DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150629

# PRELIMINARY DESIGN PACKAGE FOR PROGRAMMABLE CONTROLLER AND HYDRONIC ENERGY PACKAGE

Prepared from documents provided by

Sunkeeper Control Corporation
P. O. Box 34
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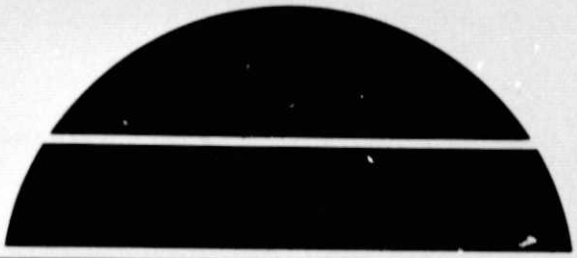
Under Contract NAS8-32257 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy







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This work was done under the technical management of Mr. James Hankins, George C. Marshall Space Flight Center, Alabama.

16. ABSTRACT

This report contains the information necessary to evaluate the preliminary design of the Sunkeeper Controller. Included in this report is a compilation of the following documents: Development Plan, Verification Plan, Hazard Analysis, Drawing List, and other information pertaining to the design of the subsystem.

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# INTRODUCTION

Sunkeeper Control, under NASA/MSFC Contract NAS8-32257, has developed three identical electronic controllers and hydronic packages for use with solar heating, combined heating and cooling, and/or hot water. The systems consist of modular components which may be integrated into a variety of configurations yet housed in a single standard cabinet package. The controller is designed to handle the following applications:

| Type | Size |
|---|---|
| Single Family Dwelling (4 persons) | 2 Zone Heating<br>Hot Water |
| Single Family Dwelling (4 persons) | 4 Zone Heating<br>Hot Water |
| Multi-family Dwelling | 4 Zone Heating<br>Hot Water |
| Multi-family Dwelling | 8 Zone Heating<br>Hot Water |
| Multi-family Dwelling | 16 Zone Heating<br>Hot Water |
| Commercial Buildings | 1 Zone Heating<br>8 Hot Water Supply Systems |
| Commercial Buildings | 8 Zone Heating<br>8 Hot Water Supply Systems |

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# DEVELOPMENT PLAN
# FOR
# INTEGRATED PROGRAMMABLE ELECTRONIC CONTROLLER AND HYDRONICS PACKAGE

SUNKEEPER CONTROL CORPORATION
ANDOVER, MASSACHUSETTS 01810

## 1.0 General

The following plan specifies the tasks to be accomplished to meet the requirements of the Statement of Work (SOW) within the established time frame of the contract. These tasks include the objectives and approaches to be followed for the successful completion of the program.

## 2.0 Objectives and Approaches

The objectives and approaches developed as part of this plan are as follows:

| | Objective | Approach |
|---|---|---|
| 2.1 | Produce drawings and specifications in sufficient detail to insure manufacturing repeatability. | Documentation |
| 2.2 | Produce an Installation, Operation and Maintenance Manual. | Documentation |
| 2.3 | Develop a logical plan for spare parts and maintenance activities. | Analysis and Documentation |
| 2.4 | Develop a Subsystem Test Performance Specification. | Analysis and Documentation |
| 2.5 | Provide provisions to monitor Subsystem Test Performance | Analysis and Documentation |
| 2.6 | Verify Subsystem Test Performance | Similarily, Analysis, Inspection, Test |
| 2.7 | Meet the Interim Performance Criteria for the Subsystem. | Testing, Analysing the Design, Determining Design Changes or Deviations |
| 2.8 | Provide Hardware Evaluation and Certification. | Analysis, Inspection, Similarity, Testing & Certifying. |

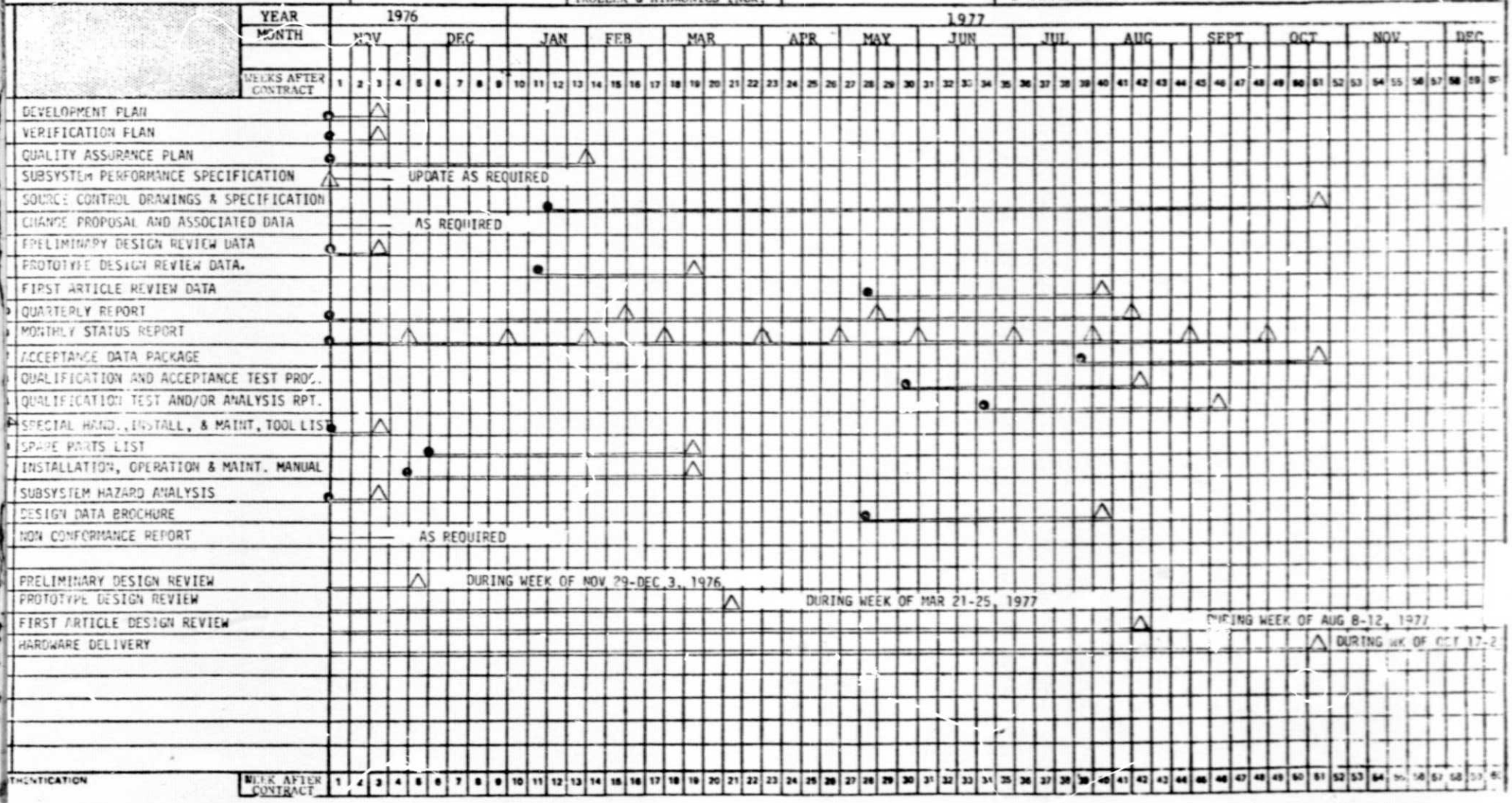
## 3.0 Schedule

3.1 This schedule is established to meet the contract requirements. Any variation that advances the following schedule can be authorized upon agreement with the Program Technical Manager.

| | |
|---|---|
| Preliminary Design Review | During week of 29 NOV to 3 DEC 1976 |
| Quarterly Reveiw | By 15 FEB 1977 |
| Prototype Design Review | During week of 21 MAR to 25 MAR 1977 |
| Quarterly Review | By 13 MAY 1977 |
| First Article Review | During week of 8 AUG to 12 AUG 1977 |
| Quarterly Review | By 15 AUG 1977 |
| Hardware Delivery | During week of 17 OCT to 21 OCT 1977 |

3.2 The attached chart outlines the program schedule for the Integrated Programmable Electronic Controller and Hydronics Package. This chart includes all of the program milestones and their projected start and completion dates.

| PROGRAM SCHEDULE | SYSTEM (PROJECT) NUMBER | SUBSYSTEM INTEGRATED PROGRAMMABLE ELECTRONIC CONTROLLER & HYDRONICS PACK. | TYPE OF SCHEDULE - | AS OF DATE 3 DECEMBER 1976 |
|---|---|---|---|---|




SCHEDULE MILESTONE △ COMPLETED MILESTONE ▲ START ●

# VERIFICATION PLAN
# FOR
# INTEGRATED PROGRAMMABLE ELECTRONIC CONTROLLER AND HYDRONICS PACKAGE

SUNKEEPER CONTROL CORPORATION
ANDOVER, MASSACHUSETTS 01810

# VERIFICATION PLAN

## 1.0 General

This Verification Plan defines the requirements for verifying that the Integrated Programmable Electronic Controller and Hydronic Subsystem complys with Sunkeeper Corporation's (SKC) Subsystem Performance Specifications and design requirements. The Verification Plan will include three (3) verification phases that utilize four (4) verification methods. These verification phases and methods are defined in the following paragraphs.

## 2.0 Verification Phases

### 2.1 Development Phase

The development phase will be used to analyze various design approaches, modular assembly configurations, and performance data from existing subsystems to assure that the selected approach will result in reliable hardware that will function with a high probability of success. This development analysis will be performed early in the program in order to finalize the subsystem configuration and design requirements. Analysis and Similarity verification methods will be used extensively during this phase of the plan.

### 2.2 Qualification Phase

The qualification phase will be used to analyze, inspect and test the subsystem to the design limits this assuring the physical and functional requirements are met. During this verification phase, test specifications will be developed and test equipment designs will be finalized. The data collected during the qualification phase will be utilized as the basis for the development of the Installation, Operation and Maintenance manual, for the evalu-

ation and certification of the subsystem hardware and for the finalization of the subsystem drawing package. Analysis, Similarity, Inspection and Test Verification methods will be used throughout this phase of the plan.

A qualification phase report will be prepared upon the completion of the qualification phase thus documenting the inspection, test and analysis results.

## 2.3 Acceptance Phase

The Acceptance Phase will be used to inspect and test the subsystem to verify that the physical and operational characteristics are within specification. Testing of a complete subsystem will be accomplished by interfacing an appropriately sized subsystem to an array of four solar collector panels (125 sq. ft.). These panels are Ownes Illinois Inc. SUNPAC units installed on the roof of the SKC Corp. facility for development testing. The SKC Corp. test facility has available several forced air over water heaters arranged in zones and the necessary storage tanks, pressure tanks and piping equipment to simulate a dwelling unit. The facility will be configured into one or more dwelling unit configurations, as necessary, instrumented and tested. This testing will be used to demonstrate compliance with performance specifications.

# 3.0 Verification Methods

## 3.1 Similarity Method

The similarity method will be employed when an item has been used in previous applications where the environmental and functional levels are similar to the application for which it is intended and data is available to prove it. Sunkeeper Control Corporation will utilize the data collected from its existing systems in the field to provide a major portion of the supporting data when the similarity method of verification is used.

## 3.2 Analysis Method

The analysis method will be employed when it has been determined that an item will meet the specified requirements through engineering evaluations and analyses. Sunkeeper Control Corporation Engineering staff is fully qualified to perform these evaluations and anayses based on their unique ability to apply state-of-the-art system and control technology to Solar Energy Systems as proven by the performance of existing systems currently in use. The analysis method of verification will be supported by engineering data and rationale used to achieve the analytical result. Independent Certification Sources will be utilized in support of these engineering evaluations and analyses.

## 3.3 Inspection Method

The inspection method will be employed when an item can be verified as complying with the specified requirements through visual methods. Inspection parameters will include physical dimension checks, configuration checks, quality of workmanship checks, etc. The inspection method for verification will verify that the hardware is constructed to Sunkeeper Control Corporation's drawings, specifications and workmanship standards.

## 3.4 Test Method

The test method of verification will be employed to verify operational parameters that cannot be verified by other means to assure that the item meets performance requirements. Tests run during the qualification phase will be at design limits while tests during the acceptance phase will be at expected operating limits. The results of all tests will be documented.

## 4.0 Verification Cross Reference Matrix

The Verification Cross Reference Matrix developed for the Integrated Programmable Electronic Controller and Hydronics Package is shown in Table I. This matrix identifies the specified design requirements, the verification phase and the verification method to be employed as part of the verification plan.

## 5.0 Test Hardware

The test hardware requirements for the verification of the Integrated Programmable Electronic Controller and Hydronics Package is listed in Table II. This listing describes the hardware, the quantity required and the rationale for its use.

## 6.0 Test Levels and Schedule

### 6.1 Development Phase

As indicated in the Verification Cross Reference Matrix there is no testing planned during the Development phase of the Verification Plan. All requirements for verification will utilize the Similarity and Anlsysis methods for verification based on the engineering and system data developed on the existing systems currently in operation at field sites.

### 6.2 Qualification Phase

As indicated in the Verification Cross Reference Matrix there is no testing planned during the Qualification phase of the Verification Plan. All requirements for verification will utilize the Similarity, Analysis and Inspection methods for verification based on engineering and systems data being promulgated from existing systems in operation.

## 6.3 Acceptance Phase

The testing planned during the Acceptance phase of the Verification Plan will be concurrent with the Subsystem Acceptance Test Program. This test program utlizes a simulated habitant interface developed by Sunkeeper Control Corporation that closely approximates actual system operation.

The schedule for start of the Acceptance Tests is 16 September 1977 and will be concluded with the hardware delivery during the period of October 17-21, 1977.

## 7.0 Government Testing

The Integrated Programmable Electronic Controller and Hydronics Package Verification Plan does not require any Government Testing of any of the components, assemblies, units or subsystems.

TABLE I

ITEM (NAME & PART NO.)
Integrated Programmable Electronic Controller and Hydronics Subsystem P/N

# VERIFICATION CROSS REFERENCE MATRIX

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

| PERFORMANCE REQUIREMENT | VERIFICATION PHASE | | | REMARKS |
|---|---|---|---|---|
| | DEVELOPMENT | QUALIFICATION | ACCEPTANCE | |
| 1.2.4 OPERATIONAL IMPAIRMENT (HW only) | N/A | N/A | N/A | |
| 1.5 HABITABILITY OF OCCUPIED SPACES | 1 | 3 | 3 | |
| 1.6 ENERGY TRANSPORT EFFICIENCY | N/A | N/A | N/A | |
| 1.6.1 THERMAL LOSSES AND ELECTRICAL POWER | 1 | 2 | 4 | |
| 1.7 CONTROL | 1 | 1 | 4 | |
| 1.7.1 INSTALLATION AND MAINTENANCE | N/A | N/A | N/A | |
| 1.7.2 MANUAL ADJUSTMENT | N/A | N/A | N/A | |
| 1.7.3 INHABITED SPACE TEMPERATURE | N/A | N/A | N/A | |
| 1.7.4 HOT WATER TEMPERATURE | N/A | N/A | N/A | |
| 2.1.1 EQUIPMENT CAPABILITIES | 1 | 2 | 4 | |
| 2.1.2 NOISE OR ERROSION-CORROSION | 1 | 1 | 3 | |
| 2.1.3 OPERATING CONDITIONS | 1 | 2 | 4 | |
| 2.1.5 ENTRAPPED AIR | N/A | N/A | N/A | |
| 2.1.6 THERMAL EXPANSION OF FLUIDS | N/A | N/A | N/A | |
| 2.1.7 PRESSURE DROPS | 1 | 2 | 4 | |
| 2.2 MECHANICAL STRESSES | 1 | 1 | 3 | |
| 2.2.1 VIBRATION STRESS | 1 | 1 | 3 | |

ITEM (NAME & PART NO.) _____

# VERIFICATION CROSS REFERENCE MATRIX

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

| PERFORMANCE REQUIREMENT | VERIFICATION PHASE | | | REMARKS |
|---|---|---|---|---|
| | DEVELOPMENT | QUALIFICATION | ACCEPTANCE | |
| 2.2.2 VIBRATION FROM MOVING PARTS | 1 | 1 | N/A | |
| 2.2.3 WATER HAMMER | 1 | 1 | 3 | |
| 2.2.4 VACUUM RELIEF PROTECTION | N/A | N/A | N/A | |
| 2.2.5 THERMAL CHANGES | N/A | N/A | N/A | |
| 2.2.6 FLEXIBLE JOINTS | 1 | 1 | 3 | |
| 2.3 LEAKAGE PREVENTION | 1 | 1 | 4 | |
| 2.3.1 PRESSURE TEST: Non Potable Fluids | 1 | 1 | 4 | |
| 2.3.2 PRESSURE TEST: Potable Water | 1 | 1 | 4 | |
| 2.5.1 SHUT DOWN IN MULTI FAMILY HOUSING | N/A | N/A | N/A | |
| 2.6 HEAT TRANSFER FLUID QUALITY | N/A | N/A | N/A | |
| 2.6.1 LIQUID QUALITY | N/A | N/A | N/A | |
| 2.6.3 FLUID TREATMENT | N/A | N/A | N/A | |
| 2.6.4 FREEZING PROTECTION | N/A | N/A | N/A | |
| 2.7 PIPING SUPPORTS | 1 | 3 | 3 | |
| 2.7.1 APPLICABLE PLUMBING STANDARDS | 1 | 1 | 3 | |
| 2.8 EXCESSIVE PRESSURE AND TEMPERATURE PROTECTION | 1 | 2 | 3 | |
| 2.8.1 RELIEF VALVES AND VENTS (H only) | N/A | N/A | N/A | |

TABLE I (con't)

ITEM (NAME & PART NO.) _____

# VERIFICATION CROSS REFERENCE MATRIX

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

| PERFORMANCE REQUIREMENT | VERIFICATION PHASE | | | REMARKS |
|---|---|---|---|---|
| | DEVELOPMENT | QUALIFICATION | ACCEPTANCE | |
| 4.1 PLUMBING AND ELECTRICAL INSTALLATION | 1 | 1 | 3 | |
| 4.1.1 PLUMBING CODES | 1 | 1 | 3 | |
| 4.1.2 ELECTRICAL CODES | 1 | 1 | 3 | |
| 4.2 FAIL SAFE CONTROLS | N/A | N/A | N/A | |
| 4.2.1 SYSTEM FAILURE PREVENTION | N/A | N/A | N/A | |
| 4.2.2 AUTOMATIC PRES-RELIEF VALVES | N/A | N/A | N/A | |
| 4.3 FIRE SAFETY | 1 | 2 | 3 | |
| 4.3.1 APPLICABLE FIRE STANDARDS | 1 | 2 | 3 | |
| 4.4 TOXIC | N/A | N/A | N/A | |
| 4.4.1 PROVISIONS OF CATCH BASINS | N/A | N/A | N/A | |
| 4.4.2 DETECTION OF TOXIC AND FLAMMABLE FLUIDS | N/A | N/A | N/A | |
| 4.5.2 IDENTIFICATION & LOCATION OF CONTROLS | 1 | 3 | 3 | |
| 4.6 PROTECTION OF POTABLE WATER & CIRCULATED AIR | 1 | 2 | 3 | |
| 4.6.1 CONTAMINATION BY MATERIALS | 1 | 2 | 3 | |
| 4.6.2 SEPARATION OF CIRCULATION LOOPS | 1 | 3 | 3 | |
| 4.6.3 BACKFLOW PREVENTION | N/A | N/A | N/A | |

TABLE I (cont'd)

| ITEM (NAME & PART NO.) | VERIFICATION CROSS REFERENCE MATRIX | | | |
|---|---|---|---|---|
| VERIFICATION METHOD: | 1. SIMILARITY | 3. INSPECTION | N/A NOT APPLICABLE | |
| | 2. ANALYSIS | 4. TEST | | |

| PERFORMANCE REQUIREMENT | VERIFICATION PHASE | | | REMARKS |
|---|---|---|---|---|
| | DEVELOPMENT | QUALIFICATION | ACCEPTANCE | |
| 4.6.4 GROWTH OF FUNGI | 1 | 1 | 3 | |
| 4.7 EXCESSIVE SURFACE TEMPERATURES | 1 | 2 | 4 | |
| 4.7.1 PROTECTION FROM HEADED COMPONENTS | 1 | 2 | 3 | |
| 5.1.3 AIRBORNE POLLUTANTS | N/A | N/A | N/A | |
| 5.2 TEMPERATURE AND PRESSURE RESISTANCE | 1 | 2 | 4 | |
| 5.2.1 THERMAL DEGRADATION | N/A | N/A | N/A | |
| 5.2.3 THERMAL CYCLING STRESSES | N/A | N/A | N/A | |
| 5.2.4 LEAKAGE | 1 | 1 | 4 | |
| 5.2.5 DETERIORATION OF GASKETS AND SEALANTS | N/A | N/A | N/A | |
| 5.3 CHEMICAL COMPATABILITY OF COMPONENTS | N/A | N/A | N/A | |
| 5.3.1 MATERIALS/TRANSFER FLUID COMPATABILITY | N/A | N/A | N/A | |
| 5.3.2 CORROSION OF DISSIMILAR MATERIALS | N/A | N/A | N/A | |
| 5.3.3 CORROSION BY LEACHABLE SUBSTANCE | N/A | N/A | N/A | |
| 5.3.4 EFFECTS OF DECOMPOSITION PRODUCTS | N/A | N/A | N/A | |

ITEM (NAME & PART NO.)

# VERIFICATION CROSS REFERENCE MATRIX

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

| PERFORMANCE REQUIREMENT | VERIFICATION PHASE | | | REMARKS |
|---|---|---|---|---|
| | DEVELOPMENT | QUALIFICATION | ACCEPTANCE | |
| 5.4 COMPONENTS INVOLVING MOVING PARTS | 1 | 2 | 3 | |
| 5.4.1 WEAR AND FATIGUE | 1 | 2 | 3 | |
| 6.1 ACCESSABILITY FOR MAINTENANCE | 1 | 3 | 3 | |
| 6.1.1 ACCESS FOR SYSTEM MAINTENANCE | 1 | 3 | 3 | |
| 6.1.2 ACCESS FOR SYSTEM MONITORING | 1 | 3 | 3 | |
| 6.1.3 DRAINING AND FILLING OF LIQUIDS | 1 | 2 | 3 | |
| 6.1.4 FLUSHING OF LIQUIDS SUBSYSTEMS | N/A | N/A | N/A | |
| 6.1.5 FILTERS | N/A | N/A | N/A | |
| 6.2 INSTALLATION, OPERATION AND MAINTENANCE MANUAL | 1 | 3 | 3 | |
| 6.2.1 INSTALLATION INSTRUCTIONS | 1 | 3 | 3 | |
| 6.2.2 MAINTENANCE AND OPERATION INSTRUCTIONS | 1 | 3 | 3 | |
| 6.2.3 MAINTENANCE PLAN | 1 | 3 | 3 | |
| 6.2.4 REPLACEMENT PARTS | 1 | 3 | 3 | |
| 6.3 REPAIR AND SERVICE PERSONNEL | 1 | 2 | 3 | |
| 6.3.1 MAINTENANCE OF H AND HC SYSTEMS | 1 | 2 | 3 | |

TABLE I (con't)

ITEM (NAME & PART NO.) _____

## VERIFICATION CROSS REFERENCE MATRIX

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

| PERFORMANCE REQUIREMENT | VERIFICATION PHASE | | | REMARKS |
|---|---|---|---|---|
| | DEVELOPMENT | QUALIFICATION | ACCEPTANCE | |
| 6.3.2 MAINTENANCE OF DHW SYSTEM | 1 | 2 | 3 | |
| 11.2.1 CHEMICAL CORROSION | 1 | 2 | 3 | |
| 11.2.2 HEAT AND MOISTURE | N/A | N/A | N/A | |

TABLE II

| DESCRIPTION | QTY | RATIONALE |
|---|---|---|
| Air Compressor (125 LB/IN$^2$) | 1 | To perform the pressure and leak checks on the Hydronics Subsystem. |
| Controller Test Box | 1 | To simulate the inputs to the Controller Assembly. |
| Digital Thermometer | 1 | To perform the thermal test requirements. |
| Domestic Hot Water System | 1 | To simulate the habitant interface to the Integrated Programmable Electronic Controller and Hydronics Package. |
| Flow Meter | 1 | To check the flow rates in the outlet lines. |
| Terminal, Portable | 1 | To input the program to the controller memory. |
| Test Manifold | 1 | To simulate the habitant interface to the Integrated Programmable Electronic Controller and Hydronics Package. |
| Thermal Chamber | 1 | To perform accelerated age testing on the Controller Assembly to weed out infant mortality problems. |
| Solar Collector Array Test Bed | 1 | To simulate the habitant interface to the Integrated Programmable Electronic Controller and Hydronics Package. |

# HAZARD ANALYSIS
# FOR
# INTEGRATED PROGRAMMABLE ELECTRONIC CONTROLLER AND HYDRONICS PACKAGE

SUNKEEPER CONTROL CORPORATION
ANDOVER, MASSACHUSETTS 01810

## 1.0 Introduction

### 1.1 Scope and Purpose

The hazard analysis contained herein is intended to evaluate the inherent safety of the Integrated Programmable Electronic Controller and Hydronics Package (IPECHP), and to present a qualitative assessment of potential hazards in installation, operation and maintenance of the equipment. The hazard analysis includes identification and categorization of potential hazards, and a description of the design, procedural and maintenance instructions, and documentation used to assure safe operation of the IPECHP.

### 1.2 Background and Approach

The IPECHP, in its normal operational environment, presents no hazards to the occupants of the facility, since the components/subassemblies are located in a locked cabinet in the utility area.

The initial installation on-site is performed by licensed electricians and plumbers, in accordance with approved safety codes. It should also be pointed out that the basic level of complexity and hazard potential of the electrical and hydronics subassemblies in no greater than typical domestic hot-water heating systems, and therefore, presents no challenge to the state-of-the-art.

## 2.0 Safety Criteria

The intent of the operational concepts of the IPECHP is to provide a completely safe controller and hydronics subsystem that can be installed and maintained by suitably trained personnel without any hazards to personnel, equipment, or structure.

## 2.1 Definitions

The definitions given below are derived from MIL-STD-882, "System Safety Program for Systems and Associated Subsystems and Equipment: Requirements for".

Safety. Freedon from those conditions that can cause injury or death to personnel, damage to or loss of equipment or property.

Systems. A composite, at any level of complexity, of operational and support equipment, personnel, facilities, and software which are used together as an entity and are capable of performing and/or supporting an operation role.

Hazard. Any real or potential condition that can cause injury or death to personnel, or damage to or loss of equipment or property.

## 2.2 Hazard Level Categories

These are qualitative measures of hazards stated in relative terms. MIL-STD-882 established and defines the following categories. The basis is that personnel error, environment, design characterictics, procedural deficiencies, or subsystem/component failure or malfunction:

a. Category I - Negligible

. . . will not resilt in personnel injury or system damage

b. Category II - Marginal

. . . can be counteracted or controlled without injury to personnel or major system damage.

c. Category III - Critical

. . . will cause personnel injury or major damage, or will require immediate corrective action for personnel or system survival.

d. Category IV - Catastrophic

. . . will cause death or sever injury to personnel, or system loss.

## 3.0 Hazard Analysis

This analysis is presented in the narrative form rather than as a matrix or "hazard tree" because of the preliminary nature of the maintenance approach at this time. The basic design concepts of the IPECHP will assure that no nazards exist to personnel occupying the facility during normal operation of the heating and hot-water system.

### 3.1 Hazard Identification

The potential hazards associated with the IPECHP can only occur in the event of a malfunction of the protective devices in the electrical and hydrinics subassemblies, or during maintenance activity which requires personnel access to the IPECHP cabinet. These potential hazards would be identified as indicated below.

a. Personnel - electrical shock, burns, injury due to mechanical malfunctions.

b. Equipment - damage or loss of function due to the component failure. (Damage would require simultaneous component and protective device failure, in the case of the electrical subassembly.

c. Structure - damage or loss of function due to major failure/ malfunction of a component or subassembly.

## 3.2 Source of Hazards

The possible sources of hazards under abnormal or maintenance conditions are enumerated in the following paragraphs.

### 3.2.1 Hazards to Personnel

During maintenance, the components which operate directly from the 115 volt AC power source could present a personnel hazard. These are the pump motors, relays, and the 115 volt/24 volt step-down transformers.

The piping and heat exchager associated with the hydronics subsystem internal to the IPECHP could reach a maximum temperature of 240°F, which could result in severe burns. Additionally, the piping could burst if external pressure regulating/safety controls were to malfunction.

Mechanical hazards to personnel would be sharp edges on cabinets, brackets, or the Controller Assembly enclosure, or heavy subassemblies that are not provided with handles or other suitable gripping means so that they could be inadvertently dropped during maintenance actions.

### 3.2.2 Hazards to Equipment

Under abnormal conditions which could result from failure of protective devices to operate, the IPECHP could suffer wiring damage or burst pipes or leaking couplings/fittings in the hydronics subassembly.

### 3.2.3 Hazards to Structure

The cabinet containing the IPECHP subassemblies could suffer permanent damage under highly abnormal conditions (i.e. component damage). However, because of its construction and the fact that it is

closed and locked during normal operation, there will be no damage to the facility caused by failure of the IPECHP in the extreme and very remote possibility of fire or explosion. Since the materials in the IPECHP are non-flammable and no volatile fluids are used in the system, the cause of a fire or explosion have to come from some malfunction or environmental anomaly external to the IPECHP.

## 3.3 Level of Hazards

### 3.3.1 Severity of Personnel Hazards

Electrical shock to maintenance personnel could be a critical to catastrophic hazard, depending on conditions of skin resistance, etc. Similarly burns from the hydronics components/ assemblies could be minor or major (marginal to critical) depending on the temperature of the part, and whether protective coverings had been removed for inspection purposes.

### 3.3.2 Severity of Hazards to Equipment

Wiring damage and/or burst pipes/fittings could result in system loss, and therefore are categorized as critical to catastrophic (major).

### 3.3.3 Severity of Hazards to Structure

Fire damage to the IPECHP cabinet could be classified as critical to catastrophic, depending on the number of components involved. Water damage from burst pipes would be considered negligible or marginal.

## 3.4 Elimination or Control of Hazards

### 3.4.1 Control of Hazards to Personnel

#### 3.4.1.1 Manufacturing

All internal wiring is connected, inspected and tested by SKC personnel prior to shipment to the installation point. UL listed motors, relays, wiring and other associated parts connected to the 120 volt powerline will be used. The completed IPECHP assembly will be tested for dielectric withstanding voltage ("hipot") capability, and leakage current, in compliance with UL standards. All of the plumbing in the hydronics package is connected, inspected and tested (at 1.5 times the operating pressure) by a licensed steamfitter at SKC prior to shipment.

Areas within the cabinet where voltages in excess of 30 volts AC (r.m.s.) are used are identified with high-voltage warning labels, and are suitably covered to prevent accidental contact by personnel. Similarly, the hydronics subassembly piping is covered with insulation and identified by high temperature warning labels.

A plastic shield is used to isolate the hydronics subassembly, located on the frame of the cabinet, from the controller subassembly, located on the door of the cabinet. All mechanical parts and enclosures have rounded corners and the edges of brackets are rounded to avoid personnel injury.

There is no overpressurization protection within the IPECHP unit. However, the external heating system piping must be designed to include suitable automatic pressure-relief valves, and manual control valves will be required at the input to the IPECHP for use by maintenance personnel.

3.4.1.2 Installation

Hydronic and electrical connections to the IPECHP unit on-site mist be made by licensed personnel in accordance with local building codes and the National Electric Code. Part of the installation instructions call for assuring that the "green wire ground" makes a good connection to the electrical ground of the facility. A ground stud on the cabinet is used for this purpose, in addition to the third wire in the power cable.

3.4.1.3 Maintenance

Maintenance operations will be performed by trained personnel who are familiar with safety requirements accociated with 120 volt AC power and pressurized hydraulic systems. In addition, the instruction manuals will include clearly emphasized warnings whenever a potentially hazardous maintenance action is undertaken. Normally, after any required tests are performed to isolate the faulty component, all voltage to the unit will be disconnected at the facility electrical control box before the maintenance action is continued.

3.4.2 Control of Hazards to Equipment



3.4.2.1 Manufacturing

The electrical components are protected from potential damage by the cabinet circuit breaker and individual branch fuses for each major subassembly. The component insulation is designed to be flame retardant and non-combustible. The hydronic subassembly could use a number of fluids, but is mainly intended for use with ordinary water, so that no toxic or flammable fluids will be present.

3.4.2.2 Installation

Comments are similar to personnel safety during installation. All operations will be performed by licensed personnel using

the same skills required for connection of ordinary domestic heating and hot-water systems.

### 3.4.2.3 Maintenance

Potential hazards to equipment during maintenance activities will be controlled by the inherent design provisions. Wiring harnesses will allow removal of electrical parts and assemblies, such as relays, motors, or the Controller Assembly without damage or the necessity of awkward positioning of heavy parts. The hydronics assembly is similarly designed such that on-site maintenance will not damage the equipment, provided that normal care is exercised.

## 3.4.3 Control of Hazards to Structure

Hazards to the IPECHP structure are controlled by the same precautions as apply to equipment hazards for the manufacturing, installation, and maintenance phases. The likelihood that a component failure would also involve failure of a fuse and circuit breaker (in series) to open the electrical circuit is so remote as to be considered impossible.

# 4.0 Residual Hazards

The only residual hazard potential in the present design of the IPECHP is associated with overpressure in the hydronics assembly during a maintenance action. However, it is expected that there will be a pressure indicator and manual shutoff valves readily accessible to the maintenance person in the event that the external automatic pressure-relief system is not functioning properly.

## 5.0 Hardware Failure Modes

### 5.1 Electrical Failures

The only electrical failure modes, at the component level, that could create a hazard would be partial short circuits in the cabinet circuit breaker series leg, a fuse (next to impossible) and an electrical part, so that excessive current would flow, causing melting of wire insulation. The current would have to be low enough so that the fuse or circuit breaker in the branch circuit of the main facility electrical box does not low, and yet high enough to raise the temperature of the wire to the insulation melting point. Again, this — even independently of the failure of the protective devices in the IPECHP to operate — is an extremely remote, if not impossible, condition.

### 5.2 Hydronics Failure

Failure of the piping or connections in the hydronics assembly would involve cracking or rupture of the piping and/or connection. The materials and processes used are rated at pressures over 50 times higher than the 60 p.s.i. used in this system, so that the likelihood of a major hazard is extremely remote.

## 6.0 Safety Documentation

A safety file will be set up and maintained throughout the duration of the program. It will contain copies of all proof testing of electrical and hydronic assemblies, records of inspections by follow-up services of Underwriters Laboratories and fire inspection personnel, and any safety reports that might be obtained from field experience, together with corrective action taken.

# SPECIAL HANDLING, INSTALLATION AND MAINTENANCE TOOL LIST FOR INTEGRATED PROGRAMMABLE ELECTRONIC CONTROLLER AND HYDRONICS PACKAGE

SUNKEEPER CONTROL CORPORATION
ANDOVER, MASSACHUSETTS 01810

# SPECIAL HANDLING, INSTALLATION AND MAINTENANCE TOOLS

## I Special Handling Tools

The Integrated Programmable Electronic Controller and Hydronics Subsystem does not require any special handling tools for routine handling of the equipment.

## II Special Installation Tools

The Integrated Programmable Electronic Controller and Hydronics Subsystem does not require any special installation tools for manual equipment installation. However, once the equipment is installed, it is necessary to check the flow rates in all of the outlet lines and to program the memory controls. To accomplish this, the equipment listed in Table I is required.

TABLE I

| PART NUMBER | NOMENCLATURE | MANUFACTURER | DESCRIPTION AND USE |
|---|---|---|---|
| | Flow Meter | Bell & Gossett | The Flow Meter is used to check the flow rate in all of the outlet lines. |
| Model 1203 | Terminal, Portable (with built in accoustic coupler) | Computer Devices Inc. (C.D.I.) | Either of the terminals listed can be used to input to the controller the necessary control programming for the desired system operation. |
| Model 745 | Terminal, Portable | Texas Instruments (T.I.) | |

## III Special Maintenance Tools

The maintenance activities associated with the Integrated Programmable Electronic Controller and Hydronics Subsystem can be accomplished without the use of any special maintenance tools.

# DRAWING LIST
# FOR
# INTEGRATED PROGRAMMABLE ELECTRONIC CONTROLLER AND HYDRONICS PACKAGE

SUNKEEPER CONTROL CORPORATION
ANDOVER, MASSACHUSETTS 01810

DRAWING LIST

The following drawings will be produced by Sunkeeper Corporation to assure product definition and manufacturing repeatability.

Controller Assembly Drawings

| | |
|---|---|
| 1016-000 | Chassis, Controller |
| 1017-000 | End Bracket, Controller |
| 1018-000 | Display Panel, Controller |
| 1019-000 | Power Supply Cover, Controller |
| 1020-000 | A.C. Cover, Controller |
| 1021-000 | Heat Sink, Controller |
| 1022-000 | Stiffener and Insulating Controller |
| 1026-000 | Capacitor Bracket, Controller |
| 1027-000 | Capacitor Board, Controller |
| 1030-000 | Assembly, Controller |

Printed Circuit Board Layout Drawings

| | |
|---|---|
| 1023-000 | Controller CPU |
| 1040-000 | Memory EXT |
| 1041-000 | Switching Module, Power |

Switching Module Drawings

| | |
|---|---|
| 1050-000 | Assembly, Power Module |
| 1051-000 | Mounting Plate, Module |
| 1052-000 | Cover, Module |

System Drawings

| | |
|---|---|
| 1060-000 | System |
| 1061-000 | System, Mechanical |
| 1062-000 | System, Schematic (Hydronic) |
| 1063-000 | System, Schematic (Electrical) |
| 1055-000 | Manifold, Hydronics |
| 1056-000 | Enclosure, Outline |
| 1057-000 | Mounting Holes |
| 1058-000 | Bracket, Mounting |

System Parts List

SKPL-005 Parts List, System

System Manual

SKM-001 Manual, Controller





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