2009 Grand Prize for Excellence in Energy Efficiency and Conservation (Association Category)

"Director-General's Prize, the Agency for Natural Resources and Energy"

[Joint winner with Nippon Petroleum Refining Company]

Reduction in Steam Losses from 100,000 Steam Traps


経済産業省委託事業

平成21年度
省エネ大賞
（組織部門）
受賞事例発表会
講演要旨集

日時：平成22年2月10日（水） 12：30～17：00
場所：東京ビッグサイト会議棟6階会議室

ENERGY CONSERVATION GRAND PRIZE

財団法人/省エネルギーセンター

TLV®

(Sponsored by Ministry of Economy, Trade and Industry)
2009 "Grand Prize for Excellence in Energy Efficiency and Conservation" (Association Category)
Quoted award-winning case report issued by the Energy Conservation Center

Reduction in Steam Losses from 100,000 Steam Traps

Nippon Petroleum Refining Company
TLV CO., LTD.

1. Background and Details of Steps Toward Energy Conservation

1-1. Background

The Nippon Oil Corporation Group is proactively engaged in efforts to reduce CO_2 emissions through activities such as reducing the amount of energy consumed throughout the entire supply chain, strategically utilizing the Kyoto Mechanisms, and offering environmentally friendly products and services.

Each and every employee at the Nippon Oil Corporation Group faithfully puts into practice according to the "Group Philosophy", "Six Values We Respect" and the "Action Guideline" while steadfastly executing their responsibilities toward the company, striving to establish business groups worthy of the trust of stakeholders, and promoting efforts toward energy conservation and the prevention of global warming, as clearly set forth in the company Standards of Conduct. In addition, the Nippon Oil Group publishes an annual CSR Report in printed form, which contains information concerning activities undertaken with regard to the construction of structures and organizations for the fulfillment of corporate social responsibilities (CSR).

Within the structure of the Nippon Oil Group Corporation, the Oil Refinery Group falls under the auspices of the Nippon Petroleum Refining Co., Ltd. The oil refining stage of processing by the Oil Refinery Group accounts for 80% of the Corporation's total CO_2 emissions. Accordingly, improving energy consumption efficiency at the refineries and manufactories (hereinafter referred to as 'refinery/refineries') is an urgent task. The goal of a 20% reduction in energy consumption compared to 1990 levels by the year 2010 was set, and a commitment to the promotion of advances such as the development and implementation of leading-edge technologies, rationalization of production processes and continued improvements in the management of daily operations and maintenance inspections is steadily yielding benefits.

At the same time, society's need for measures against global warming such as reducing pollutants in vehicle exhaust and making improvements in fuel efficiency must be met, and together with moves toward the removal of sulfur from gasoline and light oil (to a sulfur content of less than 10 ppm) manufacturing there is a trend toward an increase in energy consumption at refineries, which calls for steps toward further energy conservation.

Amidst that backdrop, reducing the amount of energy lost through steam leakage (herein after referred to as 'steam loss/steam losses') therefore forms a large pillar of energy conservation activities. From this standpoint, the proper maintenance management of steam traps is of particular importance. In the past, the arrangements for this maintenance have been made using in-house personnel.

However, the criteria for distinguishing between normal and abnormal trap operation and the methods for making such a determination (mainly by relying on the five senses of the operator) have not been clearly defined. This, in addition to the fact that the number of traps to be maintained is enormous — 100,000 traps at 7 refineries — has resulted in limitations in the ability to achieve the fulfillment of proper maintenance management.

As a solution to this, in cooperation with TLV CO., LTD., the Nippon Oil Group has established an efficient, long-term maintenance management plan that starts with an exhaustive, high precision survey being performed on the traps at each refinery on an annual basis. The results of these surveys are compiled into a database, and repairs / replacements are carried out based on an analysis of this database.

1-2. Framework of the Undertaking

Prior to initiating any activities related to the undertaking, the opinions of a wide number of people were sought, from in-house experts and people with hands-on knowledge in the field to trap manufacturers (TLV), on the issues surrounding existing maintenance management and possible points for improvement. Each refinery was also informed in advance with regard to the intent of the undertaking, and provided support such as equipment for establishing the systems required, technical support, and provisions for budgets. The activities at each refinery centered around the Technical Services Group, and a Work Division — to perform trap repairs/replacements — was added to the in-house workplace operations. In addition, TLV was asked to participate in the role of trap technical support.

1-3. Comprehension and Analysis of the Current Situation

Features and issues pertaining to existing maintenance management are as follows, and a maintenance management plan was formulated in consideration of them:

・The total number of traps at the 7 refineries is approximately 100,000, and there are limitations in being able to carry out inspections and manage the data for such an enormous number of traps

・Traps fail due to wear and age-related deterioration (all traps eventually wear out and need to be replaced)

・It is difficult to determine whether traps are failed or not (must mainly rely on the five senses)

・Steam loss from each individual trap is small, making the results of energy conservation feel too intangible

2. Details of the Undertaking

2-1. Summary of Maintenance Management Plan

As shown in Figure 1, the maintenance management plan formulated is based on an annual work cycle of procedures comprised of the 6 steps recommended in TLV's BPSTM (Best Practice of Steam Trap Management), for improved clarity and continuity of work procedures. For the implementation of each of these steps, an efficient, long-term plan based on the features and issues of the existing maintenance management was carefully and painstakingly established through discussions among the Nippon Oil Group headquarters, each refinery and TLV.

(1) Survey of All Traps

① Inspection Tools and Inspectors

The onsite trap inspection tool utilized is a comprehensive diagnosis instrument; it is able to diagnose steam leaks by measuring the ultrasonic waves emitted by the steam leak and then making a determination based on the fixed correlation between the amount of steam leakage and the level of ultrasonic sound generated by the steam leak, and also able to detect clogged traps by means of the integral temperature sensor.

The effectiveness of energy conservation efforts would be impaired if the measurement precision of such a diagnostic instrument were poor, so with the help of TLV, the measurement precision of the trap diagnostic instruments is calibrated so the inspections can be carried out with the highest of accuracy. Furthermore, it would not be possible to test each of the huge number of traps in a short period of time using only in-house personnel, so the actual inspection work is outsourced and the skill level of the inspectors is verified.

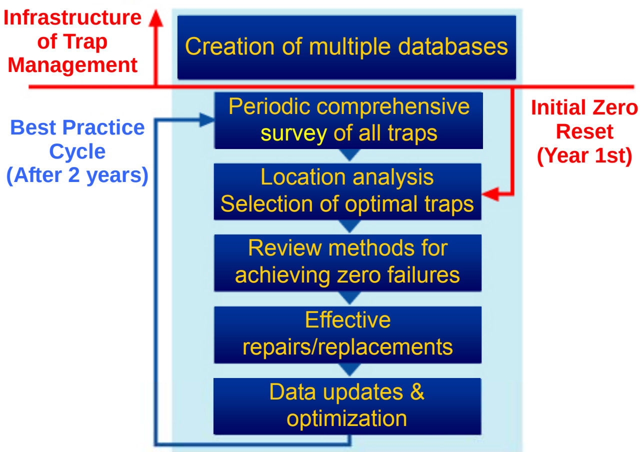


Figure 1 6 Steps (BPSTM)

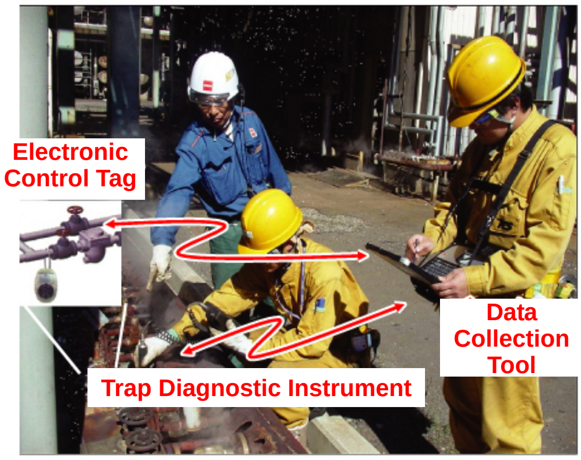


Figure 2 Scene of an Inspection

② Maximizing Survey Efficiency

In order to inspect each of the large number of traps at each of the refineries efficiently and in a manner that facilitates the process being carried out annually on subsequent years, it is essential to have inspection tools with high inspection speeds, high data collection speeds, as well as high performance data management tools.

One of the features of the TLV survey system is the use of electronic control tags (RFID's). In order to easily differentiate among the data from such a large number of traps and to manage this enormous amount of data, an electronic control tag (RFID) is attached to each of the traps in a plant, and the data (e.g. installation locations, model, operating pressure) for the trap corresponding to each RFID tag is entered into the database. The results from the trap diagnostic instrument are added to this data and the information is sent to the data collection device. The time required for the diagnostic instrument to take a reading at each trap is only 15 seconds, at which time all the data is transferred via a low-power wireless transmitter, thereby dramatically speeding up the time required for data acquisition.

The use of this survey system makes it possible to efficiently carry out annually surveys in just a short period of time.

Among the 7 refineries, the Muroran Refinery has the largest number of traps (approx. 23,000). The first year the survey system was adopted, a two-man team was able to inspect over 65 traps/day, including the time required for trap data input, moving from location to location, etc. A total of 288 teams were involved, and they were able to complete a survey of the entire trap population in only roughly 2 months. Additionally, in subsequent years there will be no need to enter trap data aside from making any updates due to new information, thus further shortening the time required for the survey and making possible the implementation of efficient annual surveys on a long-term basis.

Naturally, the usefulness of these innovative survey system tools is greatly aided if an operator who is familiar with the refinery accompanies the outsourced survey teams as they make their rounds on the first year of inspections, to give instructions relating to pertinent trap data. (Figure 2 Scene of an Inspection)

(2) Database Creation & Updates

To facilitate the management of the huge amounts of trap data collected on-site and the results of the trap surveys, IT tools such as the server of a host computer or specialized computers are used for centralized management.

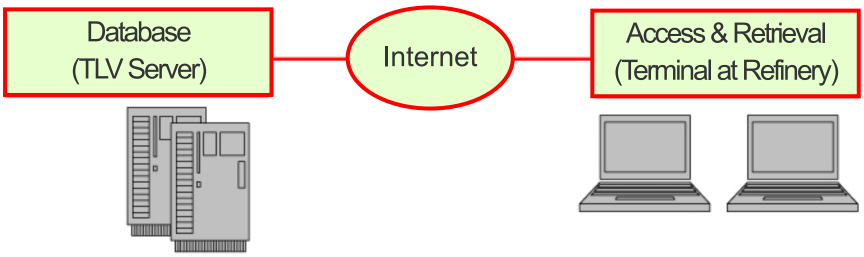
A special feature of the data management system is the creation of a computerized chart for each individual trap, and these charts are stored in a database on the TLV company server for centralized management. Maps and photographs of the actual installation sites are included with the computerized charts to allow for the immediate retrieval of installation locations and to prevent any confusion that might occur when multiple traps are situated close to each other.

(Figure 3 Sample of Computerized Chart in Management Software)

Whenever updates are made to the information due to inspections, trap replacements, etc., the centralized database is replaced with the newest version, and the up-to-date information in the database can easily be searched at any time via the Internet.

The introduction of this management software not only allows for easy access to the inspection and work records for a huge number of traps, but it also maximizes the efficiency of the administrative side of replacing failed traps, such as the confirmation of specifications, the ordering of replacement traps and the management of the trap installation/replacement work.

The software also allows for the centralized management of long-term failure analysis and the results of energy conservation measures.



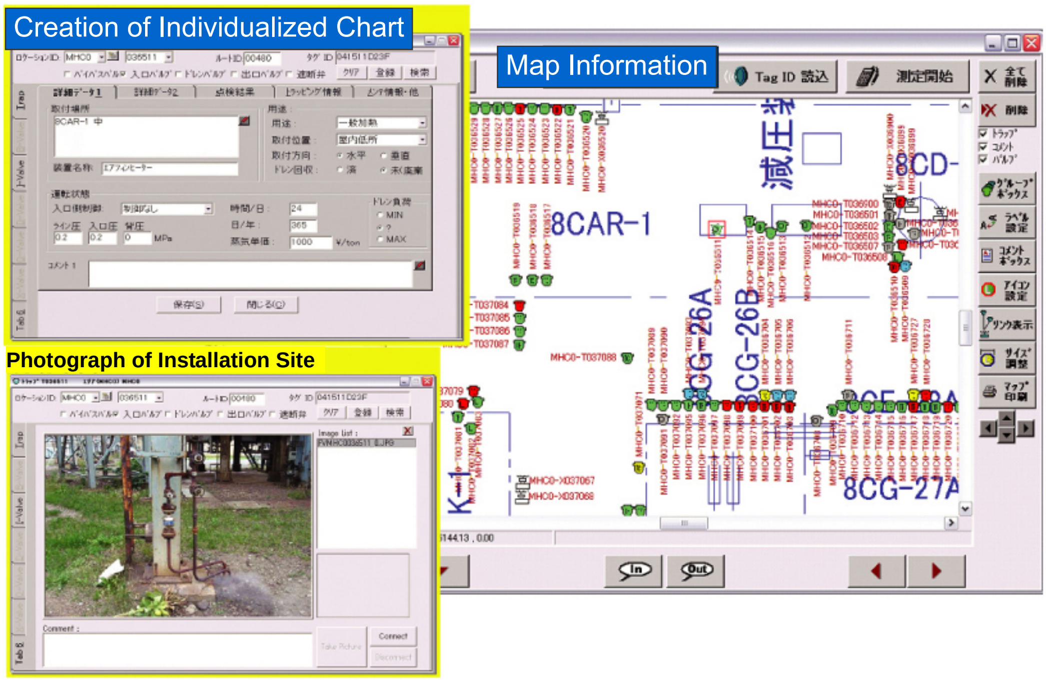


Figure 3 Management Software

(3) Replacement of Failed Traps

A policy for the analysis and replacement of failed traps was established, based on the database of inspection results, and the repair/replacement of failed traps was then carried out. Furthermore, when replacement was necessary, trap selection was made from the standpoint of LCC (lifecycle costs), thus the trap models selected were those with qualities linked to reducing total costs — excellent energy conservation properties and long service life, which reduces the burden of repairs/replacements in future years.

(4) Verification of Results of the Undertaking

Comprehension and analysis of the current situation had revealed the issue, ‘Steam loss from each individual trap is small, making the results of energy conservation feel too intangible.’ Therefore, while performing the initial year’s repairs/replacements at one of the refineries (Muroran Refinery), a flowmeter belonging to the refinery was used to incrementally track the total amount of steam loss corresponding to the failed traps replaced, in order to compare the actual amount with the steam leakage amounts estimated by the survey. This information was used in conjunction with the verified survey results. The result of this comparison, as shown in Figure 4, was that the two amounts were in accordance with one another, thus confirming the validity of the survey results obtained by the trap inspection tools.

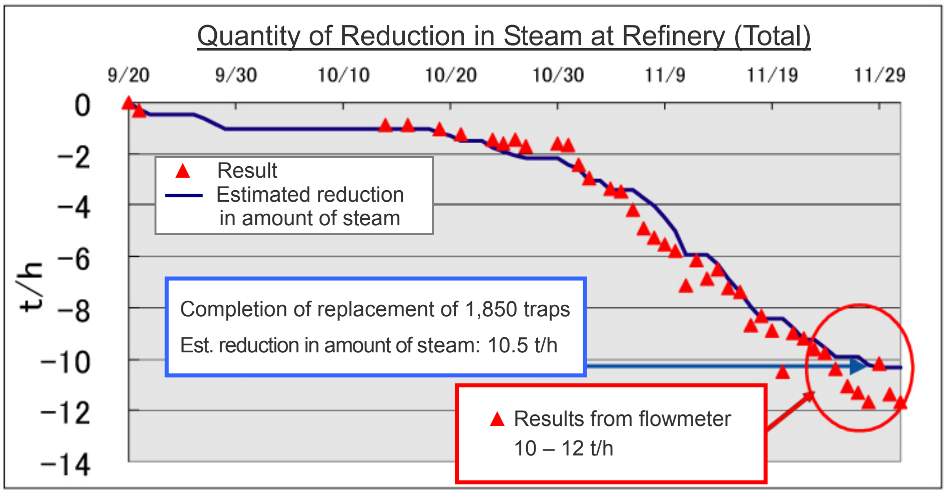


Figure 4 Verification of Results (Muroran Example)

2-2. Characteristics of the Plan

(1) Innovation, Originality

In constructing the plan, the opinions of a wide number of people were sought, from in-house experts and people with hands-on knowledge in the field to trap manufacturers, on the issues surrounding existing maintenance management and possible points for improvement. An efficient, long-term plan was introduced from a new standpoint outside of the existing framework. The main ideas were as follows:

(1) Verification and of survey technology (e.g. precision of inspection tools, skill level of inspector)
(2) Outsourcing of inspection work (consignment of manpower tasks)
(3) Improved efficiency of survey work (take advantage of management tools, such as using IT technologies, for improved efficiency and labor savings)
(4) Introduction of database management system (annual, long-term data updates and analysis)
(5) Selection of optimal trap models vital to stable equipment operation and to prevent repeated failures

(2) Versatility, Ripple Effect

Many huge equipment industries that use large amounts of steam for heating via piping and tanks, etc. and therefore have large numbers of traps installed struggle with maintenance management methods. In addition, steam is also used for air-conditioning in small- to mid-scale factories as well as large buildings, and energy conservation activities also include periodic inspections and maintenance of their steam traps.
At the Nippon Oil Group, the energy savings from their 100,000 traps is 18,000 KL (crude oil conversion) per year, yielding financial benefits of approximately 10 billion yen (assumed cost of fuel: 58,000 yen/KL). Though these financial benefits are reduced by the cost of the surveys and repairs/replacements, the profitability is still favorable. Furthermore, thanks to the fact that the maintenance management plan is now in place, it will be possible to maintain steam losses at a minimum in the future over the long term.
This undertaking is not about the implementation of leading-age energy conservation technologies, but is instead a simple action plan. This type of solid energy conservation activity may be a mere drop in the bucket, but it is worth considering this undertaking at other companies and in other types of industry, as many drops will eventually fill the bucket.

(Case Study of Results of TLV's program at Another Company) TLV's Contribution
TLV has already introduced this plan in Japan as the 'BPSTM (Best Practice of Steam Trap Management): TLV Condensate Discharge Location Management Program' at approx. 15,000 condensate discharge locations in 45 refineries of major companies such as oil refineries and petrochemical companies, and it has been achieving steady reduction in failure rates and steam losses (Figure 5). In the future, beginning with the iron and steel industries, expansion will take

place to include other major industries and small- to mid-scale plants, plans for implementation in various countries are underway, and evermore extensive energy conservation activities are being planned.

In addition to the Nippon Oil Group, another company that has achieved similar results through the implementation of this program and who has given their permission for the details of their undertaking, such as their energy conservation results, to be made public is the Kashima Oil Co., Ltd.'s Kashima Oil Refinery.

At Kashima Oil Co., Ltd.'s Kashima Oil Refinery, steam trap maintenance was already being carried out by high-level independent conservation activities. However, the steam trap failure rate was confirmed to be 17.5% (approx. 5,244 traps surveyed) prior to implementation of the program. The most recent failure rate, from 2 years after the program was first implemented, had dropped to 3.7%.As can be seen from the graph in Figure 6, zero reset after periodic inspections is extremely critical. It can also be seen that even if zero reset has been reliably carried out, some of the traps that were operating normally at that point in time will have failed by the following year and the failure rate will rise somewhat, so the practice of periodic inspections and zero reset must not be discontinued.

Additionally, TLV reported to the Kashima Oil Refinery that due to these improvements the reduction in the amount of steam used at the refinery was 2.4 ton/hour, however it has been confirmed that the results of verification by a steam flowmeter at Kashima Oil Refinery proved the figure to be even higher than this. Furthermore, though the reduction in steam achieved through implementation of the program was a 2.4 ton/hour reduction in the amount of steam used overall, this reflects an annual average of approx. 5 % of the overall steam reduction rate, or 0.48 kg/hour per each condensate discharge location.

Still further, in the case of the most large-scale of the refineries among the 45 refineries, the rate of steam savings to the total amount of steam used was a reduction of 6.1%.

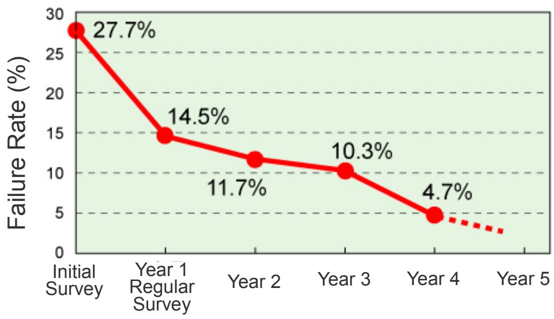


Figure 5 No. of Years on Program and Failure Rates

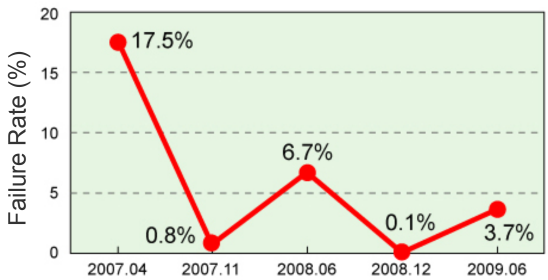


Figure 6 Changes in Failures Rates at Kashima Refinery

(3) Continuity, Durability

This undertaking was begun at each refinery in 2005, with everyone involved in devising improvements for the issues with the existing maintenance management and formulating an efficient, long-term plan that is still in use for continued management.

Furthermore, inspired by the results of this undertaking with traps and triggered by the discovery of energy losses that until now had gone unnoticed, such as inefficient operation caused by steam losses and trap failures that previously were not visible, further independently-taken energy conservation activities have resulted.

At the Muroran Refinery, one independent activity implemented — in an effort to promote ‘5S’ through energy conservation due to reduced steam losses, and improvements in the environment through the reduction of steam clouds around leaks — is the formation of a ‘Steam Cloud Search Group’ to search for leak locations in all areas and to effect repairs afterwards.

Additionally, in the pursuit of furthering their knowledge about steam and achieving additional energy conservation in operations, some of the refineries are proactively participating in TLV steam-specialized energy conservation and technical surveys to increase employee motivation.

Executives of the Nippon Oil Co., Ltd. (headquarters) are not only promoting energy conservation activities via this undertaking, but they are also offering each refinery support in the form of outfitting the structure, providing technical support and procuring the budget for efforts towards the formulation of plans for labor-savings in operations through the use of IT technologies and the training of personnel. Additionally, the continuability and sustainability of the undertaking were further enhanced when the employee motivation toward energy conservation activities rose to its highest levels ever following the results of the undertaking being made known both inside and outside the company (make it visible).

3. Energy Conservation

(1) Results

Traps failing due to age-related deterioration cannot be avoided (all traps eventually wear out and need to be replaced). In the past, periodic maintenance management was attempted. However, in addition to the criteria for judgment of whether a trap was operating normally or had failed being unclear, it was difficult to grasp the actual state of trap failures over the entire refinery due to the enormous number of traps installed. In response to this, an annual program was established whereby all the traps in each refinery were comprehensively inspected each year, the results of the survey were entered into a database, and a plan for repairs/replacements was designed and implemented based on the database.

As can be seen from the example shown in Figure 7 of the change in leakage failure rates and steam loss amounts at the main refineries (Muroran, Mizushima), trap failure rates are steadily declining each year as a result of expansion of the undertaking at each refinery since 2005. Along with this, the total amount of steam losses at the 7 refineries was estimated to be a reduction of approx. 37 t/h by 2008.

(Energy conservation results: 18,000 KL @ crude oil conversion annually, CO_2 emissions reduction: 46,000 t/year.)
In the future, together with further energy conservation through implementation of the established plan, they will continue to make sure that steam losses do not increase again.

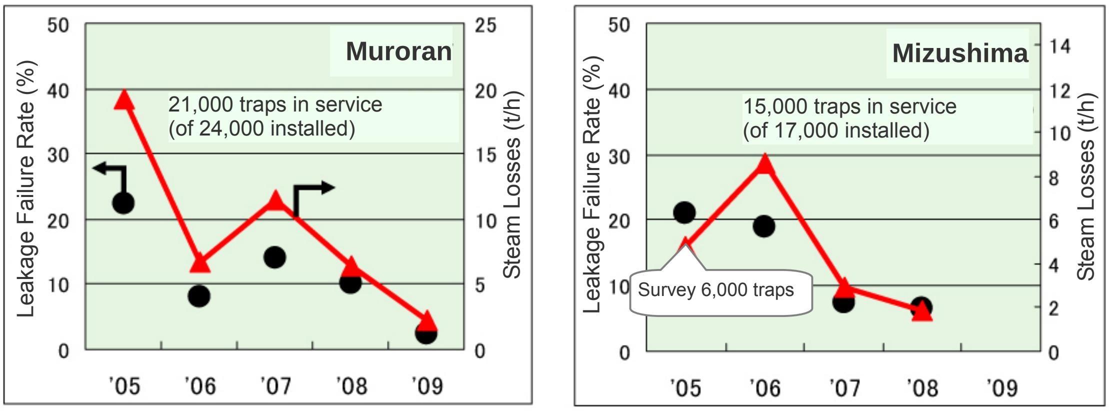


Figure 7 Change in Failure Rates & Steam Losses (at Muroran & Mizushima)

Results of Energy Conservation at 7 Refineries of the Nippon Oil Group
At crude oil conversion, energy conservation of 18,000 KL was achieved annually (CO_2 emissions reduction: 46,000 t/year)

Note: After survey of all traps in base year 2005, improvements year 2008 (after survey)

(Reference Material) Presentation of Results of Activities

The undertaking was conducted over a period of 4 years, from 2005 to 2008, however it was considered whether results of energy conservation activities before this time at one refinery (Muroran) could be viewed as actual data. A study was made of the trends in the amount of steam generated by the boiler* — the source of steam generation — and the results of energy conservation activities were compared while compensating as much as possible for the effects of the operation of steam-using equipment.
As shown in Figure 8, the result was a steady decrease in the amount of steam generated annually, with the width of the reduction being fairly close to the results of previous energy conservation activities.

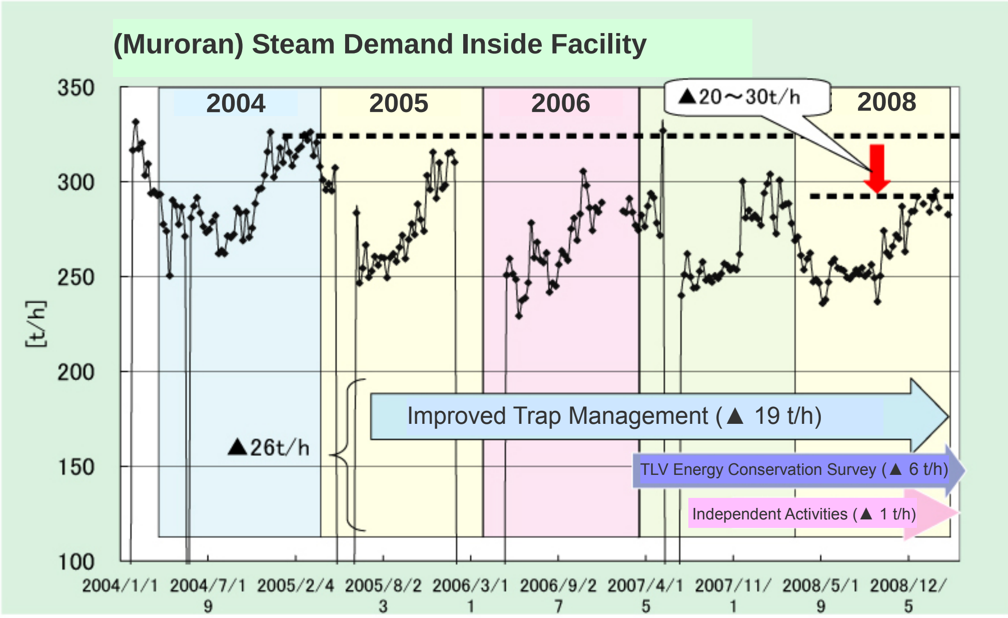


Figure 8 Changes in Boiler Steam Amount

These results were made known to all persons involved at the refinery, which raised employee motivation toward energy conservation activities to an all-time high, and to date all activities are still enthusiastically underway.

* Due to limitations on the ability to compensate for weather conditions (e.g. outdoor temperature, rain), trap replacement periods, regular on-site maintenance, etc., this data was treated as reference values.

(Reference Materials)

① Nippon Oil Corporation Group CSR Report (English web site: http://www.eneos.co.jp/english/index.html)

② 2006 National Conference on Outstanding Case Examples of Energy Conservation (Hokkaido District) Nippon Petroleum Refining Company, Muroran Refinery
(The Energy Conservation Center, Japan English web site: http://www.asiaeec-col.eccj.or.jp/index.html)

③ Trapping, Engineering (Publisher: The Energy Conservation Center, Japan)