DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150840

SYSTEM DESIGN PACKAGE FOR SIMS PROTOTYPE SYSTEM 3, SOLAR HEATING AND DOMESTIC HOT WATER

Prepared from documents furnished by

IBM Corporation, Federal Systems Division
150 Sparkman Drive
Huntsville, Alabama 35805

Under Contract NAS8-32036 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

TABLE OF CONTENTS

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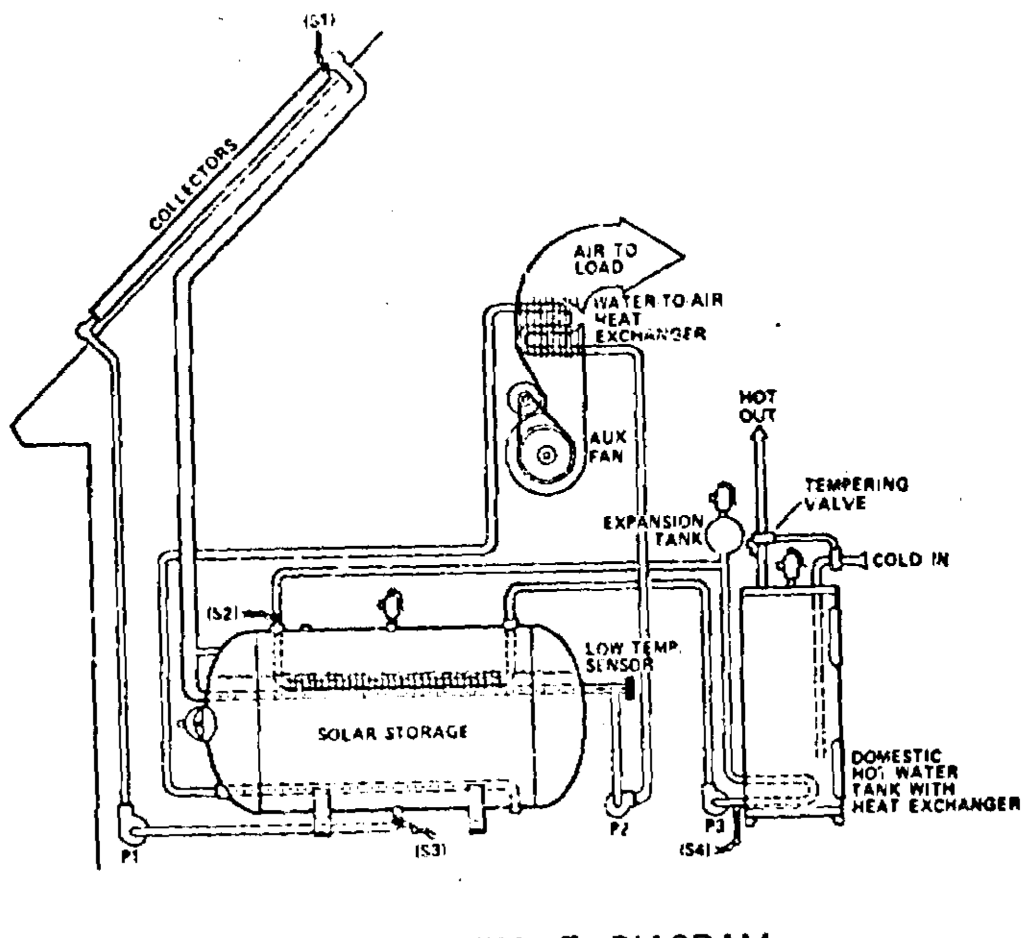
1.0 INTRODUCTION

The solar system design presented is a space and hot water heater, assembled from currently marketed components, for solar heating a single family dwelling of approximately 1200 square feet floor area. A prototype system has been designed, built and tested by IBM under contract NAS8-32036 to NASA Marshall Space Flight Center. This document provides design, performance, and hardware specifications sufficient for architectural engineers and contractors to procure, install, operate and maintain a similar solar application.



SYSTEM 3 DIAGRAM

2.0 SYSTEM DESCRIPTION

SIMS Prototype System 3 is a closed volume, passive drain down, solar system, for space and domestic water heating. Individually or in any combination (1) solar energy may be collected, (2) the house heated and/or (3) domestic water heated by energizing one of the three water pumps. The major hardware components are: (1) Sunworks flat plate collectors to capture the solar radiation, (2) an Adamson 1,000 gallon hot water storage tank, (3) a Ford Products 65 gallon tank for domestic hot water and (4) Grundfos pumps to transfer solar energy on command from the (5) Solar Control Corporation controllers. The components are configured into the collector, storage, energy transport and control subsystems which makeup the System 3 configuration. The following subsystem paragraphs describe the features of the respective subsystems. Component data provided by the respective vendors should be consulted for detailed hardware descriptions and ratings.

2.1 COLLECTOR SUBSYSTEM

Technical data on the Sunworks liquid solar collector is presented in Appendix A. The basic collector module is a 7' x 3' rectangular unit housed in an aluminum frame and weighing 114 pounds. Each module has a single 3/16" thick tempered safety glass cover for the 18.7 Ft^2 selective surface absorber area. The liquid system has a flow pattern designed to provide uniform flow through all tubes and to drain without water entrapment. Inlet and outlet fluid connections are 1" dia. copper pipe.

2.2 STORAGE SUBSYSTEM

The storage subsystem consists of an Adamson ASME 1000 gallon hot water storage tank and two internal distribution manifolds. The hot (top) and cold (bottom) distribution manifolds are designed to enhance stratification within storage. (The finned tube heat exchanger which provides heat to DHW is installed near the hot manifold.) In operation, the tank will contain approximately 900 gallons of solar heated water with the remaining volume functioning as an expansion tank and air separator. To reduce corrosion problems, the system is air tight; therefore, the internal pressure will vary with storage temperature. Pressure relief is provided at 30 psig.

2.3 ENERGY TRANSPORT SUBSYSTEM

The energy transport subsystem has three functional missions, with each function associated with one of the three circulating pumps.

2.3.1 Collector Heat Removal

Pump P1 transfers heat energy from the collectors to solar storage. A Grundfos Model UP 26-64F pumps lift water from the bottom of solar storage, through the collector array (where it is heated) and over the brink of the free fall return line. Solar heated water entering the free fall return line "drops" into storage.

2.3.2 Space Heating

Pump P2 removes heat energy from solar storage and adds it to air being circulated from the heated space. A single Grundfos Model UP 26-64F pump is capable of providing 7 gpm design flow through the coils of an liquid-to-air heat exchanger against 14 ft H_2O head. The Heat exchanger has been sized to supply 30,000 BTU/Hr from solar storage water at 120°.

2.3.3 Domestic Water Heating

The DHW pump begins to transfer heat energy from solar storage to domestic hot water storage anytime the solar storage temperature is 20°F greater than the temperature at the bottom of the DHW tank. The transfer circuit consists of a water filled loop connecting a finned tube heat exchanger in solar storage to a similar heat exchanger in DHW storage. The dual exchanger configuration provides double wall isolation between solar water and potable water. Energy transfer continues until the control differential is reduced to 4°F.

2.4 CONTROL SUBSYSTEM

The solar control subsystem provides for the independent, non-exclusive operation of each of the three liquid pumps to accomplish a desired heat transfer function. Two differential thermostats, a low temperature sensor and a standard two stage room thermostat provide the controller input signals.

The collector differential thermostat will start pump P1 when probe S1 is 20°F hotter than probe S3. When the temperature of probe S3 becomes 4°F ± 2°F colder than S1, pump P1 will turn off.

The DHW differential thermostat will start pump P3 when probe S2 is 20°F hotter than probe S4. When the temperature of probe S4 becomes 4°F ± 2°F colder than probe S2, pump P3 will turn off.

Freeze Protect: The differential thermostat is factory equipped with a freeze protect feature that will close the N-O contacts when probe #1 (typically collector probe) shows a temperature of 40°F ± 5°F. Since System 3 is designed to use passive drain down of the collectors for freeze protection, this feature must be disabled per vendor instructions from the collector control unit.

Boil Protect: The differential thermostat is factory equipped with a boil protect feature that will turn the controller off when a temperature of 180°F is reached at the collector. This feature must be disabled per vendor instructions for the unit used to control collector operation.

A wiring diagram for the control subsystem is shown in Figure 2-1.

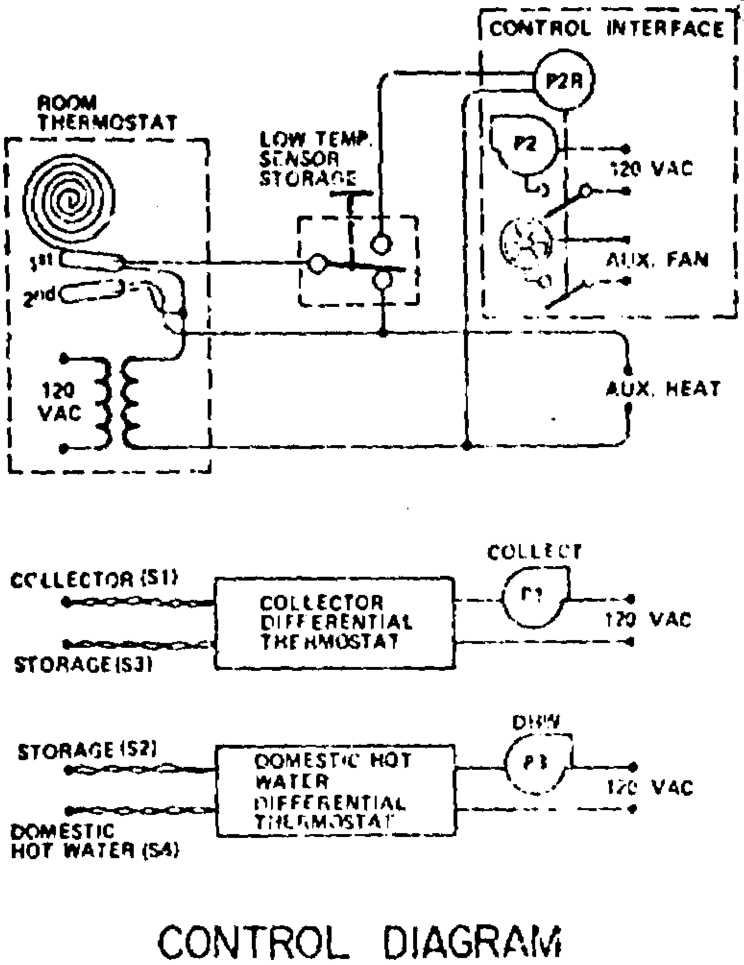
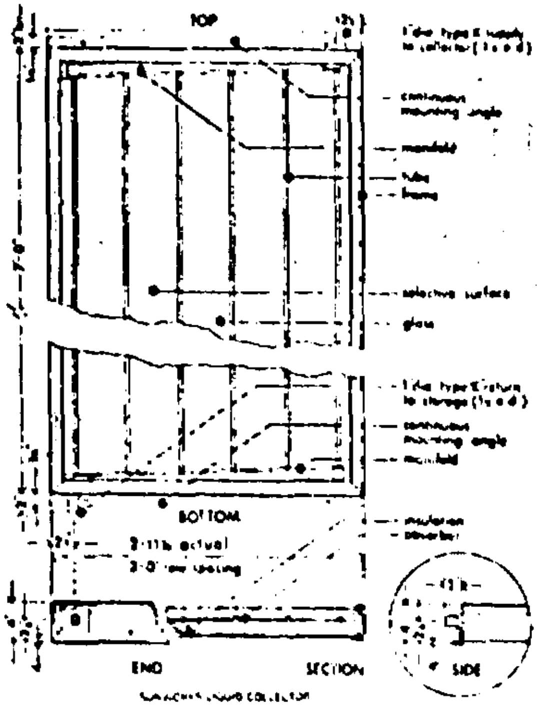
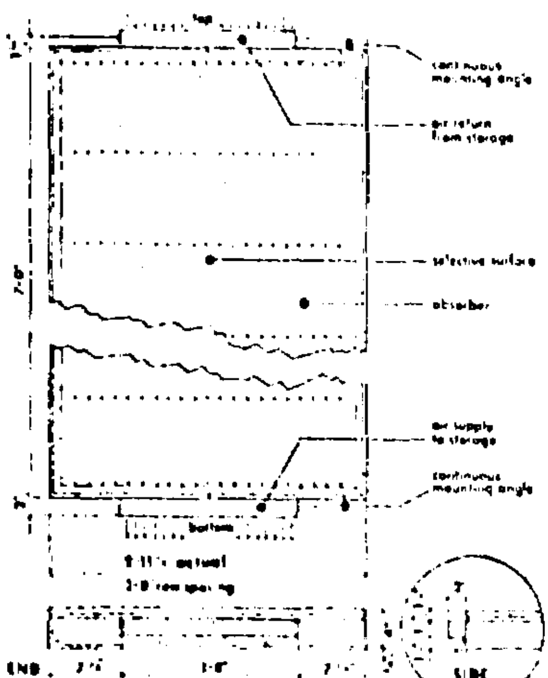


Figure 2-1 Control Wiring

APPENDIX A



SUNWORKS LIQUID COLLECTOR



SUNWORKS AIR COLLECTOR

TECHNICAL DATA ON SOLECTOR* SOLAR ENERGY COLLECTORS (LIQUID-TYPE AND AIR-TYPE)**

Cover: single glass, 3/16 in. tempered, edges swiped, 92% solar transmittance
Absorber container: sides: aluminum extrusion; rear: aluminum sheet 0.05 in. thickness
Air space between cover and absorber: approximately 1 in.
Gasketing material: neoprene "U" gasket
Weatherproofing: this module can be placed out in the weather without need for further weatherproofing
Finish on aluminum sides of container: standard mill finish. Anodized clear or black finish available at extra cost
Dimensions of surface-mounted module:
- —outside dimensions overall: 36 in. wide x 84 in. long x 4 in. thick (add 1-3/8 in. each end for continuous mounting bracket)
- —effective absorber area: 18.68 ft^2
- —ratio of usable absorber area to total surface covered: 0.902
- —glass area: 18.96 ft^2

Method of anchoring: continuous mounting bracket is fastened to each end of frame for anchoring; four predrilled holes are provided for anchor bolt or screw connections; additional holes may be drilled by installer if required
Solector solar energy collectors can be mounted end-to-end for series flow or side-by-side for parallel flow. It is recommended that no more than three collectors be connected in series. The Solector solar energy collector modules for both liquid and air are identical in size, 3 ft. wide and 4 in. thick and are available in two lengths: 5'4" long or 7'0" long

DATA ON LIQUID SOLECTOR SOLAR ENERGY COLLECTORS

Absorber
- —copper sheet: 0.010 in. thick (7 oz.)
- —selective black: minimum absorptivity .90, maximum emissivity .12; manufactured by Enthone Inc., durable to 400°F
- —copper tubes: ¼ in. ID (0.375 in. OD) M-type
- —tube spacing: 6 in. on center
- —tube pattern: grid
- —manifolds: 1 in. ID (1.125 in. OD) M-type copper
- —tube connections to manifold: silver solder
- —bond between tube and sheet: soft solder
- —connection to external piping: 1 in. ID (1.125 in. OD) K-type copper, extending 2 in. beyond collector ends; supply, top right; return, bottom left (when viewed from the top)
- —manifold/tubes pressure-tested to 15 atm; 125 psig working pressure

Insulation behind absorber: 2½ in. thick fiberglass, 1.5 lb/ft^3 density, R = 10.4
Weight per module: 113.9 pounds, filled; 111 pounds, empty. (NOTE: the liquid in the collector is equal to 0.36 gallons or 46.4 ounces or 2.90 pounds or 0.05 ft^3 or 80.5 in^3.)
Recommended flow rate through collector: 1 gph/ft^2 of collector (F_R = 0.95) (flow resistance at this rate is negligible)
Collector coolant: coolant can be inhibited alcohol-water mixtures such as standard automobile anti-freeze made by Union Carbide or duPont. In areas where regular tap water is used as a coolant, it is important that the pH be controlled between 6 and 8. These collectors can be used with other coolants but the user must contact the manufacturer for approval of specific liquids. (See guarantee statement available from Sunworks.)

DATA ON AIR SOLECTOR SOLAR ENERGY COLLECTORS

Absorber
- —copper sheet: 0.016 in. thick (12 oz.)
- —selective black: minimum absorptivity .90, maximum emissivity .12, applied by Enthone, Inc., durable to 400°F
- —air chamber: 7/8 in. high, mechanical bond to absorber
- —connection to external duct: 1⅝ in. x 20 in. duct stub extending 2 in. beyond end of collector envelope
- —distribution pattern: parallel top to bottom, behind absorber

Insulation behind absorber: 1 in. thick fiberglass plus 1 in. urethane, R = 10
Weight per module: 111 lb.
Recommended flow rate through collector: 3 cfm/ft^2 of collector (flow resistance at this rate is negligible)
NOTE: Manufacturer reserves right to change specifications and dimensions without notice.

*Trademark of Enthone, Inc. **Patents Pending

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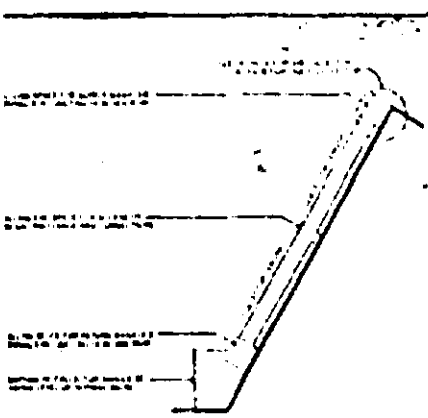
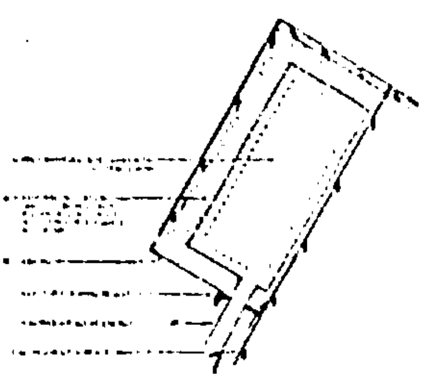
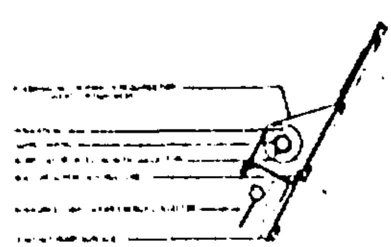


TYPICAL ROOF LOCATION COLLECTORS IN SERIES



DETAIL A

TYPICAL SUPPLY DUCT FOR AIR COLLECTOR



DETAIL B

TYPICAL SUPPLY PIPING FOR LIQUID COLLECTOR

Hot Water Storage Tanks . . .
Description, Operation, Selection Of Equipment

An Adamson Hot Water Storage Tank used in conjunction with a boiler or other independent water-heating unit, provides an alternate system for heating and storing domestic hot water. A properly sized tank will provide storage capacity sufficient to meet peak and normal system demands.

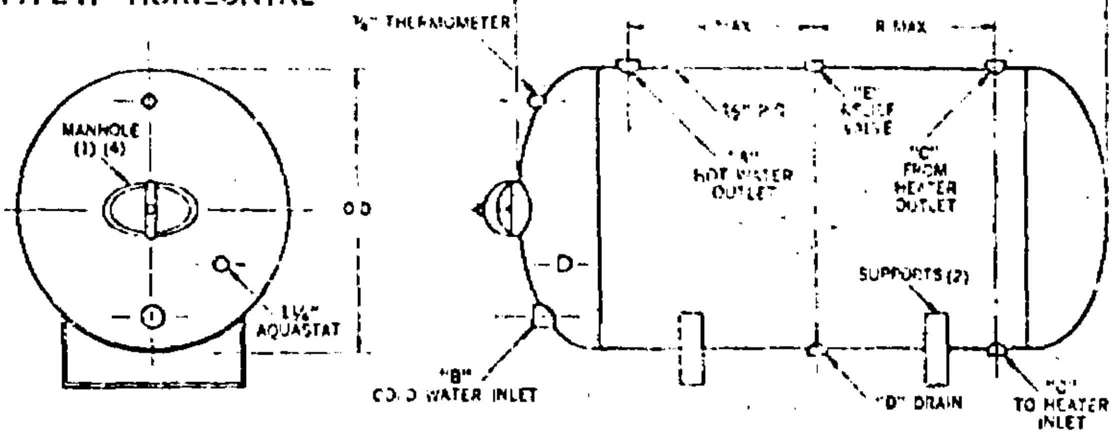
OPERATION

Incoming cold water enters the lower part of the storage tank. Either by gravity flow or forced flow, the cold water leaves the storage tank and passes through the water heating unit. The heated water is returned to the upper part of the storage tank where it is held in reserve until required by the system. As required, water is supplied to the system from the hot water outlet in the upper part of the tank.

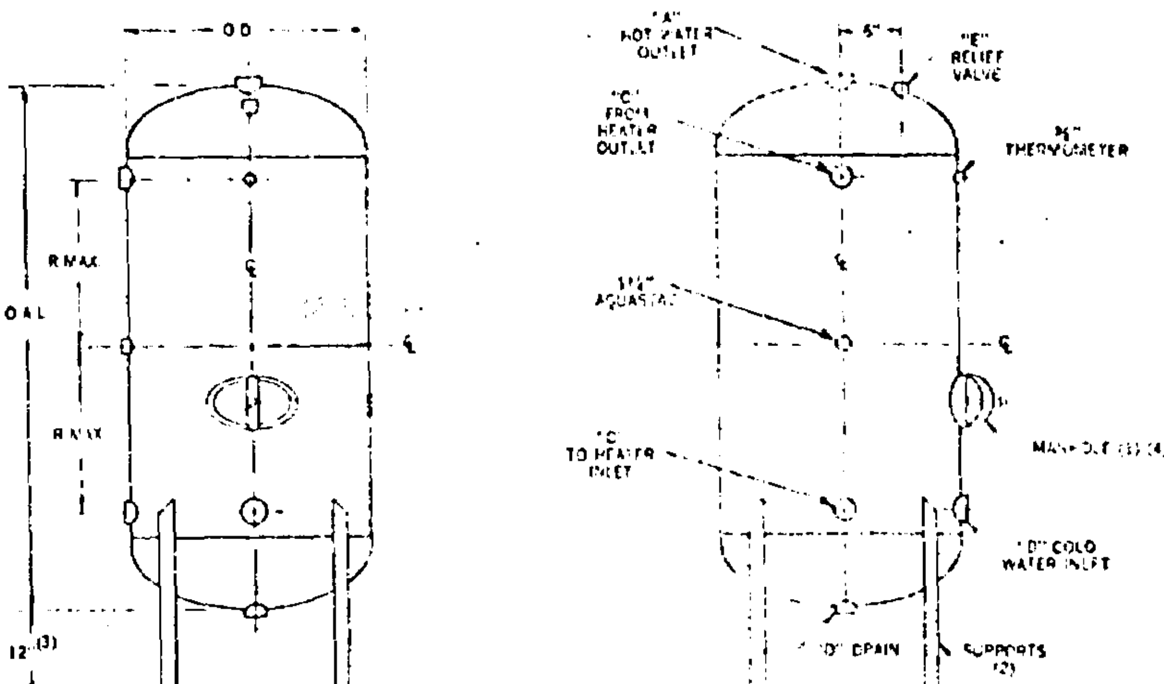
SELECTION

The charts on page 10 give normal GPH requirements of 140 F water for plumbing fixtures in various types of installations. By totaling the GPH requirement and applying storage capacity factors as illustrated, the required storage capacity can be determined. Selection of the proper size hot water storage tank can be determined from the chart on page 16.

TYPE H - HORIZONTAL



TYPE V - VERTICAL



Water Storage Heater And Tanks

TYPE H — HORIZONTAL
TYPE V — VERTICAL

Tank No	Dimensions: OD Dia. In	Dimensions: L OAL Ft	Capacity (gallons): Actual	Capacity (gallons): Nominal	Opening Sizes: A & B	Opening Sizes: C & D	Opening Sizes: E	Opening Sizes: R-Max
D 48	24	4	84	94	1½	1	1	10
D 60	24	5	107	118	1½	1	1	16
D 72	24	6	130	141	1½	1	1	22
D 84	24	7	153	165	1½	1	1	28
D 96	24	8	176	188	1½	1	1	34
D120	24	10	222	235	1½	1	1	46
E 48	30	4	127	147	1½	1	1	8
E 60	30	5	163	184	1½	1	1	14
E 72	30	6	195	220	1½	1	1	20
E 84	30	7	235	257	1½	1	1	26
E 96	30	8	270	294	1½	1	1	32
E108	30	9	305	330	1½	1	1	38
E120	30	10	342	367	1½	1	1	44
F 60	36	5	232	264	2	1½	1	13
F 72	36	6	234	317	2	1½	1	19
F 84	36	7	[illegible]	[illegible]	2	1½	1	25
F 96	36	8	[illegible]	423	2	1½	1	31
F108	36	9	439	476	2	1½	1	37
F120	36	10	490	529	2	1½	1	43
F144	36	12	594	635	2	1½	1	55
F168	36	14	697	740	2	1½	1	67
G 72	42	6	379	432	2½	1½	1½	17
G 84	42	7	455	504	2½	1½	1½	23
G 96	42	8	520	576	2½	1½	1½	29
G108	42	9	591	648	2½	1½	1½	35
G120	42	10	661	720	2½	1½	1½	41
G144	42	12	802	854	2½	1½	1½	53
G168	42	14	943	1008	2½	1½	1½	65
G192	42	16	1084	1152	2½	1½	1½	77
H 72	48	6	490	564	2½	2	1½	16
H 96	48	8	675	752	2½	2	1½	28
H120	48	10	860	940	2½	2	1½	40
H144	48	12	1045	1128	2½	2	1½	52
H168	48	14	1230	1316	2½	2	1½	64
H192	48	16	1415	1504	2½	2	1½	76
H216	48	18	1600	1692	2½	2	1½	88
J 96	54	8	844	952	2½	2	1½	26
J120	54	10	1077	1190	2½	2	1½	38
J144	54	12	1311	1428	2½	2	1½	50
J168	54	14	1546	1666	2½	2	1½	62
J192	54	16	1780	1904	2½	2	1½	74
J216	54	18	2014	2142	2½	2	1½	86
J240	54	20	2248	2380	2½	2	1½	98
K 96	60	8	1030	1175	3	2½	1½	25
K120	60	10	1323	1469	3	2½	1½	37
K144	60	12	1609	1763	3	2½	1½	49
K168	60	14	1872	2056	3	2½	1½	61
K192	60	16	2165	2353	3	2½	1½	73
K216	60	18	2478	2644	3	2½	1½	85
K240	60	20	2768	2938	3	2½	1½	97
K288	60	24	3347	3525	3	2½	1½	119
K360	60	30	4215	4409	3	2½	1½	157

Tank No	Dimensions: OD Dia. In	Dimensions: L OAL Ft	Capacity (gallons): Actual	Capacity (gallons): Nominal	Opening Sizes: A & B	Opening Sizes: C & D	Opening Sizes: E	Opening Sizes: R-Max
L 96	66	8	1281	1408	3	2½	1½	23
L120	66	10	1632	1760	3	2½	1½	35
L144	66	12	1983	2112	3	2½	1½	47
L168	66	14	2334	2465	3	2½	1½	59
L192	66	16	2685	2817	3	2½	1½	71
L216	66	18	3036	3169	3	2½	1½	83
L240	66	20	3387	3521	3	2½	1½	95
L288	66	24	4089	4225	3	2½	1½	119
L360	66	30	5141	5281	3	2½	1½	155
M120	72	10	1864	2115	3	2½	1½	34
M144	72	12	2281	2538	3	2½	1½	46
M168	72	14	2699	2961	3	2½	1½	58
M192	72	16	3116	3334	3	2½	1½	70
M216	72	18	3533	3707	3	2½	1½	82
M240	72	20	3750	4230	3	2½	1½	94
M288	72	24	4734	5076	3	2½	1½	118
M360	72	30	6036	6351	3	2½	1½	154
P120	84	10	2493	2579	4	2½	1½	31
P144	84	12	3059	3455	4	2½	1½	43
P168	84	14	3626	4030	4	2½	1½	55
P192	84	16	4195	4606	4	2½	1½	67
P216	84	18	4763	5192	4	2½	1½	79
P240	84	20	5331	5758	4	2½	1½	91
P264	84	22	5899	6334	4	2½	1½	103
P288	84	24	6467	6909	4	2½	1½	114
P312	84	26	7035	7456	4	2½	1½	126
P336	84	28	7603	8061	4	2½	1½	133
P360	84	30	8171	8637	4	2½	1½	151
S120	95	10	3193	3760	4	2½	1½	28
S144	96	12	3935	4512	4	2½	1½	40
S168	96	14	4677	5264	4	2½	1½	52
S192	96	16	5419	6016	4	2½	1½	64
S216	96	18	6162	6768	4	2½	1½	76
S240	96	20	6904	7520	4	2½	1½	88
S264	95	22	7646	8272	4	2½	1½	100
S288	96	24	8389	9024	4	2½	1½	112
S312	96	26	9131	9776	4	2½	1½	124
S336	96	28	9873	10528	4	2½	1½	136
S360	96	30	10515	11280	4	2½	1½	145
S384	95	32	11357	12032	4	2½	1½	160
S408	96	34	12100	12784	4	2½	1½	172

All Dimensions in Inches Unless Otherwise Indicated

A.S.M.E. requirements state that if the opening is greater than 3" and the working pressure is greater than 125 PSI, the opening must be a flanged nozzle.

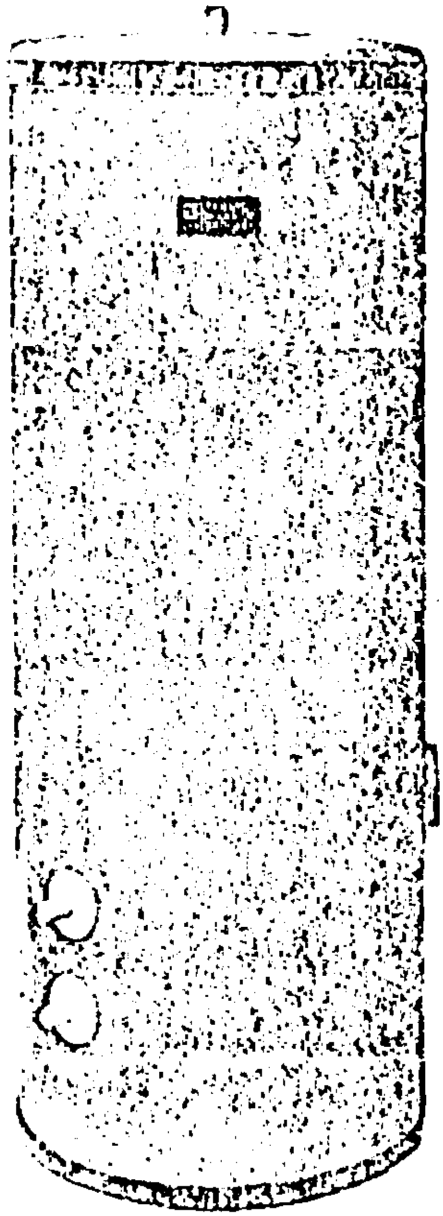
(1) 11" x 15" manhole is required on A.S.M.E. tanks 42" diameter and larger

(2) Support details are shown on pages 31 and 32

(3) Clearance can be changed as required

(4) On all lined tanks 30" and under, manhole must be in [illegible]

FORD AQUA-COIL



Uses Boiler Water With A Coil In The Tank To Supply Abundant Quantities Of Hot Water

FORD products corporation

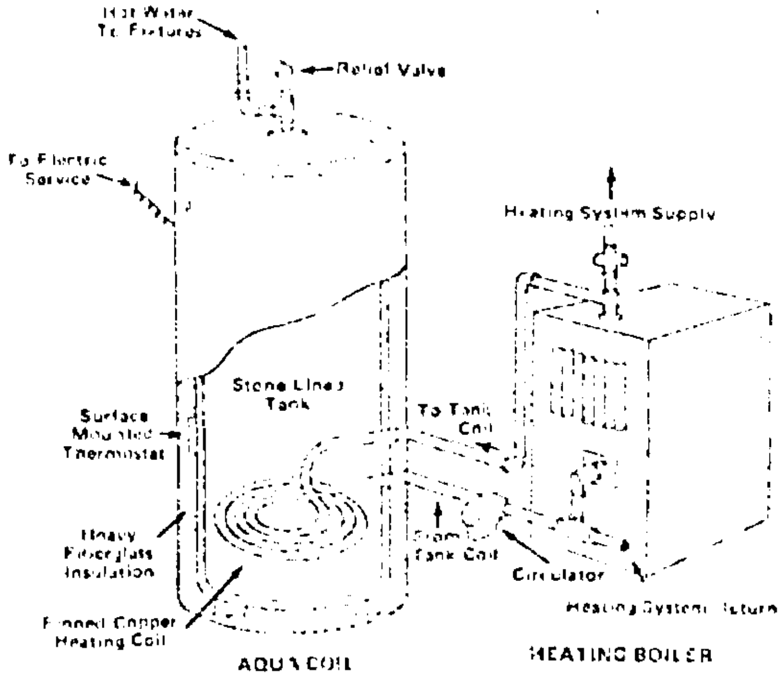
- No liming of coil
- Can use a cast-iron circulator
- Provides an abundance of hot water from modern min. boilers
- Long life stone-lined tank
- Adjustable water temperature
- Easy to install
- Eliminates pressure drop in domestic hot water system

SPECIFICATIONS

STONE-LINED MODELS
5 YEAR LIMITED WARRANTY
(Do Not Require Anode)

Model	TC40	TC65
Capacity Gallons	40	65
Height	53"	55"
Overall Diameter	20"	24"
Floor to Drain	6½"	7
Circ. Outlet to Floor	12"	13"
Max. Width	2[illegible]"	31"
Water Connections	[illegible]"	[illegible]"
Weight, Lbs	2[illegible]0	310
*Recovery Capacity	45	90

*Gal Hr. Based 100°F



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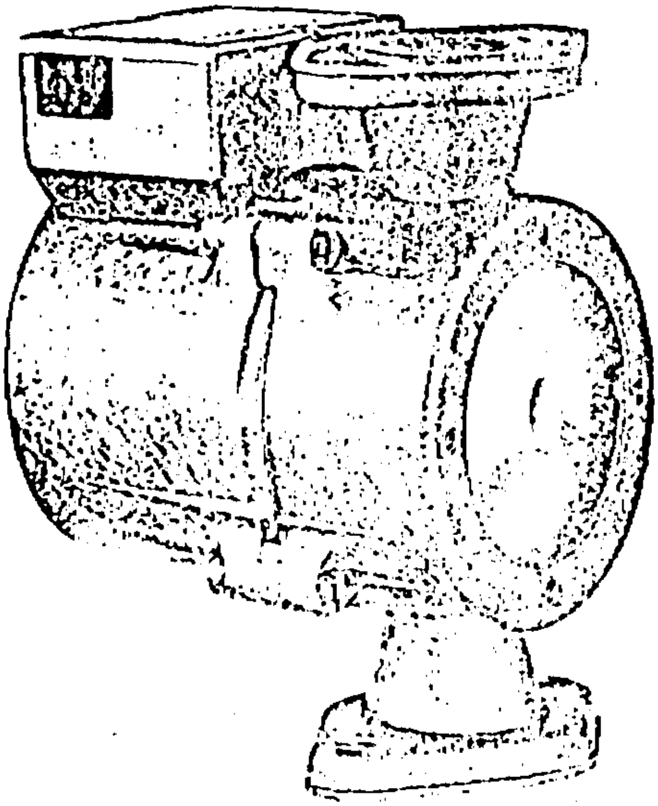
Recovery capacity is based on a boiler setting of 200°F and entering water temperature of 40°F.

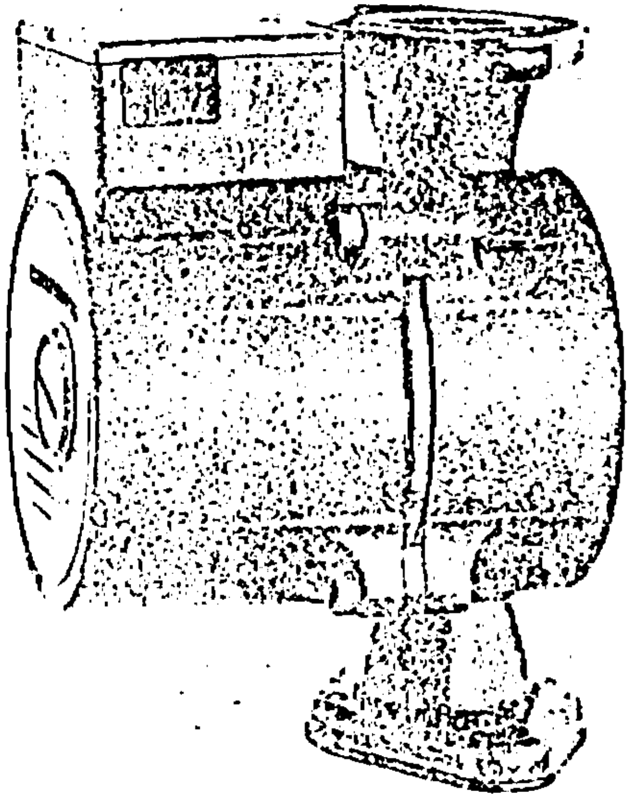
Aqua Coil includes an insulated jacket, stone lined storage tank with copper heating coil, thermostat, circulator and drain cock. Connecting piping is not included. Where boiler water temperature is not maintained, relay must be installed for domestic hot water. With a multi-zone heating system, a zone control valve may be used in place of a circulator.

Warranty certificate available on request.

FORD products corporation

Ford Products Road, Valley Cottage, New York 10989 / Phone: 914 358 8282





INFORMATION: Stainless steel circulator pump – UP 25-42 SF

The UP 25-42 SF is a revolutionary circulator pump. The water passing through the pump touches nothing but high quality fabricated stainless steel. The volute section, for example, is constructed of type 316 stainless. As with all Grundfos circulators, the UP 25-42 SF is engineered to be interchangeable with the pumps of all other major manufacturers.

CONSTRUCTION

The UP 25-42 SF is a water lubricated pump. However, in order to protect the rotor and bearings from damaging impurities which may be present in the circulating water, they are separated from the stator and the pump chamber by a liquid filled rotor can. The motor shaft extends out from the rotor can, into the pump chamber through the aluminum oxide bearing, which also functions as a seal. During initial operation, the pump is automatically self-vented; however, due to the isostatic principle, there is no further recirculation of water into the closed rotor can.

The pump's "diamond-hard" aluminum oxide bearing construction, combined with the high starting torque of the motor, ensures re-start after shutdown.

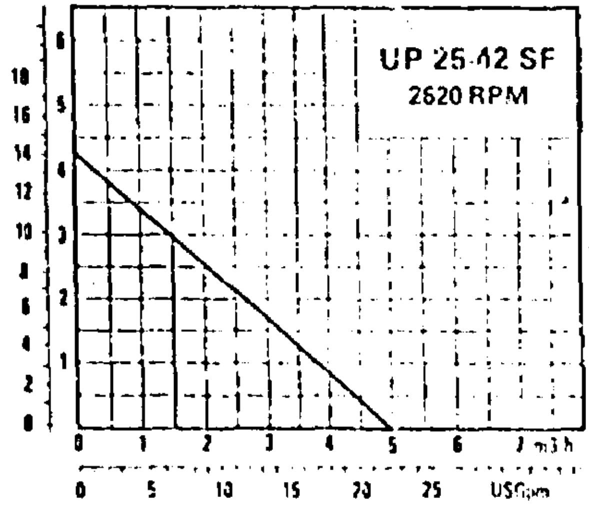
MATERIALS

Stainless steel:	Pump chamber, rotor can, shaft, rotor cladding, bearing plate, impeller, thrust bearing cover.
Aluminum oxide:	Top bearing, shaft ends, bottom bearing.
Carbon/aluminum oxide:	Thrust bearing.
Aluminum:	Motor housing, pump housing cover.
Ethylene/propylene rubber:	O-rings, gasket.
Silicon rubber:	Winding Protection.

APPLICATIONS

The UP 25-42 SF is particularly suited for open and potable systems. The stainless steel construction protects the pump from the corrosion that has plagued cast iron and bronze-lined pumps in these types of applications. The pump is intended for circulation and booster applications in domestic water systems.

PERFORMANCE CURVE UP 25-42 SF



ELECTRICAL AND PERFORMANCE DATA

The UP 25-42 SF is operated by an energy-conserving 1/20th HP (0.85 amp) motor which has built-in overload protection. However, because of advanced engineering design, the pump produces up to 14 feet of head or a flow of up to 23GPM. The pump's small size and high efficiency make it suitable for many varied applications and greatly reduces installation problems.

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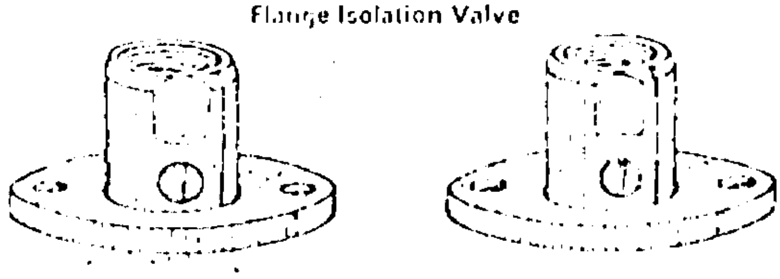
DIMENSIONS UP 25-42 SF

Type	A mm inches	B mm inches	C mm inches	D mm inches	E mm inches	H mm inches	Packing (Lxwxh) mm	Ship vol. m3 CUft	Weight Kg Lbs
UP 25-42 SF (w/flanges)	165 6 1/2	103.5 3 1/4 [illegible]	33.5 1 1/3	106 1 1/4 [illegible]	82 3 1/4	120 5 1/8	200 x 180 x 160 [illegible] 7 7/8 x 7 x 6 1/4 [illegible]	0.0 5 [illegible] 1.5	3 6 1/2

ISOLATION VALVES

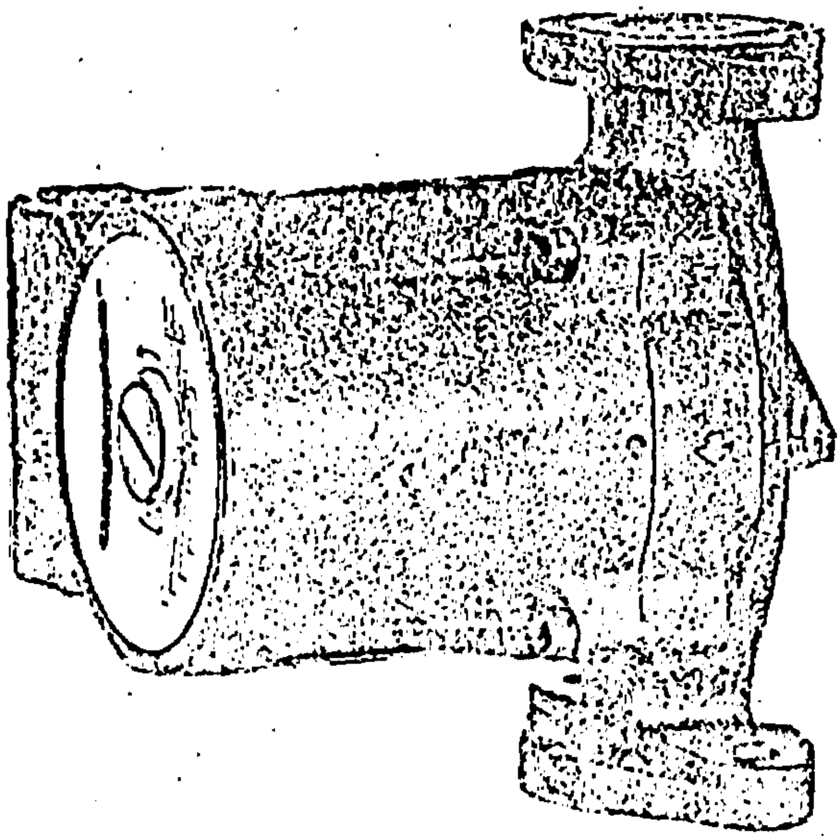
GRUNDFOS recommends the use of isolation valves with circulation pumps in all systems

Flange Isolation Valve



ORDER NUMBERS

Type	Order No.	Bronze Flanges Dim.	Bronze Flanges Order No.	Flange Valves Dim.	Flange Valves Order No.
UP 25-42 SF with flanges	51 (4 21 13 [illegible]	3/4" 1" 1¼"	51 06 51 [illegible] 51 06 52 [illegible] 51 06 53 [illegible]	1"	51 07 22 [illegible]



INFORMATION Variable Head Circulator Pump—UP 26-64

The UP 26-64 is fitted with variable-head-control. This innovative mechanism, which controls both the head and the flow produced by the pump, allows the installer, by a simple hand adjustment, to precisely match the UP 26-64 to the demands of many varying systems.

CONSTRUCTION

The UP 26-64 is a water lubricated pump. However, in order to protect the rotor and bearings from damaging impurities which may be present in the circulating water, they are separated from the stator and the pump chamber by a liquid filled rotor can. The motor shaft extends out from the rotor can, into the pump chamber through the aluminum oxide bearing, which also functions as a seal. During initial operation, the pump is automatically self-vented; however, due to the isostatic principle, there is no further recirculation of water into the closed rotor can.
The pump's "diamond-hard" aluminum oxide bearing construction, combined with the high starting torque of the motor, ensures re-start after shutdown.

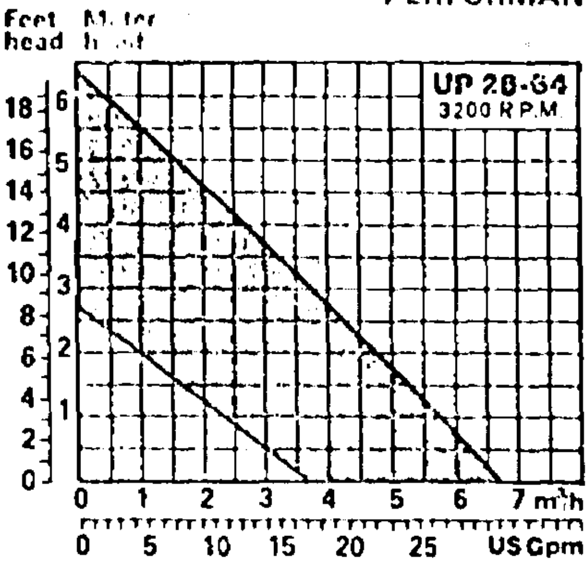
MATERIALS

Stainless steel: .... Rotor can, shaft, rotor cladding, bearing plate, impeller, variable flow adjustment plate, thrust bearing cover.
Aluminum oxide: .... Top bearing, shaft ends, bottom bearing.
Carbon/aluminum oxide: .... Thrust bearing.
Cast iron .... Pump housing.
Ethylene/propylene rubber: .... O-rings, gasket.
Silicon rubber: .... Winding Protection.

APPLICATIONS

The UP 26-64 should only be used in closed systems (i.e. solar, hydronic). The pump is intended only for the circulation of water. However, solutions such as ethylene glycol can be used without hindering pump performance. For open system applications ask for Grundfos' stainless steel volute circulator pumps.

PERFORMANCE CURVES UP 26-64



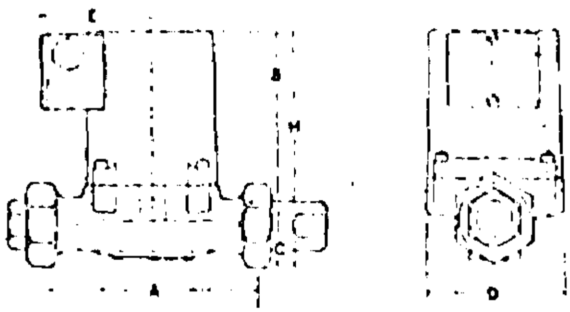
ELECTRICAL AND PERFORMANCE DATA

The UP 26-64 is operated by an energy-conserving 1/12th HP (1.65amp) motor, which has built-in overload protection. However, because of its advanced design, the pump produces heads from 8 to 20 feet or flows from 16 to 30 GPM. The pump's small size and high efficiency make it suitable for many varied applications and greatly reduces installation problems.

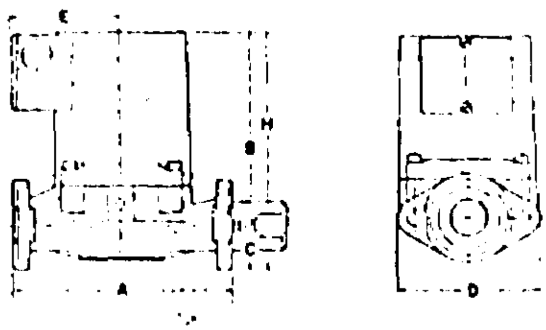
Contact Grundfos for information regarding the complete line of circulator pumps and twin pumps.

DIMENSIONS

UP 26-64 U



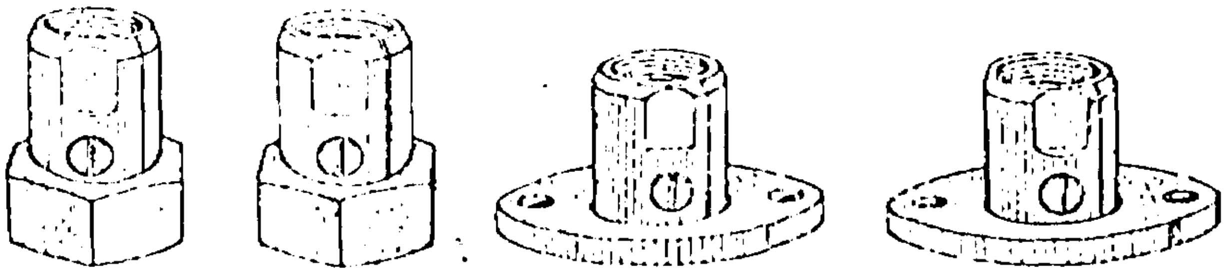
UP 26-64 F



Type	A mm inches	B mm inches	C mm inches	D mm inches	E mm inches	H mm inches	Packing L x w x h mm/"	Ship vol. M³ Cuft	Weight kg Lbs
UP 26 64U with unions	180 7 1 16	236 3 1 4	32 1 1/4	102 4 1/8	80 3 3/16	165 6 1/2	195 x 200 x 200 7 3/4 x 7 7/8 x 7 7/8	0.008 1/4	5.5 12 1/8
UP 26 64F with flanges	165 6 1 2	128 5 1 16	33.5 1 3 8	106 4 1 4	82 3 1/4	161.5 6 3 8	195 x 200 x 200 7 3 4 x 7 7/8 x 7 7/8	0.008 1/4	5.5 12 1/8

ISOLATION VALVES

GRUNDFOS recommends the use of isolation valves with circulation pumps in all systems.



Union Isolation Valve

Flange Isolation Valve

ORDER NUMBERS

		Unions		Flanges		Flange Valves Union Valves	
Type	Order No	Dim	Order No	Dim	Order No	Dim.	Order No.
UP 26 64F with flanges	52 22 30 13	3/4" 1"	51 05 21 51 05 22	3/4" 1"	51 06 01 51 06 02	1"	51 07 72
UP 26 64U with unions	52 25 20 11			1 1/4" 1 1/2"	51 06 03 51 06 04	1"	51 58 72

The Boss

for solar domestic hot water systems.

A controller that takes the mystery out of solar heating and mounts on standard electrical fixtures!

The Model 77-171 is a solid state, differential thermostat for complete control of [illegible] solar hot water systems. It installs in minutes and directly controls collector motors up to ¼ H.P. Larger motors can be controlled with an auxiliary relay.

The controller features freeze and boil protection and a tracking accuracy of ±5 F over the entire operating temperature range. A variety of surface mounted and immersible probes are available. All power components are U.L. listed.

For complete application data and installation details write or call today.

Specifications

Input voltage
Either 120 VAC ±10V or 24 VAC ±4V

Input power
3 watts, no load

Control relay
SPDT, 10A (resistive) at 28 VDC or 120 VAC. Higher ratings available

Output voltage
Either 120 VAC or 24 VAC

Sensors
Matched thermistors, (±1°C over range from 0°C to ±100°C) in various housing configurations, with high temperature Teflon® leads

Differential Turn-on Offset
Typically 20°F ±2° @ 100°F (can be adjusted by a resistor change)

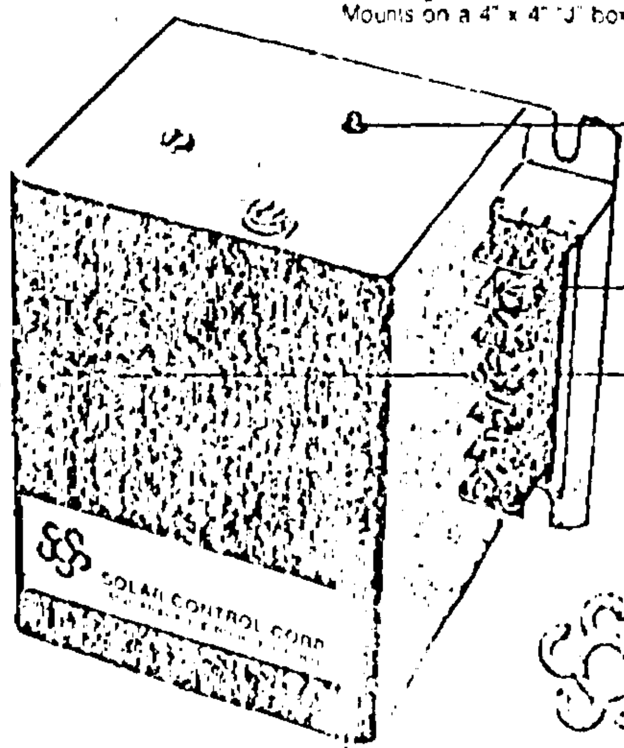
Differential Turn-off Offset
Typically 4°F ±2° @ 100 F (can be adjusted by a resistor change)

Operating Temperature Range
Controller chassis −40°F to +130°F
Sensors −40 F to +300 F

Tracking Accuracy
±5 F over entire operating range

Size
4" x 4" x 3½"

Mounting
Mounts on a 4" x 4" "J" box



SPECIAL INTRODUCTORY PRICE

$29.00

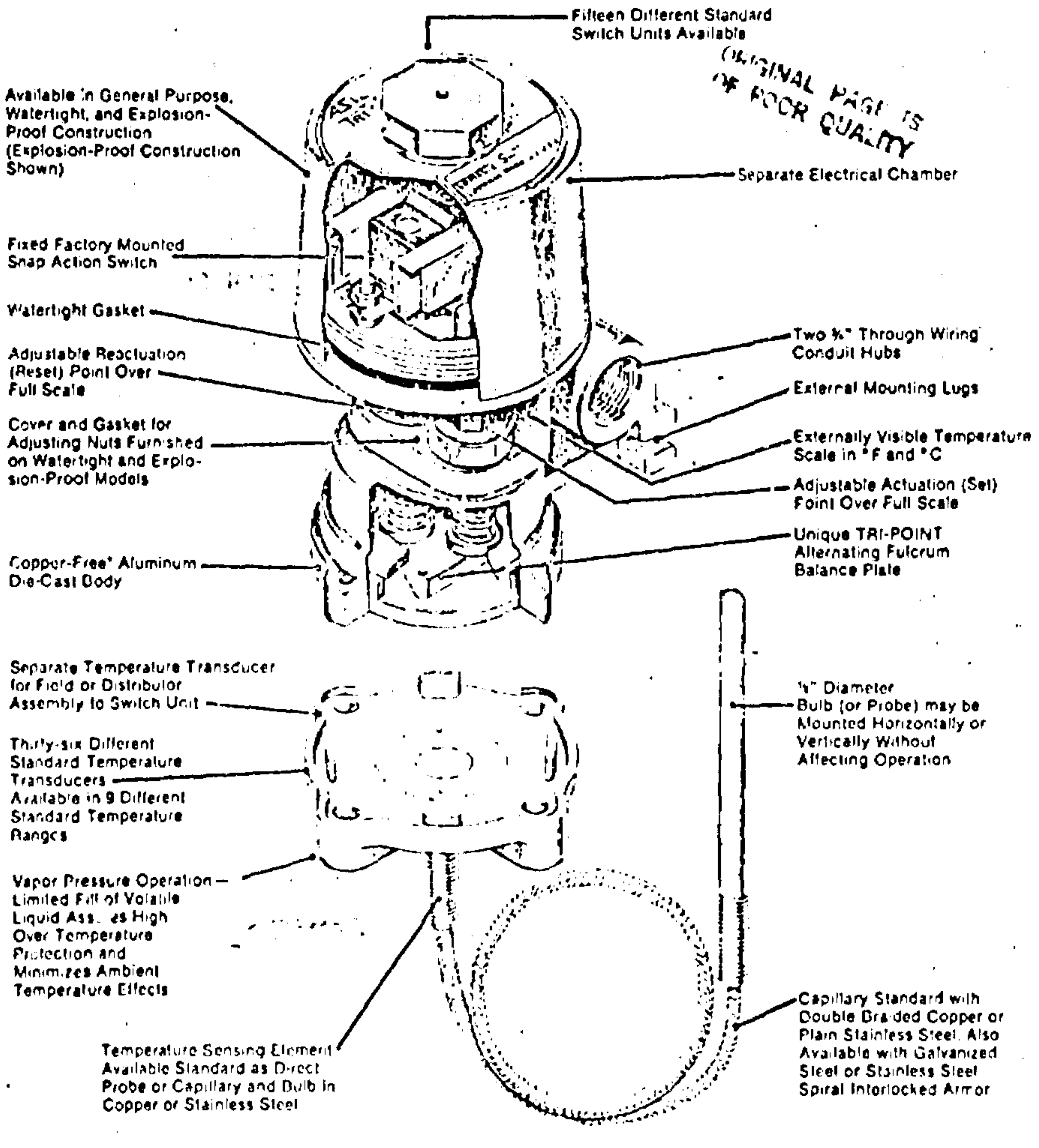
(To OCM purchasers for the duration of President Carter's Solar Hot Water Program)*

*[illegible]

SOLAR CONTROL CORP.
5595 Arapahoe Rd
Boulder, CO 80302
303-449-9180

ASCO's TRI-POINT TEMPERATURE SWITCH

incorporates the features most wanted!



*0.4% copper content or less

Temperature Switches

FIXED DEADBAND TYPE
Adjustable Set Point
Non-Adjustable Reset Point

ASCO TRI-POINT

SERIES: SB10 • SB11 • SB12

GENERAL DESCRIPTION: This series of ASCO TRI-POINT Temperature Switches is the fixed deadband type. They consist of two separate sub units, a factory adjusted switch assembly unit and a temperature transducer unit. The temperature transducer utilizes a vapor fill to actuate the switch assembly unit in response to temperature changes. These temperature switches may be purchased as an assembled unit, or they may be purchased as two separate units for field assembly. *In all cases, when ordering, the third digit of the switch assembly unit must be identical to the third digit of the temperature transducer unit.*

Example: SB10A Assembled to QA10A1
└── Must Be Identical ──┘

OPERATION: The temperature transducer uses the vapor pressure principle in which the vapor pressure of the liquid in the sensing bulb is related to the temperature being sensed. This pressure is converted into a force and transmitted to the balance plate. One adjustable spring applies a counter force to the balance plate. Movement of the balance plate is transmitted to the snap action electrical switch by an operating rod. The actuation (set) point of the switch is adjustable over the full temperature range of the switch. The reactuation (reset) point is not adjustable. The temperature difference between the set and reset points is the deadband as listed below.

OPTIONAL FEATURES: Several options are available, for details and availability, consult pages 9, 10 and 11.

ELECTRICAL INFORMATION: Consult page 9 for electrical ratings and schematics for standard and optional snap action switches.

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SPECIFICATIONS

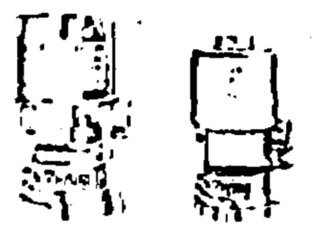
HOW TO SELECT AND ORDER

1. Determine the temperature range needed. Preferably the actuation point should be in the middle third of the span. Check that the maximum temperature rating is sufficient.
2. Read across and select one switch assembly unit with the proper enclosure.
3. Continue across the same line and select one transducer according to the construction desired.
4. Field Assembly: Order the switch assembly unit and the transducer unit by their respective catalog numbers if you desire to field assemble the temperature switch. The third digit in each catalog number must be identical.
5. Factory Assembly: Add the two catalog numbers together separated by a slash (/) if you desire a completely assembled temperature switch.

Example: For a temperature switch required to actuate at 50°F, select a 0-95°F switch. Such a temperature switch with a general purpose enclosure and copper capillary and bulb would be catalog number SB10A/QD11A1.

SWITCH ASSEMBLY UNITS

(Two 3/4" NPT Conduit Hubs Standard)



General Purpose Type — Explosion-Proof Type

TEMPERATURE TRANSDUCER UNITS

Direct Probe

Capillary and Bulb

Armored Copper Capillary or Plain Stainless Steel Capillary

	Adjustable Operating Range (In Degrees)	Max. Temp. (In Degrees)	Deadband at Mid Range* (In Degrees)	General Purpose Enclosure — Catalog No.	Watertight Enclosure — Catalog No.	Explosion-Proof Enclosure — Catalog No.	Direct Probe: Copper — Catalog No.	Direct Probe: 316 S.S. — Catalog No.	6' Capillary and Bulb: Copper (Armored Capillary) — Catalog No.	6' Capillary and Bulb: 316 S.S. (Plain Capillary) — Catalog No.
°F	−60 - 20	200	3	SB10A	SB11A	SB12A	QA10A1	QA10A5	QA11A1	QA11A5
°C	−51 - −7	93	1.7							
°F	−30 - 60	250	3	SB10A	SB11A	SB12A	QB10A1	QB10A5	QB11A1	QB11A1
°C	−34 - 16	121	1.7							
°F	0 - 95	300	4	SB10A	SB11A	SB12A	QD10A1	QD10A4	QD11A1	QD11A5
°C	−18 - 32	149	2.2							
°F	50 - 160	350	3	SB10A	SB11A	SB12A	QF10A1	QF10A4	QF11A1	QF11A[illegible]
°C	10 - 71	177	1.7							
°F	100 - 220	450	3	SB10A	SB11A	SB12A	QH10A1	QH10A4	QH11A1	QH11A4
°C	38 - 104	232	1.7							
°F	160 - 260	500	4	SB10A	SB11A	SB12A	QL10A1	QL10A4	QL11A1	QL11A4
°C	71 - 127	260	2.2							
°F	225 - 340	600	6	SB10A	SB11A	SB12A	QN10A1	QN10A4	QN11A1	QN11A4
°C	107 - 171	316	3.3							
°F	300 - 450	700	6	SB10A	SB11A	SB12A	QT10A1	QT10A4	QT11A1	QT11A4
°C	149 - 232	371	3.3							
°F	350 - 510	800	7	SB10A	SB11A	SB12A	QU10A1	QU10A4	QU11A1	QU11A4
°C	177 - 265	427	4							

*At Extreme Ends of Range, Values May Be [illegible]

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978-760-193/93 REGION No. 4

CHK	ENGRG NOTICE	LTR	DESCRIPTION	DATE	APPROVED
	66352JV	–			

DWG NO.

CONTR NO

PREPARATION

DSGN CHK

DWG CHK

DSGN APPROVAL

INTERNATIONAL BUSINESS MACHINES CORP.
FEDERAL SYSTEMS DIVISION
HUNTSVILLE, ALA. 35807

TITLE

SYSTEM PERFORMANCE SPECIFICATION
FOR SIMS PROTOTYPE SYSTEM DESIGN NO. 3

SIZE	CODE IDENT NO.	DWG NO.
A		7933451

SCALE	WT	SHEET

TABLE OF CONTENTS

1.0 INTRODUCTION

This performance specification establishes the requirements for the design and performance of the solar heating and domestic hot water system utilizing liquid flat plate collectors and a gas or electric furnace energy subsystem. It designates the Interim Performance Criteria applicable to this type system and defines the deviations. The appendices specify the system performance for the defined site location.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. Specific document reference made in subsequent shall be by basic title or reference number only.

2.1 Government Documents

Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings, January 1, 1976, U. S. Department of Housing and Urban Development.

Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems, April, 1976, NBSIR 76-1059, U. S. Department of Housing and Urban Development.

SIMS Contract Statement of Work, NAS8-30236, April 4, 1976 (with current modifications).

2.2 IBM Documents

The following document included as Appendix A-2 provides the information required by an architect or local tradesman to prepare for the site installation.

System Three Design Description; IBM 7933647-D

3.0 APPLICATION OF INTERIM PERFORMANCE CRITERIA BY TYPE OF SYSTEM

The application of each paragraph of the Interim Performance Criteria (IPC) to this type of system is provided in Table I. Since this system provides solar heating and hot water, system type "H" designates the IPC application to this system.

4.0 DEVIATION FROM INTERIM PERFORMANCE CRITERIA

The IPC deviations identified by subsystem evaluation are listed in the following paragraph.

4.1 Deviations to Residential IPC

The following deviations result from a lack of data to support compliance rather than failure experience.

4.1.1 Data supporting the use of Sunworks collectors as structural elements is not available. This application does not require collectors to provide enclosure or diaphragm rigidity to support structures.

4.1.2 Ultimate wind loading has not been demonstrated.

4.1.3 Solar degradation will require long term testing. Analytical projections based on simulator insolation predict insignificant affect.

4.1.4 Thermal degradation is acceptable over short term; however, long term data is unavailable.

The collector subsystem evaluation has identified three areas of non-conformance. These IPC requirements are: (1) ultimate load combination (paragraph 3.2.1), (2) resistance to damage (paragraph 3.3.1), and (3) transmission losses due to outgassing (paragraph 5.2.6). No vendor data was available to substantiate these requirements can be met.

TABLE I

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

Sheet 1 of 7

APPLICATION

A - APPLICABLE TO SYSTEMS INDICATED
I - APPLICABLE TO SYSTEM AND BUILDING
NA - NOT APPLICABLE

TYPE SYSTEMS

H - HEATING
HC - HEATING AND COOLING
HW - HOT WATER ONLY

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEM H	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEM H
1.1 H and HC System Performance	A	1.3.1 Collector Efficiency	A
1.1.1 Heating Design Temperatures	I	1.4 Thermal Storage	A
1.1.2 Cooling Design Temperatures	NA	1.4.1 Storage Capacity and Rate	A
1.1.3 Relative Humidity and Water Vapor Pressure	I	1.5 Habitability of Occupied Spaces	A
1.1.4 Solar Contribution	A	1.5.1 Heat or Humidity Transfer Effects	I
1.1.5 Operation Impairment	A	1.6 Energy Transport Efficiency	A
1.2 HW System Subsystem Performance	A	1.6.1 Thermal Losses and Electrical Power	A
1.2.1 Water Design Temperature	I	1.7 Control	A
1.2.2 Storage Design Capacity	A	1.7.1 Installation and Maintenance	A
1.2.3 Solar Contribution	A	1.7.2 Manual Adjustment	A
1.2.4 Operational Impairment	A	1.7.3 Inhabited Space Temperature	A
1.3 Collector Performance	A	1.7.4 Hot Water Temperature	A
		1.8 Auxiliary Energy	A
		1.8.1 Design Loads	A

TABLE I (CONTINUED)

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

APPLICATION

A - APPLICABLE TO SYSTEMS INDICATED
I - APPLICABLE TO SYSTEM AND BUILDING
NA - NOT APPLICABLE

TYPE SYSTEMS

H - HEATING
HC - HEATING AND COOLING
HW - HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H
2.8 Excessive Pressure and Temperature Protection	A	3.5.1 Design Provisions	I
2.8.1 Relief Valves and Vents	A	3.6 Creep and Residual Deflection	I
3.1 Structural Design Basis	A	3.6.1 Deflection Limitations	I
3.1.1 Applicable Standards	A	3.7 Hail Resistance	A
3.1.2 Service Loads	A	3.7.1 Hail Size and Loading	A
3.2 Failure Loads and Load Capacity	A	3.8 Constraint Loads	A
3.2.1 Ultimate Load Combinations	A	3.8.1 Foundation Settlement	A
3.2.2 Ice Loads	A	3.8.2 Constrain Loads	A
3.2.3 Vehicular Loads	I	3.9 Ponding Condition	A
3.2.4 Load Capacity	A	3.9.1 Design Provisions	A
3.3 Damage Control	A	4.1 Plumbing and Electrical Installation	A
3.3.1 Resistance to Damage	A	4.1.1 Plumbing Codes	A
3.3.2 Glazing Design	A	4.1.2 Electrical Codes	A
3.4 Cyclic Loads	A	4.2 Fail-Safe Controls	A
3.4.1 Deflection Limitations	A	4.2.1 System Failure Prevention	A
3.5 Cutting of Structural Elements	I	4.2.2 Automatic Pressure Relief Valves	A

TABLE I (CONTINUED)

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RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

Sheet 3 of 7

APPLICATION	TYPE SYSTEMS
A - APPLICABLE TO SYSTEMS INDICATED	H - HEATING
I - APPLICABLE TO SYSTEM AND BUILDING	HC - HEATING AND COOLING
NA - NOT APPLICABLE	HW - HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H
2.1 System Design Conditions	A	2.3 Leakage Prevention	A
2.1.1 Equipment Capabilities	A	2.3.1 Pressure Test Nonpotable Fluids	A
2.1.2 Noise or Erosion-Corrosion	A	2.3.2 Pressure Test: Potable Water	A
2.1.3 Operating Conditions	A	2.3.3 Air Transport Systems	A
2.1.4 Fluid Flow in Collectors	A	2.4 Collector Adjustment	A
2.1.5 Entrapped Air	A	2.4.1 Orientation and Tilt	A
2.1.6 Thermal Expansion of Fluids	A	2.4.2 Mutual Shadowing	A
2.1.7 Pressure Drops	A	2.5 Subsystem Isolation	A
2.1.8 Condensate Removal	NA	2.5.1 Shutdown in Multi-family Housing	A
2.2 Mechanical Stresses	A	2.6 Heat Transfer Fluid Quality	A
2.2.1 Vibration Stress Levels	A	2.6.1 Liquid Quality	A
2.2.2 Vibration from Moving Parts	A	2.6.2 Air Quality	A
2.2.3 Water Hammer	A	2.6.3 Fluid Quality	A
2.2.4 Vacuum Relief Protection	A	2.6.4 Freezing Protection	A
2.2.5 Thermal Changes	A	2.7 Piping Supports	A
2.2.6 Flexible Joints	A	2.7.1 Applicable Plumbing Standards	A

TABLE I (CONTINUED)

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

Sheet 4 of 7

APPLICATION

A - APPLICABLE TO SYSTEMS INDICATED
I - APPLICABLE TO SYSTEM AND BUILDING
NA - NOT APPLICABLE

TYPE SYSTEMS

H - HEATING
HC - HEATING AND COOLING
HW - HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H
4.3 Fire Safety	A	4.7 Excessive Surface Temperatures	A
4.3.1 Applicable Fire Standards	A	4.7.1 Protection from Heated Components	A
4.3.2 Penetrations through Fire Rated Assemblies	I	5.1 Effects of External Environment	A
4.4 Toxic	A	5.1.1 Solar Degradation	A
4.4.1 Provisions of Catch Basins	A	5.1.2 Soil Corrosion	A
4.4.2 Detection of Toxic and Flammable Fluids	A	5.1.3 Airborne Pollutants	A
4.5 Safety	I	5.1.4 Dirt Retention on Cover Plate Surface	A
4.5.1 Emergency Egress and Access	I	5.1.5 Abrasive Wear	A
4.5.2 Identification and Location of Controls	A	5.1.6 Fluttering by Wind	A
4.6 Protection and Potable Water and Circulated Air	A	5.2 Temperature and Pressure Resistance	A
4.6.1 Contamination by Materials	A	5.2.1 Thermal Degradation	A
4.6.2 Separation of Circulation Loops	A	5.2.2 Deterioration of Heat Transfer Fluids	A
4.6.3 Backflow Prevention	A	5.2.3 Thermal Cycling Stresses	A
4.6.4 Growth of Fungi	A	5.2.4 Leakage	A
		5.2.5 Deterioration of Gaskets and Sealants	A

TABLE I (CONTINUED)

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

Sheet 5 of 7

APPLICATION	TYPE SYSTEMS
A - APPLICABLE TO SYSTEMS INDICATED	H - HEATING
I - APPLICABLE TO SYSTEM AND BUILDING	HC - HEATING AND COOLING
NA - NOT APPLICABLE	HW - HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H
5.2.6 Transmission Losses Due to Outgassing	A	6.1.5 Filters	A
5.3 Chemical and Compatibility of Components	A	6.1.6 Potable Water Shutoff	A
5.3.1 Materials/Transfer Fluid Compatibility	A	6.2 Installation, Operation and Maintenance Manual	A
5.3.2 Corrosion of Dissimilar Materials	A	6.2.1 Installation Instructions	A
5.3.3 Corrosion by Leachable Substnace	A	6.2.2 Maintenance and Operation Instructions	A
5.3.4 Effects of Decomposition Products	A	6.2.3 Maintenance Plan	A
5.4 Components Involving Moving Parts	A	6.2.4 Replacement Parts	A
5.4.1 Wear and Fatigue	A	6.3 Repair and Service Personnel	A
6.1 Accessibility for Maintenance	A	6.3.1 Maintenance of H and HC Systems	A
6.1.1 Access for System Maintenance	A	6.3.2 Maintenance of DHW System	A
6.1.2 Access for System Monitoring	A	7.1 Design	I
6.1.3 Draining and Filling of Liquids	A	7.1.1 Dwelling Design	I
6.1.4 Flushing of Liquids Subsystems	A	7.1.2 Mobile Home Design	I
		7.1.3 Site Design	I
		7.1.4 Passive Use of Solar Energy	I

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

Sheet 6 of 7

APPLICATION	TYPE SYSTEMS
A - APPLICABLE TO SYSTEMS INDICATED	H - HEATING
I - APPLICABLE TO SYSTEM AND BUILDING	HC - HEATING AND COOLING
NA - NOT APPLICABLE	HW - HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H
7.2 Adequate Space	I	8.3 Mechanical and Electrical Functioning of Connections	I
7.2.1 Collector Area	I	8.3.1 Plumbing Connections	I
7.2.2 Storage Area	I	8.3.2 Electrical Connections	I
7.2.3 Utility Chases	I	9.1 Structures Integrity	I
7.3 Functioning of Dwelling Site	I	9.1.1 Movement in Adjacent Structures	I
7.3.1 Space Use	I	9.2 Structural Integrity of Dwelling	I
7.3.2 Shading of Adjacent Structures	I	9.2.1 Loads	I
7.3.3 Impact on Environment	I	9.2.2 Penetration of Structural Members	I
7.3.4 View	I	9.3 Structural Connections	I
8.1 Interference with Mechanical Operation	I	9.3.1 Structural Connections	I
8.1.1 Blockage of Solar Subsystem	I	9.3.2 Brittle Subsystem	I
8.1.2 Shading of Collector	I	9.3.3 Strength and Stiffness	I
8.1.3 Sensor Location	I	10.1 Safety of Dwelling and Site	I
8.2 Mechanical and Electrical Functioning of Dwelling Site	I		
8.2.1 Exhaust and Venting	I		
8.2.2 Utilities	I		

TABLE I (CONTINUED)

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

Sheet 7 of 7

APPLICATION	TYPE SYSTEMS
A - APPLICABLE TO SYSTEMS INDICATED	H - HEATING
I - APPLICABLE TO SYSTEM AND BUILDING	HC - HEATING AND COOLING
NA - NOT APPLICABLE	HW - HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H
10.1.1 Fire	I	12.2.1 Accessibility	I
10.1.2 Accidents	I	12.2.2 Ice Dams	I
11.1 Durability	I	12.3 Connections	I
11.1.1 Vegetation	I	12.3.1 Accessibility	I
11.2 Durability and Reliability of Dwelling and Site	I	13.1 Visual Characteristics of Dwelling and Site	I
11.2.1 Chemical Corrosion	A	13.1.1 Dwelling	I
11.2.2 Heat and Moisture	I	13.1.2 Neighborhood	I
11.2.3 Exterior Penetrations	I		
11.3 Durability and Reliability of Connections	A		
11.3.1 Material Compatibility	A		
12.1 Maintainability of H, HC, HW Systems	I		
12.1.1 Accessibility	I		
12.1.2 Misuse	I		
12.1.3 Permanent Maintenance Accessories	I		
12.2 Maintainability of Dwelling and Site	I		

4.2 Deviation of Commercial IPC

Not applicable.

5.0 GOVERNMENT FURNISHED PROPERTY

The following items shall be provided by the government:

(1) Collector subsystem, Sunworks Selector Liquid Cooled Model LA1001A

(1) Water Preheat Tank, Ford Products Corporation Model TC65

6.0 GOVERNMENT DIRECTED REQUIREMENTS

The following requirements are specified in NAS8-32036 and by verbal direction from the contract officer;

(a) IBM shall deliver one system of the following type:

- o Single Family Building
- o Solar Space Heating and Domestic Hot Water
- o Liquid System (Liquid Flat Plate Collector)
- o Electric Furnace or Gas Furnace Auxiliary

(b) All hardware and subsystems, except collectors, and preheat tank shall be purchased by IBM to good commercial practices as off-the-shelf hardware.

(c) Collector and storage sizing may be adjusted for each specific site.

7.0 GEOGRAPHICAL AREA

This heating and hot water system is designed for a single family residence located in the United States. Areas of application include all regions of the U.S. except regions with low heating degree days, such as Southern California and Florida.

7.1 Typical Geographical Locations

The system design accommodates variation in insolation ranges as follows:

Mean Daily Insolation (Typical Winter Mean) 625 to 1475 BTU/Ft^2

Typical Standard Metropolitan Statistical Areas (SMSA's) within these ranges are:

- Omaha, NB
- Nashville, TN
- Salt Lake City, Utah
- Kansas City, MO
- Denver, CO
- Atlanta, GA
- Las Vegas, NV
- Boston, MA
- Charleston, SC
- Pittsburg, PA
- Detroit, MI
- Wichita, KA
- El Paso, TX
- Toledo, OH

The system application may be extended to other geographical ranges, however, to achieve the optimum performance pump capacity and/or storage size may be impacted.

8.0 SYSTEM APPENDICES

APPENDIX A

PERFORMANCE SPECIFICATION FOR HUNTSVILLE, ALABAMA

A-0 SYSTEM IDENTIFICATION

This appendix defines the system performance prediction for SIMS Prototype Heating and Hot Water System, Model Number 3 to be installed in Huntsville, Alabama at the MSFC Solar Heating and Cooling Test Facility. The design average insolation (typical winter mean) is 1062 BTU/Ft^2 Day and the heating degree days (typical winter mean ^{o}F) is 3270. Test configuration is:

- 18 Sunworks liquid flat plate collectors
- 1 Adamson 1,000 gal. model K96 storage tank
- 3 Grundfos UP26-64 liquid pumps
- 1 Grundfos UP25-42SF liquid pump
- 1 Rome-Turney Liquid to Air Heat Exchanger
- 1 Ford Products Aqua Coil Domestic Water Tank
- 2 Solar Control Corp. Differential Thermostats

The test installation will not contain auxiliary space heat. Refer to IBM Drawing 7933647 for the system configuration description.

A-1 SYSTEM PERFORMANCE SHEETS

Space Heating Capacity

The system will provide solar energy for 44 percent of the total space heating load during the heating season based on an average annual heating load of 54.89 x 10^6 BTU and a peak space heating load of 33,600 BTU/Hr.

Cooling Capacity

The system will provide solar energy for N/A percent of the average total cooling during the cooling season, based on an average total cooling load of N/A BTU/Month and a peak cooling load of N/A BTU/Hr.

Auxiliary Energy

The average annual rate of auxiliary energy supplied to the heating and hot water load shall be no greater than 35.5×10^6 BTU. This shall be no greater than 47 percent of the total energy required for heating and hot water. The average rate of auxiliary energy used for cooling during the cooling season shall be no greater than N/A BTU/Month. This shall be no greater than N/A percent of the total energy required for cooling.

Hot Water

Seventy-five gallons per day of hot water shall be delivered at no less than 1.2 gal/min at temperatures no less than 140°F. Draw shall be 44 GPH. The average hot water heating load will be 20.6×10^6 BTU/year of which 25% is provided by auxiliary energy.

Operating Requirements

The maximum electrical power required to drive the solar portion of the system at its rated capacity shall be no greater than 1.0 K.W. The maximum electrical power required to drive the complete system shall be no greater than N/A K.W. The average yearly electrical energy required to drive the system shall be no greater than N/A. Water requirements for cooling condensers and/or air humidification shall be no greater than N/A gal/hr.

Physical Data

The following subsystems shall have:

	Design life no less than	Weight (filled no greater than	Installation dimensions
Heating	20 years	30 lbs	20" x 20" x 5"
Cooling	N/A years	N/A lbs	N/A
Auxiliary Energy			Note 1
Storage	20 years	10,000 lbs	5' Dia x 8"
Potable Water (or usable)	10 years	900 lbs	24" Dia x 56
Collector	20 years	114 lbs ea.	3' x 7' x 4"
Energy Transport	20 years	25 lbs	7" x 6" x 5"
Controls	20 years	10 lbs	5" x 5" x 4" ea.

Note:

1. No auxiliary energy supplied at this site except 4.5 kw heating element in DHW tank.

System Installation

System 3 component schedule, control sequence and general installation notes are contained in IBM Drawing 7933647-D. Additional design data and application information are contained in the Design Data Brochure, SIMS Prototype System 3, IBM No. 78W-0005.

PERFORMANCE SPECIFICATION FOR GLENDO, WYOMING

A-0 SYSTEM IDENTIFICATION

This appendix defines the system performance prediction for SIMS Prototype Heating and Hot Water System, Model Number 3 as installed in the designated residence at Glendo, Wyoming. The design daily average insolation (typical winter mean) is 1239 BTU/Ft^2 Day and the heating degree days (typical winter mean ^{o}F) is 7870. Site configuration is:

- 14 Sunworks liquid flat plate collectors
- 1 Adamson 1,000 gal. model K96 storage tank
- 3 Grundfos UP26-64 liquid pumps
- 1 Grundfos UP25-42SF liquid pump
- 1 Rome-Turney Liquid to Air Heat Exchanger
- 1 Ford Products Aqua Coil Domestic Water Tank
- 2 Solar Control Corp. Differential Thermostats

Refer to IBM Drawing 7933647 for the system configuration description.

A-1 SYSTEM PERFORMANCE SHEETS

Space Heating Capacity

The system will provide solar energy for 46 percent of the total space heating load during the heating season based on an average annual heating load of 94.44 x 10^6 BTU and a peak space heating load of 33,600 BTU/Hr.

Cooling Capacity

The system will provide solar energy for N/A percent of the average total cooling during the cooling season, based on an average total cooling load of N/A BTU/Month and a peak cooling load of N/A BTU/Hr.

Auxiliary Energy

The average annual rate of auxiliary energy supplied to the heating and hot water load shall be no greater than 54.1 x 10^6 BTU. This shall be no greater than 47 percent of the total energy required for heating and hot water. The average rate of auxiliary energy used for cooling during the cooling season shall be no greater than N/A BTU/Month. This shall be no greater than N/A percent of the total energy required for cooling.

Hot Water

Seventy-five gallons per day of hot water shall be delivered at no less than 1.2 gal/min at temperatures no less than 140°F. Draw shall be a 44 GPH. The average hot water heating load will be 20.6 x 10^6 BTU/year of which 20% is provided by auxiliary energy.

Operating Requirements

The maximum electrical power required to drive the solar portion of the system at its rated capacity shall be no greater than 1.0 K.W. The maximum electrical power required to drive the complete system shall be no greater than N/A K.W. The average yearly electrical energy required to drive the system shall be no greater than N/A. Water requirements for cooling condensers and/or air humidification shall be no greater than N/A gal/hr.

Physical Data

The following subsystems shall have:

	Design life no less than	Weight (filled no greater than	Installation dimensions
Heating	20 years	30 lbs	20" x [illegible]" x 5"
Cooling	N/A years	N/A lbs	N/A
Auxiliary Energy			Note 1
Storage	20 years	10,000 lbs	5' Dia x 8"
Potable Water (or usable)	10 years	900 lbs	24" Dia x 56
Collector	20 years	111 lbs ea.	3' x 7' x 4" ea.
Energy Transport	20 years	25 lbs.	7" x 6" x 5"
Controls	20 years	10 lbs	5" x 5" x 4"

Note:

1. Auxiliary energy supplied by site; except 4.5 kw heating element in DHW tank.

A-2 SYSTEM INSTALLATION DESCRIPTION

System 3 component schedule, control sequence and general installation notes are contained in IBM Drawing 7933647-D. Additional design data and application information are contained in the Design Data Brochure, SIMS Prototype System 3, DOE/NASA CR-150707.

DWG NO. 7933452

REVISIONS

CHK	ENG'G NOTICE	R	DESCRIPTION	DATE	APPROVED

Date: 18 February 1977
Revised: 7 June 1978
CDRL Item No.s - 2a
-13

CONTR NO NAS8-32036	INTERNATIONAL BUSINESS MACHINES CORP. FEDERAL SYSTEMS DIVISION HUNTSVILLE, ALA. 35807		
PREPARATION I. G. Daniel 2-28-77	TITLE: Verification Plan/Procedure for Prototype Solar Energy Heating and Hot Water System Model No. 3		
DSGN CHK			
DWG CHK			
DSGN APPROVAL [signature] 3/1/77	SIZE A	CODE IDENT NO.	DWG NO. 7933452
	SCALE	WT	SHEET 1 of 25

1. PURPOSE

1.1 The purpose of this document is to present the plan/procedure for verifying the requirements of Performance Specification for prototype solar energy heating and hot water system model No. 3.

2. SCOPE

2.1 This document describes the plan/procedure for performing prototype systems verification and includes development, qualification, and acceptance verification. Requirements for analysis verification and/or test verification are included in this plan/procedure.

3. APPLICABLE DOCUMENTS

3.1 The following documents form a part of this plan to the extent specified herein:

- o Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings, HUD - January 1, 1975.

- o Performance Specification for Prototype Heating and Hot Water System Model No. 3.

- o System 3 Design Description Drawing

4. VERIFICATION APPROACH

4.1 Prototype system verification to the requirements of the system performance specification and interim performance criteria will be accomplished in three verification categories - development, qualification, and acceptance. The verification methods utilized for system verification will be similarity, analysis, inspection, demonstration and tests as reqcuried.

Prototype system verification will commence with a detailed analysis of all system hardware, components, and subsystems and progress through system evaluation and testing. Figure I of this plan depicts a summary flow for system verification.

A detailed system test procedure for performing the test requirements of this document will be prepared. This procedure will describe the methods and procedures for conducting prototype system test on the MSFC system test breadboard facility.

Following completion of verification program, final system verification documentation will be prepared and submitted to MSFC. This will contain all information pertinent to system verification.

5. DEVELOPMENT VERIFICATION REQUIREMENTS

5.1 Hardware/Component/Subsystem Verification - All hardware, components and subsystems that comprise the prototype system shall be verified to be in accordance with the requirements of the prototype system performance specification and the interim performance criteria. Verification of hardware, components, and subsystems will be accomplished by engineering analysis, similarity, inspection, demonstration and/or testing methods.

Subsystem test evaluation will be conducted on the system collectors. All other prototype system subsystems, hardware and components will be verified individually by analysis and/or during prototype system verification.

5.2 System Development Verification - Development verification will be conducted on prototype system M/N 3 to ensure that system will perform to the requirements of the system performance specification and interim performance criteria. Development verification will consist of the following:

- Analysis of hardware, component, and subsystem evaluation data for compliance to system performance specification and interim performance criteria requirements.

- Analysis of system design for compliance to system performance specification and interim performance criteria requirements.

- o System testing on MSFC System Test Breadboard Facility. Tests to be conducted are as follows:

  - System operational functional test.

  - System capacity for control, energy collection, storage, and distribution to load at ambient conditions.

5.2.1 <u>System Operatonal Functional Test</u>. A system operational functional test shall be conducted on prototype system M/N 3. Operational functional test shall consist of the following:

- o System pressure/leakage test

- o Operation of system pumps

- o Operation of system controller

- o Measurement of pressure drop and flow rate across collector array

- o Measurement of pressure drops across system heat exchangers

5.2.2 System Test With Simulated Energy Inputs - Storage shall be supplied with 140°F water to simulate the collector flow. Flow rate shall be at design flow and shall continue until the water from the bottom of storage reaches 110°F. Test data shall be collected a minimum of two hours following flow termination. The system shall be instrumented to determine storage stratification, heat transfer to the domestic hot water, and heat transfer to the load, in the following operating states:

- o DHW PUMP P3 OFF, LOAD PUMP P2 OFF
- o DHW PUMP P3 ON, LOAD PUMP P2 OFF
- o DHW PUMP P3 OFF, LOAD PUMP P2 ON
- o DHW PUMP P3 ON, LOAD PUMP P2 ON

5.2.3 System Test At Outside Weather Conditions - The system operation in response to existing weather conditions shall be determined. Various space heating load profiles and domestic hot water demand loads shall be imposed. The system shall be instrumented to determine storage (main and DHW) stratification, heat transfer to the space heating load and heat transfer to the domestic hot water tank.

5.4 System Development Verification Test Procedures - Test procedures for conducting prototype system verification testing will be prepared and submitted to MSFC for approval. These procedures will describe the hardware configuration for testing, detailed test methods and procedures, sketches of test setup, test time, limits, data and report requirements, and all other procedural information pertinent to test evaluation program.

5.5 System Design Changes During Development Verification - Any design changes occurring during development verification will be verified by engineering analysis or test evaluation. Ample data will be provided for each design change to verify that the resultant change meets performance criteria requirements and that the resultant change has no adverse effects on the total system performance.

5.6 Development Verification Data - Test data accumulated during the early stages of development testing will be thoroughly evaluated and assessments will be performed on necessary system design changes. This will assure early design maturity of prototype system M/H 3.

5.7 Development Verification Extent/Level - Development verification program will be conducted to the extent necessary to verify that the final prototype system design meets or exceeds the requirements of the system performance specification and the interim performance criteria or that any requirement which has not been met has been properly dispositioned and MSFC approved by a deviation approval request. Any such deviation from the specified requirements will be documented in the final verification documentation and will become a part of the prototype system performance specification.

5.8 <u>Additional Development Testing</u> - Additional testing and evaluations other than those specified herein may be accomplished. Additional testing and evaluations will be coordinated with MSFC SIMS contracting officer or his designated representative. Additional testing and evaluation will be properly controlled, documented and reported.

6. QUALIFICATION VERIFICATION REQUIREMENTS/PROCEDURE

6.1 <u>Qualification Verification Requirements</u> - Requirements for qualification verification are as follows:

- Verification that the prototype system meets or exceeds the requirements of system performance specification. These requirements are:

  Interim Performance Criteria Requirements
  Government Directed Requirements
  System Identification Requirement
  Site Identification Requirement
  System Heating Capacity Requirement
  Auxiliary Energy Requirement
  Hot Water Requirement
  Operating Requirements
  System Physical Requirements (Design Life, Weight, Dimensions)

6.2 <u>Qualification Verification Procedures</u> - Procedures for verification of each qualification verification requirement are contained in the following subparagraphs.

6.2.1 <u>Interim Performance Criteria Requirement</u> - An analysis will be conducted on prototype system M/N 3 to satisfy this requirement. Each interim performance criteria requirement will be analyzed individually and recorded on an interim performance criteria certification form. This form will indicate compliance or non-compliance to the requirement and will identify the evaluation method utilized to satisfy the requirement. A sample copy of the interim performance criteria certification form is contained in Appendix I of this document. The certification form when completed will become a part of the final verification report.

6.2.2 Government Directed Requirements - This requirement will be satisfied by an analysis of the directed requirement, prototype system and the system performance specification to verify that the directed requirements have been satisfied.

6.2.3 System Identification Requirement - This requirement will be satisfied by review of performance specification and the prototype system to verify that the system is properly identified (type, contractor name, system model no.).

6.2.4 Site Identification Requirement - This requirement will be satisfied by review of performance specification to verify that the site for the prototype system is properly identified and described.

6.2.5 System Heating Capacity Requirement - This requirement will be satisfied by an analysis of the prototype system design and the climate conditions anticipated for the selected site at which the prototype system will be located. Test data obtained during system development testing will be utilized to verify the design models for the prototype system.

6.2.6 Auxiliary Energy Requirement - This requirement will be satisfied by an analysis of the prototype system load requirements and the prototype system auxiliary energy subsystem design.

6.2.7 Hot Water Requirement - This requirement will be satisfied by an analysis of the prototype system design and the hot water load requirements specified for the prototype system. Test data obtained during system development testing will be utilized to verify the design models for the hot water subsystem.

6.2.8 Operating Requirements - This requirement will be satisfied by an analysis of the prototype system design and the system operating requirements (maximum power to drive system, average yearly electrical power, water requirements). Test data obtained during system development testing will be utilized to verify the design models for the prototype system.

6.2.9 System Physical Requirements - This requirement will be satisfied by an analysis of the prototype system design and the system physical requirements (design life, weight, dimensions).

6.3 Prototype System Qualification

6.3.1 Qualification verification will consist of an analysis of all changes implemented during development verification. All test, analysis, and evaluation data originating during development verification will be evaluated to the requirements of the prototype system performance specification and interim performance criteria.

6.3.2 The prototype system will be considered qualification verified when it is determined that the final system design and hardware has met or exceeded the requirements of the system performance specification and the interim performance criteria or that any requirement which has not been met has been properly dispositioned and MSFC approved by a deviation approval request.

6.3.3 The results of qualification verification will be documented and submitted to MSFC.

7. ACCEPTANCE VERIFICATION REQUIREMENTS/PROCEDURE

7.1 Acceptance verification will be conducted on prototype system M/N 3 to verifiy that the system meets all specified requirements. Acceptance verification will consist of the following.

- o Inspection of system to verify performance specification and workmanship standards
- o Inspection of operational test data and evaluations to verify system performance
- o Inspection of acceptance data package
- o Inspection of shipping list versus hardware to be delivered
- o Inspection of shipping instructions and precautions

- Inspection of documentation required for system (installation, operation, maintenance requirements, system drawings and specifications, etc., in accordance with prototype system performance specification and data package requirements).

7.2 The results of acceptance verification will be documented and submitted to MSFC.

8. PROTOTYPE SYSTEM VERIFICATION HARDWARE DISPOSITION

Following the completion of prototype system development, qualification and acceptance verification program, the system hardware shall be removed from the MSFC test breadboard facility. The system collectors, hot water subsystem, system controller and data collection sensors shall be available for shipment to a designated demonstration site.

Test brackets and miscellaneous hardware used during system test will be retained at the MSFC breadboard facility for possible future utilization.

9. PROTOTYPE SYSTEM VERIFICATION DOCUMENTATION

9.1 Prototype System Test Procedure - Prototype system test procedure for prototype system M/N 3 will be generated utilizing the requirements of this document, prototype system performance specification, and drawings. Test procedure will be generated prior to the start of system verification testing. Test procedure shall contain at a minimum the following information.

(a) Identification of hardware/system to be verified (model number, serial number, manufacturer, size, description, etc.)

(b) Test requirements

(c) Development verification test methods/procedures

(d) Instrumentation and data requirements

(e) Location of tests to be conducted

(f) Test limits and tolerances

(g) Test equipment to be utilized

(h) Detailed test setup and system configuration sketches

(i) Test reporting procedures

9.2 Verification Documentation - Final prototype system verification documentation will be generated following completion of system verification and submitted to MSFC. The verification documentation shall consist of the following:

(a) Performance Test Report

(b) Verification Status Summary

(c) Design Data Brochure

9.2.1 Performance Test Report - Performance Test Report shall contain the following as a minimum:

(a) System identification and description

(b) Test objectives

(c) Test description and procedure

(d) Subsystem test results

(e) System test results

(f) Analysis of test data

(g) System performance

(h) Discussion of special tests

(i) Significant observations and conclusions

9.2.2 Verification Status Summary - Verification Status Summary shall contain the following as a minimum:

(a) Verification requirements

(b) Results of system interim performance criteria analysis and certification

(c) Performance specification verification analysis

(d) Acceptance verification analysis

(e) Performance analysis summary

9.2.3 Design Data Brochure - Design Data Brochure shall contain the following verification documentation as a minimum:

(a) System configuration description

(b) System functional description

(c) Identification of system components

(d) Operating instructions

(e) Maintenance requirements

(f) Installation requirements

10. VERIFICATION MATRIX

Cross reference matrix for prototype system M/N 3 verification is contained in Appendix II of this document. This matrix is applicable to system selected for physical testing.

Appendix II has been deleted from this report.

PROTOTYPE SYSTEM MODEL 3 VERIFICATION

APPROACH/FLOW

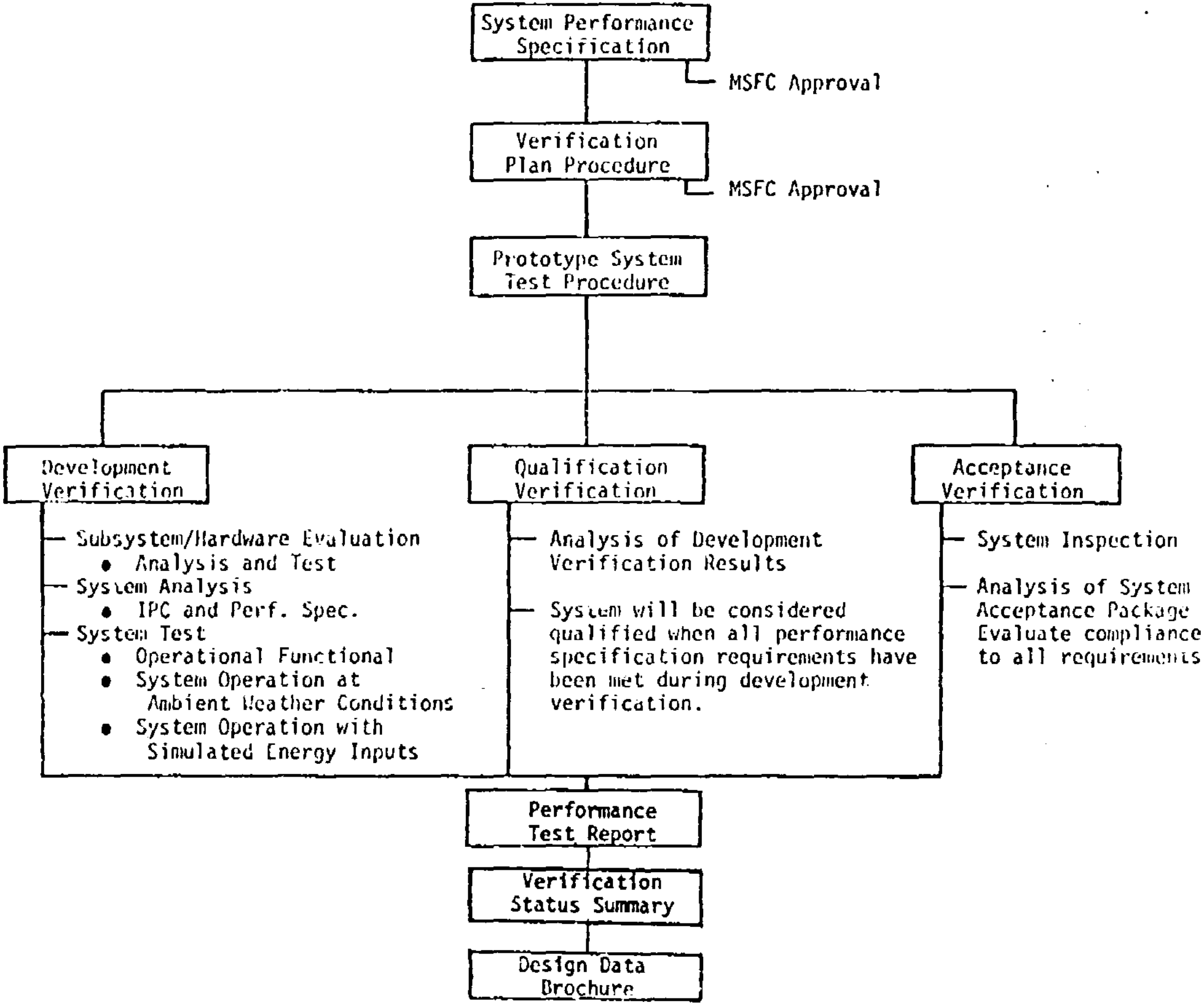

FIGURE 1

The Verification Cross Reference Matrix and the Interim Performance Criteria Certification forms have been deleted from this report.

APPENDIX I

PROTOTYPE SYSTEM NO. 3

INTERIM PERFORMANCE CRITERIA EVALUATION

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INTERIM PERFORMANCE CRITERIA
CERTIFICATION

System Type ______ Heating and Hot Water ______

System Model No. Prototype System 3 ______

System Mfg. ______ IBM ______

Analysis Conducted by [signature] ______

Date ______ 3-3-78 ______

INTERIM PERFORMANCE CRITERIA CERTIFICATION INSTRUCTIONS

I. Evaluate system for each IPC requirement listed on IPC Certification Sheets. All requirements are to be in accordance with HUD Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings. HUD - January 1, 1975.

II. Check each requirement status

Yes - Meets IPC requirement

No - Does not meet IPC requirement

N/A - Requirement not applicable

III. List IPC requirement evaluation method utilized

Analysis
Test
Inspection
Demonstration
Other

IV. All requirements which are not met shall be defined and recorded on IPC Deviation Approval Request (form attached).

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IPC REQUIREMENT	IPC NO.	MEETS IPC YES	MEETS IPC NO	N/A	EVALUATION METHOD	COMMENTS
Heating and Heating and Cooling System Performance	1.1	X			Analysis	Requires verification for specific site.
Hot Water System Subsystem Performance	1.2	X			Test & Analysis	Storage tank size and recovery rate are application critical.
Collector Performance	1.3	X			Test & Analysis	
Thermal Storage	1.4	X			Test & Analysis	
Habitability of Occupied Space	1.5	X			Design Review	
Energy Transport Efficiency	1.6	X			Test & Analysis	
Control	1.7	X			Test & Analysis	
Auxiliary Energy	1.8	X			Analysis	Requires verification for specific site.

IPC REQUIREMENT	IPC NO.	MEETS IPC		N/A	EVALUATION METHOD	COMMENTS
		YES	NO			
System Design Conditions	2.1	X			Test	
Mechanical Stresses	2.2	X			Design Analysis	
Leakage Prevention	2.3	X			Test	Applicable portions of system will be pressure tested during system installation
Collector Adjustment	2.4	X			Analysis	Site dependent design
Subsystem Isolation	2.5			X		
Heat Transfer Fluid Quality	2.6	X			Design	Water is only fluid
Piping Supports	2.7	X			Design Review	Site dependent design
Excessive Pressure and Temperature Protection	2.8	X			Test	ASME rated tank and relief protection

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IPC REQUIREMENT	IPC NO.	MEETS IPC		N/A	EVALUATION METHOD	COMMENTS
		YES	NO			
Structural Design Basis	3.1	X			Design Analysis	Structural components are conventional elements. Solar components are not lead bearing.
Service Loads	3.1.2		X		Data Review	No data available to substantiate collector meets requirements
Failure Loads and Load Capacity	3.2					No data available on solar unique components
Ultimate Load Combination	3.2.1 3.2.4		X X		Data Review	No data available to substantiate collector meets requirements
Damage Control	3.3				Operational Testing	No resulted during service loads imposed during testing.
Resistance to Damage	3.3.1		X		Data Review	No data available to substantiate collector meets requirements
Glazing Design	3.3.2		X			No data available to substantiate collector meets requirements
Cyclic Loads	3.4	X			Design Review	
Cutting of Structural	3.5			X		Review of site design required
Creep and Residual Deflection	3.6	X			Design	
Hail Resistance	3.7	X			Design Review	
Constraint Loads	3.8	X			Design Review	
Ponding Conditions	3.9	X			Design Review	

IPC REQUIREMENT	IPC NO.	MEETS IPC		N/A	EVALUATION METHOD	COMMENTS
		YES	NO			
Plumbing and Electrical Installation	4.1	X			Design Review	Installation by others to local codes and practices.
Fail Safe Controls	4.2	X			Design	
Fire Safety	4.3	X			Design Review	
Toxic and Flammable Fluids	4.4	X			Test	
Safety	4.5	X			Design Review	Review of site design required
Protection of Potable Water and Circulated Air	4.6	X			Design Review	No toxic fluid used.
Excessive Surface Temperatures	4.7	X			Tests	With the specifi... insulation
Effects of External Environment	5.1	X				Long term affects not yet available

IPC REQUIREMENT	IPC NO.	MEETS IPC		N/A	EVALUATION METHOD	COMMENTS
		YES	NO			
Temperature and Pressure Resistance	5.2	X			Test & Analysis	Stagnation temperatures not fully documented.
Transmission losses due to outgassing	5.2.6		X			No data available to substantiate collector meets requirements
Chemical compatibility of Components	5.3	X			Design Analysis	
Components involving moving parts	5.4	X			Test & Design Review	
Accessibility for maintenance	6.1	X			Design Review	Site design review required
Installation, Operation and Maintenance Manual	6.2	X			Design Data Brochure Review	
Repair and Service Personnel	6.3	X			Design	

IPC REQUIREMENT	IPC NO.	MEETS IPC YES	MEETS IPC NO	N/A	EVALUATION METHOD	COMMENTS
Design	7.1			X		
Adequate Space	7.2	X			Design Review	
Functioning of Dwelling/Facility Site	7.3			X		
Interference with Mechanical Operation	8.1			X		
Mechanical and Electrical Functioning of Dwelling and Site	8.2			X		
Mechanical and Electrical Functioning of Connectors	8.3			X		
Structural Integrity	9.1			X		
Structural Integrity of Dwelling	9.2			X		

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IPC REQUIREMENT	IPC NO.	MEETS IPC YES	MEETS IPC NO	N/A	EVALUATION METHOD	COMMENTS
Structural Connections	9.3			X		
Safety of Dwellings	10.1			X		
Durability	11.1			X		
Durability and Reliability of Dwelling and Site	11.2			X		
Durability and Reliability of Connections	11.3	X			Design Review	
Maintainability of H, HC, HW Systems	12.1			X		
Maintainability of Dwelling and Site	12.2			X		
Connections	12.3			X		
Visual Characteristics	13.1			X		

APPENDIX II

SYSTEM 3 PERFORMANCE ANALYSIS SUMMARY

PERFORMANCE ANALYSIS SUMMARY

The performance testing of SIMS Prototype System 3, in the MSFC Solar Heating and Cooling Test Facility, resulted in the following significant findings:

- SIMS Prototype System 3, based on test data projected to Nashville, Tennessee weather data, will provide 38% of the 82×10^6 BTU design heating load.

- The normal electrical energy required to drive the solar portion of the system was .6 KW.

- The flow distribution manifolds were effective in producing thermal stratification in solar storage.

- A single-tank solar domestic water heater has demonstrated to be a viable design option.

- SIMS Prototype System 3 was judged suitable for field installation.

INTERIM PERFORMANCE CRITERIA DEVIATION APPROVAL REQUEST

1. Report Number	2. Date	3. Prepared By	4. Organization	5. System Type
	7/26/76	D. Linton		Flat Plate Collector

6. System Model No.	7. System S/N	8. System Contractor	9. IPC Deviation
		Sunworks Inc.	No flow temperature operating conditions

10. IPC Number	11. IPC Paragraph	12. Approved By (IBM)	13. Approved By (MSFC)	14. Date Approved (MSFC)
	2.1.3			

15. Description of Deviation

The Vendor states that the collector core can withstand temperatures of 400° F without rupture. The no flow absorber temperature with 300 Btu/Hr ft² incident insulation could be as high as 490°F.

16. Probable Cause

17. Remarks

18. Deviation Disposition

INTERIM PERFORMANCE CRITERIA DEVIATION APPROVAL REQUEST

1. Report Number	2. Date	3. Prepared By	4. Organization	5. System Type
	7/26/76	D. Linton		Flat Plate Collector

6. System Model No.	7. System S/N	8. System Contractor	9. IPC Deviation
		Sunworks Inc.	Thermal Changes

10. IPC Number	11. IPC Paragraph	12. Approved By (IBM)	13. Approved By (MSFC)	14. Date Approved (MSFC)
	2.2.5			

15. Description of Deviation

The vendor states that the collector core is capable of withstanding one inch of water, air pressure, and 400°F temperature without rupture. Therm flow temperature could be higher.

16. Probable Cause

17 Remarks

18. Deviation Disposition

INTERIM PERFORMANCE CRITERIA DEVIATION APPROVAL REQUEST

1. Report Number	2. Date	3. Prepared By	4. Organization	5. System Type
	7/26/76	D. Linton		Flat Plate Collector
6. System Model No.	**7. System S/N**	**8. System Contractor**	**9. IPC Deviation**	
		Sunworks Inc.	Ultimate Local Combinations	
10. IPC Number	**11. IPC Paragraph**	**12. Approved By (IBM)**	**13. Approved By (MSFC)**	**14. Date Approved (MSFC)**
	3.2.1 3.3.1			

15. Description of Deviation

16. Probable Cause

17. Remarks

18. Deviation Disposition

INTERIM PERFORMANCE CRITERIA DEVIATION APPROVAL REQUEST

1. Report Number	2. Date	3. Prepared By	4. Organization	5. System Type
	7/26/76	D. Linton		Flat Plate Collector
6. System Model No.	**7. System S/N**	**8. System Contractor**	**9. IPC Deviation**	
		Sunworks Inc.	Effects of External Environment	
10. IPC Number	**11. IPC Paragraph**	**12. Approved By (IBM)**	**13. Approved By (MSFC)**	**14. Date Approved (MSFC)**
	5.1 & 5.1.1 5.2 & 5.2.1			

15. Description of Deviation

The vendor states that the collector can withstand temperatures of 400°F. The no flow absorber temperature with 300 Btu/Hr ft.^{2} incident insolation could be as high as 490°F. Also, no data was provided in the data package to evaluate the effects of prolonged exposure to sunlight.

16. Probable Cause

17. Remarks

18. Deviation Disposition

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SIMS PROTOTYPE SYSTEM 4

SPARE PARTS LIST

ITEM	NUMBER REQUIRED
Sunworks Liquid Type Collector (Model LA1001A)	1

HAZARDS ANALYSIS

PROTOTYPE SYSTEM DESIGN 3

SOLAR HEATING AND HOT WATER

February 1977
DRL 501-18

PROTOTYPE SYSTEM NO. 3 HAZARDS ANALYSIS

A hazards analysis was performed to define hazards or undesired events relative to the System 3 design, to identify the safety requirement to eliminate hazard and to indicate the means of compliance with each safety requirement.

No residual hazards have been identified and no failure modes have been identified which would contribute to the occurrence of a personnel hazard. All potential hazards identified are minor level. The use of standard off-the-shelf hardware minimizes hazards to personnel and equipment. A summary of the hazards analysis results follows.

HAZARD DATA SUMMARY

Areas of Consideration	Safety Requirement	Hazard/Undesired Event	Means of Compliance
Mechanical Protection	o Mechanical Hazards not significantly greater than conventional residence.	o Injury due to pinch or sharp edges.	o All operator and service area edges rounded.
		o Short circuits due to wire abrasion.	o Design does not present unusual or unique mechanical hazards.
		o Mechanical damage due to faulty installation.	o Drawings provided with sufficient design detail and notes to highlight proper installation.
		o Mechanical damage due to migration of components during operation.	o Drawings provided with sufficient design detail and notes to highlight proper installation.
		o Rotating Equipment	o DHW pumps have all rotating parts protected.
		o Humidity and fungus	o All equipment mounted within the residence.
Primary Voltages	o Section 516 and 616 MPS (4900.1 and 4910.1).	o Personnel Shock	o Controllers U.L. listed.
	o Part E of ANSI A119.1		o All external metal parts, surfaces and shields to be at electrical ground.
		o Equipment damage due to short circuit or overload.	o UL approved 15A circuit breaker.
Secondary Voltages		o Short between primary and secondary circuits.	o Transformer isolation and physical separation between primary and secondary circuits. UL approved.

Areas of Consideration	Safety Requirement	Hazard/Undesired Event	Means of Compliance
Electromagnetic	o Maintain circuit	o Interference between power, data and control functions.	o Sensor and control wires separated. Sensor inputs are protected by ground wires for each channel.
Fire Safety	o Use materials which do not present a fire hazard significantly greater than convential systems.	o Flammability of materials	o Used conventional components of proven safety.
			o UL recognized components
	o Proper clearance and venting of elevated temperature surface.		o All elevated temperature surfaces and pipes fully insulated.
	o Emergency egress and access not be less than conventional system.	o Occupant entrapment	o Conventional design criteria met for egress and access. Convenient and accessible equipment location.
	o Identified and accessible main shut-off valves.	o Difficulty in terminating system operation or isolating failure.	o Main shutoff valves and switches are clearly labeled and easily accessible.
Pressure Vessels	o ASME code for unfired pressure vessels.	o Over pressurization.	o Proper sized relief valves used on all pressurized vessels.
		o Mechanical rupture.	
		o Over temperature.	o High temperature limit controls.

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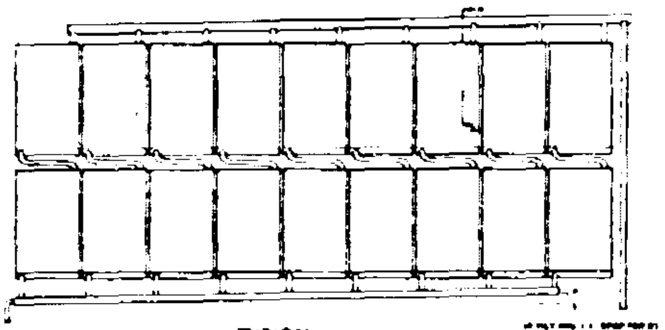
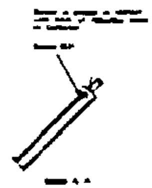
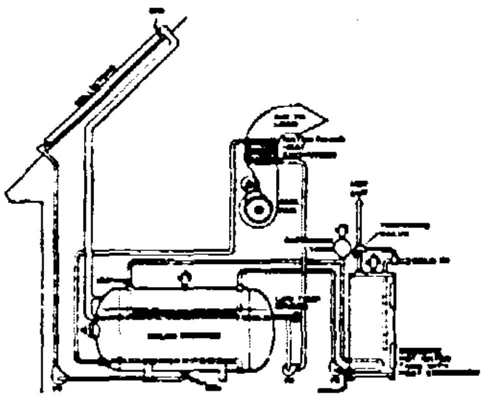
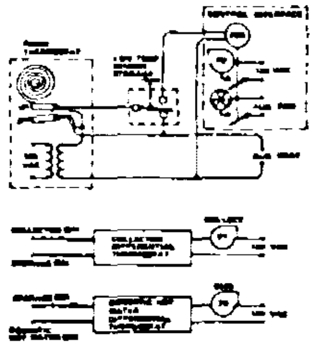


TYPICAL
SOLAR ARRAY





SYSTEM 3 DIAGRAM



CONTROL DIAGRAM

CONTROL SEQUENCE

GENERAL NOTES

COMPONENT SCHEDULE

RELATED DOCUMENTS

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7933647-D

	IBM
	SYSTEM 3
	DESIGN DESCRIPTION
	WW Scott Oct 12,77
	J.W.Perry Oct 12,77
	WW Scott Mar 16,78
	Mar 16,78

SCALE NONE

D

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