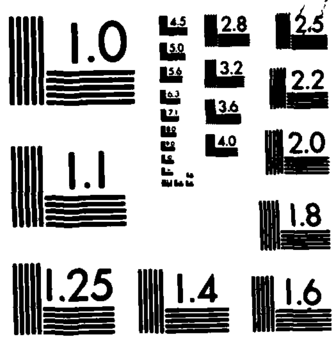
AD-A131 117 ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U) 1/5
SYSKA AND HENNESSY INC NEW YORK JAN 81
N62472-78-C-1059

UNCLASSIFIED F/G 5/3 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CONTRACT NO.
N62472-78-C-1059

Energy Conservation Guide For Industrial Processes

NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PENNSYLVANIA

JANUARY 1981

Syska & Hennessy

Enclosure ( )

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. A187117
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Energy Conservation Guide for Industrial Processes	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Syska & Hennessy, Engineers	8. CONTRACT OR GRANT NUMBER(s) N62472-78-C-1059
9. PERFORMING ORGANIZATION NAME AND ADDRESS Syska & Hennessy Engineers, 11 West 42nd Street, New York, NY 10036	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Northern Division, Naval Facilities Engineering Facilities, Naval Base, Code 111, Phila., PA 19112	12. REPORT DATE January 1981
	13. NUMBER OF PAGES Approximately 370
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA 22332	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited Distribution.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Industrial Energy Conservation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Energy Conservation Guide for Industrial Processes has simple instructions to survey energy use areas at Navy Industrial Activities like Shipyards, Naval Air Rework Facilities and Government Owned, Contractor Operated (GOCO) plants.

This guide includes information and procedures on:

- Organizing and conducting an Industrial Energy Survey;
- Evaluating purchased energy data,
- Descriptions of Industrial Systems, and
- Evaluation of industrial processes for conservation.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Enclosure (2)

DEPARTMENT OF THE NAVY
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PENNSYLVANIA 19112

Executive Order 12003 of 20 July 1977 requires a 20% reduction in energy usage in all existing federal buildings by fiscal year 1985. Fiscal year 1975 usage has been established as the baseline against which the reduction effort is to be measured.

To assist the Naval Shore Facilities to achieve their goals, the Naval Facilities Engineering Command implemented the Energy Engineering Program (EEP). Under this program, Northern Division's Energy Programs Branch, Code 111, was assigned the task of having a survey guide developed that could be used by Navy Industrial Activities in implementing an energy conservation program.

The result of this assignment is this Energy Conservation Guide for Industrial Processes which provides easy to follow instructions and procedures for systematically surveying industrial energy use areas at Navy Industrial Activities such as Naval Shipyards, Naval Air Rework Facilities and Government Owned, Contractor Operated (GOCO) plants.

Information and procedures are provided in this Guide on:

- How to organize and conduct an Industrial Energy Survey
- How to evaluate purchased energy data
- How to evaluate industrial processes for energy conservation opportunities
- How to prepare Energy Conservation Investment Program (ECIP) projects and Energy Technology Applications Program (ETAP) projects.

ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES

CONTRACT NO. N62472-78-C-1059
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

BY

SYSKA & HENNESSY, ENGINEERS
11 WEST 42ND STREET
NEW YORK, NEW YORK 10036

The material contained in Energy Conservation Guide for Industrial Processes is not intended to be used in connection with a particular installation. The adaption and use should be the responsibility of a skilled professional at the site. The contractor, Syska & Hennessy is not responsible for any claims, losses, damages or expenses arising from the use of "Energy Conservation Guide for Industrial Processes."

ENERGY CONSERVATION GUIDE

FOR

INDUSTRIAL PROCESSES

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

APPENDICES

APPENDICES (Continued)

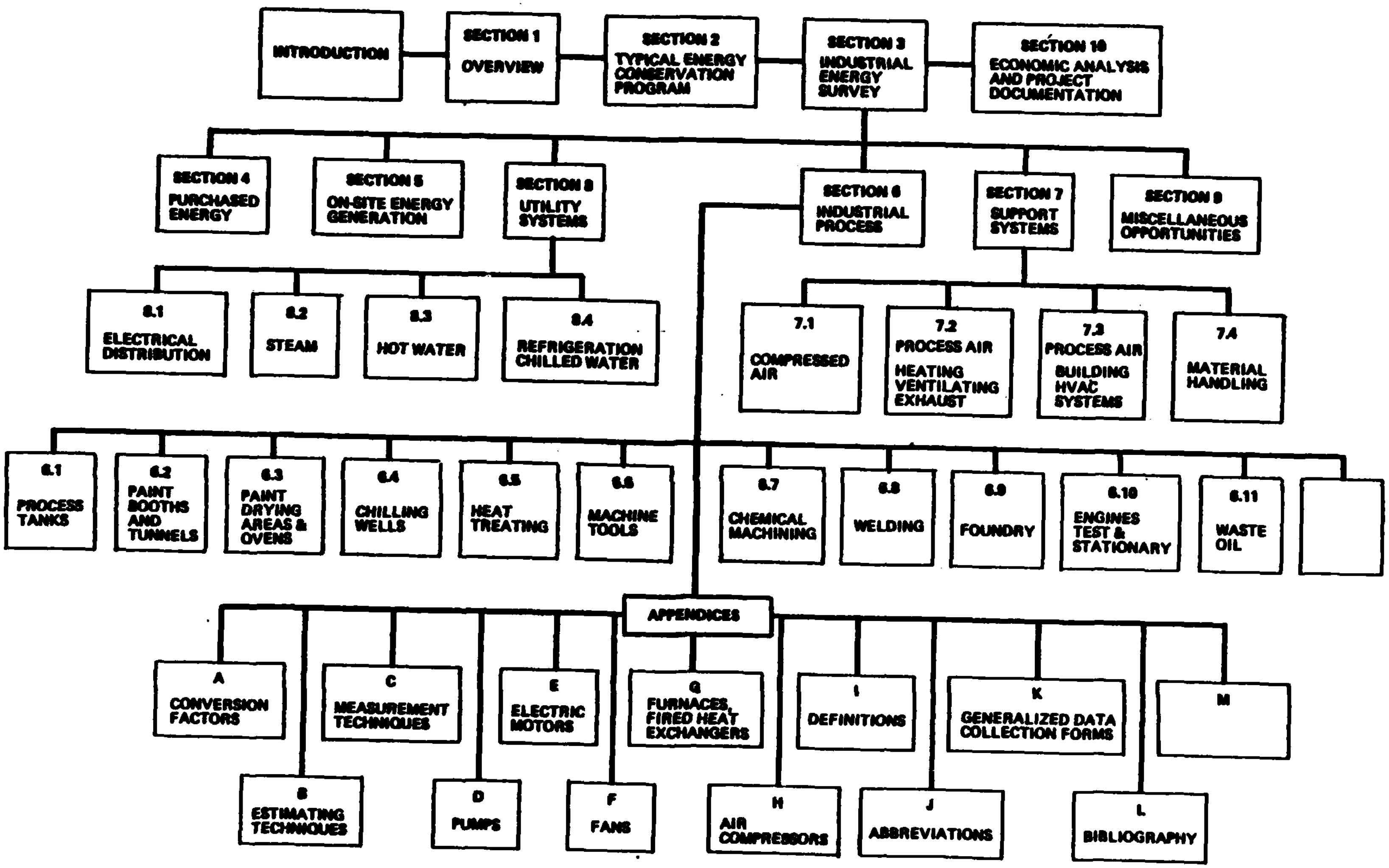
APPENDICES (Continued)

AN INTRODUCTION TO THE GUIDE

The purpose of this Guide is to provide instructions and procedures for evaluating the energy utilization of selected industrial processing equipment.

A block diagram of the contents of the Guide is presented in Figure INTRO-1. A brief description of Figure INTRO-1 and the Guide follows.

ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES



The first five sections of the GUIDE contain:

a. The answers to the most-often-asked-questions about energy conservation. The OVERVIEW sets the stage in SECTION ONE.

b. A typical Energy Conservation Program is developed in SECTION TWO.

c. How to organize and conduct an Industrial Energy Survey is the purpose of SECTION THREE.

d. How to evaluate Purchased Energy consumption data in SECTION FOUR and On-Site Energy Generation in SECTION FIVE is discussed.

The industrial processes that appear to offer practical energy conservation opportunities are included in SECTION 6. The unique features of each of the processes are listed in their appropriate subsections while information on devices which are common to most industrial processes are contained in the appendices. For example, a paint booth has its unique design and operating characteristics developed in SECTION 6.3, while generalized information about electric motors and fans is located in the APPENDICES G & H. Likewise, the information about a heat-treat oven, SECTION 6.5 will be directed towards its unique features. Energy conservation data for the fans, motors, etc. are found in the APPENDICES.

The Guidebook format has been designed to:

a. Allow for the uniqueness of each facility. Provide flexibility so that Data Collecion, Analysis and Check-off sheets can be assembled based on the type of equipment to be surveyed and the detail required in the survey.

b. Allow for flexibility in additions and updating. Data for processes not covered in this Guidebook can be added to SECTION 6 and the APPENDIX.

c. Allow easy updating so that as new energy conservation information and techniques are developed, they can be added to the Guidebook.

Support systems, such as compressed air and exhaust systems are another source of energy conservation opportunities. The systems are included in SECTION 7. For example, the paint booth survey, discussed earlier, might also include data and forms from SECTION 7.1 Compressed Air, and SECTION 7.2 Process Air: Heating, Ventilating and Exhaust.

Another survey could include a number of heated wash tanks. Each tank is without lids and requires air for agitation. The following resources in the Guide would be investigated:

SECTION 6.1, Process Tanks

SECTION 7.1, Compressed Air

SECTION 7.2, Process Air: Heating, Ventilating and Exhaust.

APPENDIX D, Pumps.

APPENDIX E, Electric Motors.

APPENDIX F, Fans.

APPENDIX H, Air Compressors.

Energy conservation opportunities found in utility systems and miscellaneous systems are developed in SECTION 8 and SECTION 9.

Energy conservation and economics are inseparable. Economic analysis and project document are explained in SECTION 10 for MILCON and Special Projects.

APPENDICES A, B, C, I and J contain definitions, abbreviations, heating values, energy measurement techniques and energy cost estimating techniques.

APPENDICES D through H contain data collection and analysis forms for the equipment common to most industrial processes - namely: pumps, electric motors, fans, furnaces-fired heat exchanges and air compressors.

Each facility has its own unique role, and as a result must operate in a specialized manner. The challenge is to develop an energy conservation plan for the facility that is neither disruptive or confusing. It is reasonable to believe that no one Guide could be developed that would be complete for every facility. The Guide, however, takes this into account and its format is designed to be flexible. A key to the success of the program will be the manner in which the personnel at a facility modify the Guide to accommodate their particular industrial processes.

SECTION 1

OVERVIEW

1.1 ITEMS TO BE CONSIDERED. Improved energy management is a worthwhile goal. Energy management is not new. Today, however, there is more emphasis on improving it. This overview of the Guide considers the following:

1.1.1 Why energy conservation?

1.1.2 What does the Guide provide?

1.1.3 What is industrial process equipment?

1.1.4 What processes typically yield potential energy savings?

1.1.5 Why are energy savings reported as source energy?

1.1.6 What are MBtu?

1.1.7 Why is the Guide format modular?

1.1.1 Why Energy Conservation?

Today's high energy costs and impending fuel shortages have propagated a new interest in energy conservation. The President's Executive Order No. 12003 requires that all federal departments and agencies adopt procedures which aim at reducing energy use in federal buildings. The order calls for a 20% reduction by 1985 from 1975 standards in existing buildings, and by 45% for new federal buildings. Since the start of 1977, department and agency heads have been initiating programs which accomplish this end. Directives from the Department of Defense and trhe Chief of Naval Operations have initiated energy conservation programs at all major naval installations.

1.1.2 <u>What Does the Guide Provide?</u>

The guide provides methods to evaluate the energy utilization of selected industrial process equipment. The guide can be used to identify and analyze cost-effective energy conservation opportunities.

It accomplishes this by identifying process equipment which has the highest energy conservation potential, and specifies the data needed for thermal and electrical analysis. The Guide describes the phases of a survey including review of related documentation, data collection, estimating energy usage and savings, modifications, and payback. It is intended that this Guide and its references be sufficient to enable facilities/utilities engineering personnel, to conduct basic industrial energy surveys. Sample data sheets are included; specific data for each type process is listed. Computational methods have been reduced to a simplified format to expedite the process of estimating energy consumption. The Guide describes how to recognize the large energy users and suggests solutions which will reduce consumption. The Guide also describes how to identify energy conservation projects and relates them to Energy Conservation Investment Program (ECIP) selection guidelines.

1.1.3 What is Industrial Process Equipment?

Industrial process equipment, as defined in this document, includes machinery, ovens, tanks, test facilities, etc., used to fabricate repair, refinish and test. Supporting laboratories are also considered to be process equipment. To complete the definition, the equipment or process should have a nameplate rating of at least 8 KW or 30,000 Btu/hr.

1.1.4 What Processes Typically Yield Potential Energy Savings?

An example of a typical plant devoted to aircraft manufacturing is Grumman Aerospace Corporation's Plant 2 in Bethpage, New York. Table A shows an apportionment of where the steam and electricity are used.

TABLE A ENERGY CONSUMPTION, TYPICAL AIRCRAFT

MFG. AND PROCESS FACILITY*

Energy User	% Plant Electric	% Plant Steam
Lights	37	-
HVAC System	15	17
Process Exhaust	13	34
Process Paint Hangar	7	33
Process Heat	3	16
Process Equipment	25	-
TOTALS	100	100

*Table A information is from the Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Virginia, Atlantic Division, NAVFAC, 1978.

The requirement for lighting and exhausting large amounts of conditioned air results in the greatest energy usage. Electric power to run exhaust and make-up fans, and steam for heating and humidification account for the bulk of energy consumed in spray finishing facilities, chemical process tanks, and vapor degreasing tanks. A considerable amount of energy is consumed in cutting, grinding, abrasive - cleaning, welding and foundry operations.

Table B shows a summary of the classification of energy savings resulting from equipment and procedural modifications. Spray finishing operations account for one-third, chemical process tanks account for one-third, and the remaining third is distributed among vapor degreasing, air compressors, cutting, grinding, foundry, and laboratories. The relative contribution to energy conservation will vary from plant to plant and by location; however, these figures indicate those areas with the greatest potential for energy reduction.

The Table B information is from the Energy Conservation Guide for Industrial Process, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978.

TABLE B POTENTIAL ENERGY SAVINGS, TYPICAL AIRCRAFT MFG. & PROCESS EQUIPMENT*

	% Potential Savings	
Processes	Electrical	Steam
Spray Finishing	36	54
Process Tank Lines	34	23
Heat-Treat	12	11
Vapor Degreasing	6	10
Air Compressors	8	-
Foundry	2	1
Cutting, Grinding, Welding	2	1
TOTALS	100	100

1.1.5 Why Are Energy Savings Reported as "Source" Energy?

The production of energy from various fuels and systems can be expressed in terms of the BTU (British Thermal Unit). The energy in a cubic foot of natural gas or a kilowatt-hour of electricity can be expressed in a common term of Btu's.

Since most electrical energy in the United States is produced in thermal plants, the source energy must take into account the efficiency of converting thermal energy to electrical energy as well as the electrical distribution losses. To produce and deliver 1 kw-hr of electricity to the plant a conversion factor of 11,600 Btu per kw-hr is used. Hence, every kw-hr conserved in the operaton of the industrial plant represents a saving of 11,600 Btu of fuel at the electric generating station. From the point of view of physics, the amount of energy in one kw-hr is 3413 Btu. The conversion factor is often used, but it does not come to grips with the efficiency of the energy conversion equipment.

1.1.6 What are M Btu?

There is considerable confusion and sometimes errors result from the interpretation of the term M Btu. Is it one thousand Btu or one million Btu? Sometimes, the term is written as MM Btu, a sure sign that M is a Roman numeral, and the term is for 1000 times 1000 Btu or one million Btu. In this document M is the abbreviation for mega, and M Btu will mean one million Btu's. Other documents may differ, and the reader should be certain of the definition used in the document.

1.1.7 Why is the Guide Format Modular?

If the time to do a comprehensive audit of the complete facility is not available, the Guide is arranged so that an energy management team can elect to do sections of it. Furthermore, the format allows for modifications to the manual should a facility, because of its uniqueness, need to emphasize or add sections.

SECTION 2

A TYPICAL ENERGY CONSERVATION PROGRAM

2.1 TYPICAL PROGRAM

The Guide deals with the energy conservation survey for an industrial facility. It is important to recognize that it is but an element of a typical energy conservation plan. The following is an outline of an energy conservation program. It is general and should be modified to conform with local situations. These guidelines are as follows:

a. Management should demonstrate their commitment and set goals.

b. Survey industrial energy uses, analyze data, and develop savings proposals.

c. Take action to conserve energy by defining and implementing projects.

d. Develop a continuing effort to assure that savings opportunities are seized as they appear.

Management can demonstrate their commitment by taking the following action:

a. Inform line supervisors of the economic reasons for energy conservation and the responsibility to take action in their areas.

b. Establish a committee with representaton from each shop, the utility department, engineering, and others; appoint a coordinator with the responsibility to report to management.

c. Plan and take part in energy audits.

d. Develop and improve energy metering, accounting and reporting.

e. Develop tough but achievable goals for energy conservation based on inputs from preliminary surveys of the departments involved.

f. Research, develop, and promote energy conservation ideas.

g. Enlist employee participation at all levels by appropraite communication and activity programs.

Survey industrial energy uses:

a. Set priorities for the various areas based on knowledge of energy usage. Do the surveys in order of priority.

b. Take readings and perform test to identify energy losses and waste.

c. Analyze the readings to determine the losses and compare with standards to arrive at potential savings.

d. Select a corrective action and make an economic evaluation to determine its feasibility.

e. Make off-hours surveys to determine wasteful situations such as unnecessary lighting, ventilation, or equipment left running.

f. Analyze major systems such as steam, water, and compressed air to improve metering; reduce leaks; and establish needs for appropriate energy recovery devices.

Take action to conserve energy by:

a. Correcting maintenance and operational problems such as leaks and unnecessary running ventilation systems. Claim savings for these as part of the program effort.

b. Preparing for each project either a short form or detailed economic analysis, as required by the estimated cost to implement.

c. Listing proposed energy conservation projects in categories such as projects requiring no cost to implement, projects requiring minor cost to implement, and so on.

d. Recommending implementation of projects according to priority based on payback times.

e. Reviewing designs of all capital projects, such as expansion, new buildings, modernization, and revisions to assure that energy is efficiently utilized.

Establish a continuing energy management program since it:

a. Provides a constant check that conservation steps in operation are being sustained.

b. Will reveal if maintenance of equipment is slipping.

c. Documents energy management savings in Btu's as well as in dollars.

The concept of developing a continuing effort to conserve energy is important. Some benefits of energy conservation are certainly achievable on a one-shot basis, but true management requires continuing vigilance to prevent operational back-sliding. The opportunities for conservation are not exhausted by a one-shot application because, with inflationary escalation of costs, new opportunities are created continuously.

SECTION 3

THE INDUSTRIAL ENERGY SURVEY

3.1 SURVEY OBJECTIVES

The survey has four distinct objectives, each necessary for a thorough understanding of energy management at the facility. They are:

a. To document the industrial energy consumption by fuel type and amount purchased, electricity purchased, and steam purchased (if any), and also the on-site production of utilities. These data will show your total utility consumption, along with total dollars spent for utilities each month during the past year; in addition, these figures will show monthly peaks and seasonal trends in usage, and may be used in specific energy-use calculations. This information will also be the basis for the economic evaluation of energy-conservation opportunities identified as a result of the audit.

b. To provide an analysis of the energy consumption of industrial processes, including the energy consumption for each process by type of fuel or energy. Such items as furnaces, ovens, exhaust systems, etc. will be evaluated and analyzed, both separately and in relation to each other, for energy consumption and efficiency.

c. To identify energy conservation opportunities and to provide alternative methods for controlling and reducing energy consumption. These will include operational changes and capital additions for such items as heat recovery and control equipment.

d. To identify monitoring equipment and provide the procedures needed for an on-going energy monitoring and control program.

3.2 PRELIMINARY TASKS BEFORE CONDUCTING THE SURVEY

a. Statement of Work and Schedule. When a facility is selected for an energy survey, the initial effort should include the following two steps. The first is to generate a statement of work and the second is to prepare a program schedule. When the survey is an "in-house" effort, this is usually the first scheduling task. Surveys done by outside contractors, however, must include and define those items in the agreed-to-work statement and schedule, which is an integral part of the contractual document.

b. Security Clearance. A list of the survey team names and their respective security levels must be submitted to the Base Security Officer to establish the required clearances and enable the issuing of badges. If the survey personnel do not have the necessary security level, an escort will have to be provided when required.

c. Alerting Plant Supervisors. Supervisors of plants to be surveyed should be informed of the arrival date of the team and their duration of stay. Plant Supervisors will be advised of needed survey team assistance from Plant Maintenance Section and will post notices in the surveyed areas which briefly describe the reasons for the energy survey. It is important to state that the survey team is not monitoring the work productivity of the employees. This notification should be two weeks in advance of the start date.

d. Scheduling Data Collection. The survey team will monitor energy usage during normal working and non-working hours. Therefore, it is necessary to schedule data collection during typical shifts as opposed to partial work load activity. It is a much easier task to schedule this effort for an "in-house" energy conservation team because of their ready availability.

3.3 REVIEW OF EXISTING INFORMATION

Documents relating to the energy survey will be reviewed prior to the start of the survey effort. Typical sources for this information are:

a. Statement of work and schedule

b. Previously completed energy conservation reports

c. Utility operating records for previous year

d. Purchased rate schedules

e. Process specifications

f. Regulations pertaining to certain processes such as OSHA and NIOSH

g. Activity engineering service requests affecting energy conservation.

3.4 REVIEW OF EXISTING DRAWINGS AND EQUIPMENT DATA

Their existence, up-to-dateness, and storage location will be confirmed before the survey begins. Typical drawings and schedules are:

a. Architectural drawings

b. Mechanical drawings

heating

air conditioning and air flow schedules

exhaust systems and air flow schedules

steam distribution

HTW distribution

chilled water distribution

c. Plant equipment

layout drawings

d. Electrical drawings

distribution

e. The in-place metering for the applicable facility or plant or process equipment.

f. The portable on-site energy measuring meters and devices.

3.5 SELECTING A SURVEY TEAM

Selecting the proper mix of talents will have a significant bearing on the success of an energy survey. Previous experience is useful, but not essential, provided a detailed plan, and instructions are followed by the participants. A strong background in heating, air conditioning and ventilating equipment is useful. A major part of industrial energy consumption is concentrated in this area. Experienced survey teams are generally a mix of mechanical and electrical engineers who have specialized in HVAC, lighting and process equipment energy conservation. Lacking previous energy conservation experience, a survey team should have some basic knowledge of the types of equipment involved. Generally, these poeple will be found in Utility or Facility Engineering groups.

Using shop personnel for some of the data collection tasks can be done successfully and has some advantages over using engineers exclusively. Many energy conservation measures require the users to implement new operational procedures. This is generally enhanced when workers have an awareness of energy conservation goals and have participated in a survey. Energy Conservation-related suggestions from shop personnel should be encouraged; experience has shown that residents of an area are more critical observers than a survey team member in a foreign area.

The size of the survey team is a function of facility size, contents, and time scheduled to complete the survey. To some extent, the experience level of the team will also be a determining factor. The data collection phase of the survey entails the review of existing documentation, collecting certain name plate ratings, energy measurements, and determining duty cycles by observation and/or interrogating users. Industrial activities having a high density of energy-using equipment require the most time for data collection. For estimating purposes, a performance factor of 30,000 sq. ft. of floor area for one man-day of survey time can be used. Office buildings, particularly modern ones, will require less time for data collection. Mechanical drawings have performance and operations details for HVAC and lighting systems; this eliminates most of the need for inspection and enables analytical work to be done using data from drawings exclusively.

The analytical and report writing phases of an energy survey should be done by technical personnel, and not delegated to shop personnel. There are definite advantages to having the same people involved in all phases of the survey. The experienced analyst, for instance, will recognize what data is necessary to gather in order to perform each computation; this will improve the efficiency of the data collection phase. Conversely, collecting unnecessary data is also minimized.

Another option to forming a survey team is to do the data collection function with regular employees, and have the analytical functions done by an energy conservation specialty organization. The advantage in hiring out the analysis work is that specialists often have computer programs to do the analysis much more expeditiously.

3.6 WHAT TO SURVEY-ASSIGNING RESPONSIBILITIES

The Survey Coverage Form is to be used in conjunction with the Survey Team Form.

3.6.1 Complete the Survey Coverage Form as follows:

a. Indicate the purpose of the program and estimate the results expected.

b. Designate the industrial areas, buildings, or shops that are to be audited.

c. Indicate the processes, systems, and other situations to be examined.

3.6.2 Complete the Survey Team Form as follows:

a. List the names of the team members, their department or shop numbers, and their team responsibilities assignments or specialities.

b. Plan to report periodically and at major states in the program to promote interest and maintain control.

3.6.3 Complete the Pre-Survey Check-Off List as follows:

a. Develop file folders for the items to be checked. In some cases copies of the data can be inserted in the folder for use by the survey team. Other times, the folder will contain the names and telephone numbers of people to contact for the data, etc. It is important to develop the pre-survey check-off sheet properly. It increases the efficiency of the survey team, and provides a record for planning future surveys.

One way to reduce the amount of effort in completing the Pre-Survey Check Off-List is to become familiar with all the sections in this Guide.

SURVEY SCOPE FORM

DATE _ _ _ _ _ _

Sheet 1 of 3

DEPT OF NAVY - NAVFAC

INDUSTRIAL ENERGY CONSERVATION PROGRAM

ACTIVITY: _ _ _ _ _ _ _ _ _ _ _ _

LOCATION: _ _ _ _ _ _ _ _ _ _ _ _

SURVEY COVERAGE: Buildings, Shops _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

_ _

PROGRAM SCOPE:

I. Industrial Processes

	Applies Yes	Applies No	Building No.
Cleaning and Coating Operations (Process Tanks)			______
Paint Booths			______
Chilling Well................................			______
Heat Treating................................			______
Machine Tools................................			______
Metal Working........................			______
Metal Machining......................			______
Wood Working.........................			______
______________......................			______

SURVEY SCOPE FORM

DATE _ _ _ _ _ _ _

Sheet 2 of 3

	Applies Yes	Applies No	Building No.
PROGRAM SCOPE: (Continued)			
Chemical Machining Operations................			______
Welding Brazing and Flame Cutting............			______
Foundry......................................			______
__________...................................			______
Engines, Stationary and Test Facilities......			______
Waste Oil Processing.........................			______
__________...................................			______

II. Support Systems.

	% Used for Industrial Process
Compressed Air.....................	
Process Air: Heating Ventilating and Exhaust.......................	
Process Building, HVAC.............	
Material Handling..................	

SURVEY TEAM & REPORT SCHEDULE FORM

DATE _ _ _ _ _ _

Sheet 3 of 3

PROGRAM SCOPE: (Continued)

III. Utility Systems

	% Used for Industrial Process
Electrical........................	
Steam.............................	
Hot Water (High Temp).............	
Refrigeration, Chilled Water......	

SURVEY TEAM AND REPORT SCHEDULE FORM

DATE ______

Sheet 1 of 1

DEPT OF NAVY - NAVFAC

INDUSTRIAL ENERGY CONSERVATION PROGRAM

ACTIVITY: ______________

LOCATION: ______________

PROGRAM TEAM;

NAME	DEPT.	RESPONSIBILITY

SCHEDULE OF REPORTS:

Report		Due Date

DEPT OF NAVY - NAVFAC

INDUSTRIAL ENERGY CONSERVATION PROGRAM

ACTIVITY: _____________

LOCATION: _____________

(Develop folders for the items to be checked)

		By	Date
I.	SURVEY SCHEDULE DEVELOPED (Milestones)	____,	____
II.	SECURITY CLEARANCE OBTAINED	____,	____
III.	PLANT SUPERVISORS ALERTED FOR THE SURVEY	____,	____

IV. PREVIOUSLY COMPLETED ENERGY CONSERVATION REPORTS.

Title	Date of Report	Title of Project Developed or Recommendation
__________	________	___________
__________	________	___________
__________	________	___________
__________	________	___________
__________	________	___________

V. ENGINEERING SERVICE REQUESTS AFFECTING ENERGY CONSERVATION.

Title	ESR #	Date of ESR	Status
--------	-----	-----------	-------
--------	-----	-----------	-------
--------	-----	-----------	-------
--------	-----	-----------	-------
--------	-----	-----------	-------

VI. LIST OF PROCESSES AND SYSTEMS TO BE CHECKED. List processes and systems to be checked along with whether the checks will be made during normal and/or non-working hours, when applicable include the actual hours.

Bldg #	Item	Normal Working Hours	Non-Working Hours

VII. OSHA & NIOSH

Regulations Affecting Subject Energy Conservation Survey

Title	Report or Regulation Filed At:
-----------------	-----------------
-----------------	-----------------
-----------------	-----------------
-----------------	-----------------
-----------------	-----------------

VIII. DRAWINGS AND SPECIFICATIONS

Architectural

Mechanical

Process steam

Process hot water

Building HVAC

Process air, heating,
ventilating and exhaust

Chilled water

Compressed air

____

____

____

Electrical

Distribution

____

____

VIII. DRAWINGS AND SPECIFICATIONS (Continued)

Applicable process and system specifications

____

____

____

Overall Plant Layout

____

____

IX. ENERGY MEASUREMENTS

1. Listing of existing meters for:

   Processes

   Systems

   Purchased Utilities

   Utilities generated-on-site

2. Listing of portable meters and recorders used for measuring energy usage of:

   Proceses

   Systems

   Purchased Utilities

   Utilities generated on site

3. List of portable instruments not available at the site that should be considered for purchase or lease.

4. Is the utility metering for the building sufficient to warrant obtaining billing data and rate schedules:

   Yes _ _ _ No _ _ _

   If yes, complete the following:

   Utility consumption, usage and billing data available, oil _ _ _ _, natural gas _ _ _ _, electricity _ _ _ _, steam _ _ _ _, HTW _ _ _ _, chilled water _ _ _ _, compressed air _ _ _ _, ______ _ _ _ _ _ _.

PRE-SURVEY CHECK OFF LIST (Continued)

Utilities-on-site generation, usage and billing data available electricity _ _ _ _ _, steam _ _ _ _, HTW _ _ _ , chilled water _ _ _ _, compressed air _ _ _ _ , __________ _ _ _ _, ____________ _ _ _ _.

Purchased or on site rate schedules, oil _ _ _ _, natural gas _ _ _ _, electricity _ _ _ _, steam_ _ _ _, compressed air _ _ _ _.

Checkoff Sheet Completed By	Date
_ _ _ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _
_ _ _ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _

SECTION 4

PURCHASED ENERGY DATA

4.1 IS THE DATA APPLICABLE TO THE SURVEY?

Purchased energy data is useful when the metering or purchase information can supply pertinent data for the buildings or processes being surveyed.

The number of buildings being surveyed coupled with the ability to separate electrical consumption and electrical demand loads on a building-by-building basis should be a consideration. Generally, metering on a per building basis at an industrial facility is seldom done. Electrical metering is usually minimized to take advantage of rate schedules. A large steam distribution system will usually have central plant metering but not have steam flow monitoring on a building-by-building basis.

For each survey, a judgement should be made during the intial planning for the survey, as to the practicality of reviewing purchased energy data.

4.2 SUPPLIER DATA (If Applicable)

Most information in this section is already at hand in the form of utility (or other supplier) contracts, billings, rate schedules, and similar data. The process is one of point-by-point familiarization with the suppliers of each energy form so that contacts can be made readily and accurately when members of the energy audit team generate questions.

The main meters, their locations and types, and the rate schedules and riders applicable to the specific location and service should be studied to make certain there is mutual understanding as to the billings, the meter readings, and the rate structure. Each utility has a rate structure unique to itself, and contacts with the business representative may be required to help clarify the details, such as demand and power factor penalty charges as they relate to opportunities for cost savings. In the case of fuels (except natural gas), there may be transportation charges, another potential savings area.

4.3 CONSUMPTION DATA (If Applicable)

The purpose of this activity is to develop a picture of seasonal energy-consumption variations. This will help to identify large energy users that are operational only certain months of the year. The effect that changes in workload or shifts have on energy consumption will be reflected in these numbers. The effect of operating various processes or parts of processes, and of drydocks, etc. will also show up.

Select a form for the type of energy being audited. Indicate delivery point or service number. Each service should be summarized independently. Forms should be copied as needed to audit each service.

Heat-conversion factor is an indication of the heat (in Btu) contained in a unit of the energy source. Enter in this space the heat-conversion factor corresponding to the service.

Energy consumption data are obtained from monthly billings. If bills were copied while collecting supplier data, enter the monthly data in the table. Otherwise, the bills must be obtained from the accounting department or the Public Works Department.

A presentation in graphic form will make seasonal consumption variations even more noticeable.

4.4 FORMS - UTILITIES, PURCHASED

The purchased energy forms are arranged in pages 4-4 to 4-11 as follows:

Utility	Supplier Data Page #	Consumption Data Page #
Electricity	4-4	4-5,4-6
Fuel Oil	4-7	4-6
Natural Gas	4-8	4-6
LP Gas	4-8	4-6
Coal	4-9	4-6
Refuse Derived Fuel	4-9	4-6
Steam	4-10	4-6, 4-11

SUPPLIER DATA - ELECTRICITY

DEPT. OF NAVY - NAVFAC　　　　BUILDING NO.: _ _ _ _ _ _

ENERGY CONSERVATION AUDIT　　　　SHOP NO. _ _ _ I.D. NO. _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _　　　　LOCATION: FL _ _ BAY _ _ _ _ _

Utility Company Name: ______________________________

Address: ______________________________

____

____

Business Representative: ____________　　Phone: ____________

MAIN METERING

				Check ( ) Type of Meter		
Service Number	Meter Location	Metering Voltage	Demand Period (15 Min/30 Min)	KWH	KW Demand	Power Factor
1						
2						
3						

BILLING

Attach rate schedule and applicable riders for each service.

PURCHASED ENERGY - ELECTRICITY

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

Service: _ _ _ _ _ _ _ _ _ _ _ _ _

VOLTAGE: _ _ _ _ _ _ _ _ _ _ _ _ _

Heat Conversion Factor 0.0116 MBtu/KWH

CONSUMPTION DATA

Month of Fiscal Year	Actual	Demand KW or KVA Billed	Quantity KWH	Cost		Energy Consumption MBtu/Period KWH x 0.0116
				Total	Per KWH	
1st _ _ _ 2nd _ _ _ 3rd _ _ _						
1st Quarter						
4th _ _ _ 5th _ _ _ 6th _ _ _						
2nd Quarter						
7th _ _ _ 8th _ _ _ 9th _ _ _						
3rd Quarter						
10th _ _ _ 11th _ _ _ 12th _ _ _						
4th Quarter						
Total Per Fiscal Year FY _ _ _ _						

Plot the above data on copies of the chart on sheet 4-6

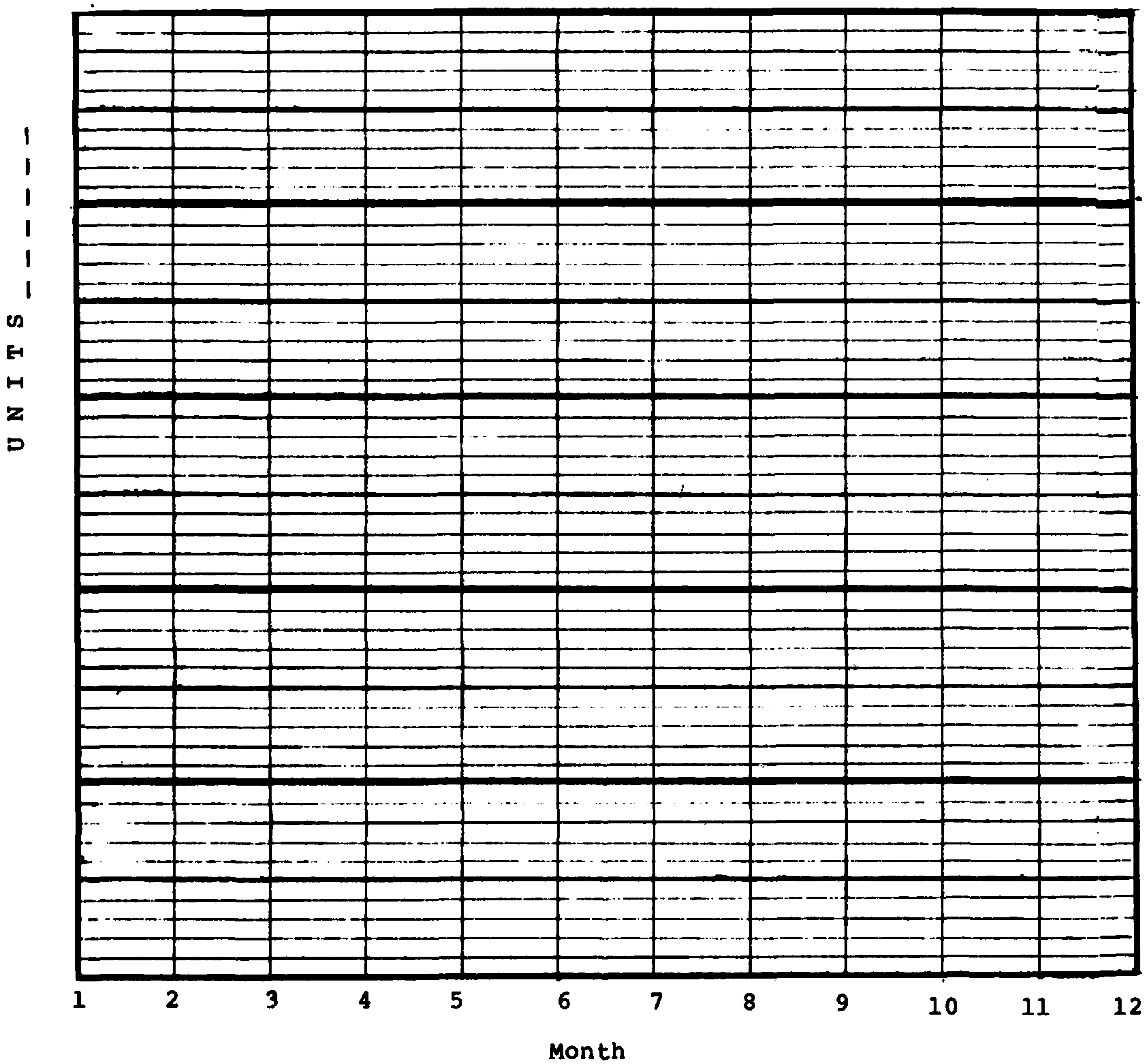
a. Demand, Actual: During the 12 months
b. Consumption: KWH during the 12 months

PURCHASED ENERGY __________ CONSUMPTION DATA

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _



SUPPLIER DATA - FUEL OIL

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

Oil Company Name: ____________________

Address: ____________________

____

____

Business Representative: ____________ Phone: ____________

DELIVERY POINTS

Point No.	Tank Size	Area Served	Oil Type	Heating Value

CONSUMPTION DATA

Develop a table similar to page 4-5. Provide columns for: Montrh of Year, Quantity Used (gallons), Total Cost per Month; Average Cost Per Gallon During the Month, Energy Consumption (MBtu/month).

CHARTS

Plot the consumption data on copies of the chart on page 4-6.

SUPPLIER DATA - NATURAL OR LP GAS

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _ _

Gas Supplier: ______________________________

Address: ______________________________

____

____

Business Representative: ____________ Phone: ____________

METERING POINTS

Service	Location	Pressure	Size	Heating Value

LP Gas Delivery Point	LP Gas Tank gal.	LP Gas Area Served	Heating Value

CONSUMPTION DATA

Develop a table similar to page 4-5. Provide columns for: Montrh of Year, Quantity Used (gallons), Total Cost per Month; Average Cost (Per 1000 cubic feet or per Gallon During the Month, Energy Consumption (MBtu/month).

CHARTS

Plot the consumption data on copies of the chart on page 4-6.

SUPPLIER DATA - COAL OR REFUSE DERIVED FUEL

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

Supplier: ______________________________

Address: ______________________________

____

____

Business Representative: ____________ Phone: ____________

DELIVERY POINTS

Point No.	Area Served	Type	Heating Value Btu/ton

CONSUMPTION DATA (RDF or Coal)

Develop a table similar to page 4-5. Provide columns for: Montrh of Year, Quantity Used (tons or gallons), Total Cost per Month; Average Cost Per Ton or Gallon During the Month, Energy Consumption (MBtu/month).

CHARTS

Plot the consumption data on copies of the chart on page 4-6.

SUPPLIER DATA - COAL OR REFUSE DERIVED FUEL

DEPT. OF NAVY - NAVFAC　　　　BUILDING NO.: _ _ _ _ _

ENERGY CONSERVATION AUDIT　　　　SHOP NO. _ _ _ I.D. NO. _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _　　　　LOCATION: FL _ _ BAY _ _ _ _ _

Utility Company Name: ______________________________

Address: ______________________________

____

____

____

Business Representative: ____________ Phone: __________

MAIN METERING

Service Number	Meter Location	Steam Conditions		Maximum Capacity lb/hr
		Pressure, psig	Temp. °F	
1				
2				
3				

BILLING

Attach most recent rate schedule and applicable riders for each service.

PURCHASED ENERGY - STEAM

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _ _

Service: _ _ _ _ _ _ _ _ _ _ _ _ _ _

Incoming Pressure: _ _ _ _ _ _ _ _ _ _ psig

Heat Conversion Factor (Heat Content) = _ _ _ _ _ _ _ Btu/lb (from Steam Tables)

CONSUMPTION DATA

Month of Fiscal Year	lbs/hr Demand		Quantity 1000 Lbs	Cost		Energy Consumption MBtu/Period
	Actual	Billed		Total	Per MLBS	Quantity x Heating Value
1st _ _ _ 2nd _ _ _ 3rd _ _ _						
1st Quarter						
4th _ _ _ 5th _ _ _ 6th _ _ _						
2nd Quarter						
7th _ _ _ 8th _ _ _ 9th _ _ _						
3rd Quarter						
10th _ _ _ 11th _ _ _ 12th _ _ _						
4th Quarter						
Total Per Fiscal Year FY _ _ _ _						

Plot the above data on copies of the chart on sheet 4-6

SECTION 5

ON - SITE ENERGY GENERATION

5.1 IS THE DATA APPLICABLE TO THE SURVEY?

On-site energy production data is applicable when the metering or estimated use can supply useful information for the buildings or process being surveyed.

5.2 EQUIPMENT DATA (If Applicable)

Using the forms accompanying this section:

a. Enter the equipment or process indentification. Consider each piece of fired equipment separately, and identify the areas served.

b. Record the characteristics of the working fluid or electric energy produced, such as pressure, voltage, etc.

c. Indicate the type of fuel or motive energy consumed.

5.3 CONSUMPTION DATA (If Applicable)

Using the forms accompanying this section:

a. Tabulate the monthly fuel consumption or fuel input for conversion data in the table, for the last fiscal year. Fuel input for conversion refers to the primary utility energy converted for an industrial process.

b. Examine the data for large variations in monthly fuel consumption and conversion rates. Look for major energy consumers that were operational during the periods of high energy consumption and conversion rates. Try to evaluate the proportion of the energy from this source used by various areas served. See if you can correlate monthly consumption or conversion rates to operating hours or operating rates. Look for major energy-consuming processes that were used during the periods of high activity such as drydock pumping. Note the gross seasonal variations due to heating by steam in winter and air conditioning by electricity (or steam) in summer.

c. Data from the production data sheet should be plotted on the production plot. The graphic format will make seasonal variations in energy consumption and conversion rates more visible.

5.4 FORMS - ON SITE ENERGY GENERATION

The energy conversion forms are arranged in pages 5-3 to 5-8 as follows:

Conversion Equipment	Equipment Data Page #	Production Data Page #
Electricity	5-3	5-3
Steam	5-5	5-5
Hot Water	5-6	5-6
Compressed Air	5-7	5-7
Chilled Water	5-8	5-8

GENERATED ENERGY - ELECTRICITY

DEPT. OF NAVY - NAVFAC   BUILDING NO.: ____________

ENERGY CONSERVATION AUDIT   SHOP NO.: ______ ID NO.: ____

ACTIVITY __________   LOCATION: FL _____ BAY _____

Generator No.: __________ Location: __________

Area Served: ______________________

Generated Voltage: ______________________

Driver: (Check One) Diesel Gas Turbine Steam Turbine

Fuel: Oil No. _______ Gas, Natural Gas, Other

Purchased Steam: __________ psig ______ °F

Generated Steam: __________ psig ______ °F Boiler # __

Month of Fiscal Year	Fuel Used Units ____	Steam Used 1000 lbs	Electricity Generated, KWH	Electricity Demand KW or KVA
1st ____				
2nd ____				
3rd ____				
1st Quarter				
4th ____				
5th ____				
6th ____				
2nd Quarter				
7th ____				
8th ____				
9th ____				
3rd Quarter				
10th ____				
11th ____				
12th ____				
4th Quarter				
Total FY __				

Plot the above data on copies of the chart on Sheet 5-4

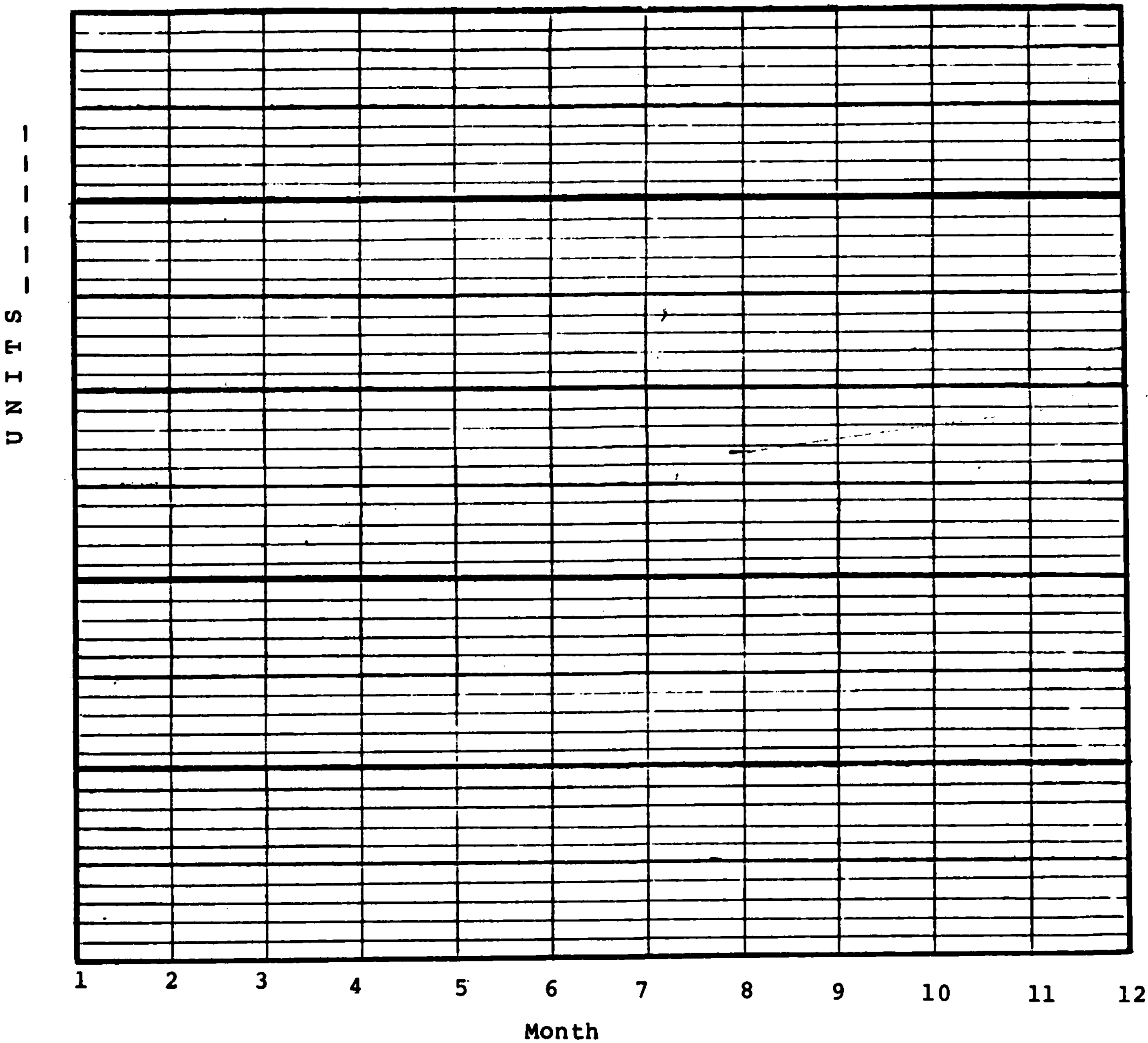
a. Demand, Actual: During the 12 months
b. Consumption: KWH during the 12 months

GENERATED ENERGY

DEPT. OF NAVY - NAVFAC BUILDING NO.: ____________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID NO.: ____

ACTIVITY ___________ LOCATION: FL ____ BAY



GENERATED ENERGY - STEAM

DEPT. OF NAVY - NAVFAC   BUILDING NO.: _ _ _ _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO.: _ _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _   LOCATION: FL _ _ _ _ BAY _ _ _ _

Boiler No.: _ _ _ _ _ _ _ _   Location: _ _ _ _ _ _ _ _ _

Areas Served: _

Boiler No.: _ _ _ _ _ _ _ _ _ _   Location: _ _ _ _ _ _ _ _

Areas Served: _

STEAM CHARACTERISTICS:

Pressure: _ _ _ _ _ _ _ _ psig

Temperature: _ _ _ _ _ _ ^{o}F

Heat Content: _ _ _ _ _ _ Btu/lb

Fuel Type (Check One)

No. _ _ _ _ _ Fuel Oil   Coal

Natural Gas   Other   Type _ _ _ _ _ _

Month of Fiscal Year	Fuel Consumed Units ____	Steam Produced 1000 lbs
1st _ _ _ _		
2nd _ _ _ _		
3rd _ _ _ _		
1st Quarter		
4th _ _ _ _		
5th _ _ _ _		
6th _ _ _ _		
2nd Quarter		
7th _ _ _ _		
8th _ _ _ _		
9th _ _ _ _		
3rd Quarter		
10th _ _ _ _		
11th _ _ _ _		
12th _ _ _ _		
4th Quarter		

Total FY _ _ _ _

Plot the above data on copies of the chart on sheet 5-4.

GENERATED ENERGY - HOT WATER, PROCESS

DEPT. OF NAVY - NAVFAC   BUILDING NO.: ____________

ENERGY CONSERVATION AUDIT   SHOP NO.: ______ ID NO.: _____

ACTIVITY ___________   LOCATION: FL _____ BAY _____

Boiler No.: _________   Location: __________

Areas Served: ____________________

HOT WATER CHARACTERISTICS:

Temperature: ____________ °F ________ psig

Heat Content: ____________ Btu/lb

Fuel Type: (Check One)

No. _______ Fuel Oil   Coal

Natural Gas   Other   Specify _ °F ____

Steam   psig

Month of Fiscal Year	Fuel Consumed Units ____	Hot Water Produced 1000 Gals
1st ____		
2nd ____		
3rd ____		
1st Quarter		
4th ____		
5th ____		
6th ____		
2nd Quarter		
7th ____		
8th ____		
9th ____		
3rd Quarter		
10th ____		
11th ____		
12th ____		
4th Quarter		
Total FY ____		

Plot the above data on copies of the chart on sheet 5-4.

GENERATED ENERGY - COMPRESSED AIR

DEPT. OF NAVY - NAVFAC BUILDING NO.: ___________

ENERGY CONSERVATION AUDIT SHOP NO.: _____ ID NO.: ____

ACTIVITY __________ LOCATION: FL ____ BAY ____

Compressor No.: _________ Location: __________

Areas Served: _________ Rate: SCFM _________

Pressure: ________________ psig

Volume measured as standard cubic feet per minute, air at 60°F, and atmospheric pressure at sea level.

Month of Fiscal Year	Electric Usage KWH	Compressed Air Produced 1000 CF
1st ____		
2nd ____		
3rd ____		
1st Quarter		
4th ____		
5th ____		
6th ____		
2nd Quarter		
7th ____		
8th ____		
9th ____		
3rd Quarter		
10th ____		
11th ____		
12th ____		
4th Quarter		

Plot the above data on copies of the chart on sheet 5-4.

GENERATED ENERGY - CHILLED WATER

DEPT. OF NAVY - NAVFAC   BUILDING NO.: _ _ _ _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ _ ID NO.:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _   LOCATION: FL _ _ _ _ BAY _ _ _ _

Chiller No.: _ _ _ _ _ _ _ _   Location: _ _ _ _ _ _ _ _ _

Area Served: _

Chilled Water Temperature: _ _ _ _ _ _ _ _ _ _ ^{o}F

Energy Source (Check One)   Steam   Electricity

Other   Specify

Purchased Steam: _ _ _ _ _ _ _ psig _ _ _ _ _ _ _ ^{o}F

Generated Steam: _ _ _ _ _ _ _ psig _ _ _ _ _ _ _ ^{o}F

Month of Fiscal Year	Electricity Consumed KWH	Steam Consumed 1000 Lbs	Chilled Water Produced 1000 Gals
1st _ _ _ _			
2nd _ _ _ _			
3rd _ _ _ _			
1st Quarter			
4th _ _ _ _			
5th _ _ _ _			
6th _ _ _ _			
2nd Quarter			
7th _ _ _ _			
8th _ _ _ _			
9th _ _ _ _			
3rd Quarter			
10th _ _ _ _			
11th _ _ _ _			
12th _ _ _ _			
4th Quarter			
Total FY _ _ _ _			

Plot the above data on copies of the chart on sheet 5-4.

SECTION 6

ENERGY CONSERVATION - INDUSTRIAL PROCESSES

PROCESS TANKS

6.1.1 INTRODUCTION:

Process tanks include those used for electroplating, degreasing, etching, stripping and other cleaning and coating operations. The heat loss from process tanks can represent significant energy losses and hence process tanks are good energy conservation modification candidates with relatively short paybacks of 1 to 3 years.

Special attention should be paid to evaporation and ventilation heat losses in process tanks. If OSHA, NIOSH and environmental regulations permit tanks containing hot fluids should have lids. Use of lids can greatly reduce evaporation heat losses and this woild reduce the need for forced (fan) space ventilation (where tanks are located). Additional economic advantage is that evaporation loss of expensive solvents is reduced.

An alternate to mechanically operated lids and covers are hollow plastic spheres or other plastic configurations that can be floated on the surface to form a layer and act as a lid.

Another area to be considered is tank insulation. Uninsulated process tanks have a high heat loss.

6.1.2 VAPOR DEGREASERS

A vapor degreaser generally is a steel tank with steam or electric heating coils located near the bottom and immersed in a few inches of a chlorinated liquid solvent such as Trichlorethylene or III-Trichlorethane. The tank may range in size from a few to over one hundred square feet, and may be hand-fed or conveyorized. Vapor from the boiling solvent fills the tank, into which the parts to be cleaned are lowered. Above the cleaning space is a condenser consisting of a water-jacket or cooling coil, where the vapor is condensed and returned to the boiling sump. The tank wall above the cooling jacket is the freeboard, and its purpose is to minimize cross drafts which will carry off vapor. Usually, the tank will have a lip exhaust along one or both long sides, above the freeboard. A liquid solvent spray lance frequently is included.

Roughly one-half the energy consumption of a typical, open-top degreaser operation is by the degreaser itself, for vapor boiling; the balance for make-up ventilation air heating and exhaust fan power. Therefore, efforts must be made to minimize exhaust ventilation. A cover must be provided which will not disturb the vapor line when opened. For this reason, a sliding cover is much preferred to a hinged one. In addition, the cover must seal the tank below the lip exhaust openings. If the degreaser is not in continous use, the cover should be kept closed except for loading/unloading and use time. Automatic electric or hydraulically-operated covers are most convenient and are most likely to be utilized by operating personnel. If the cooling jacket is operating properly, it may be possible to reduce or even turn-off the exhaust while the cover is closed. The limiting factor, easily measured, is the vapor concentration in the surrounding area, so that ventilation may be minimized by careful trial and measurement. Interlocking of cover and exhaust fan is desirable for maximum efficiency. Refrigerated cooling coils may allow elimination of exhaust fans altogether. However, their initial cost and operating expenses must be considered.

Reduction of energy use of the degreaser itself is straightforward. Insulation can reduce wall heat loss. The degreaser should be shut down for periods of non-use greater than a few hours. The most positive method of shutdown is use of automatic timers, which can turn off degreasers after an active shift, with a time delay to shut down exhaust fans shortly thereafter. A thorough energy conservation effort may result in reduction of energy usage of vapor degreasing operations by as much as 75%. In addition, the accompanying reduction in solvent loss may be even more rewarding, due to the high cost of chlorinated solvents.

6.1.3 CHEMICAL PROCESS LINES

Chemical process areas typically contain a number of tanks, aligned to allow parts to be dipped, either manually or by means of an overhead hoist, in a sequential manner to perform a particular process, such as plating, anodizing, cleaning, etc. Ventilation may be individually provided, as by a lip canopy or hood exhaust, or there may be general area ventilation. Individual tanks may be heated by gas, electricity or steam, and if heated, may or may not be insulated. Covers may exist, and if so, may or may not be utilized. Tank solutions may be agitated, by bubbling of compressed air or by mechanical means. Rinse water tanks will frequently be continuously flushed.

The conditions required of the particular process must first be determined, on an individual tank basis, and steps taken to eliminate unnecessary requirements. Exhaust flow must be minimized and shut-off when possible.

Covers should be considered to reduce ventilation requirements and to minimize surface heat loss of heated liquids. It may be possible to interlock tank exhaust with tank covers, to ventilate only when the cover is open. The use of hollow plastic spheres or other plastic configurations that can be floated on the surface to act as a lid should be investigated.

Wall insulation should be considered especially if the liquid is maintained at temperatures above 120°F. Temperatures should be reduced to the minimum allowable. For heated tanks, water-to-water heat exchangers should be considered to recover heat from continuous overflows or from the heating coil condensate. During non-active shifts, it may be possible to turn off tank heaters, reduce or eliminate ventilation, stop liquid agitation and flush flow, reduce area temperature and turn off area lights.

Maximum use of automatic controls is recommended. Covers may be electrically or pneumatically activated. Exhaust fans, heaters, agitation devices, flush flow and even area temperature and lighting can be automatically controlled by one or more timers.

6.1.4 <u>RESOURCES FOR A SURVEY</u>

Where Applicable:

The checklist, particularly when air is used for agitation.

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements and specifications provided by the facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Review instrumentation, data gathering, and calculations.

Fans and Electric Motors . . . . Appendices F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

Air Compressors . . . . Appendix H

Important to consider when dedicated (exclusively for the tanks) air compressors are used.

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ ITEM: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION FL _ _ _ _ BAY _ _ _ _ _ _

SKETCH SHEET _ _ _ _ YES _ _ _ _NO

DESIGN DATA

Plating Tanks, Fill in Blocks A and C

OTHER Tanks, Fill in Blocks B and C

BLOCK A

Plating Solution: _ _ _ _ _ _ _ Plated Material _ _ _ _ _ _

Electric-DC: _ _ _ _ _ _ _ Volts _ _ _ _ _ _ _ _ _ Amps

BLOCK B

Tank Solution: _ _ _ _ _ _ _ _ Function: _ _ _ _ _ _ _

BLOCK C

Solution Temp _ _ _ _ _ _ _ _^{o}F

Estimated temperature of surrounding surfaces in plant _ _ _ ^{o}F

Agitation: _ _ Air, Flow Regulated with Gages _ _ _ _ _ psig

or Flowmeter _ _ _ _SCFMg,_ _ _Mechanical_ _None

Heating Source Steam Coil _ _ _ _ _ _ _LBS/hr

Electric _ _ _ _ _ _ _ KW

Gas _ _ _ _ _ _ _ _ _ _ BTU/hr

Hot Water _ _ _ _ _ _ _ BTU/hr

Cooling Source Chilled Water _ _ _ _ _ LBS/hr

_ _ _ _ _ _ _, _ _ _ _ _

_ _ _ _ _ _ _, _ _ _ _ _

Tank Dimensions Length _ _ _ _ _ _ _ _ _FT

Width _ _ _ _ _ _ _ _ _

Height_ _ _ _ _ _ _ _

Solution Depth_ _ _ _ _

Conducted By _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Date _ _ _ _ _

DATA COLLECTION Sheet 2 of 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ ITEM: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION FL _ _ _ _ BAY _ _ _ _ _ _

AUDIT DATA

Plating Tanks, Fill in Blocks D and E

Other Tanks, Fill in Blocks E

BLOCK D

Electric-DC: _ _ _ _ _ _ _ _ _ _ Volts _ _ _ _ _ _ _ _ _ Amps

BLOCK E

Solution Temp _ _ _ _ _ ^{0}F

Tank Wall Temp _ _ _ _ ^{0}F

Shop (Ambient) Temp _ _ _ _ _ ^{0}F

Wall Material _ _ _ _ _ _ _ _

Painted	Yes	_ _ _ _ _ _ _	No	_ _ _ _ _ _
Insulated	Yes	_ _ _ _ _ _ _	No	_ _ _ _ _ _
Mechnical Lid	Yes	_ _ _ _ _ _ _	No	_ _ _ _ _ _
Floating Plastic Spheres	Yes	_ _ _ _ _ _ _	No	_ _ _ _ _ _

Ventilation

Lip, Hood, Open _ _ _ _ _ _ _ _

Duct Section Area _ _ _ _ _ _ _ In^2

Air Velocity _ _ _ _ _ _ _ _ _ ft/min

Duty Cycle

	Heat	Ventilation
Hours/Day	_ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _
Days/Week	_ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _

Estimated Costs:

Electricity	_ _ _ _ _ _ _ _ _
Oil	_ _ _ _ _ _ _ _ _
_ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _

CONDUCTED BY _ _ _ _ _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _ _ _ _ _

6.1.5 ESTIMATING HEAT LOSSES FROM TANKS

The tank walls and cover transfer heat to the surroundings by convection and radiation. If the tank bottom is not in contact with the floor convection losses occur. When the tank is uncovered, the heat loss from the liquid surface is by convection, radiation and evaporation.

Estimates for the heat loss from the tank walls, cover and bottom are developed in the following sections:

6.1.5.1 Estimated Heat Loss from Tank Walls, Cover and Bottom.

6.1.5.2 Estimated Heat Loss from the Fluid Surface. (No Covers).

The heat lost by the tank is the sum of the estimated heat losses in section 6.1.5.1 through 6.1.5.2.

A sample calculation is included in section 6.1.6.

6.1.5.1 Estimated Heat Loss from Tank Walls, Cover and Bottoms.

A method for estimating heat losses from tank walls, cover and bottom is by solving the following equation:

Q = $A(U_1 \text{ or } U_2)\ (T_L - T_A)$, where

Q = Tank wall, cover and bottom convection loss - Btu/hr

U_1 = Heat transfer coefficient for tank walls, bottom and cover without insulation (Btu/hr - sq ft - deg. F)

U_2 = Heat transfer coefficient for tank walls and bottom with insulation (Btu/hr - sq ft - deg. F)

A = Area - square feet

T_L = Liquid temperature - deg. F

T_A = Ambient temperature - deg. F

T_L, T_A, and A are measured values, U_1 is selected from Table 6.1 and U_2 is selected from Table 6.2. Note that the tank bottom transfers heat when not in direct contact with the floor.

6.1.5.2 Estimated Heat Loss from the Fluid Surface (no covers)

Heat loss from the exposed liquid surface of an open tank is by convection and radiation from the surface and by evaporation of the liquid. Heat loss by evaporation is a rather involved phenomenon to measure and the formula for the sum of these three different phases of heat loss is extremely complex.

The accompanying Table 6.3 is a solution of the common case of various water temperatures and air velocities where the surrounding air is 80 deg. F and 70%, relative humidity. Note that air velocities are in feet per second.

The equation is as follows:

Qc = AH, where

Qc = Combined heat loss from the fluid surface - Btu/hr

A = Open fluid surface area - sq. ft.

H = Combined heat loss from the fluid surface per square foot - Btu/hr-sq. ft.

H is selected from Table 6.3

The H values were developed for water. Fluids other than water have different heat loss characteristics. However, the majority of heated tanks have water solutions therefore for estimating purposes these H values are adequate.

Table 6.1

Heat Losses from Steel Flat Surfaces "U_1"*

(Btu/hr - sq ft - F deg temp. difference between surface and air)

	Temperature Difference F Deg Between Surface and Surrounding Air Air at 80 F							
	50	100	150	200	250	300	350	400
Vertical Surface	1.84	2.14	2.42	2.70	3.00	3.30	3.62	4.00
Horizontal Surface Facing Upward	2.03	2.37	2.67	2.97	3.28	3.59	3.92	4.31
Horizontal Surface Facing Downward	1.61	1.86	2.11	2.36	2.64	2.93	3.23	3.60

*ASHRAE Handbook of Fundamentals, 1972

Table 6.2

Heat Losses from Insulated Flat Surfaces "U_2"*

(Btu/hr - sq ft - F deg temp. difference between surface and air)

Temperature Difference Surface to Air deg F	Actual Surface Temperature Air=70 deg F deg F	Thickness of Insulation (Inches)						
		1	1.5	2	2.5	3	4	5
50	120	0.36	0.30	0.24	0.18	0.14	0.12	0.10
100	170	0.38	0.27	0.21	0.17	0.15	0.12	0.10
120	190	0.42	0.30	0.25	0.19	0.16	0.13	0.11
169	239	0.40	0.28	0.23	0.18	0.15	0.12	0.10
200	270	0.40	0.28	0.22	0.18	0.15	0.12	0.10
254	324	0.41	0.30	0.23	0.18	0.15	0.12	0.10
280	350	0.41	0.29	0.23	0.18	0.16	0.12	0.10
300	370	0.42	0.29	0.23	0.19	0.16	0.12	0.10
350	420	0.42	0.30	0.23	0.19	0.16	0.12	0.10
400	470	0.43	0.30	0.23	0.19	0.16	0.13	0.10

*Kent-Mechanical Engineers Handbook, Power Volume, Twelfth Edition

Table 6.3

Heat Loss from Water Surface "H"*
(Btu/hr - sq ft)

Air at 80 Deg F, 70% Relative Humidity

Water Temp., Deg F	Air Velocity, Feet per Second							
	0	0.5	1	2	5	10	20	50
80	17	34	40	49	66	106	185	330
100	58	96	113	135	185	280	460	920
110	210	285	320	380	540	780	1,250	2,550
120	315	420	470	560	760	1150	1,850	3,800
130	460	580	660	780	1,090	1620	2,600	5,200
140	640	780	900	1,060	1,480	2200	3,600	7,200
150	860	1,020	1,200	1,420	1,970	2950	4,800	9,700
160	1,150	1,330	1,590	1,800	2,550	3800	6,300	13,000
170	1,500	1,730	2,050	2,500	3,400	5200	8,500	17,300
180	2,000	2,400	2,750	3,400	4,700	7100	12,000	24,000
190	2,550	3,400	3,900	4,800	6,600	10,000	17,000	34,000
200	3,330	4,850	5,600	6,900	9,500	14,000	24,000	50,000

*Handbook of Air Conditioning, Heating and Ventilating, C. Strock and R. L. Koral

6.1.6 SAMPLE CALCULATIONS

Estimate the heat loss from the tank before and after the installation of a cover and insulation.

Process Tank

4 feet wide, 8 feet high, 19 feet long

Uncovered

Solution temperature 180 deg. F.

Wall temperatures, uninsulated, approx. 180 deg. F

Tank not in contact with the floor

Shop, ambient temperature 80 deg. F.

Process is such that cover can be added.

6.1.6.1 Preliminary Calculations

Vertical wall area = (2x4x6) + (2x6x19) = 276 sq. ft.

Bottom area = (4x19) = 76 sq. ft.

Liquid surface area = (4x19) = 76 sq. ft.

Proposed Cover Area = (4x19) = 76 sq. ft.

6.1.6.2 Estimated Wall and Bottom Heat Loss Without Insulation Using the Steps in Section 6.1.5.1

a. Vertical Wall Area (A_V) = 276 sq. ft.
   Bottom Area (A_B) = 76 sq. ft.

b. From Table 6.1 for a temperature difference of 100 deg. F

   U_1 for vertical surface = 2.14 Btu/hr - sq. ft. - deg. F

   U_1 for horizontal surface facing downward = 1.86 Btu/hr - sq. ft. - deg. F

c. T_L (180 deg F) - T_A (80 deg F) = 100 deg F

d. Heat Loss from walls and bottom

$$Q = (U_1 A_V + U_1 A_B) \times 100$$
$$= ((2.14 \times 276) + (1.86 \times 76)) \times 100$$
$$= 73{,}200 \text{ Btu/hr}$$

6.1.6.3 Estimated Wall and Bottom Loss with Insulation Using the Steps in Section 6.1.5.1

a. Vertical wall area (A_V) = 276 sq. ft
Bottom area (A_B) = 76 sq. ft

b. From Table 6.2 for 1 inch insulation and surface to air temperature difference of 100 deg. F

U_2 = 0.38 Btu/hr - sq. ft. - deg. F

c. T_L (180 deg. F) - T_A (80 deg. F) = 100 deg. F

d. Heat loss from walls and bottom with insulation

$$Q = (U_2A_V + U_2A_B) \times 100$$
$$= (0.38 \times 276 + 0.38 \times 76) \times 100$$
$$= 13{,}376 \text{ Btu/hr}$$

6.1.6.4 Estimated Heat Loss from a Fluid Surface with No Cover

a. Liquid surface area = 76 sq. ft.

b. From Table 6.3 heat loss from a water surface at a temperature of 180 deg. F and air velocity of 0.5 ft per second = 2,400 Btu/hr - sq. ft.

c. Combined heat loss from a fluid surface with no cover.

$$Qc = 76 \times 2400$$
$$= 182{,}400 \text{ Btu/hr}$$

6.1.6.5 Estimated Heat Loss with a Cover

a. Cover area = 76 sq. ft.

b. From Table 6.1 for a temperature difference of 100 deg. F

U_1 for horizontal surface facing upward = 2.37 Btu/hr - sq. ft. - deg. F

c. T_L(180 deg. F) - T_A(80 deg. F) = 100 deg. F

d. Heat loss from cover = A x U_1 x 100 deg. F
= 76 x 2.37 x 100
= 18,012 Btu/hr

6.1.6.6 Summary

	No Insulation Or Cover	Insulation No Cover	Insulation And Cover
Wall and Bottom Heat Loss (Btu/hr)	73,200	13,376	13,376
Surface Heat Loss (Btu/hr)	182,400	182,400	18,012
Total (Btu/hr)	256,600	195,776	31,388

DATA ANALYSIS

DEPT OF NAVY - NAVFAC BUILDING NO.: _ _
ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ I.D. NO. _ _ _ _
ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

Estimated Heat Loss Before Energy Conservation Action

Tank Surfaces: Size: _ _ _ _ ft, W _ _ _ _ ft, H _ _ _ _ ft

Bottom	=	L x W	=	_ _ _ _ _ _ _ _ _ _	sq ft
Sides	=	2 x L x H	=	_ _ _ _ _ _ _ _ _ _	sq ft
Ends	=	2 x H x W	=	_ _ _ _ _ _ _ _ _ _	sq ft
		Total Area	=	_ _ _ _ _ _ _ _ _ _	sq ft

Estimated Wall Heat Loss:

____________________ Btu/hr

Estimated Bottom Heat Loss:

____________________ Btu/hr

Estimated Liquid Surface Heat Loss:

____________________ Btu/hr

Estimated Total Heat Loss:

____________________ Btu/hr

CALCULATED BY: _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _ _ _ _ _ _ _ _

DATA ANALYSIS Sheet 2 of 2

DEPT OF NAVY - NAVFAC BUILDING NO.: _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

Estimated Heat Loss After Energy Conservation Actions

ITEM	Estimated Heat Losses MBTU/HR
Addition of Lid, Cover or hollow plastic spheres	_ _ _ _ _ _ _ _ _ _ _
Additional Wall Insulation	_ _ _ _ _ _ _ _ _ _ _
Additional Bottom Insulation	_ _ _ _ _ _ _ _ _ _ _
Change in Operating Temperature	_ _ _ _ _ _ _ _ _ _ _
Change in Ventilation Flow Rates	_ _ _ _ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _	

Annual Total Energy Savings based on the Above Items as Well as a Change In Scheduling (List below)

_ _

_ _

_ _

_ _

Annual Total

HTW or Steam Heating _ _ _ _ _ MBTU

Electric _ _ _ _ MBTU

CALCULATED BY: _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _ _ _ _ _ _ _ _

AD-A131 117 ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U) 2/5
SYSKA AND HENNESSY INC NEW YORK JAN 81
N62472-78-C-1059

UNCLASSIFIED F/G 5/3 NL

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CHECKLIST - PROCESS TANKS SHEET 1 of 5

DEPT OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I.D. NO._ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

Before evaluating specific process tanks it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specifc problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies	
	Yes	No
1. Consider insulating the paint line wash tanks and piping to reduce heat loss or use cold solutions. Some plant operators estimate they have achieved up to 20% fuel reduction in metal pretreatment operations after insulating tanks. Evaluation: _		
2. Check whether process cooling water that is presently being discharged to a sewer can be rerouted as make-up water for the tanks. Evaluation: _		
3. Check whether washers should run during downtime periods, and mealtimes. Evaluation: _		

DEPT OF NAVY - NAVFAC BUILDING NO.: ________

ENERGY CONSERVATION AUDIT SHOP NO.:____ I.D. NO.____

ACTIVITY ___________ LOCATION: FL _____ BAY _____

	Applies Yes	No
4. Can heat loss be reduced by floating plastic balls on top of the fluid in the tank? Evaluation: ______________________ ______________________		
5. Check whether steam condensate from tank heating coils can be piped to a power spray washer. Evaluation: ______________________ ______________________		
6. Check whether steam condensate from tank heating coils can be rerouted and recovered with a heat exchanger. Evaluation: ______________________ ______________________		
7. Determine whether there is a formal shutdown procedure for the plating tanks. Namely, the temperature reduction and the amount of rinse water left running. Evaluation: ______________________ ______________________		

CHECKLIST - PROCESS TANKS

DEPT OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

	Applies Yes	Applies No
8. Can the temperature of any of the tanks be reduced without impairing productivity? Evaluation: _		
9. Determine whether the washer can be eliminated by selecting a paint compatible with the lubricant being cleaned from the part. Evaluation: _		
10. Can the temperature of any of the washers be reduced with the use of low temperature detergents? Evaluation: _		
11. Minimize leaks, overflow and other fluid losses from heated process or rinse tanks. Evaluation: _		

DEPT OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I.D. NO._ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

Applies: Yes | No

12. Can the overflow from the rinse tank be used as make-up water for the wash tank?

    Evaluation: _

13. Check whether the wash tank overflow can be passed through a heat exchange to preheat the make-up water.

    Evaluation: _

14. Cover all heated tanks when not in actual use.

    Evaluation: _

15. Heavy parts degreasing is normally done in one of four ways: steam cleaning, high pressure washing, cold solvent wash, or hot vapor degreasing. Investigate the fifth and fairly new process of foam cleaning. A foam compound is sprayed on the item, left for about 15-30 minutes, and washed off. The process is far less energy intensive than steam cleaning and

DEPT OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

	Applies Yes	No
normally less energy intensive than high pressure washing.		
Evaluation: _		
16. Often compressed air is bubbled through the fluid in the tanks to provide agitation. Consider installing times to cycle the air flow, rather than have a continuous flow of air bubbles.		
Evaluation: _		
17. If compressed air is bubbled through the fluid in the tanks, consider the use of a high pressure blower in lieu of throttling high pressure compressed air.		
Evaluation: _		

6.2 PAINT BOOTHS AND TUNNELS

6.2.1 INTRODUCTION

Spray-finishing facilities range in size from one or several booths or tunnels, to entire aircraft hangers. Typically, outdoor air is filtered, heated, humidified, and delivered to one end of the area, flows across the work to remove entrained mist, passes through a mist-capturing device, and is exhausted to the outside. Newer facilities may provide for some recirculation of air (up to 60%) although this is relatively rare. Large quantities of air are required, since air flow is usually about 100 ft. per minute. Consequently, heating and humidification costs are considerable, and the opportunity for energy conservation is large.

6.2.2 SPRAY FINISHING FACILITIES

The conditions required for the particular spray process are usually determined from OSHA requirements and specifications provided by Process Engineering. These will include minimum air flow, temperature, and humidity limitations for each operation performed in the facility.

In the paint mixing/storage areas, minimum ventilation must be provided on a continuous basis (per OSHA requirements), with additional ventilation, such as hood exhaust for paint-mixing, provided only during the actual activity. For maximum effectiveness, these systems should be as automatic as possible. Flow sensors in spray apparatus will be utilized to initiate full air flow and turn on the water fall when sprayings tarts. Sensors will then turn off waterfalls and reduce ventilation for initial drying when spraying ceases. Rotary-timed swtiches will operate hood exhaust for 30 minute periods for paint-mixing activities.

6.2.3 RESOURCES FOR A SURVEY

Where Applicable:

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications provided by the facility process engineers. Heat from the loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Review of instrumentation, data gathering, and calculations.

Proper operating operating schedules as well as sizing and speeds can offer energy savings.

Important to consider when dedicated (exclusively for the paint booths and tunnels) air compressors are used.

DATA COLLECTION - PAINT SPRAY

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION FL _ _ _ _ BAY _ _ _ _ _ _

1. EQUIPMENT:

_ _ _ _ _ Water-wash spray booth (located in spray room)

_ _ _ _ _ Water wash spray tunnel (or plant floor, one end wall made up of filter pads.

_ _ _ _ _ Dry-type spray booth with baffles or filter pads.

Approximate dimensions at walk-in opening _ _ ft x _ _ ft

2. OPERATING REQUIREMENTS:

Temperature _ _ _ _ _deg. F, Relative Humidity _ _ _percent

3. AIR FLOW

Supply Source: _ _ _ _Plant Air, _ _ _ _ Outdoor Air.

Flow Rate: Supply Air Fan _ _ _ _ _ cfm

Booth _ _ _ _ _ cfm

Make-up from plant _ _ _ _ _ cfm

4. OPERATING SCHEDULE

Day	Operating Hours	Equipment Shutdown When Unloaded	Equipment Shutdown At End of Shift
_ _ _	_ _ _ am to _ _ _ pm	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _
_ _ _	_ _ _ am to _ _ _ pm	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _
_ _ _	_ _ _ am to _ _ _ pm	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _
_ _ _	_ _ _ am to _ _ _ pm	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _

CONDUCTED BY _ _ _ _ _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _ _ _ _ _

DATA COLLECTION - PAINT SPRAY

DEPT. OF NAVY - NAVFAC BUILDING NO.: ____ ITEM: ____

ENERGY CONSERVATION AUDIT SHOP NO.: ____ ID NO.: ____

ACTIVITY ________ LOCATION FL ____ BAY ______

5. AUTOMATIC CONTROLS

Air Temp ________, Relative Humitidy _____

Supply Fan: Damper _______ Speed ________

Exhaust Fan: Damper _______ Speed ________

Water Wash Pumps __________

Fans and water flow automatically controlled by flow sensor in spray apparatus _____

6. HEAT RECLAIM SYSTEM:

____

7. POSSIBLE SAVINGS

Compare the data collected with the checklist.

Consider the applicable data analysis forms in Section 7.2, and Appendices E, F and G.

CONDUCTED BY _______________ DATE __________

6.2.4 SAMPLE CALCULATIONS-PAINT SPRAY BOOTH

Estimate the amount of heat required for a paint spray booth using 100% outside air during a 21 week heating season. The flow rate is 15,000 cfm and the booth operates 16 hours a day, 5 days a week. The average outdoor temperature is 40°F and the discharge temperature of the make-up air is 80°F. How many BTU's are required? How many gallons of oil (140,000 BTU/gal) are required if the efficiency of the heating system is 60 per cent?

Preliminary Calculations

Specific heat of air = 0.24 BTU/lb-°F

Density of air = 0.075 lb/cubic ft.

$$0.24 \times 0.075 \times 60\ /\text{min/hr} = 1.08\ \frac{\text{BTU-min}}{\text{hr-cubic ft-}^{\circ}\text{F}}$$

T_M = Temperature of make-up air

$T = (T_M - T_A)$

T_A = Temperature of ambient air

then: cfm x 1.08 x Δ temp = ____________ BTU/hr

Sample Calculations

Heating requirements

cfm x 1.08 x Δ temp = ______________BTU/hr

15,000 x 1.08 x (80-40) = 648,000 BTU/hr

then:

21 weeks x 5 days/week x 16 hrs/day x 648,000 BTU/hr =

1.088 million BTU

Fuel requirements

$$\frac{1{,}088{,}000{,}000\ \text{BTU}}{140{,}000\ \text{BTU/gal} \times 0.6} = 12{,}950\ \text{gallons}$$

NOTE: the fan power requirements must also be considered.

CHECKLIST - PAINTING SYSTEM   SHEET 1 of 3

DEPT. OF NAVY - NAVFAC   BUILDING NO.: ____ ITEM: ____

ENERGY CONSERVATION AUDIT SHOP NO.: ____ ID NO.: ____

ACTIVITY ________   LOCATION FL ____ BAY ______

Before evaluating specific painting systems it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. Check booth velocity carefully to avoid over exhausting. Consider using electrostatic spray since this usually permits a reduction of booth velocity of about 40%. Evaluation: ____________________ ______________________________		
2. Consider the installation of an automatic damper in the paint spray booth stack to shut off the air flow when no painting is taking place. Evaluation ____________________ ______________________________		
3. Reduce spray booth make up air temperature to 65^{o}-68^{o}. Use outdoor air if possible, with heat recovery as necssary. Evaulation: ____________________ ______________________________		

DEPT. OF NAVY - NAVFAC   BUILDING NO.: _ _ _ _ ITEM: _ _ _ _
ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _
ACTIVITY _ _ _ _ _ _ _   LOCATION FL _ _ _ _ BAY _ _ _ _ _ _

Applies
Yes | No

4. Consider heat recovery equipment, such as heat pipes", in spray booth stacks. If heat recovery equipment is used, a regular maintenance program is required to minimize heat losses caused by paint residue build up.
   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _
   _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

5. Be sure all air filters are kept clean.
   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
   _

6. Consider use of airless spray instead of air spray paint application. While it requires about 9.5 hp to atomize 1 gpm using air spray, it requires about 1.3 hp to atomize 1 gpm using airless spray. Airless spray is particularly suited to large, heavy work pieces that must be painted in place, such as heavy equipment, barges, structural steel, ships, cranes, etc.
   Evaluation:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _
   _

7. Investigate conversion to water base painting materials. Water base usually cuts energy consumption by reducing spray booth air flow, oven exhaust, air makeup requirements, and oven times. In some cases, finishing lines have reduced total natural gas consumption up to 45%.
   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
   _

6.3 PAINT DRYERS AND OVENS

6.3.1 INTRODUCTION

Areas controlled to temperature levels to accommodate processes, are often much higher than is necessary for the process. For example, paint drying time is reduced when the surrounding air temperature is raised. This phenomenon is particularly true for the older enamels. The new two-part epoxy and polyurethane paints will cure well at lower temperatures. Paint hanger temperature can be reduced from the traditional 85°F to 70°F for drying with little increase in drying time and huge annual energy saving. Paint preparation areas (i.e., stripping, steam cleaning, anodizing, and masking) might be controlled to no more than 70°F during the heating season. For specific data concerning drying time/temperature consult paint manufacturers' literature.

6.3.2 RESOURCES FOR A SURVEY

Where Applicable: (Paint Dryers and Ovens)

Process Air; Heating, Ventilating and Exhaust Systems. . 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements and facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the feasibility of such a system.

Air Flow Measurements . . . . .Appendix B.4

Review of instrumentation, data gathering, and calculations.

Fans and Electric Motors . . . . .Appendix F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

Heat Treat Furnaces/ovens . . . . Appendix G

For ovens, items on the data collecion sheets such as surface temperatures, operation cycles and floor dimensions are useful in analyzing cycle efficiency and insulation improvement.

DATA COLLECTION AND ANALYSIS FORMS

The uniqueness or th equipment often requires the use of the generalized forms. The forms are found in Appendix K.

Data Collection Form K-3

Sketch Sheet K-4

Data Analysis Form K-5

DATA COLLECTION - DRYING OVENS SHEET 1 of 2

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ _ I.D. NO. _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _ _

1. EQUIPMENT:

Electric . . . . Gas Fired . . . . . . Oil Fired . . .

Approximate Rating:. . . . . KW . . . cfm . .gpm

Dimensions: . . . . ft x . . . . ft x . . . . . ft.

2. TEMPERATURES: . . . . . . .deg F

Ambient, Plant Area: . . . . . . .deg F

Oven Operating Temperature: . . . . . . .deg F

Outside Oven Wall Temperature . . . . . . .deg F

3. TYPES OF PAINTS;

Primers . . . . Enamel . . . . ., ...

4. OPERATING SCHEDULE:

Day	Operating Hours	No. of Batches	Percent Loaded
_ _ _	_ _ _ am to _ _ _pm	_ _ _	_ _ _
_ _ _	_ _ _ am to _ _ _pm	_ _ _	_ _ _
_ _ _	_ _ _ am to _ _ _pm	_ _ _	_ _ _
_ _ _	_ _ _ am to _ _ _pm	_ _ _	_ _ _

CHECKLIST - DRYING OVENS Sheet 1 of 6

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _ _ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _ _ _ _ _

5. AUTOMATIC CONTROLS

Temperature . . . . Process Timers . . . .

Electric Demand Interlocks . . . .

Automatic Warm-up . . . .

Automatic Exhaust Fan Controls . . . .

6. OVEN EXHAUST SYSTEM

Intake: Plant Air . . . . . ., Outside Air . . . . .

Flow Rate: (If Available . . . . cfm)

7. HEAT RECLAIM SYSTEM

. . . .

8. POSSIBLE SAVINGS

Compare the Data Collected with the Checklist.

Consider the applicable data forms in Section 7.2

and Appendices E, F and G.

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _LOCATION: FL_ _ _BAY_ _ _ _ _ _ _ _

Before evaluating specific paint dryers and ovens or drying operations it is desirable to refer to the following checklist. Although no form applying to each point is presented in this guide a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. If batch ovens are used, maximize loading and optimize working hours for highest energy efficiency. Similarly, minimize warm up time as much as possible. Evaluation: _		
2. Consider installation of oil fired paint ovens instead of gas fired. New oven technology can minimize paint discoloration and soot problems if a light, low sulfur (1%), oil is used. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies Yes	Applies No
3. Consider installation of direct fired paint oven instead of indirect fired. The heat transfer coefficient for direct fired is about 97% versus 60% for indirect fired, with comparable differences in fuel consumption. Evaluation: _		
4. Investigate converting paint ovens to the "Raw Oven Exhaust Recycle Process". This system returns part of the oven exhaust back to the oven after passing through an incinerator. Evaluation: _		
5. Conduct fuel gas analysis on burners at least once per year. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies	
	Yes	No
6. Investigate installing electric ovens instead of gas or oil fired. Higher operating costs are somewhat offset by better temperature control, constant one-fuel operation, and more readily controllable over atmosphere. Evaluation: _		
7. Consider heat recovery equipment, such as "heat pipes", in bake oven stacks. If heat recovery equipment is used, a regular maintenance program is required to minimize heat losses caused by paint residue build up. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ BAY_ _ _

	Applies	
	Yes	No
8. Consider additional paint oven wall insulation. Doubling the present thickness (usually only 2") will cut wall losses in half. Since most paint oven heat is lost through oven roofs, this portion in particular should be well insulated. Evaluation: _		
9. If applicable, consider, converting to high intensity infra-red curing which uses as little as 10% of the energy required for a comparable gas fired oven. Evaluation:_ _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies Yes	Applies No
10. Check that prime paint oven temperature is not higher than necessary. Evaluation: _		
11. Investigate changing to a primer that requires a lower bake temperature. Evaluation: _		
12. Investigate switching from conventional finishes to low temperature curing coating, such as urethanes. Oven temperature can often be reduced from 350°F to as little as 150-180°F. Often, only a partial tack free oven cure is required. Final curing takes place at room temperature. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies	
	Yes	No
13. Investigate conversion to water base painting materials. Water base usually cuts energy consumption by reducing spray booth air flow, oven exhaust, air makeup requirements, and oven times. In some cases, finishing lines have reduced total natural gas consumption up to 45%. Evaluation: _		
14. Consider the feasibility of using a water base paint that allows the dipping of wet phosphated parts into paint tanks. Evaluation: _		
15. Investigate conversion to airless paint drying from conventional oven baking. This system holds oven oxygen content to as low as 1%, with resulting reductions in oven exhaust and gas requirements. Evaluation: _		

6.4 CHILLING WELL

6.4.1 INTRODUCTION

Chilling wells are used as soaking pits for parts. It is one element in a process that develops special mechanical properties in the parts.

The wells are open pits in the plant floor. This allows an overhead crane to move, raise and lower parts and sheets in and out of the pit. Cold air is circulated within the well on a continuous basis.

Scheduling and Operating Temperature. If the operating temperasture of the pit is, for example zero degrees F determine how high the temperature can rise during unused periods and produce savings!

Pit covers. Presently pit covers do not appear feasible on the larger units. They must be insulated properly and structurally capable of frost loading. Furthermore, the covers must be easily stored during unused periods.

6.4.2 RESOURCES FOR A SURVEY

DATA COLLECTION - CHILLING WELL Sheet 1 of 1

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.:_ _

ACTIVITY_ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

1. DIMENSION:. . .ft deep x . . . ft long x . . .ft wide

2. TEMPERATURES

Ambient, Plant Area, ... degrees F

Pit Operating Temperature . . . . . degrees F

3. MATERIAL

Material chilled . . . . inches

Maximum thickness of material . . . .

4. SCHEDULE OF PIT TEMPERATURES NON-SOAKING HOURS

Weekdays: . . . . pm to . . . . . am . . . . . deg F

Weekends: . . . . pm to . . . . . am . . . . . deg F

5. REFRIGERATION SYSTEM

Location	Motor Size, HP	Estimated Operating Hours Per Day
Compressor	. . . . .	. . . .
Pit Fans	. . . . .	. . . .
Cooling Tower	. . . . .	. . . .
	. . . . .	. . . .

6. POSSIBLE SAVINGS; Consider programmed pit temperature changes during unloaded pit conditions. During the testing provide recorders on the motors to determine if real savings are occurring.

CONDUCTED BY _ _ _ _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _ _ _ _

6.5 HEAT TREATING

6.5.1 INTRODUCTION

Ovens and heat treat furnaces vary considerably in size and shape, and may be heated electrically or by gas or by steam for lower temperature ovens. Heat losses from furnaces and ovens occur by conduction through the walls and by poorly fitting doors and other leakage paths. Old furnaces and ovens with damaged insulation should be repaired or completely insulated with materials having higher "R" factors, a measure of thermal resistance. Applying additional insulation over the metallic outer skin of an oven or furnace is not recommended as a fix because the temperature rise can result in thermal distortion and rupture of the skin. Leakage at door seals and other openings can result in a significant energy loss; much of this can be avoided by routine (annual) inspection and maintenance as dictated.

Salt Baths are usually maintained at constant temperatures. Hence, the amount of insulation, the fit of the tank covers, and the duty cycle become important factors in energy conservation.

6.5.2 OVENS AND HEAT TREAT FURNACES

Ovens and furnaces are frequently allowed to run when not actually in use simply because it is convenient to do so. The time during which any furnace or oven is heated should be minimized, using the latest start-up and earliest shutdown times consistent with scheduling requirements. It is often possible to shutdown for prolonged periods by adopting batch processing. Automatic timers are generally recommended for ovens.

To reduce thermal losses, additional insulation may be added to the interior of the furnace wall over existing firebrick or other refractory using new fiberous or cellular materials applied with mechanical fasteners and/or adhesives. Manufacturers literature should be consulted for specific installation criteria. Insulation cannot be added to the outside of a furnace, because exterior shell temperatures, normally about 140°F, could be raised several hundred degrees, resulting in excessive thermal expansion and furnace failure. Door seals are critical and a procedure of scheduled maintenance, to replace seals before visible breakdown, is recommended.

Ventilation requirements may vary considerably, depending on the nature and quantity of the vapor or fumes given off. Exhaust should be reduced to the minimum necessary to control area pollutants and excess heat. A canopy hood located 3 to 4 feet above a furnace door is more efficient than a general area exhaust fan. Consideration should be given to recovery of the waste heat by an appropriate heat exchanger for utilization in other applications; e.g., space heating, hot water, preheating furnace combustion air, etc. Heat treat furnaces and ovens usually operte above 650^{o}F. There are many equipment classifications. Some are:

Direct interal fired - oil or gas burners

Indirect internal fired (radiant tube furnace).

Direct external fired recirculation gas.

Special atmosphere furnaces.

Induction trea furnaces.

Induction treating furnaces.

Dielectric heating furnaces.

Electric coil ovens and furnaces.

6.5.3 SALT BATHS

Salt baths are tanks, heated electrically or by gas, containing a melted salt at approximately 1000^{o}F, usually for solution heat-treating of aluminum. The salt bath is generally maintained at operating temperatures on a continuous basis. Therefore, the tanks should be well insulated, with a close-fitting insulated cover. it is imperative for energy conservation that cover seals be in good condition and that the cover fits tightly. Specific ventilation for control of air contaminants is generally not required. It may be possible to lower the bath temperature during periods of non-use of one or more days. Extreme care must be exercised to prevent the temperature from falling so low that the salt recrystallizes, since the remelting process requires considerable time and energy. The recommended procedure for determining potential savings is to monitor the duty cycle (energy input) of the bath at operational temperature then shut down the furnace and closely monitor the temperature decay. At the end of the anticipated shut-down period, or before, if lower temperature limit is approached, restart the heaters and monitor duty cycle as the temperature returns to normal. For example, a typical salt pot heater may be rated at 200 KW, and operate at a 25% duty cycle while maintaining 1000°F. The temperature of the salt bath may decay to 600°F in a 24-hour period, which for our example, is 100°F above the melting point of the salt. It may require 6 hours to attain the operating temperature (1000°F), during which time our typical bath heater was on a total of 6 hours (duty cycle = 100%).

Savings are as follows:

200 KW x 25% x (24+6) - 200 KW x 6 = 1500 KWH - 1200 KWH = 300 KWH.

Yearly energy savings from 52 weekly 24 hour shutdowns will total 15,600 KWH, which at $0.38 saves $593.

6.5.4 RESOURCES FOR A SURVEY

Data Collection and Analysis Sheets

Ovens . . . . 6.5-7, Appendix G

Appendix J items on the data collecion sheets such as wall surface temperatures and floor dimensions are useful in analyzing insulation improvement.

Heat Treat Furnaces . . . . Appendix G

Checklists 6.5-8

Where Applicable

Process Air: Heating, Ventilating and Exhaust Systems. 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhaust is often recovered with run-around -loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements . . . . .Appendix B.4

Review of instrumentation, data gathering, and calculations.

Fans and Electric Motors . . . . Appendix F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

DATA COLLECTION AND ANALYSIS FORMS

The uniqueness of the equipment often requires the use of the generalized forms. The forms are found in Appendix K.

DATA COLLECTION - HEAT TREAT OVENS SHEET 1 of 2

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ BAY_ _ _ _

1. EQUIPMENT:

Electric . . . .Gas Fired . . .Oil Fired . . .

Approximate Rating:. . . .KW . . .cfm . . . gpm

Dimensions: . . . . ft x . . . . . . ft x . . . . . ft.

2. TEMPERATURES: . . . . . . .deg F

Ambient, Plant Area: . . . . . . .deg F

Oven Operating Temperature: . . . . . . .deg F

Outside Oven Wall Temperature . . . . . . .deg F

3. TYPES OF PAINTS;

Primers . . . . Enamel . . . . . ., ...

4. OPERATING SCHEDULE:

Day	Operating Hours	No. of Batches	Percent Loaded
_ _ _	_ _ _ am to _ _ _pm	_ _ _	_ _ _
_ _ _	_ _ _ am to _ _ _pm	_ _ _	_ _ _
_ _ _	_ _ _ am to _ _ _pm	_ _ _	_ _ _
_ _ _	_ _ _ am to _ _ _pm	_ _ _	_ _ _

DATA COLLECTION - HEAT TREAT OVENS SHEET 2 of 2

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ _ I.D. NO. _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _ _ _

5. AUTOMATIC CONTROLS

Temperature . . . . Process Timers . . . .

Electric Demand Interlocks . . . .

Automatic Warm-up . . . .

Automatic Circulating Fan Controls . . . .

Automatic Exhaust Fan Controls . . . .

6. OVEN EXHAUST SYSTEM

Intake: Plant Air . . . ., Outside Air . . . . .

Flow Rate: (If Available). . . . . cfm

7. HEAT RECLAIM SYSTEM

. . . .

8. POSSIBLE SAVINGS

Compare the Data Collected with the Checklist.

Consider the applicable data forms in Section 7.2

and Appendices E, F and G.

CHECKLIST - HEAT TREAT OVENS Sheet 1 of 4

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _ _ _ _

Before evaluating specific heat treat ovens or operations it is desirable to refer to the following checklist. Although no specific form applying to each point as presented in this guide a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. Determine whether furnaces can be turned off when there is no scheduled production. Consider whether starting and stopping the furnaces will harm production. Evaluation: _		
2. Consider whether an automatic low-fire control is feasible when no parts are being heat treated. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

Item	Applies Yes	Applies No
3. Check furnace for heat losses from casing, ducts, etc. Use __ infrared survey instrument, __ surface pyrometer, other _ _ _ _ _ _ _ _ for tests. Some hot spots may be due to loss of fire brick. Evaluation: _	\	
4. Check roof of furnace for insulation and determine if additional roof insulation is feasible. Evaluation: _		
5. Determine whether flue gas is being cooled with heated plant air. Consider the ducting of outside air for cooling the flue gas. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies Yes	No
6. Heat recovery is at a maximum through the use of __ air preheater, waste heat recovery from stack, __ other, specify _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Evaluation: _		
7. Burners are inspected and maintained on a scheduled basis. Check whether existing burners are as efficient as available. Evaluation: _		
8. Furnace controls should include either __ a portable 0_2 analyzer for furnaces over 25 to 50 million Btu/hr or __ automated combustion controls. Evaluation: _		

DEPT. OF NAVY - NAVFAC   BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _   LOCATION: FL_ _ _BAY_ _ _

	Applies Yes	Applies No
9. Excess air should be monitored __ continuously, __ daily, weekly, __ monthly to keep within the recommended range for the fuel. Check furnace for air leaks. Evaluation:_ _		
10. Fuel oil atomization is optimum with fuel oil supply at correct temperature __. Atomizing steam is dry __, and at correct pressure __ and minimum volume __. Air atomization is used __. Evaluation: _		

6.6 MACHINE TOOLS (PROCESS MACHINERY)

6.6.1 INTRODUCTION

Machine tools (process machinery) includes all metal cutting and forming equipment from a drill press to a numerically controlled jig borer. Also included are wood working tools, structural and hydraulic test equipment, and powered hand tools. Although the combined total of all process machinery is seldom significant when compared with other categories of power users, it cannot be ignored without due consideration.

Pneumatic, electric and hydraulic tool selection will depend on the facilities available power source. However, there are advantages and disadvantages associated with each type. Pneumatic tools: can vary speed from maximum to stall, are typically lighter and smaller, are highly reliable and simple to repair. Pneumatic tools are subjected to extremely hard usage and abuse resulting in accelerated wear. Electric tools require thorough maintenance or can be dangerous to operate. Hydraulic tools run quieter but require careful observation of hydraulic pumps, hoses and possible coupling failure.

6.6.2 DEVELOPING ENERGY CONSERVATION OPPORTUNITIES FOR MACHINE TOOLS.

Measuring actual power consumption for process machinery is not a practical approach for vast manufacturing areas. Nameplate data along with loading factors and duty cycle will permit estimating power used.

Many of the metal fabricating processes are low power consumers and therefore are not candidates for energy saving modifications. The discipline of shutting off machines in this category, when not in use, is generally good. One related function which often yields energy saving is ventilation air flow used to exhaust contaminated air from work area. Frequently exhaust fans are allowed to run when the machines are not operating and even when work areas are unoccupied. Correcting this problem is not easy because it is usually not obvious when an exhaust fan is on or off. One method which has been used successfully is to interlock exhaust fan motor start/stop functions with fabricating machinery switchgear.

6.6.3 RESOURCES FOR A SURVEY

Where Applicable:

The checklist, particulary when air is used for agitation, or cleaning dies.

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Review of instrumentation, data gathering, and calculations.

DATA COLLECTION AND ANALYSIS FORMS

The uniqueness of the equipment often requires the use of the generalized forms. The forms are found in Appendix K.

CHECKLIST - MACHINE TOOLS SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

Before evaluating specific machine tool it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. Consider, for a grinding operation, different (smaller) water cooling nozzles: Evaluation: _		
2. Determine if equipping a press or other machine tool with an automatic shutdown switch when it is idle for more than 10 or 20 minutes, would be feasible. Evaluation: _		
3. Install solenoid values on machine air lines so that air is used only when the machine is productive. Evaluation: _		
4. The electrical distribution system should have a power factor of 85% or higher. If lower, it is usually due to inductive loads like electric motors. Correction can be achieved by using synchronous motors and/or system capacitors or		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-L NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies	
	Yes	No
individual motor capacitors. While the distribution system is not part of this audit, its power factor affects both motor and distribution capacity. Evaluation: _		
5. The motor and system power factors are affected by running many individual motors partly loaded. If the data analysis shows a motor load factor of 0.60 or lower, and if the motor is known not to exceed that load, determine the true horsepower requirements. This will yield a power factor improvement when the motor is replaced with a smaller one. Evaluation: _		
6. If a motor or group of motors runs lightly loaded most of the time yet full power is needed occasionally, it (they) usually cannot be replaced		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies	
	Yes	No
with smaller ones. Consider a motor capacitor or capacitor for the group. Evaluation: _		
7. Often compressed air must be bubbled through soluble machining oil. Consider installing timers to cycle the air flow, rather than have a continuous flow of air bubbles. Evaluation: _		
8. Determine whether a continuous stream of compressed air is necessary to blow scale and dirt from the dies on a mechanical power press. Consider installing cams or solenoids to produce short blasts of air. Evaluation: _		

6.7 CHEMICAL MILLING OPERATIONS

6.7.1 INTRODUCTION

Chemical milling is a process applied to the manufacture of structural parts used in the aerospace industry. It is used where conventional machinery and forming methods are too difficult to be practical. Chemical milling selectively reduces the thickness of a part, by the immersion of the work piece in a liquid-chemical bath and the resulting dissolving of the exposed metal. The process is not new since it is basically controlling surface etching. What is important is its production capability.

6.7.2 THE STEPS IN THE PROCESS

There are five steps in the process:

a. cleaning the workpiece

b. masking - applying a protective coating over the areas of the workpiece that is not to be etched.

c. scribing - removing any masking material from the material removal areas of the workpiece.

d. etching - removing the material from the workpiece by immersing it in a solution.

e. demasking - removing the residual masking material.

6.7.3 TANKS AND EQUIPMENT

The tanks and equipment will vary from installation to installation. The reader should review Section 6.1, Process Tanks, particularly the following articles:

6.1.1 Introduction

6.1.2 Vapor Degreasers

6.1.3 Chemical Process Lines

The unique tanks in the line will be the etching tanks. The energy conservation team should recognize that the system usually is designed with operator safety as the first priority and the cost of heat and process chemicals lost by evaporation as a minor priority.

Furthermore, the etching tanks must have a reliable heat source. The dissolved material in an etchant can precipitate as a result of the drop in temperature, and can be extremely difficult to remove from the tank.

An installation for a titanium chemical milling plant could contain the following:

Cleaning Line:

De-scaling tank (hot caustic)

Rinse

Hydrofluoric - nickle pickle tank

Rinse

Drying Tank

Chemical - Milling Line:

Etching Tank

Rinse Tank

Second Etching Tank (depending on the amount of chemical milling)

Both lines will also have fume extraction equipment.

6.7.4 RESOURCES FOR A SURVEY

The checklist, particularly when air is used for agitation.

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhuast is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Review of instrumentation, data gathering and calculations.

Pumps and Electric Motors . . . . Appendices D&E

Fans and Electric Motors . . . . .Appendices F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

Air Compressors . . . . Appendix H

Important to consider when dedicated (exclusively for the tanks) air compressors are used.

6.8 WELDING, BRAZING AND FLAME CUTTING

6.8.1 INTRODUCTION

Welding, Brazing, and Flame Cutting is often categorized with machine tools (process machinery). The uniqueness of some of the processes, welding in particular, warrants this special category.

6.8.2 RESOURCES FOR A SURVEY

Process Air: Heating, Ventilating and Exhaust Systems. 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements. . . . . .Appendix B.4

Review of instrumentation, data gathering and calculations.

Fans and Electric Motors . . . . .Appendices F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

6.8.3 DATA COLLECTION AND ANALYSIS FORMS

When additional items, such as those found on the checklist, are applicable then the generalized froms can be used.

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION FL _ _ _ _BAY _ _ _ _ _ _ _

Before evaluating specific welding systems it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specifc problem may be addressed and several alternatives compared to check for their economic feasibility.

SYSTEMS

	Applies Yes	Applies No
1. Investigate converting torch cutting equipment fuel from acetylene, natural gas, or propane to methylacetylene propadiene, stabilized (MAPP). This gas may result in the improved performance, higher cutting speeds, and reduced oxygen consumption. Discuss with welding engineer or vendor's representative. Evaluation: _		
2. If applicable, consider utilizing seam welding (RSEW) instead of coated electrode metal arc welding (SMAW), metallic inert-gas welding (GMAW), or submerged arc welding (SAW). The process is also less energy intensive than most other applicable welding processes. Evaluation: _		
3. Consider utilizing electronic precipitators to "scrub" welding exhaust fumes and thereby eliminate building exhaust with its attendant heat loss, or investigate bag type filters. Evaluation: _		

CHECKLIST - WELDING SYSTEMS SHEET 2 of 5

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION FL _ _ _ _BAY _ _ _ _ _ _ _

SYSTEMS

Item	Applies Yes	Applies No
4. Install solenoid valves on welder or water-cooled welding equipment supply lines to limit cooling water flow to actual welder-operating periods. Evaluation: _		
5. Consider the installation of smoke detectors to control welding exhaust fans. Evaluation: _		
6. If welding shop workload varies widely, investigate ordering new transformer-type welders with built-in power factor correcting capacitors. Evaluation: _		
7. Investigate the installation of automatic cutting torches, which normally operate at maximum speed, thus yielding maximum cutting for minimum gas consumption. Their cutting speed and accuracy can often replace more energy-intensive alternative manufacturing methods. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION FL _ _ _ _ BAY _ _ _ _ _ _ _

SYSTEMS

Applies: Yes | No

8. Consider operating automatic cutting torches on natural gas or propane instead of acetylene. Acetylene has a higher flame temperature than normally required for steel cutting.
   Evaluation: _

9. Be sure gas welding equipment connections and hoses are tight. Leaks of waste expensive gas are fire hazards.
   Evaluation: _

10. Investigate using high frequency induction heating for brazing operations instead of hand-held torch or a furnace.
   Evaluation: _

11. Replace continuous pilot lights for gas welding torches with conventional flint lighters.
   Evaluation: _

12. Be careful to avoid over-welding, either during design or fabrication. Refer to applicable standards.
   Evaluation: _

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION FL _ _ _ _BAY _ _ _ _ _ _

SYSTEMS

Applies
Yes | No

13. Use flame gouging instead of chipping hammers to remove tack welds, full welds, defects, blow holes, or sand inclusions. Consider using flame deseaming or scrafing instead of chipping hammers to remove cracks, seams scabs, and crowsfeet. Hot scarfing can clean up forgings without the cooling and reheating required by chipping.
Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

14. In general, transformer-type arc welders are more energy efficient than motor-generator welders. At full rated load, transformer-type welders will consume slightly less power than a comparable motor-generator welder. At partial or no load, however, motor generator efficiency and power factor drop appreciably.
Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

15. Investigate "stack cutting" with automatic cutting torches. In many cases, a thicker cut uses proportionately less oxygen per piece than a thinner cut. Cutting accuracy is a maximum below 2" total thickness and gradually deteriorates until the normal maximum cutting thickness of 6" is attained.
Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ ID NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION FL _ _ _ _ BAY _ _ _ _ _ _ _

SYSTEMS

	Applies Yes	Applies No
16. Shut down transformer type and motor-generator arc welders when not in use and during breaks and lunch. Savings will be minimal with transformer type welders, but will become increasingly significant when motor-generator welders are stopped. Evaluation: _		
17. Be sure unused automatic torches are turned off when not in use. Avoid excessive idle time. Evaluation: _		

6.9 FOUNDRY

6.9.1 INTRODUCTION

The foundry at a shipyard might contain furnaces, corebake ovens, casting machines, grinders, sand blast equipment, melt pots, etc. Energy conservation efforts usually are in the areas of operation and scheduling.

The typical foundry likely to be found in a naval rework facility would contain one or more spot or crucible furnaces for the melting of lead and/or zinc for use in making molds. The major potential for energy reduction usually lies in the area of minimizing exhaust of conditioned plant air. Ventilation requirements for molten metal and fluxes must be determined, and minimum ventilation rates established. If the furnace is gas-fired, a separate gas flue may not exist, especially if it is a tilting crucible. In such cases, installation of a separate flue should be considered, particularly if the hood or canopy exhaust can safely be turned off. Zinc mold compounds, such as Kirksite, may not require ventilation, if non-fuming fluxes are used and temperatures do not become excessively high. Lead-pots, however, will require instant ventilation when heated, since lead vapor is a cumulative, systemic poison. Shutdown of melting furnaces for weekends and holiday periods should be studied carefully, since long melt-times and various metallurgical problems may result. Covers are, of course, generally desirable to minimize surface heat loss.

6.9.2 RESOURCES FOR A SURVEY

Process Air: Heating, Ventilating and Exhaust Systems. 7.2

Exhausting conditioned (heated or cooled) process air usually accounts for large energy losses. Process air flow specifications are determined from OSHA requirements facility process engineers. Heat from the exhaust is often recovered with run-around-loop systems. A number of equipment manufacturers offer computer programs to determine the economic feasibility of such a system.

Air Flow Measurements. . . . . .Appendix B.4

Review of instrumentation, data gathering and calculations.

Fans and Electric Motors . . . . .Appendices F&E

Proper operating schedules as well as sizing and speeds can offer energy savings.

Where Applicable

Heat Treat Furnaces and Ovens . . . . Appendix G

MILCON Forms . . . . .Section 10.8

Sample Data and Calculations for a Heat on a Batch Furnace

ADDITIONAL DATA COLLECTION AND ANALYSIS FORMS

Sometimes, the uniqueness of the equipment requires the use of generalized fomrs. The forms are found in Appendix K.

CHECKLIST - FOUNDRY

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

Before evaluating specific equipment within the foundry or foundry operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specifc problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	No
1. Determine whether it is feasible to preheat ingots or materials in the flue sections of reverbatory furnaces. Evaluation: _		
2. Consider the use of Hi-Low firing systems in forging furnaces to reduce the temperature during idle periods. Evaluation: _		
3. Furnace controls should include either -- a portable 0_2 analyzer for furnaces over 25 to 50 million Btu/hr or -- automated combustion controls. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies Yes	Applies No
4. Excess air should be monitored -- a -- continuously, -- daily, -- weekly, -- monthly to keep within the recommended range for the fuel. Check furnace for air leaks. Evaluation: _		
5. Check furnace for heat losses from casing, ducts, etc. Use -- infrared survey instrument, -- surface pyrometer, -- other _ _ _ _ _ _ _ _ for tests. Some hot spots may be due to loss of fire brick. Evaluation: _		
6. Burners are inspected and maintained on a scheduled basis. Check whether existing burners are as efficient as available. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies Yes	Applies No
7. Fuel oil atomization is optimum with fuel oil supply at correct temperature -- . Atomizing steam is dry -- and at correct pressure -- and minimum volume -- . Air atomization is used Evaluation: _		
8. Heat recovery is at a maximum through the use of -- air preheater, waste heat recovery from stack, -- other, specify _ _ _ _ _ _ _ _ _ _ _. Evaluation: _		

6.10 ENGINE TEST FACILITIES AND STATIONARY ENGINES.

6.10.1 INTRODUCTION

The large amount of heat rejection from aircraft engines during production testing as well as the heat rejected by stationary engines at a facility suggests that this energy should be put to some useful end.

6.10.2 ENGINE TEST CELLS

Engine testing consumes large energy rates for short duty cycles. To determine an annual consumption and typical duty cycle requires a review of engine test facility data sheets which will give time at all engine power settings and fuel flow at each setting. Typical time and fuel flow data for each engine type should be recorded on a unique data sheet. Exhaust gas data is not usually available as mass flow or volume flow and will be calculated using engine design data. A proposed data collection sheet is on page 6.10-3. Economic evaluation should follow the MILCON format, Section 10.8

6.10.3 STATIONARY ENGINES

Heat recovery from stationary engines is not new. However, at each installation, the economic justification must be carefully developed for heat recovery equipment. A data collection sheet is on page 6.10-5. A data analysis sheet is on page 6.10-6. Economic evaluation should follow the MILCON format, Section 10.8.

6.10.4 RESOURCES FOR A SURVEY

DATA COLLECTION STATIONARY ENGINES SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

ENGINE TEST CELLS-THERMAL DATA

BLDG. NO. ____________

(NOTE: EACH ENGINE TYPE REQUIRES ITS OWN DATA SHEET)

ENGINE DATA

TYPE ENGINE _________________

TULE FUEL USED______________

EXHAUST GAS DATA

TEMPERATURE, FLOW RATE, AND VELOCITY

IDLE_____________ °F ______LB./SEC. _______ FT./MIN.

MILITARY POWER_____ °F ______ LB./SEC. _______ FT./MIN.

AFTER BURNER ____ °F ______ LB./SEC. _______ FT./MIN.

NO. OF ENGINES TESTED PER YEAR PER TEST CELL __________

FUEL QUANTITY USED PER ENGINE TEST ______ GALS.

NUMBER OF TEST CELLS USED __________

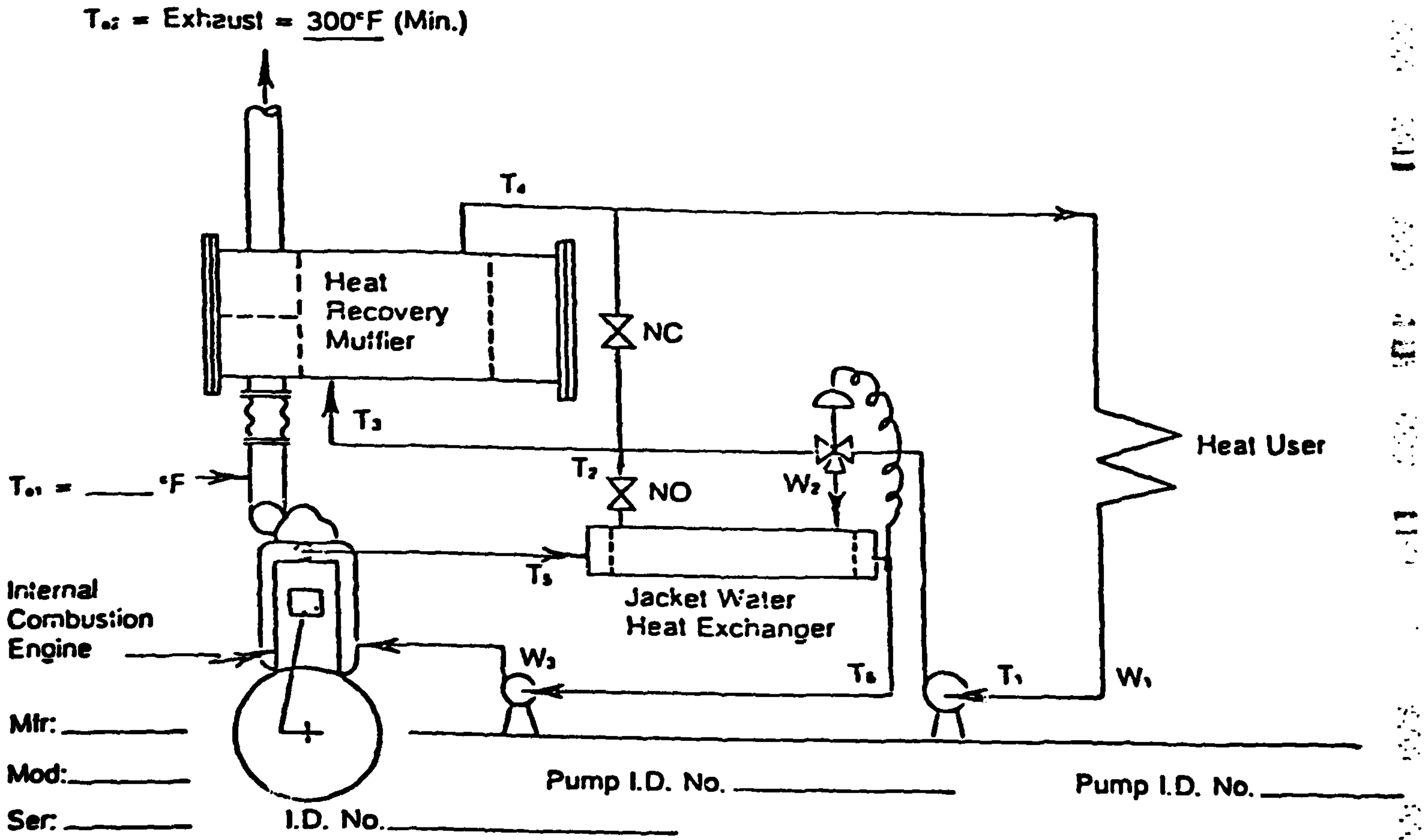
CONDUCTED BY _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _

DATA COLLECTION STATIONARY ENGINES SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _



DATA COLLECTION STATIONARY ENGINES SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

Symbol	Item	Reading
E1	Exhaust from engine	_ _^{o}F
E2	Exhaust from muffler	_ _^{o}F
T1	Return water	_ _^{o}F
T2	Jacket water temp at outlet	_ _^{o}F
T3	Water to muffler	_ _^{o}F
T4	Water from muffler	_ _^{o}F
T5	Water to jacket	_ _^{o}F
T6	Water from jacket	_ _^{o}F
W1	Heat recovery water	_ _Gal/min x 500 = _ _ _lb/hr
W2	Jacket heat recovery water	_ _Gal/min x 500 = _ _ _lb/hr
W3	Jacket water	_ _Gal/min x 500 = _ _ _lb/hr

OPERATING TIME: _ _ _ _ _hrs/day_ _ _ _ _hrs/wk _ _ _ _ _hrs/yr

Heat Recovery Equipment: Jacket Water _ _

Exhaust Heat Recovery _ _

CONDUCTED BY _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _

DATA ANALYSIS - STATIONARY ENGINES

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

EXHAUST HEAT RECOVERY: Engine BHP = _ _ _ _ _ _ _ _ _ _.

Constants: lb Exhaust/BHP-hr = 13.

Specific Heat = 0.25 Btu/lb-^{o}F.

_ _ _ BHP x _ _ _ $\frac{\text{lb Exhaust}}{\text{BHP-hr}}$ x Sp. Ht x (T_{el}-300^{o}F) = $\frac{\text{Btu}}{\text{hr}}$

_ _ _ BHP x 13 x 0.25 (_ _ _ -300) = _ _ _ $\frac{\text{Btu}}{\text{hr}}$

JACKET WATER HEAT RECOVERY: Heat Exchanger Efficiency = Exe (Est. 80%)

JWHR = W_3 x (T_5 - T_6) x $\frac{\text{EXE}}{100}$ = W_2 x (T_1 - T_2) = _ _Btu/hr

(where, W_2 and W_3 are expressed as lb/hr)

TOTAL HEAT RECOVERY:

Exhaust Heat + Jacket Water Heat = Total Heat Recovered

_ _ _ _ Btu/hr + _ _ _ _Btu/hr = _ _ _ _Btu/hr

Cost of Heat = _ _ _ _ _$/MBtu, for engine fuel

_ _ _ _Btu/hr x _ _ _ _ hrs/yr x _ _ _ _$/MBtu _ _ _ _$/yr saving

ACTION PROPOSED: _ _ Heat Recovery Muffler _ _ Heat Exchanger

_ _ Other, Specify _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

Estimated Cost of Equipment Installed: $ _ _ _ _ _ _ _ _ _ _

PAYBACK TIME:

$\frac{\text{\$ Cost of Equipment Installed}}{\text{\$/Year Heat Recovery Saving}}$ = _ _ _ _ _yrs Payback Time

CALCULATION BY _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _

CHECKLIST - STATIONARY ENGINES SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

Before evaluating stationary engines or operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specifc problem may be addressed and several alternatives compared to check for their economic feasibility.

Applies: Yes | No

ENERGY CONSERVATION OPORTUNITIES:

1. Diesel, gas, or gasoline fired engines are used as stationary prime movers _ _ _ or test run for substantial periods _ _ _ _
   Evaluation: _

2. In addition to useful shaft work (30%-33%), such engines, provide waste heat recoverable from lubrication oil (3%-5%), jacket cooling water (22%-32%), and exhaust (22%-30%). This waste heat is recoverable as hot water or low pressure steam.
   Evaluation: _

3. Economic recovery depends on: _ _ _ substantial running time, _ _ _ _ uses for the recovered heat, economic justification based on life-cycle cost compared t heat sources, and _ _ _ other considerations such as safety and reliability.
   Evaluation: _

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

	Applies	
	Yes	No
ENERGY CONSERVATION OPORTUNITIES:		
4. Nearby heat uses are: _ _ _ hot water (domestic), hot water (industrial), _ _ _ hot water or steam for absorption refrigeration, _ _ _ low pressure steam line, _ _ _ hot water recovery sump, _ _ _ other _. Evaluation: _		

6.11 WASTE OIL PROCESSING

6.11.1 INTRODUCTION

The use of waste oil as a potential energy recovery area primarily depends upon the quantity available for reprocessing. Typical sources for waste oil are used engine crankcase lubrication oil, used machine cutting oil, and substandard or contaminated aircraft fuels.

The cost of the oil refinement equipment (purifiers, centrifuges) could result in a cost/benefit ratio that would discourage any capital investment in this effort. Each area would have to be self-evaluated to determine the potential available. Used engine crankcase oil is currently being burned on a trial basis in some boilers normally utilizing No. 6 fuel oil with little processing other than coarse filtration. One positive feature is that waste oil can be collected on a "when-available" basis and the refinement process can be based on a minimum accumulation.

6.11.2 A PLAN FOR DATA COLLECTION

Tabulate all liquid waste sources from your facility.

Evaluate the largest waste sources first, because these have the largest potential for savings and for energy generation.

Indicate the location of each waste. Consider its closeness to a possible energy need, or existing furnace.

6.11.3 ITEMS TO CONSIDER IN ANALYZING THE DATA

The data analysis sheet is a tool to evaluate each waste stream. It should be reproduced as many times as necessary to evaluate all waste streams.

Identify the process which produces the waste. This will provide clues to characteristics of the waste material that may not otherwise be identified.

Describe the location of the wastes, both source and collection point or storage.

When necessary, a complete analysis of the waste should be performed in order to determine its composition. If the analytical report is available, attach it to the form.

The moisture content of a waste has a profound effect on its combustibility. Waste containing over 50-percent water should be considered separately, and a complete analysis should be performed to determine available heat.

The ash content of a waste affects flame propagation and temperature. Too high an ash content will reduce combustibilty. Ash disposal also poses a problem. As a rule, if the waste contains more than 50-percent ash, the economics of incineration are unfavorable; such cases should be considered separately.

Carefully consideration should be given to the possibility that the waste may contain explosive, toxic, corrosive, or other hazardous components that must be handled separately. (Refer to the Federal Register of 1 February 1978 for information on the Hazardous Waste Manifest System.)

The heating value should be determined in the analysis. If no analysis has been performed, the heating value should be estimated from Appendix B.

Measure or estimate the total amount of waste generated by the process in a year. Indicate also if the waste is generated in a constant flow or at what time intervals.

Before use, the combustibility should be tested by sending a sample to the manufacturer of the burner. Before mixing wastes with other wastes or with existing liquid fuels, a check of compatibility should be run in the lab.

DATA COLLECTION - LIQUID WASTE

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

No.	Material/Source	Location	Quantity/Year	Combustible?
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

CONDUCTED BY _ _ _ _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _ _ _ _ _ _

DATA COLLECTION - LIQUID WASTE SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

LIQUID WASTE DATA:

Waste Number: _ _ _ _

Source(s): _ _ _ _

Location(s) _ _ _ _

Composition: _ _ _ _ (If know ingredient, otherwise submit sample for analysis and record below)

Analytical Data _ _ _ _ Density Lbs/Gal

_ _ _ _ Viscosity: SUS or CP @ _ _ _ °F

_ _ _ _ °F: Flash Point (Open Cup)

Combustibility Test:

Compatibility Test:

*Moisture: _ _ _ _ _ _ _ _ _ _ %

*Ash: _ _ _ _ _ _ _ _ _ _ _ _ %

Dangerous
Components: _

_ _

Heating Value: _ _ _ _ _ _ _ _ _ _ _ _ _ _ Btu/Gal

Amount of Waste Available: _ _ _ _ _ _ _ _ Gal/Yr.

*If moisture or ash exceeds 50 percent, do not proceed with the calculation unless there is good reason to assume (by analysis or otherwise) that it appears worthwhile.

CALCULATIONS BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _

DATA ANALYSIS - LIQUID WASTE SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

TOTAL AVAILABLE HEAT: _ _ _ _ _ _ _ _ _ _ Btu/Year

Approximate value of available heat vs present fuel @ _ _ _ _$/gal

$$= \frac{\text{Total available heat (Btu/Yr)}}{\text{Heating Value of present fuel (Btu/gal)}} \times \text{cost of present fuel (\$/gal)}$$

PRESENT DISPOSAL METHOD:

_ _

_ _

PRESENT DISPOSAL COST:

$ _ per year

PRESENT SALE RECEIPTS:

$ _ per year

Savings possible through on-site energy utilization:

Approximate value + disposal cost = $ _ _ _ _per year

or

Approximate value - sale receipts = $ _ _ _ _per year

Comment: If the waste liquid is being sold at a higher value than its value as fuel, such sale should be continued.

CALCULATIONS BY: _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _ _

EVALUATION - LIQUID WASTE SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

Waste No.	Name	Available Heat Btu/Yr	Approx. Value $/Yr	Disposal Cost $/Yr	Total Savings $/Yr
1	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
2	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
3	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
4	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
5	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
6	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
7	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
8	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
9	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
10	_ _ _ _ _ _ _	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _
	Totals	_ _ _ _	_ _ _ _ _ _	_ _ _ _ _	_ _ _ _

CALCULATIONS BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _

CHECKLIST - LIQUID WASTE SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ I-D NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

Before evaluating specific liquid waste and handling operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specifc problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. Lubricating oils should be sampled and tested to establish whether they are ready for replacement. Apply testing to reservoirs of about 25-gal capacity and up. Evaluation: _		
2. Used lubricating oils may be recovered by draining and collecting until a large enough quantity is obtained when the oil can be processed by heating, settling, dehyrrating, filtering, and use of the restoring additives. Evaluation: _		

SECTION 7

7.1 AIR COMPRESSORS

7.1.1 INTRODUCTION

Compressors which supply shop process air are usually large energy consumers. Compressor drive motors typically r nge in size from 75 to 500 horsepower. The compressors are often multistaged piston type with unloading valves. Electric power consumed by these motors is high for all load conditions due to high no-load losses in the compressors. Typically the motor will draw about 40% of maximum rated power when the compressor is supplying zero flow. Air generating/distribution systems often have several compressors feeding a common manifold and all too often there is more capacity on line than is required, resulting in much wasted energy. This inefficiency is the result of high mechanical losses in the compressors and also the power needed to supply internal leakage losses.

7.1.2 COMPRESSOR SCHEDULING

Ideally shop air compressors should be automated to detect low manifold pressure and then start-up as required. Many industrial sites allow "standby" compressors to operate in case the flow demand should exceed the capacity of one machine. This practice is wasteful. A 250 hp motor "idling" at a 40% power draw, no compressor flow situation, will cost about $25,00/year with power priced at $0.38KWH. "No Load" data should be developed for all large compressors.

When process areas are not inhabited, the air compressors supplying these areas should be shut down. Applications requiring low pressure control air, such as HVAC control systems, should be run from small, dedicated air compressors.

7.1.3 DETECTING AIR DISTRIBUTION SYSTEM LEAKAGE

Leaky air distribution systems also waste power. One of two methods are usually used to detect system leakage. Both rely on the collecton of data during non-working hours when there is no compressed air demand.

One method is outlined in Appendix H. The percent of time a compressor runs during non-working hours at full-load, 3/4 load, etc. is determined and the estimated air leakage is calculated. The data collection requirements are shown in Appendix H, sheet H-2. The data analysis is shown on sheet H-5.

7.1.4 HEAT RECOVERY

Heat recovery systems must be carefully developed to make certain they are compatible with the compressors specifications. A data collection sheet is shown on sheet Appendix H, Sheet H-3. A data analysis sheet is shown on sheet H-6. Economic evaluation should follow the MILCON format, Section 10.8.

7.1.5 RESOURCES FOR A SURVEY

Data Collection Forms

Air Compressor . . . . Appendix H, H-1, H-2, H-3

Electric Motor . . . . Appendix E, E-3

Data Analysis Sheet

Air Compressor . . . . Appendix H, H-5, H-6

Electric Motor . . . . Appendix E, E-4, E-5

Checklists

Air Compressor 7.1-5

Electric Motors E-11

CHECKLIST - AIR COMPRESSORS SHEET 1 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

Before evaluating specific air compressors it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. Consider using a high pressure blower in lieu of compressed air for drying, or the agitation of a fluid in a tank. Evaluation: ______________________		
2. Instead of using evaporative type towers to reduce the air compressor cooling water temperature, consider using a heat exchanger to preheat either boiler or process make-up water. Evaluation: ______________________		
3. Determine the minimum air pressure required on weekends and whether an operating change is warranted. Evaluation: ______________________		

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

	Applies	
	Yes	No
4. Consider installing chain operated valves on compressed air headers so they can be closed when off-shift, and thus reduce leaks. Evaluation: ______________________________		
5. Consider installing timers on dessicant type air dryers to allow recharging cycles to more nearly follow actual needs. Evaluation: ______________________________		
6. Consider the installation of a number of small satellite compressors to carry off-shift and week-end loads, and allow the main compressor to be shut down. Evaluation: ______________________________		

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

	Applies Yes	Applies No
7. The electrical distribution system should have a power factor of 85% or higher. If lower, it is usually due to inductive loads like electric motors. Correction can be achieved by using synchronous motors and/or system capacitors or individual motor capacitors. While the distribution system is not part of this audit, its power factor affects both motor and distribution capacity. Evaluation ______________________ ___________________________		
8. The motor and system power factors are affected by running many individual motors partly loaded. If the data analysis shows a motor load factor of 0.60 or lower, and if the motor is known not to exceed that load, determine the true horsepower requirement. This will yield a power factor improvement when the motor is replaced with a smaller one.		

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

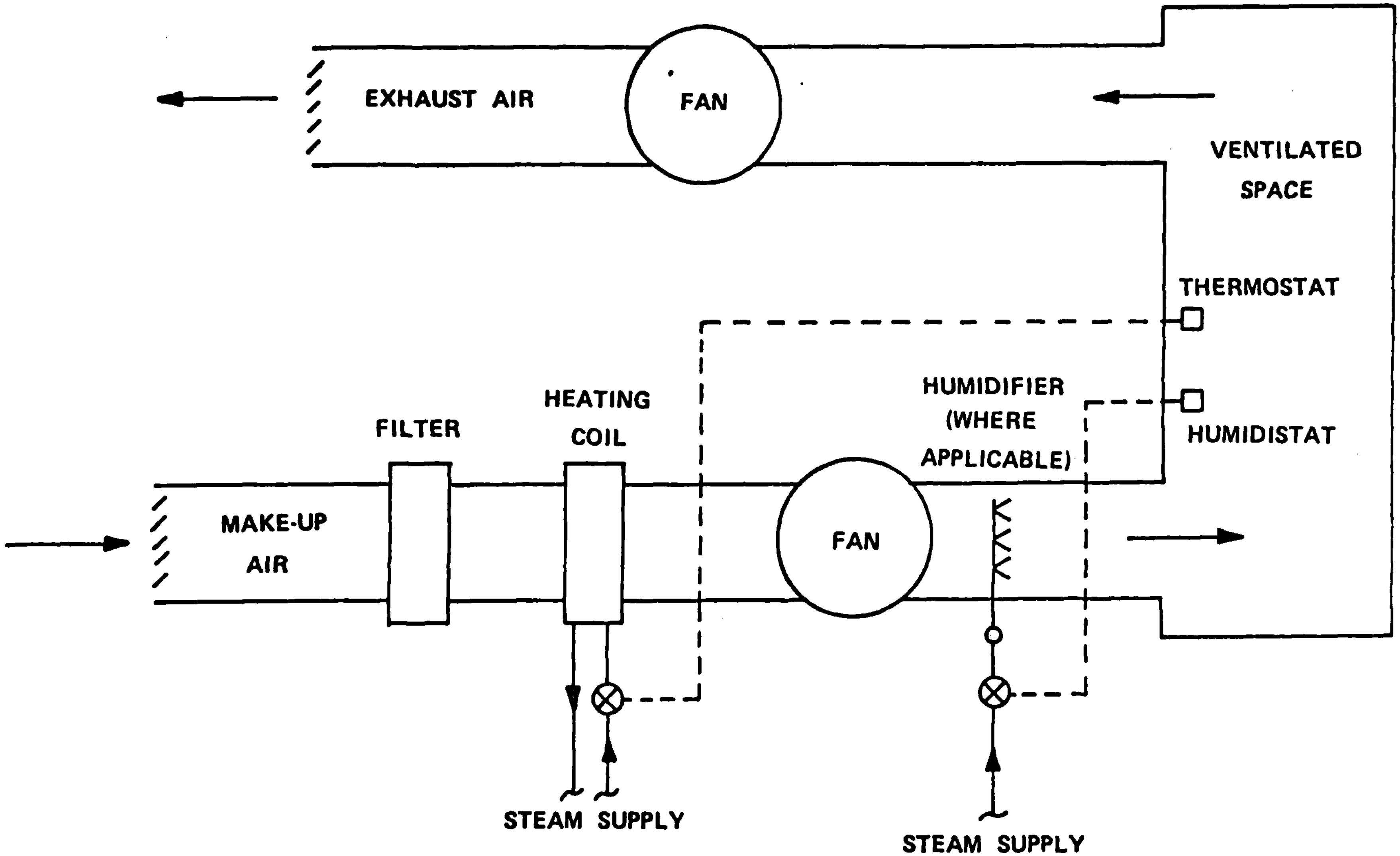
	Applies Yes	Applies No
Evaluation ______________________ ____________________________		
9. If a motor or group of motors runs lightly loaded most of the time yet full power is needed occasionally, it (they) usually cannot be replaced with smaller ones. Consider a motor capacitor or capacitor for the group.		
Evaluation ______________________ ____________________________		

7.2 PROCESS AIR: HEATING, VENTILATING AND EXHAUST SYSTEMS

7.2.1 INTRODUCTION

These systems are designed to handle large flow rates of air. Typical systems are concerned with paint stripping and cleaning, painting, and sanding. Depending on the process, the air might be drawn directly from the outside and pased through the area "untreated". Other processes will require heating humidification and sometimes cooling.

Exhausting process air accounts for more energy loss than most other causes. Exhaust flow rates in many industrial buildings far exceed the amount of make-up air which is normally supplied for employee comfort. As a result of these large exhaust flows from process fans, more make-up air must enter a building through leakage paths or from supply fans. This air is generally mixed with air in the temperature controlled zone and heated or cooled by the building HVAC system. For most industrial plants, more energy is wasted in the winter time when the heat load can be at an order of magnitude greater than it would be if no process air were exhausted. During warm weather, providing the building is not

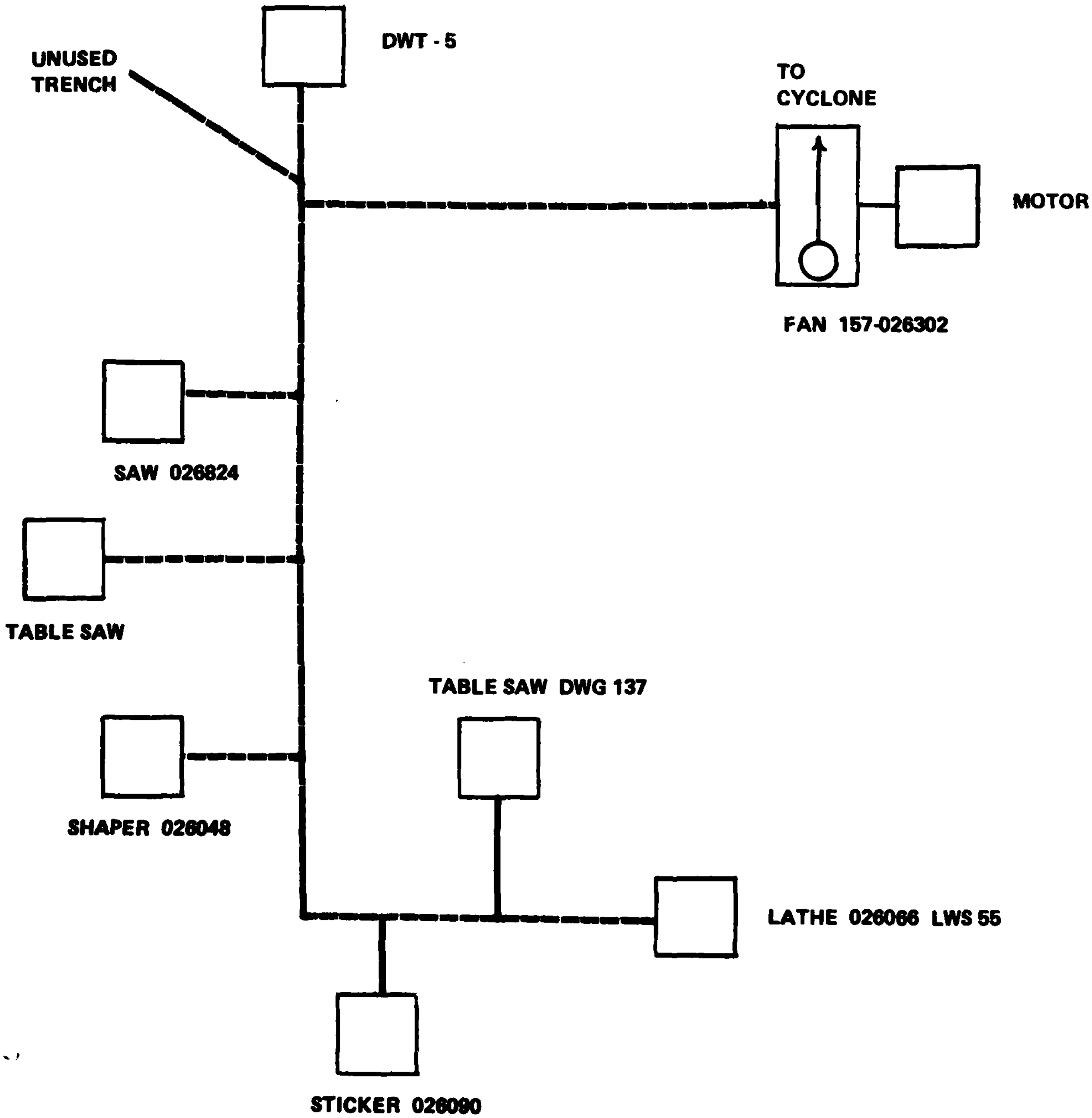


Source: Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978

FIGURE 7.2-1
TYPICAL VENTILATING SYSTEM

FIGURE 7.2-2

TYPICAL EXHAUST SYSTEM



SOURCE: Industrial Energy Field Survey Report, Philadelphia Naval Shipyard, Philadelphia, Pa., Atlantic Division, NAVFAC, 1979 cooled with mechanical refrigeration systems, energy loss due to exhausted process air decreases and is limited to the electric power used by the fan drive motors.

7.2.2 RESOURCES FOR A SURVEY

Computer programs have been developed by various organizations to aid in energy conservation analysis. The energy conservation team at a facility should review any programs that are available to determine if they will be effective at the facility as well as economical to run.

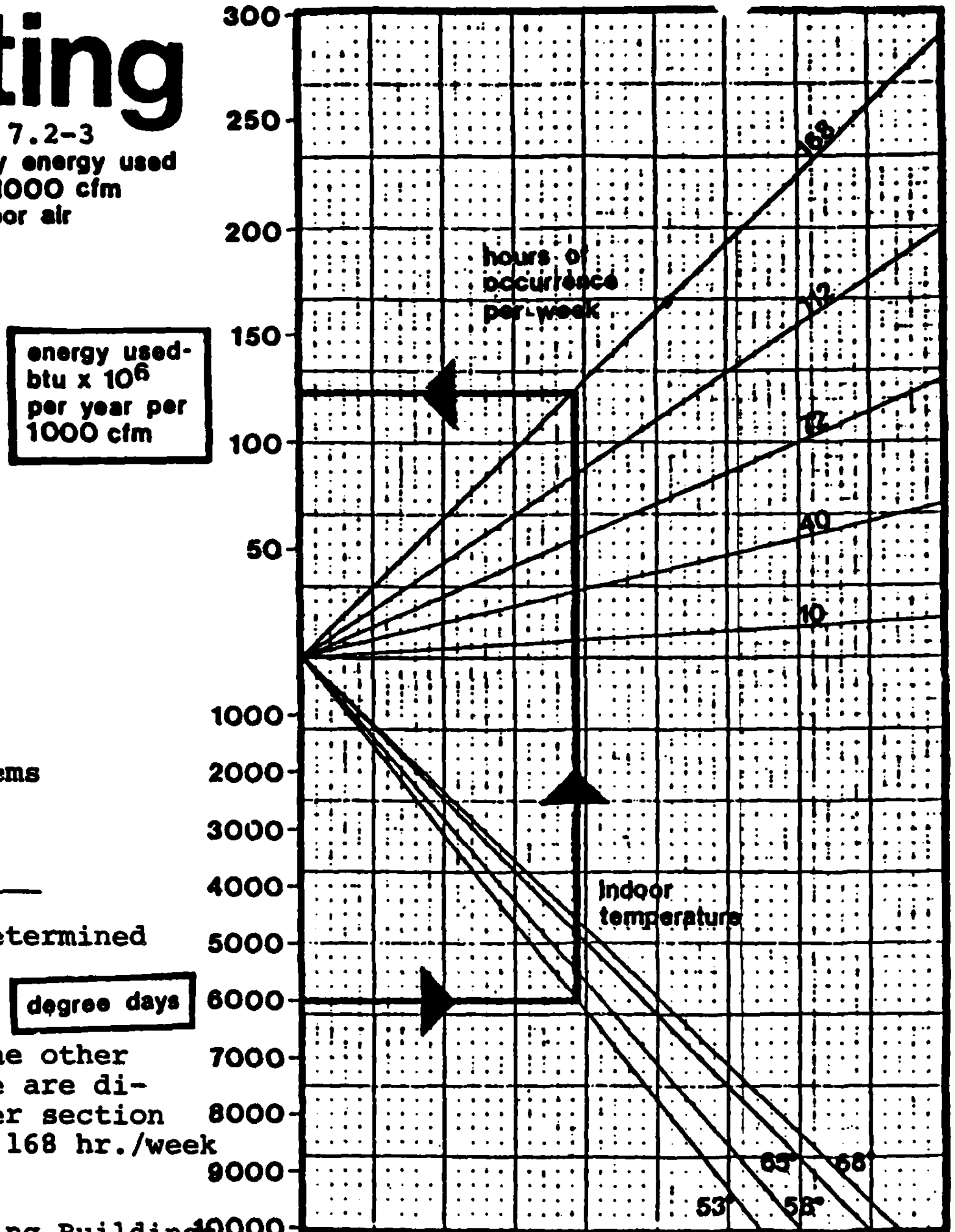
ANNUAL HEATING DEGREE-DAYS*	
Anchorage, AK	10,864
Boston, MASS	5,634
Buffalo, NY	7,062
Charleston, SC	2,033
Chicago, ILL	5,882
Detroit, MI	6,232
Jacksonville, FLA	1,239
Los Angeles, CA	2,061
Memphis, TN	3,232
Milwaukee, WIS	7,635
Minneapolis, MN	8,382
New York NY	4,871
Norfolk, VA	3,421
Pittsburgh, PA	5,987
Portland, ME	7,511
St. Louis, MO	4,484
San Diego, CA	1,458
San Francisco, CA	3,015
Seattle, WA	4,424
Washington, DC	4,224

* For definition of Degree-Day Method refer to: ASHRAE Handbook & Product Directory, 1976 Systems

FIGURE 7.2-2

heating

FIGURE 7.2-3
yearly energy used per 1000 cfm outdoor air



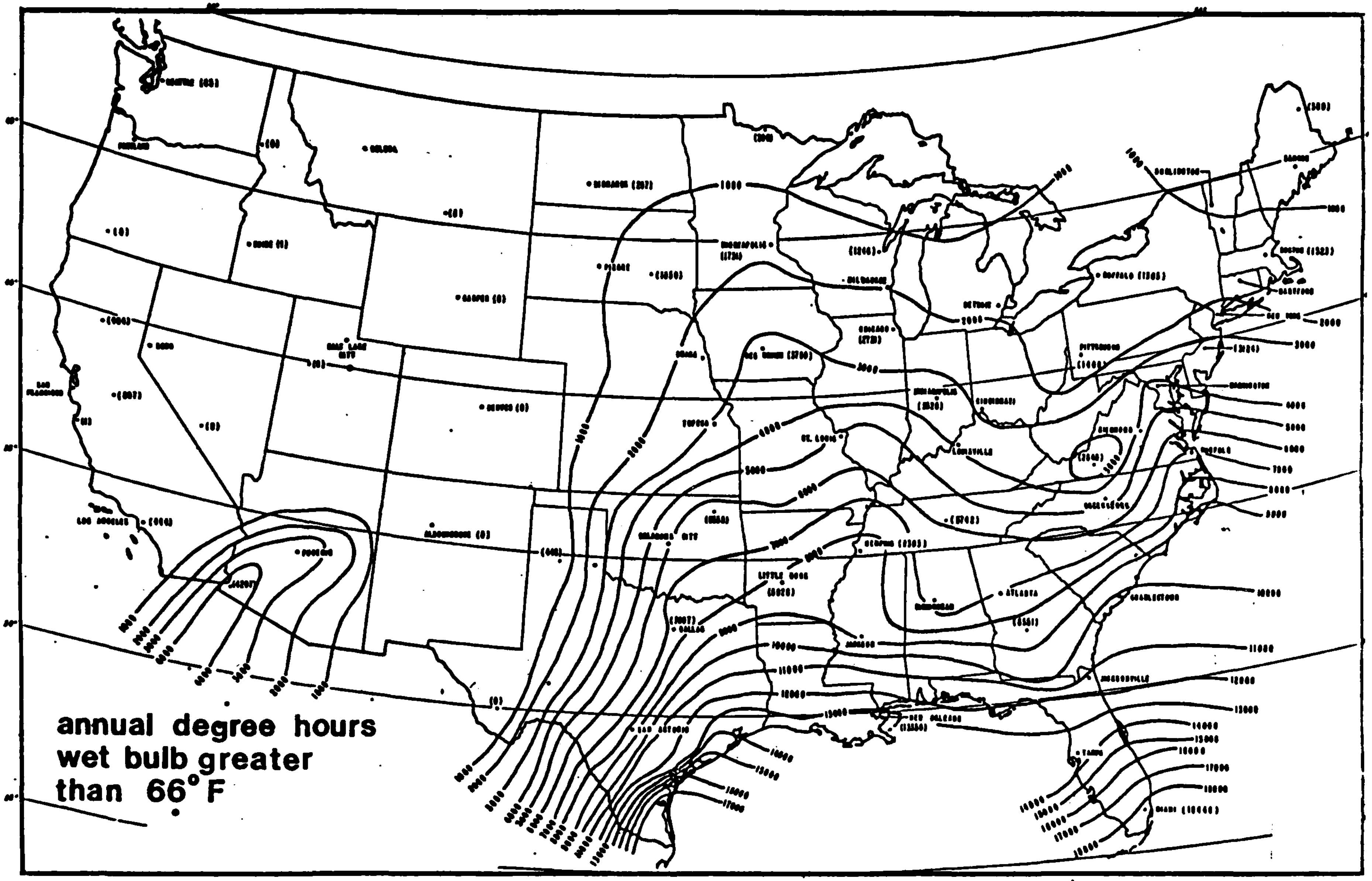
In Figure 7.2-3 the energy used per year was determined as follows:

BTU/yr.=(1000 cfm)(Degree Days/yr.)(24 hr./day)(1.08) Since degree days are based on 65°F, the other temperatures in the lower section of the figure are directly proportional to the 65°F line. The upper section proportions the hours of system operation with 168 hr./week being 100%.

Source: Guidelines for Saving Energy in Existing Buildings, ECM-1, FEA 1975

How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings - An Energy Conservation Manual, Noyes Data Corp., 1976

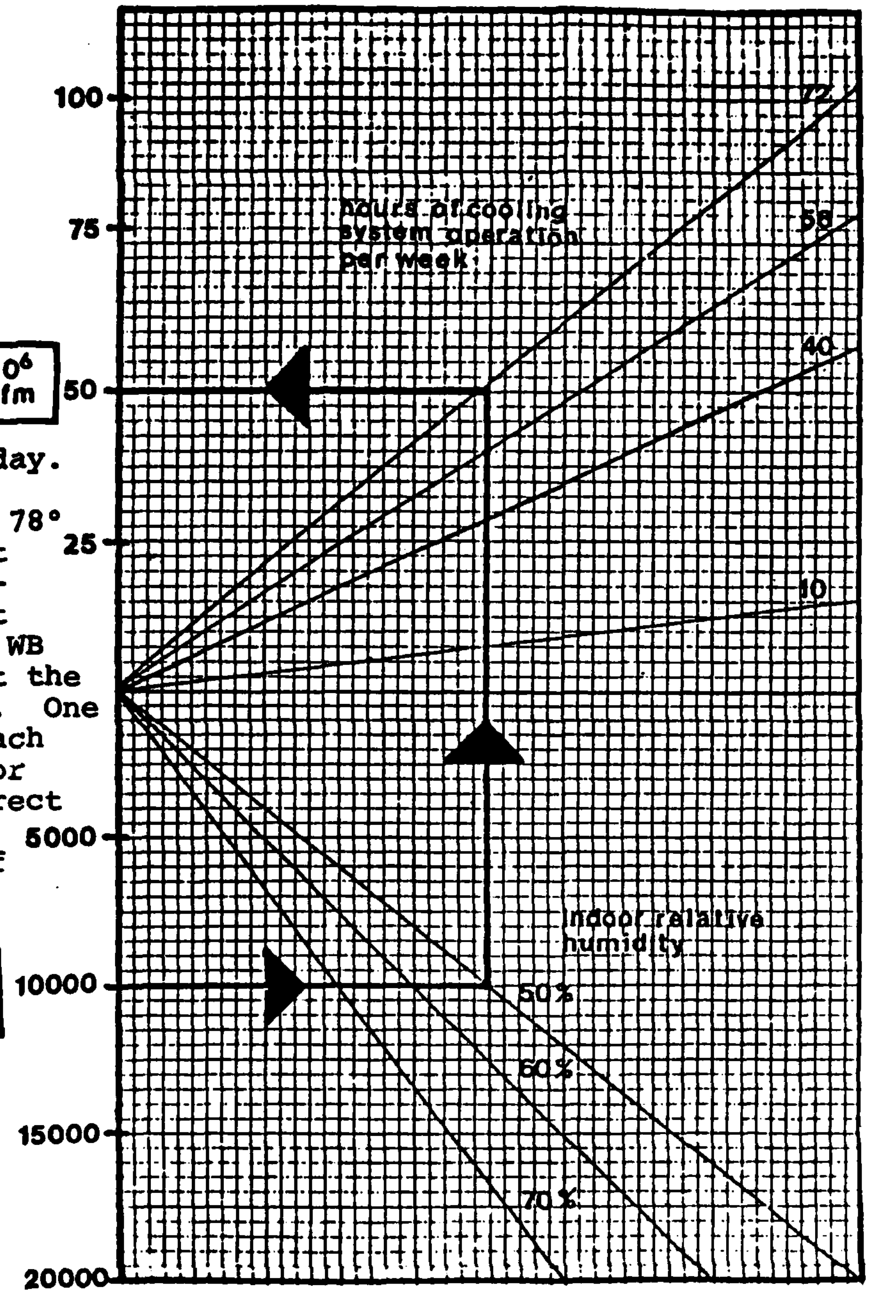
FIGURE 7.2-4



Source: Guidelines for Saving Energy in Existing Buildings, ECM-1, FEA, 1975
How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings - An Energy Conservation Manual, Noyes Data Corporation, 1976

cooling

FIGURE 7.2-5
yearly energy used
per 1000 cfm to maintain
various humidity conditions



WB degree hours based on 12 Mos/yr, 8 hr/day.

The base RH is 50% which is approximately 78° DB, 66° WB. An analysis of the total heat content of the air in the range under consideration indicates an average total heat variation of 0.93 Btu/lb. for each degree WB change at constant DB temperature and that the total heat varies nearly directly with RH. One thousand CFM is equal to 4286 lb./hr so each degree F WB hour is equal to 4286 x 0.93 or 3986 Btu. The lower section shows the direct relationship from the base of 50% RH and the upper section proportions the hours of system operation 56 Hr/Wk being 100%.

Source: Guidelines for Saving Energy in Existing Buildings, ECM-1, FEA, 1975

How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings - An Energy Conservation Manual, Noyes Data Corporation, 1976.

TABLE 7.2-1

RECOMMENDED AND MAXIMUM DUCT VELOCITIES DESIGNATION

DESIGNATION	RESIDENCES	SCHOOLS, THEATERS, PUBLIC BUILDINGS	INDUSTRIAL BUILDINGS
	RECOMMENDED VELOCITIES, fpm		
OUTSIDE AIR INTAKES	700	800	1000
FILTERS	250	300	350
HEATING COILS	450	500	600
AIR WASHERS	500	500	500
SUCTION CONNECTIONS	700	800	1000
FAN OUTLETS	100-1600	1300-2000	1600-2400
MAIN DUCTS	700-900	1000-1300	1200-1800
BRANCH DUCTS	600	600-900	800-1000
BRANCH RISERS	500	600-700	800

MAXIMUM VELOCITIES, fpm

DESIGNATION	RESIDENCES	SCHOOLS, THEATERS, PUBLIC BUILDINGS	INDUSTRIAL BUILDINGS
OUTSIDE AIR INTAKES	800	900	1200
FILTERS	300	350	350
HEATING COILS	500	600	700
AIR WASHERS	500	500	500
SUCTION CONNECTIONS	900	1000	1400
FAN OUTLETS	1700	1500-2200	1700-2800
MAIN DUCTS	800-1000	1100-1600	1300-2200
BRANCH DUCTS	700-1000	800-1300	1000-1800
BRANCH RISERS	650-800	800-1200	100-1600

Source: ASHRAE Handbook and Product Directory, 1960 Fundamentals.

7.2.3 SAMPLE CALCULATIONS/HEATING

Estimate the energy savings during the heating season when the operating hours of a ventilating system are changed. Develop a rough estimate using heating degree days as a guide.

The work space is located in Norfolk, Va. The space is conditioned to 68°F with 100% outside air. The ventilation system moves 55,000 cfm through the space. The supply air fan discharge static pressure is 1 inch of water. The exhaust fan operates on 3 phase power, 220 volts, approximately 27 amps. A sketch of the system resembles figure 7.2-1.

The fan had been operated 16 hours per day, 6 days per week. The new schedule is 10 hours per day, 5 days per week. The heating season is approximately 25 weeks. The efficiency of the heating system is approximately 75 per cent. Fuel Oil, No. 2, costs are estimated at $0.75 per gallon, and electricity costs are estimated at $0.06 per kilowatt-hour. Heating Degree Days, figure 7.2-3 are estimated at 3421.

Before the schedule change:

$$\text{Operating hours, per week} = 16\ \frac{\text{hrs}}{\text{day}} \times 6\ \frac{\text{days}}{\text{week}} = 96\ \frac{\text{hours}}{\text{week}}$$

From figure 7.2-3, a determination of the approximate annual heating energy requirements per 1000 cfm of outdoor air is accomplished using Degree days, Fig, 7.2-3, indoor temperature, and hours of occurance per week. After determining the degree-days, draw a horizontal line on fig. 7.2-3 to the desired space temperature. From that point draw a vertical line to the approximate hours of occurence per week.

From that point draw a horizontal line to determine the energy used in millions of BTU's per year per 1000 cfm. The annual energy is estimated at 53,000,000 BTU per 1000 cfm.

From fig F.1 the electrical power requirements can be estimated. On the basis of 1000 cfm, a vertical line is drawn to the one-inch of water static pressure line. From that point a horizontal line is drawn to determine the annual Kwh. From fig F-1 the estimated electrical power for 8760 hours is 2000 Kwhrs per 1000 cfm for the supply fan.

The corrected power is:

$$\frac{\text{25 weeks x 96 hrs per week}}{\text{8760 hrs.}} \times \frac{\text{2000 Kwh}}{\text{1000 cfm}} \times \text{55000 cfm} = \text{30,140 Kwh}$$

The exhaust fan electrical power is estimated from the collected data and the motor load input equation, Appendix E, sheet E-4.

$$\text{Motor Load} = \frac{\text{1.732 x Volts x Amps x P.F.}}{1000} \text{ KW}$$

$$\text{Motor Load} = \frac{1.732 \times 220 \times 27 \times .85}{1000} = \text{8.745 KW}$$

$$\text{Electrical Power} = \text{8.745 Kw} \times \text{25 wks} \times 96 \frac{\text{hrs}}{\text{WK}} = \text{20988 Kwh}$$

After the schedule change:

10 hrs. per day x 5 days per week = 50 hours per week.

From fig 7.2-3 annual heating energy used per year per 1000 cfm is estimated at 30,000,000 Btu.

For the supply fan:

$$\frac{\text{50 hrs per week}}{\text{96 hrs. per week}} \times \text{30,140 Kwh} = \text{15698 Kwh}$$

For the exhaust fan:

$$\frac{50 \text{ hrs. per week}}{96 \text{ hrs. per week}} \times 20988 \text{ Kwh} = 10931 \text{ Kwh}$$

Savings

Fuel:

System efficiency estimated at 70%

$$(53{,}000{,}000 - 30{,}000{,}000) = 23{,}000{,}000 \quad \frac{\text{Btu}}{1000 \text{ cfm}}$$

$$\frac{23{,}000{,}000\text{Btu}}{.7 \text{ (system eff.)}} \times \frac{1 \text{ gal}}{138{,}700 \text{ Btu}} = \frac{236.9 \text{ gallons}}{1000 \text{ cfm}}$$

$$55{,}000 \text{ cfm} \times \frac{236.9 \text{ gallons}}{1000 \text{ cfm}} = 13030 \text{ gallons}$$

$$13030 \text{ gallons} \times \frac{\$1.00}{\text{gallon}} = \$13{,}030$$

Electricity:

$$(30{,}140 + 20988) - (15698 + 10931) = 24{,}500 \text{ Kwh}$$

$$24{,}500 \text{ Kwh} \times \$.06/\text{Kwh} = \$1470$$

7.2.4 SAMPLE CALCULATIONS/COOLING

Estimate the cooling energy savings when the operating hours of ventilation system are changed. Develop a rough estimate using "Annual Degree Hours Wet Bulb Temperature Greater than 66F", as a guide.

Workspace located in Charleton, South Carolina. The space is conditioned to a relative humidity of 50% with 100% outdoor air. The ventilation system moves 55,000 cfm through the space. The supply air fan discharge pressure is 1 inch of water. The exhaust fan operates on 3 phase power, 220 volts, approximately 27 amps.

The fan had been operated 16 hours per day, 6 days per week. The new schedule is 10 hours per day, 5 days per week. The cooling season is approximately 25 weeks. The mechanical refrigeration system has a coefficient of performance, COP, of 3.0. This means that for every Btu of energy used to run the equipment, 3.0 Btu's are extracted from the air stream. Electricity costs are estimated at $0.06 per Kilowatt-hour.

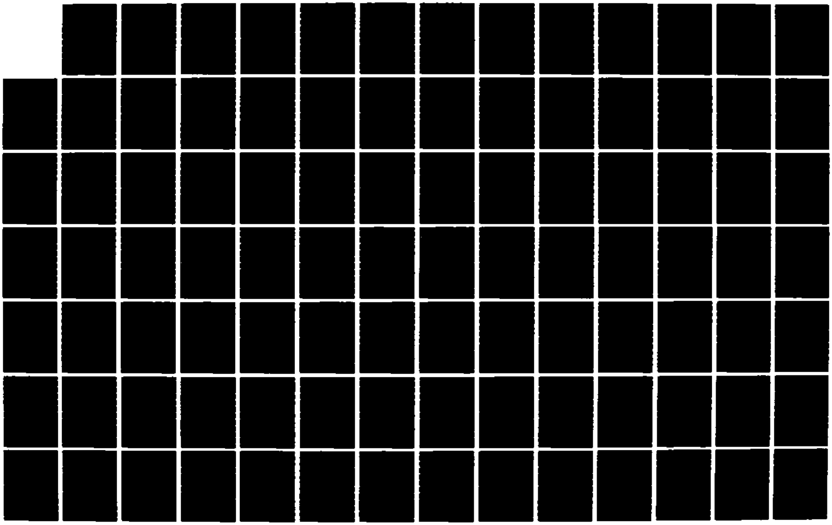
7.2.4.1 Before the schedule change:

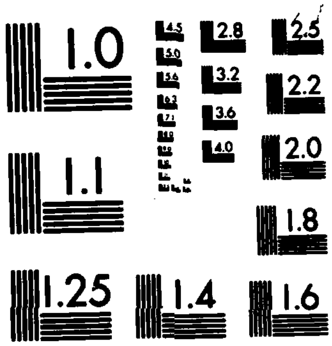
$$\text{Operating Hours, per week} = 16\ \frac{\text{hrs}}{\text{day}} \times 6\ \frac{\text{day}}{\text{week}} = 96\ \frac{\text{hours}}{\text{week}}$$

From figure 7.2-5, a determination of the approximate annual cooling energy requirements per 1000 cfm of outdoor air is accomplished using Degree-Hours Wet Bulb Temperature Greater than 66F, the indoor relative humidity, and the hours of occurrence per week. After determining the annual wet bulb degree hours above 66F WB, draw a horizontal line on fig. 7.2-5 to the desired space relative humidity. From that point draw a vertical line to the approximate hours of cooling system operation per week. From that point draw a horizontal line to determine the energy used in millions of BTU's per year per 1000 cfm. The annual energy is estimated at 85,000,000 BTU per 1000 cfm.

AD-A131 117 ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U) 3/5
SYSKA AND HENNESSY INC NEW YORK JAN 81
N62472-78-C-1059

UNCLASSIFIED F/G 5/3 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The fan power is approximately the same as in the previous example, 7.2.3. Supply fan plus exhaust fan power is 10,140 + 20988 = 51,128 Kwhr.

7.2.4.2 After the schedule change:

10 hrs. per day x 5 days per week = 50 hours per week. From figure 7.2-5 the cooling energy used is estimated at 35,000,000 BTU. The fan power is approximately the same as in the previous example, 7.2.3. Supply fan plus exhaust fan power is 15,698 + 10931 = 26,629 Kwh

Savings:

Electricity, mechanical refrigeration system.

$$\frac{50{,}000{,}000 \text{ BTU}}{3.0 \text{ (system cop)}} \times \frac{1 \text{ Kwh}}{3414 \text{ BTU}} \quad 4881.8 \ \frac{\text{Kwh}}{1000 \text{ cfm}}$$

$$4.881.8 \ \frac{\text{Kwh}}{1000 \text{ cfm}} \times 5500 \text{ cfm} = 268499 \text{ KWH}$$

$$268499 \text{ Kwh} \times \frac{\$.06}{\text{Kwh}} = \$16{,}109$$

Electricity, fan power

Same as sample calculation for previous example, 7.2.3.

Electricity cost = $1470

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ BAY _ _ _ _

VENTILATING SYSTEMS WITH HEATING

System: Heating with 100% outside air

Type of Estimate: Rough Estimate Using Heating Degree-Days

WORKSPACE CONDITIONING

	Zone Control, Temp, °F	Humidification, R. H.
Painting	________	________
Drying	________	________
Masking	________	________
Non-Working	________	________
Stripping	________	________
________	________	

HEATING COIL CAPACITY, BTU/hr.

____

____

____

PERCENT OF USEFUL SYSTEM LOADS

(A sketch is a valuable aid)

Fan capacity venting running equipment Approx. _ _ _ _%

Fan capacity venting idle equipment Approx. _ _ _ _%

DATA COLLECTION SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

AIR FLOW EQUIPMENT

(Collect Data for one of three groups below)

	Supply fan	Exhaust fan
GROUP I		
Fan capacity	________ cfm	________ cfm
Static Pressure Discharge	________ in, H_2O	________ in, H_2O
GROUP II		
Motor Voltage	________ volts	________ volts
Motor Line Current	________ amps	________ amps
GROUP III		
Area of Duct	________ ft^2	________ ft^2
Air Flow*	________ ft/min	________ ft/min
Static Pressure Disch.	________ in, H_2O	________ in, H_2O

*If Air Flow canot be measured use Table 7.2-1

ENERGY COSTS

Fuel Type ____________, Cost: $ ____________/________

System Heating Efficiency ____________%

Electrical, Cost: $ ____________/Kwhr

Estimated Motor Efficiency ____________%

DATA COLLECTION SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

OPERATING HOURS

__________hrs/day, _________ hrs/week

Length of Heating Season _____________ weeks

DEGREE DAYS (65 Degree-Day Basis)

Weather Station Location ___________

Degree Days _____________

SKETCH SHEET (If needed) Use copy of sample sheet found in Appendix K.

CONDUCTED BY: _ DATE _ _ _ _ _ _ _

DATA COLLECTION SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

VENTILATING SYSTEMS WITH COOLING

System: Cooling with 100% outside air

Type of Estimate: Rough Estimate Using Annual Degree Hours with wet bulb temperature greater than 66F.

WORKSPACE CONDITIONS

	Zone Control Temp, ^{o}F	Humidification, R. H.
Painting	________	________
Drying	________	________
Masking	________	________
Non-Working	________	________
Stripping	________	________
________	________	________

COOLING COIL CAPACITY, Btu/hr

____

____

____

DATA COLLECTION SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

AIR FLOW EQUIPMENT

(Collect Data for one of the three groups below)

	Supply fan	Exhaust fan
GROUP I		
Fan capacity	________cfm	________cfm
Static Pressure Disch.	________in, H_2O	________in, H_2O
GROUP II		
Motor Voltage	________volts	________volts
Motor Line Current	________amps	________amps
GROUP III	Supply Fan	Exhaust Fan
Area of Duct	________ft^2	________ft^2
Air Flow*	________ft/min	________ft/min
Static Pressure Disch.	________in, H_2O	________in, H_2O

* If Air Flow cannot be measured use Table 7.2.1

ENERGY COSTS

Electrical, Cost: $______________/Kwh.

Estimated Motor Efficiency______________%

OPERATING HOURS

________hrs/day________hrs/week

Length of cooling season________weeks

DEPT. OF NAVY - NAVFAC

BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT

SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _

LOCATION: FL _ _ BAY _ _ _ _

OPERATING HOURS

__________hrs/day__________hrs/week

Length of Cooling Season__________weeks

ANNUAL DEGREE HOURS WITH WET BULB

Weather Station location or nearest large city on Fig 7.2-6

TEMPERATURE GREATER THAN 66F

Degree hours with wet bulb temperature greater than 66F __________.

SKETCH SHEET (IF REQUIRED) Use copy of sample sheet found in Appendix K.

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _DATE _ _ _ _ _ _ _

DATA ANALYSIS PROCESS AIR SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

Note - Proposed Schedule Changes

Savings are often developed by:

a. Modifying startup and shutdown schedules

b. Finding open dampers at production equipment which is idle.

HEATING SAVINGS

	From Date Collection Sheet	Proposed Schedule Change
No. of Heating Degree Days	______________	______________
Approximate Control Temp.	______________	______________
No. of Operating Hours per Week	______________	______________
M BTU's/1000 CFM (Fig. 7.2-3)	______________	______________
M BTU's Saved/1000 CFM	XXXXXXXXXXXXXXX	______________
Required CFM/1000	XXXXXXXXXXXXXXX	______________
Total M BTU's Saved	XXXXXXXXXXXXXXX	______________
Heating Energy Cost, $/M BTU	XXXXXXXXXXXXXXX	______________
Estimated Annual Savings	XXXXXXXXXXXXXXX	______________

DATA ANALYSIS PROCESS AIR   SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC   BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _   LOCATION: FL _ _BAY _ _ _ _

FANS (ELECTRICAL POWER) SAVINGS

If data collected is found in:

GROUP I.	Use Fig. H-1. Compare the number of actual running hours with 8760 hours and adjust the annual Kwh.
GROUP II.	Motor, if over 5 hp is 3 phase. then Kwh = 1.732 x volts x amps x estimated power factor x no. of hrs. operated.
GROUP III.	Find Kwh using GROUP I method.

ELECTRICAL SAVINGS

	From Date Collection Sheet	Proposed Schedule Change
Supply Fan Total KWH	______________	______________
Total KWH Savings	XXXXXXXXXXXXXXXX	______________
Exhaust Fan Total KWH		
Total KWH Savings	XXXXXXXXXXXXXXX_	______________
Grand Total KWH Savings	XXXXXXXXXXXXXXXX	______________
Fan Operating Costs, $/KWH	______________	XXXXXXXXXXXXXXX
Estimated Annual Savings	XXXXXXXXXXXXXXX	______________

CALCULATED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _   DATE _ _ _ _ _ _ _

DATA ANALYSIS PROCESS AIR (COOLING) SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ BAY _ _ _ _

Note - Proposed Schedule Changes

Savings are often developed by:

a. Modifying startup and shutdown schedules

b. Finding open dampers at production equipment which is idle.

	From Date Collection Sheet	Proposed Schedule Change
COOLING SAVINGS		
Annual Degree Hours, WB more than 66°F	____________	____________
Approximate Indoor Relative Humidity	____________	____________
No. of Operating Hours per Week	____________	____________
M BTU's/1000 CFM (Fig. 7.2-5)	____________	____________
M BTU's Saved/1000 CFM	XXXXXXXXXXXXXX	____________
Required CFM/1000	____________	____________
Total MBTU's Saved	XXXXXXXXXXXXXXX	____________
MMBTU of Energy Required = $\frac{\text{Total M BTU's Saved}}{\text{Refrig. System COP}}$	XXXXXXXXXXXXXX	____________
Kwh = $\frac{\text{M BTU of Energy Req'd}}{3414}$	XXXXXXXXXXXXXX	____________
Refrig. System Operating Costs, $/Kwh	____________	____________
Estimated Annual [illegible]vir[illegible]	XXXXXXXXXXXXXX	____________

*For Fans (Electrical Power) Savings use 7.2-21

CALCULATED BY _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _ _ _ _ _

CHECKLIST - PROCESS AIR SHEET 1 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _BAY _ _ _ _

Before evaluating specific air compressors it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

Item	Applies Yes	Applies No
1. Shut down: process exhaust __, dust collection __, smoke and fume exhaust __ when not needed for: machine not running __, break time _ , lunch time __, off hours__. Evaluation: _		
2. Interlock the exhaust system to the machine it serves. Evaluation: _		
3. For multi-user exhaust systems, interlock the exhaust damper to the machine it serves. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

Applies: Yes | No

4. Provide exhaust systems which clean exhaust air and return it to the room, using one of the following: __ bag filter, __ electrostatic precipitator, or __ scrubber.

   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

   _

5. Consider changing machining (drilling coolant) from a hydraulic oil to a water soluble synthetic oil. Estimate the reduction in exhaust requirements.

   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

   _

6. Determine whether to install thermostats in the circuits of roof exhausters to turn them off when the outside temperature falls below a preset number.

   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

   _

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

Applies

Yes | No

7. Minimize fan power by supplying only sufficient flow; if duct velocity is higher than necessary change the pulley ratio between the motor and the fan. Reducing duct velocity by 1/2, reduces fan power to 1/8.

   Evaluation: _

   _

8. If possible, use covers on process tanks. This can negate the need for exhausting except when the tank is open.

   Evaluation: _

   _

9. Investigate all old applications of exhaust fans over tanks to determine if a fan is required. Changing functions of tanks in a process line has resulted in venting empty tanks and water rinse tanks.

   Evaluation: _

   _

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ ID NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

Applies: Yes | No

10. For new process or updated process areas consideration should be given to ducting outside air to ventilated processes, rather than allowing ventilation air to mix with conditioned air. This can eliminate a major part of the ventilation energy loss.

    Evaluation: _

    _

11. Recovery of a portion of the waste heat in the exhaust by use of a heat exchanger. The heat recovered may be applied to any one or combination of several uses dependent upon the economic analysis of costs and savings involved in each of the options. Some uses for waste heat recovery are space heating, heating of hot water supply, preheating of hot water supply, preheating combustion air, etc. (See NBS Handbook 121 "Waste Heat Management Guide".)

    Evaluation: _

    _

7.3 PROCESS/BUILDING HVAC SYSTEM

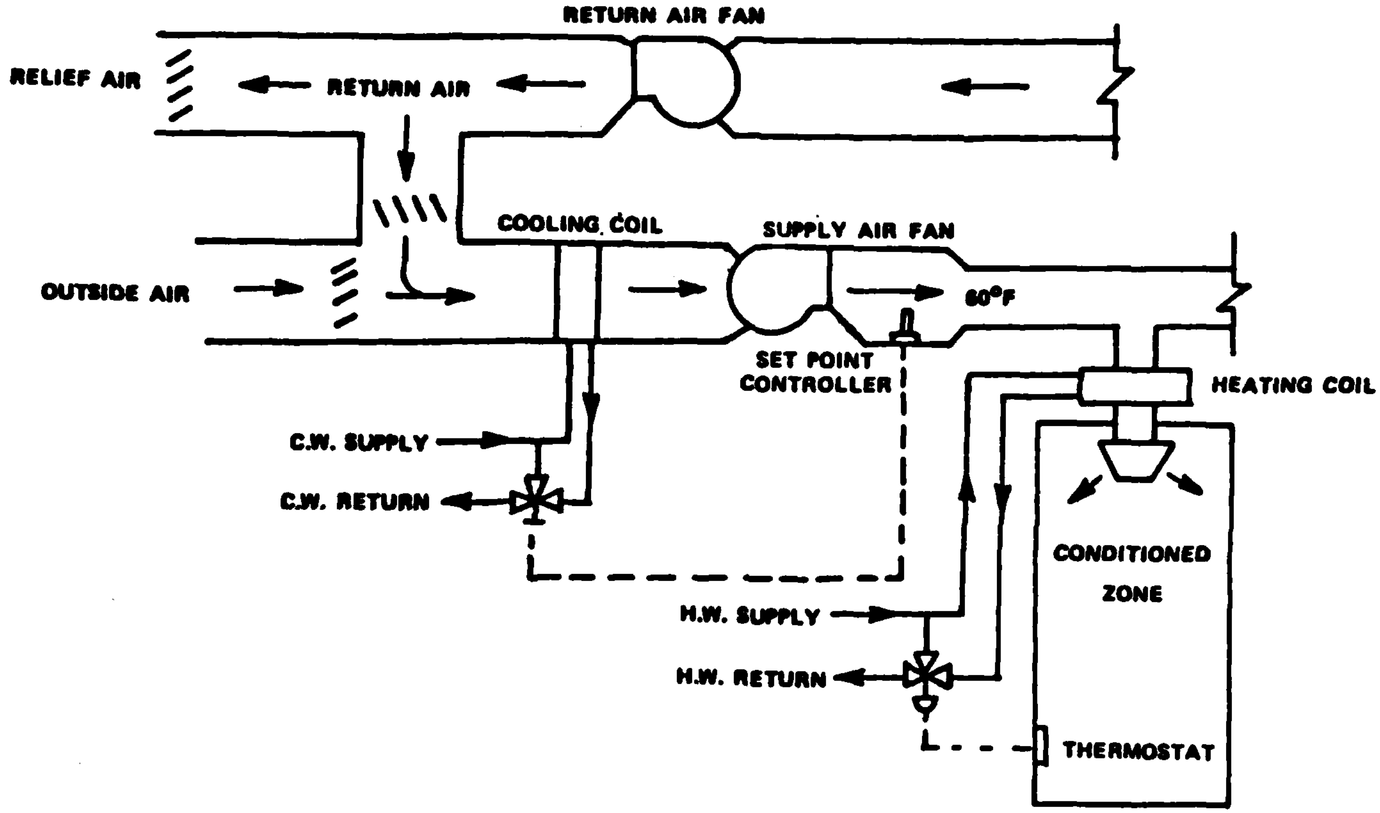
7.3.1 INTRODUCTION

Heating, ventilating and air conditioning systems (HVAC) are used in clean rooms, laboratories, computer rooms, etc. The environmental conditions imposed by the operational requirements for such applications are generally more stringent than for office areas. As a result, there are usually high energy expenditures associated with the operation of such systems. Brief discussions of four control systems are presented as well as methods of saving energy in HVAC systems.

7.3.2 SETPOINT REHEAT SYSTEMS

Setpoint Reheat Systems (see Figure 7.3-1) are characterized by a setpoint control which maintains air temperature out of a cooling coil at a predetermined value (usually 55-60^{o}F). This temperature is the dewpoint required to maintain the approximate relative humidity in the conditioned area. The air is subsequently reheated as required to control the temperature within the conditioned zone, regulated by the zone (room) thermostat. These systems were particularly popular during the era of low-cost energy due to their low initial cost and effectiveness in controlling temperature and humidity. They waste large amounts of energy as a result of simultaneous heating and cooling when the cooling load is below design level. Operation of the system is as follows:

Air returning from the conditioned zone is mixed with outside air as controlled by the return air, outdoor and exhaust air dampers. The mixed air is drawn through a filter, preheat coil (if used), and cooling coil where dehumidification takes place. A temperature sensor downstream of the cooling coil modulates the coolant flow valve to maintain coil discharge temperature to a constant, predetermined setpoint. A room thermostat in the zone modulates a valve in the reheat coil to add sufficient heat to maintain zone temperature. Decreasing of illumination level or increasing thermostat settings during the summer will not decrease energy consumption, since the reheat coils will be required to add more heat.

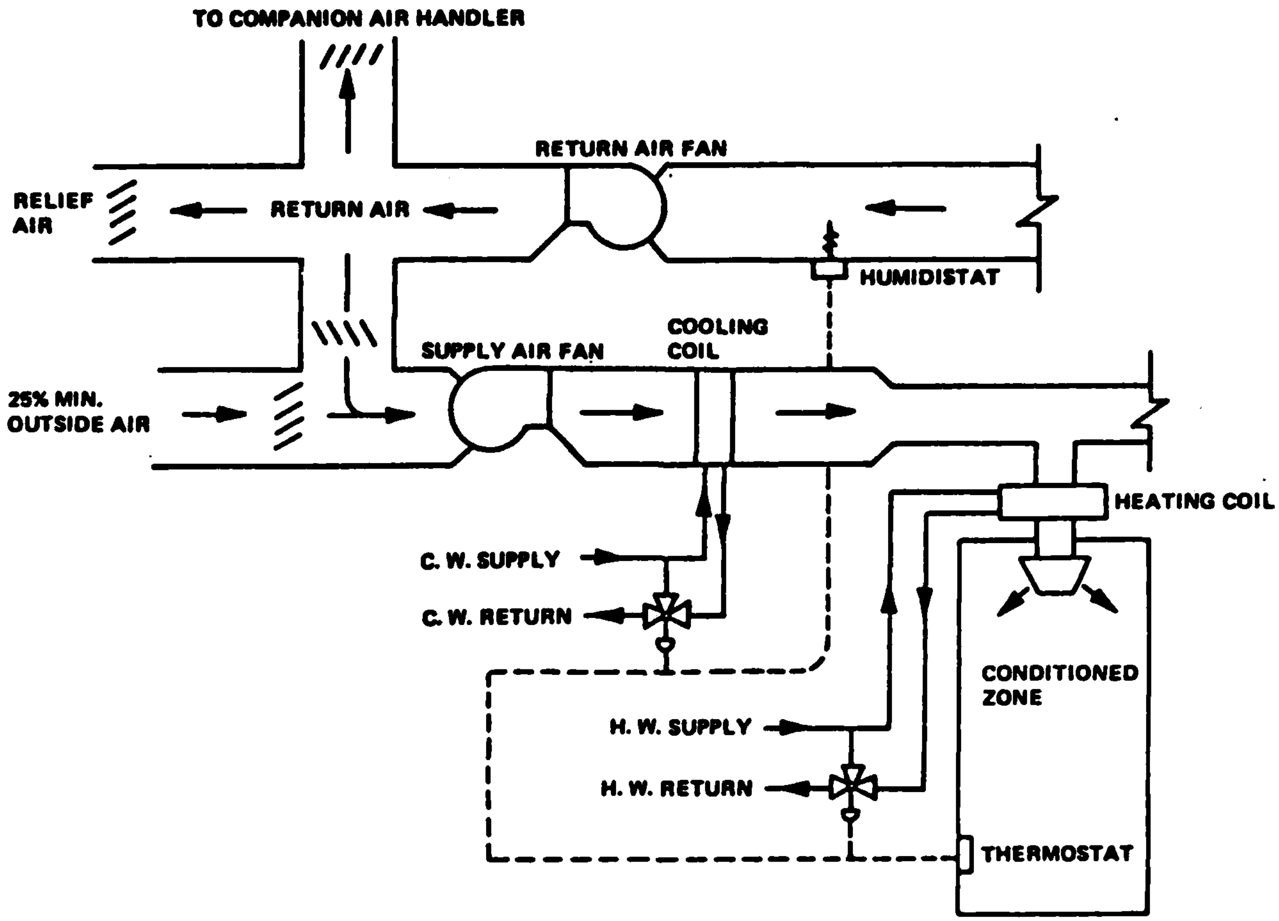


Source: Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978

FIGURE 7.3-1
TYPICAL SETPOINT/REHEAT AIR HANDLING SYSTEM

7.3.3. DEMAND CONTROL SYSTEMS

Demand Control Systems (See Figure 7.3.2) represent a common, simple method of avoiding the inherent waste associated with setpoint reheat control, by minimizing simultaneous cooling and heating except as required to limit humidity. Cooling or heating, but not both simultaneously, are controlled by the zone thermostat. Operation of the system is similar to that of the setpoint reheat except the temperature of air discharging from the cooling coil is controlled by the zone thermostat and is varied to provide cooling equal to the zone cooling load. Only after the cooling coil valve has completely closed will the heating coil valve open, providing heat equal to the zone heating load. A humidistat located in the return air flow will override the cooling coil to lower its discharge temperature when the high humidity limit is reached. if many zones are served, or if humidity limits are severe, much of the savings normally expected of this system may be lost.

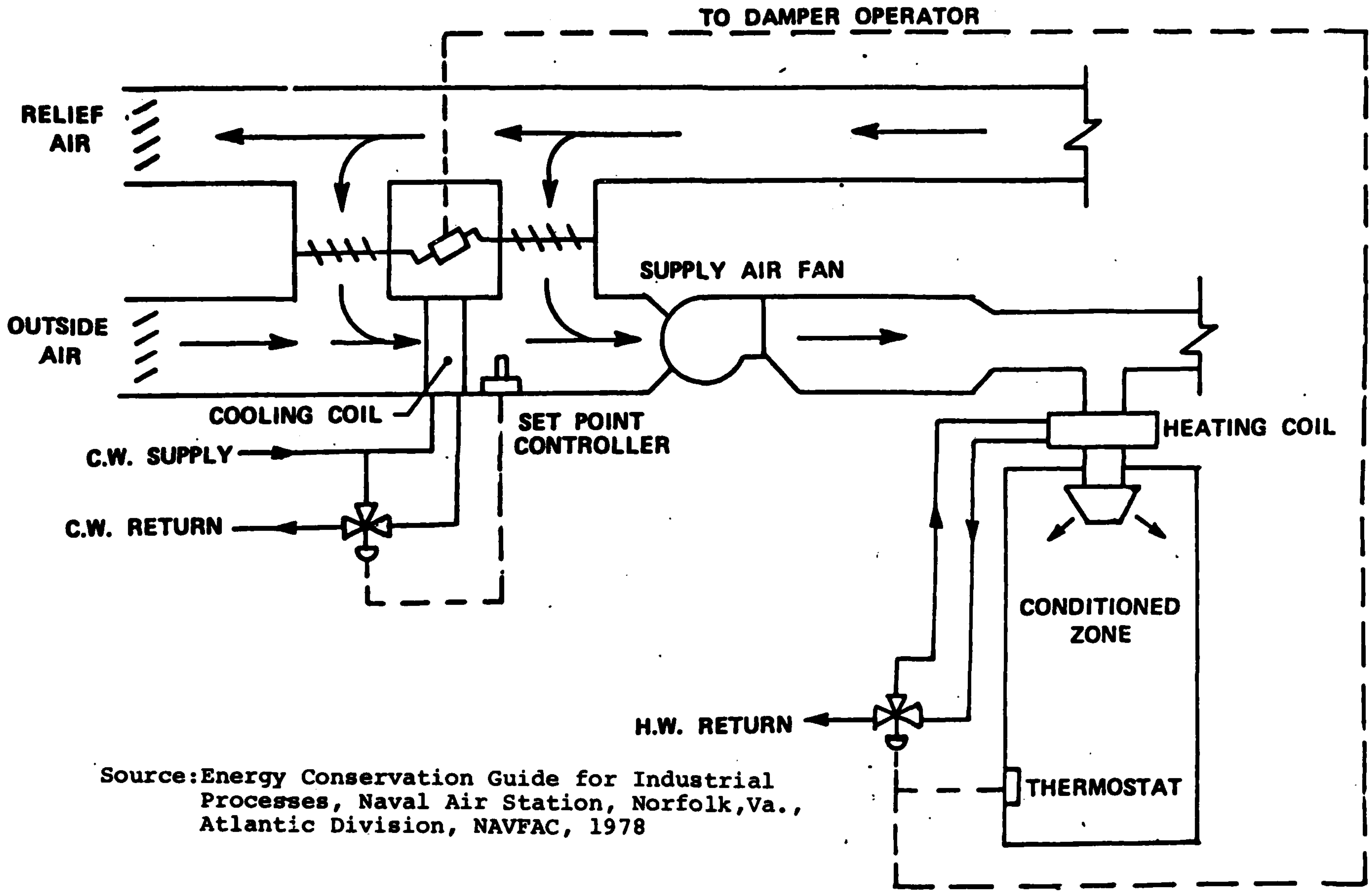


Source:Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk,Va., Atlantic Division, NAVFAC, 1978

FIGURE 7.3-2
TYPICAL DEMAND CONTROL WITH TERMINAL REHEAT

7.3.4 COIL BYPASS SYSTEMS

Coil Bypass Systems (see Figure 7.3-3) are an effective method of obtaining close control of humidity without excessive simultaneous cooling and reheating. This is made possible by cooling only as much as is necessary for zone load and humidity control, and allowing the balance to bypass the cooling coil. Operation of this system is similar to the setpoint/reheat and demand system already discussed. The zone thermostat modulates the return air and bypass dampers to provide a supply air temperature to the zone low enough to handle the zone load. The cooling coil valve is controlled by cooling coil setpoint controller. As the zone temperature decreases, the percentage of return air which bypasses the coil is increased until the maximum bypass position is reached. Only then will reheat be provided, as signaled by the zone thermostat. This is generally the most energy-efficient system when humidity is to be limited. Again, if the number of zones is large, potential savings are reduced. This modification can often be difficult to accomplish because of air handling unit configuration or layout.

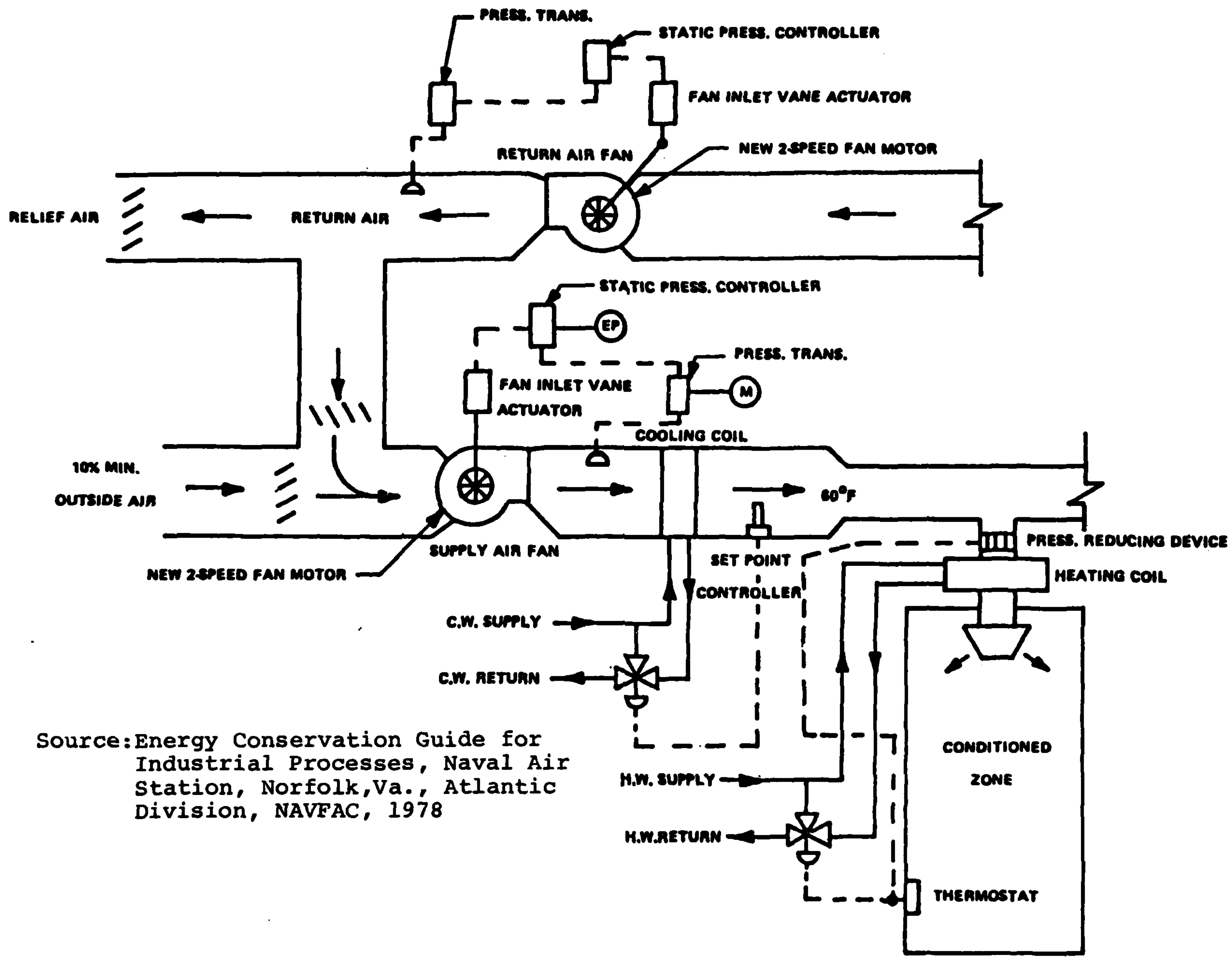


Source: Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978

FIGURE 7.3-3
TYPICAL COOLING COIL BYPASS WITH TERMINAL REHEAT

7.3.5 VARIABLE AIR VOLUME SYSTEMS

Variable Air Volume Systems (see Figure 7.3-4) are particularly efficient for those installations where many zones (10 or more) are serviced by a single HVAC unit. Since with a demand control system, the zone with the largest cooling loads will govern the cooling coil outlet temperature, the supply air will be over-cooled for all other zones. The standard terminal reheat adds heat to the other zones, sufficient to maintain the desired zone temperature, thereby still wasting considerable energy. The variable air volume (VAV) system operation differs in that each branch duct has a pressure control device upstream of the reheat coil, which reduces air flow in response to falling zone temperature. Only after the flow is at its minimum, is reheating introduced. This reduces the consumption of reheat energy, since less air is heated. In addition, as flow into the various zones is lessened, a static pressure sensing device reduces air delivery, either through fan outlet dampers, varying inlet vane geometry, fan motor speed reduction, or a combination of both, which may result in a reduction in fan motor energy consumption.



Source: Energy Conservation Guide for Industrial Processes, Naval Air Station, Norfolk, Va., Atlantic Division, NAVFAC, 1978

FIGURE 7.3-4
VARIABLE VOLUME AIR HANDLING SYSTEM

7.3.6 SAVINGS ON HVAC COSTS BY CONSIDERING CONTROL MODIFICATIONS

One general method for reconfiguring the operating modes of HVAC systems is by modifications to control equipment. This technique has been without peer in saving energy in building systems management.

In the days of low cost energy, little attention was paid to the economic considerations. Commonly, HVAC systems were configured to what is known as "setpoint reheat" types. In concept, this system cools return air and make-up air to a "setpoint" temperature and then adds heat as required by the zone temperature control system. The result is high energy costs because heating and cooling may occur similtaneously through all seasons.

To remedy this situation, the common solution is to modify control functions to the "demand system". The result is that heating and cooling operate in series, not simultaneously. This type system is energy efficient but lacks the capability to remove sufficient humidity when in a cooling mode unless the system is compromised to some extent by adding a "humidity override" feature.

Heating, cooling, humidification and dehumidification requirements must be reviewed for all processes. It is a common practice for environmental requirements to be more rigorous than are actually needed. Manufacturers of computer systems often specify tight tolerances be maintained on cooling air temperature and humidity.

Practice has proven that much broader tolerances can be adopted with no degradation in reliability.

Laboratory areas should be surveyed with several objectives in mind. Can zone setpoint temperature be raised without compromising equipment cooling? Equipment exiting temperatures should be measured. Is it feasible to collect cooling air as it exits from equipment racks/chassis so that it can be exhausted outside the controlled area? Many laboratories and clean rooms have more limited use as compared to other type industrial facilities; one shift each day for five days a week is common. During non-working hours, the cooling load is reduced by turning off lights and workers leaving. The ideal HVAC system will reduce cooling output. One way to accomplish this result is to bypass air around the cooling coils in response to a zone temperature sensor. Another way is to reduce air delivery by means of a two-speed fan, with the additional advantage of fan power savings.

Computer programs are available from various organizations to calculate the annual energy consumption of a particular system. One key to its accuracy is the data that is used to represent the weather at the facility. The energy conservation team at a facility should review any programs that are available to determine if they will be effective at the facility or economical to run.

7.3.7 SAVING ON HVAC COSTS BY IMPLEMENTING PREVENTIVE MAINTENANCE PROGRAMS FOR AIR HANDLING AND TEMPERATURE CONTROL EQUIPMENT

There is no substitute for routine equipment checks and maintenance. Lack of vigilance can result in wasted energy. Filters must be changed at regular usage intervals to prevent degradation in air flow and increased fan motor power. Fan belts should be inspected for wear and tension, and bearings routinely lubricated. Temperature controls require routine servicing and calibration. The most commonly used industrial controls are pneumatically operated and have their own unique servicing problems. Control line filters must be cleaned routinely. Actuators and sensors must be checked to validate that control functions are being accomplished. If an economizer control calls for closure to minimum position of the outside air louvers at 70°F, for instance, this must be verified. Setpoints and modulation ranges are tabulated on control diagrams for reference while verifying operation of controls.

7.3.8 SAVING ON HVAC COSTS BY MINIMIZING HUMIDIFICATION REQUIREMENTS

A reduction in humidity can result in significant energy saving. Humidity is added to dry air by water spray or saturated steam through nozzles which are installed in duct systems. The question which must be answered is, "Is humidification really necessary?". In recent years, there has been an industry-wide trend to eliminate humidification by shutting off steam jet manifolds and removing control equipment. This deletion applies to HVAC equipment used for people comfort and for process control.

Paint drying no longer requires a lower limit on humidity. The new paints dry well even in the presence of very dry winter air which is heated but not humidified. The need for humidification in laboratories and clean rooms should also be carefully reviewed. Don't be locked into humidification by an obsolete process specification; challenge the need for humidification and make the users defend the requirement.

7.3.9 SAVING ON HVAC COSTS BY REDUCING THE VENTILATION RATE:

This method is one of the most effective ways to save on HVAC costs. However, it is important that the new rates comply with the codes and process needs.

7.3.10 SAVING ON HVAC COSTS BY REDUCTION OF AIR FLOW

Reduction of Air Flow during periods of low cooling loads, (usually at night or when lights are off), can be achieved in all HVAC systems through the installation of two-speed fan motors. Motor power savings can be significant, especially if unoccupied periods are a major portion of the operating time.

7.3.11 SAVING ON HVAC COSTS BY COOLING WITH OUTDOOR AIR

The typical laboratory, clean room or computer facility has relatively high cooling loads, and is frequently located on an interior building zone with little or no exterior walls or windows. Cooling is, therefore, required year-round. When outdoor air temperatures are below those of the conditioned zone much of the year, then this cooler air can be utilized to provide inexpensive cooling. Generally, the quantity of outdoor air taken into the HVAC system is controlled in one of three ways:

7.3.11.1 Fixed dampers allow a constant flow of outside air whenever the HVAC unit is operating. The percentage of system flow which is introduced directly from outdoors may be set anywhere from the minimum required for personnel ventilation (5-10%), up to 100%. Obviously the low settings lose much available free cooling, whereas the higher settings cause excessive heating in cold weather and excessive cooling during warmer weather.

7.3.11.2 An Economizer control system positions the outside air damper in relation to return air damper to maintain the mixture at the desired temperature. In setpoint reheat systems the temperature sensor is in the mixed air stream;

for demand control systems damper control is by zone (room) thermostat. An economizer changeover temperature is selected from an analysis of the weather profile for the area and the heating and cooling loads for the zone. Above the selected economizer changeover temperature the O.A. damper is closed to minimum O.A. position. Below this temperature the O.A. damper opens wider with increasing temperature to take full advantage of the relatively cooler O.A. (cooler than return air) to provide free cooling. During extreme winter weather, the "too" cold outdoor air is mixed with the right proportion of warmer air returning from the conditioned space so that the mixture temperature will counterbalance the cooling load of the zone. Thus, the economizer control system will avoid or at least minimize the use of steam for reheating.

7.3.11.2 Enthalpy control systems are utilized to select the optrimum changeover temperature. The instrument measures the indoor and outdoor conditions of both temperature and humidity, and selects the air with the lower enthalpy. Thus, in humid areas, changeover may occur at 65^{O}F dry bulb or less, while when humidity is low, the changeover temperature may approach 80^{O}F dry bulb. Enthalpy controllers are relatively expensive, and therefore, a careful analysis is required to determine their appropriateness in any given situation.

7.3.12 DATA COLLECTION for PROCESS/BUILDING HVAC

The data collection sheets concentrate on the following aspects of the system:

7.3.12.1 The Air Distribution System-Comparison of field observations with air balancing records.

7.3.12.2 Filter Replacement Schedule

7.3.12.3 An Assessment of the Damper Controls and Damper Fit. - Requires the availability of temperature readings of:

Outside air

Return air

Mixed air

7.3.12.4 The Operating Hours and How They are Controlled.

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _

AIR BALANCE REPORT

Firm _

_ _

_ _

Date Air Balance Report Completed: _ _ _ _ _ _ _ _ _ _ _

Review the above Report to determine if there are any items with a large variance between the "actual" and "design" data. Use the report as a basis to determine if equipment modifications can be made to conserve energy. Can additional modifications be made?

Most Air Balance Reports contain three types of data sheets:

- Air Moving Equipment Test Sheet
- Static Profile of the Supply Duct Sheet
- Veolcity Traverse Sheet

Data from the Air Moving Equipment Test Sheet will be used. The data is collected from the AIR BALANCE REPORT. If the report is not available, omit this section but consider the merits of having the system tested and balanced using the procedures outlined by the American Society of Heating, Refrigerating and Air Conditioning Engineers.

DATA COLLECTION - HVAC SYSTEMS SHEET 2 OF 5

DEPT. OF NAVY - NAVFAC BUILDING NO. _________

ENERGY CONSERVATION AUDIT SHOP NO. ___ I.D. NO. ___

ACTIVITY _________ LOCATION: FL _____ BAY ___

AIR BALANCE REPORT - AIR MOVING EQUIPMENT TEST SHEET

		Electric Motor			
Fan. No.	Location	Design Amps	Actual Amps	Design horsepower	Actual horsepower
___	______	____	____	______	_______
___	______	____	____	______	_______
___	______	____	____	______	_______
___	______	____	____	______	_______
___	______	____	____	______	_______

		Outdoor Air		Return Air	
Fan No.	Location	Design CFM	Actual CFM	Design CFM	Actual CFM
___	______	____	____	______	_______
___	______	____	____	______	_______
___	______	____	____	______	_______
___	______	____	____	______	_______
___	______	____	____	______	_______

DEPT. OF NAVY - NAVFAC BUILDING NO. _________

ENERGY CONSERVATION AUDIT SHOP NO. ___ I.D. NO. ___

ACTIVITY _________ LOCATION: FL _____ BAY ___

AIR BALANCE REPORT - AIR MOVING EQUIPMENT TEST SHEET

FILTER REPLACEMENT SCHEDULE

System No.	Location	Outdoor Air Filter*	Return Air Filter*	Fan Inlet Filter*
___	______	________	______	_______
___	______	________	______	_______
___	______	________	______	_______
___	______	________	______	_______
___	______	________	______	_______

*Replacement Method

If differential pressure:

first indicate change-over P and then the type of instrumentation used to determine P

Example: p = 2 in, permanent draft gage

If replacement on a scheduled basis, indicate frequency or months.

Example: Dec, May

DATA COLLECTION - HVAC SYSTEMS   SHEET 4 OF 5

DEPT. OF NAVY - NAVFAC   BUILDING NO. _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO. _ _ _ I.D. NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _   LOCATION: FL _ _ _ _ _ BAY _ _ _

__OUTSIDE AIR CONTROL:__ Design _ _ _ _ _% ASHRAE 90-75 _ _ _ _%

__Percent outside air test:__ close outside air damper to its minimum open setting.

Outside air temperature _ _ _ _ _ _ _ _ ^oF (TOA)

Return air temperature _ _ _ _ _ _ _ _ ^oF (TRA)

Mixed air plenum temperature _ _ _ _ _ _ ^oF (TMA)

$$\text{Minimum \% Outside Air} = \frac{TRA - TMA}{TRA - TOA} \times 100 = \_\_\_\_\_\_\_\_\_\_ \%$$

$$\text{Minimum Outside Air-System Air Handling Capacity} \times \frac{\text{Min. O.A.}}{100} =$$

CFM

If primarily a "peopleload":

$$\frac{\text{Min. O.A., CFM}}{\text{No. of People}} = \_\_\_\_\_\_\_\_ \text{ CFM/person}$$

Proceed with data analysis if outside air exceeds 5 CFM/person for either season.

If primarily as process load:

refer to design data concerning minimum CFM

minimum CFM _ _ _ _ _ _ _ _ _ _ _ _

__Percent outside air damper per leakage:__ close O.A. damper fully, measure temperatures as above.

$$\text{\% O. A. Damper Leakage} = \frac{TRA - TMA}{TRA - TOA} \times 100 = \_\_\_\_\_\_ \%$$

Proceed with data analysis if over 1-2%.

DATA COLLECTION - HVAC SYSTEMS SHEET 5 OF 5

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ _ BAY _ _ _

OPERATING DATA:

System No. _ _ _ _ _ _ _

Cooling Season: from _ _ _ _ (month) to _ _ _ _ (month)

Heating Season: from _ _ _ _ (month) to _ _ _ _ (month)

	Weekdays	Saturdays	Sundays and Holidays
"Occupied" Operating Hours	from _ _ to _ _	from _ _ to _ _	from _ _ to _ _
Method of Stop-Start	_ _ _ _ _ _ _	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _
" Occupied" Temp	_ _ _ _ _ _ _	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _
RH	_ _ _ _ _ _ _	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _
"Unoccupied" Temp	_ _ _ _ _ _ _	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _
RH	_ _ _ _ _ _ _	_ _ _ _ _ _ _	_ _ _ _ _ _ _ _

DEPT. OF NAVY - NAVFAC BUILDING NO. _________

ENERGY CONSERVATION AUDIT SHOP NO. ___ I.D. NO. ___

ACTIVITY _________ LOCATION: FL _____ BAY ___

OUTSIDE AIR CONTROL: Minimize damper leakage.

The following calculations assume that a damper leaking 5 to 30% is replaced with one leaking 1% maximum.

T1 = Average Indoor Temperature for the Specific Season

T0 = Average Outdoor Temperature for the Specific Season

Heating Season:

$$\text{Air Handled (CFM)} \times \frac{100\text{-\% Damper Leakage}}{100} \times 1.08$$

$$\times (T1-T0) \times \text{Unoccupied hrs/wk} \times \frac{\text{weeks}}{\text{heating season}}$$

$$\times \frac{\text{Cost of Heat (\$/MBtu)}}{1{,}000{,}000} = \_\_\_\_\_\_\_\$ \text{ Saved}$$

Cooling Season:

$$\text{Air Handled (CFM)} \times \frac{100\text{-\% Damper leakage}}{100} \times 4.5$$

$$\times (T1 - T0) \times \text{Unoccupied hrs/wk} \times \frac{\text{weeks}}{\text{cooling season}}$$

$$\times \frac{\text{Cost of Cooling \$/MBtu}}{1{,}000} = \$ \text{ Saved}$$

CONDUCTED BY _______________ DATE: ________

DATA ANALYSIS - HVAC SYSTEMS SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ I.D. NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _

OUTSIDE AIR CONTROL: Control outside air to 5 CFM/person. (Where Applicable).

Heating Season:

Excess Outdoor Air = Min. Outdoor Air CFM/person - 5 CFM/person = _ _ _CFM/person

Excess Outdoor Air CFM/person x No. of People x 1.08 x operating hours/week x (Ti - To) x No. of weeks (heating season) x 1/1,000,000 x $/MBtu

Cooling Season

Excess Outside Air = Min. Outside Air CFM/person - 5 CFM/person = _ _ _ CFM/person

Excess Outside Air CFM/person x No. of People x 4.5 x operating hours/week x (Ti - To) x No. of weeks (cooling season) x 1/1,000,000 x $/MBtu

CALCULATIONS BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _

CHECKLIST - HVAC SYSTEMS SHEET 1 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

Before evaluating specific HVAC systems or operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. Heating, ventilating, and air conditioning systems are part of a scheduled inspection and maintenance program. Evaluation: ____________________ __________________________		
2. Optimum control settings have been established for all systems, i.e., heating, cooling, and between seasons, with daily, weekly and seasonal operating and maintenance schedules. Evaluation: ____________________ __________________________		
3. Engineers, supervisors, technicians or contract personnel are trained and qualified. Evaluation: ____________________ __________________________		

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

Applies	
Yes	No

4. For the heating season (weather up to 55°F outdoors), heating thermostats are set at 68°F or ___ °F. Unoccupied spaces are kept at ___°F manually or by timer.

   Evaluation: ______________________

   ____

5. Check outdoor air damper for leakage and correct for replace with a low leakage damper. For offices, reduce ventilation with outdoor air to zero when building, zone, or space is unoccupied. Reduce ventilation with outdoor air to 5 cfm per person or other suitable value per ASHRAE 90-75 and 62-73.

   Evaluation: ______________________

   ____

6. For the cooling season, are thermostats set and locked at 78°F or other ____ °F? During off-hours, can cooling be shut off?

   Evaluation: ______________________

   ____

CHECKLIST - HVAC SYSTEMS SHEET 3 OF 4

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

	Applies Yes	Applies No
7. Can air temperature leaving the cooling coil be as high as 58°F? Can the chilled water temperature be raised 2°F? Can the economizer control be adjusted to use outdoor air for cooling when it is below 65°F? Evaluation: ____________________ ___________________________		
8. Can static pressure be reduced on fans consistent with delivery to the farthest end of the system? ___________________________		
9. When considering changes which can be manual, consider automation as well, involving both timers and controls based on changing outdoor conditions. Evaluation: ____________________ ___________________________		

DEPT. OF NAVY - NAVFAC BUILDING NO._ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ _ _ ID. NO. _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _ _

	Applies	
	Yes	No
10. Have heat recovery units been considered for exhaust, process, transformer vaults, or others? Evaluation: _		
11. Has the air distribution system been tested and balanced? Are records or reports available? Evaluation: _		

CHECKLIST - MATERIAL HANDLING SHEET 1 OF 9

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

Before evaluating specific material-handling equipment operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. Install large double air lock type doors to prevent both sets being opened simultaneously. Evaluation_______________________ _________________________________		
2. Install a flexible covering, such as rubber or canvas strip over scrap conveyor openings in building walls. Evaluation: ______________________ _________________________________		
3. Shrouds should be used in all dock doors when possible. Investigate using air curtain fans if shrouds are not applicable. Evaluation: ______________________ _________________________________		

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

	Applies Yes	No
4. Consider the installation or two-way radio equipment on material-handling equipment to reduce the number of empty return trips. Evaluation: ______________________		
5. Investigate installing automatic door openers to minimize door "open time" with its resultant heat loss. Install adjacent 36"-48" passage doors for personnel and hand trucks. Evaluation: ______________________		
6. Discourage passenger use of freight elevators. Evaluation: ______________________		

DEPT. OF NAVY - NAVFAC | BUILDING NO.________

ENERGY CONSERVATION AUDIT | SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ | LOCATION: FL ___ BAY ____

Applies

Yes | No

CRANES AND HOISTS:

1. Avoid making a habit of using a drastically oversized crane for a drastically undersized load. If a machine frequently requires a crane to load small work pieces, consider installing a small jib crane with an electric hoist. This both frees up the main crane for heavier jobs and saves energy.

   Evaluation: ______________________

   ____

2. Install automatic timers to shut down crane motor generators if no crane moves are made within ten minutes.

   Evaluation: ______________________

   ____

3. Consider installing electrical hoists rather than air-operated hoist since a "1 horsepower" air hoist requires about 5 compressor horsepower, while a "1 horsepower" electric hoist requires only 1 horsepower.

   Evaluation: ______________________

   ____

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

Applies Yes	Applies No

FORK LIFTS:

1. Be sure fork lift air cleaners are clean. High dust locations will require centrifugal pre-cleaners to prolong filter element life.

   Evaluation: ____________________

   ____

2. Consider purchasing diesel fule fork lifts. Their reduced fuel consumption and lower maintenance should result in substantial savings over gasoline or propane lifts.

   Evaluation: ____________________

   ____

3. Where applicable, investigate replacing internal combustion fork lifts with electric fork lifts. In many cases, operating cost (and energy consumption) will be lower, and maintenance costs may be 30 percent lower. Electric trucks also have lower downtime, are non-polluting, and are quieter.

   Evaluation: ____________________

   ____

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

Item	Applies: Yes	Applies: No
4. Replace old, out-moded and inefficient motor-generator battery chargers with new solid state, power-factor corrected, high-efficiency battery chargers. Evaluation: ____________________		
5. Be careful to adjust the carburetor only when the fork lift is operating at rated water temperature, has a clean air filter, and is idling at the manufacturer's recommended speed. Evaluation ____________________		
6. Avoid excessive choke use. An LPG fueled enginer should require a choke only for starting, while a gas engine's should be opened after about 3-4 minutes. Evaluation: ____________________		

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY __________ LOCATION: FL ___ BAY ____

	Applies	
	Yes	No
7. An engine is most efficient operating at the manufacturer's recommended temperature. A "Cold" engine cannot adequately vaporize fuel, while a "hot" engine loses power and tends to vapor lock. See that the thermostat matches the manufacturer's.		
Evaluation: _______________________		
8. Be careful to select the correct weight engine lubricating oil. Too light an oil doesn't lubricate sufficiently, while heavy oil increases engine "drag". Use 10 from 0 to 32°F, 20W from 32 to 75°F, and 30W above 70°F.		
Evaluation: _______________________		
9. Be sure fork lift hydraulic relief valves are set correctly. Higher than required pressure increase horsepower needs and heat oil excessively, while low hydraulic pressure can also overheat oil and reduce machine performance.		
Evaluation: _______________________		

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

Applies	
Yes	No

10. Be sure hyudraulic valves and controls open fully. Partial opening results in slow response and excessive oil heating.

    Evaluation: ____________________

    ____

11. Don't downshift to slow down. Fork lift transmissions were never designed for this kind of load, and it wastes fuel.

    Evaluation: ____________________

    ____

12. Limit internal combustion fork lift operation to the shift with the heaviest material handling load. Other shifts should utilize electric lifts as much as feasible.

    Evaluation: ____________________

    ____

13. Avoid opening a door any higher than necessary during the heating season.

    Evaluation: ____________________

    ____

DEPT. OF NAVY - NAVFAC BUILDING NO. ________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

Applies

Yes | No

14. Install overspeed governors on all internal combustion material handling equipment, particularly fork lifts, to eliminate hot rodding.

    Evaluation: ______________________

    ____

15. Investigate fork lift records or contact manufacturers to discover the best fork lift fuel consumption. Log all machine fuel to determine operator errors or machine deterioration.

    Evaluation: ______________________

    ____

16. Fork lifts are designed to lift, travel, and lower, with travel limited to 100 yards or so. For greater distances and many trips, consider using a suitable truck.

    Evaluation: ______________________

    ____

17. Be sure pneumatic fork lift tires are properly inflated. Underinflation both damages tires and wastes fuel, about 3 ro 5% at slow speeds.

    Evaluation: ______________________

    ____

DEPT. OF NAVY - NAVFAC BUILDING NO.________

ENERGY CONSERVATION AUDIT SHOP NO.: ______ ID. NO. ___

ACTIVITY _________ LOCATION: FL ___ BAY ____

	Applies Yes	Applies No
18. Avoid using a far larger fork lift than required. For instance, use a 2,000 pound lift to maneuver oil barrels rather than a 6,000 pound lift. Evaluation: ____________________ _________________________		
19. Avoid excessive fork lift idling. Start a lift only when there is work to be done, and stop if as soon as it is completed. Evaluation: ____________________ _________________________		

SECTION 8

8.1 ELECTRICAL DISTRIBUTION

8.1.1 INTRODUCTION

Large transformers can be the source of wasted energy. For evaluation of energy conservation, a compilation of all transformer data will permit an analysis of energy losses and the feasibility of minimizing these losses by several means, e.g.: combining light loads to eliminate transformers, shutdown of transformers to match duty cycle of load.

Since most electric power companies have additional charges in their rate schedule for power factors lower than a specified limit, there is often an incentive to improve the power factor. Usually this is accomplished with capacitors and sometimes with synchronous motors. Care must be taken to insure that any proposed savings are practical.

8.1.2 TRANSFORMERS

There are two sources of energy loss in both oil-filled and dry-type transformers; these are core, sometimes called iron or hysteresis loss, and copper losses.

Core loss is a function of the transformer design and is constant as long as the transformer is energized.

Copper losses are a function of load current squared with a maximum at full load.

Listed in Table 8.1 are typical transformer losses. These figures are derived from manufacturer acceptance test results.

The actual losses of any specific transformer are specified on the transformer test report furnished by the manufacturer. Where this data is not available, the core loss may be approximated from Table 8.1, while the copper loss may be obtained by measuring current and computing the I^2R loss based on nameplate impedance. In many cases, data may be

TABLE 8.1 TRANSFORMER LOSSES

KVA Range	Approx. Core Loss % of Full Load Rating	Approx. *Copper Loss % Of Load
Dry Type Transformer Losses		
30 - 225	0.75%	0.50%
300 - 500	0.50%	0.50%
700 - 1000	0.32%	0.50%
Oil Filled Transformers		
750	0.40%	0.50%
1000	0.35%	0.50%
1500	0.30%	0.50%

*At Assumed 50% Loading

Source: Load vs. Heat Rating in Selecting Dry Type Transformers for Lowest Operating, Cost, Electric Construction and Maintenance, June 1976.

obtained from manufacturers records by furnishing serial number and other pertinent nameplate data.

8.1.3 POWER FACTOR

Some common causes of lagging power factor in an industrial facility are lightly loaded induction motors and welding machines. Usually, lighting applications are equipped with high-power-factor ballasts.

A cost-justified solution usually employs capacitors. Power factor correcting capacitors can be installed at the motor or welding machine. Often they are installed on the distribution system supplying banks of motors or welding machines.

There are economic constraints that must be considered. For example, providing more power factor correction than the power company's lower limit won't reduce the power bill. Sometimes the justification for power factor correction is to reduce plant expansion costs by eliminating the need to add a new feeder cable. In other words, high current flow in a feeder cable due to low power factor will be corrected so that new loads can be added without installing a new cable.

Power factor correction techniques are best developed by an engineering group well versed in the state-of-the-art.

Of prime importance to an energy conservation survey team would be:

8.1.3.1 To determine the annual costs of power factor penalties when compared to the annual billing.

8..3.2 If applicable, to review the recommendations of the most recent report at the facility concerning the its power factor and the recommendations that have been made.

8.1.4 <u>RESOURCES FOR A SURVEY</u>

Data Collection Forms

Transformers 8.1- 7

Data Analysis Sheet 8.1- 9

Checklists 8.1-10

Where Applicable:

Electric Motors. . . . . Appendix E

8.1.5 <u>ADDITIONAL DATA COLLECTION AND ANALYSIS FORMS</u>

Sometimes, the uniqueness of the equipment requires the use of generalized forms. The forms are found in Appendix K.

Data Collection Form K-2

Sketch Sheet K-3

Data Analysis Form K-4

DATA COLLECTION - TRANSFORMERS

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I.D. NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _

TRANSFORMERS

Transformer No. _____, Dry _____, Oil filled _____

Power Rating _____ KVA

Primary Voltage _____ volts

Secondary Voltage _____volts

Core Losses _____watts

Copper Losses _____ watts

Hours/week de-energized _____ hrs.

Transformer No. _____, Dry _____, Oil filled _____

Power Rating _____ KVA

Primary Voltage _____ volts

Secondary Voltage _____volts

Core Losses _____watts

Copper Losses _____ watts

Hours/week de-energized _____ hrs.

Transformer No. _____, Dry _____, Oil filled _____

Power Rating _____ KVA

Primary Voltage _____ volts

Secondary Voltage _____volts

Core Losses _____watts

Copper Losses _____ watts

Hours/week de-energized _____ hrs.

CONDUCTED BY _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _ _ _ _

CHECKLIST - TRANSFORMERS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.: ___________

ENERGY CONSERVATION SHOP NO.: ________ I.D. NO.: ____

ACTIVITY ________ LOCATION: FL ____ BAY ______

Before evaluating specific transformers and operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. The electrical distribution system should have a power factor of 85% or higher. If lower, it is usually due to inductive lods like electric motors. Correction can be achieved by using synchronous motors and/or system capacitors or individual motor capacitors. While the distribution system is not part of this audit, its power factor affects both motor and distribution capacity. Evaluation: ____________________ ________________________		

DEPT. OF NAVY - NAVFAC BUILDING NO.: ___________

ENERGY CONSERVATION SHOP NO.: ________ I.D. NO.: ____

ACTIVITY ________ LOCATION: FL ____ BAY ______

	Applies	
	Yes	No
2. The motor and system power factors are affected by running many individual motors partly loaded. If the data analysis shows a motor load factor of 0.60 or lower, and if the motor is known not to exceed that load, determine the true horsepower requirement. This will yield a power factor improvement when the motor is replaced with a smaller one.		

Evaluation: ____________________

____

8.2 STEAM

8.2.1 RESOURCES FOR A SURVEY

Table 8.2.2

HEAT LOSS FROM PIPES BARE AND INSULATED
(Btu/hr - Linear Foot - Degree F)

Diameter Inches	Bare* Pipe	Insulation Thickness 1/2"	3/4"	1"	1-1/2"	2"	2-1/2"	3"
1/2	0.62	0.117	0.100	0.090	0.077	0.069	0.064	0.060
3/4	0.75	0.149	0.125	0.110	0.092	0.082	0.079	0.075
1	0.93	0.180	0.148	0.129	0.106	0.093	0.085	0.079
1-1/4	1.15	0.210	0.171	0.147	0.120	0.104	0.094	0.087
2	1.59	0.298	0.237	0.200	0.159	0.136	0.120	0.110
2-1/2	1.90	0.357	0.280	0.235	0.184	0.155	0.137	0.124
3	2.28	0.415	0.323	0.269	0.0208	0.175	0.153	0.138
4	2.87	0.531	0.409	0.337	0.257	0.213	0.185	0.165
5	3.49	0.647	0.494	0.404	0.346	0.250	0.215	0.191
6	4.11	0.762	0.578	0.472	0.352	0.287	0.246	0.217
8	5.26	0.993	0.748	0.605	0.447	0.361	0.306	0.268
10	6.47	1.224	0.917	0.739	0.541	0.433	0.366	0.319
12	7.58	1.454	1.085	0.872	0.635	0.506	0.425	0.369

K for insulation = 0.30 $\frac{\text{Btu}}{\text{h} \times \text{ft}^2 \times {}^{\circ}\text{F/ft}}$ and wind velocity of 0 mph.

*Source: ASHRAE Handbook and Product Directory 1977 Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

**

The following equation is used to determine the heat loss for insulated pipes

$$Q = \frac{\left(\pi \cdot \frac{r2}{6} \right)}{\frac{r2 \cdot \ln \frac{r2}{r1}}{k} + \frac{1}{f}}$$

where:

Q = Rate of heat transfer, Btu/hr-linear foot - ^{o}F

r1 = Inside radius of insulation, inches

r2 = Outside radius of insulation, inches

k = k factor of insulation, Btu-ft/hr - ^{o}F - sq ft

f = Outside air film coefficienct (usually 1.65)

**Source: Heat Transfer, Third Edition, J. P. Holman, McGraw-Hill Book Co. 1972.

HEAT LOSS IN STACK

Table 8-2

Source: Architects and Engineers Handbook, by Industrial Combustion Inc., 1967

Add 2% radiation loss if insulated boiler and 4% if uninsulated to get total heat loss as % of Heat in Oil lost. 100% minus total heat loss in % equals overall efficiency.

FUEL OIL NO. 2

CO_2	Excess Air %	Stack Temperature - °F 300	400	500	600	700	800	900	1000
15	2	10.5	13.0	15.2	17.0	19.0	21.0	23.0	25.3
14	9	11.0	13.5	15.7	17.5	20.0	22.0	24.0	26.6
13	16	11.5	14.0	16.2	18.5	21.0	23.0	25.2	27.8
12	27	12.0	14.6	16.7	19.5	22.0	24.0	26.5	29.1
11	40	12.5	15.3	17.5	20.5	23.0	25.2	28.0	30.8
10	53	13.0	16.0	18.5	21.5	24.0	27.0	30.0	33.0
9	70	13.5	17.0	19.5	23.0	26.0	29.0	32.0	35.6
8	91	14.2	18.0	21.0	25.0	28.0	32.0	35.0	39.3
7	120	15.3	19.2	23.0	27.0	31.0	35.0	39.0	43.5
6	155	16.8	21.0	26.0	30.0	35.0	39.0	44.0	48.4
5	210	18.5	24.0	29.5	35.0	40.0	45.5	51.0	56.0
4	290	21.5	28.0	34.5	41.0	47.5	54.0	61.0	69.0

FUEL OIL NO. 5

CO_2	Excess Air %	300	400	500	600	700	800	900	1000
		Stack Temperature - °F							
16	0	9.9	13.1	15.0	17.0	19.0	21.0	23.0	25.2
15	7	10.8	13.5	15.7	17.5	19.7	21.7	24.0	26.4
14	14	11.3	14.0	16.5	18.6	21.0	22.9	25.2	27.8
13	23	11.8	14.6	17.2	19.7	22.3	24.0	26.4	29.2
12	34	12.4	15.3	17.9	20.4	23.2	25.2	27.7	30.6
11	47	12.9	15.8	18.6	21.3	23.9	26.3	29.3	32.9
10	61	13.3	16.7	19.3	22.6	25.3	28.4	30.0	33.0
9	80	13.9	17.8	20.3	24.2	27.2	30.2	33.8	37.7
8	100	14.7	18.7	22.0	26.2	29.2	33.3	36.9	41.3
7	130	15.6	20.1	24.0	28.2	32.3	36.7	41.0	45.6
6	170	17.3	22.0	27.0	31.6	36.7	40.8	46.0	50.4
5	220	19.2	24.7	30.4	36.2	41.7	47.3	53.1	58.6
4	300	22.1	28.6	35.3	42.0	49.2	55.8	63.1	71.1

Add 2% radiation loss if insulated boiler, and 4% radiation loss if uninsulated. Also heat in unconsumed particles in smoke and ashes. % of Heat in Coal as fired that is lost in stack.

BITIMINUOUS COAL (80% CARBON - 4% HYDROGEN)

CO_2	Excess Air %	Stack Temperature - °F 400	500	600	700	800	900	1000
18	3	7.	9.	11.5	15.	16.5	18.5	20.
17	10	9.5	11.5	14.	17.	18.5	20.	22.
16	17	10.5	12.5	15.	18.	20.	22.	24.5
15	25	11.	13.	16.	19.	21.	24.	26.5
14	33	11.5	14.	17.	20.	22.	25.	27.5
13	44	12.	15.	18.	21.	24.	27.	30.
12	58	13.	16.	19.	22.	26.	28.5	32.
11	70	14.	17.	20.	24.	28.	30.	33.
10	89	15.	18.	22.	26.	30.	32.	35.
9	110	16.	20.	24.	28.	32.	36.	40.
8	132	18	22.	27.	31.	36.	40.	44.
7	170	20.	25.	30.	35.	40.	46.	51.
6	213	24.	30.	36.	42	47.	54.	60.

Add 2% of radiation loss if insulated boiler and 4% radiation loss if uninsulated. Add losses from CO in stack.

NATURAL GAS (GROSS 115 BTU PER CU FT)

N_2	.005
CO_2	.005
CH_4	.830
C_2H_6	.160

CO_2	Excess Air %	Stack Temperature - °F 400	500	600	700	800	900	1000
12.1	0	17.0	19.0	20.9	23..3	25.9	28.0	30.5
11	10	17.5	19.7	21.7	24.2	26.7	29.2	31.7
10	20	18.2	20.6	22.7	25.3	27.8	30.5	33.1
9	32	18.9	21.4	23.9	26.8	29.5	32.4	37.7
8	47	19.8	22.5	25.4	28.6	31.4	34.5	37.7
7	67	21.0	24.2	27.4	30.8	34.2	37.6	41.0
6	93	22.5	26.2	29.7	33.4	37.5	41.3	44.9
5	130	25.1	29.5	33.6	38.3	43.4	47.6	52.1
4	190	27.9	33.2	24.	38.0	43.9	49.2	60.1

DATA COLLECTION - STEAM SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. ________

ENERGY CONSERVATION AUDIT SHOP NO. _____ I.D. NO.: ____

ACTIVITY ___________ LOCATION: FL __ BAY ____

NAME PLATE DATA:

Manufacturer: ____________ Model: __________

Age: ________________ Condition: _______

Generation: Steam ______ psig

Capacity Steam: ________ lb/hr

AUDIT DATA: EXCESS AIR: Flue Gas Sampling Location ____

Flue Gas Analysis: ORSAT O2 Meter Reading ______

CO_2 Reading ______ O2 ______________

O_2 Reading ______ O2 ______________

CO Reading ______ CO ______________

Analysis Total ______________

% N_2 = 100% - Analysis Total % = N_2 ________

$$\text{Excess Air} = \frac{3.78\,(O_2 - CO/2) \times 100}{N_2 - 3.78\,(O_2 - CO/2)} = \_\_\_\_\_\_\_\_$$

Where O_2, CO and N_2 are expressed as %/100.

Minimum Excess Air % Required _______________

Fuel Temperature __________ Pressure ________

AUDIT DATA: STACK

Flue Gas Temperature: __________ °F Location ______

Feedwater Temperature: _________ °F

Feedwater Rate: ______________ GPM or lb/hr

Economizer Inlet Temperature: ______ °F

Economizer Outlet Temperature: ____ °F

DATA COLLECTION - STEAM SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ I.D. NO.:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

BOILER UTILIZATION:

Steam Production Rate: _ _ _ _ _ _ _ _ _ _ _ _ _ $\frac{\text{lbs}}{\text{hr}}$

Rated Steam Capacity: _ _ _ _ _ _ _ _ _ _ _ _ _ _ $\frac{\text{lbs}}{\text{hr}}$

$\frac{\text{Actual Steam Rate}}{\text{Rated Capacity}} \times 100 =$ _ _ _ _ _ _ _ _ _ _ _ _ Percent Utilization

Blowdown Rate: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ $\frac{\text{lbs}}{\text{hr}}$

Pressure: _ psig

Temperature: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ ^{o}F

Make-Up Water Rate: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ $\frac{\text{lb}}{\text{hr}}$

BOILER CHEMICAL TREATMENT COSTS

$ _ _ _ _ _ _ _ _ _ per 1000 gallons

DATA COLLECTION - STEAM SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ I.D. NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _ _

CONDENSATE RETURN:

Condensate Return Rate: _ _ _ _ _ _ _ _ _ _ _ _ _ $\frac{\text{lbs}}{\text{hr}}$

Percent Condensate Returned = $\frac{\text{lb/hr Condensate Rate} \times 100}{\text{lb/hr Steam Rate}}$ = _ _ _ %

Condensate Temperature: _ _ _ _ _ _ _ _ _ _ _ _ _ _ ^{o}F

Make-Up Water Temperature: _ _ _ _ _ _ _ _ _ _ _ _ _ _ ^{o}F

Condition: _

_ _

_ _

Comments: _

_ _

_ _

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _ _ _ _

DATA ANALYSIS - STEAM SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ I.D. NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

SAVINGS DUE TO REDUCING EXCESS AIR: Refer to Page 8.2.2

Temperature _ _ _ _ ^{o}F

Present Excess Air _ _ _% _ _ _% Required Fuel (over theoretical)

Proposed Excess Air _ _ % _ _ _% Required Fuel

Improvement $\frac{\_\_\_\_\_\%}{100}$ x _ _ _ Fuel Used = Fuel Saved/Year
Units/yr

Fuel Saved x _ _$/Unit Fuel Cost = _ _ _$Saved/Year

Action Proposed: _ _ _ _ _ Leak Correction, _ _ _ _ _ Air/Fuel Adjustment

Other, specify _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _ _ _

DATA ANALYSIS - STEAM SHEET 2 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ _ I.D. NO.:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _BAY _ _ _ _

SAVINGS DUE TO REDUCING STACK TEMPERATURE: Refer to Page 8.2-2

Present Stack Temp _ _ _ _ _ _ % _ _ _ _ % Loss at Stack

Proposed Stack Air* _ _ _ _ _ % _ _ _ _ % Loss at Stack

Improvement = Present - Proposed = _ _ _ % Loss Reduction at Stack

_ _ _Fuel Saved x _ _ _ _ _ $/Unit Fuel Cost = _ _ _$ Saved/Year

Action Proposed: _ _ _ Feed Water Economizer, _ _ _ Air Preheater,

Other, specify _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

_ _

COMMENTS: _

_ _

_ _

*Note: Select a stack temperature 100 to 150°F above boiler steam temperature to estimate savings achieved with a feed water economizer.

CALCULATIONS BY: _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _ _ _ _ _ _

DATA ANALYSIS - STEAM   SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC   BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO. _ _ _ _ _ _ I.D. NO.:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _   LOCATION: FL _ _ _BAY _ _ _ _

SAVINGS DUE TO CONDENSATE COLLECTION AND RETURN:

Condensate Temp* _ _ _ _ ^{o}F Water Supply Temp _ _ _ _ ^{o}F

$T = T_c - T_s =$ _ _ _ _ ^{o}F

Condensate To Be Returned = _ _ _ _ _ _ _ _ _ _ lb/hr

_ _ _ _ lb/hr x T _ _ _ ^{o}F x 1 (Btu/lb-^{o}F) = _ _ _ Btu/year

_ _ _ _ Btu/hr x _ _ _ hr/ year = _ _ _ _ Btu/year

_ _ _ _ Btu/year $ _ _ _/Btu = $ _ _ _ _/year, heat saving.

Boiler Water Treatment Cost = $ _ _ _ _ _/1,000 gal

$\$$____/1,000 gal x $\frac{1{,}000 \text{ gal}}{8{,}350 \text{ lb}}$ x ___ lb/hr x ___ hr/year = $___/yr

Heat Saved + Water Treatment Saved = Total Saved Due to Condensate/Return

$ _ _ _ _ year + $ _ _ _ _ year = $ _ _ _ _ year

Action Proposed: _ _ _ _ Traps Insp. and Repair

_ _ _ _ Return Line-Install-Repair-Insulate

_ _ _ _ Other, specify _ _ _ _ _ _ _ _ _ _

_ _

COMMENTS: _

_ _

*Notes: Do calculation for each different temperature source quantity.

CALCULATIONS BY: _ _ _ _ _ _ _ _ _   DATE: _ _ _ _ _ _ _ _ _ _ _

CHECKLIST - BOILER STEAM

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _

Before evaluating specific boilers or boiler operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies: Yes	Applies: No
1. Determine whether some boilers can be shut down on weekends. (Originally this was believed to be a poor practice, some experimenters have shown otherwise.) Evaluation:_ _		
2. Consider various heat sources for pre-heating make up water--hot cutting oils, process water, condensate, etc. Evaluation: _		
3. Consider the development of a summer steam shutdown list. It will show what valves are to be closed to reduce steam distribution line losses. Evaluation:_ _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _

	Applies Yes	Applies No
4. Determine if the steam pressure can be reduced without affecting production. Evaluation: _		
5. Determine whether the steam trap maintenance program can be simplified by using temperature indicating tapes. Evaluation: _		

8.3 HOT WATER, PROCESS

8.3 RESOURCES FOR SURVEY

DATA COLLECTION - BOILER HEATING HOT WATER SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ _ I.D. NO.:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

NAME PLATE DATA:

Manufacturer: _ _ _ _ _ _ _ _ _ _ _ Model: _ _ _ _ _ _ _ _ _

Age: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Condition: _ _ _ _ _ _ _

Generation: High Temperature Hotwater: _ _ _ _ _ _ _ _ _ _

Capacity Hot Water: _ _ _ _ _ _ _ GPHR

AUDIT DATA: EXCESS AIR: SAMPLING LOCATION _ _ _ _

Flue Gas Analysis: ORSAT O2 Meter Reading _ _ _ _ _

CO_2 Reading _ _ _ _ _ O2 _ _ _ _ _ _ _ _ _ _ _ _

O_2 Reading _ _ _ _ _ O2 _ _ _ _ _ _ _ _ _ _ _ _

CO Reading _ _ _ _ _ CO _ _ _ _ _ _ _ _ _ _ _ _

Analysis Total _ _ _ _ _ _ _ _ _ _ _ _

$\% N_2 = 100\% -$ Analysis Total $\% = N_2$ _ _ _ _ _ _ _

$$\text{Excess Air} = \frac{3.78\ (O_2 - CO/2) \times 100}{N_2 - 3.78\ (O_2 - CO/2)} = \_\_\_\_\_\_\_\_$$

Minimum Excess Air Required _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Fuel Temperature _ _ _ _ _ _ °F Pressure _ _ _ _ _psig

AUDIT DATA: STACK

Flue Gas Temperature: _ _ _ _ _ _ _ _ _ °F Location _ _ _ _ _ _

Air Preheater Inlet Temperature: _ _ _ _ _ _ _ _ _ _ _ _ °F

Preheater Outlet Temperature: _ _ _ _ _ _ _ _ _ _ _ _ °F

*Express O_2, CO and N_2 as %/100.

DATA COLLECTION - BOILER HEATING HOT WATER SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ I.D. NO.:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _BAY _ _ _ _

BOILER UTILIZATION:

Heat Out: _ _ _ _Btu/lb - Heat In _ _ _ _ Btu/lb = _ _ _Btu/lb

HTHW Production Rate = GPH x 8.34 = _ _ _ _ _ _ lbs/hr

Btu Rate = _ _ _ _ lbs/hr x _ _ _ _ _Btu/lb _ _ _ _Btu/hr

Rated HTHW Capacity _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _Btu/hr

$$\frac{100 \times \text{Actual HTHW Rate}}{\text{Rated Capacity}} = 100 \times \_\_\_\_\_\_ = \text{Percent Utilization}$$

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _

DATA ANALYSIS - BOILER HEATING HOT WATER SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO. _ _ _ _ _ I.D. NO.:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ BAY _ _ _ _

SAVINGS DUE TO REDUCING EXCESS AIR: (See Page 8.2-2)

Proposed Operating Efficiency _ _ _ _ _ _ _ _ _

Present Operating Efficiency _ _ _ _ _ _ _ _ _

Efficiency Improvement (EI) _ _ _ _ _ _ _ _

_ _ _ % EI x _ _ _ _ _ Fuel Consumed/year = _ _ _ _ Fuel Saved/Year
100

_ _ _ _ _ _ _ Fuel Saved x $ _ _ _ _Fuel Unit Cost = $ _ _ _ Saved/Year

SAVINGS DUE TO REDUCING STACK TEMPERATURE: (See Table J-2)

Proposed Operating Efficiency _ _ _ _ _ _ _ _ _ _ _

Present Operating Efficiency _ _ _ _ _ _ _ _ _ _ _

Efficiency Improvement _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _% EI x _ _ _ _ Fuel Consumed/Year = _ _ Fuel Saved/Year
100

_ _ _ Fuel Saved x $ _ _ _ _ _ Fuel Unit Cost = $ _ _ _Saved/Year

COMMENTS: _

_ _

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _

DATA COLLECTION - BOILER HEATING HOT WATER SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO. ________

ENERGY CONSERVATION AUDIT SHOP NO. ______ I.D. NO.:____

ACTIVITY ____________ LOCATION: FL ____ BAY ____

Before evaluating specific heating equipment or operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. If process hot water is now heated by steam ___, electricity ____, HT hotwater ___, fuel oil ____, or gas ____, consider these alternatives: Recovered heat from nearby process or utility systems		
________ Flue gases		
________ Heat from internal combustion engines		
________ Heat of compression from air or refrigeration		
________ Compressor		
________ Solar. May need back-up or boost system (existing).		
Evaluation: ______________________ ______________________________		

DATA COLLECTION - BOILER HEATING HOT WATER SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO. ________

ENERGY CONSERVATION AUDIT SHOP NO. ______ I.D. NO.:____

ACTIVITY ____________ LOCATION: FL _____ BAY ____

	Applies	
	Yes	No
2. Heat only to the temperature required for process; used recovered waste heat for preheating and a prime heat source for boost or backup. Evaluation: ____________________ ____________________________		
3. If circulation pumps are used, turn off pumps during non-working hours. Evaluation: ____________________ ____________________________		

8.4 REFRIGERATION SYSTEMS

8.4.1 INTRODUCTION

The selection of a refrigeration system for an industrial facility depends on many factors.

Two types of refrigeration systems are encountered:

1. Mechanical vapor compression systems are the most commonly used. The compressors are driven by electric motors or steam. However, gas compared to a liquid, requires much more energy to be compressed over the same pressure range.
2. The absorption system takes advantage of the lower amount of energy required to pump a liquid. Furthermore, the absorption system can use low pressure steam or high temperature water as the major energy source.

8.4.2 REFRIGERATION PLANT - DATA COLLECTION

The collection of data for an energy conservation survey should be developed around the following list of items. It is important to remember that many factors go into the selection of a refrigeration system, hence some items will be of major importance in one facility, but will not be significant in another. A general outline of the topics covered in the data collection form are:

I. Current Operating Conditions

II. System Sized to Load

III. Condenser/Cooling Tower/Well Water

IV. Refrigeration Piping

V. Compressor (Mechanical Vapor Compression)

VI. Generator (Absorption)

VII. Evaporator

The form is used to indicate areas that could be developed for energy conservation. Data taking is minimized initially to allow the team to identify the areas. Next, each facility will develop its own data collection and data analysis forms for the specific parts of the system that can be optimized.

REFRIGERATION, CHILLED WATER

8.4.3 RESOURCES FOR A SURVEY

DATA COLLECTION - REFRIGERATION

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

System Capacity ________________

Type ______________(Mechanical Vapor Compression or Absorption)

Mechanical Vapor Compression:

Type of Compressor __________________

Type of Drive ______________, ______________hp

Refrigerant ________________

Absorption: Ammonia-Water ______________

Lithium Bromide ____________

I. CURRENT OPERATING CONDITIONS

Are operating temperatures monitored and compared with the design conditions at various loads? _________

Is the above temperature data used to indicate which heat transfer surfaces require cleaning? _________

II. SYSTEM SIZED TO LOAD

Present full production periods

Is the system sized properly?

_ _

_ _

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _ _I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ _BAY_ _ _

II. SYSTEM SIZED TO LOAD (Cont.)

Present low production loads

How is the load controlled? Is it hot gas by-pass?

_ _

_ _

_ _

Is it possible to calculate the cost of operation during low load operation?

_ _

_ _

_ _

III. CONDENSER/COOLING TOWER/WELL WATER

Well Water.

Is well water presently used or available?

_ _

_ _

Would well water (based on electricity costs to run cooling tower fans, etc) be a practical alternative to cooling towers? At high loads, at low loads? Is a study available?

_ _

_ _

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _

III. CONDENSER/COOLING TOWER/WELL WATER (Cont.)

Cooling Tower.

Is a study available to indicate if the savings associated with a lower cooling water temperature is justified by increasing cooling tower capacity, increasing fan speed, increasing the size of the fans. _

_ _

_ _

_ _

Is it feasible to investigate an energy conservation cycle to pump, treat, and clean cooling tower water so that it can be used in the process chilled water circuits. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

_ _

Condenser.

Is there the ability to recognize:

High cooling water flow_ _ _ _ _ _ _ _ _ _ _ _ _ _

Fouled tubes _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

IV. REFRIGERATION PIPING

Are the pipe surfaces insulated properly? _ _ _ _ _ _

_ _

V. COMPRESSOR. (Mechanical Vapor Compression)

Is there any indication that lengthy running times could be the cause of an inefficient compressor?_ _ _

_ _

Suction Pressure. Is the pressure lower than design, indicating that the actual load could be greater than the design load? _ _ _ _ _ _ _ _ _ _ _ _

_ _

_ _

Discharge Pressure. Determine the saturation pressure of the refrigerant for the average temperature of the cooling water in the condenser. Is the discharge pressure too high when compared to the saturated pressure? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

_ _

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ _I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

VI. GENERATOR (Absorption)

Is the generator temperature too low? Then the efficiency falls rapidly. See manufacturer's data.

_ _

_ _

Is there a method, using plant readings to determine if the tubes are fouled?_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _

VIII. EVAPORATOR

Compare the design "approach temperature" with the actual "approach temperature". "Approach temperature" is defined as the difference between the refrigerant temperature entering the evaporator and the temperature of the cooled fluid leaving the evaporator. The manufacturer's catalog should be consulted. Generally, the approach temperatures are as low as 3^{O}F and as high as 18^{O}F. This however, depends on the type and cost of the system.

_ _

_ _

_ _

8.4.4 ADDITIONAL DATA COLLECTION AND ANALYSIS FORMS

After the areas that need further investigation have been identified, specialized forms must be developed. The generalized format for the forms are found in Appendix K.

CHECK LIST - REFRIGERATION

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

Before evaluating specific refrigeration equipment or operations it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
ENERGY CONSERVATION OPPORTUNITIES:		
1. Operate water-cooled chillers with the condensing water temperature as low as possible without the risk of damage. Evaluation:_ _		
2. Provide the system with sufficient test wells and gauge connections to allow operators to check water and air flows, temperatures, and pressures. Evaluation:_ _		
3. Avoid fixed settings. Allow for adjustments and corrections to achieve maximum efficiency. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.:_ _ _ _ I-D NO.: _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Applies	
	Yes	No
4. Re-adjust settings as often as necessary to ensure the most economical operation. Set up the timer control once a schedule is established. Evaluation: _		
5. Clean exterior of cooling and air-cooled compressor coils annually or as often as necessary. Evaluation: _		
6. For chillers with water-cooled condensers, remove the condenser heads annually and clean tubes and water box. Clean the water side of the evaporator every three years or so. Evaluation: _		

CHECKLIST - REFRIGERATION SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ _ _I-D NO.: _ _ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _

	Applies Yes	Applies No
7. Maintain cooling towers annually. Evaluation: _		
8. Determine the practicality of installing thermostats to automatically control the fans on the cooling towers. Evaluation: _		
9. Consider interconnecting lightly loaded systems and eliminating extra pumping, etc. Evaluation: _		

SECTION 9

SCHEDULING AND CONSOLIDATION

9.1.1 INTRODUCTION

Until recently, energy consumption was not an important consideration when scheduling industrial processes. Now, large manufacturers are attempting to minimize demand peaks during the day when electrical rates are at a premium. Another technique which is becoming more popular is to schedule batch processing. This permits equipment shutdown for prolonged periods between batches.

9.1.2 EQUIPMENT SHUTDOWN WHEN NOT IN USE

The most efficient way to reduce power consumption is to automate equipment shutdown. Micro-procesors and switching equipment are now commercially available to implement energy management, data collection, and display.

Lighting, although not defined as a "process", is the largest energy waster at most industrial locations. Air handling fans, which could be shut off during non-working hours, are the second worst violators. Process exhaust air is also a source of much wasted energy.

Large motors, particularly older configurations, do not easily lend to automation, i.e. chiller motors and compressor motors. In these cases, manual operating procedures must be invoked; this shutdown discipline is best maintained by entering power down/up in a daily log book.

9.1.3 THE SHUTDOWN OF PROCESS HEAT DURING NON-WORKING HOURS

Liquid filled cleaning tanks, vapor degreasers, electroplating tanks, curing ovens and heat treating furnaces are all candidates for shutdown, when not in use. The importance of shutdown is directly related to thermal loss of each structure, large uninsulated tanks with high temperature contents being the higher energy users.

The duty cycle of tanks, ovens, and furnaces may be low enough to permit prolonged periods of shutdown. One approach to saving energy is to let work accumulate for several days before turning on the process. This concept may require some salesmanship to convince manufacturing scheduling managers that it is workable and will not impact timely performance.

9.1.4 CONSOLIDATING SHOPS OF SIMILAR ACTIVITY

Combining several shops of similar activity into one will usually produce significant energy savings. Duplicate equipment can be eliminated where usage is low. Ancillary benefits are reduction of building services and equipment costs. Convenience may be compromised, but good production scheduling may prevent any serious problems.

Selling the concept of consolidation to shop and industrial management personnel may be met with resistance. In addition to more efficient equipment usage, job functions can also be consolidated, thus eliminating the need for so many workers and shop supervisors. Combining shops obviously includes many considerations which are more far reaching than energy conservation. Decisions should be based upon an economic trade-off study which includes all contributing factors.

CHECKLIST - SCHEDULE SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ I.D. NO._ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL _ _BAY _ _ _ _

Before evaluating specific scheduling procedures it is desirable to refer to the following checklist. Although no specific form applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
SCHEDULING:		
1. Three shift operations concentrated in one building may permit shut-downs elsewhere. Operations recommended: heat treating. Evaluation: _		
2. Operate equipment at full load for one shift instead of partly loaded for two. Operations recommended: vapor or hot cleaning tanks, heat treat furnaces. Evaluation: _		
3. Operate with controlled cycle times in oven and furnace operations to reduce heating hours to a minimum. Evaluation _		

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ I.D. NO._ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL _ _BAY _ _ _ _

Applies

Yes | No

4. Between oven and furnace cycles, reduce heat using a cool down/reheat chart that shows the time to reheat from a given temperature.

   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

   _

5. Assign a person to make certain that machines and equipment are shut down during breaks, lunch hours and off-shifts.

   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

   _

EQUIPMENT OR PROCESS:

1. Evaluate new equipment or replacement purchases in relation to energy costs over the life cycle.

   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

   _

2. Interlock machine services such as compressed air, cooling water, exhaust damper, etc., so that they shut off when the machine is turned off.

   Evaluation: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

   _

CHECKLIST - SCHEDULE SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO.: _ _ _ _ _ _ _ _

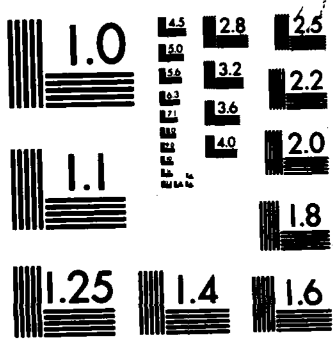
ENERGY CONSERVATION AUDIT SHOP NO.: _ _ _ I.D. NO._ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL _ _BAY _ _ _ _

	Applies	
	Yes	No
3. Install timers on certain machines to shut them down if left idling over 10 minutes. Evaluation: _		
4. Avoid substantially over sizing equipment, since it will waste power while running underloaded. Evaluation: _		
5. Study each machine tool operation to make sure the machine is loaded near its capacity. Evaluation: _		
6. Minimize test time on engines -- or use the power to generate electricity, to pump water, or to compress air. Evaluation: _		

AD-A131 117 ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U) 4/5
SYSKA AND HENNESSY INC NEW YORK JAN 81
N62472-78-C-1059

UNCLASSIFIED F/G 5/3 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SECTION 10

ECONOMIC ANALYSIS

AND PROJECT DOCUMENTATION

10.1 INTRODUCTION

Energy Conservation and economics are inseparable. Regardless of the techniques employed, the result must provide a means for establishing the worth of an energy saving project and method for setting priorities.

An Energy Conservation Project is developed as either a Military Construction Project (MILCON) or a Special Project.

The procedures and criteria used in the preparation of the preliminary engineering documents are outlined in this section. In Section 10.5, Preliminary Enginering Forms Used with Energy Conservation Projects, the most current engineering forms are contained. However, in Section 10.7, Special Project ETAP Forms - Sample Data and Calculations contained outdated forms.

10.2 PRELIMINARY ENGINEERING DOCUMENTS USED IN THE PREPARATION OF MILCON PROJECTS AND SPECIAL PROJECTS.

Project Type:	Military Construction Projects (MILCON)	Special Projects
Funding:	Energy Conservation Investment Program (ECIP)	Energy Technology Applications Program (ETAPS)
Reference Documents:	Guidelines on Preparing an Economic Analysis for Military Construction Projects for the Energy Conservation Investment Program. (ECIP)	Use ECIP Guidelines

10.2 PRELIMINARY ENGINEERING DOCUMENTS USED IN THE PREPARATION OF MILCON PROJECTS AND SPECIAL PROJECTS. (Cont'd.)

Project (cont'd) Type:	Military Construction Projects (MILCON)	Special Projects
Supporting Documents:	Form 11000/4	NAVFAC 9-11014/64 (2 sheets)
	DD Form 1391	NAVDOCKS 11013/7
	DD Form 1391c	X
	NAVFAC 11013/7	X
	Plain white sheets for:	Plain white sheets for:
	Energy Calculations	Energy Calculations
	Economic Analysis	Energy Analysis
	Cost Estimate	Cost Estimate
	ECIP Cost Analysis Summary	ECIP Cost Analysis Summary

10.3 ENERGY CONSERVATION INVESTMENT PROGRAM CRITERIA

NORTHERN DIVISION

GUIDELINES ON PREPARING AN ECONOMIC ANALYSIS FOR MILITARY CONSTRUCTION PROJECTS FOR THE ENERGY

CONSERVATION INVESTMENT PROGRAM (ECIP)

1. Military construction projects for the Energy Conservation Investment Program qualify on the basis of their energy savings and self-amortization of the investment.
2. Projects must be cost effective, that is, they must have a savings-to-investment (SIR) ratio of greater than one based on a life cycle cost analysis.
3. Projects must have an energy savings to cost ratio of at least the following values:

PROGRAM YEAR	ENERGY SAVINGS PER $1,000 OF PROJECT COST
FY-80	22 MBTU/$1000
FY-81	20 MBTU/$1000
FY-82	19 MBTU/$1000
FY-83	18 MBTU/$1000
FY-84	17 MBTU/$1000

4. Projects must have a budget cost of at least $100,000 (FY ___). Projects can include a number of different items of work.

5. Projects shall be supported with engineering calculations in sufficient detail to allow validation of energy savings. Many projects will also require supplementary sheets showing such calculations as changes in insulation "U" factors, heat loss rates, and kilowatt demand reductions.

6. Actual fuel heating value rates should be used when known. If not known, the following conversion factors will be used to permit standardized project evaluation comparisons:

Distillate Fuel Oil . . . . . .138,700 BTU/Gal

Residual Fuel Oil . . . . . . .150,000 BTU/Gal

Natural Gas . . . . .1,031,000 BTU/100 cu ft.

LPG, Propane, Butane . . . . . .95,500 BTU/GAL

Bituminuous Coal . . . . . . .24,580,000 BTU/SHORT TON

Purchased Steam . . . . .1,390 BTU/LB

Electrical Source Fuel . . . . .11,600 BTU/KWH

7. Boiler efficiencies should be included in the calculation of savings from reduced steam consumption. The resulting reduction in fuel input and boiler feedwater represent a real cost avoidance when steam consumption is reduced. The "as-consumed" cost of fuel and electricity shall be used in determining energy dollar savings. The energy costs as reported by each activity in the monthly Defense Energy Information System (DEIS-II) report are "as-consumed" costs. An "Activity Rate" or "Host Rate" which includes overhead and maintenance costs, should not be used for calculating savings. Such costs do not normally change with small percentage reductions in over all steam consumption.

8. Energy, material, and labor prices should be escalated from current rates to those projected for 30, September of the fiscal year for which the project is submitted for funding. Unless more definitive future prices can be determined or predicted for an individual activity, the following rates are to be used for escalation:

	FY-78	FY-79	FY-80	FY-81	FY-82	FY-83
SIOH Construction	8.0%	7.0%	6.5%	6.0%	6.0%	6.0%
Operations & Maintenance	7.1%	6.4%	6.2%	5.6%	5.6%	5.6%
Coal	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Fuel Oil	16.0%	16.0%	16.0%	14.0%	14.0%	14.0%
Natural Gas & LPG	15.0%	15.0%	15.0%	14.0%	14.0%	14.0%
Electricity (KWH & KW)	16.0%	16.0%	15.0%	13.0%	13.0%	13.0%

9. The life cycle cost analysis used to determine the project's savings-to-investment ratio shall utilize a base fiscal year commencing on 1, October following the project's programmed year. The long-term differential escalation rates below are to be used for computing the present work of recurring annual costs and benefits if more definitive data is not available at individual activities.

Operations and Maintenance 0%

Natural Gas and LPG 8%

Coal 5%

Electricity (KWH and KW). 7%

Fuel Oil 8%

10. The present worth factors for multiplication of recurring annual savings can be selected from the appropriate differential escalation rate column in the DISCOUNT FACTORS TABLE.

11. Economic life is the period of time over which the life cycle benefits to be gained from a project may reasonably be expected to accrue. As such, the economic life may differ from its physical and technological life. The economic lives below may be used as guides, and ordinarily will not be exceeded.

UTILITIES (plants and distribution systems) _ _ _ _25 years

ENERGY MONITORING AND CONTROL SYSTEMS _ _ _ _ _ _ _ _15 years

CONTROLS (thermostats, limit switches, ignition devices, clocks, photo-cells, flow controls, sensors, etc. - when these constitute the major and item of the project). _ _ _ _ _ 15 years

REFRIGERATION COMPRESSORS _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 15 years

EQUIPMENT _ 15 years

12. A sample calculation is attached to show the method of making an economic analysis to determine the savings-to-investment ratio (SIR). The standard MILCON forms are to be used for ECIP project documentation. In addition to the economic analysis, summary energy data plus suporting engineering calculations should be included on the MILCON forms to assist in project review. For some projects, the simplified economic analysis illustrated may not be correct. For example

when a one-time cost or benefit occurs in years after construction is complete (such as a major component replacement during the economic life of the retrofit project), then non-recurring discount factors shall be used as provided in NAVFAC P-422, "Economic Analysis Handbook".

15. The project cost used in the economic analysis is the cost of construction plus the cost of supervision, inspection and overhead.

16. Check with the Activity Public Works Department for the appropriate fiscal year (FY) for which MILCON projects and Special Projects are to be developed to support recommendations of this survey.

10.4 DISCOUNT FACTORS TABLE

ECIP INFLATION - DISCOUNT FACTORS

Discount Rate = 10%, Differential Inflation Rate = From 0 to 5%

Economic Life in Years	0%	1%	2%	3%	4%	5%
1	0.954	0.959	0.963	0.968	0.972	0.972
2	1.821	1.839	1.856	1.874	1.892	1.910
3	2.609	2.647	2.684	2.723	2.761	2.800
4	3.326	3.389	3.452	3.527	3.583	3.650
5	3.977	4.070	4.165	4.261	4.360	4.461
6	4.570	4.695	4.825	4.958	5.095	5.235
7	5.108	5.270	5.437	5.610	5.789	5.974
8	5.597	5.797	6.005	6.221	6.446	6.680
9	6.042	6.281	6.531	6.793	7.067	7.353
10	6.447	6.726	7.020	7.329	7.654	7.996
11	6.815	7.134	7.472	7.830	8.209	8.610
12	7.149	7.509	7.892	8.300	8.734	9.196
13	7.453	7.853	8.281	8.739	9.230	9.755
14	7.729	8.169	8.642	9.151	9.699	10.288
15	7.980	8.459	8.977	9.536	10.142	10.798
16	8.209	8.726	9.287	9.897	10.561	11.284
17	8.416	8.970	9.575	10.235	10.958	11.748
18	8.605	9.195	9.842	10.552	11.333	11.191
19	8.777	9.401	10.089	10.848	11.687	12.614
20	8.933	9.590	10.319	11.126	12.022	13.018
21	9.074	9.764	10.531	11.386	12.339	13.403
22	9.203	9.924	10.729	11.629	12.638	13.771
23	9.320	10.070	10.911	11.857	12.921	14.122
24	9.427	10.205	11.081	12.070	13.189	14.458
25	9.524	10.328	11.238	12.270	13.442	14.777
26	9.612	10.442	11.384	12.457	13.681	15.083
27	9.692	10.546	11.519	12.632	13.908	15.374
28	9.765	10.642	11.645	12.796	14.121	15.653
29	9.831	10.730	11.761	12.950	14.324	15.918
30	9.891	10.810	11.869	13.093	14.515	16.172

10.4 DISCOUNT FACTORS TABLE

ECIP INFLATION - DISCOUNT FACTORS

Discount Rate = 10%, Differential Inflation Rate = From 0 to 5%

Economic Life in Years	6%	7%	8%	9%	10%
1	0.982	0.986	0.991	0.995	1.000
2	1.928	1.946	1.964	1.982	2.000
3	2.839	2.879	2.919	2.959	3.000
4	3.718	3.787	3.857	3.928	4.000
5	4.564	4.670	4.777	4.887	5.000
6	5.380	5.529	5.681	5.839	6.000
7	6.166	6.364	6.569	6.781	7.000
8	6.923	7.177	7.440	7.715	8.000
9	7.653	7.968	8.296	8.640	9.000
10	8.357	8.737	9.136	9.557	10.000
11	9.035	9.485	9.961	10.465	11.000
12	9.688	10.212	10.770	11.366	12.000
13	10.317	10.920	11.565	12.258	13.000
14	10.924	11.608	12.346	13.142	14.000
15	11.508	12.278	13.112	14.018	15.000
16	12.071	12.930	13.865	14.886	16.000
17	12.614	13.563	14.603	15.746	17.000
18	13.137	14.180	15.329	16.598	18.000
19	13.641	14.779	16.041	17.443	19.000
20	13.127	15.363	16.740	18.279	20.000
21	14.595	15.930	17.427	19.109	21.000
22	15.046	16.482	18.101	19.930	22.000
23	15.480	17.019	18.762	20.745	23.000
24	15.899	17.541	19.412	21.551	24.000
25	16.303	18.049	20.050	22.351	25.000
26	17.692	18.543	20.676	23.143	26.000
27	17.066	19.023	21.291	23.928	27.000
28	17.427	19.491	21.895	24.706	28.000
29	18.775	19.946	22.488	25.477	29.000
30	18.111	20.388	23.070	26.241	30.000

ECIP DIFFERENTIAL ESCALATION RATES

Economic Life In Years	O&M Costs 0%	Coal 5%	Electricity 7%	Oil & Gas 8%
1	0.945	0.977	0.986	0.991
2	1.821	1.910	1.946	1.964
3	2.609	2.800	2.879	2.919
4	3.326	3.650	3.787	3.857
5	3.977	4.461	4.670	4.777
6	4.570	5.235	5.529	5.681
7	5.108	5.974	6.364	6.569
8	5.597	6.680	7.177	7.440
9	6.042	7.353	7.968	8.296
10	6.447	7.996	8.737	9.136
11	6.815	8.610	9.485	9.961
12	7.149	9.196	10.212	10.770
13	7.453	9.755	10.920	11.565
14	7.729	10.288	11.608	12.346
15	7.980	10.798	12.278	13.112
16	8.209	11.284	12.930	13.865
17	8.416	11.748	13.563	14.603
18	8.605	12.191	14.180	15.329
19	8.777	12.614	14.779	16.041
20	8.933	13.018	15.363	16.740
21	9.074	13.403	15.930	17.427
22	9.203	13.771	16.482	18.101
23	9.427	14.458	17.541	19.412
24	9.524	14.777	18.049	20.050
25	16.303	18.049	20.050	22.351

10.5 PRELIMINARY ENGINEERING FORMS USED WITH ENERGY CONSERVATION PROJECTS

MILITARY CONSTRUCTION PROJECTS (MILCON)

OPNAV Form 11000/4	Project Summary Sheet
DOD Form 1391	Project Description
DOD Form 1391c	Energy Analysis and Economic Analysis
NAVFAC 11013/7 (1-78)	Cost Estimate
ECIP Analysis Form	Summary of Energy and Economic Analysis

SPECIAL PROJECTS

NAVFAC Form 9-11014	Project Description
NAVFAC 11013/7(1-78)	Cost Estimate
ECIP Analysis Form	Summary of Energy and Economic Analysis

OPNAV 11000/4 (REV. 4-79)
S/N 0107-LF-110-0020

REPORT OPNAV 11000-1C

CLASSIFICATION	PROJECT FOR CORRECTION OF FACILITY DEFICIENCY	PROJECT NO. P-	
SUBMITTING ACTIVITY NAME AND LOCATION		ACTIVITY UIC	MAJOR CLAIMANT
ST ACTIVITY		HOST UIC	AREA COORD.
COMPONENT NAME		COMPONENT UIC	

EST. YEAR	USEABLE COMPL.		INVESTMENT PROGRAM	ECONOMIC ANALYSIS	PEA	SITE	RELATED PROJECTS	%W	%W/O	MAJOR CLAIMANT PRIORITY
	MOS.	CODE								
1	2	3	4	5	6	7	8	9	10	11

	CATEGORY CODE	PROJECT TITLE	AH/SU UIC	SA	SCOPE QUANTITY	U/M	ESTIMATED COST ($000)	CONST/ MISSION CODE	VAL. CODE
	12	13	14	15	16	17	18	19	20
●									
K									
L									
M									
N									
O									
P									

21. PROJECT DESCRIPTION/JUSTIFICATION

ACTIVITY CERTIFICATION. I certify that this project is required to support Activity/Mission functions.

Activity Commanding Officer — *Date*

MAJOR CLAIMANT CERTIFICATION. I certify that this project is required to support Activity/Mission functions.

Major Claimant Representative — *Date*

CERTIFICATION. This project is supported by SFPS.

EFD Commander/Commanding Officer — *Date*

(DO NOT WRITE IN THIS SPACE – FOR NAVFAC USE ONLY)
This project is authorized for entry into the MILCON R.L.

NAVFAC Authorizing Signature — *Date*

CLASSIFICATION

*U.S. GOVERNMENT PRINTING OFFICE: 1980—603-189/7572 2-1

1. COMPONENT	FY 19___ MILITARY CONSTRUCTION PROJECT DATA	2. DATE

3. INSTALLATION AND LOCATION	4. PROJECT TITLE

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)

10. DESCRIPTION OF PROPOSED CONSTRUCTION

DD FORM 1 DEC 76 1391

PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED

PAGE NO.

S/N 0102-LF-001-3910

U.S. GOVERNMENT PRINTING OFFICE: 1978—703-173/3414 2-1

1. COMPONENT	FY 19____MILITARY CONSTRUCTION PROJECT DATA	2. DATE
3. INSTALLATION AND LOCATION		
4. PROJECT TITLE		5. PROJECT NUMBER

DD FORM 1 DEC 76 1391c

PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED

PAGE NO.

S/N 0102-LF-001-3910

U.S. GOVERNMENT PRINTING OFFICE 1978—703-173/34312-1

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED

SHEET OF

ACTIVITY AND LOCATION	CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER
	ESTIMATED BY	CATEGORY CODE NUMBER
PROJECT TITLE	STATUS OF DESIGN ☐ PED ☐ 30% ☐ 100% ☐ FINAL ☐ Other (*Specify*) ______	JOB ORDER NUMBER

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL

S/N 0105-LF-010-1335

☆U. S. Government Printing Office: 1979—603-076/8486 2-1

ECIP ECONOMIC ANALYSIS SUMMARY

ACTIVITY & LOCATION ______________________________ P-______

TITLE OF PROJECT ______________________________ FY-______

INVESTMENT

1. PROJECT COSTS (Economic life of ____ years)
   a. Project cost escalated to end of program year $ ______
   b. Design costs not yet obligated . . . . $ ______
   c. Total Project Cost (a + b) .... $ ______

SAVINGS

2. ANNUAL ELECTRICITY SAVINGS: KWH: ______________
   a. Equivalent energy; KWH x 0.0116.......(MBTUs: ______)
   b. Cost per KWH at end of program year.......... $ ______
   c. First year annual dollar savings (KWH x b)... $ ______
   d. Differential escalation present worth factor. ______
   e. Discounted savings (c x d).................... $ ______

3. ANNUAL ENERGY SAVINGS (TYPE: ______________ MBTUs: ______)
   a. Cost per MBTU at end of program year......... $ ______
   b. First year annual dollar savings............. $ ______
   c. Differential escalation present worth factor. ______
   d. Discounted savings (b x c)................... $ ______

4. ANNUAL ENERGY SAVINGS (TYPE: ______________ MBTUs: ______)
   a. Cost per MBTU at end of program year......... $ ______
   b. First year annual dollar savings............. $ ______
   c. Differential escalation present worth factor. ______
   d. Discounted savings (b x c)................... $ ______

5. ANNUAL OTHER-THAN-ENERGY SAVINGS (OR COSTS)
   a. Labor.. $ ______
   b. Material & Other............................... $ ______
   c. Total (a + b).................................. $ ______
   d. 10% Discount Factor............................ ______
   e. Discounted Other-than-energy savings (or costs) $ ______

6. TOTAL FIRST YEAR ANNUAL SAVINGS (2c+3b+4b+5c).... $ ______

7. TOTAL DISCOUNTED SAVINGS (2e+3d+4d+5e)........... $ ______

COST ESCALATION

Current	* ELEC	$____	x____	x____	x____	x____	=	$ ______
rates	* OIL	$____	x____	x____	x____	x____	=	$ ______
as of	* GAS	$____	x____	x____	x____	x____	=	$ ______
______	* ____	$____	x____	x____	x____	x____	=	$ ______

RATIOS

8. DISCOUNTED SAVINGS/INVESTMENT RATIO (Line 7 ÷ 1c) ______
9. TOTAL MBTU SAVINGS ________ ÷ (Line 1a ÷ 1000) ______
10. SIMPLE PAYBACK PERIOD (1a ÷ Line 6).............. ______ YRS

SPECIAL PROJECT REQUEST
NAVFAC [illegible] (REV. [illegible])
Supersedes NAVFAC 9-11014/64 (11-68)
S/N [illegible]

Sheet 1 of

STEP TWO SUBMISSION

1. ACTIVITY [illegible] NO. | ACTIVITY NAME AND LOCATION | DATE SUBMITTED

2. PROJECT NO. | TITLE

3. TYPE
a. ☐ MAINT./REPAIR b. ☐ MINOR CONSTRUCTION/ALTERATION ☐ AIR CONDITIONING ☐ EQUIPMENT INSTALLATION

4. DESCRIBE AND STATE FUNCTION OF FACILITY
a. PROPERTY RECORD CARD NO.
b. NAVY CATEGORY CODE
c. BLDG. OR STRUCTURE NO.

5. WHAT IS THE EFFECT OF THIS PROJECT ON THE MISSION OF THE ACTIVITY?

6. THE REQUIREMENT FOR THE FACILITY IS BASED ON:
a. ☐ A CHANGE IN MISSION b. ☐ FULL-TIME CONTINUING NEED c. ☐ 3 TO 5 YEAR NEED d. ☐ LESS THAN 3 YEARS' NEED e. ☐ CURRENTLY REQUIRED LESS THAN [illegible] OF TIME f. ☐ RESERVED FOR FUTURE REQUIREMENTS

7a. EST. FUNDED COST $ | b. EST. PROJECT COST $ | c. EST. PLANNING COST $ | d. TOTAL FUNDS REQUESTED $ | e. EST. FACIL. REPL. COST $

8. DATE FACILITY CONSTRUCTED

9. IS FACILITY ON AN APPROVED BASIC FACILITY REQUIREMENTS LIST? *If "NO," how was need determined?*
☐ YES ☐ NO

10. IS PROJECT LISTED ON ANNUAL INSPECTION SUMMARY? *If answer is "NO," and AIS is applicable, explain omission.*
☐ YES ☐ NO ☐ N.A.

11. DESCRIBE CONDITION TO BE CORRECTED, OR PROBLEM TO BE SOLVED WITH PROPOSED SOLUTION. *Attach additional description if necessary, ONE PAGE ONLY.*

12. WHY IS THE PROPOSED SOLUTION BEST – AND WHAT ALTERNATIVES WERE CONSIDERED?

13. WERE ANY [illegible] EXPERTS INVITED TO REVIEW THE PROBLEM AND THIS SOLUTION? *Explain effect on solution.*
a. ☐ YES b. ☐ NO

14. HAS EFD DESIGN DIVISION REVIEWED SOLUTION? a. ☐ YES b. ☐ NO

15. CAN ANOTHER FACILITY BE ECONOMICALLY ADAPTED FOR THIS FUNCTION? a. ☐ YES b. ☐ NO

16. CAN PROJECT BE FUNDED IN PHASES? *How? How many?*
a. ☐ YES b. ☐ NO

17. THIS PROJECT IS THE RESULT OF
a. ☐ INADEQUATE MAINTENANCE b. ☐ FACILITY AGE c. ☐ DEFICIENT CONSTR. ☐ DEFICIENT DESIGN e. ☐ OTHER: __________

18. HAS THIS SPECIFIC PROBLEM BEEN CORRECTED PREVIOUSLY?
a. ☐ YES b. ☐ NO When?

HOW LONG WILL PROPOSED CORRECTIVE ACTION LAST? __________ YEARS

19. ARE COMPONENTS BEING INCREASED IN SIZE OR CAPACITY? *Explain the difference, including cost.*

☐ YES b. ☐ NO

ARE MATERIALS PROPOSED FOR USE THE SAME AS THOSE EXISTING? *If "NO," explain the difference, including cost.*

☐ YES b. ☐ NO

21. PROJECT IS PLANNED TO BE ACCOMPLISHED BY

a. ☐ STATION LABOR b. ☐ CONTRACT

22. HAS A PROJECT EVER BEEN SUBMITTED FOR THE REPLACEMENT OF THIS OR SIMILAR FACILITIES? *Check and explain if "YES."*

a. ☐ YES b. ☐ NO *When?*

23. ANTICIPATED SAVINGS IF PROJECT IS DONE THIS YEAR AS COMPARED TO A DEFERRAL OF ONE YEAR.

PROBABLE INCREASE IN PROJECT COST FOR ANY JUSTIFIABLE REASON	REDUCTION IN CURRENT MAINT. COST	REDUCTION IN CURRENT OPERATIONS COST
$	$	$

JUSTIFY ANY SAVINGS INDICATED	WHAT IS PAY BACK PERIOD OF PROJECT? *(In years)*

WILL ACCOMPLISHMENT GENERATE REQUIREMENTS FOR ADDITIONAL M&O FUNDS OR PERSONNEL? a. ☐ NO b. ☐ YES *Est. Amt.*

24. WHAT WOULD BE THE EFFECT OF DEFERRING THE PROJECT ONE YEAR?

*25. IF THE PROJECT IS NOT ACCOMPLISHED NOW, IN HOW MANY YEARS WILL THERE BE SERIOUS DAMAGE TO THE FACILITY AND/OR ITS CONTENTS OR IMPAIRMENT TO ESSENTIAL OPERATIONS? *Explain, include loss value to facility and/or contents.*

YEARS BEFORE SERIOUS DAMAGE OCCURS ________.

*26. HAS THE REDUCED UTILIZATION OF THIS SPECIFIC FACILITY AFFECTED A LARGE FACILITY SYSTEM OPERATION? *Explain.*

☐ YES b. ☐ NO BY HOW MUCH? ________%.

27. ARE THERE ANY OTHER FACTORS INVOLVED? *Check and explain.*

☐ MORALE ☐ HEALTH c. ☐ PUBLIC RELATIONS d. ☐ SAFETY e. ☐ FIRE PROTECTION f. ☐ SECURITY g. ☐ OTHER

28. CERTIFICATION BY RESPONSIBLE OFFICER AT ACTIVITY: I am personally cognizant of the need for, the essentiality of, and the proposed method of accomplishment of this project and certify that the above information is correct, and that this project meets all criteria specified in OPNAVINST 11010.20 and subsequent changes thereto.

SIGNATURE	TITLE	DATE

29. EFD TECHNICAL VALIDATION *(if required) (see para 7303, OPNAVINST 11010.20C)*

SIGNATURE	TITLE	DATE

ENCLOSURES:

a. ☐ ENGINEERING EST. *(NAVFAC 2417)* b. ☐ LOCATION PLAN(S) c. ☐ DRAWINGS d. ☐ PHOTOGRAPHS

**NOT applicable to Minor Construction, Alterations, or Equipment Installation*

NAVFAC 11014/32 (REV. 2-80)
Sheet 2 of 2

S/N 0105-LF-020-4...

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

ACTIVITY AND LOCATION	CONSTRUCTION CONTRACT NO	DATE PREPARED	SHEET OF
			IDENTIFICATION NUMBER
	ESTIMATED BY		CATEGORY CODE NUMBER
PROJECT TITLE	STATUS OF DESIGN ☐ PED ☐ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ______		JOB ORDER NUMBER

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL

S/N 0105-LF-010-1335

☆U. S. Government Printing Office: 1979—603-076/0400 3-1

ETAP ECONOMIC ANALYSIS SUMMARY

ACTIVITY & LOCATION ______________________ _____

TITLE OF PROJECT ______________________ FY-_____

INVESTMENT

1. PROJECT COSTS (Economic life of ____ years)
   a. Project cost .... $ ______
   b. Design costs .... $ ______
   c. Total Project Cost (a + b) .... $ ______

SAVINGS

2. ANNUAL ELECTRICITY SAVINGS: KWH: ______________
   a. Equivalent energy; KWH x 0.0116.......(MBTUs: ______)
   b. Cost per KWH .... $ ______
   c. First year annual dollar savings (KWH x b)... $ ______
   d. Differential escalation present worth factor. ______
   e. Discounted savings (c x d)................... $ ______

3. ANNUAL ENERGY SAVINGS (TYPE: ______________ MBTUs: ______)
   a. Cost per MBTU .... $ ______
   b. First year annual dollar savings............. $ ______
   c. Differential escalation present worth factor. ______
   d. Discounted savings (b x c)................... $ ______

4. ANNUAL ENERGY SAVINGS (TYPE: ______________ MBTUs: ______)
   a. Cost per MBTU.............................. $ ______
   b. First year annual dollar savings............. $ ______
   c. Differential escalation present worth factor. ______
   d. Discounted savings (b x c)................... $ ______

5. ANNUAL OTHER-THAN-ENERGY SAVINGS (OR COSTS)
   a. Labor.. $ ______
   b. Material & Other............................. $ ______
   c. Total (a + b)................................ $ ______
   d. 10% Discount Factor.......................... ______
   e. Discounted Other-than-energy savings(or costs)$ ______

6. TOTAL FIRST YEAR ANNUAL SAVINGS (2c+3b+4b+5c).... $ ______

7. TOTAL DISCOUNTED SAVINGS (2e+3d+4d+5e)........... $ ______

RATIOS

8. DISCOUNTED SAVINGS/INVESTMENT RATIO (Line 7 ÷ 1c) ______
9. TOTAL MBTU SAVINGS ________ ÷ (Line 1c ÷ 1000) ______
10. SIMPLE PAYBACK PERIOD (1c ÷ Line 6).............. ______ YRS

10.6 ECIP COST ANALYSIS FORM - SAMPLE DATA AND CALCULATIONS.

Description:

Building V-38 houses a paint shop on the southwestern half of the building and a mothballing shop on the northeastern half. The air supply for both halves of the building is identical. Air enters from the outside through dampers and then passes through a steam coil heat exchanger. The supply fan is located downstream of the coil. Finally the air goes through turning vanes, through a filter and into the room.

In the paint shop half of the buildings, the exhaust passes through a water wash. In the moth ball shop, the exhaust system was recently renovated. This exhaust system consists of a total of 20 individual ducts. Eight ducts manifold together to a single duct where a 10 HP fan exhausts the air. Another set of eight ducts is identically configured as described above. The four remaining ducts manifold together to a single duct where a 5 HP fan exhausts the air. Two supply air fans are driven with 35 hp electric motors.

Analysis:

During a site survey of this building, it was determined that savings could be achieved by adding unit heaters to keep the building warm during hours when the building is occupied and no painting or moth-balling is being done.

Summary of Estimated Annual Savings:

A total of 2175 MBTU can be saved if heating is done with unit heaters when ventilation is not required. Since the fans will be used less frequently, 25,300 Kwh can be saved.

Estimated Retrofit Costs:

The cost estimate for installing unit heaters in Building V-38 is shown below:

Item	Cost
8 Unit Heaters	$2120
Piping	710
Wiring	110
Steam Traps	930
Steam Valves	930
Sub-total	$4800
Controls (15%)	720
Total	$5520

The above costs include hardware, labor, overhead and profit. Allowing 20% for engineering and 25% contingencies, the total comes to $8000. This is the 1978 cost. Assuming the project will be completed in FY 1982, the escalated cost is:

$$8000 \times 1.07 \times 1.065 \times 1.06 \times 1.06 = \$10,243$$

where the factors 1.07, 1.065, etc., are escalation factors for 1979 through 1982.

Note that according to the ECIP Guidelines, the retrofit does not qualify ($10,243 vs $100,000) as a MILCON Project.

Estimated Energy Costs:

FY'79 unit energy costs are:

Electricity	$.0275/KWH ($2.37/MBTU source)
Oil	$2.03/MBTU

Data for ECIP Form, Page 10-26:

Line 1 Economic Life

From ECIP Guidelines, Item 11. Equipment Life, 15 years.

Line 2d Escalation Rates

From ECIP Guidelines, Item 9. The long term differential escalation rate for electricity is 7%. From discount factors table use economic life 15 years and differential inflation rate, 7%. Then differential escalation, present worth factor becomes 12.278.

Line 3C Escalation Rates

From ECIP Guidelines, Item 9. The long term differential escalation rate for fuel oil is 8%. From discount factors tables use economic life 15 years and differential inflation rate, 8% then differential escalation present worth factor becomes 13.112.

ECIP-ECONOMIC ANALYSIS SUMMARY

Activity and Location: NARF NORFOLK P-______

Title of Project: V-38 ADD UNIT HEATERS FY-81

INVESTMENT

1. Project cost (Economic life of 15 years)
   a. Project cost escalated to end of program year $ 10,243
   b. Design costs not yet obligated $ X
   c. Total project Cost (a + b) $ 10,243

SAVINGS

2. Annual Electricity Savings: (KWH: 25,300)
   a. Equivalent Energy: KWH x 0.0116 MBTU's 293
   b. Cost per KWH at End of Program Year $ 0.0472
   c. First Year Annual Dollar Savings (KWH x b) $ 1194
   d. Differential Escalation Present Worth Factor $ 12.278
   e. Discounted Savings (c x d) $ 14,660

3. Annual Energy Savings (Type: #2 Fuel Oil) MBTU's 2175
   a. Cost per MBTU at End of Program Year $ 3.55
   b. First Year Annual Dollar Savings $ 7721
   c. Differential Escalation Present Worth Factor $ 13,112
   d. Discounted Savings (b x c) $101,238

4. Annual Energy Savings (Type: X) MBTU's X
   a. Cost per MBTU at End of Program Year ______
   b. First Year Annual Dollar Savings $______
   c. Differential Escalation Present Worth Factor ______
   d. Discounted Savings (b x c) $______

5. Annual Other-Than-Energy Savings (Or Costs)
   a. Labor $ X
   b. Material and Other $______
   c. Total (a + b) $______
   d. 10% Discount Factor $______
   e. Discounted Other-Than-Energy Savings (Or Costs) $______

6. Total First Year Annual Savings (2c+3b+4d+5c) $ 8,915

7. Total Discounted Savings (2e+3d+4d+5e) $115,898

COST ESCALATION

Current	*ELEC	$.0275x1.16x1.13x1.13x1.13 =	$0.0472
rates of	*OIL	$2.03 x1.16x1.16x1.14x1.14 =	$3.55
as of	*GAS	$____x____x____x____x____ =	$
1979	*____	$____x____x____x____x____ =	$

RATIOS

8. Savings-to-Investment Ratio (Line 7 divided by 1c) 11.3
9. E/C Ratio (Total MBTU Saved divided by 1a/1000) 241
10. Simple Payback Period (Line 1a divided by Line 6) 1.15 YRS

Ref: NAVFAC ltr. 1113F/RHB dated 6 September 1978

Another ECIP Economic Analysis Summary is shown on page 10-28. In this case, an energy monitoring and control system is analyzed. Note that Item 4, Annual Energy Savings, is electric demand. It is not included in the total MBTU savings, Item 3 MBTU savings represent energy consumption.

Line 2c, total first year annual savings, includes the effect of line 5c. Line 5c is a negative number that accounts for the labor and service contract.

ECIP - ECONOMIC ANALYSIS SUMMARY

Activity and Location: SAMPLE NAVAL BASE #2 P-0001
Title of Project: ENERGY MONITORING AND CONTROL SYSTEM FY-81

INVESTMENT

1. Project cost (Economic life of 15 years)	
a. Project cost escalated to end of program year	$1,000,000
b. Design costs not yet obligated	$ 30,000
c. Total project Cost (a + b)	$1,030,000

SAVINGS

2. Annual Electricity Savings: (KWH: 5,100,000)	$ 59,160
a. Equivalent Energy: KWH x 0.0116 MBTU's	$ 0.0511
b. Cost per KWH at End of Program Year	$ 260,610
c. First Year Annual Dollar Savings (KWH x b)	$ 12,278
d. Differential Escalation Present Worth Factor	$3,199,776
e. Discounted Savings (c x d)	
3. Annual Energy Savings (Type: Fuel Oil #2) MBTU's	38,000
a. Cost per MBTU at End of Program Year	$ 4.44
b. First Year Annual Dollar Savings	$ 168,720
c. Differential Escalation Present Worth Factor	13.112
d. Discounted Savings (b x c)	$2,212,250
4. Annual Energy Savings (Type: Electric Demand) MBTU's	4800 KW
a. Cost per MBTU at End of Program Year	$ 6.82
b. First Year Annual Dollar Savings	$ 32,736
c. Differential Escalation Present Worth Factor	12.278
d. Discounted Savings (b x c)	$ 401,933
5. Annual Other-Than-Energy Savings (Or Costs)	
a. Labor(4160 man-hours x 10.05)	$ (41,808)
b. Material and Other (Service Contract)	$ (60,000)
c. Total (a + b)	$ (101,808)
d. 10% Discount Factor @ 0%	$ 7.980
e. Discounted Other-Than-Energy Savings (Or Costs)	$ 812,428
6. Total First Year Annual Savings (2c+3b+4d+5c)	$ 360,258
7. Total Discounted Savings (2e+3d+4d+5e)	$5,001,532

COST ESCALATION

		'78 '79 '80 '81		
Current	*ELEC	$0.03x1.12x1.16x1.16x1.13	=	$0.0511
rates of	OIL	$2.60x1.12x1.16x1.16x1.14	=	$4.44
as of	*GAS	$4.00x1.12x1.16x1.16x1.13	=	$6.82
1 Jan 78	*LABOR	$8.00x1.053x1.064x1.064x1.056	=	$10.05

RATIOS

8. Savings-to-Investment Ratio (Line 7 divided by 1c)	4.86
9. E/C Ratio (Total MBTU Saved divided by 1a/1000)	97.2
10. Simple Payback Period (Line 1a divided by Line 6)	2.8 YRS

Ref: NAVFAC ltr. 1113F/RHB dated 6 September 1978

10.7 SPECIAL PROJECT (ETAP) FORMS - SAMPLE DATA AND CALCULATIONS

Form	Description
NAVFAC 9-11014	Indicates the total funds requested to reduce fuel consumption and to save energy in Batch Furnace No. 3. Describes the improvement to the furnace.
NAVFAC 11013/7(1-78)	Cost estimate worksheet for the improvement.
ECIP Economic Analysis Survey	Based on current year program. Note that the analysis indicates that the project does not meet the criteria in the ECIP Guidelines (ECIP Guidelines, Item 2 indicates that SIR must be greater than one.) Line 8 of the ECIP Economic Analysis Summary indicates a SIR of 0.8.

DEPARTMENT OF THE NAVY
SPECIAL PROJECTS REQUEST
NAVFAC 9-11014/6A (11-68) Supersedes NAVDOCKS 2950 S/N 0105-004-0228

SHEET 1 OF 2

1. ACTIVITY SHOP NO.:
ACTIVITY NAME AND LOCATION: BOSTON NAVAL SHIPYARD, BOSTON, MA
DATE SUBMITTED: 4 APR 78

2. PROJECT NO.:
TITLE: IMPROVEMENTS TO BATCH FURNACE NO. 3, BLDG. 17, FORGE SHOP

3. TYPE
a. [ ] MAINT./REPAIR b. [ ] MINOR CONSTRUCTION/ALTERATION c. [ ] AIR CONDITIONING d. [ ] EQUIPMENT INSTALLATION

4. DESCRIPTION AND FUNCTION OF FACILITY

BATCH FURNACE NO. 3 HEAT STEEL FOR FORGING OPERATIONS.

a. PROPERTY RECORD CARD NO.
b. NAVY CATEGORY CODE
c. BLDG. OR STRUCTURE NO.

5. WHAT IS THE EFFECT OF THIS PROJECT ON THE MISSION OF THE ACTIVITY?

REDUCE FUEL CONSUMPTION AND SAVE ENERGY

6. THE REQUIREMENT FOR THE FACILITY IS BASED ON:
a. [ ] A CHANGE IN MISSION b. [X] FULL-TIME CONTINUING NEED c. [ ] 3 TO 5 YEAR NEED d. [ ] LESS THAN 3 YEARS' NEED e. [ ] CURRENTLY REQUIRED LESS THAN 50% OF TIME f. [ ] RESERVED FOR FUTURE REQUIREMENTS

7a. EST. FUNDED COST	b. EST. PROJECT COST	c. EST. PLANNING COST	d. TOTAL FUNDS REQUESTED	e. EST. FACIL. REPL. COST
$ 20,000	$18,000	$ 2,000	$ 20,000	$ ----

8. DATE FACILITY CONSTRUCTED: N/A

9. IS FACILITY ON AN APPROVED BASIC FACILITY REQUIREMENTS LIST? If "NO," how was need determined?
[ ] YES [ ] NO N/A

10. IS PROJECT LISTED ON ANNUAL INSPECTION SUMMARY? If answer is "NO," and AIS is applicable, explain exclusion.
[ ] YES [ ] NO [X] N.A.

11. 3 LINE DESCRIPTION OF CONDITION TO BE CORRECTED, OR PROBLEM TO BE SOLVED WITH PROPOSED SOLUTION. Attach additional description if necessary, ONE PAGE ONLY.

xcess heat loss thru inadequately insulated furnace walls. Remove existing insulation and replace with new 10" insulation.

12. WHY IS THE PROPOSED SOLUTION BEST - AND WHAT ALTERNATIVES WERE CONSIDERED?

Least costly and requires no modifications to furnace. No other solutions considered.

13. WERE ANY NON-NAVY EXPERTS INVITED TO REVIEW THIS PROBLEM AND THIS SOLUTION? Explain effect on solution.

a. [X] YES b. [ ] NO DEVELOPED BY ENERGY CONSERVATION TEAM.

14. HAS EFD DESIGN DIVISION REVIEWED SOLUTION? a. [X] YES b. [ ] NO

15. CAN ANOTHER FACILITY BE ECONOMICALLY ADAPTED FOR THIS FUNCTION? a. [ ] YES b. [X] NO

*16. CAN PROJECTS BE FUNDED IN INCREMENTS? How?
a. [ ] YES b. [X] NO

*17. THIS PROJECT IS THE RESULT OF
a. [ ] INADEQUATE MAINTENANCE b. [X] FACILITY AGE c. [ ] DEFICIENT CONSTR. d. [ ] DEFICIENT DESIGN e. [ ] OTHER:

*18. HAS THIS SPECIFIC PROBLEM BEEN CORRECTED PREVIOUSLY?
a. [ ] YES b. [X] NO When?

HOW LONG WILL PROPOSED CORRECTIVE ACTION LAST? 15 Years YEARS

19. ARE COMPONENTS BEING INCREASED IN SIZE OR CAPACITY? Explain the difference, including cost.
[ ] YES b. [X] NO

20. ARE MATERIALS PROPOSED FOR USE THE SAME AS THOSE EXISTING? *If "NO," explain the difference, including cost.*

a. [X] YES b. [ ] NO

21. PROJECT IS PLANNED TO BE ACCOMPLISHED BY

a. [ ] STATION LABOR b. [X] CONTRACT

22. HAS A PROJECT EVER BEEN SUBMITTED FOR THE REPLACEMENT OF THIS OR SIMILAR FACILITIES? *Check and explain if "YES".*

a. [ ] YES b. [X] NO *When?*

23. ANTICIPATED SAVINGS IF PROJECT IS DONE THIS YEAR AS COMPARED TO A DEFERRAL OF ONE YEAR.

PROBABLE INCREASE IN PROJECT COST FOR ANY JUSTIFIABLE REASON	REDUCTION IN CURRENT MAINT. COST	REDUCTION IN CURRENT OPERATIONS COST
$ 1,260	$ 0	$ 1,215.

JUSTIFY ANY SAVINGS INDICATED	WHAT IS PAY BACK PERIOD OF PROJECT? *(In years)*
Fuel oil consumption reduced by 2,960 gallons per year.	15

WILL ACCOMPLISHMENT GENERATE REQUIREMENTS FOR ADDITIONAL O&M FUNDS OR PERSONNEL? a. [X] NO b. [ ] YES *Est. Amt.*

24. WHAT WOULD BE THE EFFECT OF DEFERRING THE PROJECT ONE YEAR?

Increase Cost

*25. IF THE PROJECT IS NOT ACCOMPLISHED NOW, IN HOW MANY YEARS WILL THERE BE SERIOUS DAMAGE TO THE FACILITY AND/OR IT'S CONTENTS OR IMPAIRMENT TO ESSENTIAL OPERATIONS? *Explain, include loss value to facility and/or contents.*

YEARS BEFORE SERIOUS DAMAGE OCCURS ________. N/A

*26. HAS THE REDUCED UTILIZATION OF THIS SPECIFIC FACILITY AFFECTED A LARGE FACILITY SYSTEM OPERATION? *Explain.*

[ ] YES b. [X] NO BY HOW MUCH? ________%.

27. ARE THERE ANY OTHER FACTORS INVOLVED? *Check and explain.*

a. [ ] MORALE b. [ ] HEALTH c. [ ] PUBLIC RELATIONS d. [ ] SAFETY e. [ ] FIRE PROTECTION f. [ ] SECURITY g. [X] OTHER

ENERGY CONSERVATION

28. CERTIFICATION BY RESPONSIBLE OFFICER AT ACTIVITY: I am personally cognizant of the need for, the essentiality of, and the proposed method of accomplishment of this project and certify that the above information is correct, and that this project meets all criteria specified in OPNAVINST 11010.20 and subsequent changes thereto.

DATE	TYPED NAME OF OFFICER AND POSITION	SIGNATURE

EFD EVALUATION BY RESPONSIBLE ENGINEER: I hereby certify that this project has been thoroughly evaluated, that it is an essential project, and that it is both economically and technically sound. A rating factor is hereby assigned.

29. VALID FOR RATING FACTOR

a. [ ] FASP
b. [ ] PROJECTED MAINT.
c. [ ] NOT VALID
d. [ ] OTHER

30. EFD RATING

(1) ______ X (2) ______ X (3) ______ X (4) ______ X (5) ______ X 100 = ______

31. DATE	TYPED EVALUATOR'S NAME AND POSITION	SIGNATURE

ENCLS:

a. [ ] ENGINEERING EST. (NAVDOCKS 2417) b. [ ] LOCATION PLAN(S) c. [ ] DRAWINGS d. [ ] PHOTOGRAPHS

NAVFAC 9-11010/64 (11-68) *NOT applicable to Minor Construction, Alterations or Equipment Installation
SHEET 2 OF 2

COST ESTIMATING FORM - WORKSHEET
NAVDOCKS 2417A (REV. 5-63)
0105-013-3000

SHEET 1 OF 1

IDENTIFICATION NUMBER:

AREA OR NO	ACTIVITY	LOCATION	CATEGORY CODE NUMBER
1 ?ND	BOSTON NAVSHIPYD	BOSTON, MA	

PROJECT (OR LINE ITEM) TITLE

REINSULATE BATCH FURNACE NO. 3, BLDG. 17, FORGE SHOP

ITEM (OR FEATURE) DESCRIPTION (Abbreviate if necessary)	QUANTITIES		MATERIAL COSTS		LABOR COST		ENGINEERING ESTIMATE	
	NO. OF UNITS	UNIT	UNIT COST	COST	UNIT COST	COST	UNIT COST	COST
1	2	3	4	5	6	7	8	9
REMOVE INSULATION		LS						4,000
NEW INSULATION (10")	140	SF	75	10,500	25	3,500	100	14,000
								18,000

PREPARED BY (Name)	APPROVED BY	TITLE OF ORGANIZATION	DATE
JOHN SMITH	FRANK JONES	A&E COMPANY	15 MAR 79

U.S. GOVERNMENT PRINTING OFFICE 1977

Activity and Location:	ECIP ECONOMIC ANALYSIS	P-
Title of Project:	IMPROVEMENTS TO BATCH FURNACE NO. 3	FY-78

INVESTMENT

1. Project cost (Economic life of 15 years)
   a. Project cost escalated to end of program year — $20,000
   b. Design costs not yet obligated — $ X
   c. Total project Cost (a + b) (for current year program) — $20,000

SAVINGS

2. Annual Electricity Savings: (KWH: X)
   a. Equivalent Energy: KWH x 0.0116 MBTU's — $____
   b. Cost per KWH at End of Program Year — $____
   c. First Year Annual Dollar Savings (KWH x b) — $____
   d. Differential Escalation Present Worth Factor — $____
   e. Discounted Savings (c x d) — $____

3. Annual Energy Savings (Type: Fuel Oil #2) MBTU's — 411
   a. Cost per MBTU at End of Program Year — $ 2.97
   b. First Year Annual Dollar Savings — $ 1221
   c. Differential Escalation Present Worth Factor — 13.112
   d. Discounted Savings (b x c) — $16,009

4. Annual Energy Savings (Type: X) MBTU's
   a. Cost per MBTU at End of Program Year — $____
   b. First Year Annual Dollar Savings — $____
   c. Differential Escalation Present Worth Factor — $____
   d. Discounted Savings (b x c) — $____

5. Annual Other-Than-Energy Savings (Or Costs)
   a. Labor — $____
   b. Material and Other — $____
   c. Total (a + b) — $____
   d. 10% Discount Factor — $____
   e. Discounted Other-Than-Energy Savings (Or Costs) — $____

6. Total First Year Annual Savings (2c+3b+4d+5c) — $ 1221

7. Total Discounted Savings (2e+3d+4d+5e) — $16,009

COST ESCALATION (for current year program)

Current	*ELEC	$___	x___	x___	x___	x___	=	$___
rates of	*OIL	$2.97	x___	x___	x___	x___	=	$2.97
as of	*GAS	$___	x___	x___	x___	x___	=	$___
	*	$___	x___	x___	x___	x___	=	$___

RATIOS

8. Savings-to-Investment Ratio (Line 7 divided by 1c) — 0.80
9. E/C Ratio (Total MBTU Saved divided by 1a/1000) — 20.55
10. Simple Payback Period (Line 1a divided by Line 6) — 16.4 YRS

Ref: NAVFAC ltr. 1113F/RHB dated 6 September 1978

10.8 MILCON FORMS - SAMPLE DATA AND CALCULATIONS

The sheets are arranged to determine the following:

Is there a valid Energy Conservation Project for the Batch Furnace at the Boston Naval Shipyard?

If the project should be requested, what forms are required?

Procedure	Description
Energy Analysis and Calculations on Unlined White Paper	Heat Balance on a Batch Furnace
Economic Analysis on Unlined White Paper	Economic analysis using cost data and ECIP criteria.

The results from the above indicate that a MILCON project should be requested.

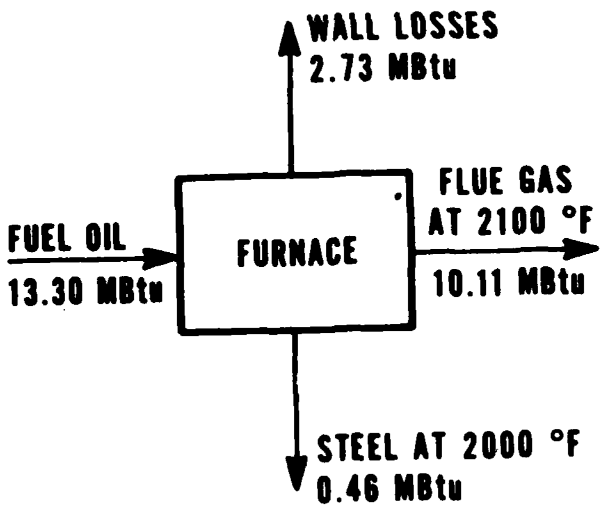
Form	Description
OPNAV 11000/4	Project Summary Sheet
DD 1391	Project Description
DD 1391C	Energy Calculation, Economic Analysis using ECIP Guidelines
NAVFAC 11013/7	Cost Estimates
ECIP Cost Analysis	Not needed - in this case. Analysis was covered on DD 1391C

ENERGY ANALYSIS AND CALCULATIONS

Heat Balance on A Batch Furnace

An oil fired furnace heats one-ton batches of steel to 200^{o}F for a forging operation. The furnace burns 95 gallons of No. 2 fuel oil during each two-hour cycle. This oil yields 13.3 MBtu (13,3000,000 Btu). The stack temperature is 2100^{o}F, and an analysis of the flue gas shows an oxygen content of 11 percent, meaning that the furnace uses 100 percent excess air, twice the amount of air theoretically needed to completely burn the fuel.

The heat is as follows:



For simplicity, this example considers only the fuel used while actually heating a batch of steel. It ignores the fuel used to heat up a cold furnace and to keep it hot while unloading one batch and loading the next. Because of this, actual savings due to a conservation project will be greater than those estimated in this example. Any change which saves energy during operation will also save some energy during warm up and during idling.

The only energy input to this system is the burning fuel oil. At an energy content of 140,000 Btu per gallon for No. 2 oil,

Heat Input = 140,000 Btu/gal x 95 gal = 13.30 MBtu.

The same quantity of energy must also leave the furnace during each cycle; it does so in three forms:

(1) The heat content of the steel is the weight of the steel times its temperature increase times its specific heat of 0.12 Btu/lb^{o}F. If the steel enters the furnace at 100^{o}F, then the energy removed from the furnace by a heated one-ton batch will be:

Heat in steel = 2000 lb x (200-100) ^{o}F x 0.12 Btu/lb^{o}F = 456,000 Btu, or 0.46 MBtu.

(2) The stack loss represents the energy escapting in the hot flue gas. Referring to figure 3 note that a stack temperature of 2100^{o}F, and with 100 percent excess air, the stack loss is 76 percent of the fuel burned.

Stack loss = 13.30 MBtu x 0.76 + 10.11 MBtu.

(3) Conduction and radiation losses from the furnace walls and roof must make up the remainder of the energy output

Wall losses = 13.30 - (0.46 + 10.11) = 2.73 MBtu

Output = 0.46 + 10.11 + 2.73 = 13.30 MBtu per cycle

It is evident in this FIRST HEAT BALANCE that most (76 percent) of the energy is wasted up the exhaust stack. Looking at figure 3, one can observe that the stack loss is least when the amount of combustion air is precisely the amount required to completely burn the fuel. If a large amount of excess air is supplied, much of the energy of the fuel is used to heat the air and the satack loss becomes very large. Conversely of course, if insufficient air is supplied, the fuel will not be completely burned and energy will again be wasted. A reasonable quantity of excess air when burning fuel oil is about 20 percent, or when burning natural gas about 5 to 10 percent.

Excess air can be reduced by adjusting the burners, by throttling the air inlets, and by repairing cracks, holes, and ill-fitting doors. The stack damper should also be adjusted to maintain a very slight positive pressure in the fire-box to prevent the infiltration of unwanted air. The goal of 20 percent excess air is reached when, the flue gas analysis shows 3.5 percent oxygen and approximately 13 percent carbon dioxide.

At 20 percent excess air, figure 3 shows that the stack loss in only 46 percent of the fuel energy instead of the original 76 percent. The energy absorbed by the steel remains at 0.46 MBtu. This total 2.73 + 0.46 = 3.19 MBtu, is now 54 percent of the total input (100%-46% = 54%). The total fuel energy needed per cycle is therefore:

Input = 3.19 MBtu/0.54 = 5.91 MBtu.

Input = 3.19 MBtu/0.54 = 5.91 MBtu.

With this input, we can make a SECOND HEAT BALANCE:

Input	Output
5.91 MBtu	Steel 0.46 MBtu
(42.2 gal of oil)	Stack 2.72 MBtu
	Walls 2.73 MBtu
	Total 5.91 MBtu

In the second heat balance, even after adjusting the excess air to the practical minimum, energy is being wasted up the stack at the rate of 2.72 MBtu per cycle, or at 500 cycles per year, 1360 MBtu per year.

Some of this heat can be recovered by passing the flue gas through a heat exchanger, or through a waste heat boiler. The recovered heat can be used for a variety of purposes; following are some of those frequently suggested.

(1) Make steam for process use, for electrical power generation, or for space heating.

(2) Heat water for processing or for space heating.

(3) Preheat combustion air for the furnace.

(4) Preheat the product entering the furnace.

(5) Heat air for space heating.

According to the stack loss vs. excess air chart, at 20 percent excess air and a stack temperature of 1100^{0}F, the stack loss is 23.5 percent of the fuel fired. The other two outputs, the 2.19 MBtu for conduction losses and for heat in the hot steel, must therefore amount to: 100 percent -23.5 percent = 76.5 percent of the fuel. Under this condition,

Fuel energy = 3.19 x 1/0.765 = 4.17 MBtu per cycle.

Stack loss = 4.17 x 0.235 = 0.98 MBtu per cycle.

At this point, the largest energy loss in the system is the 2.73 MBtu lost by conduction and radiation through the walls and roof of the furnace.

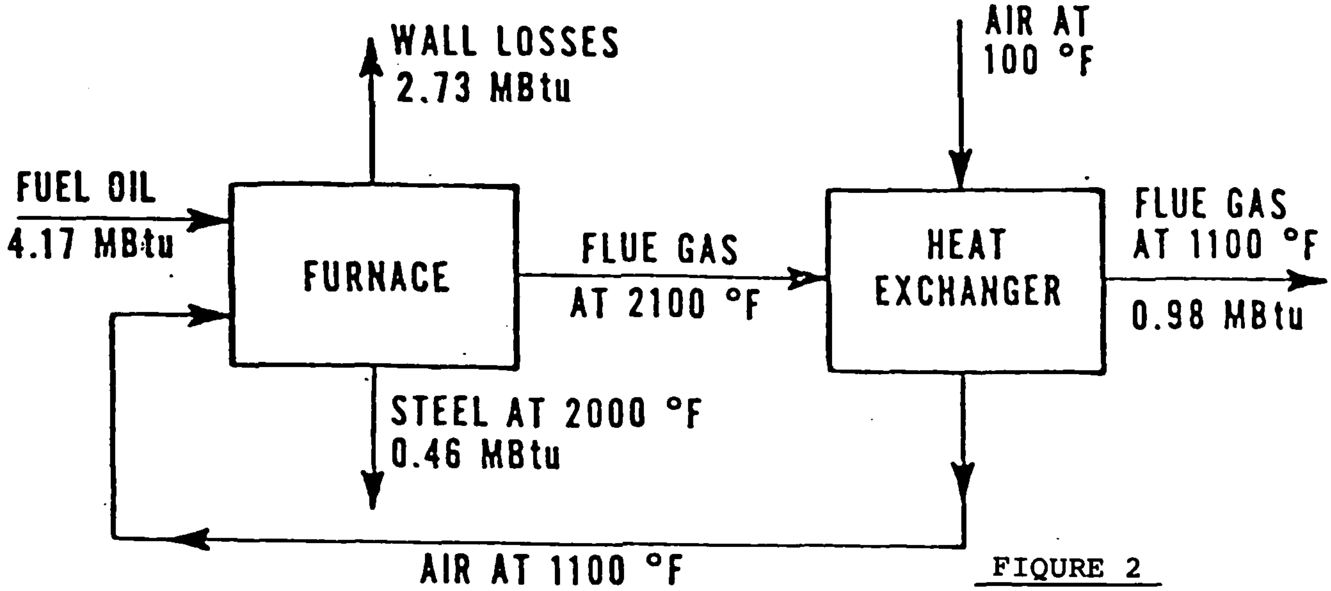


FIGURE 2

The best use for the recovered heat depends on the process and the particular plant conditions. In this case, with a batch furnace and possibly a rather uneven schedule, preheating the combustion air might be the best use. Figure 2 shows the heat flow with such an arrangement as a THIRD HEAT BALANCE. The numbers are MBtu of energy for a two hour furnace cycle.

To estimate the fuel usage under these conditions, consider the entire diagram as a single system with one heat input (the air at 100°F is considered not to carry any heat), and three outputs. Two of the outputs are the heat in the steel and the conduction losses. The sum of these outputs is 3.19 MBtu as in the second heat balance. The third output is the waste flue gas at 1100°F. (Since the mass of flue gas is

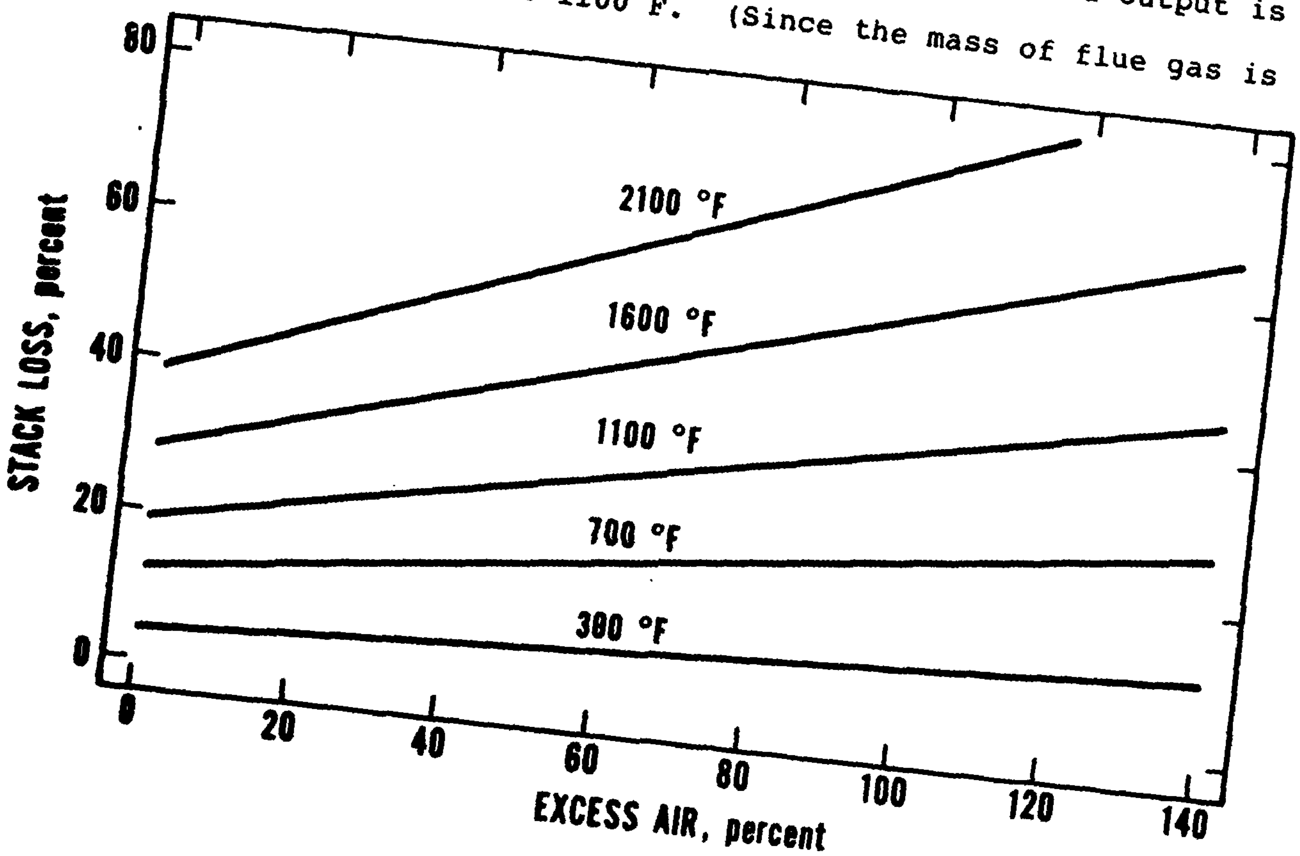


Figure 3

approximately equal to the mass of combustion air, it is reasonable to estimate that if the air is heated by 1000°F, the flue gas will be cooled by the same amount).

If we further assume that suitable repair or addition to the insulation can reduce this loss to 1.90 MBtu per cycle, a FORUTH HEAT BALANCE performed in a similar manner shows that this will reduce the fuel input to 3.08, and the stack loss to 0.72 MBtu per cycle.

The following table summarizes the heat balance analyses of the furnace system:

Batch Furnace Heat Balances (Two-Hour Cycle)

	Condition	Input	Stack Loss	Conduction Loss	Heat in Steel	Efficiency
		MBtu	MBtu	MBtu	MBtu	Percent
(1)	Original system	13.30	10.11	2.73	0.46	3.5
(2)	Reduce excess air	5.91	2.72	2.73	0.46	7.8
(3)	Preheat air	4.17	0.98	2.73	0.46	11.0
(4)	Add insulation	3.08	0.72	1.90	0.46	14.9

Assuming a production rate of 50 cyeles per year, the annual energy savings would be:

= 500 cycles per year x (13.30 - 3.08) MBtu's/year

= 5,110 MBtu's/year

For No. 2 fuel oil at 140,000 BTU's per gallon, the annual saving would be:

$$= \frac{5{,}110 \times 1{,}000{,}000 \text{ BTU's/year}}{140{,}000 \text{ BTU's/gallon}} = 36{,}500 \text{ Gallons/year}$$

Extracted from: Energy Management of Furnaces, Kilns and Ovens, National Bureau of Standards, Handbook 124, January 1978.

ECONOMIC ANALYSIS

1. Using the energy analysis and calculations as the basis for an economic analysis:

a. The energy analysis indicates this recommendation would save 36,500 gallons of No. 2 fuel oil per year.

b. From the Activity we have determined that the present day cost for No. 2 fuel oil is $0.41/gallon. (1978 prices).

c. An engineering cost estimate has been made and it was determined that the construction cost for this recommendation would be $78,000.

2. Since the present cost of the project is $78,000, the program year for the MILCON project must be determined. (See paragraph 4 of the Guidelines). To determine if this project would qualify for the ECIP Program, we must make an Economic Analysis (see paragraph 1, 2 and 3 of the Guidelines).

3. If this project does qualify for the ECIP Program, it would be submitted for the FY-81 Program (see paragraph 16 of escalated to the program year (see paragraph 8 of the Guidelines) and therefore all costs and savings must be escalated to the program year (see paragraph 8 of the Guidelines).

4. For this example, we will assume that today's date is April 4, 1978. This date is in the third quarter of FY-78. Therefore, all escalations must be for two quarters of FY-78, all of FY-79, FY-80 and FY-81 (see paragraph 8 of the Guidelines).

a. To establish the cost savings for this project:
Gallons of Fuel Oil Saved per Year = 36,500
Present day Cost of the Fuel Oil = $0.41/gallon

$$\text{Escalation} = \frac{\text{FY-78}}{(1.08)} \times \frac{\text{FY-79}}{(1.16)} \times \frac{\text{FY-80}}{(1.16)} \times \frac{\text{FY-81}}{(1.14)} = 1.66$$

Cost Savings = 36,500 gal x $0.41/gal x 1.66 = $24,840/year

b. To establish the project cost:

Engineering Co. Estimate = $78,000

Added Cost for Supervision, Inspection, Overhead (SIOH) = 5.5%

$$\text{Escalation} = \frac{\text{FY-78}}{(1.04)} \times \frac{\text{FY-79}}{(1.07)} \times \frac{\text{FY-80}}{(1.065)} \times \frac{\text{FY-81}}{(1.06)} = 1.26$$

Project Cost = ($78,000 + 0.055 x $78,000) x 1.26 = $103,700

*Government administrative costs chargeable to the project.

c. To determine the ECIP Inflation - Discount Factor, use the Discount Factors Table.

(1) This project involves repairs and adjustment to the furnace, installation of a heat exchanger and insulation of the furnace. Repairs and adjustments and insulation of the furnace are all associated with the furnace life. Assume the furnace has at least 25 years of service life (we cannot use a longer period for equipment) so these items also will have a 25 year economic life (see paragraph 11 of the Guidelines).

(2) The long term differential escalation rate for fuel oil is 8% (see paragraph 9 of the Guidelines).

(3) The present worth factor for the recurring annual savings is 20.05 (for 8% differential inflation rate and 25 year economic life from the Discount Factors Table).

d. To calculate the savings to investment ratio (SIR): (see paragraph 2 of the Guidelines).

Cost Savings = $24,840/year

Project Cost = $103,700

Present Worth Factor = 20.05

$$SIR = \frac{\text{(Annual Savings) (Present Worth Factor)}}{\text{Project Cost}} = \frac{\$24,840 \times 20.05}{\$103,700} = 4.8$$

e. To calculate the energy savings to cost ratio:

Energy Savings = 5,110 MBtu's/Year (from the Energy Analysis and Calculations Sheets)

Project Cost divided by 1,000 = 103.7

$$\text{Energy Savings to Cost} = \frac{\text{5,110 MBtu's}}{103} = \text{49.3 MBtu's/\$1000 Proj.}$$

f. To calculate the simple amortization period:

Cost Savings = $24,840/year

Project Cost = $103,700

Simple Amortization Period

$$= \frac{\text{Project Cost}}{\text{Cost Savings}} = \frac{\$103,700}{\$24,840} = \text{4.2 Years}$$

5. This project has a savings-to-investment ratio of greater than one (paragraph 4d shows 4.8) and the energy savings to cost ratio is 49.3 MBtu's/$1000 Project Cost Paragraph 8 of the Guidelines indicates the minimum requirement for FY-81 of 20 MBtu's/$1000 Project Cost). This project qualifies for the ECIP Program and should be written up in MILCON Project format.

REPORT SYMBOL OPNAV 11000-1C

PROJECT FOR CORRECTION OF FACILITY DEFICIENCY
OPNAV 11000/4 (REV. 3-73)
S/N 0107-LF-110-0035

CLASSIFICATION

PROJECT NO. P –

A. SUBMITTING ACTIVITY NAME AND LOCATION: BOSTON NAVAL SHIPYARD, BOSTON, MA

B. ACTIVITY UIC

C. AREA COORD. CODE

D. CLAIMANT CODE

E. DATE OF LATEST FDR

F. HOST ACTIVITY AND LOCATION: SAME

G. HOST UIC

H. COMPONENT NAME

I. COMPONENT UIC

	CATEGORY CODE	PROJECT TITLE	ALTERNATE HOST UIC	SPECIAL AREA	SCOPE: QUANTITY	SCOPE: U/M	ESTIMATED COST ($000)	EST. COST YEAR	USABLE COMPL. DATE: MOS	USABLE COMPL. DATE: Code	% REQ. SATISFIED: W	% REQ. SATISFIED: W/O	INVESTMENT: Prog.	INVESTMENT: Master Plan	ECONOMIC ANALYSIS	E I A	S I T E	MC PRIORITY	CONST/MISSION CODE	VAL. CODE
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J		Repairs to Batch Furnace				LS	10.6	78	10	5			70	999	3.14					
K		Install Heat Exchanger			1	EA	69.2													
L		Insulate Furnace Walls			600	SF	23.9													
M																				
N																				
O																				

21 RELATED PROJECTS: None

CATEGORY CODE	REQUIREMENT BFRL DTD	EXISTING ASSETS DTD (from 11000/2 and 11000/3): ADEQUATE	EXISTING ASSETS: SUBSTD	OTHER ASSETS (from 11000/3): FUNDED	OTHER ASSETS: NON NAVY	PREVIOUS PROJECTS: QTY	PREVIOUS PROJECTS: P-No.	DEFICIENCY	TOTAL THIS PROJECT	DEFICIENCY REMAINING
22	23	24	25	26	27	28	29	30	31	32

33 PROJECT DESCRIPTION/JUSTIFICATION

This project will provide repairs to a batch furnace to reduce excess air use, provision of a heat exchanger to reclaim waste heat and furnace wall insulation to reduce heat loss. Project will result in a savings of 36,500 gallons of No. 2 Fuel Oil and $24,840 per year.

34. ACTIVITY CERTIFICATION. I certify that this project is required to support activity/mission functions.

Activity Commanding Officer — Date

35. EFD CERTIFICATION. This project is supported by SFPS.

EFD Commander/Commanding Officer — Date

36. MAJOR CLAIMANT CERTIFICATION. I certify that this project is required to support activity/mission functions.

Major Claimant Representative — Date

37. DO NOT WRITE IN THIS SPACE – FOR NAVFAC USE ONLY.
This project is authorized for entry into the MILCON R.L.

NAVFAC Authorizing Signature — Date

CLASSIFICATION

ATTACHMENT (4)

1. DATE	2. FISCAL YEAR	MILITARY CONSTRUCTION PROJECT DATA	3. DEPARTMENT	4. INSTALLATION
4 Apr 76	1981		NAVY	BOSTON NAVAL SHIPYARD

5. PROPOSED AUTHORIZATION	6. PRIOR AUTHORIZATION	7. CATEGORY CODE NUMBER	8. PROGRAM ELEMENT NUMBER	9. STATE/COUNTRY
$ 103,700	P.L.			BOSTON, MA

10. PROPOSED APPROPRIATION	11. BUDGET ACCOUNT NUMBER	12. PROJECT NUMBER	13. PROJECT TITLE
$ 103,700			ENERGY CONSER. IMPROV. TO BATCH FURNACE

SECTION A - DESCRIPTION OF PROJECT

14. TYPE OF CONSTRUCTION	
a. PERMANENT	
b. SEMI-PERMANENT	
c. TEMPORARY	
16. TYPE OF WORK	
a. NEW FACILITY	
b. ADDITION	
c. ALTERATION	
d. CONVERSION	
e. OTHER (Specify)	
17. REPLACEMENT	
18. TYPE OF DESIGN	
a. STANDARD DESIGN	
b. SPECIAL DESIGN	
c. DRAWING NO.	

15. PHYSICAL CHARACTERISTICS OF PRIMARY FACILITY

a. NO. OF BLDGS	b. NO. OF STORIES	c. LENGTH	d. WIDTH
e. DESIGN CAPACITY		f. GROSS AREA	
g. COOLING	CAP.	COST ($)	

19. DESCRIPTION OF WORK TO BE DONE

Energy Conservation Improvements to Batch Furnace No. 3 in Building 17, Forge Shop:

a. Adjust burners, throttle air inlets, repair cracks, holes and badly fitted doors.

b. Install an air-to-air type heat exchanger to reclaim heat from flue gases to pre-heat combustion air.

c. Increase furnace wall insulation.

SECTION B - COST ESTIMATES

20. PRIMARY FACILITY	U/M	QUANTITY	UNIT COST	COST ($000)
Improv. to Batch Furnace		/	$	$ [illegible]
a. Repairs and Adjustments	LS	( )		([illegible])
b. Install Heat Exchanger	EA	(1)	[illegible]	([illegible])
c. Insulate Furnace Walls	SF	([illegible])	[illegible]	([illegible])
d.		( )		( )
21. SUPPORTING FACILITIES				$
a.				( )
b.				( )
c.				( )
d.				( )
e.				( )
f.				( )
g.				( )
h.				( )
i.				( )
j.				( )
22. TOTAL PROJECT COST				$ [illegible]

SECTION C - BASIS OF REQUIREMENT

23. QUANTITATIVE DATA (U/M)		
a. TOTAL REQUIREMENT		
b. EXISTING SUBSTANDARD	( )	
c. EXISTING ADEQUATE		
d. FUNDED, NOT IN INVENTORY		
e. ADEQUATE ASSETS (c + d)		
	AUTHORIZED	FUNDED
f. UNFUNDED PRIOR AUTHORIZATION		
g. INCLUDED IN FY ____ PROGRAM		
h. DEFICIENCY (a - e - f - g)		
24. RELATED PROJECTS		

25. REQUIREMENT FOR PROJECT

MISSION AND PROJECT: The principal mission of the Shipyard is the repair, overhaul, alteration, and conversion of Naval surface ships and conventional submarines. This project will make improvements to a batch furnace to conserve energy.

REQUIREMENT: To reduce energy losses due to deteriorated condition of the furnace, excessive heat losses in the flue gases and inadequate insulation.

CURRENT SITUATION: This furnace was installed when energy conservation was not critical and, therefore, has inadequate insulation and no provision for reclaiming heat from the flue gases and as a result is consuming more energy than is necessary.

IMPACT IF NOT PROVIDED: 5,100 MBTUs of energy and $24,040 will be wasted annually. This project will save 36,500 gallons of No. 2 fuel oil annually. Energy savings to cost ratio = 49.3 MBTU/$1,000 project cost. SIR = 3.14.

DD FORM 1 OCT 76 1391 S/N 0102-LF-013 8001

Page No. [illegible]

1. DATE	2. FISCAL YEAR	MILITARY CONSTRUCTION PROJECT DATA (Continued)	3. DEPARTMENT	4. INSTALLATION
4 Apr 76	1981		NAVY	BOSTON NAVAL SHIPYARD
5. PROJECT NUMBER		6. PROJECT TITLE: ENERGY CONSERVATION IMPROVEMENT TO BATCH FURNACE		

<u>Energy Analysis</u>

1. Oil fired batch furnace heats one-ton batches of steel for forging operations:

   Furnace burns 95 gallons of fuel oil (No. 2) during a two hour cycle.
   Annual production is 500 cycles
   Energy content of No. 2 fuel oil = 140,000 BTU/gallon
   Stack temperature = 2,100°F
   Flue gas shows 11% oxygen
   Room temperature = 100°F

2. Heat balance, present operations:

   Heat input = 95 gallons x 140,000 BTU/gallon

   = 13,300,000 BTU (13.3 MBTU)

   Heat to steel = 2,000 lbs x (2,000 - 100)°F x 0.12 BTU/LB/°F

   = 456,000 BTU (0.46 MBTU)

   Stack losses - From handbook tables, for a stack temperature of 2,100°F with 100% excess air, the stack loss is 76% of the fuel energy input

   = .76 x 95 x 140,000.

   = 10,100,000 BTU (10.1 MBTU)

   Wall losses

   = 13.3 - 0.46 - 10.1

   = 2.73 MBTU

DD FORM 1391c

1. DATE	2. FISCAL YEAR	MILITARY CONSTRUCTION PROJECT DATA (Continued)	3. DEPARTMENT	4. INSTALLATION
4 Apr 78	1981		NAVY	BOSTON NAVAL SHIPYARD
5. PROJECT NUMBER	6. PROJECT TITLE	ENERGY CONSERVATION IMPROVEMENT TO BATCH FURNACE		

3. Heat input resulting from reducing excess air to 20% by adjusting burners, throttling air inlets, repairing cracks and holes and badly fitted doors.

Stack losses - From handbook tables for a stack temperature of 2,100°F with 20% excess air, the stack loss is 46% of the fuel energy input.

Heat to steel and wall loss will account for the remainder of the fuel energy input, or 54% of the total.

$$.54 \text{ Fuel Energy Input} = 0.46 \text{ MBTU} + 2.73 \text{ MBTU}$$

$$\text{Fuel Energy Input} = \frac{(0.46 + 2.73) \text{ MBTU}}{.54}$$

$$= 5.91 \text{ MBTU}$$

4. With the above corrections made, install a heat exchanger to use waste heat from the stack gases to preheat the air supplied to the furnace. The heat exchanger selected will raise the temperature of the air by 1,000°F. Since the mass of flue gas is approximately equal to the mass of combustion air, it is reasonable to expect that if the air is heat by 1,000°F, the flue gas temperature will be reduced by the same amount.

Stack losses - From handbook tables, for a stack temperature of 1,100°F with 20% excess air, the stack loss is 23.5 of the fuel energy input.

Heat to steel and wall loss will account for the remainder of the fuel energy input, or 76.5% of the total.

$$.765 \text{ Fuel Energy Input} = 0.46 \text{ MBTU} + 2.73 \text{ MBTU}$$

$$\text{Fuel Energy Input} = \frac{(0.46 + 2.73) \text{ MBTU}}{.765}$$

$$= 4.17 \text{ MBTU}$$

1. DATE	2. FISCAL YEAR	MILITARY CONSTRUCTION PROJECT DATA (Continued)	3. DEPARTMENT	4. INSTALLATION
4 Apr 78	1981		NAVY	BOSTON NAVAL SHIPYARD
5. PROJECT NUMBER		6. PROJECT TITLE ENERGY CONSERVATION IMPROVEMENT TO BATCH FURNACE		

5. By increasing the wall insulation in addition to the above, the wall loss can be reduced to 1.90 MBTU.

Stack losses will remain at 23.5% of the fuel energy input and the heat to steel and wall loss will account for the remainder of the fuel energy input, or 76.5% of the total.

$$.765 \text{ Fuel Energy Input} = 0.46 \text{ MBTU} + 1.90 \text{ MBTU}$$

$$\text{Fuel Energy Input} = \frac{(0.46 + 1.90) \text{ MBTU}}{.765}$$

$$= 3.08 \text{ MBTU}$$

6. Energy Saved

$= (13.3 - 3.08)$ MBTU

$= 10.22$ MBTU

7. For 500 cycles per year

Energy Saved $= 10.22 \text{ MBTU} \times 500$

$= 5,100$ MBTU/year

For No. 2 fuel oil at 140,000 BTU/gallon

$$\text{Fuel Oil Saved} = \frac{5,110 \times 10^6 \text{ BTU/year}}{140,00 \text{ BTU/gallon}}$$

$= 36,500$ gallons/year

1. DATE	2. FISCAL YEAR	MILITARY CONSTRUCTION PROJECT DATA (Continued)	3. DEPARTMENT	4. INSTALLATION
4 Apr 78	1981		NAVY	BOSTON NAVAL SHIPYARD
5. PROJECT NUMBER	6. PROJECT TITLE: ENERGY CONSERVATION IMPROVEMENT TO BATCH FURNACE			

Economic Analysis

Fuel Oil Saved = 36,500 gallons/year
Fuel Oil Cost = $0.41/gallon
Engineering Cost Estimate = $78,000

1. Cost Savings

= 36,500 gallons/year x $0.41/gallon x 1.66*

= $24,840/year

2. Project Cost

= ($78,000 + 0.055** x $78,000) x 1.26*

= $103,700

3. Savings-to-Investment Ratio (SIR)

$$SIR = \frac{\text{Annual Savings x Present Worth Factor}}{\text{Project Cost}}$$

$$= \frac{\$24,840 \times 13.112}{\$103,700}$$

= 3.14

4. Energy Savings to Cost Ratio

Project Cost ÷ 1,000 = 103.7

$$\text{Energy Savings to Cost Ratio} = \frac{5,110 \text{ MBTU}}{103.7}$$

= 49.3 MBTU/$1,000 Project Cost

DD FORM 1391c

1. DATE	2. FISCAL YEAR	MILITARY CONSTRUCTION PROJECT DATA (Continued)	3. DEPARTMENT	4. INSTALLATION
4 Apr 78	1981		NAVY	BOSTON NAVAL SHIPYARD
5. PROJECT NUMBER		6. PROJECT TITLE: ENERGY CONSERVATION IMPROVEMENT TO BATCH FURNACE		

5. Simple Amortization Period

$$P = \frac{\text{Project Cost}}{\text{Cost Savings}}$$

$$= \frac{\$103,700}{\$24,640}$$

= 4.2 Years

---

* Escalation factor based on an assumed increase in fuel oil costs of 8% for 6 months of FY-78 and 16% each year for FY-79, FY-80, and FY-81 and an assumed increase in construction costs of 4% for 6 months of FY-78, 7% for FY-79, 6.5% for FY-80, and 6.0% for FY-81. Per latest NAVFAC guidance.

** 5.5% government administration costs chargeable to the project.

DD FORM 1391c

Page No. 647

COST ESTIMATING FORM - WORKSHEET

SHEET 1 OF 1

AREA CO NO	ACTIVITY	LOCATION	IDENTIFICATION NUMBER / CATEGORY CODE NUMBER
1 ND	BOSTON NAVSHIPYD	BOSTON, MA	

PROJECT TITLE

ENERGY CONSERVATION IMPROVEMENTS TO BATCH FURNACE, NO. 3, BLDG. 17, FORGE SHOP

ITEM (OR FEATURE) DESCRIPTION (Abbreviate if necessary)	QUANTITIES: NO. OF UNITS	UNIT	MATERIAL COSTS: UNIT COST	COST	LABOR COST: UNIT COST	COST	ENGINEERING ESTIMATE: UNIT COST	COST
	2	3	4	5	6	7	8	9
ADJUST BURNERS	4	EA	75	300	300	1200	375	1,500
REPAIR CRACKS	150	FT	7	1050	3	450	10	1,500
REPAIR HOLES	10	EA	150	1500	50	500	200	2,000
TROTTLE AIR INLETS	4	EA			250	1000	250	1,000
REFIT DOORS	2 E	EA	200	400	800	1600	1600	2,000
REMOVE AIR INLETS		LS						500
REMOVE STACK		LS						500
HEAT EXCHANGER	1	EA	40000	40000	2200	2200	42200	42,200
SHEET METAL	1000	CB	0.80	800	2.20	2200	3	3,000
INSULATION (4")	200	SF	15	3000	5	1000	20	4,000
DAMPERS, CONTROLS		LS						1,000
REMOVE INSULATION		LS						4,000
NEW INSULATION (10")	140	SF	75	10,500	25	3500	100	14,000
								78,000

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
JOHN SMITH	FRANK JONES	A&E COMPANY	15 MAR 78

APPENDIX A

ENERGY CONVERSION FACTORS

A.1 ENERGY CONVERSION FACTORS, ELECTRICAL

Electrical (Site)	3,413 BTU/KWH
Electrical (Source)	11,600 BTU/KWH

Site electrical energy is the energy measured at the input to the site electrical substations. The site energy conversion factor is 3,413 BTU/Kwh. Source energy refers back to the electric power generating plant. Source energy gives the true picture of the cost to generate electric power because it includes the power plant inefficiencies. The commonly used source conversion factor is 11,600 BTU/Kwh, which is to say, that it takes 11,600 BTU worth of oil to produce 1 Kwh.

A.2 FUEL HEATING VALUES

Typical fuel heating values are listed in the following table:

Fuel	Typical Fuel Heating Value
Natural Gas	1,031 BTU/SCF
Fuel Oil No. 6*	150,000 BTU/Gallon
Fuel Oil No. 2*	138,700 BTU/Gallon
Coal	12,290 BTU/Lb.
LPG (Propane or Butane)	95,500 BTU/Gallon
Crude Oil	5.8×10^6 BTU/Barrel (Barrel=42 Gallons)
Gasoline (Auto)	125,000 BTU/Gallon
Aviation Gas	125,000 BTU/Gallon

A.3 TYPICAL HEATING VALUES OF COMPONENTS OF INDUSTRIAL SCRAP AND MUNICIPAL, REFUSE

INDUSTRIAL SCRAP

	Btu/lb
Rubber	12,420
Tires, bus and auto	18,000
Leather scrap	8,140
Cork scrap	12,400
Paraffin	16,803-18,600

WASTE LIQUIDS

Industrial Sludge	3,700-4,200
Dirty Solvents	10,000-16,000
Naphta	20,250
Spent Lubricants	10,000-14,000
Gasoline	20,700
Naphthalene	18,500
Fuel Oil Residue	18,000
Paint Wastes	6,000-10,000

PAPER WASTES

Brown Paper	7,090
Cardboard	6,800
Corrugated Board	6,830
Tarpaper	10,120
Waxed Paper	10,790

DOMESTIC REFUSE

Paper, cardboard, cartons, bags	7,840
Wood carts, boxes, crapwood	7,825
Garbage	2,230
Rags-cotton-linen	6,540
Textiles, natural	8,040
Textiles, synthetic	15,000
Refuse Derived Fuel, Municipal	5,500

Source: Consumat - An Alternate Energy Source, Energy Bulletin No. 10-874, Consumat Systems, Inc.

APPENDIX B

ENERGY MEASUREMENT

TECHNIQUES

B.1 ELECTRICAL MEASUREMENTS

Large electric motors, such as those used to drive air compressors and chiller compressors, are usually installed with instrumented control panels which display line voltage, line current, and sometimes power factor. By monitoring these meters at regular intervals during a typical day, energy consumption can be estimated by integrating the area under a trace of power and time.

Older motor installations and motors which are smaller than 100 HP usually do not have "built-in" instrumentation. In order to obtain accurate energy consumption profiles, "clamp-on" electric meters can be used. The most convenient device is a recording ammeter. It provides a continuous trace of current and thus enables the computation of power at any time. By monitoring for a day or week, typical load profiles are obtained.

In order of relative significance, the principal factors which identify large energy users are nameplate ratings, load ratios, and equipment duty cycles.

B.1 (cont'd)

Electrical nameplate ratings indicate maximum input and output power.

Equipment load factor ratio is average power in divided by nameplate power in. Many large motors are used at a fractional part of their rated capacity, consequently the nameplate data may not in itself classify it as a heavy energy consumer. Load factor ratio data is necessary to further identify the heavy energy users.

Duty cycle is a profile of equipment usage over a periodic work cycle, usually one day or one week.

The large users of electric power in industrial process areas are exhaust fans, which often run continuously and pump heated or cooled air to the outside environment; air compressors, process tanks, and chiller drive motors.

One problem associated with measuring electric power to a motor is finding a convenient place to clamp the "current transformer" type sensor of the recording meter. Power leads to and at the motor are usually inaccessibly shrouded in conduit. Motor control panels often provide the access to exposed leads. Survey members should not attempt to connect meters. This is a job for the maintenance electrician normally assigned to that building.

Voltage and frequency variations are assumed to be minimal and have a negligible effect on the energy computations suggested in this guide. Power factor may be measured be measured conveniently, assume a value of 0.90 lagging.

B.2 SUGGESTED LIST OF TEST EQUIPMENT FOR ELECTRICAL MEASUREMENTS

	Name	Function
1.	Clamp-on ammeter -	Used to measure amperage of various circuits -- motors, etc.
2.	Power Factor Meter	Used to measure system or motor power factor.
3.	Recording Ammeter	Used to continuously monitor system or motor loads.
4.	Recording Voltmeter	Used to measure voltage variations on a system.
5.	Voltmeter 0-150 volts 0-300 volts 0-600 volts	Used to measure system voltage and balance between phases.
6.	__________	__________
7.	__________	__________

B.3 STEAM MEASUREMENTS

Even modern industrial facilities seldom have a steam monitoring system which gives consumption on a per building basis. Central steam plant metering gives daily recordings of flow from each boiler.

Steam usage by individual process is necessarily a computational method requiring knowledge of thermal losses, and steam enthalpy. Many industrial sites produce saturated steam for heating and process usage. Steam flow to a convector type heat exchanger is calculated taking the convector rating in Btu/Hr and dividing by the change in enthalpy of the steam. Enthalpy "in" is read from a saturated steam table at heat exchanger pressure or zero in the case of a system with no return. Steam flow to turbines and engines is usually estimated by measuring the output loading machine, such as an alternator. This output energy rate divided by system efficiency (alternator and turbine) gives input energy rate. Measuring steam pressure and temperature in and exhaust steam temperature and pressure allows one to look up enthalpy change and in a manner similar to the convector, steam flow is estimated.

Often steam consumption is measured by determining the number of times a condensate receiver pump motor operates. The pump is usually controlled with level switches in the condensate well. Prior to the test, personnel determine the average amount of condensate pumped each time the pump motor

B.3 STEAM MEASUREMENTS (cont'd)

operates to reduce the condensate level in the well. The consumption is the result of the number of times the pump runs times the average amount of condensate discharged for each pump operation.

B.4 AIR FLOW MEASUREMENTS

PITOT TUBE

The most widely used instrument for the measurement of duct velocities. The manometr water leg (inches of water) is used to measure the velocity.

$$V = 10.96.5 \sqrt{\frac{\text{inches of water}}{\text{specific weight of air}}}$$

where:

V	= velocity, feet per minute
inches of water	= manometer reading
specific weight of air	= weight of cubic foot of dry air plus the weight of the moisture in the same cubic foot of air.

Unless the velocity in the duct is considered uniform, a traverse of the duct cross section is made. The American Society of Heating, Refrigerating and Air Conditioning Engineers (Publishers of the ASHRAE Fundamentals Volume) suggests the following traverses when using a pitot tube:

Rectangular Ducts. Divide the cross section into equal rectangular areas. Measure the velocity in the center of each area. The suggested number of areas to select is 16 to 64. ASHRAE suggests that for less than 64 equal areas, the centers of the areas shold not be more than 6 inches apart. The velocity results for each of the areas in the traverse are then averaged.

Circular Ducts. In each quadrant of the cross section, starting from the centerline of the duct, measure the velocities at 0.316R, 0.548R, 0.707R, 0.0837R, 0.949R. The circular cross section can be divided into smaller sectors of wedges than the four quadrants. The velocity results from each of the areas in the traverse are then averaged.

Anemometer (Wheel-Type)

A widely used instrument. it contains a miniature bladed wheel. The wheel revolves in the air steam and drives a pointer. A stop watch is usually required to convert the meter reading to velocity (feet per minute). When used at supply or exhaust grilles, calculations, involving correction factors are required. Furthermore, the dial on the anemometer must be faced in a particular direction depending on whether the grille is for supply or exhaust. The anemometer manufacturer's operating and calculating procedures should be followed.

OTHER ANEMOMETERS

Various types of anemometers are available such as: deflecting vane, heated thermocouple and hot wire. An outline of applications, ranges, precision, etc., is contained in the ASHRAE Fundamentals Volume.

DATA COLLECTION - AIR FLOW SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO._ _ _ _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _ _ _ _

Air System Name: _

Associated With the Following Process_ _ _ _ _ _ _ _ _ _ _ _ _

LOCATION OF THE VELOCITY MEASUREMENTS:

Supply _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Return _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Exhaust _ _ _ _ _ _ _ _ _ _ _ _ _ _

DAMPER POSITIONS (If Required):

Outside Air Damper _ _ _ _ _ _ _ _ _ Percent Open

Return Air Damper _ _ _ _ _ _ _ _ _ _ Percent Open

Exhaust Air Damper _ _ _ _ _ _ _ _ _ _Percent Open

DUCT OR GRILLE DIMENSIONS:

Duct _ _ _ _ _ _ _ _ Circular _ _ _ _ _

Dimensions _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Gross Area _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Square Feet

Net Free Area (Supply Grilles) _ _ _ _ _ Square Feet

INSTRUMENT:

Pitot Tube _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Anemometer _ _ _ _ _ _ _ _ , Type _ _ _ _ _

DATA COLLECTION - AIR FLOW

DEPT. OF NAVY - NAVFAC   BUILDING NO. _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO. _ _ _ _ _ _ _   I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _   LOCATION: FL _ _ _ BAY _ _ _ _ _ _

DUCT STATIC PRESSURE (If needed) _ _ _ _ _ _ _ inches of water

AIR STREAM:

Dry Bulb Temperature _ _ _ _ _ _ _ _ _ _ _ degrees F

Wet Bulb or Relative Humidity (If Needed) _ _ _ _ _ _ _ _

SKETCH OF CROSS SECTION AREA:

Location	Pitot Tube Inches of Water	Vane-Type Anemometer Indicator	Vane-Type Anemometer Time Interval

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _   DATE: _ _ _ _ _ _ _

DATA COLLECTION - AIR FLOW SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO. _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO._ _ _ _ _ _ I.D. NO. _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ BAY _ _ _ _ _ _

RESULTS FROM FOLLOWING CALCULATIONS:

Average Velocity _ _ _ _ _ _ _ _ _ _ Feet Per Minute

Flow _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Feet Per Minute

Location	Calculated Velocity FPM

SAMPLE CALCULATIONS:

For pitot tube, include specific weight of air and velocity equation for rotating vane anemometer follow manufacturers instructions. If a flow factor is used, please indicate it.

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _ _

B.5 SUGGESTED LIST OF TEST EQUIPMENT FOR MECHANICAL EQUIPMENT MEASUREMENTS

	Name	Function
1.	Orsat Analyzer	Flue gas analyzer, measures CO_2, O_2 and CO.
2.	O_2 Analyzer	Flue gas analyzer used to find O_2 and combustibles.
3.	Thermocouples	A selection of thermocouple probes to handle temperature measurements of air flow, surface, liquid, or other. Read with a portable digital temperature meter or a potentiometer.
4.	Inclined Manometer 0.05" to 0.25" H_2O	Used to measure small pressure differentials.
5.	"U" Tube Hg Manometer 0.26" Hg	Used to measure higher pressure differentials.
6.	Pitot Tube a. "S" Type b. Standard Type	Used to measure air velocity and pressure
7.	Portable pH Meter	Used to check pH of the boiler, water, condensate and aqueous waste streams.
8.	Portable Conductivity Meter	Used to check conductivity of boilerwater, feedwater, condensate, and aqueous waste streams.
9.	Bimetallic Thermometers	Used to measure fluid temperature where there is no permanent thermometer, or as a check.
10.	Glass Thermometers	Used to measure temperatures from 0-250 deg F.

B.5 SUGGESTED LIST OF TEST EQUIPMENT FOR MECHANICAL EQUIPMENT MEASUREMENTS (cont'd)

11.	Psychrometers	A hygrometer that uses the difference in readings between two thermometers, one having a wet bulb ventilated to cause evaporation and others having a dry bulb as a measure of atmospheric moisture.
12.	Surface Pyrometer a. 0-500 deg F b. 0-800 deg F c. 0-1,200 deg F	Used to measure surface temperature of vessels, pipes, and other objects.
13.	Calibrated Buckets	Used to measure the volume of a stream for checking amount of fluid flow.
14.	Stop-watch	Used to time the flow of a liquid into a measured bucket to determine flow rate.
15.	Velometer	Used to measure airflow directly, employing a dial indicating meter calibrated directly in feet per minute. Replacement probes enable measurements in ducts or in free space.
16.	Hot-Wire Anemometer	Used to measure air flow in a duct.
17.	Van Anemometer	Used to measure air flow.
18.	Pressure Gages 0-60 psig; 0-600 psig 0-100 psig; 0-1,000 psig 0-300 psig	Used to measure various system pressure.
19.	Recording Thermometer	Used to monitor temperature for a period of time.
20.	Fluid Leak Detector	Used to check for any gaseous leaks on systems connections.
21.	Strobo-Tachometer	Used to measure RPM's of a rotating machinery part.
22.	______________________	______________________

APPENDIX C

ENERGY ESTIMATING TECHNIQUES

C.1 ESTIMATING ELECTRIC ENERGY COSTS

Generally, electric energy cost is based upon three factors; peak demand during the billing period, total Kwh usage, and time-of-day usage. Another contributing factor is fuel cost which is factored into the computation of utility bills as a Fuel Adjustment Factor. When it is necessary to make projected energy costs, one must be aware of the fuel adjustment factor trend.

Energy consumption can sometimes be re-scheduled to take advantage of lower cost power. By limiting power demand during the billing interval in the on-peak time, demand charges can be greatly reduced. Large process users which run after "peak time" will realize large cost savings. For example, Plant A operates two work shifts per day with a peak demand of 2,000 KW and a monthly consumption of one million Kwh. Plant B operates three work shifts per day with a peak demand of 1500 KW and a monthly consumption of one million Kwh. The savings on electric power can be $2100/month, which is entirely attributable to reducing the demand charge.

C.2 ESTIMATING THE COST OF STEAM CONSUMPTION

The absence of steam flow measuring instrumentation requires a computational method for estimating the cost of steam consumed by individual processes.

Steam cost purchased from a utility is usually based on total usage, and includes a fuel adjustment factor. Peak demand and time of day usage rates are often not a part of the rate. Usually, steam generated at the facility is back-charged to the various users. The facility often develops its own steam costs. It allocates the costs of operating and maintenance labor, equipment, and fuel costs to the users.

Steam generating plant efficiency can usually be obtained from a Facilities/Utilities Engineering group. If this is not available, use E = 82% as representative value. Distribution losses may also be obtained *from* Facilities/Utilities Engineering. In the event that no data is available, assume a distribution loss of 12%.

Since steam consumption by an individual process is seldom, if ever, measured directly. Estimating steam flow and total consumption must then be arrived at by a computation based on thermal characteristics. For a tank, such as discussed in 6.3 steam flow to the heater coil can be approximated by estimated heat losses to the surrounding environment, Q_L, and dividing this number by the enthalpy change in the coil.

APPENDIX D

PUMPS

DATA COLLECTION - PUMP CENTRIFUGAL SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO.:_ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ I.D. NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

NAME PLATE DATA

Manufacturer:_ _ _ _ _ _ Mod. No.: _ _ _ _ _ Ser. No. _ _ _

Size and Type: _ _ _ _ _ Stages: _ _ _ _ _ _ _ _

Pump Curve No. _ _ _ _ _ Discharge Size: _ _ _ _ _ _ in.

Suction Size: _ _ _ _ _ In. Cap.: _ _ _ _ gpm Head: _ _ _ _f

RPM: _ _ _ _ _ _ _ _ _ _ Impeller Diameter: _ _ _ _ _

Motor HP: _ _ _ _ _ _ _ Motor I-D No.: _ _ _ _ _ _ _

AUDIT DATA

Motor Load: _ _ _ _ _ _ Volts: _ _ _ _ _ _ Amps: _ _ _ _ _

Pressures: Suction: _ _ _ _ _ _ psig Discharge: _ _ _ psig

Fluid Pumped: _ _ _ Temperature: _ _ °F Specific Gravity _ _ _

Noise: _ _ Yes _ _ No Gland Leakage _ _ Yes _ _ No

Hours of Operation Per: Day _ _ _ _ Week _ _ _ _ Year _ _ _

Flow Rate _ _ _ _ _ _ _gpm

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _

DATA COLLECTION - PUMP CENTRIFUGAL   SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC   BUILDING NO.:_ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO:_ _ _ _ _ _ I.D. NO.:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _   LOCATION: FL_ _ _BAY_ _ _

PUMP EFFICIENCY

Note: Used when flow rate is known.

IDEAL PUMP HORSEPOWER REQUIREMENTS:

$$\text{Ideal BHP} = \frac{Q \times HS}{3960} = \frac{\_\_\_\_\_\_\_\_\_\_}{3960} = \_\_\_\_\_\_\_\_\_\_ \text{Hp}$$

Where Q = Flow, gpm

H = System head, ft.

S = Specific gravity of liquid being pumped.

ACTUAL MOTOR INPUT HORSEPOWER: (3 Phase)

$$P = \frac{1.7321 \times E \times I \times \text{Power Factor}}{746} = .00232 \times \_\_\_\_\_\_\_$$

$$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \text{Horsepower}$$

Where:

E = Line neutral volts

I = Line current. amps.

MOTOR HORSEPOWER DELIVERED TO PUMP COUPLING:

Actual Pump HP = Actual Motor Input Horsepower x Motor EFF.

= ____________x_____________

= ____________Horsepower

$$\text{PUMP EFFICIENCY} = \frac{\text{Ideal BHP}}{\text{Actual Pump BHP}} \times 100$$

$$= \_\_\_\_\_\_\_\_\_\_\_\_ \times 100$$

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _   DATE: _ _ _ _ _ _ _

DATA ANALYSIS - PUMP CENTRIFUGAL

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO: _ _ _ _ _ _ I.D. NO:_ _ _ _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _

COMPARISON OF PUMP EFFICIENCY:

Compare the pump efficiency with appropriate pump performance curves.

Small (Booster) centrifugal pumps have efficiences that range from 45 to 70 percent.

Comparision:

From pump curves________________percent.

From pump efficiency calculations____________ percent.

PUMP OPERATIONAL CHECK

Note: Used When Flow Rate is Not Metered

If the process permits, close the discharge valve and record the inlet and discharge pressures:

Inlet pressure_____________________________

Discharge pressure_________________________

Compare the actual total head with the pump curves at zero flow.

From pump curves__________________________

From observed data________________________

CONDUCTED BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE:_ _ _ _ _ _ _

APPENDIX E

ELECTRIC MOTORS

E.1 ESTIMATING ELECTRICAL MOTOR LOAD CONSUMPTION

Nameplate

Nameplate motor ratings should be used with caution and experienced engineering judgment. For a more accurate estimate of true power consumption some measurements must be made.

Motor Load Factor or Equipment Loading Ratio

The ideal approach, time permitting, would be to install a recording ammeter to the motor supply for a period of time representative of normal operations. The record may then be integrated visually or mechanically over a fixed time period to determine total load for that period. This actual load may then be compared to nameplate data to determine the motor loading factor (MLF) or the equipment loading ratio (ELR)

$$\text{Motor Loading Factor} = \text{Equipment Loading Ratio} = \frac{\text{Average Power}}{\text{Peak Power}}$$

In the majority of cases, it is not necessary, nor is time and equipment available for generation of continuous records. In these cases, the use of a clamp-on ammeter and simple voltmeter will provide instantaneous readings which can be used to determine the MLF or ELR.

Duty Cycle

Another factor in determining annual consumption is the duty cycle. Duty cycles relate to the portion of total time during which equipment is operative. Many pieces of equipment are not in continuous use and, when operating, cycle on and off.

E.1 ESTIMATING ELECTRICAL MOTOR LOAD CONSUMPTION (Cont'd)

The use of elapsed time indicators or operational records, where available, would be the preferred source of information to show past and/or present usage. Lacking any proven history of operation one has to rely on the judgement of the shop foreman. If more than one shift operation is involved foremen on both shifts should be consulted and any overtime usage averaged out to sum up an annual (Hrs./Yr.) duty cycle.

Duty cycle, unfortunately, is a more difficult item to arrive at with reasonable accuracy. The use of some equipment may be sporadic, and the true duty is difficult to determine. In many cases, shop foremen feel compelled to defend their area by over-emphasizing the usage of equipment. However, careful observation on a spot check basis over several days can indicate if estimated duty cycles have to be corrected.

Annual electrical consumption may then be calculated as follows: Annual Consumption (KWH)=Average Load KW x Duty Cycle (Hrs./Yr.)

E.2 DATA COLLECTION - ELECTRIC MOTORS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _ I-D NO:_ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _ _

NAME PLATE DATA:

Motor Data: Mfr:_ _ _ _ _ _ Mod. No.:_ _ _ _ Frame Type _ _ _ _

Motor Identification No._ _ _ _ _ _ _ _ _ _ _ _Serial No._ _ _ _

HP_ _ _ _ _ _ _ Volts:_ _ _ _ _Amps:_ _ _ _ _ Phase:_ _ _RPM: _ _

Equipment Driven Data:

Type of Equipment Driven:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Equipment Identification No._ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Manufacturer_ _ _ _ _ _ _ _ _ _ _ _ _ _Mod. No._ _ _ _ _ _

Serial No._ _.

AUDIT DATA:

	Measured	Assumed	Calculated
Volts:	_ _ _ _	_ _ _ _	
Amperes:	_ _ _ _	_ _ _ _	
Power Factor:	_ _ _ _	_ _ _ _	
Watts:	_ _ _ _	_ _ _ _	_ _ _ _ _ _
Operation, Hrs/Day:	_ _ _ _	_ _ _ _	
Operation, Days/Week:	_ _ _ _	_ _ _ _	

DATA COLLECTION - ELECTRIC MOTORS   SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC   BUILDING NO:_ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO:_ _ _ _ _ I-D NO:_ _ _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _ _

<u>CONDITIONS</u>:

<u>Service</u>:_ _

<u>Operation Being Performed</u>: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

<u>Equipment Condition</u>: _

<u>COMMENTS</u>:_ _

_ _

_ _

CONDUCTED BY:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _DATE:_ _ _ _ _ _ _ _ _ _ _ _

E.3. DATA ANALYSIS - ELECTRIC MOTORS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _ _

MOTOR LOAD DATA:

Volts:_ _ _ _ _ _ _ _ _ _ Amperes:_ _ _ _ _ _ _ _ _ Watts: _ _ _ _

POWER FACTOR: (3-Phase)

Calculated if watts, volts, and amps have been measured:

$$\frac{\text{watts}}{\text{volts} \times \text{amps} \times 1.732} = \_\_\_\_\_\_, \text{ power factor}$$

Power factor from manufacturer's data_ _ _ _ _ _ _ _ _ _ _ _ _.

CALCULATIONS BY: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _ _

MOTOR LOAD (INPUT):

$$\text{Motor Load (3-Phase)} = \frac{\text{Volts} \times \text{Amps} \times \text{PF} \times \sqrt{\text{Phase}}}{1000} = \_\_\_\_$$

$$= \frac{\_\_\,v \times \_\_\,a \times \_\_\,PF \times 1.732}{1000} = \_\_\_\_ \text{ KW}$$

MOTOR LOAD (OUTPUT):

$$\text{Motor Load} = \frac{\text{KW} \times \text{Efficiency}}{0.746} = \_\_\_\_\_\_\_\_\_\_\_\_\_ \text{HP}$$

MOTOR LOADING FACTOR OR EQUIPMENT LOADING RATIO

$$\text{Motor Loading Factor*} = \frac{\text{Measured Input KW}}{\text{Name Plate Input KW}} \text{ or } \frac{\text{Measured HP}}{\text{Name Plate HP}}$$

MLF = (__________________) = _ _ _ _ _ _ _

( ) = _ _ _ _ _ _ _

*If over 1.0, the motor is overloaded. If under 0.6, the motor is underloaded.

E.4 POWER FACTORS

APPROXIMATE POWER FACTORS - MOTOR OPERATING AT RATED FULL-LOAD

Motor Rating Hp	Power Factor: Conventional	Power Factor: High Efficiency
5	.79	.87
7.5	.80	.88
10	.81	.88
15	.82	.88
20	.83	.88
25	.83	.88

APPROXIMATE POWER FACTORS - CONVENTIONAL MOTORS OPERATING AT LESS THAN RATED FULL-LOAD

Motor Rating, %	Power Factor
100	.80
75	.74
50	.62
25	.44

E.5 MOTOR EFFICIENCIES - FULL LOAD

APPROXIMATE MOTOR EFFICIENCIES - MOTOR OPERATING AT RATED FULL-LOAD

Motor Rating Hp	Efficiency % Conventional	Efficiency % High Efficiency
5	83	87
7.5	85	88
10	86	89
15	87	90
20	88	91
25	89	91

E.6 ECONOMIC EVALUATION - ELECTRIC MOTORS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _ _

ECONOMIC EVALUATION OF MOTOR LOAD CORRECTION:

Proposed Corrective

Action: _

_ _

_ _

Estimate of Installed Cost: $ _ _ _ _ _ _ _ _ _ _ _ _ _ _

SAVINGS FROM MOTOR LOAD CORRECTION:

If the motor load factor is 0.6 or less, select a possible replacement motor whose horsepower rating just exceeds the measured load and complete the following:

	HP	Efficiency	KW Input = $\frac{\text{HP x 0.746}}{\text{Efficiency}}$
Existing Motor	_ _	_ _ _ _	_ _ _ _
Proposed Motor	_ _	_ _ _ _	_ _ _ _

Power Savings = Existing Motor - Proposed Motor = _ _ KW Savings (if possible)

ECONOMIC EVALUATION - ELECTRIC MOTORS SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO: _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ _ _ I-D NO: _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL _ _ _ _ BAY _ _ _ _

$$\frac{W}{1000} \times \frac{\text{Hours}}{\text{Days}} \times \frac{\text{Days}}{\text{Years}} = \text{KWH Saved/Year}$$

_ _ _ _ _ KWH Saved x _ _ _ _ $/KWH = $ _ _ _ _ _ Saving/Year

PAYBACK FOR MOTOR LOAD CORRECTION

$$\text{Payback Period (Years)} = \frac{\text{Installed Cost}}{\text{Annual Savings}} = \frac{\$\_\_\_\_}{\$/\text{yr}} = \text{Years}$$

COMMENTS: _

_ _

_ _

_ _

ECONOMIC EVALUATION BY: _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _

CHECKLIST - - ELECTRIC MOTORS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ _BAY_ _ _ _

Before evaluating specific electric motors or operations it is desirable to refer to the following checklist. Although no specific forms applying to each point is presented in this guide, a specific problem may be addressed and several alternatives compared to check for their economic feasibility.

	Applies Yes	Applies No
1. The electrical distribution system should have a power factor 85% or higher. If lower, it is usually due to inductive loads like electric motors. Correction can be achieved by using synchronous motors and/or system capacitors or individual motor capacitors. While the distribution system is not part of this audit, its power factor affects both motor and distribution capacity. Evaluation: _		

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ _BAY_ _ _ _

	Applies	
	Yes	No
2. The motor and system power factors are affected by running many individual motors partly loaded. If the data analysis shows a motor load factor of 0.60 or lower, and if the motor is known not to exceed that load, determine the true horsepower requirement. This will yield a power factor improvement when the motor is replaced with a smaller one. Evaluation: _		
3. If a motor or group of motors runs lightly loaded most of the year full power is needed occasionally, it (they) usually cannot be replaced with smaller ones. Consider a motor capacitor or a capacitor for the group. Evaluation: _		

APPENDIX F

FANS

F.1 INTRODUCTION

Fans are used to circulate gas or air in low pressure systems and are usually one of three types; namely, centrifugal, axial, or propeller. The centrifugal fan is the most widely used. Applications of the axial fan are increasing in the U.S. The propeller fan can move large quantities of air but does not produce any significant pressure increase.

F.2 FAN LAWS

In a system, the following fan laws hold:

1. The capacity is directly proportional to the speed. Increase the speed of Fan A from 200 rpm @ 70,000 cfm to a speed of 250 rpm. Calculate the change in capacity.

$$70{,}000 \times \frac{(250)}{(200)} = 87{,}500 \text{ cfm}$$

2. The pressure (static, velocity, or total) is proportional to the square of the fan speed. If the static discharge pressure of Fan A was 1 in of water at 200 rpm, calculate the new static pressure.

$$1 \times \frac{(250)^2}{(200)^2} = 1.56 \text{ in water}$$

3. The horsepower required is proportional to the cube of the fan speed.

If the air horsepower of Fan A was 11 hp, calculate the new air horsepower.

$$11 \times \frac{(250)^3}{(200)^3} = 21.5 \text{ hp.}$$

It is also important to recognize that since the duct velocity is directly proportional to the duct flow (capacity), and capacity is directly proportional to the fan speed, then:

3a. The horsepower is proportional to the cube of the flow.

If the duct velocity can be reduced by 1/2 then the fan power can be reduced to 1/8.

Three other laws are:

4. At constant discharge pressure, the speed, capacity and horsepower are inversely proportional to the square root of the density.

5. At constant speed and capacity, the pressure and the horsepower are proportional to the density of the air.

6. At constant weight delivered, the capacity, speed and pressure are inversely proportional to the density and the horsepower is inversely proportional to the square of the density.

F.3 ANNUAL FAN ENERGY

In calculating Kwh for figure F-1 the following formulas were used.

$$HP_{air} = \frac{hs/12(62.4)\ CFM}{33,000} = \frac{hs\ (CFM)}{6,350}$$

h_s = Static Pressure in inches of H_2O

CFM = Cubic feet per minute of air delivered

$$\text{Motor HP in} = \frac{HP_{air}}{E_{fan} \times E_{motor}}$$

(Assume E_{fan} = .6, E_{motor} = .85)

Annual kwh = Motor HP x 0.746 = 8760 hrs/yr

Sample calculation:

Fan, 100,000 cfm, discharge pressure (static) is 1 inch of water, operates 3000 hours per year. Estimate the electric power requirements (Kwh)

$$HP_{air} = \frac{1(100,000)}{6350} = 15.75\ \text{hp}$$

$$\text{Motor } HP_{in} = \frac{15.75}{.6x.85} = \frac{15.75}{.51} = 30.9\ \text{hp}$$

$$\text{Annual Kwh} = 30.9\ \text{hp} \times \frac{.746\ \text{kw}}{\text{hp}} \times 3000\ \text{hrs /year} = 69154\ \text{Kwh.}$$

Using Figure F-1:

Determine the kilowatts hour on the basis of each 1000 cfm. At 1000 cfm draw a vertical line to the 1"S.P. line. From that point read to the left, annual Kwh = 2000.

Then

$$\frac{2000\ \text{Kwh}}{1000\ \text{cfm}} \times \frac{3000}{8760} \times 100{,}000\ \text{cfm}$$

= 68493 Kwh (which is reasonable when compared to the calculation).

F.4 FAN MOTOR SELECTION FOR CENTRIFUGAL FANS

For centrifugal fans, the fan maximum horsepower and the starting torque should be considered when selecting the fan motor. In an effort to minimize the electric motor size, it is possible that the motor will not be able to accelerate the fan wheel without damaging the motor.

Before equipment changes are made, the fan wheel inertia and the starting torque of the motor should reviewed.

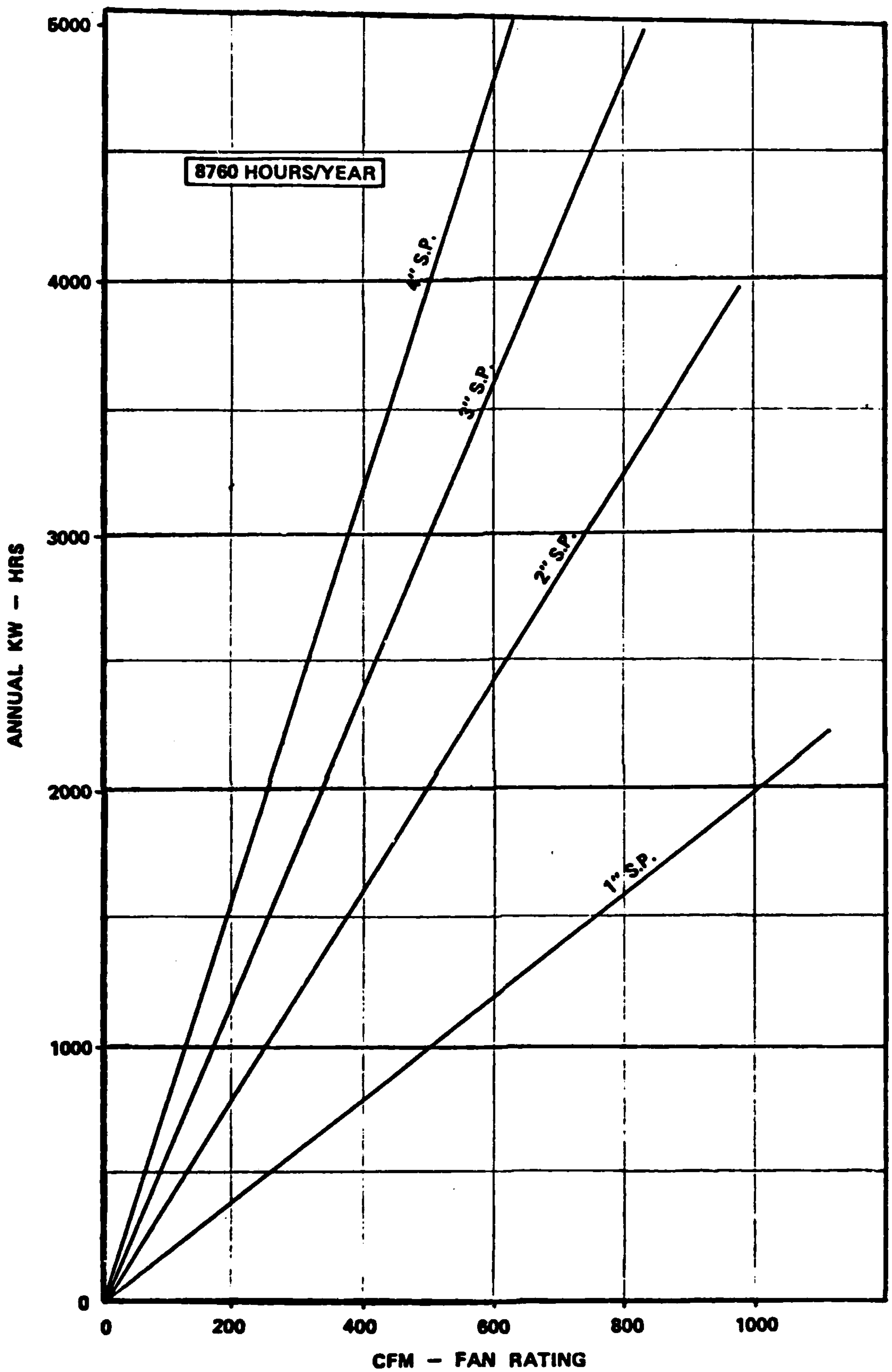


FIGURE F-1
ANNUAL FAN ENERGY – KWH

Prepared by Syska and Hennessy, Inc.

APPENDIX G

FURNACES - FIRED HEAT EXCHANGERS

G.1 DATA COLLECTION HEAT TREAT FURNACES/OVENS SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ BAY_ _ _

(Cross-Out Inappropriate Items)

AUDIT DATA:

Stack Exhaust_ _ _ _ °F before Economizer
_ _ _ _ _ °F After Economizer

_ _ _ _ °F In
_ _ _ _ °F Out

Heat Losses
Air_ _ _ _ °F
Fuel, Type_ _ _ _ _ Rating_ _ _ _ CFH GPM KW

Heat Loss Data: Surface Temps_ _ _ _ _ _ _ °F Vert
_ _ _ _ _ _ _ °F Horiz

Economizer:_ _ _ _ Yes_ _ _ _ _No

Fuel:_ _ _ _ _ _ _ _ _ Heating Value_ _ _ _ _ _ _ _ _ _ _ _

Flue Gas Composition: % Vol: CO^2_ _ O_2_ _ CO_ _ HC_ _ N_2_ _

Operation: Batch:_ _ _ _ _Firing Rate:_ _ % of Full Firing Rate

PRODUCT DATA:

Batch Weight_ _ _ _ _lbs Sp Ht_ _ if data are not available for a specific steel and temperature range, use 0.17 Btu/lb-°F.

OPERATION CYCLES:

Hrs/Batch_ _ _ _ _ _ Batches/Day_ _ _ _ _ Batches/Yr_ _ _ _ _ _

Time Idle Hot_ _ _ _ _ _Hrs/Yr_ _ _ _ _ Time Idle Cold_ _ _Hrs/Yr

FLOOR DIMENSIONS:

Length_ _ _ _ _ _ _
Width_ _ _ _ _ _ _
Floor Area_ _ _ _ _ _ _

CONDUCTED BY:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE:_ _ _ _ _ _

G.2 DATA ANALYSIS - HEAT TREAT FURNACES/OVENS SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _ I-D NO:_ _ _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ BAY_ _ _ _

(Cross-Out Inappropriate Items)

CYCLE EFFICIENCY:

Heat Input to Charge:
lbs x Sp Ht x Temp. Rise ^oF = _ _ _ _ _ Btu/Charge

Heat Input to Furnace:

Hrs Op'n x Fuel CFH x Btu/1000 CF =_ _ _ Btu/Furnace Cycle

Furnace Efficiency =

$$\frac{\text{Heat Input to Charge x No. Charges/Cycle}}{\text{Heat Input to Furnace Cycle}} \times 100 = \_\ \_\ \_\%\ \text{Efficiency}$$

PERCENT EXCESS AIR CALCULATION:

$$\text{Excess Air} = \frac{3.78(O_2 - CO/2) \times 100}{N_2 - 3.78(O_2 - CO/2)} = \%,\ \text{flue gas expressed as }\%100.$$

Percent Excess Air Recommended _ _ _ _%(See Table G-1)

CALCULATIONS BY:_ _ _ _ _ _ _ _ _ _ _ DATE:_ _ _ _ _ _ _

DATA ANALYSIS - HEAT TREAT FURNACES/OVENS

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _ _ I-D NO:_ _ _ _ _ _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ BAY_ _ _ _

CONSIDERATION FOR INSULATION IMPROVEMENT:

	Inches	R-Value
Refractories: (See Table G-2)	_ _ _ _	_ _ _ _ _
Insulation:	_ _ _ _	_ _ _ _ _
Outside Air Film		_ _ 0.63_
	Total:	_ _ _ _ _

Heat Transmission Coefficient ("U" value = 1/R = Btu/h/sq. ft/^{O}F)

OPERATING CONDITIONS

Total Outside Oven Wall Area: _ _ _ _ _ _ _ _ sq. ft.

Operating Oven Temperature: _ _ _ _ _ _ _ _ deg. F

Operating Hours/Year _ _ _ _ _ _ _ _ hours/yr

Average Room Temperature _ _ _ _ _ _ _ _ deg. F

PRESENT OVEN WALL HEAT LOSS

"u" x Outside Oven Wall Area x (Operating Temperature - Ambient Temperature) x Operating Hours/Year

$$= \_\_\_\_\_\_ \text{ Btu/yr.} \times \frac{1}{1{,}000{,}000} = \_\_\_\_\_\_ \text{ MBtu/yr}$$

CALCULATIONS BY _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE _ _ _ _ _ _

DATA ANALYSIS - HEAT TREAT FURNACES/OVENS SHEET 3 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _ I-D NO:_ _ _ _ _ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ BAY_ _ _ _

CONSIDERATION FOR INSULATION IMPROVEMENT

PROPOSED OVEN WALL CONSTRUCTION

	Inches	R-Value
Present Wall:		_ _ _ _
Ceramic Wall Insulation:	_ _ _ _	_ _ _ _
	Total:	1/R = "U" new

PROJECTED OVEN WALL HEAT LOSS

"U" new x Outside Oven Wall Area x (Operating Temperature - Ambient Temperature) x Operating Hours/Year = _ _ _ _ _ _ _ _ _ _Btu/yr.

PROJECTED SAVINGS

Heating Energy Savings = Present Oven Wall Heat Loss- Projected Oven Wall Heat Loss = _ _ _ _ _ _ _ _ _ Btu/yr x $\frac{1}{1,000,000}$ = MBtu

Equivalent Fuel Energy Savings = Heating Energy Savings (_ _ _ _ MBtu)/(MBtu/Unit Fuel Type)

Cost Savings = Heat Energy Savings (MBtu) x $/MBtu = $ /year saved

CALCULATIONS BY: _ _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _ _ _

ECONOMIC ANALYSIS HEAT TREAT FURNACES/OVENS SHEET 1 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _ _ _I-D NO:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

FUEL SAVINGS DUE TO REDUCING EXCESS AIR: (See Figure J-3)

Percent Excess Fuel Required_ _ _ _ _ _ _ _ _ _ _ _ _ _%

Proposed Excess Fuel Required_ _ _ _ _ _ _ _ _ _ _ _ _ %

Fuel Efficiency Improvement (FEI)_ _ _ _ _ _ _ _ _ _ _ _%

FEI $\frac{\_\_\_\_\_\_\_\%}{100}$ x_ _ _ _Fuel Consumed/Year = _ _Fuel Saved/Year

Unit Fuel Saved x MBtu/Unit Fuel $_ _ _ /MBtu = $_ _ Saved/Year

INSULATION ECONOMICS:

	Original	New Insulation
Heat-Up Time	_ _ _ hrs	_ _ _ hrs
Heat-Up Fuel Used	_ _ _ units	_ _ _units
Fuel Used Normal Running	_ _ _units	_ _ _units
Fuel Used_ _ _ hrs/day	_ _ _units	_ _ _units

Fuel Saved/Day_ _ _ _ _ Unit Fuel x_ _ _ No. of Day/Year =

Units Fuel Saved/Year x MBtu's/Unit Fuel

MBtu's Fuel Saved/Year x_ _ _ $/MBtu =_ _ _$/Year Saved

Units are cubic feet for gas and gallons for fuel oil.

CALCULATIONS BY:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _DATE:_ _ _ _ _ _ _

ECONOMIC ANALYSIS HEAT TREAT FURNACES/OVENS SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _ _ I-D NO:_ _ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ _BAY_ _ _

SAVINGS DUE TO HEAT RECOVERY

_ _ _ _ Exhaust Gas Recirculation

_ _ _ _ Process Heat Recovery From Exhaust Gas

_ _ _ _ Combustion Air Preheat System (Stack Recuperator)

Comments:_ _

_ _

_ _

_ _

_ _

CALCULATIONS BY:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _DATE:_ _ _ _ _ _ _ _ _

AD-A131 117 ENERGY CONSERVATION GUIDE FOR INDUSTRIAL PROCESSES(U) 5/5
SYSKA AND HENNESSY INC NEW YORK JAN 81
N62472-78-C-1059

UNCLASSIFIED F/G 5/3 NL

END
FILMED
DTIC

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE G-1

G.4 INDUSTRY GUIDELINES FOR PERCENT CO_2 AND EXCESS AIR

MAXIMUM CO_2 RANGES FOR COMMON FUELS

Fuel	% CO_2 By Volume
Blast furnace gas	24.6 - 25.3
Bituminous coal	17.7 - 19.3
Anthracite coal	19.3 - 19.85
Coke oven gas (CO 6%)	9.23 - 10.6
Natural gas	11.6 - 12.7
Oil	14.25 - 16.35
Wood	20.1 - 20.5

USUAL AMOUNT EXCESS AIR SUPPLIED TO FUEL-BURNING EQUIPMENT

Fuel	Type of Furnace or Burners	Excess Air % by Weight
Blast Furnace gas	Intertube nozzle-type burners	15-18
Coal	Spreader stoker	30-60
	Water-cooled vibrating-grate stoker	30-60
	Chain-grate and traveling-grate stokers	15-50
	Underfeed stoker	20-50
Natural, coke - oven, and refinery gas	Register-type burners	5-10
	Multifuel burners	7-12
Fuel Oil	Oil burners, register type	5-10
	Multi fuel burners and flat-flame	10-20
Wood	Dutch oven (10-23% through grates) and Hofft-type	20-25

Source: Steam, Thirty-Ninth Edition, The Babcock and Wilcox Company, 1978

TABLE G.2

G.5 Mean Thermal Resistivity ((sq ft) (hour) (deg F) (in. Thickness) per Btu) of Typical Refractories

Refractory Type	Mean temperatures between the hot and cold face, deg. F						
	200	400	800	1200	1600	2000	2400
Alumina (fused)	...	0.05	0.05	0.04	0.04	0.03	0.03
Chrome	...	0.13	0.11	0.10	0.09	0.08	0.08
Fire clay (high-heat duty)	0.20	0.17	0.14	0.13	0.10	0.09	0.08
Fire clay (super duty)	0.17	0.14	0.13	0.11	0.10	0.08	0.08
High-alumina	0.17	0.14	0.13	0.11	0.10	0.08	0.08
Kaolin	...	...	0.09	0.08	0.08	0.08	0.07
Magnesite	...	0.03	0.03	0.03	0.04	0.04	0.04
Refractory proceloin	...	0.07	0.07	0.06	0.06	0.05	0.05
Silica	...	0.13	0.10	0.08	0.08	0.07	0.07
Silicon carbide (clay bonded)	...	...	0.01	0.01	0.02	0.02	0.02
Sillimanite (mullite)	...	0.10	0.09	0.08	0.08	0.07	0.07
Insulating fire-brick (2600F)	...	0.63	0.50	0.50	0.31	0.26	...

Source: Derived from: Standard Handbook for Mechanical Engineers, Seventh Edition, McGraw-Hill Book Company, 1967.

APPENDIX H

AIR COMPRESSORS

DATA COLLECTION - COMPRESSED AIR SHEET 1 OF 3

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION: FL_ _BAY_ _ _

NAME PLATE DATA:

Manufacturer:_ _ _ _ _ _Mod. No._ _ _ _ _ _Ser. No._ _ _ _ _

Horse Power:_ _ _ _ _ _ Max Capacity: _ _ _ _ _ _ _ _ _ _ CFM

Nominal Discharge Pressure:_ _ _ _psi Press. Set Points: High_ _

Low_ _ _

No. of Stages:_ _ _ _ _ _ _ _ _ _ _ _ _ Year Built:_ _ _ _ _ _ _ _ _

AUDIT DATA:

Condition of Equipment:_ _

_ _

_ _

Name Plate CFM:_ _ _Name Plate Amps:_ _ _ _Name Plate Volts _ _

Actual Amps:_ _ _ _ _ _ Comp. Disch. Press:_ _ _ _ _ _ _ _ _psi

Compressed Air Generation (Actual):_ _ _ _ _ _ _ _ _ _ _ _ _ CFM

$$\frac{\text{Name Plate CFM}}{\text{Name Plate Amps}} = \frac{(\qquad\qquad)\ \text{Actual CFM}}{\text{Actual Amps}}$$

$$\text{CFM Actual} = \frac{\text{Name Plate CFM } (\qquad) \times \text{Actual Amps } (\quad)}{\text{Name Plate Amps}} = \_\ \_ \text{ CFM}$$

Operating hours/day_ _ _ _ _ _ _ _ _ _ _

Operating days/week_ _ _ _ _ _ _ _ _ _ _

DATA COLLECTION - COMPRESSED AIR

DEPT. OF NAVY - NAVFAC   BUILDING NO:_ _ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO:_ _ _ _ _ I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _   LOCATION: FL_ _ _BAY_ _ _

GENERAL SYSTEM LEAKAGE: If no major leaks can be located but leaks are suspected, collect the following data during non-working hours when there is no compressed air demand.

Actual Time	Load Rating	Elapsed Time	Percent of Total Elapsed Time	Amperes
_ _ _ _	Idle (no Load)	_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _
_ _ _ _	1/4 Load	_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _
_ _ _ _ _	1/2 Load	_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _
_ _ _ _ _	3/4 Load	_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _
_ _ _ _ _	Full Load	_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _
Total Elapsed Time		_ _ _ _ _	100%	

PRESSURE REDUCTION:

Note: It is energy wasteful to compress air to the pressure requirement of the highest pressure and reduce it for all others. By this data collection we estimate the volume of lower pressure air usage and perhaps its analysis justify the purchase of a lower pressure compressor to satisfy the demand.

DATA COLLECTION - COMPRESSED AIR

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _ _ I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ LOCATION: FL_ _ _BAY_ _ _

	Pressure (psig) Min.	Max.	Volume cfm
System Air Pressure	____	____	_____
High Pressure Required	____	____	_____
1st Reduced Pressure Required	____	____	_____
2nd Reduced Pressure Required	_____	_____	_____
3rd Reduced Pressure Required	_____	_____	_____

HEAT RECOVERY-COMPRESSION: BASIC DATA

Compressor Size:_ _ _ _ _ _ _ _ _ _ _HP

Air Pressure:_ _ _ _ _ _ _ _ _ _ _ _ psig

Air discharge temperature:_ _ _ _ _ _ _ _ _ _ °F

COOLING WATER: TEMPERATURES

Oil-cooler: _ _ _ _ _ _ °F inlet; _ _ _ _ _ _ °F outlet

Aftercooler: _ _ _ _ _ _ °F inlet; _ _ _ _ _ _ °F outlet

Intercooler: _ _ _ _ _ _ °F inlet; _ _ _ _ _ _ °F outlet

Jacket/Head: _ _ _ _ _ _ °F inlet; _ _ _ _ _ _ _°F outlet

Jacket/Head: _ _ _ _ _ _ °F inlet; _ _ _ _ _ _ _°F outlet

Jacket/Head: _ _ _ _ _ _ °F inlet; _ _ _ _ _ _ _°F outlet

Jacket/Head: _ _ _ _ _ _ °F inlet; _ _ _ _ _ _ _°F outlet

Observe which cooling water items are piped in series. Series piping, when feasible, provides higher temperature in the cooling water and prevents condensation in the compressor cylinders. Check before changing.

CONDUCTED BY:_ _ _ _ _ _ _ _ _ _ _DATE:_ _ _ _ _ _ _ _ _ _ _ _

H.2 ECONOMIC ANALYSIS - COMPRESSED AIR

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _

ENERGY CONSERVATION AUDIT SHOP NO:_ _ _ _ _I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ LOCATION: FL_ _ BAY_ _ _

GENERAL SYSTEM LEAKAGE:

Fraction of total elapsed time idling x 0 cfm = 0

Fraction of total elapsed time at 1/4 load x 1/4 load cfm = _ _ _ _

Fraction of total elapsed time at 1/2 load x 1/2 load cfm = _ _ _ _

Fraction of total elapsed time at 3/4 load x 3/4 load cfm = _ _ _ _

Fraction of total elapsed time at full load x full load cfm = _ _ _ _

Estimated leakage, cfm = _ _ _ _

PRESSURE REDUCTION, BHP ANALYSIS

	Pressure (psig) Min.	Pressure (psig) Max.	Volume cfm	BHP 100 cfm
System Air Pressure	_ _ _	_ _ _	_ _ _ _	_ _ _ _
High Pressure Required	_ _ _	_ _ _	_ _ _ _	_ _ _ _
1st Reduced Pressure Required	_ _ _	_ _ _	_ _ _ _	_ _ _ _
2nd Reduced Pressure Required	_ _ _	_ _ _	_ _ _ _	_ _ _ _
3rd Reduced Pressure Required	_ _ _	_ _ _	_ _ _ _	_ _ _ _

CALCULATIONS BY: _ _ _ _ _ _ _ _ _ _ _ DATE: _ _ _ _ _ _ _ _

ECONOMIC ANALYSIS - COMPRESSED AIR   SHEET 2 OF 2

DEPT. OF NAVY - NAVFAC   BUILDING NO:_ _ _ _ _ _

ENERGY CONSERVATION AUDIT   SHOP NO:_ _ _ _ _I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _   LOCATION: FL_ _ BAY_ _ _

The following formulas enable one to analyze the operation for potential energy savings. Data necessary to complete these calculations appear on the previous pages.

SAVINGS DUE TO LEAKAGE REDUCTION:

$\frac{\text{CFM (Est. Leakage)}}{\text{CFM (Max.)}}$ x rated HP x 0.746 = _ _ _ KW Saved

_ _ _KW x_ _ _hours/day x_ _days/year =_ _ Kwh/year saved

_ _ _Kwh/year saved x _ _ _$/Kwh = _ _ _$/year saved

SAVINGS DUE TO AIR PRESSURE REDUCTION:

$\frac{\text{Rated CFM}}{\text{100 CFM}}$ x_ _ _ _ _ _ _% full load x _ _ _ _ _ _ HP/100

HP/100 CFM Reduction x_ _ _ _ _hr/year operation x 0.746 KW/HP x

_ _ _ $/per Kwh = $_ _ _ _ _ _ _ _savings/year.

SAVINGS DUE TO HEAT RECOVERY:

_ _ _ _gal/hr x 8.34 lb/gal x 1 Btu/lb-^{o}F x (T_1 _ - T_2 _)

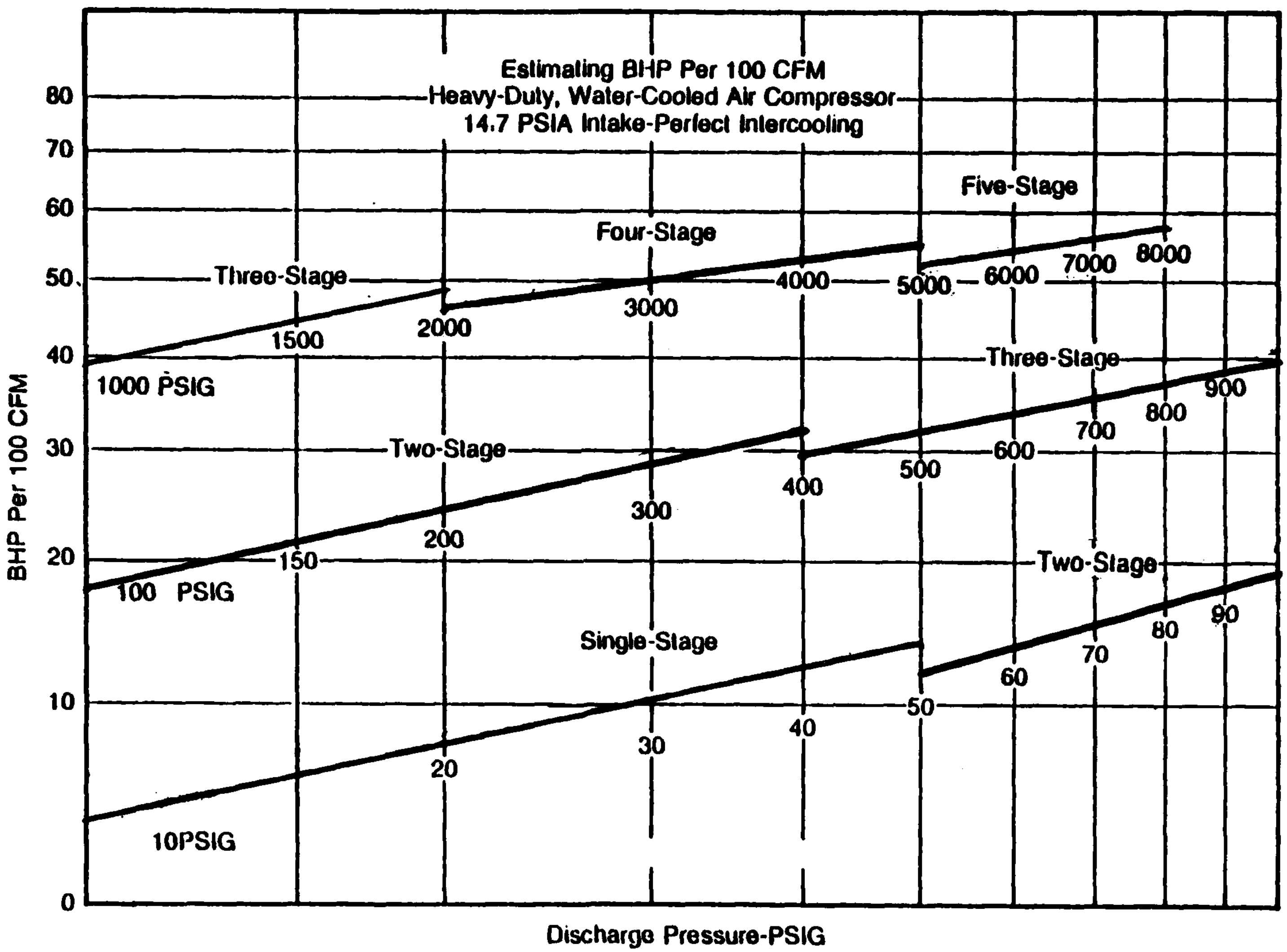
= _ _ _ _ _Btu/hr saved.

_ _ _ _ _ Btu/hr x _ _ _ _ hrs of operation = _ _ _ Btu/yr

$\frac{\text{Btu/yr}}{1,000,000}$ x _ _ _ _ _$/MBtu* = $_ _ _ _ _ Cost Savings/Year

*When the heat saved by collecting and recovering the heat from compressor cooling water will replace steam for heating, use the cost of steam ($/MBTU). Otherwise, use the appropriate value.

CALCULATIONS BY:_ _ _ _ _ _ _ _ _ DATE:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _



Source: Compressed Air and Gas Data, Third Edition, Ingersoll-Rand Company,1980

FIGURE I-7 ESTIMATION OF BHP PER 100 CFM FOR HEAVY-DUTY, WATER-COOLER AIR COMPRESSOR

TABLE H.1

INDUSTRIAL TOOL AIR REQUIREMENTS

Tool	Air Required @ 90 PSIG With 100% Use Factor
2-5#	12 CFM
10-15#	30 CFM
Drills	
1/16-3/8"	25 CFM
1" Wood Borer	40 CFM
2" Wood Borer	80 CFM
Grinders	
4" Horizontal	50 CFM
6" Horizontal	50 CFM
8" Horizontal	50 CFM
5" Horizontal	22 CFM
7" Vertical Sander/Grinder	30 CFM
9" Vertical Sander/Grinder	53 CFM
Hoist	
1000 Pound Capacity	1 Cu. Ft./Ft. of Lift
1-5 Ton Capacity	5 Cu. Ft./Ft. of Lift
Impact Wrench	
1/4" Drive Size	5 CFM
3/8"	5 CFM
1/2"	10 CFM
3/4"	20 CFM
1-1/4"	30 CFM

Tool	Air Required @ 90 PSIG With 100% Use Factor
Angle Nut Setters	
5/16" Capacity	20 CFM
1/2" 3/4" Capacity	30 CFM
Paint Spray Guns	
Average	7 CFM
Range	20-20 CFM
Riveters	
3/32" - 1" rivets larger weighing 18-22 lbs.	12 CFM
Rammers	
1" x 4" cuclinder	25 CFM
1-1/4" x 5" cyclinder	28 CFM
1-1/2" x 6" cyclinder	39 CFM
Screw Drivers	
#2-#6 Screw	5 CFM
#6-5/16" Screw	10 CFM

Source: Compressed Air and Gas Data, Third Edition, Ingersoll-Rand, 19[illegible]

TABLE H-2

COMPRESSED-AIR LEAKAGE

In cubic feet of free air per minute
at standard atmospheric pressure and 70°F

Gage Pressure before Orifice (psig)	Diameter of Orifice				
	1/8"	1/4"	1/2"	3/4"	1"
20	8	31	126	283	503
30	10	41	162	365	648
40	12	50	198	446	793
50	15	59	235	528	938
60	17	68	271	609	1082
70	19	77	307	690	1227
80	21	86	343	771	1371
90	24	95	379	853	1561
100	26	104	415	934	1661
110	28	113	452	1016	1806

Table is based on 100% coefficient of flow. For well rounded entrance multiply values by 0.97. For sharp edged orifices a multiplier of 0.61 may be used for approximate results.

The above was calculated by the following formula:

$$W = 0.5303 \frac{ACp1}{T_1}$$

where: W = discharge in lbs. per sec.

A = area of orifice in sq. in.

c = coefficient of flow

P_1 = upstream total pressure in lbs. per sq. in. absolute.

T_1 = upstream temperature ° abs.

Values used in calculating above table were; C= 1.0,

P_1 = gauge pressure + 14.7 lbs/sq. in.

T_1 = 530°F abs.

Weights (W) were converted to vol·mes using density factor of 0.07494 lbs./cu. ft.

Source: Compressed Air and Gas Data, Third Edition, Ingersoll-Rand, 1980.

APPENDIX I

INDUSTRIAL ENERGY

CONSERVATION DEFINITIONS

Absorption Chiller	A refrigeration machine using heat as the power input, a salt solution such as lithum bromide as an absorbent and water as a refrigerant.
Air Changes	Expression of ventilation rate in terms of room or building volume, usually air changes/hour.
Ambient Temperature	The temperature of the surrounding space or environment.
British Thermal Unit, Btu	A heat unit equal to the amount of heat required to raise on pound of water one degree Fahrenheit.
Centrifugal Chiller	A refrigeration machine using mechanical energy input to drive a centrifugal compressor to generate chilled water.
Centrifugal Fan	A device for propelling air by centrifugal action. Forward curved fan rotor blades are sloped forward relative to direction of rotation. Backward curved blades are generally more efficient.
Condensate	Water obtained by changing the state of water vapor (i.e., steam or moisture in air) from a gas to a liquid, usually by cooling.
Condenser	A heat exchanger which removes latent heat from a vapor changing it to its liquid state.

Condenser, Refrigerant	A heat exchanger which rejects the heat from compressed refrigerant to an appropriate cooling medium.
Conductivity, Thermal	A measure of the thermal-conducting properties of a single material expressed in units of Btu per (hour) (sq ft) (degree F per inch of thickness).
Cooling Tower	A device that cools water directly by evaporation.
Damper	A device used to vary the volume of air passing through an air outlet, inlet, or duct.
Demand Factor	The ratio of the maximum demand of a system to the total connected load of the system under consideration.
Desiccant	A substance possessing the ability to absorb moisture.
Dry-Bulb Temperature	The measure of the sensible temperature of air.
Economizer Cycle	A method of operating an air conditioning system to reduce refrigeration load. Whenever the outdoor air conditions are more favorable (lower heat content) than return air conditions, the outdoor air quantity is increased.
Efficiency of Utilization	The ratio of useful energy to the total energy consumed. Values for estimating are: electric resistance heating = 1; electric heat pump = 2; fuel fired hot water = 0.6; fuel fired steam = 0.7 to 0.8.
Energy	The capacity of a substance, either latent or apparent, to exert force through a distance, i.e., to do work.

Energy, External	The kind of energy represented by the product of pressure and volume.
Energy, Internal	The energy possessed by a substance because of the motion and configuration of its atoms and molecules.
Energy, Kinetic	The energy a substance possesses by virtue of its motion or velocity.
Enthalpy (Heat Content)	The sum of internal and external energies. In practice, it is the sum of latent and sensible heat.
Evaporator	A process unit which adds latent heat to a liquid changing it to a gaseous state. In a refrigeration system, it is the component which absorbs heat by vaporizing a refrigerant.
Heat, Latent	The quantity of heat required to affect a change in state at a constant temperature, vaporization, condensation, melting, or freezing.
Heat Pump, Reverse Cycle	A refrigeration machine possessing the capability of reversing the flow so that its output can be either heating or cooling. When used for heating, it extracts heat from a low-temperature source raising its temperature to the point where it can be used.
Heat, Sensible	Heat transfer that results in a temperature change, but no change in state.
Heat Source	A quantity of heat available for use, expressed in Btu's.

Heat, Specific — Ratio of the amount of heat required to raise a unit mass of material 1 degree to that required to raise a unit mass of water 1 degree.

Heat Transmission — Anyone of a number of coefficients used in the calculation of heat transmission by conduction, convection, and radiation, through various materials and structures. Usually expressed in Btu/hr/sq ft/F. See "U" value.

Humidity, Relative — A measurement indicating moisture content of air, expressed as % of saturation.

Life-Cycle Cost — The cost of equipment over its entire life including material, energy, and maintenance costs.

Load Leveling — Deferment of certain loads to limit electrical power demand to a pre-determined level.

Make-up — Water or other fluid supplied to a system to replace that lost by blowdown, leakage, evaporation, etc.

Orifice Plate — Device inserved in a pipe or duct which causes a pressure drop across it. Depending on orifice size, it can be used to restrict flow or form part of a measuring device.

Orsat Apparatus — A device for measuring the composition of boiler or furnace flue gases.

Orsat Apparatus — A device for measuring the composition of boiler or furnace flue gases.

Power Factor — The ratio W/VA in AC circuits. When the power factor is unity, VA equals W.

R-Value	The resistance to heat flow expressed in units of (sq ft) (hour) (degree F)/Btu; reciprocal of U-Value.
Refuse Derived Fuel (RDF)	Processed municipal refuse, generally with non-combustibles removed, then ground.
Software	Term used in relation to computers, normally describing computer programs.
Ton of Refrigeration	A means of expressing cooling capacity: 1 ton = 12,000 Btu/hour
U-Value	A coefficient expressing the thermal conductance of a composite structure in Btu per (square foot) (hour) (degree F temperature difference).
Vapor Barrier	A moisture-impervious layer designed to prevent moisture migration.
Wet-Bulb Temperature	The lowest temperature attainable by evaporating water in the air without the addition or subtraction of energy. it is measured by a wet bulb psychrometer, and is used with the dry bulb temperature to determine relative humidity.

APPENDIX J

ABBREVIATIONS/SYMBOLS

A, a, or amp(s)	Ampere(s)
AC	Alternating electrical current
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BHP	Brake horsepower
BTU or BTu	British thermal unit
KBTU	Thousands of Btu
MBTU	Millions of Btu
CF or cu ft	Cubic feet
CFM	Cubic feet per minute
1000 CF	Thousands of cubic feet
1000 CFM	Thousands of cubic feet per minute
Chemical Symbols	
CO	Carbon monxide
CO_2	Carbon dioxide
H_2O	Water
N_2	Nitrogen
O_2	Oxygen
COP	Coefficient of performance
CU	Coefficient of utilization
DBT	Dry bulb temperature

DC	Direct electrical current
DEIS	Defense Energy Information System
DIA	Diameter
Dimensions:	
D	Depth
H	Height
L	Length
W	Width
DOD	Department of Defense
ECIP	Energy Conservation Investment Program
EI	Efficiency Improvement
ETAP	Energy Technology Application Program
FC	Foot candles
FT or ft	Feet; linear measure, pressure head
sq ft or ft^2	Square feet - area
Cu ft or ft^3	Cubic feet volume
FY	Fiscal year (Federal starts October 1)
GAL or gal(s)	Gallon(s)
GPM or gpm	Gallons per minute
H	Head of liquid, feet
HID	High intensity discharge lamps
HTHW	High temperature hot water

HVAC	Heating, ventilating, and air conditioning
HZ or hz	Hertz - frequency in cycles per second
ID No.	Identification number (USN)
K	Kilo - prefix for thousands
KVA	Kilovolt ampere(s)
KW	Kilowatt(s)
KWH	Kilowatt hour(s)
LBS or lbs	Pound(s)
MLBS	Thousands of pounds
LPG	Liquefied petroleum gas
M	Millions, e.g., M Btu*
MFR or mfr	Manufacturer's name
MILCON	Military Contruction
MOD. NO.	Model No.
MU	Make-up (Usually water or air)
NAVFAC	Naval Facility

*In some utility billings of gas, it will be reported as MCF meaning thousands of cubic feet of gas.

O.A.	Outside air
OPNAV	Naval Operations
PF	Power Factor (alternating electrical current)
PPM or ppm	Parts per million
PSIA or psia	Pressure (pounds per square inch absolute)
PSIG or psig	Pressure (pounds per squre inch gauge)
Q	Flow in gpm
RDF	Refuse derived fuel
RPM or rpm	Revolutions per minute
S or SG	Specific gravity
SCFM	Standard cubic feet per minute (air or gases)
SER. NO.	Serial No. (of equipment)
SIR	Savings/investment ratio
T	Temperature
TI	Temperature, indoor
TO	Temperature, outdoor
T_1	Temperature, inlet
T_2	Temperature, outlet
TD or T	Temperature difference
V or v	Volts
Vol	Volume
W or w	Watts
WBT	Wet bulb temperature
WT	Weight

APPENDIX K

GENERALIZED FORMS

DATA COLLECTION	For specialized or unique equipment. Data collection includes information found on nameplates, the design document, and the on-site audit. Format to be developed at and by the facility.
SKETCH SHEET	Used to improve the description of the various systems.
DATA ANALYSIS SHEETS	Used to determine if energy savings are feasible.

The data collection and analysis forms should be developed by considering:

a. Items from the checklist sheets.

b. Energy consumption: fuel gas and fuel flow rate, or if electric, the average rated KW.

c. Usage: number of identical units, number of units typically operating, number of hours operated a week.

d. Operating conditions: air flow rates, temperatures, loading rates, utilization of preheat and precool.

e. Applicable systems: can the forms in the Guidebook be used for the pumps, fans, air compressors, etc., associated with the equipment? For example: Section 6.2, Paint-Booths: Are dedicated compressors (Appendix H) used with the spray washers? How are the exhausters (Section 7.2 and Appendix F) operated?

Section 6.3, Paint Dryers and Ovens: Are oven exhaust and make-up air (Section 7.2 and Appendix F) requirements minimized?

Section 6.4, Chilling Well: is a dedicated refrigeration system (Section 8.4) used?

Section 6.5, Heat Treating: A large variety of equipment is available. Equipment operating requirements should be studied carefully. Material can be heated electrically (salt, induction) or it can be heated with fuels? Are fans (Appendix F) and furnaces (Appendix G) involved?

Section 6.6, Machine Tools: Are dedicated pumps (Appendix D) and air compressors (Appendix H) involved?

Section 6.8, Welding: Are cooling systems (Section 8.4) or exhausters (Appendix F) involved?

Section 6.9, Foundry: Often includes equipment listed in Heat-Treating (Section 6.5)

DATA COLLECTION SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ _ _I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ _ BAY_ _ _ _

(DATA COLLECTION FORMAT TO BE DEVELOPED AT THE FACILITY)

NAME PLATE DATA

DESIGN DATA

AUDIT DATA

CONDUCTED BY _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ DATE _ _ _

SKETCH SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ITEM:_ _ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _ I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ _BAY_ _ _ _

SKETCH NO.:_ _ _ _DATE: _ _ _ _ SCALE:_ _ _ _ DRAWN BY:_ _ _ _

DATA ANALYSIS SHEET 1 OF 1

DEPT. OF NAVY - NAVFAC BUILDING NO:_ _ _ _ _ _ _

ENERGY CONSERVATION AUDIT: SHOP NO.: _ _ _ _ _I-D NO:_ _ _

ACTIVITY _ _ _ _ _ _ _ _ _ LOCATION: FL_ _ _ BAY_ _ _ _

(DATA ANALYSIS FORMAT TO BE DEVELOPED AT THE FACILITY)

APPENDIX L

BIBLIOGRAPHY

BOOKS

1. Plant Engineers' and Managers' Guide to Energy Conservation, A. Thurnann, P.E.
   Van Nostrand, Reinhold, 1977

2. Practical Techniques for Saving Energy in the Chemical, Petroleum and Metals Industries.
   Noyes Data Corporation, 1977

3. American Society of Heating, Refrigerating and Air Conditioning Engineers.
   Handbook of Fundamentals, 1972
   Handbook of Fundamentals, 1960
   Systems Volume, 1973

4. Elementary Steam Power Engineering. 3rd Edition.
   John Wiley & Sons, Inc., NY

5. Ingersoll-Rand
   Compressed Air and Gas Data.

6. The Babcox and Wilcox Company.
   Steam - It's Generation and Use. 37th Edition.

7. Practical Heat Recovery,
   John Wiley & Sons

8. The North American Manufacturing Company
   North American Combustion Handbook. 1st Edition.

9. Chemical Milling.
   William T. Harris
   Clarendon Press, Great Britain

APPENDIX L (Cont'd)

Publications and Reports

1. Federal Energy Administration

The Data Base, The Potential for Energy Conservation in Nine Selected Industries. 1974

2. Federal Energy Administration.

Total Energy Management, A Practical Handbook on Energy Conservation and Management. (First Edition)

3. Energy Management, Engineering of Conservation Systems

Roy F. Weston, Inc., 1975

4. Industrial Energy Conservation, 101

Ideas at Work, General Motors Corporation, 1977

5. U.S. Navy Industrial Energy Survey Guide For Industrial Reserve Ordinance Plants, Draft Survey Forms and Description, U.S. Navy Contract N62472-78-C-1060, FluiDyne Engineering Corp., 1978

6. Industrial Energy Survey Guide for the U.S. Naval Shipyard Facilities

Roy F. Weston, Inc., 1978

7. Energy Conservation Guide for Industrial Processes, Prepared for Naval Air Station, Naval Air Rework Facility, Norfolk, Virginia. (Phase I)

U.S. Navy Contract N62470-78-B-3827

Grumman Aerospace Corp., 1978

APPENDIX L (Cont'd)

8. Energy Conservation Guide for Industrial Processes, Prepared for Naval Air Station, Naval Air Rework Facility, Norfolk, Virginia. (Phase II)
U.S. Navy Contract N62470-78-B-3827
Grumman Aerospace Corp., 1978

9. NBS Handbook 121 "Waste Heat Management Guide."

10. Energy Conservation Guide for Industrial Processes, Prepared for Naval Air Station, Naval Air Rework Facility, Norfolk, Virginia. (Phase I and Phase II) U.S. Navy Contract N62470-78-B-3827 Grumman Aerospace Corp., 1978.

11. NBS Handbook 121 "Waste Heat Management Guide." Department of Commerce and Federal Energy Administration, 1977.

12. Guidelines for Saving Energy in Existing Buildings-Building Owners and Operators Manual, ECM-1, Federal Energy Administration (DOE), 1975.

13. Guidelines for Saving Energy in Existing Buildings-Enginers, Architects and Operators Manual, ECM-2, Federal Operators Manual, ECM-2, Federal Energy Administration, (DOE), 1975.

14. NBS Handbook 124, Energy Management in Furnaces, Kilns and Ovens, U.S. Department of Commerce and Federal Energy Administration, 1978.

APPENDIX L (Cont'd)

15. Maintenance Engineering Handbook, Second Edition, L.C. Morrow, McGraw-Hill Book Company, 1966

16. Standard Handbooks for Mechanical Engineers, Seventh Edition, Theodore Baumeister, McGraw-Hill Book Company, 1967

17. Kent-Mechanical Engineer's Handbook, Power Volume, Twelfth Edition.

18. Handbook of Air Conditioning, Heating and Ventilating, C. Strock and R. L. Koral.

*U.S. GOVERNMENT PRINTING OFFICE: 1981/708-919