Feature / Considering Energy Conservation for Air Compressors

Improving Compressed Air Quality And Countermeasures Against Leaks

This leaflet is an excerpt from an article written by Mr. Kouzou Matsuno of the Facilities Management Section, Takasago Administration Department, MITSUBISHI HITACHI POWER SYSTEMS, LTD. for the March 2014 issue of “The Energy Conservation”, showcasing the results of the “SonicMan Survey” air/gas leak survey conducted by TTS LTD., an associate company of TLV CO., LTD.

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Improving Compressed Air Quality And Countermeasures Against Leaks

MISTUBISHI HITACHI POWER SYSTEMS engages the issues related to compressed air from the two sides of "Leak investigation and repair" and "Resolution of pressure loss caused by entrained oil and condensate". Through the accumulation of steady efforts, great sucesses in energy conservation have been achieved, such as a reduction in electricity use amounting to 130,000 kWh per year.

(Editorial Department)

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1. Introduction

We are a new company launched in February 2014 by the merging of the thermal power generation system businesses of Mitsubishi Heavy Industries, Ltd. and Hitachi, Ltd. The improvement example that we would like to introduce at this time is that which is being carried out at our Takasago plant.

Compressed air is used in a wide array of applications in our company from the driving force for manual grinders, and the automatic tool changers on high power large scale machine tools, to the automatic pallet changer used to position workpieces.

Normally, even if the compressed air system is leaking air severely enough to produce an audible noise, since it will have no great effect on personnel in regards to safety, maintenance tends to be delayed.

What taught us the importance of this maintenance was a summary chart prepared for a plant examination conducted by the Kansai Bureau of Economy, Trade and Industry in 2004. That summary chart showed that the electricity used by the air compressor to produce compressed air accounted for 4% of the total electricity used by manufacturing equipment. And when we looked at how that air was being used in the plant in order to reduce this energy use we found that, for example,

- There was oil and moisture mixed with the air, and before using manual tools such as air grinders, a blowdown would be performed to discharge these contaminants.
- An air trap was installed on each header to discharge condensate.
- For metal spraying equipment, because oil entrained in the air had a large effect on quality, filters as well as drying / cooling devices were installed to maintain quality.
- There were many air leaks in high places whose repair was delayed.

From these things we realized that "Leak investigation and repair" and "Resolution of pressure loss caused by entrained oil and condensate" would both be themes for compressed air system energy conservation.

Below we introduce examples of what we did to resolve these 2 challenges.

2. Improving compressed air quality

First, regarding "Resolution of pressure loss caused by entrained oil and condensate", we checked for the presence of condensate in the piping near the outlet of the air compressor which is the compressed air supply source, in the furthest pipe end from the supply source, and around the equipment consuming the greatest amounts of air; and also measured the ambient and compressed air temperatures at the supply source, the ambient and compressed air temperatures at the furthest ends of the piping, and the compressed air pressures at the supply source and at the furthest end of the piping.

The results showed that ① condensate was produced at a temperature of 36℃ or below. ② the average pressure loss was 0.054 MPa. ③ the pressure loss due to condensate in the piping was 0.025MPa.

In order to get rid of this condensate, we installed a compressed air dehumidifier.

In selecting a dehumidifier, taking into account energy efficiency and ease of maintenance, instead of a refrigerator type we installed moisture and oil removal equipment with a compressed air heater ("Hygro Master Model − α °DP" made by HYGRO MASTER INC.) at the supply source with dew point control as shown in Fig. 1 and Photo 1.

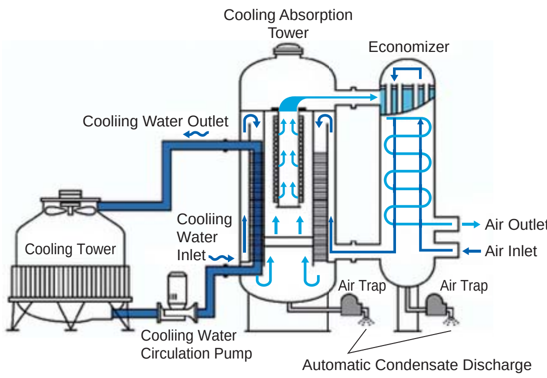


Fig. 1. Moisture and Oil Removal Equipment

Photo 1. Installation Status

After this equipment was installed, measurements similar to the previously mentioned investigation were carried out and the effectiveness was confirmed. Condensate-free air was, of course, realized, and as shown in Fig. 2, the average pressure loss dropped from 0.054MPa to 0.024MPa − a 0.03MPa reduction. Consequently, converting this savings to electrical energy, we see that a 130,000kWh yearly reduction in energy use was achieved.

In addition, some of the grinders used in production could not use air as a motive medium because entrained condensate and oil would be discharged and stick to the product, compromising product quality. As a consequence they were using nitrogen as a motive medium instead, but now that it is possible to use condensate-free air, the cost of nitrogen, 7.9 million JPY per year, could be reduced.

Furthermore, this equipment has been adopted at many other plants within our company and is contributing to company energy conservation and product quality improvement.

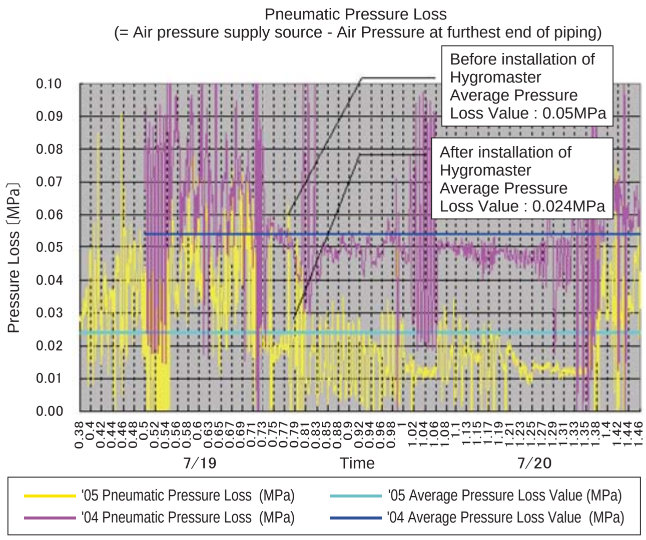


Fig 2. Pressure loss comparison

3. Countermeasures against leaks

Piping that is positioned high up in the building is difficult to inspect using the five senses or soapy water, and so comes to be neglected.

Even if a leak is at eye level, if it is very small likewise the difficulty in determining the leak point will cause it to be similarly neglected.

One primary reason leaks are left unrepaired is that the leak amount has not been measured / quantified, so their importance is not understood and the leaks come to be ignored.

Because, up until now, the process for inspecting and repairing air and gas leaks was not clearly established, leak diagnosis methods, frequency, records, subsequent repairs, etc. were stipulated when the field survey for the energy conservation law was carried out.

Next we'll intoduce a breakdown of the activity from that diagnosis to assessment and maintenance.

On investigating methods of accurately quantifying leak amount without relying on the five senses of the workers, we became aware of a method using ultrasonic waves that can detect even minute air leaks. From the fact that it would be difficult to fully deal with the investigation accuracy problem internally, we engaged a diagnosis service offered by TTS LTD., an associate company of TLV CO. LTD. that utilizes unique ultrasonic diagnostic technology. As Fig. 3 shows, this technology utilizes special diagnostic equipment to detect the ultrasonic waves generated when pressurized gas passes through a narrow passage (leak hole) and is discharged to a lower pressure area (the atmosphere, etc.), then identify the leak location and quantify (estimate) the amount of leakage.

Gaining a comprehensive understanding of the leakage in one stroke, not only allows us to grasp the overall loss for the plant, it also enables multifaceted analysis by different areas in a plant, air/gas types, etc., and makes it possible to set the priority of countermeasures.

After identifying the leak location, a tag showing leakage amount as well as other data needed for aggregation, as shown in Photo 2, is affixed at the leak location to make clear diagnosis results.

However, if the diagnostic and repair work were carried out separately, since there was a risk of overlooking leak locations or leak tracing on the information list when the repair work was carried out, a maintenance worker accompanied the inspector to perform simple repairs such as re-torquing as soon as the leak was discovered, enabling a "detection and immediatel repair" system which raised maintenance efficiency to a higher level.

Because, with this simple repair work it can be immediately confirmed whether or not the leakage has been stopped, the effectiveness rate for simple repairs is basically 100%. Also, for things that cannot be fixed with simple repairs, a budget acquisition request is issued and maintenance work carried out at a later date.

Furthermore, this diagnostic technology was applied in the same way to the piping for each of the manufacturing gases used (nitrogen, oxygen, argon, carbon dioxide, LPG) to identify leak locations, quantify leak amounts, then carry out "detection and immediately repair".

This initiative was begun in 2004, and once a year since then diagnosis and repair have continued to be carried out. The results of the compressed air and manufacturing gas leak countermeasures are as follows.

As shown in Fig. 4, compared to 2004 when the diagnostic work was begun, 2013 shows a 71% reduction in leak cost, greatly contributing to cost reduction. Because of recurring leaks due to the variation in aging of the supply piping and the quality of repairs, the reduction in the number of leak locations is not linear, but a 36% reduction has been achieved.

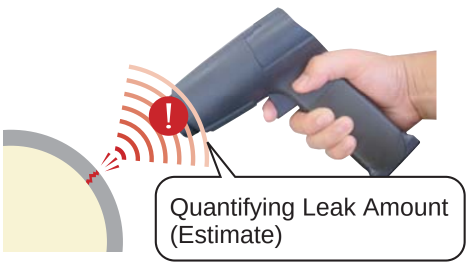


Fig 3. Diagnostic device

Photo 2. Tagging diagnostic results

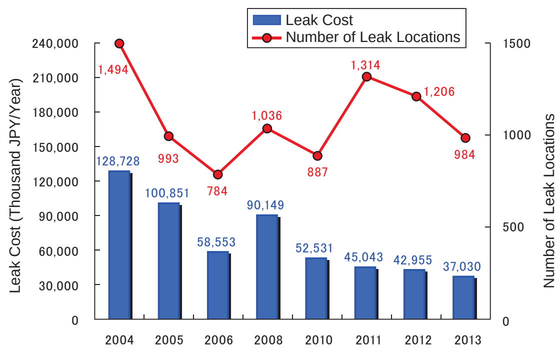
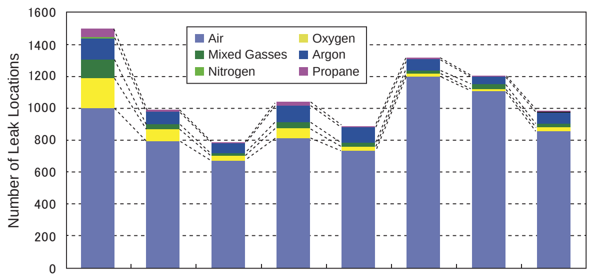


Fig. 4. Change in leak amount and leak cost



	2004	2005	2006	2008	2010	2011	2012	2013
Air	999	793	673	813	734	1,200	1,107	860
Oxygen	190	74	27	63	26	16	14	24
Mixed Gasses	118	30	16	39	25	21	29	23
Argon	127	80	64	101	92	67	47	69
Carbonic Acid	0	0	0	0	0	0	0	0
Nitrogen	11	3	1	1	2	5	0	2
Propane	49	13	3	19	8	5	9	3
Location Total	1,494	993	784	1,036	887	1,314	1,206	981

Fig. 5. Change in number of leak locations

Concerning the number of leak locations by air/gas type, as Fig. 5 shows, compressed air has the greatest number of leaks and although this number fluctuates yearly it seems to be leveling out.

As shown in Fig. 6, looking at the leakage by components from the most recent inspection conducted in 2013, we realized that valves account for 49%, hoses 21%, and couplers 11%, comprising a total of 81% of leaks.

As can be seen from Fig. 6, that trend is the same for 2013 and from the fact that component deterioration is the principle cause, we are continuing to replace deteriorated components with the following points garnered from the diagnosis results in mind:

- Review of header management procedure
- Use correct components and perform installation work properly
- Prompt repair or replacement of leaking components
- Keep hoses from coming in contact with components that may damage them
- Piping repair work

Large manufacturing equipment has been rearranged for production system upgrades thus far. Because of this, disused locations have increased, and air/gas leaks have occurred in these disused locations as well.

In order to eliminate this waste, we are implementing "Investigation of disused locations (headers, etc.) and unused areas", and halting air/gas supply to them.

When implementing these improvements, because there are so many different departments using air or other gases, it would be inefficient to have each department carry out the leak diagnosis and repair leading to improvements themselves. Thus the inspection schedule, budget acquisition, implementation, and reporting of diagnosis results are handled by the Facilities Administration Department as an executive office, while the details such as loss amount, leakage trend, etc. are presented by TTS at a debriefing attended by all departments after which each department will use the inspection record to make repairs within the areas under their jurisdiction.

Moreover, to gain an understanding of actual energy consumption, a knowledge of the supply lines and primary consumption points is needed. But since compressed air systems can be so easily extended, the supply line map has not stayed consistent with the actual extent of the supply line system. The supply line map is carried along during the leak diagnosis, compared to the actual state of the supply line system and updated to match, then later copied over to the CAD drawing to be maintained as the latest version. After this procedure was established, the supply line map was fully updated in 2009 and the procedure was followed every year since, thereby maintaining an up to date version of the supply line map.

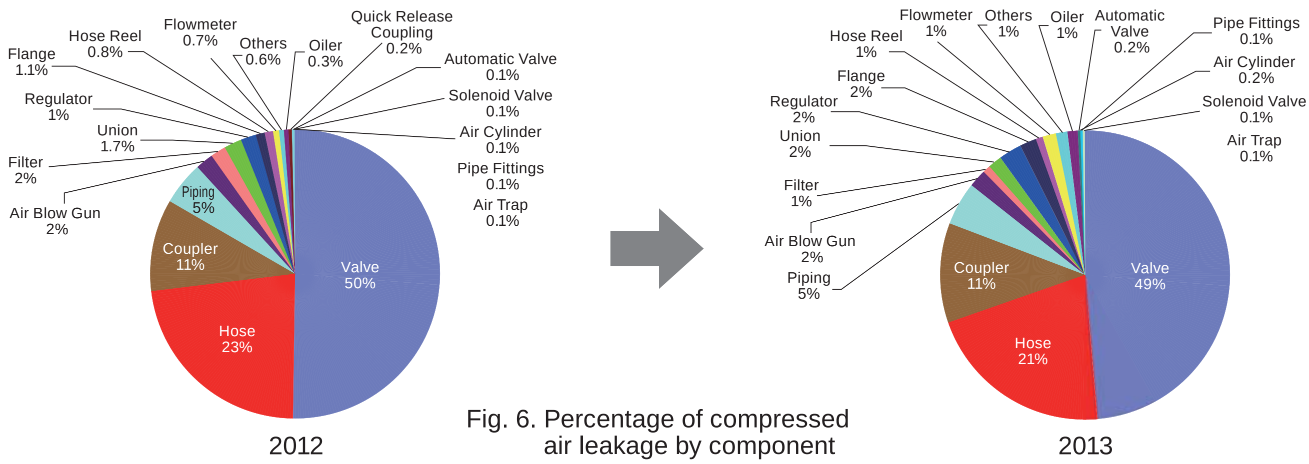


Fig. 6. Percentage of compressed air leakage by component

This supply line map is also useful in times of emergency such as gas leaks. Thus leak diagnosis is helping to improve other maintenance management.

4. Common "leakage" examples

In the preceding paragraph, we introduce several examples of conditions in our plant as shown in the graph in Fig. 7. Please use it as a reference when reviewing your plant.

1) Leakage from opening of unused valves
Many leaks were discovered coming from connecting caps. (Refer to Fig. 7)

2) No component is connected to the hose end
A hose was found whose end was not connected to anything but whose valve was open so that it was leaking argon gas continuously.
(Refer to Fig. 8)

3) Leakage from a new air header
Leakage was discovered that was due to theuse of inappropriate fittings / components.
(Refer to Fig. 9)

4) Handling of hoses
・A hose crossing a pathway was covered by a metal step, but the step pinched the hose and the hose developed a break resulting in leaking.
(Refer to Fig. 10)
・An argon hose melted and a hole was generated, causing a leak, because the hose was in contact with the grounding bolt for a welding machine.
(Refer to Fig. 11)

5) Corrosion of piping / hoses at outdoor workplaces
In addition, there were many leaks that were caused by deterioration of piping and equipment.
(Refer to Fig. 12)

Many of these examples were caused by things that were overlooked during daily production activities/work and accumulated to result in leaks, there are also things that even the repeated energy conservation patrols passed over without noticing.

Therefore, it is quite essential and effective to employ a team consisting of a diagnostic specialist who can carry out the inspection using ultrasonic diagnosis equipment instead of using the five senses to accurately discover leaks and can give us advice regarding maintenance, and a maintenance worker to carry out simple repairs. We will continue to use this method from here out to advance our energy conservation, environmental, and safety measures.

5. Towards even more stable air supply

The air supply to the majority of factories in our plant is handled by a centralized system and extends

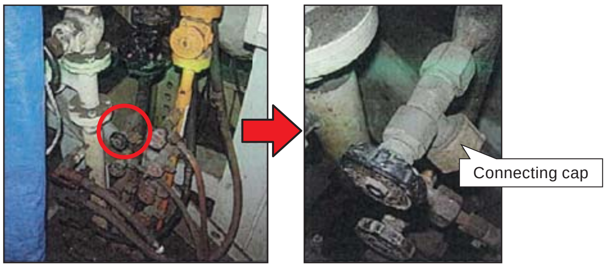


Fig. 7 Leakage from opening of valves

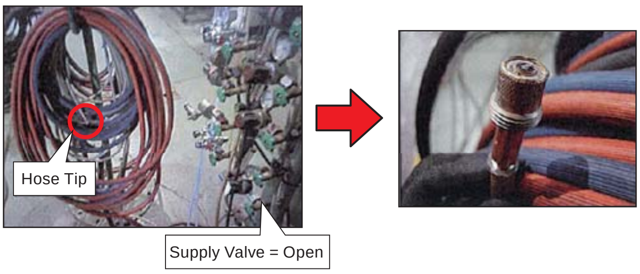


Fig. 8 Unconnectd hose end

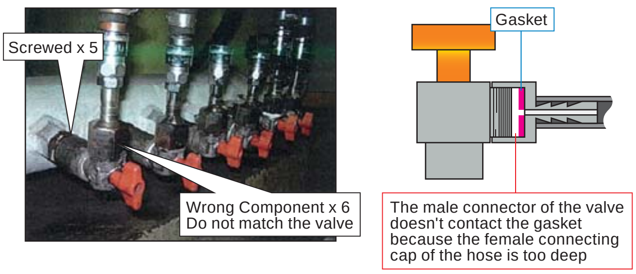


Fig. 9 Inappropriate fittings / components

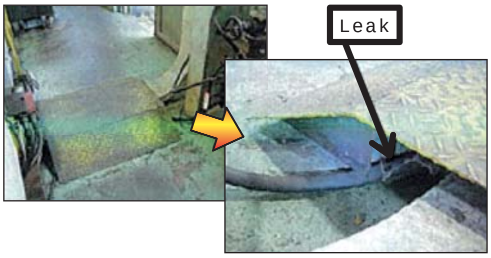


Fig. 10 Pinched Hose

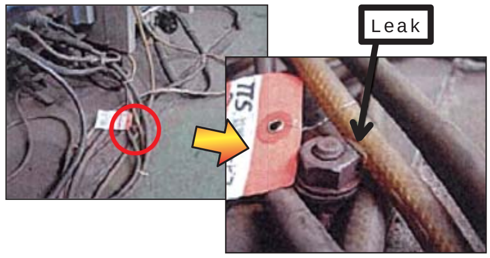
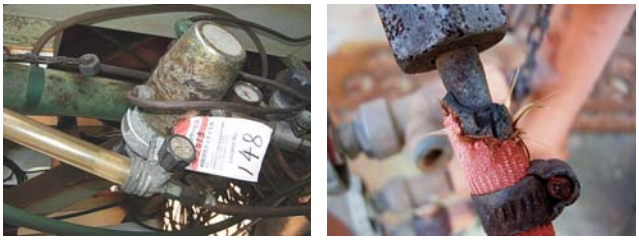


Fig. 11 Hose touching grounding bolt



Leakage from the regulator　　Deterioration of hose

Fig. 12 Leaks caused by deterioration

to a total of about 15 km. In order to maintain air pressure and quality at the extremities of the system, leak diagnosis and repairs have been carried out repeatedly, but problems with the air supply piping such as entrained condensate/oil, leaks, etc. that lead to a pressure drop, can be said to be occurring proportional to the total length of the air supply piping. Also, they surely have a large impact on the operation of the compressor.

Currently, in order to solve these problems and ensure stable air quality, pressure, and supply, we have just started to consider moving to a supply air system using distributed air compressors with compact supply scopes that correspond to the actual demands of the various air consumption areas and equipment, by utilizing the experience, knowledge and records gained from leak diagnosis and repair activities up to this point, so that we may achieve even greater energy savings.

In considering this course of action, there are various issues to ponder such as "should not have too many compressors by dividing the air consumption areas up too finely", or conversely "should not underestimate the air consumption amount thus leading to air supply deficiencies", and in order to avoid these problems "how to merge which areas with which, how to arrange the back-up system". We plan to handle each issue one at a time and move forward with improvements until we achieve total optimization of the air supply system.

6. In conclusion

Countermeasures against leaks in the air/gas supply piping are a battle against the aging and deterioration of equipment and are a long battle without limits. From these things, as if the wearing down of saw teeth on the leakage chart year after year, we will continue to patiently implement the cycle of diagnosis (inspection) and repair.

In order to safely, quickly, and inexpensively manufacture products, equipment must be able to function at its maximal capability to manifest the proscribed results. For this reason, by incorporating the "evaluation criteria" prescribed by the Energy Conservation Law, stipulated in the "energy conservation points" and "maintenance points" as part of a "control standard", and adequately implementing the items contained therein, we must maintain the ability to manifest the prescribed functionality.

In short, it is essential to revitalize maintenance activities for facilities.

In the end, energy conservation activity forms a trinity with environmental preservation and facility maintenance activities, and we are furthering our activities with the belief that consideration of the interaction of these elements is vital.

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