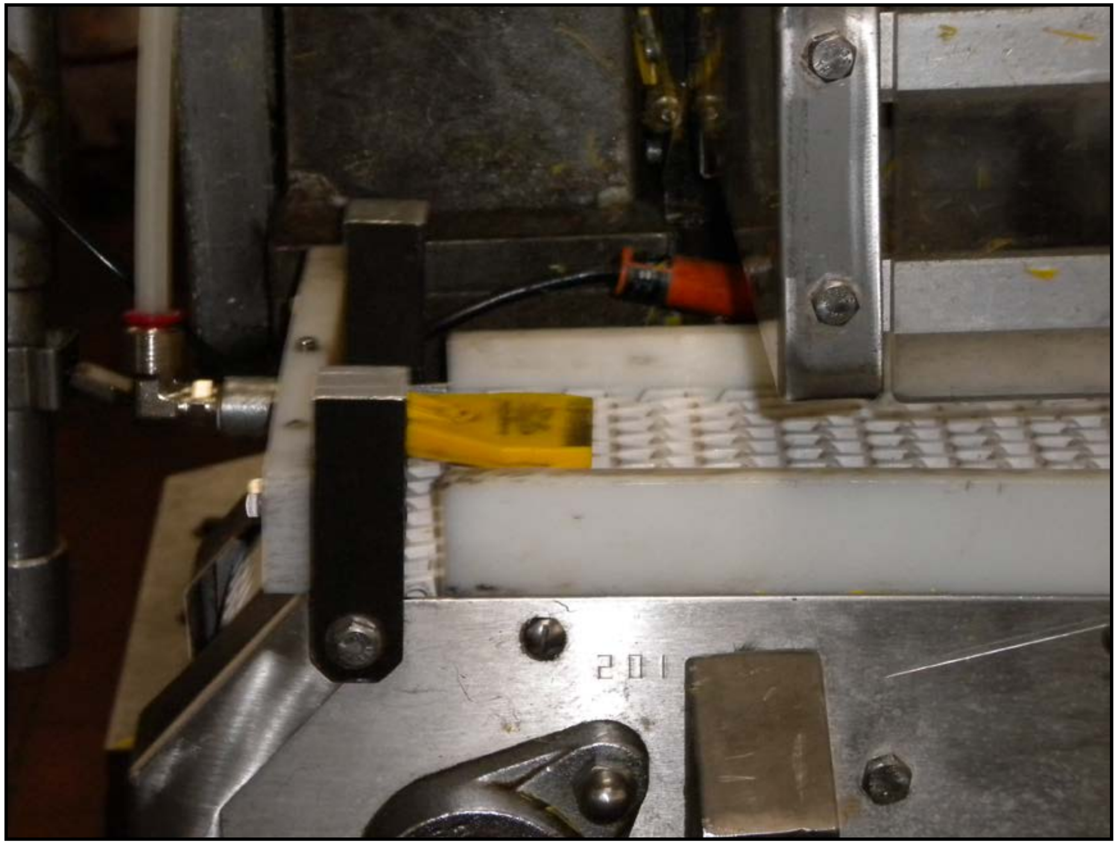
Air knives blow to keep packages together as they move down the line.

- Pressure is regulated down,
- but far away from product.

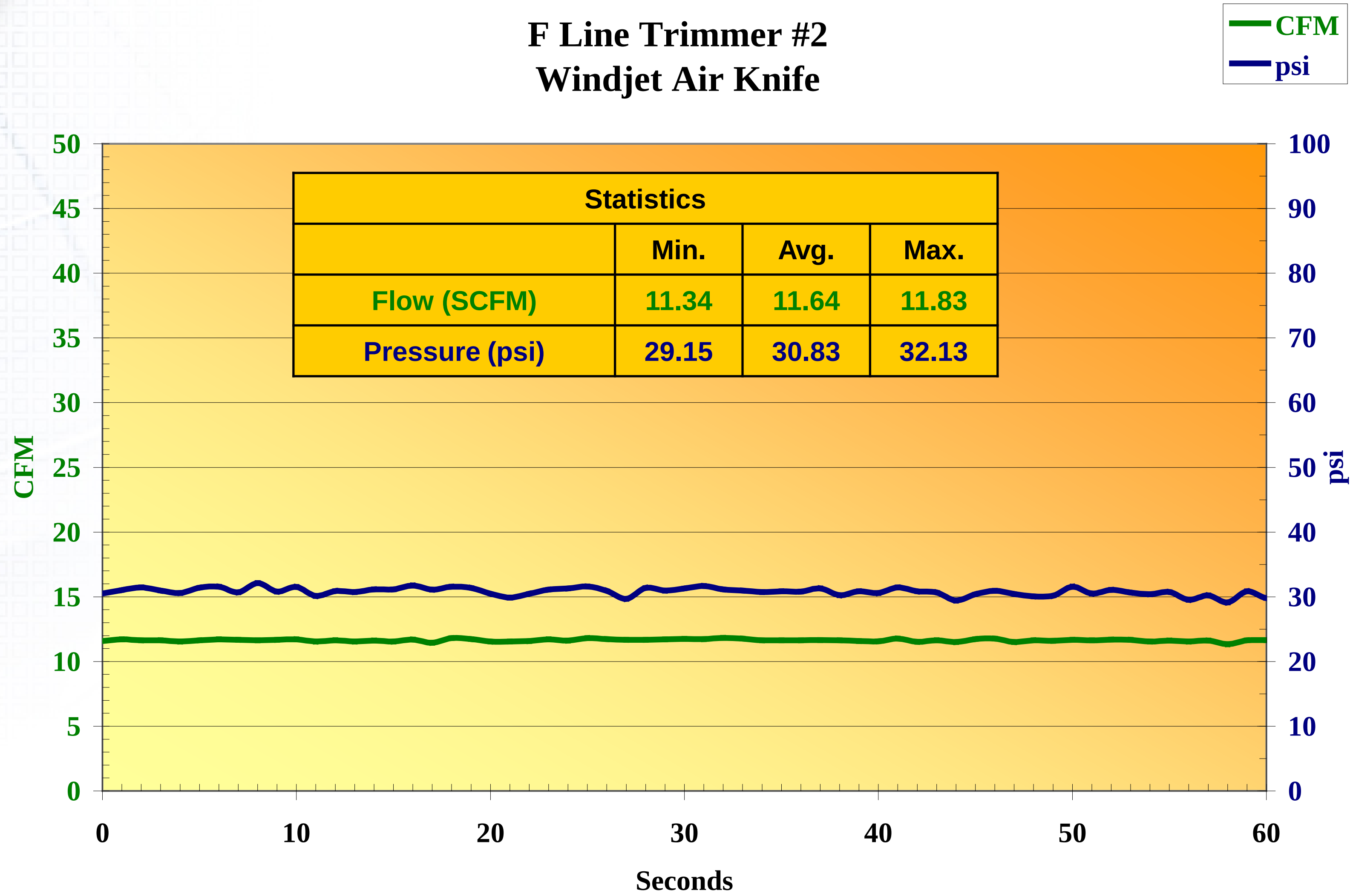
- If moved closer:
  - Use lower pressure
  - Uses less energy.

- The knives are far away
  - little impact pressure
  - necessity of these knives?

- Knives blow continuously
  - Controlled by a solenoid valve when not required.



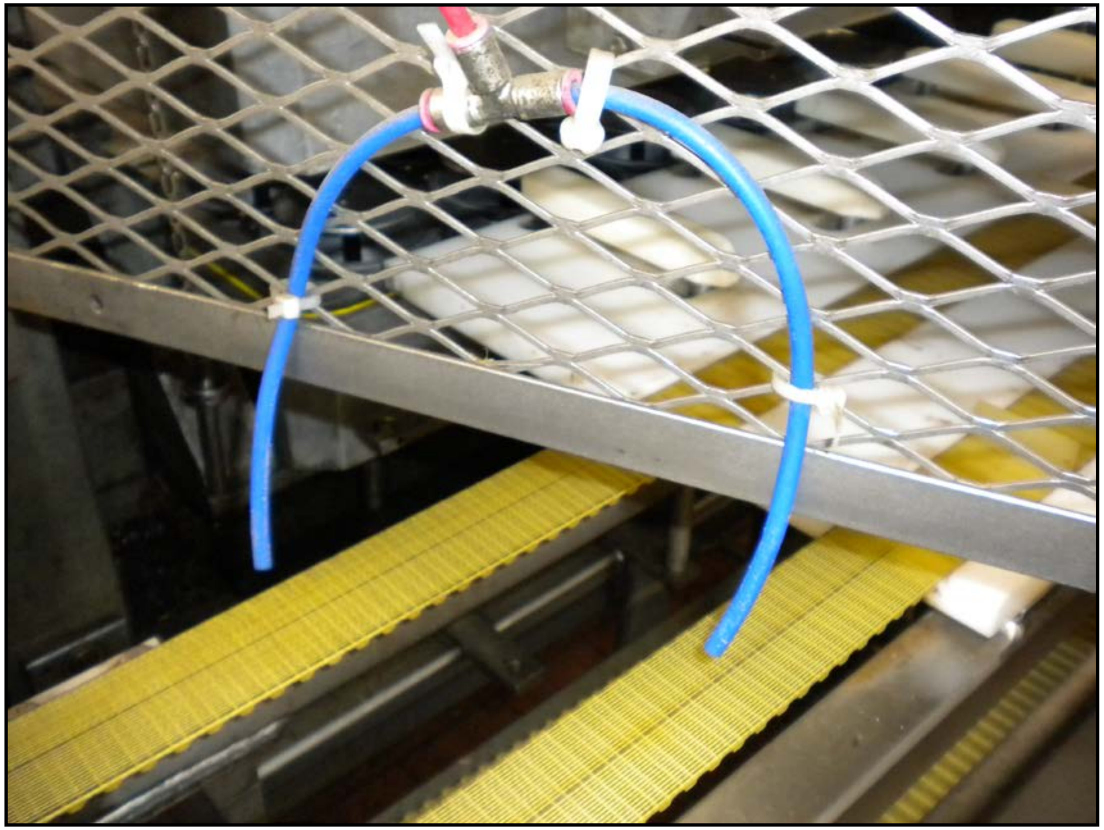
Case Study – Air Knife



Statistics			
	Min.	Avg.	Max.
Flow (SCFM)	11.34	11.64	11.83
Pressure (psi)	29.15	30.83	32.13

Case Study - Solutions

4th Floor Line F1
There are two ¼" tubes running from a union tee fitting blowing air on the conveyor on line F1. This air is blowing continually, and was noticed blowing even when the line was down.
Air Consumption = 30.00 SCFM



Case Study - Solutions

4th Floor – Line D Pack Cutter

As discussed in the air blow section, downstream of the pack cutter there are two air blow applications in use. Both applications are blowing constantly and are consuming an abundance of air.

Air Consumption = 34.37 SCFM

Case Study - Solutions

4th Floor – Line D Box Filler

There are two Silvent air knives blowing to hold packages against the rail on line D. One is pointed correctly, and one is missing, however both are running constantly.

Air Consumption =
37.30 SCFM

Case Study – Intermittent Demand Summary

Intermittent Demand Applications		
1	4th Floor - Line F1 - 2 nozzles	5.84 SCFM
2	4th Floor - Line F1 - 1/4" tube (2) blowing @ 40 psi	20.46 SCFM
3	4th Floor - Line F Cutters - 1 Lechler/1 Windjet	11.64 SCFM
4	4th Floor - Line G Package Cutter - Windjet 727-15 @ line pressure	14.57 SCFM
5	7th Floor - Line E Pack Filler Belt - Air bar & 1/4" orifices (2) @ line pressure	34.37 SCFM
6	4th Floor - Line D Pack Cutter - Lechler knife & 1/4" orifice	34.37 SCFM
7	4th Floor - Line D Box Filler - 2 air knives	37.30 SCFM
8	6th Floor - Line 3 - Air blow bar (27 holes)	20.00 SCFM

Case Study – Hypothetical Cost

The Hypothetical Cost of Intermittent Demand (Line F1 air blow)

Current Demand: Operates 24/7/365 (8760 hours) at a cost of $1,541.

Hypothetical (True) Demand : Operates 16 hours/day (5,840 hours) at a cost of $1,028.

(Includes downtime for breaks, maintenance, etc.)

The savings based on this intermittent demand is $513.

Intermittent Demand Return on Investment Example	
Line F1's air blow cost of annual operation	$1,541
Line F1's hypothetical cost of annual operation	$1,028
Cost of Valve Reduces air blow annual operation by 5616 hours	$79.35
Total Savings Year One	$433.65

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Design Alternatives

Ecologically Conscious Pneumatic Systems

Solutions That Save

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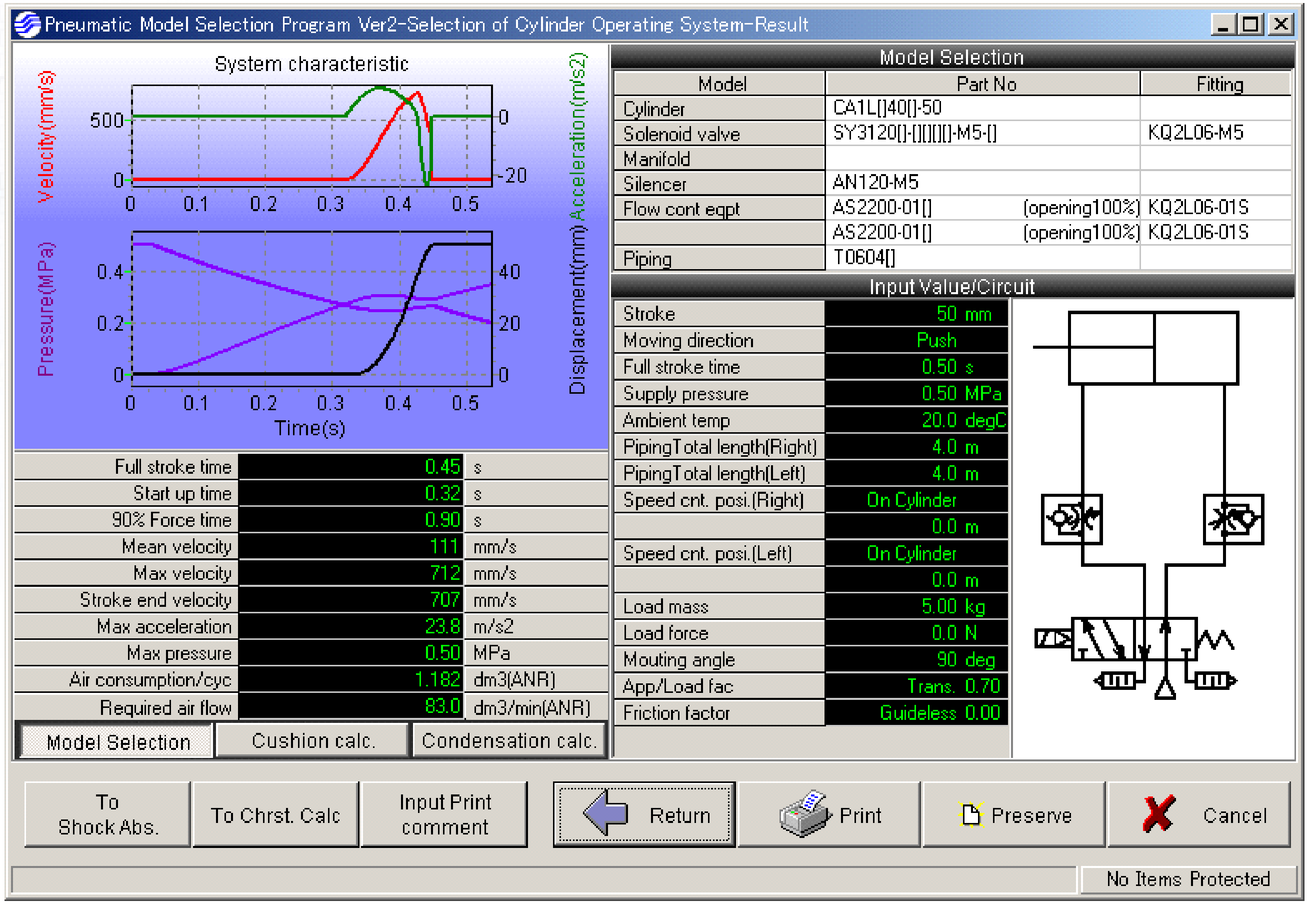
Design Alternatives

- Examples
  - Sizing
  - Double Acting VS. Single Acting
  - Tubing length: Filling tube with no benefit
  - Pressure Control
- Solutions
  - Right-Size Cylinders
  - Single Acting Cylinders
  - Shorten Tubing
  - Reduce pressure on non-working stroke
- Potential Savings
- Case Studies

Model Selection Program

Output Screen

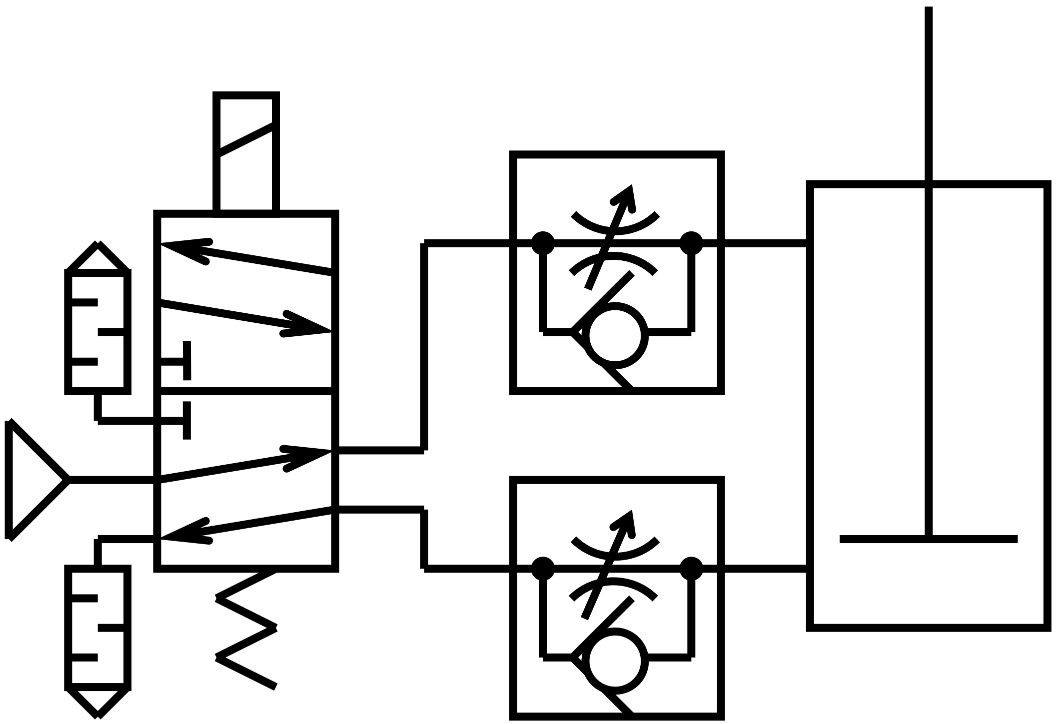
Choose the most efficient system:



Design Alternatives

Consider Single-Acting over Double Acting

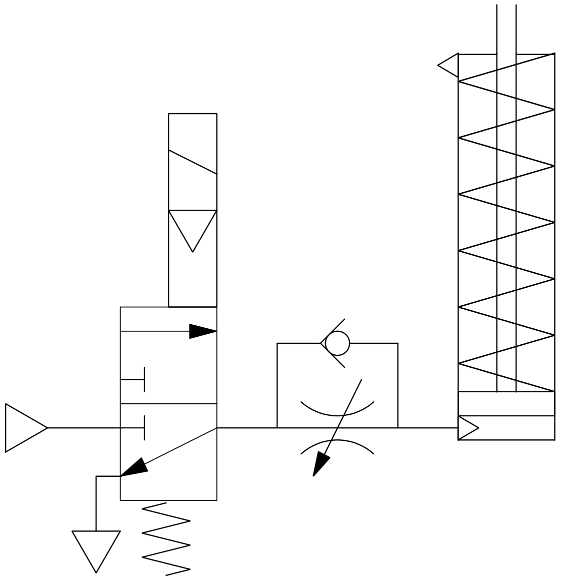
- **Ways to save:**
  - **Gravity Down?**
  - **Single Acting Cylinder?**
  - **Use Air Piloted Solenoid**



50% Savings

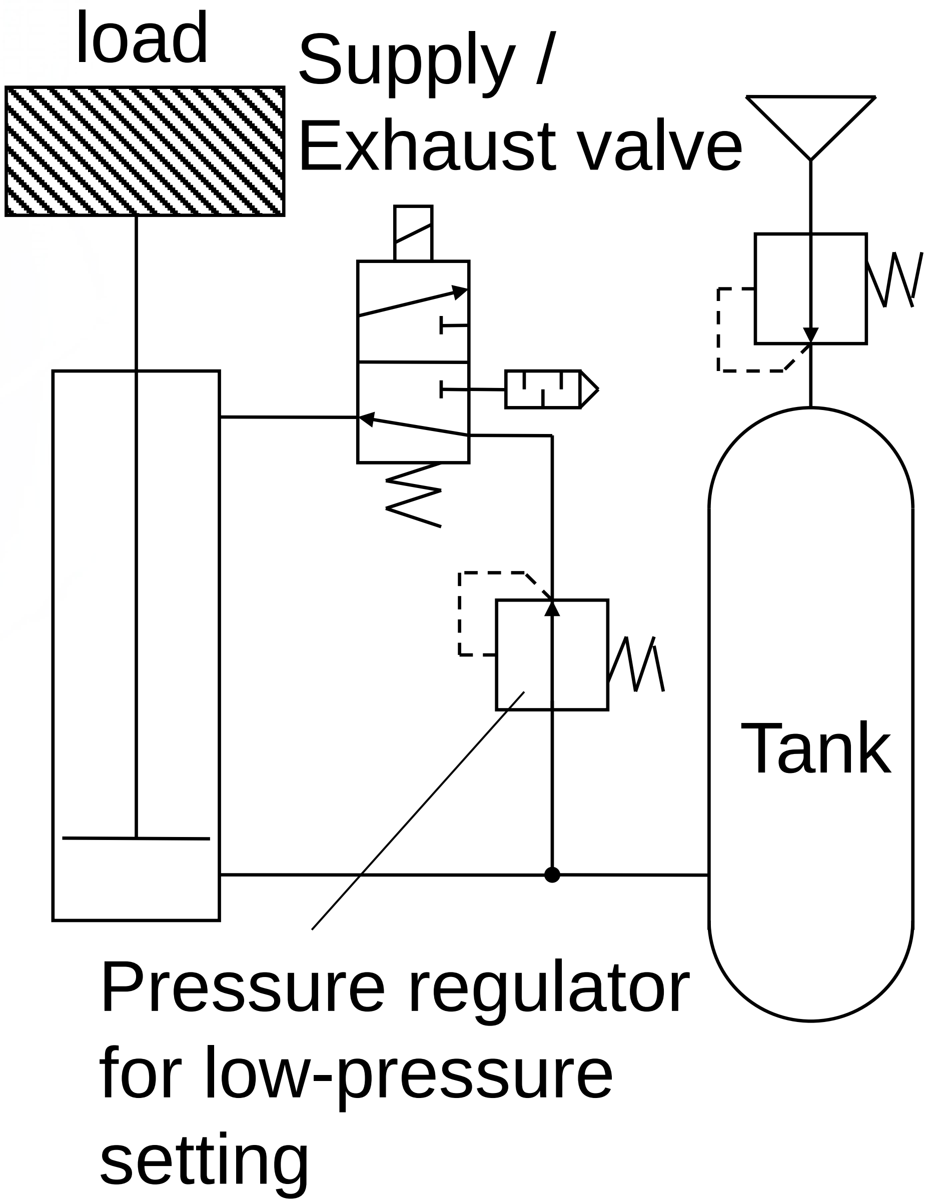
Design Alternatives

Single Acting Cylinder



Design Alternatives

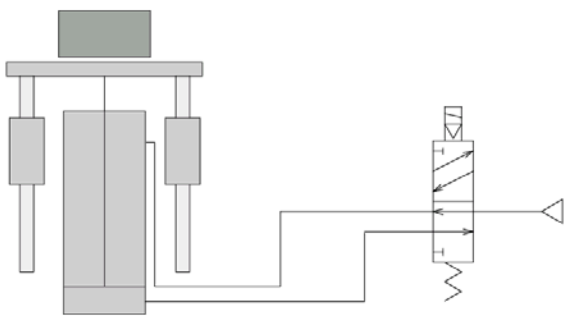
Energy Saving Lifter

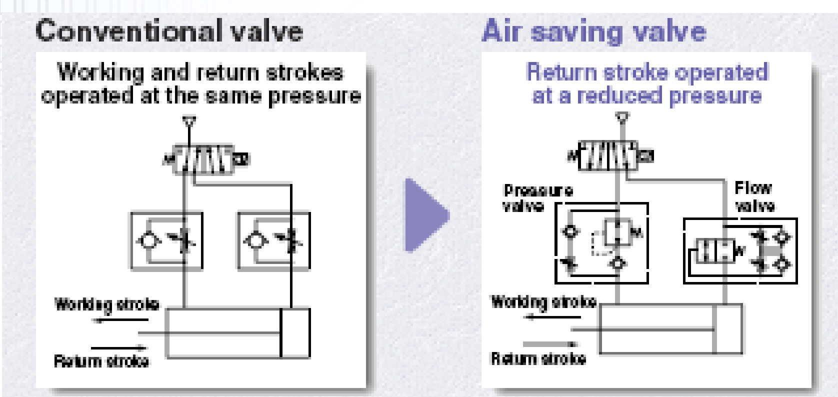


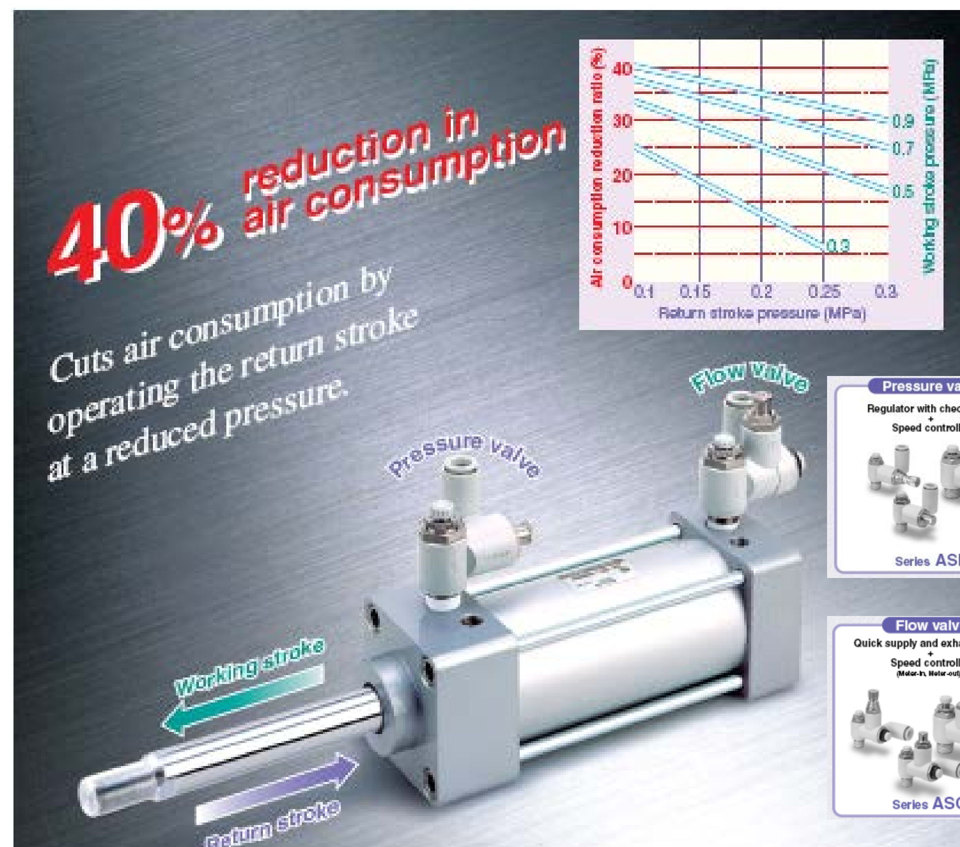
75% Savings

Design Alternatives

- Extend and retract strokes frequently do not require the same operating pressure. A reduction in pressure on the non-working side of the cylinder will lead to significant energy savings.







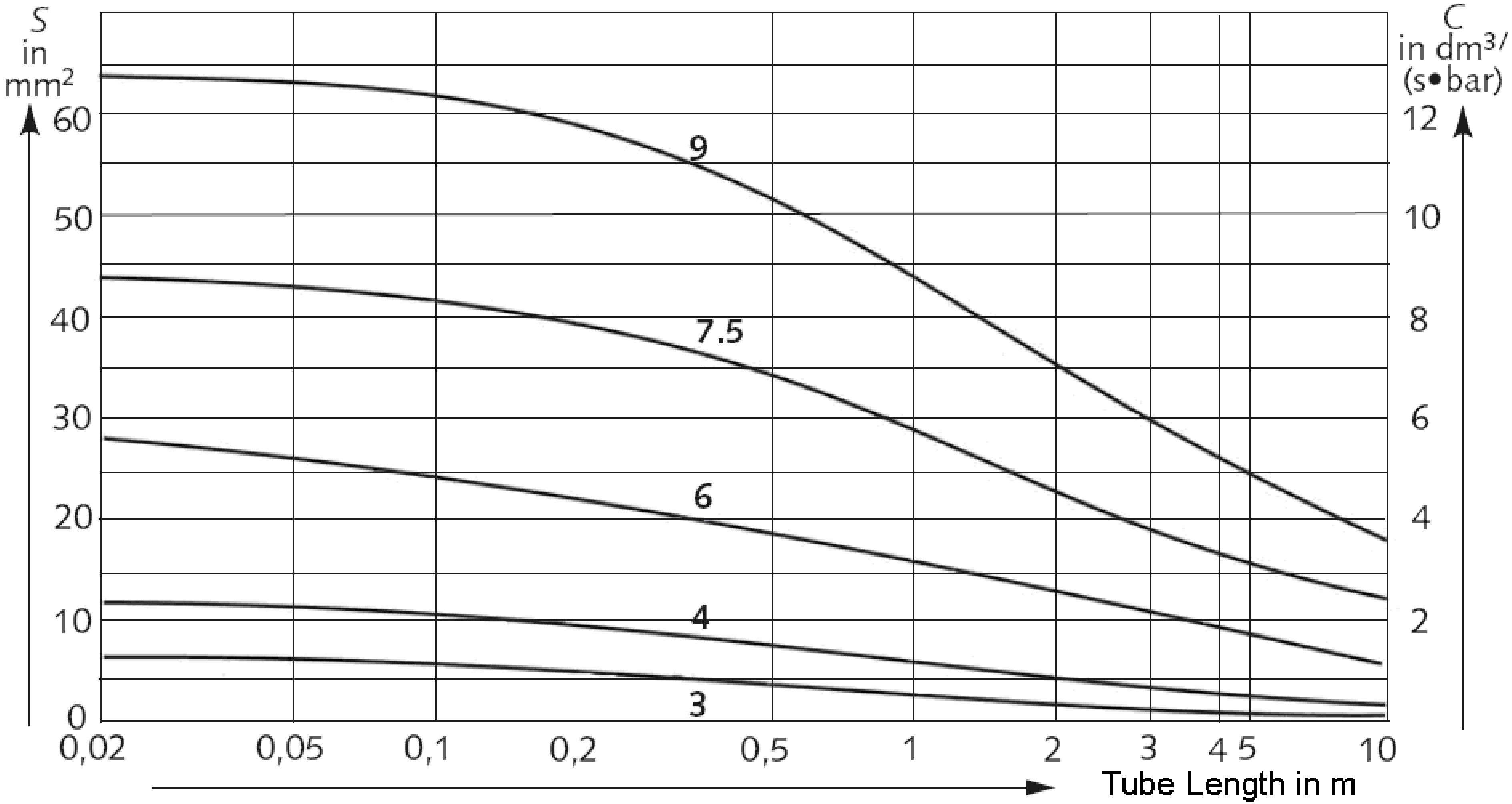
Design Alternatives

Tubing Length

- Consider that air used to fill the tubing on the way to the actuator is wasted! There is no work being done by this air!
- The conductance of tubing decreases dramatically with an increase in length
  - Shorten tubing as much as feasible
  - Beware that larger diameter = larger volume
  - Size tubing for flow required – don't guess!

Design Alternatives

Tubing Length



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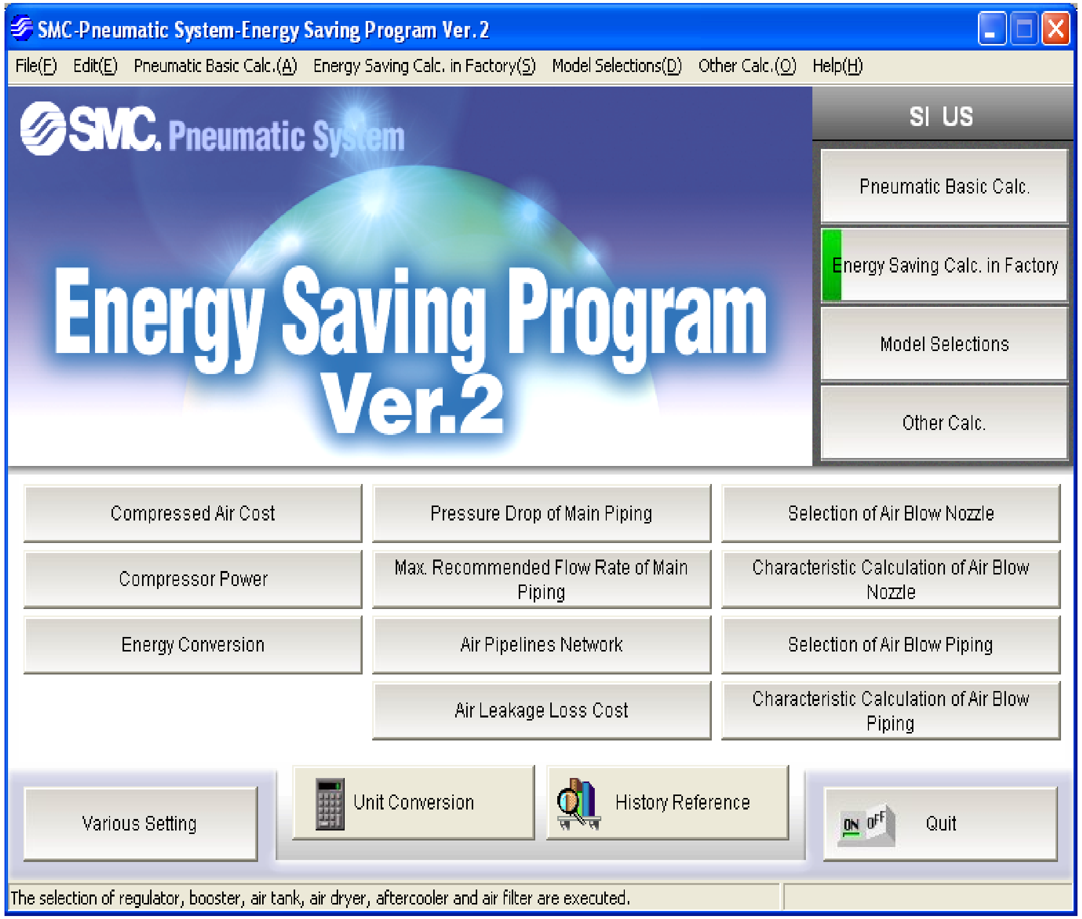
Energy Savings Program

Suggestions on other ways to save:

Ø Energy savings calculations include:

- Compressed air cost
- Compressor power
- Energy conversion
- Pressure drop of main piping
- Max. recommended flow rate of main piping
- Air pipeline network layout
- Air leakage loss cost
- Selection of air blow nozzle
- Selection of air blow piping



How to Proceed

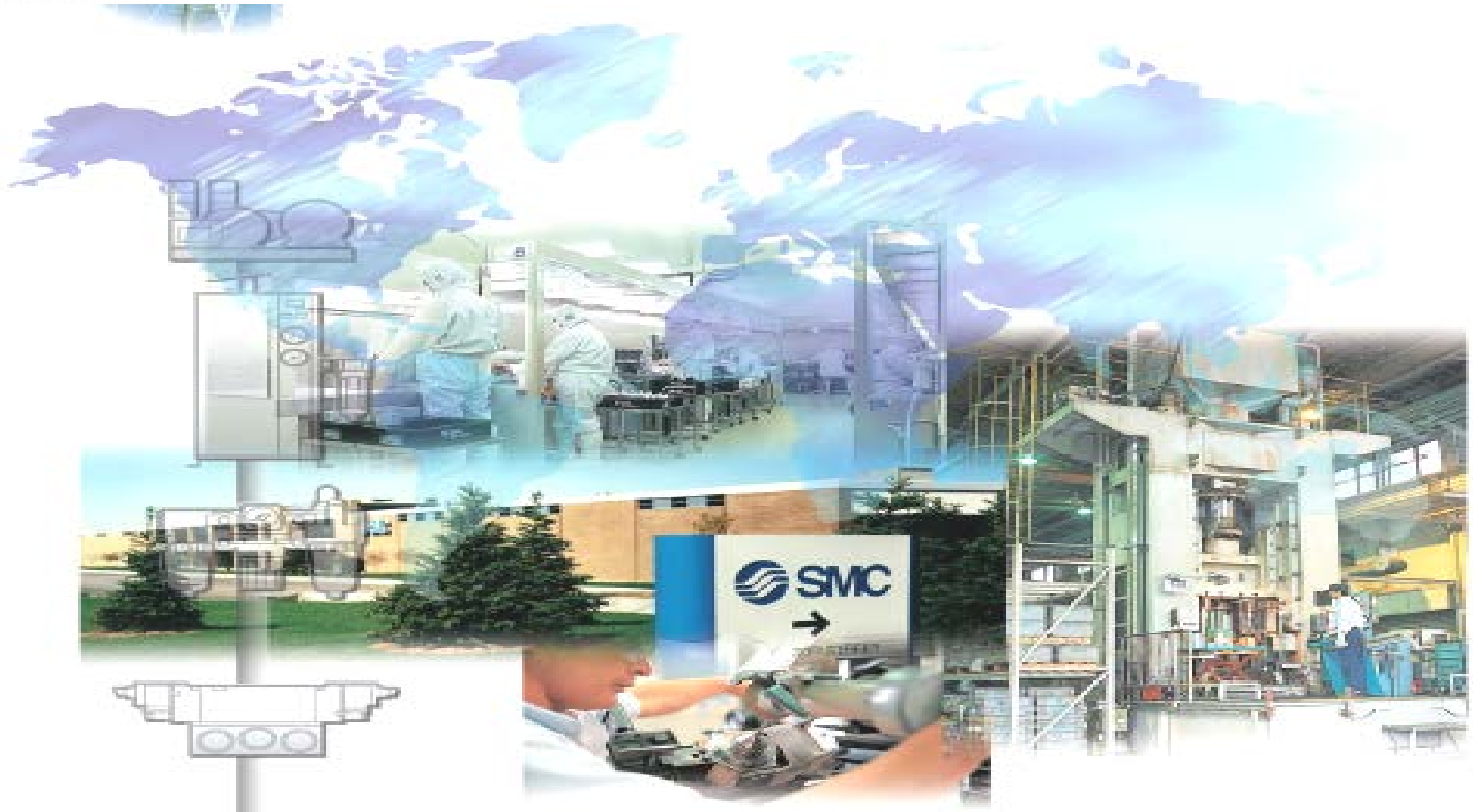
Ecologically
Conscious
Pneumatic
Systems

Solutions That Save

How to Proceed

- Take corrective action.
- Ensure future performance by setting standards of efficiency for compressors and point-of-use pneumatic systems.
- Make system performance part of the preventative maintenance schedule.
- Continue to utilize SMC for technical support when you have questions.

Thank you



If you have any questions or require additional information, please contact your local SMC salesperson.