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Steam System Efficiency Improvements in Refineries in Fushun, China

Project Design Document

Prepared by

Sachu Constantine (QualityTonnes) and
Kerry Phillips (Beijing Tuofeng Armstrong Steam System Energy Conservation Technologies Co., Ltd).
15 Guangmao Avenue, Daxing Industrial Development Zone, Beijing 102600
Tel: 86-010-69208558
Fax: 86-010-69201991
sconstantine@qualitytonnes.com/ www.qualitytonnes.com
kphillips@armstrongservice.com/ www.armstrong.com.cn

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Armstrong

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A. General Description of Project

A.1 Title of Project: *Steam System Efficiency Improvements in Refineries in Fushun, China*

A.2 Description of Project Activity

The purpose of this project is to improve the efficiency of steam use in seven industrial facilities owned by Fushun Petrochemical (FP), a subsidiary of Petrochina. This project will optimize the steam distribution, end-use and condensate return. The project will lead to reduced Greenhouse Gas (GHG) Emissions, because it will reduce the fossil fuels required for steam generation in FP, while maintaining the same production levels. The steam at FP is generated from coal. The project will

- Optimize/Redesign the condensate return system:
  - Install equipment to treat the condensate to comply with the boiler feed water requirements, to reuse it, thereby reducing heating requirements (without this project, some condensate could be collected but is too contaminated to be used as feed water)
  - Recover the flash steam and the heat from the condensate that can not be used otherwise
  - Replace heat exchangers to improve heat exchange, avoid leaks and contaminations
  - Build new condensate return lines to collect currently drained condensate

- Improve the steam distribution system and steam use:
  - Perform steam trap surveys and implement recommendations for repair and replacement
  - Install new steam traps and return the condensate to the boiler house
  - Inspect the distribution and return lines and repair leaks
  - Establish and maintain continuing Employee Education Program to increase steam awareness and maintain results

Benefits of the Project and General Contributions to Sustainable Development:

- Reduction in coal use needed to generate steam and all of the associated emissions: carbon dioxide, carbon monoxide, SO2, NOx, mercury and particulates.

- Improvement in water conservation, thus reducing the need for use of new water in an already water-stressed area.

- By reducing impurities, such as oil, iron and silica, and by recycling the condensate, water discharge quality will be enhanced since much of the industrial wastewater in Fushun is not treated. Poor water quality is a major challenge in China, particularly in industrial areas like Fushun.[1]

- Enhance productivity of the facilities and reduce energy, operation and maintenance costs.

- Provide additional labor hours for equipment replacement/installation and steam inspection program.

- ***Water Savings:*** The dramatic water use reduction from this project will allow FP to maintain their current level of output with a dramatically smaller footprint on the local water systems. Water scarcity is a huge problem in China, and the first phase of the FP project (completed in 2001) is estimated to save roughly 300 million gallons of water per year. A larger second phase of steam efficiency improvements will be implemented if carbon finance is obtained, and the water savings will likely be even higher.

  According to the World Bank, of China's 617 cities, 300 are facing water shortages, and demand for water is only going to increase. The World Bank estimates that China's total annual water use is currently 520 billion cubic meters. Given the growth of demand in the industrial and municipal sectors, China will need to increase water resources to 670 billion cubic meters by 2010. It is estimated that only about one half of this increased demand can be met through additional development of water resources – *the remainder will need to be met through water savings or demand management.* Already, China's farmers now face strong competition for water from cities and industry. Residential demand for water is projected to increase from 31 billion tons in 1995 to 134 billion tons in 2030. The demand for water by industry is projected to grow even faster, from 52 billion tons to 269 billion tons.

[1] According to the World Resources Institute: "Research in Shenyang and Fushun showed that the incidence of intestinal infections and enlargement of the liver was, respectively, 49 percent and 36 percent higher in the irrigated areas than in the control area. There were twice as many cancer patients in the sewage-irrigated area. In Fushun, in Liaoning Province, more than 13,000 hectares of farmland are irrigated with water polluted with oil. The adjusted rate of malignant tumor mortality was almost twice that of the control area, and the incidence of congenital malformation was double the rate in the control area."

A.3 Project Participants: *Note on Investor Party: No contract for the sale of the CERs has been agreed at the time of writing the PDD and so there is no formal involvement of an investor party at this stage*

QualityTonnes, LLC (POINT OF CONTACT): QualityTonnes is a developer of energy efficiency projects. QualityTonnes works to obtain financing from a variety of sources, including carbon finance and has arranged carbon trades. QualityTonnes staff has arranged financing for millions of dollars worth of energy efficiency projects in Brazil, India, Ghana, Russia, Mexico, Philippines, Ukraine and other Eastern European countries.

Armstrong International: Armstrong is one of the world's premier suppliers of steam equipment and services. Armstrong manufactures steam traps, condensate return technology, hot water systems, compressed air systems, HVAC and refrigeration equipment.

Fushun Petrochemical, a subsidiary of PetroChina, is a major producer of petroleum, paraffin, lubes and alkyl benzene. Its other main products include diesel, coal oil, ethylene, acrylic fiber, acrylonitrile, fatty alcohol and chemical plastics

A.4 Technical Description of the Project Activity

A.4.1 Location of Project Activity

A.4.1.1: Host Country Party(ies): People's Republic of China

A.4.1.2: Region: Liaoning Province of Northeast China – about 950 kilometers northeast of Beijing.

A.4.1.3: City: Fushun

A.4.1.4 Details on the physical location: Fushun (population of 1.4 million), sometimes referred to as the "City of Coal," is a highly industrialized area. It is connected by rail with nearby Shenyang (Mukden) and with Dalian. Oil shale deposits are mined there and processed in the Fushun oil refineries. Fushun also has a major aluminum reduction plant and factories producing automobiles, machinery, chemicals, cement, and rubber. The city was developed by Russia, then occupied by Japan until 1945. The region is also a very dry area, suffering from much of the water shortages facing the rest of Northern China.

Fushun is located in the east of Liaoning Province, 45 kilometers from Shenyang the capital. The total area of Fushun is 10,816 square kilometers. The east and south part of Fushun are surrounded with high mountains and thick forests; the west is a plain formed by Hunhe River. The climate is continental with the type of seasonal wind of the North-warm zone.

Location of Sub-Plants within the Fushun Petrochemical Company: In 2001 Beijing Tuofeng Armstrong (T-A) implemented optimization projects in the following plants:

- Refinery No. 1 (new plant)
- Refinery No.3
- Detergent Chemical Plant

The future projects recommended for installation, if funding is available (if CO2 trading takes place), are located in:

- Refinery No. 1 (old plant)
- Refinery No.2
- Ethylene Plant
- Acrylic Fiber plant

A.4.2 Category of Project Activity: Energy Efficiency

A.4.3 Technology to be employed by the project activity:

Steam is used in most industrial processes all over the world, particularly in chemical and petroleum refining applications. In most developed countries, for example, the petroleum industry uses about 40 percent of its energy use to generate steam, a figure that is even higher in the chemical industry.

Four basic components make up a steam system: a boiler, distribution piping, heat exchangers and/or process equipment, and a condensate return system. As steam is distributed through the system, it begins to lose energy and by the time the steam reaches the point where it does work (at a heat exchanger or process equipment), it begins to turn back to water (condensate). Condensate also forms along the distribution system. When condensate forms, it needs to be removed right away because it very quickly reduces the quality of the steam and efficiency of the system. A closed-loop system (returning the condensate) is optimal, because the condensate, with its waste heat, can be reused – saving a great deal of energy and water, chemicals for treatment and sewer charges.

Essential to removing condensate are steam traps, which are mechanical valves installed through the distribution system that open to discharge condensate, air and other impurities that reduce the efficiency of steam lines. When using steam, at any temperatures and pressures, failure to remove the condensate, the air and non-condensable substances reduce the heat transfer and causes "water hammer", causing significant energy waste and unsafe working conditions. In most industrial facilities, steam traps are often not applied nor installed properly, not inspected often enough, or not replaced when determined to be failed.

Failed steam traps fall into two categories with associated consequences:

1) *Failed closed or undersized and flooded* – this type of steam trap failure obstructs the process, not allowing the condensate to be removed and possibly blocking the flow of steam through the system
2) *Failed open, leaking or blowing through* – this type of failure causes steam loss leading to performance inefficiencies and other steam system problems

In addition, steam leaks frequently occur in piping, valves, steam traps and other connections. In all the above conditions, if no actions are taken, the steam loss is significant, fossil fuel is wasted and the level of GHG emissions is increased.

The following is the technology that was installed in Phase I. The same technology (though in different quantities) will be installed in Phase II. Details on the project investments themselves can be found in Annex 6.

- Condensate refining polishing equipment with automatic control systemm
    a) Elf Oil Coalescer
    b) SepraEight Condensate Polishing System
    c) Armstrong Pump Trap
    On-line condensate quality monitoring device:
    Condensate collection manifolds
- Steam traps: 2280 sets of various models and spec
- Heat exchangers
- Pipeline: 10,000 meters installed
- Civil construction (plant): ~200 m^2
- A steam management program, including on-going training and education of the FP personnel

Steam maintenance training for local counterparts is critical to the success of any steam improvement program. As part of the program, local staff will be trained in monitoring and maintaining steam systems.

A.4.4 Brief explanation of how anthropogenic emissions of GHG by source are to be reduced, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances.

This project will reduce CO_2 emissions in two ways:

1. *Optimize and redesign the condensate return system.* When steam moves through a distribution line, it begins to lose energy, and as a result, some steam condenses to hot water. This project will enable the heated water to be treated – with impurities removed – and reused. The waste heat will then be put back into the system (boiler feed water), requiring less coal for the same amount of steam production (note: all the steam in this facility is generated on-site by coal). Because the water is hot condensate and not cold water, it takes less coal to bring up the temperature to the required level, i.e. 115°C. In large industrial facilities, steam is generally produced on-site. Coal savings can be calculated from steam savings based on the measured boiler efficiency. Coal savings can then be converted to CO_2 reductions based on the coal's average carbon content.

2. *Improve the steam distribution system.* When steam loses energy and condenses to water, it greatly reduces the efficiency of steam distribution. Thus, condensate has to be discharged as quickly and often as possible to maximize efficiency, and the method for discharge is a mechanical valve called a steam trap. If a trap fails, leaks or is blowing through steam, efficiency suffers significantly, requiring a greater amount of fuel input for the same amount of steam output. By conducting a steam trap survey and replacing faulty traps with durable, high-quality technology – efficiency is significantly improved. This method of steam trap survey and replacement is applicable to any industrial facility that uses steam. A steam trap maintenance program, including training, measuring instruments, and data collection and analysis techniques are included in most steam trap retrofit projects to ensure savings are realized and maintained.

The GHG emissions will be reduced as all the reusable condensate will be returned to the power plants in the different areas and all the steam traps loosing steam/not removing condensate will be repaired or replaced. By efficiently removing hot condensate and reusing it as feed-water, less coal will be required to generate the same amount of steam as the baseline scenario which uses much cooler raw water. This project improves the efficiency ratio of fuel input to steam output. In the absence of this activity, more coal would be required to generate the same amount of steam.

Without this project, the emissions would at best remain at the same levels. More likely, emissions would increase as steam leaks and the overall quality of the system would decline. To be conservative, however, the baseline will assume flat emission levels. In the first phase of this project, more than 2,000 steam traps were replaced and the condensate system improved to the point that condensate was reusable. In the absence of this project, the condensate would have continued to be expelled, missing the opportunity to reuse the energy in the waste heat. Also before the project, the steam traps – many of which were blown, leaking or otherwise faulty – would have continued to allow condensate within steam lines to block the smooth flow of steam, wasting energy. The use of these technologies would be expanded in the second phase, not yet implemented due to lack of financing.

Before this activity, FP had no steam maintenance program. As with many industrial facilities, energy management is simply not a priority – and reduction of costs, while attractive, simply take a back seat to competing management and investment priorities. Since the steam lines and traps in these facilities have not been improved before this activity, and condensate had been drained for years, there is no reason to think they would be in the future (about 60% of the traps in Phase I were faulty). Thus, in the absence of this CDM activity, it is reasonable to assume that emissions would remain the same or gradually increase over time.

Another barrier is lack of knowledge. According to an article in PM Engineer Magazine:

"The weakest link when it comes to steam systems may not be an individual component, but a fundamental lack of knowledge. For example, a steam trap, when properly installed, may be the most beneficial but least understood piece of equipment in the system. However, the lack of knowledge about steam traps and how they function can result in excessive energy loss, compounded environmental costs, productivity problems, and yes, safety concerns for personnel and property.

Higher education seldom offers courses covering a comprehensive overview of steam traps. Therefore, plumbing and mechanical engineers and professionals are left to fend for themselves and to ferret out useful information."

The final key barrier is lack of finance. These projects do lower operational costs, but the financing for the project must compete with other company priorities, such as investment for expansion of production, acquisition of new businesses, etc. It is possible in more developed countries to obtain capital from private investors that finance the projects and are paid back through the energy savings (energy service companies or ESCOs). However, the ESCO market is non-existent in China due to a number of market barriers, including lack of finance, lack of experience in ESCO/performance contracting, and weak contract law. In addition, ESCOs still need capital themselves, and bank financing is relatively expensive in China. In the past, most bankers have shown little interest in projects that do not explicitly raise revenues through new production (energy efficiency projects lower costs).

Armstrong proposed to improve steam efficiency in all seven facilities in the FP complex, however financing was not available. Thus, the project was divided into two phases. In the first phase of the project (3 facilities out of 7), Armstrong financed the projects under a risky and commercially unsustainable performance contract agreement. In other words, Armstrong cannot provide the financing for future projects without an additional revenue stream – eg: carbon finance. The second, larger phase of the project has not been implemented due to a lack of capital. Given the investment required for comprehensive steam process improvements, it is not realistic to assume that either Armstrong or FP would use its internal financing or raise capital externally (if that were the case, then the projects would have already been implemented). However, the prospect of selling the carbon offsets from the first phase of the post-2000 project – as well as Phase II – makes the project much more financially attractive and will encourage FP to provide its own additional resources necessary to implement the improvements.

A.4.5 Public Funding: No public funding is being provided for this activity.

B. Baseline Methodology

B.1 Title and reference of methodology applied to project activity

According to the UNFCCC decision CP.7 Article 12, Paragraph 48, the project sponsor can use one of three baseline methodologies.

(a) Existing actual or historical emissions;
(b) Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment, or
(c) The average emissions of similar project activities undertaken in the previous five years in similar economic, environmental and technological circumstances, and whose performance is among the top 20% of their category.

The baseline methodology for this project will be (a). The methodology we are using is entitled ***Steam efficiency improvements by replacing steam traps and reusing hot-water condensate***. It is a new methodology being proposed and is covered in Annex 3.

B.2. Justification of the choice of the methodology and why it is applicable to the project activity

Methodology (A) is the most appropriate for this project. It is applicable because we can measure the historical fuel input and steam output before the project to determine the 'business as usual' baseline GHG emissions. The steam industry, through years of analysis, has developed universally-accepted methodologies to determine the steam savings for particular technologies/managements practices. We can use these methods to determine the steam savings that result from the project. The steam savings – both from steam trap replacement and from waste heat utilized from the returned condensate – lead to equal steam output for less fuel input. The steam savings can be directly translated into reduced coal consumption and the resulting CO2 emissions reductions. This can be done by calculating how much coal would have been required to produce the steam that is now being saved – coal that would have been burned but for the implementation of this project.

This method, called "Stipulated Savings", is based on the stipulated steam loss from failed traps based on clear and tested formulas. The baseline is determined by a steam trap survey to measure exactly what the situation is with each trap (some industrial facilities have a thousand steam traps or more). For each steam trap that is faulty, determined by measuring the pressure in the steam line, the trap's orifice, application and status (is it leaking, blown or not collecting the condensate optimally), we can calculate the steam losses by formulas – particularly the Masoneilan and Napier formulas – described in Annex 4.

Once steam savings are calculated, we can determine, based on the boiler's measured efficiency, the amount of coal required to generate the steam that was previously lost (and is now saved after that project). That calculation can be used to determine the level of coal not required after the project compared to the coal required before the project. Determining the carbon content of the non-combusted coal leads to GHG reductions (this ratio is a straight calculation based on the total boiler efficiency and the coal's carbon content). Thus, we can compare the emissions after the project with the historical emissions before the project.[2]

Finally, because the condensate is treated and can now be reused as a useful energy source, we can measure the condensate flow back the deaerator in the boiler house (the flow is metered and the temperature measured), and using a straightforward formula, calculate the coal savings from producing steam from hot condensate versus cold raw water and the ensuing GHG reductions.

Why this approach: In terms of measuring steam savings, the Masoneilan and Napier formulas are recognized as the industry standard (see Annex 3-4). Various, commercially-available software programs designed to estimate steam losses have used these formulas, which are described in the Annexes. For example, there is a program, called TrapBase97© for Windows, which is a steam trap tracking relational database system designed to assist industrial and commercial facilities in developing and maintaining a systematic steam system survey program. This particular program uses the Napier and Masoneilan formulas to calculate steam losses, demonstrating that this methodology is industry accepted. Based on these formulas, this project will use a modified formula that makes the steam-loss calculations more conservative, which

[2] Because we are calculating the steam being saved – and those calculations depend on pressure and amount of steam generated – we can use this method regardless of changes in production levels. Production of steam may vary from year to year, but these formulas take this into account.

satisfies the end-users that steam losses, and therefore GHG reductions, are not being over-estimated.

B.3. Description of how the methodology is applied in the context of the project activity

In this project, a steam trap survey will be developed to identify traps that have failed. Gathering such data as hours of operation, pressure and orifice size, the formulas described above will be applied to calculate steam losses. For the condensate return, we will use the metered flow and temperature to assess how much fuel will be displaced as a result of this activity. The savings will be compared to FP carbon emissions before the project started. The baseline carbon emissions factor (CEF) for steam will be calculated, based on the efficiency of the existing boilers and the carbon content of the burned coal (Heating value and Carbon content)

The data about

- Fuel heating value and carbon (and other pollutants) content in the burned coal;
- Boiler efficiency and ratio of coal use (kilojoules input) to steam generation (kilojoules output);

will be collected from the respective plants records and will be applied in the formulas. *(see details about calculation in section E.4).* This data will be collected for two years before the project and every year after the project is implemented.

- Steam savings include:
  - Indirect steam savings based on saved condensate used as feed water (waste heat utilized, in gigajoules, and the reuse of that heat into steam production).
  - Direct steam savings from replaced steam traps, distribution improvements, and maintenance.

Conversion from steam savings to CO2 savings: Once the steam savings (direct and indirect steam in tons/yr) are determined, the CO_2 Emission Reduction will be calculated based on the equivalent coal used to generate this steam given the boiler efficiency and the coal's average carbon content. *(see details about calculation in section E.4).*

Conversion of condensate recovery into indirect steam savings into CO2 reductions: Once the condensate savings (tons/yr) are determined, the indirect steam production efficiency gains will be calculated. It will be based on the temperature differential between the condensate return and the raw water previously used in the process and the quantity of condensate return measured by flow (waste heat reused) *(see details about calculation in section E.4).*

B.4. Description of how anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of CDM project activity (explanation of how and why this project is additional and therefore not the baseline scenario).

The emissions reductions realized through this project are additional for the following reasons:

- Without this project, FP would have continued to generate steam in similar or greater quantities to maintain production levels requiring the same or greater quantities of coal. This project reduces steam and thus the coal required to produce maintain production levels. Burning less coal to maintain production levels clearly leads to a reduction in GHG emissions from the business as usual scenario.

- The potential CDM financing is a major driver in getting this and other similar projects implemented. The first phase of the Fushun project was financed under a risky performance contracting mechanism by Armstrong (project costs are repaid by the end-user through energy savings). This financing package will not be repeated by Armstrong or other similar companies. Inadequacies in China's capital markets, contract law, and practical rules of business make performance contracting in China far too volatile for many projects to be implemented. This can be seen in the FP's inability to obtain financing either internally or externally for the second phase. The funding provided by selling the emissions reductions from the entire project will be directly responsible for the complete implementation of the second phase of the project.

- Innumerable steam projects and other similar capital intensive energy efficiency projects go unrealized in China and around the world. This continues to be the case even though these projects have been proven cost effective. In fact, some estimates have indicated that cost-effective energy efficiency opportunities alone could bring the Annex One countries into Kyoto compliance. The fact that these projects are not implemented is prima facia evidence that market barriers impede or prevent investments in energy efficiency.

- The overall global market for steam traps is estimated to be $1.5 billion. In typical industrial facilities, 15-20 percent of steam traps will be inoperative; in

China, the figure can be 50% or more. Few industrial companies have an effective steam trap maintenance and replacement program, which can reduce the average number of inoperative steam traps to less than 5 percent – saving about 10 percent of the energy in a steam distribution system. Because boilers in steam systems typically are 80 percent efficient, the expected savings from steam trap maintenance and replacement is estimated to be 8 percent. And this is the case in the developed world, where energy costs can be high, and cost-effective, steam-saving opportunities are *still* not taken advantage of. In less developed countries, where there are greater institutional, market and financial barriers, we should have even fewer expectations that these opportunities will be seized. Thus we can conclude that this steam improvement project is not the baseline scenario – meaning that we cannot expect Fushun Petrochemical to undertake steam efficiency improvements in the absence of this activity.

Without this CDM activity, steam traps would continue to leak; condensate would continue to build up in steam lines; condensate that is discharged would continue to be expelled into the environment and not reused. Thus the baseline would continue to be the old steam input to product output ratio (product meaning what the steam is finally used to produce). The new baseline would show a dramatically improved efficiency in steam usage.

Barriers to Energy Efficiency in China: The World Bank recently completed a study that looked at the potential for energy efficiency projects to reduce GHG emissions. Although this analysis that energy efficiency projects have sound life-cycle financial returns, only a very small portion have been implemented. The following information is from http://www.pnl.gov/china/emcproj.htm. Among the barriers are:

(a) Inadequate information. Companies lack information about energy-saving investments, especially on financial aspects and the implementation experiences of others. China has developed various mechanisms for distribution of technical information on energy efficient technologies and renovation measures within the energy conservation community and to interested factory engineers. The system falls far short of current needs, not only in terms of coverage, but particularly in terms of focus -- little information is available for the real decision-makers (enterprise managers) concerning how specific energy conservation projects can be implemented.

(b) Technology transfer barriers. While some state-of-the-art energy efficient technologies have been introduced in China, they have not been widely distributed and the average technological level of much equipment is still quite low. Production of high-energy efficiency equipment, based on technologies developed in other countries, is just beginning in China, and has not yet significantly penetrated the domestic market.

(c) Risk. Perceived technical and financial risks to enterprises in adopting innovative energy saving technologies are very high in China. Fears that a new technology may not work, could interrupt production, may take time to perfect, or will not actually result in financial savings, all inhibit enterprise management from adopting new energy-saving technologies.

(d) Real and perceived insignificance of many energy efficiency investments. Many worthwhile energy efficiency investments are relatively small, and while they may yield sound financial returns, the value of the savings achieved typically is only a small percentage of enterprise operating costs. This is particularly true in the case of Fushun Petrochemical, which is a huge enterprise. Where Enterprise managers are most interested in expanding production and increasing market share, and, especially if there is some perceived risk involved, they usually show little interest in these types of projects.

(e) High transaction costs. Much of the potential for energy savings in China is through implementation of large numbers of individually small projects. However, energy efficiency projects often carry high costs (particularly high opportunity costs of key skilled enterprise personnel) for obtaining and checking information, planning and design, arranging financing, implementation scheduling, monitoring initial performance and implementing necessary adjustments. Especially where the benefits are relatively small, enterprises are reluctant to incur these costs.

(f) Difficulties in arranging financing. Most banks and other lending institutions in China are hesitant to lend for projects to reduce operating costs alone. Financial institutions in China (and elsewhere) are generally not familiar or adept at analyzing the financial aspects of these investments, and hence even less willing to extend credit for energy conservation projects.

(g) Institutional constraints. China's present energy conservation system, while extensive, is not geared to provide the type of support needed by enterprises under the market system. Market-based institutions, such as the Energy Service Companies (ESCOs) developed in other countries to pursue contract energy management ventures, do not exist in China. No international ESCOs are active in China, largely due to the lack of familiarity and any experience in the concept in China, and the degree of difficulty and perceived high risks of establishing and enforcing energy management contracts.

In FP the project was divided in two phases, but due to financial difficulties, Phase II is still not implemented. See Annex 6 for detailed description of the investments made under Phase I and to be made under Phase II. These improvements were implemented by

Armstrong and would have been done by FP alone. Thus, what is described in Annex 6 is definitely not the baseline scenario.

B.5. Description of how the definition of the project boundary related to the baseline methodology is applied to the project activity

All of the emissions reductions will take place within the refineries. Thus the baseline methodology was applied only to the project activity in the facilities themselves.

B.6 Details of Baseline Development

B.6.1 Date of completing the final draft of the baseline section: May 27, 2003
B.6.2. Name of person/entity determining the baseline

Sachu Constantine (QualityTonnes)
Kerry Phillips (Beijing Tuofeng Armstrong Steam System Energy Conservation Technologies Co., Ltd).
15 Guangmao Avenue, Daxing Industrial Development Zone, Beijing 102600
Tel: 86-010-69208558
Fax: 86-010-69201991
sconstantine@qualitytonnes.com/ www.qualitytonnes.com
kphillips@armstrongservice.com/ www.armstrong.com.cn

C. Duration of the Project Activity/Crediting Period

C.1. Duration of the Project Activity

C.1.1 Starting Date of Project Activity: The project was commissioned in June of 2001; Phase Two of the project will begin one month after sale of the first emissions reductions. It is the proceeds from sales of emissions reductions from the two years of tonnage (June 2001-2003) that will be used to start financing for Phase II.

C.1.2. Expected operational lifetime of the project activity: 10 years

C.2. Choice of the crediting period and related information

C.2.2. Fixed Crediting Period (10 years, 0 months)
C.2.2.1 Starting Date: June 2001

C.2.1.2. Length: 10 years

D. Monitoring Methodology and Plan

D.1. Name and reference of approved methodology applied to the project activity:

The monitoring methodology used for this project is entitled *monitoring steam system efficiency improvements.* This proposed methodology is described in detail in Appendix 4.

D.2. Justification of the choice of methodology and why it is applicable to the project activity

The only significant emission source identified in the baseline relates to the generation of steam. Emissions reduction will be achieved by avoided fossil (coal) based steam generation due to the overall steam system efficiency improvement, including avoided direct and indirect waste of steam.

Direct Savings (Steam Traps): As the steam system efficiency increases, we can calculate the reduction in CO_2 emissions, using a method called "Stipulated Savings" – the stipulated steam loss from failed traps. The baseline is determined by the measured steam supply to each area of the plant and a steam trap survey to measure exactly what the situation is with each trap (some industrial facilities have a thousand steam traps or more). For each steam trap that is in a failed condition, by measuring the pressure in the steam line, the trap's its orifice, application and status (is it leaking, blown or not collecting the condensate optimally), we can calculate the steam losses by formulas described in Annex 4. They are also accepted by the International Organization for Standardization (ISO).

Once steam savings are calculated, we can determine the amount of coal required to generate the steam that was previously lost (and is now saved after that project). That calculation can be used to determine the level of coal not required after the project compared to the coal required before the project. Determining the carbon content of the combusted coal leads to GHG reductions (this ratio is a straight calculation based on the total boiler efficiency and the coal carbon content). Thus, we can compare the emissions after the project with the historical emissions before the project.

Indirect Steam Savings (Condensate Return): Because the condensate is treated and can now be reused as a useful energy source, we can measure the condensate flow back the boiler (the flow is metered and the temperature measured), and using a straightforward formula, calculate the indirect steam savings – and thus coal and GHG reductions. This is described in Section E and in Annex 4.

D.3. Data to be collected in order to monitor emissions from the project activity and how this data will be archived

As the GHG Emission reduction will be based on steam and condensate savings, the following items will be monitored:

- Fuel heating value based on the type of coal;
- Carbon content based on the type of coal;
- Boiler efficiency and ratio of coal use (kilojoules input) to steam output (kilojoules output);
- Steam savings:

  Indirect steam savings based on Accumulated condensate return amounts from each project (different subplants of FP)

  Direct steam savings from steam traps - Steam traps repaired or replaced with all the parameters required to define the steam loss through the specific trap and application and the specific conditions
- Steam Load (L_S)

  The total steam consumption of the systems, which are within the scope of optimization.
- Recovered Condensate (Q)

  The condensate with the temperature and quality up to the designed standards, and which is returned to the boiler house.
- Temperature of Condensate (T)

  The temperature of the condensate (actually-measured) at the end of the system.
- Steam Traps in Operation (m)

  Total number of Steam Traps in Operation

ID #	Data Type	Data Variable	Data Unit	Measured or calculated?	Recording frequency	Proportion of data to be monitored	How data will be archived	For how long will data will be kept?	Comment
D3-1	Mass	Steam Load Total, L_S	tons	M	Quarterly	100%	Electronic	2 years until after CERs are issued	
D3-2	Mass	Condensate Recovered*, Q	tons	M	Quarterly	100%	Electronic	2 years until after CERs are issued	*Measures indirect steam savings and thus waste heat that can be reused*
D3-3	Temperature	Condensate Temperature, T	Degree C	M	Quarterly	100%	Electronic	2 years until after CERs are issued	
D3-4	Temperature	Make-up Water Temperature, Tw	Degree C	M	Quarterly	100%	Electronic	2 years until after CERs are issued	
D3-5	Quantity	Steam traps in Operation, m	units	M	Quarterly/ Annually	25%/ 100%	Electronic	2 years until after CERs are issued	
D3-6	Mass	Steam Savings Direct **, L_{ST}	tons	C	Quarterly	100%	Electronic	2 years until after CERs are issued	For each steam trap a separate form is filled out and the steam losses are calculated

D3-7	Mass	Steam Savings Indirect (from condensate), L_Q	tons	C	Quarterly	100%	Electronic	2 years until after CERs are issued	
D3-8	Mass	Steam Savings Total, L_T	tons	C	Quarterly	100%	Electronic	2 years until after CERs are issued	
D3-9	Intensity	Fuel Heating value	kjoules/kg	M	Quarterly	100%	Electronic	2 years until after CERs are issued	provided by the plant
D3-10	Concentration	Fuel type and carbon Content	%	M	Quarterly	100%	Electronic	2 years until after CERs are issued	provided by the plant
D3-11	Efficiency	Boiler efficiency	%	M or C	Quarterly	100%	Electronic	2 years until after CERs are issued	provided by the plant

** Measures indirect steam savings and thus waste heat that can be reused*
** For each steam trap a separate form is filled out and the steam losses are calculated Based on the Armstrong's conservatively adjusted Masoneillian formula used in determining steam loss through an orifice (see Annex 4).

For each trap, the engineer collects information, which is used as an input in an Excel spreadsheet, based on the Masoneillian formula. As a result from the input from each steam trap, the steam loss for the entire plant is calculated and summarized.

D.4. Potential sources of emissions which are significant and reasonable attributable to the project activity, but which are not included in the project boundary, and identification if and how data will be collected and archived on these emissions sources.

No significant emissions due to the project activity will take place outside the project boundary.

D.5. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHG within the project boundary and identification if and how such data will be collected and archived.

ID #	Data type	Data Variable	Data Unit	Measured or calculated?	Will data be collected on this item	How data will be achieved	For how long will data will be kept?
5-1	Mass	Steam Load Total, L_S	tons	M	Already collected	Electronic	2 years until after CERs are issued
5-2	Energy content/ intensity	Coal Heating value	kjoules/kg	M	Already collected	Electronic	2 years until after CERs are issued
5-3	Pollution content/ intensity	Coal type and carbon Content	%	M	Already collected	Electronic	2 years until after CERs are issued
5-4	N/A	Boiler efficiency	%	C	Already collected	Electronic	2 years until after CERs are issued

D.6 Quality control (QC) and Quality Assurance (QA) procedures are being undertaken for data monitored.

Data	Uncertainty level of data--high, med., low	Are QA/QC procedures planned for these data	Explanation of why QA/QC procedures are or are not being planned
D3-1	Low	Yes	Meters on steam lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below
D3-2	Low	Yes	Meters on condensate lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below
D3-3	Low	Yes	Temperature transmitters on condensate lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below
D3-4	Low	Yes	Proper QA/QC procedures need to be in place to ensure an accurate accounting and analysis of data
D3-5	Low	Yes	Same as above
D3-6	Low	Yes	Same as above
D3-7	Low	Yes	Same as above
D3-8	Low	Yes	Same as above
D3-9	Low	Yes	Same as above
D3-10	Low	Yes	Same as above
D3-11	Low	Yes	Same as above
D-5-1	Low	Yes	Data already collected
D-5-2	Low	Yes	Data already collected
D-5-3	Low	Yes	Data already collected
D-5-4	Low	Yes	Data already collected

The meter reading records will be readily accessible for auditors.
Calibration test records will be maintained for auditors.

D.7 Name of person/entity determining the monitoring methodology

Sachu Constantine (QualityTonnes)
Kerry Phillips (Beijing Tuofeng Armstrong Steam System Energy Conservation Technologies Co., Ltd).
15 Guangmao Avenue, Daxing Industrial Development Zone, Beijing 102600

Quality Tonnes

Tel: 86-010-69208558
Fax: 86-010-69201991
scontantine@qualitytonnes.com; www.qualitytonnes.com
kphillips@armstrongservice.com/ www.armstrong.com.cn

E. Calculation of GHG Emissions by Sources

E.1. Description of formulae used to estimate anthropogenic emissions by sources of greenhouse gases of the project activity within the project boundary.

There will be no additional emissions of GHG as a result of project activity.

E.2. Description of formulae used to estimate leakage, defined as: the net change of anthropogenic emissions by source of GHG which occurs outside the project boundary, and that is measurable and attributable to the project activity.

There are no potential sources of leakages.

E.3. Sum of E.1 and E.2 representing the project activity emissions

Zero

E.4. Description of formulae used to estimated the anthropogenic emissions by sources of greenhouse gases of the baseline.

The only source of greenhouse gas emissions in the baseline is CO_2 emitted from coal burned in the process of creating steam.

The amount of CO_2 emitted is found by quantifying the number of broken traps and applying the industry standard Masoneilan formula to measure total direct steam savings L_{ST}. In addition, the amount of condensate returned as feedwater and its heating value, is calculated to determine indirect steam savings L_Q.

Total steam savings $\mathbf{L_T}$ = Direct Steam Savings $\mathbf{L_{ST}}$ + Indirect Steam Savings $\mathbf{L_Q}$

$$\mathbf{L_T = L_{ST} + L_Q}$$

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Total steam savings is converted to total coal based on the heat content needed to produce the wasted steam and heat raw water up to the temperature of the returned condensate. The carbon content of the coal is the determined and then the CO_2 emissions associated with its burning are derived.

E.5 Difference between E.4 and E.3 representing the emissions reductions of the project activity.

Since there are no leakages or additional sources, the direct CO_2 emissions calculated in Section E4 represent the emissions reduction of the project activity.

The total net reductions in CO_2 emissions, according to the formulae above, will lead to a total of approximately 827,282 tons over the course of the crediting period (see bottom of E.6).

E.6 Table providing values obtained when applying formulae above

Note: Details on the sub-projects themselves can be found in Annex 6.

Quantifying the amount of CO_2 emissions in the baseline begins with counting the number of inoperable steam traps. Using the industry standard Masoneilan formulae, the number of malfunctioning traps is translated into steam loss through an orifice and is conservatively adjusted for steam loss calculations through steam trap orifice at real conditions (Annex 4). Using the following data collected, the total direct steam savings **,** L_{ST} **(tons** were estimated to be 45,000 tons of steam per year with steam trap replacement. See Next Page. The 45,000 tons came from the 1,400 traps that were failed, even though a total of more than 2,200 were replaced.

Site: Detergent Plant of the Fushun Petrochemicals
Survey Date: March, 2000

Condition	Operation	Orifice	Pressure in	Pressure out	Safety Factor	Service Factor	Estimated Steam Savings per Hour	Estimated Steam Savings per Year	Number of traps failed in this condi-tion	Estimated Steam Savings (kg/hr)		Annual Total Saving*
	Hr/yr	inch	MPa	Mpa	SF	FS	kg/hr	tons/trap	# #	Winter	Summer	tons
BLOW THRU	8400	1/8	0.5	0	1.75	0.90	10.6	89	30	318	318	2,673
LEAKING	8400	1/8	0.5	0	1.75	0.90	2.7	22	20	53	53	445
Rapid Cycling	8400	1/8	0.5	0	1.75	0.90	2.1	18	20	42	42	356
BLOW THRU	4200	7/64	0.5	0	3	1.40	12.6	53	630	7958		33,425
LEAKING	4200	7/64	0.5	0	3	1.40	3.2	13	360	1137		4,775
Rapid Cycling	4200	7/64	0.5	0	3	1.40	2.5	11	315	796		3,343
Plugged	4200	7/64	0.5	0	3	1.40	0.0	0	50	0	0	0
								Total Failed Traps	**1426**	**10,305**	**414**	**45,017**
								Process	70			
								Drip & Tracers	1355			

***From last column on the previous page: to calculate steam losses, see methodology in Annex 4.**

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Steam savings calculated		45,000	tons
	Steam traps Population	2,376	traps
	Steam traps drip traps & tracers	95%	
	Steam traps Drip & Tracers	2257	traps
	Steam traps failed	60%	
Steam traps failed		1425	traps
	Failed drip & tracers	1355	traps
	Failed Process traps	70	traps

2. Conversion of condensate recovery into indirect steam savings. Once the condensate savings (tons/yr) are determined, the indirect steam usage reduction will be calculated based on the equivalent steam used to generate the waste heat reused by returning the condensate. Following are the data required and examples of its values used further in the calculations:

- Condensate recovered, Q = 585,000 tons
- Hot Water heat content @ 90°C, i = 380.5 kj/kg
- Make-up Water heat content @ 20°C, i = 83.6 kj/kg
- Usable heat value in 0.5 MPa Steam i = 2675 kj/kg

Indirect steam savings, L_Q (tons) = [Hot Water heat content @ °C (kj/kg) - Make-up Water heat content @ °C (kj/kg)] x condensate savings Q (tons/yr) / Steam Heat value @ MPa (kj/kg)

L_Q = (380.5 kj/kg – 83.6 kj/kg) × 585000 ton / 2675 kj/kg = 65,000 (ton/ year)

3. Total steam savings (tons):

Total steam savings $\mathbf{L_T}$ = Direct Steam Savings $\mathbf{L_{ST}}$ + Indirect Steam Savings $\mathbf{L_Q}$
$\mathbf{L_T = L_{ST} + L_Q}$

In September 2000, construction of thefollowing three projects were first started. By June 2001, all these three projects were completed and put into use.

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➢ Total indirect steam savings (by utilizing the waste heat in the recovered condensate): (Total condensate recovered: 585,000 (tons/year) (metered) see above for calculations)	65,000 ton/ year
➢ Total direct steam savings:	45,000 ton/ year
➢ **Total steam savings:**	**110,000 ton/year**

4. Conversion from steam savings to coal savings: Once the steam savings (tons/yr, direct and indirect steam) are determined, the CO_2 Emission Reduction will be calculated based on the equivalent coal used to generate this steam. Following are the data required and the values used further in the calculations:

- The local coal heat value @ 25080 kj/kg (from Shanxi region)
- Average boiler efficiency @ 75% **.** The generally acknowledged boiler efficiency for medium and large coal burning boilers in FP is between 70—80%. Based on this range, boiler efficiency used for calculations is 75%, which is rather high.
- The steam heat value @ 2675 kj/kg at 0.5 Mpa (from steam tables)

Equivalent Coal savings (tons coal/ton steam) = Steam generated (ton) x steam heat value (kj/kg at given Mpa) / coal heat value (kj/kg) / boiler efficiency (%)
Then,
1 ton × 2675 kj/steam kg/ 25080 kj/coal kg / 75% eff = 0.14221 ton coal/ ton steam

Annual Coal savings (tons/yr) = Annual steam savings (tons/year) x Equivalent Coal savings (tons coal/ton steam)

Then,
Equivalent Coal Saved:
110,000 ton steam × 0.14221 ton coal/ ton steam= 15,643 ton coal/ year

5. Conversion from Coal savings to CO2 savings: Following are the data required and the values used further in the calculations:

Carbon content of coal @ 70%
According to the industry analysis by Shanxi Coal Industry (one of the main coal production bases in China), coal content in coal is as follows:

60-77% for lignite coal
74-92% for bituminous coal
90-98% for anthracite coal

The actual coal content in application is normally lower than these values. Based on this as well as figures from other coal producers, the average coal content value of 70% was used.

Complete Combustion process
$C + O_2 = CO_2 + Heat$
Thus, for each pound-moll of carbon in the coal, during the combustion process, there is a equivalent formation of carbon dioxide.

Carbon C – 12 mols
Oxygen O_2 - 2 x 16 =32 mols
Carbon Dioxide CO_2 - 12 + 2 x 16 = 44 mols

Mol content of C in CO_2 = 12 / 44 = 0.272727

Then,

Equivalent Reduced CO_2 Emissions (ton CO_2/ ton coal) =
= Coal saving (1 tons) x Carbon content in coal (%) / Carbon C (lb-mol) x Carbon Dioxide CO_2 (lb-mol)

Then,

Equivalent Reduced CO_2 Emissions (ton CO_2/ ton coal):
1 ton coal × 70% carbon / 12 mol carbon * 44 mol CO2 = 2.56 ton CO2/ton coal

Annual Reduced CO_2 Emissions (ton CO_2/ year) =
= Equivalent Coal savings (tons/yr) x Equivalent Reduced CO_2 Emissions (ton CO_2/ ton coal)

Then,

Annual Reduced CO_2 Emissions:
15,643 ton coal × 2.56 ton CO_2/ ton coal = **40,046 ton CO_2/ year**

6. Carbon Emissions Factor (CEF)

The carbon emission factor is the Carbon emissions reduced from one ton of steam saving at given coal quality and steam pressure. If FP maintains the same boiler efficiency and the coal used is from the same Shangxi region, the CEF could be used as a shortcut for quick CO2 emission calculations.

Carbon Emissions Factor (ton CO_2/ ton steam) = Equivalent Coal savings (tons coal/ton steam) * Equivalent Reduced CO_2 Emissions (ton CO_2/ ton coal)

Then,
Carbon Emissions Factor (ton CO_2/ ton steam) = 0.14221 ton coal/ ton steam * 2.56 ton CO2/ton coal = 0.3651 ton CO_2/ ton steam

*7. **Total Carbon Emissions Reduction (tons CO_2):***
After the amount of saved steam is determined, apply the CEF to calculate the CO_2 emission reduction

Total Carbon Emissions Reduction (tons CO_2) = Total steam savings (tons) * CEF
Then,
Total Carbon Emissions Reduction (tons CO_2) = 110,000 tons steam* 0.364 = 40,046 tons CO_2 Emissions Reduction

Phase II of the Project To Be Implemented With Carbon Finance

If funding is available, the FP will proceed further with the Second phase of the project. The following plants within FP are under consideration for future project implementation, i.e.:

1) Refinery No. 2
2) Acrylic Fiber Plant
3) Refiney No. 1 Old Area
4) Ethylene Plant

	Refinery No. 1 Old Area	Ethylene	Refinery No. 2	Acylic Fiber
Annual steam savings (Ton)	25,076	36,050	34,078	68,305
Coal savings (Ton)	3,574	5,138	4,857	9,735
CO2 reduction (Ton)	9,149	13,153	12,433	24,921

CO2 reduction is calculated according to the calculation method applied for those implemented 3 projects during phase 1.

FUSHUN	Condensate	Indirect steam savings (from Condensate)	Direct steam	Total Saved Steam	Coal savings	CO2 reduction
	tons/yr	tons/yr	tons/yr	tons/yr	ton	ton
Total Phase 1	585,000	65,000	45,000	110,000	15,643	**40,046**
Phase II- Future Projects						
IV REFINERY NO. 1 (old Area)	228,000	25,076	0	25,076	3,574	**9,149**
V ETHYLENE PLANT (2500 Traps)	21,840	2,402	33,648	36,050	5,138	**13,153**
VI REFINERY NO. 2 (561 Traps)	309,960	22,500	11,578	34,078	4,857	**12,433**
VII ACRYLIC FIBER (1308 Traps)	464,000	27,300	41,005	68,305	9,735	**24,921**
Phase II Total (4369 Traps)	1,023,800	77,278	86,231	163,509	23,304	**59,656**
Phase I and II (6649 Traps)	1,608,800	141,617	131,231	273,509	38,947	**99,702**

**Precise savings to be determined in conjunction with DOE in validation phase, but steam savings are based on # failed traps and additional condensate recovered. See Annex 6 for detailed project descriptions*

Table providing total values when all formulas are applied

Year	**Steam Savings (Tons)**	**CO2 Reductions (Tons)**
2001-02	110,000	40,046
2002-03	110,000	40,046
2003-04 – *carbon finance reinvested into new projects*	135,000	49,276
2004-05	273,509	99,702
2005-06	273,509	99,702
2006-07	273,509	99,702
2007-08	273,509	99,702
2008-09	273,509	99,702
2009-10	273,509	99,702
2010-11	273,509	99,702
TOTAL	***2,269,563***	***827,282***

F. Environmental Impacts

F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts

The only environmental impacts from this work are positive – reductions in coal use and associated pollution, as well as reduction in water pollution. In addition, because of the reuse of condensate as feed water for the steam system, the project will greatly reduce the raw water requirements for the plant which is located in a severely water stressed region of China. In fact, the project will result in electricity savings as these plants will require less water pumped into the steam systems.

There are no negative environmental impacts from the installation of steam traps, new steam lines, condensate return systems, etc. The technologies are easily transportable and installation does not require any major construction equipment. This project does not require an environmental impact statement under Chinese law.

F.2. If impacts are considered significant by the project participants of the host party.

NA

G. Stakeholder Comments

G.1 Brief Description of the process on how comments by stakeholders have been invited and compiled

Because this project has no discernable negative environmental impacts, because the equipment installed is itself relatively small (not requiring major transportation or other energy inputs), and because there are no other contributions to noise, air or water pollution outside the facilities, we believe no public comments were necessary. Below, however, is a letter of support from Petrochina on the first phase of the project.

G.2 Summary of comments received – Letter from PetroChina/Fushun Petrochemical

PetroChina
中国石油

Fushun Petrochemical Condensate Recovery & Re-use Project

The "condensate recovery and re-use" project (the Project), which is conducted under the joint efforts between Fushun Petrochemical and Beijing Tuofeng Armstrong Steam System Energy Conservation Technologies Co., ltd. (T-A) in the form of paying by saving, was signed in Dec. 1999, at a value of 14.64 Million RMB. Phase I of the project includes 3 plants under Fushun Petrochemical (i.e., Refinery No. 1 plant (new area), Refinery No. 3, and the Detergent Chemical Plant), and was put into implementation from Sept. 2000 and completed in June 2001.

Since the commissioning of the Project, significant savings have been realized:

- 585,000 tons of annual condensate recovered
- 45,000 tons of annual steam saved
- 6.2686 Million RMB of Project overall annual savings
- Total investment payback within 2.4 years.

In this Project, T-A's advanced technologies in system optimization and energy conservation have been utilized in the overall system optimization of steam distribution, steam utilization, water drainage, and condensate recovery & refined treatment. The condensate, after being treated, can be recycled directly back to the mid-pressure boilers and thus a favorable cycle of steam savings, condensate recovery and heat recovery can be established.

In this project, T-A makes the initial investment by providing technologies, fund, equipment, and organizes the construction work. After the project investment is paid back with the savings achieved, the two companies share the project profits. The whole set of equipment as well as the achievements of the optimization project will become the property of Fushun Petrochemical upon the expiration of the contract.

To date, T-A's superior technology and expertise has achieved great success in Refinery No. 1, Refinery No. 3, and the Detergent Chemical Plant. The newly added systems now are working in good harmony with the original systems, and have been integrated into the

normal production process, with major economic and technological targets hitting at or beyond the design targets.
We conclude T-A's trial a success in making initial investment, getting the investment back from the project savings and sharing the project profits. T-A's technology and expertise in steam system optimization, reasonable water drainage, as well as condensate recovery and refined treatment can well satisfy the production requirements.

Phase I projects of Fushun Petrochemical have achieved satisfactory successes both to T-A and to Fushun Petrochemical.

Fushun Petrochemical Division, PetroChina
Date: 8th, Jan. 2002

Acceptance Report

On

Condensate Recovery and Reuse Project

By

Fushun Petrochemical Subsidiary

Fushun Petrochemical Subsidiary
(company stamp)

Beijing Tuofeng Armstrong Steam System Energy Conservation Technologies Co., Ltd.
(company stamp)

August 2001

Acceptance Report
on
Condensate Recovery and Reuse Project Phase I
Fushun Petrochemical Company

Project Phase I covers three subcontracts, namely Refinery No. 1 New Area, Refinery No. 3, and Detergent Chemical Plant. Construction of the three subcontracts were implemented in succession starting from September 2000, and were completed finally in June 2001.

The three subsidiaries, Refinery No. 1, Refinery No. 3, and Detergent Chemical Plant, organized and completed project acceptance separately on 28th May, 2001, on 28th Dec., 2000, and on 28th June 2001. Steam savings started from November 2000. Based on the actual performance of the project and the measurement and verification over the last 6 months, the savings are very significant, with total condensate recovery amounting to 585,000 tons, steam conservation reaching 45,000 tons.

To guarantee the advancement of the technologies applied in the project, the reliability of the operation and the completeness of literature and documents, various divisions from Fushun Petrochemical Company, namely Production and Operating Division, Mechanical and Motive Power Equipment Division, Quality, Safety and Environmental Protection Division, Finance and Assets Division, Budget Division, Auditing and Supervision Division, led by with Production and Operation Division, made a joint acceptance for the Project Phase I, in addition to the respective project acceptances made by the three subsidiaries already. Following is the results from this joint project acceptance:

1. The condensate treatment technique applied in this project, as the patent technology from Armstrong, is the first–class technology internationally, and is the first of its kind in China.
2. The system enjoys high automation. It is controlled by PLC program, with switchable computer operating panel. Index for water quality such as oil content, conductance, etc. can be monitored and controlled on line. System failure can be detected automatically, switched and restarted. Computers are employed in the system's overall operating process for the management and control on safety and measuring systems, meeting well the requirements as stipulated in the contracts.
3. The literature and documents are complete and all-inclusive. After nearly half-a-year operation, all devices prove to be safe, stable and reliable. In detail,
   - the on-line oil content monitoring gauge works reliably, with the condensate cut off automatically once the oil content surpassing the set value.
   - Chain safety controls on fluid level and pressure difference, etc function reliably, guaranteeing the safe operation of the equipment.
   - The resin blanketing, evenly spread and stable, and the filters, leakage free, quite satisfy the design requirements.

- The automatic protection film system works steadily, with no breakage or peeling even when running at 50% surplus over the designed value range.
- In PLC control program, after repeated tests, both the manual switch and the automatic operation have proven to be steady and reliable, quite satisfying the design requirements.
- The emergency stops in the system function perfectly, safeguarding the safe recess of the system.
- In the Detergent Chemical plant, the steam saving is very significant with the replaced steam traps, steam saving rate being as high as 30%, literally eliminating the "white dragons".
- The system's back pressure has reached the designed requirements, the pressure for return water remaining stable.
- The individual heat exchanging process, after being tested, has reached the anticipated design goals, recycling fully the thermal energy contained in the condensate.

4. The newly added systems have been working in good harmony with the original systems and have been integrated into the normal manufacturing process. Major economic and technical targets have satisfied or even surpassed the original design requirements.
5. The outlet water quality meets the National Standard SD163-85 as defined in the contract as well as the monitoring index of Fushun petrochemical. There are some deviations between the actual inlet water quality and the designed value and Party B is asked to make further improvement.

The experts have unanimously agreed to the Acceptance of this Project.

G.3 Report on how due account was taken of any comments received: N/A

Annexes

Annex 1: Information on participants in the project activity

Organization	QualityTonnes
Street	15 Guangmao Avenue
Building	Daxing Industrial Development Zone
City	Beijing
State/Region	Beijing, 102600
Country	People's Republic of China
Telephone	86-010-69208558
Fax	86-010-69201991
E-mail	sconstantine@qualitytonnes.com
URL	www.qualitytonnes.com
Represented by	
Title	Mr.
Last Name	Sachu
First Name	Constantine
Department	Management
Mobile #	N/A
Direct Fax	Same
Direct Tel	Same
Personal e-mail	Same

Organization	Beijing Tuofeng Armstrong Steam System Energy Conservation Technologies Co., Ltd
Street	15 Guangmao Avenue
Building	Daxing Industrial Development Zone
City	Beijing
State/Region	Beijing, 102600
Country	People's Republic of China
Telephone	86-010-69208558
Fax	86-010-69201991
E-mail	kphillips@armstrongservice.com/
URL	www.armstrong.com.cn
Represented by	
Title	Mr.

Last Name	Phillips
First Name	Kerry
Department	Management/Sales
Mobile #	N/A
Direct Fax	Same
Direct Tel	Same
Personal e-mail	Same

Organization	Fushun Petrochemical
Street	
Building	
City	Fushun
State/Region	Liaoning
Country	People's Republic of China
Telephone	86-(0413)2439688 /2433359
Fax	86-(0413)2420988
E-mail	
URL	http://www.petrochina.com.cn
Represented by	
Title	Mr.
Last Name	Qian
First Name	Liu
Department	Vice General Manager
Mobile #	N/A
Direct Fax	Same
Direct Tel	Same
Personal e-mail	Same

Annex 2: Information regarding public funding

No public funding has been used in this project.

Annex 3: New baseline methodology

1. Title of Proposed Methodology: ***Steam efficiency improvements by replacing steam traps and reusing hot-water condensate***

2. Description of Methodology

2.1 General Approach

(X) Existing actual or historical emissions.

( ) Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment;

( ) The average emissions of similar project activities undertaken in the previous five years in similar economic, environmental and technological circumstances, and whose performance is among the top 20% of their category.

2.2. Overall Description:

Creating a baseline for a steam system efficiency project focuses on determining the pre-project condition of 1) the entire steam trap population (how many traps were failed and how), as well as 2) the amount and heating value of the condensate returned as feedwater (if any – very often, all condensate is discharged). Because this methodology, as many energy efficiency calculations, is based on stipulated savings of steam from improvements in equipment, technology, and O&M practices, there is no need to measure the total pre-project emissions. Rather, as is the industry standard, we can calculate the difference in pre-project conditions with post-project conditions and accurately determine savings in steam. This can be directly translated into savings of fossil fuel by calculating how much fuel would have been be required to generate the steam that was previously being wasted (and thus CO2 emissions avoided – as calculated in Annex 4).

The baseline for this methodology is thus an intensive survey of pre-project steam trap conditions and pre-project condensate return. The monitoring methodology in Annex 4 then compares the pre-project conditions with post-project conditions to determine steam savings and CO2 reductions.

The baseline is designed to look primarily at the steam trap population, and therefore, it is necessary to do a steam trap survey – an inspection of the entire steam trap population (every steam trap), in each site separately. For the steam traps portion of the project, the steam trap survey is the basis for:

- The overall evaluation of the steam trap system
- The calculation of steam savings
- All future recommendations to be implemented during the project.

During the steam trap survey, data is collected about:

- Total number of steam traps – installed and in actual operation
- All pertinent information about each trap, including the physical installation (see details in the attached steam trap log sheet data in Annex 12)
- The actual working conditions for each trap- application, pressures, hours of operation, specifics
- The actual operating condition for each trap – in or out of service, good or failed, and if failed, loosing steam or not, and under what failed conditions (see details in the following steam trap survey detailed description).

STEAM TRAP SURVEYS
SCOPE OF WORK, & TECHNICAL SPECIFICATIONS AT THE JOB SITE

1. All steam traps are located, identified, and tagged with a metal tag and clip.

2. Each trap is tested to determine its operating condition. The method used shall include ultrasonic listening, visual inspection where possible and automated steam trap monitoring systems. (The customer should supply a means to reach traps that are difficult to access, e.g., ladders, forklifts, etc.)

3. Note is made of specific problems. Some are: water hammer, poor or improper insulation, steam leaks in piping or valves, improper installation of traps, and other steam related problems.

4. Trap Survey – Log Sheet Data:

    a. Tag Number
    b. Location
    c. Elevation
    d. Manufacturer and Model Number
    e. Connection Size
    f. Pressure:
    g. (P.I.) Pressure In – actual steam pressure going into trap
    h. (P.O.) Pressure Out – actual steam pressure coming out of trap
    i. Application (Drip, Tracer, Coil, Process, Air Vents, Liquid Drainers)
    j. Equipment (Unit heater, Radiator, Humidifier, etc.)
    k. Piping (Direction, Valve In, Strainer, Valve Out)
    l. Trap Condition (Operating Mode)
    m. Comments

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NOTE: All personnel testing the traps should be Expert Trained Technicians.

After the field steam trap survey is finished, the data is processed and organized in the following reports and summaries, and submitted to the plant.

- Steam Trap Survey Summary – Overall description of the survey, including time, duration, location, number of traps surveyed, defective, wasted steam and dollar loss. It also describes the costs used for the savings. A breakdown of defective traps (by type of failure) as a percentage of the total in service traps is included. Complete listing of all failed traps is attached in a separate report.

- Energy Loss Summary – Includes steam loss of defective steam traps in kilograms and dollars, steam cost factors as cost of steam and hours of operation, and economic overview and payback.

- Steam Loss report – List of all traps wasting energy, listed in descending order

- Summaries
  - By Trap Type
  - By Manufacturer
  - By Condition
  - By Application

- Reports
  - Defective Trap reports
    - Defective traps wasting energy
    - Defective traps not wasting energy
  - Log Sheet Data – includes all steam traps on site

The terminology and abbreviations used in the steam trap survey log sheets (see next 2 pages) and the reports is also explained in summary tables.

TRAP OPERATING CONDITION

TERMS	DESCRIPTION	DEFINITION
OK	Good Trap	Trap in normal operating mode.
BT	Blow Thru	Trap has failed in an open mode with maximum steam loss. Trap should be repaired or replaced.
LK	Leaking	Trap has failed in a partially open mode with a steam loss of approximately 25% of maximum. Trap should be repaired or

		replaced.
RC	Rapid Cycling	Disc trap going into failure mode.
PL	Plugged	Trap has failed in a closed position and is backing up condensate. Trap should be repaired or replaced.
FL	Flooded	Trap is assumed to be undersized and unable to handle the condensate load. Trap should be replaced with proper size.
OS	Out of Service	The steam supply line is off and the trap is not in service.
NT	Not Tested	Trap in service but not tested due to inaccessibility, unable to reach, too high, etc.

Here is just a summary just to give a general example (not from any particular plant)

OPERATING CONDITION SUMMARY

Condition	Population	% of Total	% of In-service
Blow thru	45	8.35%	11.17%
Flooded*	7	1.30%	1.74%
Good	296	54.92%	73.5%
Leaking	4	0.74%	0.99%
Not tested*	1	0.19%	na
Out of service**	135	25.05%	na
Plugged*	50	9.28%	12.41%
Rapid cycling 1	0.19%	0.25%	0.33%
Totals:	539	100.00%	100.0%

* No savings associated with replacement of these steam traps.
** Air Handlers were not calling for steam during audit. Need to schedule next survey during coldest month. See attached spreadsheet trap report for a complete listing of all traps.

On the next page is a sample Steam Trap Survey form used for baselining.

Number of months traps are in use

Drip ______ Coil ______

Tracer ______ Process ______

Date Survey Taker

Page ______ of

Quality Tonnes

ENERGY MANAGEMENT SERVICES

CUSTOMER NAME	CITY/STATE	REPRESENTATIVE	SURVEYORS NAMES	COST OF ST
ADDRESS	CONTACT			$

TRAP TAG NO.	LOCATION (CHECK IF OUTSIDE)	ELEVATION	MFR. MODEL	CONN. SIZE (In.)	PRESSURE P-I P-O	PRESSURE SUP	PRESSURE DIS	APPLICATION	EQUIPMENT	MTHS IN USE	PIPING DIR	PIPING VLV in	PIPING STR	PIPING VLV out	COND.	COMMENTS / RECOMMEND
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		
				1/2 3/4 1				DP TR CL PS AV LD			H V A S	0 1 2	0 1 2	0 1 2		

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Notes:

NOTE ON STEAM TRAP TESTING: A combination of testing methods is used in accurately predicting the operating condition of a trap. The use of an ultrasonic listening device with visual observation when possible is generally the best option. When an atmospheric discharge is not possible, the use of the ultrasonic listening device can be used to determine the operating condition of the steam trap.

Temperature measurement cannot show the operating condition of the trap. It is merely a sign of corresponding saturation steam pressure upstream of the trap and pressure of the condensate return system downstream of the trap. Determining the amount of backpressure in the condensate system helps to quantify the amount of live steam lost through a failed trap.

The ultrasonic listening device gives a good understanding of how the trap is operating. A normally operating inverted bucket trap emits a definite burst of sound when the bucket sinks and opens the trap valve; thereby discharging condensate until entering steam floats the bucket and closes the valve. In the presence of extremely low loads, the bucket is heard as a continuous clattering sound. This is sometimes called a “dribbling trap.” This is still a normal operating steam trap with no steam loss. This could also be a sign of an oversized trap, therefore, requiring a smaller or restrictive orifice.

A definite cycle rate is heard when a disc trap is operating normally as the disc lifts off the inlet orifice allowing condensate to flow through the outlet passage, and then closes the orifice in the presence of steam.

The normal operating sounds of a float and thermostatic trap are difficult to distinguish, as it is a constant flow device with no cycle rate. By shutting off the inlet valve and letting condensate collect, and then releasing a large condensate load to the trap, the trap is heard opening and then modulating down to the steady state flow. The thermostatic air vent in a float and thermostatic trap often opens rather infrequently to release air, making its working condition difficult to determine.

A thermostatic steam trap has a cycle, but it is much more gentle in nature than the inverted bucket or disc trap. A sub cooling thermostatic steam trap is similar in operation to the float trap. It may have either a bellows or a bimetallic spring as the actuation device, opening and closing the trap according to the set temperature differential.

A final determination of the operation of a steam trap is visual. This test can only be done if there is an atmospheric discharge or test valve. If there is a test valve after the trap, close off the valve to condensate return and open the test valve to atmosphere. The steam trap will now act as an atmospheric discharge trap. If there is high backpressure in the condensate return system, some generic types of steam traps operate differently when discharging to atmosphere than to the condensate return system. Therefore, it is important to know how the different generic types of traps operate under varying conditions. Opening a test valve ahead of the trap can also determine if the trap is backing up condensate.

The actual piping arrangement with the application can give some insight as to freezing problems, formation of vacuum, backpressure and poor piping configurations that may affect the operation of the trap.

Use a systems approach when testing steam traps, there are times when, after further investigation, what seems to be a defective trap is actually a piping or application problem. More information on steam trap surveys is included in the other documents, including a sample steam trap survey and report, steam trap flow-chart, and sample data collection form.

Condensate return: The basis of the condensate return baseline is the measured temperature difference between the return condensate and the raw water it is replacing. All the condensate that is reused means additional energy in the form of hot water for no extra fuel input. So the reduction in energy requirements leads directly to less fuel input, and the formula for converted condensate return to generation in reusable steam (again for no additional fuel input) The formulas are not project specific and could be applied to any condensate return project.
Following are the data required:

- Condensate recovered pre-project, Q, tons (from meter)
- Hot Water (=condensate) heat content @ °C, kj/kg (from water or steam tables)
- Make-up Water heat content @ °C, kj/kg (from water or steam tables)
- Usable steam heat value @ MPa , kj/kg (from steam tables)

Indirect Steam Savings Baseline, L_Q (tons) = (Hot Water heat content @ °C (kj/kg) - Make-up Water heat content @ °C (kj/kg)) x pre-project condensate (tons/yr) / Steam Heat Value @ MPa Steam (kj/kg)

If no condensate is currently reused as input, the baseline is simply the difference between the energy required to turn raw water into steam and the energy required to

3. Key parameters/assumptions (including emissions factors and activity levels), and data sources considered and used:

The key parameters for this project are the following:

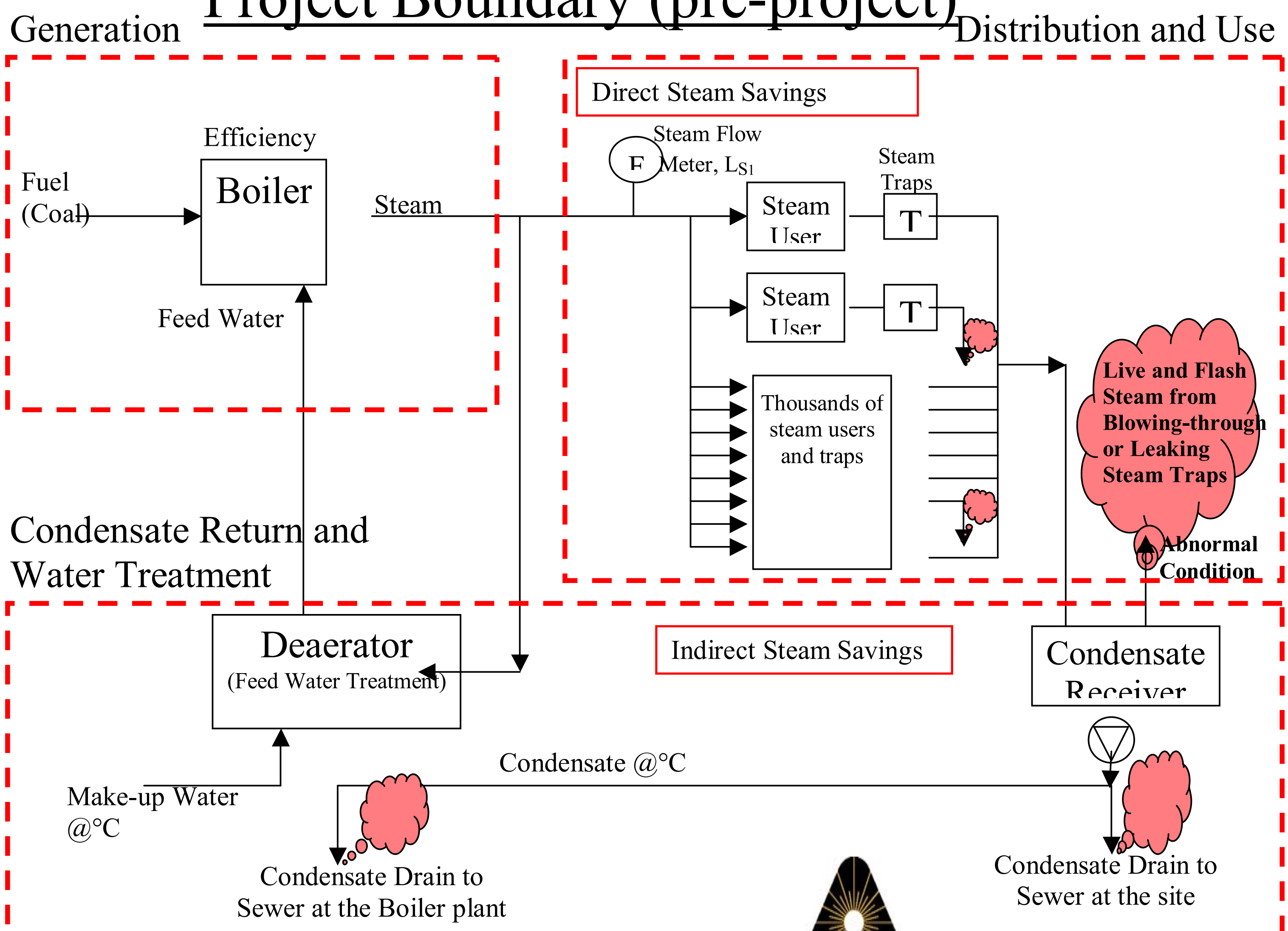
- Steam supply (tons) and characteristics of the system – pressure, flow, etc. – as well as steam heat value
- Fuel use to generate that amount of steam (tons) and carbon content of that fuel.
- Average efficiency of the boiler
- Ratio of fuel input to steam output
- Total steam traps (based on survey), including all characteristics of the trap that will affect monitoring (orifice size, application, pressure of steam line at that point)
- Based on that survey, number of traps that are failed
- Condensate used before the project and condensate discharged. Once the condensate savings (tons/yr) are determined, the indirect steam usage reduction will be calculated based on the equivalent steam used to generate the waste heat reused by returning the condensate.

4. Definition of the project boundary related to the baseline methodology:

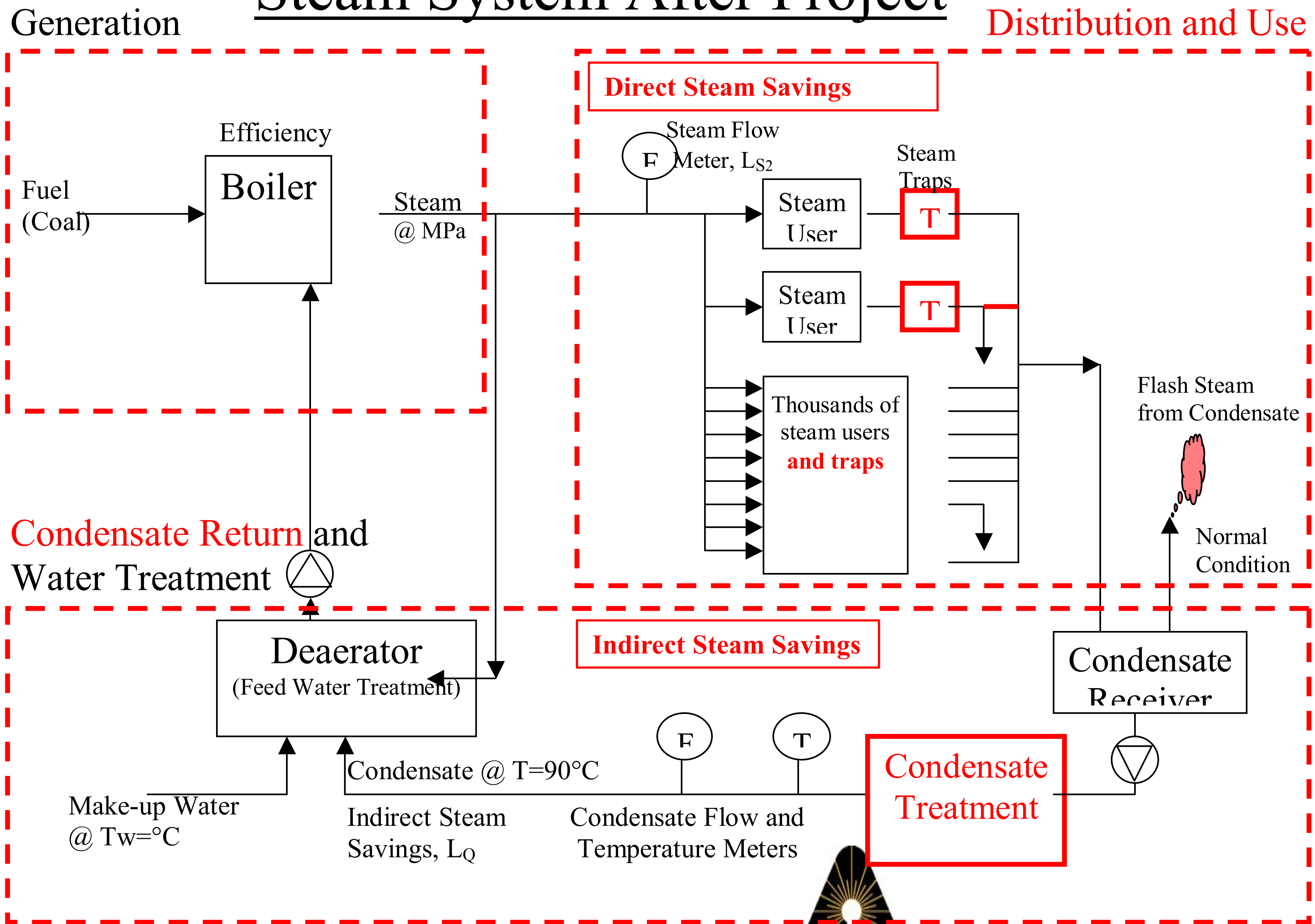
The project boundary for these projects are industrial facilities, where steam is generated on-site. Thus, the project has a clear boundary in the sense of a closed loop (both energy generation and the consumption of that energy is in the same facility and considered by this project activity – see charts below).

There is one source of potential additional energy consumption, and that is additional electricity to pump condensate whereas previously the condensate was discharged into the sewers. The project requires condensate pumps to be installed and therefore use electricity. However, this is considered immaterial because the water to produce steam has to come from somewhere, and the electricity from pumping cold raw water into the facility would certainly be greater than the pumping of hot condensate from within the project boundary. (Greater head from groundwater pumped on site and greater distance from water pumped from surface source)

Project Boundary (pre-project)



Steam System After Project



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5. Assessment of uncertainties:

One key area of uncertainty is whether or not the facility has a steam trap replacement program. If there is an on-going effort to replace steam traps, that would obviously affect the baseline. Thus, it will be necessary to undertake formal analyses to check that there are no performance related contracts already in place, quality-control or inspection and maintenance procedures that would mean that the stream traps and other equipment are routinely maintained. In most developing-world industries, there is no effort to conduct steam trap maintenance, but in cases where there are, the baseline will be adjusted accordingly, based on interviews with the facilities managers. For example, if the facility replaces only completely blown traps on an annual basis, the baseline would take out the blown traps and focus on direct steam savings from traps that would not be replaced under the facilities *existing* steam trap maintenance program.

Another area of uncertainty is steam trap performance. Due to a variety of factors, steam traps fail, and it will be necessary to replace steam traps. Each replaced trap will be checked at least once per year. If the trap is failed, then it has to be replaced, and the assumption must be that it was defective back to the day of the previous check when it was functioning normally, even though the trap may have failed months after the last inspection. This is just to be as conservative as possible.

6. Description of how the baseline methodology addressed the calculation of baseline emissions and the determination of project additionality:

The baseline methodology calculates how much fuel is required to generate a ton of steam, based on the ratio of fuel input to steam output (how much fuel is required to generate how much steam), based on an average boiler efficiency. When a ton of steam is lost due to steam leaks, poor efficiency from excessive condensate entering the steam line, etc., then the amount of fuel needed to generate that ton of steam lost – and therefore GHG reductions – can then be determined.

For the project to be additional, no steam trap maintenance program should be implemented or about to be adopted. Thus, after the steam trap survey, the project developer can assume that the baseline is set and steam traps would not be replaced but for the CDM activity. In addition, the project developer should demonstrate that no efforts to recover condensate would likely take place in the future.

7. Description of how the baseline methodology addresses any potential leakage of the project activity:

There are no significant sources of leakages in this project, except perhaps for the electricity required as a result of condensate return. However, this is offset because electricity would be required to pump raw water into the steam boiler.

8. Criteria used in developing the proposed baseline methodology, including an explanation of how the baseline methodology was developed in a transparent and conservative manner:

The main criteria for developing the baseline methodology is the industry-accepted methods for steam trap surveys, testing and calculation for losses, based on industry-accepted formulas. The process for surveying steam traps to find which ones are failed (described in Section 2.2) is quite transparent and is conservative because we are calculating emissions reductions only when traps are blowing live steam, leaking or rapid cycling. In most facilities, more traps are replaced than fit into those three categories because the orifice may be the wrong size for the application or a variety of other reasons. In this case, there will be additional energy savings, however we are only counting these three failed states because it is easiest to measure conclusively the direct steam losses.

During the steam trap survey, if one identifies a trap that is working, it may be the case that it would fail a year or more into the future, particularly given the poor technology in many developing-world factories. However, if a trap is working during the baseline survey, this methodology would assume that the trap would continue working into the future, because when it would fail is unknown – this is another attempt to be conservative. In other words, the baseline is likely to deteriorate in the absence of a maintenance program, but this methodology assumes it will stay flat. Finally, if a replaced steam trap is failed during an inspection later on, then all emissions reductions for that entire year should be forfeited. Because we do not know at what point between the annual inspections the trap failed, we have to be conservative and assume it failed the day after the last check.

Finally, this methodology assumes that none of the condensate that is generated from the steam generation process is recovered. In cases when it is partially used, then the baseline has to take that into account, and the monitoring of the project can only measure the additional condensate that was previously discharged before the project.

9. Assessment of strengths and weaknesses of the baseline methodology:

Strengths: Use of industry-accepted steam trap surveys and steam loss formulas, which are very conservative.

Weaknesses: Given the years the baseline methods have been used in the steam industry, weaknesses and problems have generally been ironed out.

10. Other considerations, such as a description of how national and/or sectoral policies and circumstances have been taken into account:

It is unlikely, given the particular nature of this technology, that there are national and sectoral policies which would affect the baseline. However, the project developer using this methodology should conduct some research to ensure that there are no regulations that provide standard sectoral policies requiring specific steam maintenance.

Annex 4: New monitoring methodology

Proposed new monitoring methodology

We are proposing a new monitoring methodology entitled *monitoring steam system efficiency improvements.*

1. **Brief Description of the new methodology :**

Every year, a steam trap survey conducted to ensure that each trap is operating effectively (engineers at the complex will be inspecting the traps as part of the steam management exercise started as a result of this CDM activity). Those not operating effectively will be replaced. Those that are will be compared to what the trap in that exact location was doing in the original baseline survey. So if a trap were blowing live steam in the original steam trap survey and is now operating effectively, one would apply the formulas described below calculating the steam losses generated before the trap was replaced. That measurement, multiplied by all the traps replaced, will enable the project developer to have a total aggregate of steam savings in tons. The formulas estimating steam loss calculations are below:

The direct steam loss, L_{ST}, for each plant is based on the summary of the losses through each trap in the steam trap system. The Stipulated Savings (direct steam loss) is calculated, based on the data collected during the field steam trap survey, on trap-by-trap basis. A simple software program, which is not site specific and is applicable for any steam trap loss calculation, can be used to easily calculate the savings into a database.

Following are the data required for each trap:

- the trap manufacturer (from the nameplate)
- model (either from the nameplate or from a lookup table)
- orifice size (either from the nameplate or from a lookup table)
- the operating pressure at the trap inlet (from gage on the plant steam header)
- the operating pressures at the trap outlet (from gage on the plant condensate headers)
- the steam trap application / category of service – from the field observations

- the steam trap operating conditions – from test based on knowledge and experience
- hours of operations – from plant

In a practical steam trap survey, the technician enters data for the operating pressures, the category of service, the trap model, and the orifice size (either from the nameplate or from a lookup table). Conversion of pressures to absolute values, determination of service factor, F_S , and flow coefficient, C_V, , and the steam loss computation can all handled by a simple spreadsheet program.

Below is the formula used to calculate steam savings, and the industry-standard derivation of that formula. The derivation is the Masoneilan, but is has been adjusted to be more conservative, which gives the end-user client additional assurance that if anything, steam savings are underestimated.

The equation used to calculate the Stipulated Savings steam *loss* through a trap that has failed open is:

$$W = F_S\, C_V \sqrt{(P_1 - P_2)(P_1 + P_2)}$$

where F_S.= service factor taking in consideration the steam trap application and condensate flow

C_V = flow coefficient (not to be confused with the discharge coefficient C_D which corrects for the effect of the vena contracta in basic orifice flow calculations.)

P_1 = upstream pressure, psia

P_2 = downstream pressure, psia, with the limitation that $P_2 \geq (P_1/2)$; therefore **if** the actual downstream pressure is less than $P_1/2$, **the value of $P_2 = P_1/2$ is used in the formula**.

The following is a detailed description and discussion of the formula derivation

The formula used widely by the steam-trap industry for computing steam loss through a failed trap is based upon the well-known Masoneilan formula for saturated steam flow through an orifice. The Masoneilan formula is:

$$W = 2.1\,C_V\sqrt{(P_1 - P_2)(P_1 + P_2)} \qquad (1)$$

where W = steam flow, lb/hr

C_V = flow coefficient (not to be confused with the discharge coefficient C_D which corrects for the effect of the vena contracta in basic orifice flow calculations.)

P_1 = upstream pressure, psia

P_2 = downstream pressure, psia, with the limitation that $P_2 \geq (P_1/2)$; therefore **if** the actual downstream pressure is less than $P_1/2$, **the value of $P_2 = P_1/2$ is used in the formula**.

Equation (1) gives the steam flow in terms of the flow coefficient C_V. However, C_V values are not commonly published for steam traps, and it is therefore necessary to find a method of determining the C_V value. If we consider higher pressure differentials, the Napier formula gives us a value for the flow rate. (Note that the Napier formula is *only* valid for inlet pressure more than twice the *actual* outlet pressure.) With a factor to convert the result to lb/hr, the steam flow rate through an orifice is given by:

$$W = AP_1\left(\frac{3600}{70}\right) \qquad (2)$$

where $A = \frac{\pi}{4}d^2$ with d being the orifice diameter in inches.

Combining equations (1) and (2), and setting $P_2 = P_1/2$, yields the definition of the flow coefficient as:

$$C_V = 22.1\,d^2 \qquad (3)$$

Either of the above equations will give us the flow of dry saturated steam through an orifice. However, we are interested in the steam *loss* through an orifice with a significant amount of condensate also flowing through the same orifice. Note that most steam traps are selected for their application using a “safety factor” for the condensate load. The safety factor S is the ratio of the trap (orifice) capacity to the actual condensate load. Therefore, the amount of condensate that is actually discharged is $1/S$ of the orifice capability.

If a trap has failed wide open, it will be handling its "normal" amount of condensate, and also blowing through live steam. The simplest estimate of the steam loss (and also the most conservative) is to assume that the steam and the condensate "share" the orifice in direct proportionality. Therefore, we may expect that the ratio of actual steam loss to the theoretical steam flow capacity is $1 - 1/S$ or $(S - 1)/S$. This can be combined with the 2.1 factor at the beginning of the Masoneilan formula, to create what we call the "service factor" F_S.

$$F_S = 2.1\left(\frac{S-1}{S}\right) \tag{4}$$

Replacing the first term of equation (1) by F_S, we obtain the equation used to evaluate steam *loss* through a trap that has failed open:

$$W = F_S\, C_V \sqrt{(P_1 - P_2)(P_1 + P_2)} \tag{5}$$

Along with equations (4) and (5) defining C_V and F_S, this provides the steam loss formula used in many industry standard (trap survey) programs.

It is almost impossible to evaluate the service factor exactly, since we do not know the actual condensate load that is going through a trap. We also do not necessarily know the true capacity of the trap. However, on the basis of standard sizing practice, as well as some observations from practical installations, we can sort traps into either "process" or "drip and tracer" traps. For these two broad categories of traps, and also for the case of simple steam flow through an orifice, we can determine service factors as follows:

Category	Capacity safety factor S	Service factor F_S
Process traps	1.75	0.9
Drip and tracer traps	3.0	1.4
Steam flow, no condensate	(Very large)	2.1

At this point it should be noted that the Masoneilan, Napier, and other industry standard formulas are all *exactly equivalent* for steam flow through an orifice with $P_2 = 0.5\ P_1$. The Masoneilan and other industry standard formulas are capable of handling steam flow with higher back pressures if needed.

These formula is applied to the next chart, which shows the stipulated steam loss calculations through the same orifice (1/4”) at the same pressures (Pin=100 psig, Pout=20 psig) and any same other conditions, but under different applications and failure modes. The steam losses are added up from all the traps to determine Direct Steam Savings $\mathbf{L}_{ST}$.

SAMPLE STIPULATED STEAM LOSS CALCULATIONS TABLE BASED ON FORMULAS ABOVE

Orifice - 1/4”
Pin=100 psig
Pout=20 psig

Application	Condition	Steam Loss (kg/hr)
Air Vent	Blow-thru	131.5
Coil	Blow-thru	56.1
Drip	Blow-thru	87.3
Process	Blow-thru	56.1
Tracer	Blow-thru	87.3
Air Vent	Leaking	32.9
Coil	Leaking	14.0
Drip	Leaking	21.8
Process	Leaking	14.0
Tracer	Leaking	21.8
Air Vent	Rapid Cycling	26.3
Coil	Rapid Cycling	11.2
Drip	Rapid Cycling	17.5
Process	Rapid Cycling	11.2
Tracer	Rapid Cycling	17.5

Monitoring of Condensate Return: Once the condensate savings (based on condensate Q, tons/yr, and temperature T, °C) are measured, the indirect steam usage reduction will be calculated based on the equivalent steam used to generate the waste heat reused by returning the condensate. The formulas are not project specific and could be applied to any condensate return project. Following are the data required:

- Condensate recovered pre-project, Q, tons (from meter)
- Condensate recovered post-project, Q, tons (from meter)
- Hot Water (=condensate) heat content @ °C, kj/kg (from water or steam tables)
- Make-up Water heat content @ °C, kj/kg (from water or steam tables)
- Usable steam heat value @ MPa , kj/kg (from steam tables)

Indirect Steam Savings, L_Q (tons) = [(Hot Water heat content @ °C (kj/kg) - Make-up Water heat content @ °C (kj/kg)) x (post-project condensate recovered (tons/yr)) / Steam Heat Value @ MPa Steam (kj/kg)] – [(Hot Water heat content @ °C (kj/kg) - Make-up Water heat content @ °C (kj/kg)) x pre-project condensate (tons/yr) / Steam Heat Value @ MPa Steam (kj/kg)]

Total steam savings $\mathbf{L_T}$ = Direct Steam Savings $\mathbf{L_{ST}}$ + Indirect Steam Savings $\mathbf{L_Q}$

$\mathbf{L_T = L_{ST} + L_Q}$

Conversion from steam savings to fuel savings: Once the steam savings (tons/yr, direct and indirect steam) are determined, the CO_2 Emission Reduction will be calculated based on the equivalent fossil fuel used to generate this steam. Following are the data required and the values used further in the calculations:

- The local fuel heat value @ kj/kg
- Average boiler efficiency @ X%
- The steam heat value @ Mpa steam (kj/kg) (from steam tables)

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Equivalent fuel savings (units of fuel/ton steam) = Steam generated (tons) x steam heat value (kj/kg at given Mpa) / fuel heat value (kj/kg) / boiler efficiency (%)

Annual fuel savings (units/yr) = Annual steam savings $\mathbf{L_T}$ (tons/year) x Equivalent fuel savings (unit fuel/ton steam)

Conversion from Fuel savings to CO2 savings: Following are the data required and the values used further in the calculations:

Carbon content of fuel (measured or derived from default emissions factors)

Complete Combustion process for carbon based fuel
$C + O_2 = CO_2 + Heat$
Thus, for each pound-moll of carbon in the fuel, during the combustion process, there is an equivalent formation of carbon dioxide.

Then,

Equivalent Reduced CO_2 Emissions (ton CO_2/ unit fuel) =
= fuel saving (1 unit) x Carbon content in coal (%) / Carbon C (lb-mol) x Carbon Dioxide CO_2 (lb-mol)

Annual Reduced CO_2 Emissions (ton CO_2/ year) =
= Equivalent fuel savings (unit/yr) x Equivalent Reduced CO_2 Emissions (ton CO_2/ fuel unit)

Carbon Emissions Factor (CEF)

The carbon emission factor is the Carbon emissions reduced from one ton of steam saving at given fossil fuel quality and steam pressure. If the project site maintains the same boiler efficiency and the fuel used has consistent carbon content, the CEF could be used as a shortcut for quick CO2 emission calculations.

Carbon Emissions Factor (ton CO_2/ ton steam) = Equivalent fuel savings (unit fuel/ton steam) * Equivalent Reduced CO_2 Emissions (ton CO_2/ unit fuel)

Total Carbon Emissions Reduction (tons CO_2):
After the amount of saved steam is determined, apply the CEF to calculate the CO_2 emission reduction

Total Carbon Emissions Reduction (tons CO_2) = Total steam savings (tons) * CEF

2. **Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived**

ID #	Data Type	Data Variable	Data Unit	Measured or calculated?	Recording frequency	Proportion of data to be monitored	How data will be archived	For how long will data will be kept?	Comment
A4-1	Mass	Steam Load Total, L_S	tons	M	Quarterly	100%	Electronic	2 years until after CERs are issued	
A4-2	Mass	Condensate Recovered*, Q	tons	M	Quarterly	100%	Electronic	2 years until after CERs are issued	*Measures indirect steam savings and thus waste heat that can be reused*
A4-3	Temperature	Condensate Temperature, T	Degree C	M	Quarterly	100%	Electronic	2 years until after CERs are issued	
A4-4	Temperature	Make-up Water Temperature, Tw	Degree C	M	Quarterly	100%	Electronic	2 years until after CERs are issued	
A4-5	Quantity	Steam traps in Operation, m	units	M	Quarterly/ Annually	25%/ 100%	Electronic	2 years until after CERs are issued	
A4-6	Mass	Steam Savings Direct **, L_{ST}	tons	C	Quarterly	100%	Electronic	2 years until after CERs are issued	For each steam trap a separate form is filled out and the steam losses

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									are calculated
A4-7	Mass	Steam Savings Indirect (from condensate), L_Q	tons	C	Quarterly	100%	Electronic	2 years until after CERs are issued	
A4-8	Mass	Steam Savings Total, L_T	tons	C	Quarterly	100%	Electronic	2 years until after CERs are issued	
A4-9	Intensity	Fuel Heating value	kjoules/kg	M	Quarterly	100%	Electronic	2 years until after CERs are issued	provided by the plant
A4-10	Concentration	Fuel type and carbon Content	%	M	Quarterly	100%	Electronic	2 years until after CERs are issued	provided by the plant
A4-11	Efficiency	Boiler efficiency	%	M or C	Quarterly	100%	Electronic	2 years until after CERs are issued	provided by the plant

3. **Potential sources of emissions which are significant and reasonably attributable to the project activity, but which are not included in the project boundary, and identification if and how data will be collected and archived on these emission sources.**

No significant emissions due to this type of project activity will take place outside the project boundary.

4. **Assumptions Used in the Methodology:**

The carbon content of fuel may be based on the default emissions factors.

5. **Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored.**

Data	Uncertainty level of data--high, med., low	Are QA/QC procedures planned for these data	Explanation of why QA/QC procedures are or are not being planned
A4-1	Low	Yes	Meters on steam lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below
A4-2	Low	Yes	Meters on condensate lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below
A4-3	Low	Yes	Temperature transmitters on condensate lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below
A4-4	Low	Yes	Proper QA/QC procedures need to be in place to ensure an accurate accounting and analysis of data
A4-5	Low	Yes	Same as above
A4-6	Low	Yes	Same as above
A4-7	Low	Yes	Same as above
A4-8	Low	Yes	Same as above
A4-9	Low	Yes	Same as above
A4-10	Low	Yes	Same as above
A4-11	Low	Yes	Same as above

6. **What are the potential strengths and weaknesses of this methodology?** *(Please outline how the accuracy and completeness of the new methodology compares to that of approved methodologies.)*

To date there are no approved methodologies of this type to directly compare this methodology with. However, within the steam industry, this methodology is based on the industry standard that has been tried, tested and refined over an extended period of time. It will be applicable to many situations and usable by many potential project developers.

The weakness of this methodology is the relatively labor-intensive process for inspecting steam traps. There are a few testing methods described in Annex 3, and any of these methods are acceptable, however, they do require engineers to check each one at least once a year.

7. **Has this methodology been applied successfully elsewhere and, if so, in which circumstances?**

This methodology is being used in the first Phase of the Fushun Project, but is used around the world because it is the industry standard within the steam industry. It is accepted and practiced by steam system manufacturers, vendors, and their customers to calculate savings and negotiate contracts. Over the years, it has been refined in testing labs, universities, and used in countless projects.

Annex 5: Table: Baseline Data

The baseline was determined by the following key data points:

1. Carbon content of the coal used to generate the steam (data source: Fushun Petrochemical – FP)

Carbon content of coal @ 70%. According to the industry analysis by Shanxi Coal Industry (one of the main coal production bases in China), coal content in coal is as follows:

60-77% for lignite coal
74-92% for bituminous coal
90-98% for anthracite coal
The actual coal content in application is normally lower than these values. Based on this as well as figures from other coal producers, the average coal content value of 70% was used.

The local coal heat value @ 25080 kj/kg (from Shanxi region)

2. Boiler Efficiency: Average boiler efficiency @ 75%**.** The generally acknowledged boiler efficiency for medium and large coal burning boilers in FP is between 70—80%. Based on this range, boiler efficiency used for calculations is 75%, which is rather high.

3. Number of tons of steam generated per ton of coal (data source: FP)

4. Total steam supply to process equipment and heat exchangers (data source: FP)

5. Total number of steam traps (data source: FP)

6. Total number of steam traps considered failed (data source: Armstrong steam trap survey)

7. Temperature of raw water pumped into steam boiler and temperature of hot condensate discharged (to be later used) (data source: FP)

8. The carbon emission factor is the Carbon emissions reduced from one ton of steam saving at given coal quality and steam pressure. If FP maintains the same boiler

efficiency and the coal used is from the same Shangxi region, the CEF could be used as a shortcut for quick CO2 emission calculations.

Carbon Emissions Factor (ton CO_2/ ton steam) = Equivalent Coal savings (tons coal/ton steam) * Equivalent Reduced CO_2 Emissions (ton CO_2/ ton coal). Carbon Emissions Factor (ton CO_2/ ton steam) = 0.14221 ton coal/ ton steam * 2.56 ton CO2/ton coal = 0.3651 ton CO_2/ ton steam

ANNEX 6

In FP the project was divided in two phases, but due to financial difficulties, Phase II is still not implemented. Below is what happened in Phase I one of the Project, which will be replicated in Phase II. These improvements described below were implemented by Armstrong and would have been done by FP alone. Thus, what is described below is definitely not the baseline scenario.

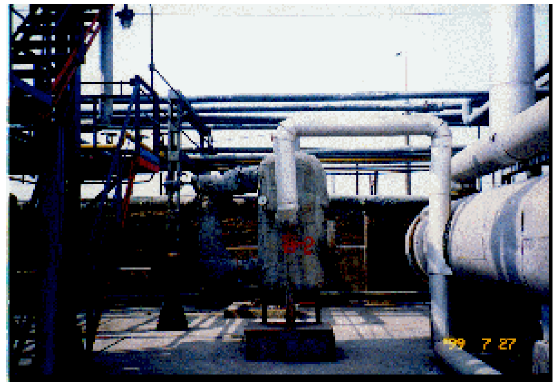
<u>Refinery No. 1 New Area</u>

Problems Existing in the Current Condensate Return System of the New Area of Refinery No.1

The discontinuous operations on some sections of the condensate return system resulted in iron contamination in the condensate, and leaks in the heating coils caused oil contamination. Despite the presence of a condensate return system from the condensate station to the receiving tank of the boiler house, the returned condensate could not be utilized as boiler feedwater due to the high content of iron and oil

After the new equipment was installed, the returned condensate could be use as boiler feed water. The savings are listed in the tables in the following chapters.

<u>Refinery No. 3, Problem 1</u>



In the Sulfur Unit, the condensate from the reboiler was returned using a level-control vessel to remove the condensate. The condensate level in the control vessel was elevated relative to the tubes in the heat exchanger, causing flooding of the heat exchanger. A flooded heat exchanger does not use the entire heat transfer surface efficiently, increasing steam pressure requirements for the reboiler. The flooding also causes tube corrosion, and shortens the heat exchanger's operational life time.

Optimization Proposal

According to the actual onsite condition and relevant technical requirements, the reboiler needed a suitable mechanical condensate removal device. Installing it at the reboiler ensured fast removal of the condensate and prevented flooding of the heat

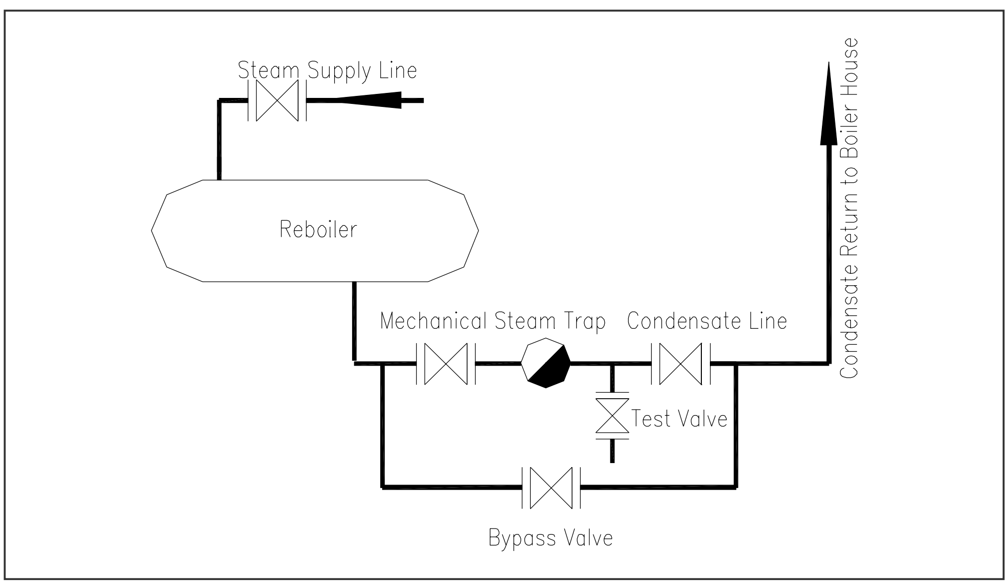


Figure 2. Proposed Steam System Setup for The Reboiler

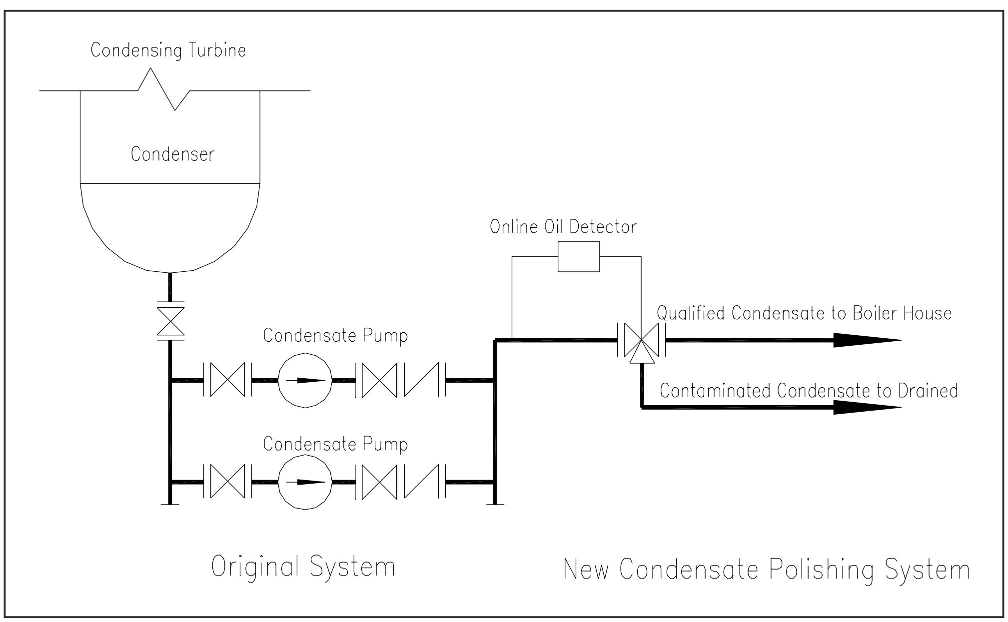
exchanger. When the entire heat exchanger surface is utilized, less steam pressure may be required at the reboiler. Another benefit is the low pressure drop across the mechanical condensate removal device, allowing enough pressure to return condensate to the water tank in the Boiler House.

Savings: Improving the condensate return system at the sulfur plant reboiler, reduced steam usage reduction by about 10%.

Problem 2: One steam turbine unit has been in operation for a long time. The turbine's lubricant oil leaks into the condensate causing oil contamination. The contaminated condensate can not be used as boiler feed water. Typically this leakage is caused by a mechanical seal failure. Such mechanical seal failures often occur in turbines towards the end of normal operational cycles and are detected and repaired during regular maintanence turnaround.

Optimization Proposal (see figure 3 below)

Since the mechanical seal failure is an occasional problem, an online oil detector and a pneumatic 3-way valve were installed. This helped reduce contaminants, so when the oil content in the condensate is within the allowable range of the LP (low pressure) boiler's feed water specification, the condensate is returned to the deaerator and used as boiler feed water. If the oil content in the condensate exceeds the allowable parameters for the LP boiler, the pneumatic 3-way valve diverts the condensate to be drained. This should trigger a maintanence check to determine the source of contamination. Once the condensate quality is within the boiler feed water requirements, then the condensate will



be returned as boiler feed water again.

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Savings: After optimization, the condensate will be returned and used as boiler feed water, when it is within the allowable parameters. Contaminated condensate drained as wastewater will be minimized, and oil leaks through mechanical seals on the turbine can be detected quickly and minimized.

Problem 3
The condensate from the hydrogen-manufacturing unit is process condensate. It contains CO_2 and CH_4, so it cannot be used as boiler feed water. It is used as industrial water and domestic water.

Optimization Proposals
The projects/activities implemented included conducting detailed water quality tests on samples collected at actual site and evaluate the contaminants. A suitable water treatment system was installed to ensure the water quality meets the required specifications of waste heat boiler feed water. The condensate was now pumped to the deaerator of the waste heat boiler in the hydrogen manufacturing unit. After optimization, the condensate is now used as waste heat boiler feed water.

Detergent Chemical Plant

Improve Steam Trap System

In Detergent Chemical Plant, the main steam consumers are in Linear Alkyl Benzene Phase I Unit, Linear Alkyl Benzene Phase II Unit, Fatty Alcohol Unit and the Tank Farm.

Due to the long and cold winter (4 months of the year the temperatures are below 0°C), and the nature of the processed products, all the lines need to be steam traced, to maintain proper processing temperatures and prevent freezing. The proper design and installation of steam tracing is critical for proper plant operation.

These conditions require a large number of steam traps to be installed on steam tracing lines. During the study, 2376 steam traps were located in the plant. (More than 90% of the steam trap population was installed on tracing lines or drip legs). To evaluate the initial savings, Armstrong conducted an engineered audit on all of the installed 2376 steam straps, and 60% of them were found in a failed condition

Many steam traps were not suitable for their function, nor piped properly for the freezing conditions and were cracked or removed, allowing for the steam to blow-through directly into the atmosphere. This results in not only a direct steam loss, but also creates an unsafe working environment. Most of the steam traps were a locally manufactured, disk or thermostatic type, which have larger orifices. These types of traps, based on the nature of their operation, create additional steam losses in rain and snow events, even without being failed.

Note: Only failed traps are counted in the steam savings and GHG reductions. This is an attempt to be as conservative as possible. Some additional savings in energy and GHGs are most likely taking place from traps that are replacing those which are sub-optimal but technically not failing. In the case of Phase I, more than 2200 traps were replaced, but just over 1,400 were actually counted as failing.

Optimization Proposal: During the steam trap survey, Armstrong focused on trap mechanical performance, as well as application, sizing and piping conditions. The selection of the right type of trap and size for a given application is imperative for achieving optimum steam trap performance. Based on the survey, the necessary corrective measures in the piping and the steam traps for repair/replacement were recommended. After the plant approval, the recommended piping changes and steam traps were installed and inspected as per the signed agreement with FP (see Annex 4)

Summary of the steam traps survey and steam system improvements after the survey is provided in the following table.

Location	Detergent plant	
Measured Steam Supply	239,681	Tons/year
Steam Traps Population	2,376	Traps
Steam Traps Surveyed	2,376	Traps
Steam traps failed	1426	Traps
Steam Traps Failed	60%	
Steam traps replaced	2280	Traps
Steam loss as approved by FP	19%	
Steam savings	45,000	Tons/year

Savings: The calculated and approved savings from the failed steam traps replacement are 45,000 tons per year (based on formulas in Annex 4). The savings consist of reduced steam generation (fuel, treated water and sewer, chemicals).

Complete Condensate Return System

Background

Condensate from the heat exchangers and the steam tracing lines in the Alkyl Benzene Unit and the Fatty Alcohol Unit – thirteen condensate return lines in total – was returned

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to two flash tanks in the condensate return station. The condensate from the bottom of the flash tank was drained by gravity to two 50 m^3 underground condensate collection tanks. With the existing water treatment equipment the quality of the condensate could not meet the required boiler feed water specifications and was drained at the boiler house and was not re-used.

Problems

1. *Undersized Condensate Return Flash Tanks*

Before the project started, there was a condensate return system that returned some 1.0 Mpa MP steam condensate to 2 flash tanks, 1.2 m in diameter and 1.3 m in height. The flash steam was routed to a low pressure steam heat exchanger in the Boiler House. And the condensate was returned to two 50m^3underground condensate return tanks

There were some problems in the Flash Tanks' original design. The condensate and the flash steam could not be fully separated, which caused a lot of condensate carry over with flash steam. The condensate from the flash steam line was being drained directly to the sewer to ensure proper flow of the flash steam.

2. *Condensate Quality Is Not Adequate For Boiler Feed Water*

From the condensate quality testing result, the condensate had SiO_2 contamination, and because of the leakage in the heat coil in the heat exchanger, the condensate also had oil contamination. The plant has an existing setup for routing the condensate from the condensate return station to the deaerator in the Boiler House. Because of the oil (1.2mg/l) and SiO_2 (120µg/l) contamination, the condensate could not be used as boiler feed water.

In all of these cases, the problem was corrected, enabling use of condensate for boiler feed water.

3. *Condensate Not Returned Due to Low Pressure*

There are only 8 t/h condensate returned at present. The reasons for not returning for most condensate include: condensate pressure is too low, unbalanced pressure, and underground leaking in the condensate return line. All this condensate, after the optimization, was returned and reused.

4. *No Condensate Return System In Tank Farms*

There are 4 Heavy Oil Tanks in the outer

boundary tank farm. The tanks use steam tracing and heating coil for heating. The heating coils were suspected to have leaks, and caused contamination in the condensate. The physical distance from the tank farm to the Condensate Return Station is quite far, about 300m, and the condensate pressure is very low. Therefore, the condensate return system for the tank farm was not considered in the original condensate return system design. The condensate was drained to the sewer.

Optimization Proposal

After analyzing the initial collected data, onsite study information and optimization technical requirements, the following optimization proposals were implemented:

1. Redesign and Install New Condensate Flash Tanks

When condensate goes through a pressure drop, part of the condensate turns to low pressure flash steam. The flash tank should have enough space to fully separate the flash steam from the condensate, and ensure the free flow of the flash steam. This minimizes condensate contained in the flash steam, and allows for efficient condensate removal.

In accordance with the returned condensate pressure, flowrates, and the relevant back pressure of the flash steam, two redesigned flash tanks were installed to complete the flash steam utilization system.

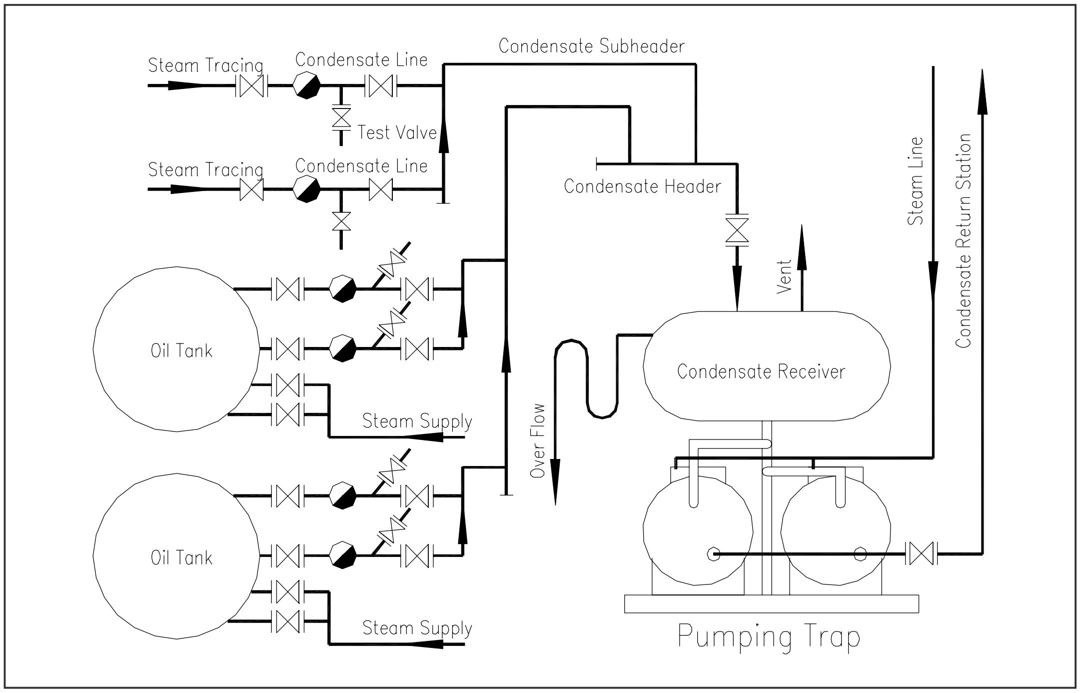
2. Optimize Part of The Condensate Return System

There are 13 condensate return lines in the system and 5 of them are buried underground. If condensate could not be returned due to low pressure, installation pumps or pump traps were considered. The mechanical integrity of all condensate return lines was inspected as well as the leaking underground condensate pipe lines. According to the inspection results, all the flow problems existing in the condensate return line were fixed and repaired.

3. *Addition of Tank Farm Condensate Return System*

In the heavy oil Tank Farm, a new pump was installed to return the condensate to the condensate-return station. The flow chart is shown below.

Figure 1: Tank Farm Condensate Return System



4. *Add Water Treatment System*

In accordance with the condensate water quality testing results, an appropriate water treatment system to remove iron and oil from the condensate was installed. This ensures that the condensate meets the Boiler Feed Water standard specifications. Treated condensate is now sent to the deaerator as boiler feed water.

Savings: After optimizing the condensate return system, the more returned condensate could be used as boiler feed water. The heat content of the condensate return saves on input energy for the boiler as compared to the use of raw (cold) water.

The implementation of the three subcontracts, started in September 2000, and was completed in June 2001. Based on the actual performance of the project, the steam savings are very significant, with a condensate recovery totaling 585,000 tons, and steam conservation reaching 45,000 tons per year (see Annex 5 -- Acceptance Report – these results were accepted by FP, the client).

Similar improvements have been identified but not implemented in the other FP facilities. The calculations for the estimated savings are described in Annex 4. These additional projects include the following:

REFINERY NO. 1 OLD AREA

Complete The Condensate Treatment System in Heating Station

Background: In the Refinery No.1 Old Area, the condensate from the hot water heating station is returned to an Iron Removing unit. After the iron is removed, the treated condensate is supposed to be sent to the softened water tank in the West Boiler House.

The condensate treatment system is not operating properly. Therefore, the treated condensate does not meet the specifications of boiler feed water.

Optimization Proposals: In accordance to the condensate water quality testing results, the project will select a suitable water treatment system to remove iron from condensate and ensure the condensate qualifies the MP Boiler Feed Water standard specifications. Treated condensate will be sent to the deaerator as boiler feed water.

Savings: After installing the suitable Iron removal system, the returned condensate will be used as boiler feed water. (See projected savings at the end of the Refinery #1 Old Area)

Utilize The Flash Steam from a Waste Heat Boiler Blowdown in Summer

Background: The flash steam from one boiler is used for unit heating in winter, but not utilized in summer. In summer, the flash steam from the continuous blowdown is vented directly to atmosphere. (See the picture on the right)

Optimization Proposals: The CDM activity and investment will enable FP to fully utilize the blowdown flash steam to reduce wasted energy. The flash steam will be routed to the deaerator located outside the West Boiler House. The flash steam rate of the continuous blowdown of waste heat boiler is about 30%. The amount of the vented flash steam in the waste heat boiler is about 0.8ton/h.

Tank Farm Condensate Return: The Refinery No. 1 Old Area has 3 Heavy Oil Tank Farms. The steam is used for tracing and coil heating. There is no condensate return system existing in the tank farms. There are about 30 Heavy Oil Tanks located in 3 tank farms, and they all use steam for tracing and heat coil. Since the condensate pressure is too low, and oil contamination in condensate is a possibility, no condensate return system has been considered, causing a large amount of steam and condensate loss.

Optimization Proposals: In tank farms, this CDM activity will allow for a condensate return system to be installed. The returned condensate will be piped to the deaerators for the steam generators in Distillation Unit and Coker Unit. The proposed tank farm steam system drawing is shown in Figure 1. After installing the condensate return system in the tank farms, the returned condensate will be used as boiler feed water

*Savings Summary Refinery #1 (old plant)***:** The total savings from Refinery #1 (old plant) are 228,000 tons of condensate or equivalent indirect steam 25,076 tons/yr.

ETHYLENE CHEMICAL PLANT

*Optimize Steam Trapping System***:** The main steam consumers in the Ethylene Chemical Plant include epoxy ethane unit, diethanol unit, ethylene unit, butylene unit, polyethylene unit, polypropylene unit, steam turbines, heat exchangers, steam tracing and heating coils for tank farms.

The steam trap system in the Ethylene plant and its present condition is comparable to the Detergent plant (already implemented). Initially, a complete steam trap survey will be done on the entire steam trap population, and steam losses will be calculated. The proposal will replicate the proposal for the Detergent plant. Based on initial studies, the expected traps for replacement are 2500 with direct steam savings of estimated 33,648 tons per year. (This assumes the same ratio of failed traps to total traps replaced – 62% -- as in Phase I, when more traps were replaced than were technically failed).

Solve The Back Pressure Problem, Prevent LP Condensate Directly Drained
In the Ethylene Chemical Plant, the condensate from heat exchangers and steam tracing is returned to the condensate receiver next to each heat exchanger. A water level control valve on each condensate receiver then should discharge the condensate to a common condensate return station in Ethylene Unit. Then it is supposed to be routed to the water treatment

system before being used as boiler feed water.

There are about 10 low pressure (LP) condensate receivers, each of them located after a heat exchanger or reboiler, to collect condensate and discharge it to the common condensate return station. Since the heat exchangers and reboilers are controlling the steam flow through control valves, the condensate pressure drops below the condensate return header pressure. When the pressure of the LP condensate is too low, the condensate cannot be returned. Since the process cannot tolerate heat exchanger flooding, condensate is drained locally to the sewer at each receiver.

Optimization Proposal
For all the condensate that cannot be returned because of the low pressure, this CDM activity will install pumping traps after each of the LP condensate receivers. According to the actual onsite condition, suitable locations for installing the pumping traps will be chosen. The recovered condensate will be sent to the common condensate return station.

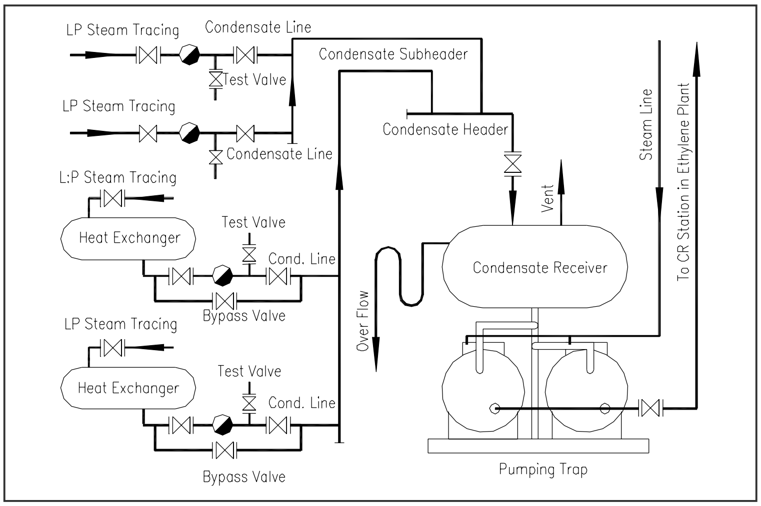


Figure 4. Proposed LP Condensate Return System for Ethylene Plant

Savings: After installing pumping traps, all the drained LP condensate can be returned. The expected savings are 21,840 tons of condensate or equivalent indirect steam 2400 tons/yr.

REFINERY NO 2
Optimize Steam Trapping System
The steam trap system in Refinery #2 and its present condition is comparable to the Detergent plant. Initially a complete steam trap survey will be done on the entire steam

trap population, and steam losses calculated. The proposal will replicate the proposal for the Detergent plant. The expected traps for replacement are 561 with direct steam savings of 11,578 tons per year.

Establish condensate Return and Treatment System

There are 22 steam consuming units in this plant. Due to design problems in the existing condensate recovery system, there are constant problems such as condensate lagging and pipeline freezing. Thus, the condensate in five units is directly discharged to the sewer. The condensate already recovered and reused as LP boiler feed water is not treated and is often forced to be discharged directly once the ion contents such as oil, iron or silicon exceed the designed standard. This does not only result in waste of water and heat resources, but will also damage the thermal equipment.

Optimization Proposal: Establish separate condensate return system in the five units and return the condensate via back pressure. Route the recovered condensate from different collection points in a pressurized close loop to the deaerator water station. Condensate coming from the replaced steam traps at other units will be routed directly to the nearest collection point via the existing condensate return system and sent to the deaerator station. The expected savings are 309,960 tons of condensate or equivalent indirect steam savings of 22,500 tons/yr.

ACRYLIC FIBER PLANT

Optimize Steam Trapping System

The indirect steam consumers in Acrylic Fiber Plant are mainly processes and tracing lines. Originally, steam traps were designed for all these indirect steam consumers. In reality, those steam traps installed on the tracing lines never have been replaced ever since they were installed 10 years ago and almost all of them were in a failed condition, resulting in huge steam leakage. Those steam traps installed at the heat exchangers suffer from short service life. Few of them can survive a heating season. Some of them can only operate for 10 days.

Steam trapping population in the pipeline is generally small. Most pipes are only installed with drip legs at the end or the expansion of the pipe. And not all drip legs are installed with steam traps. Those installed steam traps are not all configured properly. The proposal will replicate the proposal for the Detergent plant. The expected traps for replacement are 1308 with direct steam savings of 41,005 tons per year.

Optimize Condensate Return & Reuse

At present, the condensate recovery rate in the Acrylic Fiber Plant is relatively low. The recovered condensate is not reused due to problems in the existing condensate return system. In order to solve the steam erosion problem, industrial water is routed in it and thus the recovered condensate quality is greatly undermined and can only be reused as feed water to demineralized water station.

Optimization Proposal: The proposal is to establish a new condensate return system and stop adding industrial water to the condensate. The quality of the recovered condensate will be greatly improved and can be reused as demineralized water to incinerator and reactor in the Acrylic Fiber Plant to generate LP and MP steam. The remaining condensate can be used as secondary demineralized water in the main Power Plant. The expected savings are 464,000 tons of condensate or equivalent indirect steam savings of 27,300 tons/yr.