NUCON International, Inc.

VAPOR EMISSION CONTROL AT A PHARMACEUTICAL SEMI-WORKS

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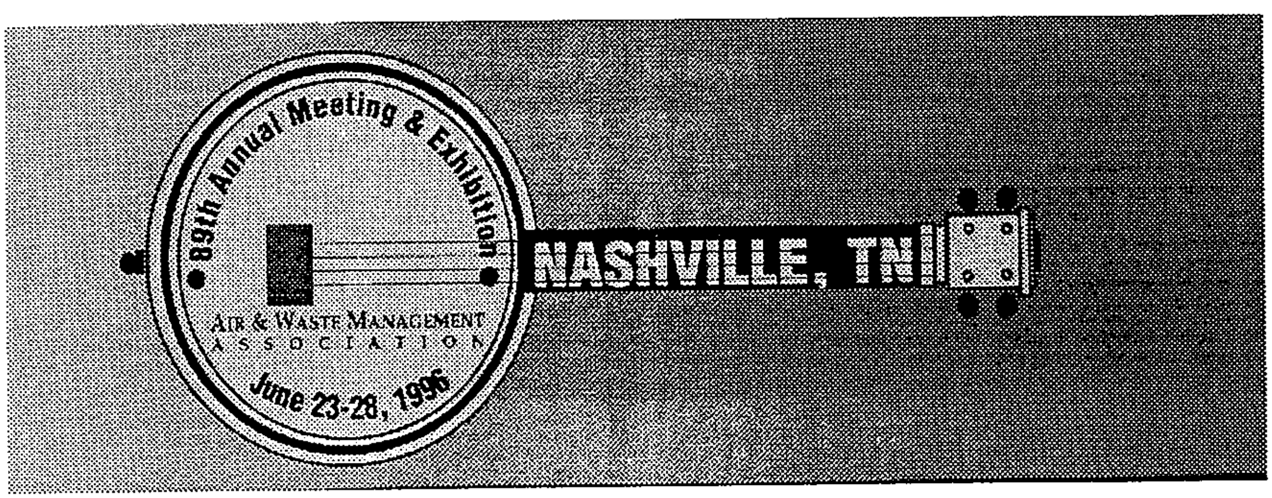

INTRODUCTION

Various types of processing equipment were being installed at a pharmaceutical manufacturing complex to provide small production lots of product. Solvents would be used as vehicles for coatings and emission control was required. The emission control equipment would have to be operable on an intermittent basis, be able to control a variety of solvents with varying concentrations and be capable of handling airflows ranging from zero to the capacity of the largest coating equipment. A condensing system using Brayton cycle solvent recovery heat pump (BRAYCYCLE®) technology was selected. The scope of this paper includes the design criteria, the selection process and operating results.

FACILITY AND EQUIPMENT DESCRIPTION

The construction of a the New Solid Dosage Form Facility at Sandoz was completed in the fall of 1994. The new Solvent Handling Building (SHB), along with the renovated existing facility was designed to meet the research, development and regulatory challenges of the latter 1990's. The building, which was attached to the process area, is two story with a partial basement. Since flammable solvents are present in piping and tanks, the entire building is designated hazardous, Class I Division 2.

The product processing area was built to provide expanded formulation capabilities for modified release drug delivery products, and other innovations. It incorporated ventilation and waste water handling concepts designed to provide worker safety, environmental compliance, and "clinical" manufacturing capability.

There are four major process units which use and exhaust solvents, a fluid bed processor, two tablet coaters, and a tray dryer (see Figure 1). To minimize problems associated with the use of recycled fluids, the air is passed from the process units through the emission control device and out to atmosphere. Therefore, there is no cross contamination and the environmental issues are kept separate from the product processing requirements.

The emission control system (ECS) is located indoors. The space had been allocated before the type of process was selected and it was a fairly confined area. The footprint of the space was 20ft. By 55ft. The ceiling height was 24ft., but various HVAC equipment, ducting and electrical conduit was to be installed on top of the ECS.

EMISSION CONTROL REQUIREMENTS

The requirements for air emission control of both Particulates and Volatile Organic Compounds (VOC) are mandated by the Federal Environmental Protection Agency (EPA) and the more stringent New Jersey Department of Environmental Protection (DEP). The ECS was designed to meet the DEP requirements that new equipment must emit less than 3 lbs/hr VOC. A control device is also required to control particulate emissions to less than 0.5 lbs./hr.

OPERATING REQUIREMENTS

Planning for the facility was conducted several years before installation. The types of products to be processed were not fully defined. Therefore, several solvents and combinations were included as potential components in the solvent laden air (SLA). They included methanol, ethanol, acetone, methylene chloride and isopropanol. In some cases, there would be mixtures such as methanol/methylene chloride.

The pharmaceutical processing equipment was selected to provide flexibility. The coaters and dryers would use both solvent and aqueous based formulations. The batches would vary in size and more than one piece of equipment might operate at one time, each exhausting air to the ECS. The air flows would range from 250 SCFM to a maximum of 1760 SCFM. During startup of the ECS, the inlet would be fresh or recirculated air. The emission standards would have to be met during any and all operating modes. Operations at the facility would be conducted primarily on the day shift on weekdays. It would be necessary to start and stop the ECS daily.

EMISSION CONTROL EQUIPMENT SELECTION

A number of options for the emission control equipment were evaluated:

1. Reverse Brayton cycle condensation
2. Carbon adsorption
    A. Reverse Brayton cycle regeneration
    B. Steam regeneration
    C. Nitrogen regeneration
3. Recycle with condensation (-20 °C)
4. Thermal or catalytic oxidation

The choices were eventually narrowed to three, reverse Brayton cycle condensation, carbon adsorption with reverse Brayton cycle regeneration and Recycled nitrogen with condensation. The recycle concept was rejected because high concentrations of solvent would be cycled back to the pharmaceutical processing equipment. Carbon adsorption would not be effective for methanol. The low temperature (-95°C) condensing provided by the BRAYCYCLE® system would meet the emission control requirements for all operating schemes. The capital and operating costs were competitive with other once-through systems and the equipment had been used in a similar pharmaceutical processing application.

EMISSION CONTROL PROCESS DESCRIPTION

The technique chosen to prevent solvent emissions was to simply reduce the temperature to a low enough level to condense the solvents so they could be separated from the air. Since most of the solvents had freezing points near -100°C, that general temperature level was chosen as the primary design criteria. The BRAYCYCLE® process, conceived in 1979 and developed over the next 15 years can achieve this temperature level with a fairly simple process scheme. The process design is shown in Figure 2.

The solvent laden air (SLA) from the coating equipment exhaust enters the process and is compressed in three stages. A multi-stage centrifugal compressor set raises the pressure to about 17 psig. Final compression to 23 psig takes place in the turbo compressor. In order to minimize compressor size, coolers are installed to remove the heat of compression from each stage. In order to prevent freeze-up in the low temperature section of the process, the SLA is then passed through a desiccant bed dryer. One bed removes water while the other one is being regenerated. The next step is precooling in the heat interchanger from which the SLA passes into the turbo expander. Both of these steps result in solvent condensation and the liquid is removed from the air. The cold air then passes back through the recuperator and is exhausted to atmosphere or returned to the system inlet. This recycle feature allows 100% turndown on SLA flow.

Most of the condensation takes place in the heat interchanger and the liquid is separated in a vertical cylindrical vessel with a standard demister. However, in order to meet the specified outlet concentration limits, a high efficiency, submicron mist eliminator was installed downstream of the expander. At this point the temperature is controlled at just above the freezing point of the solvent being recovered.

During startup, air is recirculated from exhaust back to the inlet. Therefore, the air is dry and there is no water being adsorbed on the desiccant beds. If outside air was circulated during this time, a significant portion of the desiccant capacity would be used. During regeneration of the desiccant, the air is circulated in a closed loop so that any solvent held by the desiccant will be condensed and collected rather than being exhausted to atmosphere.

Startup and shutdown of the system is coordinated with the operation of the pharmaceutical processing equipment. Shutdown can also be accomplished by merely inputting the stop directive and the PLC performs all necessary functions for safe shutdown.

OPERATING PERFORMANCE

Since the ECS would be started up daily, it was important that the time required to reach operating temperature be minimized. Some conventional refrigeration systems require up to 12 hours to cool down, and therefore must be operated continuously with resulting high power consumption. Expander operating temperatures during a typical startup are shown in Figure 3. Solvent spraying was initiated at about 10:15 which was about 1 hour after system start.

Control of the temperature at the expander outlet is critical for performance of the ECS. If the temperature is too low, the solvent will freeze and plug up the final mist eliminator. If the temperature is too high, too much solvent will remain in the vapor phase and be exhausted to atmosphere. Primary temperature control is accomplished by adjusting flow through the system with a flow control valve at the inlet to the compressor. A secondary impact of high flow is high system pressure. A test was performed to evaluate this effect and the results are shown in Figure 4. At an expander inlet pressure of 22 psig, the expander outlet temperature dropped to -90 °C. When the flow was reduced and the pressure dropped at 13:00 and 13:40, the temperature rose. The lowest temperature , -99 °C, was achieved when the flow was maximized and the pressure was just over 23 psig.

The most important performance criteria is the solvent removal efficiency. Any condensing system will have a fixed concentration of solvent in the outlet at a given set of operating conditions. The actual removal efficiency, represented as a percent of the inlet concentration, will vary with the inlet concentration. For example, the typical outlet concentration of ethanol from the ECS is 125 ppmv. If the inlet concentration is 12,500 ppmv, the resulting efficiency is 99%. If the inlet concentration is only 1,250 ppmv, the efficiency is 90%. Therefore, condensing systems are used most frequently in situations when the inlet concentration is high. A plot of the inlet and outlet concentrations during a typical day of operation is shown in Figure 5. The outlet concentration was typically 125 ppmv which represented a recovery efficiency of 98.8%. During this run, 800 SCFM was being exhausted to atmosphere, and the quantity of ethanol discharged was 0.71 lbs/hr.

NEW FEATURES

The BCSRHP technology is still evolving and as problems are encountered, solutions are devised. That was the case during design and startup of the Sandoz system. One of the desires was to be able to help the client solve operating problems quickly. Since the vendors office is 600 miles from the installed unit, personal visits would be costly. A modem link was established which allowed evaluation of the operating parameters from the vendors location. It was also useful to walk the client through changes in the PLC program to optimize operations and to modify process parameters for unique situations.

Fine mist removal from an expander outlet is achieved in the gas processing industry with standard impact type mesh pads. However, the solvent recovery situation is different because the quantity of solvent condensed is much lower. The result is that very fine particles are formed which cannot be removed by the standard equipment. A diffusion type mist eliminator was incorporated into the design of this system and essentially complete removal of the submicron mist particles generated in the expander was achieved.

For all previous Brayton cycle solvent recovery heat pump units the flow control was not critical. They were either completely closed or open loop designs. In this case, a combination would be used and variable flow control was required. A flow control damper was installed upstream of the first compressor stage to both control process temperature and balance inlet and bypass flows.

CONCLUSIONS

The emission control application at the Sandoz was unique because of the variations in air flow, solvent type and operating schedule. The BRAYCYCLE® condensing system has met all specifications and operating criteria. It is operating trouble free on a daily basis.

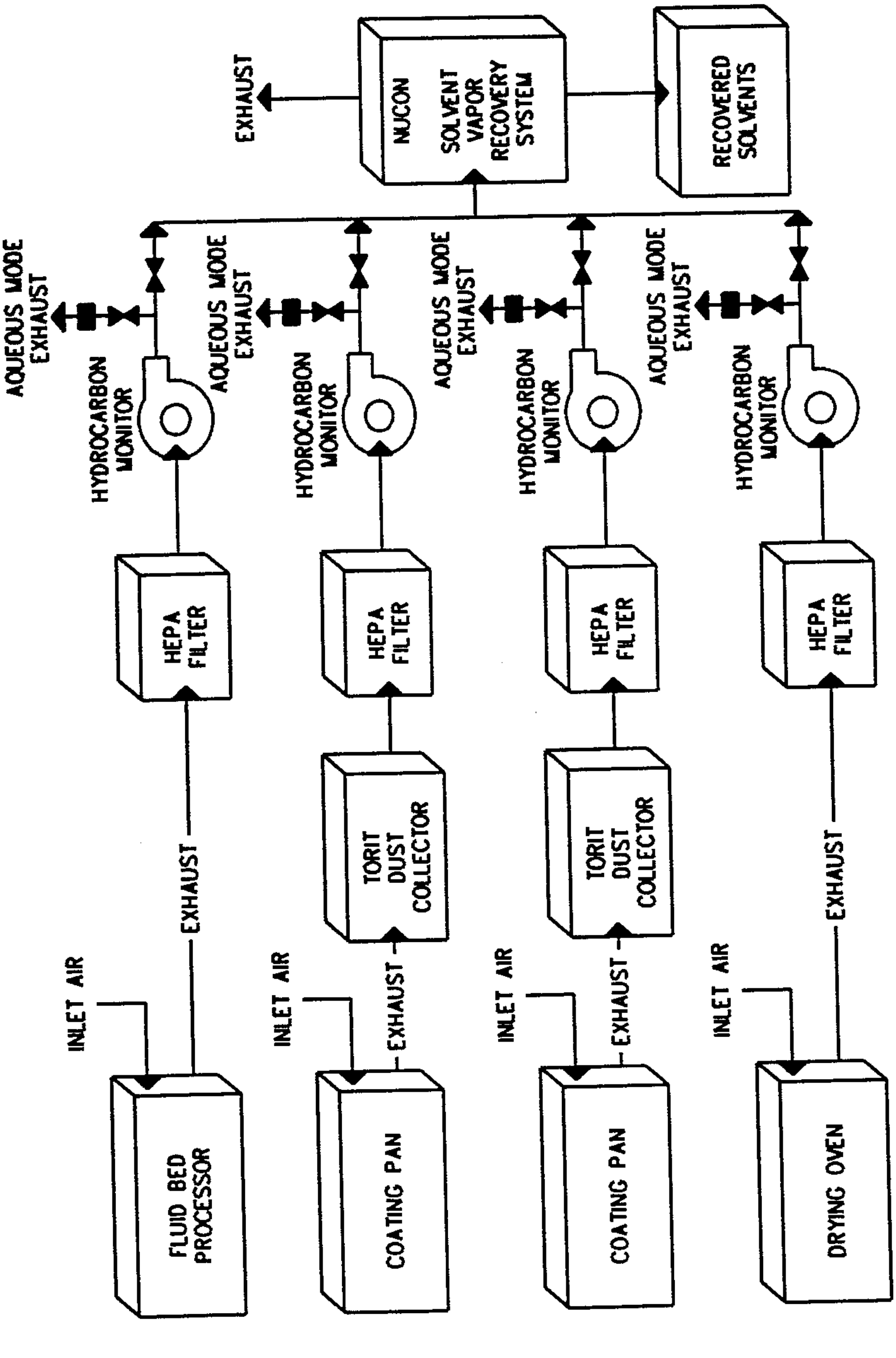

Figure 1 Emission Control System

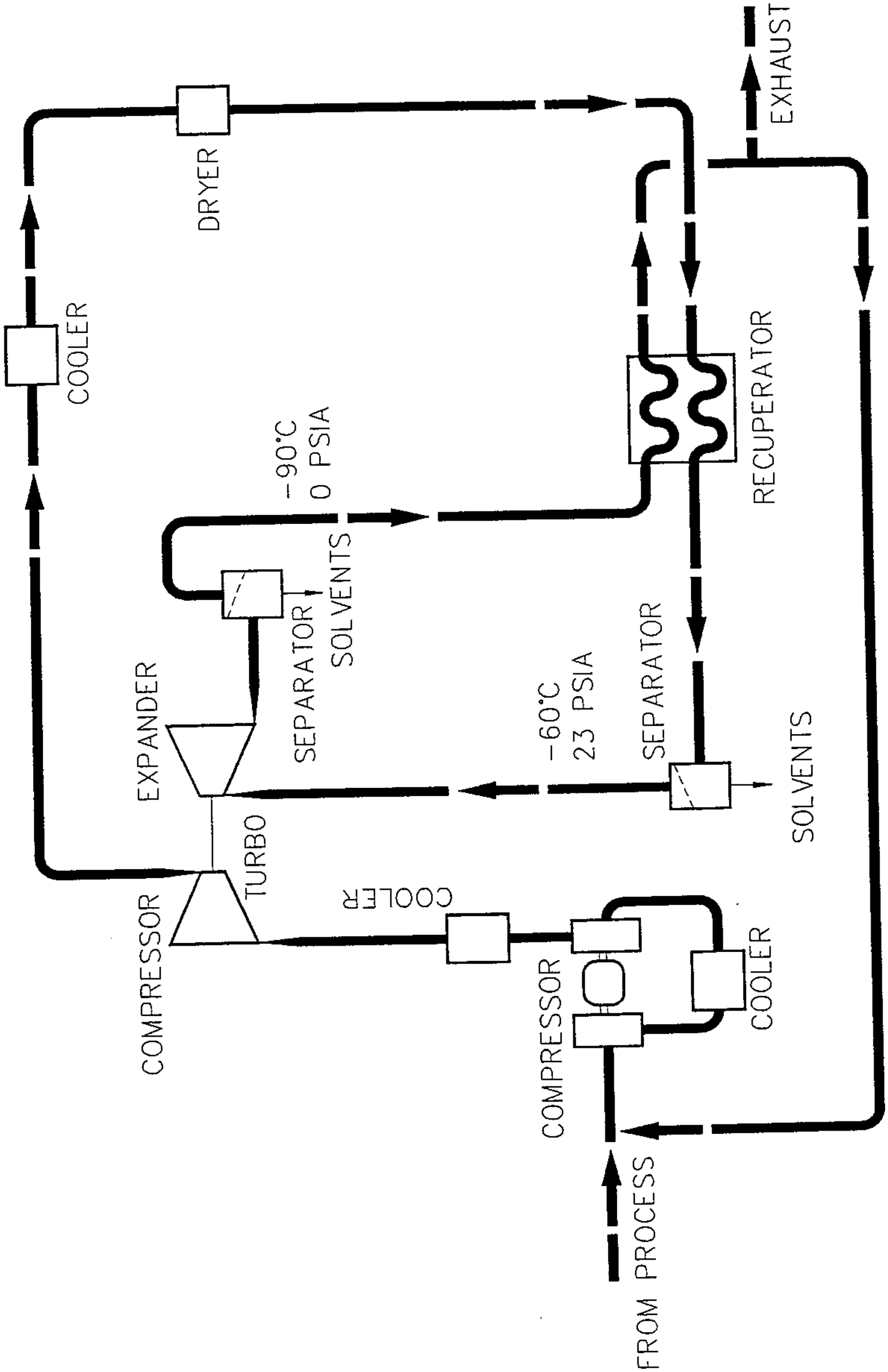

Figure 2 Process Flow Diagram

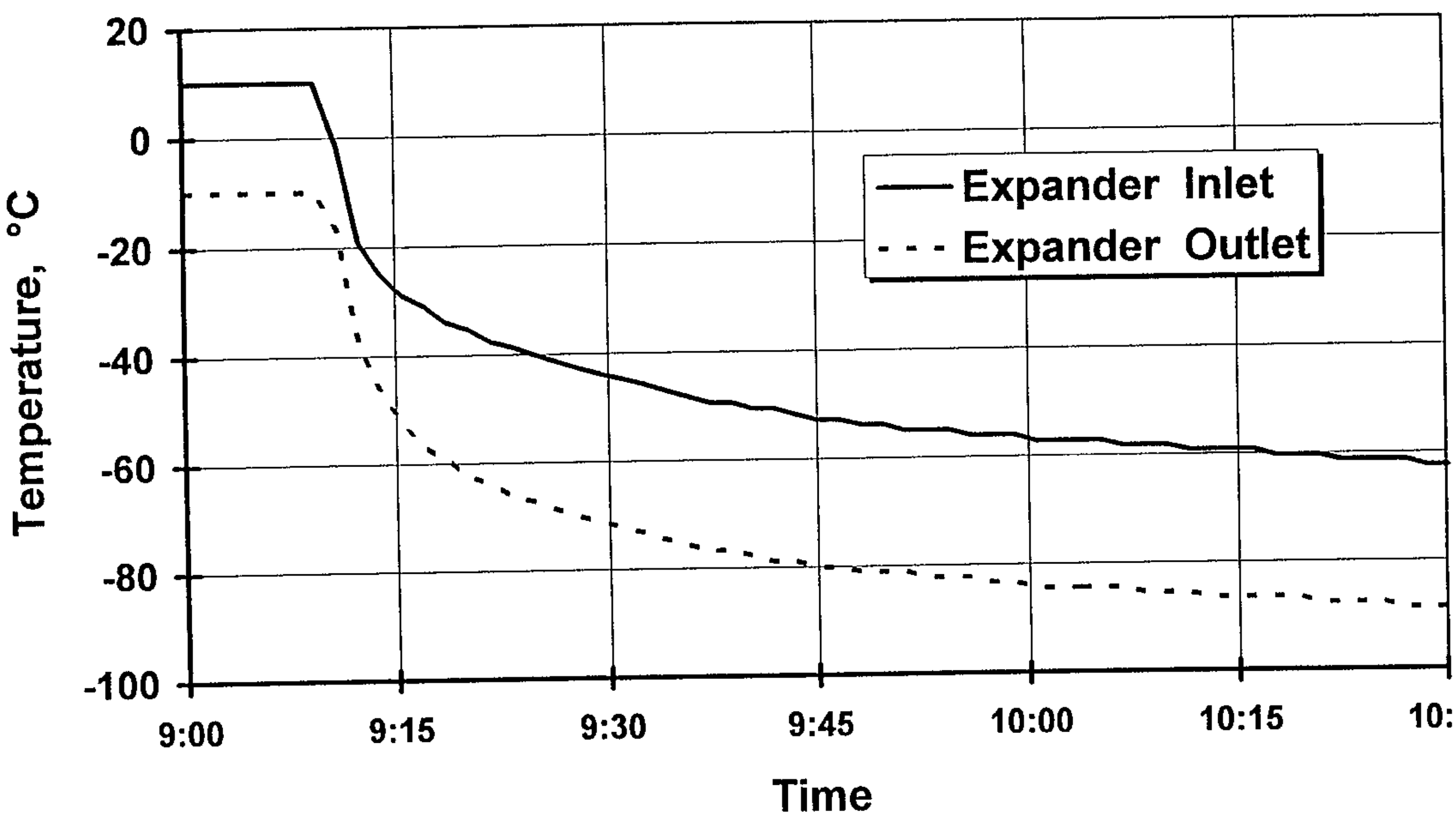

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Figure 3 Expander temperatures during startup

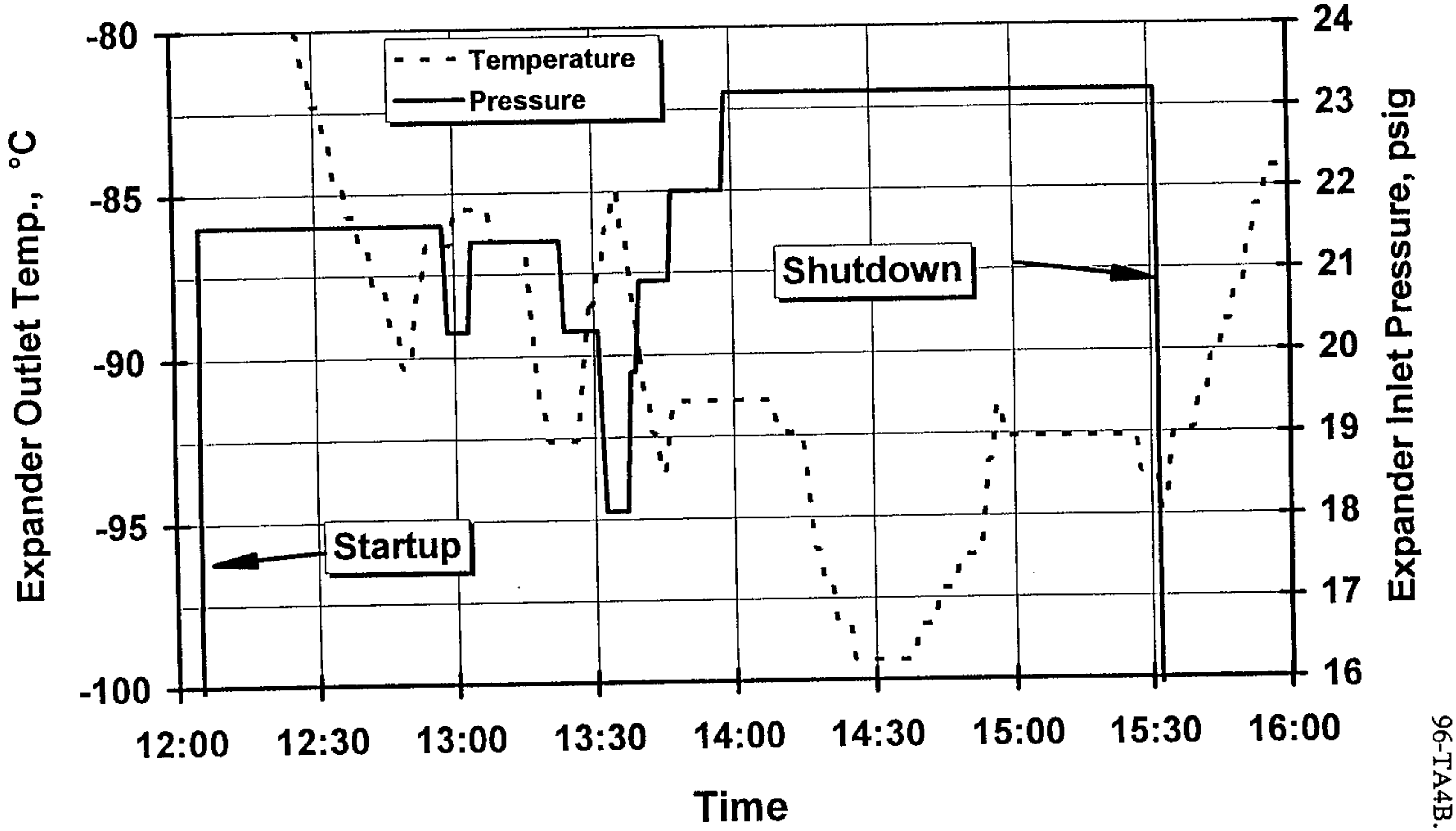

Figure 4 Temperature Control

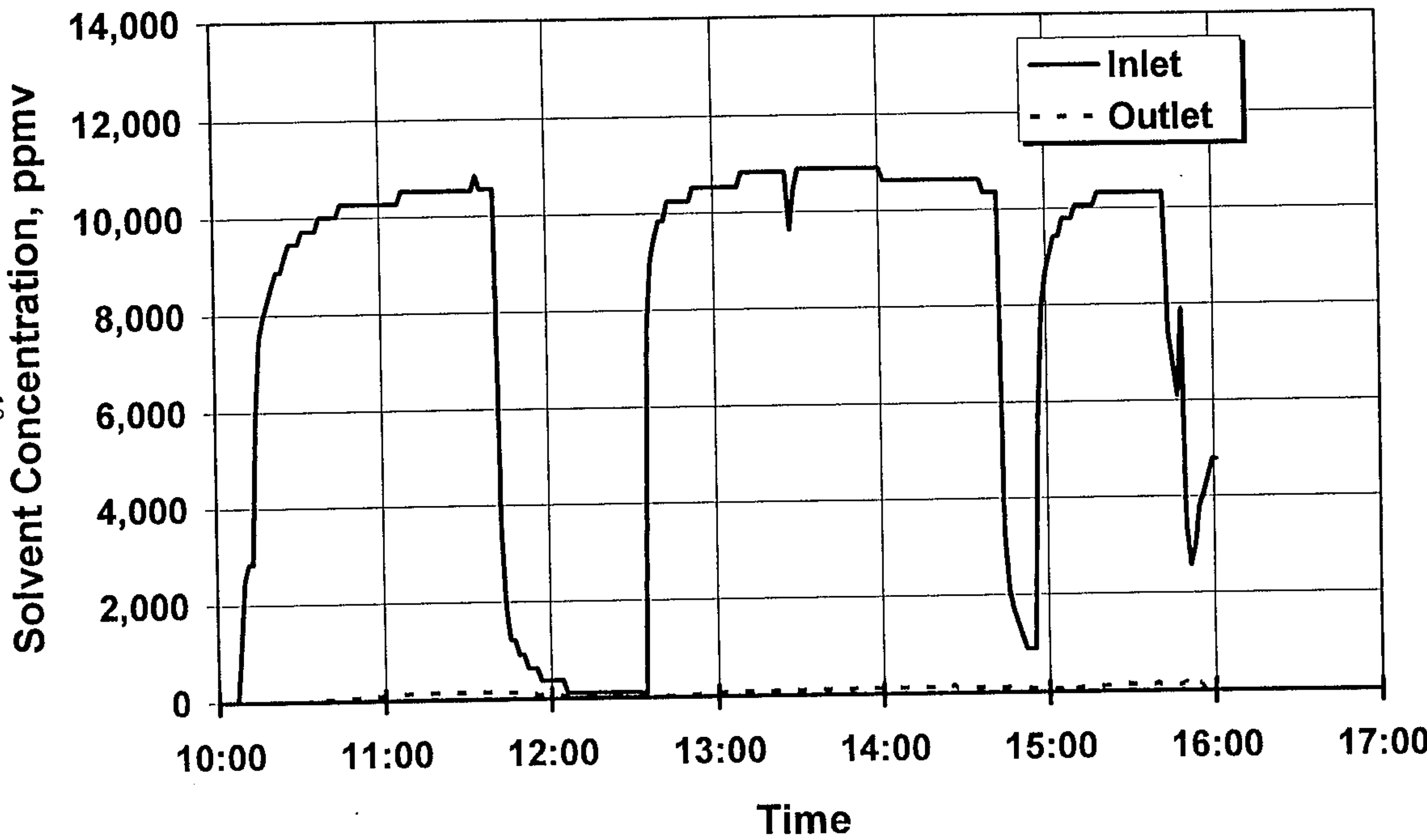

Figure 5 Solvent Recovery Performance

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