NEW PRACTICE CASE STUDY 120

Energy and cost savings through the installation of low maintenance steam traps

Withington Hospital, Manchester

- **Fuel savings of 19%**
- **CO_2 and NO_X emissions reduced by 19%**
- **Low maintenance requirements**
- **Cost savings worth £9,600/year**
- **Payback period of 2.4 years**

NEW PRACTICE CASE STUDY 120

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

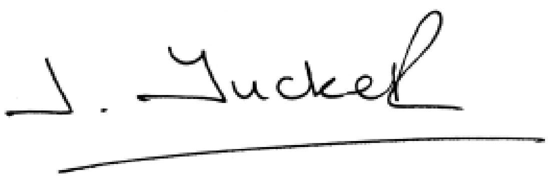
BEST PRACTICE PROGRAMME

HOST ORGANISATION

The provision of clean linen is essential to any hospital. The laundry at Withington processes all types of linen from bed sheets to specialist materials used to drape patients undergoing specialist cardio-thoracic surgery.

The laundry, which is a major user of steam, had suffered from a lack of maintenance to the steam traps due to various operational difficulties. As a result it was decided to install 86 low maintenance traps. These have successfully reduced the laundry's maintenance requirement, which in turn has resulted in energy savings worth over £10,000/year.

The Trust is now considering fitting similar traps to other equipment throughout its hospitals.



Mr John Tucker, Estates Manager
SMUH NHS Trust

SOUTH MANCHESTER UNIVERSITY HOSPITALS NHS TRUST

The Trust is one of the largest in the country and in 1998/99 provided care for 80,000 inpatients and day cases, 280,000 outpatients and 80,000 people who attended accident and emergency.

The laundry processes 1.8 million kg of linen each year and is operated by Gardner Merchant Ltd as part of a PFI arrangement.

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BACKGROUND

The laundry at Withington Hospital is managed by the Estates Department of South Manchester University Hospitals NHS Trust. It serves Withington and other hospitals within the Trust, with an annual throughput of 1.8 million kg of laundered items. Steam is supplied to the hospital and the laundry from a central boiler house, which is adjacent to the laundry.

The laundry normally operates during the day, Monday to Friday, and until midday on Saturdays. Prior to this project the laundry used approximately 2.7 tonnes/hour of steam during normal operation, excluding space heating. During the heating season steam use increases by 0.25 tonnes/hour. The main steam users are:

- Two continuous batch washers.
- Six tumble dryers.
- Three ironing machines.
- A tunnel dryer.

Maintenance of the steam and condensate systems (Fig 1) is a low priority, due in part to budget and manning constraints and the problems of carrying out maintenance with the steam system in use. As a result, 500 kg/hour of steam was being discharged from the vent pipe on the condensate receiver, causing an unsightly plume and associated energy losses. An energy audit and steam trap survey showed that 11 out of 63 steam traps surveyed were failed open, allowing live steam to pass into the condensate system. A further four were failed closed. This survey excluded most of the space heating equipment.

A decision was taken to replace all, except two, of the steam traps in the laundry with fixed orifice condensate discharge traps (FOCDT) which have no moving parts and, in principle, require little maintenance. A total of 86 traps were installed plus modifications to local piping.

Steam plume before project *(See also page 6)*

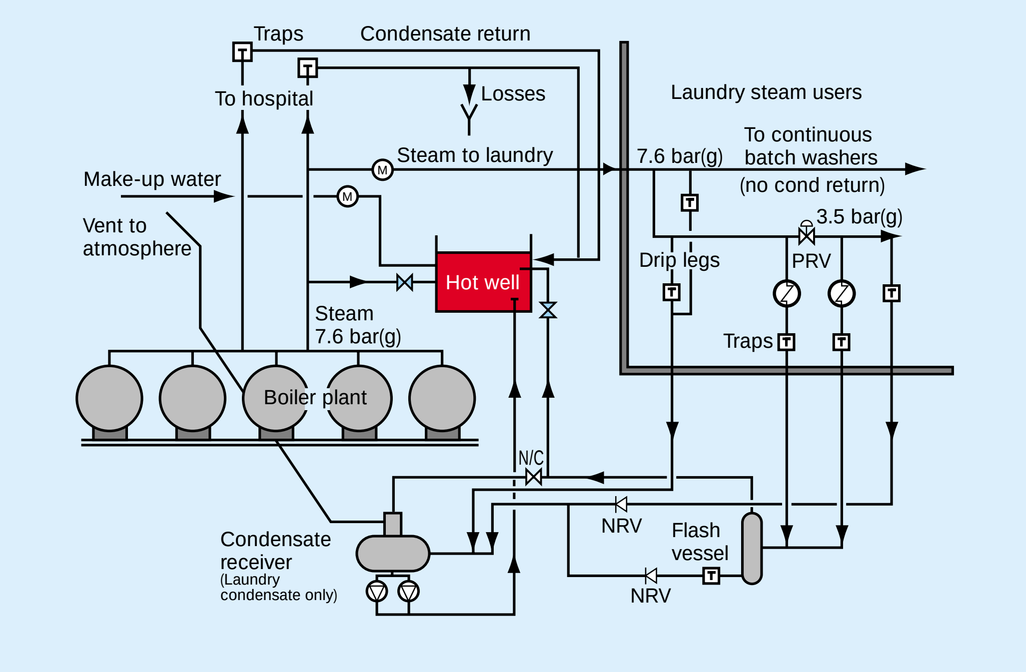

Fig 1 The steam and condensate systems

The project was monitored independently by Thermal Developments Ltd. Tel: 01740 621614.

The equipment was supplied by Gardner Energy Management Ltd (GEM) Tel: 0117 9077377 www.gemtrap.com

There may be other suppliers of similar services and energy efficient equipment in the market. Please consult your supply directories or contact ETSU who may be able to provide you with more details.

FIXED ORIFICE CONDENSATE DISCHARGE TRAPS (FOCDT)

Cut away view of a GEM venturi FOCDT

A FOCDT is either a simple restriction or venturi orifice installed in the condensate discharge line. It is protected by a fine mesh strainer and sized to pass the amount of condensate corresponding to the thermal duty of the pipe or equipment being drained. Unlike conventional steam traps they have no moving parts and therefore require less maintenance.

One concern regarding FOCDTs is that they may be unable to handle safely and efficiently the range of operating conditions experienced. If a FOCDT is correctly sized for normal load conditions, there is a perception that condensate will back up at high loads (such as start up) leading to reduced heat transfer performance or potentially dangerous water hammer in steam piping. Conversely the FOCDT will pass live steam at low loads. Another concern is that the very small discharge orifices (down to 0.5 mm), may get blocked by debris or deposits from the condensate. However, manufacturers claim that FOCDTs have a self-regulating capability that allows them to handle the range of loads to which a correctly sized unit will be subjected and that blockage is prevented by the use of a fine-mesh strainer before the FOCDT.

A restricting orifice, for the same upstream and downstream pressures, will allow a much greater mass flow of non-flashing liquid condensate than it will of steam. However, little data is available on the fluid dynamics of upstream conditions between these two extremes that are relevant to the discharge of condensate.

The laundry equipment at Withington is subject to a varying condensate load and constant upstream pressure from the full steam system - these are difficult operating conditions for a FOCDT. More usually steam for a process heating duty is regulated by a control valve, which at reduced loads automatically lowers the pressure within the steam space and hence the flow capacity of the orifice. Fig 2 shows the results of a theoretical analysis of the fluid dynamics of a venturi-type FOCDT. It covers a full range of flow conditions, from cool condensate to dry steam, for a constant upstream pressure (Refs 1-3).

This shows that the flow capacity greatly increases, by up to 300%, with sub-cooling of the condensate below the upstream saturation temperature. The turndown, before live steam leakage occurs, depends on the extent of sub-cooling in normal operation. Over a normal turndown range, the passage of live steam will be small if the FOCDT is correctly sized. Indeed, it will probably be similar to the loss at low loads from a conventional trap that is in good working order.

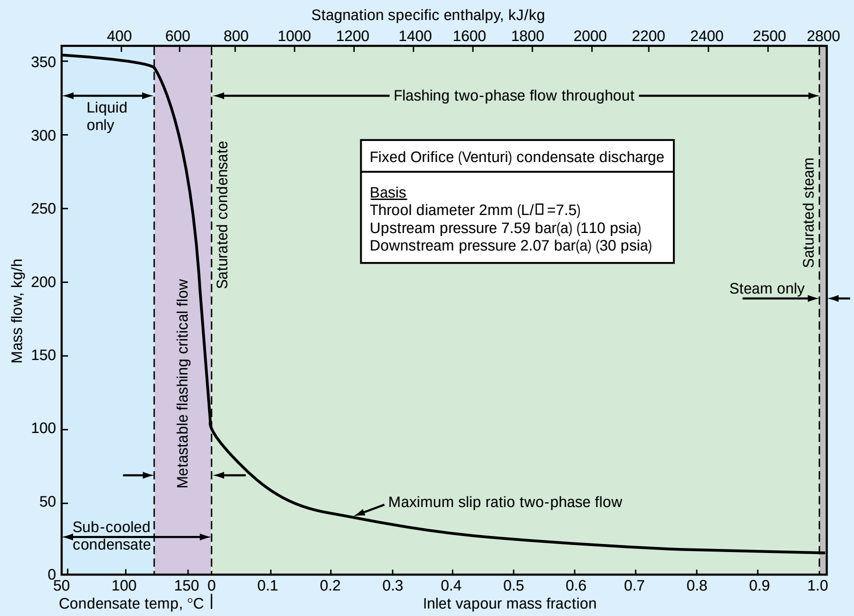

Fig 2 Flow through a FOCDT as a function of upstream fluid condition

Refs

(1) Bailey, J. F., Metastable flow of saturated water, Trans ASME, Nov 1951, 109-116.

(2) Faletti, D. W. & Moulton, R. W., Two-phase critical flow of steam-water mixtures, A.I.Ch.E. Journal, 9, (2), Mar 1963, 247-253.

(3) Cruver, J. E. & Moulton, R. W., Critical flow of liquid-vapor mixtures, A.I.Ch.E. Journal, 13, (1), Jan 1967, 52-60.

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OPERATING EXPERIENCE

The replacement of the traps on the main laundry equipment resulted in an immediate and dramatic reduction in the steam plume from the condensate receiver vent. However, the performance of two of the ironing machines was unsatisfactory and checks revealed that condensate was not draining properly. This was resolved by re-sizing and replacing nine traps. When the original FOCDTs were removed they were partially fouled by a jointing compound that had been used in their installation because of the rough surfaces on the unions provided. Investigation revealed that three other traps were cold and one was oversized, passing live steam. Remedial work was undertaken, following which all FOCDTs operated satisfactorily.

A final survey, carried out on completion in January 1999, found that a small number of the more recently installed FOCDTs were cold due to blockage by jointing compound; these were cleaned and refitted. The manufacturer has since modified the equipment specification so that all FOCDTs over 15 mm nominal size have Navy fittings with brass inserts. They also recommend that each new trap installed should be checked for blockage that might occur due to pipe disturbance or compound.

After the start of the heating season in 1999 some of the small non-critical FOCDs on space heating equipment were prone to blockage, necessitating their removal for cleaning. FOCDs on the process equipment and steam mains have not blocked and the problem is thought to be due to the poor condition of the low-pressure steam piping.

The steam supply to the laundry is shut off and restarted on a daily basis, and there has been no evidence of water hammer or condensate retention in the steam piping. Trap replacement has not been detrimental to the operation of the laundry equipment and the steam vent plume is no longer a problem.

Independent monitoring was carried out three times over a 12-month period, including one month prior to the replacement of any of the existing steam traps. The first stage of post-installation monitoring was after the traps on the main laundry equipment were replaced, including the seven largest traps (20 mm and 25 mm) that were known to be failed-open. This period preceded the start of the heating season. The final post-installation monitoring, which followed the end of the heating season, was five months after the project was completed. The main results are summarized in Table 1.

Table 1 Results of project monitoring, laundry run-time averages

Period	Operating hours	Steam to laundry kg/hour	Steam to vent kg/hour	Condensate receiver pressure bar(g)
Pre-installation monitoring (9 July - 8 Aug 1998)	248	2,700	539	0.63
Initial post-installation monitoring (17 Aug - 19 Sep 1998)	256	2,244	146	0.25
Final post-installation monitoring (10 Jun - 7 Jul 1999)	252	2,153	59	0.17

FOCDT installation

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ENERGY AND ENVIRONMENTAL BENEFITS

Table 2 Emissions to atmosphere associated with laundry steam supply

	Before steam trap replacement	After steam trap replacement
Carbon dioxide, tonnes/year	1,236	999
Reduction, tonnes/year	-	237
Reduction, %	-	19.2
Oxides of nitrogen, kg/year	1,243	1,004
Reduction, kg/year	-	239
Reduction, %	-	19.2

Note: NO_x emissions based on 200 mg/Nm^3 for combustion of natural gas.

Steam plume after FOCDT installation

The installation of FOCDT traps at Withington has reduced the laundry's maintenance requirement, which in turn has cut steam consumption by 547 kg/hour. This equates to a boiler fuel saving of 1,666 MJ/hour or 463 kW. The laundry operated for 2,850 hours during the monitoring period, giving an annual fuel saving of 1,319 MWh. Using a factor of 1.015 to account for losses in the production, treatment and distribution of natural gas, the annual primary energy saving resulting from the project is 1,340 MWh (4,820 GJ or 45,720 therms).

During laundry running hours the initial summer steam usage was 2,700 kg/hour. Adding an average of 150 kg/hour to allow for additional steam used during the heating season gives a year-round mean of 2,850 kg/hour. The saving of 547 kg/hour represents a 19.2% reduction in the amount of steam used in the laundry.

Many of the smaller traps are fitted on space heating appliances. Some of these traps will pass live steam but this would only occur during the heating season and so was not identified by the monitoring. The actual year-round saving may be in excess of 600 kg/hour.

Table 2 shows the reductions in carbon dioxide and nitrogen oxides resulting from the reduced fuel consumption. In addition, the plume of steam has been greatly reduced giving local environmental improvements.

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ECONOMICS AND OVERALL ASSESSMENT

Based on a price of 0.65 p/kWh (19.0 p/therm) for interruptible natural gas, the annual energy cost savings resulting from reduced maintenance were £8,570. The reduction in the steam plume also saves £1,780/year in water treatment costs (based on a typical cost of 0.13 p/kg (£1.30/m3) for raw water and water treatment). The actual saving will be greater as the metered flow does not take full account of water carryover, nor is it possible to allow for the greater saving that will apply during the heating season.

Additional maintenance to clear blockages in the smallest FOCDTs (on the space heating equipment) may prove to be an ongoing problem due to the condition of the low pressure steam piping. It is estimated that this work would cost £750/year.

In addition, the project focussed attention on the energy efficient operation of the laundry and helped solve operational problems with the flash vessel and the exhaust heat recovery equipment on the tumble dryers.

The annual savings of £9,600 give a payback period of 2.4 years on the total installed cost of £23,370.

The ironers and dryers at Withington Hospital laundry

Condensate receiver

Table 3 Project costs, revenue and payback period

Capital costs	**£**
Equipment cost	18,370
Installation labour and supervision	5,000
Installed cost of the project	23,370
Savings	**£**
Annual energy cost saving	8,570
Annual treated water cost saving	1,780
Deduct maintenance costs	(750)
Total annual saving	9,600
Simple payback period	**2.4**

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CONCLUSIONS AND FUTURE INSTALLATIONS

The installation of FOCDTs at Withington Hospital has reduced the laundry's maintenance requirement, which in turn has reduced the steam plume and cut boiler fuel consumption by 19%. There have been no problems due to water hammer, underperformance or steam leakage. Similar savings could have been achieved, certainly in the short term, at a considerably lower initial cost by replacing or refurbishing the faulty traps. However, whether such improvements could have been sustained with conventional traps in the circumstances at Withington is unknown. It was for this reason that management installed FOCDTs.

The benefit of installing FOCDTs is dependant on the condition of the existing steam traps and condensate return system. This is a site-specific issue and each case should be evaluated against alternatives. For the laundry the options were:

1. Continue as before, i.e. 'fire-fighting' maintenance only.
2. Replace faulty traps identified by the survey.
3. Replace faulty traps and establish a trap testing and maintenance programme.
4. Replace all existing traps with FOCDTs.

A simple analysis showed the economics to favour Option 3 for life cycles up to eight years, thereafter the balance is slightly in favour of Option 4. However, in the case of the laundry, the maintenance constraints made Option 3 impractical. At other sites, a regular trap testing and maintenance programme may be the best solution.

The greatest barrier to the wider adoption of FOCDT technology is the issue of orifice sizing, and the serious consequences that could result from their perceived inability to effectively drain condensate under start up conditions. There were no such problems at the laundry where the steam supply is isolated and restarted daily. The theoretical analysis also supports the claim of greatly increased flow capacity with sub-cooled condensate. However, where existing steam piping is corroded or fouled the potential for blockage of the smallest FOCDTs is a factor that needs to be considered.

Suitable sized strainers should be used to prevent debris reaching FOCDTs.

There are many potential applications for FOCDTs in the UK to remove condensate from steam systems. Sites that already have an effective steam trap maintenance programme in operation (GPCS 368, Savings in steam distribution by the re-use of flash steam and steam trap maintenance) will be unable to justify the replacement of existing steam traps, except on a non-ideal piecemeal basis. However, FOCDTs should be considered where new steam systems are being installed or in existing systems where steam trap maintenance or reliability is a problem.

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Further information

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General Information: describes concepts and approaches yet to be fully established as good practice.

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