2009 Prize of Director General of Agency for Natural Resources and Energy

Reduction in Steam Leaks from 100,000 Steam Traps

Nippon Petroleum Refining Co., Ltd.
TLV Co., Ltd.

1. Background and History of Energy-saving Promotion

(1) Background

The Nippon Oil Corporation group is aggressively engaged in CO_2 reduction activities throughout the entire supply chain, such as reduction in energy consumption, strategic use of the Kyoto Protocol, and the supply of eco-friendly goods and services. In this group, each employee is obligated to sincerely adhere to the [Group philosophy・Six items of esteem・Behavioral policy] and fulfill his/her responsibility to society, and the group itself aims to establish a corporate group trusted by stakeholders and to promote the prevention of global warming, and energy saving is clearly raised as one of the behavioral policies. Also, while it is establishing the system and administration to promote corporate social responsibility (CSR), the group is transmitting every year internally and externally the information on its activities as the CSR report.

Amid the activities of this group, Nippon Petroleum Refining Co., Ltd., is in charge of the oil refining division of the group. CO_2 emission volume at an oil refining stage accounts for some 80% of the group's total. Therefore, the company grasped as the most critical issue the improvement of energy consumption efficiency at its refineries and plants (hereafter business establishment) and set the target of reducing energy basic unit by 20% by 2010 compared with 1990. To achieve the target, the company has been promoting development and introduction of the latest technology, rationalization of the manufacturing processes, management enhancement of operation and maintenance inspection. The company is seeing results steadily emerging.

On the other hand, to meet the social needs of clean car exhaust gas and global warming prevention by increased fuel efficiency, the company is manufacturing sulfur-free gasoline and gas oil (10 ppm or less of sulfur level), resulting in the increase in energy consumption at business establishments. Thus, more active energy-saving activities are needed. Amid this background, reduction in energy loss by steam leak (hereafter steam loss) is one of the

main pillars in the energy-saving activities, especially the proper maintenance and management of trap is important from this viewpoint. The company has long been engaged in this on its own. However, besides the fact that the judgment standards and confirmation method (primarily depended by the five senses of the operator) to determine whether the trap function is normal or abnormal are unclear, due to the enormous volume of 100,000 units from the seven business establishments, there was a limitation to enhancement of maintenance and management. Thus, we planned to build in collaboration with TLV Co., Ltd., the effective and sustainable mechanism of maintenance and management that allows us to comprehensively and accurately audit the traps of each business establishment each year, put the audit results into the database, and repair the traps based on the database analysis.

(2) Implementation Structure

Prior to the start of this activity, we sought opinions widely from internal experts and operators and the trap maker (TLV) about issues and improvements of the traditional maintenance and management. Then, the head office did purpose explanations to each business establishment, arrangement of the system, technical support, and budgeting. Finally, we launched the activity. At each business establishment, the activity started including primarily the technical service department, inside operation sites, and the construction department that makes the repair. Also, we asked TLV to participate and provide technical support on trap.

(3) Understanding and Analysis of Current Situation

The characteristics and issues of the traditional maintenance and management are as follows: Based on these facts, we crafted the mechanism of maintenance and management.

- Due to the enormous volume of around 100,000 traps from 7 business establishments, there is a limitation to audit operation and data management.
- Poor performance due to degradation over years (expendables)
- Difficult to determine whether it is normal or abnormal (primarily relying on 5 sense)
- Due to small amount of steam loss per trap, no perception of energy-saving effect

2. Contents of Activity

(1) Outline of Mechanism of Maintenance and Management

As Fig. 1 shows, the clarity and continuity of the operation are enhanced for the mechanism of maintenance and management crafted this time based on the yearly operation cycle flow called [6 steps] recommended by TLV in BPSTM (Best Practice of Steam Trap Management). In implementing each step, the head office, each business establishment and TLV reviewed the past characteristics and issues with new ideas and built an efficient and sustainable mechanism.

1) All counts audit

(a) Tools and staff to audit

A trap audit tool used at the worksite utilizes the principle that the steam leak volume and level of ultrasound emitted when the steam leaks correlate with each other. In addition, the tool is fitted with a thermometer so that a clog in the trap can be found, becoming a general audit tool.

As an audit tool with low accuracy may spoil the energy-saving effect, we validated the measurement accuracy of the audit tool in cooperation with TLV and adopted tools with higher accuracy. Also, since the internal human resources are not enough to audit the enormous number of traps within a short period, we decided to outsource the audit operations and examined the skill level of the audit staff.

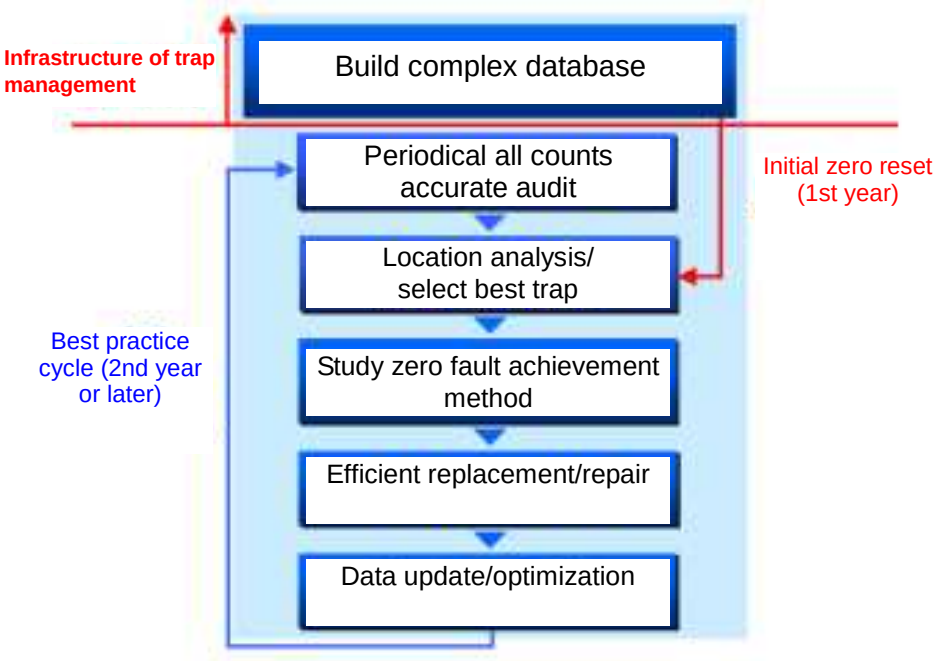

Fig.1 6 Steps (BPSTM)

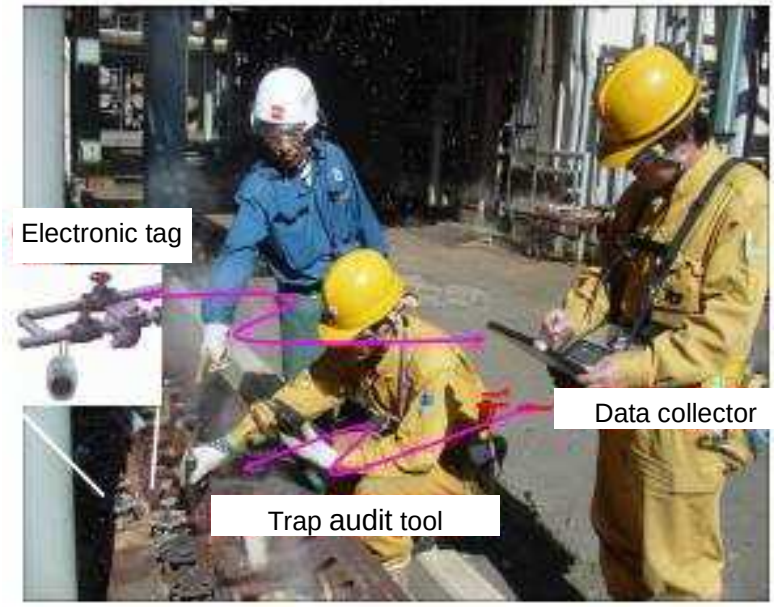

Fig.2 Audit

(b) Increase audit efficiency

In order to be able to efficiently and continually audit all of enormous number of traps of each business establishment every year, the audit speed of audit tool, data collection speed, and management tool are indispensable features. The audit system of TLV attaches an electronic management tag (RFID) to all traps at the worksite to identify and manage the

huge amount of data and sends the trap data (installation location, model, used pressure, etc.) of each electronic management tag, along with the audit results obtained by trap audit tools, to the data collector. As the measurement time of an audit tool is only about 15 seconds and the data is mutually sent immediately by low power radio, the data collection speed is extremely high.

The use of these audit systems allows us to efficiently audit traps in short time every year. In the case of the Muroran Refinery, where the number of installed traps is the largest (approx. 23,000) among the seven business establishments, one team consisting of two members managed to audit 65 traps or more a day for the first year when the audit system was introduced, including time spent on trap data input and moving from one place to another. The audit of all traps took only some two months by 288 teams in all. As for the audit of all traps in the second year or later, since the input of trap data is unnecessary as long as there are no updates, the audit period can be further shortened, making it possible to audit efficiently and continually every year.
When the audit is made in the first year, expert operators who know the worksite well should attend the audit with the outsourcing company staff and issue the proper instructions on trap data. Otherwise, the epoch-making audit system is useless. (See Fig. 2: Audit)

2) Build and update the database

To manage huge amount of trap data collected at the worksites and audit results, we make it a rule that they are to be centrally managed via IT tools, such as host computer server or dedicated PC.

The data management system enables us to craft an electronic data card for each trap and centrally manage them as the database by the server computer of TLV. The map data and site photo data are attached to the electronic data card so that the trap installation location can be quickly searched. No mistake to mix with other traps in the area can happen. (See Fig. 3: Management software sample of electronic data card)
Also, when the audit or replacement construction, etc. changes, the database is updated to the latest, and the latest data can always be searched easily via the Internet. The introduction of this management software enables us to centrally manage not only the audit history or construction history of a huge number of traps but also confirm the specs related to bad trap replacement construction, efficient operation of ordering/construction, long-term fault analysis, or energy-saving effects.

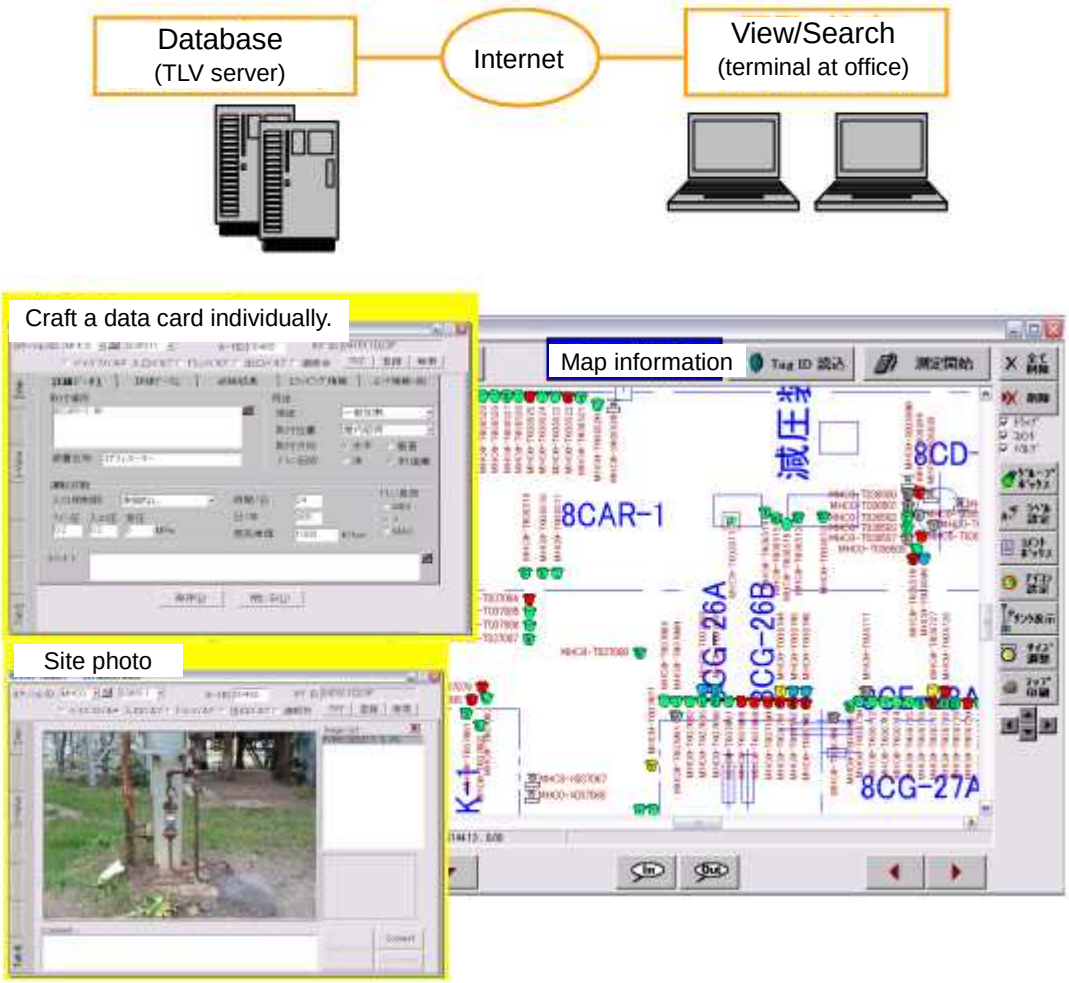

Fig. 3 Management Software

3) Replacement of faulty trap

Based on the database of audit results, we analyze the data of faults, decide on the policy for replacement or repair, and implement the repair construction of faulty traps. Also, in implementing replacement or repair, we employ the viewpoint of LCC (life cycle cost) a long-life product that is excellent in terms of energy saving and poses less of a burden on the repair construction as the best model to reduce the total cost.

4) Verification of activity effect

In consideration of the characteristic [Due to small amount of steam loss per trap, no perception of energy-saving effect] mentioned in 1.(3) Current Status and Analysis, a certain business establishment (Muroran), with its steam flow meter, is tracking the steam loss

volume equivalent to faulty trap replacement repair on the occasion of repair in the first year and is validating in comparison with the steam loss volume predicted by the audit. This serves as verification of the audit results as well. As a result, the actual figure and the predicted figure match up pretty well with each other as shown in Fig. 4, which verifies that the audit results using a trap audit tool are correct.

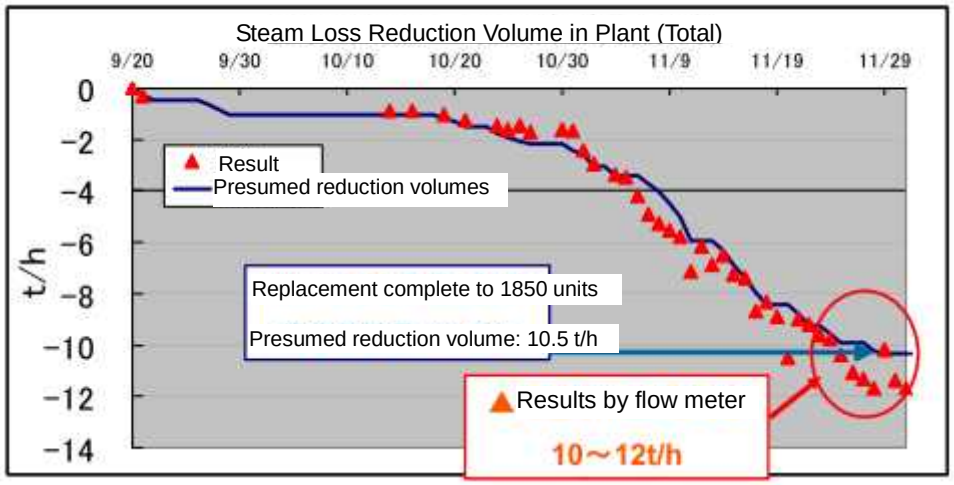

Fig. 4 Validation of Effects (Case of Muroran)

(2) Characteristics of mechanism

1) Advancement / Creativity

In building the mechanism, we sought opinions from internal experts and operators and a trap maker on the issues and improvements of the past maintenance and management and adopted ideas from new viewpoints downplaying the past frames so that the mechanism will work efficiently and continually. The following are the major ideas:

- Validation of audit technique (accuracy of audit device, skill of test staff)
- Outsourcing of audit operations (Commission of man power operation)
- Efficient audit operations (high efficiency, labor savings by enhancing management tools like use of IT technology)
- Introduction of database management system (continual data update and data analysis every year)
- Selection of a best model as a trap critical to repeated faulty and/or safe operation of equipment

(2) Versatility / Applicability

In an industry with a large-scale facility that consumes huge volumes of steam to heat tubes and tanks, lots of traps are being used, causing many users to worry about the maintenance and management. Also, in small or mid-scale factories and large buildings, steam is being used for heating. Therefore, the periodic audit and maintenance of traps are the energy-saving activity itself.

In our case, the energy-saving effect for 100,000 units of traps is 18,000 kL/year (crude oil equivalent) and the economic advantage is around 1 billion yen (fuel cost: assuming 58,000 yen/kL). On the other hand, the cost spent on audit and repair was considered an economic advantage, proving it is economically sound. Also, by introducing ideas that make the mechanism of maintenance and management work, it is possible to continuously keep the steam loss to a minimum from now on, too. Though this activity is not the introduction of the state-of-the-art energy-saving technology but just a conservative activity, it is a steady energy-saving activity that is sure to produce good results, as a proverb says that a penny saved is a penny gained. We think this activity is worth trying for other companies and industries.

(Cases of TLV developing to other companies) *Written by TLV

TLV has already introduced this mechanism in Japan as [BPSTM: TLV drainage location management program] to about 150,000 drainage locations of 45 major business establishments of oil refineries or oil chemical companies, steadily achieving a reduction in the fault rate and steam loss (See Fig. 5). TLV is also proceeding with development and implementation of this program to other large industries, like the steel industry and small to mid-size factories, and overseas, planning a much wider energy-saving activity.

The following are the cases of Kashima Refinery of Kashima Oil Co., Ltd., which achieved the same effects as Nippon Petroleum Refining Co., Ltd., by introducing this program. (We received permission to disclose their energy-saving effects.)

Kashima Refinery of Kashima Oil Co., Ltd. were managing steam traps at a high level through their own maintenance. However, before the introduction of the program, the fault rate of their steam traps was 17.5% (Number of audited units: 5,244). Currently, two years after the introduction of the program, the fault rate of their steam traps has decreased to 3.7%. As the graph of Fig. 6 shows, zero reset after the periodic maintenance is very important. Also, even if the zero reset is surely done, some traps that are normal at the time may become faulty by next year, causing the fault rate to rise slightly. Therefore, the periodic inspection and zero reset must not be stopped.

Though we reported to our customers that Kashima Refinery succeeded in reducing steam

by 2.4 tons per hour, the result of validation done by Kashima Refinery with a steam flow meter showed the actual figure is higher than 2.4 tons per hour. Even if the total steam reduction is 2.4 tons per hour after the introduction of the program, that figure is tantamount to the yearly average of some 5%. Also, the reduction for one location of drainage is 0.48 Kg/h.

As the result of steam-saving rate against total steam consumption volume, the example of the largest business establishment among 45 establishments shows the reduction of 6.1%.

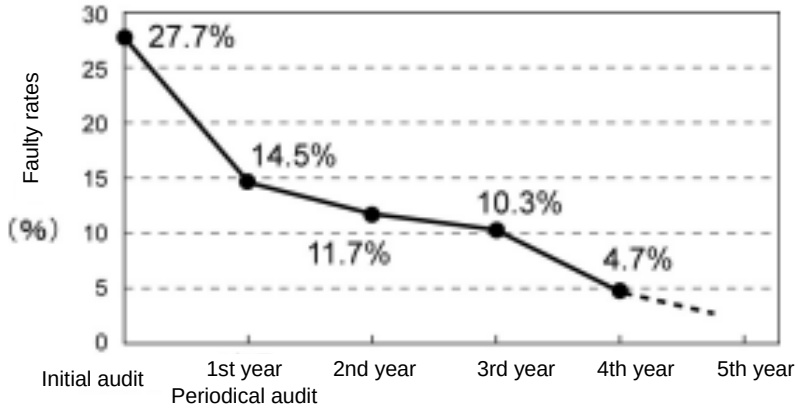

Fig.5 Program elapsed years and faulty rate

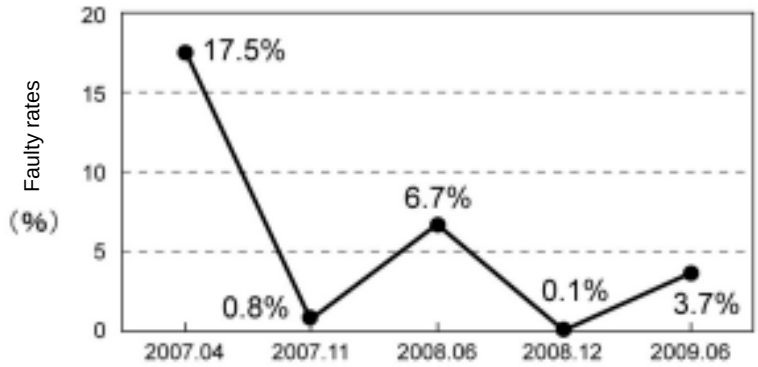

Fig. 6 Trend of trap faulty rate in Kashima Refinery

(3) Continuity / Sustainability

This activity was launched at each business establishment from 2005. We have been improving the issues of the past maintenance management with new ideas and have established an effective and sustainable mechanism, which is being sustained and managed now. Being encouraged by the effects gained from trap activities, we have been extracting unnoticed energy losses, such as steam loss at unnoticed place and ineffective

operations resulting from faults, leading to enhanced voluntary energy-saving activities. In Muroran's case, to promote energy saving by reducing steam losses and "5S" by improving the unclear environment around leakage locations, they formed the [Steam Unclearness Search Team] to look for leakage locations, conducting voluntary activities to search all areas and do repair work. Also, employees' motivation hiked, leading to improved knowledge of steam and pursuit of energy-saving operations. There are some business establishments that are actively attending the energy-saving audits and technology investigations hosted by TLV and specifically aimed at steam.

Through these activities, business leaders of this company (head office) are not only promoting energy-saving activities but also supporting each business establishment with operation saving through IT, settlement of the mechanism, human education, arrangement of the system, technical support, and securing the budget. Also, the results of these activities are disclosed internally and externally (Visualization), causing employees' motivation for energy-saving activities to further hike and contributing to continuity and sustainability.

3. Energy-saving

(1) Effects

Poor performance of traps due to degradation over time is unavoidable (expendables). Although each business establishment was engaged in periodic maintenance and management in the past, they were unable to grasp the status of faulty traps because of the enormous amount of installed traps in addition to the unclear judgment standards to determine whether a product is normal or abnormal. Therefore, we built the mechanism that allows us to audit every year all traps at each establishment, enter the audit results into the database, and make and implement repair plans based on the database. These activities are now settled as operations to be done every year.

As you can see from leak fault rates of major establishments (Muroran, Mizushima) and trend examples of steam loss volume shown in Fig. 6, the faulty trap rate has been steadily declining every year as a result of the development of this program to each establishment from 2005. It is now assumed that the total steam loss from 7 establishments was reduced by some 37 tons per hour till 2008.
(Energy-saving effect: 18,000 kL/y @ crude oil equivalent, CO_2 emission volume reduction: 46,000 tons/y)

We intend to further proceed with energy saving by actively utilizing the settled mechanism and continue it so as not to let steam loss increase again.

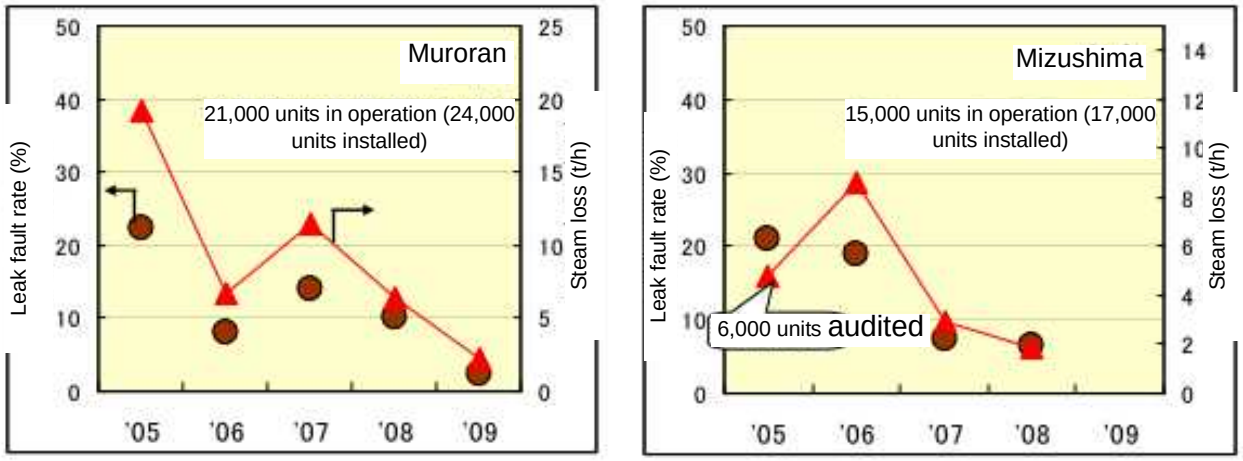

Fig. 6 Fault rate and trend of steam loss (examples of Muroran and Mizushima)

Energy-saving effects of 7 establishments of Nippon Petroleum Refining Co., Ltd.

Energy saving of 18,000 kL/y of crude oil equivalent has been accomplished.
(Reduction in CO_2 emission volume: 46,000 tons/y)

* Base year: After all units audited in 2005, Improved year: 2008 (post-audit)

(Reference) Introduction of activity results

In 2008, four years passed from 2005 when the activity was launched. Muroran Refinery validated whether the results of their energy-saving activities are reflected in the real data. After correcting as much as possible the operation impact of steam equipment, they described the trend* for the steam volume of a boiler that produces steam and compared it with the results of energy-saving activity.

As a result, the steam volume has been steadily declining every year as shown in Fig. 7. The reduction volume is almost equivalent to the results of the energy-saving activity.

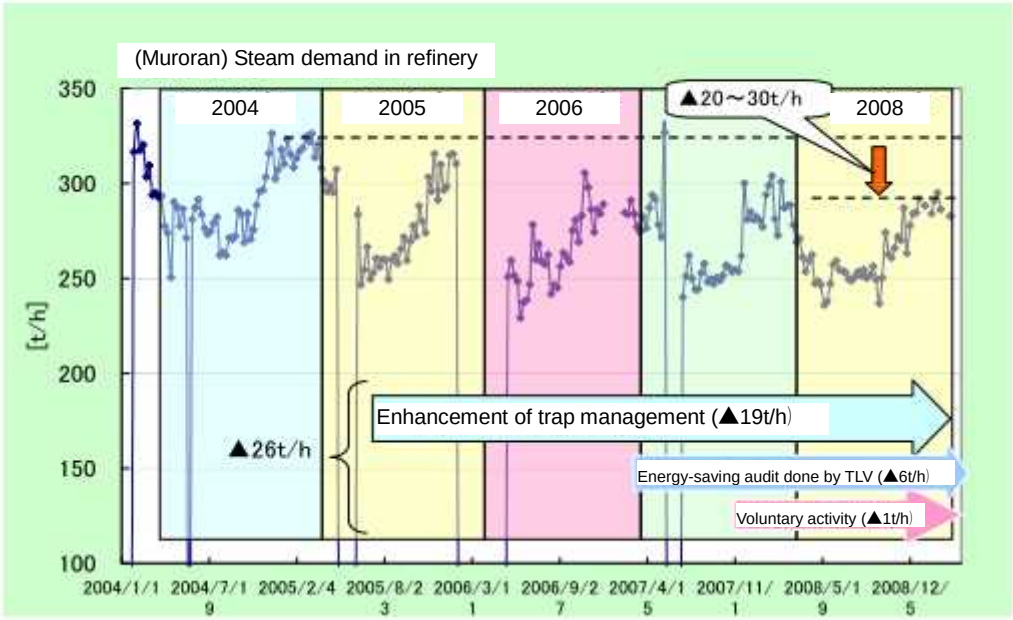

Fig. 7 Trend of boiler steam volume

These results were disclosed to those concerned. Employees' motivation for energy-saving activity is rising more than ever. They are now engaged in various activities.

* Since there is a limitation to the correction of weather conditions (external temperature, rain, etc.), trap replacement timing, and daily repairs at the worksite, this data should be treated as a reference.

(Reference materials)

- Nippon Oil Corporation group CSR report (HP: http://www.eneos.co.jp/)
- Energy-saving excellent case convention in 2006 (Hokkaido area)
  - Nippon Petroleum Refining Co., Ltd. Muroran Refinery
  - (HP of Energy-saving Center: http://www.eccj.or.jp/)
- Trapping Engineering (Published: Energy-saving Center)