PRODUCT INDEX			
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ITEM	*DESCRIPTION*	*PRICE*	
	Sorted By Category		
	**** PRICES SUBJECT TO CHANGE WITHOUT NOTICE ****		
	PLEASE CALL TO CONFIRM PRICING PRIOR TO RELEASING A QUOTATION OR ORDER		
LIQUID CHROMATOGRAPHS			
0210-5000	MODEL 210 ISOCRATIC MULTI-LINE UV HPLC SYSTEM	$5,995.00	
0210-0150	MODEL 220 UPGRADE TO BINARY GRADIENT	$3,995.00	
0210-4000	UPGRADE TO 4/6 CHANNEL PEAKSIMPLE DATA SYSTEM	$995.00	
8500-0025	UPGRADE TO VARIABLE WAVELENGTH UV DETECTOR	$4,595.00	
0210-2050	HPLC INJECTION VALVE WITH REMOTE START	$895.00	
0219-0200	BINARY GRADIENT SYSTEM W/4-Ch. DATA SYSTEM, MODEL 210	$9,995.00	
8500-2000	REFRACTIVE INDEX DETECTOR	$6,495.00	
8670-0090	UV/CONDUCTIVITY DETECTOR BOARD (REPLACEMENT)	$495.00	NEW
GAS CHROMATOGRAPHS			
0110-0003	110 CHASSIS, 110VAC 60Hz	$1,795.00	
0110-1005	110 GASLESS EDUCATIONAL CCD VIRTUAL OVEN GC, SERIAL	$3,995.00	DISCONT.
0110-0350	HYDROGEN GENERATOR MOUNTED ON MODEL 110 CHASSIS	$2,495.00	DISCONT.
0110-2203	110 CHASSIS, 220VAC 50Hz	$1,795.00	
0110-5010	110 VIRTUAL OVEN GC CHASSIS, 110VAC 60Hz	$3,995.00	DISCONT.
0110-5210	110 VIRTUAL OVEN GC CHASSIS, 220VAC 50Hz	$3,995.00	DISCONT.
0310-0000	310 EDUCATIONAL TCD GC, SERIAL CHASSIS (NO COOLING)	$4,595.00	
0310-0003	310 GC MAINFRAME W/ EPC, SERIAL CHASSIS	$4,995.00	
0310-1000	310 EDUCATIONAL TCD GC, SERIAL CHASSIS (WITH COOLING)	$5,295.00	
0310-1005	310 GASLESS EDUCATIONAL CCD GC, SERIAL CHASSIS, NO COOL	$4,795.00	
0310-1006	310 GASLESS EDUCATIONAL CCD GC, SERIAL CHASSIS W/COOLING	$5,495.00	
0310-1117	310 GASLESS EXPLOSIVES GC, TID	$7,495.00	
0310-1150	310 GASLESS ETHANOL GC (CCD), ISOTHERMAL OVEN, SERIAL	$4,295.00	
0310-1151	310 GASLESS ETHANOL GC (CCD), PROGRAMMABLE OVEN, SERIAL	$4,995.00	
0310-2203	310 GC MAINFRAME W/ EPC, 220V 50Hz MODEL	$4,995.00	
8610-0003	8610C GC MAINFRAME w/ EPC	$4,995.00	
8610-0004	8610D GC MAINFRAME w/ DUAL COLUMN OVENS	$7,495.00	
8610-0025	8610C METHOD 25 GC (CH4/NON-CH4 HC)	$10,495.00	

8610-0050	8610C BTEX GAS CHROMATOGRAPH, METHOD 5030 COMPLIANT	$17,995.00	
8610-0051	8610C BTEX GAS CHROMATOGRAPH, METHOD 5030/5035 COMPLIANT	$19,490.00	
8610-0059	8610C ENVIRONMENTAL GC (PID-FID/DELCD-P&T)	$20,995.00	
8610-0060	8610C MUDLOGGING GC (FID-CCD)	$11,495.00	
8610-0070	8610C MULTIPLE GAS ANALYZER GC - TCD	$9,995.00	
8610-0071	8610C MULTIPLE GAS ANALYZER TCD FID METH	$12,995.00	
8610-0072	8610C MULTIPLE GAS ANALYZER TCD HID	$13,495.00	
8610-0073	8610C MULTIPLE GAS + SULFUR ANALYZER	$18,995.00	
8610-0114	8610C AIR MONITORING GC (TO-14)	$20,995.00	
8610-0270	8610C MULTIPLE GAS GC II (TCD)	$10,995.00	
8610-0271	8610C MULTIPLE GAS GC II (TCD-FID-METH)	$13,995.00	
8610-0272	8610C MULTIPLE GAS GC II (TCD-HID)	$14,495.00	
8610-1005	8610C EDUCATIONAL FID GC, SERIAL CHASSIS	$6,295.00	
8610-1007	8610C EDUCATIONAL TCD GC, SERIAL CHASSIS	$6,295.00	
8610-1117	8610C EXPLOSIVES GC (TID)	$8,995.00	
8610-1500	8610C CFC GAS CHROMATOGRAPH WITH TCD	$6,995.00	
8610-1510	8610C CFC GAS CHROMATOGRAPH WITH FID	$6,995.00	
8610-2203	8610C GC MAINFRAME, 220V 50Hz MODEL	$4,995.00	
8610-2204	8610D GC MAINFRAME, DUAL OVEN 220V MODEL	$7,495.00	
8610-3070	8610C BTU GAS ANALYZER GC, TCD	$9,995.00	CHANGE
8610-3489	8610C BREATH ANALYZER GC	$13,995.00	
8610-5400	8610C BASIC CAPILLARY FID GC	$7,995.00	
8610-5670	8610C SULFUR GC, FID/FPD	$14,250.00	
8610-5700	8610C SPME GC	$8,995.00	
DETECTORS			
•	***CCD***		
0110-2007	CCD MOUNTED ON MODEL 110 CHASSIS	$2,790.00	
8670-2007	REPLACEMENT CCD DETECTOR ELEMENT	$75.00	
8690-2007	CCD DETECTOR	$995.00	
•	***FID-DELCD***		
8670-0150	FID CERAMIC IGNITOR ELEMENT	$75.00	
8670-0155	FID COLLECTOR ELECTRODE CABLE WITH BNC CONNECTOR	$30.00	
8670-1024	FID DETECTOR BODY	$300.00	
8670-1025	FID DETECTOR BODY FOR METHANIZER	$400.00	
8670-1029	DELCD HEATER / COLLECTOR ASSEMBLY	$300.00	
0110-2026	FID-DELCD MOUNTED ON MODEL 110 CHASSIS	$6,790.00	
8690-2026	FID-DELCD DETECTOR ASSEMBLY (FID-DELCD)	$4,995.00	
•	***ECD***		
0110-0020	ECD MOUNTED ON MODEL 110 CHASSIS	$7,290.00	
8690-0020	ECD DETECTOR	$5,495.00	
•	***FID***		
0110-0010	FID MOUNTED ON MODEL 110 CHASSIS	$3,790.00	
0110-1080	FID-FPD MOUNTED ON MODEL 110 CHASSIS	$6,790.00	
0110-4010	FID-PID MOUNTED ON MODEL 110 CHASSIS	$7,285.00	
0110-2026	FID-DELCD MOUNTED ON 110 CHASSIS	$6,790.00	
8670-0150	FID IGNITOR	$75.00	
8670-0154	FID COLLECTOR ELECTRODE (REPL. 8610C)	$20.00	
8670-0155	FID COLLECTOR ELECTRODE CABLE (REPL. 8610C)	$30.00	
8670-1024	FID / NPD DETECTOR BODY	$300.00	

8670-1025	FID DETECTOR BODY FOR METHANIZER	$400.00	NEW
8680-0350	EXTERNAL HYDROGEN GENERATOR, 50ML./MIN. VERSION	$2,295.00	
8690-0010	FID DETECTOR	$1,995.00	
8690-0350	HYDROGEN GENERATOR, BUILT-IN	$1,795.00	DISCONT.
8690-1115	FID / NPD CONVERTIBLE DETECTOR	$3,495.00	
8690-2026	FID/DELCD DETECTOR	$4,995.00	
•	***NPD***		
8670-0120	NPD BEAD (REPLACEMENT ONLY)	$300.00	
8670-1024	NPD / FID DETECTOR BODY	$300.00	
0110-0015	NPD MOUNTED ON MODEL 110 CHASSIS	$4,790.00	
8690-0015	NPD DETECTOR	$2,995.00	
8690-1015	NPD CONVERSION KIT FOR FID	$1,295.00	
8690-1115	FID / NPD CONVERTIBLE DETECTOR	$3,495.00	
8690-2615	NPD-DELCD SERIES DETECTOR	$5,995.00	
•	***PID***		
8670-1240	PID CELL ASSEMBLY	$500.00	
8670-1242	PID LAMP 10.6eV w/ SEAL, 106-TYPE	$500.00	
8670-1243	PID LAMP 10.2eV w/ SEAL, 103C-TYPE	$500.00	
8670-1244	PID LAMP SEAL, TEFLON®, PACK OF 10	$50.00	
8670-1245	PID 45VDC BATTERY (REPLACEMENT)	$25.00	
8670-1246	PID HV POWER SUPPLY TRANSFORMER, 8610 A, B MODEL	$100.00	
8670-1247	PID HV POWER SUPPLY CIRCUIT BOARD, 8610C, 310 MODEL	$125.00	
8670-1248	PID DETECTOR INLET BULKHEAD FITTING	$200.00	
0110-0040	PID MOUNTED ON MODEL 110 CHASSIS	$5,290.00	
0110-4010	PID-FID MOUNTED ON MODEL 110 CHASSIS	$7,285.00	
0110-2426	PID-FID-DELCD MOUNTED ON MODEL 110 CHASSIS	$10,285.00	
8690-0040	PID DETECTOR	$3,495.00	
•	***FPD***		
0110-0080	FPD MOUNTED ON MODEL 110 CHASSIS	$5,790.00	
0110-0085	DFPD MOUNTED ON MODEL 110 CHASSIS	$9,790.00	
8670-0080	PHOTOMULTIPLIER (PMT) TUBE	$995.00	
8670-0081	FPD DETECTOR BODY	$1,000.00	
8670-0082	SULFUR WAVELENGTH FILTER	$100.00	
8670-0083	PHOSPHORUS WAVELENGTH FILTER	$100.00	
8670-0084	NEW FPD DETECTOR BODY WITH BUILT-IN SULFUR FILTER	$495.00	
8680-0350	EXTERNAL HYDROGEN GENERATOR, 50ML./MIN. VERSION	$2,295.00	
8680-1080	FPD-FID MOUNTED ON MODEL 110 CHASSIS	$6,795.00	
8690-0080	FPD DETECTOR	$3,995.00	
8690-0085	SIMULTANEOUS S/P FPD DETECTOR (DFPD)	$7,995.00	
8690-0350	HYDROGEN GENERATOR, BUILT-IN	$1,795.00	DISCONT.
8690-1080	FPD-FID DUAL DETECTOR (DUAL ELECTRONICS)	$4,995.00	
8690-2085	DFPD-FID DETECTOR (3 AMPLIFIERS)	$8,995.00	
•	***TCD***		
8670-0011	TCD GAIN SWITCH	$30.00	
8670-9007	UPGRADE TCD TO HIGH TEMPERATURE MODEL (HARDWARE ONLY)	$1,000.00	
8670-9100	TCD CELL STAINLESS STEEL, GOWMAC-TYPE	$1,000.00	
8670-9110	O-RING FOR TCD FILAMENT, EACH (MIN. QTY 10)	$2.00	
8670-9120	TCD FILAMENT, TUNGSTEN-RHENIUM	$75.00	
8670-9121	TCD FILAMENT, GOLD PLATED, SET OF FOUR (AuW 13-300)	$600.00	
8670-9122	O-RING, FOR TCD FILAMENT, PACK OF 10	$20.00	

8670-9125	TCD FILAMENT PROTECTION CIRCUIT (RETROFIT)	$495.00	
8670-9127	TCD CELL w/ FILAMENTS, SRI MODEL (EXCHANGE)	$595.00	
0110-0007	TCD MOUNTED ON MODEL 110 CHASSIS	$3,790.00	
8690-0007	TCD DETECTOR	$1,995.00	
8690-0008	SINGLE FILAMENT TCD DETECTOR	$1,295.00	
8690-9007	TCD DETECTOR, HIGH TEMPERATURE (discont. - incorp. into std. TCD)	$2,495.00	DISCONT.
•	***HID***		
8670-0031	HID DETECTOR BODY	$250.00	
8690-0030	HID DETECTOR, SRI DESIGN	$3,495.00	
0110-0030	HID MOUNTED ON MODEL 110 CHASSIS	$5,290.00	
•	***TID***		
8670-0017	TID DETECTOR BEAD	$300.00	
8690-0017	TID DETECTOR	$2,495.00	
0110-0017	TID MOUNTED ON MODEL 110 CHASSIS	$4,290.00	
•	***AUTOSAMPLERS***		
8640-0010	LIQUID AUTOSAMPLER, 20 VIAL RACK	$6,495.00	
8640-0020	20 POSITION TRAY, SPARE, FOR 2mL VIALS	$495.00	
8640-0021	COOLED SAMPLE TRAY	$895.00	
8670-0068	SYRINGE NEEDLE, REPLACEMENT, FOR LIQUID AUTOSAMPLER	$75.00	
8670-2368	INJECTION PORT COUPLER TO LIQUID AUTOSAMPLER CAROUSEL	$150.00	
8690-0068	LIQUID AUTOSAMPLER CAROUSEL, 42 VIAL TRAY	$7,995.00	
8690-0053	10 STATION PURGE-AND-TRAP AUTOSAMPLER	$5,995.00	
8690-0075	ON-LINE LIQUID SAMPLER, FOR P&T	$3,495.00	
8690-1068	ON-LINE SYRINGE SAMPLER (NO CAROUSEL)	$5,995.00	
8690-2253	10 STATION PURGE-AND-TRAP AUTOSAMPLER 220 V	$6,195.00	
•	***DIRECT INJECTION***		
8670-0034	HEATED SPLIT INJECTOR BODY	$695.00	
8670-0072	NARROW BORE SPME INJECTOR SLEEVE (FOR HTD. INJ.)	$150.00	
8670-1034	SILCOSTEEL LINER FOR SPLIT/SPLITLESS INJECTOR	$20.00	
8670-1353	SILICONE SEPTA (PACK OF 25)	$50.00	
8670-9090	SEPTUM NUT w/ GUIDE FOR 26GA. NEEDLE	$30.00	
8670-9093	0.53mm CAPILLARY COLUMN ADAPTER	$20.00	
8670-9094	INJECTOR BODY	$250.00	
8670-9095	SEPTUM NUT W/ GUIDE FOR 20GA. NEEDLE	$30.00	
8670-9305	HEATED TRANSFER LINE MOD. w/ PLUG	$300.00	
8670-9550	SYRINGE 10 uL	$40.00	
8690-0023	ADDITIONAL ON-COLUMN INJECTOR, EPC CIRCUIT	$1,295.00	
8690-0025	HEATED INJECTION PORT UPGRADE	$795.00	
8690-0034	SPLIT/SPLITLESS INJECTOR UPGRADE, AUTO. VENT	$1,495.00	
8690-0035	GAS PHASE SPLITTER	$795.00	
8690-0045	HEATED STATIC HEADSPACE INJECTOR	$5,995.00	
8690-2022	ADDITIONAL EPC CONTROL ZONE (NO INJECTOR)	$895.00	
8690-2023	ADDITIONAL INJECTION PORT WITHOUT EPC CONTROL/CARRIER	$495.00	
8690-7034	HEATED SPLIT/SPLITLESS INJECTOR UPGRADE WITH PTV	$1,995.00	
8690-8034	HEATED SPLIT/SPLITLESS INJECTOR UPGRADE WITH PTV, VALVE	$3,995.00	
•	***PURGE & TRAP***		
8670-1300	BLANK TRAP	$20.00	
8670-1305	TENAX GR TRAP	$75.00	
8670-1315	CARBOSIEVE II TRAP	$75.00	
8670-1320	CARBOPACK B TRAP	$75.00	

8670-1324	POLISHING FILTER, 3"	$75.00	
8670-1330	TEFLON TEST TUBE SEALS (1 PAIR), FOR P&T	$15.00	
8670-1335	SPARGE TEST TUBES (10 PACK)	$10.00	
8670-1350	PURGE & TRAP SPARGING HEAD w/ GAS INJ. PORT	$350.00	
8670-1450	TRAP HEATER ASSEMBLY WITH T-COUPLE	$250.00	
8670-5050	HOT WAND ASSEMBLY (REPLACEMT. HEATER ONLY)	$295.00	
8670-9556	1/16" S.S. TUBE FOR P&T SPARGE GAS	$20.00	
8680-0052	VOA VIAL ACCESSORY FOR METHOD 5035, FOR ANY P&T	$2,995.00	
8680-5050	HOT WAND ACCESSORY, ADJUSTABLE, 110V	$795.00	
8690-0051	AUTOMATED PURGE AND TRAP CONCENTRATOR, METHOD 5030	$5,995.00	
8690-0052	AUTOMATED PURGE AND TRAP CONCENTRATOR, METHOD 5030/35	$7,495.00	
8690-0053	10 SAMPLE PURGE AND TRAP AUTOSAMPLER, w/4 RELAY BD	$6,995.00	
8690-0054	10 SAMPLE METHOD 5035 PURGE-AND-TRAP SAMPLER	$6,995.00	
8690-0055	10 SAMPLE HEADSPACE AUTOSAMPLER, w/4 RELAY BD	$6,995.00	
8690-0064	ELECTRIC VALVE ACTUATOR (REPLACEMT. w/ TRD)	$595.00	
8690-0075	ON-LINE LIQUID SAMPLER FOR PURGE-AND-TRAP	$3,495.00	
8690-0086	CRYOCOOL w/ ELECTRONICS FOR P&T TRAPS	$995.00	
8690-0097	TRAP PACKING ACCESSORY	$150.00	
8690-1051	METHOD TO-14 AIR CONCENTRATOR AND VAC PUMP INTERFACE	$5,995.00	
8690-1052	METHOD TO-14 AIR CONCENTRATOR, AS ABOVE, w/TUBE DESORBER	$6,995.00	
8690-2253	10 STATION PURGE-AND-TRAP AUTOSAMPLER 220V, 4 REL BD	$6,195.00	
8690-5052	UPGRADE PURGE & TRAP TO 5030/5035 COMPLIANT	$1,495.00	
	• ***THERMAL DESORBERS***		
8670-0062	VALCO T ROTOR HIGH TEMP.	$125.00	
8670-1501	DESORBER BULKHEAD	$350.00	
8670-1502	GAS DELIVERY LINE WITH CONNECTOR, THERMAL DESORBER	$100.00	
8670-1590	3/8" GRAPHITE FERRULE FOR TSD (EACH)	$5.00	
8690-1087	THERMAL DESORBER SAMPLE TUBE (PK. OF 10)	$100.00	
8690-1088	THERMAL SOIL DESORBER, MANUAL ACTUATOR	$2,995.00	
	• ***VALVES***		
8670-0060	VALCO E ROTOR MID TEMP.	$125.00	
8670-0061	VALCO P ROTOR LOW TEMP.	$125.00	
8670-0062	VALCO T ROTOR HIGH TEMP.	$125.00	
8670-8000	SAMPLE LOOP (SPECIFY VOLUME BETWEEN 0.5mL and 3.0mL)	$50.00	
8690-0062	4 PORT LIQUID SAMPLING VALVE, ELECTRIC ACTUATOR	$1,995.00	
8690-0063	MANUAL GAS SAMPLE VALVE, 10 PORT	$995.00	
8690-0064	ELECT. VALVE ACTUATOR (REPLACEMT. w/ TRD)	$595.00	
8690-0065	AUTOMATED GAS SAMPLE VALVE, 10 PORT	$1,995.00	
8690-0066	10 INPUT HEATED STREAM SELECTOR W/ TRANSFER LINE	$3,495.00	
8690-0067	BLOCK HEATER w/ CARTRIDGE FOR GAS VALVE	$495.00	
8690-0069	SOLENOID-CONTROLLED GAS VALVE	$395.00	
8690-0072	VACUUM PUMP INTERFACE, DATA SYSTEM CONTROLLED (NO PUMP)	$495.00	
8690-0083	CRYOTRAP LOOP, AUTOMATED CONTROL	$1,495.00	
8690-0084	HEATED / FAST COOLING TRAP AND PLUMBING	$1,495.00	
8690-0088	THERMOSTATTED VALVE OVEN	$795.00	
8690-0089	UNHEATED INSULATED VALVE OVEN	$250.00	
	• ***INJECTOR ACCESSORIES***		
8670-0025	HEATED INJECTION PORT CARRIER INLET	$100.00	
8690-0075	ON-LINE LIQUID SAMPLER	$2,995.00	
8670-2368	INJECTION PORT COUPLER TO LIQUID AUTOSAMPLER CAROUSEL	$150.00	
8670-8000	SAMPLE LOOP (0.5 to 3.0cc, SPECIFY)	$50.00	

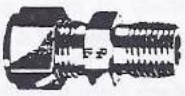
LABOR			
8660-1000	LABOR	CALL	
8660-1500	REFURBISH / TUNE-UP (MIN. CHARGE, DEPENDS ON GC CONFIG.)	$750.00	
8660-2000	TRAINING, DAY RATE IN-HOUSE	$800.00	
8660-3000	RENTAL	CALL	
MANUALS			
8600-MANU	SRI GC MANUAL	$150.00	
8600-SOFT	PEAKSIMPLE SOFTWARE MANUAL	$100.00	
DATA SYSTEMS			
8600-5500	PEAKSIMPLE PARA WINDOWS SPANISH UPGRADE MOD., WIN 3.11	$295.00	
•	***DATA SYSTEM HOST PCs***		
8600-9000	DATA SYSTEM HOST NOTEBOOK PC w/ PTR.	$2,995.00	
8600-9010	DATA SYSTEM HOST DESKTOP PC w/ PTR.	$2,595.00	
8600-9050	MULTIMEDIA DATA SYSTEM HOST DESKTOP PC W/ PTR.	$3,495.00	
•	***A/D BUS SYSTEM (WHILE SUPPLIES LAST)***		
8600-2000	PEAKSIMPLE II DATA SYSTEM FOR MS-DOS	$1,195.00	
8600-2010	A/D BOARD FOR ADDITIONAL CHANNEL	$595.00	
8600-2015	RIBBON CABLE FOR A/D BOARD	$30.00	
8600-2020	INTERFACE BOARD FOR A/D BOARD	$295.00	
8600-SOFT	PEAKSIMPLE DATA SYSTEM MANUAL	$100.00	
•	***SERIAL DATA SYSTEM***		
8600-1053	RETROFIT 1 CH. DATA SYSTEM INTO EXISTING GC	$1,395.00	
8600-1055	PEAKSIMPLE 1-CH. DATA SYSTEM KIT, MODEL 203	$1,395.00	
8600-1056	8 RELAY BOARD FOR MODEL 203 SERIAL INTERFACE	$195.00	
8600-1057	PEAKSIMPLE 1-CH. DATA SYSTEM RETROFIT IN EXISTING GC	$1,395.00	
8600-1255	PEAKSIMPLE 1-CH. DATA SYSTEM KIT, MODEL 203, 220VAC 50Hz	$1,495.00	
8600-2022	SINGLE-GAS EPC OPTION FOR MODEL 202 UNITS	$495.00	
8600-4000	PEAKSIMPLE FOR WINDOWS SOFTWARE UPGRADE	$895.00	DISCONT.
8600-4030	PEAKSIMPLE FOR WINDOWS SOFTWARE UPDATE	$99.00	DISCONT.
8600-4053	RETROFIT 4 CH. DATA SYSTEM INTO EXISTING GC	$2,395.00	
8600-4055	PEAKSIMPLE 4 CH. SERIAL DATA SYSTEM KIT, 110V MOD.202	$2,395.00	
8600-4056	SWITCHED AC OUTLET FOR SERIAL DATA SYSTEM	$195.00	
8600-4060	4 RELAY BOARD FOR GC RETROFIT SERIAL INTERFACE, 8610C	$175.00	
8600-4065	8 RELAY BOARD FOR GC RETROFIT SERIAL INTERFACE, 8610B	$250.00	
8600-4255	PEAKSIMPLE 4 CH. SERIAL DATA SYSTEM KIT, 220V MOD.202	$2,395.00	
8600-4500	PEAKSIMPLE 32-BIT UPGRADE FOR 16-BIT USER	$99.00	
8600-5500	PEAKSIMPLE PARA WINDOWS SPANISH UPGRADE MODULE	$295.00	
8600-5655	1 CH. DATA SYSTEM WITH H2 / HC SENSOR INSTALLED	$1,595.00	
8600-SOFT	PEAKSIMPLE DATA SYSTEM MANUAL W/ TUTORIAL	$100.00	
8670-0232	SERIAL CABLE, RS-232 (DB-9 CONNECTORS), 6'	$25.00	
•	***USB DATA SYSTEM***		
8600-6055	PEAKSIMPLE 6 CH. USB DATA SYSTEM KIT, 110V MOD. 302	$2,395.00	
8600-6255	PEAKSIMPLE 6 CH. USB DATA SYSTEM KIT, 220V MOD. 302	$2,395.00	
COLUMNS			
8600-PKC1	3' x 1/8" S.S. PACKED COLUMN	$100.00	
8600-PKC2	6' x 1/8" S.S. PACKED COLUMN	$150.00	
8600-PKC3	3' x 1/8" TEFLON PORAPAK Q PACKED COLUMN	$150.00	
8600-PKC4	CTR1 DOUBLE PACKED COLUMN	$300.00	

8600-PKC5	24' x 1/8" S.S. AT-1000/CARBOPACK B CFC PACKED COLUMN	$495.00	
8600-WBC1	15M CAPILLARY COLUMN	$300.00	
8600-WBC2	15M MXT-5 CAP. COLUMN	$300.00	
8600-WBC3	30M CAPILLARY COLUMN	$500.00	
8600-WBC4	60M CAPILLARY COLUMN	$875.00	
8600-WBC7	30M MXT-1 CAP. COLUMN	$500.00	
8600-WBC8	30M MXT-5 CAP. COLUMN	$500.00	
8600-WBCX	30M MXT-WAX CAP. COLUMN	$500.00	
ACCESSORIES			
8600-C346	GAS LINE INSTALLATION KIT CGA346	$395.00	
8600-C350	GAS LINE INSTALLATION KIT CGA350	$395.00	
8600-C380	GAS LINE INSTALLATION KIT CGA380	$395.00	
8600-C580	GAS LINE INSTALLATION KIT CGA580	$395.00	
8600-C590	GAS LINE INSTALLATION KIT CGA590	$395.00	
8670-1081	METHANIZER TUBE REPLACEMENT- 6" x 1/8"	$100.00	
8670-1082	METHANIZER TUBE REPLACEMENT- 2" x 1/8" - FOR NEW 8610C GC	$100.00	
8670-5000	CIGARETTE LIGHTER POWER SUPPLY, 300W 12VDC	$495.00	
8670-9305	HEATED TRANSFER LINE MOD. w/ PLUG	$300.00	
8670-9554	SRI TUBING CUTTER FOR COPPER TUBING	$10.00	
8680-0052	METHOD 5035 COMPLIANT VOA VIAL SPARGE ACCESSORY	$3,495.00	
8680-0350	EXTERNAL HYDROGEN GENERATOR, 50ML./MIN. VERSION	$2,295.00	
8680-5050	HOT WAND ACCESSORY, ADJUSTABLE, 110V	$795.00	
8690-0070	INTERNAL WHISPER-QUIET AIR COMPRESSOR, 110V	$595.00	
8690-0073	VACUUM PUMP INTERFACE, AUTOMATED	$495.00	
8690-0081	METHANIZER ACCESSORY	$995.00	
8690-0082	METHANIZER ACCESSORY, IN JET	$995.00	
8690-0095	REUSEABLE SHIPPING CONTAINER	$200.00	
8690-0350	HYDROGEN GENERATOR, BUILT-IN, 25mL/min VOLUME	$1,795.00	
8690-0351	HYDROGEN GENERATOR, BUILT-IN, 50mL/min VOLUME	$2,795.00	
8690-2270	INTERNAL WHISPER-QUIET AIR COMPRESSOR, 220V	$695.00	
8690-5510	DIGITAL MULTIMETER, GENERAL PURPOSE	$69.95	
8690-5600	H2 / HC LEAK DETECTOR, AC POWERED	$299.95	
8690-5655	H2 / HC LEAK DETECTOR, BUILT INTO 1 CH. DATA SYSTEM	$1,595.00	NEW
PARTS			
8600-MAIN	GC MAINTENANCE KIT, SPECIFY 110V OR 220V, 8610C	$495.00	
8670-0011	TCD GAIN SWITCH	$30.00	
8670-0017	TID DETECTOR BEAD	$300.00	
8670-0025	HEATED INJECTION PORT CARRIER INLET	$100.00	
8670-0031	HID DETECTOR BODY	$250.00	
8670-0034	HEATED SPLIT INJECTOR BODY	$695.00	
8670-0060	VALCO E ROTOR MID TEMP.	$125.00	
8670-0061	VALCO P ROTOR LOW TEMP.	$125.00	
8670-0062	VALCO T ROTOR HIGH TEMP.	$125.00	
8670-0068	SYRINGE NEEDLE, REPLACEMENT, FOR LIQUID AUTOSAMPLER	$75.00	
8670-0072	NARROW BORE SPME INJECTOR SLEEVE (FOR HTD. INJ.)	$150.00	
8670-0080	PMT TUBE	$995.00	
8670-0081	PMT DETECTOR BODY	$1,000.00	
8670-0082	SULPHUR WAVELENGTH FILTER	$100.00	
8670-0083	PHOSPHORUS WAVELENGTH FILTER	$100.00	
8670-0084	NEW FPD DETECTOR BODY WITH BUILT-IN SULFUR FILTER	$495.00	
8670-0090	UV/CONDUCTIVITY DETECTOR BOARD (REPLACEMENT)	$495.00	
8670-0120	NPD BEAD (REPLACEMENT ONLY)	$300.00	
8670-0150	FID IGNITOR / ELCD HEATER	$75.00	
8670-0154	FID COLLECTOR ELECTRODE (REPL. 8610C)	$20.00	

8670-0155	FID COLLECTOR ELECTRODE CABLE (REPL. 8610C)	$30.00	
8670-0232	SERIAL CABLE, RS-232 (DB-9 CONNECTORS), 6'	$25.00	
8670-1024	FID / NPD DETECTOR BODY	$300.00	
8670-1025	FID DETECTOR BODY FOR METHANIZER	$400.00	
8670-1034	SILCOSTEEL LINER FOR SPLIT/SPLITLESS INJECTOR	$20.00	
8670-1081	METHANIZER TUBE REPLACEMENT- 6" x 1/8"	$100.00	
8670-1082	METHANIZER IN-JET TUBE REPLACEMENT- 2" x 1/8"	$100.00	NEW
8670-1357	PORTER PRESSURE REGULATOR w/ SENSOR	$325.00	
8670-1400	OVEN HEATER / SOCKET SET, 110 OR 220V	$50.00	
8670-1401	OVEN HEATER ELEMENT FOR 8610A, B, 9300A GC's	$40.00	
8670-1402	OVEN HEATER SOCKET FOR 8610A, B, 9300A GC's	$10.00	
8670-1403	OVEN HEATER ELEMENT FOR 8610C GC, 110V	$50.00	
8670-1404	OVEN HEATER ELEMENT FOR 8610C GC, 220V	$50.00	
8670-1590	3/8" GRAPHITE FERRULE FOR TSD	$5.00	
8670-1814	1/4" TO 1/8" REDUCING FITTING, FOR CTR COLUMN, ETC.	$25.00	
8670-1815	1/4" TO 1/8" REDUCING FITTING, WITH 1/16" GAS LINE ENTRY	$100.00	
8670-1853	GRAPHITE REDUCING FERRULE, 1/8" - 0.8mm, PACK OF 10	$30.00	
8670-2368	INJECTION PORT COUPLER TO LIQUID AUTOSAMPLER CAROUSEL	$150.00	
8670-6000	DIGITAL FLOW CONTROLLER	$350.00	
8670-6010	FLUISTOR (EPC MODULE) WITH CONNECTOR	$150.00	
8670-6021	TANK PRES. REGULATOR w/ CGA FITTING	$250.00	
8670-6022	NORGREN GAS PRESSURE REGULATOR	$75.00	
8670-6023	NORGREN PRESSURE REGULATOR w/ SENSOR	$150.00	
8670-6024	WATTS GAS PRESSURE REGULATOR	$100.00	
8670-6025	WATTS PRESSURE REGULATOR w/ SENSOR	$175.00	
8670-6026	GAUGE FOR REGULATOR	$40.00	
8670-6500	OVEN CIRCULATING FAN w/ SQUIIREL CAGE	$100.00	
8670-6550	GREY OVEN COOLING FAN	$100.00	
8670-6575	COOLING FAN MUFFIN	$75.00	
8670-6600	COLUMN OVEN LID, 8610B	$100.00	
8670-9001	GC MAINTENANCE KIT, 8610C 110V	$495.00	
8670-9002	GC MAINTENANCE KIT, 8610C 220V	$495.00	
8670-9003	GC MAINTENANCE KIT, 8610B 110V	$395.00	
8670-9004	GC MAINTENANCE KIT, 8610B 220V	$395.00	
8670-9093	0.53mm CAPILLARY COLUMN ADAPTER	$20.00	
8670-9305	HEATED TRANSFER LINE, CAPILLARY TUBING	$50.00	
8670-9555	TUBING COPPER 1/8" PER FT.	$1.00	
8690-0072	VACUUM PUMP INTERFACE, DATA SYSTEM CONTROLLED (NO PUMP)	$495.00	
8690-0081	METHANIZER ACCESSORY	$995.00	
8690-0095	REUSEABLE SHIPPING CONTAINER	$200.00	
8690-0151	NAFEON MEMBRANE REPLACEMENT FOR 50ML HYDROGEN GEN.	$100.00	
8690-0152	NAFEON MEMBRANE REPLACEMENT FOR 25ML HYDROGEN GEN.	$100.00	
8690-1070	REPLACEMENT AIR FILTER	$100.00	
8690-7000	OP-AMP CHIP	$10.00	
8690-7100	SCR - TRIAC CIRCUIT BOARD	$250.00	
TRAINING			
8660-2000	TRAINING, DAY RATE IN-HOUSE	$800.00	

Chromatographic Fittings

Parker CPI fittings are rapidly becoming the standard in the chromatographic industry. A unique one piece ferrule does away with the two piece design of other manufacturers. This ends assembly confusion and insures better sealing during make-up. Parker CPI components are interchangeable with all Swagelok® components used in chromatography.

Description	Size	Parker No.	Cat. No.	Price	Cat No.	Price
FITTINGS			**BRASS**		**STAINLESS**	
 NUTS	1/16"	1-BZ	14057	$13.00/10	141575	$25.00/5
	1/8" (10/pkg)	2-BZ	14058	7.50	14158	30.00
	3/16" (10/pkg)	3-BZ	60000	7.00	61000	28.00
	1/4" (10/pkg)	4-BZ	14059	5.50	14159	28.00
	3/8"	6-BZ	60002	9.00/10	610025	23.00/5
	1/2" (5/pkg)	8-BZ	600045	10.00	610045	34.00
 FERRULES Only One Required	1/16"	1-TZ	14060	16.00/10	141605	30.00/5
	1/8" (10/pkg)	2-TZ	14061	10.50	14161	32.00
	3/16" (10/pkg)	3-TZ	60006	10.00	61006	29.00
	1/4" (10/pkg)	4-TZ	14062	10.00	14162	28.00
	3/8"	6-TZ	60008	11.00/10	610085	20.00/5
	1/2" (5/pkg)	8-TZ	600105	12.00	610105	25.00
 TEES	1/16" x 1/16" x 1/16"	1-1-1-JBZ	14075	16.00	14175	61.00
	1/8" x 1/8" x 1/8"	2-2-2-JBZ	14053	11.00	14176	30.00
	3/16" x 3/16" x 3/16"	3-3-3-JBZ	60012	13.00	61012	41.00
	1/4" x 1/4" x 1/4"	4-4-4-JBZ	14077	11.00	14177	32.00
	3/8" x 3/8" x 3/8"	6-6-6-JBZ	60014	15.00	61014	48.00
	1/2" x 1/2" x 1/2"	8-8-8-JBZ	60016	22.00	61016	74.00
 UNIONS	1/16" x 1/16"	1-1-HBZ	14063	7.00	14163	23.00
	1/8" x 1/8"	2-2-HBZ	14065	5.00	14165	15.00
	3/16" x 3/16"	3-3-HBZ	60018	5.50	61018	17.00
	1/4" x 1/4"	4-4-HBZ	14068	4.00	14168	14.00
	3/8" x 3/8"	6-6-HBZ	60020	6.50	61020	25.00
	1/2" x 1/2"	8-8-HBZ	60022	10.50	61022	38.00
 REDUCING UNION	1/8" to 1/16"	2-1-HBZ	14064	5.50	14164	21.00
	3/16" to 1/8"	3-2-HBZ	60024	6.00	61024	17.00
	1/4" to 1/16"	4-1-HBZ	60026	5.50	14166	18.00
	1/4" to 1/8"	4-2-HBZ	60028	4.50	61028	16.00
	1/4" to 3/16"	4-3-HBZ	14067	5.00	14167	17.00
	3/8" to 1/16"	6-1-HBZ	—	—	14174	31.00
	3/8" to 1/4"	6-4-HBZ	60030	6.50	61030	26.00
 CAPILLARY UNION	1/16" x 1/16"	1-1-Z7HBZ7	—	—	28812	41.00
 MALE CONNECTORS	1/16" to 1/16" MPT	1-1-FBZ	60034	5.50	61034	19.00
	1/16" to 1/8" MPT	1-2-FBZ	60036	5.00	61036	20.00
	1/8" to 1/8" MPT	2-2-FBZ	60038	3.00	61038	11.00
	1/8" to 1/4" MPT	2-4-FBZ	60039	4.00	61039	11.00
	3/16" to 1/8" MPT	3-2-FBZ	60040	3.75	61040	12.00
	1/4" to 1/8" MPT	4-2-FBZ	60042	3.50	61042	9.00
	3/8" to 1/8" MPT	6-2-FBZ	60044	4.75	61044	14.00
	1/4" to 1/4" MPT	4-4-FBZ	14069	3.50	61082	10.00
	3/8" to 1/4" MPT	6-4-FBZ	60046	4.75	61046	16.00
 FEMALE CONNECTORS	1/8" to 1/8" FPT	2-2-GBZ	60048	4.00	61048	13.00
	1/8" to 1/4" FPT	2-4-GBZ	14071	5.50	61084	18.00
	1/4" to 1/8" FPT	4-2-GBZ	60050	5.50	61050	12.00
	1/4" to 1/4" FPT	4-4-GBZ	14072	5.25	61086	15.00
	3/16" to 1/8" FPT	3-2-GBZ	60052	5.00	61052	15.00
	3/8" to 1/8" FPT	6-2-GBZ	60054	6.00	61054	19.00
	3/8" to 1/4" FPT	6-4-GBZ	60056	6.25	61056	20.00
 TUBE END CONNECTOR	1/16" to 1/8" Tube	2-1-TRBZ	60058	5.00	61058	19.00
	1/16" to 1/4" Tube	4-1-TRBZ	—	—	61059	24.00
	1/8" to 1/4" Tube	4-2-TRBZ	60060	4.00	61060	13.00
	1/8" to 3/16" Tube	3-2-TRBZ	60062	4.50	61062	15.00
	3/16" to 1/4" Tube	4-3-TRBZ	60064	4.50	61064	16.00
	1/4" to 1/8" Tube	2-4-TRBZ	14073	5.50	14169	16.00
	1/4" to 3/8" Tube	6-4-TRBZ	60066	5.25	61066	15.00
	3/8" to 1/4" Tube	4-6-TRBZ	60068	6.50	61068	20.00
 CAPS	1/16"	1-PNBZ	14047	4.00	14151	14.00
	1/8"	2-PNBZ	14051	2.50	14152	9.00
	3/16"	3-PNBZ	60070	2.50	61070	10.50
	1/4"	4-PNBZ	14052	2.50	14153	7.50
	3/8"	6-PNBZ	60072	5.50	61072	11.00
	1/2"	8-PNBZ	60074	5.00	61074	18.00
 PLUGS	1/16"	1-FNZ	14054	4.25	14154	17.00
	1/8"	2-FNZ	14055	3.00	14155	10.00
	3/16"	3-FNZ	60076	2.50	61076	11.50
	1/4"	4-FNZ	14066	2.25	14156	6.50
	3/8"	6-FNZ	60078	3.00	61078	10.00
	1/2"	8-FNZ	60080	4.75	61080	15.00

FMT=Female Pipe Thread

MPT=Male Pipe Thread

Ferrules

The ferrules listed here are made from synthetic materials to be used primarily for making glass-to-metal and glass-to-glass connections. These ferrules can also be used conveniently for metal columns. They do not lock into place and so can be removed or moved to a different position on the column for use with different instruments. A wide variety of materials and sizes are available. A summary table of the properties of each type of ferrule appears below.

Teflon® Ferrules

Teflon ferrules were the first improvement over O-rings for connecting glass columns to instruments. Being soft, they form seals even with finger tightening. They will conform to the shape of the column and fitting upon compression. Their upper temperature limit of 250°C and their cold-flow properties make them unsuitable for high temperatures and for temperature programming.

Graphite Ferrules

Alltech's graphite ferrules are made from 99.95% pure graphite. This means no bleed or decomposition products at high temperatures. They are available as either the one-piece design or as the front ferrules which must be used with a metal-back ferrule. Like Teflon, the one-piece graphite is soft and will conform to unusual shapes when compressed. With care, they are reusable but not for as many times as the Vespel ferrules. Their upper temperature limit is 450°C.

Vespel® Ferrules

Vespel was developed for commercial use in 1962. In 1973 the advantage of Vespel ferrules for chromatography was realized. In that same year, Alltech was the first to introduce a full line of Vespel ferrules for GC columns. These ferrules do not cold flow, are completely reusable and can be used at temperatures up to 350°C+. They are suitable for metal, Teflon and glass columns. At high temperatures they have a tendency to seize on the glass and metal surfaces. This can be prevented by applying a small amount of Never-Seez® to the back of the ferrules or by using the new Vespel/graphite ferrules.

Vespel/Graphite Ferrules

The recent development of Vespel/graphite composites giv better results than either Vespel or graphite alone. They do not stick to glass or metal, are completely reusable, and are less brittle than Vespel. The composite is usable at temperatures up to 400°C.

Two types of composites are available. The VG1 composite is 85% Vespel/15% graphite while the VG2 type is 60% Vespel/ 40% graphite. Alltech recommends the VG1 as the best all-purpose ferrule, while many of our customers prefer the added lubricity of the VG2 ferrule.

Straight Ferrules

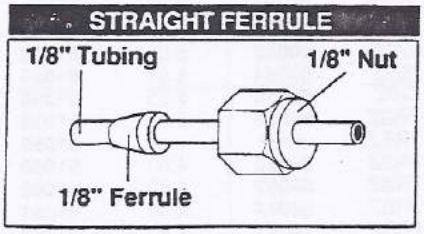
Straight ferrules are used on glass, metal and Teflon columns where the tubing size and fitting size are the same (eg., 1/8" to 1/8" fitting). They are available in all materials in a variety of sizes.

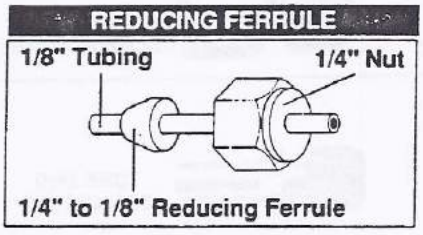
Reducing Ferrules

Reducing ferrules are used when you need to connect tubing of one size to a larger fitting. Frequently, glass columns, especially those of 4mm ID, are 6mm OD and so require 1/4" to 6mm reducing ferrules. A 1/8" column can be adapted to 1/4" fittings or injection ports with a 1/4" to 1/8" reducing ferrule. Most capillary columns connect to 1/16" fittings, but the OD of the capillaries vary from about 0.32mm to 1.6mm. For this reason, a wide variety of 1/16" ferrules with holes from 0.4mm to 1/16" are offered.

Zero-Series No-Hole Ferrules

Alltech pioneered the use of the "Zero-Series Ferrules." These are available in a variety of sizes and construction materials. They can be used as is to seal off a fitting, or you can custom drill them to suit your needs. For capillary columns of unusual sizes, we offer the Alltech Ferrule Drilling Rig.

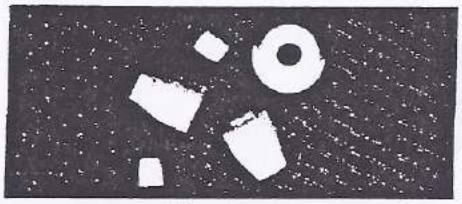




Material	Temp Limit	Reusability	Resealing Properties	Suitability for Glass	Temp Prog
FERRULE PROPERTIES					
Teflon	250°C	Good	Excellent	Excellent	No
Graphite	450°C	Good	Excellent	Excellent	Yes
Vespel	350°C+	Excellent	Good	Good	Yes
Vespel/Graphite VG1	400°C	Excellent	Good	Excellent	Yes
Vespel/Graphite VG2	400°C	Excellent	Good	Excellent	Yes
O-Rings	200°C	Poor	Poor	Poor	Fair

Teflon® Ferrules

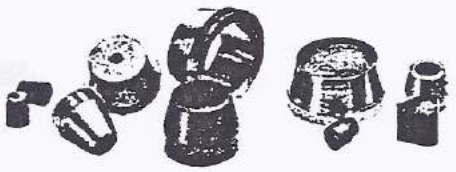
- 100% Pure Virgin Teflon
- No Fillers
- Forms Seals with Finger Tightening
- Reusable
- Use up to 250°C



Cat. No.	Size	Qty	Price
TEFLON STRAIGHT FERRULES			
SF-600-T	3/8" Straight Ferrules	10	$10.50
SF-400-T	1/4" Straight Ferrules	10	6.50
SF-300-T	3/16" Straght Ferrules	10	6.50
SF-200-T	1/8" Straight Ferrules	10	6.50
SF-100-T	1/16" Straight Ferrules	10	6.50
TEFLON REDUCING FERRULES			
RF-400/6MM-T	1/4" to 6mm Ferrules	10	$8.50
RF-400/300-T	1/4" to 3/16" Ferrules	10	7.50
RF-400/200-T	1/4" to 1/8" Ferrules	10	7.50
RF-400/100-T	1/4" to 1/16" Ferrules	10	7.50
RF-200/100-T	1/8" to 1/16" Ferrules	10	7.50
TEFLON NO-HOLE FERRULES			
RF-400/0-T	1/4" No-Hole Ferrules	10	$8.50
RF-200/0-T	1/8" No-Hole Ferrules	10	8.50
RF-100/0-T	1/16" No-Hole Ferrules	10	8.50

Graphite Ferrules

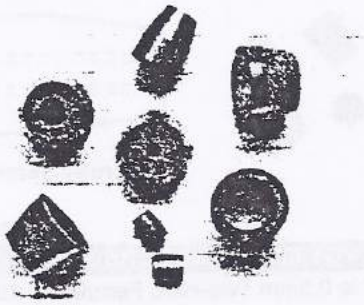
- 99.95% Pure Graphite
- No Fillers
- Forms Seals with Finger Tightening
- Reusable, with Care
- Use up to 450°C



Cat. No.	Size	Qty	Price
GRAPHITE STRAIGHT FERRULES			
SF-800-G	1/2" Straight Ferrules	10	$24.00
SF-600-G	3/8" Straight Ferrules	10	21.00
SF-400-G	1/4" Straight Ferrules	10	21.00
SF-200-G	1/8" Straight Ferrules	10	21.00
SF-100-G	1/16" Straight Ferrules	10	21.00
GRAPHITE REDUCING FERRULES			
RF-400/6MM-G	1/4" to 6mm Ferrules	10	$21.00
RF-400/200-G	1/4" to 1/8" Ferrules	10	21.00
RF-400/100-G	1/4" to 1/16" Ferrules	10	21.00
RF-200/100-G	1/8" to 1/16" Ferrules	10	21.00
RF-200/0.8-G	1/8" to 0.8mm Ferrules	10	21.00
RF-200/0.5-G	1/8" to 0.5mm Ferrules	10	21.00
RF-200/0.4-G	1/8" to 0.4mm Ferrules	10	21.00
RF-100/1.0-G	1/16" to 1.0mm Ferrules	10	21.00
RF-100/0.8-G	1/16" to 0.8mm Ferrules	10	21.00
RF-100/0.5-G	1/16" to 0.5mm Ferrules	10	21.00
RF-100/0.4-G	1/16" to 0.4mm Ferrules	10	21.00

Vespel® Ferrules

- High-Temperature Polyimide
- No Fillers
- Forms Seals with Minimal Tightening
- Completely Reusable
- Use up to 350°C+



Cat. No.	Size	Qty	Price
VESPEL STRAIGHT FERRULES			
SF-400-V	1/4" Straight Ferrules	10	$26.00
15459	1/4" "Shorty" Ferrules*	10	26.00
SF-200-V	1/8" Straight Ferrules	10	26.00
15458	1/8" "Shorty" Ferrules*	10	26.00
SF-100-V	1/16" Straight Ferrules	10	26.00
VESPEL REDUCING FERRULES			
RF-400/6MM-V	1/4" to 6mm Ferrules	10	$26.00
RF-400/300-V	1/4" to 3/16" Ferrules	10	26.00
RF-400/200-V	1/4" to 1/8" Ferrules	10	26.00
RF-400/100-V	1/4" to 1/16" Ferrules	10	26.00
RF-200/100-V	1/8" to 1/16" Ferrules	10	26.00
RF-100/1.0-V	1/16" to 1.0mm Ferrules	10	26.00
RF-100/0.9-V	1/16" to 0.9mm Ferrules	10	26.00
RF-100/0.8-V	1/16" to 0.8mm Ferrules	10	26.00
RF-100/0.5-V	1/16" to 0.5mm Ferrules	10	26.00
RF-100/0.4-V	1/16" to 0.4mm Ferrules	10	26.00
VESPEL NO-HOLE FERRULES			
RF-400/0-V	1/4" No-Hole Ferrules	10	$26.00
RF-200/0-V	1/8" No-Hole Ferrules	10	26.00
RF-100/0-V	1/16" No-Hole Ferrules	10	26.00

* "Shorty" ferrules are the Applied Science type of the same size as the Parker one-piece metal ferrule.

VG1 - Vespel®/Graphite Ferrules

- High-Temperature Composite
- 85% Vespel + 15% Graphite
- Forms Seals with Minimal Tightening
- Completely Reusable
- Use up To 400°C

VG2 - Vespel/Graphite Ferrules

- High-Temperature Composite
- 60% Vespel + 40% Graphite
- Forms Seals with Minimal Tightening
- Completely Reusable
- Use up to 400°C

Cat. No.	Size	Qty	Price
VG1 STRAIGHT FERRULES			
SF-400-VG1	1/4" Straight Ferrules	10	$29.00
15449	1/4" "Shorty" Ferrules*	10	29.00
SF-200-VG1	1/8" Straight Ferrules	10	29.00
15450	1/8" "Shorty" Ferrules*	10	29.00
SF-100-VG1	1/16" Straight Ferrules	10	29.00
VG1 REDUCING FERRULES			
400/6MM-VG1	1/4" to 6mm Ferrules	10	$29.00
400/300-VG1	1/4" to 3/16" Ferrules	10	29.00
400/200-VG1	1/4" to 1/8" Ferrules	10	29.00
400/100-VG1	1/4" to 1/16" Ferrules	10	29.00
200/100-VG1	1/8" to 1/16" Ferrules	10	29.00
200/0.8-VG1	1/8" to 0.8mm Ferrules	10	29.00
200/0.5-VG1	1/8" to 0.5mm Ferrules	10	29.00
200/0.4-VG1	1/8" to 0.4mm Ferrules	10	29.00
100/1.0-VG1	1/16" to 1.0mm Ferrules	10	29.00
100/0.9-VG1	1/16" to 0.9mm Ferrules	10	29.00
100/0.8-VG1	1/16" to 0.8mm Ferrules	10	29.00
100/0.5-VG1	1/16" to 0.5mm Ferrules	10	29.00
100/0.4-VG1	1/16" to 0.4mm Ferrules	10	29.00
VG1 NO-HOLE FERRULES			
400/0-VG1	1/4" No-Hole Ferrules	10	$29.00
200/0-VG1	1/8" No-Hole Ferrules	10	29.00
100/0-VG1	1/16" No-Hole Ferrules	10	29.00

Cat. No.	Size	Qty	Price
VG2 STRAIGHT FERRULES			
SF-400-VG2	1/4" Straight Ferrules	10	$29.00
15451	1/4" "Shorty" Ferrules*	10	29.00
SF-200-VG2	1/8" Straight Ferrules	10	29.00
15452	1/8" "Shorty" Ferrules*	10	29.00
SF-100-VG2	1/16" Straight Ferrules	10	29.00
VG2 REDUCING FERRULES			
400/6MM-VG2	1/4" to 6mm Ferrules	10	$29.00
400/300-VG2	1/4" to 3/16" Ferrules	10	29.00
400/200-VG2	1/4" to 1/8" Ferrules	10	29.00
400/100-VG2	1/4" to 1/16" Ferrules	10	29.00
200/100-VG2	1/8" to 1/16" Ferrules	10	29.00
200/0.8-VG2	1/8" to 0.8mm Ferrules	10	29.0
200/0.5-VG2	1/8" to 0.5mm Ferrules	10	29.00
200/0.4-VG2	1/8" to 0.4mm Ferrules	10	29.00
100/1.0-VG2	1/16" to 1.0mm Ferrules	10	29.00
100/0.9-VG2	1/16" to 0.9mm Ferrules	10	29.00
100/0.8-VG2	1/16" to 0.8mm Ferrules	10	29.00
100/0.5-VG2	1/16" to 0.5mm Ferrules	10	29.00
100/0.4-VG2	1/16" to 0.4mm Ferrules	10	29.00
VG2 NO-HOLE FERRULES			
400/0-VG2	1/4" No-Hole Ferrules	10	$29.00
200/0-VG2	1/8" No-Hole Ferrules	10	29.00
100/0-VG2	1/16" No-Hole Ferrules	10	29.00

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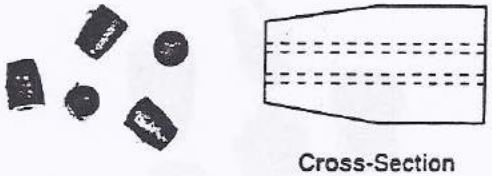
A variety of Two-Hole ferrules are available which allow the user to connect two capillaries to the same end of a compression fitting. This arrangement can be used for splitting the effluent of a single capillary or packed column in order to use two different detectors, for sample recovery, or even for splitting the injected sample to two different capillary or packed columns.

Use the 0.4mm Two-Hole ferrules for connecting 0.25mm ID fused silica tubing and the 0.5mm Two-Hole ferrules for connecting 0.32mm ID fused silica tubing. Both VG1 (85% Vespel + 15% graphite) and VG2 (60% Vespel + 40% graphite) are available.



Cross-Section

Cat. No.	Size	Qty	Price
VG1 TWO-HOLE FERRULES			
15486	1/16" to 0.5mm Two-Hole Ferrules	10	$35.00
15481	1/16" to 0.4mm Two-Hole Ferrules	10	35.00
VG2 TWO-HOLE FERRULES			
15488	1/16" to 0.5mm Two-Hole Ferrules	10	$35.00

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- SRI Instruments, Inc.

The Impact of Calibration on Data Quality

Re-evaluating the calibration process to meet more restrictive requirements for litigation quality data.

By Richard G. Mealy and Kim D. Johnson

The calibration process represents the initial controlling mechanism for the generation of quality data, yet there is a general lack of guidance regarding specific evaluation techniques for this process. One of the drawbacks of providing such little guidance is the potential loss of data comparability, one of the chief data quality objectives identified by the EPA. This article examines critical aspects of the calibration process, and identifies those features that, if overlooked, can significantly impact the quality of the data generated. Initially, a comparison of calibration processes, as outlined in the various regulatory programs, is presented. To provide a more focused scope, discussion is limited to the impact on methods for the analysis of volatile organics, pesticide/PCBs and semivolatile organics. The concepts can be extended to other analytical methods.

It is important to note that some of the issues raised here have been addressed in regulatory programs that were not evaluated specifically for this article. The USATHAMA program in particular has incorporated a requirement that calibration data be subject to statistical tests for both Zero Intercept and Lack of Fit, which serve to resolve some of the problems associated with nonlinear data and calibration intercepts.

COMPARISON OF REGULATORY APPROACHES TO CALIBRATION

There exists a great deal of difference in the calibration protocols and requirements of the key regulatory programs, including the 500[1] and 600[2] series of EPA methods, those published in SW-846,[3] and the Contract Laboratory Program.[4] See Table 1 for a summary of calibration requirements of the various regulatory methodologies.

In general, the 600 series of methods offers the least amount of guidance, and thus is the most open to individual interpretation. More recent revisions to the 500 series of methods for analyses conducted under the Safe Drinking Water Act (SDWA) program introduce several new requirements that provide greater control over the accuracy of the resultant calibration. As Table 1 indicates, wide variation exists in the number of calibration standards required both within and across the series of regulatory protocols. One particularly important assumption that the 500, 600 and 8000[5] series all share relates to curve linearity. In each of these methods, if the percent relative standard deviation (%RSD) of response factors associated with calibration standards is within certain criteria (10 to 35 percent), "then linearity through the origin can be assumed." Clearly, there are widely ranging views regarding when the intercept of a calibration curve deviates significantly from the origin. In keeping with the goal to establish data comparability, there is a need to consider the incorporation of a statistical technique to provide an objective means of determining whether a particular set of data essentially has a zero intercept.

In the event that %RSD criteria cannot be achieved, three of the four programs allow the user to simply prepare a calibration "curve" from concentration vs. instrument response. Unfortunately, there are no requirements for the type of curve algorithm (linear regression, polynomial fit, etc.) allowed.

As cleanup criteria continue to evolve, this variability between the different regulator protocols can have significant, adverse impact on the comparability of data generated by laboratories. Due to either regional or site-specific preferences, analytical programs can be based on methodologies from any of these programs. While each of the programs is considered to be designed to produce quality analytical data, the differences between the cali-

bration protocols will result in significantly different data quality.

In order to provide more control over the calibration process, each element of the process must be considered so that the most appropriate combination of elements is employed. The basic "parts" of the calibration are shown below:

- number of calibration levels
- calibration algorithm
- calibration levels
- calibration acceptance criteria
- effect of "curve-smoothing" routines

The remainder of this article focuses on detailed analysis of each of these sections. In particular, those aspects that potentially lead to inaccurate or biased data are discussed. In addition, we identify areas of the methods that are open to interpretation or require further guidance.

NUMBER OF CALIBRATION LEVELS

Essentially, as the number of calibration levels increases, the relative risk is reduced, as a better picture of the analyte's performance is obtained. The analytical run-time is also an important consideration in determining the number of levels to employ. For analyses with a relatively short analysis time, such as the majority of inorganic parameters, additional calibration levels do not represent a burden to production. This is not the case, however, for most organic analyses, with routine run times of 40 to 60 minutes. Laboratories are engaged in a constant struggle between quality and production. While an increased number of calibration levels would improve the quality of the data, this is not always possible. The implications of establishing calibration "curves" with a minimum of data points are brought to light in the next few sections.

CALIBRATION ALGORITHM

While most laboratories default to the standard (least squares) method of linear regression analysis to develop a calibration algorithm, a wide array of nonlinear calibration technique options are available. These options, including polynomial fits, exponential and power curves, segmented fits and even specific manufacturer options, are routinely provided as part of the software bundled with instrument data stations.

The most common approaches to quantitation use an average response factor (e.g., in GC/MS), single point quantitation (multicomponent analytes such as PCBs), and multiple point calibration "curves." Of these approaches, single point quantitation has the greatest potential for inaccuracy because the response from the single standard analyzed is deemed to be representative of the linearity of the analyte in question. There are two sources of error in single-point quantitation. First, any error in the preparation or concentration of the standard will directly affect quantitation. In addition, if the level chosen actually represents a significantly nonlinear portion of the relationship between response and concentration, substantial bias will be introduced.

The use of an average response factor is designed to normalize differences in response factors over the calibration range. The drawback to this approach is if only a single response factor deviates significantly from the others, the bias is normalized by distributing an equivalent degree of bias in the opposite direction over the other standards.

Nonlinear data require more advanced statistical treatment. Typically, regressions of a higher order, quadratic equations or polynomial fits of the data are employed. The main precaution associated with these techniques is the minimum number of data points required. As the minimum number of points required to form a line is two, then a linear regression (1st order polynomial fit) actually requires a minimum of three data points to be significant. Similarly, with each higher order equation, one more data point is required. As with a simple linear regression, the correlation coefficient must not be used as a measure of linearity. The correlation coefficient only provides a measure of how well the data points fit the equation generated. Finally, as the degree of nonlinearity increases, the curve of a 2nd or 3rd order polynomial becomes parabolic (Figures 1, 2). This results, at the upper end of the curve, in two solutions for a given data point. Unless the actual curve is carefully evaluated, the analyst may not even be aware that multiple solutions are possible for a given response. The consequence associated with this type of situation is that significantly inaccurate data could be reported.

Essentially, a linear regression results in the equation for a straight line, whereas polynomial fits above the 1st order will result in the equation for a curve. The most recent versions of 524.1, 524.2 and 525, GC/MS methods for the analysis of volatile and semivolatile organics, specifically allow the use of 2nd or 3rd order

Table 1: Comparison of regulatory method requirements for various aspects of the calibration process.

	500	600	8000	CLP
# Standards	• 3 to 5 • 5 recommended • 1 point allowable with criteria • 6 pre-set: 525	3 minimum	5 minimum	5: general GC/MS 4: 8 B/N/A 3: Pesticides 1: Multicomponents
Low standard	• Near, but above EDLs, to • 2-10x ML	Each analyte near, but above MDL.	Each analyte near, but above MDL.	Contractually set
Calibration Range	Range factor: 20: 3 minimum 50: 4 minimum 100: 5 minimum	• Expected range of samples • Detector range	• Expected range of samples • Detector range	Contractually set
Initial Calibration: Requirement to use mean RF	RSD: < 10% (502) < 20% (508,524) < 30% (525)	RSD: < 10% (601,602,608) < 35% (624,625)	RSD < 20%	• Generally, RSD: < 20.5% (GC/MS) < 10-15% (GC) • No RSD criteria for: - 20 B/N/A - 10 VOA
Initial Calibration: Alternative to RF	• Generate a plot of peak height or area response vs. concentration • No acceptance criteria	• Generate a plot of peak height or area response vs. concentration • No acceptance criteria	• Generate a plot of peak height or area response vs. concentration • No acceptance criteria	Use mean RRF
Continuing Calibration (CCV) Frequency	• Daily (502,508) • per 8 hours (524,525)	Once daily	• Once daily • More frequently for ECD methods (8080)	Every 12 hours
CCV Acceptance Criteria	% of initial standard response: ± 30%: 524,525 ± 20%: 502,508	• % of initial standard response: ± 15%: 608 ± 20%: 625 • Analyte specific QC check standard: 601,602,624	Standard response within ± 15% of initial response	Maximum %D = 25% for most

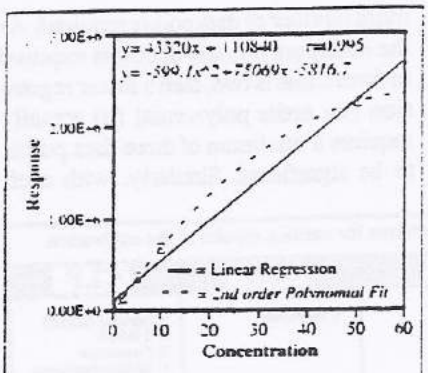

Figure 1: Sample Data Set 1. Comparison of Linear regression vs. 2nd order Polynomial Fit.

regression equations if the response factor criteria cannot be met. Figure 3 shows the curves that are associated with a linear fit as well as polynomial fits of orders 2 through 5 for Sample Data Set #1. Note, in particular, the significant differences in the curve fit to the data in the region between points D and E. If these higher level curves are used for the Sample Data Set, serious inaccuracies would result at the upper range of the curve—the recommended range for sample quantitation.

While, in specific cases, each of these statistical manipulations of calibration data can provide a "better fit" of the calibration equation to the data, they can also have significant impact on the quality of the data generated. Essentially, with the number of statistical programs readily available, an equation can be found that will provide a mathematical solution (i.e., "fit") to any set of data. Consequently, without a complete understanding of the actual effect on the raw data, none of these statistical techniques should be used in the generation of data for regulatory compliance.

CALIBRATION LEVELS

The specific levels that are selected for calibration can have a significant impact on the validity of the calibration equation. Calibration levels should be established based on consideration of: 1. the range of the levels, 2. the reportable detection limit and 3. the linear range of the analyte(s). The majority of the regulatory programs reviewed provide little guidance with respect to the range of calibration levels. A generic statement is provided indicating that the levels selected should be based on the expected range of sample results. In some cases, the "expected" sample concentrations exceed the working linear range of the detector. In the interest of obtaining accurate results, it is more important to define the linear range of the analyte and/or instrument, and dilute sample concentrations that exceed this range.

A wide calibration range, based on only a few calibration levels, will nearly always result in a correlation coefficient greater than 0.995, which is frequently used as the sole calibration evaluation criterion. In the example of Sample Data Set #2, the linear regression calculated from all five data points yields a correlation coefficient of 0.963. If only the first two and the uppermost data points are used (10, 20 and 200), however, the correlation coefficient is increased to 0.999. This is a consequence of the derivation of

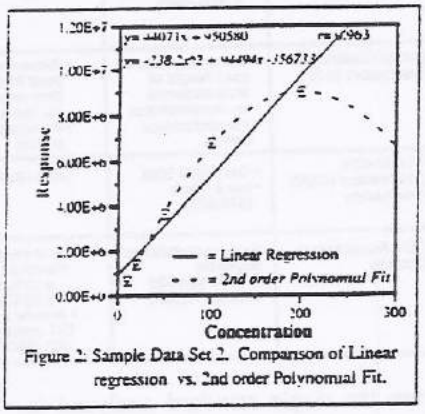

Figure 2: Sample Data Set 2. Comparison of Linear regression vs. 2nd order Polynomial Fit.

the correlation coefficient.

The relative difference between the concentration of the low-level standard and the reportable detection limit is critical to providing confidence in the accuracy of low-level measurements. Bias is more pronounced as the calibration curve approaches the detection limit for a particular analyte. Consequently, if the low-level standard is significantly greater than the detection limit, then accuracy in the proximity of the detection limit is compromised, because linearity of response has not been evaluated in this region. Ultimately, the detection limit itself may come into question. While the majority of the regulatory methods specify that the low-level standard must be prepared at a concentration "near, but above, the detection limit," methods 524.1 and 524.2 allow the low-level standard concentration to be as much as 10 times higher than the detection limit.[1]

Finally, analytes have detector-specific linear ranges. In order to accurately evaluate nonlinear regions of the curve, there must not be a significant difference between the uppermost standard (X) and the (X-1) concentration level. The consequence of not considering this in a calibration is that the user may fail to identify a parabolic curve. This is one of the consequences that can result from establishing calibration levels based solely on the expected concentration range of the samples.

Revisions to the 500 series of methods represent the first attempt (other than the CLP program, where calibration levels are contractually defined) to provide stronger guidance regarding the calibration range. Methods 524.1 and 524.2 require at least three calibration levels to encompass a factor of 20 calibration range (i.e., 1 to 20, 10 to 200). In addition, at least four standards are required to cover a range of a factor of 50, and at least five standards are required for a range factor of 100.

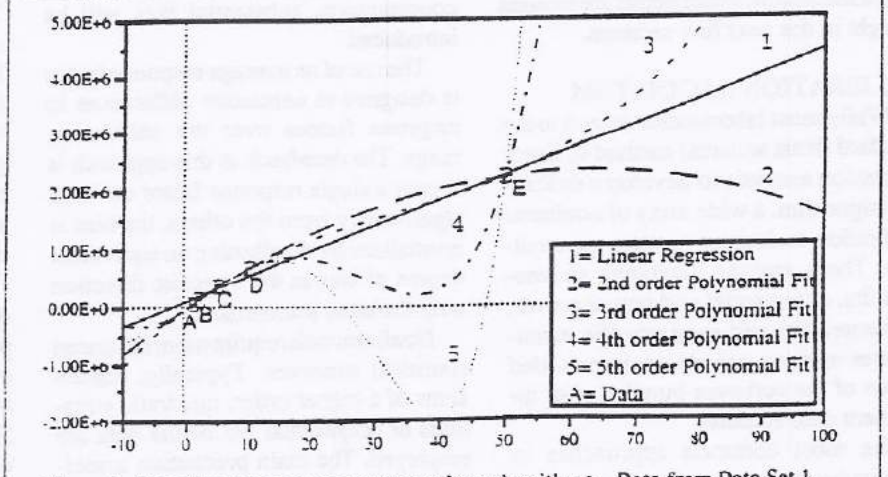

Figure 3: Plot of curves generated using various algorithms. Data from Data Set 1.

CALIBRATION ACCEPTANCE CRITERIA

Once a calibration has been performed, there must be a set of criteria to determine if the curve is acceptable for use in generating analytical results. This is one of the key weaknesses in the published regulatory methodology. With the exception of the CLP program, the referenced regulatory methods have only established acceptance criteria if the mean response factor is to be used for quantitation. The alternative, if %RSD criteria (relative standard deviation of response factors from the calibration curve) cannot be achieved, is to simply generate a plot of concentration vs. response or response factor. This allows the generation of data without control of data quality until the analysis of the first continuing calibration standard, where a limited measure of control is obtained. In addition to %RSD criteria, the CLP program has established minimum response factor criteria for most analytes. This requirement is associated with confidence in the ability to detect the analyte, however, rather than in quantitation of the analyte.

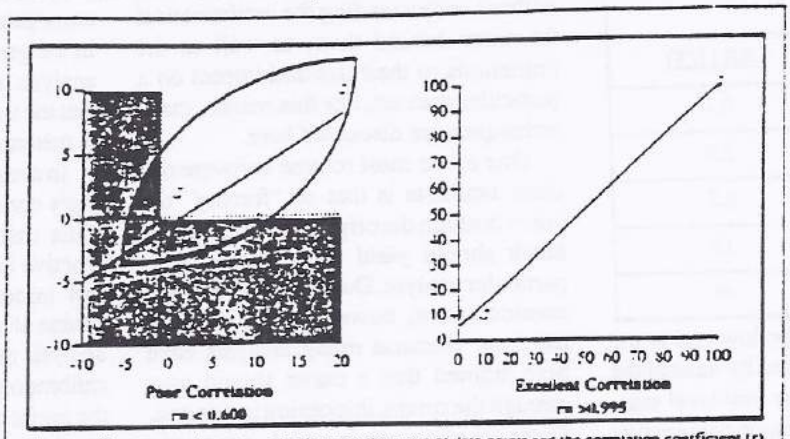

Figure 4: Illustration of the relationship between the range of data points and the correlation coefficient (r).

As indicated in Table 1, even the acceptance criteria associated with continuing calibration verification (CCV) offer little assurance of accurate quantitation. The most stringent CCV acceptance criteria are found in Method 502.2, which requires the analysis of a midpoint standard to yield a response within ±20 percent of that obtained for the same standard in the initial calibration. In addition, this method requires the analysis of a laboratory fortified blank (LFB) per batch of 20 or fewer samples, fortified at a concentration of 20 µg/L.

For a set of data that is essentially linear, the mathematical basis of a linear regression attempts to establish the midpoint of the curve as the point which deviates least from the linear equation. The extent of the deviation then increases at the extremes. The deviation is absolute rather than relative to concentration, which creates the greatest impact at the lower end of the curve. Due to the magnitude of response associated with the highest calibration level, the relative effect is minimal. In the case of strongly nonlinear data, such as that in Sample Data Set #2, the point at which the curve becomes nonlinear (in this case, the upper calibration level) is central in the minimization of deviation from the curve. This effect is evident in Table 4, which indicates that relatively minimal bias occurs in the upper calibration level, even considering such nonlinear data.

Table 2A: Sample Data Set 1

X	Y	Response Factor
1	65000	65000
2	140000	70000
5	365000	73000
10	680000	68000
50	2250000	45000
		RSD = 17.3%

The relationship between bias and concentration has its greatest impact on the continuing calibration verification (CCV) process. The concentration of the CCV is typically equal to the midpoint concentration of the initial multipoint calibration. With linear calibrations (typically the norm), the midpoint level is associated with the least degree of bias from the plot of the calibration equation. Consequently, if the overall accuracy of the analysis is less than 20 percent, there is a significant probability that the acceptance criteria for the CCV and the fortified laboratory blanks can be met.

The correlation coefficient ("r") is the most commonly used statistical measure of calibration acceptability. One long-standing misconception is that this parameter also provides a measure of linearity. The correlation coefficient is a measure of the "goodness of fit" of a series of data points. Basically, the correlation coefficient can be viewed as a mathematical process that determines the tightest ellipse that defines a set of data. The more the ellipse resembles a straight line, the higher the "r" value (to a maximum of 1.00). The more the data appear to be randomly distributed, or the ellipse appears more as a circle, the lower the "r" value (to a minimum of 0). This effect is illustrated in Figure 4. Consequently, even a particular random set of data can result in a high "r" value if the data range is such that the data can be described by a tight ellipse.

Table 2B: Sample Data Set 2

X	Y	Response Factor
10	650.000	65000
20	1,400.00	70000
50	3,650.00	73000
100	6,800.00	68000
200	9,000.00	45000
		RSD = 17.3%

Calibration acceptance criteria should be designed to evaluate the relationship between the intercept of the calibration equation and the reportable detection limit

(RDL). The data in Tables 2A and 2B, for Sample Data Sets #1 and #2 show signifi-

Table 3: Calculated X values for Sample Data Set 1 using both Linear Regression (LSR) and LSR weighted 1/X.

X	LSR	LSR (1/X)
1	-1.1	0.4
2	0.7	2.0
5	5.9	6.7
10	13	13
50	49	46

cant negative bias at the low end of the calibration. If, as required by most of the regulatory methods, the low-level standard is just slightly greater than the actual RDL, then the RDL would clearly not be valid for these calibration sets. One requirement that should be imposed on calibration data is that the x-intercept (expressed as concentration) should be no greater than 50 percent of the RDL. This will minimize the reporting of low-level false positive results.

One final consideration regarding the evaluation of calibration data is the bias at each calibration level that results from obtaining a concentration from the calibration evaluation using the actual raw calibration data. The software in use today provides graphic representations of the calibration data, but the plots are typically too small and the resolution too poor to be used to accurately evaluate point-specific bias. Each of the generally accepted calibration evaluation mechanisms should be considered no more than a single data assessment tool, rather than an absolute indicator of calibration acceptability. For example, the correlation coefficient, used frequently in the inorganic arena, can provide misleading information if there is a significant range between the uppermost and lower calibration levels.

EFFECT OF CURVE "SMOOTHING" ROUTINES

With the advent of powerful software routines and instrument data stations, the analyst is now provided with a series of tools that can be used to "smooth" the fit of any curve. While these techniques certainly are not an element of the calibration process, their use is rapidly becoming routine. High-powered calibration algorithms are most often used without understanding the mathematical functions behind them as well as the limitations to their use and impact on a particular data set. For this reason, these techniques are discussed here.

One of the most routine software options available is that of "forcing" the curve through the origin. Theoretically, a blank should yield no response for a particular analyte. Due to signal-to-noise considerations, however, this is rarely the case. Because many analysts have been trained that a curve should pass through the origin, this option is selected. There are two ways in which curves can be forced through the origin. The first is a simple mathematical formula designed to result in a slope and zero-intercept. The other option is a manual one, which is based on the repetitive inclusion of (0,0) data points until the curve is eventually forced through the origin.

Table 4: Summary of the bias observed in Sample Data Set 1 data using different quantitation techniques.

				Single Point Quantitation		
X	LSR	PF2	$\overline{RF}$	Low (1)	Mid(10)	High(50)
1	(206%)	6%	1%	0%	(4%)	44%
2	(66%)	(2%)	9%	8%	3%	56%
5	17%	(1%)	14%	12%	7%	62%
10	31%	0%	6%	5%	0%	51%
50	(1%)	0%	(30%)	(31%)	(34%)	0%

$\overline{RF}$ = Average Response Factor
LSR = Linear Regression (Least Squares)
PF2 = Polynomial Fit (2nd order)

Curve "weighting" techniques are often used to obtain a better fit of the data points at either extreme of the calibration range. Typically, the low end of the curve is susceptible to poor fit of the calibration equation. The most common weighting routine employed to improve the fit is a 1/X manipulation of the data. Basically, each data point is weighted by a factor of the inverse of the associated concentration. The result of this weighting, for the entire set of data, is a 91-point curve vs. the original five-point curve. The results of this weighting are summarized in Table 3. The table indicates that a significantly better fit is achieved at the low end of the curve while affecting the midpoint and upper range only minimally.

While each of these techniques results in a better fit of the data points to the calibration equation, they remain little more than data manipulation techniques. In the generation of environmental data, analysts must be trained to understand that the use of these techniques can result in misinterpretation of the data.

In a regulatory climate that is increasingly concerned with quality assurance, most data quality assessments remain reactive in that they rely on quality control information generated during the course of analysis, rather than prior to the analysis of environmental samples. The calibration process should be viewed as the initial opportunity to assess the quality of data to be generated. Consequently, there is a need for more structure and guidance in the evaluation process in order to provide analytical methods that ensure data comparability. ❑

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HayeSep® analytical polymers and packed columns are now available to chromatographers at a reasonable cost. Hayes Separations, Inc. takes pride in providing the necessary technical assistance to support our users. We guarantee that our polymers are better than any other on the market and we are continuing to develop and test new packings for specific separation problems.

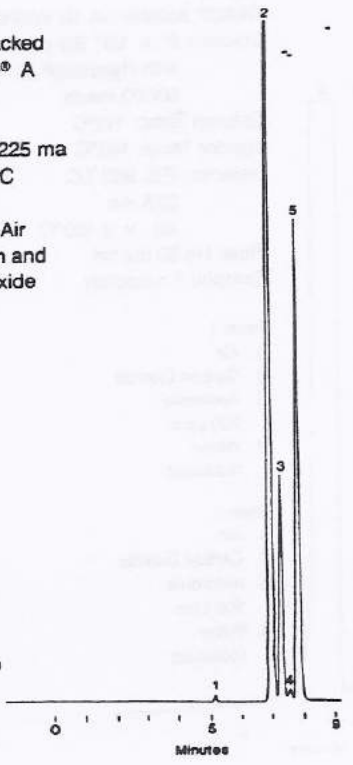
HayeSep® polymers are thoroughly cleaned and preconditioned for twelve hours under oxygen-free nitrogen before packaging. These handling techniques produce polymers which are consistently the same, with no shrinkage and minimum bleed. Columns packed with HayeSep® require minimum conditioning.

HayeSep® Polymer	Maximum Operating Temp.	Surface Area m^2/gram	Tapped Bulk Density gram/cc	Polymer Composition*	Polarity (1=lowest 9=highest)
A	165°C	526	0.356	DVB (high purity) EGDM (high purity)	7
B	190°C	608	0.330	DVB/PEI	8
C	250°C	442	0.322	DVB/ACN	6
D	290°C	795	0.3311	DVB (high purity)	1
N	165°C	405	0.355	DVB/EGDM	9
P	250°C	165	0.420	DVB/Styrene	3
Q	275°C	582	0.351	DVB	2
R	250°C	344	0.324	DVB/NV2P	5
S	250°C	583	0.334	DVB/4VP	4
T	165°C	250	0.381	EGDM	10

*DVB Divinylbenzene
EGDM Ethyleneglycoldimethacrylate
PEI Polyethyleneimine
ACN Acrylonitrile
NV2P N-vinyl-2-pyrollidinone
4VP 4-vinyl-pyridine

HayeSep® A This polymer separates permanent gases (hydrogen, nitrogen, oxygen, argon, carbon monoxide, and nitric oxide) at ambient temperatures. It also exhibits good separation characteristics for the C2's, hydrogen sulphide and water at higher temperatures.

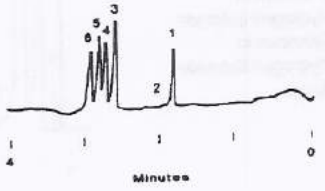
Figure 1
PERMANENT GASES
Column: 36′ × 1/8″ packed with HayeSep® A 80/100 mesh
Column Temp: 25°
Detector: P.E. 900 T.C. 225 ma Att. × 2 180°C
Flow: He 23 cc/min
Sample: 25 microliters Air plus Hydrogen and Carbon Monoxide



1. Hydrogen 5%
2. Nitrogen 48.5%
3. Oxygen 13%
4. Argon 0.5%
5. Carbon Monoxide 33%

Figure 2
PERMANENT GAS STANDARD 500 ppm
Column: 25′ × 1mm packed with HayeSep® A 170/200 mesh
Column Temp: 23°C
Flow: He 15 cc/min
Sample: 20 microliters

1. Neon
2. Hydrogen
3. Nitrogen
4. Oxygen
5. Argon
6. Carbon Monoxide



HayeSep® B Designed to separate the C1 and C2 amines as well as trace levels of ammonia and water, this polymer eliminates the need for caustic washing of material prior to packing.

Figure 3
AMINES #1
Column: 5′ x 1/8″ SS packed with HayeSep® B 80/100 mesh
Column Temp: 140° up to 190°C at 16°C/min
Injector Temp: 150°C
Detector: P.E. 900 T.C. 175 ma Att. x 8 180°C
Flow: He 30 cc/min
Sample: 0.2 microliters with on-column injection

1. Air
2. Water
3. Methylamine
4. Dimethylamine
5. Trimethylamine
6. Ethylene diamine

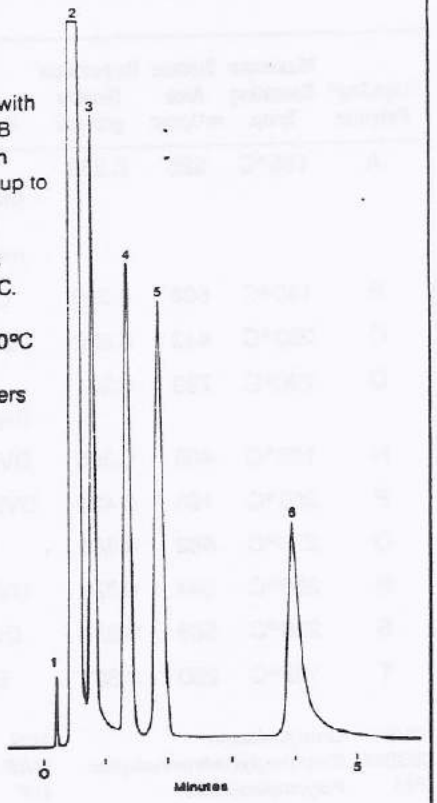
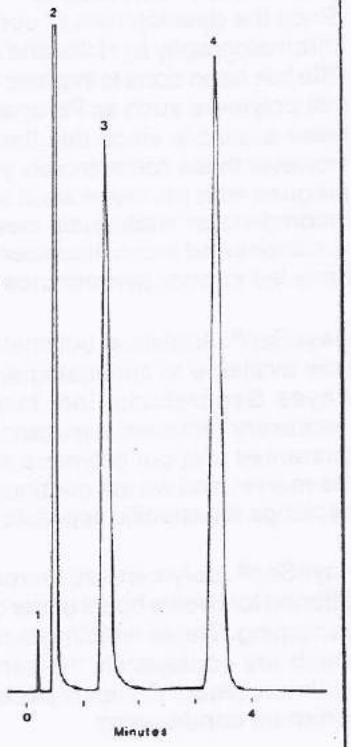


Figure 4
AMINES #2
Column: 5′ x 1/8″ packed with HayeSep® B 80/100 mesh
Column Temp: 140°C up to 190°C at 16°C/min
Injector Temp: 150°C
Detector: P.E. 900 T.C. 175 ma Att. x 8 180°C
Flow: He 30 cc/min
Sample: On-column injection

1. Air
2. Water
3. Ethylamine
4. Diethylamine



HayeSep® C This polymer is designed for polar hydrocarbons such as hydrogen cyanide, ammonia, hydrogen sulphide and water. HayeSep C® has similar separation characteristics to Chromosorb® 104.

Figure 5
AMMONIA IN HYDROGEN SULPHIDE
Column: 5′ x 1/8″ packed with HayeSep® C 80/100 mesh
Column Temp: 70°C
Injector Temp: 200°C
Detector: P.E. 900 T.C. 225 ma Att. x 2 180°C
Flow: He 30 cc/min
Sample: 100 microliters

1. Air
2. Carbon Dioxide
3. Ammonia
   Trace 1: approx 15%
   Trace 2: approx 1.5%
4. Hydrogen Sulphide
5. Unknown in Hydrogen Sulphide
6. Unknown in Hydrogen Sulphide
7. Water

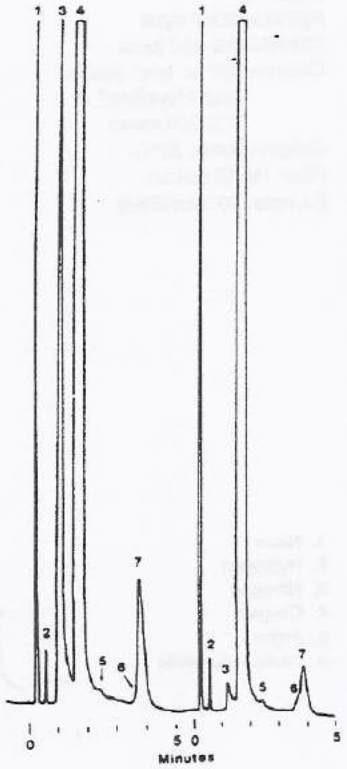
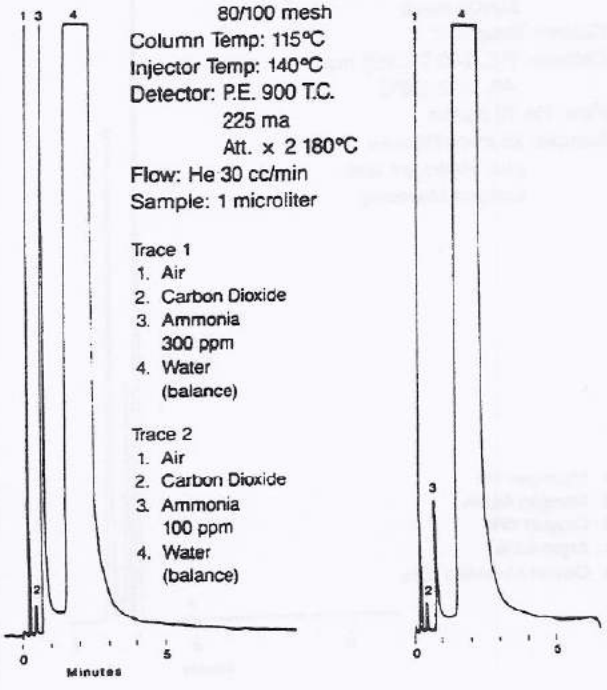


Figure 6
TRACE AMMONIA IN WATER
Column: 5′ x 1/8″ SS packed with HayeSep® C 80/100 mesh
Column Temp: 115°C
Injector Temp: 140°C
Detector: P.E. 900 T.C. 225 ma Att. x 2 180°C
Flow: He 30 cc/min
Sample: 1 microliter

Trace 1
1. Air
2. Carbon Dioxide
3. Ammonia 300 ppm
4. Water (balance)

Trace 2
1. Air
2. Carbon Dioxide
3. Ammonia 100 ppm
4. Water (balance)



HayeSep® N, P, Q, R, S, and T These polymers are interchangeable with the Porapak® series for separations of low molecular weight materials containing halogens, sulphurs, water, alcohols, glycols, free fatty acids, esters, ketones and aldehydes.

Figure 7
AMMONIA
Column: 8′ × 1/8″ SS packed with HayeSep® P 60/80 mesh
Column Temp: 80°C
Injector Temp: 150°C
Manifold Temp: 180°C
Detector: T.C. 175 ma 200°C
Flow: He 30 cc/min
Sample: 0.1 microliters of NH_4OH with on-column injection

1. Air
2. Ammonia 35%
3. Water 65%

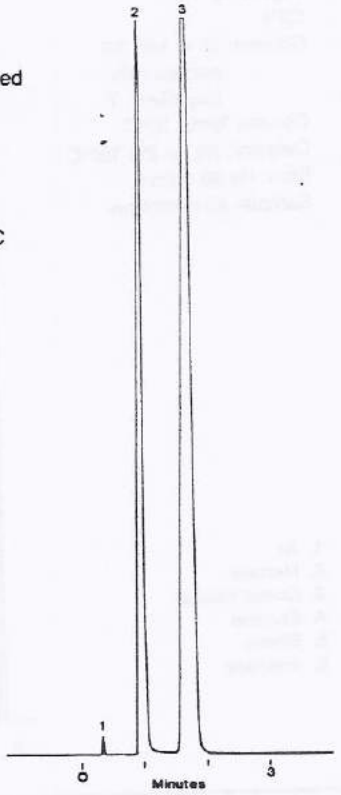


Figure 8
SOLVENTS
Column: 8′ × 1/8″ SS packed with HayeSep® P 60/80 mesh
Column Temp: 80°C up to 180°C at 16°C/min
Injector Temp: 150°
Manifold Temp: 180°C
Detector: 175 ma 200°C
Flow: He 30 cc/min
Sample: 0.2 microliters with on-column injection

1. Air
2. Water
3. Methanol
4. Ethanol
5. Acetone
6. Chloroform

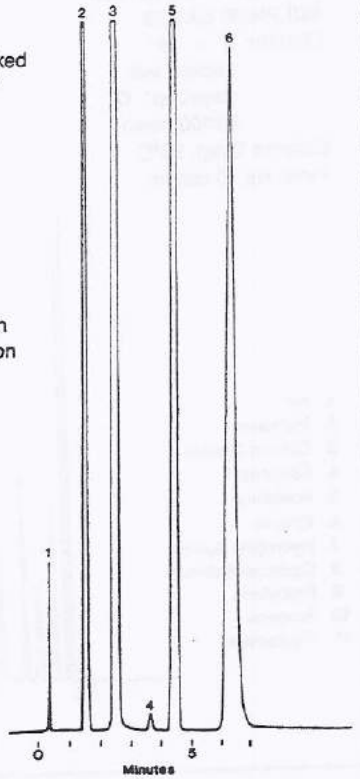


Figure 9
TRACE WATER ANALYSIS
Column: 9′ × 1/8″ Ni packed with HayeSep® R 80/100 mesh
Column Temp: 118°C
Flow: He 30 cc/min
Detector: Varian T.C. with Bendix On-Line Process Analyzer
Sample: 10 microliters Ethyl Chloride

1. Air
2. Water 12 ppm
3. Hydrogen Chloride
4. Ethyl Chloride

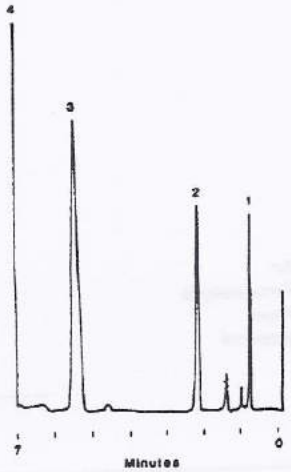


Figure 10
MAPP GAS
Column: 10′ × 1/8″ SS packed with HayeSep® R
Column Temp: 80°
Flow: He 30 cc/min
Sample: 15 microliters

1. Air
2. Methane
3. Carbon Dioxide
4. Ethane
5. Propylene
6. Propane
7. Propadiene
8. Methyl Acetylene

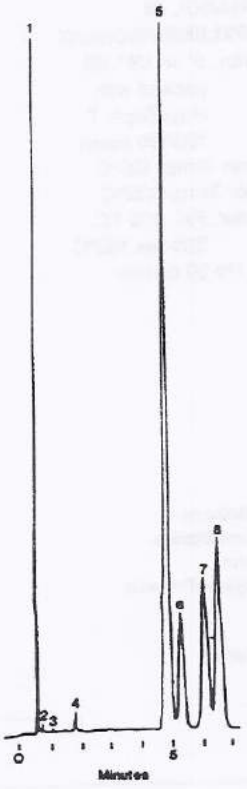
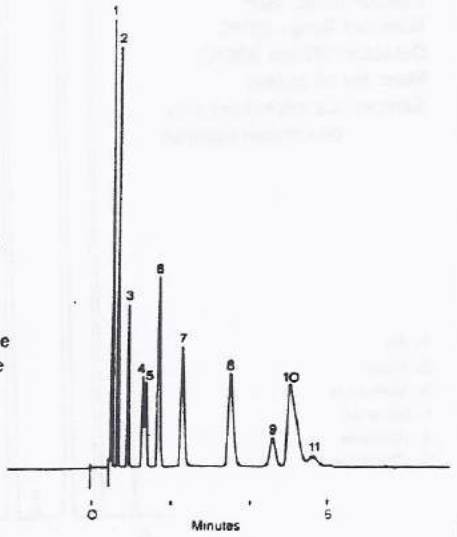
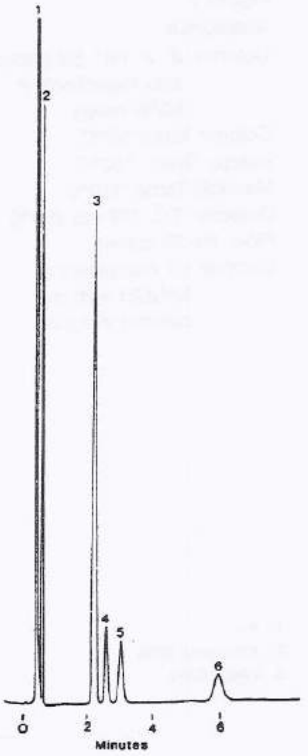


Figure 11
HYDROCARBONS AND SULPHUR GASES
Column: 8′ × 1/8″
packed with
HayeSep® Q
80/100 mesh
Column Temp: 90°C
Flow: He 30 cc/min



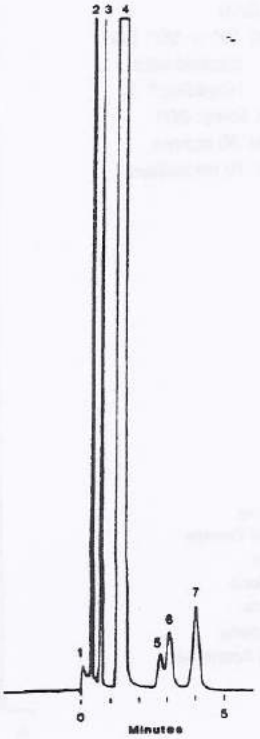
1. Air
2. Methane
3. Carbon Dioxide
4. Ethylene
5. Acetylene
6. Ethane
7. Hydrogen Sulfide
8. Carbonyl Sulfide
9. Propylene
10. Propane
11. Propadiene

Figure 12
C2's
Column: 5′ × 1/8″ SS
packed with
HayeSep® T
Column Temp: 32°C
Detector: Att. × 216 180°C
Flow: He 30 cc/min
Sample: 50 microliters



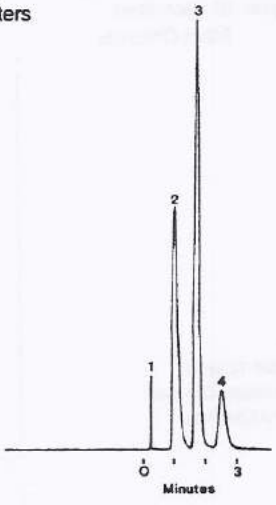
1. Air
2. Methane
3. Carbon Dioxide
4. Ethylene
5. Ethane
6. Acetylene

Figure 13
METHANOL IN PROPYLENE/PROPANE
Column: 5′ × 1/8″ SS
packed with
HayeSep® T
100/120 mesh
Column Temp: 120°C
Injector Temp: 132°C
Detector: P.E. 900 T.C.
225 ma 150°C
Flow: He 30 cc/min



1. Air/Methane
2. Carbon Dioxide
3. Ethane
4. Propylene/Propane
5. C4
6. C4
7. Methanol

Figure 14
FORMALDEHYDE
Column: 5′ × 1/8″ SS packed
with HayeSep® T
100/120 mesh
Column Temp: 132°C
Injector Temp: 165°
Detector: P.E. 900 T.C.
175 MA
Att. × 32 180°C
Flow: He 30 cc/min
Sample: 0.2 microliters



1. Air
2. Formaldehyde
3. Water
4. Methanol

INTRODUCING A UNIQUE NEW PRODUCT

HayeSep® D This new polymer made from high purity divinylbenzene is unavailable anywhere else. It has a high surface area and higher operating temperatures than competitive polymers. Available in four different porosities with surface areas from 790 to over 800 m^2/gram, this range allows flexibility, since in water/ethane separations porosity determines the order of elution.

These D formulations exhibit superior separation characteristics for light gases. Significant separation abilities include the separation of CO and CO_2 from room air at ambient temperatures and the separation of acetylene prior to other C2's. HayeSep® D is particularly useful in the separation and analysis of water and hydrogen sulphide.

Comparisons of D Formulations

	Average Diameter (microns)	Bulk Density gram/cc	Porosity %	Surface Area m^2/gram
Dip	.0317	.3283	69.1	774
D	.0308	.3311	70.35	803
D_B	.0332	.3334	64.2	781

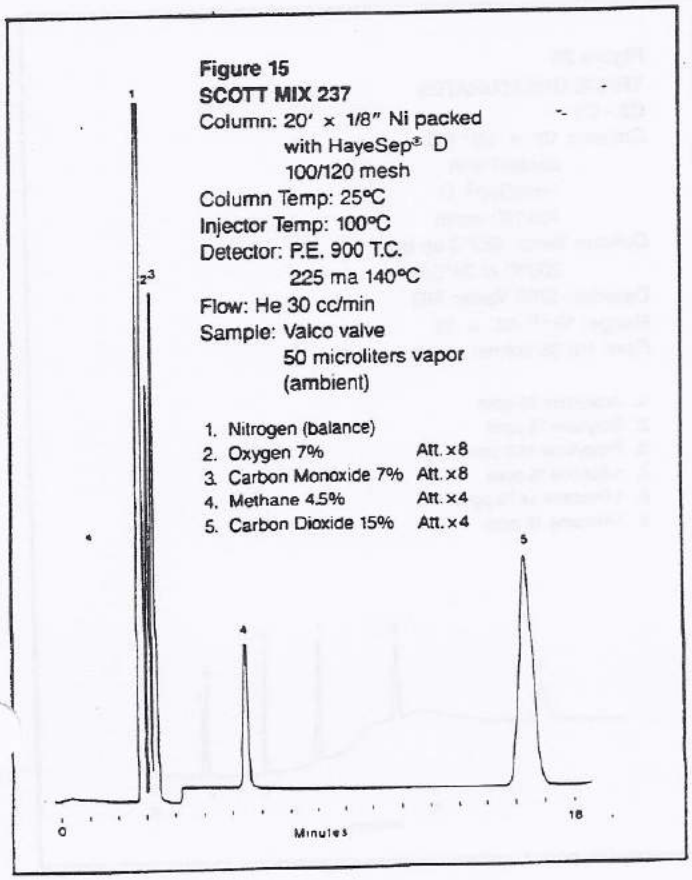


Figure 15
SCOTT MIX 237
Column: 20' x 1/8" Ni packed with HayeSep® D 100/120 mesh
Column Temp: 25°C
Injector Temp: 100°C
Detector: P.E. 900 T.C. 225 ma 140°C
Flow: He 30 cc/min
Sample: Valco valve 50 microliters vapor (ambient)

1. Nitrogen (balance)
2. Oxygen 7% Att. x8
3. Carbon Monoxide 7% Att. x8
4. Methane 4.5% Att. x4
5. Carbon Dioxide 15% Att. x4

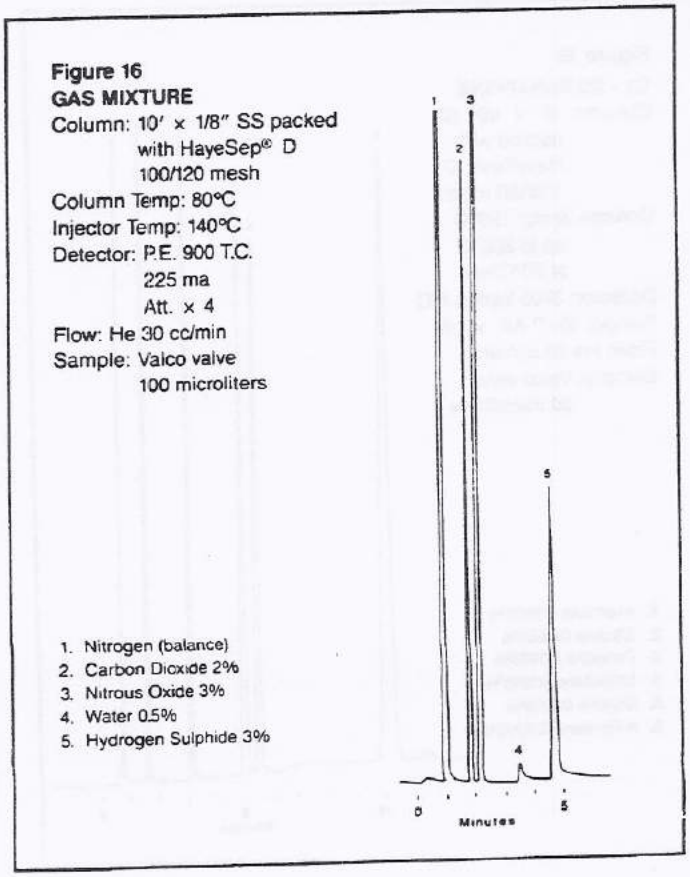


Figure 16
GAS MIXTURE
Column: 10' x 1/8" SS packed with HayeSep® D 100/120 mesh
Column Temp: 80°C
Injector Temp: 140°C
Detector: P.E. 900 T.C. 225 ma Att. x 4
Flow: He 30 cc/min
Sample: Valco valve 100 microliters

1. Nitrogen (balance)
2. Carbon Dioxide 2%
3. Nitrous Oxide 3%
4. Water 0.5%
5. Hydrogen Sulphide 3%

Figure 17
SCOTT MIX 216 (Programmed)
Column: 20′ × 1/8″ Ni packed
with HayeSep® D
100/120 mesh
Column Temp: 40°C/2 min
programmed
up to 110°C
at 24°C/min
Injector Temp: 100°C
Detector: P.E. 900 T.C.
225 ma 140°C
Flow: He 30 cc/min
Sample: Valco valve
100 microliters
(ambient)

1. Nitrogen (balance)
2. Carbon Monoxide 1% Att.×2
3. Methane 1% Att.×2
4. Carbon Dioxide 1% Att.×2
5. Acetylene 1% Att.×2
6. Ethylene 1% Att.×2
7. Ethane 1% Att.×2

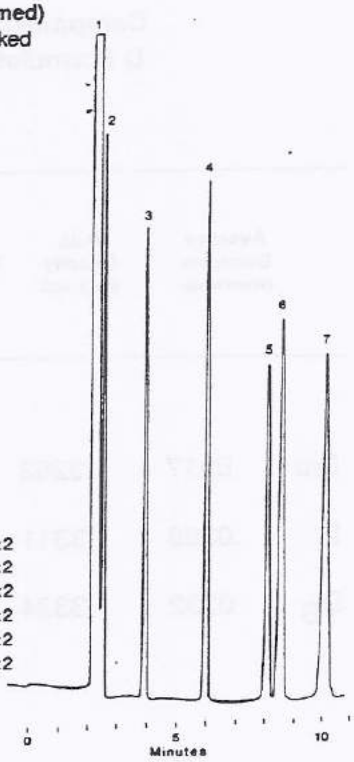


Figure 18
C1 - C2's
Column: 10′ × 1/8″ SS packed
with HayeSep® D
100/120 mesh
Column Temp: 80°C Isothermal
Detector: 3700 Varian FID
Range: 10^{-11} Att. × 16
Flow: He 35 cc/min

1. Methane 1%
2. Acetylene 1%
3. Ethylene 1%
4. Ethane 1%

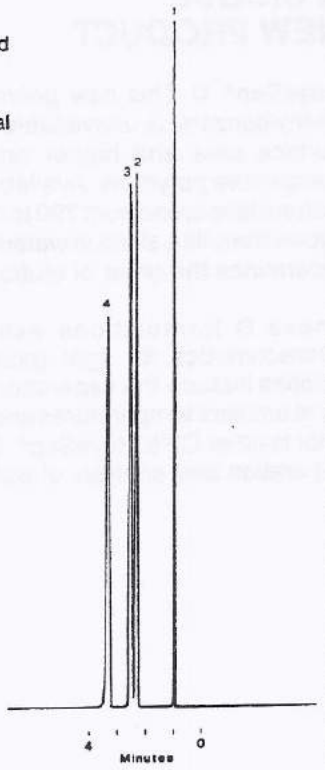


Figure 19
C1 - C5 PARAFFINS
Column: 10′ × 1/8″ SS
packed with
HayeSep® D
100/120 mesh
Column Temp: 120°C
up to 200°C
at 20°C/min
Detector: 3700 Varian FID
Range: 10^{-11} Att. × 16
Flow: He 35 cc/min
Sample: Valco valve
50 microliters

1. Methane 0.1894%
2. Ethane 0.0965%
3. Propane 0.0989%
4. Isobutane 0.1019%
5. Butane 0.1019%
6. n-Pentane 0.2002%

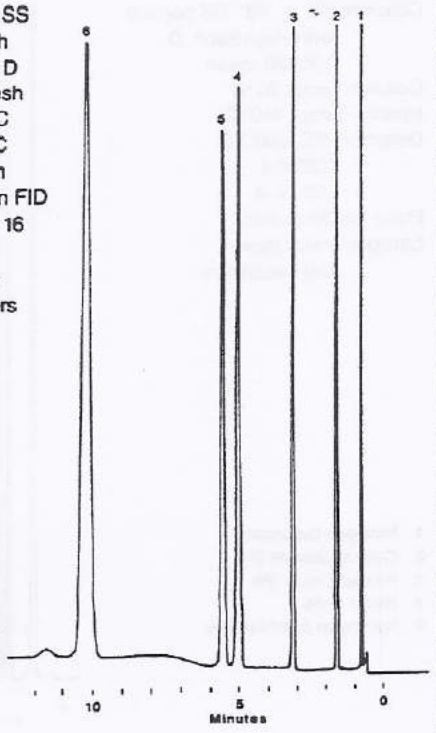


Figure 20
TRACE UNSATURATES
C2 - C6
Column: 10′ × 1/8″ SS
packed with
HayeSep® D
100/120 mesh
Column Temp: 120°C up to
200°C at 24°C/min
Detector: 3700 Varian FID
Range: 10^{-11} Att. × 16
Flow: He 35 cc/min

1. Acetylene 16 ppm
2. Ethylene 15 ppm
3. Propylene 14.3 ppm
4. 1-Butene 15 ppm
5. 1-Pentene 14.75 ppm
6. 1-Hexene 16 ppm

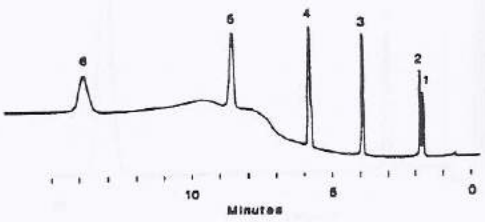


Figure 21
TRACE ACETALDEHYDE IN AIR 2500 ppm
Column: 3′ × 1/8″ SS packed with HayeSep® D 100/120 mesh
Column Temp: 100°C
Injector Temp: 140°C
Detector: P.E. 900 T.C. 225 ma 140°C
Flow: He 30 cc/min
Sample: Valco valve 100 microliters

1. Air
2. Water
3. Acetaldehyde 2500 ppm (vol.)

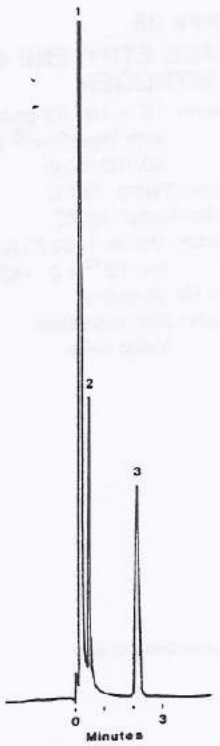


Figure 22
TEQUILA HEADSPACE
Column: 3′ × 1/8″ SS packed with HayeSep® D 80/120 mesh
Column Temp: 100°
Injector Temp: 140°C
Detector: P.E. 900 T.C. 225 ma 140°C
Flow: He 30 cc/min
Sample: Valco valve 100 microliters

1. Air Att.×1
2. Carbon Dioxide Att.×1
3. Water Att.×1
4. Methanol Att.×1
5. Acetaldehyde Att.×1
6. Ethanol Att.×8

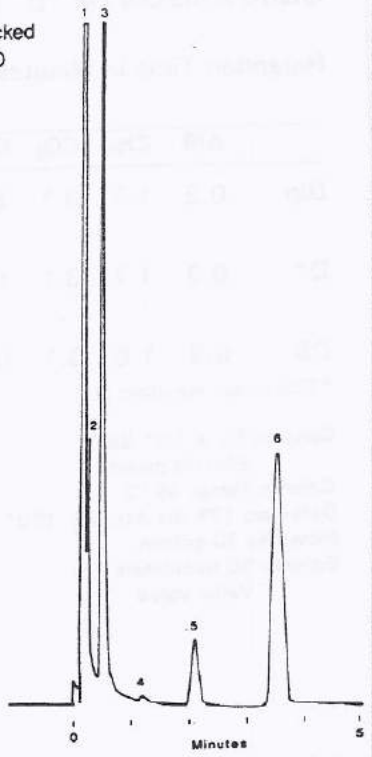


Figure 23
TRACE ALCOHOLS IN WATER
Column: 10′ × 1/8″ packed with HayeSep® D 80/100 mesh
Column Temp: 75°C up to 150°C at 16°C/min
Flow: He 33 cc/min
Injector Temp: 125°C
Detector: P.E. 900 T.C. 225 ma Att. × 1 140°C
Sample: 3 microliters

1. Methanol 500 ppm
2. Ethanol 200 ppm

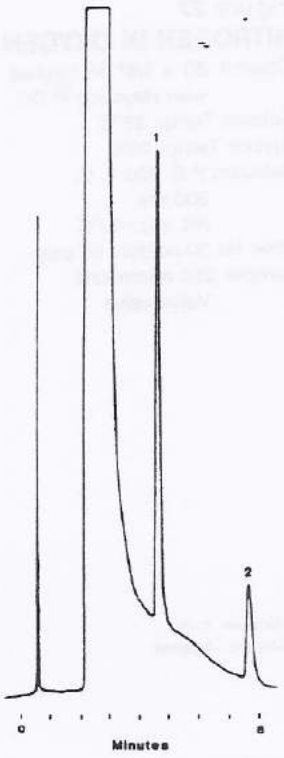
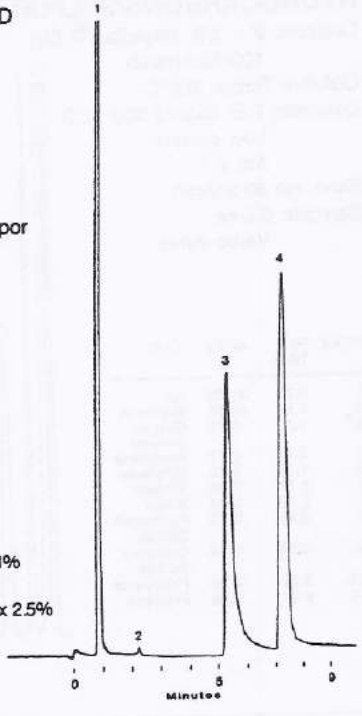


Figure 24
HYDROGEN SULPHIDE
Column: 10′ × 1/8″ Ni packed with HayeSep® D 100/120 mesh
Column Temp: 60°C
Injector Temp: 100°C
Detector: P.E. 900 T.C. 225 ma 140°C
Flow: He 30 cc/min
Sample: Valco valve 50 microliters vapor (ambient)

1. Air (balance)
2. Carbon Dioxide approx 0.1%
3. Water approx 2.5%
4. Hydrogen Sulphide approx 2.5%



COMPARISON OF "D" FORMULATIONS

Retention Time in Minutes

	AIR	CH_4	CO_2	C_2H_2	C_2H_4	C_2H_6	H_2O
Dip	0.9	1.7	3.1	5.4	5.8	8.3	9.0
D*	0.9	1.7	3.1	5.8	6.1	8.4	8.6
DB	0.9	1.6	3.1	6.1	6.6	8.7	8.1

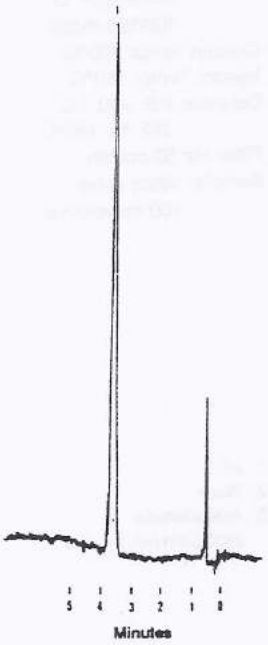
*This is our standard D.

Column: 10' x 1/8" SS
80/100 mesh
Column Temp: 45°C
Detector: 175 ma Att. x 2 150°
Flow: He 30 cc/min
Sample: 50 microliters
Valco valve

Figure 25
TRACE ETHYLENE OXIDE IN NITROGEN

Column: 10' x 1/8" SS packed
with HayeSep® D
80/100 mesh
Column Temp: 130°C
Injector Temp: 100°C
Detector: Varian 1400 F.I.D.
Att. 10^{-12} x 2 140°C
Flow: He 30 cc/min
Sample: 250 microliters
Valco valve

1. Ethylene Oxide 23 ppm

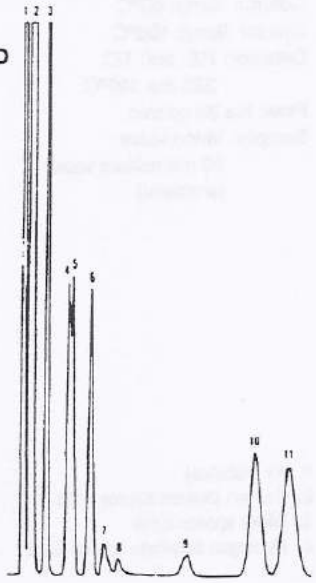


Courtesy of John Booker Co.

Figure 26
HYDROCARBONS/SULFUR GASES

Column: 9' x 1/8" HayeSep® Dip
100/120 mesh
Column Temp: 100°C
Detector: P.E. Sigma 300 TCD
Low current
Att. x 1
Flow: He 30 cc/min
Sample: 0.5 cc
Valco valve

PEAK	RET. TIME	AREA %	CPD
1.	0.71	31.59	Air
2.	0.86	46.88	Methane
3.	1.23	5.48	Carbon Dioxide
4.	1.71	2.17	Acetylene
5.	1.79	2.72	Ethylene
6.	2.19	3.09	Ethane
7.	2.52	0.45	Water
8.	2.83	0.19	Hydrogen Sulfide
9.	4.30	0.44	Carbonyl Sulfide
10.	5.82	3.36	Propylene
11.	6.57	3.59	Propane



Courtesy of John Booker Co.

Figure 27
NITROGEN IN OXYGEN

Column: 30' x 1/8" SS packed
with HayeSep® DB
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C.
300 ma
Att. x 2 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Nitrogen 0.4%
2. Oxygen - balance

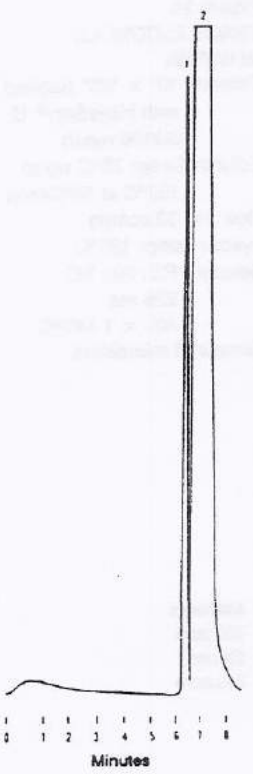


Figure 28
SCOTT MIX 234

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C.
300 ma 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Hydrogen 4% Att. x 01
2. Nitrogen 5% Att. x 32
3. Carbon Monoxide 5% Att. x 32
4. Methane 4% Att. x 32
5. Carbon Dioxide 5% Att. x 08

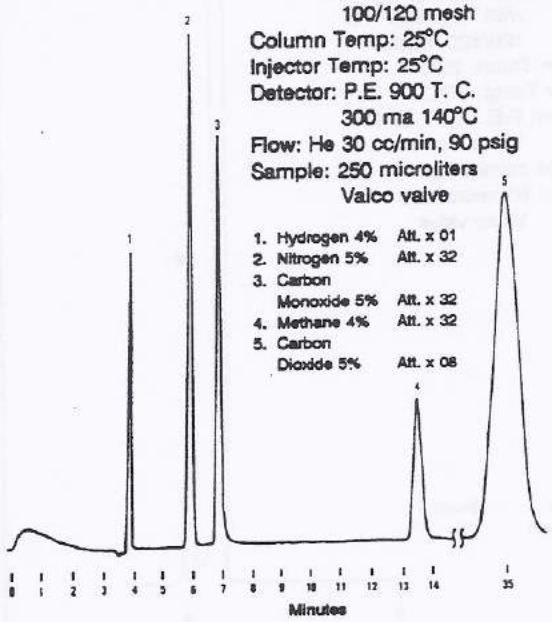


Figure 29
AIR

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C.
300 ma
Att. x 32 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Nitrogen 78%
2. Oxygen 21%
3. Argon 0.94%

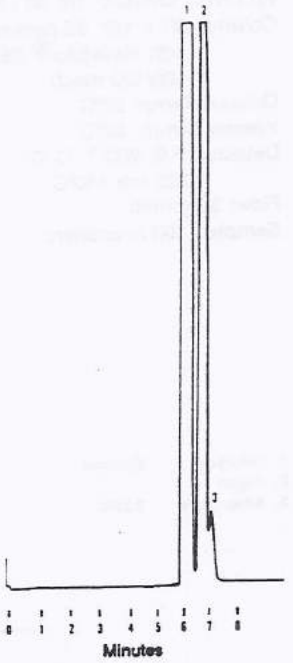


Figure 30
NITROGEN IN ARGON

Column: 30' x 1/8" SS packed
with HayeSep® D
100/120 mesh
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C.
300 ma
Att. x 1 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Nitrogen 373 ppm
2. Argon - balance

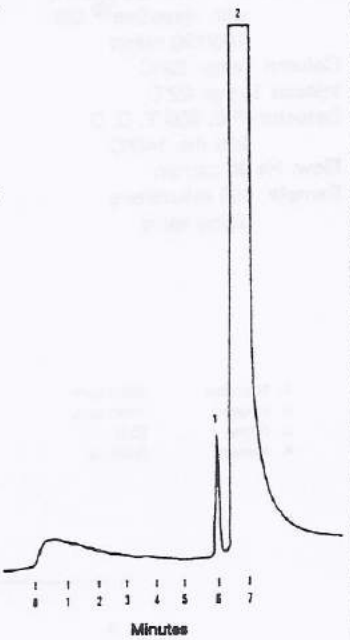


Figure 31
ETHYLENE AND SCOTT MIX 216

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 120°C
Injector Temp: 120°C
Detector: P.E. 900 T. C.
300 ma
Att. x 1 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Nitrogen
2. Carbon Monoxide
3. Methane
4. Carbon Dioxide
5. Acetylene 924 ppm
6. Ethylene
7. Water
8. Ethane

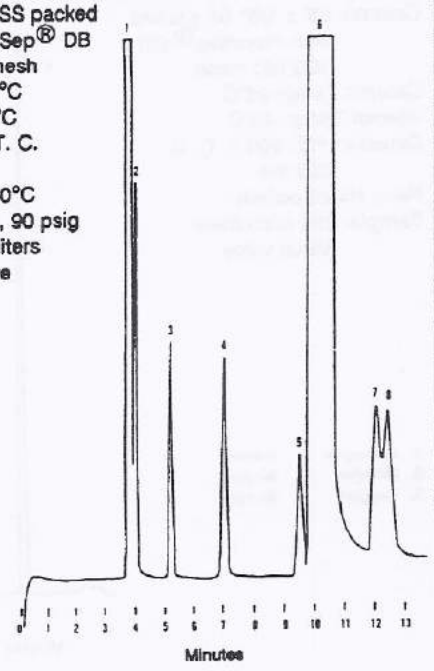
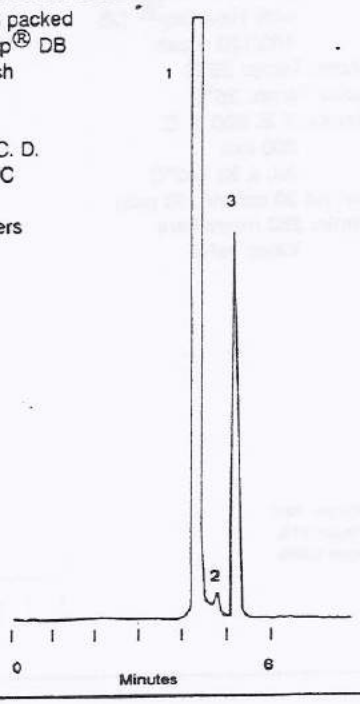


Figure 32
NITRIC OXIDE IN NITROGEN

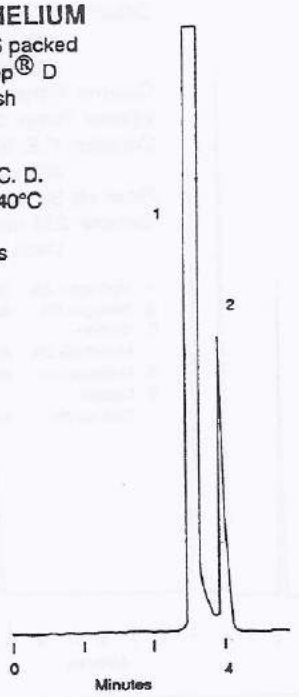
Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 22°C
Injector Temp: 22°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: 30 cc/min
Sample: 100 microliters



1.	Nitrogen	Balance
2.	Argon	
3.	Nitric Oxide	0.58%

Figure 33
HYDROGEN IN HELIUM

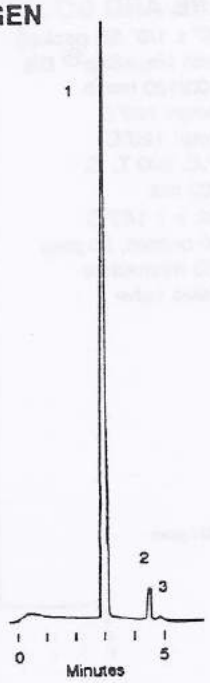
Column: 25' x 1/8" SS packed
with HayeSep® D
100/120 mesh
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C. D.
150 ma at 140°C
Flow: 24 cc/min N_2
Sample: 50 microliters
Valco valve



1.	Helium	Balance
2.	Hydrogen	1%

Figure 34
IMPURITIES IN HYDROGEN

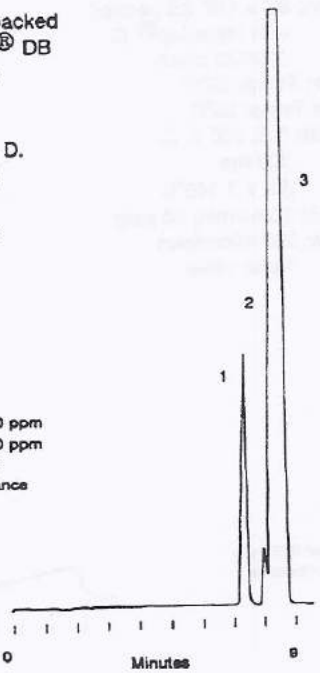
Column: 25' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C. D.
225 ma
Flow: He 25 cc/min
Sample: 250 microliters
Valco valve



1.	Hydrogen	Balance
2.	Nitrogen	60 ppm
3.	Oxygen	20 ppm

Figure 35
AIR IN ARGON

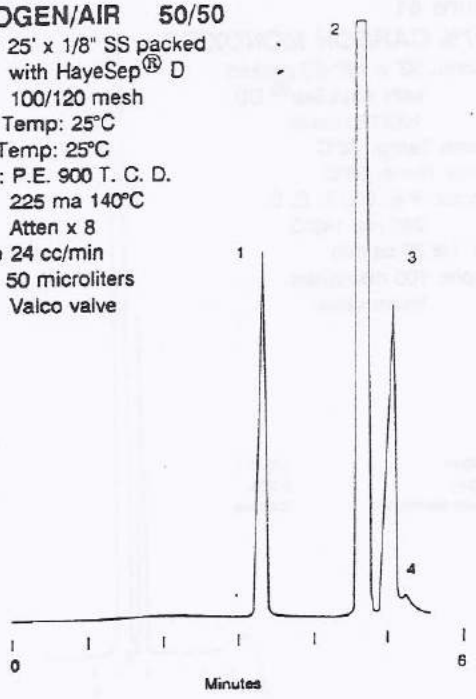
Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 22°C
Injector Temp: 22°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: He 30 cc/min
Sample: 100 microliters
Valco valve



1.	Nitrogen	6000 ppm
2.	Oxygen	1600 ppm
3.	Argon	25%
4.	Helium	Balance

Figure 36
HYDROGEN/AIR 50/50

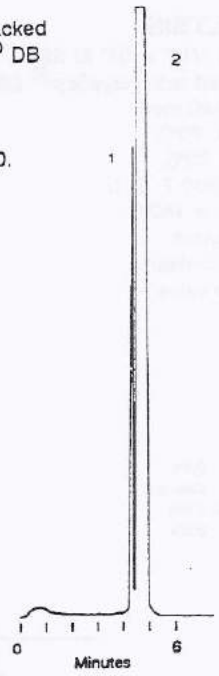
Column: 25' x 1/8" SS packed
with HayeSep® D
100/120 mesh
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Atten x 8
Flow: He 24 cc/min
Sample: 50 microliters
Valco valve



1. Hydrogen
2. Nitrogen
3. Oxygen
4. Argon

Figure 37
99.6% OXYGEN

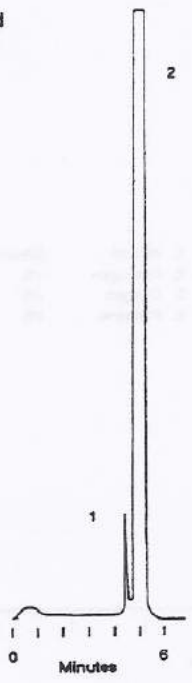
Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 22°C
Injector Temp: 22°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: He 20 cc/min
Sample: 100 microliters
Valco valve



1. Nitrogen 0.4%
2. Oxygen Balance

Figure 38
99.995% ARGON

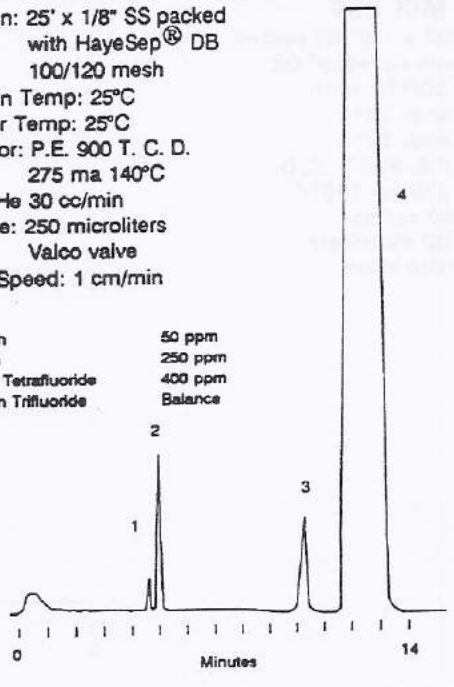
Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 22°C
Injector Temp: 22°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: He 30 cc/min
Sample: 100 microliters
Valco valve



1. Nitrogen 50 ppm
2. Argon Balance

Figure 39
IMPURITIES IN NITROGEN TRIFLUORIDE

Column: 25' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C. D.
275 ma 140°C
Flow: He 30 cc/min
Sample: 250 microliters
Valco valve
Chart Speed: 1 cm/min



1. Nitrogen 50 ppm
2. Oxygen 250 ppm
3. Carbon Tetrafluoride 400 ppm
4. Nitrogen Trifluoride Balance

Figure 40
FAST ANALYSIS

Column: 48" x 1/16" x .04" ID SS
packed with HayeSep® DB
100/120 mesh
Column Temp: 70°C
Injector Temp: 70°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: He 16 cc/min
Sample: 10 microliters
Valco valve

1.	Nitrogen	2.7%
2.	Methane	Balance
3.	Carbon Dioxide	3.0%
4.	Ethane	3.5%

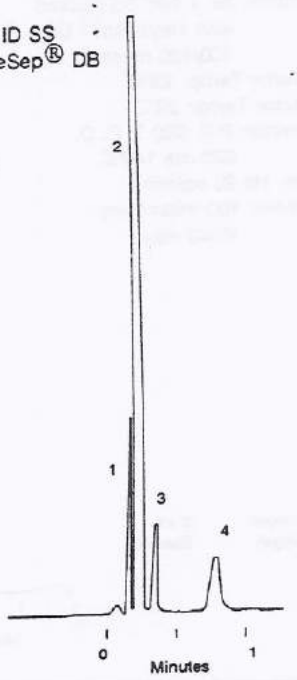


Figure 41
99.7% CARBON MONOXIDE

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 22°C
Injector Temp: 22°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: He 30 cc/min
Sample: 100 microliters
Valco valve

1.	Nitrogen	0.28%
2.	Oxygen	0.02%
4.	Carbon Monoxide	Balance

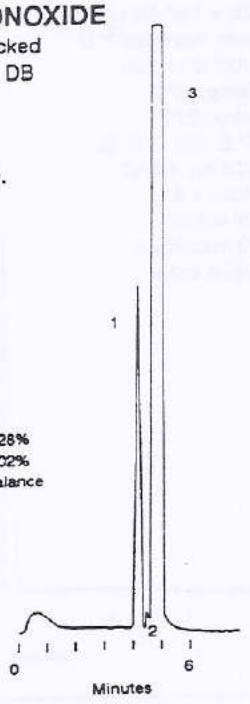
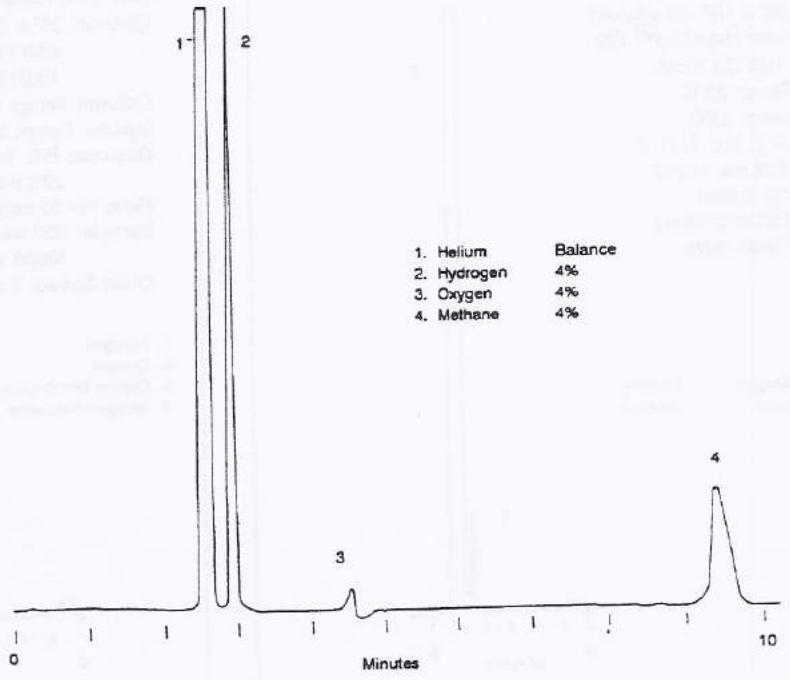


Figure 42
SCOTT MIX 234

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh
Column Temp: 22°C
Injector Temp: 22°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: N_2 30 cc/min
Sample: 100 microliters
Valco valve

1.	Helium	Balance
2.	Hydrogen	4%
3.	Oxygen	4%
4.	Methane	4%

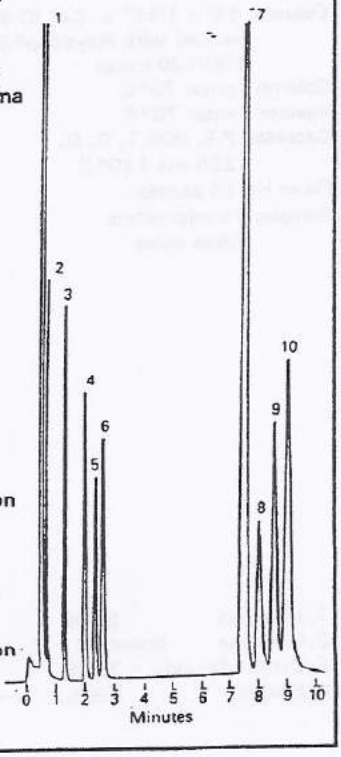


POROUS POLYMER MICROPACKED COLUMNS

Hayes Separations, Inc. has been making porous polymers for ten years. We have occasionally made micropacked columns for various customers as well as supplied packings for this purpose. A few examples of these are listed on the following pages. Of interest is the elution time of acetylene relative to ethylene and ethane. Figure 43 shows acetylene between ethylene and ethane; Figure 47 shows acetylene behind ethylene and ethane; Figure 46 shows acetylene in front of ethylene and ethane; Figure 48 shows rapid elution of impurities in methane. References for the production of porous polymers are listed below.

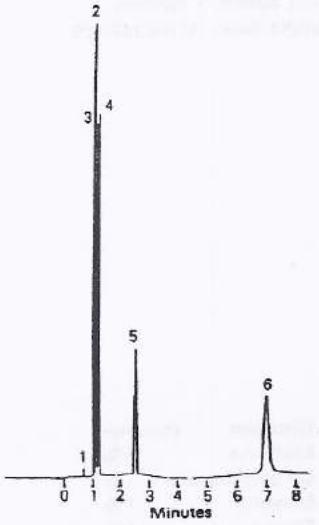
1) Hollis, O.L., Analytical Chemistry 38:309-316 (1966).
2) Hollis, O.L. and Hayes, W.V., J. Gas Chrom. 4:235-239 (1966).
3) Hollis, O.L. and Hayes, W.V., Gas Chrom., A.B. Littlewood, editor, The Institute of Petroleum, Rome, 1966, p. 57-74.
4) U.S. Patent - 3,357,158 December 12, 1967.
5) U.S. Patent - 3,458,976 August 5, 1969.
6) 1966 IR 100 Award (R&D magazine).

Figure 43
SCOTT MIX 216 + MAPP GAS
Column: 10' x 1/16" x .04"
packed with HayeSep® S
100/120 mesh
Column Temp: 60°C 3min up to
90°C at 8°C/min
Detector: P.E. 990 T. C. D. 225 ma
Flow: He 14 cc/min
Chart Speed: 1 cm/min
Sample: 50 microliters



1. Nitrogen
2. Methane
3. Carbon Dioxide
4. Ethylene
5. Acetylene
6. Ethane
7. Propylene
8. Propane
9. Propadiene
10. Methyacetylene

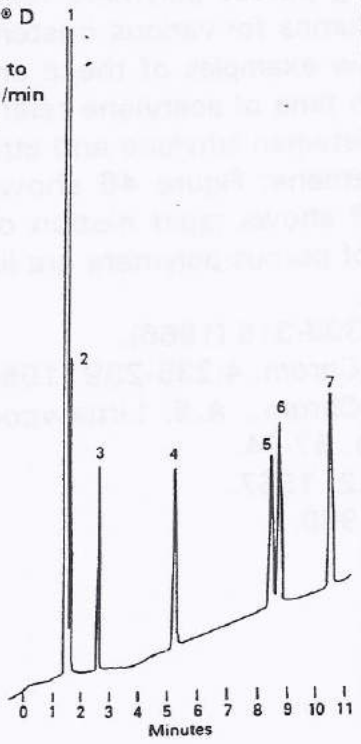
Figure 44
SCOTT MIX 234
Column: 20' x 1/16" x .04" SS
packed with HayeSep®D
100/120 mesh
Column Temp: 25°C
Detector: P.E. 900 T. C. D. 225 ma
140°C
Att. x 4
Flow: 13.3 cc/min He
Chart Speed: 1 cm/min
Sample Size: 25 microliters



1. Hydrogen	4%
2. Nitrogen	5%
3. Oxygen	5%
4. Carbon Monoxide	5%
5. Methane	5%
6. Carbon Dioxide	5%

Figure 45
MIX 216 PROGRAMMED

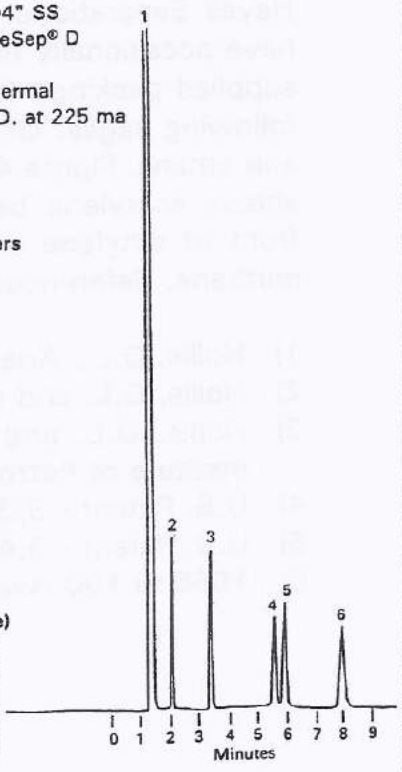
Column: 20' x 1/16" x .04" SS
packed with HayeSep® D
100/120 mesh
Column Temp: 25°C 2min up to
110°C at 8°C/min
Detector: P.E. 900 T. C. D. at
225 ma 140°C
Att. x 4
Flow: 13.33 cc/min He
Chart Speed: 1 cm/min
Sample Size: 25 microliters



1. Nitrogen	1%
2. Carbon Monoxide	1%
3. Methane	1%
4. Carbon Dioxide	1%
5. Acetylene	1%
6. Ethylene	1%
7. Ethane	1%

Figure 46
SCOTT MIX 216

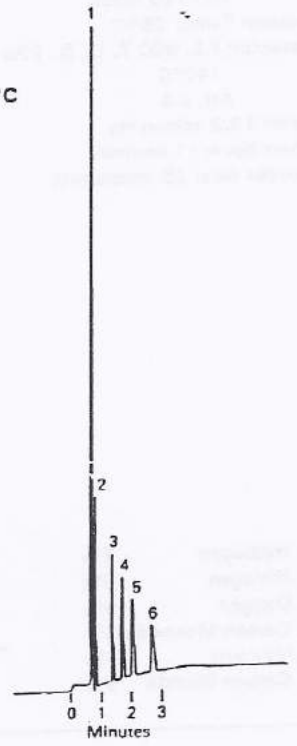
Column: 20' x 1/16" x .04" SS
packed with HayeSep® D
100/120 mesh
Column Temp: 70° Isothermal
Detector: P.E. 900 T. C. D. at 225 ma
140°C
Att. x 4
Flow: 13.3 cc/min He
Chart Speed: 1 cm/min
Sample Size: 10 microliters



1. Nitrogen	(balance)
2. Methane	1%
3. Carbon Dioxide	1%
4. Acetylene	1%
5. Ethylene	1%
6. Ethane	1%

Figure 47
SCOTT MIX 216

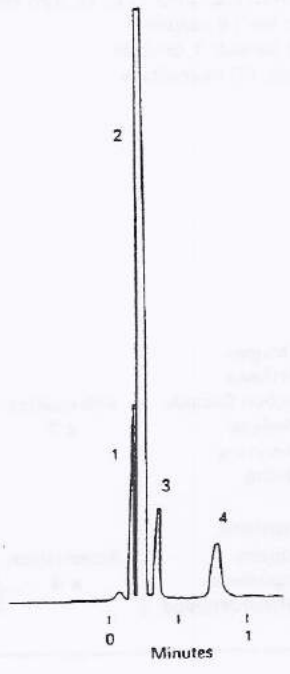
Column: 15' x 1/16" x .03"
packed with HayeSep® A
120/140 mesh
Column Temp: 45°C
Detector: VICI micro T. C. D. 120°C
Att. x 8
Flow: He 8 cc/min
Chart Speed: 1 cm/min
Sample Size: 10 microliters



1. Nitrogen	(balance)
2. Methane	1%
3. Carbon Dioxide	1%
4. Ethylene	1%
5. Ethane	1%
6. Acetylene	1%

Figure 48
FAST ANALYSIS

Column: 48' x 1/16" x .04" ID SS
packed with HayeSep® DB
100/120 mesh
Column Temp: 70°C
Injector Temp: 70°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: He 16 cc/min
Sample: 10 microliters
Valco valve



1. Nitrogen	2.7%
2. Methane	(balance)
3. Carbon Dioxide	3.0%
4. Ethane	3.5%

HAYESEP RT'S RELATIVE TO C_2H_6

6' X 1/8" ss Columns

HayeSep 80/100 mesh

60°C - 30 cc/min. Helium

Courtesy: Brian Thompson, Varian

Compound	A	B	C	D	DB	DIP
CF_4	.13	.10	.08	.10	.10	.10
CH_4	.09	.12	.11	.11	.11	.12
CO_2	.54	.32	.47	.31	.30	.30
N_2O	.62	.44	.59	.42	.42	.43
F116	.63	.49	.45	.51	.52	.53
C_2H_2	1.29	.65	1.03	.64	.62	.64
SF_6	.81	.65	.64	.68	.68	.68
C_2H_4	.81	.71	.75	.70	.70	.70
NH_3	1.58	.71	1.21	.90	.65	.98
F13	1.10	.90	.84	.87	.88	.90
C_2H_6	1.00	1.00	1.00	1.00	1.00	1.00
H_2O	7.06	1.14	5.31	1.08	.95	1.10
H_2S	2.06	1.45	2.20	1.36	1.35	1.39
COS	3.02	2.59	3.10	2.56	2.58	2.59
F22	7.63	3.11	6.34	3.30	3.31	3.35
C_3H_6	4.70	3.75	4.41	4.01	4.11	4.10
C_3H_8	4.94	4.43	4.70	4.73	4.84	4.84
SO_2	10.23	3.84	5.31	3.67	3.82	3.68
PD	6.19	4.63	5.80	4.79	4.87	4.90
MA	8.09	4.70	7.03	4.92	4.96	5.00
CP	5.90	5.02	5.89	5.18	5.32	5.26
F12	7.83	5.71	6.79	6.38	6.47	6.46
IC_4	17.92	14.73	16.21	16.74	17.18	17.32
1 , 3 BD	24.94	16.00	22.93	18.62	19.10	19.48
F114	27.35	18.35	21.46	21.48	22.11	22.88
NC_4	23.60	19.33	21.21	22.26	22.66	23.01

RELATIVE RETENTION TIMES

Ethane = 1.00

Columns 6' x 1/8" SS 65°C
He 30 cc/min

Compound	N	Q	R	S	T
Hydrogen	0.19	.143	0.17	.19	.21
Air	0.23	.186	0.2	.21	.25
Nitric oxide	0.25	.217	0.21	.23	.33
Methane	0.30	.256	0.28	0.3	.35
Carbon dioxide	0.71	0.45	0.50	0.52	0.85
Nitrous oxide	0.80	0.57	0.59	0.59	—
Ethlyene	0.83	0.74	0.78	0.78	0.9
Acetylene	1.41	0.74	1.0	0.87	2.11
Ethane	1.0	1.0	1.0	1.0	1.0
Water	10.1	1.45	6.8	4.12	19.1
Hydrogen sulphide	2.1	1.40	1.73	1.87	2.88
Hydrogen cyanide	19.3	2.31	15.6	8.26	28.8
Carbonyl sulphide	2.82	2.33	2.46	2.63	3.4
Sulphur dioxide	12.0	3.05	9.78	17.8	19.0
Propylene	4.66	3.20	3.45	3.65	4.91
Propane	4.66	3.67	3.88	4.1	4.63
Propadiene	6.50	4.12	4.39	4.7	7.55
Methylacetylene	9.5	4.12	4.84	5.14	11.3
Methyl chloride	7.43	3.93	4.67	4.92	9.2
Vinyl chloride	14.9	6.04	9.04	9.7	17.3
Ethylene oxide	17.7	6.06	8.78	9.7	23.3
Ethyl chloride	35.0	12.25	19.3	20.7	43.2
Carbon disulphide	—	32.4	—	—	40.7

Operating and Instruction Manual
for
Cobra L/S Autosampler

EST Analytical
503 Commercial Drive
Fairfield, Ohio 45014
Phone: 513-642-0100

Limited Warranty

EST Analytical hereby warrants the equipment supplied herewith to be free from defects in material and workmanship at the time of shipment. EST (the manufacturer), agrees to either repair or replace at our sole option, free of parts and labor charges at our factory, any parts of such equipment which under normal conditions of use prove defective within twelve (12) months (one year) from the date of shipment to the end user. EST has the option of inspecting the goods claimed defective at the Buyer's place of business or having the defective equipment returned to EST, transportation charges prepaid, for inspection. If an item is found defective under warranty, the repaired or replaced item will be returned to the buyer via the same mode of transportation by which it was received. This warranty does not cover equipment or parts of equipment which are modified by the Buyer. The following goods are warranted for the periods set forth only:

(a) Items produced by third party manufacturers shall carry that warranty provided to EST by said third party manufacturers. Such warranty shall be passed by EST, to the Buyer.

(b) This warranty does not apply to items consumed in the ordinary course of use of the goods, such as, but not limited to septa, vials, caps, syringes and needles.

(c) This warranty does not cover bent, broken, or plugged needles, glass breakage, or the replacement or repair of parts due to accident, misuse or contamination, or loss or damage to equipment sustained in transit. Claims for damage sustained in transit must be filed with the transit agency. **Notice: All instruments should be insured with the shipping carrier prior to shipping, even if the repair is covered under warranty. The insurance must be purchased by the customer, not by EST Analytical.**

The foregoing warranty and remedy are exclusive and expressly in lieu of all other warranties, expressed or implied, including but not limited to any warranty of fitness for purpose or any warranty of merchantability.

Safety Information

CAUTION !

The Auto Sampler system will move rapidly to inject the sample into the gas chromatograph. This movement may prove hazardous if untrained personnel are utilizing the system. The system should be operated with all covers and latches secure. The syringe may move at any time. Make certain that all movement paths are clear at all times before powering on the system. Additionally, the syringe or needle may be bent broken very easily if proper setup instructions are not followed EXACTLY. Only trained personnel should attempt to operate the AutoSampler.

The Auto Sampler may operate on 110 VAC to 240 VAC, 50 to 60 Hz, electrical voltage only. This level of voltage may be life threatening if contacted. There are no user serviceable parts located within the housing of the Auto Sampler or power supply. If electrical problems are suspected contact the factory.

Conventions

This manual uses the following conventions:

Bold indicates emphasis or a minor heading.

Italics indicates the current function on the display that is being emphasized. It is usually a display parameter that will be changing as the AutoSampler performs a task.

CAUTION ! messages precede warnings of procedures or practices which, if not followed correctly, could cause serious personal injury or damage to instrumentation.

Symbols as Marked on the Equipment or in the Operators Manual.

Protective ground (earth) terminal.

ATTENTION

This symbol is indicating special care should be given to this section of the manual.

CAUTION

This symbol is indication any incorrect operation could result in an error or damage to the instrument.

WARNING

This symbol is indication any incorrect operation could result in personal injurty or damage to the instrument.

- All safety precautions MUST be adheared to when installing and operating the Auto Sampler.
- Please read this manual throughly before proceeding to install or operate the Auto Sampler.
- Be certain all personal in the laboratory are trained and are familar with the operation of the Auto Sampler.
- When replacement parts are ordered, use only EST Analytical parts and part numbers.

TABLE OF CONTENTS

1.0 Introduction

1.1 Product Description

The Cobra L/S Auto Sampler combines state-of-the-art component technology with easy-to-use operating features that meet routine as well as research level autosampling requirements.

The Cobra L/S is an all-electric, stepper motor driven autosampler providing rugged reliability and pinpoint injection accuracy. The syringe mechanism moves back-and-forth and in-and-out across the sample tray to access sample vials, multiple solvent vials, standards, etc.

Variable inject volumes, injection speed, needle dwell times, number of samples per vial, multiple methods per run, solvent flush, air gaping, dual column operation and a host of other autosampling options are all standard and easily programmed on the Cobra L/S's menu driven keypad.

The unit uses screw-cap or crimp-top septum vials and easily interfaces with your GC system with all the remote inputs/outputs—ready signal, injection mark, etc.—plus RS 232 for direct communication with an IBM or compatible personal computer. Mounting is easy and allows for quick changes between GC's if desired. Syringe/injector alignment is via the keypad. The control module mounts on either side of the autosampler for easy access.

1.2 Key Features

- Direct Syringe Injection: Uses 1.5µl - 100µl syringes for minimum sample volume and maximum flexibility.
- All Electric: No additional cost for gases.
- Priority Manual Sample feature allows the current analysis to be interrupted for RUSH samples.
- Variable Sample Fill Rate for viscous samples.
- Variable Injection Rate to optimize chromatography based on injector type and analytes of interest.
- Dual Injector Operation allows maximum productivity from GC with dual injectors and columns.
- Programmable Injector Alignment: No manual adjustments to align injection ports.
- Variable Dwell Time for hot needle injection techniques.

- Post Solvent Rinse user definable with two separate rinse solutions.
- Internal Standard Injection
- Two Solvent Rinse capability minimizes cross contamination.
- Easy To Operate Menu-driven system simplifies method setup and allows for multiple method linking. Up to 10 different methods available.
- A sample may be run from any position in the sample tray in Manual or Auto mode.
- Large 120 or 200 position sample tray for overnight operation that lifts off for easy loading.
- The syringe may be programmed for simple or complex injection sequences through a simple keypad entry system allowing for any type of sample handling with one system.
- Totally controlled sequences of syringe purging and rinsing allowing improved peak resolution and minimum compound carry over.
- Fast easy programming from the touch pad keyboard terminal.
- Easily readable backlit LCD display.
- Compact size, requires less space than other autosampler systems.
- Easy hook up and installation.

1.3 Specifications

- Tray Capacity: 120 sample vials — 2 ml, 12 mm x 32 mm vials; 2 Solvent, 1 or 2 Waste, 10 ml vials
- Sample Size Reproducibility Typically 1% or better.
- Minimum Sample Size: 1% of Syringe Volume
- Sample Injections per Vial: 1 to 100; or sample vial capacity.
- Standard Injection: 1% to 100% of syringe capacity (standard volume plus sample volume cannot exceed the syringe volume.
- Operating Temperature: 15° to 35°C Storage Temperature: 0° C to 85° C
- Relative Humidity: 10 to 90%
- Line Voltage: 100-240 VAC; 50-60 Hz, 115-160 VA

- Weight: Auto Sampler Unit - 17 lbs 3 oz..: 7.8 Kilograms
- Size: Auto Sampler Unit - 25 x 10 x 17 inches : 63.5 cm x 35.5 cm x 43.2 cm

2.0 Installation

2.1 Installation Protocol

The complete installation of the Cobra L/S includes the following steps:

1. Unpack the Auto Sampler and make certain all parts and supplies are available.
2. Install the mounting bracket to the GC per separate instructions.
3. Install the Auto Sampler onto the mounting bracket.
4. Install the cable from the Display/Keypad Terminal box to the rear of the Cobra L/S, see Figure 2.0.
5. Connect the Remote I/O cable between the Auto Sampler and the GC or data system. See Section 9.0.
6. Connect the power supply power cord to the rear of the Auto Sampler and then plug the main power cord into a grounded AC power source.
7. Install the syringe assembly. See Section 4.1.
8. Perform the Setup and Target Setup procedures (some of these may require removal of the syringe.) Verify the initial mounting bracket alignment to the injection port on the chromatograph. See Section 5.0.

2.2 Unpacking the Auto Sampler

Carefully unpack and inspect the Auto Sampler. Inspect the instrument for possible shipping damage. If damage is discovered, immediately notify the shipping carrier and then EST Analytical. Do not return the instrument without first notifying EST Analytical and obtaining a Return Goods (RG) authorization number. If possible, please store the shipping cartons and all packing material for possible future use.

2.3 Parts and Materials

The following parts list is included in the accessory kit.

- Sample Tray
- Power Cord w/ Power supply
- Sample Syringe
- Optional Mount Bracket (This must be purchased seperately)
- I/O Cable (comes with bracket)
- 4 Solvent / Waste Vials (10 ml)
- 4 Solvent / Waste Caps with Septa
- 4 extra Waste/Solvent Septa
- Operators Manual

2.4 Power Requirements

The Auto Sampler is an all electric system with only a maximum of 24 VDC present in the cabinet . No gases or other energy sources are required. The power requirement for the system is an input to the power supply of 100-224 volts and a line frequency of 50 to 60 Hz.. Make certain the electrical voltage is a constant source with no severe drops or spikes in the voltage. If the power source is not certain, install a power conditioner on the electrical line.

2.5 Interfacing to an Analyzer

To properly interface the Auto Sampler to the GC, the GC ready (or Analyzer Ready) signal and the remote start signal must be located on the GC and or Data Collection Device. Each GC is different and it may be necessary to refer to the instrument's manual, or contact a representative for the correct location of the ready and start signals. Connection points on gas chromatographs are unique to each system, therefore, a specially wired cable is required. To insure correct operation of the system follow the wiring schematic supplied with each cable. If a problem exists please consult the factory.

The Auto Sampler may also be operated in the Local mode if a GC ready signal is not available. The Local mode allows the Auto Sampler to inject a sample based on a cycle time setting without receiving a ready signal . See Method Parameters Section for more details.

The connections will be from the Auto Sampler's Remote I/O connector (25 Pin D), located on the rear of Cobra L/S, to the chromatograph's I/O "D" connector or appropriate terminal block connector(s).

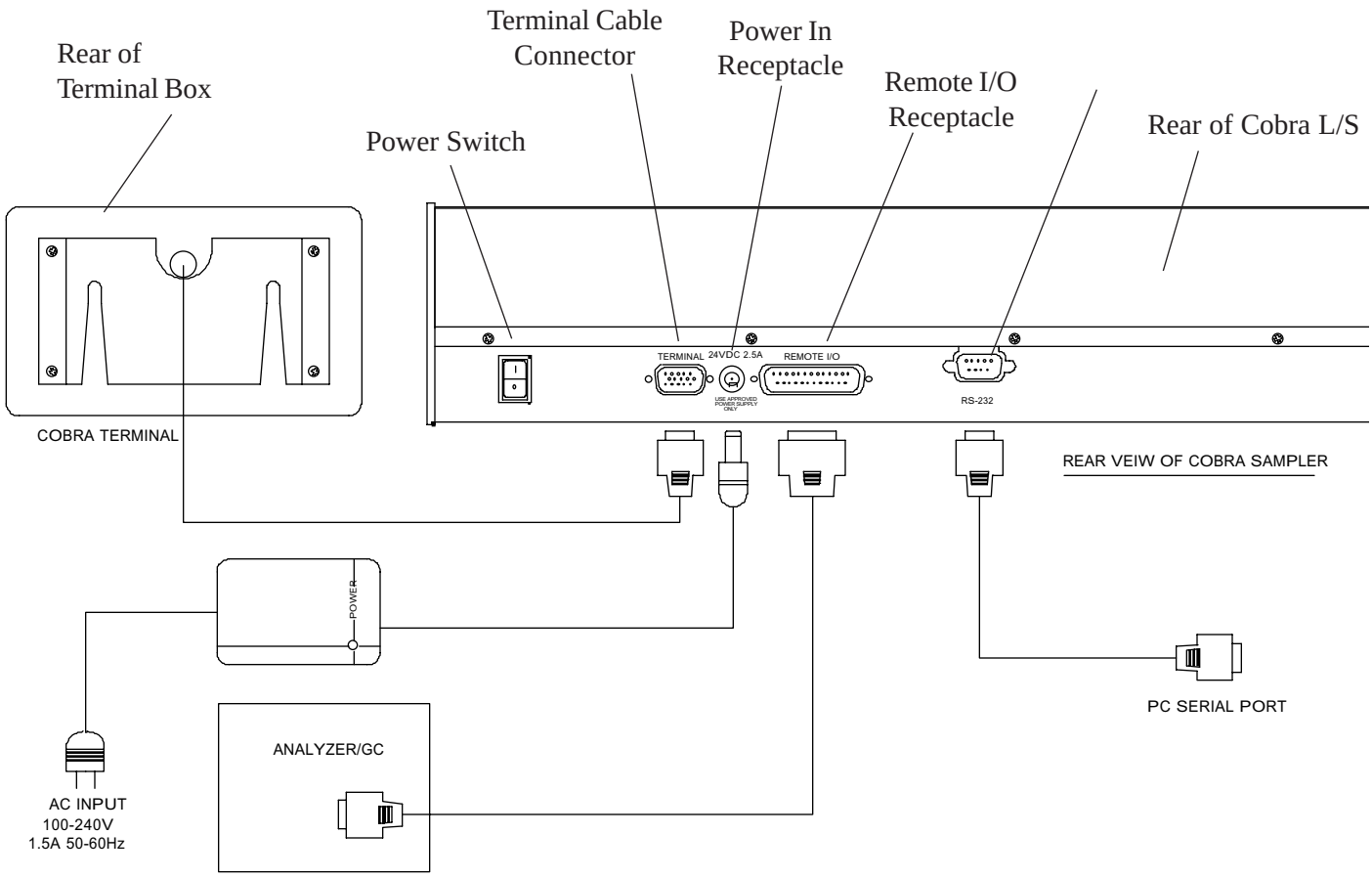


Figure 2.0

Figure 2.0 shows the complete installation of cables to the GC and for RS 232 remote control. **Be certain all cable connections are made before the power to the Cobra L/S is turned on.**

2.6 Sample Tray Installation

Unwrap the sample tray and place it onto the sample tray brackets. The tray will only mount in one direction as there are alignment pegs on the holder brackets and corresponding alignment slots in the tray. Once installed, place an empty vial with cap and septa in vial position #1 and the waste / solvent locations to be used. Be certain the waste/solvent tray is located on the correct side of the sample tray for your GC. Note, the waste / solvent tray may be located on either side of the sample tray, see Figures 2.6 & 2.6 a.

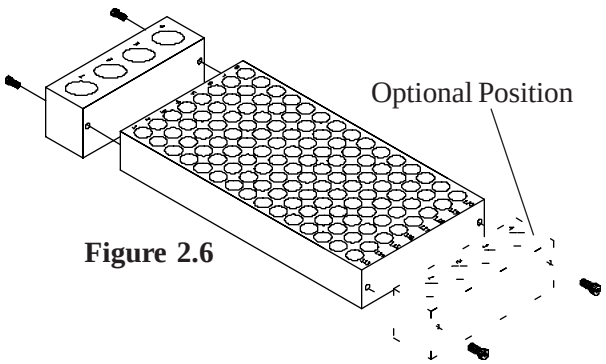


Figure 2.6

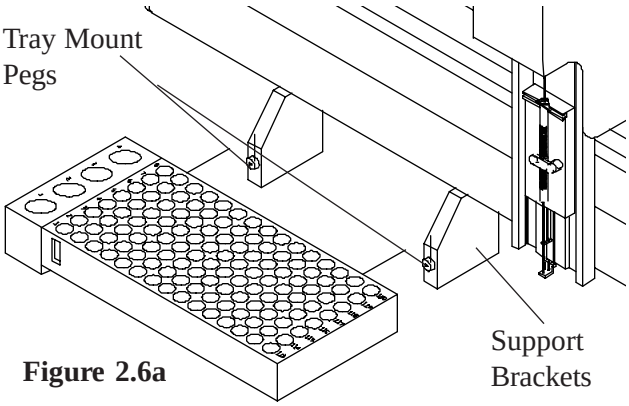
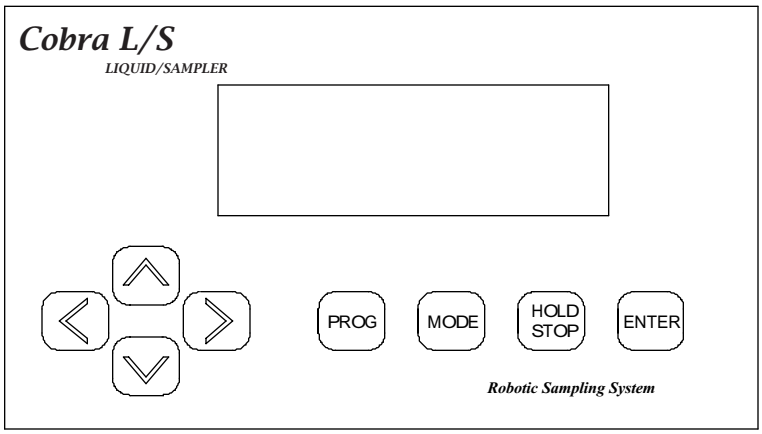


Figure 2.6a

3.0 Keyboard Definition

The keyboard provides for a complete entry of all Setup, Method, Configuration, Diagnostics as well as motor operations. The keys perform the following operations. (See Operational Keys, Section 7.0, for a complete description of Key Functions.)



Hold/Stop Key: Provides both a "Hold" in the current operation and/or a complete abort of the current operation and allows for an exit out of a menu.

Mode Key: Selects the desired Mode of operation: Automatic, Manual or Flush.

Program (Prog) Key: Provides access to: Methods, Configure and Diagnostics menus.

Enter Key: Accepts the numeric value entry and/or menu item selection. It also scrolls to the next data entry item in applicable situations.

Arrow Keys: Allows for selection of all data, the L/R keys allow for increasing or decreasing numerical values and the U/D for scrolling within a menu or parameter.

4.0 Syringe Setup

The Cobra L/S will accept most manufacturers syringes however, a SGE 10µl, FN (P/N 506303) is shipped as standard. NOTE: If another syringe brand is used there may be some adjustment required to the lower needle guide.

Select the "Configure" menu using the "Prog" key and follow the instructions for "Syringe Setup".

4.1 Syringe Installation

1. Loosen the syringe plunger thumbscrew (1) and the two 4-40 socket head screws (4) securing the holder.

2. Insert the syringe needle (10) into the mid needle guide (9) and then down into the lower guide (11).

3. Insert the syringe flange (3) into the notch (4) in the upper section of the syringe holder (8).

Raise the plunger thumbscrew (1), holding it up, insert the syringe plunger thumbpiece (3) into the T-slot in the plunger retainer. Lower the plunger retainer thumbscrew and tighten securely. Rotate the syringe clamp (6), 90 degrees, to hold the syringe (7) in place.

4. Set the plunger to its zero position by sliding the holder (8) up until it touches the needle, **then back it down about 1/64"** and tightening the two 4-40 socket head screws (4).

5. Verify that the needle (10) does not extend beyond the lower needle guide (11). Place your finger under the lower needle guide and check. The needle tip should not be felt. If the needle tip can be felt, the needle guide requires adjustment, consult factory.

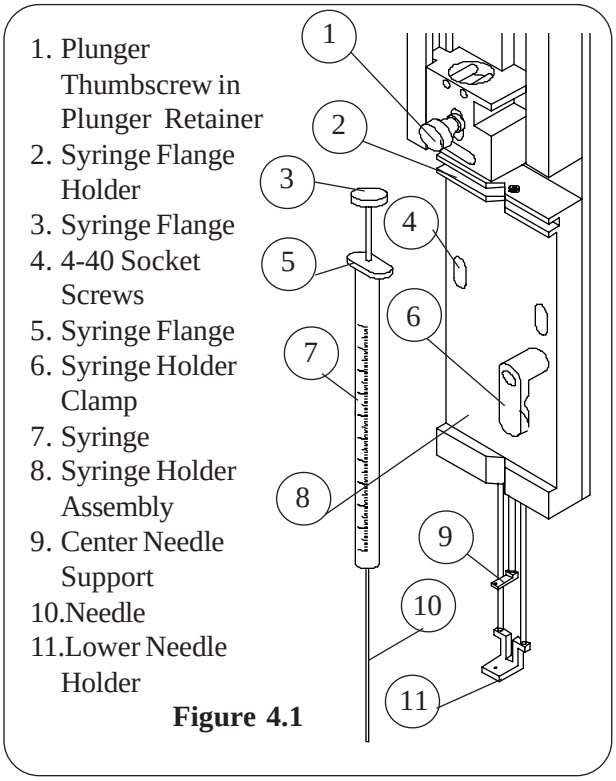


Figure 4.1

4.2 Syringe Calibration

The syringe plunger must be properly calibrated to insure injection accuracy. The procedure is performed in the "Cobra Setup" section of the control program. Press the "Prog" key and select the “Cobra Setup” menu, press the Enter key and select the "Configuration" Menu line, press Enter. Now, with the down arrow key select "Vol Calib", press Enter. The "Syringe Setup" screen is now showing.

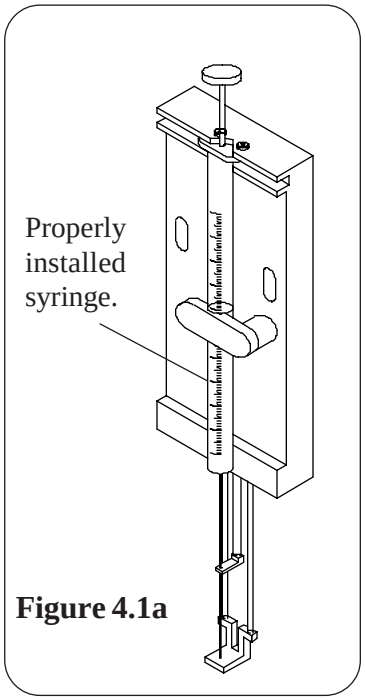


Figure 4.1a

Manually adjust the plunger to zero (if required) by adjusting the holder up, until the syringe plunger touches the bottom of the syringe, then back it down about 1/64", tighten the two 4-40 socket head screws, press the Enter key.

The next screen adjusts the maximum stroke of the plunger. With the Left/Right arrow keys, move the plunger up, such that the end of the plunger is on the maximum graduation mark of the syringe installed. (Note, record the value show on the line "Volume" for future use). Press the Enter key. Next, using the Left/Right arrow keys, adjust the plunger stroke to the maximum position allowed on the syringe barrel. This is generally about 10% above the syringe volume. Press the Enter key.
NOTE: If the plunger motor "chatters", the syringe holder is set too high not allowing the plunger sensor to be reached. Loosen the two 4-40 socket head screws and slowly lower the holder until the motor stops chattering. The plunger sensor has now been homed. Look at the plunger to be sure it is at the "0" mark.

The plunger has now been set to the maximum graduation (100%) mark on the syringe scale. This will allow the software to properly calculate the sample and rinse volume parameters.

5.0 Target Setup

CAUTION: ***Severe damage can occur to the Syringe, Sample Vials, and/or Chromatography Instrumentation if incorrect parameters are set. Remove the syringe from the holder.***

CAUTION: ***The mounting bracket must be correctly installed before attempting Target Setup.***

5.1 Target Setup Protocol

The Auto Sampler is designed to inject from up to 220 samples from .8 ml sample vials, however, the 120 position 2 ml vial tray is standard, into most types of GC septum injection ports. Two injection ports may be established anywhere along the travel length of the syringe arm.

Target Setup involves completing the following steps.

1. Installing the Mount Bracket and Auto Sampler to the analyzer.

2. Installing the Syringe Holder and Sample Tray with the Waste / Solvent installed on the correct side for you GC inlet configuration.

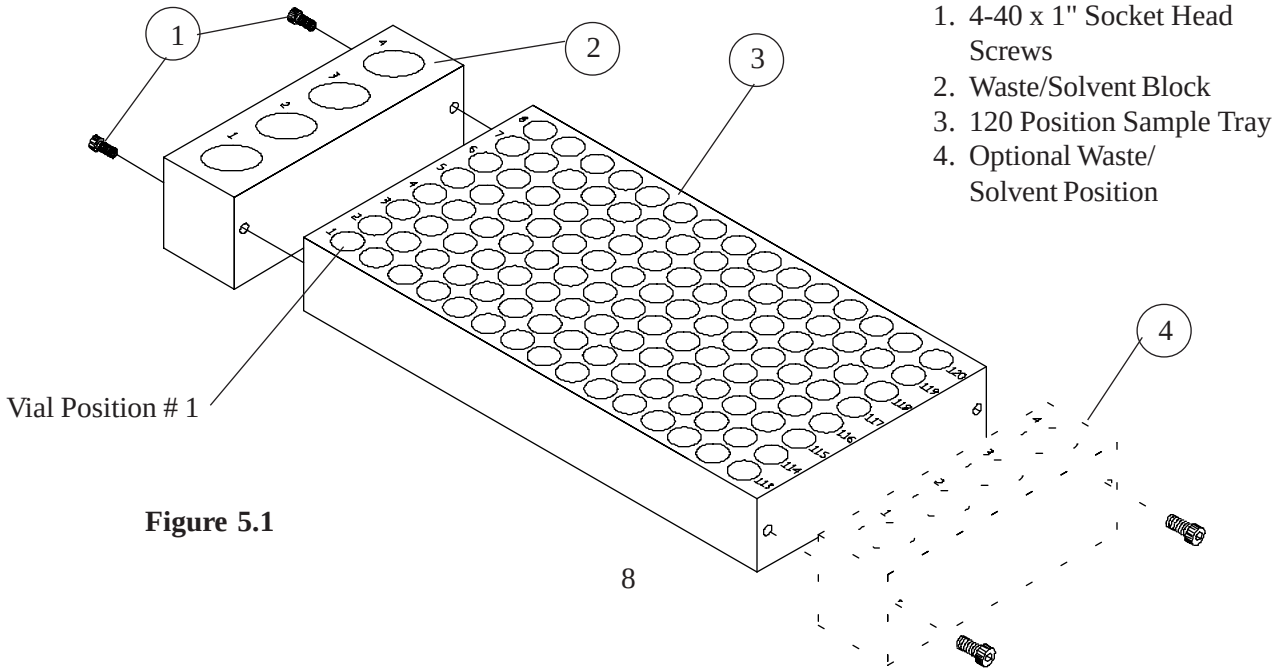
3. Syringe Installation and Calibration **(be certain the syringe is removed before beginning Target Setup).**

4. Selecting the Sample Tray Style.

5. Calibrating the sample vial #1 position. **Note, never allow the needle to pierce the septum of an empty vial. Always have liquid in the vial. This will help lubricate the needle in the septum.**

6. Setting Flush Vertical and Waste Vertical positions.

7. Calibrating the syringe to the injection port(s) location(s).



1. 4-40 x 1" Socket Head Screws
2. Waste/Solvent Block
3. 120 Position Sample Tray
4. Optional Waste/ Solvent Position

Figure 5.1

5.2 Motor Positioning Guidelines

When setting up the Sample Tray and Injection Inlet positions the arrow keys act as a directional input for axis movement (Left / Right arrow keys for Left / Right movement and the Up / Down arrow keys for Front / Rear movement). This movement is achieved when the operator **"taps"** or pushes a directional arrow key momentarily. If the movement is not "fine" enough, the step rate may be changed from "Continuous" to "Jog", and the number of steps per movement may be changed.

To access this menu, from the "Target Coordinate Setup" menu, move the head to a target and then press the "Mode" key. The "Select:" menu comes up, from here, the type of movement, either Jog or Continuous may be set, also the number of steps per movement. Changes are made by pressing the "Mode" key or the arrow keys. The default step rate is factory set at 10. To exit the menu press the Stop key.

5.3 Target Coordinate Setup

Press the "Prog" key and select "Cobra Setup." Select the "Configuration" menu line and press Enter. Scroll to the "Sample 1" line and press Enter. Press Enter and the syringe arm will move slightly to the left and out. The arrow keys are now used to move the syringe arm over to the center of vial #1. Press either the Left or Right arrow key to move the arm to the approximate center position of the first row of vials. Using the Up or Down arrow key, toggle to the "For/Back" menu line, use the Left or Right arrows to move the arm to the approximate center of vial #1. Toggle to the "Vertical" menu line and with the Right arrow key, lower the syringe arm to just above the vial cap. Install the syringe and make the final adjustments to the needle position. **The needle must be positioned down into the vial to not hit the bottom!.** After the setup is complete write down the number coordinates for future use.

Press the Enter key and the arm will move to home, toggle to the next menu line "Waste", press Enter. The same X-Y-Z coordinates must now be established for the Waste (1 & 2) and for Rinse (1 & 2) and for the injection Inlets A & B. The procedure for these settings is the same as for Sample #1. The only difference is the inlets will require a finer adjustment than the vials. Once all the coordinates have been established install the syringe and recheck the target locations.

6.0 Method Definition

6.1 Method Editing

The Cobra L/S allows 10 methods to be saved into memory. To edit a method, press the "Prog" key, select "Method Edit", enter the method number and press Enter. The next menu will allow entry into the selected Method. Press the Enter key and the parameters will be displayed. The Method parameters will then cycle through with each touch of the Enter key or Up\Down arrow, allowing changes to be made. The method editing may be exited at any time by pressing "Prog" or the Hold\Stop key. If the Enter key has been pressed changes will automatically be saved. If an invalid entry is made, the system will not save the entry. Refer to the following parameter list for values for each parameter. The parameter values are in brackets [xxx].

6.2 Method Parameters

Parameter	Range	Description
First Vial	[1 to 120]	The first sample vial to be injected.
Last Vial	[1 to 120]	The last sample vial to be injected.
#Inject/Sample	[1-100]	The number of injections to be performed on each individual sample.
#Rinse/Solv #1	[0-20]	After a sample is injected, the syringe will be rinsed this number of times using Solvent #1.
#Rinse/Solv #2	[0-20]	After a sample is injected, the syringe will be rinsed this number of times using Solvent #2.
Rinse Volume %	[0-100%]	The percentage of the total volume of the syringe to be used in rinsing, i.e... a setting of 50% when utilizing a 10 µl syringe would allow 5 µl of rinse solution to be drawn into the syringe for every rinse.
Rinse Fill Rate %	[0-100%]	The plunger stepper motor speed will be adjusted to a speed rating per the input value. Use a lower number if more viscous solvents are being used to avoid air bubbles.
Standard Volume %	[0-100%]	The percentage of the total syringe volume used when adding a standard to a sample, i.e... a setting of 10% (when utilizing a 10µl syringe) would cause 1µl of standard solution to be drawn into the syringe each time a sample was to be injected. If this parameter is used, each sample injection will have standard added to the syringe along with the sample. Note, the standard is always drawn into the syringe first and the sum of the standard volume and sample cannot exceed 100%.
Sample Volume %	[0-100%]	The percentage of the total syringe volume used, i.e... a setting of 10% (when utilizing a 10µl syringe) will inject 1µl of sample solution.

Sample Rinse	[0-10]	The number of times the syringe is filled with sample and "emptied" to the waste vial. The volume of sample loaded into the syringe will be according to the Sample Volume % Parameter.
Sample Pumps	[0-10]	The syringe will be flushed this number of times with standard/sample solution before the final standard / sample solution is drawn into the syringe prior to injection. The syringe will remain in the sample vial for this process. This helps to purge air bubbles from the syringe before drawing in the final sample to be injected.
Sample Fill Rate %	[0-100%]	The plunger motor fill rate speed will may be controlled with this value. Use 100% for the fastest plunger operation. Use a lower number if more viscous samples are being used to avoid bubble formation.
Sample Inj Rate %	[0-100%]	The plunger injection speed is controlled with this parameter. Use a lower number if more viscous samples are being used to increase reproducibility. Use 100% for the fastest injection speed.
Syringe Offset %	[0-20%]	The syringe offset determines what volume of sample remains in the syringe at the completion of an injection. A value of 10% to 20% may be useful in avoiding volume errors due to bubbles caused by certain sample types. The offset is ignored during the rinse cycle. This parameter MUST be set to if the Pre-Fill air parameter is being used.
PreFill Air %	[0-100%]	The amount of air to be drawn into the syringe before drawing in the standard/sample. This provides a head space of air to help purge the syringe of the entire sample during injection. The value entered is a percentage of the total syringe volume, i.e. a setting of 10% (when utilizing a 10µl syringe) will draw 1µl of air into the syringe. **See "Syringe Offset Parameter".** Note, the sum of the standard volume & sample volume & Prefill Air % cannot exceed 100% of the syringe capacity.

MidFill Air %	[0-100%]	The amount of air to be drawn into the syringe after drawing the sample/standard volume. This air space will be utilized as a buffer between the two different solutions in the syringe. The value entered is a percentage of the total syringe volume i.e. a setting of 10% (when utilizing a 10µl syringe) will draw 1µl of air into the syringe each time a standard solution is drawn into the syringe. This parameter is not used if the Standard Volume is set to "0".
PostFill Air %	[0-100%]	The amount of air to be drawn into the syringe after the sample is drawn into the syringe. This air volume can reduce "needle burn off" of sample in the injection port. The value entered is a percentage of the total syringe volume, i.e. a setting of 10% (when utilizing a 10µl syringe) will cause 1µl of air to be drawn into the syringe after the sample solution is drawn into the syringe.
Start Delay	[0-999 min.]	This parameter allows the autosampler to begin its sampling sequence at a future time, up to 999 minutes from the start point.
PreInj Delay	[0-600 sec.]	The number of seconds to pause after the syringe needle has entered the sample injection port. In systems where "needle burn" occurs this value can help separate the initial solvent injection from the main sample injection.
PostInj Delay	[0-600 sec.]	The number of seconds to pause (Dwell) after the sample has been injected. This feature allows the sample, time to completely leave the needle, before the needle is withdrawn from the injection port. GC Start and Data Start signals have been activated.
Inject Target	[A, B, A&B, A+B]	There are two injection targets possible, "A" and "B". The sample will be injected into the assigned target(s). The position of the inlets does not matter, they can be left/right or front/rear. Multiple targets may be selected by entering one of the A, B combination values. The Left/Right arrow keys will scroll through the selections available.

	[A&B]	All volume of standard/sample is drawn into the syringe for both inlet injections. Injection of the sample volume is made into port A and then the syringe goes directly to port B and injects the remaining volume. The injection volume per inlet, is whatever percent was programmed.
	[A+B]	The programmed standard/sample volume is drawn into the syringe and injected into port A. Without rinsing, the syringe returns to the standard/sample vial and draws the programmed volume of standard/sample solution, this is then injected into port B.
PostFill Delay	[0-60 sec.]	This parameter allows a pause after the plunger has pulled the programmed sample volume into the syringe barrel. This delay, in seconds, allows viscous samples to completely fill the syringe barrel before the syringe needle is removed from the sample vial.
Operate Mode	[Remote / Internal]	Remote or Local operating modes are selectable by using the Left/Right arrow keys. In the Local mode, the Cobra L/S operates according to the Cycle Time Parameter. In the Remote mode, a GC Ready or Start signal must be received, and the Cycle Timer must be at "0" before the injection can begin.
Cycle Time Minutes	[0-999 min.]	Begins counting time from when the injection is made, (plunger is depressed). The next sample injection process will not start until this amount of time has elapsed. The syringe will however be rinsed, after the injection, according to the number of Rinses programmed. If the duration of post-rinse sequences requires a longer time period than the Cycle time, this parameter is not the determining time between injection cycles. This parameter is only required when running in the Local mode.
Aux. Time Minutes	[0-999 min.]	The auxiliary timer begins marking time when the sampling sequence begins. At the end of the programmed time, the Auxiliary Output switch is pulsed.

Link to Method	[0-10]	Methods may be linked together allowing the Cobra L\S to run multiple methods in a continuous process. Note: Circular linkage of a single method is allowed providing for continuous sample operations. When the method parameter is set to "0", the Cobra L\S will only run the one selected method.

See Section 6.3.2 for an example of Method Parameter Setup values. The Method example may be used for most sample situations.

6.3 Utilizing Standard Solutions

The Cobra L/S allows standard solutions to be automatically added to the sample injection. The syringe will first fill with standard solution and then move to the sample vial and pull up the sample into the syringe. Both sample and standard will then be injected as one “sample”.

Standards are loaded into the tray in the far right vial column, vial positions 113 to 120. When a Standard Volume is programmed, the syringe will move to the standard vial position along each row of sample. As an example, all samples processed in vial row #1 will use position # 113 as the standard location. All samples in row # 2 will use position # 114 as the standard location. This pattern is used all the way to row # 8 Standard position # 120. What this means is samples **CANNOT** be loaded in locations 113 -120, this is reserved for Standards **ONLY**!

This method works well for injection methods into single injectors and in the dual inject mode [A+B] (see Inject Target parameter in Section 6.2). It does not work in the dual inject mode [A&B] because the sample and standard are not sufficiently mixed in the syringe.

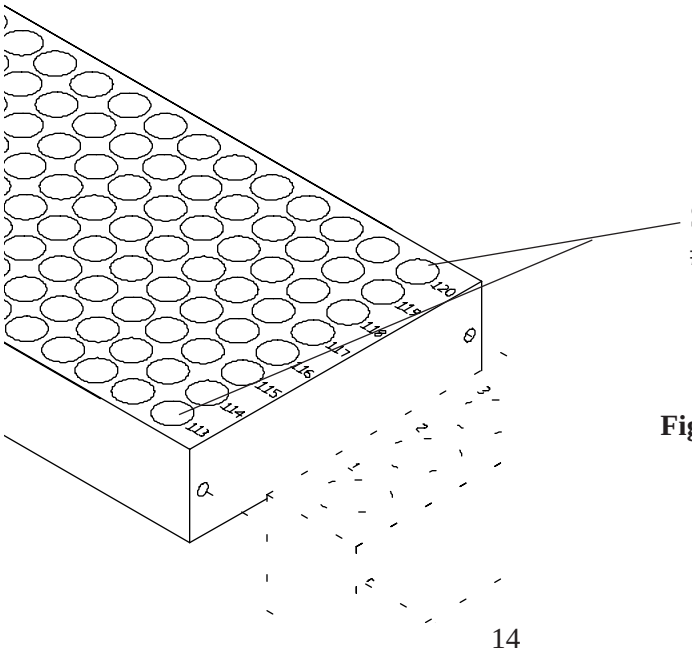


Figure 6.3

6.4 Suggested Method Parameter Values Utilizing Hexane and Methylene Chloride

Use the following as an example to setup Method Parameter Values. These values are suggested for solvents such as Hexane and Methylene Chloride. This Method is with a 5µl syringe installed. The sample is 1 µl, with a .25 µl offset injecting into inlet A. The syringe will be rinsed with 5µl of rinse #1 twice and #2 once. Prior to injection, it will dump the rinse twice, into waste, and then flush in the vial 5 times. This should eliminate any bubble problems with any solvent.

Method Parameter	**Initial Value**
# Inject/Sample	1
# Rinse/Solvent #1	2
# Rinse/Solvent #2	1
Rinse Volume %	100
Rinse Fill Rate %	10
Sample Volume %	20
# Dumps/Inject	2
# Flushes/Inject	5
Sample Fill Rate	10
Sample Inject Rate	100
Syringe Offset	5
Operating Mode	Remote

7.0 Operational Keys

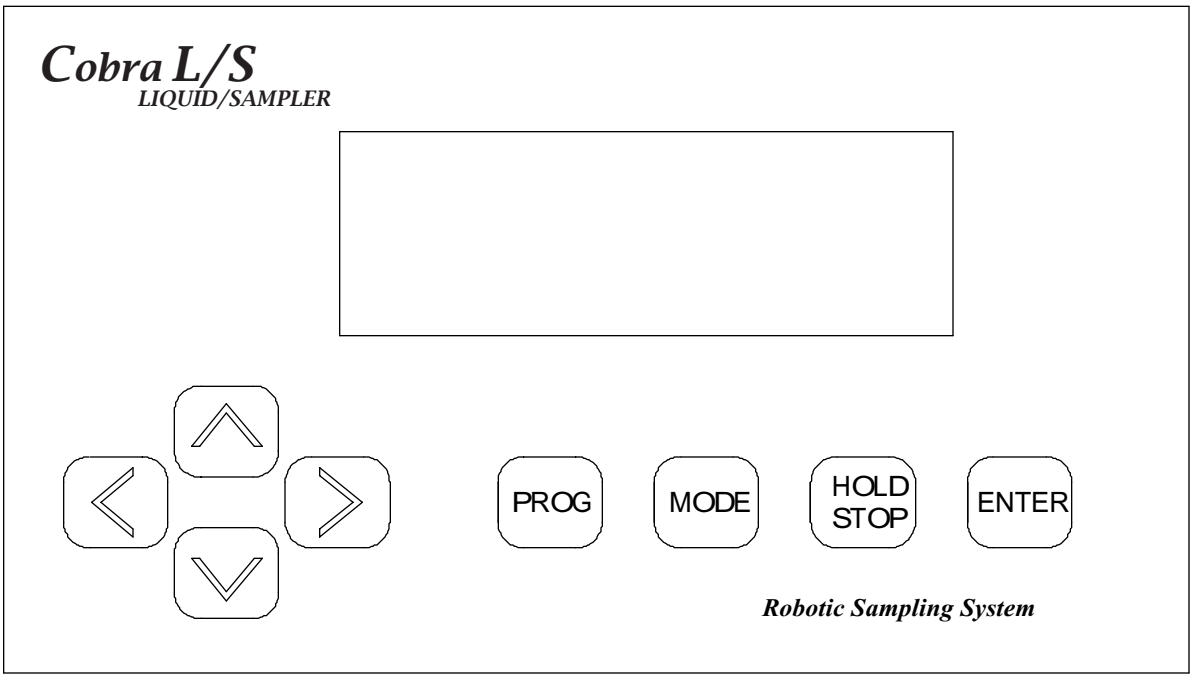
7.1 Hold/Stop Key

The Pause/Stop Key performs two (2) functions:

1. Pause the current Auto Sampler operation at its completion. **The sampling continues until a complete sample injection cycle is completed.** The method parameters and/or the system parameters may then be edited or a priority **Manual Injection** may be performed. The system may then resume the AutoRun (where it paused) and complete the method.

2. Abort the current AutoRun or other function. The Syringe contents may be dumped to waste and/or immediately returned to its "Home" position and the AutoRun **may not** be resumed from the point it was stopped.

NOTE: The EndPause can be turned off at any point before it is actually executed by pressing the Enter Key.



Cobra L/S Keyboard Overlay

Press Hold/Stop Key - One Time.

During any operation of the Auto Sampler the **"Hold/Stop" Key** may be pressed. Hold the key down until the "End Pause" message appears. For an operation pause, the screen will display the prompt "***End Pause***". The Auto Sampler will continue until the current injection cycle is completed.

At this point practically any aspect of the Auto Sampler may be updated. Methods may be edited, a Priority Manual Sample may be performed or any of the System parameters may be changed. To resume the AutoRun from the point it was paused, press the **"Enter" Key**.

Press Hold/Stop Key - Two Times.

Pressing the **"Hold/Stop" Key** the second time will immediately stop the motors. A prompt will appear on the screen to allow the syringe contents to be dumped to the waste vial before returning the syringe to its home position and reset. The method or AutoRun cannot be resumed from the position it was stopped without editing the method and changing the "First Vial Position". If the syringe contains any solution at this point, press the **"Enter" Key** to allow it to be dumped into the waste vial before returning the syringe to its home position.

CAUTION: Syringe contents will be emptied where the syringe is currently positioned if the "Hold/Stop" key is pressed instead of the "Enter" Key. This could cause hazardous and/or corrosive chemicals to be dispensed into the atmosphere and/or onto the Auto Sampler and Analyzer.

7.2 Prog (Program) Key

The Prog Key is used to access the Cobra L/S Method Edit and Setup menus. The user must select either the Method Edit or Setup screen with the Up/Down arrow keys and press Enter. If Method Edit is selected, enter with the Left/Right keys, a method number from #1-10 and press the Enter Key. The display will change to the method number entered allowing for editing or review.

If the Setup menu line is selected, the next screen allows access to the "Configuration, Maintenance, Diagnostics and Motor Speeds" menus. These menus will be discussed in detail in Section 8.

To exit the "Prog" key selection press the Hold/Stop key.

7.3 Mode Key

The mode key allows the user to begin running samples. Press the "Mode" key and the next screen will display the selection of "Auto Run" or "Manual Run." The user can select either mode with the Up/Down arrow keys. If the Auto Run is desired enter the method number, with the Left/Right arrow keys, then press Enter. This will immediately begin the sampling sequence per the Method selected.

If the Manual mode is selected, the next screen allows the user to run a single sample or rinse the syringe. If a sample is to be run the user must enter the Method number and the sample vial number to run. The Left/Right arrow keys are used to enter this data. Press the Enter key and the sequence begins.

If Sample Rinse is selected, the next screen allows the user to enter the Method number to run the rinse syringe sequence. Press the Enter key to begin the sequence.

NOTE: The Auto Sampler will rinse the syringe according to the parameters in the Method number selected. It is advised that a Method be dedicated to the desired syringe flushing cycle and stored for future use.

8.0 Cobra L/S Setup Menus

The Setup Menu allows the user to access the Cobra L/S Configuration, Maintenance, Diagnostics and Motor Speed menus. These menus provide complete setup and diagnostic tools for installation and performance setup. **Note: Several of the menus in this section are intended only for a service technician.**

8.1 Configuration Menu

Configuration menu allows the setup of the sample tray and all needle targets (these were discussed in detail in Sections 4.0 and 5.0).

8.2 Maintenance Menu

Maintenance menu displays the current Firmware revision code and the Plunger count. This is useful in knowing the life cycle of a Teflon tip style syringe plunger. The count can be reset by using the Left/Right arrow keys. To exit the menu press the Hold/Stop key.

8.3 Diagnostics Menu

CAUTION: Only trained personnel should operate the Cobra L/S whenever the Diagnostics menu is accessed. Damage to the syringe, sample vials and/or chromatography instrument could be severe if untrained personnel attempt to use this menu without a complete understanding of is purpose!

This menu will allow the *trained* operator to move the Front/Back, Vertical, Plunger and Right/Left axis. Additionally, the motor movement parameters may be changed. These are the beginning and ending ramping and the final speed settings. **NOTE: If this menu has been accessed, the menu line "Enter To Test", will cause each axis to move until the Stop key is pressed!**

8.3.1 Relay Output Testing

Additional diagnostic information is available for relay testing. These are the GC/Data, Auxiliary and Spare Output relays and the Input signal data. This information is useful for determining if one of the output relays is not working. Relays maybe wired for normally open or normally closed, the closure is for .5 seconds. The default setting is in the N.O. mode.

From the Diagnostics menu, scroll, using the UP/Down arrow keys, to the relay desired for testing, press the enter key. The display will show the selected output, i.e....GC/DATA Start, Enter to test, Stop to exit.

To preform the test be certain the I/O cable is properly connected or a VOM meter is set to the correct position to test the output. Follow the instructions on the display.

8.3.2 Input Signal Test

This screen allows the GC ready signal to be tested. The normal state should be OFF, once an input signal is received, the OFF will toggle to ON. The screen line "Spare 7" is an indicator showing that the spare (these are signal line inputs for future use) signals are floating "high."

8.3.3 Motor Delay

CAUTION: Only trained service personnel should operate the Cobra L/S whenever this Diagnostics menu is accessed. Damage to the syringe, sample vials and/or chromatography instrument could be severe if untrained personnel attempt to use this menu without a complete understanding of is purpose! This menu is intended for the service technician.

This menu allows the stepper motor delay time (in milliseconds) to be changed. This time is the duration of pause at the end of one motor movement and the start of the next motor movement. The factory default is 100 ms. The Left/Right arrows will change the value. Press Enter to exit.

To test the new time setting you must scroll to one of the motor axis movement menu lines. The best one is probably the Left/Right axis, follow the screen prompts to access moving "all" motors.

8.3.4 Motor Speeds

This screen allows the service technician access to settings for all the motor speeds. This information should be used for reference only. ***ONLY TRAINED SERVICE TECHNICIANS SHOULD ATTEMPT TO MAKE MOTOR SETTING CHANGES!*** The Motor speed settings are set and confirmed when the individual axis menu is selected.

In the Motor Speeds menu, each axis can be moved for testing, and if necessary, the speed values changed. This allows each of the movement parameters to be altered, ramping for beginning and ending (F; delay between steps for starting rate), (R; delay between steps for final rate), (S; acceleration or ramping speed). Once these settings are entered the Motor Speed menu will allow the user the check the settings.

The settings are:
Speed...this is the final speed of the motor.
Initial Rate (Initrat)...this is the plunger's initial movement speed.
Acceleration (Accel)...this is the speed for beginning (accelerate) and ending (decelerate) motor speeds for the balance of the motors.

9.0 External I/O Connections

The Cobra L/S has a 25 pin "D" connector on the rear of the cabinet for External I/O connections, i.e. GC Ready, GC Start, Data Start, etc. The following is a list and pin locations for the signals. Note: The Cobra L/S is supplied with an External I/O cable that will be specific to your GC system however, not all functions shown will be wired in your cable. Be certain the cable you received is correct for your system, see Figure 9.0 for complete cable connections.

Pin #	**Signal**
1.	Signal Ground
2.	In 1 Ground
3.	In 2 Ground
4.	In 3 Ground
5.	GC Start N/O
6.	GC Start N/C
7.	Data Start Com
8.	Auxiliary N/O
9.	Auxiliary N/C
14.	GC Ready Input
18.	GC Start Com
19.	Data Start N/O
20.	Data Start N/C
21.	Auxiliary Com
22.	Spare Out N/O
23.	Spare Out N/C
24.	Ground
25.	5 VDC Out

10.0 Remote Control (RS 232 Serial Link)

The Cobra L/S can be Remote Controlled through its Serial Interface Link, labeled "RS 232." This may be accomplished in either the "Remote or Local" Mode (this is programmed in the Methods). Commands may be received from either the Host PC or the keypad, however the keypad is LOCKED out with a message on the on the LCD while the PC is programming. The Cobra L/S is started by a signal generated by either the GC Ready signal, the Host PC or the keypad.

The Cobra L/S requires a 9 conductor cable to Receive, Transmit and Ground, fed straight through. If you do not have a cable consult the factory. Plug the cable into the 9 position "D" connector on the rear of the Cobra L/S labeled "RS 232" and then into the 9 pin serial connector on the rear of your PC.

10.1 Data Format

The Data Transmission from the host to the Cobra L/S and from the Cobra L/S to the host use the same data format. Communications are RS 232 as follows: 19200 baud, no parity, 8 bits, 1 stop bit and no handshaking.

10.2 Command Summary from Host to Cobra L/S

All Commands require 3 bytes, followed by a CR. Shorter commands should be padded with a CR to make them 4 bytes long, total.

Q Get Cobra's attention (Cobra will stop running, and echo ok) and print "PC Host active" on line 4 of the LCD screen. When the PC host releases control, "PC link Idle", will appear on line 4 of the LCD, if the Cobra L/S was idle, otherwise, the run will continue from where it was interrupted, unless an Rn or Gn command had been issued by the host. Note that parameters updated with the MWn command will not take effect until the batch is started the next time.

Attempts to communicate with the Cobra L/S while it is performing a manually initiated rinse will be ignored.

After the Cobra L/S has responded to the Q command, the following commands are available:

Note...For commands with a method parameter, the examples use method 1. In the Mode After column, remote indicates the PC Host stays in control after the command is executed, and the Cobra keypad is disabled. Local means control has transferred back to the Cobra.

Command	Example	Mode After	Description
MWn	77 87 01 13	Remote	Program method parameters (requires parameter string to follow)
SW	83 87 13 13	Remote	Program system parameters (requires parameter string to follow)
Rn	82 01 13 13	Remote	Start running method n
V0	86 48 13 13	Local	Turn off Verbose mode, no status messages will be sent while the Cobra is running
V1	86 49 13 13	Local	Turn on Verbose mode, "PC Host active" LCD message changes to "Linked to host"
MRn	77 82 01 13	Remote	Request Method parameters for method n
SR	87 82 13 13	Remote	Request System parameters
ST	87 84 13 13	Local	Request Current status. One of the following series of two binary bytes, followed by CR will be sent: 1-10, 1-12 0-Running method, sample 0, 101 - Manual mode, 0, 102 - Idle
GO	71 79 13 13	Local	Resume running if a method was interrupted, or return to local control if Cobra was not running.

GN	71 78 13 13	Local	Resume running at beginning of current cycle, after dumping syringe contents to waste, or return to local control.
AB	65 66 13 13	Local	Abort current method, dump syringe and return to local control
Q	81 13 13 13	Remote	Echo "ok", useful for synchronizing with Cobra, works to establish communications initially, and does no harm if communications are already working
<ESC>	27 13 13 13	Remote	Return cobra to local keypad control, and continue method if one was interrupted (Same effect ad GO)

For both Rn and Gn, the Cobra will transmit "Run Complete" CR when the method is complete. The system will wait for a keypad press, or any character over the serial link, and then return control to the Cobra. A remote program will have to re-send Q to get back to control. All commands should be terminated with a Carriage Return (binary 13). All method #'s (n) should be binary, not ASCII value, i.e. 77 82 49 01 for MR1, except the Rn command, in which the n can be either the ASCII equivalent, or the binary value, i.e. 82 01 13 13 and 82 49 13 13 will both start Run 1.

10.3 Cobra L/S Command Details

To program a method remotely from a host PC:

1) PC sends a Q to get sampler's attention

2) PC waits for ok, indicating Cobra is ready

3) PC sends "MWn" CR, to indicate method is to be programmed.

4) PC waits for ok CR, indicating the Cobra is ready

5) PC sends the following binary string, all word (2 byte) values:

Byte#	#Bytes	Content	Allowed Range (PC code must enforce these limits)
0	2	First Vial	1-120
2	2	Last Vial	1-120
4	2	Num of repeats/sample	1-100
6	2	# of rinse ones	0-20
8	2	# of rinse twos	0-20
10	2	rinse volume	0-100%
12	2	Rinse fill rate	0-100%
14	2	Standard Volume	0-100%
16	2	Sample Volume	0-100%
18	2	Num of solvent dumps/inject	0-10
20	2	Num of solv. flushes/inject	0-100

22	2	Sample Fill Rate	0-100%
24	2	Sample dispense rate	0-100%
26	2	Syringe Offset	0-20%
28	2	Prefill Air	0-100%
30	2	MidFill Air	0-100%
32	2	Postfill Air	0-100%
34	2	Start delay (seconds)	0-999
36	2	Pause before sample dispense	0-600
38	2	Pause after sample dispense	0-600
40	2	Target	0-3 (0-A, 1-B, 2-A&B 3-A+B)
42	2	Pause after sample fill	0-60
44	2	Operation mode	0-1 (0-continuous, 1-GC trigger)
46	2	Cycle time (secs) when Opmode=0	0-999
48	2	Seconds till auxiliary relay closure	0-999 (clock starts at cycle start)
50	2	Link to method # on method completion	0-10 0 for no link
52	1	CR	

6) Cobra will respond with ok

7) Host sends Rn to start method n. Cobra will respond by starting method. For example, sending R1 (binary 82 49 13 13) starts method 1, whether or not it was just programmed. To start Cobra in Verbose mode, where status reports are sent while running, send the V (86 49 13 13) command first.

10.4 Program System Parameters

1. PC sends a Q to get sampler's attention

2. PC waits for ok, indicating Cobra is ready

3. PC sends "SW" (binary 83 87) to indicate system parameters are be programmed.

4. PC sends the following binary string:

Byte#	#Bytes	Content	Allowed Range
0	2	Right/Left Final Speed	0-999
2	2	Forward/Back Speed	0-999
4	2	Vertical Final Speed	0-999
6	2	Plunger Final Speed	0-999
8	2	Plunger Initial Rate	0-999
10	1	Plunger Acceleration	0-255
11	1	Normal Acceleration	0-255

12	1	Vertical Acceleration	0-255
13	1	Tray Size	0-3 (only 0 currently supported)

5. Cobra will respond with ok.

10.5 System Errors

Undefined commands will get a response “Undefined command”
All parameters must be in their allowed range, Cobra will not edit incoming values.
Cobra will wait for an enter key press (ASCII 13) to continue after an error.

10.6 Error codes

1 Undefined command
2 Invalid value
3 Not yet supported
4 Current run must be aborted first

11.0 Cobra L/S Installation of Cables and Mounting Hardware

The following section details the Cobra L/S mounting bracket hardware and I/O cable installation. Refer to the drawings for detail.

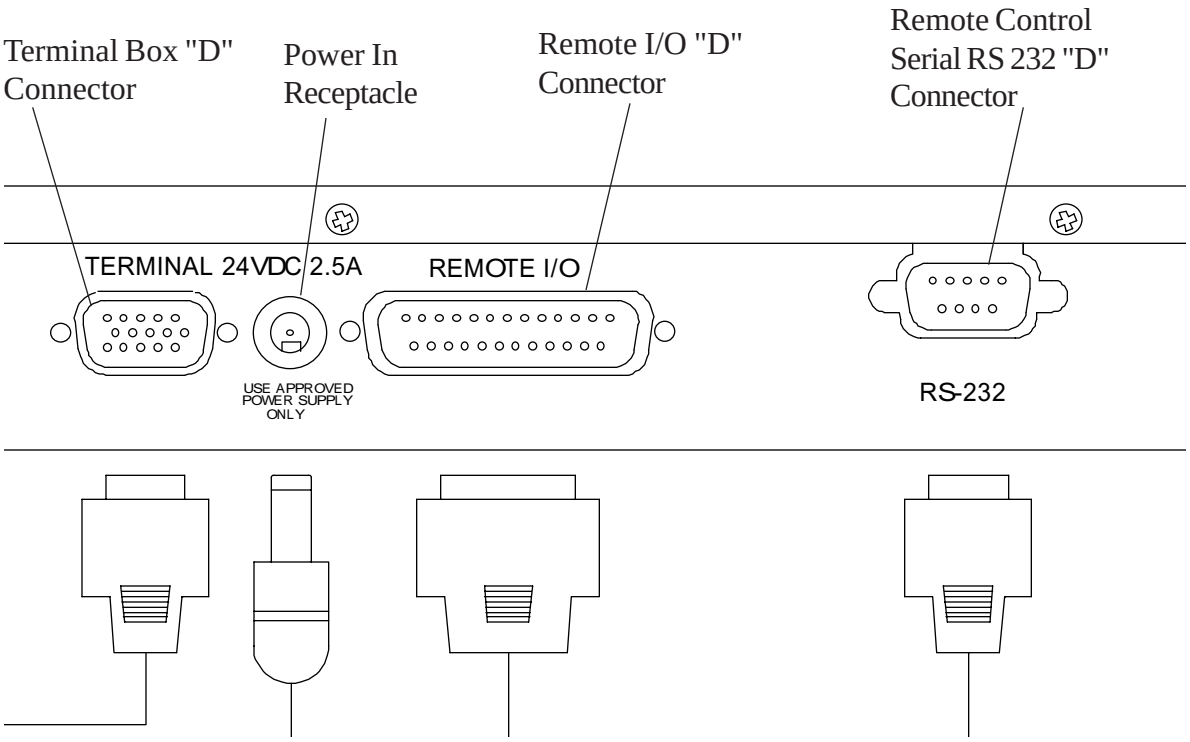
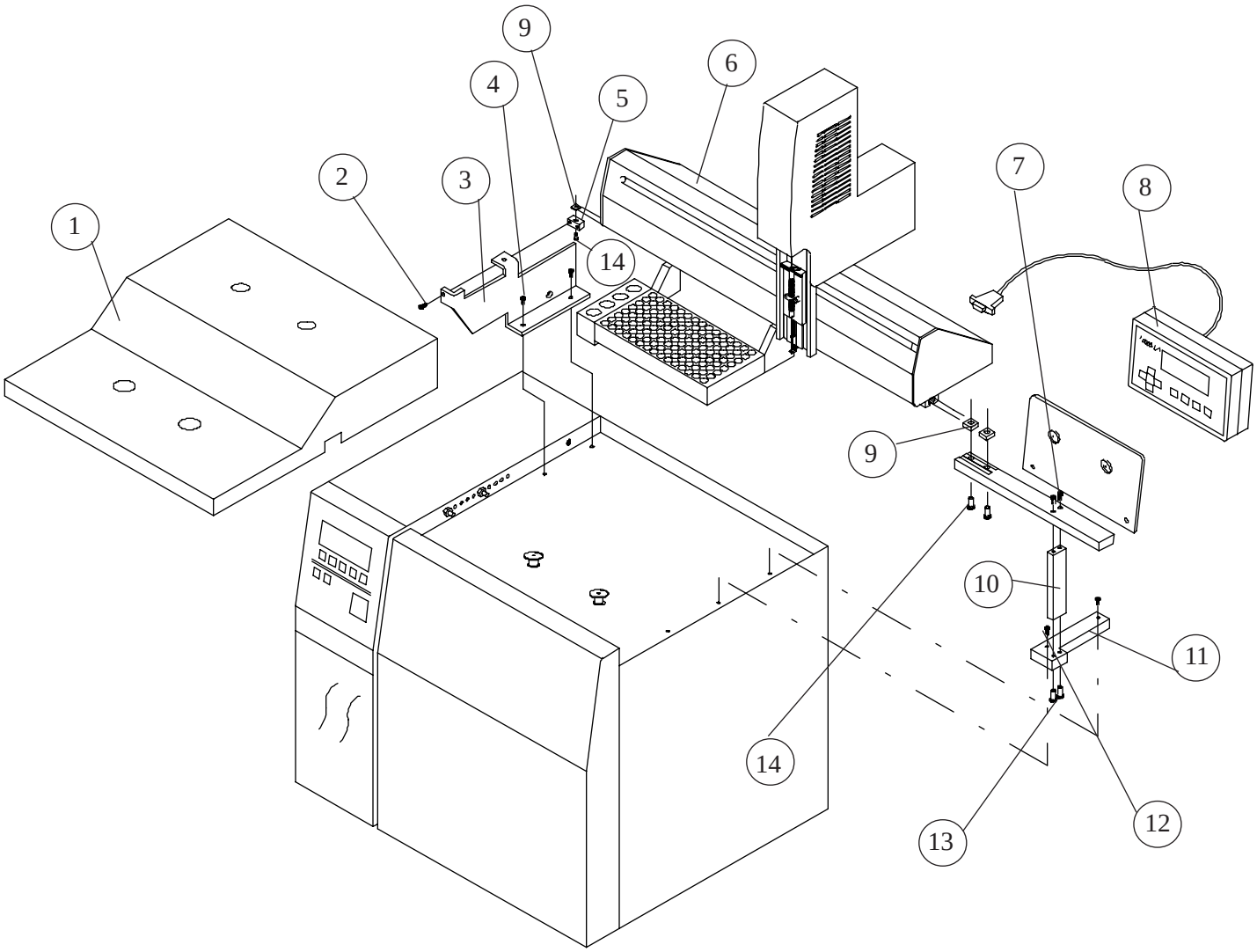


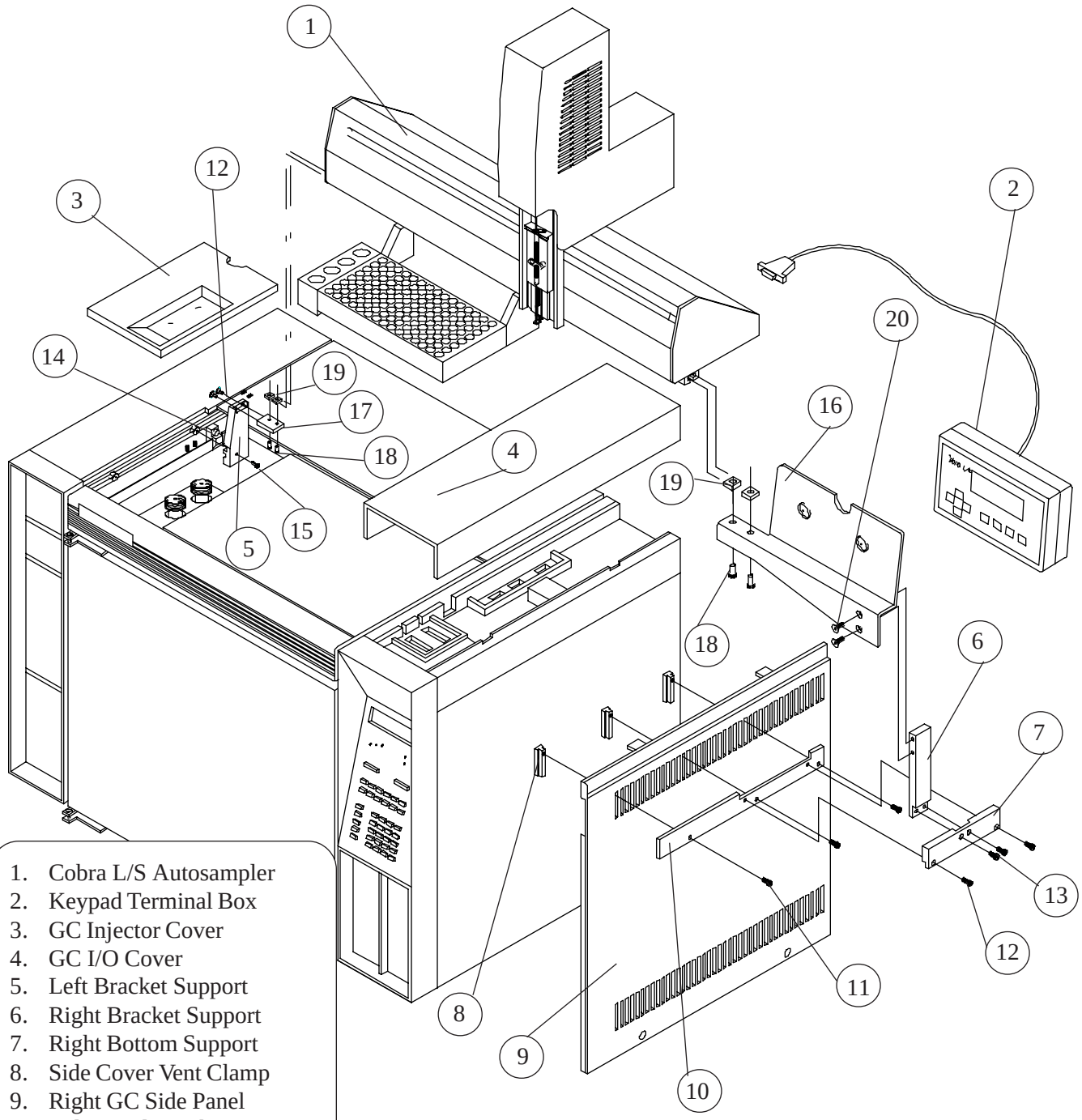
Figure 11.0
Cobra L/S Rear Panel

11.1 Installation of the Cobra L/S to the Gow-Mac 600 Gas Chromatograph



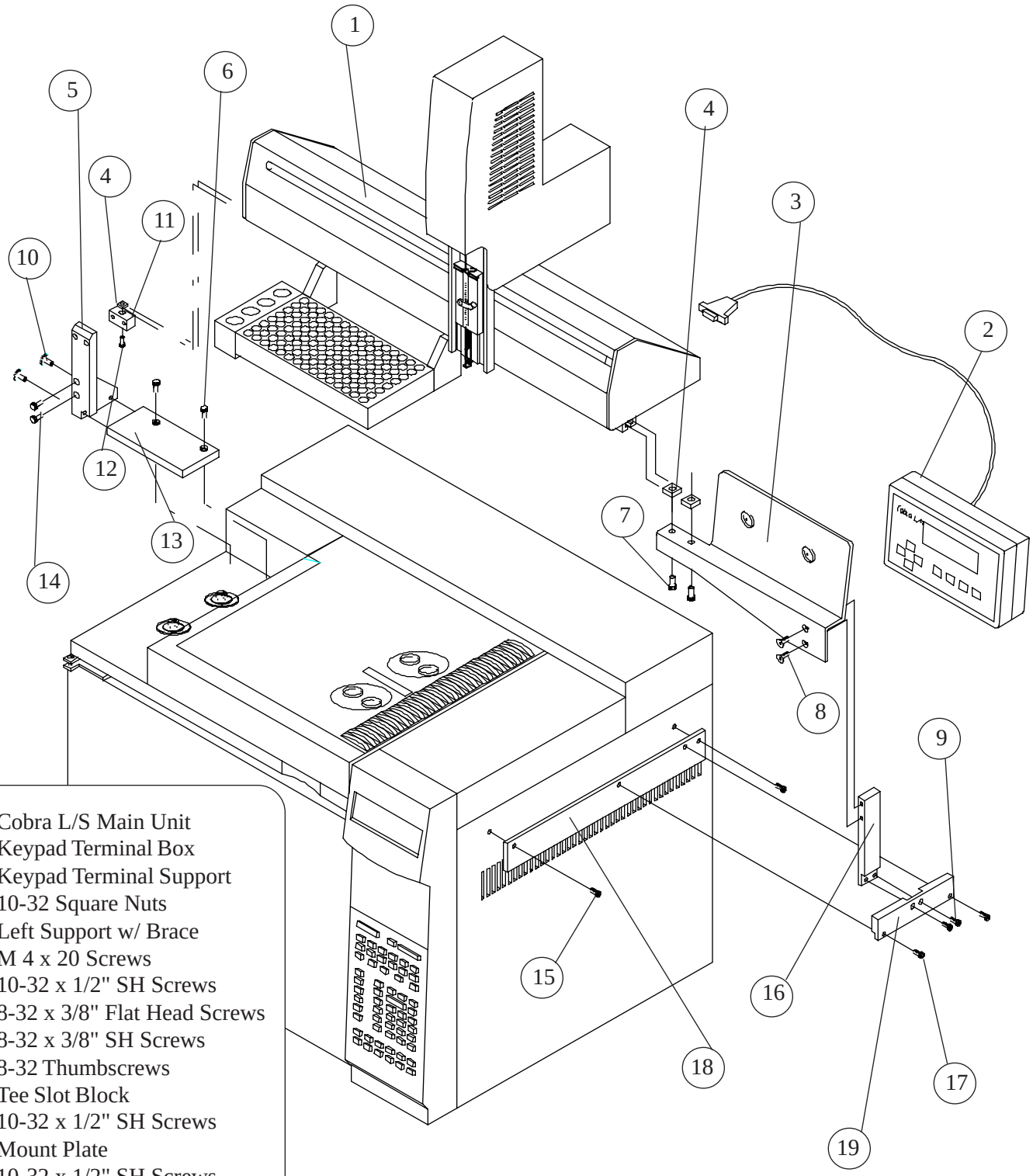
1. GC Oven Top
2. 6-32 x 1/2" SH Screw W/ #6 Lockwashers
3. Left Mount Bracket
4. 10-32 x 1/2" SH Screws W/ #10 Lockwashers
5. Bracket Mount Block
6. Cobra L/S
7. 8-32 x 1/2 SH Screws
8. Keypad Terminal
9. 10-32 Square Nuts
10. Right Vertical Mount Block
11. Right Bottom Mount Block
12. M4 x 20mm Screws
13. 8-32 x 1/2 SH Screws W/ #8 Lockwashers
14. 10-32 x 1/2" SH Screws

11.2 Installation of the Cobra L/S to the HP 5890 Gas Chromatograph



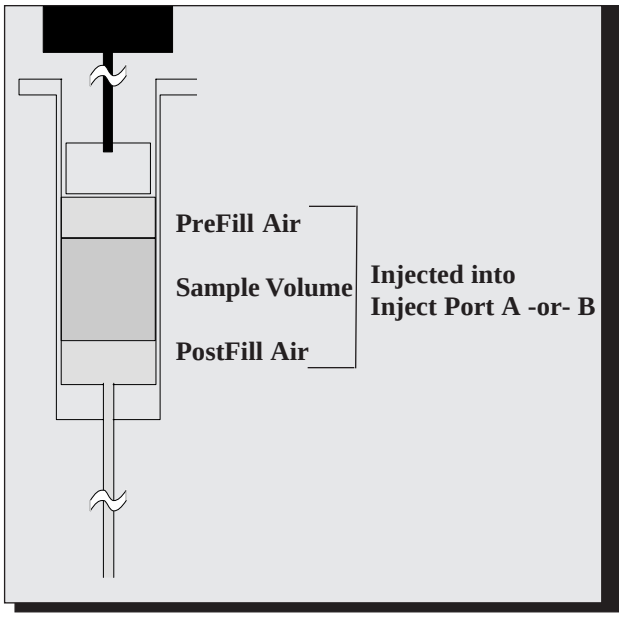
1. Cobra L/S Autosampler
2. Keypad Terminal Box
3. GC Injector Cover
4. GC I/O Cover
5. Left Bracket Support
6. Right Bracket Support
7. Right Bottom Support
8. Side Cover Vent Clamp
9. Right GC Side Panel
10. Side Panel Bracket Support
11. 6-32 x 1/2" SH Screws
12. 8-32 x 1/2" SH Screws
13. 8-32 x 3/8" SH Screws
14. Boss Extension on GC
15. 8-32 x 3/4" SH Screws
16. Keypad Terminal Support
17. Left Tee Slot Block
18. 10-32 x 1/2" SH Screws
19. 10-32 Square Nuts
20. 8-32 x 3/8" Flat Head Screw

11.3 Installation of the Cobra L/S to the HP 6890 Gas Chromatograph

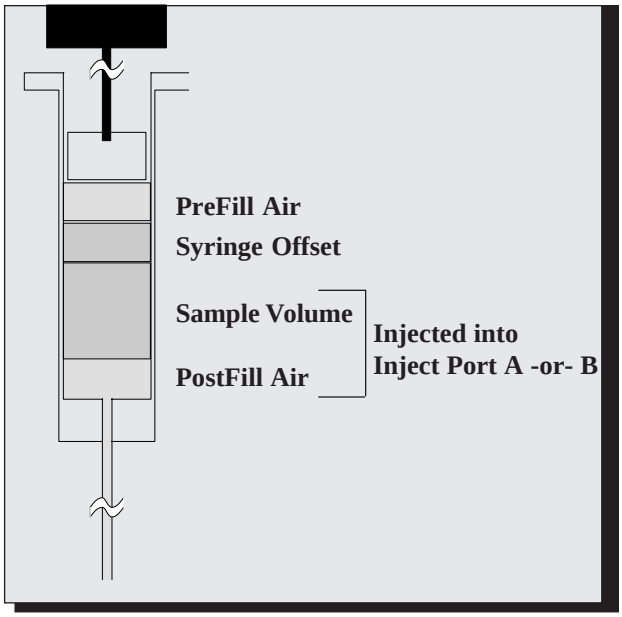


1. Cobra L/S Main Unit
2.. Keypad Terminal Box
3. Keypad Terminal Support
4. 10-32 Square Nuts
5. Left Support w/ Brace
6. M 4 x 20 Screws
7. 10-32 x 1/2" SH Screws
8. 8-32 x 3/8" Flat Head Screws
9. 8-32 x 3/8" SH Screws
10. 8-32 Thumbscrews
11. Tee Slot Block
12. 10-32 x 1/2" SH Screws
13. Mount Plate
14. 10-32 x 1/2" SH Screws
15. M 4 x 20 Screws
16. Right Support
17. 8-32 x 1/2 SH Screws
18. Right GC Mount Plate
19. Right Mount Bar

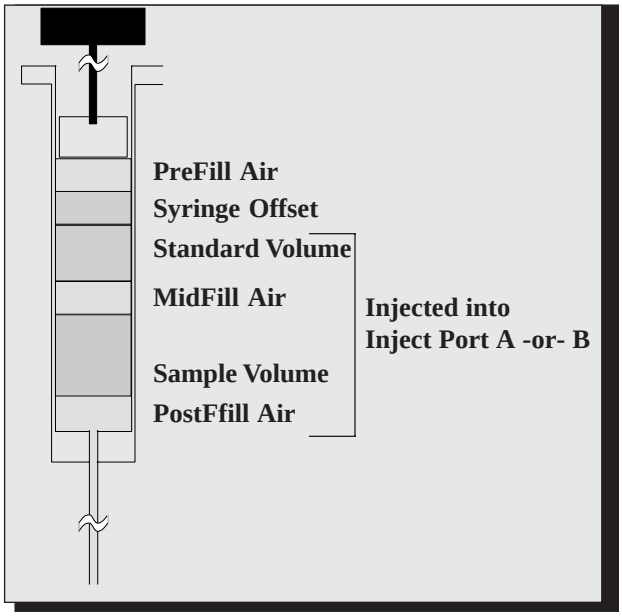
Appendix: Syringe Operation Drawings



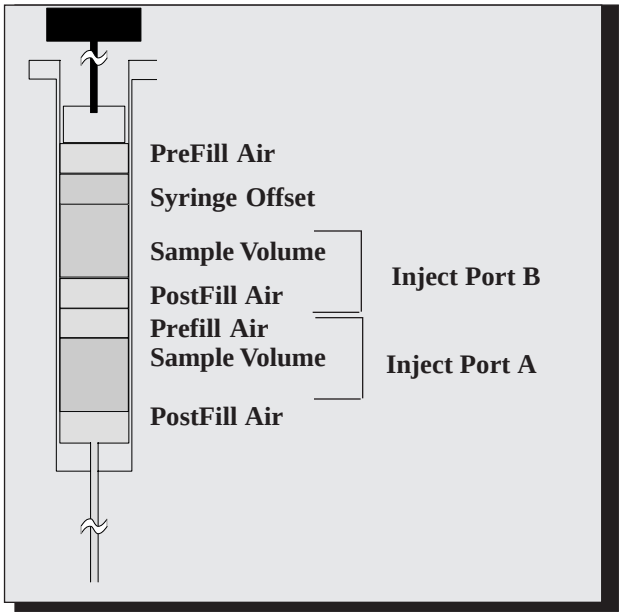
Example 1 - Standard Injection Setup



Example 2 - Syringe Offset Used



Example 3 - Using Syringe Offset and Standard Offset



Example 4 - Using Syringe Offset and Inject Mode = A&B

Use this chart space to log in any method parameters that you must use on a frequent basis.
