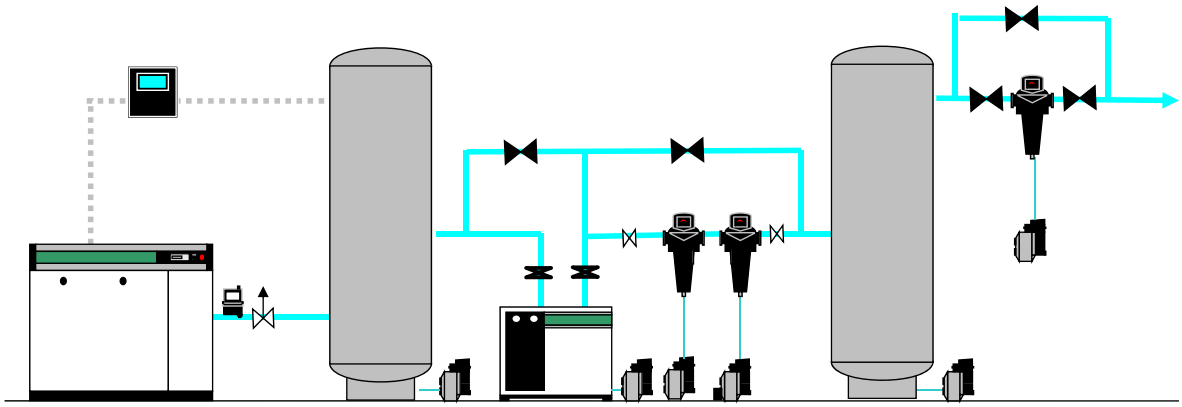
Training on
'Japanese low carbon technologies and best practices for compressed air systems'

(For energy auditors and energy managers)



IGES
Institute for Global Environmental Strategies

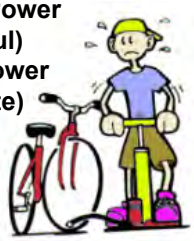
Contents

Overview of compressed air system

Advantages:

- Easy to use
- Clean
- Air can be returned to atmosphere
- Quick movement
- Light & small actuator
- Safe if leakage (no spark)

Hydraulic Power (Powerful)
Electric Power (Accurate)



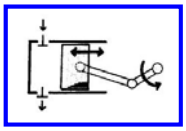
- **Volumetric**
- **Boil - Charles's Principle**

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

(* P: Pressure, V: Volume, T: Temperature)

When volume decreases, pressure goes up.

Piston



Screw

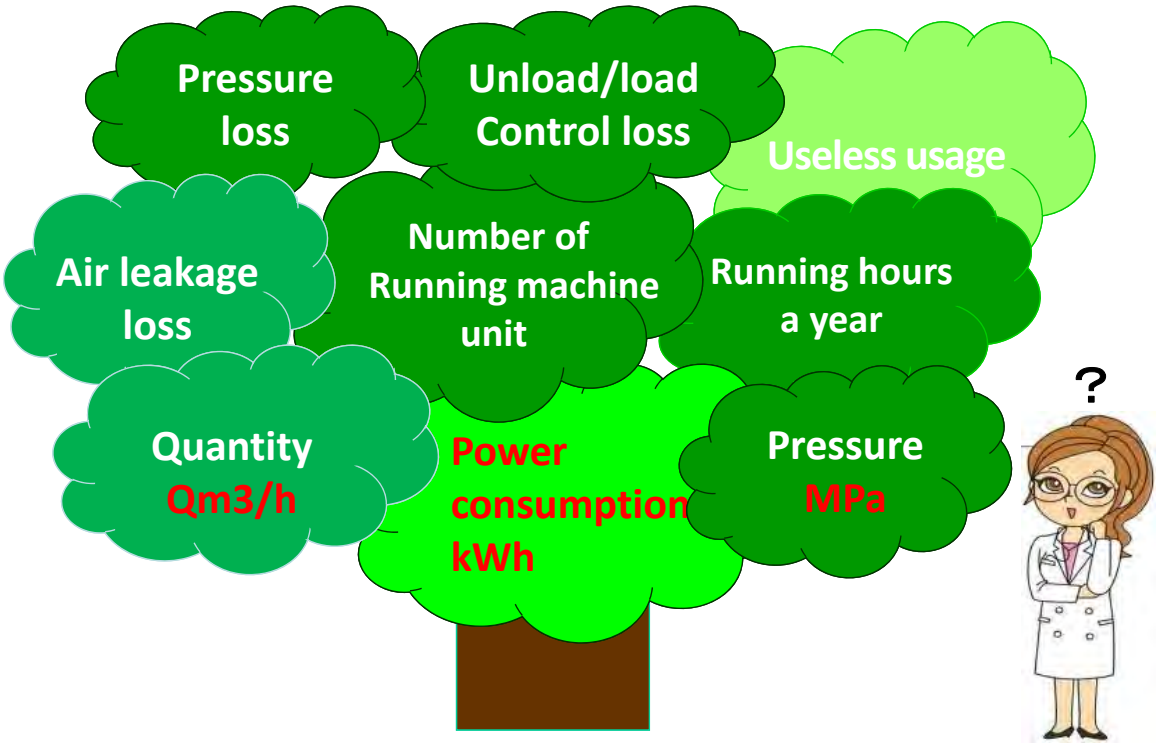
Scroll

Applications

o Industry: Petroleum refining, petrochemical, steel, mining, automobile, electronics, food processing, pharma, etc.

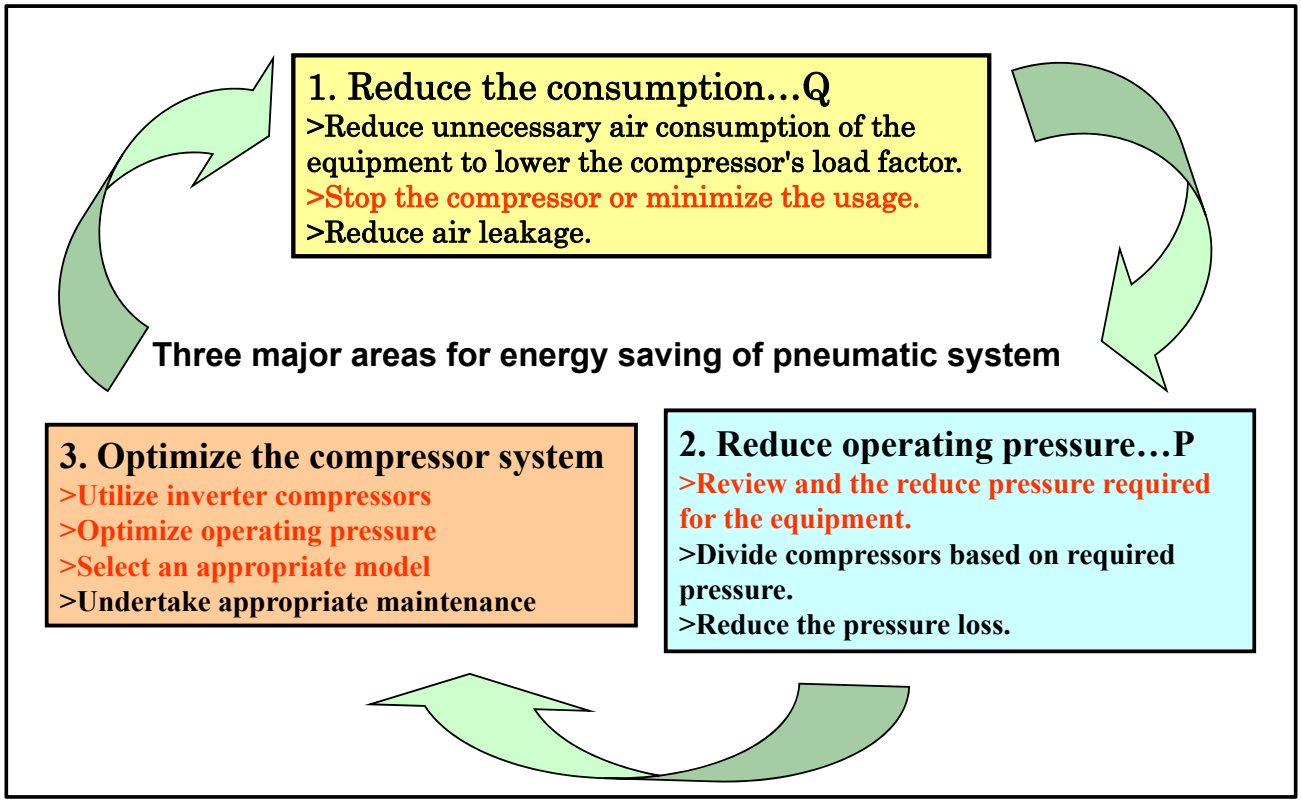
o Commercial and transport: Wastewater treatment, cleaning, pneumatic tools, air brake system, elevators, etc.

What constitutes to the energy consumption of an air compressor?



Key points for energy saving in compressor equipment

Flow of improvement in pneumatic system



Key words for energy saving in compressed air systems

Identification of waste and key word for KAIZEN

stop	・Stop high pressure operating and stop the supply of air to non usable area.
reduce	・Reduce compressed air pressure as you need.
repair	・Repair compressor system and air leakage points.
change	・Replace an old compressor by introducing with high-efficiency product
recover	・Recover energy such as exhaust hot air.
Shut down	・Shut down the supply of compressed air during night time, lunch time and break time.

Do you use the energy efficiently?

The activity continued is necessary for energy saving, step by step.

STEP1. Assessment of current conditions
STEP2. Monitoring
STEP3. Check loss point

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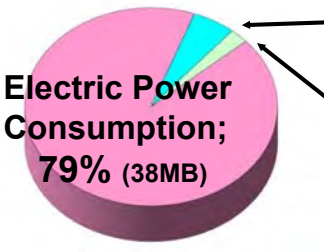
Energy consumption & cost effectiveness

Most of compressor LCC is used for power consumption.



Maintenance cost: 12%
(6.0MB) full maintenance, Overhaul 3times, 6000hs service 17times.

Initial cost: 9%(maximum)
(4.2MB) (compressor, air-dryer, filters, air-tank, installation/starting, piping, etc.)

Note: LCC = Life Cycle Cost
<Example>
- Oil flooded 75kW class rotary screw (standard type)
- 6000h/y operation
- 3.8B/kWh
- 60% Load example
- Total cost: 20 yrs. average

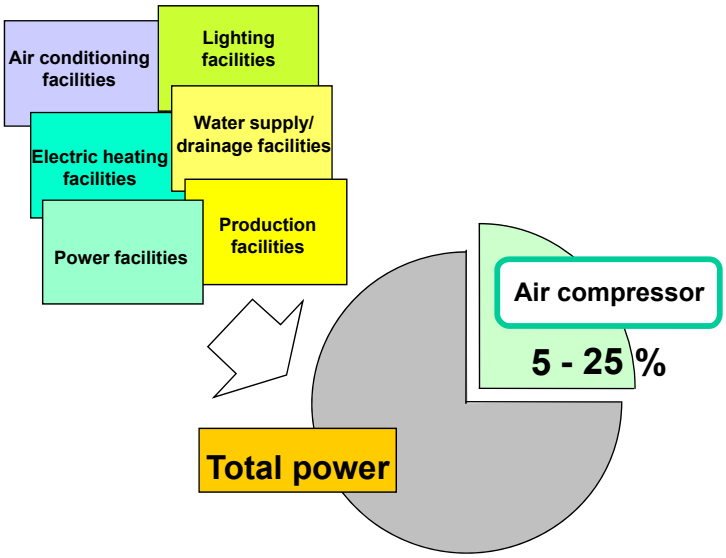
Specific Energy Consumption

How much for 1㎥ of compressed air? --- Example of quick calculation (60%load)

How much cost for your company? 0.4B/M3?

Energy cost (0.68B／㎥) = $\frac{\text{Input Power } 84\text{ (kWh)} \times 0.88}{\text{FAD } 13.2\text{ (㎥/min)} \times 0.6 \times 60\text{ (min)}} \times \text{Electricity cost } 3.8\text{(B/kWh)}$

Distribution of energy consumption in industries



- Industrial energy consumption accounts for approximately 40% of the total energy consumption in Thailand.
- Air compressors energy consumption share is approximately 5% to 25% in almost every industry in Thailand.(20~25% in Japan)
- Therefore energy saving for compressors needs to be addressed urgently.

Contents

Knowledge;The plant should repeatedly check the following

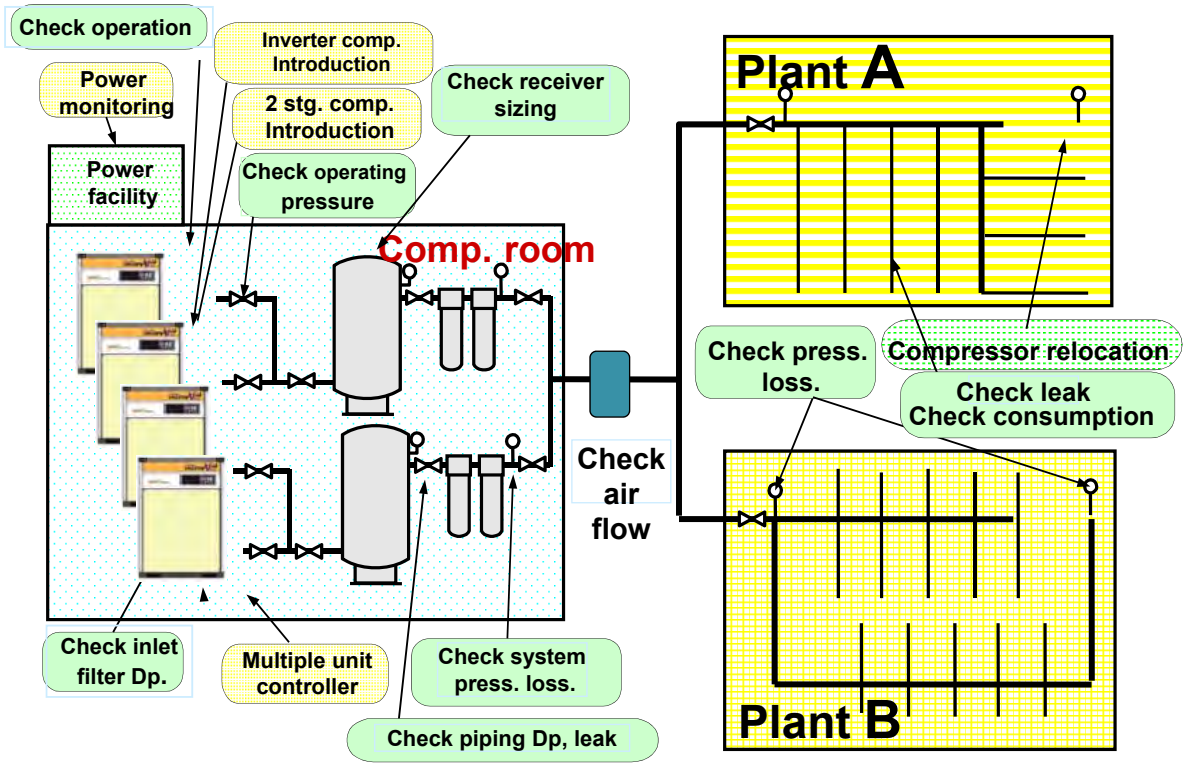
- Cases where there is potential for energy saving -

- ○ Having two or more compressors, but controls are not well organized.
- ○ Load fluctuation is excessive.
- ○ Receiver tank capacity is small for the compressor.
- ○ Air piping is thinner and longer for the air quantity used.
- ○ Pressure usage is high.
- ○ Boost valve is used.
- ○ Many pressure-reducing valves are used.
- ○ Compressor has been aged.
- ○ Factory and equipment have deteriorated, which causes many leaks.
- ○ Sizes of compressors are unequal, therefore, balance is bad.

- Cases where there is no potential for energy saving -

- × Compressor is used with high load factor (Operating with 80~100%)
- × Almost constant discharge-pressure is used.
- × The expectation of compressor is low, even if effective, since the rate of compressor in a factory is low.
- × Obtaining energy-saving effect is hard since the operation time per day is short.
- × Inverter-type compressor has already been introduced and energy-saving activities have been deploying.
- × Compressor is used at minimum pressure.

Check points in compressed air system



Check points of Walk Through (flows)

Compressor system

Compressor

- Setting pressure
- Current sampling loading/ unloading
- Operating condition run/ stop
- Measuring device installation location
- check time load/unload

Around compressor:
- Pipe size and route
- Presence of tank
- Auxiliary equipment arrangement, processing capacity
- Presence / absence of number control
  In some cases: model, set pressure
  The target compressor
- Installation environment
  Air intake / exhaust, position of ventilator, temperature
- Installation location of measuring instruments (pressure)

Hearing

Hearing:
- Unit price of electricity
- Required pressure
- Purpose of measurement
- Day/night operation
- Holiday operation
- Current capacity utilization rate
- Future operation increase and decrease and plan

Factory check

User side:
- Pipe size and route
  → piping system diagram
- Use of air
- End pressure
- Pressure in use
  Setting pressure of regulator

Confirmation of other machines

Are you checking other than around the compressor?

Do you know the user's intentions?

Key of check list; customer's information

Customer name;

Survey date:
Interviewee:
Production:
Operating hours: Hours/day
Total electricity consumption: kWh/year(production is busy now)
Power required for compressor: % of total energy consumption kWh)
Electric power unit price (B/kwh): B
Existing compressor: total units using for compressor rooms
compressor room1;
compressor room2;
Supplemental equipment: L Air tank for each ,Air Dryer and filters
Uses: , etc.
CO2 emission factor; 0.0005897ton/kWh

Check points: uses of compressed air

Use for	What is point	Possibility to recommend
Blow gun	Nozzle diameter	Reduce air consumption; air saving nozzle
Air cylinder	Speed controlled?	Reduce air consumption; air saving valve
spinning	Strings color(dirt of oil?)	Oil free system, booster compressor
Air jet	Pressure and speed	High pressure and oil free
Pneumatic	Pressure variation	Install air tank(near by side)
Press machine	Pressure drop?	Install air tank(near by side), modify piping
Air hummer	Pressure drop?	Install air tank(near by side), modify piping
Booster mechanical	How many times occur	Booster motor or high pressure compressor
Drain trap	Always blow off	Minimum blow off air type
Air blow	pressure	Possibility to use blower
Air ration	pressure	It had better use blower or roots
Cool down	Direct blowing?	Clean air(air-dryer and filtering)
Stop valve	Grove valve? How many use	Full bore ball valve
connector	Joint or socket, how long	Pressure lossless connector
purge	One shot	Install air tank, re-built piping system

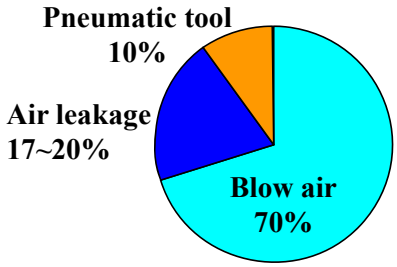
Contents

Energy savings measures - operational

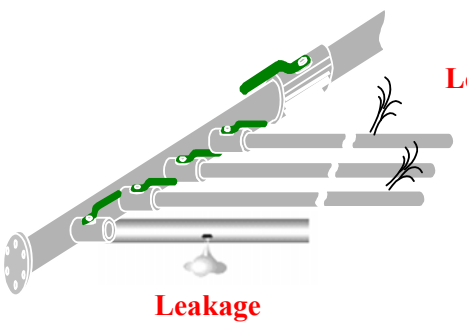
- Leakages (savings 10 to 40 %)
- Pipe sizing & design (savings 7 to 20 %)
- Type and overall condition (savings 7 to 15 %)
- Pressure settings for reciprocating, screw type (savings 8 to 16 %)

How to check air leakage?

Recommendation: Determine the total leakage and reduce it by Leakage Checking Method



1. Operate the compressor at night, or on a holiday, and shut it down when achieving a predetermined pressure value.
2. When the compressor is shut down, due to the leakage, the pressure will automatically decrease. The amount of leakage can be known by measuring the time (t) taken to decrease the pressure by 0.1MPa.

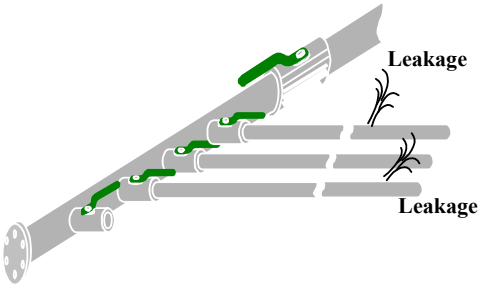


The formula to determine the leakage (C) is given below:

$$C = \frac{(P1 - P2) \times V}{Po \times t}$$

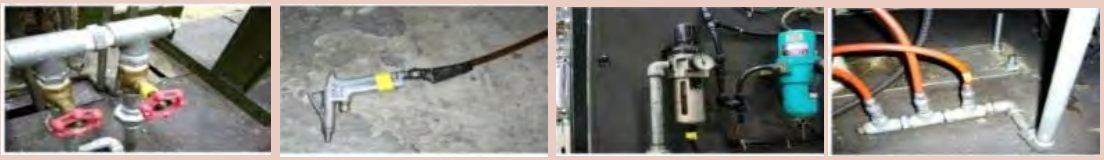
With:
C = Volume of leakage (M3/min)
P1= Predetermined pressure (MPa) (gauge pressure + 0.101MPa)
P2= Pressure after leakage (MPa) (gauge pressure + 0.101MPa)
T = Time taken to reduce pressure from P1 to P2 (min)
Po = Atmospheric air pressure(MPa)
V = Piping capacity (Mm3) (In case of your company; ?? m3)

Leakage checking method



- Leakage check is performed at night or on holidays when the plant is not in operation.
- Once the compressor is operated and raised up to predetermined pressure, stop the compressor and measure the time required for pressure reduction of 1bar from the predetermined pressure.
- Since all of this leads to waste of energy, quick actions are vital.
- It is possible to calculate the amount of leakage from the above investigation, then leakage locations need to be identified in the next step.
- Keeping that in mind, take measures from the most leakage prone areas.
- Leakage cannot be completely stopped with one-time measures.
- Continuous monitoring is required.

Places where air leakage is likely to occur



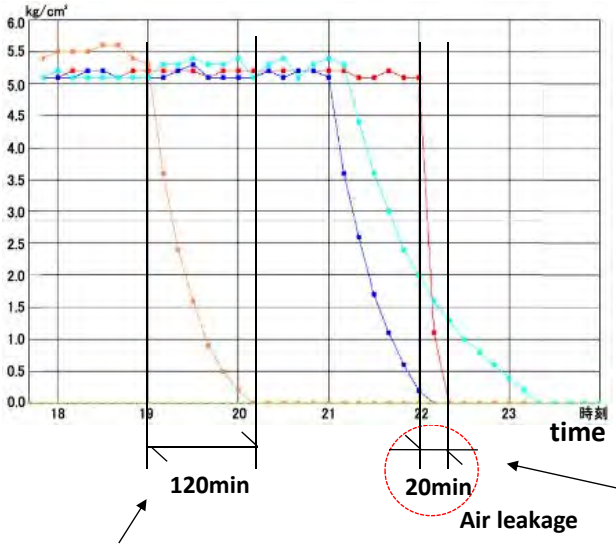
Valve | Blow gun | Regulator | Piping coupling

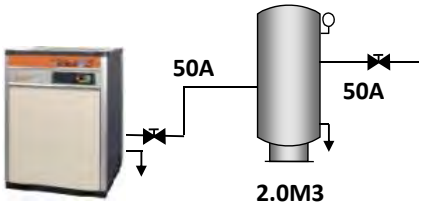
- Occurrence of air leakage as shown above, covers as much as 20% of the total average plants.
- The amount of leakage can be calculated by the formula in the next slide, after confirming, the same leakage areas can be identified and effective leakage reduction can be achieved.
- Target reduction is half of the total ratio.

Measuring air leakage in facility

On holiday: after stopping compressor

pressure





Piping length total 50A x 50m (until stop valve)

C = 2.0 + (0.05 x 0.05xπ/4 x 50) = 2.1M3

$$Q1 = \frac{(P1 - P2) \times C}{Psxt}$$

$$\frac{((5.1 + 1) - (0+1)) \times 2.1}{1 \times 20}$$

= 0.536M3/min

$$Q2 = \frac{((5.1 + 1) - (0+1)) \times 2.1}{1 \times 120}$$

= 0.09M3/min(1.4%)

This is not so big amount

Air leakage loss in annual

0.536M3/minx0.4B/M3x60minx6000H/year

= 77,184B/year

(loss is 0.536/6.5 = 0.082…8.2%)

Verification of wasteful points in piping

Four wasteful points in piping

(1) Pipes with many bends

If a pipe has many bends,pressure loss occurs, causing energy loss.
Apart from bends required for controlling heat expansion and vibration, reduce the bends as much as possible.

(2) Pipes with many partitions

Partitions, such as check valves and other valves, cause a large loss.
Select valves that cause a minimum loss or reduce the number of partitions.

(3) Small-bore pipes

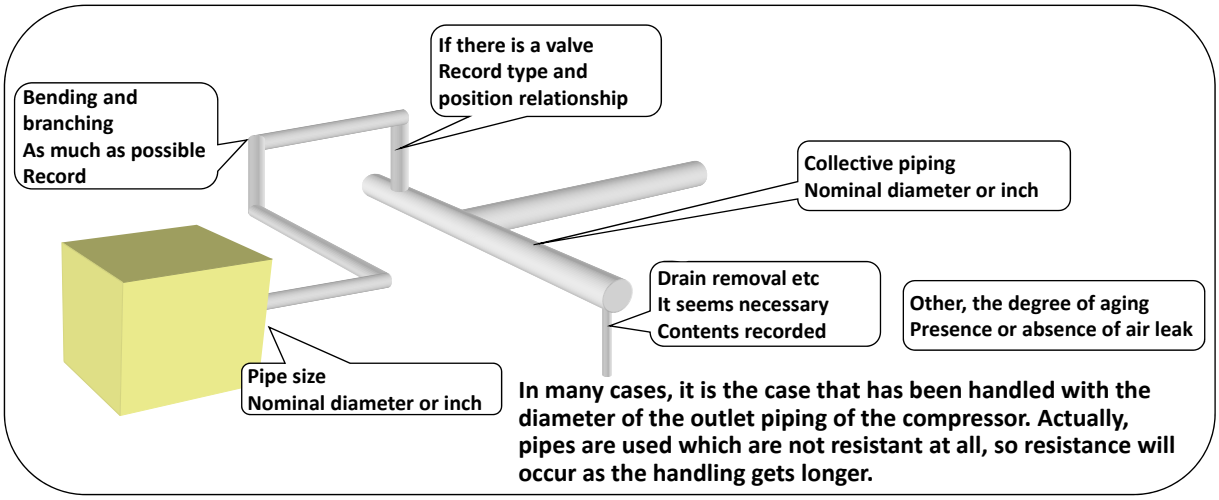
Pipes should have an appropriate size to flow the required rate of air. Small pipes cause large loss.
Large pipes achieve a higher rate of energy saving, if available in terms of cost.

(4) Long pipes

The longer the pipe, the larger the loss.
The shorter the pipe relative to the equipment, the more advantageous it is for energy saving.

*** What are "three bends"?**
*** How much is the valve resistance?**
*** Isn't the pipe connected to the compressor appropriately sized?**
*** What is "supply air loss"?**

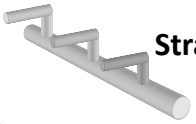
Piping



In many cases, it is the case that has been handled with the diameter of the outlet piping of the compressor. Actually, pipes are used which are not resistant at all, so resistance will occur as the handling gets longer.

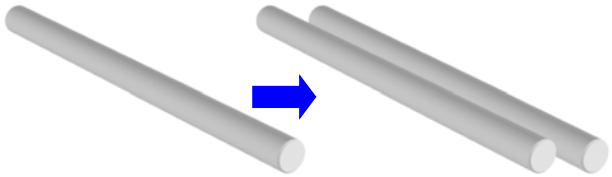
What is ideal piping

- Thick enough, the main tube loop
- No diaphragm
- The length of the handling is short
- No bending, no branching
- Use valves with low resistance
- Drain water does not accumulate

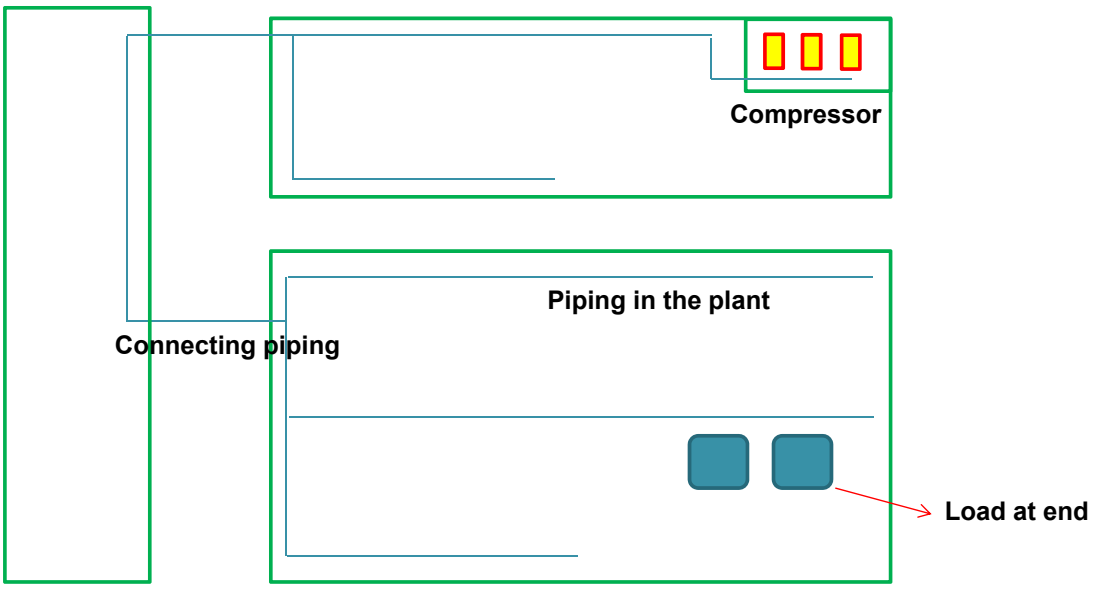


Straight, short, straight!

When piping can not be thickened, construct piping in parallel.
There is a way (If it is the same thickness, you can double it).
Pressure loss will be one fourth.



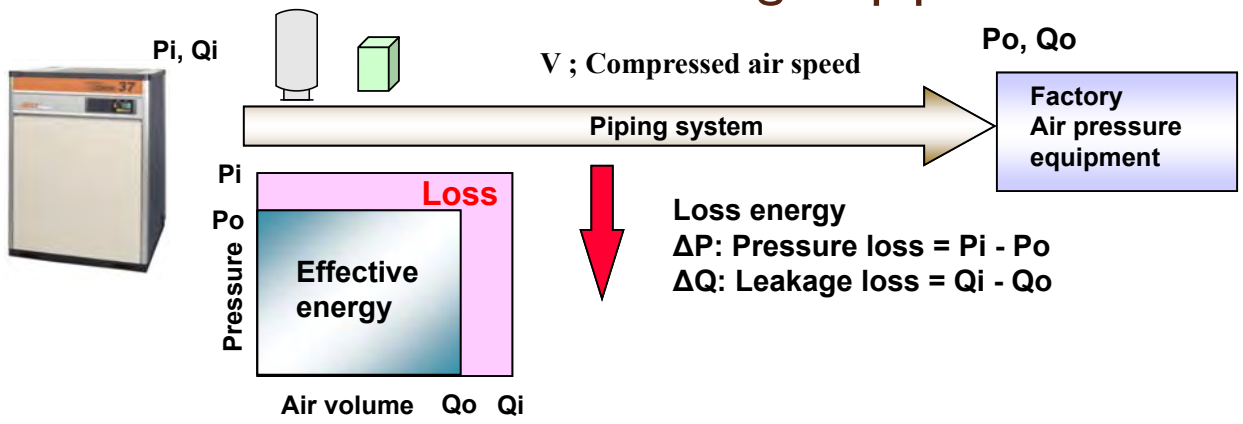
What are the causes of pressure drop?



Causes for pressure drop

1. Insufficient capacity of compressor --- Insufficient number of operating units, performance deterioration
2. Increase in consumption --- Increase in consumption equipment, overlapping of patterns, increase in leakage
3. Thin piping --- can not cope with clipping
4. Unable to follow pressure fluctuation at the terminal --- Insufficient piping capacity

Pressure loss through a pipe



$$\text{Flow rate in the pipe. V (m/s)} = \frac{Qi \text{ Compressor's discharge air volume} \times Ps/Pd}{A \text{ Sectional area of discharge pipe} \times 60}$$

The flow rate in the pipe is desirably 4 to 5 m/s. - Economic speed

The smaller the pipe size, the higher the flow rate, causing a larger loss in the pipe. Accordingly an energy loss is generated, reducing the energy-saving effect.

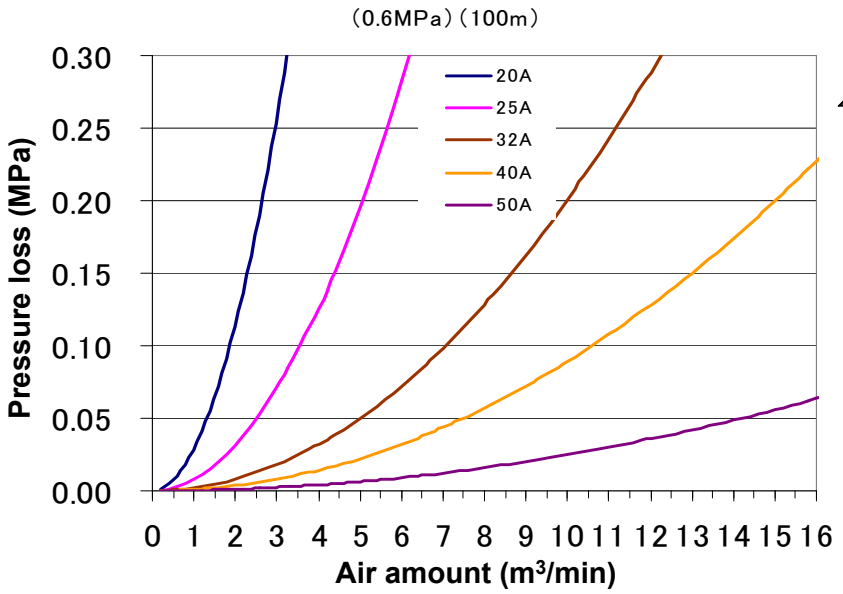
- **Example of 75-kW Air compressor(Japan Model)**

(Discharge pressure: 0.69 MPa, discharge air volume: 13.2 M3/min), size of discharge air pipe: 50A

V = 13.2 x 0.101 / (0.101 + 0.69) ÷ 0.05 ÷ 0.05 ÷ 3.14 / 4 ÷ 60

= 14.31 m/sec (This is a very high speed.) The energy-saving effect is low.

Let's calculate appropriate pipe size

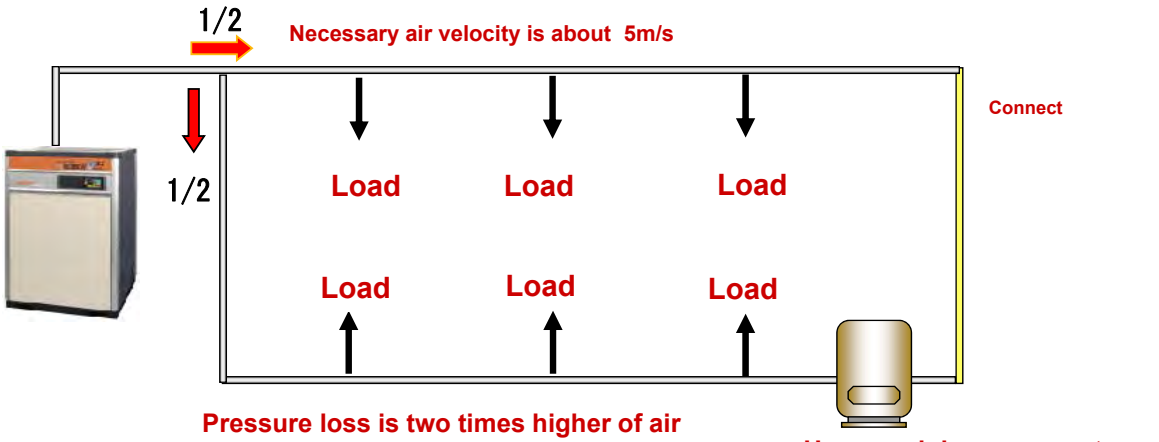


$$\Delta P = 0.39\mu \times \frac{\ell}{d} \times \frac{\gamma \ v^2}{2g} \times 10^{-4}$$

ΔP Pressure loss (MPa)
μ friction coefficient
ℓ length of piping m
D diameter of pipe m
γ density of air kg/m3
(0.1013MPa, 0°C)
V speed of the air m/s
g The gravity 9.81m/s2

Changing air velocity through internal pipe

--- loop piping



Pressure loss is two times higher of air velocity in proportion

Pressure loss is minimized to one quarter, only to make loop piping!

How much improvement can be made with loop piping?

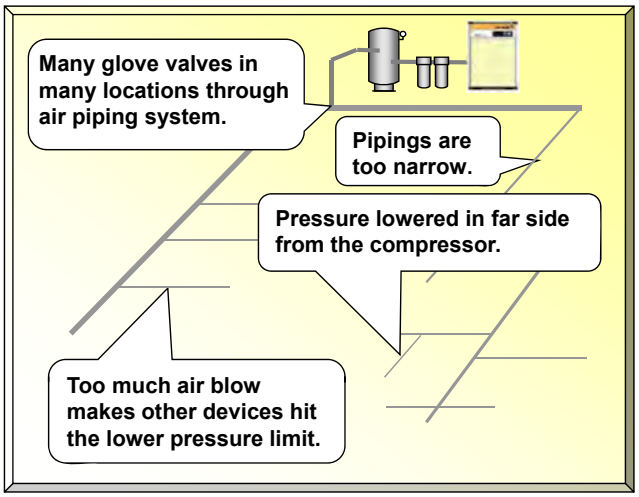
If there is imbalance among load, pressure loss become one quarter, to make loop piping.

Pressure optimization by piping system redesign

What is an efficient way to deal with local low pressure demand?
Do you have similar cases like this in your factory?

1. Un-stabilized factory air.
   [Status] Pressure on far side from compressor unstable.
   Pressure down when other systems are ON.
2. Due to budget allowance, no uniformity on air system such as devices, piping (size, route, valves).

What kind of improvement in this case?

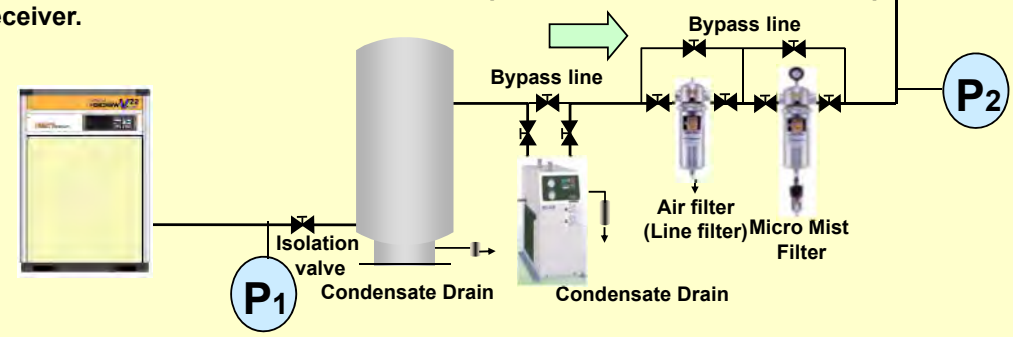


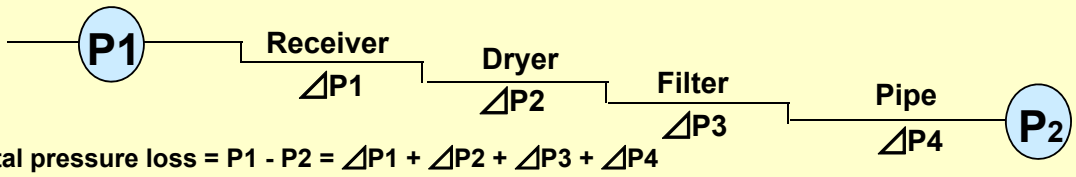
How do loop piping, size, bend and valves affect proper pressure in system?

Pressure loss of compressor equipment

Any system causes a pressure loss.
Think of how to minimize the loss.

Recommended layout (reference example): Compressor -> Receiver -> Dryer -> Filter
Point: This reduces the pressure loss between the compressor and the receiver.



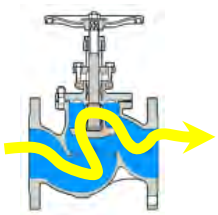


Total pressure loss = P1 - P2 = ⊿P1 + ⊿P2 + ⊿P3 + ⊿P4

To achieve a higher rate of energy saving, select a pipe having a diameter one size larger than the compressor's discharge pipe diameter. Also, select air dryers and filters having a capacity one size larger.

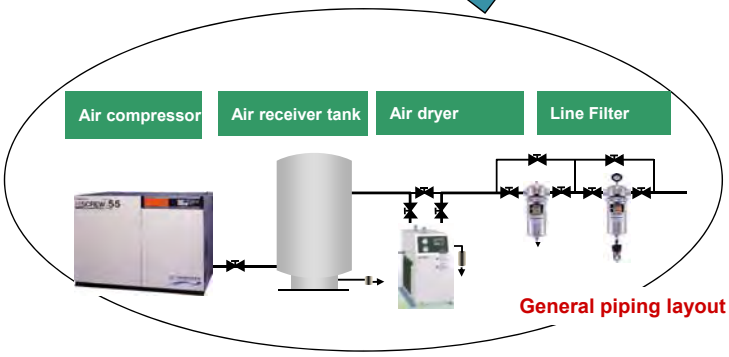
Pressure loss depends on valve types and shapes

Big loss・・・・

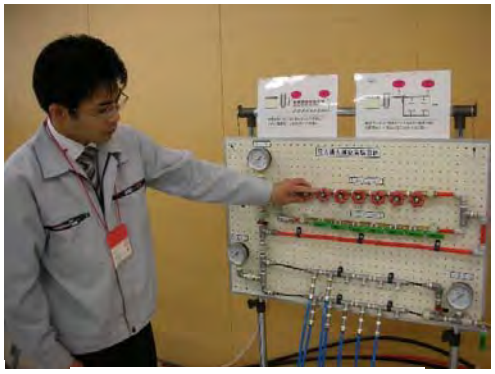


Gate valve has 40~60 times more loss of pressure compared with straight pipe

7 pcs of glove valve(* Valve)**

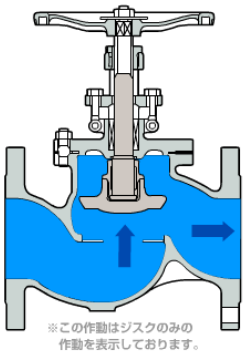


General piping layout



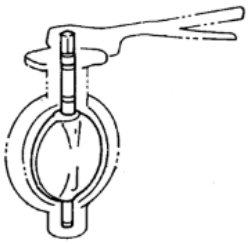
Pressure loss caused by different types of valve

Valve types and shapes

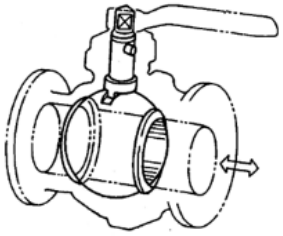


Grove valve

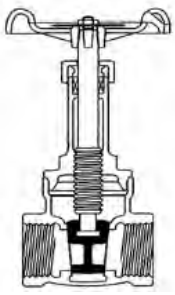
Big loss
But good for adjustment



Butterfly valve

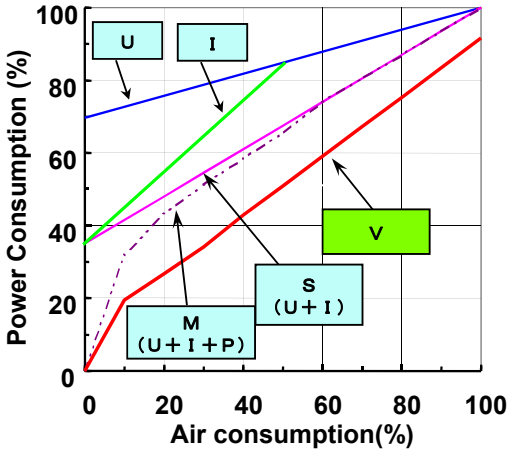


Ball valve
(choose full bore type)



Gate valve

Capacity control for rotary screw



U: Modulation
When demand decrease and discharge pressure increase, compressor squeeze the inlet valve. Good for continuous operation and small load fluctuation. Energy saving effect is small.

I: Integral
When demand decrease and discharge pressure increase to set point, close inlet valve and purge air in oil tank to reduce shaft power. Energy saving effect is bigger than U type.

S: U+I (New control method)
Built-in micro-computer choose according to load automatically. It reduce the pressure in oil tank when low load. Energy saving effect is bigger than U type.

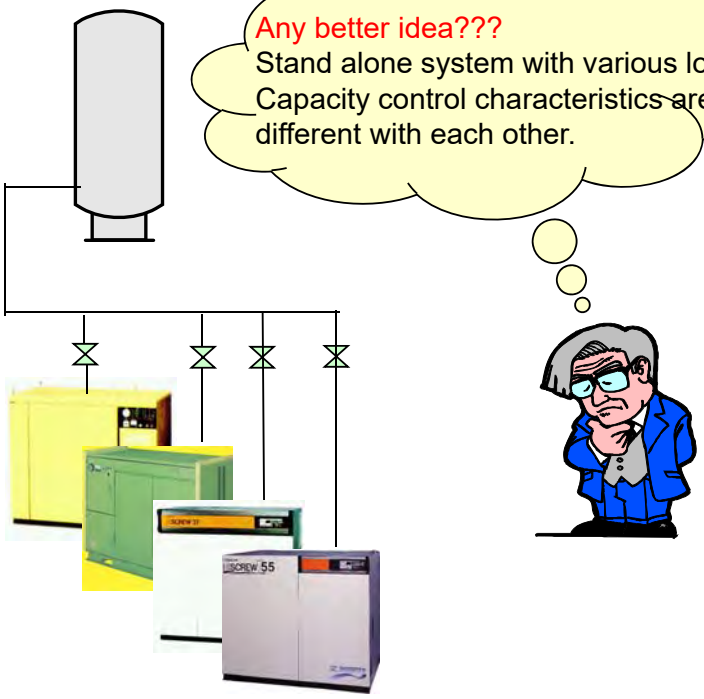
M: U+I+P (microcomputer control)
Automatic selection among U, I, P(motor on/off) according to load. It is good for interval use of air and big fluctuation. Energy effect is bigger than S type.

V: Variable Speed Control
Control Speed/Frequency by inverter/other devices with pressure sensor. It can maintain the pressure at same level, power consumption is proportional to load. Energy saving effect is bigger than any other method.

➢ **Important points**

A good compressor is not a compressor with a large air delivery capacity, but a compressor with excellent control characteristics is the best one, which is called the energy efficiency product.

Are the compressors running unnecessarily?



We've got an idea!

Example of variable speed control compressor installation.

1. Assign base unit and collect loads. (to the compressor with good capacity control characteristics)
2. STOP the leftover compressor.
3. STOP during off time. (adopt schedule setting operation)

Install variable speed control compressor

Contents

Example of Compressor Audit

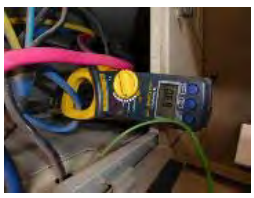
▪▪▪Measurement of pressure fluctuation, air flow and power

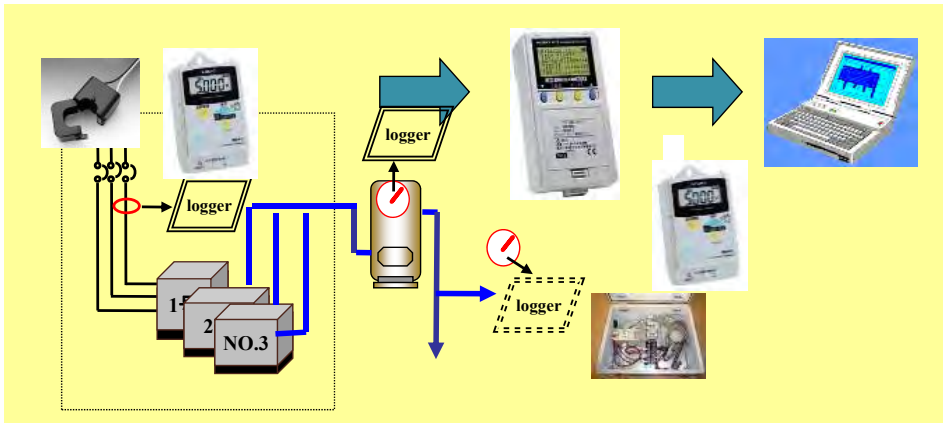
Measurement of Pressure fluctuation

Data logging of pressure

Load ratio of Amperage

Power analyzer





Audit method

Concrete example of failure

- Example of manufacturing company

Average values are important.

- Results of energy saving are obtained based on average values. However, it is dangerous to be deceived by average values. Some characteristics do not appear in an average value measurement time (for example, data for each 10 seconds versus data of one point for 30 minutes). Caution needs to be taken because energy saving characteristics are calculated based on average values.

Find the peak.

- If the peak is missed, an appropriate model cannot be selected. It is dangerous if there is a peak even in a short period of time. Measures to be taken are different between instantaneous peaks and continuous peaks lasting for several minutes.

Data changes depending on the season.

- Is the measurement diagnosis performed during the peak or bottom period? The measurement time is important because annual values are estimated based on these data. Check with the customer.

Understand the control characteristics in advance.

- The air volume rate varies depending on the characteristics. It also varies depending on the pressure. Check the characteristics of other companies ' machines in advance because the value varies depending on the manufacturer and the model.

Are actual operation and data linked?

- Visually check. Record the actual data when visiting the customer site. If possible, record the maximum and minimum current values to facilitate the diagnosis.

Variation of data?

- Identify why the variation occurs. Is the pipe size small? Is there a choke (check valve or other valve)? Is the tank capacity small?

Isn't there a rapid pressure drop?

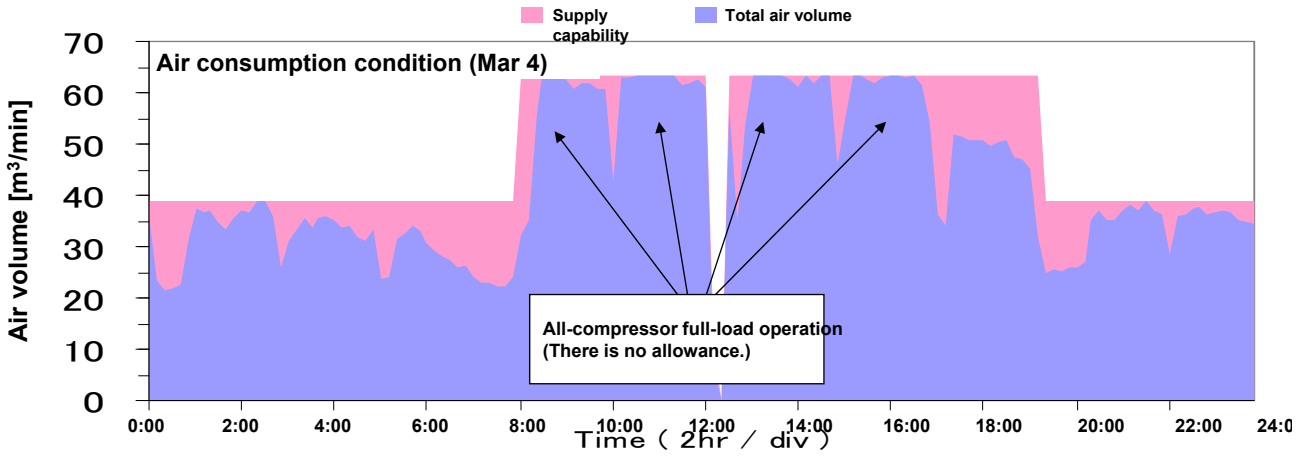
- Extension may be more necessary than energy saving. This is dangerous!

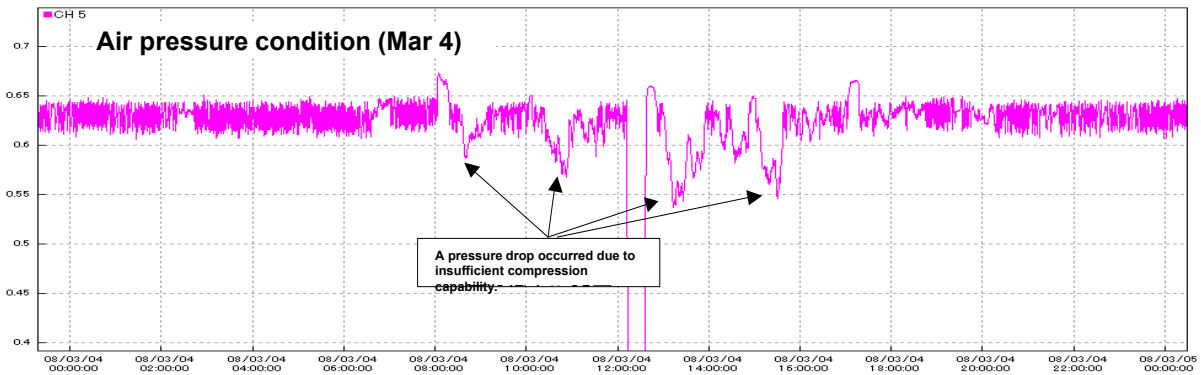
Be careful about downsizing.

- If failed, it cannot be undone. When replacing the equipment, keep the old machine as backup.

Be careful about deficiency in compressor performance

--- An incorrect proposal may cause a serious trouble

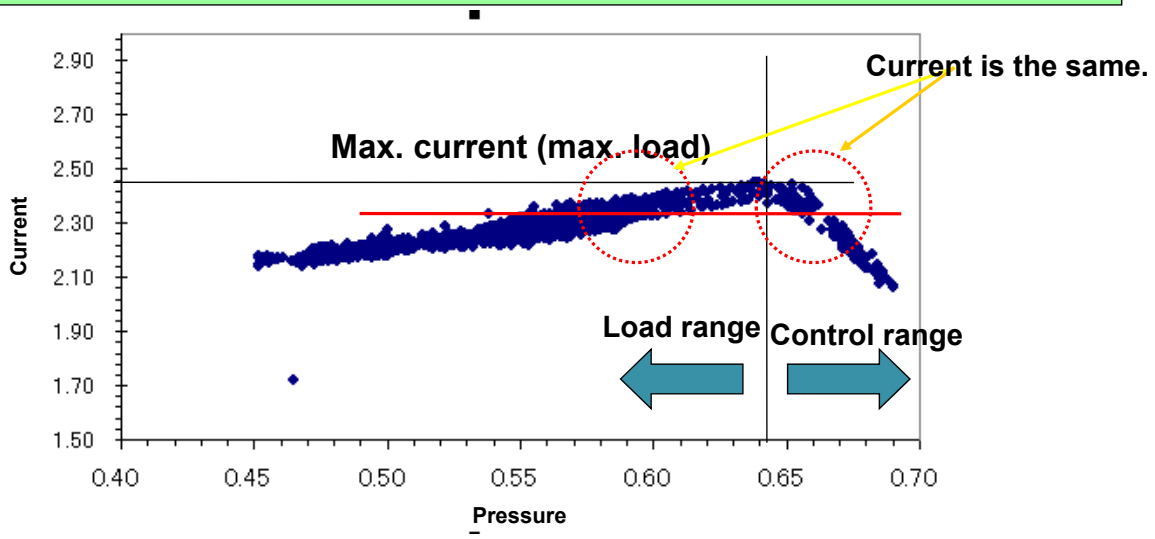




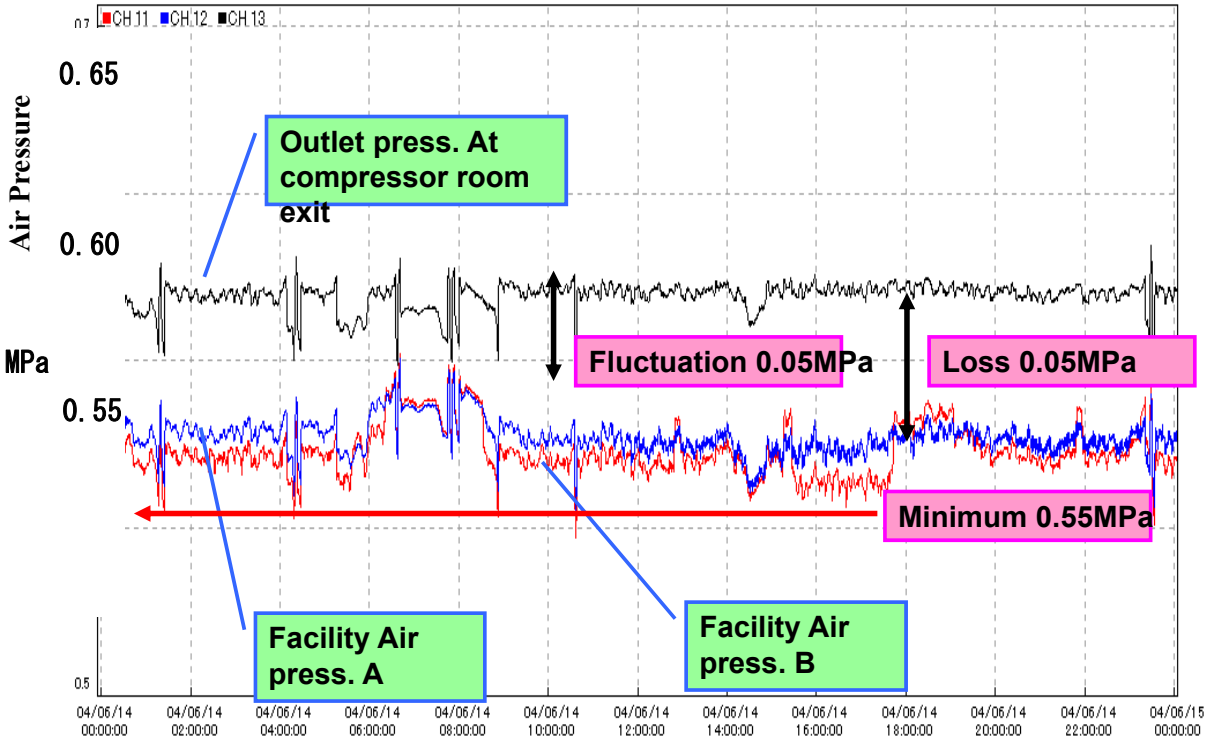
Care is required for measurement diagnosis

A measurement diagnosis was performed at the customer ‘s requirement. As a result of data analysis, it was analysed that unload was occurring because the current was low. A downsized model was proposed and immediately employed. However, pressure drop occurred, inhibiting the plant operation.

Cause: Misunderstanding of pressure fluctuation and power data - the state where air is lacking was misunderstood as unload. In reality, the pressure dropped due to the lack of air, and that state was maintained.
Action taken: It was determined that the machine would be replaced with a one-size larger model.



What to know? --- Example of pressure. Fluctuation in a day

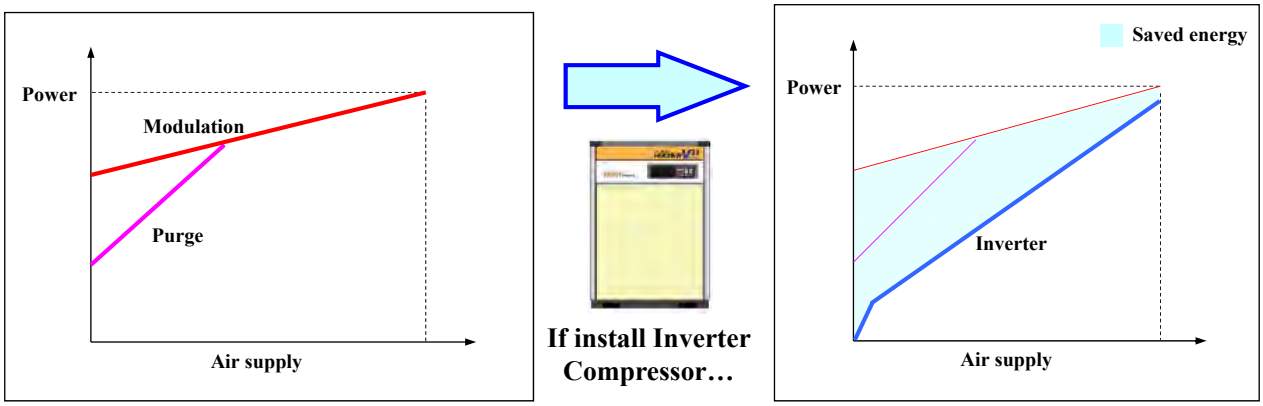


Energy saving measures - technological

- Replacement of existing air compressor with inverter type screw air compressor
- Introduction high pressure localization if compressed air requirement is at different pressures

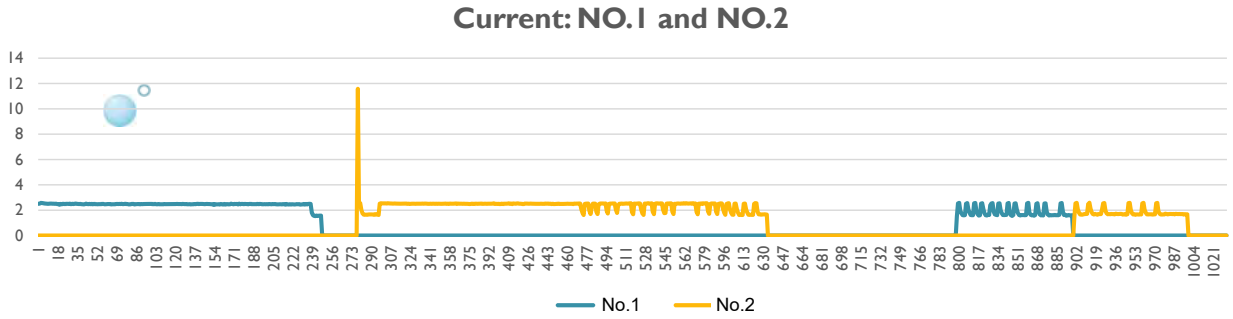
Compressor unloading method optimization
– Inverter Drive

Conventional unloading method (modulation and/or purge) consumes unnecessary power during unloading. Inverter drive can save power!!!

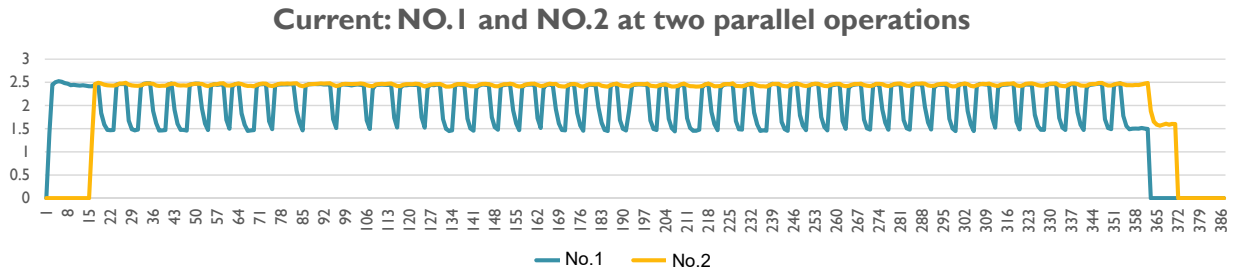


When you calculate the cost for several years, you can pay back the cost within 3 or 4 years. (reducing power consumption=energy cost down=profit)
Not only reduction in energy but also protect the environment which reduces CO_2.

Consideration on the amount of air from operation status



Stable driving situation. Driving control is done well here.

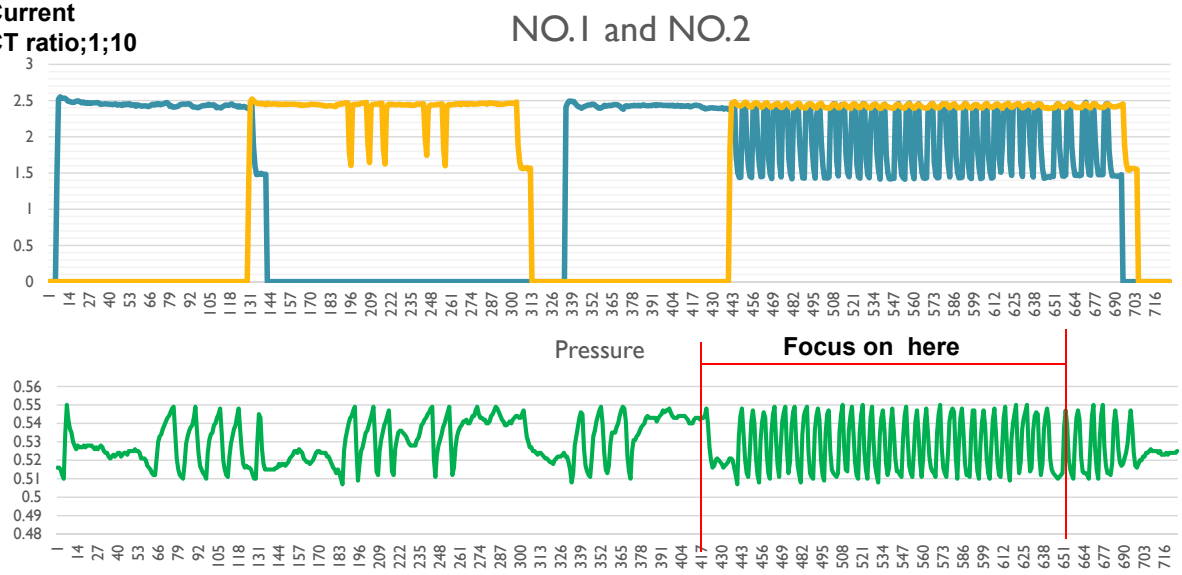


The variation of NO.1 is load 40" and no load 60". Consumption side seems to be constant because the action is patterned. Since the load factor is 40%, the increased air consumption is about 6.7M3/min. The result of 1 hour 40 minutes fluctuation was obtained through analysis of the operation time at two parallel operations. This seems the peak point.

Case study: pressure variation

Compressor; screw type 110kW x 2, 0.7MPa, and 16.8M3/min

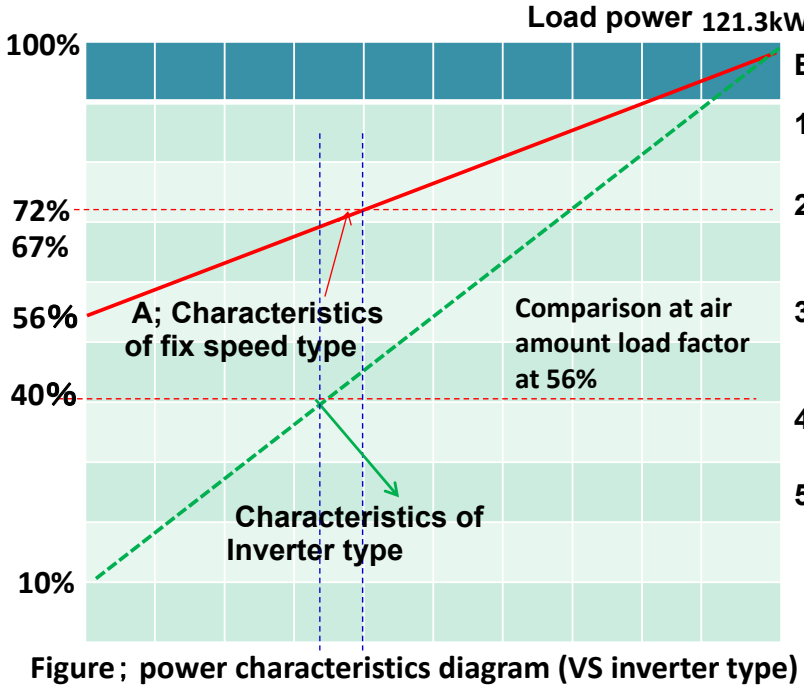
Current
CT ratio;1;10



Although it is well-balanced by one alternate operation, it is unbalanced in two parallel operations.
Unbalanced time lasts 1 hour 40 minutes. It corresponds to 8 hours in one day.
Controlling this interval with an inverter compressor will save energy.
The load factor is 40%
Load; 2.5A x 10 x 3.3kV x 1.73 x 0.85 = 121.3kW Unload; 1.4A x 10 x 3.3kV x 1.73 x 0.85 = 68.0kW

Energy-saving effect of changing to inverter type

Characteristics diagram of foreign manufacture 【A】
⇨ Minimum power load factor 56% (Fix speed type)
Characteristics diagram of Japanese manufacture 【B】
⇨ Minimum power load factor 10 ~ 20% (VSD integrated type)



Figure; power characteristics diagram (VS inverter type)

Estimation of energy-saving potential

1: Power load factor of fix speed is 56%
It is not energy saving.

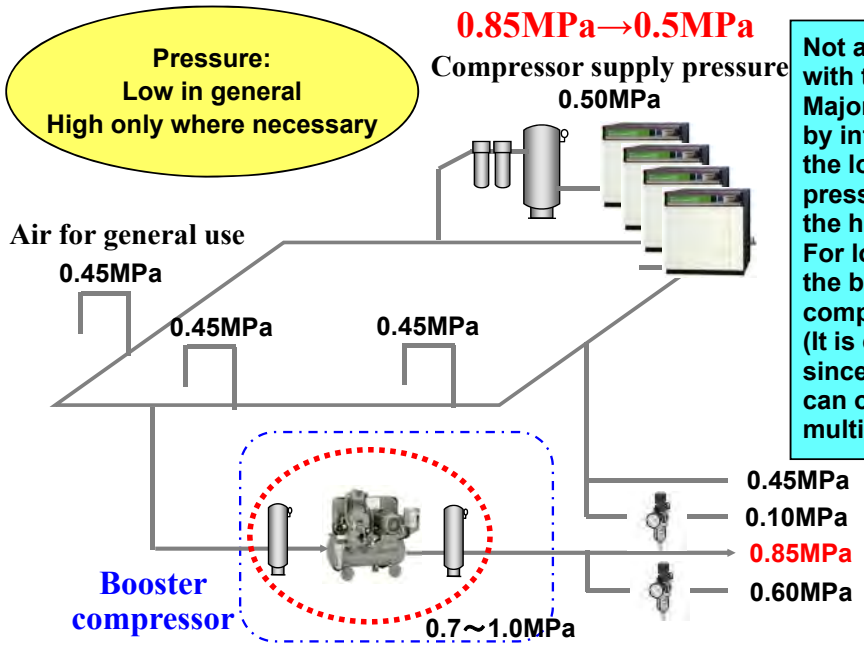
2: Average air amount load factor is 40%
Power load factor at this time is 72%
110÷0.9x0.72=88.0kW

3: Air amount load factor of inverter-type compressor is 35%
Power load factor at this time is 40%

4: 100÷0.93 x0.4 = 43.0kW
Energy - saving ; 88 – 43 = 45kW

5: If annual operating hours is set to 2,500h, energy saving of 45.0kW x 2,500h = 112,500kWh (112,500kWhx3.8B/kWh=427,500B) can be expected. Approx. 56Ton of the reduction effect in CO2 conversion is expected. (0.0005Ton/kWh)

Efficient usage --- Example of Local High Pressurizing



Not all air used at factory is running with the same pressure.
Major energy saving can be expected by introducing low pressurizing for the low-pressure equipment and high pressurizing for the high-pressure equipment.
For local high-pressurizing, use of the boosting valve and the booster compressor is recommended.
(It is excellent in terms of energy since use of the booster compressor can obtain the same effect as the multi-stage compressor)

- Operation pressure of high pressure use section is 0.85MPa now using 37kW 3 compressors.
- Energy reduction of nearly 15% can be achieved if this operation pressure can be lowered up to
- 0.50MPa. In short, reduction of 37kW ÷ 0.9 x 2.5 units x 0.15 = 15.4kW can be achieved.
- Also, the load factor of the power for booster is set at 50% by using booster at 7.5kW,
- 7.5kW ÷ 0.9 x 0.5 = 4.2kW
- Therefore, energy saving of 15.4 - 4.2 = 11.2kW can be achieved.
- Annual energy savings is 11.2kW x 8000h = 89,600kWh (340,480B)

Contents

How to select air compressor

Cost	Small	Medium	Large
Payback period	Very short (less than half year)	Case by case	MAX. 4 years
Ease of implementation	Easy (Soft technology)	Slightly difficult (Hard + Soft technology)	Difficult (Hard + Soft technology)
Effect	Small ~ medium	Medium	1. Large
Items to be implemented	1. Reduce air pressure 2. Stop supply for not-in-use area 3. Repair leakage 4. Ventilate compressor room to cool down 5. Efficient air equipment blow gun, air cylinder, nozzle, joint, valves	1. Restructure piping system 2. Size up air-dryer and filter 3. Size up receiver tank 4. Use booster compressor 5. Divide pressure	1. Make clean air system oil-free system 2. Provide drive multi units with multi-controller system 3. Use VFD(VSD) compressor 4. Restructure compressor system choose large size or divide 5. Recover energy

Important points for selecting an air compressor system

- Compression Principle (Volumetric & Centrifugal)
- Lubricant & Sealing (Oil-flooded & Oil-free)
- No. of Compression Stages (Single Stage & 2 Stages)
- Cooling Methods (Air-cooled & Water-cooled)
- Number of units (Large size or divisible system)

Effective usage of air

Mainly, usage of air is divided into; ① Air blow, ② Machine driving

① Air blow

◆ Consuming most air in a factory【No.1】

A continuous air sound used in a factory increases the amount of air consumption considerably if having much air blow work and continuous use.

As for blow gun, a nozzle-type gun saves energy.

【Checking point 】

① Diameter of air blow outlet... (consumption is "large", if the size is large)

② Pressure of outlet (supply pressure) ... (consumption is "large", if the pressure is high)

③ Time and frequency

② For machine driving (Actuator)

◆ The air used for "actuator (air cylinder)" driving isn't so large, but guaranteed minimum pressure is required since it is needed to provide the power.

Note: Are【Supply pressure】and supply amount appropriate?

The air supply amount can be reduced by 30 % when installing air saving valve in the exhaust outlet of air cylinder.

Checking regulator's pressure gauge to confirm whether or not it can be decompressed.

Also, the consumption can be reduced by combining with air saving valve.

Environment for compressor

Fresh

(Never install at such places !)

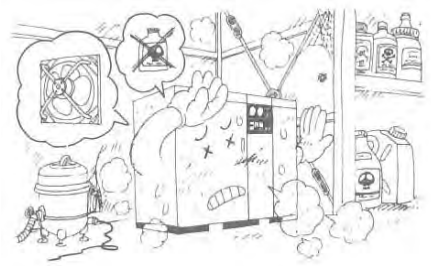
- If the air at the installation site is not good then the compressor cannot perform efficiently.
  - Harmful gases in surrounding area (corrosion, degradation, damage)
  - Dust, foreign substances (early damage, performance degradation)
  - Sealed room (reduction of air volume, temperature)
  - Near the sea (salt damage, corrosion)

Cold

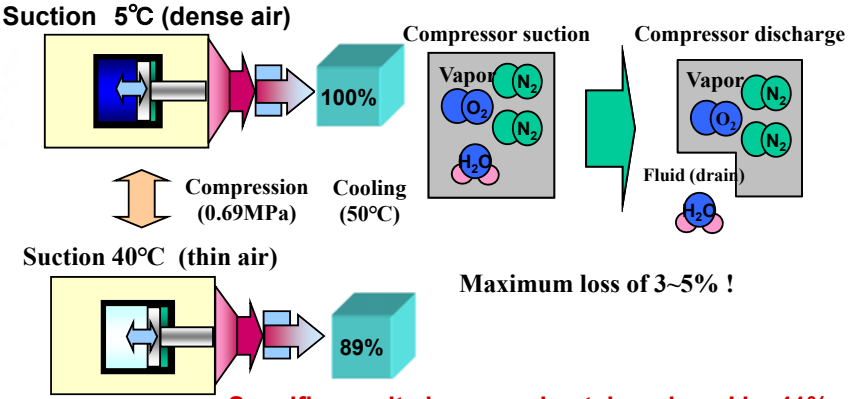
- In displacement compressor, even if the suction temperature changes, air volume shown by suction status hardly changes. (Screw, reciprocating compressor)
- If pressure and temperature are same, with the lower suction temperature, the same amount of discharge air can be provided at relatively lesser amount of air suction.

Dry

- Part of the moisture in the suction air is condensed for draining and then it is discharged. Hence at higher humidity, amount of compressed air of compressor outlet can be reduced.



The performance is affected due to filter clogging.
5~10% effect on performance is perfectly natural.



Maximum loss of 3~5% !

Specific gravity is approximately reduced by 11%

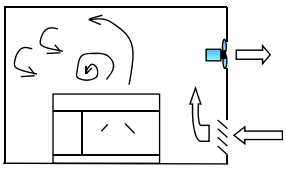
For low density air, qty is small.

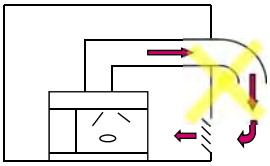
Notes for duct installation work

Provide a suction port low on the wall on the opposite side of the discharge port.

Be careful that the discharge port and suction port are placed on the same side.

In such a case, the room will not be ventilated at all.

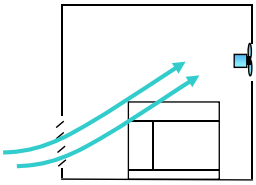




It's hot!

Temperature increase trouble due to shortcut

Smooth air flow
Appropriate cooling

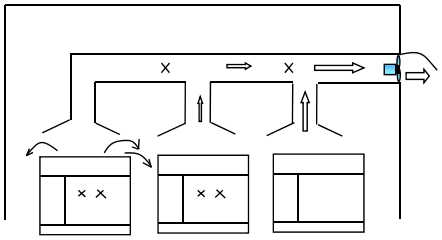


Be sure to provide a separate discharge duct for each compressor. Do not share a discharge duct for 2 or 3 compressors.

Air will not be discharged properly, leading to a failure.

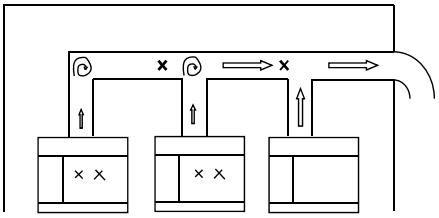
The same rule applies when air is discharged through a duct using a blower or ventilator.

Even with forced exhaust, if ducts are combined into a single duct, balance will not be maintained. Overflowing discharge air may be taken into the neighbor machine.



Air is not taken in!

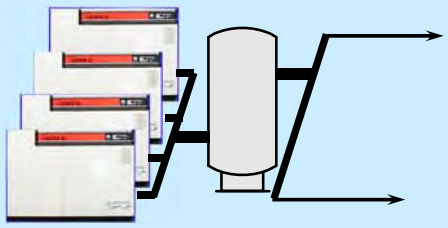
It's hot!



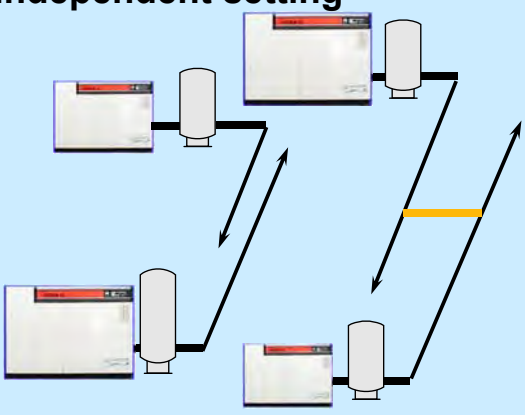
Air is not discharged!

Which setting leads to more energy saving: collective or independent?

Collective setting



Independent setting



Setting Type	Collective	Independent
Daily Maintenance	Easy	Need to assign stuff for each line
Regular maintenance	Easy	Need maintenance in each line
Pressure flexibility	Need to operate with the highest pressure equipment (Some loss)	Able to apply appropriate pressure for each piece of equipment (Minimum loss)
Pressure loss	Some Piping tends to be long	Small Piping can be short Adjustment can be made in each line
Air leak	Affects whole air supply system	Affects only line with the leakage
Multi-unit Control	Available	Unavailable

Energy saving can be made by Inverter compressor for both collective & independent settings

1. Collective setting: Inverter compressor absorbs load fluctuation

2. Independent setting: Easy to accomplish energy saving

Daily inspection and periodic inspection are essential for energy saving

In case of compressor malfunctions or sudden stops, it may be cause the factory line stops its operation, or cause serious troubles in production or unexpected situations such as a serious accident. This is not the most unwanted situation for energy saving.
Daily inspection and periodic inspection, which will check if the compressor could be operated efficiently and stably, are very important to maintain normal operating conditions.

The three key points for the inspections are described below.

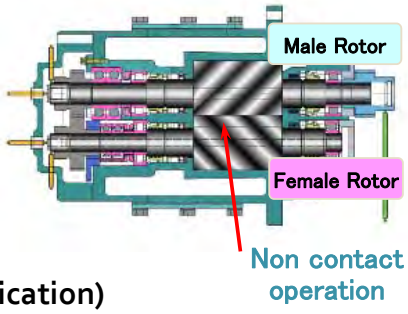
Carry out proper maintenance
Please make a proper maintenance by referring to the maintenance schedule and the contents of maintenance recommended by the manufacturer.
Proper maintenance means that the people with mechanical expertise plans and implements the maintenance based on the lifecycle of the parts.

Use genuine parts specified by the manufacturer
Genuine parts are the most appropriate parts for good and stable operation.
Even though the shape and model number are the same, there are large differences in function, performance, etc. between the commercial parts and the genuine parts.

Carry out periodical maintenance
The serious industrial accidents happened in recent years tend to be occurring due to defective maintenance or no-maintenance.
In addition, periodical maintenance enables to prevent large troubles occurring in the future by taking measures in advance after grasping the trends such as the conditions of wearing, corrosion, and deterioration of machines, etc.

Oil free air compressor

High skills and materials are necessary to manufacture.
Sealing is important even in high-speed operations.
Maintenance cost is higher than oil-flooded type.
Efficiency is slightly less than oil-flooded type.
Price is higher than oil-flooded type; in fact nearly double.



but

Oil-free compressor can get very clean air (class zero certification)
It can be used for high technology products and high quality use to develop industries for
Electronics, semi-conductors, food, medical supplies, textiles, and others
Oil-free air can meet HACCP, FSSC22000 and GMP regulations.

- **HACCP; Hazard Analysis Critical Control Point**
- **ISO-22000 & FSSC22000; Foundation for Food Safety Certification**
- **GMP; Good Manufacturing Practice**

Advanced technologies below are used into the compressors.

- **Reciprocating compressor**
- **Screw compressor**
- **Scroll compressor**
- **Centrifugal compressor**

Contents

Example of power consumption reduction with inverter compressor

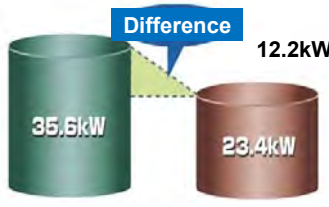
■ **Installation procedure**

Energy-saving diagnosis of air compressor (Measurement of 37kW conventional compressor x 1 unit)

Diagnosis result	Improvement content
- Average load factor: 52% - Power consumption: 23,600 kWh/month	- 37-kW inverter compressor x 1 unit installed - 34% power reduction

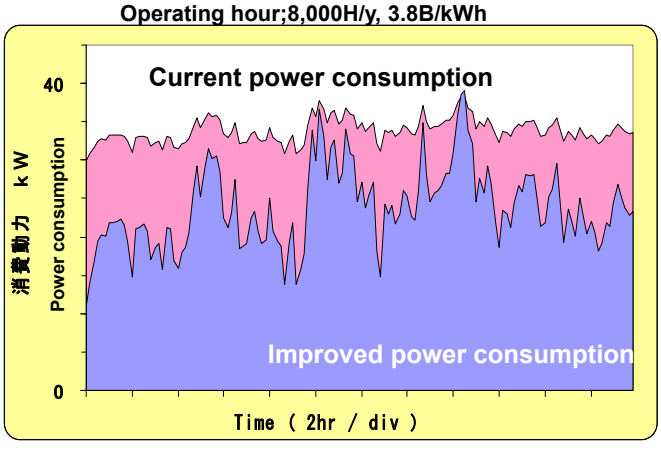
■ **Investment and effect**

- Investment amount: 700,000THB for a 37kW inverter compressor
- Energy-saving effect: 370,880B/year



12.2kWx8000H=97,600kWh

Operating hour;8,000H/y, 3.8B/kWh



■ **Spillover effects**

- Investment in protection of global environment through CO_2 reduction (-34%)
- Investment in longer overhaul cycle (8 years) because of improved component durability, leading to reduced maintenance cost (-30%)

Example of increased energy consumption

One of 2 old machines were replaced with the latest model.
Because the latest model machine had a higher discharge air volume, it was operated as a base machine.
As a result, energy consumption increased by approximately 10%.

Cause: The older machine was operated with capacity control. Because naturally it did not have good control characteristics, power consumption increased.
Action taken: Make the latest model machine dedicated for capacity control. As a result, approximately 20% energy saving was achieved.

Existing machines

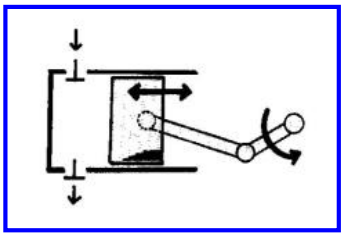
There was a need of energy saving.

Replacement machines

The highly-efficient inverter was operated as a base machine.

Example of concrete proposal

160 kW SCREW



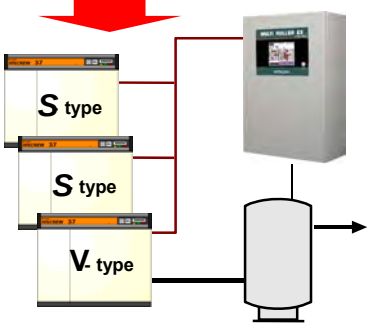
150kW RECIPRO

Proposal 1: Use of large two-stage compressor OSP-160S5WT

case1
Energy saving 28%

Proposal 2: Use of 2 inverters + Alternate operation panel OSP-75VW x 2 units

case2
Energy saving 46%



Proposal 3: Multiple unit control + Use of inverter OSP-55SA x 2 + 55VA

case3
Energy saving 20%

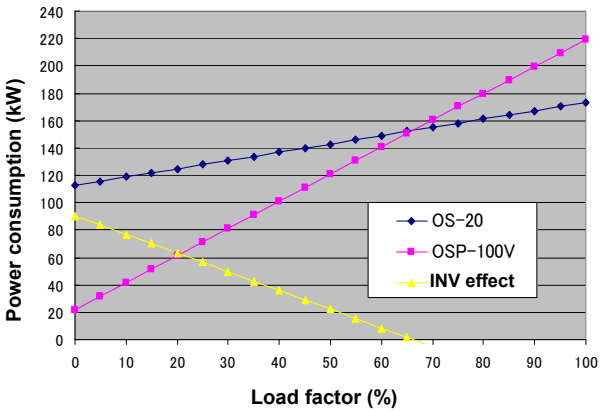
Concrete example of failure

--- Example from a Manufacturing Company

What was the cause of failure? Identify the cause.
- Learn from the failure to do it better the next time.

Dividing, use of inverters, replacing

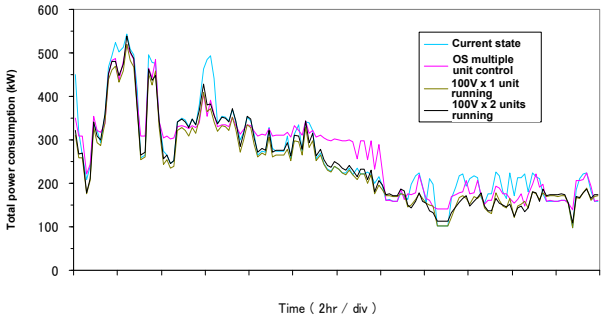
200kWSCREW (35.0 M³/min)



Ended up with increased energy consumption

Why?
Incorrect understanding of power characteristics
Separate control

100kWINVERTER SCREW x 2 units (36.2 M³/min)



Contents

IE cord regulation

IE (International Energy-efficiency Class)

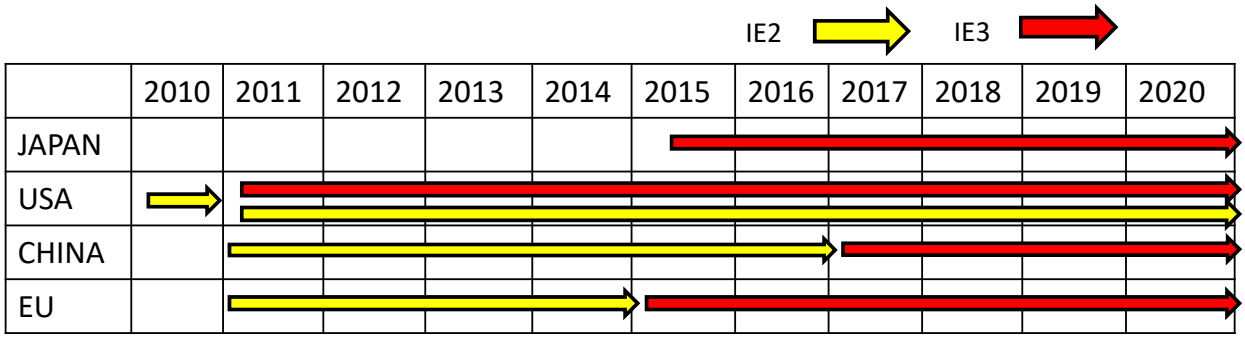
IE5	Super premium	IEC60034-30-1 (Annex)
IE4	Super premium	IEC60034-30-1
IE3	Premium	IEC60034-30-1(JIS C 4213)
IE2	High efficiency	**JIS C4212**
IE1	Standard class	**JIS C4210**

HITACHI IE5 MOTOR

HITACHI IE3 MOTOR

■ IE3 regulation

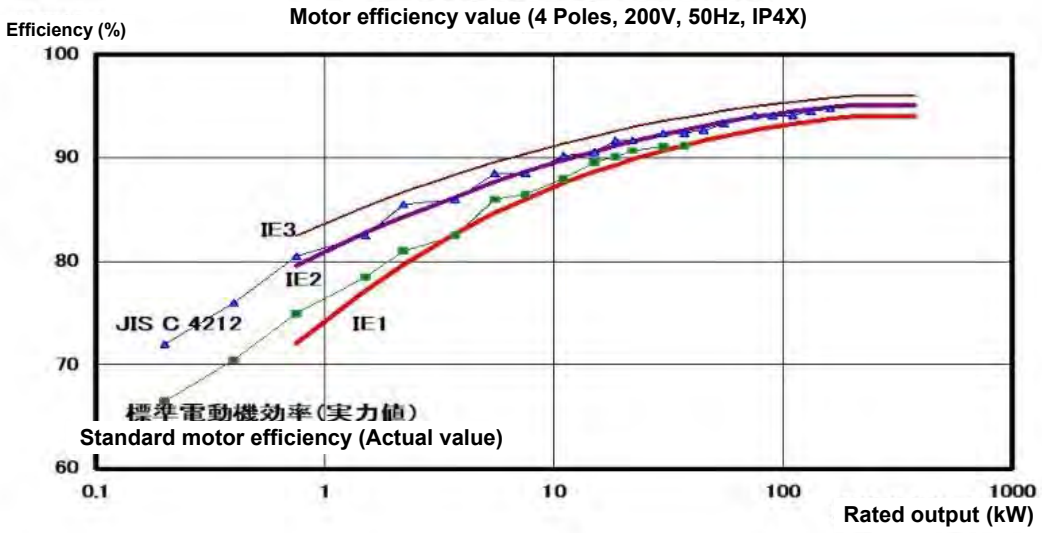
In japan using high class motor productive JIS C4212, it is IE2 level motor until March 2015.
From April 2015 Up to 0.75～375kW (less than 1000V) motor IE cord up one class to reduce CO_2.



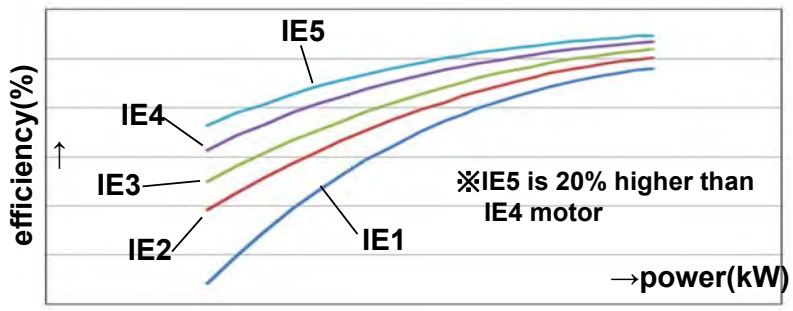
State of overseas regulations and international standards

- Efficiency regulations for lone motors are promoted overseas.
- The efficiency standard IEC60034-30 was instituted in October, 2008.

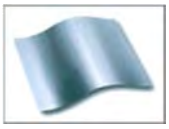
IE1: JIS C 4210 equivalent, IE2: JIS C 4212 equivalent, IE3: started from April 2015



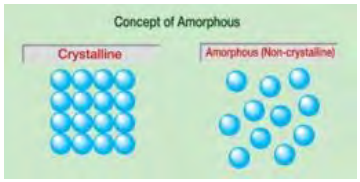
IE5 motor is made by amorphous metal



Efficiency of IE class motor（50Hz)



Amorphous metal



Amorphous transformer

Iron loss is 1/10 and the material by which loss has substantially compared with the flat rolled magnetic steel sheets and strip used for a conventional motor for amorphous metal.
For super energy saving series, amorphous metal is used as iron core for the transformer.

Power consumption management of compressors

--- Energy management system ISO 50001

In ISO 50001 and ISO 14001, energy management is proposed along with energy conservation, and cost control (consumption) of the equipment.
In order to know the power consumption of the compressor, only monitoring of power is not sufficient but grasping the rate of air flow is also important.
For this reason, installing air flow meters to manage the power consumption is recommended.

[Example of air flow meter]
- **Oval --- Hybrid sensor（25 ~ 150A）**
  Inlet type（150A）
- **AZBIL**
- **Flowcell --- Microwave type**
- **Aichi tokei --- 25A ~ 200A**

Aichi tokei

Oval

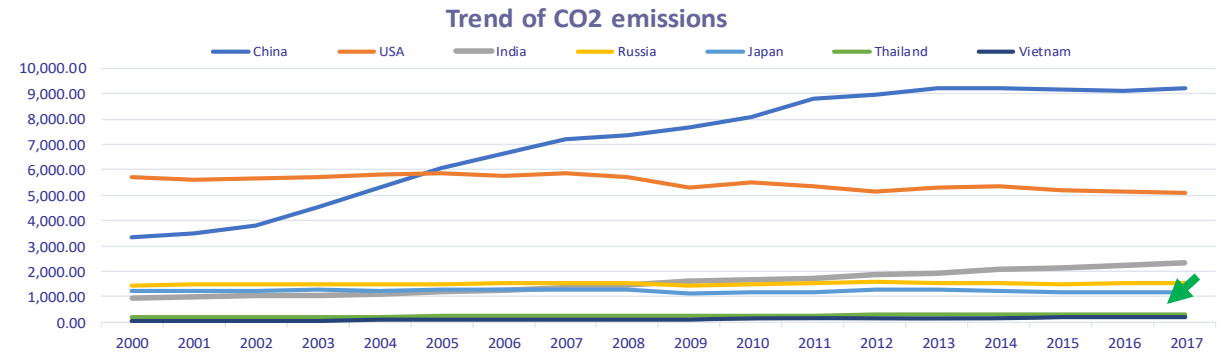
Flowcell

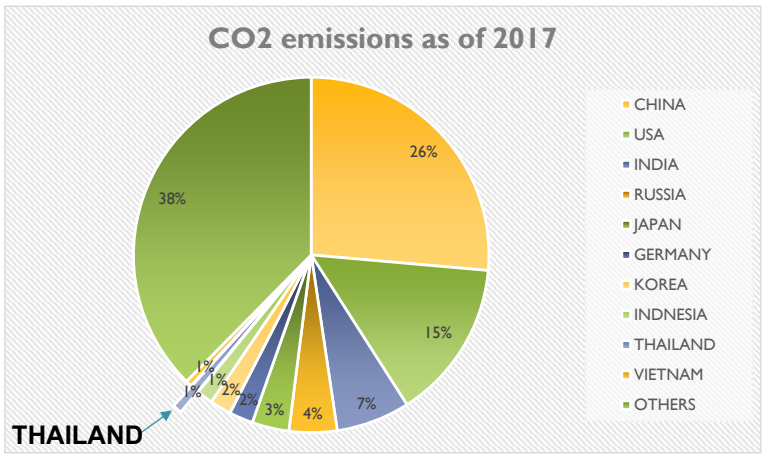
AZBIL

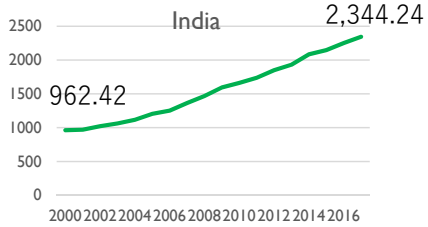
Contents

» Reference

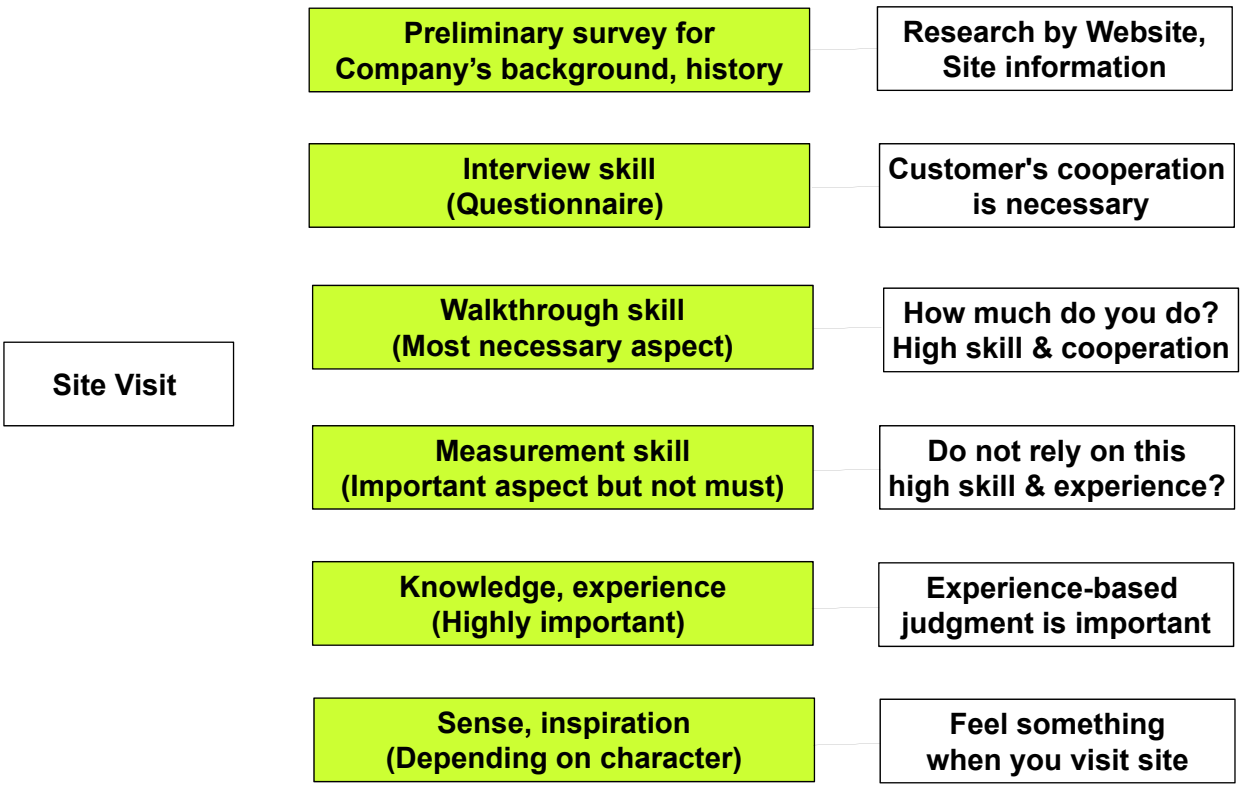
Reference: Trend of CO2 emissions







Reference: What are the necessary points?

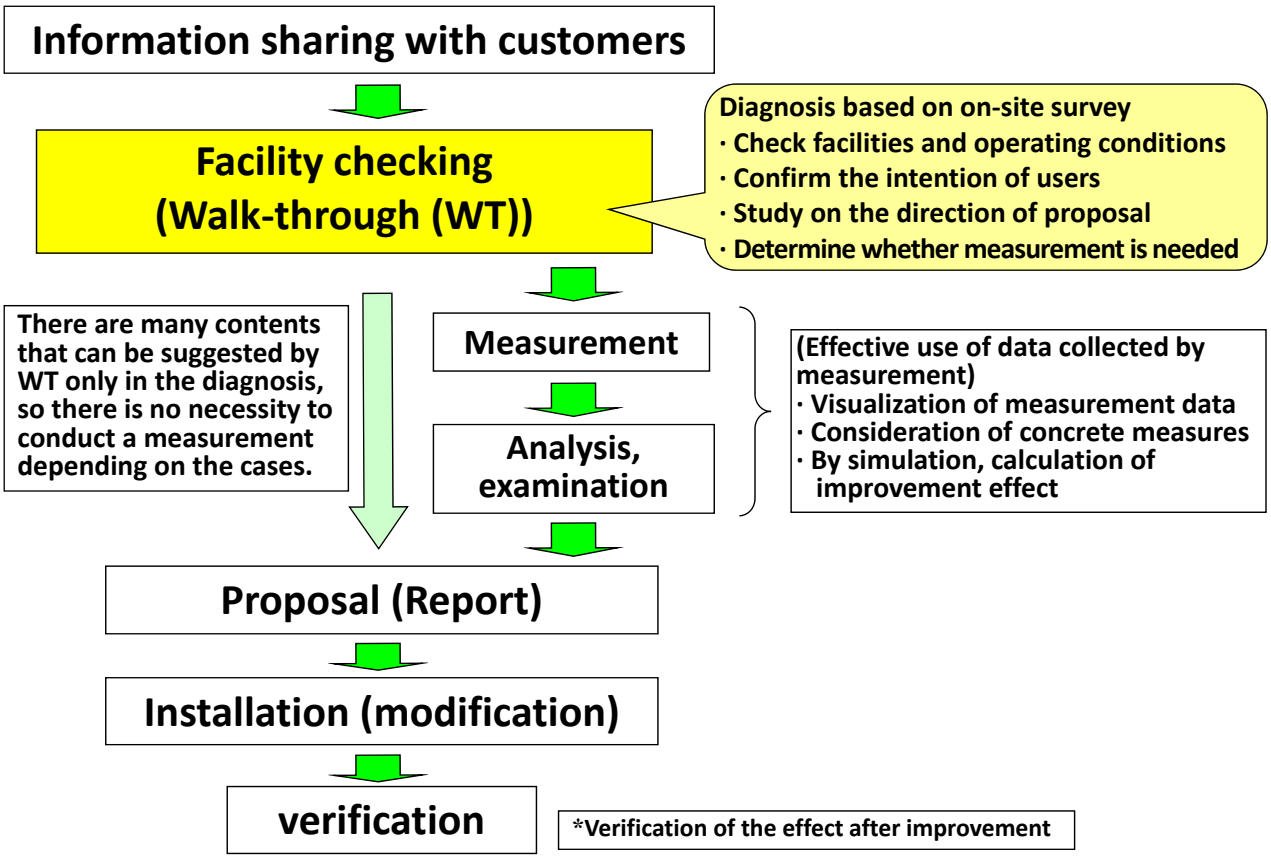


Reference: Check certification

What kind of certification does the customer have?

Certification	For what	Possibility to recommend
ISO9001	Management document	Maintenance schedule
ISO14001	Management environment	Energy saving, drain treatment
ISO/TS16949	Management auto-industry	Energy saving, filtering
ISO50001	Energy management	Monitoring , air flow meter, wat meter, FEMS
ISO22000	Management foods	Oil-free, Clean air system(filtering)
FSSC22000	safety foods	Oil-free, Clean air system(filtering)
HACCP	Hazard analysis foods	Oil-free, Clean air system(filtering)
GMP	Food, medical, cosmetics	Oil-free, Clean air system(filtering)
Heart recovery	Energy recovering method	Water cooled type(heart changer)
Class zero	Compressed air regulation	Oil-free(no oil in compressed air)
ISO8573	Compressed air quality	Clean air system, air-dryer system
Freon gas R12,R22	Freon gas regulation 2020	Air-dryer system
Remote monitoring	Communication system	Management, condition , maintenance

Reference: How do you perceive energy audit?



Reference: Environment for compressor

The deterioration of the environment degrades the performance of the compressor.
Proposing the installation environment of compressor is also an important factor for energy saving.

Higher temperature ... Intake of air with low air density (light) will degrade performance.
Temperature rise caused by ventilation failure due to a sealed room.
The air density decreases due to the lowering of suction pressure.
The decrease rate of performance is proportional to the air weight ratio, but with an increase of 1 deg. C.
Performance worsens 1/273 minutes at a time.

Air contamination ... The amount of air sucked by filter clogging will decrease.
Due to clogging of -500 mm Aq, the discharge air volume drops by 5%.

In case humidity is high · · · Humidity is high, water vapor expands and influences the amount of air sucked in.
The degradation of the performance given by humidity is determined by the saturated moisture content (Temperature, humidity, atmospheric pressure), its maximum value is said to be 3-5%.

Thank you

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