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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) describes the process for constructing, assembling, and testing aerosol samplers for use in the IMPROVE aerosol sampling network. There are several type of modules in use.

- Satellite Sampling Module: These modules require a separate signal from a controller to start and stop sampling. There are two variations of the satellite module: $PM_{2.5}$ and PM_{10}. These are identical except the $PM_{2.5}$ module has a fine inlet and a cyclone, while the PM_{10} module has either a Sierra or Wedding PM_{10} inlet.
- Independent Controller Module (IC): These non-sampling modules control multiple satellite sampling modules. There are several versions with minor variations. One major variation is the addition of a lock-out circuit to prevent a second sample collected without an intervening sample change.
- Single Independent Module (SIM): This sampling module includes the clock controller in the sampling module. It cannot control satellite sampling modules.
- SIM-Controller (SC): This sampling module includes the clock controller in the sampling module, plus the relays to control satellite sampling modules. This module is now used in place of the independent controller module.

The various configurations of the controller modules are listed in Table 1.

Table 1 Controller Module Configurations.

code	pump relay voltage	multiple pump relay location	pump outlet location	thermostat and position	lock-out device
IC1	24V	external	box in pump house		no
IC1L	24V	external	box in pump house		yes
IC2	110V	internal	box on module		no
IC2L	110V	internal	box on module		yes
IC3	24V	internal	box on module		no
IC3L	24V	internal	box on module		yes
SIM1	24V	none	1 on module	under	no
SIM2	24V	none	1 on module	on	no
SIM2L	24V	none	1 on module	on	yes
SC1	24V	external	box on module	on	no
SC1L	24V	external	box on module	onr	yes

IC Independent Controller non-sampling, controls satellite sampling modules
SIM Single Independent Module sampling, self-controlling only
SC SIM-Controller sampling, controls self and satellite sampling modules

thermostat and position: under: under the heater panel with relays
on: on the heater panel

IMPROVE aerosol samplers are constructed and tested in the Crocker Nuclear Lab shop by technicians under the supervision of the Field Specialist. Upon completion of the construction process, the sampler is set up on the work bench and thoroughly tested. Testing procedures include:

1. Verifying the vacuum system has no leaks and all components are operating properly
2. Verifying the electrical systems (the clock controller, elapsed timers, solenoids, pumps, and switches) function properly individually, and as a system.

2.0 RESPONSIBILITIES

2.1 Project Manager

The project manager shall:

- Verify receipt of a contract or purchase order for the requested aerosol samplers.
- Inform the field specialist of the aerosol samplers to be constructed.
- Approve all purchase orders for parts or supplies to construct the aerosol samplers.

2.2 Field Specialist

The field specialist shall:

- Determine the number and type of parts necessary to construct the aerosol samplers.
- Write purchase orders for parts and equipment to construct aerosol samplers.
- Receive, inspect, and approve all parts prior to use, verifying they meet the specifications listed in the blue prints.
- Oversee construction of the aerosol samplers by the research technicians.
- Oversee testing of the aerosol samplers by the research technicians.

2.3 Technician

The technician shall:

- Construct parts for aerosol samplers, following blueprints.
- Assemble aerosol samplers, according to blueprints
- Test aerosol samplers to verify proper functioning.

3.0 REQUIRED EQUIPMENT AND MATERIALS

Both sampler and controller module construction require the following:

- Tool kit with 8" and 10" adjustable crescent wrench, channel lock pliers, needle nose pliers, cutting pliers, standard 1/4" through 11/16" combination wrench set, Phillips and flat-head screwdrivers, Allen head wrenches, wire snips, line powered drill, standard drill bit set, standard hole saw set, voltmeter, wire ties, electrical tape, Teflon plumbers tape, hammer, tape measure, level, vacuum grease.
- Mechanical shop facilities including a drill press, machinery to cut, punch, and bend sheet metal, and a lathe.
- Supplies, such as PVC glues, alcohol, water, rags and towels, pens, etc.

These are the minimal requirements for initiating construction. The module specific requirements, in addition to those listed above are as follows:

3.1 Sampling Module Parts

3.1.1 Sampling Module and Ventilation System Parts		Drawing #
1	machined gray fiberglass module box, Robroy Industries #RJ1816HPL	C76-NPS-2402A
2	louvers 4 1/2" x 3 3/4" x 1/2" gray plastic	
8	pan head screws 6/32 x 3/8"	
8	nuts and washers, 6/32	
2	1 3/4" hole covers, aluminum	

3.1.2 Parts for Back Plate Assembly and Installation		
3.1.2.1 Parts for Back plate Construction and Installation		Drawing #
1	universal aluminum back plate	C76-NPS-2392A
6	#8/32 thread inserts	
12	#6 thread inserts	
4	# 1/4 - 20 thread inserts	
4	10/32 x 3/8" panhead screws	
3.1.2.2 Manifold Parts		
4	10/24 x 1/4" Filister head screws (plate to manifold)	
4	8/32 x 1 1/4" panhead screws	
1	CAJON™ VCO female connector	
1	CAJON™ VCO male connector	
1	adjustable critical orifice	
1	3/8" compress align male brass elbow with 1/4" npt port	
1	new style machined solenoid manifold (PVC) or old style machined solenoid manifold (aluminum)	C76-NPS-2367A and C76-NPS-2367C or C76-NPS-2367
1	new style machined solenoid manifold, back plate or old style machined solenoid manifold, back plate	C76-NPS-2367B or C76-NPS-2367
1	old style machined solenoid manifold, PVC support block	C76-NPS-2385
1	PM10 orifice meter for D module	C76-NPS-2471A

3.1.2.3 PM_{10} Funnel and Funnel Support Parts		
1	piece machined aluminum for PM_{10} funnel support	C76-NPS-2401A
4	1/4 - 20 x 3/8" panhead screws	
1	Funnel Inlet for PM_{10} Module	C76-NPS-2395A
1	new style cover plate for funnel or old style cover plate for funnel	C76-NPS-2358A or C76-NPS-2358
4	filter adapter rings for new style cover plate or filter adapter rings for old style cover plate	C76-NPS-2358A or C76-NPS-2358
1	Filter Hold Down Clamp, anodized machined aluminum	C76-NPS-2369
1	o-ring 200-124	
1	o-ring 200-156	
8	o-rings 200-016	
2	Cover Plate Port Caps, machined PVC	C76-NPS-2386A or C76-NPS-2386
1	panhead screw 10/24 x 4"	
1	10/24 knurled knob	
1	1" aluminum spacer for 10/24 screw	
1	1/2" aluminum spacer for 10/24 screw	
3.1.2.4 Electrical Parts		
1	roll of 14 terminal blocks, AMP Flexblock™ Modular Terminal Block System, 300V, 15Amp, 6/32 stud, Part #1-604102-1	
1	16 block segment of AMP Flexblock™ Terminal Block track	
2	AMP End Stop #6, Part #604111-1	
10	AMP Faston Tab™, 90° bend, double end, Part # 3-601989-3	
14	AMP Faston Tab™, 45° bend, double end, Part # 3-601989-2	
2	AMP terminal jumpers, Part # 601985-2	
17	female panduit #16-18	
4	6/32 x 3/8" panhead screws	
1	6 wire cable, 16 gauge, from controller module	
	16 gauge wire, several feet , in black, white, red, orange, green, blue, & yellow	Lots of Wire
3.1.2.5 Solenoid Valve Parts		
4	ASCO Red Hat Solenoids	
4	1/2" female SWAGELOK cassette fittings	
4	CAJON hex nipples with machined o-ring groove	C76-NPS-2367
4	o-rings 200-011	
8	female panduit (blue) 14-16	
8	8/32 locking nylon nuts	
8	8/32 x 3/8" panhead screws	

3.1.3 Inlet Tee & Stack Parts		Drawing #
3.1.3.1 Fine Module Inlet Tee & Stack Parts		
1	New inlet tee : 1 piece machined aluminum	C76-NPS-2814
1	o-ring 200-222	

1	o-ring 200-227	
2	10/32 x 1/2" screws and washers	
1	stack plug: 1 piece machined aluminum	C76-NPS-2395B
1	o-ring 200-216	
1	7/16" dia. 3/8" thread plug	
1	machined PVC stack support	C76-NPS-2382A
2	pan head screws & washers 1/4 - 20 x 1 3/4"	
2	pan head screws & washers 1/4 - 20 x 3/4"	
1	1 1/2" outer dia. 1/16" wall aluminum stack per module, 3' to 12' , as required.	
1	B module inlet stack Denuder	C76-NPS-2439A
1	jig to assemble denuder	C76-NPS-2439B
6	pop rivets, (5/8" rivet, hole size 0.130")	
1	2' length 1 1/4" outer dia. 1/16" wall aluminum tubing	
1	2' length 1" outer dia. 1/16" wall aluminum tubing	
1	2' length 3/4" outer dia. 1/16" wall aluminum tubing	
1	2' length 1/2" outer dia. 1/16" wall aluminum tubing	
3.1.3.2 PM_{10} Inlet & Stack Parts		
1	1 1/4" outer dia. 1/16" wall 3' to 12' aluminum PM_{10} stack	
2	o-rings 200-124	
1	rubber grommet, for 1 1/2" dia. hole, (1 1/4" inner dia.)	

3.1.4 Face Plate Parts		Drawing #
3.1.4.1 Face Plate Construction Parts		
1	machined aluminum face plate	C76-NPS-2368
2	PVC blocks (6"x3/4"x1/2") or metal support brackets	
4	wood screws: flathead 3/4" long	
	silicone sealant or bonding glue	
4	sheet metal screws: Phillips 3/8"	
3.1.4.2 Parts for Pressure Gauge Assembly		
1	pressure gauge 30" Hg max. vac. AMETEK V844U 2930	
	138000 1/8 ANPT CBM	
1	brass 45° double female elbow 3/8" thread	
1	brass double male hex 3/8" to 1/2" tubing fitting for 3/8" tubing	
1	10" segment PARKER PARFLEX HDPE 3/8" O.D. x 0.062 w.p. 300 PSI QC35 LlLl tubing	
2	brass hose fittings for 3/8" hose, 1/2" thread	
3.1.4.3 Parts for Magnehelic Gauge Assembly		
1	Magnehelic Gauge, Dwyer, max. 1" water, Cat # 2001	
2	brass hex nipple, 7/16" dia. 3/8" thread	

3	6/32 x 2½" round head screws	
3	6/32 x ½" pan head screws	
3	magnehelic mounting brackets	
1	piece of tygothane tubing, 5/16" outer dia., 1/16" wall,19" long (to low pressure magnehelic outlet)	
1	piece tygothane tubing, 5/16" outer dia., 1/16" wall, 20" long (to high pressure magnehelic outlet)	
2	brass sleeves to fit magnehelic nipples	
3.1.4.4 Switches and Elapsed Timers		
1	on/off switch: 2 position, 3 panduit posts on back	
2	toggle switches 3 panduit posts on back	
2	Hecon or KEP flanged 2 1/8" x 1 1/8" resetable elapsed timers. Motor driven	

3.1.5 Cyclone Parts		Drawing #
1	new style cover plate for cyclone or old style cover plate for cyclone	C76-NPS-2358A or C76-NPS-2358
4	filter adapter rings for new style cyclone cover plate or filter adapter rings for old style cyclone cover plate	C76-NPS-2358A or C76-NPS-2358B
1	Filter Hold Down Clamp, anodized machined aluminum	C76-NPS-2369
1	new style cyclone: 5 pieces machined aluminum or old style cyclone: 5 pieces machined aluminum	C76 NPS-2356A & C76 NPS-2357A or C76 NPS-2356 & C76 NPS-2357
1	o-ring 200-118 (collection cup o-ring)	
1	o-ring 200-128 (new style cyclone inlet body to lower cyclone body)	
1	o-ring 200-130 (old style cyclone inlet body to lower cyclone body)	
1	o-ring 200-014 (cyclone throat o-ring)	
1	o-ring 200-123 (cyclone inlet body to stack coupler)	
1	o-ring 200-124 (cyclone inlet body to cyclone funnel)	
1	o-ring 200-156 (cyclone cover plate to cyclone funnel)	
8	o-rings 200-016 (filter adapter o-rings, new style cover plate) or	
8	o-rings: four 200-016 (filter adapter ring o-rings) and four 200-017 (old style cover plate to filter adapter ring o-rings)	
2	Cover Plate Port Caps, machined PVC	C76-NPS-2386A or C76-NPS-2386
4	panhead screws 10/24 x 2" (for cyclone body)	
1	panhead screw 10/24 x 4" (for cover plate)	
4	panhead screws 10/24 x 1/2" (old style cyclone only)	
1	10/24 knurled knob (for cover plate)	
1	1" aluminum spacer for 10/24 screw (for cover plate)	
1	1/2" aluminum spacer for 10/24 screw (for cover plate)	
2	¼ - 20 x 1" pan head screws (cyclone to stack coupler)	
2	hex threaded nipples for 1/4" tygon tubing	

	3.1.6 Sampler Inlet Head Parts	Drawing #
	3.1.6.1 Parts for Fine Inlet Head Assembly	
1	piece machined aluminum	C76-NPS-2381C
1	aluminum cap 3" dia. 2 3/16" high	
3	4/40 x 3/4" round head screw	
1	o-ring 200-128	
1	1 7/8" circle of 60x60 stainless steel wire mesh screen	
3	#4 CLR spacers, ½" long	
1	1/8" dia. 3/4" long aluminum post	
	3.1.6.2 Parts for PM_{10} Inlet Head	
	Sierra Anderson 16.7 lpm PM_{10} Inlet Head	
2	o-rings 200-124 replacement	
	or	
	Wedding 18.9 lpm PM_{10} Inlet Head	
2	o-rings 2-26 replacement	

	3.1.7 Pump Parts	Drawing #
1	12VAC, 60Hz double piston pump, Rocr-T	
1	1length PARKER PARFLEX HDPE 3/8" O.D. x 0.062 w.p. 300 PSI QC35 LllLl tubing to run between module and pump	
2	brass hose fittings for 3/8" hose, 1/2" thread	
1	brass hex female to male 1/2" npt pipe extender	
1	1/2" tubing fitting for 3/8" tubing to 1/2" Npt fitting brass elbow	

	3.1.8 Sampling Module Diagrams	Drawing #
	IMPROVE 2.5µm cut point sampling module	C76-NPS-2366
	IMPROVE 10µm cut point sampling module (PM_{10})	C76-NPS-2366
	IMPROVE aerosol sampling site	C76-NPS-2430
	Example IMPROVE aerosol sampler enclosure (shed)	C76 NPS-2841 & C76 NPS-2842

3.2 SIM Parts

A SIM (Single Independent Module) is a sampling module with a clock controller permitting it to operate as an independent sampler. The parts and diagrams required to construct a SIM module, in addition to the parts listed in Section 3.1, are listed below.

3.2.1 Ventilation System Parts		Drawing #
1	machined aluminum heater support	C76-NE-2517 & C76-NE-2517A
1	aluminum heat shield	C76-NE-2517A
1	9/16" inner dia. rubber grommet McMaster 39600k19	
1	thermostat omega/McMaster CCD100N-055/3599K32	
2	6/32 x 1/4" pan head screws, nuts, and lock washers	
1	22-14 AWG wire nut	
2	16-14 AWG ring terminal, #6 stud	
3	terminal blocks, AMP Flexblock Modular Terminal Block System, 300V, 15Amp, 6/32 stud, Part #1-604102-1	
1	5 block segment of AMP Flexblock Terminal Block track	
2	AMP End Stop #6, Part #604111-1	
3	AMP Fast Tab, 90° bend, double end, Part # 3-601989-3	
2	6/32 x 3/8" pan head screws, nuts, and lock washers	
1	strip heater McMaster # 3576K71	
2	1/4 - 20 x 1 1/2" panhead screws	
2	1/4 - 20 washers	
6	1/4 - 20 nuts	
2	1" x 1" squares of heat resistant plastic	
2	6" length 1/8" diameter fiberglass tubing	
2	16-14 AWG ring, #10 stud	
4	16-14 female panduit, insulated, covered	
4	panhead screws 6/32 x 3/8"	
1	SPRITE fan, 3 1/4" x 3 1/3" x 1 5/8", bolt through mounting, 115V, 60 Hz, 9 W, Model SP2A2L	
1	thermostat	
4	pan head screws 6/32 x 2 1/2"	
4	6/32 nuts	
2	#18-22 female panduit, unstranded	
2	#14-16 female panduit, stranded	

3.2.2 Electrical System Parts		
1	female flanged receptacle 3 prong Hubbell for pump	
1	male flanged receptacle 3 prong Hubbell for power	
4	6/32 x 3/8" pan head screws for outlet plug installation	
4	6/32 nuts for outlet plug installation	

1	flanged breaker switch: on/off 2" x 1", 2 panduit posts	
1	two position switch, manual override for pumps	
1	Magnetek 120VAC transformer, Sec 24VCT @ 2.4A Type FD7-24, quick connect fittings	
2	8/32 x 3/8" pan head screws	
2	8/32 lock washers	
4	#16-18 covered, insulated female panduit	
4	relays, switched by 24VAC signal	
1	relay track , cut to 5 1/2", (for mounting relays)	
5	relay clips (hold relays in place on track)	
2	6/32 x 3/8" pan head screws (mount track to back plate)	
20	#14-18 fork head terminal, #6 stud, insulated	
1	GRASSELIN 7 day clock controller (3 pieces)	
2	panhead screws 6/32 x 1/2"	
2	6/32 nuts	
	silicone sealant (use to waterproof module where holes or fittings have been added to the exterior)	
8	female panduit #14-16 stranded	
1	6 wire cable, 16 gauge	
	several feet of 16 gauge wire: black, white, gray, red, orange, green, blue, & yellow	

3.3 SIM-Controller Parts

The SIM-Controller is a SIM with extra components to permit it to control separate satellite sampling modules. The parts and diagrams required to construct a SIM-Controller, in addition to the parts listed in Section 3.2, are listed below.

3.3.1 Transformer		
1	120 VAC 60Hz, 24VCT @ 4.0A, Magnetek FD8-24	
3.3.2 Pump Delay Outlet Box Parts		
3	pump delay relays, 8 sec., 16 sec., 24 sec.	
1	rain proof outlet box, Type 3R (sheets 1 & 2)	C76-NPS-2403A
3	8/32 nuts to mount pump delay relays	
16	panduits female #14-16 covered	
1	2' section of 1/2" liquitight conduit	
2	1/2" liquitight connectors	
1	4 foot section #14 black wire	
1	4 foot section #14 white wire	
1	2 foot section of 6 wire cable, 16 gauge	
3.3.3 Pump Outlet Box Parts		
1	Quad rain tight outlet box	
2	duplex outlets	
1	2 foot section of 6 wire cable	
16	panduits female #14-16 covered	
1	2' section of 1/2" liquitight conduit	
1	1/2" liquitight connectors	
3.3.4 SIM Module Diagrams		
1	electrical controller, schematic	C76-NPS-2362
1	contactor box (pump delay outlet box)	C76-NPS-2403
1	relay connections	C76-NPS-2420

3.4 Independent Controller Module Parts

With the introduction of the SIM-Controller, the Independent Controller Module is no longer being constructed. However, and because replacement parts may be required for maintenance, the parts required to construct an IMPROVE controller module are listed below.

Independent Controller Module Parts		
	Wiring schematic for controller module	C76-NPS-2362
1	machined gray fiberglass module box, Robroy Industries #RJ1816HPL	C76-NPS-2402
1	back plate, machined 1/16" aluminum	
2	louvers 4 1/2" x 3 3/4" x 1/2" gray plastic	
8	pan head screws 6/32 x 3/8"	
8	nuts and washers, 6/32	
1	inset male 110V power plug	
1	face plate, 6"x15" x1/16" steel plate with piano hinge to cover pump delay relays and wiring	
2	8/32 x 1/2" sheet metal screws	
2	face plate supports, 6"x 5 5/8" x1/16" steel bracket, one connected to piano hinge, the other free	
2	8/32x 1/2" sheet metal screws	
1	lower wire cover, 9 1/2" x 4 3/4" x 1/16" aluminum cover for terminal strip	
2	8/32 x 3/8" pan head screws	
1	heater cover, 5"x 5"x 1/16" aluminum sheet	
2	8/32 x 3/8" pan head screws	
2	8/32 nuts	
2	heater supports, 4"x1 1/2"x 1" brackets	
2	8/32 x 3/8" sheet metal screws	
2	8/32 x 1/2" pan head screws	
2	8/32 nuts	
1	strip heater McMaster # 3576K71	
1	box fan, 3 5/8" square, 1" thick, 120V, 60Hz, ETRI model 99xw	
4	6/32x1 1/2" pan head screws	
4	6/32 nuts	
2	#18-24 female panduit, unstranded	
2	thermostats. Fan set at 85°, heater set at 30°, mounted under face plate	
4	8/32 sheet metal screws	
5	relays, 120VAC, 7.5Amp, 116 Hp, RH2B-U	

1	relay track (for mounting relays)	
6	relay clips (hold relays in place on track)	
2	6/32 x 3/8" pan head screws (mount track to back plate)	
30	#14-16 spade head panduit	
3	pump delay relays, delays of 8 seconds, 16 seconds, and 24 seconds on 120VAC signal	
6	8/32 sheet metal screws	
1	19 position double sided terminal strip with wire trap fittings	
4	6/32 x 1/2" pan head screws	
1	fuse, 20Amp Bus fuse	
1	fuse holder	
1	transformer, 120VAC 60Hz, 24VCT @ 4.0A, Magnetek FD8-24	
2	8/32 x 3/8" pan head screws	
4	#16-18 covered female panduit	
1	Grasslin 7 day clock controller (3 pieces)	
1	INTERMATIC 30 minute timer, 120VAC	
1	lock out relay	
1	6 wire cable harness to run the sampling modules	
1	6 wire cable length to run to the pump house	
1	several feet of red, orange, yellow, green, blue, black and white #12 wire.	
1	20' each of #10 white, black, and green wire	
1	pump house, Weather House model 210B, Science Applications International Corporation, (*l x w x h* = 24" x 30" x 48")	C76-NPS-2403
1	contactor box and relay support plate	C76-NPS-2403 & C76-NPS-2420
4	relays, 120VAC, 7.5Amp, 116 Hp, RH2B-U	
10	6/32 x 1/4" pan head screws	
10	6/32 nuts	
1	4 position double sided terminal strip	
30	#12 spade wire connectors	
1	4 plex outlet box, for pump outlet plug	
2	20' length 1/2" liquitight flexible metal conduit (or 3/8")	
4	mounting fittings for 1/2" liquitight conduit (or 3/8")	
30	#14-16 spade wire connectors	

4.0 METHODS

The procedures for constructing sampling and controller modules are described in the following subsections:

4.1 Constructing an IMPROVE protocol aerosol sampling module.
- 4.1.1 Constructing an IMPROVE sampling module.
- 4.1.2 Constructing a SIM Sampling Module.
- 4.1.3 Constructing a SIM Controller Module A

4.2 Constructing an IMPROVE controller module

4.1 Constructing an IMPROVE Protocol Aerosol Sampling Module

The procedures for constructing a sampling module are outlined in the following three subsections. For a Satellite Sampling Module, use only section 4.1.1. For a SIM, use sections 4.1.1 and 4.1.2. For a SIM-Controller use all three sections.

4.1.1 Constructing a Sampling Module.

1. See section 3.1.1
2. Using the appropriately sized hole saws, drill the holes described in C76-NPS-2402A through the fiberglass module enclosure. Note the differences in the 2.5µm and 10µm sampling module hole configurations. Do not drill the hole on the top of the module for a PM_{10} inlet if the module will not be used for PM_{10} sampling. Use a dust mask and protective clothing. A vacuum connection to collect fugitive fiberglass is suggested. Water may be used for cooling the drills and cleaning the modules following drilling. Silicone sealant should be applied in a very thin coat over any cut edges to seal the fibers in place.
3. Drill 3/16" holes in the four corners of the gray louvers to match the holes drilled in the fiberglass module for mounting the louvers.
4. Mount one louver over the hole on the base of the module, using four 6/32 x 3/8" pan head screws and nuts.
5. Mount the second louver over the hole on the upper right side of the module next to the latch, using four 6/32 x 3/8" pan head screws and nuts.
6. Install aluminum covers over the two 1 3/4" holes in the base of the module, as these holes are not necessary for this type of sampling module.
7. See section 3.1.2.1
8. Following the schematic C76-NPS-2392A, cut and punch sheet aluminum to create a back plate. Use a press to install the threaded inserts.
9. See section 3.1.2.2
10. Construct the solenoid manifold according to the schematics C76-NPS-2367A and C76-NPS-2367C.
11. Construct the solenoid manifold back plate according to the schematics C76-NPS-2367B.
12. Assemble the solenoid manifold. Attach the back plate to the manifold using 10/24x1/4" fillister head screws. Install the male brass elbow at the end of the manifold, tightening it firmly so the elbow is normal to the manifold back plate. Install the VCO male connector in the outlet port, threading it in securely to prevent leaks.

13. Connect the partially assembled solenoid manifold to the sampler back plate using the four 8/32x1 1/4" pan head screws to bolt through the back plate into the manifold.
14. Install the back plate in the fiberglass module using the four 10/32x3/8" pan head screws.
15. If the module is to be a D module (10µm), see section 3.1.2.3, then follow the procedure below to install the filter manifold. If it is to be a 2.5µm, skip to #15.
    - Construct the funnel support following the diagram C76-NPS-2401A, bolting it to the back plate of the module with two 1/4-20x3/8" screws.
    - Construct and assemble the funnel, the cover plate, the hold down clamp, and the port caps following the schematics C76-NPS-2395A, C76-NPS-2358A or C76-NPS-2358, C76-NPS-2369, C76-NPS-2386A or C76-NPS-2386. Install the o-rings, and the 10/24x4" support screw with spacers to support the hold down clamp and the knurled knob on the cover plate.
    - Attach the funnel to the funnel support using two 1/4-20x3/8" screws.
    - Install the cover plate with hold down clamp on the funnel, and the port covers.
    - Install the rubber grommet (1 1/4" ID) in the 1 1/2" hole in the top of the module in line with the top of the funnel.
16. See section 3.1.2.4
17. Construct the terminal strip.
    - Install the End stop at one end of the support track.
    - Slide the 14 terminal blocks into the track.
    - Install the second End stop on the support track to hold the blocks in place.
    - Remove the 6/32 screws from the terminal blocks.
    - Place one 45° Faston Tab on each terminal block, lining up the screw holes.
    - Place one 90° Fast Tab on ten consecutive terminal blocks, starting at one end.
    - Re-install the 6/32 screws to hold the Fast Tabs on the terminal blocks.
18. Attach the terminal strip to the back plate, using the holes in the upper right hand side of the back plate and four 6/32 x 3/8" pan head screws. Verify the end with the four blocks that did not have both a 45° and a 90° Fast Tab installed is the lower end.
19. See section 3.1.2.5
20. Construct the solenoids.
    - Thread the 1/2" Swagelock fitting into the input end of the solenoid, using teflon plumbing tape and tightening firmly to prevent leaks.
    - Machine the CAJON hex nipple fitting according to the schematic C76-NPS-2367.
    - Thread the machined CAJON hex nipple fitting into the output end of the solenoid, using Teflon plumbing tape and tightening firmly to prevent leaks.
    - Install a 200-011 o-ring into the machined o-ring groove on the hex nipple, and lightly coat it with vacuum grease.
21. Install a 200-011 o-ring in the o-ring groove on each of two port blocks, and install them in the second and fourth positions from the left of the solenoid manifold. Push them firmly into the port holes.

22. Install the two solenoids in the first and third positions from the left on the solenoid manifold by pushing them firmly into the open port.
23. Attach each solenoid to the manifold back plate with two 8/32 x 3/8" pan head screws. Bolt through the back plate and solenoid brackets to an 8/32 locking nylon nut on the solenoid side of the plate.
24. For a 2.5µm sampler, see section 3.1.3.1, then follow the steps listed below. For a 10µm (D module) sampler, skip to #26.
    - Construct an inlet tee, following the schematic C76-NPS-2814, and installing the necessary o-rings.
    - Construct a stack plug, following the schematic C76-NPS-2395B, but without drilling the hole for the nipple. Install the 200-216 o-ring.
    - Install the inlet tee in the sampling module, on the lower left hand side in the space provided. Bolt it in place using two 10/32 x 1/2" screws with washers. Verify the tee is mounted parallel to the back plate, as the cyclone it supports must be vertical to function properly. Adjust the tee as necessary.
    - Construct a stack support following the schematic C76-NPS-2382B.
    - Bolt the bottom of the support to the upper left side of the module through the pre-drilled holes, using two 1/4 - 20 x 3/4" screws with washers.
    - Cut the aluminum stack to the required length, and turn the lower and upper two inches on the lathe to insure the ends are round and 1 1/2" outer diameter.
    - Verify the stack will seal inside the inlet tee and pass though the stack support, and will be vertical (parallel to the back of the module). If not, adjustments to the stack support location should be made at this time.
25. For B modules only, construct a denuder.
    a. Cut the tubing to the lengths indicated.
    b. Turn both ends of the tubing in the lathe to remove burrs and create a thinner, sloping profile to oncoming air.
    c. Assemble the denuder using the jig described in C76-NPS-2439B, according to the schematics in C76-NPS-2439A, using six 5/8" pop rivets.
    d. Run hot water forcibly through the denuder for 3 to five minutes to remove construction artifact and contaminants.
    e. Place the denuder in an ultrasound bath with 10ml of reagent grade ammonia and 1/16 teaspoons of Alconox™ glass cleaner per liter of water.
    f. Run the ultrasound bath for at least 30 minutes.
    g. Remove the denuder promptly and rinse thoroughly with hot water for several minutes.
    h. Rinse the denuder with distilled de-ionized water.
    i. Allow the denuder to dry.
    j. Create a solution of Na_2CO_3 and reagent grade glycerol in distilled water. The required concentrations are 71grams of Na_2CO_3 and 30ml of glycerol per liter of water. Agitate the solution thoroughly until all the Na_2CO_3 is dissolved. Heating the distilled water aids dissolving the Na_2CO_3.
    k. Immerse the denuder completely in the Na_2CO_3 solution for several minutes, agitating it to ensure all surfaces are coated.

l. Remove the denuder from the solution and allow it to air dry. Place it on clean lab towels to absorb excess Na_2CO_3.
m. Store the excess Na_2CO_3 solution in a clean, sealed, labeled beaker for re-use.

26. For D modules only, see section 3.1.3.2. Cut the 1 1/4" diameter aluminum stack to the required length and turn the upper and lower two inches on the lathe to insure the ends are round and 1 1/4" in outer diameter.
27. See section 3.1.4.1
28. Construct a face plate for the module following the schematic C76-NPS-2368.
29. See section 3.1.4.2
30. Assemble the pressure gauge.
    - Using Teflon plumbers tape, attach the 45° female fitting to the pressure gauge, ensuring the orientation is such that the opening points directly downward from the gauge if mounted on a vertical surface.
    - Using Teflon tape, attach the brass double male hex fitting to the 45° female fitting.
    - Slide a brass hose fitting over one end of the 10" segment of hose.
    - Press the end of the hose firmly into the opening on the double male hex fitting, and, while holding the hose in place, use a wrench to tighten the brass hose fitting on the male fitting. When tightened adequately, the hose fitting will be compressed onto the hose, forming a leak tight fitting.
    - Slide the hose through the hole on the front of the face plate for the pressure gauge, pulling the pressure gauge body through until the lip of the gauge is flush with the surface of the face plate.
    - Install the mounting brackets, included with the gauge, to hold the gauge in place. Verify the gauge is oriented such that it will be readable when mounted in the sampler.
31. See section 3.1.4.3
32. Install the magnehelic gauge on the face plate.
    - Using the included hardware, install port plugs, using Teflon tape to reduce the chance for leaks, in the two ports on the side of the magnehelic gauge.
    - Install the included brass nipples in the two port positions on the back of the magnehelic gauge. Use Teflon tape on the threads to reduce the chance for leaks.
    - Slide the 19" length of tubing over the nipple on the low pressure port (labeled LOW on the magnehelic).
    - Slide the 20" length of tubing over the nipple on the high pressure port (labeled HIGH on the magnehelic).
    - Slide the hose through the hole in on the front of the face plate for the magnehelic gauge, pulling the gauge body through until the lip of the gauge is flush with the surface of the face plate.
    - Attach the three magnehelic mounting brackets to the magnehelic body, following the instructions enclosed in the magnehelic, using the three 6/32 x 1/2" screws.
    - Mount the magnehelic gauge to the face plate by bolting the 6/32 x 2 1/2" screws through the mounting brackets to the back surface of the face plate.

Tighten them firmly to securely hold the magnehelic in place, first verifying the magnehelic is oriented properly.

33. See section 3.1.4.4
34. Cover the two lower elapsed timer mounting holes and toggle switch mounting holes with a strip of aluminum tape.
35. Install the two toggle switches.
    - Remove the knurled ring and the lock bolt from the face of the switch.
    - Slide the switch through the face plate such that the body of the switch is behind the plate, and the groove in the threads on the switch lines up with the groove in the mounting hole on the face plate.
    - Install the lock bolt on the switch, tightening it securely to hold the switch in place.
    - Install the knurled ring on the switch above the lock ring.
36. Install the two elapsed timers.
    - Remove the plastic knurled knob from the back of the elapsed timer, removing the metal mounting bracket at the same time.
    - Slide the elapsed timer, wires first, through the face plate, pulling the body of the timer after until the lip of the timer rests on the front surface of the face plate.
    - Install the metal mounting bracket on the elapsed timer, tightening the plastic knurled knob to hold it in place.
37. Install the face plate in the module.
    - Install the support blocks or support brackets in the module such that the face plate, when bolted to the supports will be in the upper part of the module, inset 1/4". Use wood screws to bolt through the module into the support brackets.
    - Install the face plate on the support brackets, using sheet metal screws to bolt the face plate to the bracket.
38. See section 3.1.2.4
39. Wire the sampling module according to the directions and appropriate schematic in TI 101C.
40. See section 3.1.5
41. Construct and assemble the cyclone following the schematics listed in section 3.1.5, using a small amount of vacuum grease to lubricate the o-rings.
42. See section 3.1.6.
43. For 2.5µm sampling modules (A, B, or C modules), construct an inlet head following the schematic C76-NPS-2381C.
44. See section 3.1.7.1.
45. Assemble the pumps, one for each sampling module.
    - Remove the protective plastic shipping plug from the inlet port on the pump
    - Using Teflon plumber tape, firmly thread the brass pipe extender into the inlet port on the pump.
    - Using Teflon plumber tape, firmly thread the brass elbow to the pipe extender, ensuring the port on the elbow is facing upward when the elbow is tightened into place.

- Slide an end of the hose through the hole in the lower left side of the base of the sampling module.
- Slide a brass hose fitting over the end of the hose. Press the end of the hose into the port on the brass elbow from the solenoid manifold and, using a wrench, tighten the brass hose fitting onto the elbow. This will seal the hose fitting onto the hose to provide a leak proof connection.
- Slide a brass hose fitting over the other end of the hose. Press this end of the hose into the port on the brass elbow from the pump and, using a wrench, tighten the brass hose fitting onto the elbow. This will seal the hose fitting onto the hose to provide a leak proof connection. The
- Plug the pump into the power outlet switched by the controller module.

46. The sampling module is complete, requiring only testing of the electrical and vacuum systems prior to acceptance for use. If you wish to construct a SIM or a SIM-Controller Module, continue with section 4.1.2.

4.1.2 Constructing a SIM or SIM-Controller

47. Using a standard screw driver, pry off the two 1 3/4" hole covers on the bottom of the module.
48. See section 3.2.1.
49. Install the female 3 prong power receptacle.
    - Connect a 5" length of 16 gauge black wire to the 110V "hot" connector on the female 3 prong power receptacle (brass fitting).
    - Connect an 8" length of 16 gauge white wire to the 110V common port on the power receptacle (aluminum fitting).
    - Connect a 5" length of 16 gauge green wire to the ground port on the power receptacle (green fitting).
    - Thread the wires into the module through the 1 3/4" hole on the right side of the module base, pulling the plug receptacle through until the lip of the receptacle is flush with the base of the module.
    - Orient the receptacle such that the ground connection is closest to the module back plate.
    - Install a #10 stud ring terminal on the free end of the ground wire.
    - Unscrew the 10/32 x 3/8" screw holding the lower right corner of the back plate to the module, slide the ring connector over the screw, and re-install the screw.
    - Mark the positions of the holes in the lip of the female power receptacle on the gray module, and drill 1/8" holes through the gray module at these positions.
    - Using two 6/32 x 3/8" screws and nuts, bolt the power receptacle to the base of the module.
50. Install the male 3 prong power receptacle.
    - Connect an 18" length of 16 gauge black wire to the 110V "hot" connector on the male 3 prong power receptacle (brass fitting).
    - Connect a 14" length of 16 gauge white wire to the 110V common port on the power receptacle (aluminum fitting).

- Connect a 5" length of 16 gauge green wire to the ground port on the power receptacle (green fitting).
- Thread the wires into the module through the 1 3/4" hole on the left side of the module base, pulling the plug receptacle through until the lip of the receptacle is flush with the base of the module.
- Orient the receptacle such that the ground connection is closest to the module back plate.
- Install a #10 stud ring terminal on the free end of the ground wire.
- Unscrew the 10/32 x 3/8" screw holding the lower left corner of the back plate to the module, slide the ring connector over the screw, and re-install the screw.
- Mark the positions of the holes in the lip of the male power receptacle on the gray module, and drill 1/8" holes through the gray module at these positions.
- Using two 6/32 x 3/8" screws and nuts, bolt the power receptacle to the base of the module.

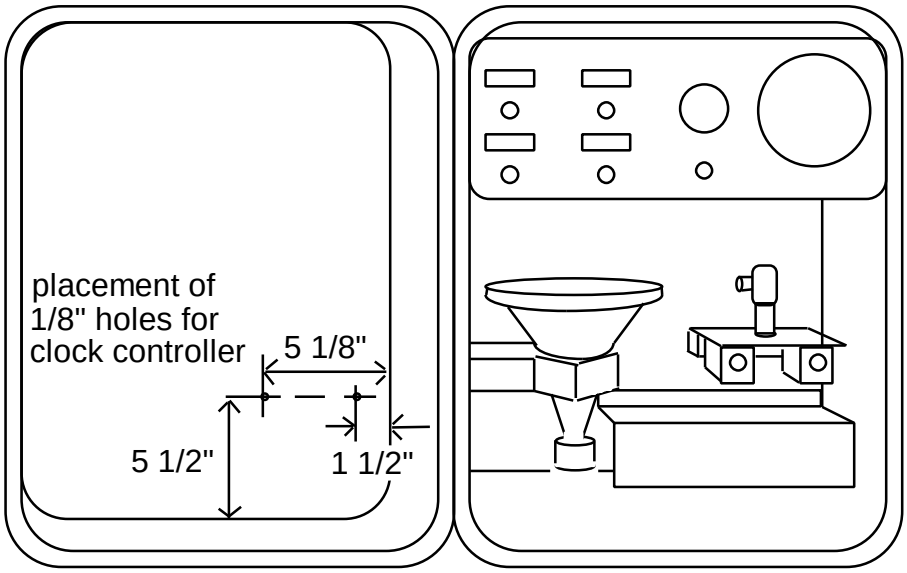
51. See section 3.2.1
52. Mount the thermostat.
    - Following the schematics listed in 3.2.1, create the heater support and shield.
    - Install the 9/16" grommet on the heater support.
    - Thread the three wires from the thermostat through the grommet, then bolt the thermostat to the heater support using two 6/32 x 1/4" screws, nuts, and lock washers.
    - Clip the ground wire (beige) from the thermostat so it extends 1" through the grommet, strip the end, and install a wire nut.
    - Clip the other two wires (red, black) from the thermostat so they extend approximately 2" from the grommet, strip the ends, and install #6 stud ring terminals.
53. Mount the terminal strip.
    - Install the terminal strip End stop at one end of the support track.
    - Slide the 3 terminal blocks into the track.
    - Install the second End stop on the support track to hold the blocks in place.
    - Using two 6/32 x 3/8" screws, nuts, and lock washers, mount the terminal strip on the heater support plate.
    - Remove the 6/32 screws from the terminal blocks.
    - Clip one mounting tab each from two of the 90° Faston Tabs
    - Mount the Faston Tabs on the terminal strip in the positions shown in NPS-NE-2517A.
    - Connect the two wires from the thermostat to the terminal strip, in the clipped tab positions, bolting through the ring terminals to hold them in place.
54. Install the heater.
    - See diagram NPS-NE-2517A.
    - Construct the heater cover.
    - Bolt the heater to the heater support plate using 1/4 - 20 x 1 1/2 screws. Bolt through a 1/4 - 20 washer, through the heater, through a square of heat resistant plastic, through the heater support, through a 1/4 - 20 nut (tighten to hold heater firmly in place), through another 1/4 - 20 nut, through the heater

cover, and through another 1/4 - 20 nut (tighten firmly to keep heater cover in place).

- Cut one 6" length of yellow wire insulation material.
- Cut two 7" lengths of #16 wire (white), and thread them through the wire insulation.
- Strip the ends of the wire, and attach a #10 ring terminal to the two wires on one end of the insulation.
- Remove the 10/32 nuts on the strip heater posts and mount the ring terminals on the posts, re-installing the nuts to hold them in place, and adjusting the wires and insulation so the maximum amount of wire is covered near the heater.
- Attach female insulated, covered panduit to the free ends of the wires, and attach them to the terminal strip in the positions indicated in NPS-NE-2517A.

55. Install the fan.
    - Remove the four 6/32 x 3/8" pan head screws from the louver mounted on the side of the module, and install four 6/32 x 2 1/2" screws.
    - Slide the fan over the four screws, and bolt it in place with the 6/32 nuts.
    - Unscrew the nut on the upper back screw, installing the fan thermostat over the screw before reinstalling the nut.
    - Cut a 2" length of black wire, strip both ends, and install a #18-22 female panduit on one end, and a #14-16 female panduit to the other end.
    - Mount the #18-22 panduit end of the wire to the fan.
    - Mount the #14-16 panduit end of the wire to the thermostat.
56. Install the relays.
    - Mount the relay track to the two holes with #6 threaded inserts spaced 4" apart near the to of the back plate. Use the two 6/32 x 3/8" screws.
    - Slide the four relays, separated by relay clips, onto the track and install clips at both ends of the track.
57. Mount the transformer to the two #8 threaded inserts on the upper left side of the back plate, facing the terminal connections toward the top of the module, using two 8/32 x 3/8" screws with lock washers.
58. Mount the clock controller to the inside of the module door.
    - Drill two 1/8" holes in the module door; as shown in Figure 1 below.

Figure 1 Placement of Holes for SIM Clock Controller



- Bolt the clock controller mounting bracket to the door of the module using two 6/32 x 1/2" screws and nuts. Apply a small amount of silicone sealant to seal the holes through the module door.
- The clock controller back plate is locked onto the mounting bracket by a red latch on the bottom of the back plate. The latch may be released by pulling it outward slightly with a screw driver.
- The clock controller body has several metal plates which must be lined up with the holders on the controller back plate before being pressed into place. The plates make an electrical connection, and must not be bent. Once pressed firmly into place, the screw on the base of the clock controller body is threaded into the hole in the back plate to secure the clock in position.

59. Install the pump override switch on the face plate below the pressure gauge. "Manual" or "on" should be the position with the switch to the left. "Auto" or "off" should be the position with the switch to the right.
60. Press the flanged breaker switch into position on the heater support strip, as shown in NPS-NE-2517A.
61. Wire the module following the appropriate schematic in TI 101C
62. Using four 6/32 x 3/8" pan head screws, attach the heater support to the module back plate.
63. The SIM is complete, requiring only testing of the electrical and vacuum systems prior to acceptance for use. If you wish to construct a SIM-Controller Module, continue with section 4.1.3. If not, the assembly is complete.

4.1.3 Constructing a SIM-Controller Module

64. Verify the holes to mount the latching relay and transformer on the back plate are in the positions indicated in C76-NPS-2392B If the holes have not been pre-drilled and fitted with threaded inserts, you will have to use 3/8" self tapping sheet metal screws to mount the relay. Do not mount the relay or the transformer at this time.
65. Remove the heater support by unscrewing the four 6/32 x 3/8" screws holding it in place.
66. Remove the male power receptacle by unscrewing two 6/32 x 3/8" screws, and disconnecting the attached wires.
67. Remove the female power receptacle by unscrewing two 6/32 x 3/8" screws.
68. Disconnect the 16 gauge white wire from the power receptacle and install a 4' long section of 12 gauge white wire in its place.
69. Disconnect the length of 16 gauge black wire between the power receptacle and the breaker switch. Replace it with two lengths of 12 gauge black wire; one 5" long with a female panduit on one end , the second 4' long. The 5" wire will connect the 110V "hot" power from the receptacle to the breaker switch. The 4' wire will run from the 110V "hot" port on the power receptacle up around the inside of the module to the hole for the male power receptacle.
70. Re-install the female power receptacle.
71. Use the 4' length of 12 gauge white wire to replace the 16 gauge white wire that ran up, around the inside of the module, to the male power receptacle. Cut the 12 gauge wire when necessary to allow junctions with the 16 gauge wires from: the thermostat for the fan; the transformer; the clock controller.
72. Re-install the heater support plate, using the four 6/32 x 3/8" screws.
73. Install the latching relay following the instructions below in steps 1 through 10. See the wiring diagram in TI 102C.

    1. Find a suitable area in which to mount the relay socket above the solenoid valves. Use the pre-drilled holes if possible, securing it with two 6/32 x 3/8" screws. If no pre-drilled holes exist, i.e. for an old sampler, secure the relay to the back plate with two sheet metal screws.
    2. Remove the four screws securing the top instrument panel. Unscrew the lower tube fitting for the Vacuum Gauge Line. Move the panel out of the way. Locate a place in the upper right hand corner of the back plate to mount the new transformer. The spot directly above the terminal strip seems the most ideal. Position the transformer so that the wires are projecting out to the left. If there are pre-drilled holes for the transformer, use these, with 6/32 x 3/8" screws to secure it in place. If not, secure the transformer with two sheet metal screws with washers.
    3. Locate the insulated six wire cable coming from the Clock Controller. The four channel wires (red, orange, green, blue) in this cable will either connect to the toggle switches on the face plate, or to the relays on the back plate.

a. The four colored wires from the clock controller run to the left quick connect position on the toggle switches below the Elapsed Timers. Many of the SIMS will have colored wires; red, orange, green, and blue, running to the back of these switches. These wires originate from the Clock Controller, ch. 1, ch.2, ch. 3, and ch. 4, and then they are daisy-chained to the rest of the circuit via the push-on quick-connects behind the switches. **Taking great care**, cut the four wires from the clock controller, right behind the quick-connects attached to the switches. Make sure to cut only the red, orange, green, and blue wires going to ch.1, ch.2, ch.3 and ch.4 of the Clock Controller, leaving the other wire and quick-connect intact. Crimp 1/4" female quick-connects to the red, orange, and green wires. Attach a 22/14 AWG wire nut to the blue wire.

b. The four colored wires from the clock controller run directly to the relay sockets. For this version, remove the fork terminals attached to the red, orange, and green wires from the #14 terminal of the relay sockets. Clip the fork terminal off the green wire and attach a 1/4" female quick-connect.

4. Attach one of the blue Quick-Tap Splice Connectors to the white wire going to the old transformer in the upper left hand corner. This is an insulation displacement connector and is **not a crimp connector.** Place the white wire in the metal slot of the Splice Tap and close the other half of the plastic clam shell over the wire. With a small pair of pliers, gently squeeze down on the two halves of plastic until you hear a light click. This is all that is necessary for a good connection. Do not attempt to squeeze tighter. Plug the Male Quick-Connect attached to the white wire of the new transformer into the end of the Quick-Tap Splice.
5. Attach the black lead from the new transformer to the #12 terminal of one of the relay sockets. The #12 terminals of all the relays should already be daisy-chained together.
6. Identify the blue and yellow leads from the newly installed Latching Relay. They should each have a small pink Quick-Connect. Attach these two Quick-Connects to the outer two free terminals on the newly installed transformer. Try not to bend the terminals and make doubly sure that the terminal tab slides directly into the center of the Quick-Connect and not under the plastic housing. Plug them in any order, but do not plug them into the center terminal, that is a center tap.
7. Identify the red and orange wires coming from new Latching Relay with Fork Terminals. Place the red wire Fork Terminal under the existing red lead on terminal #14 of the left most relay socket. Place the orange wire Fork Terminal under the existing orange lead on Terminal #14 of the relay socket second from the left.
8. Identify the red, orange, and green wires from the new Latching Relay with red 1/4" Quick-Connects. Plug each of these into their counterparts prepared in step 3.

8b. **Addendum for SIMS in which the controller wires ran to the relays.** Take the red and orange wire mentioned in step 8 and remove them from the

Latching Relay Socket. In their place, slide the red and orange wires from the clock controller cable.

9. Looking at the Vertical Terminal Strip on the right side of the module and counting down from the top, locate terminals' 5,6, and 7. They should all be joined together by jumpers. These are the 24 Volt return terminals. Identify the gray lead from the new Latching Relay with the pink 1/4" Quick-Connect. Plug this into any of the three return terminals on the Strip.
10. Reattach the Instrument Panel and the Vacuum Gauge Line. This completes the Electrical Installation and Modification.

74. Construct a pump delay outlet box, following the schematics in C76-NPS-2403A sheets 1 and 2.
75. Construct a pump outlet box.
    - Connect the pump outlet box to the pump delay outlet box with liquitight conduit.
    - Run the wires from the relay box to the outlet box.
    - Connect the ground wire to the screw connection in the back corner of the box.
    - Connect the white wire to the four "common" positions on the outlets.
    - Connect the wires (red, yellow, green, blue, white) to the power outlets in the "hot " positions. Note that by convention, the red wire is connected to the upper left outlet, the yellow to the upper right outlet, the green to the lower left outlet, and the blue to the lower right outlet. These outlets are labeled "A" for the red outlet, "B" for the yellow outlet, "C" for the green outlet, and "D" for the blue outlet.

4.2 Constructing an Independent Controller Module

The Independent Controller Module was designed and built by contractors following the electrical schematic C76-NPS-2362A. This design is no longer being constructed, having been replaced by the SIM-Controller module. Since these modules do exist in the network, the parts listing is included, but as no more will ever be made, no assembly constructions will be provided.

The wiring diagrams for the various configurations of the Independent Controller Module are included in TI 101C. For information on the parts and diagrams used, see section 3.4.