DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150872

CERTIFICATION REPORT FOR THE CALMAC SOLAR POWERED PUMP

Prepared from documents furnished by

Calmac Manufacturing Company
150 S. Van Brunt Street
Englewood, New Jersey 17631

Under Contract NAS8-32253 with

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

For the U. S. Department of Energy

U.S. Department of Energy

Solar Energy

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA CR-150872		

4. TITLE AND SUBTITLE	5. REPORT DATE
Certification Report for the Calmac Solar Powered Pump	December 1978
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS Calmac Manufacturing Company 150 S. Van Brunt Street Englewood, New Jersey 17631	10. WORK UNIT NO.
	11. CONTRACT OR GRANT NO. NAS8-32253
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546	13. TYPE OF REPORT & PERIOD COVERED Contractor Report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

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

16. ABSTRACT

This document constitutes the certification of the CALMAC solar powered thermopump. Each element of the specification is delineated, together with the verification, based on analysis, similarity, inspection, or testing.

Some retyping and reformatting of this document have been done in the interest of clarity.

17. KEY WORDS	18. DISTRIBUTION STATEMENT UC-59c
	Unclassified-Unlimited William A. Brooksbank WILLIAM A. BROOKSBANK, JR. Mgr, Solar Heating and Cooling Project Office

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	39	NTIS

MSFC - Form 3292 (Rev. December 1972)

For sale by National Technical Information Service, Springfield, Virginia 22161

TABLE OF CONTENTS

CERTIFICATION STATEMENT

The CALMAC solar-powered thermopump was evaluated for conformance to applicable national standards and codes and to specification directed by the National Aeronautics and Space Administration. The CALMAC pump met all requirements and was evaluated as fit for public use.

George Miles, PE, New Jersey
VP, Pilot Machine Designers

Calvin D. MacCracken
President, CALMAC Mfg. Corp.

John M. Armstrong
VP, CALMAC Mfg. Corp.

Mark MacCracken
Project Engineer, CALMAC Mfg. Corp.

1.2.4 Criterion — Operational Impairment. The functional capability of the DHW system/subsystem shall not be impaired to a greater extent than conventional systems when system repairs or modifications are being made.

Evaluation — Engineering review of specifications and drawings.

Commentary — This criterion is intended to ensure that the shutdown for repair or modification of solar powered portions (e.g., the collector subsystem) of the DHW system/subsystem will not impair the function of the DHW system/subsystem for periods of time longer than those expected for conventional hot water equipment.

The duplication of components such as heat exchangers, controls and pumps is dependent upon the degree of integration of the auxiliary energy subsystem and the availability of replacement parts.

In the event of pump failure the backup system--required in solar systems because of the possibility of cloudy weather--would take over. The pump can also be replaced temporarily by a conventional pump if a power source is available and continuous operation is required.

2.1 Requirement — System design conditions. The systems for heating (H) and combined heating and cooling (HC) and the domestic hot water (DHW) system/subsystem shall be capable of functioning at their designed flow rates, pressures and temperatures.

2.1.1 Criterion — Equipment capabilities. Pumps, fans, or other components shall be sized to move the heat transfer fluid through the collector, piping and/or ducts at design flow rates.

Evaluation — Review of drawings, specifications, historical performance, previous test data, and design calculations. Systems or applications that do not lend themselves to engineering analysis may require prototype tests to demonstrate compliance.

Commentary — In order to transfer heat through the system/subsystem, a number of different transfer approaches such as gravity circulation, combined forced and gravity circulation, or forced circulation may be used.

The pumping capacity of the pump is a function of the heat pressure, as in conventional pumps, plus the temperature of the fluid being pumped and the amount of steam input, which is a function of the insolation and the efficiency of the concentrating collector. The pumping characteristics of the pump are compatible with conventional solar systems in that the flow through the pump increases with the steam input and the temperature of the water being pumped through it--which is exactly as the design of the system would generally want.

2.1.2 Criterion Noise or erosion-corrosion. The piping or ducts and associated fittings shall be sized to carry the heat transfer fluid at design flow rates without excessive noise, as defined by HUD[1], or erosion-corrosion.

Evaluation Review of drawings, specifications, historical performance, previous test data and design calculations.

Commentary In order to prevent whistling noise in piping and cavitation noise in fittings and valves, it is recognized practice to limit velocities of transfer fluids to 8fps[2]. Lower velocities may be required depending on the limit set by the pipe manufacturer to prevent deterioration of their piping materials due to erosion-corrosion. It is common practice to limit flow velocities in small diameter copper tubing to 4fps when water having a pH value lower than 6.9 or softened water is used. A velocity of 4fps is commonly used as the upper limit for hot water piping with working temperatures above 150°F for copper tubing[2]. Some equipment designs may require higher flow velocities in order to inhibit scale formation. In air ducts, the velocities normally should not exceed recognized values, e.g., the values listed on U.L. labels.

The smallest orifice carrying the fluid being pumped is 1". At 10 GPM the flow rate through a 1" pipe is 4.14 FPS.

TEST RECORD

Contract #NAS8-32253

Project: Solar Pump

1. Item Being Tested: Pump efficiency and performance (2.13)

2. Test Objectives: To determine the pump curves for the solar pump and to compare them to specifications stated in contract.

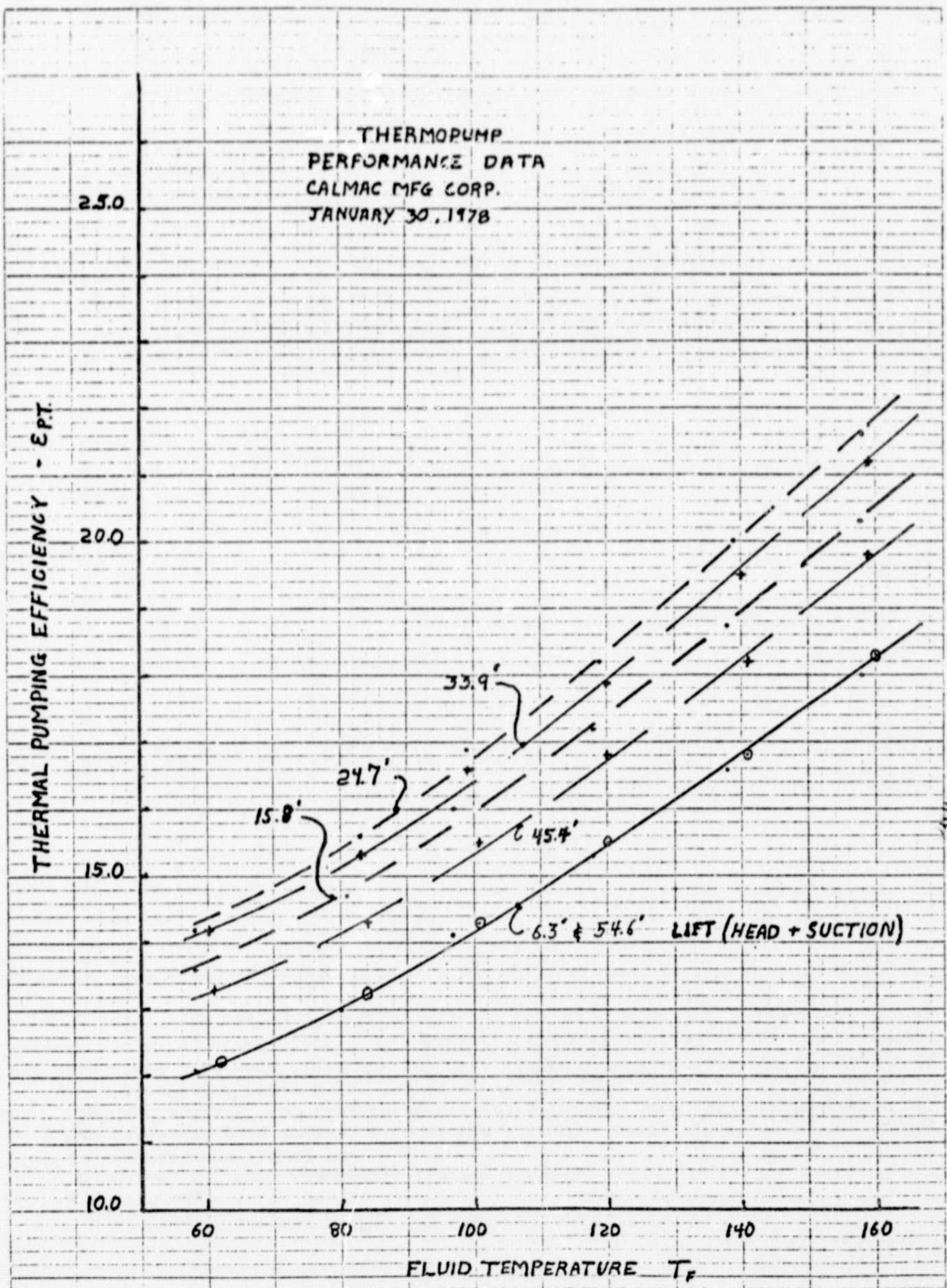
3. Location of test facilities and scheduled test dates:
CALMAC factory,

4. Prerequisites for Passing or Failing: It must meet specification stated in contract

5. Test Procedures: The pump will be run at various head pressures at various fluid temperatures. All important parameters {steam temp., steam pressure, steam quality, head pressure, suction pressure, liquid temp (in and out), flow rate (main flow and collector flow), and insolation} will be recorded. With these parameters, both the efficiences of the pump and collector can be determined. Various pumping curves will also be generated: GPM vs. BTU input @ Various head pressures (P_H) and Temp = constant
GPM vs. Overall efficiency (ϵ_{ov}) @ Various P_H and Temp = C
GPM vs. Temp H_2O (T_w) @ Various P_H, BTU in = C

6. Test Results:

See attached curves summarizing results, plus accompanying data, page 31.



ORIGINAL PAGE IS OF POOR QUALITY

CALMAC

TEST RECORD

Contract #NAS8-32253

Project: Solar Pump

1. Item Being Tested: Pump vibration and noise levels (2.2.2 + 2.2.1)

2. Test Objectives: To verify that there will be no failure of the pump due to vibration, and that any vibration will not cause noise levels above HUD specifications listed in criteria.

3. Location of test facilities and scheduled test dates:
CALMAC factory, May 15-November 15

4. Prerequisites for Passing or Failing: The pump should run relatively silently. Since it cycles once every 15 sec., there is no problem with vibrations reaching a natural frequency of any surrounding parts. Therefore we will take readings on the amount of noise the pump gives off. If the average dB reading is less than 65 dB, it will pass.

5. Test Procedures: The test will be taken during the 500 hours Thermal Degradation Test. A Decibel meter will be periodically checked for readouts. This data will be recorded, and later averaged out in respect to time. The time-averaged amount will be checked with our standard and also HUD's standards.

6. Test Results:

In continuous operation during testing vibration did not cause any damage to the pump, collector or mounting system.

A General Radio Sound Level Meter Model 1565-A was used to record sound levels. The instrument was calibrated by General Electric just prior to the test. The pump hooked up to the steam generator under normal running conditions. Directions for proper sound measurements accompanying the instruction manual were followed. Sound level readings were taken on all weighting networks. The network recommended by the manual for pumps, motors, fans, etc., is network B. The results were as follows:

		Scale=
Background noise	52 dB	BS
Pumping noise	55-62 dB	BS
Pumping Noise	55-63 dB	BF

(BS is slow response, BF is fast response.)

2.1.3 Criterion **Operating conditions.** Collectors, space heaters, water heaters, pumps, valves, regulating orifices, pressure regulators and similar components shall be capable of being operated over the pressure and temperature ranges anticipated in actual service without breakage, rupture, binding, galling, or significant loss in pressure that could impair their intended function.

Evaluation Review of drawings, specifications, historical performance, previous test data and design calculations. Systems or components that do not lend themselves to engineering analysis shall be tested at the maximum and minimum service temperatures with anticipated fluid pressures. To show compliance with this criterion it is desirable that the design consist of components that are covered by recognized standards, where available, and are specified by the manufacturer to be suitable for the pressure, temperature, and flow application.

See testing for Criterion 2.3.1 and 5.2.4 plus testing for this specific Criterion.

2.2 Requirement **Mechanical stresses.** Mechanical stresses that arise within the system shall not cause damage or malfunction of the system or its components.

2.2.1 Criterion **Vibration stress levels.** Vibrations in piping, ducts, instrumentation lines, and control devices shall be controlled to reduce stress levels below those that could cause fatigue and subsequent component damage.

Evaluation Review of drawings, specifications, historical performance, and previous test data for adequate piping and equipment supports.

Commentary Examples of possible vibration sources in piping are as follows:

a. Lengths of piping and connecting equipment that are resonant with pressure pulsation frequency.
b. Vibration resulting from motors, pumps, fans, and compressors which are not properly mounted.
c. Water hammer and quick closing valves.
d. Expansion and contraction of piping on hangers.
e. Wind pulsations on certain lengths and diameters of piping supported by loose hangers or supports.

The use of silent check valves reduces the hammering as the pump changes from one phase of the pumping cycle to the other. The pump is supported by a mount on which it sits without a mechanical fastening. The pump is held in place by the four pipes connected to it. These pipes must be hung at the time of installation to allow adequate room for expansion and contractions, and movement from wind.

2.2.2 Criterion — Vibration from moving parts. Pumps, fans and compressors or similar equipment shall be balanced and/or mounted in a manner that will avoid vibration that could cause damage or excessive noise as defined by HUD[1].

Evaluation — Review of drawings and specifications. Prototype inspection and testing if deemed necessary. The equipment supporting structure shall not have natural frequencies within ± 20 percent of the operating speeds. The equipment wher mounted and placed in operation should not exceed a self-excited vibration velocity of 0.10 inches per second when measured with a vibration meter on the bearing caps of the machine in the vertical, horizontal, and axial directions or measured at the equipment mounting feet if the bearing caps are concealed[8].

See test results. The pump does not have any rotating parts as conventional pumps have, so the pump does not have an operating speed in the conventional sense which might lead to resonance and vibration.

2.2.4 Criterion — Vacuum relief protection. Closed storage tanks and piping located at elevations above the system served shall be suitably protected against collapse by pressure if subjected to a vacuum. Such components shall be designed to withstand such pressures or have vacuum relief protection.

Evaluation — Review of drawings and specifications.

Commentary — Possible collapse of large diameter tanks and piping by atmospheric pressure is an important design consideration[11].

The pump will be located above the midway point of the collector system and is therefore subject possibly to a vacuum. The pressure cooker is rated to take 35 PSI internal pressure and has been subjected to a vacuum of 10PSI without evidence of damage. In the event of a more extreme vacuum the gasket sealing the pump would give in to relieve the pressure difference.

2.2.5 Criterion — Thermal changes. The system components and assemblies shall be designed to allow for the thermal contraction and expansion that would occur over the service temperature range.

Evaluation — Review of drawings, specifications and calculations.

Commentary — Piping and other components may experience changes in dimensions as a result of temperature changes. Such changes can result in excessive stresses within the piping, piping supports, structure, pumps, compressors, and solar collectors if means are not incorporated in the piping system design to allow for the thermal movement.

See 2.2.1 for piping connections. Inside the pump, the inner cylinder and the float can expand and contract freely because there is adequate room for play between all the components.

2.3 Requirement <u>Leakage prevention</u>. System assemblies containing heat transfer fluids shall not leak to an extent greater than that specified in the design when operated at the design conditions.

2.3.1 Criterion <u>Pressure test: nonpotable fluids</u>. Those portions of the H, HC and DHW systems which contain heat transfer fluids (other than air) and are not directly connected to the potable water supply shall not leak when pressures of not less than 1-1/2 times their working pressure are imposed for a minimum of 15 minutes.

Evaluation Review of specifications and testing. The test pressure shall be applied for a period of time necessary to inspect each joint for leakage. The pressure gage would be observed for this period to determine that a pressure drop has not occurred.

Commentary Various building codes differ with regard to pressure tests. One plumbing code requires hydrostatic testing at the working pressure for water supply piping[12]. Another code requires hydrostatic testing at the working pressure or an air pressure test of not less than 50 psi for not less than 15 minutes[13]. A third code requires a hydrostatic test of not less than 25 psi above the working pressure [14]. However, plumbing codes do not give guidance concerning solar systems which can contain liquids other than water. In these cases, hydrostatic testing of the system at 1-1/2 times the maximum is considered to be appropriate[15]. "Dead-weight" testers are frequently used to calibrate pressure gages[16].

See test results.

<u>TEST RECORD</u>

Contract #NAS8-32253

Project: Solar Pump

1. Item Being Tested: Pump gasket system (2.3.1.and 5.2.4)
2. Test Objectives: To verify that the solar pump system doesn't leak at 150% of it maximum operating pressure.
3. Location of test facilities and scheduled test dates: CALMAC factory, March 8, 1977
4. Prerequisites for Passing or Failing: The test will be considered successful if the system remains at the test pressure for 1/2 hour.
5. Test Procedures: The system will be filled with the heat transfer fluid (water) and then pressurized with our city water supply. When the pressure reaches the test pressure (1.50 x 22.0 psi = 32.5 psi), the system will be sealed (the supply valve will be closed). Since water is basically an incompressible fluid, even the smallest leak would make a large change in the pressure reading.
6. Test Results: This test was conducted on September 2 inaccordance with the above procedures and no leaking of the gasket was observed.

2.6.3 Criterion — Liquid quality. The system shall have means to prevent contamination by foreign substances that could impair the flow and quality of the heat transfer fluid beyond acceptable limits.

Evaluation — Review of piping drawings and specifications.

Commentary — The piping in some solar collectors and heat exchangers may have small cross sections in which blockage by dirt, scale, pieces of gasket material, pieces of packing, or other foreign matter in the heat transfer fluid could occur.

The smallest cross-section in the xxx pump is the 1/2" vapor tube. This diameter is too large to be clogged by small pieces of sediment, dirt and so forth. Where larger pieces of foreign matter are a problem, a filter should be used in the system to protect the collectors as well as the pump.

2.6.4 Criterion — Freezing protection. Heat transfer liquids shall be prevented from freezing at the lowest ambient temperatures that will be encountered in actual use where such freezing would impair the function of the system.

Evaluation — Review of drawings and specifications.

Commentary — The purpose of this criterion is to insure that rupture or other damage to solar collectors and associated piping and equipment will not occur from expansion of water if it freezes. The intent of this criterion is not to restrict the designer to the use of antifreeze solutions.

The pump is not freeze-tolerant, and either the pressure cooker or the inlet/outlet pipes could burst on freezing. The pump must be protected when operated in freezing conditions by the use of glycol antifreeze as the heat transfer fluid for freeze protection.

2.7 Requirement — Piping supports. Pipe hangers, pipe trenches, and other supports shall carry the static and operational loads normally imposed without impairing system function.

2.7.1 Criterion — Applicable plumbing standards. Piping shall be installed in accordance with Section 615 of the MPS (4900 1 and 4910.1)[3] and Part C of the ANSI A119.1[19], where applicable.

Evaluation — Review of drawings, calculations and specifications.

Commentary — Both above-ground and underground piping and heat distribution installations are dealt with in the HUD MPS and other references [20] [21] [22] [23].

Nothing in the pump design requires other than conventional inlet and outlet pipe connections and supports.

2.8 Requirement — Excessive pressure and temperature protection. The piping system and associated equipment shall be protected against rupture or leakage from excessive pressures and temperatures.

2.8.1 Criterion — Relief valves and vents. As required for protection of a particular system design, combination temperature and pressure relief valves, separate pressure relief valves, pressure reducing valves, and/or atmospheric vents shall be provided.

Evaluation — Review of drawings and specifications.

Commentary — This criterion is intended to prevent safety hazards resulting from inadequate pressure and temperature protection.

A pressure relief valve set to open at 30 PSI should be installed in the steam line leading from the collector to the pump. See the operating manual.

3.1 Requirement — Structural design basis. The structural design of the heating (H), combined heating and cooling (HC) and domestic hot water (DHW) systems including connections and supporting structural elements shall be in accordance with nationally recognized codes and standards and shall be based on loads anticipated during the service life of the systems.

3.1.1 Criterion — Applicable standards. The structural design and construction of H, HC and DHW systems including connections and structural supports thereof shall comply with the following provisions:

Conventional elements* shall comply with the provisions of the HUD Minimum Property Standards (MPS)[1] for single family and multifamily housing or ANSI A119.1[4], in the case of mobile homes, and such additional criteria as specified in this chapter. Non-conventional elements** shall comply with all the criteria stipulated in this chapter.

Evaluation — Review of drawings, specifications and structural calculations.

Commentary — In addition to complying with the design and construction provisions of the MPS or ANSI A119.1 (for mobile homes), conventional elements and connections are required to comply with Criteria 3.1.2 (Service loads), 3.2.2 (Ice loads), 3.2.3 (Vehicular loads), 3.5.1 (Design provisions - cutting of structural elements), 3.7.1 (Hail size and loading), and 3.9.1 (Design provisions - ponding conditions).

See 3.1.2

3.1.2 Criterion <u>Service loads</u>. The following loads shall be used in the structural design of conventional and non-conventional elements and connections of H, HC and DHW systems:

1. Dead loads (D) shall be the "Design Dead Loads" stipulated in Section 601-3 of the MPS.

2. Live loads (L) shall be all applicable 'Design Live Loads" stipulated in Section 601-4 and "Snow Loads" stipulated in Section 601-5 of the MPS.

3. Wind loads (W) shall be "Wind Loads" stipulated in Section 601-6 of the MPS. In all cases consideration of local wind conditions shall be assured by compliance with Section 6.3.3 of ANSI A58.1[2].

4. Earthquake loads (E) shall be those stipulated in Section 601-9 of the MPS which references the provisions of the Uniform Building Code (UBC) [3]. For non-conventional system components and connections, the value of "Cp" used in the UBC shall be taken as 2.0.

1. Dead load equals the system's own weight, which is about 25 pounds when full. The bottom area of the pump is about .8 ft^2, so D = 32 PSF.

2. L = 20 PSF per section 601-5 of the MPS.

3. W = 1.25 x 15 PSF = 19 PSF per Section 601-6 of the MPS.

4. $E = Z \times I \times C_p \times S \times W_p$
$= 1 \times 1 \times 2 \times 1 \times 32$
= 32 PSF

I= Importance factor = 1
Z = 1
S = 1 where $C_p = 2$
W_p = 32 (weight per square foot)

This criterion simply establishes service load standards. Analysis of the pump's ability to meet these loads is covered in the other criteria.

5. Constraint loads caused by the environment, normal functioning of the system and time-dependent changes within the materials of the system shall be taken as the most severe likely to be encountered during the service life.

6. Constraint loads induced by differential foundation settlement shall be taken as those corresponding to a differential foundation settlement of the magnitude stated under Criterion 3.8.1.

7. Ice loads (I) shall be taken as those produced by the accumulation of ice on surfaces exposed to the natural environment. The thickness of ice shall be determined in accordance with Criterion 3.2.2.

8. Hail loads (H) shall be taken as those produced by the impact of hail on surfaces exposed to the natural environment. Hail particle size and kinetic energy at impact shall be determined in accordance with Criterion 3.7.1.

9. Vehicular loads on below grade installations shall be determined in accordance with Criterion 3.2.3.

Evaluation — For experimental or analytical evaluation of structural response, the selection of system components shall be done in a manner representing the least margin of safety to the system but consistent with its interaction with structural systems to which they are attached. Test loads applied to the system components shall result in the most critical conditions encountered in service. Additional eccentricities of loading caused by drift due to lateral loads and anticipated differential foundation settlements shall be provided for in tests of supporting structural elements of the system. The effects of service history caused by fatigue, sustained load, temperature, moisture, ultraviolet light or other environmental factors, shall be provided for in tests.

Commentary — The intent of the criterion is to state the required reliability of performance and, therefore, the specified loads should have a defined probability of occurrence.

The assumption is made (with the exception of wind and snow loads, which are based on statistical analysis) that the MPS "design loads" are loads anticipated during the service life of the system.

The minimum uniformly distributed live load on relatively flat horizontal and inclined surfaces of the system is taken in accordance with roof loads prescribed by MPS. Snow Load is based on ANSI A58.1 and is treated as live load in lieu of the MPS roof load if it produces a more severe loading condition. This is consistent with MPS which uses ANSI A58.1 by reference.

Earthquake loads are determined by the applicable provisions of the Uniform Building Code. It is recognized that for cases involving new material applications it may be difficult to select the appropriate C_p factor. The prescribed C_p value intended for use with nonconventional elements and connections is consistent with the values specified in UBC for connections of exterior panels.

5. Neither the environment, normal functioning of the system, or time-dependent changes are expected to exert loads approaching the loads imposed by such factors as ice or live loads.

6. See 3.8.1

7. See 3.2.2

8. See 3.7.1

9. Vehicular loads do not apply as the pump will not be installed below grade.

3.2 Requirement — Failure loads and load capacity. The structural elements and connections of the H, HC and DHW systems shall not fail under ultimate loads expected during the service life of the system.

3.2.1 Criterion — Ultimate load combinations. Non-conventional elements and connections shall comply with this criterion. (Conventional elements and connections are deemed to satisfy this criterion.)

Structural components, connections and supporting elements shall be designed for the following ultimate load combinations:

(1) 1.4 D + 1.7 L
(2) 0.9 D + 1.7 W
(3) 0.9 D + 1.45 E
(4) 1.1 D + 1.3 L + 1.7 W
(5) 1.1 D + 1.3 L + 1.45 E

where the multipliers are load factors and the letters are the service loads defined in Criterion 3.1.2.

Evaluation Review of structural calculations, specifications and drawings.

Commentary The intent of the criterion (along with Criterion 3.2.4) is to provide a minimum level of safety against loading situations which have a suitably low probability of occurrence during the service life. The load factors represent present-day design practice for building structures and are similar to the load factors used in ACI 318[5]. These factors will produce ultimate loads comparable to those presently used in the design of steel structures. Adoption of similar levels of performance requirements for the H, HC and DHW systems will also permit the designer to explore the potential use of system components as structural elements for purposes of providing enclosure or diaphragm rigidity to the supporting structure in addition to their primary heating and/or cooling function.

(1) $1.4D + 1.7L = 79$
(2) $.9D + 1.7W = 61$
(3) $.9D + 1.45E = 56$
(4) $1.1D + 1.3L + 1.7W = 94$
(5) $1.1D + 1.3L + 1.45E = 108$

The pump has been subjected to a vacuum of more than 10 PSI, which equals an external force of 1440 PSF. The above ultimate loads do not approach this stress.

3.2.2 Criterion <u>Ice Loads</u>.

(a) Above-ground installations of conventional elements for which ultimate design provisions apply, and of all non-conventional elements, including connections and structural supports thereof, shall comply with Criterion 3.2.1 for load combinations (1) and (4) in which live load (L) shall be taken as that produced by the accumulation of ice on all surfaces exposed to the natural environment.

(b) Above-ground installations of conventional elements for which working stress design provisions apply, including connections and structural supports thereof, shall comply with Criterion 3.2.2(a) with the following modification: load factors in load combinations (1) and (4) of Criterion 3.2.1 shall be taken as 1.0.

The radial thickness of ice around the circumference of exposed wires, pipes, and structural members shall be based on the annual frequency of occurrence of glaze shown in Figure 3.2.2 (see reference [6]) and shall be computed as follows:

Mean annual number of days with glaze	under 1	1-4	4-8	over 8
Thickness of ice (inches)	0	1/2	3/4	1.0

Evaluation Review of structural calculations.

Commentary The intent of this criterion is to account for the effect of ice loads primarily on wires, pipes and other similar components which are exposed to the natural environment, in recognition of the fact that ice storms have been particularly detrimental to such components in the past.

The map of Figure 3.2.2 with documented information of the accumulation of ice recorded for major ice storms [6] and ice loads considered in the design of steel transmission pole structures [7] have been utilized to relate thickness of ice to frequency of occurrence of such storms. This assumption is made in view of a lack of statistical data on accumulation of ice and should result in a generally conservative practice even though it is recognized that thickness of ice cannot be solely expressed in terms of rate of occurrence.

1" thickness of ice equals 1/12 of a cubic foot, which weighs 62.4 pounds, so 1/12 equals 5.2 pounds. L=5.2

(1) 1.4 D + 1.7L = 1.4 x 32 + 1.7 x 5.2 = 54 PSF
(2) 1.1D + 1.3L + 1.7W = 1.1 x 32 + 1.3 x 5.2 + 1.7 x 19 = 81 PSF

81 PSF is much less than the 1000 PSF strength of the pump casing.

3.3 Requirement — Damage control. The structural elements and connections of H, HC and DHW systems shall be designed to withstand service loads without damage of unacceptable magnitude.

3.3.1 Criterion — Resistance to damage. Non-conventional elements and connections shall comply with this criterion. (Conventional elements and connections are deemed to satisfy this criterion.)

Under the effect of deflections caused by loading combinations of (1), (2) and (4) of Criterion 3.2.1, with load factors of 1.0, in addition to the anticipated creep deflections, the system as a whole or any component, connection or support thereof, shall not suffer permanent damage which would require replacement or repair, or which would impair its intended function during its service life.

Evaluation — Evaluation of documented data for design, tests, and installation. Evaluation and/or testing of components and elements where deemed essential. Determination of compliance with generally accepted standards and engineering and trade practices, where applicable.

The criterion is deemed satisfied if it can be demonstrated that deflections caused by the specified load combinations can be accommodated by suitable details or adequate flexibility.

Commentary — The intent of this criterion is to provide for the proper functioning of the system under service loading conditions without breakdown or permanent impairment beyond levels comparable to conventional heating and cooling systems.

The maximum loading of Criterion 3.2.1 (1), (2) and (4) is 94 PSF. the pump's ability to stand more than 1000 PSF means that damage is not a problem.

3.4 Requirement — Cyclic loads. The structural elements and connections of H, HC and DHW systems shall not fail under the application of cyclic loads expected during the service life.

3.4.1 Criterion — Deflection limitations. Non-conventional elements and connections shall comply with this criterion. (Conventional elements and connections are deemed to satisfy this criterion.)

Structural components, connections and supporting elements shall be capable of resisting the following repeated loads without failure and without a residual deflection in excess of 25 percent of the maximum deflection measured in the first cycle of load application:

(1) 100 cycles from 1.0 D to 1.0 D + 0.5 L
(2) 1000 cycles from 1.0 D to 1.0 D + 0.5 W

Evaluation Physical simulation and testing or analysis based on available test data.

The cyclic loading (1) and (2) shall be assumed to be applied after reducing system slack by the prior application of one preloading cycle of the following loads:

for (1) from (1D) to (1D + 1L)

for (2) from (1D) to (1D + 1W)

Cyclic loading shall commence only after deflection recovery from the preloading cycle is substantially complete. The residual deflection shall be taken as the difference between the deflection measured 24 hours after removal of the superimposed cyclic load and the residual deflection, if any, not recovered from the preloading cycle.

Commentary Even though the service load history cannot be simulated the imposition of the stipulated cyclic loads is intended as a conservative representation of service conditions. The residual deflection limitation assures preservation of structural integrity under cyclic loading.

1.0D = 32 1.0D + .5L = 42
1.0D = 32 1.0D + .5W = 42

Application of this load will not cause any measurable deflection at all.

3.7.1 Criterion <u>Hail size and loading</u>. System components and supporting structural elements that will be exposed to the natural environment in service shall be designed to resist, without excessive damage or major impairment of the functioning of the system, the perpendicular impact of falling hail having a particle diameter (in inches) equal to 0.3d where d is the mean annual number of days with hail determined on the basis of the hail map shown in Figure 3.7.1 [6].

Evaluation Evaluation will be based on analysis using known structural information on the physical characteristics of the system components or on physical simulation and testing using the NBS hail resistance test described in the NBS Building Science Series 23[9]. In the absence of physical test data, the portion of the kinetic energy dissipated by system components shall be taken as 50 percent of the kinetic energy at impact corresponding to the resultant velocity specified in Table 3.7.1 (reproduced from Ref. [10]) for the predetermined hail size.

In cases where protective measures are provided to prevent impact of hail on system components, such as the use of screens or deflectors, these protective measures shall be included in the test specimens.

Commentary It is not the intent of this criterion to prevent punching or local cracking of nonstructural elements such as glass cover plates of collector panels under hail impact, but rather to control damage by keeping it at a level which would not create a major curtailment in the functioning of the system, premature failure or hazards created by excessive shattering of glazed elements.

The correlation of hail size with mean annual number of days with hail is based on studies on the probability of exceedance of a given particle size as a function of frequency of occurrence of hail, a twenty year recurrence interval reflecting the life expectancy of the system and observations of statistical data [11] indicating that a representative hailstorm area is generally one order of magnitude smaller than the regions for which statistical information is compiled.

The worst condition in the U.S. is 6-8 days/year (mean = 7 days). 7 x .3 = 2.1". From Table 3.7.1 the kinetic energy at impact for a 2 1/4" ice sphere is 50.96 foot-pounds. 50% of that is 25.5. This impact will have no effect on the pump casing.

3.8 Requirement Constraint loads. The structural elements and connections of H, HC and DHW systems shall comply with Criterion 3.2.1 while simultaneously subjected to constraint loads expected during the service life.

3.8.1 Criterion Foundation settlement; contraction and expansion. Non-conventional elements and connections shall comply with this criterion. (Conventional elements and connections are deemed to satisfy this criterion.)

System components, connections and supporting elements shall comply with Criterion 3.2.1 while simultaneously subjected to the following constraint conditions:

1. A differential foundation settlement of 2 inches in any horizontal distance of 50 feet except that in cases where the foundation at a particular site is specifically designed to control differential settlements, the constraint conditions should be those consistent with the specified design. Uplift forces caused by a swelling of expansive soils shall be calculated assuming a level of 0.9D for gravity loads.

2. Constraint loads arising from thermal expansion and contraction of system components and structural elements or from time-dependent changes within the material.

Evaluation Analysis and/or physical simulation.

Commentary Soil-structure interaction is usually a design function since constraint loads are dependent on the characteristics of the soil as well as the effects of structural framing. Due to economic considerations in foundation design, the assumption is usually made that the superstructure is capable of accommodating a reasonable amount of differential settlement. The requirement in part (1) is consistent with observed performance of conventionally designed foundations and represents the threshold at which structural damage occurs. This criterion is relaxed when special precautions are used in foundation design to control differential settlements.

The requirements in part (2) of the criterion account for other types of constraint loads such as those introduced by thermal expansion and contraction of system components or creep and shrinkage in supporting structural elements.

The pump is not designed to be a part of the structure or even mechanically fastened to it. It is held in place by the four pipes running in and out of it, which should absorb loads resulting from foundation settlement or exapnsion and contraction. See 2.2.1.

4.1 Requirement — Plumbing and electrical installation. The design and installation of the systems for heating (H), combined heating and cooling (HC) and the domestic hot water (DHW) system/subsystem and their components shall be in accordance with nationally recognized plumbing and electrical codes and standards for health and safety, where applicable.

4.1.1 Criterion — Plumbing codes and standards. Plumbing materials and equipment and their installation shall be in accordance with Sections 515 and 615 of the MPS (4900.1 and 4910.1)[1] and Part C of ANSI A119.1[2], where applicable.

Evaluation — Review of drawings and specifications. Testing to show compliance, where necessary.

Commentary — Suitable standards are available for conventional equipment. Unique innovative installations may require special consideration.

All plumbing connections to the pump are standard. A review of the National Standard Plumbing Code did not indicate any area where the pump would not be in compliance.

4.2 Requirement — Fail-safe controls. The H, HC and DHW systems shall be fail-safe in the event of damage to system components or a power failure.

4.2.1 Criterion — System failure prevention. The control subsystem shall be designed so that in the event of a power failure, or a failure of any of the components in the subsystem, the temperatures and/or pressures developed in the H, HC and DHW systems will not be damaging to any of the components of the systems, and the building, or present a danger to the occupants. The safety devices shall meet the requirements of Section 515-6.4 of the MPS (4900.1 and 4910.1)[1].

Evaluation — Review of drawings, specifications and design calculations.

Perform test of fail-safe control installation for all probable failure events.

Commentary — The excessive pressures and temperatures that can build up in collectors under "no flow" conditions are an important consideration. Consideration should be given to the thermal shock which could occur when cool heat transfer fluids are introduced into collectors which have been exposed to solar radiation under "no flow" conditions.

See test results.

TEST RECORD

Contract #NAS8-32253

Project: Solar Pump

1. Item Being Tested: Fail-Safe system features (4.2.1)

2. Test Objectives: To verify that if a power failure, or any failure of other components in the system, should occur, no damage will result to the other components of the system or to the building and its occupants.

3. Location of test facilities and scheduled test dates:
   CALMAC factory,

4. Prerequisites for Passing or Failing: If the pressure relief valve opens at the prescribed pressure, the fail safe system will have passed. The test will be repeated a number of times. Since only the pump will be tested, and not the collectors, we will use the steam generator for our test.

5. Test Procedures: The pressure relief valve will be set at 32 psi. The steam generator will be set at approximately 50 psi, and the valve on the head side of the pump will be closed. The pressure in the pump will then keep building, since no water is being pumped. The pressure at which the pressure relief valve opens will be recorded. This procedure will be repeated at least ten times in order to determine the variance of the pressure relief valve.

6. Test Results:

   The reliability of the pressure relief system has been tested purposely and inadvertently on numerous occasions during the period April through August. On all occasions the relief valve has functioned as intended.

4.2.2 Criterion <u>Automatic pressure relief valves</u>. Adequately sized and responsive automatic pressure relief valves shall be provided in those parts of the energy transport subsystem containing pressurized fluids. Automatic pressure relief valves shall be set to open at not less than 25 percent in excess of working pressure and at not more than maximum pressure for which the subsystem is designed.

Evaluation Review of plans and specifications, and/or determination that methods, devices, and materials to be used are approved by a recognized testing and evaluation agency as being suitable for the proposed use.

See Criterion 4.2.1 and accompanying test results.

4.3 Requirement <u>Fire safety</u>. The design and installation of the H, HC and DHW systems and their components shall provide a minimum level of fire safety consistant with applicable codes and standards.

4.3.1 Criterion <u>Applicable fire standards</u>. Assemblies and the materials used in the H, HC and DHW systems shall comply with nationally recognized codes and standards for fire safety, where applicable.

Evaluation Review of drawings and specifications for conformance with the MPS, ANSI A119.1, and applicable sections of NFPA 89M[4], NFPA 90A and 90B[5], NFPA 211[6], NFPA 54[7], NFPA 31[8], ASTM E 108[9] and the National Electric Code [10]. Testing to show compliance, when necessary. Potential heat, rate of heat release, ease of ignition, and smoke generation will be considered in assessing potential fire hazards.

Commentary It is the intent of this criterion to (1) prevent the use of materials, equipment and fluids which present a fire hazard significantly greater than that of conventional systems, (2) to provide proper clearances and venting of heat build-up for those system components that operate at elevated temperatures, and (3) to give consideration to the combustibility of materials adjacent to high temperature components in determining the clearances that are required.

A review of the specifications for the materials used in the pump indicates compliance with applicable fire standards.

4.4 Requirement <u>Toxic and flammable fluids</u>. Heat transfer fluids which require special handling because of toxicity and/or flammability shall not be used unless the systems in which they are used are designed to avoid exposing the occupants of dwellings to unreasonable hazards.

4.4.1 Criterion <u>Provision of catch basins</u>. Adequately sized and protected catch basins shall be provided, when liquids requiring special handling are used, to collect and store the overflow from pressure relief valves, liquids drained from the system when it is being serviced, potential leakage, and accidental drainage.

Evaluation Review of drawings and specifications.

Commentary The leakage of toxic fluids into the ground could contaminate the ground water.

The system may be operated using glycol antifreeze solutions. Fluid may vent from the pressure relief valve in the event of overheating and excess pressure buildup. A catch basin or a drain to a catch basin is recommended and is a standard part of any solar heating or cooling system.

4. Requirement — Safety under emergency conditions. In the event of emergencies, the H, HC and DHW systems shall not unduly hinder the movement of occupants of the building or emergency personnel. Life safety hazards which could occur as a result of failures of the above systems shall not be greater than those imposed by conventional systems.

4.5.2 Criterion — Identification and location of controls. Main shutoff valves and switches shall be conspicuously marked and placed in easily accessible locations.

Evaluation — Review of drawings and specifications.

The pump will be located above the collector system away from easy access and exposure. Valves controlling the system may or may not be located near the pump. To stop the cycling of the pump the source of steam must be cut off--this can be done by moving the concentrating collectors away from being focussed directly on the sun. Closing a valve in the steam supply line will cause the buildup of pressure which will be handled through the pressure relief valve in the system.

4.6 Requirement — Protection of potable water and circulated air. No material, form of construction, fixture, appurtenance or item of equipment shall be employed that will support the growth of micro-organisms or introduce toxic substances, impurities, bacteria or chemicals into potable water and air circulation systems in quantities sufficient to cause disease or harmful physiological effects.

4.6.1 Criterion — Contamination by materials. Materials which come in direct contact with potable water shall not affect the taste, odor or physical quality and appearance of the water in an undesirable manner.

Evaluation — Review of plans and specifications for compliance with the 1962 Edition of the Public Health Service Drinking Water Standards [11].

The pump is not approved for use with potable water systems.

4.6.4 Criterion — Growth of fungi. Components and materials used in the H, HC and DHW systems shall not promote the growth of fungi, mold or mildew.

Evaluation — When tested in accordance with Appendix D, Section E of the MPS (4900.1 and 4910.1)[1], there should be no evidence of the growth of fungi.

Commentary — Special consideration should be given to the presence of fungi in air handling systems since such micro-organisms are frequently allergenic.

Fungi can feed on some organic materials and generally thrive in warm, moist environments. They can be killed by sufficiently low wavelength ultraviolet radiation but much of this radiation may be absorbed by the earth's atmosphere. It may be possible for fungi to grow on both the interior and exterior of collector components and possibly affect the collector performance.

The circulation of steam through the pump will destroy all fungi, mold and mildew.

4.7 Requirement — Excessive surface temperatures. Temperatures of exterior surfaces of the H, HC and DHW systems shall not create a hazard.

4.7.1 Criterion — Protection from heating components. Subassemblies of the H, HC and DHW systems that are accessible, located in areas normally subjected to public traffic and which are maintained at elevated temperatures shall either be insulated to maintain their surface temperatures at or below 140°F at all times during their operation or suitably isolated. Any other exposed areas that are maintained at hazardous temperatures shall be identified with appropriate warning signs.

Evaluation — Review of drawings and specifications.

The surface temperature of the pump may reach temperatures in the range of 250-260°F. However, the pump is designed to be placed above the midway point of the collectors, which should locate it where it will not be readily accessible. The manual makes note of the possible danger from the hot surface temperature.

5.1 Requirement — Effects of external environment. The systems for heating (H) and combined heating and cooling (HC) and the domestic hot water (DHW) system/subsystem and their various subassemblies shall not be affected by external environmental factors to an extent that will significantly impair their function during their design life.

5.1.1 Criterion — Solar degradation. Components or materials that are exposed to sunlight shall not undergo changes in their properties during their design life that would significantly impair the function of the system.

a. When components or materials are exposed to UV radiation in combination with an intermittent water spray at their maximum "no-flow" temperature, there shall be no signs of excessive deterioration such as cracking, crazing, embrittlement, etching, loss of adhesion, changes in permeability, loss in flexural strength or any other changes that would significantly affect the performance of the components in the system.

b. The collector shall be capable of providing its rated output after exposure to levels and intensities of solar radiation and temperatures that are equivalent to those that would be expected in actual use over the life of the collector.

Evaluation — Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 03 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary — The transmittance, emittance and absorptance data required to estimate the effects of degradation by solar radiation in reducing the collector efficiency are available for most materials currently being used in collectors.

The maximum "no flow" temperature and other in-use temperatures are discussed in detail in Section 01 of the Appendix at the end of this chapter.

Only the exterior surface of the pump is exposed to direct solar radiation. Aluminum is not affected adversely by UV radiation or the temperatures the pump surface might reach.

5.1.3 Criterion — Airborne pollutants. Components that are exposed to airborne pollutants such as ozone, salt spray, SO_2, NO_x, and/or HCl with or without the presence of moisture shall be resistant to attack by these factors to the extent that these factors shall not significantly impair the performance of the components during their design life.

Evaluation — Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 05 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

The maximum pollutant levels in the area(s) where the system will be installed shall be used to determine the pollutant levels required for testing. If components are to be used in areas where they are not exposed to any or all of these pollutants, tests that are not applicable need not be conducted.

Commentary, — Ozone concentrations in normal dry air have been reported to range from 1-5 pphm/volume. However, concentrations of 100 pphm/volume have been reported during very smoggy conditions. Ozone is known to degrade some organic materials but it has little effect on inorganic materials other than metals.

The effects of solar radiation in combination with airborne pollutant may also be an important consideration.

The pump is sealed, so only the external face of the cooker is exposed to the environment. The cooker is made of 1/4" aluminum which should resist all corrosion.

5.2 Requirement — Temperature and pressure resistance. Components shall be capable of performing their intended function for their design life when exposed to the temperatures and pressures that can be developed in the system.

5.2.1 Criterion — Thermal degradation. Components shall not thermally degrade to the extent that their function will be reduced below acceptable levels during their design life when exposed to in-use temperatures.

Evaluation — Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 06 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary — Some organic components which may be used in the system may be particularly susceptible to thermal degradation under prolonged exposure.

See Test Results.

CALMAC

TEST RECORD

Contract #NAS8-32253

Project: Solar Pump

1. Item Being Tested: Pump durability (5.2.1)

2. Test Objectives: To verify that the pumps components will not thermally degrade within its design life, to a point where it will not meet specifications.

3. Location of test facilities and scheduled test dates: August - November, 1977
CALMAC Factory,

4. Prerequisites for Passing or Failing: The pump will pass if, after 500 hours of cycling un der simulated conditions, it

   1. Performs comparably (within experimental limits) of prior tests.

   2. Shows no visible signs of deterioration.

5. Test Procedures: The pump will be tested for thermal degradation at the same time it is being tested for vibration and performance. Before starting the test, the pump will be inspected visually, and then tested at average conditions. After 500 hours the pump will again be inspected at average conditions and then disassembled and inspected.

6. Test Results:

During the period from August to November the pump was operated for testing and development purposes under a variety of conditions using both the steam generator and the concentrating collectors. During this period an estimated 500 hours of use was logged on the pump and no deterioration because of heat or moisture was noted.

5.2.2 Criterion — Deterioration of heat transfer fluids. Except when such changes are allowed by the design of the system, the heat transfer fluid shall not freeze, give rise to excessive precipitation, otherwise lose its homogeneity, boil, change pH or undergo large changes in viscosity when exposed to its intended service temperature and pressure range.

Evaluation — Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 07 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary — Thermal cycling may cause metastable precipitation to occur. Systems may be pressurized to prevent boiling.

Glycol antifreeze with corrosion inhibitors is a well-tested heat transfer fluid in applications such as this. It must, however, be maintained properly and inspected at least once a year.

5.2.3 Criterion — Thermal cycling stresses. The H, HC and DHW systems and their various subassemblies shall be capable of withstanding the stresses induced by thermal cycling for their respective design lives.

Evaluation — Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 08 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Physical restraints that will be imposed on the system in actual use shall be considered when testing is required.

Commentary — This criterion is intended to identify potential problems that may occur as a result of differential thermal movement. Thermal compatibility is especially critical in the case of collectors which may contain large expanses of glazing. Edge flaws in glass may result in cracking of the glass when it is under stress.

Dimensions of the pump are small and there is adequate room for differential movement between all the components.

5.2.4 Criterion — Leakage. All assemblies or subassemblies which contain heat transfer fluids (other than air) shall not leak when tested at a pressure equal to 150% of the working pressure of the system over the entire service temperature range.

Evaluation — Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 09 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary — This criterion is intended for materials which may creep or become brittle at service temperatures.

See Criterion 2.3.1 and accompanying test results.

5.2.5 Criterion **Deterioration of gaskets and sealants.** Gaskets and sealants in direct contact with heat transfer liquids shall be capable of withstanding repeated cycles consisting of soaking and drying under in-use conditions without significantly impairing their ability to function during their design life.

Evaluation Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 10 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary Gaskets, sealants, and similar organic materials frequently swell when exposed to liquids and shrink upon drying, thus losing their ability to function.

The rubber gasket sealing the pressure cooker is the same gasket used in conventional application of the pressure cooker. If necessary, it can be easily removed and replaced.

The 1300 3M cement is waterpoof and not subject to soaking and drying out over time. The cork is used in other applications as a gasket/sealing material. See Criterion 5.2.1 and accompanying test results.

See the data sheet for the silicone foam sealant used on the cork. This material has shown no signs of deterioration during extended testing.

5.3 Requirement **Chemical compatibility of components.** Materials used in the systems and their various subassemblies shall have sufficient chemical compatibility to prevent corrosive wear and deterioration that would significantly shorten the intended service life of components under in-use conditions.

5.3.1 Criterion **Materials/transfer fluid compatibility.** Materials designed to be used in contact with heat transfer fluids shall not be corroded by these fluids to the extent that their function will be significantly impaired under in-use conditions during their intended service lives.

Evaluation Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 12 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary Corrosion by heat transfer fluids could be a serious problem in solar energy systems.

The level of corrosion inhibitor in the glycol antifreeze heat transfer fluid must be maintained or corrosion of the aluminum may result. The aluminum that the pressure cooker is made out of is 1/4" so it should be able to withstand a modest amount of corrosion without deterioration.

5.3.2 Criterion — Corrosion of dissimilar materials. Non-isolated dissimilar materials with or without corrosion resistant finishes, where used either in contact with a transfer fluid, or without such contact, shall not be corroded to the extent that their function will be significantly impaired under in-use conditions during their intended service lives.

Evaluation — Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 13 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary — The use of corrosion inhibitors or dielectric fittings that electrically isolate dissimilar materials may be desirable. In the case of plastics, plasticizer migration may be a concern. The presence of pinholes in protective coatings may drastically accelerate corrosive action.

The materials used in the pump--galvanized steel, aluminum, brass, copper, cork and stainless steel--will be protected from corrosion by the use of corrosion inhibitors when glycol is used. Water criculating in a closed loop will not lead to corrosion in the system. The different materials that might corrode when in direct contact--copper and aluminum--are separated from each other.

5.3.3 Criterion — Corrosion by leachable substances. Chemical substances that can be leached by moisture from any of the materials within the system shall not cause corrosive deterioration of any other components that would significantly impair the ability of these components to perform their intended function over their service lives.

Evaluation — Documentation of satisfactory long term performance under in-use' conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 14 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary — Salts such as those that can be leached by moisture from some types of glass fiber and mineral wool insulation or from organic components may cause corrosion of system components that are in close proximity.

The only material that might leach chemicals is the cork, and the use of cork as a sealing/gasekting material in the automotive field and elsewhere shows no evidence that it leaches any corrosive substance.

5.3.4 Criterion — Effects of decomposition products. Chemical decomposition products that are expelled from components under in-use conditions shall not cause the degradation of other components within the system to the extent that it would significantly impair their ability to perform their intended function over their service lives.

Evaluation — Documentation of satisfactory long term performance under in-use conditions or engineering analysis. Where adequate existing information is unavailable, testing using either the methodology outlined in Section 15 of the Appendix given at the end of this chapter or other methods which can be shown to meet the intent of the criterion will be used.

Commentary — Some components may yield degradation products during their service life without impairing their function or aesthetic properties. These degradation products could significantly impair the performance of other components in the system.

None of the materials used decomposed during use and testing during the developemnt of the pump. No outgassing from the cork was ever observed.

5.4 Requirement — Components involving moving parts. Components that involve moving parts, with normal maintenance, shall be capable of performing their intended function without excessive wear or deterioration for their service lives.

5.4.1 Criterion — Wear and fatigue. Check valves, pressure regulators, pumps, electrical switches, and similar components shall be capable of operating under in-use conditions for their intended lifespans without exhibiting wear or fatigue that would reduce their performance below specified levels.

Evaluation — Documentation of satisfactory long-term performance under in-use conditions, engineering analysis, or testing using an experimental verification procedure which can be shown to meet the intent of the criterion. Either the number of cycles that would be expected in actual service under in-use conditions, or an accelerated procedure shall be used for experimental verification.

Commentary — In some applications, less expensive components which are readily replaced but have shorter expected lifespans may be more desirable than more reliable but more costly components.

Inclusion of the heat transfer fluid during tests of components with moving parts may be helpful. In particular, very hard crystalline precipitates may be formed from some types of heat transfer fluids and their additives.

The check valves in the system are all standard plumbing items. There are no other moving parts in the traditional sense--the float moves by floating on the surface of the fluid being pumped but there is no wear resulting from this movement.

6.1 Requirement — Accessibility for maintenance and servicing. The systems for heating (H), combined heating and cooling (HC) and the domestic hot water (DHW) system/subsystem shall be designed, constructed, and installed to provide sufficient access for general maintenance, convenient servicing and monitoring of system performance.

6.1.1 Criterion — Access for system maintenance. All individual items of equipment and components of the H, HC and DHW systems which may require periodic examination, adjusting, servicing and/or maintenance shall be accessible for inspection, service, repair, removal or replacement without dismantling of any adjoining major piece of equipment or subsystem.

Evaluation — Review of drawings and specifications.

Commentary — Accessibility as a function of component life is an important consideration.

Information on access provisions is provided in Reference [1].

The top of the pressure cooker is readily opened and the cork cylinder can be lifted out easily for inspection and repair.

6.1.2 Criterion — Access for system monitoring. Appropriate access for sensors shall be provided for inspecting and checking essential system parameters such as temperature, pressure and critical voltages.

Evaluation — Review of drawings and specifications for the location of test fittings.

Commentary — Adequately located test fittings will permit system monitoring and expedite the maintenance and repair of equipment.

Temperature and pressure of the system can be measured at any of the inlet and outlet fittings by disconnecting the piping and inserting a gauge. No other monitoring should be necessary.

6.1.3 Criterion __Draining and filling of liquids.__ **To facilitate system or subsystem maintenance and repair, subsystems employing liquids shall be capable of being conveniently filled and drained.**

Evaluation — Review of drawings and specifications.

Commentary — The potential buildup of vapor which could create air pockets and thus block or restrict the flow of heat transfer fluids should be considered. (See Criterion 2.1.5)

The pump can be readily drained through the steam return line to the concentrating collector. This line is connected to the pump at the bottom of the cooker.

6.1.4 Criterion __Flushing of liquid subsystems.__ Suitable connections shall be provided for the flushing (cleaning) of liquid energy transport subsystems.

Evaluation — Review of drawings and specifications.

Commentary — **The recommendations of the system manufacturer for cleaning agents compatible with the materials of the system should be followed.**

The pump can be flushed with water to remove any bits of material accumulated in the interior of the pump. The flushing can be accomplished by disconnecting the return line to the collector and letting water flow through that connection. Or the pump can be opened from the top and the inner cylinder completely removed. The continual flow of steam through the collector should keep the pump free from fouling on the pump walls, so cleaning should not be necessary.

6.1.5 Criterion __Filters.__ Filters shall be designed and located so that they can be cleaned or replaced with minimum disruption to the system and adjacent equipment. Cleaning frequencies shall be specified by the system manufacturer in the maintenance manual.

Evaluation — Review of drawings and specifications.

Clogging of the pump is not expected to be a problem as there are no small passageways in the system. Bits of cork from the pump, however, could get into the system and clog other parts of the system, so a filter after the pump is recommended. It should be cleaned one week ~~xxex~~ after startup and once a year thereafter. See the operating manual.

6.2 Requirement __Installation, operation and maintenance manual.__ **A manual shall be provided for the installation, operation and maintenance of the H, HC and DHW systems.**

6.2.1 Criterion __Installation instructions.__ The manual shall include physical, functional and procedural instructions describing how the subassemblies of the H, HC and DHW systems are to be installed.

These instructions shall include descriptions of both interconnections between the system subassemblies and their interfaces and connections with the dwelling and site.

Evaluation — Review of installation instructions.

See the pump manual.

6.2.2 Criterion Maintenance and operation instructions. The manual shall completely describe the H, HC and DHW systems, their breakdown into subsystems, their relationship to external systems and elements, their performance characteristics, and their required parts and procedures for meeting specified capabilities.

The manual shall list all parts of the systems, by subsystem, describing as necessary for clear understanding of operation, maintenance, repair and replacement, such characteristics as shapes, dimensions, materials, weights, functions and performance characteristics. The manual shall include a tabulation of those specific performance requirements which are dependent upon specific maintenance procedures. The maintenance procedures, including ordinary, preventive and minor repairs, shall be cross-referenced for all subsystems and organized into a maintenance cycle. The manual shall fully describe operation procedures for all parts of the system including those required for implementation of specified planned changes in mode of operation.

Evaluation Review of maintenance and operating instructions.

See the pump manual.

6.2.3 Criterion Maintenance plan. The manual shall include a comprehensive plan for maintaining the specified performance of the H, HC and DHW systems for their design service lives.

The plan shall include all the necessary ordinary maintenance, preventive maintenance and minor repair work and projections for equipment replacement.

Evaluation Review of maintenance plan.

See the pump manual.

6.2.4 Criterion Replacement parts. Parts, components, special tools and test equipment required for service, repair or replacement shall be commercially available or available from the system or subsystem manufacturer or supplier.

Evaluation Review of specifications for the availability of parts.

Commentary This criterion is intended to preclude long periods of system downtime due to the need for the repair or replacement of parts.

CALMAC will inventory and supply parts or material that might require replacement. If the cork innercylinder wears out, it will have to be returned to CALMAC for rebuilding.

6.3 Requirement Repair and service personnel. The H, HC and DHW systems shall be designed in such a manner that they can be conveniently repaired by qualified service personnel.

6.3.1 Criterion Maintenance of H and HC systems. The H and HC systems shall be capable of being serviced with a minimum amount of special equipment by a trained HVAC service technician using a maintenance manual.

Evaluation Review of drawings, specifications, and maintenance instructions.

Commentary The complexity and design of certain components may require their removal and replacement for repair of the system.

See the pump manual and Criterion 6.1.1.

6.3.2 Criterion Maintenance of DHW system. The DHW system shall be capable of being serviced with a minimum amount of special equipment by a qualified service technician using a maintenance manual.

Evaluation Review of drawings, specifications, and maintenance instructions.

See pump manual and Criterion 6.1.1.

8.3 Requirement Mechanical and electrical functioning of connections. The connections between the H, HC, and DHW systems and the dwelling or site shall function mechanically or electrically as intended.

8.3.1 Criterion Plumbing connections. Plumbing connections between the solar subsystems and water service or waste disposal systems shall be in accordance with the MPS[3] or ANSI A119.1[4], as applicable.

Evaluation Review of mechanical drawings and any details or specifications related to plumbing connections.

Commentary Particular attention should be given to making sure that plumbing connections are dimensionally coordinated, that pipe sizes and threads are compatible, and that changes in direction do not unduly restrict the flow of fluid.

The pipe connections at the four inlet and outlet points are standard 3/4", 1" or 1 1/2" NPT fittings.

11.2.1 Criterion Chemical corrosion. Solar subsystems shall not cause chemical corrosion of the building or site elements to an extent that would significantly impair their intended performance.

Evaluation See Evaluation: Criteria 5.3.3 and 5.3.4 in Chapter Five, Systems and Components.

See Criterion 5.3.4 and 5.3.3 and 5.3.4,

11.2.2 Criterion Heat and moisture. Roof mounted solar subsystems shall not cause a buildup of heat or moisture that would cause excessive deterioration of the roofing system or other components of the dwelling.

Evaluation Review of architectural plans, specifications and calculations for temperature buildup caused by solar subsystems.

Commentary The presence of the collector can cause abnormal heat rises which could cause thermal degradation and the buildup of moisture which could cause rotting.

The maximum surface temperature of the pump will be 260°F, which is not high enough to be a problem because the area involved is very small. Similarly, the area of the bottom of the pump is too small to lead to the buildup of moisture between the bottom of the pump and it's supporting surface.

THERMOPUMP TEST DATA

	LIQUID TEMP.	PRESSURE DIS.	PRESSURE SUC.	NO. OF CYCLES	LBS. PUMP CYCLE	LBS. PUMPED	START TIME	STOP TIME	ELAPSED TIME	FLOW RATE	GEN. INPUT	PUMP EFF.
	°F	PSI	Hg"		LBS.	LBS.	MIN-SEC	MIN-SEC	MIN-SEC	GPM	KW	%
11-21-77	98	3.5	4	5	18.7	93.5	42:03	45:40	3:37	3.1	2.6	15.4
	98	4.5	4	5	18.7	93.5	51:10	54:55	3:45	3.0	2.6	15.6
	99	6.0	4	5	18.7	93.5	02:20	06:05	3:45	3.0	2.6	16.1
	99	6.0	4	5	18.8	94.0	09:12	12:58	3:46	3.0	2.6	16.6
	99	8.1	4	5	18.7	93.5	17:35	21:35	4:00	2.8	2.6	16.7
	100	8.0	4	5	18.8	94.0	24:03	28:07	4:04	2.8	2.6	16.7
	100	12.5	4	5	18.7	93.5	38:18	42:47	4:29	2.5	2.6	16.9
11-22-77	58	1.0	4	5	18.9	94.5	34:53	38:40	3:47	3.0	2.6	12.1
	58	5.0	4	5	18.8	94.0	44:12	48:23	4:11	2.7	2.6	13.6
	58	9.0	4	5	18.8	94.0	55:20	00:03	4:43	2.4	2.6	14.2
	60	13.0	4	5	19.0	95.0	08:28	14:12	5:44	2.0	2.6	14.2
	61	18.0	4	5	18.8	94.0	20:10	26:28	6:18	1.8	2.6	13.3
	62	22.0	4	5	18.9	94.5	33:50	41:57	8:07	1.4	2.6	12.2
	80	1.0	4	5	19.0	95.0	25:06	28:40	3:34	3.2	2.6	13.0
	81	5.0	4	5	18.8	94.0	33:38	37:40	4:02	2.8	2.6	14.7
	83	9.0	4	5	18.9	94.5	44:05	48:27	4:22	2.6	2.6	15.6
	83	13.0	4	5	18.9	94.5	53:52	59:02	5:10	2.2	2.6	15.3
	84	18.0	4	5	18.8	94.0	07:41	13:37	5:56	1.9	2.6	14.3
	84	22.0	4	5	18.8	94.0	19:48	26:52	7:03	1.6	2.6	13.2
	97	1.0	4	5	19.0	95.0	02:15	05:32	3:17	3.5	2.6	14.1
	97	5.0	4	5	19.0	95.0	10:21	14:09	3:48	3.0	2.6	16.0
	99	9.0	4	5	18.8	94.0	20:07	24:18	4:11	2.7	2.6	16.9
	99	13.0	4	5	18.7	93.5	31:41	36:23	4:42	2.4	2.6	16.6
	101	18.0	4	5	18.9	94.0	43:24	48:48	5:24	2.1	2.6	15.5
	101	22.0	4	5	18.8	94.0	56:14	02:10	5:56	1.9	2.6	14.3
11-22-78	118	1.0	4	5	18.9	94.5	38:21	41:16	2:55	3.9	2.6	15.3
	118	5.0	4	5	18.9	94.5	47:40	51:06	3:26	3.3	2.6	17.2
	119	9.0	4	5	18.8	94.0	56:50	00:43	3:53	2.9	2.6	18.2
	120	13.0	4	5	18.9	94.5	06:51	11:23	4:32	2.5	2.6	17.9
	120	18.0	4	5	18.9	94.5	17:10	22:19	5:09	2.2	2.6	16.8
	121	22.0	4	5	18.9	94.5	27:41	33:21	5:40	2.0	2.6	15.5
	138	1.0	4	5	18.9	94.5	09:11	11:53	2:42	4.2	2.6	16.6
	138	5.0	4	5	18.9	94.5	16:47	20:01	3:14	3.5	2.6	18.7
	139	9.0	4	5	18.9	94.5	25:23	29:03	3:40	3.1	2.6	20.0
	140	13.0	4	5	18.9	94.5	36:10	40:14	4:04	2.8	2.6	19.5
	141	18.0	4	5	18.9	94.5	46:30	51:14	4:44	2.4	2.6	18.2
	141	22.0	4	5	18.8	94.0	57:01	02:26	5:25	2.1	2.6	16.8
	158	1.0	4	5	18.9	94.5	31:25	34:00	2:35	4.4	2.6	18.0
	158	5.0	4	5	18.9	94.5	39.21	42:11	2:50	4.0	2.6	20.3
	158	9.0	4	5	18.9	94.5	47:36	50:56	3:20	3.4	2.6	21.6
	159	13.0	4	5	18.9	94.5	57:10	00:57	3:47	3.0	2.6	21.2
	159	18.0	4	5	18.9	94.5	07:52	12:12	4:20	2.6	2.6	19.8
	160	22.0	4	5	18.9	94.5	18:33	23:43	5:10	2.2	2.6	18.3

APPENDIX

Appendix, as referenced in this report, has been deleted since it is a part of the Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings, document number NBSIR 76-1187, dated November 1976.

	Telephone	TWX
Canton, Mass. 02021	(617) 828-3300	(710) 348-1324
Gardena, Calif. 90248	(213) 321-6650	(910) 346-6730
Northbrook, Ill. 60062	(312) 272-6700	(910) 686-0006

PLASTICS/CERAMICS FOR ELECTRONICS

Emerson & Cuming, Inc.

DIELECTRIC MATERIALS DIVISION
CANTON, MASSACHUSETTS

TECHNICAL BULLETIN 6-2-15

ECCOFOAM® SIL

Foam-In-Place Silicone Rubber

ECCOFOAM SIL is a white foam-in-place silicone rubber. It is supplied as a readily flowable material to which a small amount of catalyst is added. Pot life is about 30 minutes, allowing plenty of time for mixing and pouring. The catalyzed resin foams and cures at moderate elevated temperatures.

Cured ECCOFOAM SIL has excellent shock-absorbing and vibration dampening characteristics. Electronic components are readily embedded in the foam. It can be used at temperatures in excess of 400°F (204°C) and remains flexible down to -65°F (-54°C). ECCOFOAM SIL bonds to itself, but releases well from non-porous mold surfaces. For improved adhesion to metals and plastics, a prime coat with ECCOSIL Primer 33 is recommended. The primer is brushed on or sprayed as a thin coat and allowed to dry 1 hour before pouring the ECCOFOAM SIL. For better release from porous surfaces, Emerson & Cuming, Inc. Mold Release 122S (Technical Bulletin 20-12) may be used.

<u>Typical Properties of Cured ECCOFOAM SIL</u>

Color	White
Temperature -- Continuous, °F (°C)	-65 to +400 (-54 to 204)
Intermittent, °F (°C)	up to 500 (260)
Density, lbs/ft^3 (g/cc)	18.7 to 31.2 (0.3 to 0.5)
Pressure to compress to 75% of original thickness, psi (kg/cm^2)	5 to 15 (0.4 to 1.05)
Tensile Strength, psi (kg/cm^2)	100 to 150 (7 to 10.5)
Dielectric Constant, 10^2 to 10^{10} Hz	approx. 1.3 to 1.4
Dissipation Factor, 10^2 to 10^{10} Hz	below 0.01

<u>Instructions:</u>

The cured density and cell size of the ECCOFOAM SIL will depend on several factors, such as, catalyst amount, cure temperature, and mold shape. General procedure is as follows:

1. Mix ECCOFOAM SIL thoroughly in the container in which received.
2. To 100 parts, by weight, of ECCOFOAM SIL, add 0.5 to 2.0 parts by weight of Catalyst 25. The exact amount used will determine foam structure and density. (If a medicine dropper is used for catalyst addition, calibrate it first. About 40 drops from a medicine dropper equals 1 gram.) Mix very thoroughly and pour into the mold. Pot life is about 30 minutes.
3. Place in an oven for 2 hours at 212°F (100°C). Foaming and cure takes place in the oven. Expanded volume of the foam is two to three times the original volume.

Where foam structure is critical, it is best to check out the foaming behavior first. Put 25 grams of ECCOFOAM SIL in a paper cup; add 0.25 grams of Catalyst 25 and mix thoroughly. Cure in an oven 2 hours at 100°C. After curing, allow sample to cool. Then slit open the cup and foam with a blade to inspect cell size and foam structure.

The following points should be noted when trying to optimize foam structure:

1. Foam density and toughness will increase with catalyst concentration.
2. Foam density may be increased by allowing the catalyzed resin to stand at room temperature in the mold for 15 to 45 minutes before oven curing.
3. A more even foam structure is produced when curing is carried out in a convection oven rather than a forced-air oven. The slower rate of heat transfer into the mold is desirable.

The handling of this product should present no problems if care is exercised. Use in a well ventilated area. Avoid skin contact. Primers and catalysts should be handled with special care.

Scotch-Grip

RUBBER ADHESIVE

PRODUCT SPECIFICATION

1300

DATED:

APRIL 1, 1972
Revised July 15, 1977

DESCRIPTION:

- A fast drying adhesive that develops high immediate strength. Has excellent heat resistance.
- Bonds Neoprene, reclaim, SB-R and Butyl rubber to metal, wood, most plastics and many other substrates.

PHYSICAL PROPERTIES

BASE Synthetic Elastomer	**NET WEIGHT** 7.3 ± .2 lbs./gal.	**CONSISTENCY** Medium Syrup
SOLVENT* Petroleum Distillate, Methyl Ethyl Ketone (MEK)	**FLASH POINT** −14°F.	**VISCOSITY (APPROX.)** 2400 cps
COLOR Yellow	**SOLIDS CONTENT (APPROX.)** 37%	**BROOKFIELD VISCOMETER** RVF #4 sp. @ 20 rpm

*Contains Non-Photochemically reactive solvent, Southern California APCD Rule 102 (Jan. 9, 1976).

APPLICATION CHARACTERISTICS

METHOD Brush or Flow	**COVERAGE** (1 MIL DRY FILM) 396 sq. ft./gal.	**BONDING RANGE** (10 Mil Wet Film, 2 Surfaces) Up to 12 Minutes

EQUIPMENT SUGGESTIONS

5 Gallon Pail Dispensing System:

1. Pump—4:1 double acting ball type check pump, 4 cu. in./cycle 3" air motor.
2. Pail Cover required to reduce solvent loss.

55 Gallon Drum Dispensing System:

1. Pump—4:1 ratio double acting ball type check pump, 4 cu. in./cycle 3" air motor, bung style pump.

Accessories:

1. Hose—Samuel Moore Synflex hose or equivalent. 500 psi working pressure minimum.

Chemical Resistance Requirements:

1. Synthetic materials in contact with this adhesive must be resistant to ketones and aromatic solvents. Compar, nylon and Teflon are suggested.

Adhesives, Coatings and Sealers Division 3M COMPANY

3M CENTER, ST. PAUL, MINN. 55101 PHONE: 733-1110 AREA CODE 612

PERFORMANCE CHARACTERISTICS

180° PEEL STRENGTH Canvas/Steel			OVERLAP SHEAR STRENGTH ¼" Birch/¼" Birch	
Time @ 75°F.	Test Temp.	Value (lbs./in. width)	Test Temp.	Value (psi)
1 day	75°F.	18	−30°F.	343
3 days	75°F.	48	75°F.	549
5 days	75°F.	51	150°F.	195
7 days	75°F.	52	180°F.	136
2 wk.	75°F.	30	200°F.	85
3 wk.	75°F.	20	225°F.	85
after 3 wk.	−30°F.	49		
after 3 wk.	150°F.	32.5		
after 3 wk.	180°F.	26		

All test data reported represent the typical average obtained using the testing procedures described. The typical range, where applicable, represents the range in average values that can be expected on multiple lots of material.

The data reported portray typical product performance and are not intended to be used for specification limits. Establishment of specification limits, certification requirements, and the test procedures involved must be reviewed and approved by 3M.

DIRECTIONS FOR USE

SURFACE PREPARATION: Surfaces must be clean, dry and dust free. Wiping with Scotch-Grip Brand Solvent No. 3* will aid in removing oil and dirt. For best results, temperature of adhesive and surfaces should be at least 65°F. If stored below 30°F., warm up, followed by thorough agitation may be required.
APPLICATION: Stir well before using. Brush or flow a thin, uniform coat of adhesive on each surface. Allow adhesive to dry until tacky but so that it does not transfer to your knuckle (maximum dry time about 4 minutes). Assemble materials with sufficient pressure to insure contact.
DRYING TIME: Bonded parts have high immediate strength to facilitate normal handling.
CLEAN-UP: Excess adhesive may be removed with Methyl Ethyl Ketone, Toluol, or Scotch-Grip Solvent No. 2 or 3.*
REACTIVATION: Greater immediate strength may be obtained by solvent reactivation. To solvent reactivate, coat both surfaces with adhesive. Allow to dry tack-free. *Lightly* wipe one surface with Methyl Ethyl Ketone.* Complete bond within 30 seconds.
*When using solvents for reactivation extinguish ignition sources and observe proper precautionary measures for handling such materials.

STORAGE AND HANDLING

Store product at 60-80°F. for maximum storage life. Higher temperatures reduce normal storage life. Lower temperatures cause increased viscosity of a temporary nature. Rotate stock on a "first in-first out" basis. Upon request, your 3M Adhesives, Coatings and Sealers Sales Representative will be pleased to advise you of the anticipated shelf life of this product under the storage conditions in your plant.

Clean-up can be accomplished with Methyl Ethyl Ketone, Toluol or Scotch-Grip Brand Solvent No. 2 or 3. When using solvents for clean-up, extinguish ignition sources and observe proper precautionary measures for handling such materials.

Shipping—The following information is provided for use in helping you determine the proper packaging, labeling and marking in accordance with hazardous materials regulations.

NMFC SHIPPING CLASSIFICATION: Adhesive Cements, NOI. Red label required.

DANGER! EXTREMELY FLAMMABLE.

Do not use near heat, sparks and open flames. The vapors given off from this product will burn. Contains petroleum distillate and MEK (Methyl Ethyl Ketone). Use only in well ventilated areas with enough air movement to remove vapors and prevent vapor buildup above allowable limits.

Avoid prolonged breathing of vapor. Avoid eye contact. Avoid prolonged or repeated contact with skin. Suggested first aid for eye contact: immediately flush with plenty of water for at least 10 minutes and call a physician. If swallowed, do not induce vomiting, call physician immediately. Keep container closed when not in use. Keep out of reach of children.

IMPORTANT NOTICE TO PURCHASER

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, but the accuracy or completeness thereof is not guaranteed, and the following is made in lieu of all warranties, express or implied:

Seller's and manufacturer's only obligation shall be to replace such quantity of the product proved to be defective. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct or consequential, arising out of the use of or the inability to use the product. Before using, user shall determine the suitability of the product for his intended use, and user assumes all risk and liability whatsoever in connection therewith.

No statement or recommendation not contained herein shall have any force or effect unless in an agreement signed by officers of seller and manufacturer.

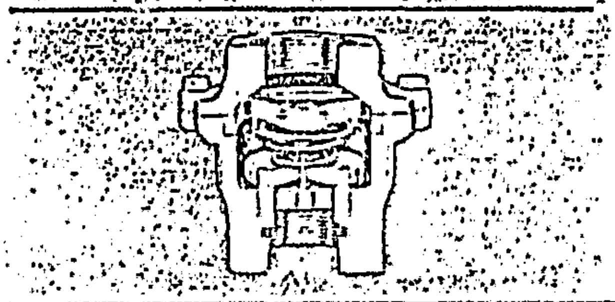
Revised and reprinted 7/15/77.
Z-1300(77.4)R2
LITHO IN U.S.A.

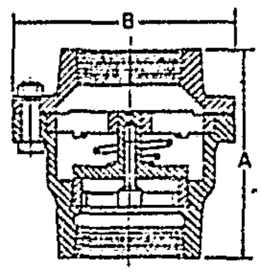
SCREWED END SILENT CHECK VALVES

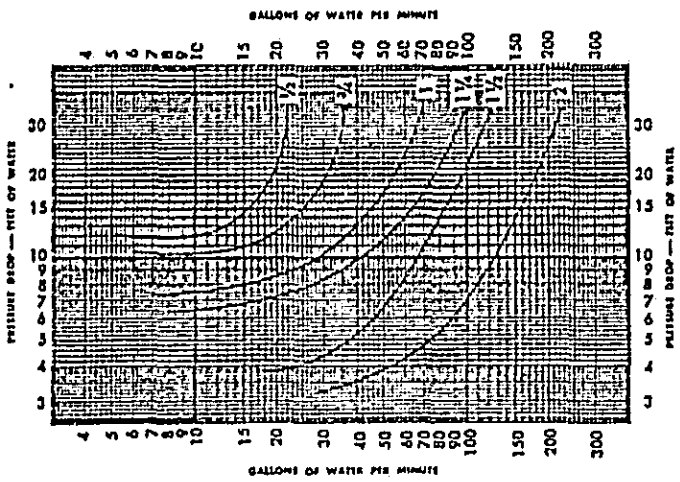
#203-AP Iron body
Sizes 1"-2" — bronze trim — 250 #WOG

#203-BP Bronze body
Sizes 1/2"-2" — bronze trim — 300 #WOG

#203-HT Type 316 Stainless steel body and trim
Sizes 1/2"-2" — 300 #WOG







SERVICE RECOMMENDATIONS: For liquid service, in accordance with ASA rated working pressures. For installation in pump suction or discharge piping. Satisfactory for certain types of air service — consult the factory. Spring automatically closes disc at zero flow — before flow reversal occurs and thereby prevents surge and water hammer.

FEATURES: Completely guided disc — both top and bottom.
Minimum open area through the valve equal to 110% of the area of corresponding pipe size.
High lift disc — all sizes feature discs which lift 1/3" per one inch of pipe size.
Replaceable, interchangeable parts.

ORDERING INFORMATION: We require all of the pertinent information relating to the operating conditions for which the valves are intended. Operating pressure, temperature, flow rates and/or velocity and the type of pump used in the installation. If corrosive fluids are involved we should be so advised. For certain applications among which are pump suction and volatile liquid handling our valves require springs heavier or lighter than those furnished as standard and in the absence of complete information we reserve the right to furnish standard springs.

INSTALLATION: Equally effective installed horizontally, vertically or at any other angle. No special tools required. We strongly suggest the installation of a strainer in the piping, located ahead of the pump. This sound measure will insure protection for both the pump and the working parts of the valve.

PRESSURE DROP: See pressure drop charts which are the results of actual physical tests. Available in certified form.

TESTING: Each valve is subjected to several tests, including hydrostatic testing of both the shell and the seat, in complete accordance with ASA standards. Certified test reports available.

CONSTRUCTION: Seats and discs are hand lapped to a fine finish and all parts are completely interchangeable. Stainless steel trim is available.

The guiding we have designed into this valve insures against the disc cocking out of position, regardless of the angle at which the valve is installed.

Springs furnished in stainless steel for all model numbers.

#203-AP and #203-BP furnished with graphited asbestos gaskets. #203-HT furnished with Blue African asbestos, Teflon, or any other material specified.

MEASUREMENTS AND WEIGHTS — APPROXIMATE — APPLY FOR CERTIFIED DRAWINGS

	SIZE	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
	"A"	3"	3"	4 1/8"	4 1/8"	4 1/4"	4 1/2"
	"B"	3"	3"	3 11/16"	3 7/8"	4 3/8"	5 1/8"
WGHT	#203-AP or #203-HT	2	3	3 1/2	4 1/2	5 1/2	7 1/2
WGHT	#203-BP	2	3	4	5	6	8

MUELLER STEAM SPECIALTY • BROOKLYN, N.Y. 11222

 ☆U.S. GOVERNMENT PRINTING 1979–640-081/433 REGION NO. 436