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SUCCESSFUL STEAM SYSTEM OPERATION STRATEGIES

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ABSTRACT

The proper function and performance of any steam system are an important part of the global energy and environmental picture. This paper presents some of the various engineering, operating, and energy conservation techniques that can help lead to the successful operation of a steam system. The results of 16 steam systemfield studies will be presented. Nine of these facilities identified $2,746,000 worth of annual savings tied to the changes made in the monitoring and maintenance of the steam system piping, valving, and steam trapping. These savings were achieved not with trade secrets but with procedures already documented in ASHRAE standards. Many obstacles must be overcome to successfully implement any program. It is often necessary both to overcome some problems with communications and people. Facilities are grouped and reviewed by heavy industry, light industry, food and pharamaceuticals, and institutional and commercial.

INTRODUCTION

The proper functioning and performance of any steam system are an important part of the global energy and environmental picture. This is especially significant when considering that the United States uses approximately 25% of the total world energy consumption. The industrial sector consumes between 35% and 37% of *all* energy used in the United States. Almost half this energy (about 14 -16%) goes toward making steam for use by industry (Makansi 1985).

In a commercial and institutional facility, approximately 50% of the energy consumed is used for space conditioning. Steam has a vital role here whether it is used directly for heating, in converters for making hot water, in turbine drives on chillers, or as an energy source for absorption refrigeration.

The purpose of this paper is to present some of the various engineering, operating, and energy conservation techniques that can lead to the successful operation of a steam system. These strategies deal with the operation of the system outside the powerhouse walls. There can be many opportunities in the vast network of heat exchangers, piping, valving, and fittings that exists in most facilities. Control valves and steam traps have a unique function in this part of the system. They control the performance and efficiency in much the same way as the boiler combustion controls do.

During the past several years, many field studies have been performed to determine successful techniques for monitoring and maintaining this vital part of the steam system. Commercial, institutional, and industrial systems have been studied. In some of these cases, definite documented savings occurred. In the cases we will present here, operation and maintenance strategies were identified that directly correlated to savings.

STEAM SYSTEM FIELD STUDIES

The results of 16 steam system field studies will be presented consisting of studies in five heavy manufacturing facilities, four light manufacturing facilities, three food or pharmaceutical facilities, and four institutional or commercial facilities. Of the 16 facilities, 9 were willing to provide for publication hourly steam generation figures, which came to a total of 2,078,000 lb/h (262 kg/s) of steam-generating capacity. These nine facilities, through their engineering, energy conservation, and operating strategies, identified $2,746,000 worth of annual savings. Savings were tied to the changes made in the monitoring and maintenance of the *steam system* piping, valving, and steam trapping.

These savings were achieved not with mysterious trade secrets but with procedures already documented in ASHRAE standards for energy conservation. *Energy Conservation in Existing Buildings—Institutional* (ASHRAE 1991) and *Energy Conservation in Existing Facilities—Industrial* (ASHRAE 1984) are available to assist energy conservation managers, facilities managers, physical plant administrators, and maintenance managers in the identification and implementation of energy conservation strategies.

Both of the ASHRAE energy conservation standards set forth a straightforward compliance procedure. As a part of this compliance procedure, both standards request an energy

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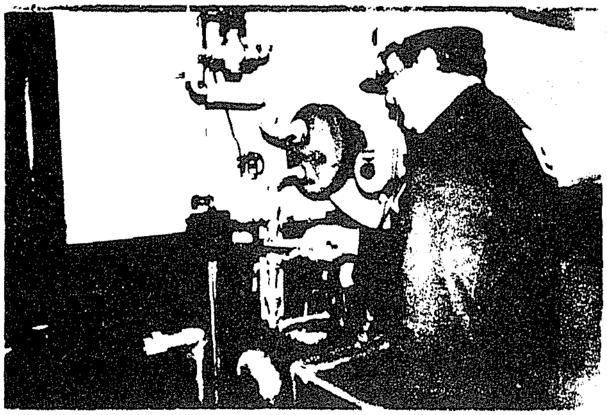

Figure 1 *Steam trap testing with a listening device.*

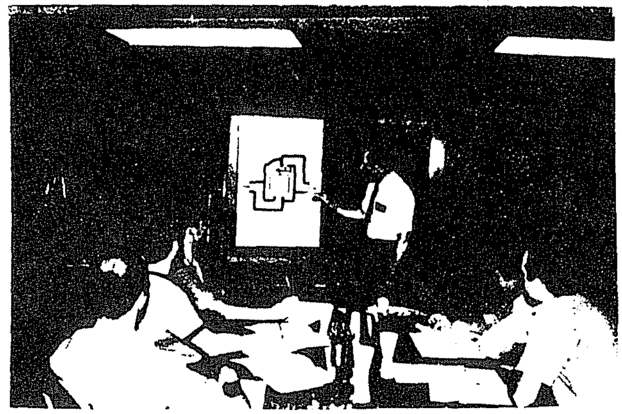

Figure 2 A *steam conservation team learns about steam trap performance.*

survey or energy audit which documents the sources and uses of energy within the facility.

With respect to steam system monitoring and maintenance, the two energy conservation standards are almost identical:

The institutional standard says:

> *"A preventive maintenance program should be established for each piece of equipment to ensure that it is properly maintained for maximum efficiency. This maintenance program should include written schedules for...boilers...heat exchangers...steam traps, strainers, insulation...heating specialties, piping, valves..."(ASHRAE* 1991).

The industrial standard says:

> *"A preventive maintenance program shall be established with consideration of manufacturer's recommendations for energy consuming equipment to insure that it is properly maintained to operate at maximum efficiency. Such maintenance schedules shall include...boilers...heating specialties, piping, valves, steam traps, and associated controls"(ASFIRAE* 1984).

To embark upon an in-depth steam system monitoring program would require a major commitment on the part of engineering, energy conservation, and maintenance management. Many familiar obstacles must be overcome to successfully implement such a program. Typically the problem is one or more of the following:

1. Cannot get true/consistent commitment from top management.
2. Do not have the means to "prove" actual savings.

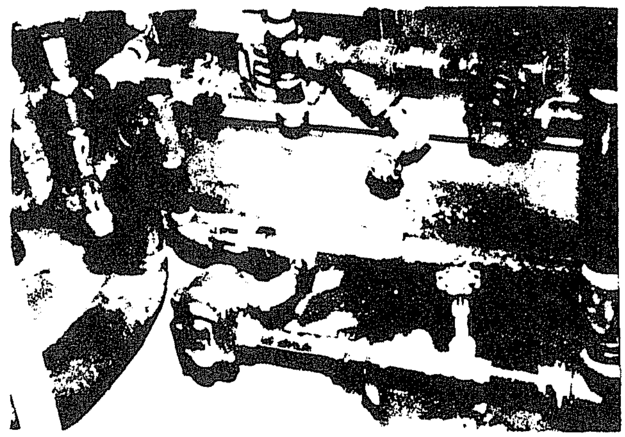

Figure 3 *The tag located downstream of the trap can be bar coded to speed monitoring.*

4. Difficult to sustain interest and commitment to programs requiring ongoing maintenance—easier to get commitment for one-time corrective measures.
5. Inertia—basic resistance to change.
6. Lack of communication between corporate—plant management, plant staff, plant crews.
7. Corporate "hurdle rates" are very high and the race for corporate funding is very stiff.
8. Key personnel do not believe there is a problem.
9. Maintenance people are not properly trained.

How, then, did the nine facilities described above with an average steam output of 230,000 lb/h (29 kg/s) achieve an average of $305,000 savings annually? The answer lies in proper implementation of the existing ASHRAE energy conservation standards *and* taking special steps to overcome some of the problems with communication and people outlined above.

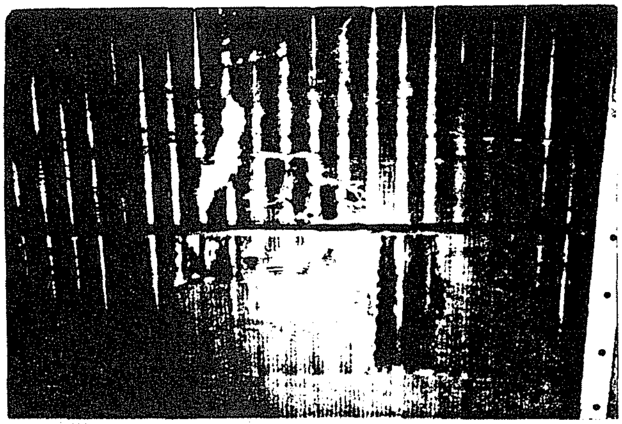

Figure 4 *Poor heating coil drainage in a freezing environment can damage tubes.*

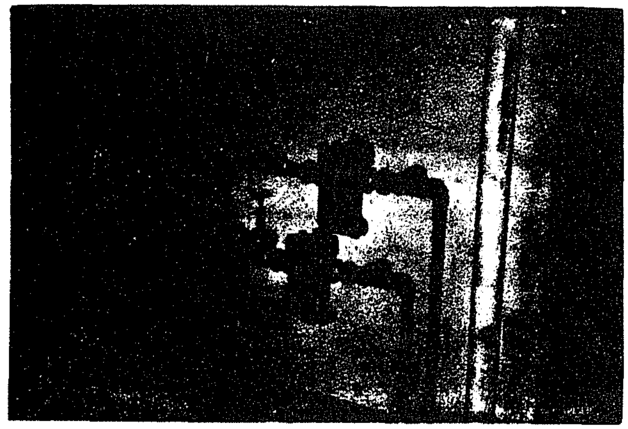

Figure 5 *Vacuum breakers upstream of the steam traps allow condensate to drain, avoiding freeze damage.*

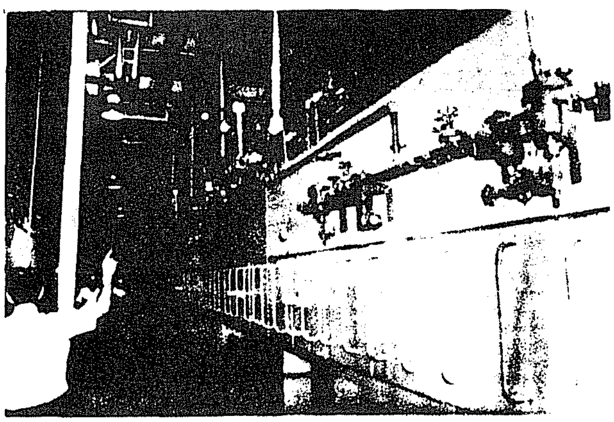

Figure 6 *Steam and condensate drainage piping are now accessible for monitoring and repair.*

FIELD STUDY REVIEW BY INDUSTRY

Following is a review the field study results of the 16 plants which are grouped into four areas: heavy manufacturing, light manufacturing, food or pharmaceutical, and institutional or commercial. This review will include the steam generation rate at maximum, the gross amount of savings that resulted, and the primary steps to detect and implement these strategies.

Heavy Industry

An Indiana automotive assembly facility generated 405,000 lb/h (51 kg/s) of steam. The installation of new steam traps was estimated to reduce steam requirements for building heat by about 30%. In addition, maintenance requirements were reduced by eight man-hours per week. The primary strategy used to implement these savings was a survey of 75% of the plant's steam traps which uncovered a 27% failure rate. To maintain the savings, two pipe fitters were assigned to constantly monitor the steam trap population. In Figure 1, steam trap monitoring is accomplished by listening to the trap for evidence of leakage or failure.

An Indiana steel mill generating 500,000 lb/h (63 kg/s) of steam per hour was able to save $193,000 over a two-year period. The primary strategies for accomplishing this were setting up an accounting system whereby each plant area was billed for its steam, a statistical analysis that studied steam consumption vs. production rate, and setting up a steam conservation team with specialized training about steam system fundamentals and energy conservation practices.

A Michigan automotive glass plant purchased 400,000,000 lb. (181,400,000 kg) of steam per year from a local utility. They were able to save $600,000 in a one-year period by developing a "save energy" motivation program and by also establishing a goal of reducing the inventory of steam traps and fittings. A training program was established to train people how energy can be conserved and on to select fittings and steam traps to reduce the number of units required in maintenance stores and stocks. As shown in Figure 2, training a team about steam trap performance is essential to create understanding of why trap monitoring impacts energy conservation.

An Ohio aircraft engine plant generating 545,000 lb/h (69 kg/s) of steam was able to save $360,000/year. The primary strategies were making a training video, establishing a steam trap and fitting data base, and setting up a preventive maintenance program utilizing bar code readers to record history as well as make the maintenance team's job easier. Figure 3 shows two steam traps. The bottom trap is tagged between the union and check valve, so it stays behind even when the trap is changed. The tag can be bar coded to speed trap monitoring. Data-logging devices can then record trap status, completing the maintenance history.

A Michigan automotive assembly and parts plant with a 220,000 lb/h (28 kg/s) steam generation rate had a 14% process steam load. The yearly savings calculation is pending as of this writing, but their program focuses on reducing waste, putting steam traps and steam fittings into a data base, and establishing a job-sharing program whereby the system can be maintained but multiple trades are not required.

Light Industry

A Connecticut aerospace company with a 210,000 lb/h (26 kg/s) steam generation rate was able to save $21,000/year. The primary strategy was to survey steam traps and steam system fittings and to develop a testing and selection manual so that knowledge would be preserved and potentially shared with other divisions.

A South Carolina chemical manufacturer with a 170,000 lb/h (21 kg/s) steam generation rate has been able to reduce the amount of heat required per pound of product by 50% over eight years. This was accomplished by a steam loss testing program on various steam traps and steam system fittings, as well as an effort to simplify and standardize on a smaller number of traps, thereby preventing both inventory costs and potential misapplications.

A Minnesota specialty adhesives manufacturer had a steam generation rate of 170,000 lb/h (21 kg/s) of which 70% was process load. Savings achieved were primarily in the area of lost production time due to system freeze-ups. In Figure 4, coil tubes suffer freeze damage, causing leaks and inaccurate process control. Leaking water into the heated airstream causes temperature and humidity fluctuations. The piping system changes helped prevent freeze damage as well as increasing "up" time by reducing other types of heat exchanger and fitting failures. As shown in Figure 5, modified steam trap installations now have vacuum breakers upstream and check valves downstream. To aid proper drainage, condensate backflow must be avoided. Problem detection and corrections are now routine and occur more quickly. This was achieved by a preventive maintenance program and development of a specialized maintenance wagon where complete repair parts, sub-assemblies, vices, and tools are all available on a single cart.

An Ohio laminating plant with a steam generation rate of 120,000 lb/h (15 kg/s) was able to reduce annual steam costs by $240,000. This was accomplished by re-piping the steam supply and condensate drainage lines to be outside of process ovens so they are now accessible for maintenance, replacing the leaking heat exchangers, and establishing a data base for steam system fittings. In Figure 6, we see the abc's of condensate drainage are now in place. Traps must be accessible, below the drain, and close to the drain point.

Food and Pharmaceuticals

An Indiana bean-processing plant with steam consumption of 110,000 lb/h (14 kg/s) was able to achieve a steam savings of $525,000/year. This was accomplished by setting up a steam system task force, performing a steam system survey, and training key engineering and maintenance personnel with regard to engineering practices, steam system sizing, selection procedures, and preventive maintenance.

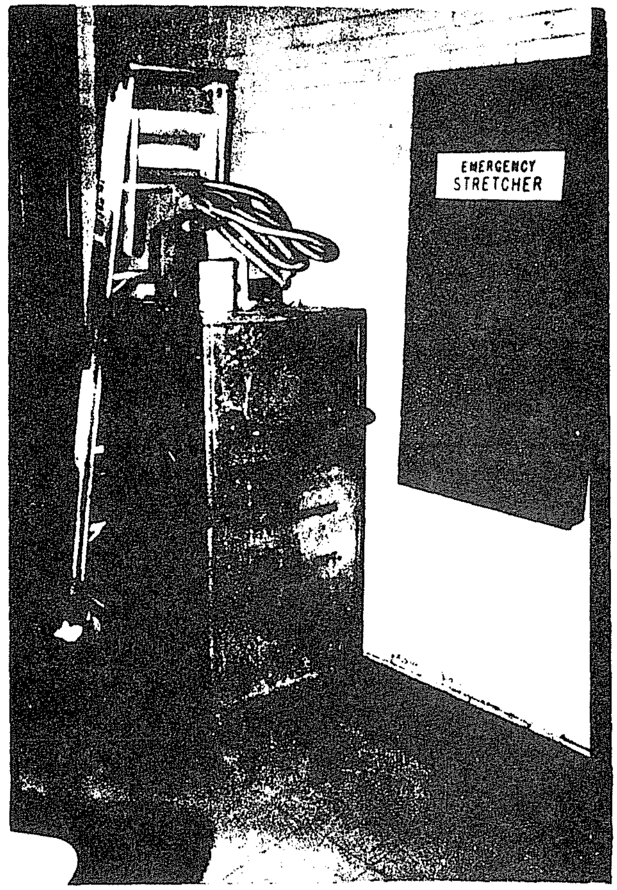

Figure 7 A *specialized steam maintenance wagon saves time and energy.*

A Michigan chemical and pharmaceutical facility with a 100,000 lb/h (13 kg/s) steam consumption initially achieved a $400,000/year savings that is now increased to $700,000/ year. The first phase was accomplished via implementation of an inspection and preventive maintenance program. The second phase was possible due to a condensate recovery program that avoids various condensate losses and returns recovered condensate to the boiler where it can be reused.

An Ohio food manufacturer with a steam consumption rate of 130,000 lb/h (16 kg/s) was able to save $600,000/year. The steam conservation allowed the plant to avoid gas peak flow reduction, where the utility would reduce gas flow to the plant, thereby limiting production. To achieve this conservation, a training program and condensate return and recovery programs were implemented.

Institutional and Commercial

An Ontario 1,000-bed hospital was purchasing steam from the local utility and district steam system. The program, which achieved a savings of $305,000 (U.S.), was prompted by an analysis where heat consumption per bed was calculated and analyzed. The leaking and misapplied steam sys-

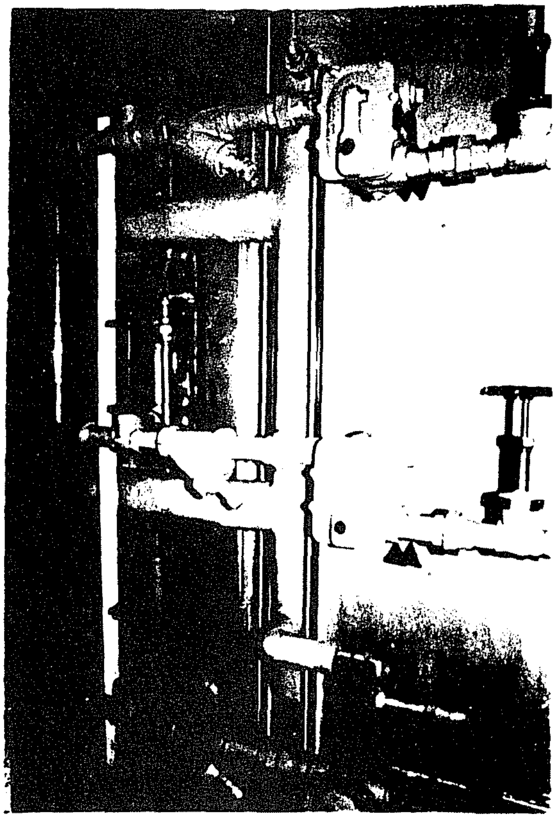

Figure 8 *Each trap is tagged for identification, and the bottom unit has been outfitted with new parts.*

standardization program was put into effect to reduce inventory, misapplications, and losses when failures do occur.

An Illinois hospital with a steam consumption of 63,000 lb/h (8 kg/s) was able to achieve an annual savings of $32,000 by fixing freeze-up and humidification problems. In addition, a steam system survey was performed, and leaking steam traps were replaced.

An Ivy League university medical school was purchasing 203,000,000 lb/yr (92,000,000 kg/yr) of steam from the district heating system. Savings of $300,000/yr were achieved by performing a steam system survey and hiring an outside contractor to come in and perform a once-through overhaul. To keep the system operational and preserve the savings, a maintenance training program was implemented and specialized steam wagons were constructed and outfitted with replacements, pipe fittings, wrenches, vices, and diagnostic tools, as shown in Figure 7.

A Michigan office/hotel complex had a steam consumption of 300,000 lb/h (38 kg/s), Savings achieved in the first 40 days following the implementation of a maintenance program were $170,000. This was achieved by developing maintenance kits for fast and easy correction of problems and putting steam system fittings in a data base where the results of periodic testing could be stored and analyzed when future failures occur. As shown in Figure 8, the traps have been tagged for identification in the data base. The bottom trap has a new cap with parts pre-installed for quick repair.

SUMMARY

Reviewing these case history field studies and the primary strategies for achieving these successful results allows us to draw some conclusions. Five separate strategies have emerged from these field studies/case histories:

1. In 9 out of the 16 cases, a detailed steam system survey was performed. Both ASHRAE standards recommend that a broad overall energy audit be conducted. An analysis of these audit results may identify further audits to be conducted on specific systems within the facility. This might often be the case with the steam system. When a survey is performed, certain key areas and problems tend to surface. Concentrating on these vital areas and problems is how tremendous savings can be achieved with relatively little effort.
2. Seven of the 16 cases had a primary strategy that included special effort on the part of building maintenance staff. Kits, wagons, videos, and testing manuals might require a special effort on the part of maintenance to put together but, in the long run, make their job simpler and easier to plan. What takes some effort today ends up saving time and money in the performance of day-to-day operations.
3. Seven of the 16 facilities also cited the need for further training as part of their primary strategy. While some training is probably involved in all 16 cases, a special effort was made in these 7 cases to attend seminars outside the facility or set up special classroom training on a regular basis within the facility. In this case, "knowledge not shared is energy wasted."
4. Five of the 16 facilities made system standardization part of the primary strategy. Many potential misapplications and hidden inventory costs lie lurking in the hodgepodge of system fittings that is a normal part of a facility's equipment population. Study the applications and make an effort to standardize.
5. Four of the 16 identified teamwork as part of their primary strategy. Four or five people from a variety of disciplines were the core group in most cases.

CONCLUSION

Two separate types of problems exist and must be accounted for when implementing a steam system improvement program. The first type of problem is technical. The ASHRAE energy conservation standards have described a complete procedure to discover technical problems in systems.

The second type is people or communication problems. The sixteen cases presented here show how different facilities address *both* the technical *and* people/communication problems. Detailed energy audits and surveys, special maintenance efforts, training, standardization, and teamwork have been successfully used in combination to address both types of problems.

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DISCUSSION

Clinton W. Phillips, Engineering Consultant, Olney, MD: The savings described based on implementing improved maintenance, training, etc., are impressive. When these improvements have been implemented, what will the benchmark be for evaluating future performance?

Walter T. Deacon: Due to the variety of industries, a universal benchmark is difficult to obtain. In chemical processing, a PINCH analysis could be performed to determine sources of further efficiencies. In other industries, contacts at technical society meetings may be the best source of benchmark information.