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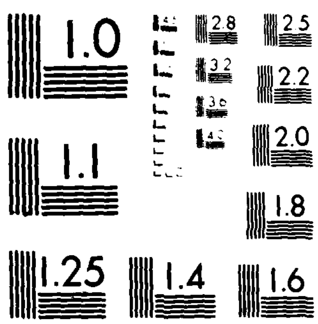

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DEVELOPMENT OF ACCELERATED FUEL-ENGINES QUALIFICATION PROCEDURES METHODOLOGY VOLUME II

INTERIM REPORT
AFLRL No. 144
APPENDICES

AD A113532

By

J.A. Russell
J.P. Cuellar, Jr.
J.C. Tyler
J.Erwin
W.K. Knutson
R.A. Alvarez
U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas

R.L. Stenberg
F.O. Zimmer
U.S. Army Aviation Research and Development Command
St. Louis, Missouri

R.L. Rentz
T.J. Timbario
Mueller Associates, Inc.
Baltimore, Maryland

E. Rodman
S.M. Sokolow
Hamilton Standard Corporation
Windsor Locks, Connecticut

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Alternate Fuels	Test methodology	Elastomer compatibility
Synthetic Fuels	Army equipments	
Shale Fuels	Fuels, Lubricity, Corrosion	
Coal Fuels	Qualification procedures	
Fuel Systems Components	Thermal stability	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Activities and findings are reported for a 12-month program aimed at the development of procedures for accelerating the qualification of new fuels on Army equipment, emphasizing those derived from oil shale and coal. Principal activities were identification of key tactical and combat surface and air vehicles, powerplants, and fuels systems components; identification of critical properties peculiar to new fuels anticipated to have significant impact upon Army materiel; laboratory evaluations of materials

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20. ABSTRACT (cont'd)

compatibility and fuels characteristics (including lubricity, elastomer compatibility, thermal stability, and corrosion); full-scale fuel systems component testing, and an overall review and evaluation of existing engine/fuel system qualification procedures. Conclusions and recommendations are presented in terms of methodology and criteria which will realistically address key peculiarities of alternative fuels and thus serve to accelerate their qualification for field Army use.

18. SUPPLEMENTARY NOTES (cont'd)

US Army Mobility Equipment Research and Development Command, ATTN: DRDME-GL, Fort Belvoir, VA 22060.

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APPENDIX A

AVRADCOM AIRCRAFT/ENGINE COMPONENT LISTINGS

ARMY AIRCRAFT FUEL SYSTEM COMPONENT SURVEY

A1. AIRCRAFT: AH-1G/S (Bell Helicopter Textron)

COMPONENT	MANUFACTURER	BELL PART NO. (MFGR. PART NO.)	COMMENTS
Self Sealing Hose		209-060-668-1	Stratoflex 156 and Aeroquip 235 Buna-N compound could be affected by increase in aromatics and peroxide.
	Aeroquip	(AE1007402J0264)	
	Stratoflex	(156672-10-0264)	
Manifold Valve		205-060-611-3	
	Circle Seal Control	(P13-389)	
	Ronson Hydraulic Units Corporation	(42C42603)	
Self-Sealing Valve, Breakaway		205-063-601-15	
	Aeroquip	(AE96056M)	
	Wiggins	(CW118/15)	
Defuel/Sump Drain Valve (Manual)		209-060-655-5	
	Auto-Valve, Inc.	(96C-5)	
	Shaw Aero Devices, Inc.	(A-440-2)	
Filter Drain Valve		209-060-656-1	
	Auto-Valve, Inc.	(375C-62S)	
Check Valve (Bleed)		209-060-657-1	
	Stellar Hyd. Co.	(69250)	
	Circle Seal Controls	(2632T-4TT-5)	
Shut Off Valve	ITT General Controls	(AV16B1748D)	
Sump Drain Valve, Crashworthy		209-060-661-1	
	Auto-Valve, Inc.	(96C-4)	
	Shaw Aero Devices, Inc.	(A-470)	
Check Valve		209-060-670	
	Auto-Valve, Inc.	(96C-4)	
	Shaw Aero Devices, Inc.	(A-470)	

A1. AIRCRAFT: AF-1G/S (Continued)

COMPONENT	MANUAFACTURER	BELL PART NO. (MFGR. PART NO.)	COMMENTS
Fuel Gage, Tank Unit		209-060-602-3	
(Transmitter)	Simmonds	(393008-032)	
	Gull	(200-040-005)	
Crashworthy/Self-Sealing		209-060-652-1/3	
Fuel Tank	Uniroyal	(FCR-56293)	
		(FCR-56294)	
Cap and Adapter		206-062-660-1 (G)	
		206-062-650-1 (S)	
	Shaw Aero Devices, Inc.	(416-635)	
Closed Circuit Receiver		209-060-694-3	
	Hydraulic Research	(745000-3)	
Inter-Tank Fuel Crossover		209-060-653-1	
	Goodyear	(AFA8000362)	
	Uniroyal	(FCE-55262)	
	Firestone	(50051)	
Boost Pump (Electric)		205-060-606-3	
	Lear-Siegler	(RG12240D2)	Lear-Siegler pump is centrifugal type, submerged motor. It has Buna-N elastomers and one stationery shaft of silicone.
	Globe	(164A168-1)	Globe pump is a centrifugal with a submerged motor which is sealed and completely dry. Seal is a stainless steel or dyallphthilate diaphragm.
Fuel Filter		204-040-760-5	
	Michigan Dynamic	(100103)	
	Fram	(165516)	
Low Level Float Switch	Revere Corp. of America	(F74356)	
Pressure Switch		204-062-542-3	
	Custom Component, Inc.	(7G44)	
Quick Disconnect Coupling		209-060-692-1	
	Aeroquip	(AE96385J)	
	Wiggins	(CW116/01)	

A1. AIRCRAFT: AF-1G/S (Continued)

COMPONENT	MANUFACTURER	BELL PART NO. (MFGR. PART NO.)	COMMENTS
Self-Sealing Coupling		209-060-654-1	
	Aeroquip	(AE96312J)	

A2. AIRCRAFT: UH-1D/H (Bell Helicopter Textron)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. PART NO.)	COMMENTS
1. Main Fuel System			
Self Sealing Hose		205-062-650-9	Stratoflex 156 and Aeroquip 235
	Stratoflex	(B6671-10-0336)	Buna-N compound could be
	Aeroquip	(AE1007399J0336)	sensitive to increases in aromatics and peroxide.
Check Valve (self sealing)		205-063-601-11	
	Aeroquip Corp.	(AE 96311J)	
	E. B. Wiggins, Inc.	(CW 118/11)	
Sump Drain Valve (Manual)	Auto Valve, Inc.	(967B12)	
Drain Valve (Manual)		205-062-656-1	
	Auto Valve, Inc.	(967B-5)	
	Shaw Aero Devices, Inc.	(A 470-1)	
Fuel Shutoff Valve (Motorized)		205-060-612-3	
	ITT General Controls	(AV 16B1667D)	
Siphon Breaker Valve		204-061-689-1	
	Circle Seal Controls	P13-262-1	relief valve
	Ronson Hydraulic Units Corp.	42C42604	check valve
Fuel Quantity Gage (Capacitance)		205-061-633-13	
	Simmonds Precision	(39 3004-01699)	
Gravity/CCR Receptacle		209-060-651-5	
	E.B. Wiggins	(CCR101/5)	
	Hydraulics Research	(744000-5)	
Crashworthy Self-Sealing Fuel Cell		205-062-635-7	Nitrite rubber innerliner
	Goodyear	(2F1637014)	

A2. AIRCRAFT: UH-1D/H (Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. PART NO.)	COMMENTS
Boost Pump - Electrical		205-060-606-3	Lear-Siegler is centrifugal type, submerged motor. Has Buna-N elastomers and one stationary shaft seal made of silicon.
	Globe	(164A168-2)	
	Lear-Siegler	(RG 12240D2)	
Boost Pump - Air		205-060-607-5	
Motor Driven	Hydro-Aire Div. (Crane Co.)	(60-3515)	
	Lear-Siegler	(RG 12470)	
Ejector Pump		205-061-634-1	
	Arkwin Industries	(13A006-1)	
	Allen Aircraft Products	(610E100)	
Flapper Valve		205-060-666-1	
	Allen Aircraft Products	(24C156)	
‹iller Cap - Gravity CCR		209-060-651-5	
	Shaw Aero Devices, Inc.	(FC 3500-30)	
		(PC 3500-159)	
Fuel Filter		204-040-760	
	Mich. Dynamics	(100103)	
	Fram	(165516)	
2. Auxiliary Fuel System			
Crashworthy Fuel Cells		205-061-621-3/4	Fabric inner liner.
	Uniroyal	(FCB-55121)	
Vent Valve		204-061-689	
	Ronson Hydraulic Unit Corp.	(42C42604)	
	Circle Seal Controls	(P13-262-1)	

A2. AIRCRAFT: UH-1D/H (Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. PART NO.	COMMENTS
Transfer Pump-Electric	Lear-Siegler Globe Industries	205-061-626-3 (RR 125802) (164A166)	Lear-Siegler pump is centrifugal type, submerged motor has Buna-N elastomers and one stationary shaft seal of silicon.
Float Switch - Shutoff	Revere Corp. of America	204-060-654-5 (F-74070-2)	Includes a check valve: (205-062-655-1) Aeroquip AE 95318G Wiggins CW 118/09
Check Valve	Vinson Mfg. Co. James Pond & Clark	205-061-623 (A-62083) (869A-12BB-54)	

Army Aircraft Fuel System Component Survey

A3. AIRCRAFT: OH-6A (Hughes Helicopters) - Crashworthy

COMPONENT	MANUFACTURER	Hughes P/N (Vendor P/N)	COMMENTS
Self Sealing Hose	Aeroquip Corp. Stratoflex	369A8486 (AE1008247J0132) (156755EEF0132)	Aeroquip Hose (AE 235), Buna Hose will be sensitive to increases in Aromatics and Peroxides, but less sensitive than AE 502.
Breakaway Fuel Valve, In-Line	E.B. Wiggins Aeroquip	369A8468 (CW108/01) (AE 97124H)	
Breakaway Valve, Fuel	E.B. Wiggins Aeroquip	369A8467 (CW 107/01) (AE 97122J)	
Emergency Shutoff Valve, Fuel Vent Line	Hydraulics Research	369A8420 (701100-1)	

A3. AIRCRAFT: OH-6A (Continued)

COMPONENT	MANUFACTURER	Hughes P/N (Vendor P/N)	COMMENTS
Valve Assembly - Fuel Shut-off (Crash Resistant Fuel System)		369A8469	
	Allen Aircraft Prod.	(8D146)	
	ITT General Controls	(AV24D1128)	
	Parker Hannifan	(2720031)	
	Dukes Astronautics Co.	(4571-00)	
	PNEU Draulics Inc.	(3212)	
Fuel Quantity - Transmitter		369A4520-3	
Fuel Drain Valve - Crashworthy		369A8482-3	
	E.B. Wiggins	(H56F)	
	Hydraulics Research	(773100-3)	
Gravity Valve, Breakaway		369A8470	
	E.B. Wiggins	(CWH57F)	
Closed Circuit Rec. Assy.		369A8471	
	Hydraulics Research	(744100-1)	
Fuel Cell - Self Sealing		369A8465	Nitrile rubber inner liner.
	Goodyear	(AJA8000758)	
Electric Boost Pump		369A8143	
	TRW	(1C3-40)	
	Globe	(164A-134)	
Gravity Filler Cap	Shaw Aero Devices, Inc.	(35001-2)	
CCR Filler Cap	Shaw Aero Devices, Inc.	(416-50)	

Army Aitcraft Fuel System Component Survey
A4. AIRCRAFT: CH-47 C (Boeing Vertol)

COMPONENT	MANUFACTURER	Airframe P/N (MFGR'S P/N)	COMMENTS
Main Fuel System:			
Self-Sealing Hose	Aeroquip	114PS466 (AE 502)	Buna Compound sensitive to aromatics and peroxides
Check Valve-Thermal Relief	Hydraulic Research	114PS456-1 (314400-1)	
Drain Valve, Fuel Tank	Hydraulic Research Wiggins	114PS465-1 (772500-1) (B7V)	
Check Valve	Hydraulic Research	114PS454-1/2 (220400-1)	
Fuel Probe (tank unit)	Gull Airborne Simmonds Precision	114PS471-2/3 114PS472-1 (012-003-004) (010-017-005) (391057-148)	
Fuel Cells (Main) - self-sealing	Goodyear Uniroyal	114PS458-1 114PS448-15 (AJA8000705) (FCR56562)	Goodyear cell has a nitrile liner. Uniroyal cell has a fabric inner liner.
Fuel Cells (Auxiliary) -	Goodyear Uniroyal	114PS459-1 (AJA8000704) (FCR-56563)	Goodyear cells have nitrile inner liners, Uniroyal cells have fabric inner liners.
Boost Pump - motor operated	Lear-Siegler	114P4111-3 (RG12200E)	A.C. motor drive, centrifugal pump, motor is wet. Elsatomeric material is Buna-N. (Potting compound Shell Epon 828, activator General Mills Versamid 125).

A4. AIRCRAFT: CH-47 C (Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR'S P/N)	COMMENTS
Cap, Filler Opening	Shaw Aero Devices, Inc.	(416-50)	
Motor Driven Pump - auxiliary power	Lear-Siegler	114P4010-1 (RG 15150G)	Dry D.C. motor, vane type. Buna-N is elastomeric material. Has a diaphram of DuPont fairoprene.
Motor driven gate valve	ITT General Controls	114PS401-2 (AV 16B1832D)	
Fuel Selector Valve	Valcor Engineering Corporation	114PS402-2 (V36100-05)	
(Solenoid Valve)		(V3400-02)	
Adapter, Fuel Tank	Shaw Aero Devices, Inc.	(416-736)	
Vent Valve	Hydraulic Research Purolator	114PS457-1/2 (760300-1) (7542049)	
Pressure Actuated Switch	Hydra-Electric Inc.	114PS407-1 (1129)	
Breakaway Fitting	Hydraulic Research	114PS462-5/6/4 (780100-4/5/6)	
Strainer Element Sediment		114PS4258-1	
Quick Disconnect Coupling	Wiggins	375201-6/16	

A4. AIRCRAFT: CH-47C (Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR'S P/N)	COMMENTS
Cock, Poppet Drain	Auto-Valve, Inc.	114P4015-1 (475C-73N)	
Fuel Line Drain Valve	Hydraulic Research Wiggins	114PS464-1 (772700-1) CW 105/01	

A4. AIRCRAFT: CH-47D (ECP 714)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR'S P/N)	COMMENTS
Pressure Fuel Adapter (Manifold Assembly)	Hydraulic Research	114PS412 (714300-1)	
Motor - Operated Valve	Whittaker Controls	114PS494 (233454/233455)	
Pressure Fueling Shutoff	Hydraulic Research	114PS409-1 (787800)	
Break Away Fitting (2 in.)	Hydraulic Research	114PS408 (711800)	
Float Valve (Condensate Drain)	Derogene, Inc.	114PS419-2 (79001601-101)	
Break Away Fitting (1 in.)	Hydraulic Research	114PS414 (711900)	

A4. AIRCRAFT: CH-47D (Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR'S P/N)	COMMENTS
Thermistor (Tank Empty - Pump Shutoff)	Simmonds Precision	(473344)	
Two-Way Check Valve	Hydraulic Research	114PS415 (32800)	
Tank Sump & Vent Condensate Drain	Hydraulic Research	114PS509 (777300)	
Quick Disconnect Coupling	Symetrics, Inc.	114PS491 (BV 15016-3)	
Manifold Scavenge Ejector Pump	Hydraulic Research	114PS413 (710800-1)	
Fuel Level Control Assembly	Hydraulic Research	114PS478 (776600)	

Army Aircraft Fuel System Component Survey
A5. AIRCRAFT: OH-58C (Bell Helicopter Textron)

COMPONENT	MANUFACTURER	BELL PART NO. (MFGR. PART NO.)	COMMENTS
Self-Sealing Hose		206-062-610-7	Stratoflex hose is 156 type, Buna-N compound. Could be sensitive to increase in aromatics or peroxides.
	Stratoflex		
Fuel, Check Valve, B/A		206-062-604-1	
	E. B. Wiggins	(CW 101/01)	
	Hydraulic Research	(780300-1)	
Shutoff Valve, Manual	Shaw Aero Devices, Inc.	206-062-603 (A-870-1)	

A5. AIRCRAFT: OH-58C (Bell Helicopter Textron)
(Continued)

COMPONENT	MANUFACTURER	BELL PART NO. (MFGR. PART NO.)	COMMENTS
Quantity Transmitter (Capacitance)			
	Simmonds Precision	(391087-001)	
Quantity Transmitter (Capacitance) Low Fuel Warning		206-062-605-1	
	Simmonds Precision	(391057-129)	
Crashworthy Fuel Tank		206-062-602-1/3	
	Firestone	(37945)	Firestone cell has a fabric inner-liner.
	Goodyear	(AJA8000566)	Goodyear fuel cells have nitrile inner liners, sensitive to aromatics and peroxides.
Pressure Switch		204-062-542-3	
	Custom Component Inc.	(7G44)	
Closed Circuit/Gravity Fuel Receptacle		209-060-651-9	
	E. B. Wiggins	(CCR 101-09)	
	Hydraulic Research	(744000-9)	
Sump Drain Valve (Poppet)		206-062-640-1	
	Auto-Valve, Inc.	(96C-16)	
Boost Pump (Electric)		206-062-628-1/3	
	Lear-Siegler, Inc.	(RR-12240L)	Lear-Siegler is DC motor driven, centrifugal type, submerged pump, Buna-N elastomers, one silicon stationary shaft seal.
	Parker Hannifin (Airborne Div)	(2C27-1)	
	Globe Industries	(164A137)	

A5. AIRCRAFT: OH-58C (Bell Helicopter Textron) (Continued)

COMPONENT	MANUFACTURER	BELL PART NO. (MFGR. PART NO.)	COMMENTS
Low Level Switch (Float)	Revere Corp. of America	(F 8300-114)	
Cap and Adapter Assembly		206-062-660-1	
	Shaw Aero Devices, Inc.	(416-50)	

A6. AIRCRAFT: UH-60A (Sikorsky Aircraft)

COMPONENT	MANUFACTURER	SIKORSKY P/N (VENDOR P/N)	COMMENTS
1. Main Fuel System			
Self Sealing Hose			Buna compound, sensitive to increases in aromatics and peroxides.
	Aeroquip	(AE502)	
Inlet Check Valve (non B/A)		65307-08007-101	
	Allen A/C Products	(8C157)	
Manual Valve (Fuel Selector)		65317-03006-112	
	Allen A/C Products	(16BS106-12)	
Self-Sealing Breakaway Valve		70307-03002-103	
	Aeroquip	(AE80606G,typical)	
Vent Valve		70307-03007-103	
	Parker-Hannifin	(2750088-102)	

A6. AIRCRAFT: UH-60A (Sikorsky Aircraft)
(Continued)

COMPONENT	MANUFACTURER	SIKORSKY P/N (VENDOR P/N)	COMMENTS
Prime Shutoff Valve		70307-03024-101	
	Valcor	(V5000-114)	
Low Level Shutoff Valve		70307-03025-101	
	Parker-Hannifin	(1323-585285)	
Fuel/Defuel Valve		70307-03026-101	
	Parker-Hannifin	(2770052-101)	
High Level Shutoff Valve		70307-03012-103	
	Parker-Hannifin	(2770076-106)	
Check Valve (Crossfeed)		70307-03043-101	
	Parker-Hannifin	(2770057-101)	
Fuel Inlet Valve (Main)		70307-03045-101	
	Parker-Hannifin	(2770006-101)	
Level Sensor (Capacitance)		70307-03004-108	
	Simmonds Precision	(391057-289)	
Low Level Warning (Capacitance)		70307-03004-110	
	Simmonds Precision	(472580-010)	

A6. AIRCRAFT: UH-60A (Sikorsky Aircraft) (Continued)

COMPONENT	MANUFACTURER	SIKORSKY P/N (VENDOR P/N)	COMMENTS
Sump Drain Probe (Fuel Sampling)		70307-03018-102	
	Auto Valve, Inc.	(971C-21)	
Sump Drain Valve (Manual Drain)		70307-03018-103	
	Auto Valve, Inc.	(971D-22)	
Refueling Receptacle (CCR & SPP)		70307-03011-101	
	Parker-Hannifin	(2730535)	
Nozzle and Receiver Assembly			
	Wiggins	(CCN 101/01) (CCR 101/03)	
Crashworthy Self-Sealing Fuel Tank		70307-63003-102	
	Goodyear	(2F1-6-42416)	Nitrile innerliner
Prime Pump		70307-03005-102	D.C. motor, positive displacement vane type pump, fully wet. Viton elastomers, also uses a 3M Scotch cast 9 potting compound.
	Lear-Siegler	(RR36680B)	
2. Range Extension Kit			
Shutoff Valve (Motorized)		65307-03065-103	
	ITT General Controls	(AV 16B2059D) (AV 16B2067D)	

A6. AIRCRAFT: UH-60A (Sikorsky Aircraft)
(Continued)

COMPONENT	MANUFACTURER	SIKORSKY P/N (VENDOR P/N)	COMMENTS
Self-Sealing Breakaway Valves		70070-30103-103/104 70070-30802-102	
	Aeroquip	(AE 80614M/5P/6P)	
Pressure Relief Valve		70070-30901-102	
	Wiggins	(RVS21K)	
Fuel Quantity Gage (Capacitance)		70070-30102-101/102	
	Simmonds Precision	(391057-246/247)	
Crashworthy/Non Self-Sealing Tank		70070-30101	
	Goodyear	(2F1-C-42523)	Nitrile inner liner
Transfer Pump (Motorized, electric)		61300-63188-101	
	Lear-Siegler	(RR 36260)	Vane type pump. Buna-N elastomers. Has a lip seal of Sirvine (Chicago Rawhide).

Army Aircraft Fuel System Component Survey
A7. AIRCRAFT: YAH-64 (Hughes Helicopter)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. PART NO.)	COMMENTS
Hose, Self Sealing		7-211642021-22/23	Buna (AE 502) Compound sensitive to Aromatics and Peroxides
	Aeroquip	(AE705219-3)	

A7. AIRCRAFT: YAH-64 (Hughes Helicopter)
(Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. PART NO.)	COMMENTS
Breakaway Valve		Typical 7-211642041	
	Aeroquip	(AE81358K)	
Level Control Shut-off		7-21164202	
	Hydraulic Research	(736300)	
Fuel Pilot Valve		7-211642003	
	Hydraulic Research	(743900)	
Crossfeed and Firewall Shutoff Valve		7-211642045	
	ITT General Controls	(AV16E1291)	
APU Shutoff Valve		7-211642059	
	ITT General Controls	(AV24B1291AR)	
Check Valve Fwd Cell		7-211642032	
	Parker-Hannifin	(2770103)	
Check Valve Aft Cell		7-211642033	
	Parker-Hannifin	(2770104)	
Aux. Fuel Check Valve		7-117420063	
	Lord Industries	(L81400-8CC)	
Shutoff Transfer Valve		7-211642004	
	ITT General Controls	(AV24B1293)	

A7. AIRCRAFT: YAH-64 (Hughes Helicopter)
(Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. PART NO.)	COMMENTS
Fuel Quantity Sensor		Typical 7-211642075	
	Simmonds Precision	(391001-372)	
Fwd Fuel Tank		7-211641001	Fabric innerliner.
	Firestone	(37832)	
Aft Fuel Tank		7-211641002	Fabric innerliner.
	Firestone	(37833)	
Boost Pump, Air Driven		7-211642078	
	Pneu-Devices	(2307)	
APU Boost Pump, Electric Driven		7-211642062	D.C. motor drive, vane type pump, Motor dry. Buna-N elastomers.
	Lear-Siegler	(RG36810)	Diaphram of DuPont fairoprene.
Transfer Pump, Air Motor Driven		7-211642052	
	Pneu-Devices	(2284-5)	
Fuel Pressure Switch		7-211642074	
	Hydra-Electric, Inc.	(9111)	
Breakaway Coupling		7-117420069	
	Aeroquip	(AE98102H)	
Pullaway Coupling		7-267100011	
	Aeroquip	(XAE80861H)	

A7. AIRCRAFT: YAH-64 (Hughes Helicopter)
(Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. PART NO.)	COMMENTS
Fuel Drop Tank-Metal	Sargent-Fletcher	7-211642081	
Check Valve - Controllable Filler		7-117420021	
	Shaw Aero Devices, Inc.	(457-264) (457-780 Prod)	

Army Aircraft Fuel System Component Survey
A8. AIRCRAFT: OV-1B/C (Grumman Aerospace)

COMPONENT	VENDOR	AIRFRAME MFGR. P/N (VENDOR's PART NO.)	COMMENTS
Mainfuel System			
Self-Sealing Hose	Aeroquip	(AE502-12)	Buna Compound, sensitive to Aromatics and Peroxides.
Check Valve	Circle Seal Controls	(8869A-4TT-56)	
Plug Valve	Janitrol Aero.	(52-0504-1)	
Float Valve	Parker-Hannifin	(1321-517310) (1323-585905)	
Motorized Gate Valve	ITT General Controls	(AV16B1296D)	
Rotary Valve - (Drop Tank) Solenoid Actuated		134SCP112-3	
	Parker-Hannifin	(19-758-51)	

A8. AIRCRAFT: OV-1B/C (Grumman Aerospace) (Continued)

COMPONENT	VENDOR	AIRFRAME MFGR. P/N (VENDOR'S PART NO.)	COMMENTS
Check Valve - Cylinder (Drop Tank)	Parker-Hannifin	(1111-548189-1)	
Fuel Gage - quantity	Honeywell, Inc.	134SCP114-1/3/5 (FG200A-50)	
Adapter & Cap - Pressure Fueling		134SCP125-1	
	J.C. Carter Co.	(6450)	
	Parker-Hannifin	(23-758-1)	
Fuel Tank - Fuselage		134SCP103-7	
	Uniroyal	(FCR-46312)	Uniroyal cells have fabric inner liner.
	Goodyear	(2F1-6-26903)	Goodyear tank has nitrile rubber inner liner.
Sediment Strainer	Western Electric Co., Inc.	(52-2309-002)	
Valve	Parker-Hannifin	(1111-527919)	
Swing Check Valve	Parker-Hannifin	(1111-548390)	
Flexible Coupling	Wiggins	(3605-16D/20D)	
Ejector Pump	Allen Aircraft Products, Inc.	(612E501)	
Centrifugal Pump (Electrical)	Lear-Siegler, Inc.	134SCP115-7 (RR11970A)	Centrifugal pump, dry motor, Buna-N elastomers, two silicone shaft seals.
Pressure Switch	Consolidated Controls Corporation	(R6607-1-46/47)	

A8. AIRCRAFT: OV-1B/C (Grumman Aerospace)
(Continued)

COMPONENT	VENDOR	AIRFRAME MFGR. P/N (VENDOR'S PART NO.)	COMMENTS
Gravity Fueling Filler Cap		(15600V1-156-1)	
Sump Drain	Auto Valve, Inc.	(1100B52ZG) (1100B52Z1)	
2 Range Extension and Drop Tank			
Aluminum Drop Tank	Sargent-Fletcher	134P10150-1	
Rotary Pump - Electric	Lear-Siegler, Inc.	134SCP123-3 (RG16550A)	Vane type pump, line mounted. Buna-N elastomers, diaphram of fairoprene, gasket material - velamoid.
Fuel Quantity Probe	Sargent-Fletcher	(50179)	
Fuel Cap and Adapter	Sargent-Fletcher	(50251)	
Pressure/Vacuum Relief Valve	Sargent-Fletcher	(50233)	

Army Aircraft Fuel System Component Survey
A9. AIRCRAFT: RU/U-21 (Beech Aircraft Co.)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. P/N)	COMMENTS
Check Valve	Dukes Inc.	(2375-00/367-00/ 3124-00/3298-00)	

A9. AIRCRAFT: RU/U-21 (Beech Aircraft Co.)
(Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. P/N)	COMMENTS
Non Self-Sealing Hose	Aeroquip Corp.	(701012-1200170)	Lightweight, approaches a thermal plastic (less sensitive to aromatics)
Check Valve	Circle Seal Controls	(8869A-12BT-2)	
Solenoid Actuated Transfer Feed Valve	ITT General Controls	50-389095 (AV1B1602)	
Solenoid Avtuated Shutoff Valve	Dukes Inc.	(3153-00-9)	
Gate Valve - Motorized	ITT General Controls	(AV16B1700B)	
Check Valve	Parker Hannifin	(1111-595272)	
Swing Check Valve	Dukes Inc.	(3298-00)	
Check Valve - Safety Relief	Circle Seal Controls	(5132A-4TT-55)	
Fuel Quantity - Transmitter	Simmonds Precision Products, Inc.	(B1239-3636)	
Fuel Flow - Transmitter	Bendix Corporation	(9133-25B1)	
Fuel Cap (Adapter)	H & E Aircraft Co.	96-380036-11 (HE651-11)	
Electric Boost Pump	Delaval Turbine	50-389053-5 (72443)	

A9. AIRCRAFT: RU/U-21 (Beech Aircraft Co.)
(Continued)

COMPONENT	MANUFACTURER	AIRFRAME P/N (MFGR. PART NO.)	COMMENTS
Pressure Switch	Aircraft Controls Co.	50-389055-1/2 (GP-8000-50-1)	
Fuel Filter (Heated)	Airmaze Division of North American Rockwell	(02W05847)	
Fuel Drain Valve	Janitrol Aero	HE 751-1-300	
Gravity Filler Cap	Koehler-Dayton, Inc.	(37810-1)	
Sump Drain	Curtis Dyna Products Corporation	(CCA3400)	
Fuel Drain Valve (Nacelle)	Ruska Precision Corp.	91-380001 (8634-1)	
Coupling	Wiggins	(3605-12D)	
2 Range Extension Kit			
Ferry Fuel Pump - Electric	Dukes Astronautics Co.	(1132-00-1)	The ferry fuel tanks are fabricated from aluminum - no liners.
Ferry Fuel Pump - Manual	Christen Industries	(30264)	The ferry fuel tanks are fabricated from aluminum - no liners.
Manual Selector Valve	Auto Valve, Inc.	(73C-8B1)	
Main Fuel Tanks (Non Self-Sealing)	Goodyear	50-380135/380140/ 380141/380142 (2F1-6-34055/2F1-6-36211)	

Army Aircraft Fuel System Component Survey
A10. T53-L-13B/703/7A/15/701A (AVCO-LYCOMING)

COMPONENT	VENDOR'S PART NO. (ENGINE CO. P/N)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Starting Solenoid Valve	AV1F1155-1 AF56C-39A (1-300-191-02)	ITT General Conts (Aerospace Prods) Eckel Valve Corp	Internal Rubber Packing Conforms on MIL-P-5315 Two Position Electrically Opened, Spring-Loaded Closed Valve with an Internal 100 Mesh Filter	Contaminants and corrosion.
Starting Fuel Manifold Assembly	(1-170-430/420-01)	Kreisler Industrial Corp		Corrosion.
Starting Fuel Nozzle	6660042 24143 (1-300-405)	Parker Hannifan Delavan	Atomizing Nozzle, Incorporates a Starting Fuel Purge System to Help Eliminate Clogging of Start Fuel Nozzle Due to Coking	Contaminants, thermal stability and viscosity.
Igniter Plug	10-390045-1 5611387 FHE 211-2 (1-300-348)	Bendix AC Champion		May require change if viscosity causes starting problems.
Combustor Drain Valve	(1-160-220-03)	Foremost Precision Reb Ind		Contamination, thermal stability.
Main Manifold Assembly	(1-160-160-09/10)	Lycoming	Two-Section, Dual-Channeled Assembly	Corrosion

A10. T53-L-13B/703/7A/15/701A (AVCO-LYCOMING)
(Continued)

COMPONENT	VENDOR'S PART NO. (ENGINE CO. P/N)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Main Fuel Injector	26518 6660001 (1-300-347)	Parker Hannifin Delavan	Atomizing Dual Orifice Nozzle	Particulates or Contamination Can Accumulate in Swirl Chamber and Change Flow Characteristics, Thermal Stability and Viscosity.
Fuel Control with Integral Pump	84200A7A/100770A4	Chandler-Evans	Consists of a Power Turbine Governor and a Computer Assembly Plus High Pressure Pump (87352/7E820/85034) Which Is a Rotary Gear (-701A uses a vane for better protection against contamination).	Low Lubricity and Contaminants Will Affect the Gear Pump, Buna-N O-rings and Seals in Pump and Control Will Be Affected by Increased Level of Aromatics or Peroxides. Contaminants Could Also Create Problems in Close Tolerance Parts in the Control
Flow Divider (Linear Directional Valve)	(1-180-190-03)	Arkwin Industries, Inc. Lycoming Processer Industries, Inc.	Controls Flow to the Engine Nozzles According to a Pre-Determined Schedule of Primary vs Secondary Air	Particulates Could Cause Stickage, Also Could be Affected by Low Lubricity and by a Decrease in Thermal Stability.

A10. T53-L-13B/703/7A/15/701A (AVCO-LYCOMING)
(Continued)

COMPONENT	VENDOR'S PART NO. (ENGINE CO. P/N)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
7A/15/701A (ONLY)				
Fuel Filter	045468	Bendix Filter Corp.	Incorporates an Impending Bypass 10m Nominal	Could Be Affected by Viscosity Changes. An Increase in Particulates (Less than 10 Micron Size) May Require a Change in Element Filtration. Moisture Absorbancy.
Fuel Heater	5A470-001 VA5267586	Tavitrol United A/C Products		Thermal Stability and Corrosion.

Army Aircraft Fuel System Component Survey
A11. T63-A-700/720 (Detroit Diesel Allison)

COMPONENT	VENDOR'S PART NO. (ENGINE CO. P/N)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Fuel Pump and Filter	685492 (5A/700) 23003114 (720) 386500-5 (TRW)	Sundstrand TRW (alternate vendor)	Gear Dual element on -700, single element on -720.	Low lubricity and contamination. Moisture absorbancy.
Gas Producer Fuel Control	6871111(5A/700) 6895672 (720)	Bendix	Pneumatic communication with power turbine governor (Model DP-D3)	Lubricity and contamination (non-rotating metering valve). Aromatics and peroxides.

A11. T63-A-700/720 (Detroit Diesel Allison)
(Continued)

COMPONENT	VENDOR'S PART NO. (ENGINE CO. P/N)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Fuel Nozzle	6852020 (5A/700) 5233333 (720)	DED Diesel Equipment Division GM	Dual orifice atomizing with built-in metering valve	Contamination (fluted metering valve), thermal stability.
Igniter	FHE-161-9 5611071	Champion AC		Will require change if viscosity increases and causes starting problems.
Combustor* Drain Valve (Plug and Check)	6854255 (CV) MS9015-03 (Plug)			Contaminants and Corrosion
Check Valve	252402-1	Bendix		Contaminants and Corrosion

*Two ports for different applications OH-58 (Engine sits horizontally), OH-6 (Engine is at a 45° Angle)

Army Aircraft Fuel System Component Survey
A12. T55-L-11ASA/11D/712 (AVCO-LYCOMING)

COMPONENT	VENDOR'S PART NO. (ENGINE CO. P/N)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Start Fuel Nozzle	6660039 (2-300-216-02)	Parker-Hannifin Delavan		Contamination, thermal stability, viscosity
In-Line Filter	21350 (2-300-311-01)	Mectron	712 Engine has an impending bypass	Particulates, viscosity and moisture absorbancy

A12. T55-L-11ASA/11D/712 (AVCO-LYCOMING)
(Continued)

COMPONENT	VENDOR'S PART NO. (ENGINE CO. P/N)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Flow Divider	(2-161-390-01)	Arkwin Ind. Inc.		Contaminants, lubricity and thermal stability
Start Fuel Solenoid	AV1F11 55-1 (1-800-191-06)	ITT Genl Controls Aerospace Products		Contaminants and Corrosion
Main Manifold Assembly	2-160-950-14/15	Lycoming		Corrosion
Boost Pump	025028-107 (2-160-790-04)	Chandler Evans	Centrifugal	Contamination
Main or Static Fuel Filter	048757-01 (2-300-277-01)	Facet Enterprises, Inc. Filter Products Div.		Particulates, viscosity and moisture absorbancy
Oil Cooler Assembly	2-160-750-02	Lycoming		Thermal stability could cause fuel breakdown and deposition all along the line.
Fuel Control	739222-6 (2-161-620-11) (2-161-620-39*)	Hamilton Standard	Contains Buna-N O-rings and seals	Particulates, increase in aromatics and peroxides.
High Pressure Pump		Sundstrand	Gear pump	Low lubricity fuel will affect gear wear
Igniters	2-300-217-02			May require change if viscosity increases and causes starting problems

A12. T55-L-11ASA/11D/712 (AVCO-LYCOMING)
(Continued)

COMPONENT	VENDOR'S PART. NO. (ENGINE CO. P/N)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Main Fuel Injectors	2-300-677-03 (712) 2-300-216 (11D)	Delavan	Dual orifice atomizing on the 11D and airblast on the 712.	Contamination, thermal stability and viscosity.

*Preferred for T55-L-11D (without inlet guide vane controller)

Army Aircraft Fuel System Component Survey
A13. T-700-GE-700 (General Electric)

COMPONENT	VENDOR'S (ENGINE CO.) PART NO.	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Boost Pump (centrifugal, mixed flow)	RR 53150E1 (P/N 3033T33G02)	Lear-Siegler	Anodized Al housing, fluorosilicone O-ring (static), carbon in stainless steel case (dynamic)	Extremely sensitive to contaminants (no filter ahead of it). Fuel vapor pressure (cavitation)
Fuel Filter (10u nominal, 30u absolute) (impending bypass pop-up)	AD-9985-55 (P/N 5035T76P07)	Aircraft Porous Media, Inc.	Viton and fluorosilicone O-rings. Adhesive: Epoxy-ISO Chem. 130819546 (APMS-PM-0010).	Affected by viscosity changes. Increase in fine contaminants may require change in element filtration.
Hydromechanical Unit (HMU)	763700-3 (P/N 6038T62P04)	Hamilton-Standard	Many critical parts-spool valves, cam followers, flapper valves, bearings, gears, & seals. Sliding seals - graphite filled teflon.	Corrosion, contaminants, lubricity, aromatics. Viscosity could affect scheduling.

A13. T-700-GE-700 (General Electric)
(Continued)

COMPONENT	VENDOR'S (ENGINE CO.) PART NO.	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Fuel-Oil Cooler	(P/N 4046T25601)	United Aircraft Products		Thermal stability, coking, (no problems to this date)
Sequence Valve*	0212021 (P/N 3033T32G01)	Arkwin Industries	O-rings: nichols 6072 compound teflon impregnated fluorosilicone	Contaminants, lubricity, thermal stability
Primer Nozzles (atomizing)	Primer (P/N 4046T78P05)	Parker-Hannifin	Primer nozzle has insulating tube to help prevent coking.	Contamination, thermal stability, viscosity.
Fuel Injectors (airblast)	Injector (P/N 6035T64602)	Parker-Hannifin		Contamination, thermal stability, viscosity.
High Pressure Fuel Pump** (vane type)	PF4-038-6B	Vickers	Adhesive wafer (3M, AF-31) on end plate	Lubricity and contamination (due to rubbing of vanes on cam ring and rotor on end plates)

* This valve is being redesigned ; to be called pressurizing and overspeed unit (POU)
** Installed in HMU

Army Aircraft Fuel System Component Survey

A14. PT6A-20/21/27/28/38/41 and T74-CP-700/702 (Pratt & Whitney Canada)

COMPONENT T74-GP-700/PT6A-20/21	(ENGINE MFGR. NO.) (VENDOR PART NO.)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Main Fuel Control Unit	2524245-3 2524546-1	Bendix	Same Basic Control as in T63 (Model No. DP-F2. Incorporates starting Fuel Function	Lubricity and contamination (non-rotating metering value) Aromatics and peroxides.
Fuel Pump	(4V146R100)	Vickers	Vane type pump	Lubricity and contamination (due to rubbing of vanes on cam ring and rotor on end plates).
Oil to Fuel Heater	8426B	Southwind Div. of Stewartwarner Corporation		Reduced thermal stability could cause fuel breakdown and deposition.
Fuel Nozzles	3013635	*	Pressure Atomizing Simplex	Contamination, thermal stability, viscosity.
Igniters	3014054	*		May require change if viscosity increases and causes starting problems.
Automatic Dump Valve	DV 1003-40	Lucas Rotox, Ltd.		Contaminants
Compressor Drain Valve	3007009	*		Contaminants

A14. PT6A-20/21/27/28/38/41 and T74-CP-700/702 (Pratt & Whitney Canada)
(Continued)

COMPONENT T74-GP-700/PT6A-20/21	(ENGINE MFGR. NO.) (VENDOR PART NO.)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Transfer Tube	3010146	*		Stainless steel, seals could be affected by aromatics or peroxides.
Fuel Manifold (Adapter Assy.)	3011098 3011099	*		Stainless steel, seals could be affected by aromatics or peroxides.
Flow Divider				Contaminants, lubricity and thermal stability.
Main Fuel Control Unit	2524389-1 2524547-1	Bendix	Same Basic Control as in T63 (Model No. DP-F2)	Lubricity and contamination (non-rotating metering value) Aromatics and peroxides.
Fuel Pump	0 24800-104-01	Sundstrand	Gear type pump	Lubricity and contamination
Starting Fuel Control	11011563	Lucas Rotax, Ltd.	Incorporates Flow Division Function	Lubricity, contamination, Aromatics and Peroxides.
Oil to Fuel Heater	VA 525193-6	United Aircraft Product		Reduced thermal stability could cause fuel breakdown and deposition.

A14. PT6A-20/21/27/28/38/41 and T74-CP-700/702 (Pratt & Whitney Canada)
(Continued)

COMPONENT T74-CP-702/PT6A-27/28	ENGINE MFGR. NO. (VENDOR PART NO.)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Fuel Nozzle	3010036	*	Pressure Atomizing	Contamination, thermal stability, viscosity.
Igniter	3014054	*		May require change if viscosity increases and causes starting problems.
Transfer Tube	3011155	*		Stainless steel, seals could be affected by aromatics or peroxides.
Primary Adapter	3014704	*		Stainless steel, seals could be affected by aromatics or peroxides.
Secondary Adapter	3014705	*		Stainless steel, seals could be affected by aromatics or peroxides.
Adapter Drain Valve	3011071	*		Contaminants.

*Vendor information is not available.

Army Aircraft Fuel System Component Survey
A15. T-62T-2A1 (SOLAR)

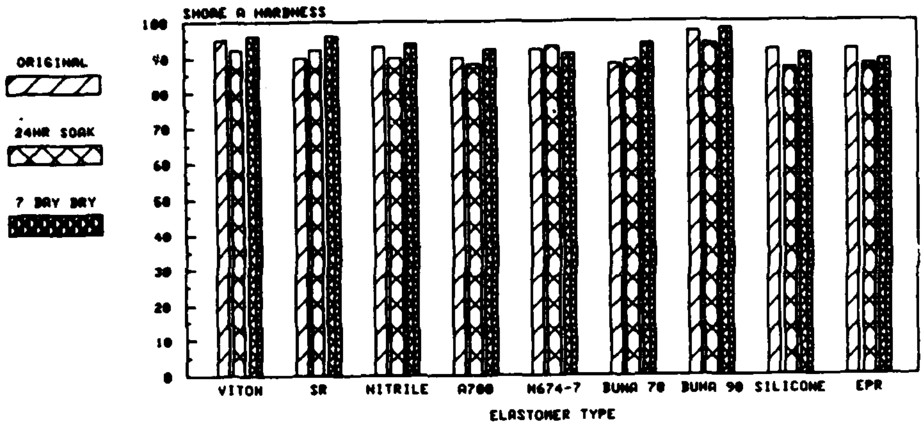
COMPONENT	VENDOR'S PART NUMBER	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES)
Fuel Control	100829-100	Solar		Corrosion, contaminants, lubricity, aromatics and peroxides.
Fuel Pump (Gear Type)	102-203-1	DeLaval		Low lubricity and contaminants.
Fuel Filter	2250-4005 75 75486	Carborundum Corp Purolator Products		Contaminants, viscosity and moisture absorbancy.
Start Fuel Solenoid Valve	37695-100	Solar		Contaminants and corrosion.
Main Fuel Solenoid Valve	37696-100	Solar		Contaminants and corrosion.
Start Fuel Nozzle	28022-4	Delavan Mfg Co		Contamination, thermal stability and viscosity.
Main Fuel Injectors	19050	Delavan Jay Craft Engr		Contamination, thermal stability and viscosity.

Army Aircraft Fuel System Component Survey
A16. GTCP 36-55(H) (GARRETT AiResearch)

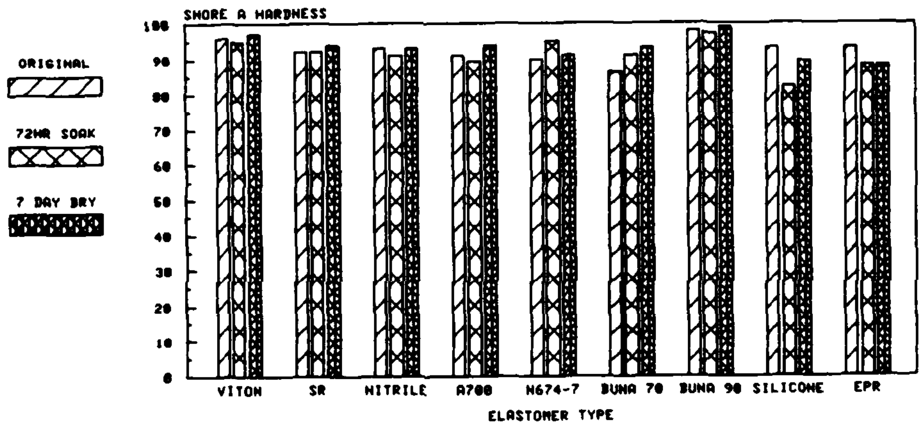
COMPONENT	ENGINE MFGR. P/N (VENDOR'S PART NUMBER)	VENDOR	BRIEF DESCRIPTION (UNIQUE FEATURES)	COMMENTS (SENSITIVITY TO FUEL CHANGES
Gear Pump Fuel Control	3882660-1	Garrett AiResearch design made by Aero Hydraulics Division	Control contains integral gear pump and 3 micron filter (electronic torque motor made by Servotronics)	Will be sensitive to increase in level of contaminants and low lubricity fuel. Uses only fluorosilicone seals and O-rings so relatively insensitive to increase in aromatics or peroxides.
Fuel shutoff solenoid	692545-6	Valcor		Contaminants and corrosion.
Piloted air blast atomizer	3830061-2	Delavan	Start fuel is supplied through primary (simple pressure atomizing), run fuel through a secondary air blast orifice.	Contamination, thermal stability, viscosity.
High energy igniter plug	369964-5	Champion		
Fuel Manifold			Stainless steel tube running to the single atomizer.	

APPENDIX B

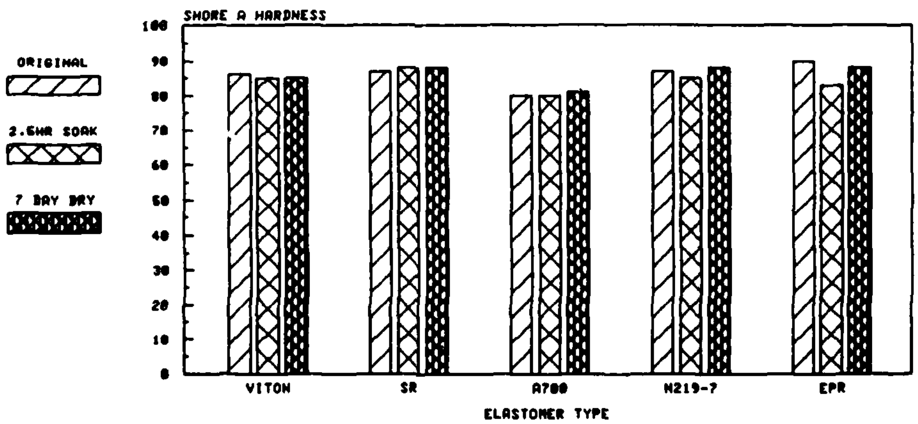
AFLRL ELASTOMER SWELL AND HARDNESS DATA



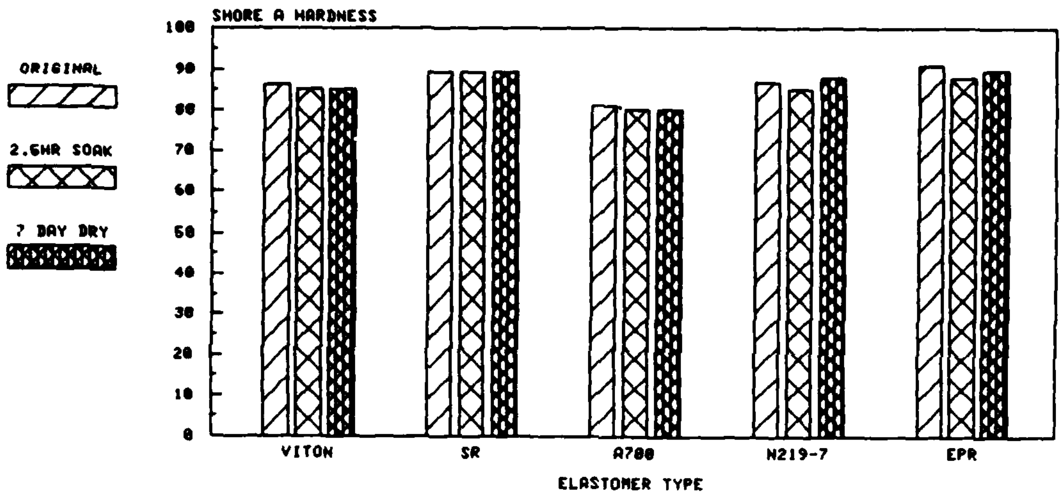
SHORE A HARDNESS WITH PETROLEUM DF2
(SOAK TEMP = 75°F TIME = 24HR)



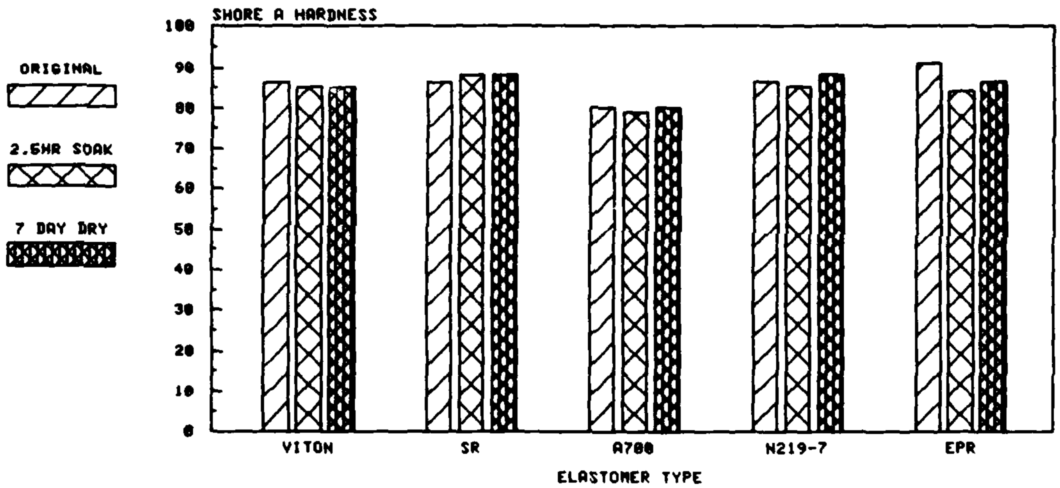
SHORE A HARDNESS WITH PETROLEUM DF2
(SOAK TEMP = 75°F TIME = 72HR)



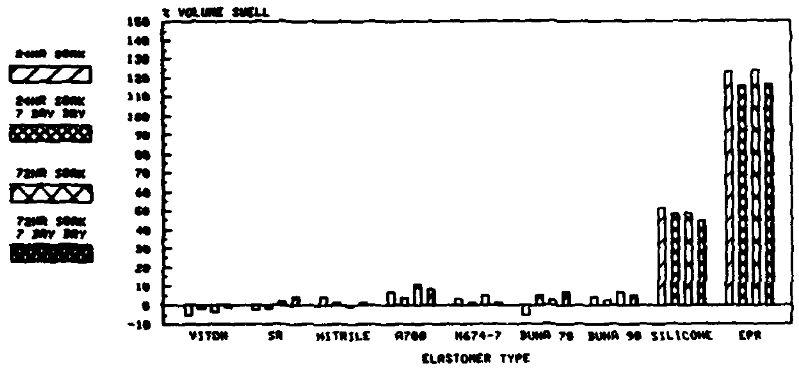
SHORE A HARDNESS WITH PETROLEUM DF2
(SOAK TEMP = 150°F TOFT: TENSION)



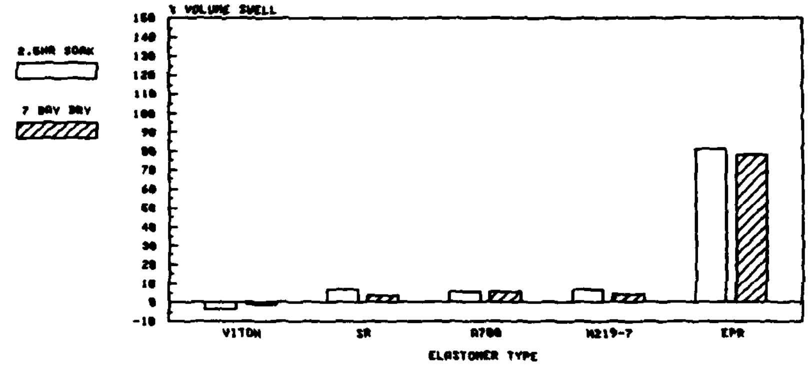
SHORE A HARDNESS WITH PETROLEUM DF2
(SOAK TEMP = 150°F TOFT: COMPRESSION)



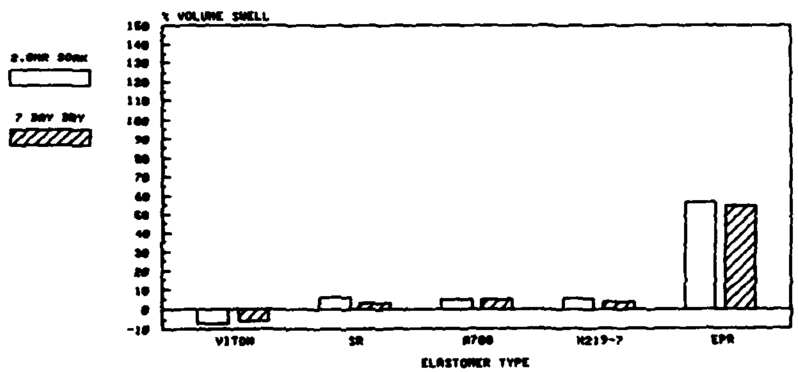
SHORE A HARDNESS WITH PETROLEUM DF2
(SOAK TEMP = 150°F TOFT: FREE)



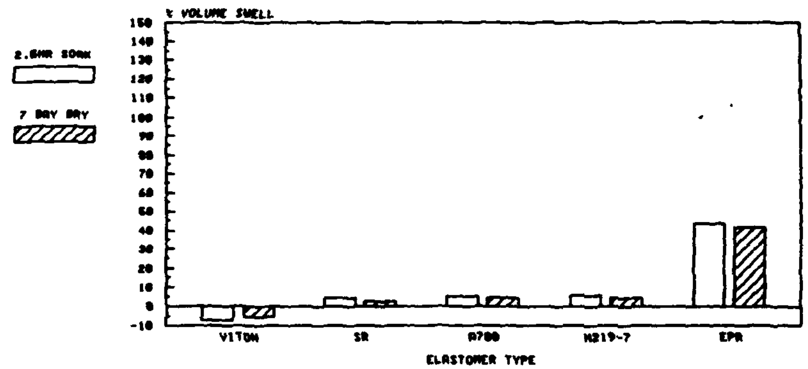
PERCENT VOLUME SWELL WITH PETROLEUM DF2
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL WITH PETROLEUM DF2
(SOAK TEMP = 150°F TOFT: FREE)



PERCENT VOLUME SWELL WITH PETROLEUM DF2
(SOAK TEMP = 150°F TOFT: TENSION)



PERCENT VOLUME SWELL WITH PETROLEUM DF2
(SOAK TEMP = 150°F TOFT: COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.771	-2.7	-2.4	-3.0	2.0
SAMPLE 2	1.774	-7.2	-1.4	-3.0	0.0
AVERAGE	1.772	-5.0	-1.9	-3.0	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.783	-1.9	-0.5	-2.0	1.0
SAMPLE 2	1.773	-5.2	-1.6	1.0	1.0
AVERAGE	1.778	-3.5	-1.0	-0.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.252	-2.4	-2.1	2.0	5.0
SAMPLE 2	1.255	-2.1	-1.8	2.0	7.0
AVERAGE	1.254	-2.3	-1.9	2.0	6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.251	2.3	3.9	1.0	1.0
SAMPLE 2	1.259	1.8	4.2	0.0	3.0
AVERAGE	1.255	2.0	4.0	0.5	2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.265	4.8	1.8	-3.0	3.0
SAMPLE 2	1.262	3.2	0.8	-2.0	0.0
AVERAGE	1.263	4.0	1.3	-2.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.271	-0.5	1.5	-2.0	1.0
SAMPLE 2	1.269	-1.0	1.2	-1.0	0.0
AVERAGE	1.270	-0.7	1.3	-1.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.310	6.4	3.4	-3.0	1.0
SAMPLE 2	1.319	7.1	4.0	-2.0	2.0
AVERAGE	1.315	6.7	3.7	-2.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.336	10.8	7.8	-1.0	3.0
SAMPLE 2	1.335	10.4	8.1	-3.0	2.0
AVERAGE	1.335	10.6	8.0	-2.0	2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.277	3.4	2.0	1.0	1.0
SAMPLE 2	1.255	1.9	0.6	0.0	-3.0
AVERAGE	1.266	2.7	1.3	0.5	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.278	4.8	1.0	7.0	-2.0
SAMPLE 2	1.283	5.1	1.7	2.0	3.0
AVERAGE	1.280	4.9	1.3	4.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.265	-3.4	5.8	1.0	7.0
SAMPLE 2	1.236	-6.5	3.8	1.0	6.0
AVERAGE	1.250	-5.0	4.8	1.0	6.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.237	2.4	7.3	6.0	8.0
SAMPLE 2	1.228	2.0	5.5	4.0	5.0
AVERAGE	1.232	2.2	6.4	5.0	6.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.288	3.2	2.1	0.0	1.0
SAMPLE 2	1.290	4.7	3.1	-6.0	0.0
AVERAGE	1.289	3.9	2.6	-3.0	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DFF2	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.276	6.4	4.2	0.0	1.0
SAMPLE 2	1.278	6.4	5.6	-1.0	1.0
AVERAGE	1.277	6.4	4.9	-0.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.318	51.2	48.3	-4.0	-1.0
SAMPLE 2	1.380	50.9	47.3	-6.0	-2.0
AVERAGE	1.349	51.0	47.8	-5.0	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.387	50.2	45.8	-11.0	-3.0
SAMPLE 2	1.384	46.7	41.7	-10.0	-5.0
AVERAGE	1.386	48.4	43.8	-10.5	-4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.209	125.0	118.9	-4.0	-2.0
SAMPLE 2	1.218	121.2	113.3	-3.0	-4.0
AVERAGE	1.213	123.1	116.1	-3.5	-3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.219	124.0	117.3	-4.0	-5.0
SAMPLE 2	1.221	124.9	116.3	-6.0	-4.0
AVERAGE	1.220	124.4	116.8	-5.0	-4.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	SR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.247	3.2	2.0	0.0	-1.0
SAMPLE 2	1.248	3.3	2.1	-1.0	0.0
SAMPLE 3	1.249	4.4	2.3	0.0	-1.0
SAMPLE 4	1.250	4.9	2.5	1.0	1.0
SAMPLE 5	1.250	3.6	2.6	-1.0	0.0
AVERAGE	1.249	3.9	2.3	-0.2	-0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.245	5.9	2.9	2.0	1.0
SAMPLE 2	1.248	7.8	3.4	1.0	2.0
SAMPLE 3	1.248	6.8	5.0	1.0	3.0
SAMPLE 4	1.264	14.0	9.7	2.0	1.0
SAMPLE 5	1.251	8.1	4.0	0.0	0.0
AVERAGE	1.251	8.5	5.0	1.2	1.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.245	5.6	3.3	1.0	2.0
SAMPLE 2	1.248	6.9	5.0	1.0	2.0
SAMPLE 3	1.245	5.9	3.7	0.0	0.0
SAMPLE 4	1.247	5.7	1.4	1.0	-1.0
SAMPLE 5	1.247	5.1	0.2	0.0	0.0
AVERAGE	1.246	5.8	2.7	0.6	0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	N219-7	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.250	6.7	4.6	-1.0	1.0
SAMPLE 2	1.257	5.2	4.7	-4.0	2.0
SAMPLE 3	1.246	4.8	3.7	0.0	2.0
SAMPLE 4	1.247	5.3	3.7	-2.0	2.0
SAMPLE 5	1.250	5.0	3.6	-6.0	0.0
AVERAGE	1.250	5.4	4.1	-2.6	1.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.247	6.4	4.6	-2.0	2.0
SAMPLE 2	1.252	9.5	7.5	-1.0	2.0
SAMPLE 3	1.248	7.0	3.9	-1.0	2.0
SAMPLE 4	1.247	4.8	3.3	-1.0	1.0
SAMPLE 5	1.244	4.7	3.2	-1.0	1.0
AVERAGE	1.247	6.5	4.5	-1.2	1.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.243	4.7	3.3	-4.0	-2.0
SAMPLE 2	1.250	5.6	3.5	-2.0	2.0
SAMPLE 3	1.249	5.4	3.4	0.0	3.0
SAMPLE 4	1.249	5.9	3.7	-2.0	0.0
SAMPLE 5	1.246	5.5	3.4	-1.0	2.0
AVERAGE	1.247	5.4	3.4	-1.8	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	EPR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.207	43.6	42.4	-1.0	2.0
SAMPLE 2	1.195	40.4	39.5	0.0	0.0
SAMPLE 3	1.199	45.6	43.7	-3.0	-4.0
SAMPLE 4	1.206	41.3	38.8	-4.0	-2.0
SAMPLE 5	1.212	45.8	44.6	-5.0	0.0
AVERAGE	1.204	43.4	41.8	-2.6	-0.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.189	90.7	85.9	-10.0	-3.0
SAMPLE 2	1.187	84.3	81.3	-8.0	-7.0
SAMPLE 3	1.191	87.6	82.1	-6.0	-11.0
SAMPLE 4	1.187	81.4	80.5	-7.0	-5.0
SAMPLE 5	1.187	61.1	61.7	-5.0	-3.0
AVERAGE	1.188	81.0	78.3	-7.2	-5.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.189	64.5	63.3	-8.0	-4.0
SAMPLE 2	1.188	55.7	55.5	-9.0	-4.0
SAMPLE 3	1.181	57.1	53.8	-6.0	-3.0
SAMPLE 4	1.184	58.6	56.6	-5.0	-2.0
SAMPLE 5	1.183	44.4	44.9	-8.0	-2.0
AVERAGE	1.185	56.1	54.8	-7.2	-3.0

FUEL	ELASTOMER	ENVIRON	SJAK TIME	TEMP	DRY TIME
PETR.DF2	VITON	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.690	-7.0	-3.5	-1.0	0.0
SAMPLE 2	1.658	-7.0	-5.1	-1.0	-2.0
SAMPLE 3	1.652	-6.9	-5.5	0.0	-2.0
SAMPLE 4	1.655	-7.1	-5.8	-1.0	0.0
SAMPLE 5	1.649	-7.5	-6.3	-1.0	-1.0
AVERAGE	1.661	-7.1	-5.2	-0.8	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.652	-6.1	-6.0	-2.0	-2.0
SAMPLE 2	1.649	-7.3	-5.4	0.0	1.0
SAMPLE 3	1.658	-6.6	-4.8	0.0	0.0
SAMPLE 4	1.651	-6.7	-5.6	-1.0	-2.0
SAMPLE 5	1.655	-7.0	-5.5	-2.0	-2.0
AVERAGE	1.653	-6.7	-5.4	-1.0	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.651	-6.9	-5.6	-3.0	-2.0
SAMPLE 2	1.644	-10.3	-5.5	0.0	1.0
SAMPLE 3	1.655	-5.8	-5.5	-2.0	-3.0
SAMPLE 4	1.621	-6.6	-6.2	-1.0	-1.0
SAMPLE 5	1.658	-6.5	-5.2	-2.0	-1.0
AVERAGE	1.645	-7.2	-5.6	-1.6	-1.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.267	4.7	2.9	3.0	1.0
SAMPLE 2	1.264	4.6	3.8	0.0	-1.0
SAMPLE 3	1.264	4.7	4.3	-2.0	-1.0
SAMPLE 4	1.261	4.8	5.0	-1.0	0.0
SAMPLE 5	1.261	4.3	4.2	-1.0	-1.0
AVERAGE	1.263	4.6	4.0	-0.2	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	A700	FREE	2.5HR	150F	7DAY

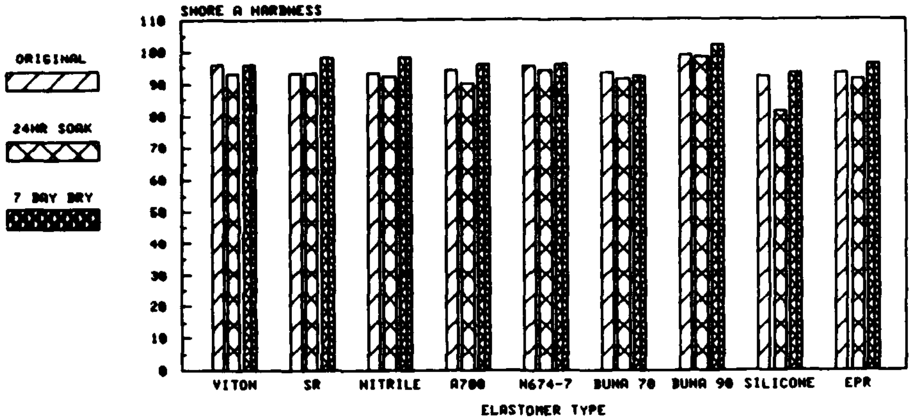
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.259	5.1	5.7	-2.0	-1.0
SAMPLE 2	1.255	4.9	5.6	-2.0	0.0
SAMPLE 3	1.254	5.0	5.2	0.0	0.0
SAMPLE 4	1.250	5.6	5.4	-1.0	0.0
SAMPLE 5	1.251	4.8	4.8	-1.0	-1.0
AVERAGE	1.254	5.1	5.3	-1.2	-0.4

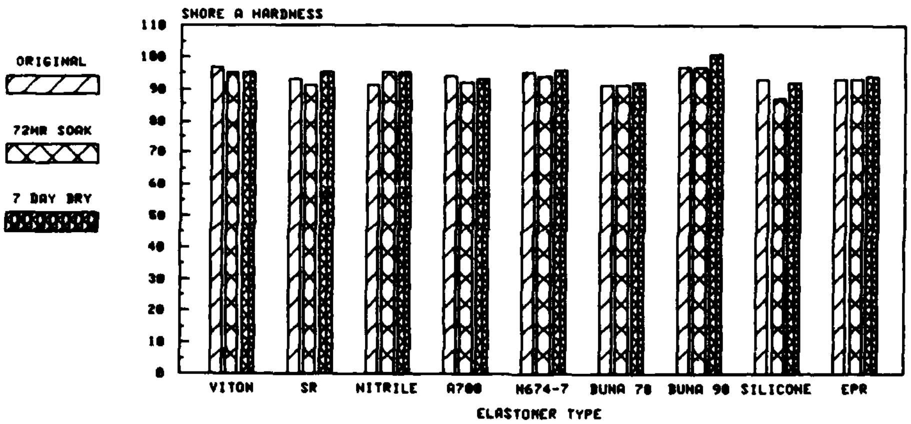
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PETR.DF2	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

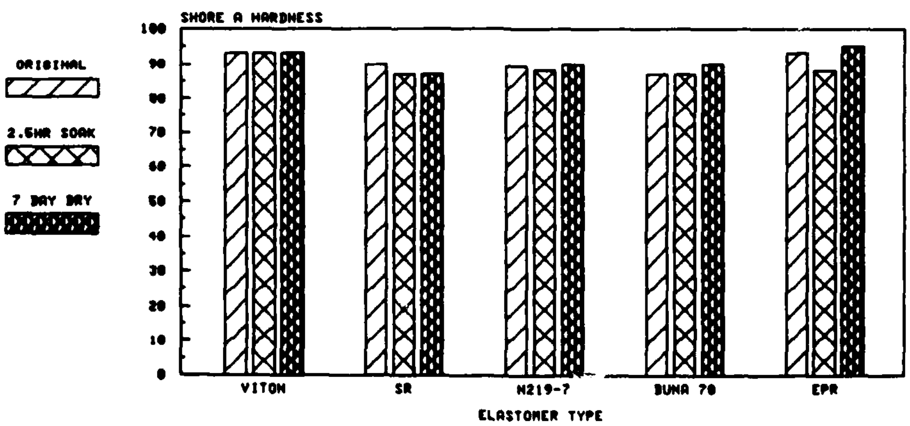
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.249	4.7	4.0	-2.0	-2.0
SAMPLE 2	1.251	5.2	5.3	-1.0	1.0
SAMPLE 3	1.252	5.4	5.2	0.0	0.0
SAMPLE 4	1.256	4.8	4.7	0.0	1.0
SAMPLE 5	1.255	4.5	4.9	1.0	1.0
AVERAGE	1.253	4.9	4.8	-0.4	0.2



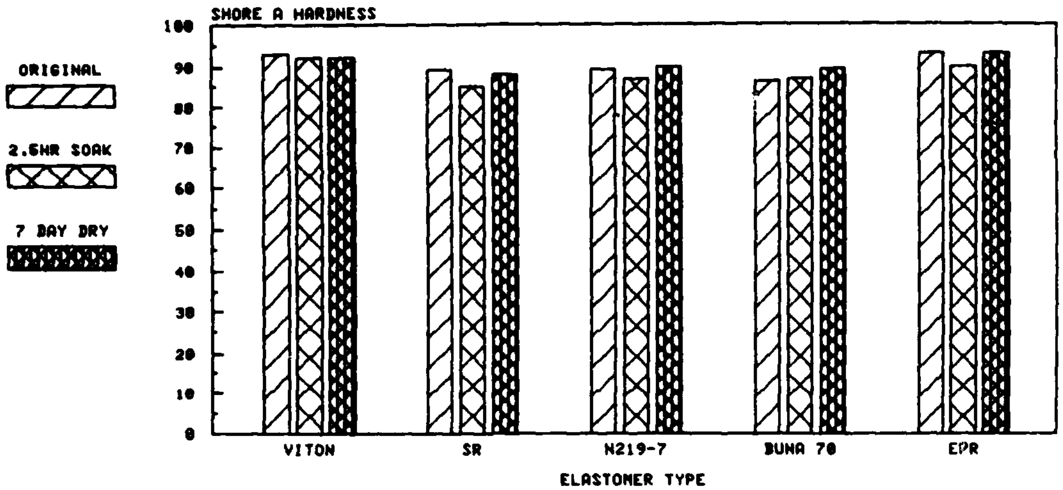
SHORE A HARDNESS WITH MTG GASOLINE
(SOAK TEMP = 75°F TIME = 24HR)



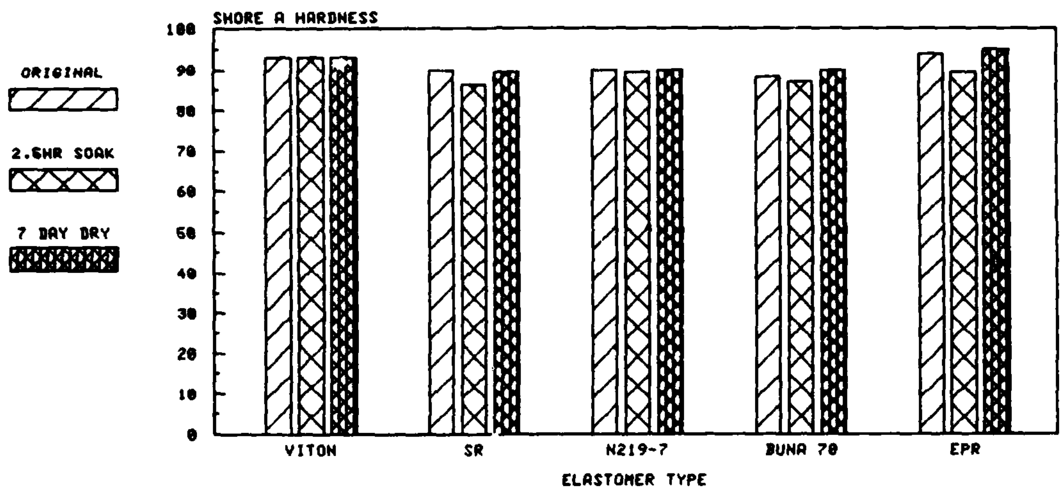
SHORE A HARDNESS WITH MTG GASOLINE
(SOAK TEMP = 75°F TIME = 72HR)



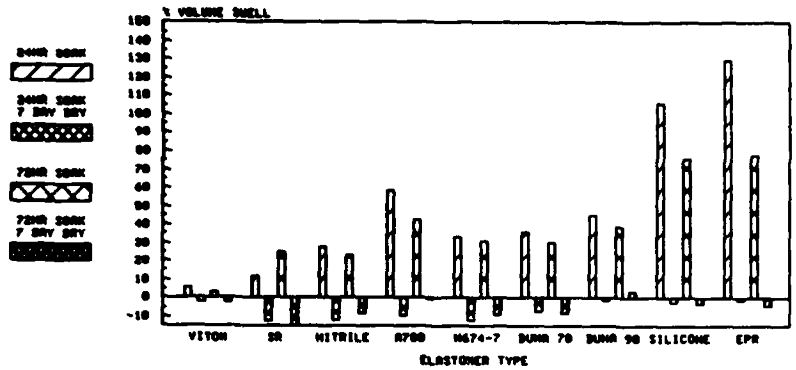
SHORE A HARDNESS - MTG GASOLINE
(SOAK TEMP = 150°F TOFT - TENSION)



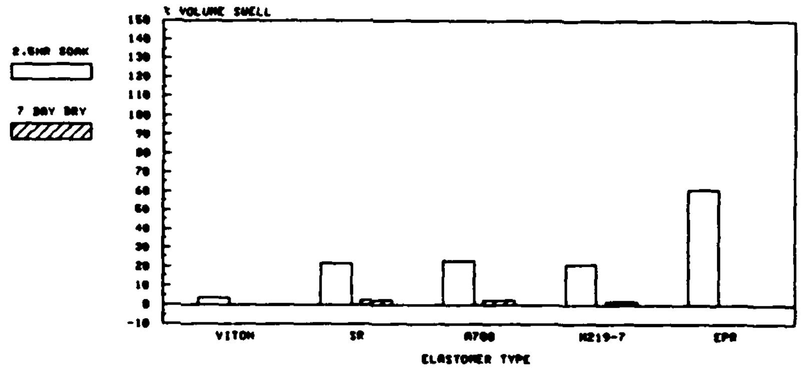
SHORE A HARDNESS - MTG GASOLINE
(SOAK TEMP = 150°F TOFT - COMPRESSION)



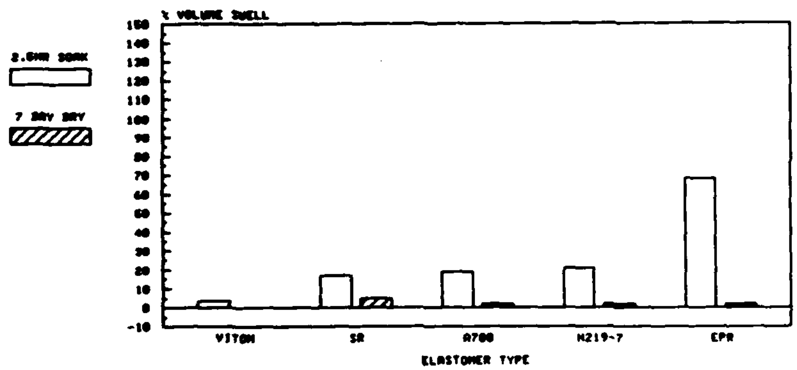
SHORE A HARDNESS - MTG GASOLINE
(SOAK TEMP = 150°F TOFT - FREE)



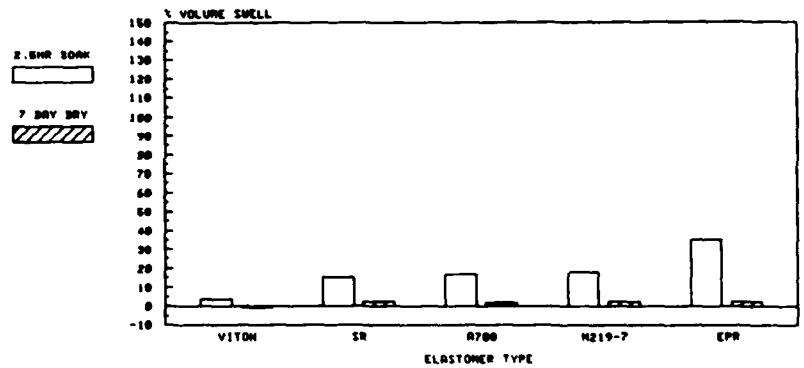
PERCENT VOLUME SWELL - MTG GASOLINE
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL - MTG GASOLINE
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL - MTG GASOLINE
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL - MTG GASOLINE
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.764	3.1	-2.2	-2.0	1.0
SAMPLE 2	1.778	7.7	-2.2	-4.0	-2.0
AVERAGE	1.771	5.4	-2.2	-3.0	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.764	3.1	-2.0	-2.0	1.0
SAMPLE 2	1.763	2.8	-2.5	-1.0	-4.0
AVERAGE	1.763	3.0	-2.3	-1.5	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.252	14.5	-11.4	-1.0	4.0
SAMPLE 2	1.252	9.3	-13.2	1.0	5.0
AVERAGE	1.252	11.9	-12.3	0.0	4.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.249	23.1	-14.8	-3.0	2.0
SAMPLE 2	1.269	27.3	-15.7	-1.0	2.0
AVERAGE	1.259	25.2	-15.2	-2.0	2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.264	28.2	-12.0	-1.0	6.0
SAMPLE 2	1.283	27.9	-11.4	-1.0	5.0
AVERAGE	1.273	28.1	-11.7	-1.0	5.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.287	24.2	-8.3	4.0	4.0
SAMPLE 2	1.288	22.0	-8.5	4.0	4.0
AVERAGE	1.287	23.1	-8.4	4.0	4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.269	58.4	-9.7	-4.0	2.0
SAMPLE 2	1.267	58.7	-9.6	-4.0	2.0
AVERAGE	1.268	58.5	-9.6	-4.0	2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.261	44.1	1.5	-1.0	-1.0
SAMPLE 2	1.248	41.5	-2.4	-3.0	-1.0
AVERAGE	1.255	42.8	-0.5	-2.0	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	N674-N	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.264	31.3	-12.1	1.0	6.0
SAMPLE 2	1.287	35.3	-11.7	0.0	2.0
AVERAGE	1.275	33.3	-11.9	0.5	4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	N674-N	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.281	32.2	-8.9	-3.0	-1.0
SAMPLE 2	1.280	29.7	-9.0	0.0	3.0
AVERAGE	1.281	30.9	-8.9	-1.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.233	35.6	-7.7	-3.0	5.0
SAMPLE 2	1.238	35.9	-6.3	-2.0	3.0
AVERAGE	1.236	35.8	-7.0	-2.5	4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.233	31.9	-9.0	0.0	0.0
SAMPLE 2	1.231	29.0	-7.6	1.0	3.0
AVERAGE	1.232	30.5	-8.3	0.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.283	44.5	-1.1	0.0	4.0
SAMPLE 2	1.284	44.8	-1.5	0.0	3.0
AVERAGE	1.284	44.7	-1.3	0.0	3.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.281	37.4	4.0	-1.0	3.0
SAMPLE 2	1.278	39.8	4.0	1.0	5.0
AVERAGE	1.280	38.6	4.0	0.0	4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.296	107.4	-1.3	-11.0	2.0
SAMPLE 2	1.389	104.4	-3.5	-11.0	-1.0
AVERAGE	1.342	105.9	-2.4	-11.0	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.289	82.7	-1.9	-6.0	0.0
SAMPLE 2	1.363	68.6	-4.3	-5.0	-1.0
AVERAGE	1.326	75.6	-3.1	-5.5	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.262	132.8	-2.2	-2.0	3.0
SAMPLE 2	1.253	126.6	-0.5	-3.0	2.0
AVERAGE	1.258	129.7	-1.3	-2.5	2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.261	79.9	2.6	-1.0	-1.0
SAMPLE 2	1.219	75.6	-10.8	0.0	3.0
AVERAGE	1.240	77.7	-4.1	-0.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	SR	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.254	12.8	1.5	0.0	2.0
SAMPLE 2	1.254	15.7	1.7	-2.0	0.0
SAMPLE 3	1.252	15.9	2.8	-3.0	-1.0
SAMPLE 4	1.255	15.4	2.2	-14.0	0.0
SAMPLE 5	1.257	15.3	2.2	-1.0	1.0
AVERAGE	1.255	15.0	2.1	-4.0	0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.251	21.1	2.0	-4.0	0.0
SAMPLE 2	1.252	21.1	1.9	-4.0	-2.0
SAMPLE 3	1.246	21.1	1.9	-5.0	0.0
SAMPLE 4	1.255	22.6	2.1	-1.0	2.0
SAMPLE 5	1.256	22.3	2.4	-[illegible].0	0.0
AVERAGE	1.252	21.6	2.0	-3.6	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.248	18.7	1.8	-4.0	1.0
SAMPLE 2	1.250	21.8	0.3	-4.0	1.0
SAMPLE 3	1.250	14.2	0.4	-6.0	-2.0
SAMPLE 4	1.250	20.4	0.1	-3.0	-1.0
SAMPLE 5	1.342	9.3	21.3	0.0	4.0
AVERAGE	1.268	16.9	4.8	-3.4	0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	N219-7	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%V RY)	HC(WET)	HC(DRY)
SAMPLE 1	1.251	18.0	1.0	-2.0	1.0
SAMPLE 2	1.253	17.1	1.7	-2.0	2.0
SAMPLE 3	1.252	18.2	3.3	-3.0	-2.0
SAMPLE 4	1.256	17.4	3.0	-1.0	-1.0
SAMPLE 5	1.256	21.2	3.2	-2.0	1.0
AVERAGE	1.254	18.4	2.5	-2.0	0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.250	20.2	3.2	-1.0	1.0
SAMPLE 2	1.249	23.2	1.3	-3.0	-1.0
SAMPLE 3	1.255	20.8	1.7	-3.0	0.0
SAMPLE 4	1.253	20.4	1.8	0.0	0.0
SAMPLE 5	1.252	20.9	0.7	-1.0	-1.0
AVERAGE	1.252	21.1	1.7	-1.6	-0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.253	24.1	2.6	-1.0	2.0
SAMPLE 2	1.245	17.8	0.8	-2.0	2.0
SAMPLE 3	1.246	18.5	1.7	-2.0	1.0
SAMPLE 4	1.249	21.6	1.1	0.0	1.0
SAMPLE 5	1.251	21.8	1.1	-1.0	1.0
AVERAGE	1.249	20.8	1.5	-1.2	1.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	EPR	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.198	33.8	5.0	-2.0	1.0
SAMPLE 2	1.203	37.0	0.6	-5.0	0.0
SAMPLE 3	1.203	31.9	0.9	-4.0	1.0
SAMPLE 4	1.210	39.1	3.9	-3.0	-1.0
SAMPLE 5	1.185	33.1	2.0	-4.0	-3.0
AVERAGE	1.200	35.0	2.5	-3.6	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.191	61.5	-4.6	-4.0	3.0
SAMPLE 2	1.190	60.3	-3.2	-4.0	0.0
SAMPLE 3	1.194	64.5	1.5	-6.0	-1.0
SAMPLE 4	1.191	61.9	3.4	-7.0	-1.0
SAMPLE 5	1.192	58.4	4.4	-4.0	1.0
AVERAGE	1.192	61.3	0.3	-5.0	0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.191	71.2	1.4	-6.0	2.0
SAMPLE 2	1.191	64.2	4.9	-5.0	1.0
SAMPLE 3	1.193	71.9	2.0	-5.0	1.0
SAMPLE 4	1.190	67.3	-4.8	-5.0	2.0
SAMPLE 5	1.193	65.1	3.9	-4.0	6.0
AVERAGE	1.192	68.0	1.5	-5.0	2.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	VITON	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.838	4.7	0.7	-1.0	2.0
SAMPLE 2	1.822	3.9	-0.0	0.0	-1.0
SAMPLE 3	1.801	2.7	-0.6	-1.0	0.0
SAMPLE 4	1.803	3.0	-0.5	0.0	-2.0
SAMPLE 5	1.804	3.1	-1.1	-1.0	0.0
AVERAGE	1.814	3.5	-0.3	-0.6	-0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.810	3.3	-1.0	-1.0	1.0
SAMPLE 2	1.808	3.1	1.0	0.0	1.0
SAMPLE 3	1.811	3.7	-1.7	0.0	0.0
SAMPLE 4	1.817	3.7	1.0	1.0	2.0
SAMPLE 5	1.819	3.9	0.8	-1.0	-3.0
AVERAGE	1.813	3.5	-0.0	-0.2	0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.798	3.4	-0.2	1.0	0.0
SAMPLE 2	1.807	3.5	0.4	-1.0	-1.0
SAMPLE 3	1.808	3.2	-0.9	1.0	0.0
SAMPLE 4	1.825	4.5	-0.0	0.0	1.0
SAMPLE 5	1.826	4.1	0.1	-1.0	1.0
AVERAGE	1.813	3.7	-0.1	0.0	0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	A700	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.263	16.8	1.3	2.0	4.0
SAMPLE 2	1.265	19.1	1.1	-1.0	3.0
SAMPLE 3	1.255	16.2	0.1	0.0	2.0
SAMPLE 4	1.255	17.9	2.8	2.0	4.0
SAMPLE 5	1.256	16.0	3.8	-1.0	2.0
AVERAGE	1.259	17.2	1.8	0.4	3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	A700	FREE	2.5HR	150F	7DAY

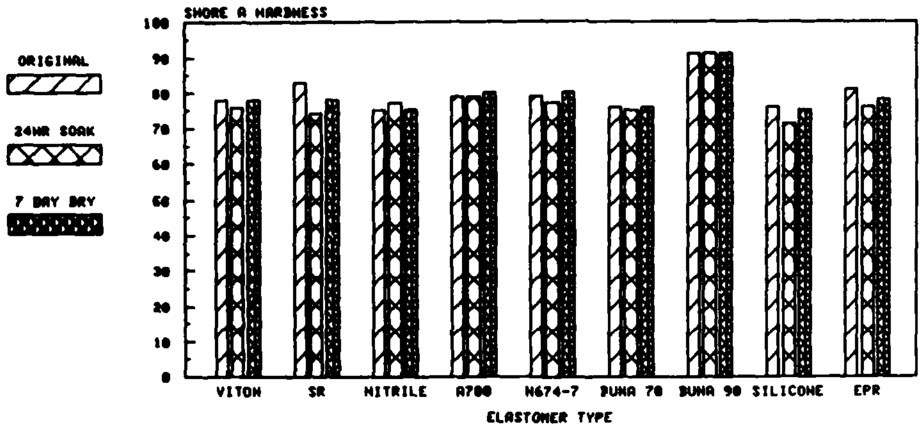
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.257	24.2	4.5	0.0	4.0
SAMPLE 2	1.256	24.1	0.3	-1.0	1.0
SAMPLE 3	1.251	21.2	3.8	-1.0	1.0
SAMPLE 4	1.245	19.5	1.8	0.0	1.0
SAMPLE 5	1.249	24.5	2.8	-2.0	1.0
AVERAGE	1.252	22.7	2.6	-0.8	1.6

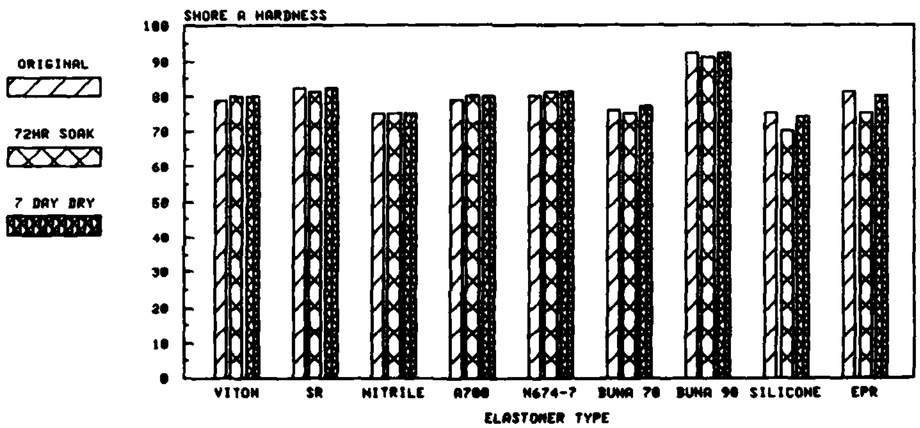
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
MTG	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

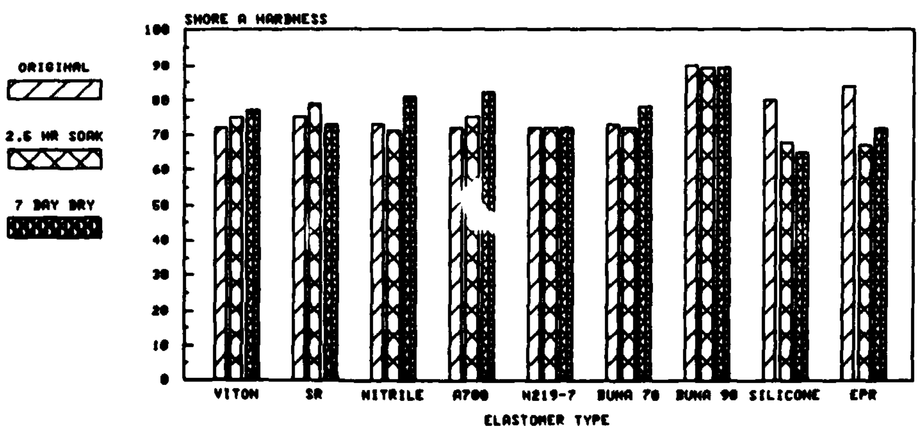
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.249	19.7	2.3	-4.0	1.0
SAMPLE 2	1.254	18.3	2.4	2.0	4.0
SAMPLE 3	1.250	18.6	-0.5	1.0	5.0
SAMPLE 4	1.250	18.0	1.6	0.0	2.0
SAMPLE 5	1.254	19.1	2.0	-2.0	1.0
AVERAGE	1.251	18.7	1.5	-0.6	2.6



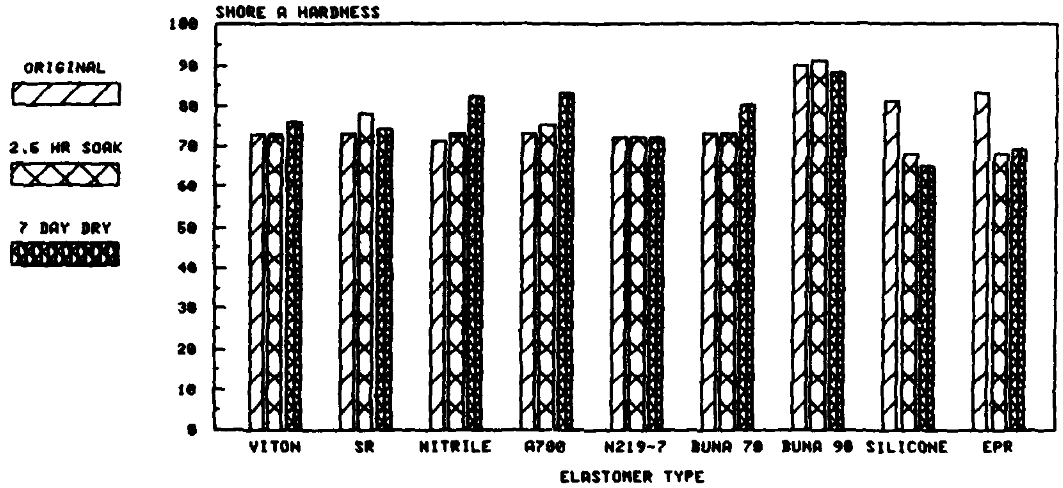
SHORE A HARDNESS WITH PARAHO DFM
(SOAK TEMP = 75°F   TIME = 24HR)



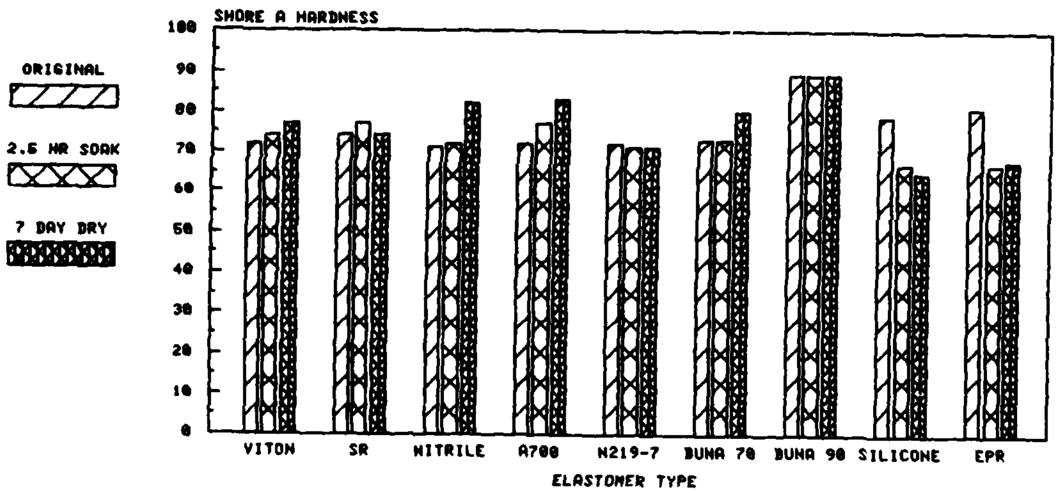
SHORE A HARDNESS WITH PARAHO DFM
(SOAK TEMP = 75°F   TIME = 72HR)



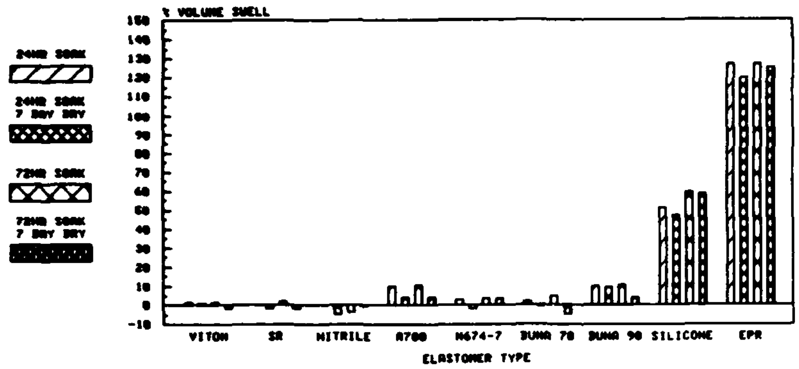
SHORE A HARDNESS WITH PARAHO DFM
(SOAK TEMP = 150°F   TOFT - FREE)



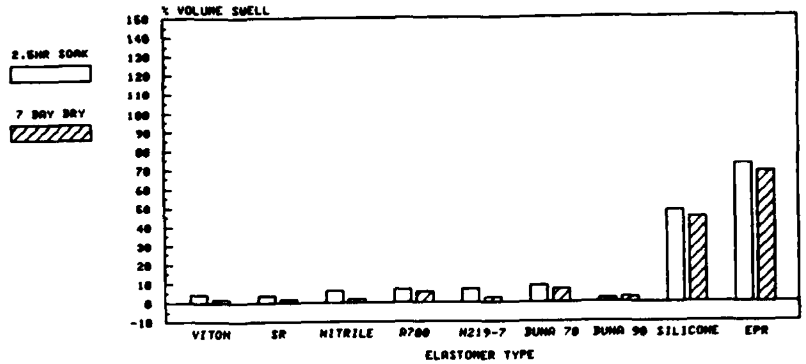
SHORE A HARDNESS WITH PARAHO DFM
(SOAK TEMP = 150°F TOFT - TENSION)



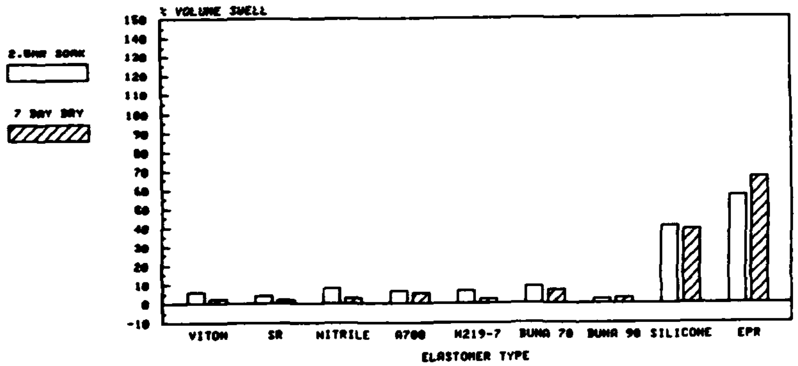
SHORE A HARDNESS WITH PARAHO DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



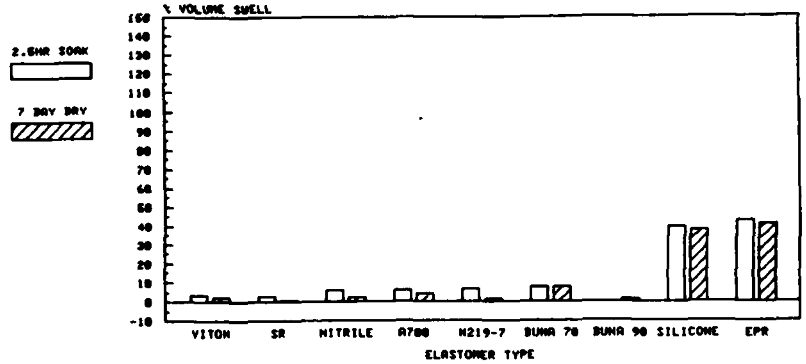
PERCENT VOLUME SWELL WITH PARAHO DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL WITH PARAHO DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL WITH PARAHO DFM
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL WITH PARAHO DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.786	3.1	1.3	-2.0	0.0
SAMPLE 2	1.725	-1.2	0.1	-1.0	0.0
AVERAGE	1.755	1.0	0.7	-1.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.756	3.4	-0.6	1.0	1.0
SAMPLE 2	1.717	-1.3	-2.8	1.0	1.0
AVERAGE	1.736	1.0	-1.7	1.0	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.266	5.1	-1.0	-9.0	-5.0
SAMPLE 2	1.278	4.8	-0.7	-9.0	-5.0
AVERAGE	1.272	4.9	-0.8	-9.0	-5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.275	3.9	-0.7	-1.0	0.0
SAMPLE 2	1.247	3.6	-0.3	0.0	1.0
AVERAGE	1.261	3.8	-0.5	-0.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.233	-1.1	-5.9	2.0	0.0
SAMPLE 2	1.269	3.1	-2.0	5.0	3.0
AVERAGE	1.251	1.0	-3.9	3.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.180	-3.0	-1.2	0.0	0.0
SAMPLE 2	1.233	-3.6	-0.3	0.0	0.0
AVERAGE	1.206	-3.3	-0.8	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.367	13.5	5.3	0.0	0.0
SAMPLE 2	1.336	6.8	3.3	0.0	0.0
AVERAGE	1.351	10.2	4.3	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.334	13.3	4.9	1.0	1.0
SAMPLE 2	1.309	7.9	3.2	0.0	0.0
AVERAGE	1.321	10.6	4.1	0.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.271	2.1	-1.8	-2.0	1.0
SAMPLE 2	1.275	3.4	-1.6	-1.0	2.0
AVERAGE	1.273	2.8	-1.7	-1.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.294	1.5	4.2	1.0	1.0
SAMPLE 2	1.290	5.6	3.3	0.0	0.0
AVERAGE	1.292	3.6	3.8	0.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.264	4.9	2.2	-2.0	-1.0
SAMPLE 2	1.259	5.0	3.3	-1.0	0.0
AVERAGE	1.262	5.0	2.7	-1.5	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.190	2.7	-6.2	-1.0	1.0
SAMPLE 2	1.218	6.5	-2.9	-2.0	-1.0
AVERAGE	1.204	4.6	-4.5	-1.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1 388	13.9	8.6	-1.0	1.0
SAMPLE 2	1.321	6.4	3.1	0.0	0.0
AVERAGE	1.355	10.1	5.9	-0.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.326	11.7	4.9	-1.0	0.0
SAMPLE 2	1.308	9.3	3.0	-1.0	0.0
AVERAGE	1.317	10.5	4.0	-1.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.208	55.3	49.5	-6.0	0.0
SAMPLE 2	1.316	46.4	44.3	-5.0	-1.0
AVERAGE	1.262	50.8	46.9	-5.5	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.368	58.1	59.5	-5.0	-1.0
SAMPLE 2	1.400	60.6	57.5	-4.0	-1.0
AVERAGE	1.384	59.3	58.5	-4.5	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.238	128.7	119.6	-4.0	-2.0
SAMPLE 2	1.226	124.4	119.4	-7.0	-4.0
AVERAGE	1.232	126.5	119.5	-5.5	-3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.235	127.7	125.3	-6.0	-1.0
SAMPLE 2	1.229	125.5	124.6	-5.0	-2.0
AVERAGE	1.232	126.6	125.0	-5.5	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.242	3.5	0.2	3.0	0.0
SAMPLE 2	1.241	3.0	0.0	4.0	0.0
SAMPLE 3	1.242	3.1	1.1	3.0	0.0
SAMPLE 4	1.235	2.3	0.2	4.0	0.0
SAMPLE 5	1.240	2.2	0.3	4.0	0.0
AVERAGE	1.240	2.8	0.4	3.6	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.239	2.8	0.5	5.0	0.0
SAMPLE 2	1.244	3.2	1.2	5.0	2.0
SAMPLE 3	1.247	3.3	1.6	4.0	-2.0
SAMPLE 4	1.248	4.1	2.1	6.0	0.0
SAMPLE 5	1.252	4.4	2.2	4.0	0.0
AVERAGE	1.246	3.6	1.5	4.8	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.250	3.7	1.8	5.0	1.0
SAMPLE 2	1.248	3.2	1.1	4.0	0.0
SAMPLE 3	1.252	3.5	1.2	5.0	1.0
SAMPLE 4	1.256	3.8	1.1	7.0	2.0
SAMPLE 5	1.256	4.0	1.7	8.0	2.0
AVERAGE	1.252	3.6	1.4	5.8	1.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	NITRILE	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.265	4.5	2.3	-2.0	9.0
SAMPLE 2	1.262	6.8	2.6	-3.0	10.0
SAMPLE 3	1.262	6.5	2.2	-3.0	9.0
SAMPLE 4	1.257	5.4	2.1	2.0	10.0
SAMPLE 5	1.260	6.0	2.8	1.0	11.0
AVERAGE	1.261	5.8	2.4	-1.0	9.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	NITRILE	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.257	5.8	2.3	2.0	10.0
SAMPLE 2	1.254	5.4	1.8	0.0	11.0
SAMPLE 3	1.254	4.9	2.0	-2.0	8.0
SAMPLE 4	1.255	6.6	2.3	3.0	11.0
SAMPLE 5	1.251	5.2	1.7	2.0	13.0
AVERAGE	1.254	5.6	2.0	1.0	10.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	NITRILE	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.257	6.9	1.6	1.0	8.0
SAMPLE 2	1.254	5.2	1.5	2.0	10.0
SAMPLE 3	1.257	6.8	2.5	2.0	11.0
SAMPLE 4	1.258	6.0	1.8	-2.0	9.0
SAMPLE 5	1.257	5.9	2.0	-2.0	8.0
AVERAGE	1.257	6.2	1.9	0.2	9.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	N219-7	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.271	3.9	1.2	0.0	-1.0
SAMPLE 2	1.268	6.4	1.2	0.0	0.0
SAMPLE 3	1.273	6.7	1.4	-1.0	-1.0
SAMPLE 4	1.271	6.8	1.2	0.0	1.0
SAMPLE 5	1.271	7.3	1.0	0.0	0.0
AVERAGE	1.271	6.2	1.2	-0.2	-0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.274	6.2	2.1	0.0	1.0
SAMPLE 2	1.278	7.3	2.2	0.0	-1.0
SAMPLE 3	1.278	6.0	2.4	0.0	0.0
SAMPLE 4	1.304	8.1	4.2	0.0	0.0
SAMPLE 5	1.291	6.9	2.2	1.0	0.0
AVERAGE	1.285	6.9	2.6	0.2	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.288	7.2	1.7	1.0	0.0
SAMPLE 2	1.288	7.5	2.3	2.0	1.0
SAMPLE 3	1.279	6.1	2.1	-26.1	1.4
SAMPLE 4	1.280	6.2	2.9	0.0	0.0
SAMPLE 5	1.280	5.7	2.6	0.0	0.0
AVERAGE	1.283	6.5	2.3	-4.6	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 70	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.267	5.3	8.8	0.0	7.0
SAMPLE 2	1.217	11.1	11.4	0.0	4.0
SAMPLE 3	1.210	7.5	9.7	0.0	7.0
SAMPLE 4	1.204	6.1	6.8	0.0	8.0
SAMPLE 5	1.208	8.2	3.0	0.0	9.0
AVERAGE	1.221	7.7	7.9	0.0	7.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 70	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.208	8.9	5.5	0.0	7.0
SAMPLE 2	1.206	9.2	3.5	0.0	6.0
SAMPLE 3	1.212	10.0	10.2	-1.0	5.0
SAMPLE 4	1.208	8.5	6.1	0.0	6.0
SAMPLE 5	1.209	8.9	7.5	0.0	8.0
AVERAGE	1.209	9.1	6.5	-0.2	6.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 70	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.211	8.3	5.7	0.0	7.0
SAMPLE 2	1.212	7.9	9.7	0.0	7.0
SAMPLE 3	1.234	10.1	10.3	0.0	7.0
SAMPLE 4	1.229	8.8	4.4	0.0	7.0
SAMPLE 5	1.227	8.7	4.8	0.0	6.0
AVERAGE	1.223	8.8	7.0	0.0	6.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 90	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.306	1.0	1.8	0.0	-1.0
SAMPLE 2	1.295	-2.7	-2.2	0.0	-2.0
SAMPLE 3	1.304	1.0	1.9	0.0	0.0
SAMPLE 4	1.304	1.1	2.1	0.0	-2.0
SAMPLE 5	1.305	1.3	2.3	8.0	6.0
AVERAGE	1.303	0.3	1.2	1.6	0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 90	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.303	1.1	2.0	4.0	2.0
SAMPLE 2	1.305	1.3	1.9	0.0	0.0
SAMPLE 3	1.305	1.4	2.0	-1.0	-1.0
SAMPLE 4	1.309	1.8	2.6	1.0	1.0
SAMPLE 5	1.309	1.7	2.4	2.0	1.0
AVERAGE	1.306	1.5	2.2	1.2	0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	BUNA 90	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.307	1.8	2.2	0.0	2.0
SAMPLE 2	1.304	2.1	2.5	1.0	1.0
SAMPLE 3	1.308	2.4	2.6	1.0	-2.0
SAMPLE 4	1.313	3.1	3.0	0.0	-1.0
SAMPLE 5	1.321	3.8	3.4	1.0	-1.0
AVERAGE	1.311	2.6	2.7	0.6	-0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SILICONE	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.516	36.7	35.6	-14.0	-14.0
SAMPLE 2	1.547	42.7	41.8	-12.0	-14.0
SAMPLE 3	1.548	41.1	39.3	-12.0	-14.0
SAMPLE 4	1.543	40.8	39.3	-11.0	-13.0
SAMPLE 5	1.544	35.3	33.2	-13.0	-14.0
AVERAGE	1.540	39.3	37.8	-12.4	-13.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SILICONE	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.538	48.5	37.4	-15.0	-14.0
SAMPLE 2	1.512	47.6	45.6	-12.0	-14.0
SAMPLE 3	1.525	45.7	44.0	-12.0	-15.0
SAMPLE 4	1.529	49.6	47.8	-15.0	-17.0
SAMPLE 5	1.557	49.4	46.9	-14.0	-14.0
AVERAGE	1.532	48.2	44.4	-13.6	-14.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	SILICONE	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DAT(

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.544	38.6	37.4	-13.0	-13.0
SAMPLE 2	1.559	50.4	47.4	-13.0	-15.0
SAMPLE 3	1.529	38.3	35.5	-13.0	-16.0
SAMPLE 4	1.536	38.1	36.5	-13.0	-13.0
SAMPLE 5	1.531	37.3	35.8	-11.0	-12.0
AVERAGE	1.540	40.5	38.5	-12.6	-13.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	EPR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.193	37.6	37.6	-19.0	-19.0
SAMPLE 2	1.188	41.0	39.5	-19.0	-15.0
SAMPLE 3	1.187	47.1	45.0	-14.0	-13.0
SAMPLE 4	1.187	36.9	35.1	-20.0	-16.0
SAMPLE 5	1.191	50.7	48.6	-17.0	-11.0
AVERAGE	1.189	42.7	41.2	-17.8	-14.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.193	64.6	62.1	-16.0	-16.0
SAMPLE 2	1.191	73.0	69.9	-18.0	-13.0
SAMPLE 3	1.194	71.6	70.0	-16.0	-16.0
SAMPLE 4	1.191	65.3	57.7	-17.0	-11.0
SAMPLE 5	1.191	88.1	84.2	-21.0	-13.0
AVERAGE	1.192	72.5	68.8	-17.6	-13.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.191	38.9	64.5	-21.0	-16.0
SAMPLE 2	1.190	34.9	63.9	-16.0	-13.0
SAMPLE 3	1.195	70.3	68.2	-15.0	-14.0
SAMPLE 4	1.193	64.3	62.7	-19.0	-16.0
SAMPLE 5	1.199	72.9	70.5	-18.0	-15.0
AVERAGE	1.194	56.3	66.0	-17.8	-14.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	VITON	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.863	3.2	1.0	2.0	5.0
SAMPLE 2	1.866	3.7	3.3	-1.0	1.0
SAMPLE 3	1.856	4.2	2.8	2.0	5.0
SAMPLE 4	1.846	2.9	2.6	2.0	4.0
SAMPLE 5	1.853	3.5	2.3	0.0	4.0
AVERAGE	1.857	3.5	2.4	1.0	3.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.841	2.7	1.5	3.0	4.0
SAMPLE 2	1.849	4.0	1.5	1.0	5.0
SAMPLE 3	1.852	4.1	2.3	3.0	5.0
SAMPLE 4	1.843	3.5	2.0	4.0	6.0
SAMPLE 5	1.847	3.7	2.0	5.0	6.0
AVERAGE	1.846	3.6	1.9	3.2	5.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.858	3.4	2.2	1.0	2.0
SAMPLE 2	1.854	3.4	2.0	2.0	3.0
SAMPLE 3	1.854	4.9	2.7	0.0	3.0
SAMPLE 4	1.855	5.9	3.0	4.0	5.0
SAMPLE 5	1.852	4.8	2.5	1.0	2.0
AVERAGE	1.855	4.5	2.5	1.6	3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.263	4.5	3.7	1.0	11.0
SAMPLE 2	1.262	5.8	3.7	7.0	10.0
SAMPLE 3	1.267	5.4	4.4	5.0	11.0
SAMPLE 4	1.269	6.3	4.8	5.0	13.0
SAMPLE 5	1.273	6.2	4.8	7.0	11.0
AVERAGE	1.267	5.7	4.3	5.0	11.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	A700	FREE	2.5HR	150F	7DAY

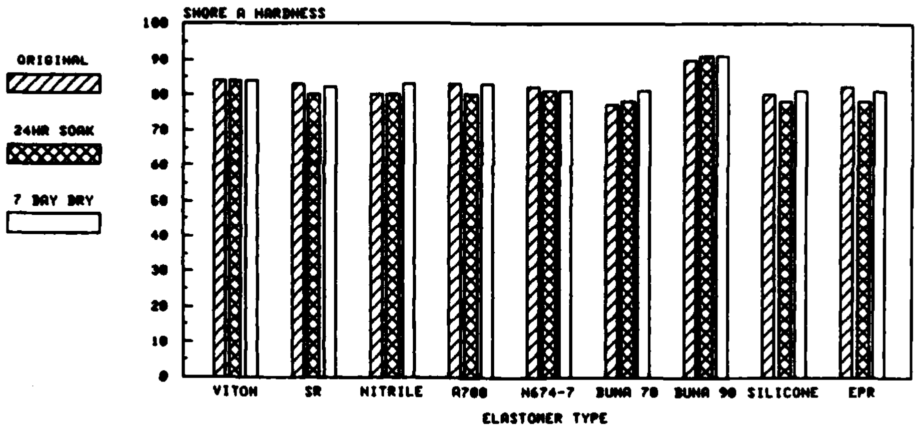
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.268	6.8	5.6	3.0	10.0
SAMPLE 2	1.269	6.2	5.2	2.0	9.0
SAMPLE 3	1.267	6.2	4.9	6.0	7.0
SAMPLE 4	1.274	7.4	6.0	1.0	9.0
SAMPLE 5	1.269	5.9	5.2	3.0	7.0
AVERAGE	1.269	6.5	5.4	3.0	8.4

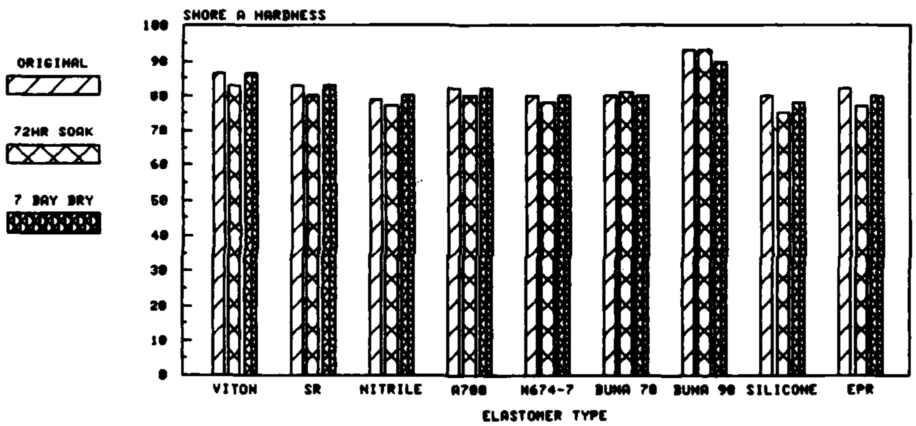
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

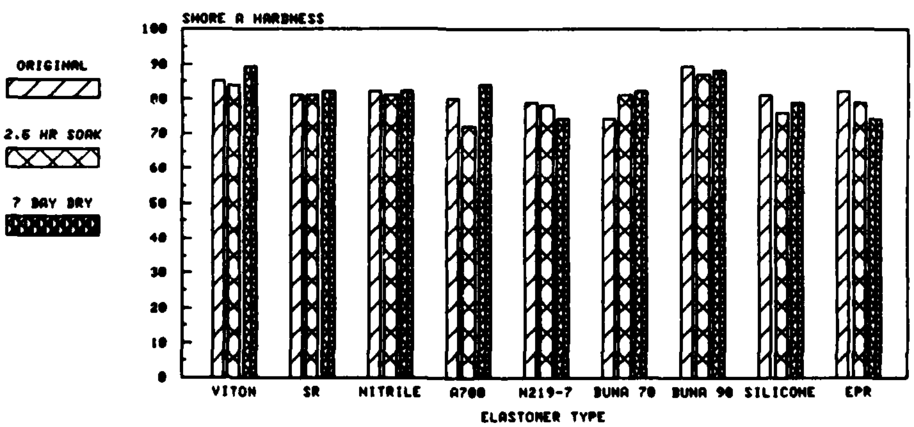
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.263	5.3	5.1	3.0	9.0
SAMPLE 2	1.265	6.5	4.8	4.0	9.0
SAMPLE 3	1.266	6.5	5.5	2.0	10.0
SAMPLE 4	1.271	6.4	5.6	4.0	11.0
SAMPLE 5	1.268	6.7	5.6	4.0	12.0
AVERAGE	1.267	6.3	5.3	3.4	10.2



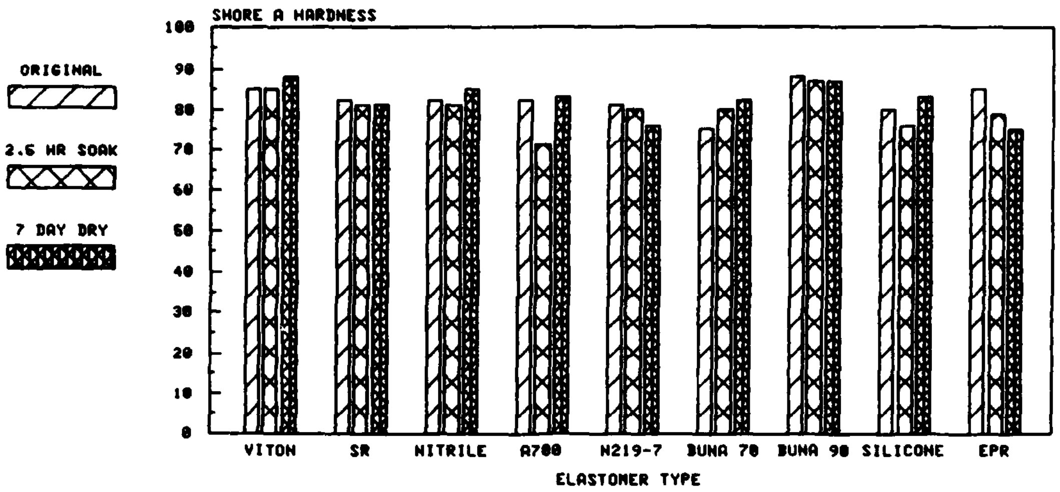
SHORE A HARDNESS WITH 50% AROMATICS DFM
(SOAK TEMP = 75°F TIME = 24HR)



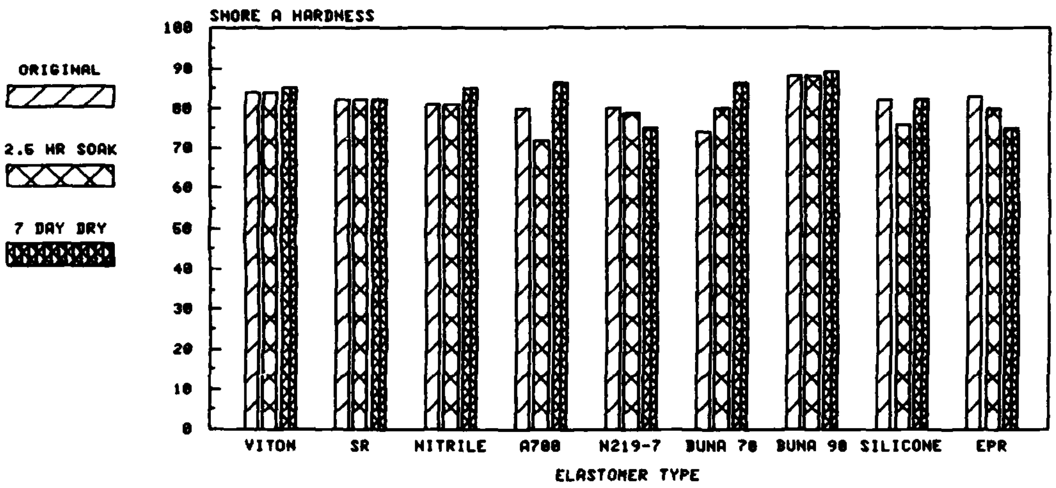
SHORE A HARDNESS WITH 50% AROMATICS DFM
(SOAK TEMP = 75°F TIME = 72HR)



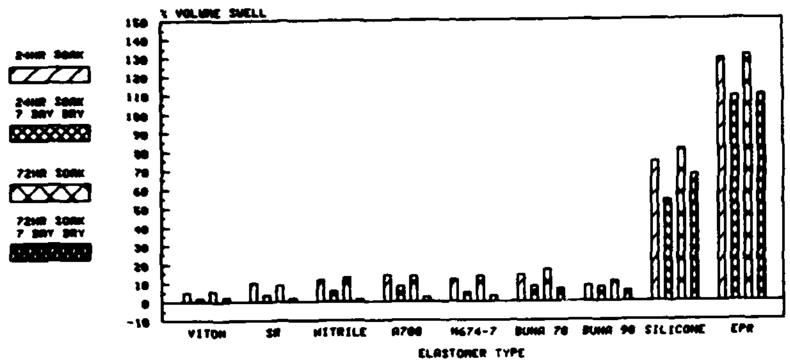
SHORE A HARDNESS - 50% AROMATICS DFM
(SOAK TEMP = 150°F TOFT - FREE)



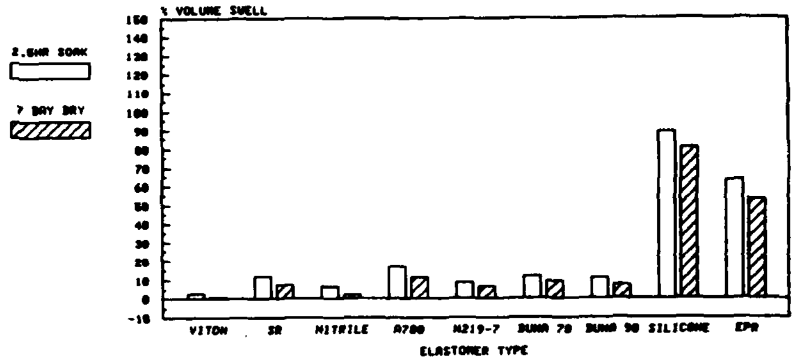
SHORE A HARDNESS - 50% AROMATICS DFM
(SOAK TEMP = 150°F TOFT - TENSION)



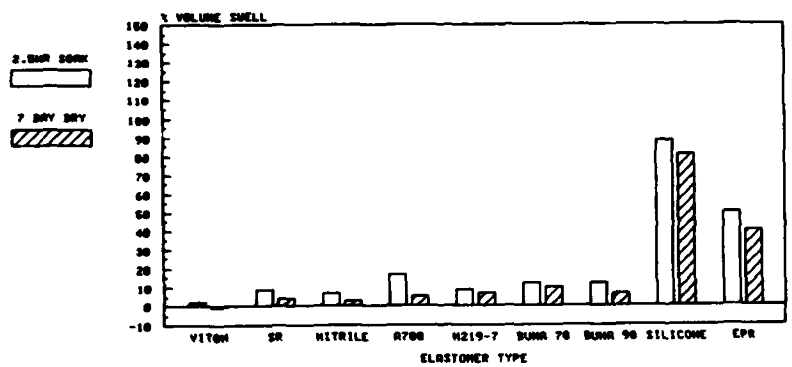
SHORE A HARDNESS - 50% AROMATICS DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



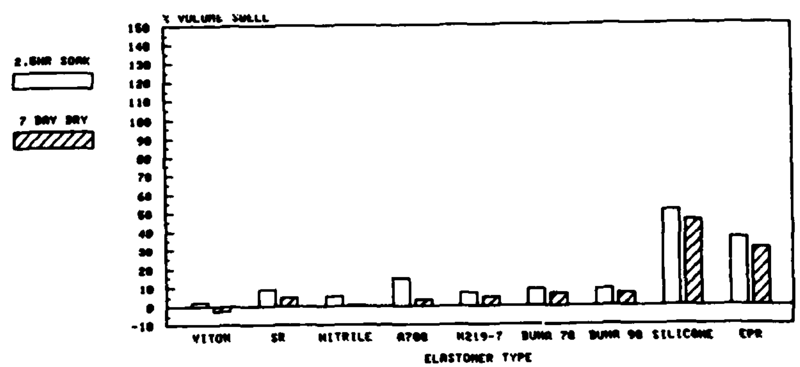
PERCENT VOLUME SWELL - 50% AROMATIC DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL - 50% AROMATICS DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL - 50% AROMATICS DFM
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL - 50% AROMATICS DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.788	4.3	1.2	-2.0	-5.0
SAMPLE 2	1.827	5.8	2.5	0.0	0.0
AVERAGE	1.808	5.0	1.9	-1.0	-2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.814	6.2	3.7	-3.0	0.0
SAMPLE 2	1.814	4.3	0.8	-3.0	0.0
AVERAGE	1.814	5.2	2.2	-3.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.249	10.0	4.0	-3.0	-1.0
SAMPLE 2	1.253	9.9	3.3	-2.0	-4.0
AVERAGE	1.251	9.9	3.7	-2.5	-2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.250	9.9	3.3	-3.0	0.0
SAMPLE 2	1.248	8.3	0.0	-3.0	-1.0
AVERAGE	1.249	9.1	1.7	-3.0	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.282	11.8	4.8	-1.0	5.0
SAMPLE 2	1.277	11.4	5.8	0.0	3.0
AVERAGE	1.279	11.6	5.3	-0.5	4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.290	12.4	1.8	-2.0	1.0
SAMPLE 2	1.300	13.2	0.3	-2.0	0.0
AVERAGE	1.295	12.8	1.1	-2.0	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.294	16.1	9.1	-3.0	-3.0
SAMPLE 2	1.301	11.9	7.7	-3.0	0.0
AVERAGE	1.298	14.0	8.4	-3.0	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.302	13.0	1.8	-2.0	0.0
SAMPLE 2	1.302	13.9	2.8	-3.0	0.0
AVERAGE	1.302	13.4	2.3	-2.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.281	12.1	5.6	1.0	3.0
SAMPLE 2	1.279	11.3	4.1	-1.0	-1.0
AVERAGE	1.280	11.7	4.8	0.0	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.288	13.6	3.4	-2.0	0.0
SAMPLE 2	1.285	13.3	2.7	-2.0	-1.0
AVERAGE	1.286	13.4	3.0	-2.0	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.255	14.5	8.3	1.0	4.0
SAMPLE 2	1.252	13.9	8.5	2 0	3.0
AVERAGE	1.253	14.2	8.4	1.5	3.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.249	16.0	7.3	1.0	0.0
SAMPLE 2	1.248	17.5	6.1	2.0	0.0
AVERAGE	1.249	16.8	6.7	1.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.297	8.7	8.1	1.0	1.0
SAMPLE 2	1.296	7.9	7.3	-1.0	-1.0
AVERAGE	1.296	8.3	7.7	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.301	10.3	6.7	0.0	-3.0
SAMPLE 2	1.283	10.9	4.1	1.0	0.0
AVERAGE	1.292	10.6	5.4	0.5	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.396	70.8	52.2	-2.0	-4.0
SAMPLE 2	1.409	76.5	54.7	-2.0	1.0
AVERAGE	1.402	73.7	53.4	-2.0	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.326	89.5	75.3	-5.0	-2.0
SAMPLE 2	1.402	71.7	57.9	-5.0	-2.0
AVERAGE	1.364	80.6	66.6	-5.0	-2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.224	128.9	105.8	-4.0	-1.0
SAMPLE 2	1.224	128.9	110.9	-5.0	-2.0
AVERAGE	1.224	128.9	108.3	-4.5	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.231	132.1	109.0	-5.0	725.0
SAMPLE 2	1.232	129.4	110.6	-5.0	-3.0
AVERAGE	1.232	130.8	109.8	-5.0	361.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.274	8.7	4.9	-2.0	-1.0
SAMPLE 2	1.274	8.4	4.7	1.0	1.0
SAMPLE 3	1.273	7.9	4.1	0.0	0.0
SAMPLE 4	1.279	8.9	4.8	-2.0	0.0
SAMPLE 5	1.279	8.9	4.8	-3.0	-2.0
AVERAGE	1.276	8.6	4.7	-1.2	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.281	11.2	7.3	1.0	5.0
SAMPLE 2	1.277	12.5	6.4	1.0	4.0
SAMPLE 3	1.279	10.9	6.6	0.0	1.0
SAMPLE 4	1.304	13.7	8.7	0.0	2.0
SAMPLE 5	1.305	13.0	8.7	-2.0	0.0
AVERAGE	1.289	12.2	7.6	0.0	2.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.262	9.9	5.3	-2.0	0.0
SAMPLE 2	1.265	7.7	2.7	-2.0	-1.0
SAMPLE 3	1.270	6.2	2.5	-1.0	-1.0
SAMPLE 4	1.262	11.6	5.8	-3.0	-1.0
SAMPLE 5	1.266	9.3	4.2	-3.0	1.0
AVERAGE	1.265	8.9	4.1	-2.2	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	NITRILE	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.245	5.7	1.2	0.0	5.0
SAMPLE 2	1.246	5.1	-2.6	0.0	4.0
SAMPLE 3	1.245	5.9	2.0	0.0	4.0
SAMPLE 4	1.244	4.4	0.8	0.0	2.0
SAMPLE 5	1.246	5.9	2.0	0.0	4.0
AVERAGE	1.245	5.4	0.7	0.0	3.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	NITRILE	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.246	6.9	2.3	-2.0	-1.0
SAMPLE 2	1.247	6.9	2.3	-3.0	2.0
SAMPLE 3	1.245	6.2	2.0	-1.0	0.0
SAMPLE 4	1.249	6.6	2.7	-1.0	5.0
SAMPLE 5	1.247	6.5	2.5	-1.0	3.0
AVERAGE	1.247	6.6	2.4	-1.6	1.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	NITRILE	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.248	7.9	3.9	-1.0	2.0
SAMPLE 2	1.248	9.0	3.9	0.0	3.0
SAMPLE 3	1.251	6.8	2.8	-1.0	3.0
SAMPLE 4	1.252	3.2	0.4	-2.0	0.0
SAMPLE 5	1.246	7.2	2.4	-1.0	2.0
AVERAGE	1.249	6.8	2.7	-1.0	2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	N219-7	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.242	6.2	4.8	-1.0	-3.0
SAMPLE 2	1.244	7.1	5.5	-1.0	-4.0
SAMPLE 3	1.245	7.4	5.8	-1.0	-5.0
SAMPLE 4	1.243	6.0	1.4	-1.0	-3.0
SAMPLE 5	1.246	8.7	5.3	1.0	-4.0
AVERAGE	1.244	7.1	4.6	-0.6	-3.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.244	8.6	5.8	-2.0	-6.0
SAMPLE 2	1.246	8.4	6.7	-1.0	-5.0
SAMPLE 3	1.246	11.1	7.5	-1.0	-5.0
SAMPLE 4	1.245	8.3	5.9	-1.0	-7.0
SAMPLE 5	1.248	8.0	6.3	-2.0	-7.0
AVERAGE	1.246	8.9	6.4	-1.4	-6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.248	8.3	6.6	-2.0	-6.0
SAMPLE 2	1.249	10.0	7.7	-1.0	-4.0
SAMPLE 3	1.247	8.5	6.2	-1.0	-5.0
SAMPLE 4	1.246	9.1	6.8	-1.0	-5.0
SAMPLE 5	1.245	8.0	6.8	-1.0	-5.0
AVERAGE	1.247	8.8	6.8	-1.2	-5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 70	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.217	9.3	7.4	8.0	12.0
SAMPLE 2	1.215	9.4	6.5	7.0	9.0
SAMPLE 3	1.212	8.2	6.0	9.0	11.0
SAMPLE 4	1.217	8.8	6.5	6.0	12.0
SAMPLE 5	1.220	9.8	6.7	6.0	12.0
AVERAGE	1.216	9.1	6.6	7.2	11.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 70	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.219	11.9	8.6	7.0	9.0
SAMPLE 2	1.219	12.8	9.8	5.0	9.0
SAMPLE 3	1.219	12.7	9.5	7.0	8.0
SAMPLE 4	1.229	11.9	9.5	7.0	11.0
SAMPLE 5	1.225	13.0	9.9	4.0	9.0
AVERAGE	1.222	12.5	9.4	6.0	9.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 70	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.226	12.1	9.2	7.0	11.0
SAMPLE 2	1.225	11.8	10.1	7.0	11.0
SAMPLE 3	1.225	12.2	9.2	5.0	7.0
SAMPLE 4	1.228	13.6	10.1	5.0	10.0
SAMPLE 5	1.224	12.8	10.2	6.0	9.0
AVERAGE	1.225	12.5	9.8	6.0	9.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 90	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.317	7.1	4.9	-2.0	-1.0
SAMPLE 2	1.319	9.0	6.1	-1.0	-1.0
SAMPLE 3	1.321	8.1	5.8	-2.0	-1.0
SAMPLE 4	1.317	9.9	7.2	-2.0	-1.0
SAMPLE 5	1.321	10.3	7.4	-1.0	-1.0
AVERAGE	1.319	8.9	6.3	-1.6	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 90	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.319	10.5	7.1	-3.0	-1.0
SAMPLE 2	1.321	10.8	7.2	-2.0	-1.0
SAMPLE 3	1.318	12.6	8.6	-2.0	-1.0
SAMPLE 4	1.318	11.8	8.3	0.0	0.0
SAMPLE 5	1.323	10.8	7.2	0.0	1.0
AVERAGE	1.320	11.3	7.7	-1.4	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	BUNA 90	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.318	12.5	6.6	-1.0	-1.0
SAMPLE 2	1.319	11.1	5.5	-2.0	-1.0
SAMPLE 3	1.330	13.7	7.7	-1.0	-1.0
SAMPLE 4	1.324	11.8	7.1	-2.0	-2.0
SAMPLE 5	1.324	11.7	6.5	-3.0	-3.0
AVERAGE	1.323	12.1	6.7	-1.8	-1.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SILICONE	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.522	30.9	27.9	-4.0	1.0
SAMPLE 2	1.523	41.6	35.6	-7.0	1.0
SAMPLE 3	1.527	35.5	25.7	-7.0	-3.0
SAMPLE 4	1.525	42.0	35.1	-6.0	0.0
SAMPLE 5	1.528	37.3	30.2	-6.0	-1.0
AVERAGE	1.525	37.5	30.9	-6.0	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SILICONE	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.530	59.0	48.9	-5.0	-2.0
SAMPLE 2	1.531	57.0	48.8	-5.0	-1.0
SAMPLE 3	1.536	68.9	57.8	-4.0	1.0
SAMPLE 4	1.531	60.3	50.2	-6.0	1.0
SAMPLE 5	1.536	68.6	57.6	-6.0	1.0
AVERAGE	1.533	62.8	52.7	-5.2	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	SILICONE	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.536	49.7	41.0	-6.0	2.0
SAMPLE 2	1.534	49.9	42.9	-6.0	1.0
SAMPLE 3	1.536	50.4	39.9	-4.0	3.0
SAMPLE 4	1.538	49.2	39.0	-4.0	3.0
SAMPLE 5	1.537	49.5	37.5	-6.0	-3.0
AVERAGE	1.536	49.7	40.0	-5.2	1.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	EPR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.208	47.3	42.0	0.0	-5.0
SAMPLE 2	1.207	43.0	38.9	-2.0	-8.0
SAMPLE 3	1.207	48.6	43.8	-3.0	-8.0
SAMPLE 4	1.206	59.2	52.9	-1.0	-8.0
SAMPLE 5	1.209	61.5	55.1	-1.0	-8.0
AVERAGE	1.207	51.9	46.6	-1.4	-7.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.207	83.8	74.7	-3.0	-8.0
SAMPLE 2	1.206	74.8	68.0	-3.0	-8.0
SAMPLE 3	1.208	87.1	79.3	-3.0	-8.0
SAMPLE 4	1.205	92.0	80.8	-2.0	-6.0
SAMPLE 5	1.207	106.6	99.8	-3.0	-8.0
AVERAGE	1.207	88.9	80.5	-2.8	-7.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.205	84.1	76.0	-3.0	-7.0
SAMPLE 2	1.210	93.2	86.6	-1.0	-6.0
SAMPLE 3	1.212	90.5	82.9	-6.0	-10.0
SAMPLE 4	1.205	87.1	79.8	-1.0	-7.0
SAMPLE 5	1.205	84.3	77.2	-5.0	-10.0
AVERAGE	1.207	87.8	80.5	-3.2	-8.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	VITON	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.832	2.2	-1.0	2.0	4.0
SAMPLE 2	1.817	3.2	-5.2	1.0	3.0
SAMPLE 3	1.820	2.2	-1.7	0.0	1.0
SAMPLE 4	1.816	3.4	-1.3	2.0	3.0
SAMPLE 5	1.822	1.4	-1.8	2.0	2.0
AVERAGE	1.821	2.5	-2.2	1.4	2.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	VITON	2.5HR	150F	7DAY	0%AROM

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.827	2.7	-0.7	1.0	2.0
SAMPLE 2	1.822	1.1	-1.8	0.0	6.0
SAMPLE 3	1.839	6.7	-0.3	-1.0	4.0
SAMPLE 4	1.831	2.2	-0.9	1.0	4.0
SAMPLE 5	1.832	2.3	-0.7	0.0	6.0
AVERAGE	1.830	3.0	-0.9	0.2	4.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.832	1.7	-0.4	1.0	5.0
SAMPLE 2	1.832	2.0	-0.6	0.0	3.0
SAMPLE 3	1.836	2.7	-0.5	0.0	3.0
SAMPLE 4	1.836	1.5	-0.8	-2.0	1.0
SAMPLE 5	1.837	3.0	-0.4	0.0	1.0
AVERAGE	1.835	2.2	-0.5	-0.2	2.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.272	15.6	4.1	-8.0	6.0
SAMPLE 2	1.267	15.6	4.3	-9.0	3.0
SAMPLE 3	1.269	10.9	3.6	-10.0	5.0
SAMPLE 4	1.272	15.3	3.9	-7.0	10.0
SAMPLE 5	1.267	15.7	3.3	-8.0	5.0
AVERAGE	1.269	14.6	3.8	-8.4	5.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	A700	FREE	2.5HR	150F	7DAY

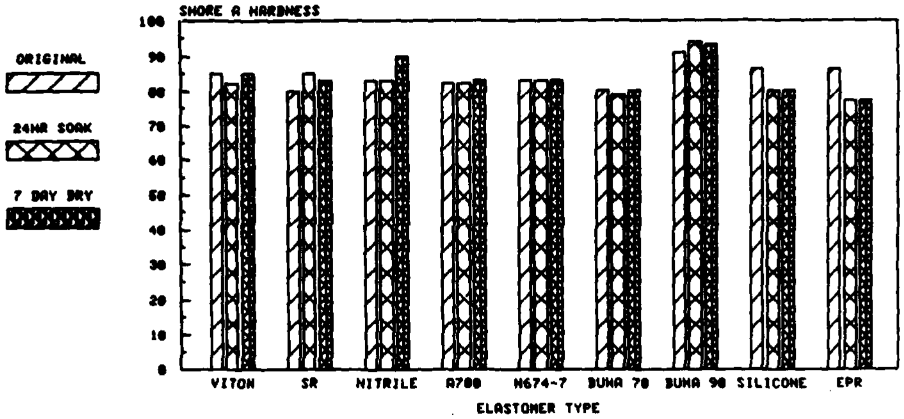
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.261	16.4	22.1	-8.0	6.0
SAMPLE 2	1.263	16.9	23.2	-10.0	5.0
SAMPLE 3	1.265	18.3	5.3	-8.0	3.0
SAMPLE 4	1.265	16.9	4.2	-8.0	4.0
SAMPLE 5	1.266	16.8	3.9	-10.0	4.0
AVERAGE	1.264	17.1	11.7	-8.8	4.4

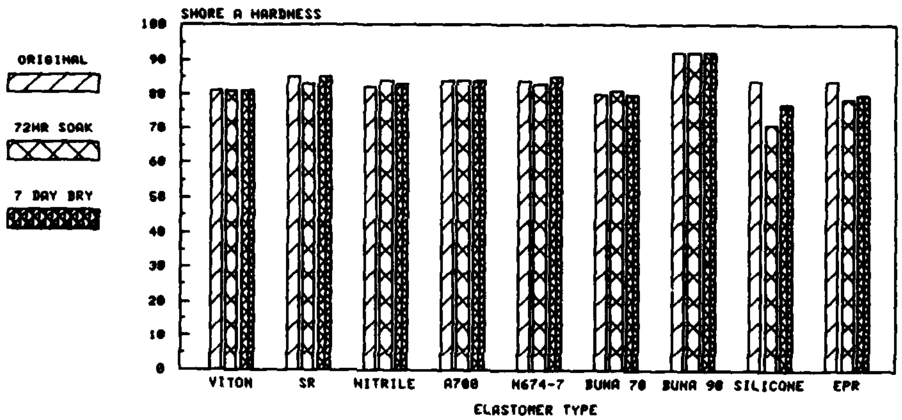
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
50%AROM	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.269	18.3	4.0	-9.0	6.0
SAMPLE 2	1.271	18.8	4.9	-10.0	4.0
SAMPLE 3	1.220	9.9	0.4	-11.0	1.0
SAMPLE 4	1.274	17.7	6.6	-10.0	3.0
SAMPLE 5	1.269	16.7	6.2	-8.0	3.0
AVERAGE	1.261	16.3	4.4	-9.6	3.4



SHORE A HARDNESS - 10% AROMATICS DFM
(SOAK TEMP = 75°F TIME = 24HR)



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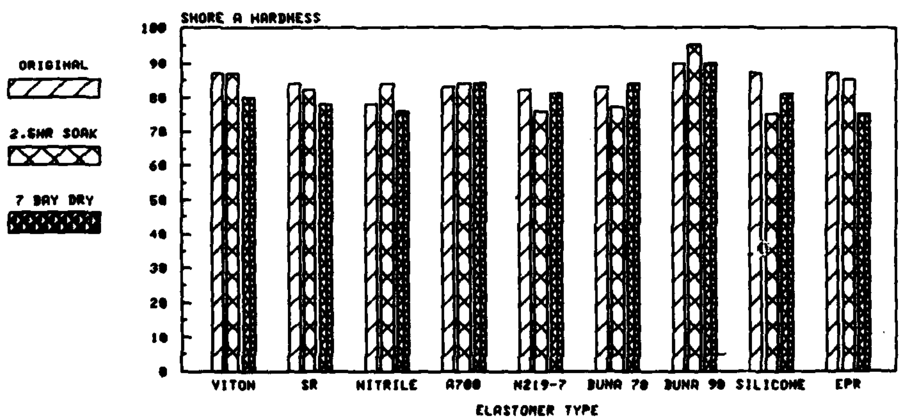
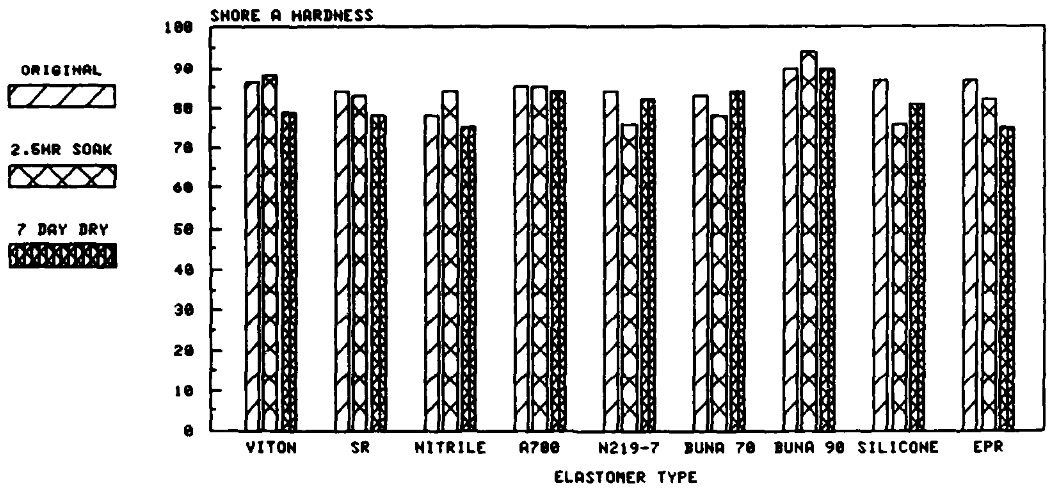
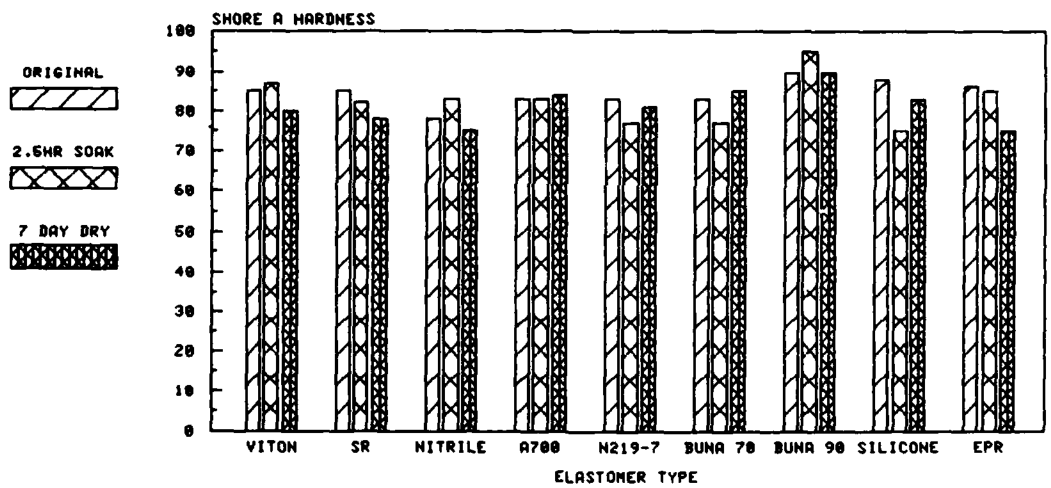
(SOAK TEMP = 75°F TIME = 72HR)



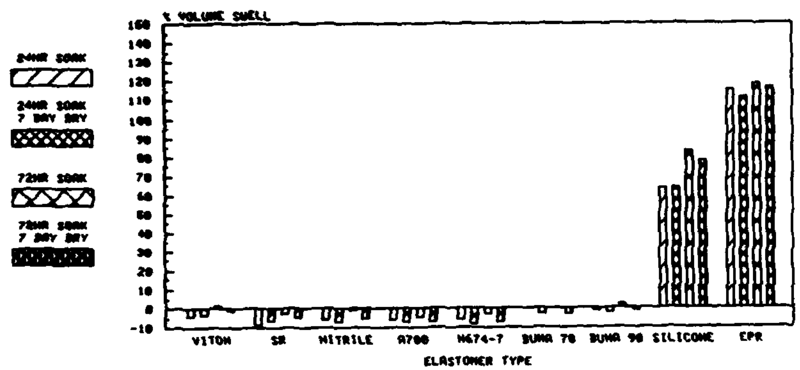
SHORE A HARDNESS - 10% AROMATICS DFM
(SOAK TEMP = 150°F TOFT -FREE)



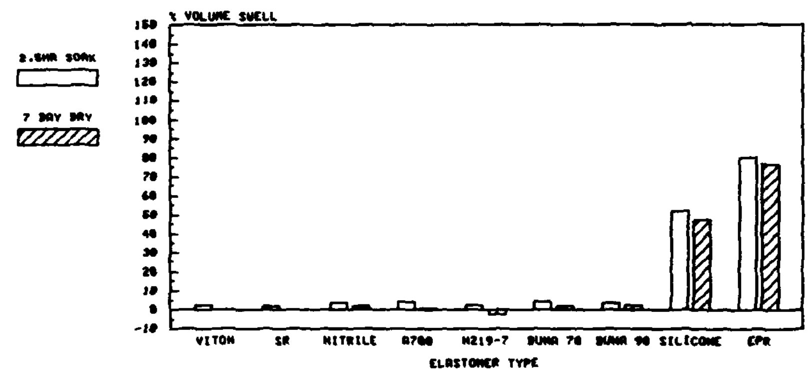
SHORE A HARDNESS - 10% AROMATICS DFM
(SOAK TEMP = 150°F TOFT - TENSION)



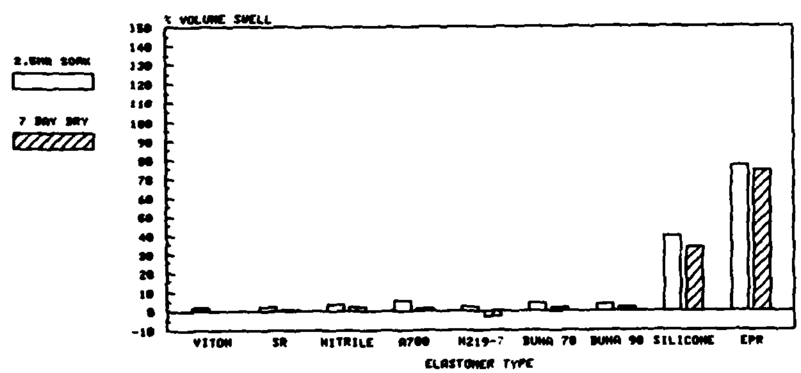
SHORE A HARDNESS - 10% AROMATICS DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



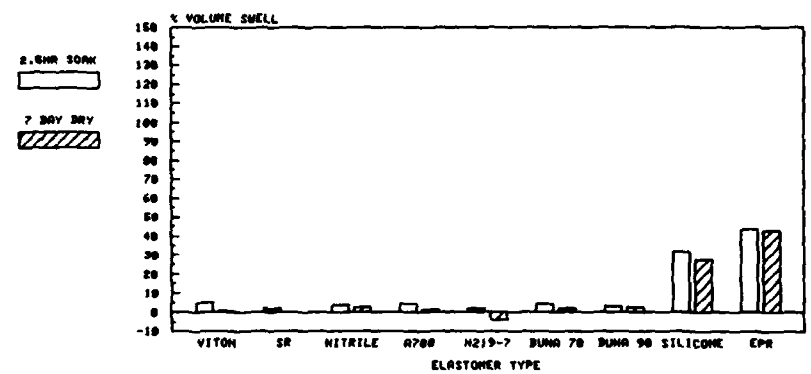
PERCENT VOLUME SWELL - 10% AROMATIC DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL - 10% AROMATIC DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL - 10% AROMATIC DFM
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL - 10% AROMATIC DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.752	-4.8	-5.1	5.0	3.0
SAMPLE 2	1.756	-3.8	-1.5	5.0	3.0
AVERAGE	1.754	-4.3	-3.3	5.0	3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.759	1.1	-0.8	0.0	0.0
SAMPLE 2	1.743	1.6	-1.3	0.0	0.0
AVERAGE	1.751	1.3	-1.0	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.175	-9.0	-6.0	-3.0	0.0
SAMPLE 2	1.205	-8.1	-7.0	-3.0	0.0
AVERAGE	1.190	-8.6	-6.5	-3.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.217	-5.7	-4.6	-2.0	0.0
SAMPLE 2	1.229	-0.2	-4.6	-2.0	0.0
AVERAGE	1.223	-2.9	-4.6	-2.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.229	-5.5	-8.3	1.0	7.0
SAMPLE 2	1.230	-5.7	-6.2	1.0	7.0
AVERAGE	1.229	-5.6	-7.2	1.0	7.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.231	-3.5	-6.3	2.0	1.0
SAMPLE 2	1.262	1.1	-3.9	1.0	1.0
AVERAGE	1.247	-1.2	-5.1	1.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.250	-5.5	-7.3	1.0	1.0
SAMPLE 2	1.248	-5.8	-6.9	0.0	1.0
AVERAGE	1.249	-5.6	-7.1	0.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.249	-4.3	-5.9	0.0	0.0
SAMPLE 2	1.231	-5.2	-8.2	0.0	0.0
AVERAGE	1.240	-4.8	-7.0	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.232	-5.7	-7.0	0.0	0.0
SAMPLE 2	1.230	-6.0	-9.6	0.0	0.0
AVERAGE	1.231	-5.8	-8.3	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.243	-2.8	-7.6	-1.0	1.0
SAMPLE 2	1.244	-2.5	-6.8	-1.0	1.0
AVERAGE	1.244	-2.7	-7.2	-1.0	1.0

AD-A113 532 SOUTHWEST RESEARCH INST SAN ANTONIO TX ARMY FUELS AN--ETC F/G 15/F
DEVELOPMENT OF ACCELERATED FUEL-ENGINES QUALIFICATION PROCEDURE--F
DEC 81 J A RUSSELL, J P CUELLAR, J C TYLER DAAK70-80-C-0001
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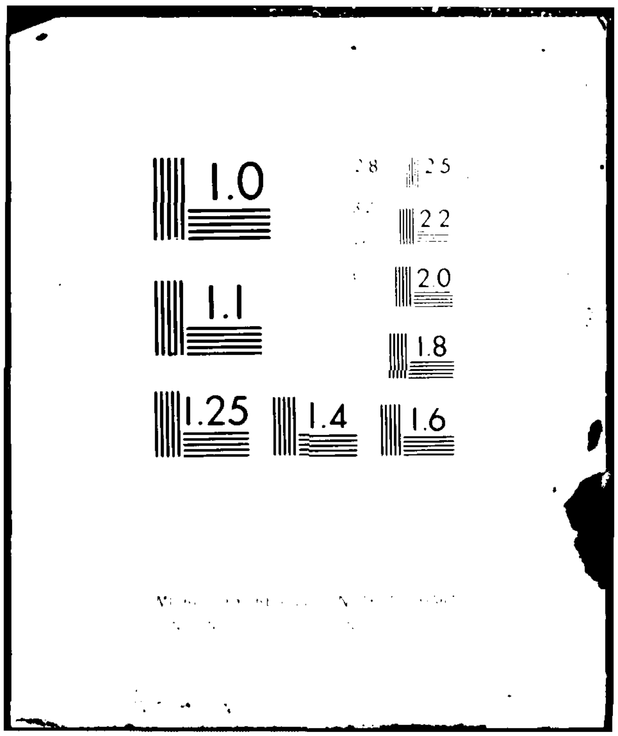
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2.2
2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.205	0.6	-3.0	1.0	0.0
SAMPLE 2	1.200	-1.1	-3.2	0.0	0.0
AVERAGE	1.202	-0.2	-3.1	0.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.205	0.6	-3.0	1.0	0.0
SAMPLE 2	1.200	-1.1	-3.2	0.0	0.0
AVERAGE	1.202	-0.2	-3.1	0.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.263	0.0	-2.4	4.0	4.0
SAMPLE 2	1.270	-2.9	-2.7	2.0	1.0
AVERAGE	1.267	-1.4	-2.5	3.0	2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.268	1.8	-0.6	0.0	0.0
SAMPLE 2	1.264	1.5	-1.2	1.0	1.0
AVERAGE	1.266	1.6	-0.9	0.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.382	61.3	63.0	-4.0	-6.0
SAMPLE 2	1.378	66.0	63.2	-7.0	-6.0
AVERAGE	1.380	63.6	63.1	-5.5	-6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.256	80.9	77.1	-13.0	-6.0
SAMPLE 2	1.275	84.5	77.4	-12.0	-7.0
AVERAGE	1.266	82.7	77.2	-12.5	-6.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.203	116.8	112.3	-9.0	-9.0
SAMPLE 2	1.194	113.5	109.6	-9.0	-9.0
AVERAGE	1.198	115.2	111.0	-9.0	-9.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
10%AROM	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.194	117.6	110.3	-5.0	-4.0
SAMPLE 2	1.220	118.6	122.5	-6.0	-5.0
AVERAGE	1.207	118.1	116.4	-5.5	-4.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	SR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.262	3.2	0.9	-3.0	-6.0
SAMPLE 2	1.248	1.6	-0.0	-2.0	-7.0
SAMPLE 3	1.246	1.2	-0.4	-2.0	-7.0
SAMPLE 4	1.245	1.0	-0.1	-3.0	-6.0
SAMPLE 5	1.246	1.8	0.2	-4.0	-8.0
AVERAGE	1.249	1.8	0.1	-2.8	-6.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.248	1.8	-0.3	-1.0	-4.0
SAMPLE 2	1.250	1.9	0.0	-5.0	-9.0
SAMPLE 3	1.252	1.6	-0.1	-3.0	-8.0
SAMPLE 4	1.253	2.2	0.7	-2.0	-6.0
SAMPLE 5	1.251	2.1	0.8	-1.0	-6.0
AVERAGE	1.251	1.9	0.2	-2.4	-6.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.251	2.6	0.8	0.0	-5.0
SAMPLE 2	1.251	2.0	0.4	-2.0	-7.0
SAMPLE 3	1.254	2.2	0.2	0.0	-5.0
SAMPLE 4	1.255	2.1	0.5	-3.0	-7.0
SAMPLE 5	1.254	2.4	0.6	-2.0	-7.0
AVERAGE	1.253	2.2	0.5	-1.4	-6.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	NITRILE	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.272	5.2	2.3	5.0	-2.0
SAMPLE 2	1.260	3.2	2.3	8.0	-3.0
SAMPLE 3	1.262	3.1	2.8	4.0	-4.0
SAMPLE 4	1.264	3.7	2.8	4.0	-3.0
SAMPLE 5	1.262	3.5	2.5	4.0	-3.0
AVERAGE	1.264	3.7	2.5	5.0	-3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	NITRILE	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.260	3.8	2.5	5.0	-3.0
SAMPLE 2	1.264	3.3	2.3	7.0	-3.0
SAMPLE 3	1.263	3.3	1.4	7.0	-1.0
SAMPLE 4	1.262	3.2	2.3	3.0	-3.0
SAMPLE 5	1.259	2.7	1.6	5.0	-2.0
AVERAGE	1.261	3.3	2.0	5.4	-2.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	NITRILE	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.260	3.5	2.2	7.0	-3.0
SAMPLE 2	1.255	3.1	2.1	5.0	-3.0
SAMPLE 3	1.258	3.8	2.5	7.0	-2 [illegible]
SAMPLE 4	1.260	3.3	2.2	7.0	-3 [illegible]
SAMPLE 5	1.261	2.8	2.3	4.0	-2 [illegible]
AVERAGE	1.259	3.3	2.2	6.0	-2.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	N219-7	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.246	1.1	-2.1	-8.0	-4.0
SAMPLE 2	1.225	2.2	-5.7	-9.0	-5.0
SAMPLE 3	1.271	2.1	-2.8	-7.0	-1.0
SAMPLE 4	1.251	2.1	-6.3	-6.0	-2.0
SAMPLE 5	1.246	1.9	-3.6	-5.0	-1.0
AVERAGE	1.248	1.9	-4.1	-7.0	-2.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.254	1.9	-3.0	-7.0	-1.0
SAMPLE 2	1.254	2.6	-3.6	-8.0	-1.0
SAMPLE 3	1.256	2.3	-0.4	-5.0	0.0
SAMPLE 4	1.248	1.7	-0.8	-4.0	1.0
SAMPLE 5	1.251	1.9	-3.9	-5.0	-2.0
AVERAGE	1.252	2.1	-2.3	-5.8	-0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.254	2.1	-4.6	-10.0	-4.0
SAMPLE 2	1.250	2.5	-2.8	-6.0	-3.0
SAMPLE 3	1.254	2.5	-2.2	-6.0	0.0
SAMPLE 4	1.252	2.4	-2.8	-10.0	-4.0
SAMPLE 5	1.256	2.7	-1.3	-7.0	-2.0
AVERAGE	1.253	2.4	-2.8	-7.8	-2.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	BUNA 70	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.212	4.5	2.0	-5.0	2.0
SAMPLE 2	1.210	4.6	2.4	-6.0	2.0
SAMPLE 3	1.204	4.4	2.2	-5.0	3.0
SAMPLE 4	1.207	4.0	1.8	-4.0	2.0
SAMPLE 5	1.208	3.9	1.7	-3.0	2.0
AVERAGE	1.208	4.3	2.0	-4.6	2.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	BUNA 70	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.205	3.8	1.8	-7.0	1.0
SAMPLE 2	1.207	4.4	2.2	-5.0	0.0
SAMPLE 3	1.209	3.5	1.3	-5.0	1.0
SAMPLE 4	1.211	5.0	2.3	-7.0	2.0
SAMPLE 5	1.209	4.7	2.1	-6.0	2.0
AVERAGE	1.208	4.3	1.9	-6.0	1.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	BUNA 70	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.210	4.5	2.2	-5.0	1.0
SAMPLE 2	1.212	4.8	1.5	-4.0	0.0
SAMPLE 3	1.206	4.1	2.0	-7.0	-1.0
SAMPLE 4	1.208	3.9	2.0	-8.0	0.0
SAMPLE 5	1.205	3.7	1.8	-7.0	1.0
AVERAGE	1.208	4.2	1.9	-6.2	0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	BUNA 90	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.319	3.8	3.0	4.0	-1.0
SAMPLE 2	1.320	2.8	1.6	5.0	1.0
SAMPLE 3	1.318	3.3	2.1	4.0	0.0
SAMPLE 4	1.319	3.1	2.2	4.0	-2.0
SAMPLE 5	1.317	3.1	1.8	5.0	1.0
AVERAGE	1.319	3.2	2.1	4.4	-0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	BUNA 90	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.318	2.9	2.2	7.0	-1.0
SAMPLE 2	1.320	3.2	2.5	3.0	0.0
SAMPLE 3	1.322	4.0	2.4	5.0	0.0
SAMPLE 4	1.324	3.8	2.4	6.0	-1.0
SAMPLE 5	1.322	3.9	1.7	4.0	0.0
AVERAGE	1.321	3.6	2.2	5.0	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	BUNA 90	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.320	3.3	1.9	4.0	0.0
SAMPLE 2	1.322	3.7	2.4	3.0	0.0
SAMPLE 3	1.324	3.9	2.4	4.0	0.0
SAMPLE 4	1.316	4.6	1.6	5.0	-1.0
SAMPLE 5	1.317	2.9	1.2	4.0	1.0
AVERAGE	1.320	3.7	1.9	4.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	SILICONE	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.525	31.4	28.9	-12.0	-4.0
SAMPLE 2	1.505	29.1	25.5	-12.0	-7.0
SAMPLE 3	1.510	32.8	26.4	-13.0	-7.0
SAMPLE 4	1.509	31.9	27.8	-13.0	-6.0
SAMPLE 5	1.530	33.7	29.4	-11.0	-4.0
AVERAGE	1.516	31.8	27.6	-12.2	-5.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	SILICONE	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.502	50.0	45.4	-10.0	-3.0
SAMPLE 2	1.499	48.5	44.0	-11.0	-5.0
SAMPLE 3	1.507	49.1	43.5	-13.0	-7.0
SAMPLE 4	1.508	64.7	59.6	-11.0	-7.0
SAMPLE 5	1.509	45.5	40.9	-13.0	-8.0
AVERAGE	1.505	51.6	46.7	-11.6	-6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	SILICONE	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.506	39.4	35.8	-10.0	-5.0
SAMPLE 2	1.505	38.5	34.7	-11.0	-5.0
SAMPLE 3	1.493	36.0	28.3	-10.0	-5.0
SAMPLE 4	1.507	39.7	34.6	-11.0	-8.0
SAMPLE 5	1.509	41.7	34.2	-12.0	-2.0
AVERAGE	1.504	39.1	33.5	-10.8	-5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	EPR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.201	37.0	36.3	1.0	-9.0
SAMPLE 2	1.199	43.1	42.4	-1.0	-11.0
SAMPLE 3	1.196	43.1	43.4	-2.0	-11.0
SAMPLE 4	1.195	42.3	42.3	-1.0	-11.0
SAMPLE 5	1.201	52.1	51.0	-1.0	-12.0
AVERAGE	1.198	43.5	43.1	-0.8	-10.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.200	79.1	77.4	-4.0	-13.0
SAMPLE 2	1.198	84.1	80.9	-1.0	-11.0
SAMPLE 3	1.199	73.5	69.7	-2.0	-12.0
SAMPLE 4	1.200	85.2	81.0	-4.0	-13.0
SAMPLE 5	1.200	76.0	73.1	-1.0	-10.0
AVERAGE	1.199	79.6	76.4	-2.4	-11.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.201	69.1	67.1	-2.0	-12.0
SAMPLE 2	1.201	75.0	73.6	-3.0	-13.0
SAMPLE 3	1.206	98.5	95.1	-6.0	-10.0
SAMPLE 4	1.202	74.7	70.5	-5.0	-11.0
SAMPLE 5	1.202	64.6	63.2	-9.0	-15.0
AVERAGE	1.202	76.4	73.9	-5.0	-12.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	VITON	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.851	4.3	0.6	2.0	-5.0
SAMPLE 2	1.850	6.8	0.9	1.0	-5.0
SAMPLE 3	1.849	6.6	0.9	4.0	-5.0
SAMPLE 4	1.849	2.8	0.9	2.0	-5.0
SAMPLE 5	1.848	3.6	1.0	4.0	-5.0
AVERAGE	1.849	4.8	0.9	2.6	-5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.845	2.7	-0.7	1.0	-7.0
SAMPLE 2	1.844	2.5	0.0	0.0	-8.0
SAMPLE 3	1.845	1.8	0.0	0.0	-8.0
SAMPLE 4	1.851	2.8	0.5	0.0	-8.0
SAMPLE 5	1.848	2.7	0.2	2.0	-5.0
AVERAGE	1.847	2.5	0.0	0.6	-7.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.837	1.6	-0.3	3.0	-7.0
SAMPLE 2	1.830	1.3	-0.6	1.0	-8.0
SAMPLE 3	1.834	2.3	-0.4	1.0	-9.0
SAMPLE 4	1.776	1.5	-0.2	5.0	-4.0
SAMPLE 5	1.847	3.2	0.5	-1.0	-9.0
AVERAGE	1.825	2.0	-0.2	1.8	-7.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.266	4.2	4.6	-3.0	0.0
SAMPLE 2	1.262	3.9	0.8	0.0	0.0
SAMPLE 3	1.265	4.0	0.9	0.0	1.0
SAMPLE 4	1.262	3.9	0.2	-1.0	1.0
SAMPLE 5	1.265	4.4	0.5	1.0	1.0
AVERAGE	1.264	4.1	1.4	-0.6	0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	A700	FREE	2.5HR	150F	7DAY

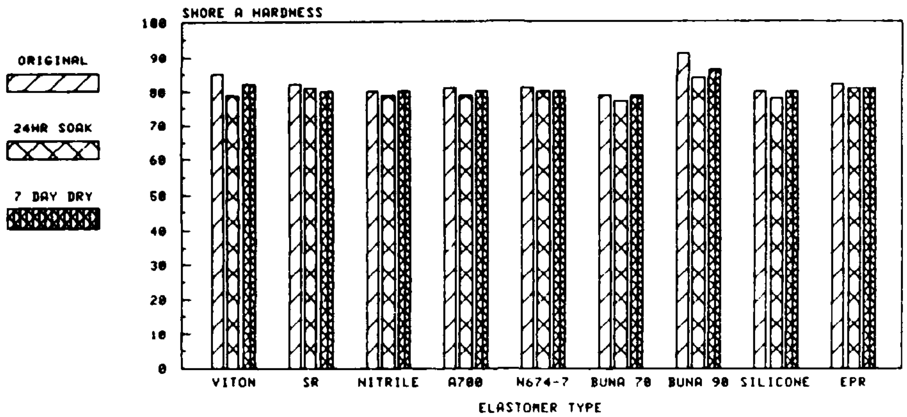
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.266	4.8	0.5	0.0	2.0
SAMPLE 2	1.269	1.3	0.9	0.0	-1.0
SAMPLE 3	1.270	4.8	0.1	0.0	2.0
SAMPLE 4	1.270	4.7	0.3	0.0	0.0
SAMPLE 5	1.269	4.8	0.0	0.0	0.0
AVERAGE	1.269	4.1	0.4	0.0	0.6

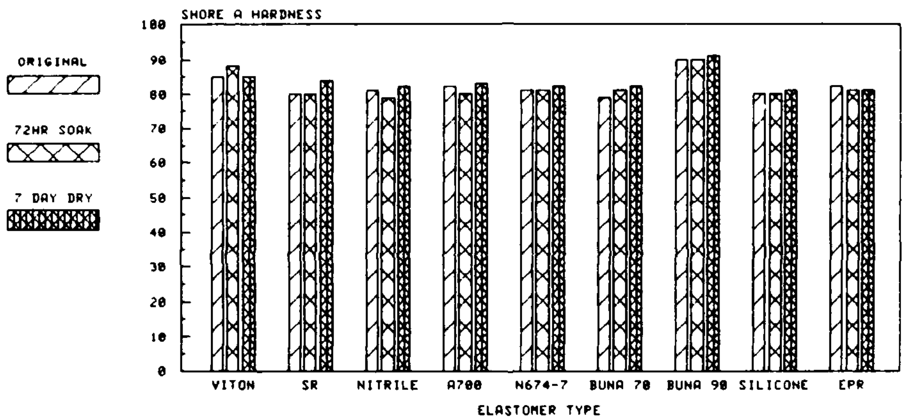
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
DFM 10%AR	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

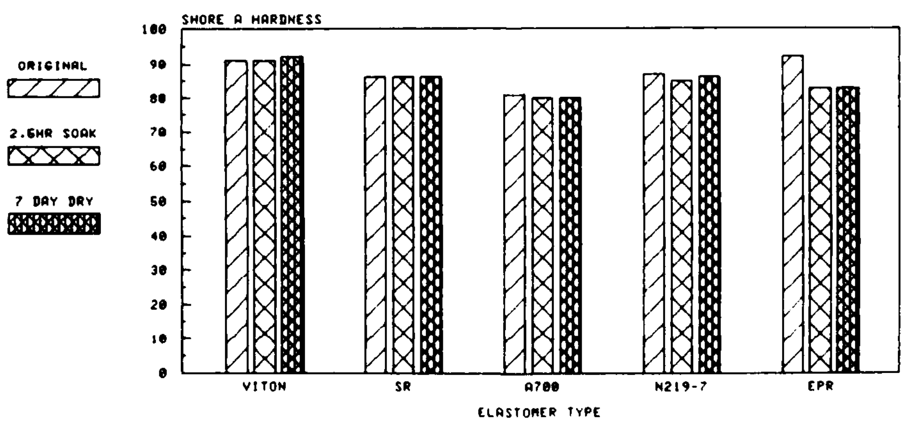
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.274	5.2	0.9	0.0	-1.0
SAMPLE 2	1.274	5.5	1.1	0.0	0.0
SAMPLE 3	1.275	5.4	1.7	0.0	1.0
SAMPLE 4	1.277	5.5	0.8	0.0	2.0
SAMPLE 5	1.277	5.7	1.1	0.0	0.0
AVERAGE	1.275	5.5	1.1	0.0	0.0



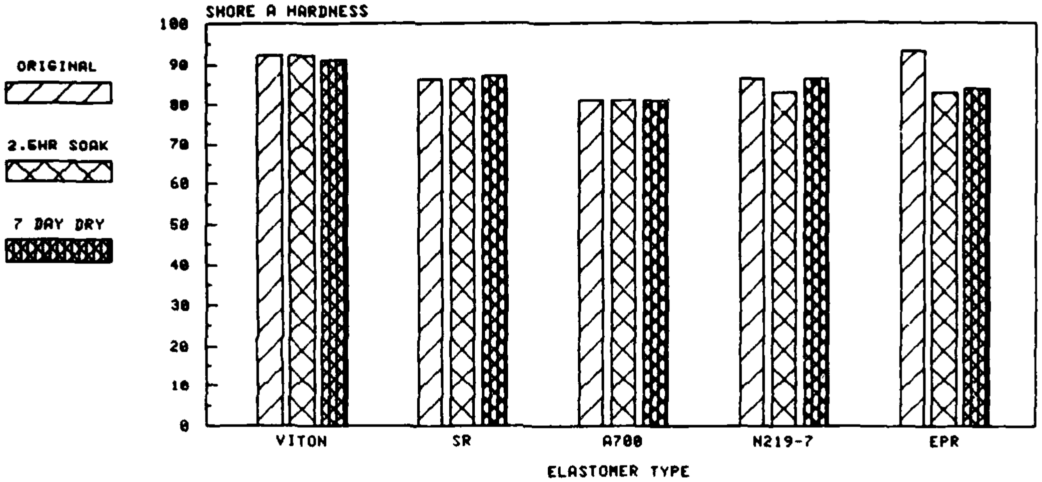
SHORE A HARDNESS WITH BYCYCLIC DFM
(SOAK TEMP = 75°F TIME = 24HR)



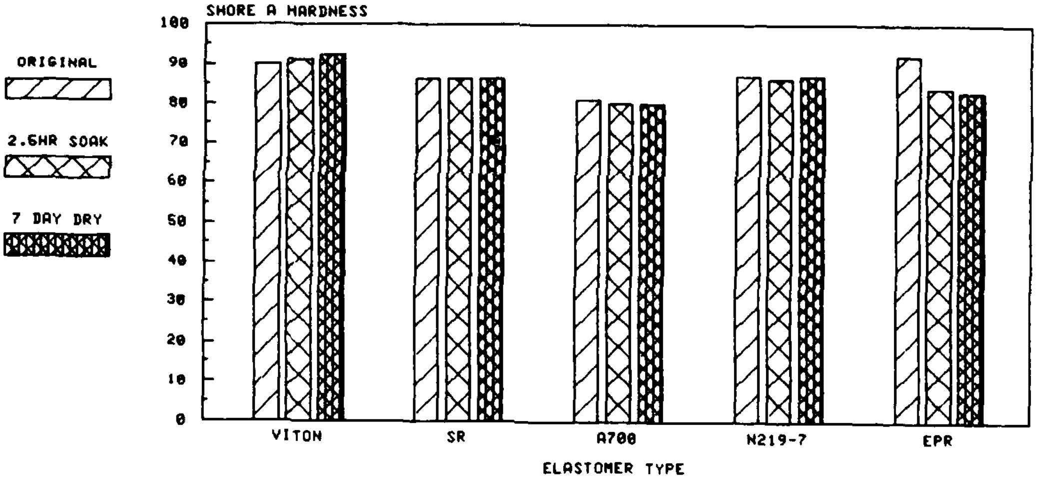
SHORE A HARDNESS WITH BYCYCLIC DFM
(SOAK TEMP = 75°F TIME = 72HR)



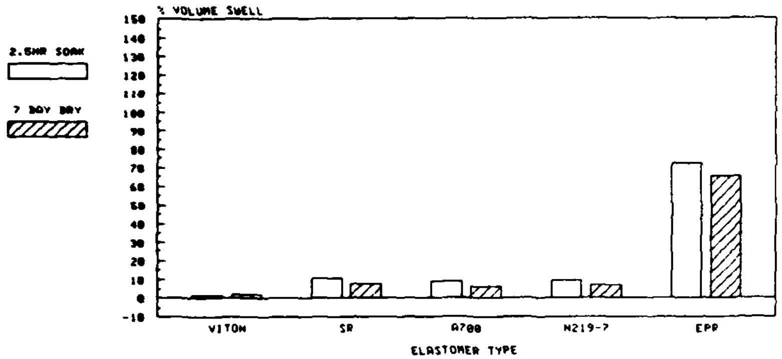
SHORE A HARDNESS - BYCYCLIC DFM
(SOAK TEMP = 150°F TOFT - FREE)



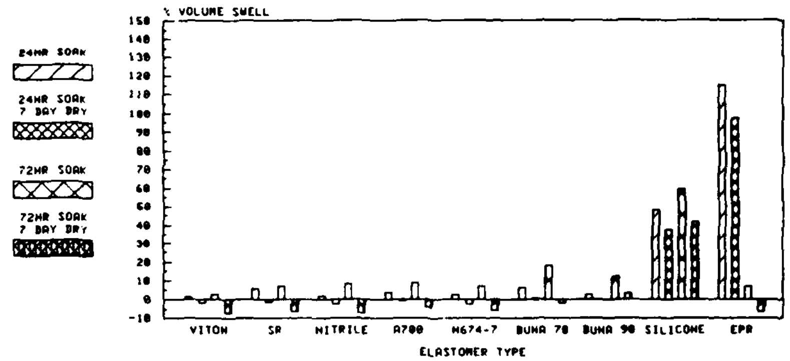
SHORE A HARDNESS - BYCYCLIC DFM
(SOAK TEMP = 150°F TOFT - TENSION)



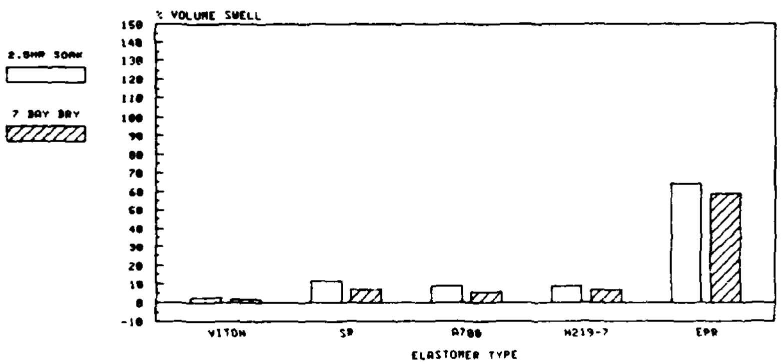
SHORE A HARDNESS - BYCYCLIC DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



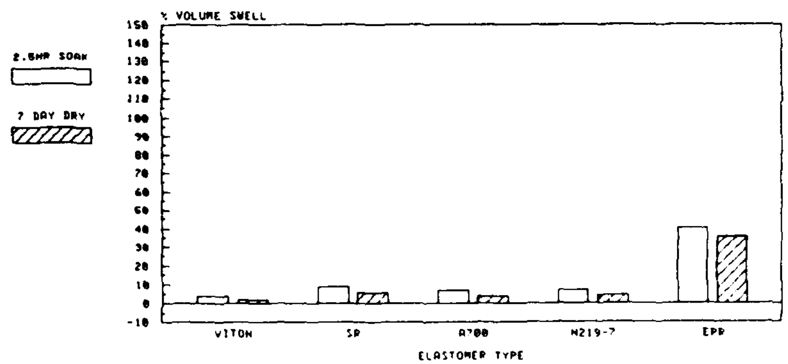
PERCENT VOLUME SWELL WITH BYCYCLIC DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL WITH BYCYCLIC DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL WITH BYCYCLIC DFM
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL WITH BYCYCLIC DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.809	3.3	0.0	-6.0	-2.0
SAMPLE 2	1.765	-0.5	-3.1	-7.0	-5.0
AVERAGE	1.787	1.4	-1.5	-6.5	-3.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.752	1.8	-6.1	3.0	2.0
SAMPLE 2	1.750	3.0	-8.4	4.0	-1.0
AVERAGE	1.751	2.4	-7.2	3.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.234	5.3	-0.3	-3.0	-3.0
SAMPLE 2	1.221	4.9	-1.6	0.0	-1.0
AVERAGE	1.228	5.1	-0.9	-1.5	2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.216	6.8	-5.4	-1.0	4.0
SAMPLE 2	1.218	7.4	-8.0	0.0	3.0
AVERAGE	1.217	7.1	-6.7	-0.5	3.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.214	1.3	-3.0	1.0	1.0
SAMPLE 2	1.222	1.3	-2.0	0.0	2.0
AVERAGE	1.218	1.3	-2.5	0.5	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.208	8.5	-7.2	-1.0	3.0
SAMPLE 2	1.219	8.1	-7.3	-2.0	-1.0
AVERAGE	1.214	8.3	-7.3	-1.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.264	4.1	-1.0	-1.0	1.0
SAMPLE 2	1.247	3.0	-0.3	-2.0	-1.0
AVERAGE	1.256	3.5	-0.6	-1.5	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.248	8.2	-4.7	-2.0	2.0
SAMPLE 2	1.260	9.7	-3.9	-2.0	1.0
AVERAGE	1.254	8.9	-4.3	-2.0	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.236	3.1	-2.0	-2.0	-2.0
SAMPLE 2	1.224	1.9	-2.8	1.0	1.0
AVERAGE	1.230	2.5	-2.4	-0.5	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.235	7.9	-6.0	0.0	1.0
SAMPLE 2	1.232	6.6	-5.5	0.0	0.0
AVERAGE	1.233	7.3	-5.8	0.0	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.194	5.3	0.2	-3.0	-1.0
SAMPLE 2	1.199	6.4	1.5	-1.0	0.0
AVERAGE	1.197	5.8	0.8	-2.0	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.198	20.1	-0.3	2.0	3.0
SAMPLE 2	1.182	16.2	-2.9	1.0	2.0
AVERAGE	1.190	18.1	-1.6	1.5	2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.247	2.7	0.6	-6.0	-5.0
SAMPLE 2	1.245	1.6	-0.6	-7.0	-4.0
AVERAGE	1.246	2.2	0.0	-6.5	-4.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.274	12.9	4.7	-6.0	0.0
SAMPLE 2	1.265	11.8	1.3	0.0	1.0
AVERAGE	1.270	12.4	3.0	-3.0	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.339	46.3	35.5	-2.0	0.0
SAMPLE 2	1.377	48.7	39.1	-2.0	-1.0
AVERAGE	1.358	47.5	37.3	-2.0	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.362	54.0	37.2	0.0	2.0
SAMPLE 2	1.251	65.0	46.6	1.0	1.0
AVERAGE	1.306	59.5	41.9	0.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.176	111.8	93.5	-1.0	0.0
SAMPLE 2	1.178	118.3	101.7	-2.0	-3.0
AVERAGE	1.177	115.0	97.6	-1.5	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.165	112.4	91.4	-1.0	-2.0
SAMPLE 2	1.164	115.3	93.6	-2.0	-1.0
AVERAGE	1.165	113.9	92.5	-1.5	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	SR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.260	7.7	5.0	0.0	2.0
SAMPLE 2	1.255	7.9	5.5	0.0	3.0
SAMPLE 3	1.260	8.5	4.7	0.0	0.0
SAMPLE 4	1.265	11.3	4.9	0.0	0.0
SAMPLE 5	1.269	9.3	6.6	0.0	1.0
AVERAGE	1.262	8.9	5.3	0.0	1.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.265	11.3	8.8	0.0	1.0
SAMPLE 2	1.249	9.4	7.6	0.0	1.0
SAMPLE 3	1.255	9.5	6.6	0.0	-1.0
SAMPLE 4	1.254	10.6	6.8	0.0	2.0
SAMPLE 5	1.250	10.9	7.6	0.0	1.0
AVERAGE	1.255	10.3	7.5	0.0	0.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.255	9.7	6.9	0.0	1.0
SAMPLE 2	1.257	11.7	8.8	0.0	3.0
SAMPLE 3	1.257	10.3	6.7	0.0	1.0
SAMPLE 4	1.250	13.3	6.8	0.0	1.0
SAMPLE 5	1.250	13.8	6.7	0.0	0.0
AVERAGE	1.254	11.7	7.2	0.0	1.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	N219-7	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.246	6.5	2.7	-4.0	-1.0
SAMPLE 2	1.262	8.8	3.9	-1.0	0.0
SAMPLE 3	1.246	5.6	4.4	-2.0	0.0
SAMPLE 4	1.251	7.6	5.6	-2.0	0.0
SAMPLE 5	1.243	6.5	4.8	0.0	1.0
AVERAGE	1.250	7.0	4.3	-1.8	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.244	8.7	7.2	-2.0	1.0
SAMPLE 2	1.246	10.3	7.8	-3.0	-2.0
SAMPLE 3	1.245	10.3	8.0	-6.0	4.0
SAMPLE 4	1.250	8.5	6.4	-1.0	-3.0
SAMPLE 5	1.248	9.2	7.3	-3.0	0.0
AVERAGE	1.247	9.4	7.3	-3.0	1.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.251	8.5	6.8	-1.0	0.0
SAMPLE 2	1.252	9.7	8.3	-3.0	0.0
SAMPLE 3	1.249	9.7	7.4	-4.0	0.0
SAMPLE 4	1.253	8.8	3.2	-4.0	0.0
SAMPLE 5	1.254	8.9	7.3	-2.0	1.0
AVERAGE	1.252	9.1	6.6	-2.8	0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	EPR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.186	40.1	36.8	-8.0	-10.0
SAMPLE 2	1.182	35.9	30.6	-8.0	-6.0
SAMPLE 3	1.193	43.6	36.9	-13.0	-12.0
SAMPLE 4	1.194	39.5	35.7	-6.0	-9.0
SAMPLE 5	1.191	42.1	39.4	-6.0	-8.0
AVERAGE	1.189	40.2	35.9	-8.2	-9.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.188	64.8	57.3	-9.0	-10.0
SAMPLE 2	1.192	67.1	60.3	-8.0	-7.0
SAMPLE 3	1.190	64.1	58.0	-12.0	-13.0
SAMPLE 4	1.189	64.4	58.8	-10.0	-10.0
SAMPLE 5	1.194	99.9	91.7	-11.0	-8.0
AVERAGE	1.190	72.1	65.2	-10.0	-9.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.191	67.6	61.6	-12.0	-13.0
SAMPLE 2	1.185	55.6	53.6	-9.0	-8.0
SAMPLE 3	1.189	61.4	57.3	-8.0	-7.0
SAMPLE 4	1.192	61.9	56.2	-11.0	-8.0
SAMPLE 5	1.185	72.5	64.9	-9.0	-8.0
AVERAGE	1.188	63.8	58.7	-9.8	-8.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	VITON	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.831	3.8	1.8	1.0	4.0
SAMPLE 2	1.819	5.5	1.5	0.0	-1.0
SAMPLE 3	1.824	2.4	1.9	1.0	3.0
SAMPLE 4	1.814	2.0	1.2	1.0	1.0
SAMPLE 5	1.824	3.0	2.0	0.0	-1.0
AVERAGE	1.822	3.4	1.7	0.6	1.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.822	2.8	1.8	0.0	0.0
SAMPLE 2	1.824	0.3	2.1	0.0	2.0
SAMPLE 3	1.827	1.7	2.2	1.0	2.0
SAMPLE 4	1.834	1.3	2.2	1.0	2.0
SAMPLE 5	1.816	0.8	1.6	1.0	1.0
AVERAGE	1.824	1.4	2.0	0.6	1.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.822	3.1	1.8	0.0	0.0
SAMPLE 2	1.818	0.5	1.6	0.0	-2.0
SAMPLE 3	1.820	5.1	2.3	1.0	1.0
SAMPLE 4	1.815	0.6	1.6	-1.0	-2.0
SAMPLE 5	1.820	1.1	1.8	1.0	2.0
AVERAGE	1.819	2.1	1.8	0.2	-0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.258	5.6	3.0	-1.0	0.0
SAMPLE 2	1.255	6.3	3.2	-2.0	-2.0
SAMPLE 3	1.252	6.0	3.4	-1.0	-1.0
SAMPLE 4	1.253	6.6	3.3	0.0	0.0
SAMPLE 5	1.248	7.4	3.9	-1.0	-1.0
AVERAGE	1.253	6.4	3.4	-1.0	-0.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	A700	FREE	2.5HR	150F	7DAY

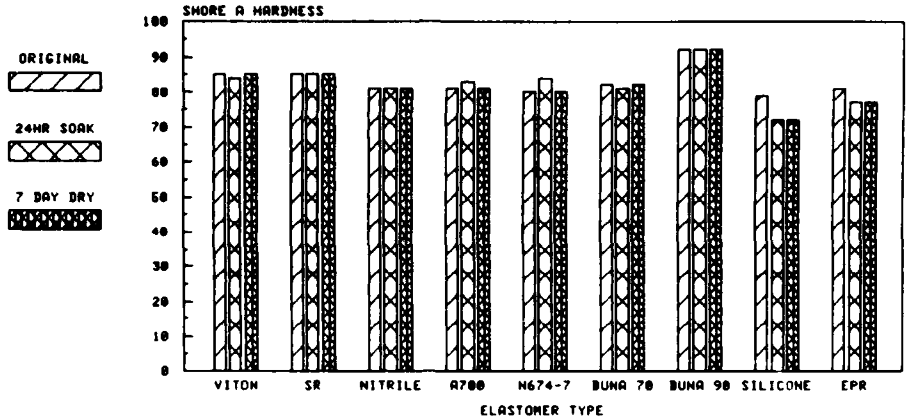
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.250	10.2	6.1	0.0	0.0
SAMPLE 2	1.248	8.8	5.9	-2.0	-2.0
SAMPLE 3	1.247	8.3	5.7	-1.0	-2.0
SAMPLE 4	1.248	8.2	4.8	0.0	0.0
SAMPLE 5	1.247	9.1	6.1	1.0	0.0
AVERAGE	1.248	8.9	5.7	-0.4	-0.8

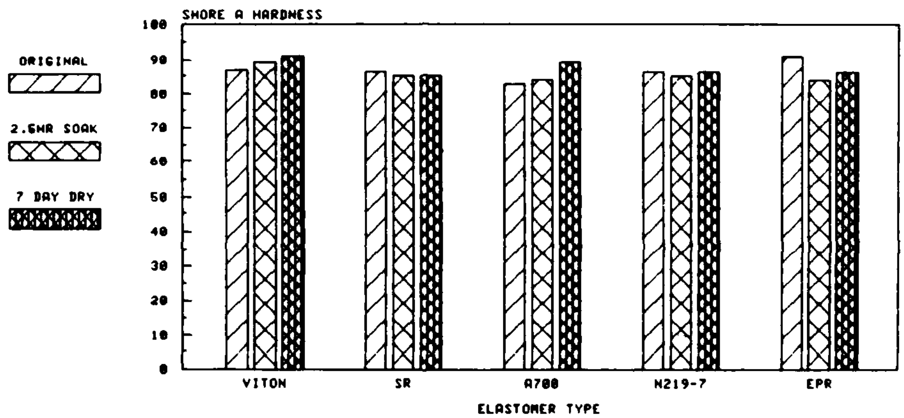
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
BYCYCLIC	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

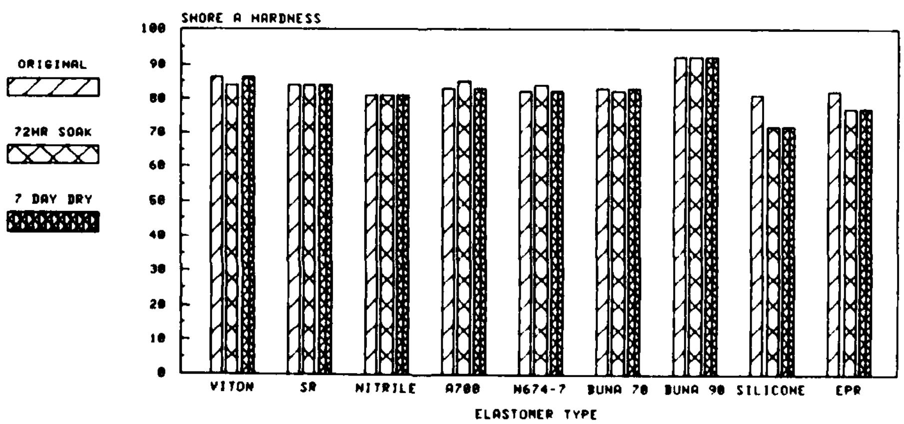
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.250	7.5	5.1	0.0	1.0
SAMPLE 2	1.248	8.7	5.3	1.0	0.0
SAMPLE 3	1.248	8.4	4.2	-1.0	-1.0
SAMPLE 4	1.252	9.0	5.3	0.0	-1.0
SAMPLE 5	1.250	10.1	5.5	-1.0	0.0
AVERAGE	1.250	8.7	5.1	-0.2	-0.2



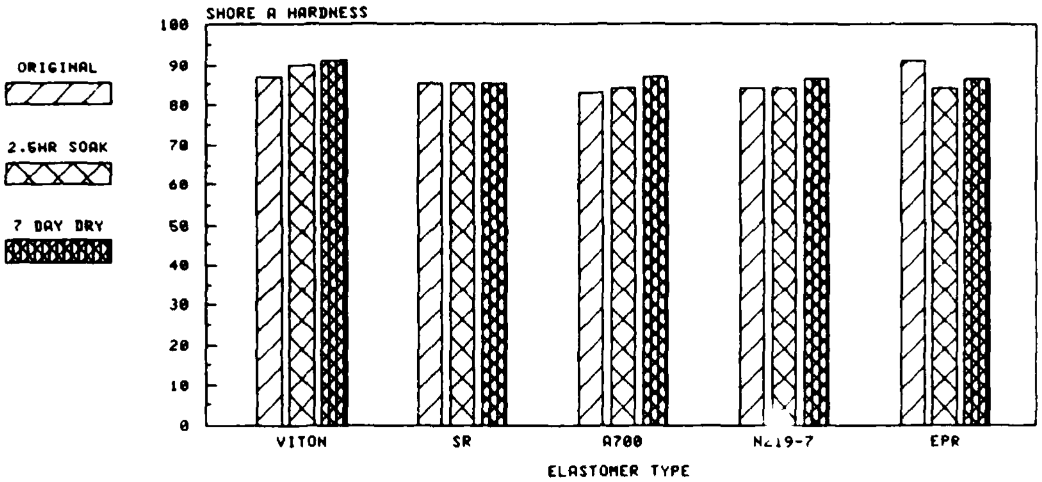
SHORE A HARDNESS - 400 PPM NITROGEN DFM
(SOAK TEMP = 75°F SOAK TIME - 24 HR)



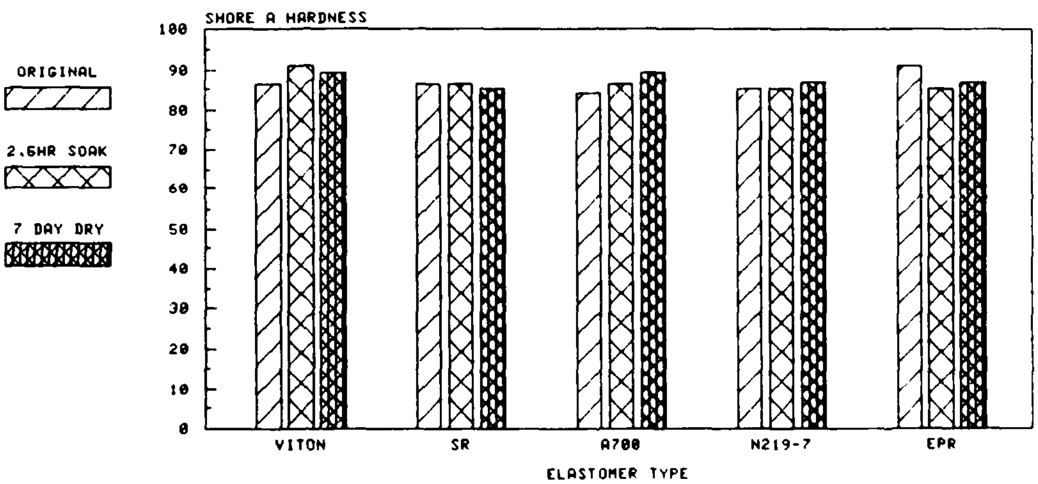
SHORE A HARDNESS - 400 PPM NITROGEN DFM
(SOAK TEMP = 75°F SOAK TIME = 72 HR)



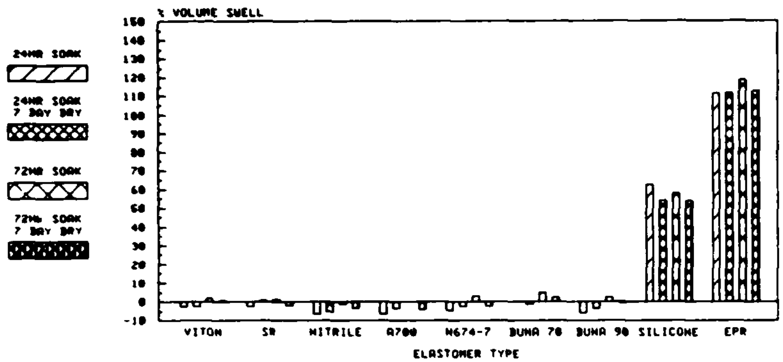
SHORE A HARDNESS - 400 PPM NITROGEN DFM
(SOAK TEMP = 150°F TOFT - FREE)



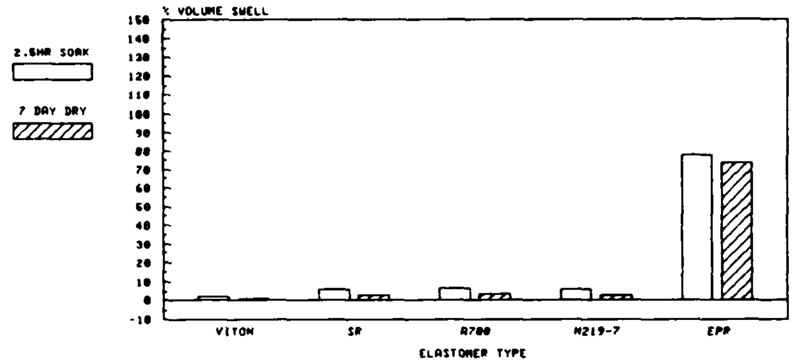
SHORE A HARDNESS - 400 PPM NITROGEN DFM
(SOAK TEMP = 150°F TOFT - TENSION)



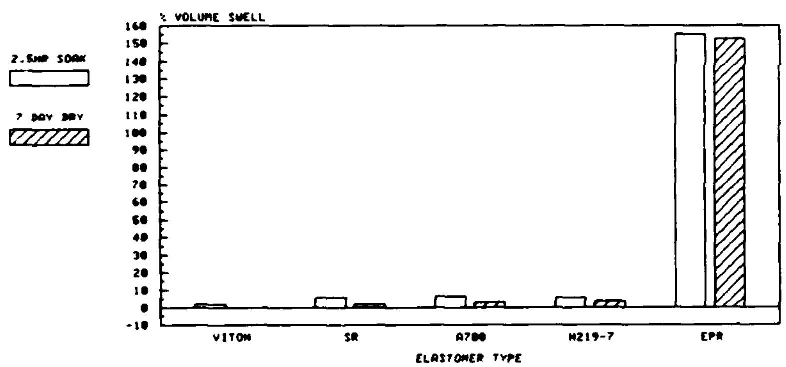
SHORE A HARDNESS - 400 PPM NITROGEN DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



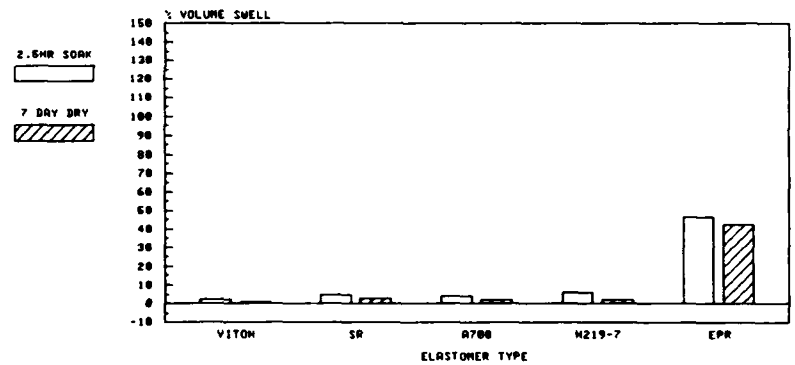
PERCENT VOLUME SWELL - 400 PPM NITROGEN DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL - 400 PPM NITROGEN DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL - 400 PPM NITROGEN DFM
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL - 400 PPM NITROGEN DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.783	-2.3	-2.3	-2.0	0.0
SAMPLE 2	1.796	-3.0	-2.6	-1.0	0.0
AVERAGE	1.790	-2.6	-2.5	-1.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.780	1.8	0.5	-2.0	-1.0
SAMPLE 2	1.791	2.0	1.2	-2.0	0 0
AVERAGE	1.785	1.9	0.8	-2.0	-0 5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.240	-0.2	-0.6	0.0	0.0
SAMPLE 2	1.249	-4.7	2.4	0.0	0.0
AVERAGE	1.244	-2.4	0.9	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.231	1.1	-1.0	0.0	0.0
SAMPLE 2	1.232	1.4	-2.4	0.0	0.0
AVERAGE	1.232	1.3	-1.7	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.221	-6.0	-5.4	0.0	0.0
SAMPLE 2	1.225	-7.2	-5.3	0.0	0.0
AVERAGE	1.223	-6.6	-5.3	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.212	-2.4	-4.9	0.0	0.0
SAMPLE 2	1.215	-0.3	-2.2	0.0	0.0
AVERAGE	1.213	-1.3	-3.5	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.242	-5.6	-2.1	3.0	0.0
SAMPLE 2	1.223	-7.5	-4.7	2.0	0.0
AVERAGE	1.232	-6.6	-3.4	2.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.223	-0.9	-4.1	2.0	0.0
SAMPLE 2	1.212	0.6	-3.6	3.0	0.0
AVERAGE	1.217	-0.2	-3.8	2.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.236	-3.2	-1.9	4.0	0.0
SAMPLE 2	1.233	-5.8	-3.3	3.0	3.0
AVERAGE	1.235	-4.5	-2.6	3.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.231	2.1	-2.6	2.0	0.0
SAMPLE 2	1.240	3.2	-2.3	3.0	0.0
AVERAGE	1.236	2.7	-2.4	2.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.211	1.7	-0.8	79.0	80.0
SAMPLE 2	1.198	-1.6	-1.9	-1.0	0.0
AVERAGE	1.205	0.1	-1.3	39.0	40.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.201	4.3	2.6	-1.0	0.0
SAMPLE 2	1.218	5.5	2.2	-1.0	-1.0
AVERAGE	1.210	4.9	2.4	-1.0	-0.5

FUEL	ELASTOM'R	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.230	-5.7	-3.5	0.0	0.0
SAMPLE 2	1.239	-5.7	-3.5	0.0	0.0
AVERAGE	1.235	-5.7	-3.5	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.232	1.7	-0.5	0.0	0.0
SAMPLE 2	1.250	3.3	-0.5	0.0	0.0
AVERAGE	1.241	2.5	-0.5	0.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.354	65.8	50.2	-7.0	-7.0
SAMPLE 2	1.259	57.9	57.6	-7.0	-7.0
AVERAGE	1.307	61.9	53.9	-7.0	-7.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.333	53.2	48.3	-8.0	-8.0
SAMPLE 2	1.395	62.2	57.8	-9.0	-9.0
AVERAGE	1.364	57.7	53.1	-8.5	-8.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.176	113.9	112.3	-4.0	-4.0
SAMPLE 2	1.163	109.2	110.5	-5.0	-5.0
AVERAGE	1.170	111.6	111.4	-4.5	-4.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.189	119.2	113.0	-5.0	-5.0
SAMPLE 2	1.168	117.3	111.8	-5.0	-5.0
AVERAGE	1.179	118.3	112.4	-5.0	-5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	SR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.279	5.1	3.6	1.0	-1.0
SAMPLE 2	1.266	4.3	1.7	-3.0	-2.0
SAMPLE 3	1.269	4.0	1.5	0.0	-1.0
SAMPLE 4	1.272	5.3	3.4	2.0	0.0
SAMPLE 5	1.277	5.7	3.7	0.0	0.0
AVERAGE	1.272	4.9	2.8	0.0	-0.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.275	6.8	3.8	-2.0	-1.0
SAMPLE 2	1.270	5.8	3.8	0.0	0.0
SAMPLE 3	1.261	5.3	2.9	-2.0	-1.0
SAMPLE 4	1.262	5.1	2.7	1.0	0.0
SAMPLE 5	1.264	5.3	2.7	-1.0	-1.0
AVERAGE	1.266	5.6	3.2	-0.8	-0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.260	2.9	2.6	0.0	0.0
SAMPLE 2	1.261	6.2	2.3	-1.0	-1.0
SAMPLE 3	1.268	6.5	2.6	0.0	2.0
SAMPLE 4	1.262	5.7	2.3	1.0	2.0
SAMPLE 5	1.265	8.5	1.3	1.0	0.0
AVERAGE	1.263	5.9	2.2	0.2	0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	N219-7	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.274	9.7	1.5	-1.0	2.0
SAMPLE 2	1.267	4.5	2.3	2.0	3.0
SAMPLE 3	1.273	4.6	2.6	2.0	2.0
SAMPLE 4	1.272	5.0	2.0	1.0	2.0
SAMPLE 5	1.273	5.4	0.7	0.0	-1.0
AVERAGE	1.272	5.8	1.8	0.8	1.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.277	6.7	2.7	0.0	3.0
SAMPLE 2	1.271	5.4	1.1	0.0	1.0
SAMPLE 3	1.274	5.2	3.4	-1.0	1.0
SAMPLE 4	1.283	5.8	4.3	1.0	2.0
SAMPLE 5	1.279	5.5	3.8	-2.0	-2.0
AVERAGE	1.277	5.7	3.1	-0.4	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.277	5.8	3.2	0.0	1.0
SAMPLE 2	1.276	5.3	3.6	-3.0	1.0
SAMPLE 3	1.271	5.2	3.4	2.0	3.0
SAMPLE 4	1.272	3.9	4.2	-1.0	1.0
SAMPLE 5	1.275	7.0	3.8	2.0	4.0
AVERAGE	1.274	5.4	3.7	0.0	2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	EPR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.199	45.9	41.9	-4.0	-3.0
SAMPLE 2	1.190	41.1	37.3	-7.0	-4.0
SAMPLE 3	1.203	46.6	42.7	-7.0	-3.0
SAMPLE 4	1.207	54.4	48.0	-7.0	-6.0
SAMPLE 5	1.203	45.2	39.8	-6.0	-1.0
AVERAGE	1.200	46.6	42.0	-6.2	-3.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.207	75.8	71.7	-6.0	-5.0
SAMPLE 2	1.202	76.6	72.3	-7.0	-3.0
SAMPLE 3	1.205	74.8	67.5	-11.0	-6.0
SAMPLE 4	1.206	87.4	82.8	-6.0	-3.0
SAMPLE 5	1.208	76.3	75.0	-8.0	-6.0
AVERAGE	1.206	78.2	73.8	-7.6	-4.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.323	155.6	154.2	-6.0	-5.0
SAMPLE 2	1.309	143.6	140.8	-8.0	-7.0
SAMPLE 3	1.323	161.8	158.3	-7.0	-5.0
SAMPLE 4	1.342	161.0	158.9	-6.0	-3.0
SAMPLE 5	1.329	152.9	150.8	-6.0	-4.0
AVERAGE	1.325	155.0	152.6	-6.6	-4.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	VITON	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.834	4.2	0.5	5.0	4.0
SAMPLE 2	1.831	1.7	0.4	5.0	2.0
SAMPLE 3	1.826	1.0	-0.0	7.0	4.0
SAMPLE 4	1.834	2.0	1.0	4.0	2.0
SAMPLE 5	1.830	2.0	0.7	6.0	4.0
AVERAGE	1.831	2.2	0.5	5.4	3.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.835	1.8	0.5	0.0	3.0
SAMPLE 2	1.833	1.6	0.8	0.0	3.0
SAMPLE 3	1.827	1.6	0.6	6.0	6.0
SAMPLE 4	1.829	1.9	0.4	4.0	5.0
SAMPLE 5	1.831	1.5	0.9	4.0	3.0
AVERAGE	1.831	1.7	0.6	2.8	4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.833	1.4	0.8	4.0	6.0
SAMPLE 2	1.833	1.9	-0.1	2.0	4.0
SAMPLE 3	1.838	1.5	-0.4	5.0	5.0
SAMPLE 4	1.835	1.3	-0.4	1.0	5.0
SAMPLE 5	1.838	2.1	-0.6	5.0	4.0
AVERAGE	1.835	1.6	-0.2	3.4	4.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.263	4.5	1.7	3.0	7.0
SAMPLE 2	1.265	4.2	1.9	3.0	8.0
SAMPLE 3	1.263	4.4	1.7	-1.0	2.0
SAMPLE 4	1.263	3.9	1.9	1.0	5.0
SAMPLE 5	1.269	4.4	2.3	3.0	5.0
AVERAGE	1.265	4.3	1.9	1.8	5.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	A700	FREE	2.5HR	150F	7DAY

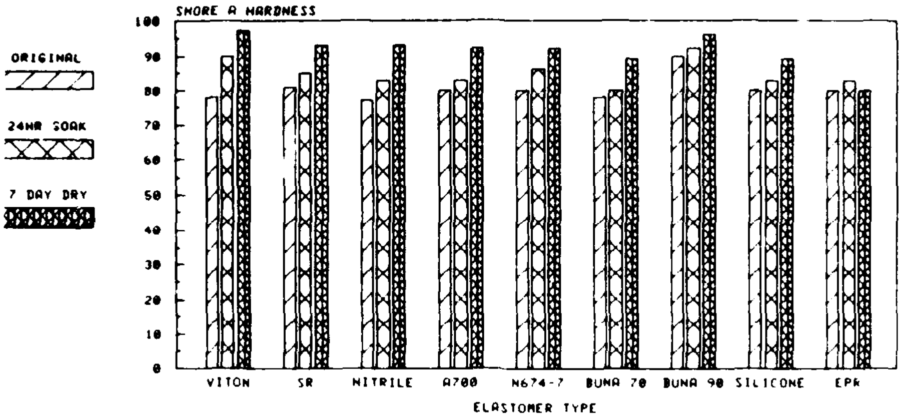
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.264	5.4	3.0	1.0	7.0
SAMPLE 2	1.272	6.1	3.6	2.0	5.0
SAMPLE 3	1.271	6.5	4.0	-2.0	3.0
SAMPLE 4	1.266	6.6	3.6	0.0	6.0
SAMPLE 5	1.272	6.6	3.5	-1.0	7.0
AVERAGE	1.269	6.2	3.5	0.0	5.6

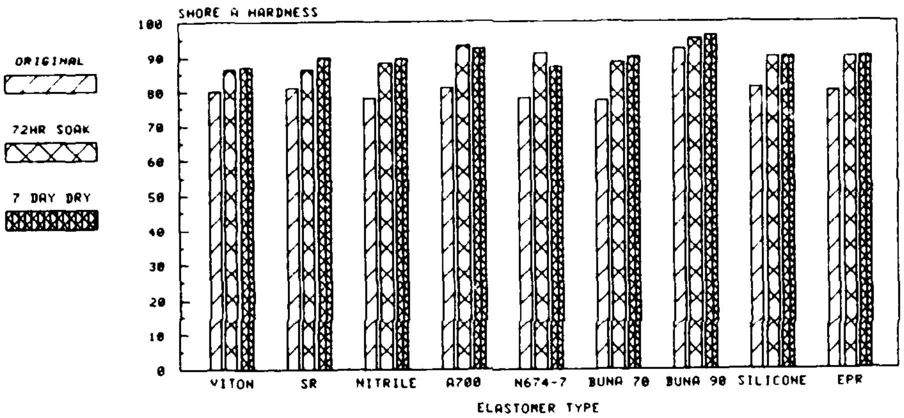
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
NITR.DFM	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

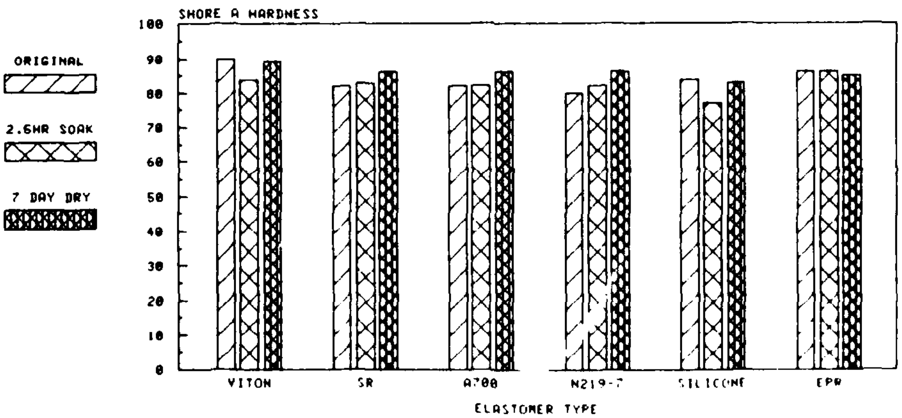
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.271	5.8	3.2	1.0	5.0
SAMPLE 2	1.264	6.7	3.4	0.0	3.0
SAMPLE 3	1.266	6.7	3.1	1.0	3.0
SAMPLE 4	1.265	6.5	3.5	2.0	3.0
SAMPLE 5	1.267	6.3	2.7	0.0	6.0
AVERAGE	1.266	6.4	3.2	0.8	4.0



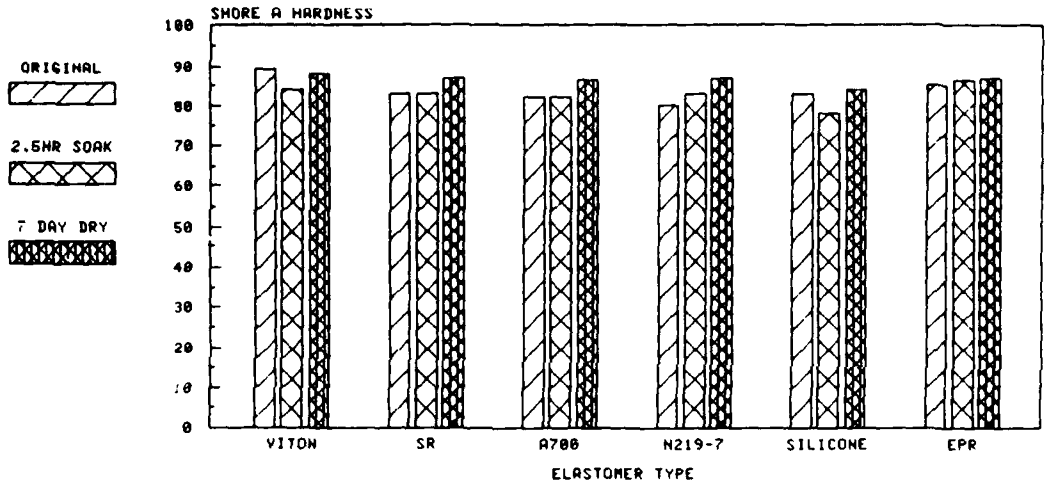
SHORE A HARDNESS - HIGH PEROXIDE DFM
(SOAK TEMP = 75°F SOAK TIME = 24 HR)



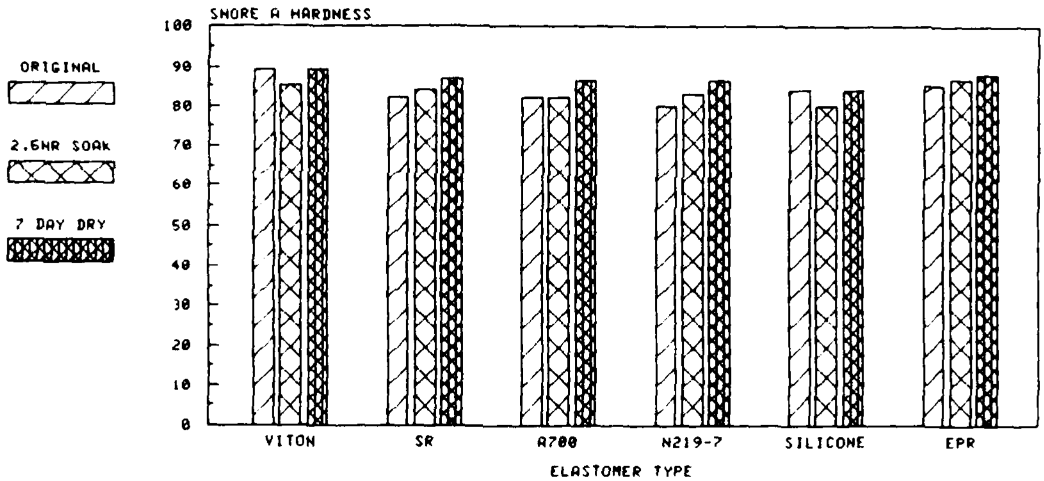
SHORE A HARDNESS - HIGH PEROXIDE DFM
(SOAK TEMP = 75°F SOAK TIME = 72 HR)



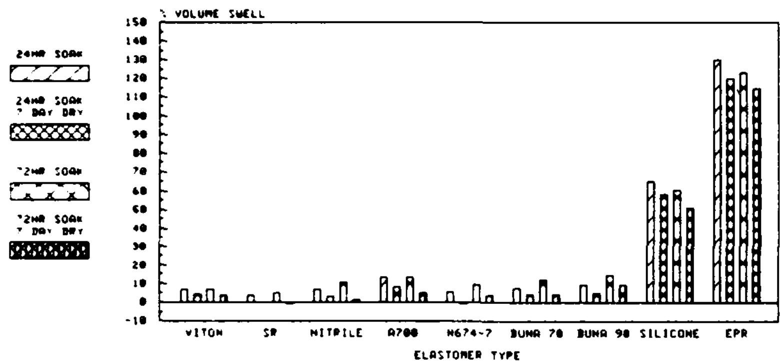
SHORE A HARDNESS - HIGH PEROXIDE DFM
(SOAK TEMP = 150°F TOFT - FREE)



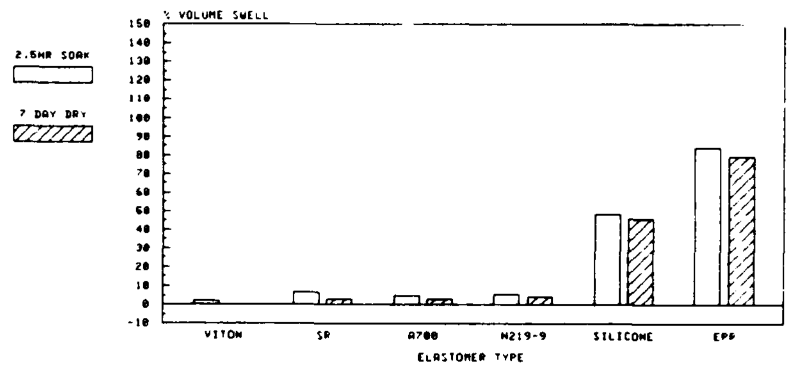
SHORE A HARDNESS - HIGH PEROXIDE DFM
(SOAK TEMP = 150°F TOFT - TENSION)



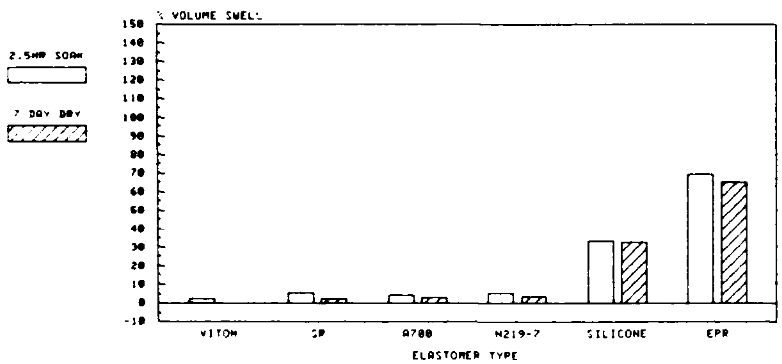
SHORE A HARDNESS - HIGH PEROXIDE DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



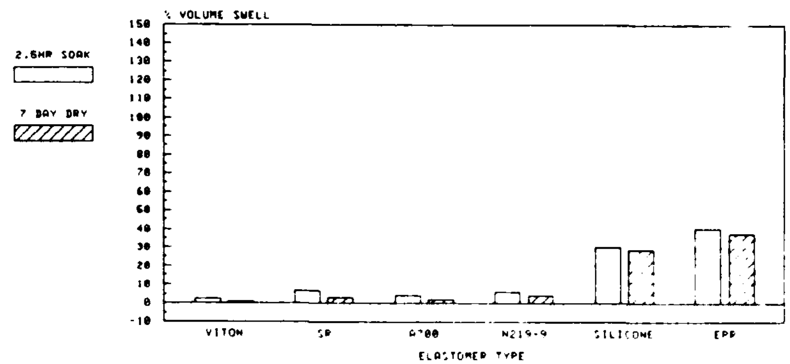
PERCENT VOLUME SWELL - HIGH PEROXIDE DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL - HIGH PEROXIDE DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL - HIGH PEROXIDE DFM
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL - HIGH PEROXIDE DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.949	8.5	5.7	12.0	18.0
SAMPLE 2	1.871	5.8	2.3	11.0	17.0
AVERAGE	1.910	7.2	4.0	11.5	17.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX DFM	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.896	7.4	3.9	3.0	7.0
SAMPLE 2	1.885	7.0	2.8	11.0	10.0
AVERAGE	1.890	7.2	3.3	7.0	8.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.273	2.9	0.3	6.0	11.0
SAMPLE 2	1.289	4.1	0.3	2.0	12.0
AVERAGE	1.281	3.5	0.3	4.0	11.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.290	7.0	0.2	7.0	9.0
SAMPLE 2	1.289	2.5	-0.7	6.0	10.0
AVERAGE	1.289	4.8	-0.3	6.5	9.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.334	9.0	3.3	6.0	14.0
SAMPLE 2	1.325	5.2	3.1	6.0	17.0
AVERAGE	1.330	7.1	3.2	6.0	15.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX DFM	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.324	12.9	1.3	11.0	12.0
SAMPLE 2	1.313	8.5	1.4	8.0	8.0
AVERAGE	1.319	10.7	1.3	9.5	10.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX DFM	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.411	15.0	9.1	4.0	12.0
SAMPLE 2	1.374	11.7	7.3	4.0	10.0
AVERAGE	1.392	13.4	8.2	4.0	11.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX DFM	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.350	13.5	4.9	11.0	11.0
SAMPLE 2	1.356	13.6	4.9	13.0	10.0
AVERAGE	1.353	13.5	4.9	12.0	10.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.304	4.2	-0.7	7.0	11.0
SAMPLE 2	1.299	6.0	-1.0	5.0	13.0
AVERAGE	1.301	5.1	-0.8	6.0	12.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX DFM	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.309	8.4	2.9	11.0	7.0
SAMPLE 2	1.323	10.5	4.5	12.0	8.0
AVERAGE	1.316	9.5	3.7	11.5	7.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX DFM	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.288	7.8	4.7	-1.0	7.0
SAMPLE 2	1.289	7.5	4.0	4.0	14.0
AVERAGE	1.289	7.6	4.3	1.5	10.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.289	10.9	4.3	10.0	12.0
SAMPLE 2	1.279	13.8	4.1	9.0	6.0
AVERAGE	1.284	12.3	4.2	9.5	9.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.330	8.4	5.0	3.0	7.0
SAMPLE 2	1.351	10.4	5.0	0.0	7.0
AVERAGE	1.340	9.4	5.0	1.5	7.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.375	14.5	9.9	4.0	4.0
SAMPLE 2	1.369	14.3	9.2	3.0	6.0
AVERAGE	1.372	14.4	9.5	3.5	5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.441	61.4	55.4	4.0	9.0
SAMPLE 2	1.362	68.4	60.4	2.0	10.0
AVERAGE	1.401	64.9	57.9	3.0	9.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.428	61.6	51.6	8.0	11.0
SAMPLE 2	1.414	59.1	50.3	12.0	8.0
AVERAGE	1.421	60.4	51.0	10.0	9.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.257	129.7	121.1	4.0	0.0
SAMPLE 2	1.262	131.4	119.5	6.0	1.0
AVERAGE	1.260	130.5	120.3	5.0	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.248	123.3	113.6	10.0	10.0
SAMPLE 2	1.251	123.3	116.7	11.0	9.0
AVERAGE	1.250	123.3	115.2	10.5	9.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.277	9.5	5.5	4.0	8.0
SAMPLE 2	1.265	5.0	2.1	4.0	4.0
SAMPLE 3	1.266	4.7	2.2	1.0	4.0
SAMPLE 4	1.269	6.5	3.1	0.0	5.0
SAMPLE 5	1.268	6.5	3.0	3.0	5.0
AVERAGE	1.269	6.4	3.2	2.4	5.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.262	5.6	3.6	1.0	5.0
SAMPLE 2	1.261	6.1	2.7	2.0	4.0
SAMPLE 3	1.261	5.4	2.8	2.0	4.0
SAMPLE 4	1.261	9.8	2.9	1.0	4.0
SAMPLE 5	1.257	5.6	2.7	1.0	2.0
AVERAGE	1.261	6.5	3.0	1.4	3.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.259	6.1	3.0	1.0	3.0
SAMPLE 2	1.264	6.0	2.8	-1.0	4.0
SAMPLE 3	1.262	5.9	3.1	-1.0	3.0
SAMPLE 4	1.263	6.0	3.4	2.0	4.0
SAMPLE 5	1.217	2.1	-0.2	1.0	4.0
AVERAGE	1.253	5.2	2.4	0.4	3.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	N219-7	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.292	6.2	4.9	4.0	6.0
SAMPLE 2	1.285	7.7	4.4	2.0	5.0
SAMPLE 3	1.282	5.5	3.3	3.0	7.0
SAMPLE 4	1.278	5.6	3.8	2.0	7.0
SAMPLE 5	1.274	5.1	3.5	4.0	5.0
AVERAGE	1.282	6.0	4.0	3.0	6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.273	5.3	3.9	3.0	7.0
SAMPLE 2	1.267	5.0	3.6	2.0	6.0
SAMPLE 3	1.273	5.5	4.2	2.0	8.0
SAMPLE 4	1.268	5.6	4.4	4.0	6.0
SAMPLE 5	1.268	4.8	3.5	2.0	7.0
AVERAGE	1.270	5.3	3.9	2.6	6.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.275	5.1	4.1	4.0	6.0
SAMPLE 2	1.271	6.0	4.2	3.0	7.0
SAMPLE 3	1.268	4.4	3.1	3.0	7.0
SAMPLE 4	1.272	5.1	3.6	4.0	8.0
SAMPLE 5	1.274	5.2	3.8	3.0	7.0
AVERAGE	1.272	5.2	3.8	3.4	7.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SILICONE	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.526	29.9	28.3	-2.0	3.0
SAMPLE 2	1.526	31.1	29.3	-3.0	0.0
SAMPLE 3	1.522	31.2	29.6	-4.0	1.0
SAMPLE 4	1.530	29.1	27.6	-5.0	1.0
SAMPLE 5	1.535	31.5	29.7	-5.0	-1.0
AVERAGE	1.528	30.6	28.9	-3.8	0.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SILICONE	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.527	47.0	45.0	-6.0	-2.0
SAMPLE 2	1.526	45.5	41.9	-8.0	-2.0
SAMPLE 3	1.527	46.1	44.0	-6.0	-2.0
SAMPLE 4	1.530	47.1	45.0	-6.0	2.0
SAMPLE 5	1.532	55.6	53.5	-6.0	1.0
AVERAGE	1.528	48.3	45.9	-6.4	-0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	SILICONE	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.528	38.4	37.4	-6.0	1.0
SAMPLE 2	1.540	31.6	30.9	-6.0	1.0
SAMPLE 3	1.526	36.7	36.0	-5.0	-1.0
SAMPLE 4	1.529	31.0	30.0	-4.0	2.0
SAMPLE 5	1.537	30.8	29.7	-7.0	1.0
AVERAGE	1.532	33.7	32.8	-5.6	0.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	EPR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.205	39.5	36.8	3.0	1.0
SAMPLE 2	1.206	39.5	37.0	3.0	6.0
SAMPLE 3	1.208	42.5	38.3	2.0	2.0
SAMPLE 4	1.204	37.9	35.2	3.0	4.0
SAMPLE 5	1.216	42.0	39.2	2.0	6.0
AVERAGE	1.208	40.3	7.3	2.6	3.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.209	84.0	79.7	0.0	2.0
SAMPLE 2	1.210	78.7	74.0	-3.0	-4.0
SAMPLE 3	1.211	81.8	77.5	-2.0	-2.0
SAMPLE 4	1.212	93.5	88.7	4.0	1.0
SAMPLE 5	1.212	80.4	76.2	1.0	-1.0
AVERAGE	1.211	83.7	79.2	0.0	-0.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.212	62.5	57.9	-2.0	2.0
SAMPLE 2	1.208	74.1	69.5	-2.0	5.0
SAMPLE 3	1.209	70.5	66.6	1.0	5.0
SAMPLE 4	1.213	72.8	69.4	-3.0	2.0
SAMPLE 5	1.213	65.6	62.7	2.0	0.0
AVERAGE	1.211	69.1	65.2	-0.8	2.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	VITON	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.847	2.5	0.1	-5.0	0.0
SAMPLE 2	1.845	2.8	0.8	-5.0	-1.0
SAMPLE 3	1.842	2.9	0.6	-7.0	-1.0
SAMPLE 4	1.839	2.8	0.7	-2.0	0.0
SAMPLE 5	1.838	1.7	0.7	-4.0	0.0
AVERAGE	1.842	2.6	0.6	-4.6	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.843	1.9	0.4	-7.0	-1.0
SAMPLE 2	1.841	1.6	0.5	-7.0	-1.0
SAMPLE 3	1.838	2.3	0.5	-5.0	-1.0
SAMPLE 4	1.840	2.0	0.1	-5.0	0.0
SAMPLE 5	1.833	1.7	0.0	-7.0	-2.0
AVERAGE	1.839	1.9	0.3	-6.2	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.846	3.4	0.9	-5.0	0.0
SAMPLE 2	1.843	2.5	0.1	-1.0	-6.0
SAMPLE 3	1.845	2.7	0.4	-5.0	0.0
SAMPLE 4	1.832	0.8	-0.1	-3.0	-1.0
SAMPLE 5	1.838	1.9	0.2	-5.0	0.0
AVERAGE	1.841	2.3	0.3	-3.8	-1.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.261	3.5	1.7	1.0	4.0
SAMPLE 2	1.257	4.0	2.1	1.0	4.0
SAMPLE 3	1.257	3.9	2.4	2.0	6.0
SAMPLE 4	1.257	4.6	2.0	-1.0	4.0
SAMPLE 5	1.255	4.5	1.8	0.0	3.0
AVERAGE	1.257	4.1	2.0	0.6	4.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	A700	FREE	2.5HR	150F	7DAY

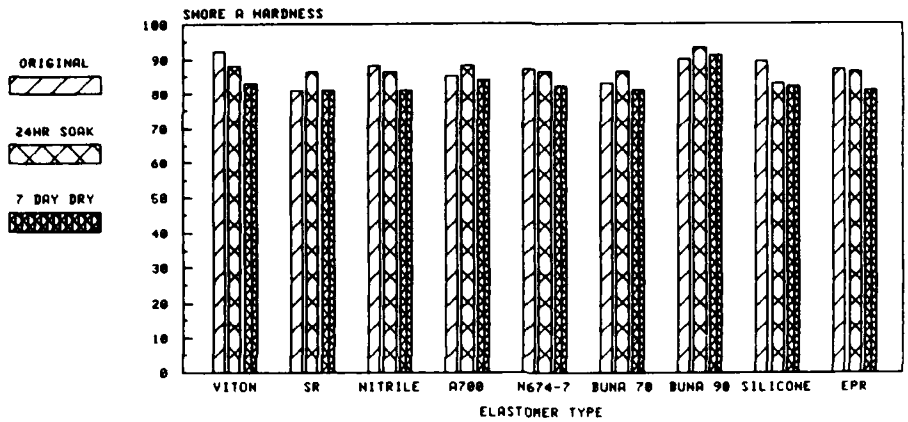
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.254	5.2	2.5	-1.0	2.0
SAMPLE 2	1.253	5.3	2.9	-1.0	3.0
SAMPLE 3	1.254	4.8	3.4	-1.0	3.0
SAMPLE 4	1.254	4.2	2.9	-1.0	3.0
SAMPLE 5	1.257	3.3	2.7	-1.0	5.0
AVERAGE	1.254	4.5	2.9	-1.0	3.2

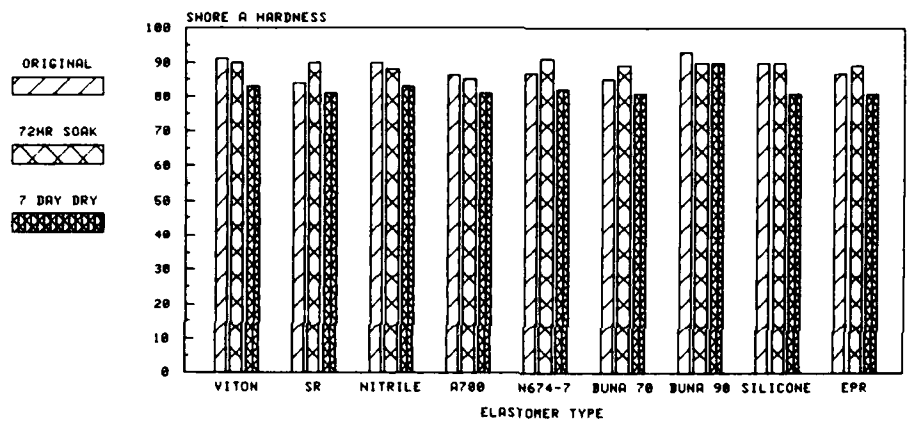
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
PEROX.DFM	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

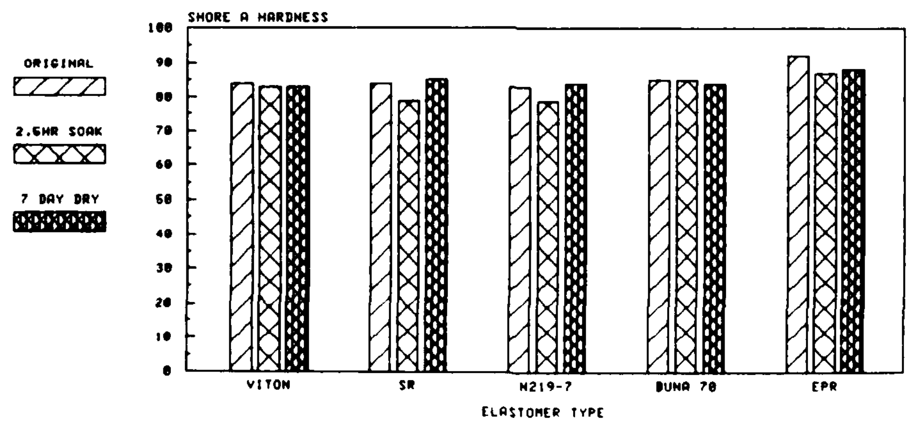
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.252	3.2	2.5	-1.0	3.0
SAMPLE 2	1.260	4.7	2.7	1.0	5.0
SAMPLE 3	1.260	4.1	3.1	-3.0	4.0
SAMPLE 4	1.260	3.8	2.6	0.0	4.0
SAMPLE 5	1.258	4.3	2.7	0.0	4.0
AVERAGE	1.258	4.0	2.7	-0.6	4.0



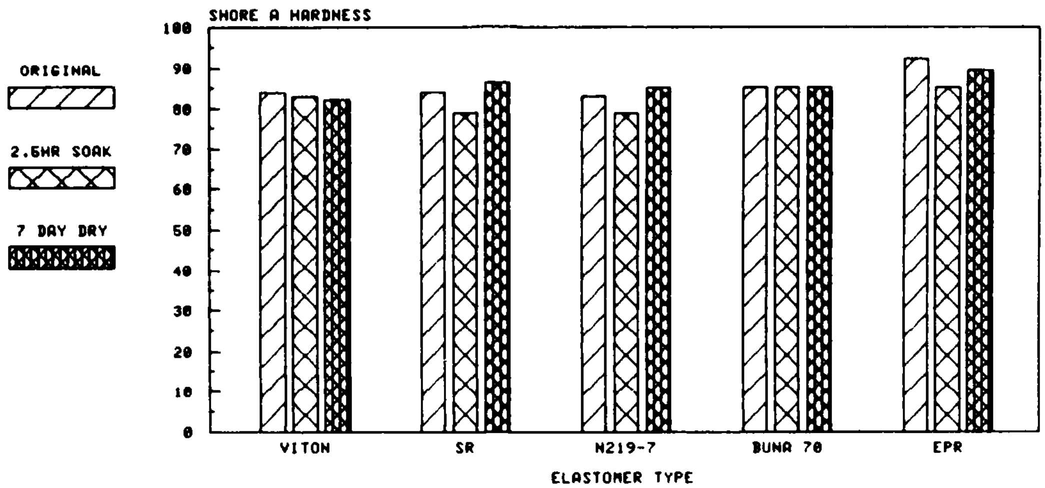
SHORE A HARDNESS - 0.5% SULFUR DFM
(SOAK TEMP = 75°F SOAK TIME = 24 HR)



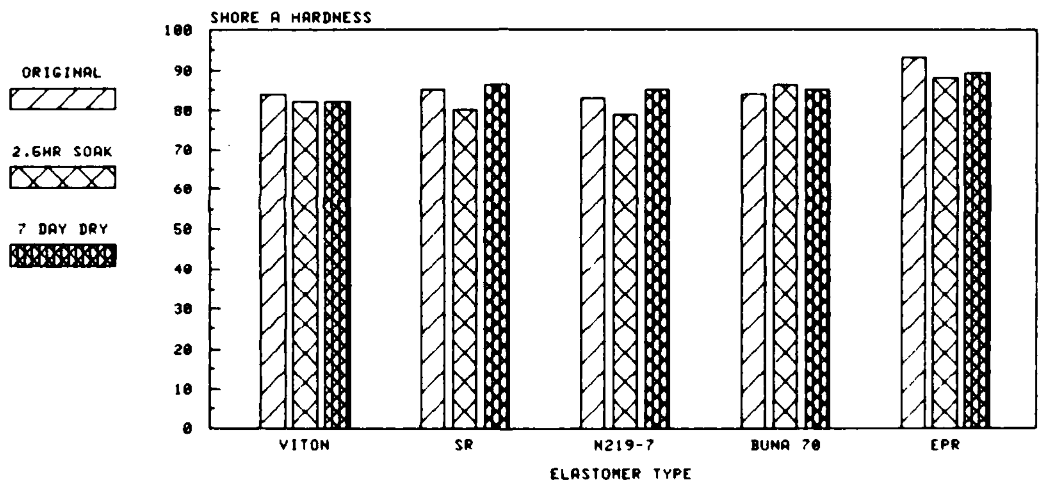
SHORE A HARDNESS - 0.5% SULFUR DFM
(SOAK TEMP = 75°F SOAK TIME = 72 HR)



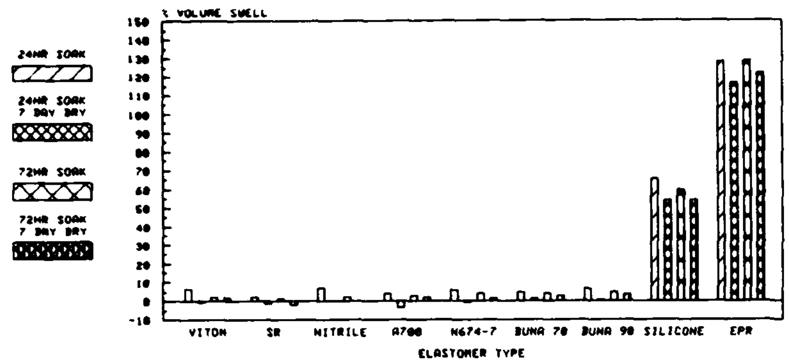
SHORE A HARDNESS - 0.5% SULFUR DFM
(SOAK TEMP = 150°F TOFT - FREE)



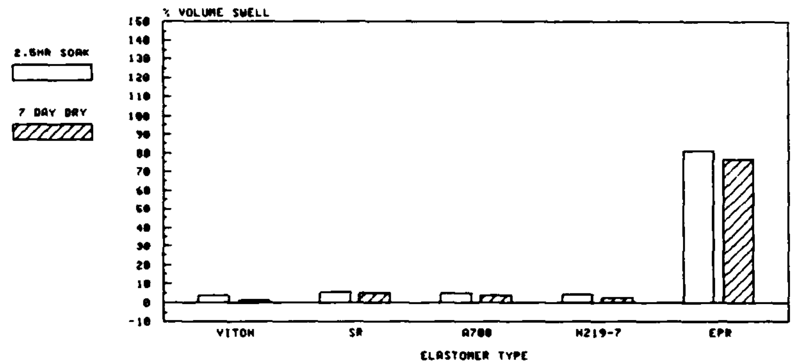
SHORE A HARDNESS - 0.5% SULFUR DFM
(SOAK TEMP = 150°F TOFT - TENSION)



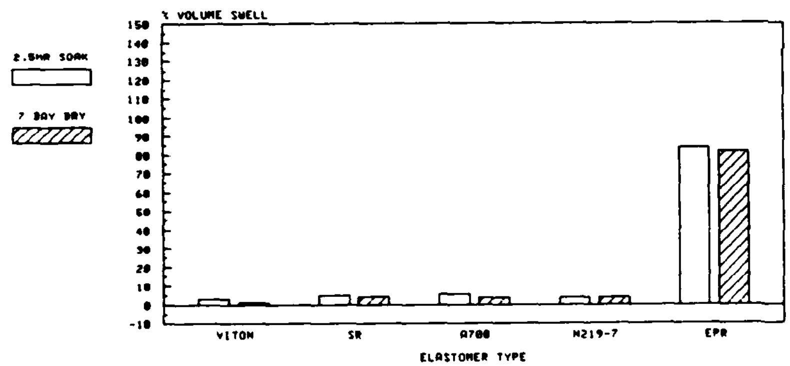
SHORE A HARDNESS - 0.5% SULFUR DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



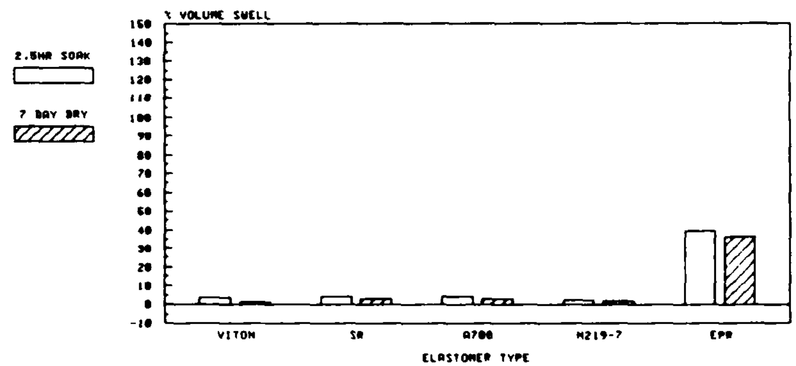
PERCENT VOLUME SWELL - 0.5% SULFUR DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL - 0.5% SULFUR DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL - 0.5% SULFUR DFM
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL - 0.5% SULFUR DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.836	8.4	-0.8	-4.0	-9.0
SAMPLE 2	1.846	4.5	0.2	-4.0	-8.0
AVERAGE	1.841	6.4	-0.3	-4.0	-8.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.842	2.5	1.9	-1.0	-8.0
SAMPLE 2	1.833	2.1	1.1	0.0	-8.0
AVERAGE	1.837	2.3	1.5	-0.5	-8.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.294	2.3	-0.5	9.0	0.0
SAMPLE 2	1.284	2.0	-1.5	1.0	-1.0
AVERAGE	1.289	2.2	-1.0	5.0	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.283	1.5	-2.6	4.0	-5.0
SAMPLE 2	1.281	0.5	-1.1	8.0	-2.0
AVERAGE	1.282	1.0	-1.9	6.0	-3.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.343	7.0	1.6	-2.0	-7.0
SAMPLE 2	1.309	6.9	-1.8	-1.0	-6.0
AVERAGE	1.326	6.9	-0.1	-1.5	-6.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.297	2.1	-0.5	-1.0	-7.0
SAMPLE 2	1.290	2.0	0.3	-2.0	-7.0
AVERAGE	1.293	2.1	-0.1	-1.5	-7.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.254	4.0	-4.4	5.0	-1.0
SAMPLE 2	1.283	4.1	-2.1	3.0	-1.0
AVERAGE	1.268	4.1	-3.3	4.0	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.317	4.0	2.4	1.0	-6.0
SAMPLE 2	1.292	2.3	1.3	-1.0	-3.0
AVERAGE	1.304	3.2	1.8	0.0	-4.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.302	6.0	-0.7	-1.0	-5.0
SAMPLE 2	1.304	5.8	-0.8	-1.0	-5.0
AVERAGE	1.303	5.9	-0.7	-1.0	-5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.294	4.3	0.8	4.0	-6.0
SAMPLE 2	1.309	3.5	1.2	4.0	-5.0
AVERAGE	1.301	3.9	1.0	4.0	-5.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.282	6.3	3.3	2.0	-2.0
SAMPLE 2	1.252	3.6	-1.0	4.0	-2.0
AVERAGE	1.267	4.9	1.2	3.0	-2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.250	4.1	3.2	5.0	-2.0
SAMPLE 2	1.247	4.3	3.3	3.0	-5.0
AVERAGE	1.248	4.2	3.2	4.0	-3.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.305	6.1	0.5	4.0	2.0
SAMPLE 2	1.307	6.4	1.2	2.0	0.0
AVERAGE	1.306	6.2	0.9	3.0	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.308	4.4	4.6	-6.0	-3.0
SAMPLE 2	1.306	4.8	2.7	0.0	-3.0
AVERAGE	1.307	4.6	3.6	-3.0	-3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.437	62.1	51.8	-6.0	-8.0
SAMPLE 2	1.336	67.9	55.3	-6.0	-6.0
AVERAGE	1.386	65.0	53.5	-6.0	-7.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.446	59.2	53.5	0.0	-9.0
SAMPLE 2	1.388	59.6	54.3	0.0	-9.0
AVERAGE	1.417	59.4	53.9	0.0	-9.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.226	125.0	114.1	-3.0	-7.0
SAMPLE 2	1.261	131.0	119.0	1.0	-5.0
AVERAGE	1.243	128.0	116.5	-1.0	-6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.259	130.2	123.1	1.0	-7.0
SAMPLE 2	1.250	128.4	120.8	3.0	-6.0
AVERAGE	1.255	129.3	122.0	2.0	-6.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	SR	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.266	4.6	1.5	-6.0	1.0
SAMPLE 2	1.260	4.9	3.2	-6.0	1.0
SAMPLE 3	1.261	3.9	1.8	-4.0	3.0
SAMPLE 4	1.259	3.9	3.6	-2.0	2.0
SAMPLE 5	1.259	4.4	3.8	-6.0	2.0
AVERAGE	1.261	4.3	2.8	-4.8	1.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	SR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.254	5.8	4.8	-5.0	0.0
SAMPLE 2	1.254	4.9	4.0	-4.0	2.0
SAMPLE 3	1.258	5.0	4.2	-4.0	2.0
SAMPLE 4	1.262	5.4	5.0	-7.0	-1.0
SAMPLE 5	1.265	5.2	4.6	-6.0	1.0
AVERAGE	1.259	5.3	4.5	-5.2	0.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	SR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.255	5.3	4.1	-6.0	0.0
SAMPLE 2	1.256	4.9	3.7	-8.0	1.0
SAMPLE 3	1.254	4.9	4.0	-5.0	3.0
SAMPLE 4	1.254	4.6	3.8	-5.0	1.0
SAMPLE 5	1.255	5.0	3.8	-4.0	3.0
AVERAGE	1.255	5.0	3.9	-5.6	1.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	N219-7	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.255	2.4	2.4	-4.0	3.0
SAMPLE 2	1.257	2.2	2.1	-5.0	1.0
SAMPLE 3	1.259	2.3	1.9	-3.0	2.0
SAMPLE 4	1.255	2.7	2.5	-4.0	5.0
SAMPLE 5	1.250	1.6	1.2	-3.0	2.0
AVERAGE	1.255	2.2	2.0	-3.8	2.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	N219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.253	3.7	2.0	-2.0	3.0
SAMPLE 2	1.245	3.4	1.7	-4.0	3.0
SAMPLE 3	1.253	4.3	2.6	-5.0	-1.0
SAMPLE 4	1.259	4.0	2.4	-7.0	-1.0
SAMPLE 5	1.257	5.4	3.6	-2.0	1.0
AVERAGE	1.253	4.1	2.4	-4.0	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SUF.DFM	N219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.253	4.0	3.2	-4.0	1.0
SAMPLE 2	1.225	0.9	0.4	-2.0	2.0
SAMPLE 3	1.269	4.7	4.6	-3.0	2.0
SAMPLE 4	1.266	4.8	4.7	-3.0	5.0
SAMPLE 5	1.258	3.2	3.6	-5.0	0.0
AVERAGE	1.254	3.5	3.3	-3.4	2.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	EPR	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.202	35.6	33.0	-5.0	-6.0
SAMPLE 2	1.216	46.0	43.0	-4.0	-5.0
SAMPLE 3	1.214	39.0	33.2	-7.0	-3.0
SAMPLE 4	1.211	38.4	35.0	-4.0	-2.0
SAMPLE 5	1.210	37.6	36.4	-4.0	-3.0
AVERAGE	1.210	39.3	36.1	-4.8	-3.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.203	84.7	77.6	-5.0	-3.0
SAMPLE 2	1.210	84.5	79.7	-8.0	-8.0
SAMPLE 3	1.206	71.9	64.9	-5.0	-3.0
SAMPLE 4	1.212	87.2	83.4	-6.0	-6.0
SAMPLE 5	1.215	77.0	74.5	-5.0	-4.0
AVERAGE	1.209	81.1	76.0	-5.8	-4.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.208	57.6	56.3	-5.0	-5.0
SAMPLE 2	1.319	150.2	146.6	-6.0	-3.0
SAMPLE 3	1.211	79.8	74.7	-6.0	-3.0
SAMPLE 4	1.210	64.2	66.5	-4.0	-3.0
SAMPLE 5	1.207	66.4	64.1	-8.0	-4.0
AVERAGE	1.231	83.6	81.6	-5.8	-3.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	VITON	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.853	3.0	0.6	-3.0	-2.0
SAMPLE 2	1.845	4.0	0.8	-2.0	-2.0
SAMPLE 3	1.868	5.0	2.3	-4.0	-4.0
SAMPLE 4	1.852	3.7	1.5	-2.0	-2.0
SAMPLE 5	1.844	3.5	1.0	-2.0	-3.0
AVERAGE	1.852	3.8	1.2	-2.6	-2.[illegible]

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.849	2.8	1.3	-1.0	-1.0
SAMPLE 2	1.849	4.4	1.6	-1.0	-2.0
SAMPLE 3	1.843	3.1	0.5	-2.0	-1.0
SAMPLE 4	1.839	3.6	1.2	1.0	1.0
SAMPLE 5	1.845	3.4	1.3	-1.0	0.0
AVERAGE	1.845	3.5	1.2	-0.8	-0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.837	2.9	1.0	-2.0	-3.0
SAMPLE 2	1.833	2.3	0.6	-1.0	-2.0
SAMPLE 3	1.839	3.3	0.4	0.0	-1.0
SAMPLE 4	1.845	3.2	1.3	-2.0	-2.0
SAMPLE 5	1.847	4.0	1.8	-1.0	-1.0
AVERAGE	1.840	3.1	1.0	-1.2	-1.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.259	5.5	2.3	3.0	2.0
SAMPLE 2	1.264	4.5	2.3	1.0	0.0
SAMPLE 3	1.265	3.8	2.8	3.0	3.0
SAMPLE 4	1.259	2.5	2.8	3.0	1.0
SAMPLE 5	1.260	3.2	3.2	0.0	-1.0
AVERAGE	1.262	3.9	2.7	2.0	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	A700	FREE	2.5HR	150F	7DAY

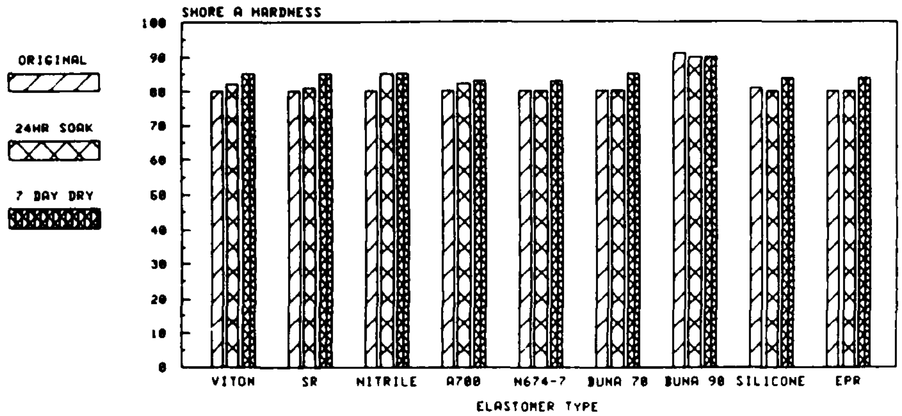
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.262	4.5	2.2	-3.0	-2.0
SAMPLE 2	1.263	4.4	3.2	1.0	0.0
SAMPLE 3	1.262	5.2	4.2	1.0	1.0
SAMPLE 4	1.264	4.2	3.6	0.0	-2.0
SAMPLE 5	1.258	4.8	3.6	-1.0	-1.0
AVERAGE	1.262	4.6	3.4	-0.4	-0.8

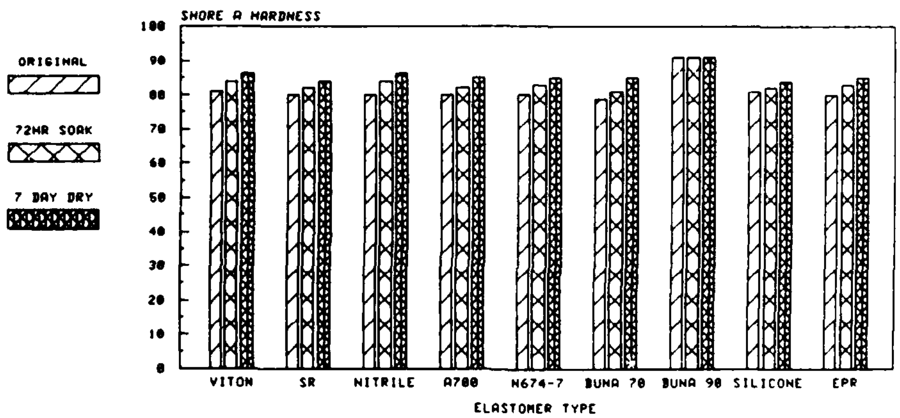
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
SULF.DFM	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

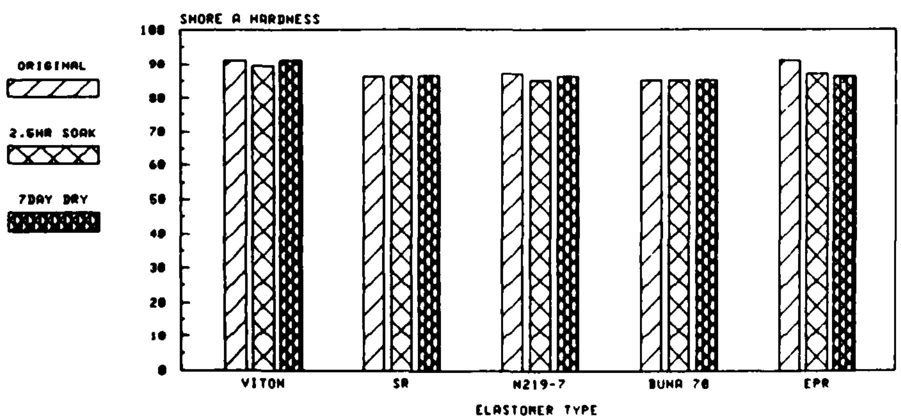
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.260	4.6	4.0	0.0	1.0
SAMPLE 2	1.261	4.7	4.6	0.0	0.0
SAMPLE 3	1.278	6.8	4.7	0.0	2.0
SAMPLE 4	1.265	5.3	3.8	0.0	-1.0
SAMPLE 5	1.262	5.0	1.5	0.0	0.0
AVERAGE	1.265	5.3	3.7	0.0	0.4



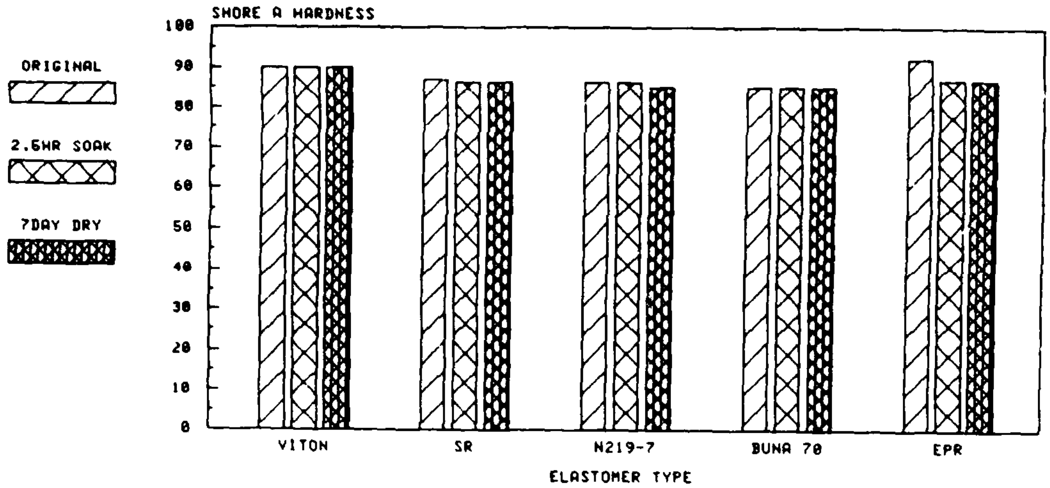
SHORE A HARDNESS - 0.1 TAN DFM
(SOAK TEMP = 75°F SOAK TIME - 24 HR)



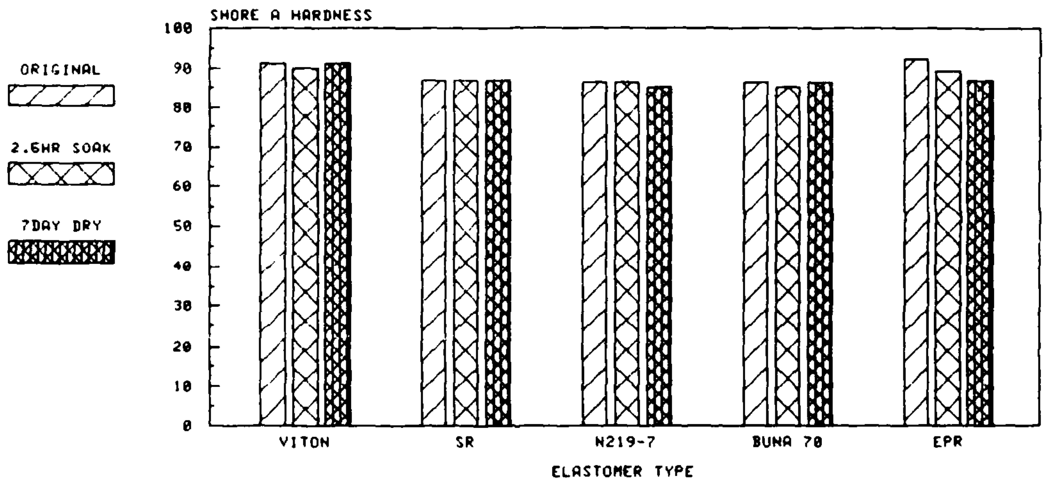
SHORE A HARDNESS - 0.1 TAN DFM
(SOAK TEMP = 75°F SOAK TIME - 72 HR)



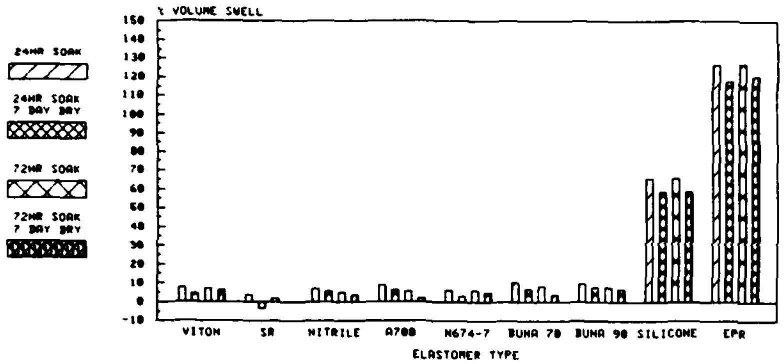
SHORE A HARDNESS - 0.1 TAN DFM
(SOAK TEMP 150°F TOFT - FREE)



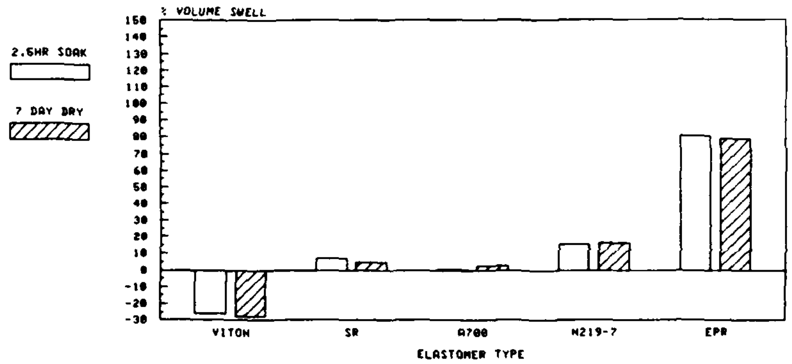
SHORE A HARDNESS - 0.1 TAN DFM
(SOAK TEMP = 150°F TOFT - TENSION)



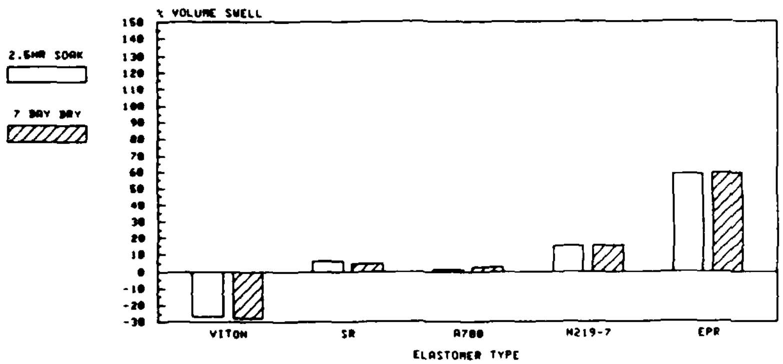
SHORE A HARDNESS - 0.1 TAN DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



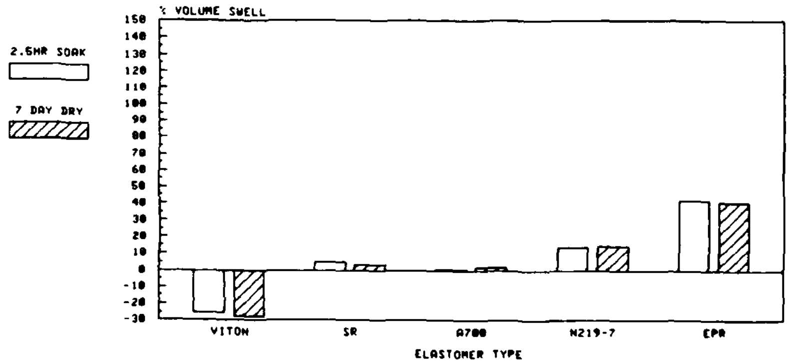
PERCENT VOLUME SWELL - 0.1 TAN DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL - 0.1 TAN DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL - 0.1 TAN DFM
(SOAK TEMP = 150°F TOFT - TENSION)



PERCENT VOLUME SWELL - 0.1 TAN DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.849	7.6	4.1	2.0	6.0
SAMPLE 2	1.871	8.3	3.8	1.0	4.0
AVERAGE	1.860	7.9	4.0	1.5	5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.881	7.7	5.9	3.0	5.0
SAMPLE 2	1.875	6.6	5.8	2.0	5.0
AVERAGE	1.878	7.2	5.8	2.5	5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.263	2.6	-6.3	2.0	6.0
SAMPLE 2	1.284	4.5	-0.5	-1.0	4.0
AVERAGE	1.273	3.5	-3.4	0.5	5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.287	2.5	0.5	1.0	5.0
SAMPLE 2	1.282	1.2	-0.7	3.0	4.0
AVERAGE	1.285	1.8	-0.1	2.0	4.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.311	7.7	5.1	5.0	5.0
SAMPLE 2	1.309	6.5	5.2	5.0	7.0
AVERAGE	1.310	7.1	5.1	5.0	6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.312	3.5	2.2	4.0	6.0
SAMPLE 2	1.315	5.5	5.2	5.0	6.0
AVERAGE	1.313	4.5	3.7	4.5	6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.332	9.3	6.7	2.0	4.0
SAMPLE 2	1.320	8.7	4.6	2.0	2.0
AVERAGE	1.326	9.0	5.7	2.0	3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.323	6.6	1.6	2.0	4.0
SAMPLE 2	1.315	4.2	1.5	1.0	4.0
AVERAGE	1.319	5.4	1.5	1.5	4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.289	6.1	2.6	0.0	3.0
SAMPLE 2	1.290	5.5	3.8	-1.0	2.0
AVERAGE	1.289	5.8	3.2	-0.5	2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.325	6.4	5.3	3.0	5.0
SAMPLE 2	1.314	5.7	4.4	2.0	5.0
AVERAGE	1.319	6.0	4.8	2.5	5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.282	11.2	6.8	1.0	6.0
SAMPLE 2	1.280	9.2	6.2	0.0	6.0
AVERAGE	1.281	10.2	6.5	0.5	6.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.280	7.9	-1.1	2.0	6.0
SAMPLE 2	1.278	9.2	8.4	2.0	7.0
AVERAGE	1.279	8.5	3.6	2.0	6.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.338	9.6	7.5	-3.0	-2.0
SAMPLE 2	1.342	9.5	8.0	0.0	0.0
AVERAGE	1.340	9.6	7.8	-1.5	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.339	8.0	4.9	1.0	0.0
SAMPLE 2	1.333	7.2	7.6	0.0	1.0
AVERAGE	1.336	7.6	6.2	0.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.451	60.6	54.4	-2.0	2.0
SAMPLE 2	1.320	71.0	62.9	-1.0	3.0
AVERAGE	1.385	65.8	58.7	-1.5	2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.314	65.8	61.6	-1.0	1.0
SAMPLE 2	1.314	65.8	55.8	1.0	4.0
AVERAGE	1.314	65.8	58.7	0.0	2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.262	127.8	117.0	0.0	4.0
SAMPLE 2	1.245	125.9	118.5	-1.0	4.0
AVERAGE	1.253	126.8	117.8	-0.5	4.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.247	128.3	122.8	2.0	4.0
SAMPLE 2	1.240	126.0	118.5	4.0	6.0
AVERAGE	1.243	127.1	120.7	3.0	5.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	SYN.RUBBER	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.273	5.2	3.0	0.0	0.0
SAMPLE 2	1.267	4.4	2.1	0.0	-1.0
SAMPLE 3	1.273	5.5	2.5	0.0	1.0
SAMPLE 4	1.271	5.3	3.2	0.0	-4.0
SAMPLE 5	1.268	5.0	3.3	0.0	2.0
AVERAGE	1.270	5.1	2.8	0.0	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	SYN.RUBBER	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.276	7.6	5.2	0.0	-1.0
SAMPLE 2	1.268	6.6	4.1	0.0	1.0
SAMPLE 3	1.273	7.0	4.9	0.0	-2.0
SAMPLE 4	1.263	6.0	3.5	0.0	0.0
SAMPLE 5	1.262	6.3	4.0	0.0	-1.0
AVERAGE	1.268	6.7	4.3	0.0	0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
1TAN DFM	SYN.RUBBER	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.269	7.3	4.6	0.0	-3.0
SAMPLE 2	1.273	5.7	4.1	0.0	0.0
SAMPLE 3	1.265	6.1	3.4	0.0	1.0
SAMPLE 4	1.263	6.9	3.8	0.0	0.0
SAMPLE 5	1.267	6.6	4.6	0.0	0.0
AVERAGE	1.267	6.5	4.1	0.0	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	N-219-7	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.286	13.7	14.4	1.0	0.0
SAMPLE 2	1.283	13.1	13.6	-1.0	-1.0
SAMPLE 3	1.287	14.1	15.0	-1.0	0.0
SAMPLE 4	1.291	14.3	14.4	1.0	-1.0
SAMPLE 5	1.290	14.3	14.3	2.0	0.0
AVERAGE	1.287	13.9	14.3	0.4	-0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	N-219-7	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.295	16.2	15.9	-1.0	-1.0
SAMPLE 2	1.291	16.4	15.5	-2.0	-3.0
SAMPLE 3	1.300	16.3	15.8	0.0	-1.0
SAMPLE 4	1.298	15.5	16.6	-3.0	-1.0
SAMPLE 5	1.294	14.8	16.1	-2.0	0.0
AVERAGE	1.295	15.8	16.0	-1.6	-1.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	N-219-7	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.296	15.3	15.8	0.0	0.0
SAMPLE 2	1.291	14.8	14.9	-2.0	-2.0
SAMPLE 3	1.293	14.1	15.9	0.0	-2.0
SAMPLE 4	1.294	15.1	16.2	0.0	-1.0
SAMPLE 5	1.296	14.4	15.3	0.0	2.0
AVERAGE	1.294	14.8	15.6	-0.4	-0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	BUNA 70	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.267	1.0	1.8	1.0	1.0
SAMPLE 2	1.265	-0.0	1.6	-1.0	1.0
SAMPLE 3	1.265	0.7	1.3	0.0	1.0
SAMPLE 4	1.268	1.0	2.3	-2.0	-1.0
SAMPLE 5	1.266	0.9	1.7	0.0	1.0
AVERAGE	1.266	0.7	1.7	-0.4	0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	BUNA 70	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.261	0.3	1.8	-1.0	-1.0
SAMPLE 2	1.259	-0.1	1.9	1.0	1.0
SAMPLE 3	1.259	1.0	2.2	0.0	-1.0
SAMPLE 4	1.263	0.9	2.5	2.0	3.0
SAMPLE 5	1.261	1.0	2.3	0.0	0.0
AVERAGE	1.261	0.6	2.2	0.4	0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	BUNA 70	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.267	1.3	3.1	-1.0	-2.0
SAMPLE 2	1.268	1.2	3.3	-2.0	1.0
SAMPLE 3	1.259	2.1	1.5	-1.0	0.0
SAMPLE 4	1.263	0.8	2.2	2.0	2.0
SAMPLE 5	1.265	-0.3	2.6	0.0	-2.0
AVERAGE	1.265	1.0	2.6	-0.4	-0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	EPR	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.202	42.7	41.2	-2.0	-5.0
SAMPLE 2	1.195	41.4	40.5	-3.0	-3.0
SAMPLE 3	1.194	42.3	40.9	-2.0	-5.0
SAMPLE 4	1.191	41.2	40.2	-5.0	-7.0
SAMPLE 5	1.194	40.8	39.4	-3.0	-6.0
AVERAGE	1.195	41.7	40.5	-3.0	-5.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	EPR	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.197	90.9	87.2	-4.0	-5.0
SAMPLE 2	1.193	63.0	60.9	-1.0	-5.0
SAMPLE 3	1.193	88.1	85.5	-3.0	-6.0
SAMPLE 4	1.192	96.0	93.3	-6.0	-5.0
SAMPLE 5	1.193	63.8	62.9	-4.0	-3.0
AVERAGE	1.194	80.4	78.0	-3.6	-4.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	EPR	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.187	61.5	67.4	-3.0	-3.0
SAMPLE 2	1.191	52.5	51.6	-5.0	-5.0
SAMPLE 3	1.190	57.0	56.2	-3.0	-3.0
SAMPLE 4	1.188	59.9	59.0	-5.0	-6.0
SAMPLE 5	1.194	62.0	61.6	-7.0	7.0
AVERAGE	1.190	58.6	59.2	-4.6	-4.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	VITON	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.324	-22.3	-27.1	-1.0	1.0
SAMPLE 2	1.319	-26.3	-28.4	-1.0	1.0
SAMPLE 3	1.322	-25.6	-28.7	-2.0	0.0
SAMPLE 4	1.325	-25.3	-28.3	1.0	3.0
SAMPLE 5	1.325	-26.1	-28.7	0.0	0.0
AVERAGE	1.323	-25.1	-28.2	-0.6	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	VITON	FREE	2.5HR	150F	5DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.308	-26.7	-30.0	-4.0	-1.0
SAMPLE 2	1.322	-24.7	-27.0	0.0	2.0
SAMPLE 3	1.308	-27.8	-29.5	2.0	1.0
SAMPLE 4	1.331	-23.4	-25.9	-2.0	-2.0
SAMPLE 5	1.319	-26.9	-28.4	-2.0	1.0
AVERAGE	1.318	-25.9	-28.1	-1.2	0.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.329	-25.7	-27.5	0.0	4.0
SAMPLE 2	1.323	-26.5	-27.9	-1.0	1.0
SAMPLE 3	1.317	-26.5	-28.3	2.0	0.0
SAMPLE 4	1.318	-26.6	-28.5	-1.0	2.0
SAMPLE 5	1.319	-26.9	-28.0	0.0	0.0
AVERAGE	1.321	-26.4	-28.0	0.0	1.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	A700	COMP	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.267	1.0	1.8	1.0	1.0
SAMPLE 2	1.265	-0.0	1.6	-1.0	1.0
SAMPLE 3	1.265	0.7	1.3	0.0	1.0
SAMPLE 4	1.268	1.0	2.3	-2.0	-1.0
SAMPLE 5	1.266	0.9	1.7	0.0	1.0
AVERAGE	1.266	0.7	1.7	-0.4	0.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	A700	FREE	2.5HR	150F	7DAY

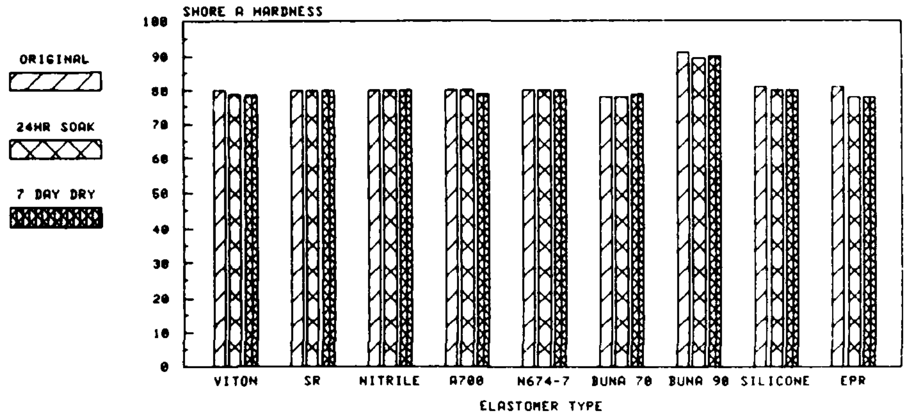
WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.261	0.3	1.8	-1.0	-1.0
SAMPLE 2	1.259	-0.1	1.9	1.0	1.0
SAMPLE 3	1.259	1.0	2.2	0.0	-1.0
SAMPLE 4	1.263	0.9	2.5	2.0	3.0
SAMPLE 5	1.261	1.0	2.3	0.0	0.0
AVERAGE	1.261	0.6	2.2	0.4	0.4

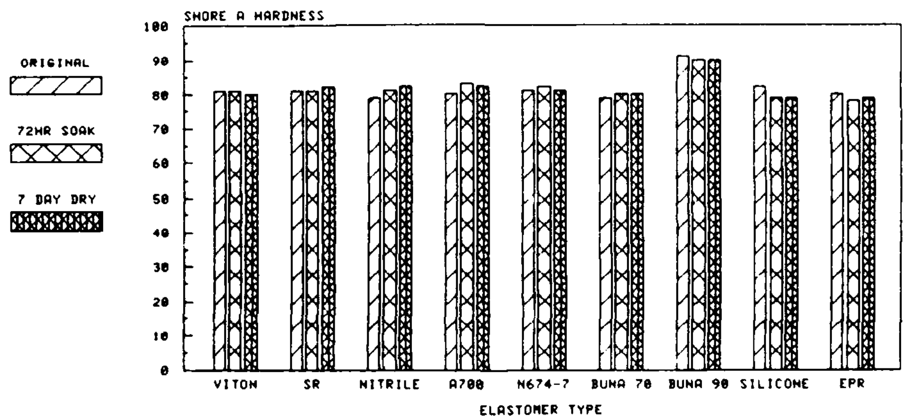
FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
.1TAN DFM	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

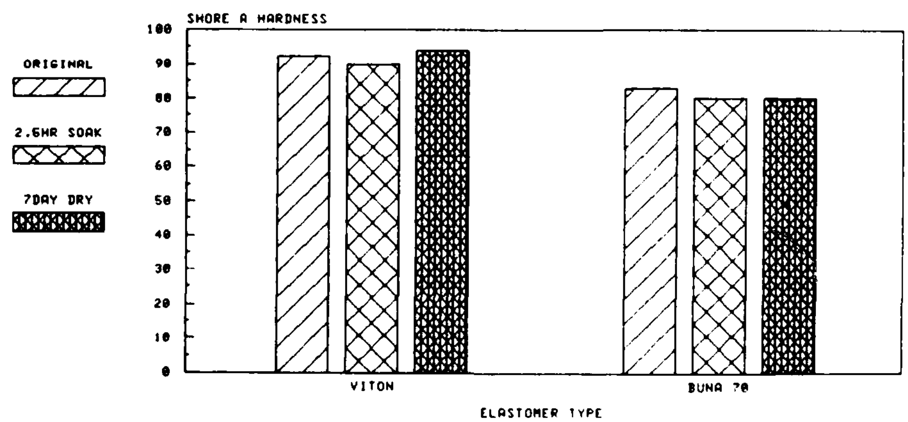
	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.267	1.3	3.1	-1.0	-2.0
SAMPLE 2	1.268	1.2	3.3	-2.0	1.0
SAMPLE 3	1.259	2.1	1.5	-1.0	0.0
SAMPLE 4	1.263	0.8	2.2	2.0	[illegible]
SAMPLE 5	1.265	-0.3	2.6	0.0	[illegible]
AVERAGE	1.265	1.0	2.6	-0.4	[illegible]



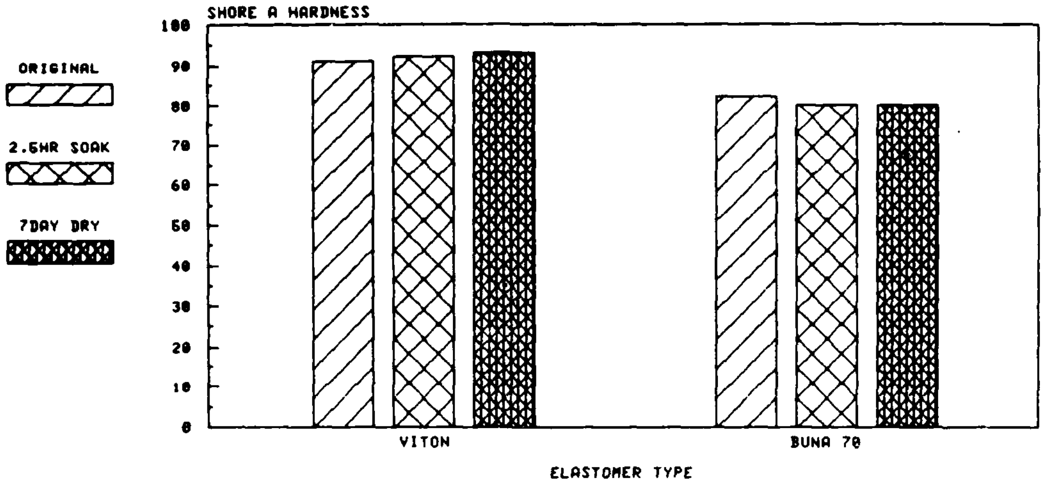
SHORE A HARDNESS - COMPOSITE DFM
(SOAK TEMP = 75°F SOAK TIME = 24 HR)



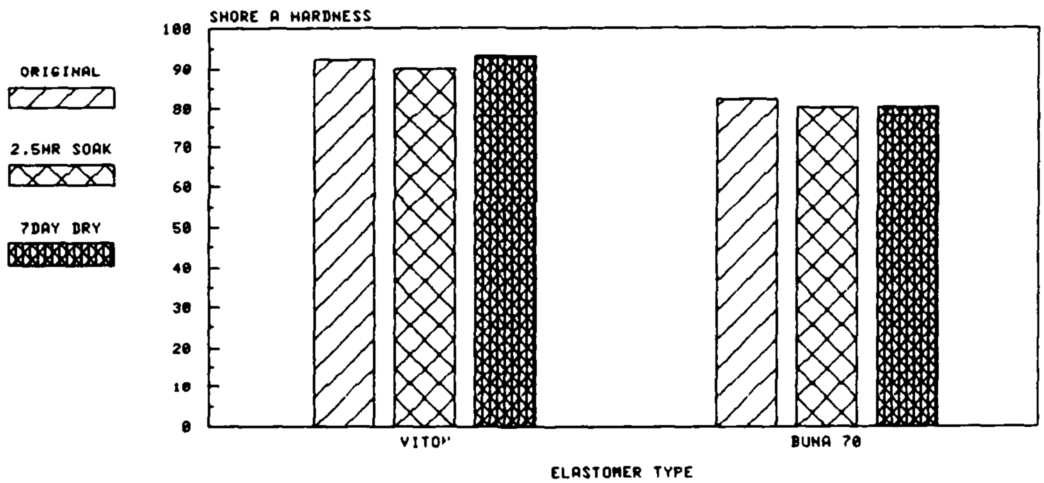
SHORE A HARDNESS - COMPOSITE DFM
(SOAK TEMP = 75°F SOAK TIME = 72 HR)



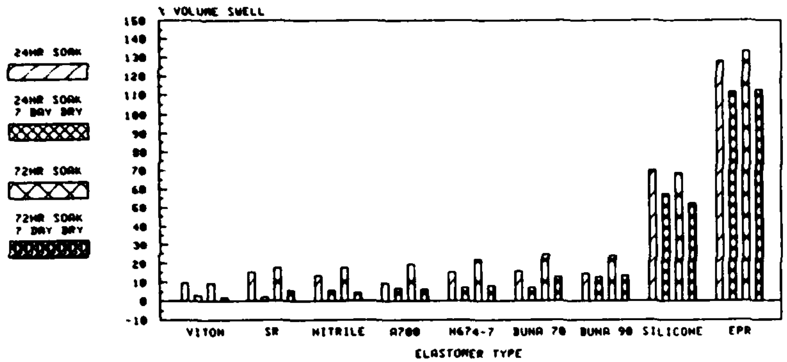
SHORE A HARDNESS - COMPOSITE DFM
(SOAK TEMP = 150°F TOFT - FREE)



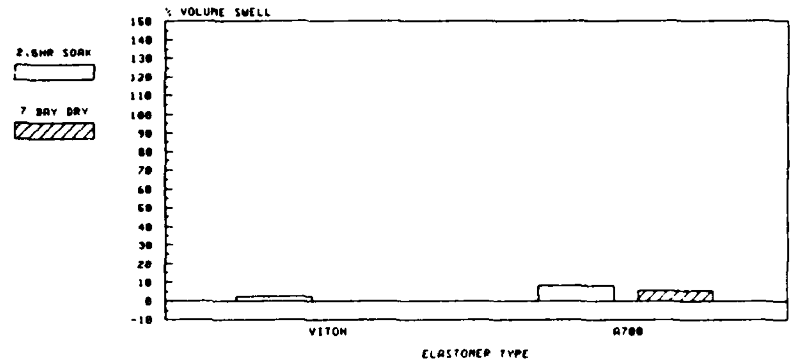
SHORE A HARDNESS - COMPOSITE DFM
(SOAK TEMP = 150°F TOFT - TENSION)



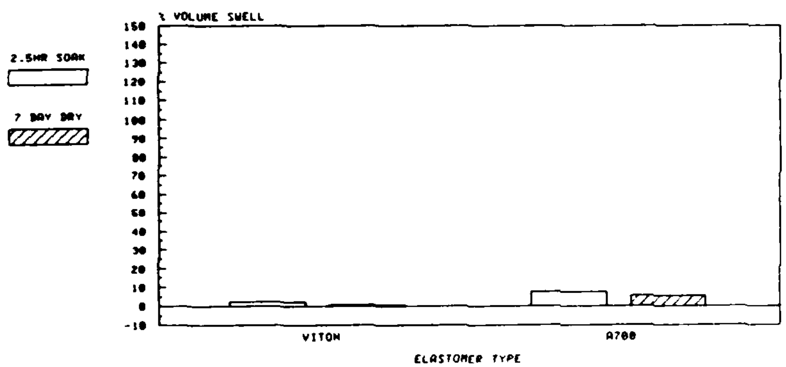
SHORE A HARDNESS - COMPOSITE DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)



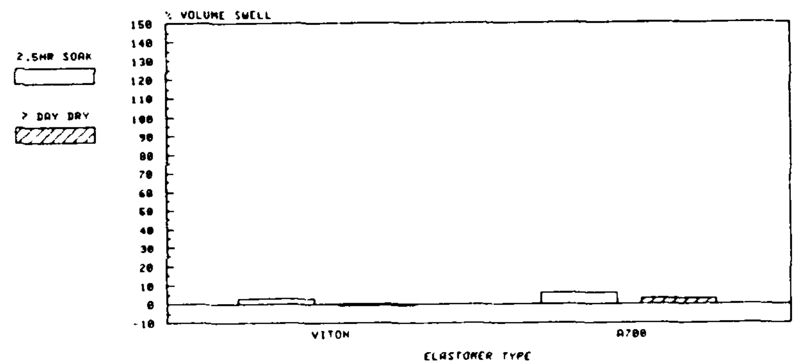
PERCENT VOLUME SWELL - COMPOSITE DFM
(SOAK TEMP = 75°F)



PERCENT VOLUME SWELL - COMPOSITE DFM
(SOAK TEMP = 150°F TOFT - FREE)



PERCENT VOLUME SWELL - COMPOSITE DFM
(SOAK TEMP ~ 150°F TOFT - TENSION)



PERCENT VOLUME SWELL - COMPOSITE DFM
(SOAK TEMP = 150°F TOFT - COMPRESSION)

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	VITON	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.882	9.5	3.0	0.0	-1.0
SAMPLE 2	1.887	8.9	3.3	-1.0	0.0
AVERAGE	1.884	9.2	3.1	-0.5	-0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	VITON	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.884	8.4	1.6	1.0	-1.0
SAMPLE 2	1.888	10.9	2.1	0.0	-1.0
AVERAGE	1.886	9.6	1.9	0.5	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	SR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.325	14.6	6.4	-1.0	-3.0
SAMPLE 2	1.332	15.8	7.8	0.0	0.0
AVERAGE	1.329	15.2	7.1	-0.5	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	SR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.327	18.8	5.7	0.0	1.0
SAMPLE 2	1.314	17.0	4.4	1.0	1.0
AVERAGE	1.320	17.9	5.1	0.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	NITRILE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.316	13.2	4.9	1.0	0.0
SAMPLE 2	1.321	13.5	6.1	0.0	0.0
AVERAGE	1.318	13.4	5.5	0.5	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	NITRILE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.318	17.6	3.7	1.0	1.0
SAMPLE 2	1.315	17.1	4.7	2.0	4.0
AVERAGE	1.317	17.4	4.2	1.5	2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	A700	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.286	10.0	4.9	-1.0	-1.0
SAMPLE 2	1.311	8.7	8.3	0.0	-1.0
AVERAGE	1.298	9.3	6.6	-0.5	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	A700	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.339	20.0	7.1	4.0	2.0
SAMPLE 2	1.311	18.7	5.2	1.0	1.0
AVERAGE	1.325	19.3	6.1	2.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	N674-7	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.342	16.7	9.3	0.0	0.0
SAMPLE 2	1.335	14.1	4.6	1.0	1.0
AVERAGE	1.338	15.4	6.9	0.5	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	N674-7	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.342	21.9	7.4	1.0	1.0
SAMPLE 2	1.375	23.0	9.1	1.0	-1.0
AVERAGE	1.358	22.4	8.2	1.0	0.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	BUNA 70	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.287	16.5	7.6	0.0	1.0
SAMPLE 2	1.279	15.1	6.8	0.0	0.0
AVERAGE	1.283	15.8	7.2	0.0	0.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	BUNA 70	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.287	24.6	12.9	1.0	1.0
SAMPLE 2	1.286	24.5	12.8	2.0	2.0
AVERAGE	1.286	24.5	12.8	1.5	1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	BUNA 90	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.431	18.9	15.2	-2.0	-2.0
SAMPLE 2	1.358	10.0	10.7	-1.0	-1.0
AVERAGE	1.394	14.4	12.9	-1.5	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	BUNA 90	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.367	25.8	14.9	-2.0	-1.0
SAMPLE 2	1.362	22.7	12.7	-1.0	-1.0
AVERAGE	1.364	24.3	13.8	-1.5	-1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	SILICONE	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.498	69.4	57.0	-2.0	-1.0
SAMPLE 2	1.445	70.3	58.2	-1.0	-1.0
AVERAGE	1.472	69.9	57.6	-1.5	1.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	SILICONE	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.482	69.6	52.9	-3.0	-4.0
SAMPLE 2	1.423	68.5	52.0	-3.0	-2.0
AVERAGE	1.452	69.1	52.4	-3.0	3.0

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	EPR	FREE	24HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.257	128.1	112.4	-3.0	-3.0
SAMPLE 2	1.250	127.4	110.4	-2.0	-2.0
AVERAGE	1.254	127.8	111.4	-2.5	-2.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	EPR	FREE	72HR	75F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.254	135.6	114.7	-2.0	-2.0
SAMPLE 2	1.247	130.9	110.6	-2.0	-1.0
AVERAGE	1.251	133.3	112.7	-2.0	-1.5

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	VITON	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.849	4.9	1.7	-3.0	1.0
SAMPLE 2	1.839	4.4	0.4	-2.0	2.0
SAMPLE 3	1.814	2.6	-1.2	-1.0	0.0
SAMPLE 4	1.80[illegible]	2.2	-1.3	-2.0	2.0
SAMPLE 5	1.82[illegible]	2.1	-1.0	-3.0	-3.0
AVERAGE	1.82[illegible]	3.2	-0.3	-2.2	0.4

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	VITON	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.846	3.4	-0.0	-1.0	4.0
SAMPLE 2	1.821	1.7	-1.3	-3.0	3.0
SAMPLE 3	1.842	3.3	-0.2	-1.0	1.0
SAMPLE 4	1.824	2.6	0.4	-1.0	1.0
SAMPLE 5	1.829	2.2	0.3	-1.0	2.0
AVERAGE	1.832	2.6	-0.2	-1.4	2.[illegible]

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	VITON	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.832	2.2	1.0	1.0	1.0
SAMPLE 2	1.850	0.6	1.8	0.0	1.0
SAMPLE 3	1.841	3.3	0.7	1.0	3.0
SAMPLE 4	1.819	2.3	0.3	0.0	2.0
SAMPLE 5	1.822	2.2	-0.2	0.0	2.0
AVERAGE	1.833	2.1	0.7	0.4	1.8

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	A700	COMP.	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.255	6.3	3.4	-2.0	-2.0
SAMPLE 2	1.253	6.1	2.6	-3.0	-3.0
SAMPLE 3	1.253	6.1	3.0	-2.0	-2.0
SAMPLE 4	1.255	5.5	2.8	-1.0	0.0
SAMPLE 5	1.252	6.2	3.5	-1.0	-1.0
AVERAGE	1.254	6.0	3.1	-1.8	-1.6

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	A700	FREE	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.253	8.6	4.7	-3.0	-2.0
SAMPLE 2	1.250	8.3	5.0	-2.0	-2.0
SAMPLE 3	1.251	7.6	4.8	-3.0	-2.0
SAMPLE 4	1.250	7.9	4.3	-1.0	-2.0
SAMPLE 5	1.255	9.3	6.4	-3.0	-3.0
AVERAGE	1.252	8.3	5.1	-2.4	-2.2

FUEL	ELASTOMER	ENVIRON	SOAK TIME	TEMP	DRY TIME
COMP.DFM	A700	TENSION	2.5HR	150F	7DAY

WEIGHT & HARDNESS DATA

	SG	%VS(WET)	%VS(DRY)	HC(WET)	HC(DRY)
SAMPLE 1	1.255	7.4	4.9	-1.0	0.0
SAMPLE 2	1.253	8.3	6.0	-1.0	1.0
SAMPLE 3	1.254	7.1	4.4	-1.0	1.0
SAMPLE 4	1.253	7.7	5.7	-3.0	-3.0
SAMPLE 5	1.250	6.6	4.9	-1.0	-2.0
AVERAGE	1.253	7.4	5.2	1.4	1.4

APPENDIX C

AFLRL ELASTOMER RETENTION PROPERTIES

Retention Properties of Viton #V2224

Original Properties	
Tensile, PSI	1323
100 % Modulus, PSI	715
200% Modulus, PSI	1312
Elongation, %	203

After 72 hours at room temp in AL-10150-SP	
Tensile Retained, %	94
100% Modulus Retained, %	99
200% Modulus Retained, %	--
Elongation Retained, %	89

After 72 hours at room temp. in AL-10635-SP	
Tensile Retained, %	91
100% Modulus Retained, %	98
200% Modulus Retained, %	--
Elongation Retained, %	84

After 72 hours at room temp. in AL-10636-SP	
Tensile Retained, %	102
100% Modulus Retained, %	114
200% Modulus Retained, %	--
Elongation Retained, %	85

After 72 hours at room temp. in AL-10637-SP	
Tensile Retained, %	93
10% Modulus Retained, %	107
200% Modulus Retained, %	--
Elongation Retained, %	87

After 72 hours at room temp in AL-10666-SP	
Tensile Retained, %	97
100% Modulus Retained, %	109
200% Moduls Retained, %	--
Elongation Retained, %	87

After 72 hours at room temp. in AL-10684-SP	
Tensile Retained, %	105
100% Modulus Retained, %	109
200% Modulus Retained, %	--
Elongation Retained, %	87

After 72 hours at room temp in AL-10731-SP	
Tensile Retained, %	96
100% Modulus Retained, %	103
200% Modulus Retained, %	--
Elongation Retained, %	90

After 72 hours at room temp in AL-10732-SP	
Tensile Retained, %	99
100% Modulus Retained, %	108
200% Modulus Retained, %	--
Elongation Retained, %	85

After 72 hours at room temp in AL-10746-SP	
Tensile Retained, %	94
100% Modulus Retained, %	103
200% Modulus Retained, %	--
Elongation Retained, %	89

Retention Properties of Buna N #2260

Original	
Tensile, PSI	2030
100% Modulus, PSI	282
200% Modulus, PSI	733
Elongation, %	473

After 72 hours at room temp in AL-10150-SP	
Tensile, Retained, %	90
100% Modulus Retained, %	95
200% Modulus Retained, %	96
Elongation Retained, %	93

After 72 hours at room temp in AL-10635-SP	
Tensile Retained, %	96
100% Modulus Retained, %	95
200% Modulus Retained, %	97
Elongation Retained, %	101

After 72 hours at room temp in AL-10636-SP	
Tensile Retained, %	90
100% Modulus Retained, %	100
200% Modulus Retained, %	102
Elongation Retained, %	93

After 72 hours at room temp in AL-10637-SP	
Tensile Retained, %	92
100% Modulus Retained, %	98
200% Modulus Retained, %	98
Elongation Retained, %	94

After 72 hours at room temp in AL-10666-SP	
Tensile Retained, %	90
100% Modulus Retained, %	95
200% Modulus Retained, %	99
Elongation Retained, %	93

After 72 hours at room temp in AL-10684-SP	
Tensile Retained, %	93
100% Modulus Retained, %	95
200% Modulus Retained, %	98
Elongation Retained, %	96

After 72 hours at room temp in AL-10731-SP	
Tensile Retained, %	84
100% Modulus Retained, %	91
200% Modulus Retained, %	99
Elongation Retained, %	84

After 72 hours at room temp in AL-10732-SP	
Tensile Retained, %	91
100% Modulus Retained, %	99
200% Modulus Retained, %	107
Elongation Retained, %	93

After 72 hours at room temp in AL-10746-SP	
Tensile Retained, %	74
100% Moduls Retained, %	9
200% Modulus Retained, %	104
Elongation Retained, %	73

Retention Properties of Buna N #2061

Original	
Tensile, PSI	1775
100% Modulus, PSI	450
200% Modulus, PSI	1187
Elongation, %	310

After 72 hours at room temp in AL-10150-SP	
Tensile Retained, %	85
100% Modulus, %	89
200% Modulus, %	93
Elongation Retained, %	87

After 72 hours at room temp in AL-10635-SP	
Tensile Retained, %	92
100% Modulus Retained, %	102
200% Modulus Retained, %	100
Elongation Retained, %	86

After 72 hours at room temp in AL-10636-SP	
Tensile Retained, %	72
100% Modulus Retained, %	98
200% Modulus Retained, %	101
Elongation Retained, %	71

After 72 hours at room temp in AL-10637-SP	
Tensile Retained, %	83
100% Modulus Retained, %	101
200% Modulus Retained, %	102
Elongation Retained, %	77

After 72 hours at room temp in AL-10666-SP	
Tensile Retained, %	86
100% Modulus Retained, %	102
200% Modulus Retained, %	102
Elongation Retained, %	81

After 72 hours at room temp in AL-10684-SP	
Tensile Retained, %	84
100% Modulus Retained, %	95
200% Modulus Retained, %	99
Elongation Retained, %	84

After 72 hours at room temp in AL-10731-SP	
Tensile Retained, %	69
100% Modulus Retained, %	98
200% Modulus Retained, %	95
Elongation Retained, %	69

After 72 hours at room temp in AL-10732-SP	
Tensile Retained, %	86
100% Modulus Retained, %	103
200% Modulus Retained, %	102
Elongation Retained, %	81

After 72 hours at room temp. in AL-10746-SP	
Tensile Retained, %	64
100% Modulus Retained,%	83
200% Modulus Retained, %	95
Elongation Retained, %	65

Retention Properties of Nitrile #2107

Original	
Tensile, PSI	2720
100% Modulus, PSI	673
200% Modulus, PSI	2200
Elongation, %	250

After 72 hours at room temp in AL-10150-SP	
Tensile Retained, %	84
100% Modulus Retained, %	93
200% Modulus Retained, %	98
Elongation Retained, %	86

After 72 hours at room temp in AL-10635-SP	
Tensile Retained, %	84
100% Modulus Retained, %	107
200% Modulus Retained, %	101
Elongation Retained, %	84

After 72 hours at room temp in AL-10636-SP	
Tensile Retained, %	71
100% Modulus Retained, %	111
200% Modulus Retained, %	--
Elongation Retained, %	72

After 72 hours at room temp in AL-10637-SP	
Tensile Retained, %	61
100% Modulus Retained, %	98
200% Modulus Retained, %	--
Elongation Retained, %	68

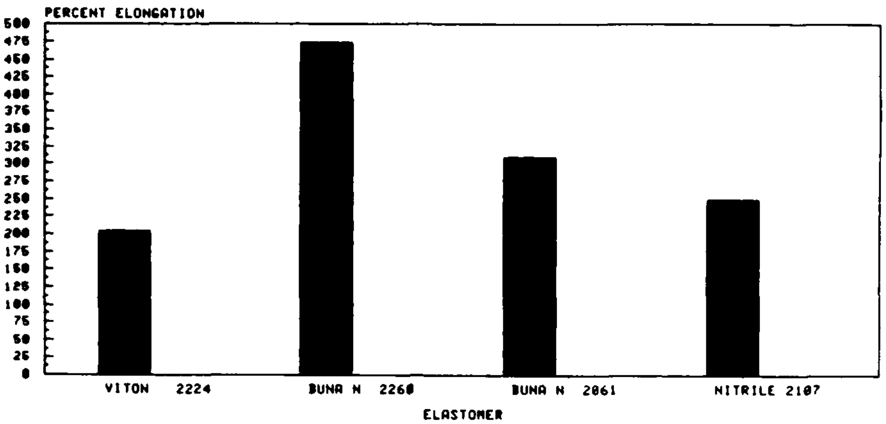
After 72 hours at room temp in AL-10666-SP	
Tensile Retained, %	70
100% Modulus Retained, %	109
200% Modulus Retained, %	--
Elongation Retained, %	

After 72 hours at room temp. in AL-10684-SP	
Tensile Retained, %	81
100% Modulus Retained, %	96
200% Modulus Retained, %	98
Elongation Retained, %	82

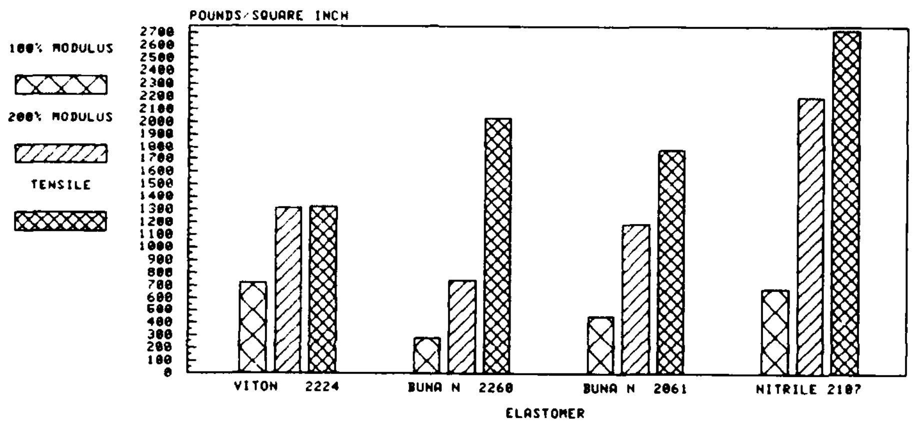
After 72 hours at room temp in AL-10731-SP	
Tensile Retained, %	67
100% Modulus Retained, %	98
200% Modulus Retained, %	--
Elongation Retained, %	73

AFter 72 hours at room temp in AL-10732-SP	
Tensile Retained, %	61
100% Modulus Retained, %	96
200% Modulus Retained, %	--
Elongation Retained, %	68

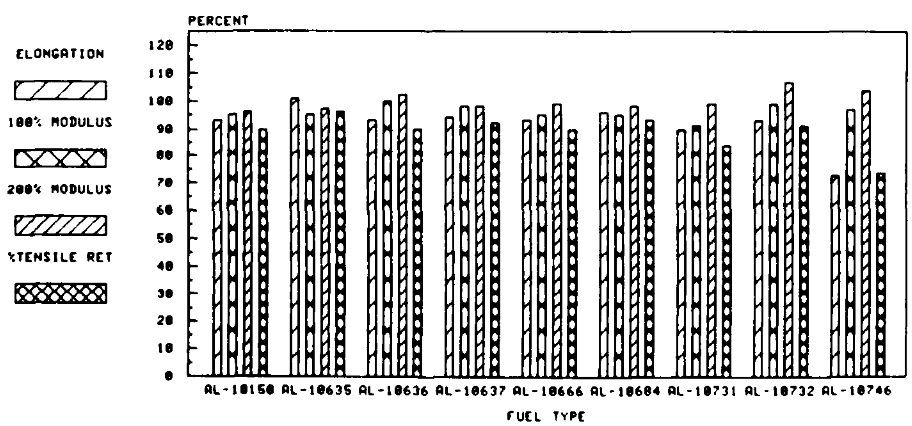
After 72 hours at room temp in AL-10746-SP	
Tensile Retained, %	60
100% Modulus Retained, %	94
200% Modulus Retained, %	--
Elongation Retained, %	67



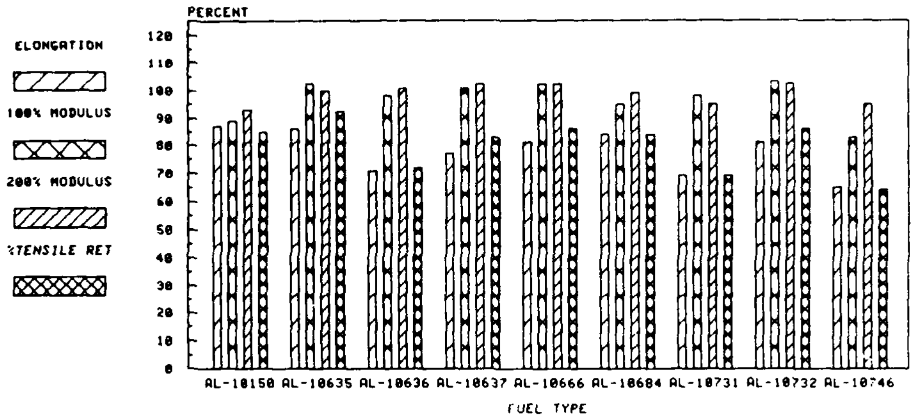
ORIGINAL PROPERTIES OF ELASTOMERS
ELONGATION



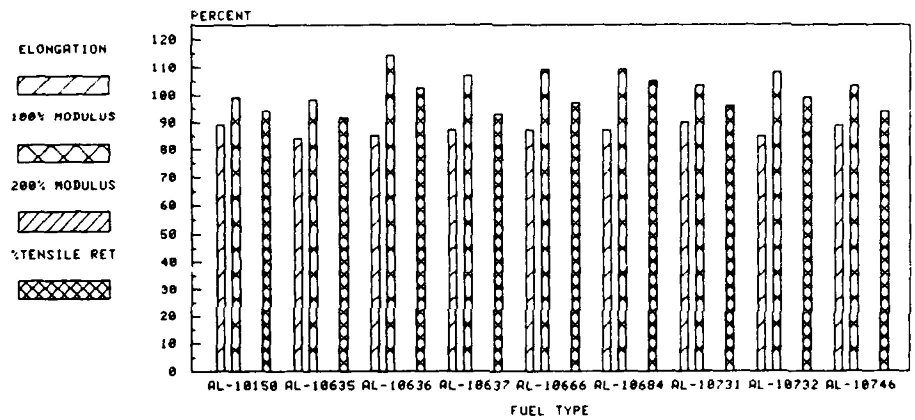
ORIGINAL PROPERTIES OF ELASTOMERS
POUNDS/SQUARE INCH



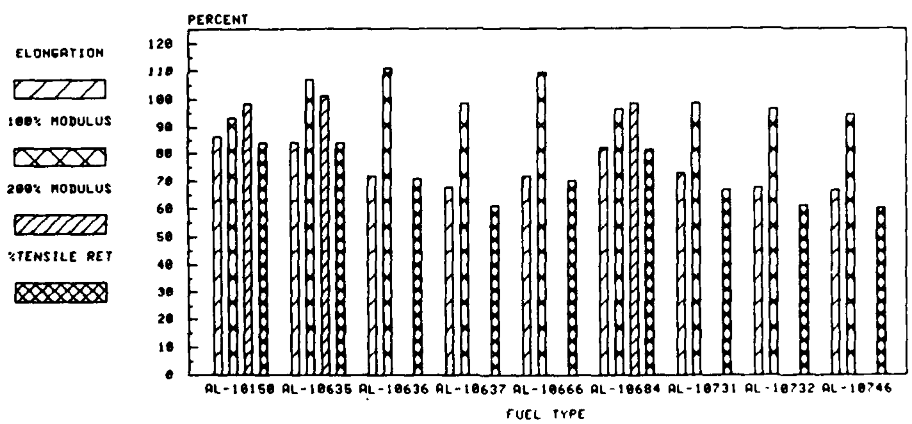
RETENTION PROPERTIES OF BUNA-N #2260
AFTER 72 HR AT ROOM TEMPERATURE



RETENTION PROPERTIES OF BUNA-N #2061
AFTER 72 HR AT ROOM TEMPERATURE



RETENTION PROPERTIES OF VITON #2224
AFTER 72 HR AT ROOM TEMPERATURE



RETENTION PROPERTIES OF NITRILE #2107
AFTER 72 HR AT ROOM TEMPERATURE

APPENDIX D

No. 1	JFC 78 500-Hour Shale Oil Plan of Test, April 20, 1981
No. 2	JFC 78 Shale Oil Fuel Plan of Test, Revised July 30, 1981
No. 3	Pre and Post Test Definition Data
No. 4	Spot Calibration
No. 5	Flow Test
No. 6	Fuel Characteristics and Lubricity and Interfacial Tension
No. 7	Detailed Component Test Results
No. 8	Summary of Pre and Post Calibration Test Results
No. 9	Plotted Definition Data Results
No. 10	Disassembly and Inspection Results

APPENDIX D-1

JFC 78 500-HOUR SHALE OIL

PLAN OF TEST

APRIL 20, 1981

PURPOSE OF TEST

The purpose of this test plan is to define the test procedures required to run a JFC 78 500-hour mission cycle endurance test. This program covers the necessary effort to perform the test using fuel derived from shale oil. The work will be performed under contract with Southwest Research Institute. The shale oil fuel has low lubricity and high aromatic content. The test is to determine if the shale oil fuel has a detrimental effect on the control.

DISCUSSION

Test Setup

The following test rigs and test equipment will be used:

(1) Control calibration plus pre and post test definition data will be performed on Rig 52, 53, 18, 100, 101, or C-3 using MIL-7024.

(2) Mission cycle testing and spot calibration Rig B-3B per Figure 2.

(3) A JFC 78-4 control, P/N 763700, S/N 93747 will be used for the test.

(4) S/N 86088 will be used to test out the Rig B-3B, to make sure all the functions operate before S/N 93747 is used.

The following instrumentation will be required on B-3B Rig (set as shown in Figure 2).

Speed Readout Sensor	Range	Req Accuracy
Magnetic Pick-up/Tooth Wheel	0 - 11,000 rpm	±3 rpm
Temperature		
Fuel Control Inlet	+80 to 180°F	
Fuel Control Outlet	+80 to 200°F	±4°
T_2 Sensor	+20 to 120°F	

Position (LVDT)	Range	Rig Accuracy
LDS Linear Stroke	0 - 70°	±1%
PAS Linear Stroke	0 - 118°	±1%
VG Position	0 - 1.7 in	±1%

Fuel Flow	Range	Rig Accuracy
Turbine Meter	50 - 900 pph	3% at Calibrated Temp.

Pressure		
P_3 (P3)	0 - 300 psia	±1%
Boost Pressure	0 - 100 psig	
Engine Clay Filter ΔP	0 - 50 psia	
Control Inlet (P_{in})	0 - 100 psig	
Control Body (P_B)	0 - 160 psig	
Regulated Pressure (P_R - P_B	0 - 200 psi	
Control Discharge (P_{out})	0 - 1000 psig	
Throttle Valve ΔP(T.V. ΔP)	0 - 50 psi	
5μ Filter ΔP	0 - 5 psi	±1%

Power Supply	
Torque Motor Suitcase Tester	0 - 100 ma

Rig Setup and Precautions

(1) IMPORTANT: No Vaseline to be used in rig setup.

(2) Use Iso for setup with a second JFC 78 control.
CAUTION: The JFC 78 vane pump can be damaged by sustained operation at speeds above 11,000 rpm and high fuel temperatures. At no time is the control to be operated in overspeed or manual shut-off for a period in excess of 20 seconds.

(3) Flush rig with freon and blow out with N_2 prior to filling with shale oil where possible.
CAUTION: When filling with shale oil, make sure all pumps and plumbing have been cleaned (NO DETERGENT). Fuel should be kept sealed when possible to maintain aromatic content.

(4) Fuel supply is limited, check carefully for leaks prior to start-up. After 500 hour test, shale oil may be returned to SWRI.

(5) Ground all plumbing to prevent arcing.

(6) Containers which have been subjected to special cleaning will be used for fuel samples.

(7) Rig must be a closed loop system to maintain the aromatic content.

Hardware Inspection and Test

All hardware will be visually examined for nicks, scratches, blemishes, etc. All discrepancies will be recorded on the experimental inspection report. Any questionable components will be replaced. The throttle valve, VG pilot valve and pump will be flow tested per Appendix A-III.

Assembly

When assembling unit S/N 93747, no vaseline is to be used. The only lubricant that may be used is calibrating fluid MIL-7024.

Calibration

After assembly and calibration, an acceptance test shall be run per HS 7666. Special definition data will be run per Appendix A-1. After completion of the definition data, an audit test shall be run per HS 7666.

Testing

The following tests shall be run in the order listed.

Control Installation on Cyclic Rig

After the control has been drained of MIL-7024 as completely as possible, the unit will be installed on the test rig. Iso-octane will then circulate through the test rig and control S/N 93747. Every hour, a sample of Iso-octane will be taken and an interfacial tension test will be run per ASTM D971-50. The circulating of Iso-octane will continue until the interfacial tension test levels off or 8 hours. The Iso-octane will then be drained from the control rig completely. The rig should be flushed with freon and blown out with N_2, also the clay and 5μ filter should be replaced prior to filling with shale oil. When filling with shale oil, make sure all pumps and plumbing have been cleaned (NO DETERGENT). Photos should be taken of the rig and setup.

Spot Calibration

After the rig is filled, a spot calibration shall be made per Appendix A-II.

Special Data

Automatic data will be taken by the Portable Acquisition Terminal hourly or once per shift if data must be taken manually. The data will consist of Wf, Speed, P_3, T_2, T.V. ΔP, P_R, at two of the pinball conditions. These two conditions will be idle and the mid-point P_3 position. The special data will be taken at random temperatures from +20°F to +120°F. Fuel samples, in specially cleaned containers will be taken for SWRI and P&WA Lab at the start of the test and after 50 hours, 250 hours, 300 hours and finish. Also, at various times, samples should be taken to the Chemical Lab for an interfacial tension test per ASTM D971-50.

Hot Temperature

Upon completion of the spot calibration, the subject hardware shall be operated as specified below. Components shall be operated according to the test cycle shown on Figure 2 for 50 hours. Each cycle consists of a 75 minute mission at a control fuel inlet temperature of 157°F ±20°F.

Spot Calibration

After completion of the 50 hours hot temperature test, a spot calibration shall be made per Appendix A-II.

Room Temperature

Upon completion of the spot calibration, the subject hardware will be operated at a fuel inlet temperature of +85°F ±20°F for the same cycle as the hot temperature test for 200 hours.

Spot Calibration

After completion of the 200 hours room temperature test, a spot calibration shall be made per Appendix A-II.

Hot Temperature

Same as above hot temperature test for 50 hours.

Spot Calibration

After hot temperature test, a spot calibration per Appendix A-II shall be run.

Room Temperature

Same as above room temperature test for 200 hours.

Spot Calibration

After room temperature test, a spot calibration per Appendix A II shall be run.

Post Test Calibration

After completion of the spot calibration, the unit will be taken to a production certified rig to run an "as is" acceptance calibration and definition data per Appendix A-I.

Tear Down and Inspection

After analysis of the above data, the control shall be disassembled and examined. Hardware condition shall be inspected and recorded on the experimental inspection report. The throttle valve, VG pilot valve and pump will be flow tested per Appendix A-III.

APPENDIX D-2

JFC 78 - SHALE OIL FUEL

PLAN OF TEST

Revised 7/30/81

PURPOSE OF TEST

The purpose of this test plan is to define the test procedures required to run a JFC 78 mission cycle endurance test. This program covers the necessary effort to perform the test using fuel derived from shale oil. The work will be performed under contract with Southwest Research Institute. The shale oil fuel has low libricity and high aromatic content. The test is to determine if the shale oil fuel has a detrimental effect on the control. The target test time will be 300 hours total (200 hours with room temperature fuel and 100 hours with a fuel inlet temperature of 157°F ±20°F.

DISCUSSION

Test Setup

The following test rigs and test equipment will be used:

(1) Control calibration plus pre and post test definition data will be performed on Rig 52, 53, 18, 100, 101, or C-3 using MIL-7024.

(2) Mission cycle testing and spot calibration Rig B-3B per Figure 2.

(3) A JFC 78-4 control, P/N 763700, S/N 93747 2ill be used for the test.

The following instrumentation will be required on B-3B Rig (set as shown in Figure 2).

Speed Readout Sensor	Range	Rig Accuracy
Magnetic Pick-up/Tooth Wheel	0 - 11,000 rpm	±3 rpm
Temperature		
Fuel Control Inlet	+80 to 180°F	
Fuel Control Outlet	+80 to 200°F	±4°
T_2 Sensor	+20 to 120°F	

	Range	Rig Accuracy
Position (LVDT)		
LDS Linear Stroke	0 - 70°	±1%
PAS Linear Stroke	0 - 118°	±1%
VG Position	0 - 1.7 in	±1%
Fuel Flow		
Turbine Meter	50 - 900 pph	3% at Calibrated Temp.
Pressure		
P_3 (P_3)	0 - 300 psia	±1%
Boost Pressure	0 - 100 psig	↑
Engine Clay Filter ΔP	0 - 50 psia	|
Control Inlet (P_{in})	0 - 100 psig	|
Control Body (P_B)	0 - 160 psig	|
Regulated Pressure (P_R - P_B)	0 - 200 psig	|
Control Discharge (P_{out})	0 - 1000 psig	|
Throttle Valve P(T.V. ΔP)	0 - 50 psi	↓
5µ Filter ΔP	0 - 5 psi	±1%
Power Supply		
Torque Motor Suitcase Tester	0 - 100 ma	

Rig Setup and Precautions

(1) IMPORTANT: No Vaseline to be used in rig setup.

CAUTION: The JFC 78 vane pump can be damaged by sustained operation at speeds above 11,000 rpm and high fuel temperatures. At no time is the control to be operated in overspeed or manual shut-off for a period in excess of 20 seconds.

CAUTION: When filling with shale oil, make sure all pumps and plumbing have been cleaned (NO DETERGENT). Fuel should be kept sealed when possible to maintain aromatic content.

(2) Fuel supply is limited, check carefully for leaks prior to start-up. After the test, the shale oil may be returned to SWRI.

(3) Ground all plumbing to prevent arcing.

(4) Containers which have been subjected to special cleaning will be used for fuel samples.

(5) Rig must be closed loop system to maintain the aromatic content.

(6) CAUTION: The maximum fuel temperature safety device is to be set for 140°F during the room temperature phase.

Hardware Inspection and Test

All hardware will be visually examined for nicks, scratches, blemishes, etc. All discrepancies will be recorded on the experimental inspection report. Any questionable components will be replaced. The throttle valve, VG pilot valve and pump will be flow tested per Appendix A-III.

Assembly

When assembling unit S/N 93747, no vaseline is to be used. The only lubricant that may used is calibrating fluid MIL-7024.

Calibration

After assembly and calibration, an acceptance test shall be run per HS 7666. Special definition data will be run per Appendix A-I. After completion of the definition data, an audit test shall be run per HS 7666.

Testing

Control Installation on Cyclic Rig - After the control has been drained of MIL-7024 as completely as possible, the control will be flushed with shale oil fuel and then installed on the rig. The rig should be purged with N_2, also the clay and other rig filters should be replaced prior to filling with shale oil. When filling the rig with shale oil, make sure all pumps and plumbing have been cleaned (NO DETERGENT).

Spot Calibration - After the rig is filled, a spot calibration shall be made per Appendix A-II.

Special Data

Automatic data will be taken by the Portable Acquisition Terminal twice per 75 minute cycle. The data will consist of Wf, speed, P_3, T_2, T.V. ΔP, P_R, fuel inlet and outlet temperature, LDS, PAS, and VG position, fuel inlet and outlet pressure, body pressure, clay filter ΔP and 5 micron filter ΔP, at two of the pinball conditions. These two conditions will be idle and the mid-point P_3 position. The special data will be taken at random temperatures from +20°F to +120°F. Fuel samples, in specially cleaned containers will be taken for SWRI and HS Lab at the start of the test and after 50 hours, 200 hours, and finish. Also, at various times, samples should be taken to the Chemical Lab for an interfacial tension test per ASTM D971-50.

Room Temperature

Upon completion of the spot calibration, the subject hardware will be operated at a fuel inlet temperature of +85°F ±20°F for the cycle shown in Figure 18 a target of 200 hours (160 cycles).

Spot Calibration

After completion of the room temperature test, a spot calibration shall be made per Appendix A-II.

Hot Temperature

After completion of the room temperature test and the spot calibration, remove the clay filter. Reset the maximum fuel temperature safety device for 190°F. Continue cycling per Figure 18 for 100 hours (80 cycles), with a fuel inlet temperature of 157°F ±20°F.

Spot Calibration

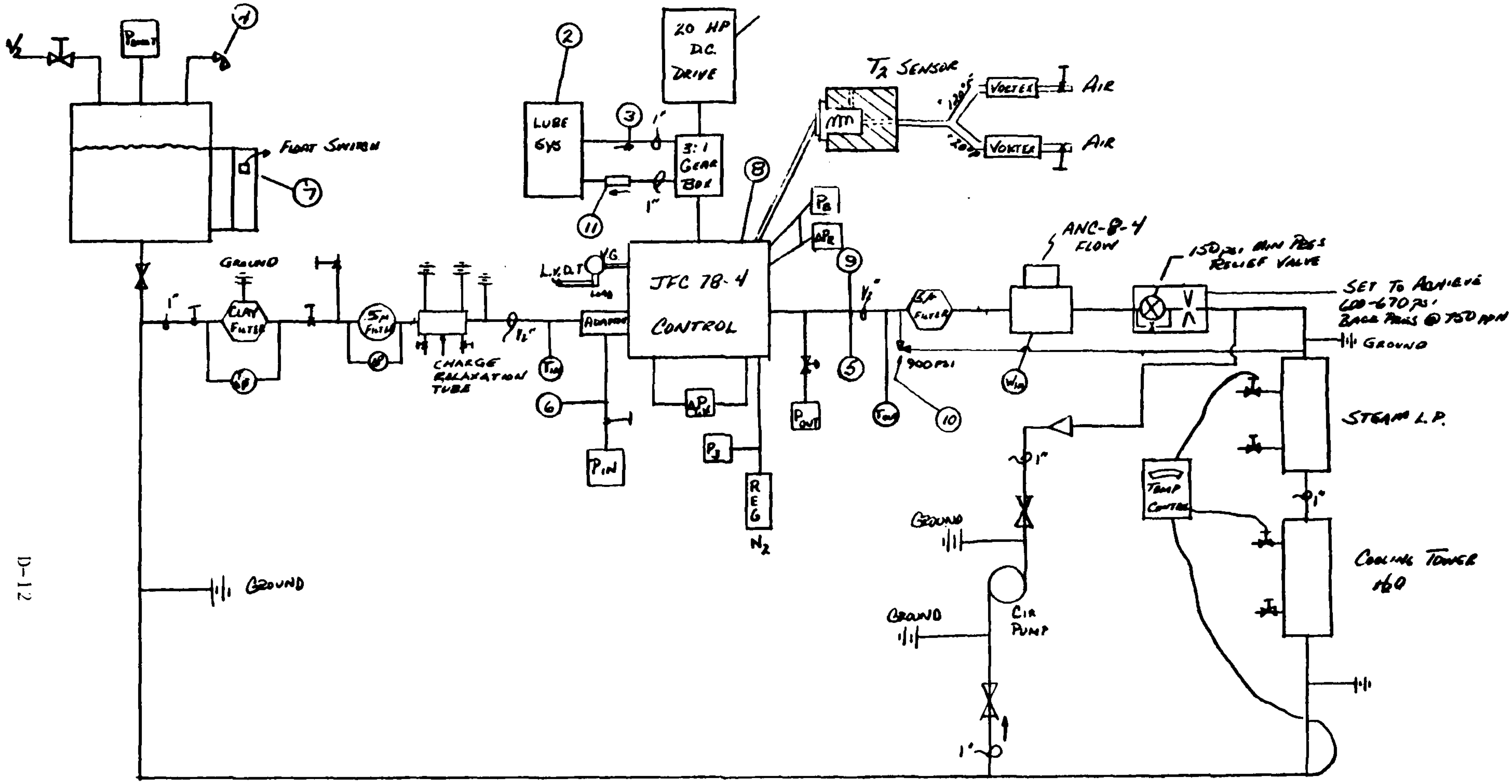
After hot temperature test, a spot calibration per Appendix A-II shall be run.

Post Test Calibration

After completion of the spot calibration, the unit will be taken to a production certified rig to run an "as is" acceptance calibration and definition data per Appendix A-I.

Teardown and Inspection

After analysis of the above data, the control shall be disassembled and examined. Hardware condition shall be inspected and recorded on the experimental inspection report. The throttle valve, VG pilot valve and pump will be flow tested per Appendix A-III.



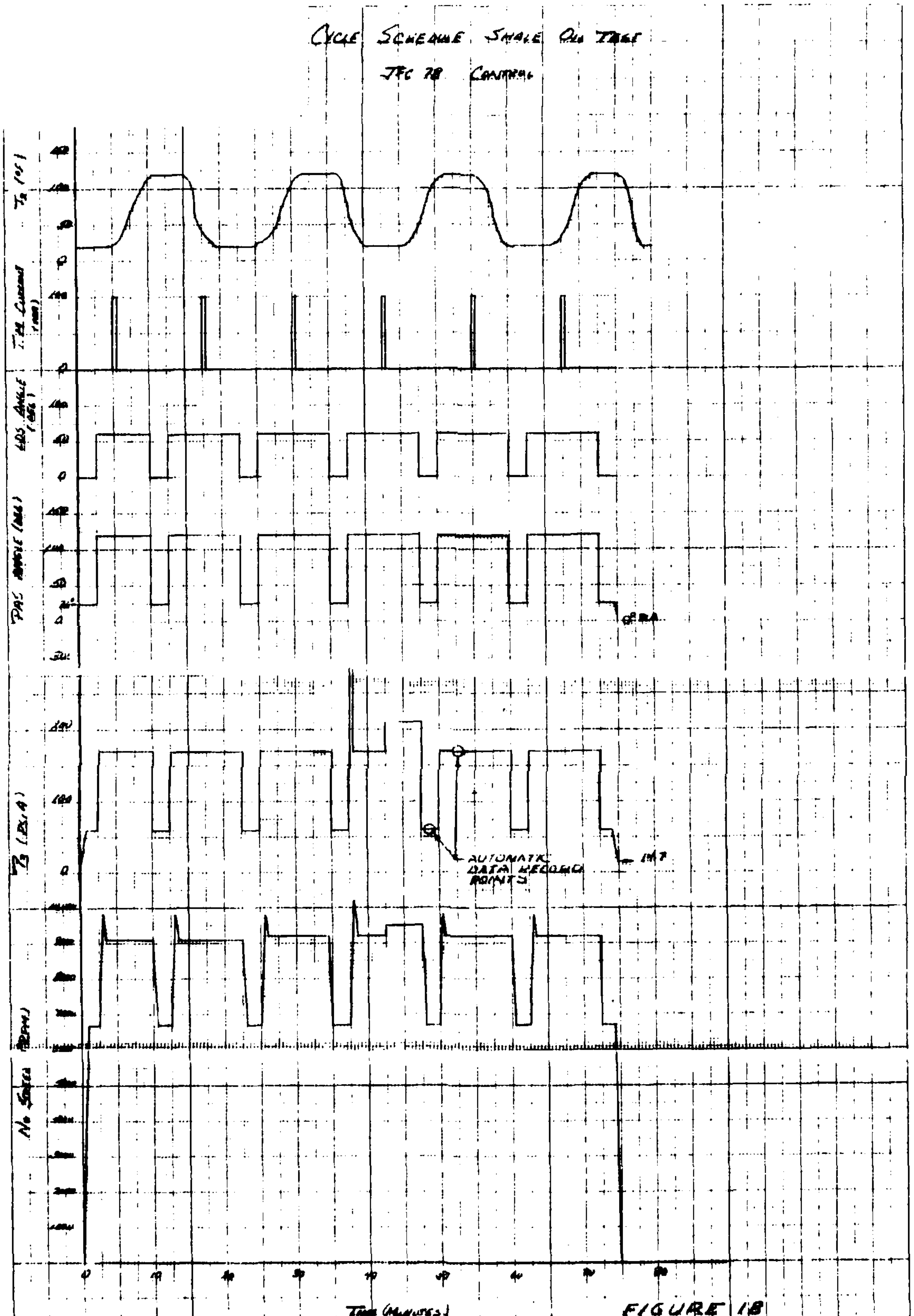
① DC. DRIVE OVERSPEED
② LUBE OIL TEMP
③ LUBE MIN. LUBE PRESS.
④ 50psi RELIEF
⑤ MIN FUEL PRES
⑥ LO BOOST PRES
⑦ FUEL LEVEL (LOW)
⑧ MAX FUEL TEMP
⑨ MAX OUTLET PRES.
⑩ 900 psi RELIEF

ACTUAL PLUMBING SCHEMATIC

H.S. RIG B-3B

⑪ TYGON SIGHT TUBE

FIGURE 2



CYCLE SCHEDULE SHALE OIL TEST
JFC 78 CONTROL
AUTOMATIC DATA RECORDING POINTS
TIME (MINUTES)

FIGURE 18

APPENDIX D-3

PRE & POST TEST DEFINITION DATA

1. ACCEPTANCE CALIBRATION PER HS

2. NG SERVO DISPLACEMENT

Set PAS = 118°, P_3 = 100 psia. T_2 = 60°. Record Ng servo displacement at 500 rpm increments from 1000 to 7000 rpm and 200 rpm increments from 7000 to 10,800 rpm. Run hysteresis in the same increments.

3. MAXIMUM LINE

Set PAS 118°. Ng = 9600 rpm, T_2 = 60° and record Wf, Pr and ΔP at 10 psi increments from 200 to 20 to 200 psia.

4. MINIMUM LINE

Set PAS = 26°, LDS = 0°, Ng = 7600 rpm, T_2 = 60°F and record Wf, Pr and ΔP at 10 psi increments from 200 to 40 to 200 psia.

5. ACCEL LINES (BACK MIL DROOP OUT OF THE WAY)

T_2 = +140°F. Set PAS = 118°, P_3 = 100 psia. Record Wf at speeds of 3000, 3600, 4000, 4500, 5000, 5500, 6000, 6200, 6500, 6700, 7000, 7500, 8000, 8500, 9000, 9400, 9600, 9800, 10,000, 10,200, 10,300, 10,400, 10,500.
T_2 = +60°F, PAS = 118°, P_3 = 100 psia. Record Wf at speeds of 3000, 3500, 4000, 4500, 5000, 5500, 6000, 6500, 7000, 8000, 8500, 9000, 9100, 9200, 9300, 9400, 9500, 9600, 9700, 9800, 9900, 10,000, 10,100, 10,200, 10,300, 10,400, 10,500.
T_2 = 20°F, PAS = 118°, P_3 = 100 psia. Record Wf at speeds of 3000, 3600, 4000, 4500, 4800, 5000, 5200, 5500, 6000, 6500, 6800, 7000, 7200, 7400, 7600, 8000, 8400, 8600, 8800, 9000, 9100, 9200, 9400, 9600, 9800, 10,000.

6. VARIABLE MIN RATIO

Set PAS = 26°, T_2 = 60°, P_3 = 200 psia. Set Ng 10,400, 10,200, 10,000, 9800, 9600, 9400, 9200, 9000 rpm and record Wf.

7. MIN FLOW SPEED

Set PAS = 118°, P_3 = 5 psia. Record fuel flow and T.V. ΔP at 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, and 1700 rpm.

8. MIL DROOP

Set PAS = 117.5, P_3 = 200 psia, LDS = 70°. T_2 = +60°F. Set Ng from 9800 to 10,800 to 9800. Record Wf at 100 rpm increments. T_2 = +60°F. Set Ng from 10,000 to 10, 200 to 10,000 rpm. Record Wf at 20 rpm increments. T_2 = -20°F. Set Ng from 9000 to 10,000, to 9000 rpm. Record Wf at 100 rpm increments. T_2 = +140°F. Set Ng from 9800 to 10,800 to 9800 rpm. Record Wf at 100 rpm increments.

9. IDLE DROOP

Set PAS = 26°F, P_3 = 60 psia. LDS = 0°. T_2 = +60°F. Ng 6000 to 7000 to 6000 rpm in 100 rpm increments. Record Wf. T_2 = +60°F. Ng 6500 to 6700 to 6500 rpm. Record Wf at 20 rpm increments. T_2 = -20°F. Ng 6000 to 6800 to 6000 rpm in 100 rpm increments. Record Wf. T_2 = +140°F. Ng 6200 to 7400 to 6200 rpm in 100 rpm increments. Record Wf.

10. VG STROKE

Set PAS = 118°, P_3 = 150 psia (load to oppose motion). T_2 = +60°F. Set Ng from 7700 to 10,100 to 7700 rpm in 200 rpm increments. Record VG displacement. T_2 = -20°F. Set Ng from 7100 to 9500 to 7100 in 200 rpm increments. Record VG displacement. T_2 = +140°F. Set Ng from 8200 to 10,600 to 8200 in 200 rpm increments. Record VG displacement.

11. VG T_2 HYSTERESIS

Set PAS = 118°F, P_3 = 120 psia, Ng = 8600 rpm. Vary T_2 from -65°F to +160°F to -65°F. Record VG displacement at approximately 20° increments.

12. TOPPING HYSTERESIS

Set PAS = 118°F, P_3 = 200 psia, Ng = 10,200 rpm. Vary T_2 from -65°F to +160°F to -65°F. Record Wf at approximately 20° increments.

13. Np SERVO CALIBRATION

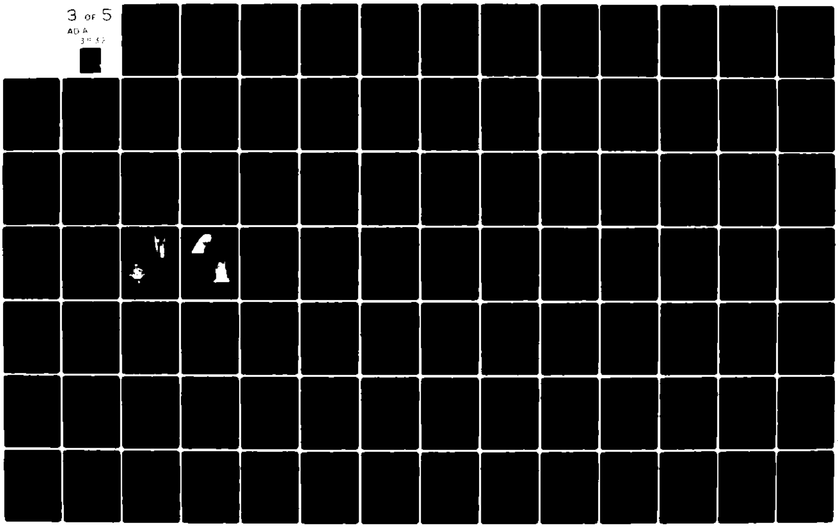
Set Ng = 10,200, PAS = 118°, LDS = 90°, P_3 = 200 psia, T_2 = 60°F.
a) Vary Np piston from end to end with the electrical test box in closed loop position. Record Vr and Wf every 0.005 V/V in the range when fuel flow changes.
b) Repeate "a" at Ng = 9012, PAS - 118°, LDS = 30°, P_3 = 152 psia.

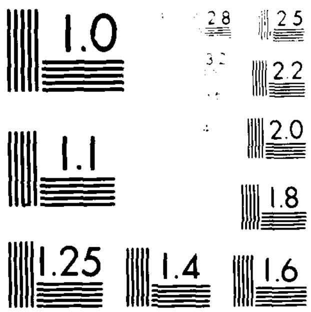
14. MAX UPTRIM

Set PAS = 117.5, P_3 = 200 psia, T_2 = 60°F, LDS = 15.0°. Set Np servo to maximum position. Record Vr. Set speed 9400 to 10,400 to 9400 in 200 rpm increments. Record Wf.

AD-A113 532 SOUTHWEST RESEARCH INST SAN ANTONIO TX ARMY FUELS AN--ETC F/G 15/F
DEVELOPMENT OF ACCELERATED FUEL-ENGINES QUALIFICATION PROCEDURE--F
DEC 81 J A RUSSELL, J P CUELLAR, J C TYLER DAAK70-80-C-0001
UNCLASSIFIED AFLRL-144-VOL-2 NL

3 OF 5
AD A
113532




1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

15. MAX DOWN TRIM

Set PAS = 117.5°, LDS = 50.0°, P_3 = 70 psia, T_2 = 60°F. Set Np servo to minimum position. Record Vr. Set speed from 6500 to 7900 to 6500 rpm in 200 rpm increments. Record Wf.

16. Np SERVO NULL POINT

Set PAS = 117.5°, P_3 = 152 psia, T_2 = 60°F, LDS = 90°, Speed = 9012 rpm. With test box set in closed loop, adjust LVDT voltage ratio adjustment to obtain Wf = 380 ±2 pph. Record Wf, T.M. current and voltage ratio.

APPENDIX D-4

SPOT CALIBRATION

1. MINIMUM FLOW SPEED

   Set PAS = 118^{o}, P_3 = 5 psia. Record fuel flow and T.V. ΔP at 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600 and 1700 rpm.

2. MAXIMUM RATIO

   Set PAS = 118^{o}, LDS = 90^{o}, Ng = 9600 rpm, T_2 = $+120^{o}F$. Record Wf and ΔP at 20 psi increments 20 to 200 to 20 psia.

3. MINIMUM RATIO

   Set PAS = 25^{o}, LDS = 0^{o}, T_2 = $+120^{o}F$, Ng = 7600 rpm. Record Wf and ΔP at 20 psi increments 200 to 40 to 200 psia.

4. VG

   Set PAS = 118^{o}, LDS = 90^{o}, T_2 = $+120^{o}F$, P_3 = 150 psia. Record Vg position at 7700, 8000, 8300, 8600, 9000, 9400, 9700, 10,000 rpm.

5. MAXIMUM DROOP

   Set PAS = 118^{o}, LDS = 90^{o}, T_2 = $120^{o}F$, P_3 = 200 psia. Record Wf and ΔP at 10,000, 10,200, 10,400, 10,600 rpm.

6. IDLE DROOP

   Set PAS = 26^{o}, LDS = 0^{o}, T_2 = $+120^{o}F$, P_3 = 60 psia. Record Wf and ΔP at 6200, 6400, 6600, 6800, 7000 rpm.

APPENDIX D-5

FLOW TEST

1.	Throttle Valve	Flow test per Note 17 of drawing 763617.
2.	Vg Pilot Valve	Flow test per Note 12 of drawing 737890.
3.	Pump Calibration	New Vickers pump S/N MX-329517 with test data from Vickers test record 7419. Pump will be returned to Vickers to run the above test data from Vickers test record 7419 after the 500 hours test.

APPENDIX D-6

TABLE I

FUEL CHARACTERISTICS

PROPERTY		STANDARD	TEST FLUID
	SAMPLE NO.	MIL-T-5624L	AL-10596-SP-T
	FUEL TYPE	GRADE JP-4	JP-4
	SOURCE	MIL SPEC	PARAHO/PETR
Distillation,			
°C(°F)		D86	D86
10%, max		----	99(211)
20%, max		145(293)	121(249)
50%, max		190(374)	175(347)
90%, max		245(473)	220(428)
EP, max		270(518)	243(470)
Residue, vol%, max		1.5	1.0
Loss,vol%,max		1.5	0
Vapor Pressure			
100°F, kPa		14-21	17.5
Freezing Point,			
°C(°F) max		-58(-72)	<-60
Water Reaction			
interface rating, max		1b	1
Water Separation Index,		85	100
mofified, min			
TAN,mg KOH/g, max		0.015	0.01
Aromatics,			
vol%, max		25.0	21.9
Olefins,			
vol%, max		5.0	0.4
Mercaptan Sulfur,			
wt%, max		0.001	0.000
Doctor Test		----	Positive, "Sour"
Sulfur,			
wt%, max		0.40	.004
Nitrogen, ppm		----	2
Copper strip Corr.			
2 hr @212°F, max		1b	2b
Density,			
kg/l, min (15°C)		0.751	0.7849
Density,			
kg/l, max (15°C)		0.802	0.7849

HAMILTON STANDARD TEST FUEL (CONT'D)

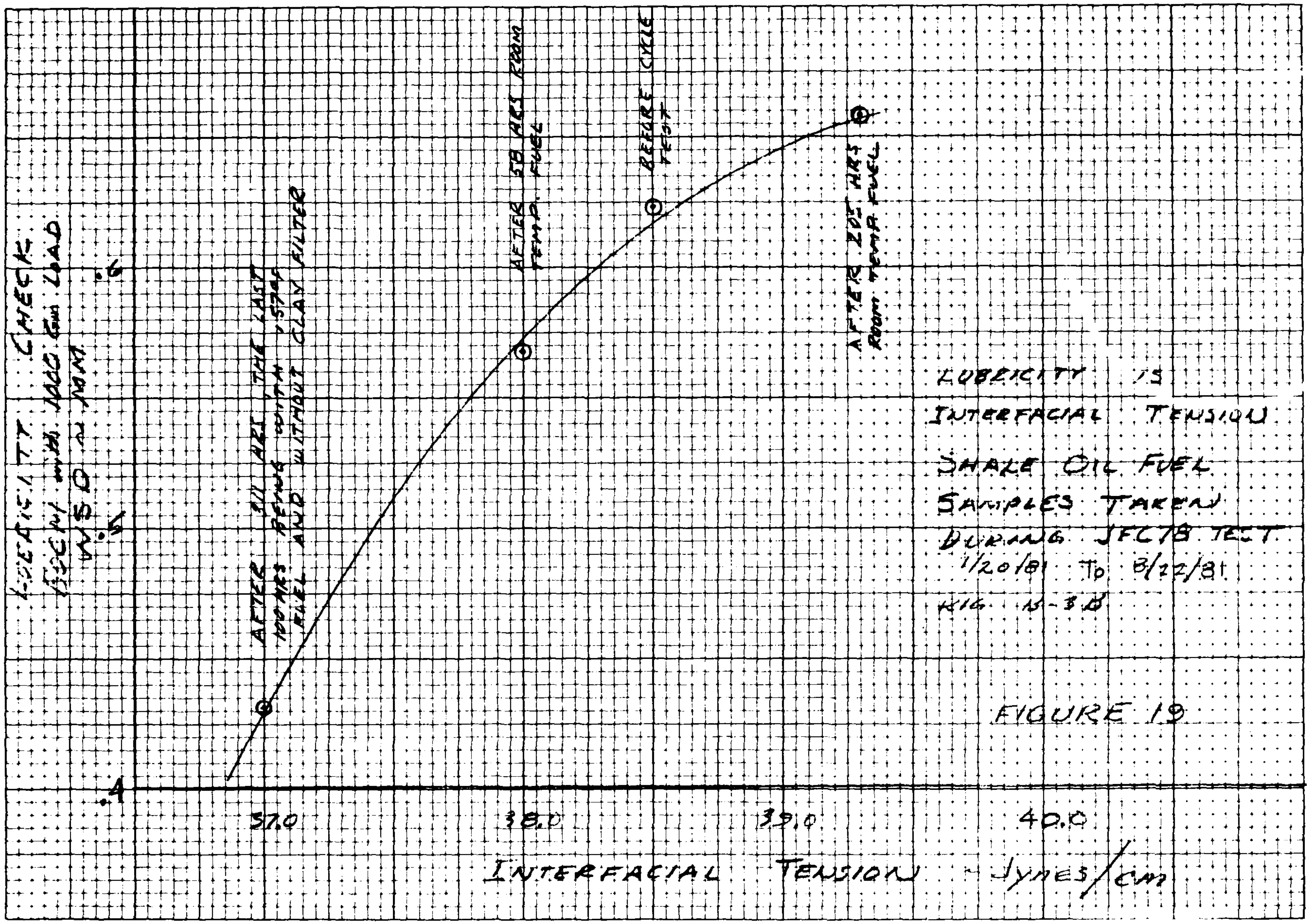
API Gravity, max (15°C)	57.0	48.7
API Gravity, min (15°C)	45.0	48.7
Thermal Stability (JFTOT)		
P, mm Hg, max	25	0
deposit code, max	3	1
Existent Gum, mg/dl, max	7.0	1.5
Particulate Matter, mg/l, max	1.0	0.1
Filtration Time, minutes, max	15	N/A
Aniline Point, °C	----	44.8
Heating Value		
Aniline-Gravity, min	5250	5503
LHV, MG/kg, min	42.8	44.4
LHV, Btu/lb, min	18400	19100
Hydrogen Content wt%, min	13.6	13.6
or Smoke Point, mm, min	20.0	N/A
Fuel System Icing Inhibitor, vol%	0.10-0.15	N/A
Fuel Electrical Conductivity, pS/m	200-600	0
Viscosity, cSt		
40 °C	----	0.84
-20 °C	----	2.05
Saybolt Color	----	+28

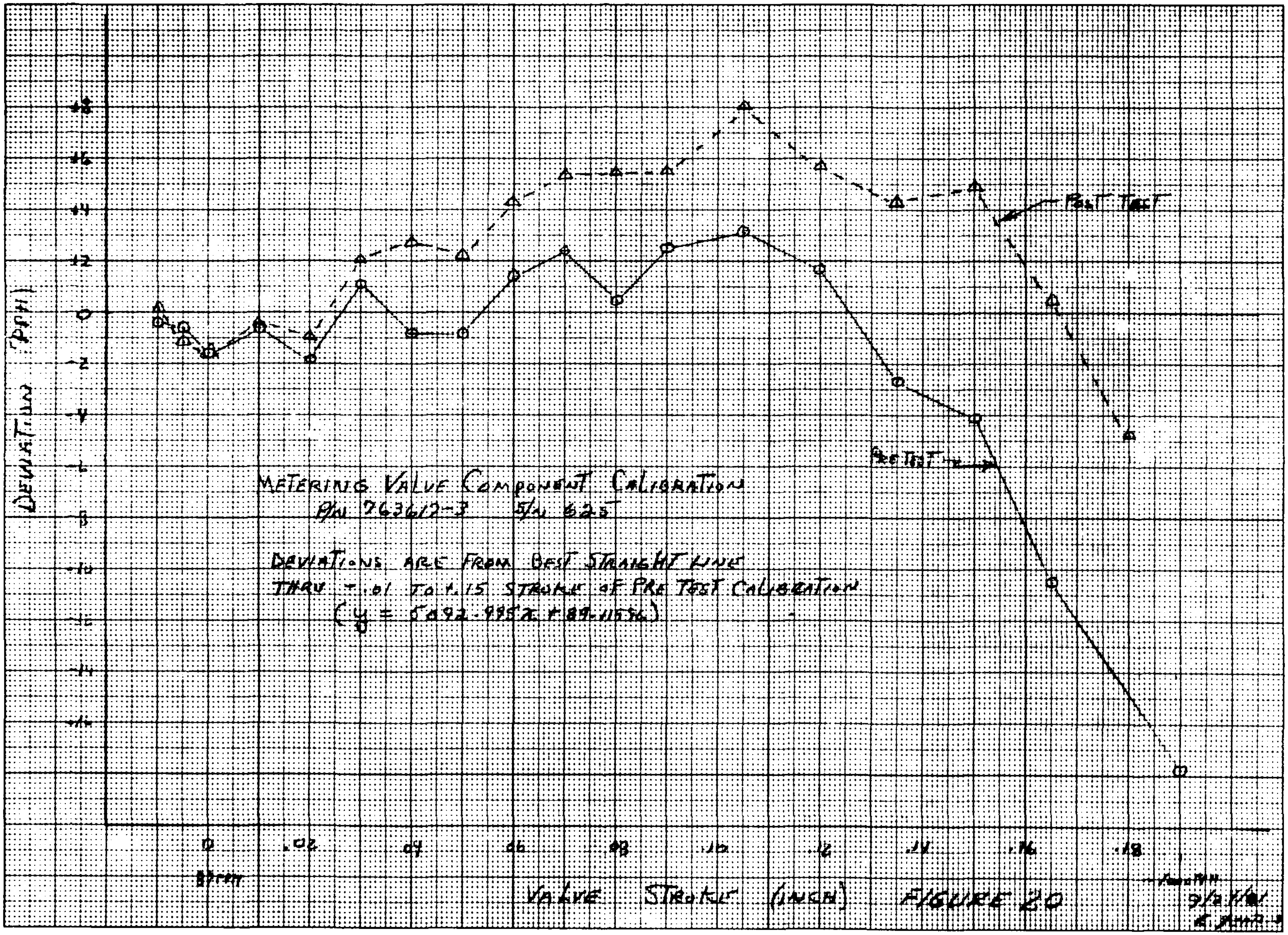
TABLE 2

LUBRICITY AND INTERFACIAL TENSION

- Ball on cylinder method (BOCM) using a 1000 gram load was used to check lubricity
- Interfacial tension tests were run per ASTM D971-50

TEST TIME	WSD ~ mm	INTERFACIAL TENSION TEST RESULTS ~ DYNES/cm
After approx. 10 hours of control calibration and rig check out. Prior to initiation of cycle test.	.624	38.5
After 58 hours of cycling with room temperature fuel	.569	38.0
After 205 hours of cycling with room temperature fuel	.659	39.3
After 106 hours of cyclic testing with hot fuel ($157^{o} \pm 20^{o}F$)	.431	37.0


LUBRICITY CHECK
BOCM with 1000 Gm LOAD
WSD ~ MM
.6
.5
.4
AFTER 311 HRS THE LAST 100 HRS BEING WITH 1574 FUEL AND WITHOUT CLAY FILTER
AFTER 58 HRS ROOM TEMP. FUEL
BEFORE CYCLE TEST
AFTER 201 HRS ROOM TEMP FUEL
LUBRICITY VS INTERFACIAL TENSION
SHALE OIL FUEL
SAMPLES TAKEN DURING JFCTB TEST
1/20/81 TO 8/22/81
RIG 15-3B
FIGURE 19
37.0
38.0
39.0
40.0
INTERFACIAL TENSION ~ Dynes/cm


METERING VALVE COMPONENT CALIBRATION
P/N 763612-3 S/N 625
DEVIATIONS ARE FROM BEST STRAIGHT LINE
THRU +.01 TO +.15 STROKE OF PRE TEST CALIBRATION
(y = 5092.995x + 89.1156)
POST TEST
PRE TEST
DEVIATION (PPH)
+8
+6
+4
+2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
VALVE STROKE (INCH)
FIGURE 20

Pump Component Calibration

P/N 751056-7 S/N MX 329517

	Limits	1/26/79 Pre Test	9/18/81 Post Test
Flow at 9947 RPM 700 PSID	6.40 GPM Min	6.88 GPM	6.65 GPM
Flow at 9947 RPM 100 PSID	7.43 GPM Max	7.13 GPM	7.01 GPM
Flow at 1291 RPM 250 PSID	.63 GPM Min	*.825 GPM	.627 GPM
Leakage at 10,400 RPM 700 PSIG	5 Drops/10 Min Max	None	None

* *This data point appears to be in error.* Typical values for flow at at 1290 RPM vary from 0.63 to 0.70 GPM.

FIGURE 21

Vg Pilot Valve Component Calibration

P/N 737890-5

	Pre Test	Post Test
Valve Gain	71.25 PPH/.001 Inch	71.25 PPH/.001 Inch
Valve Lap	.00095 Overlap	.00085 Overlap
Null Leakage	80.7 PPH	90 PPH

FIGURE 22

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL UNIT CALIBRATION 93747

TEST POINT	NG RPM	P3 PSIA	T2 ^{o}F	PAS DEG	LDS DEG	NEW PART Wf LIMITS	PRE TEST	POST TEST	NEW PART Vg LIMITS	PRE TEST	POST TEST
	Minimum Flow										
2	1290	15				57.5 - 62.5	60.4	59.7			
	Start and Idle Droop 60^{o}F T2										
4	3000	19	60	26	0	61 - 67	63.5	64.5			
5	4000	25				80 - 86	82	83.5			
6	5000	34				115 - 126	117.5	120			
7	5800	45				162 - 178	170	171			
8	6500	60				+23 to +33 of 9	+29	+29.5			
9	6700	60				135 - 145	142	137.5			
10	6900	60				-23 to -33 of 9	-29	-28.5			
11	6700	60	60	26		135 - 145	140	137			
	Acceleration Schedule 60^{o}F T2										
12	6700	62	60	117.5	70	220 - 236	225	230			

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL UNIT CALIBRATION (cont.) S/N 93747

TEST POINT	NG RPM	P3 PSIA	T2 ^{o}F	PAS DEG	LDS DEG	NEW PART Wf LIMITS	PRE TEST	POST TEST	NEW PART Vg LIMITS	PRE TEST	POST TEST
Minimum Ratio											
13	7600	50	60	26	0	69 - 76	71.5	73.5			
14	7600	100				141 - 149	145	148			
15	7600	150				211 - 224	219	222			
16	7600	200	60	26	0	283 - 297	293	295			
Variable Min Ratio											
17	9600	150	60	26	0	225 - 261	257	255			
18	10146	204	60	26	0	411 - 444	438	438			
Acceleration and V.G. Schedule 60^{o}F T2											
19	8000	100	60	117.5	70	333 - 351	344	(352)	.155 - .235	.197	.220
20	8800	152				540 - 566	553	564	.836 - .886	.867	.870
21	9300	200				717 - 757	724	730	1.253 - 1.303	1.274	1.280
22	9600	25				86 - 96	91	88			
23	9600	50				176 - 189	185	181			
24	9600	100				352 - 374	368	370			
25	9600	150				529 - 559	554	549			

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL UNIT CALIBRATION (cont.) S/N 93747

TEST POINT	NG RPM	P3 PSIA	T2 °F	PAS DEG	LDS DEG	NEW PART Wf LIMITS	PRE TEST	POST TEST	NEW PART Vg LIMITS	PRE TEST	POST TEST
	Acceleration and V.G. Schedule 60°F T2 (cont.)										
26	9600	200	60	117.5	70	696 - 749	720	722	1.487 - 1.567	1.519	1.522
27	9600	270				770 - 800	791	797			
28	9600	100				352 - 374	365	369			
29	9900	200	60	117.5	70	685 - 730	702	707	1.686 - 1.714	1.701	1.703
	Max Droop Schedule at 60°F T2										
30	10150	200	60	117.5	70	+20 to +30 of 31	+22	+20			
31	10200	200				578 - 621	613	590			
32	10250	200				-20 to -30 of 31	-21	-23			
33	10200	200	60	117.5	70	578 - 621	613	591			
	V.G. Hysteresis										
34	8800	152	60	117.5	70				±.020 of 20	± .010	*
	Idle Repeatability										
35	6620	60	60	26	0	135 - 145	140	137			

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL UNIT CALIBRATION (cont.) S/N 93747

TEST POINT	NG RPM	P3 PSIA	T2 °F	PAS DEG	LDS DEG	NEW PART Wf LIMITS	PRE TEST	POST TEST	NEW PART Vg LIMITS	PRE TEST	POST TEST
	Start and Idle Droop at -20°F T2										
36	4000	26	-20	26	0	87 - 93	(85)	89			
37	5000	40				139 - 151	139	143			
38	5800	54				182 - 196	185	187.5			
39	6463	63				129 - 147	135	132			
40	6563	63	-20	26	0	-20 to -28 of 39	-26	-26			
	Acceleration Schedule at -20°F T2										
41	6563	70	-20	117.5	70	220 - 237	225	230			
42	7261	90				273 - 291	281	284	.035 - .164	.150	.154
43	8094	152				493 - 519	503	513	.812 - .908	.896	.906
44	8800	210				719 - 765	720	737	1.430 - 1.570	1.536	1.547
45	9300	220				612 - 680	643	642	1.686 - 1.714	1.701	1.703
46	9400	220	-20	117.5	70	-44 to -65 of 45	-50	-50			
	Start and Idle Droop at +140°F T2										
47	4000	23	+140	26	0	73 - 81	75	73.5			
48	5000	30				105 - 113	107	107			

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL UNIT CALIBRATION (cont.) S/N 93747

TEST POINT	NG RPM	P3 PSIA	T2 °F	PAS DEG	LDS DEG	NEW PART Wf LIMITS	PRE TEST	POST TEST	NEW PART Vg LIMITS	PRE TEST	POST TEST
49	5800	38	+140	26	0	146 - 156	144	149			
50	6809	50				119 - 136	127	127			
51	7009	50	+140	26	0	-15 to -23 of 50	-20	-22			
	Acceleration Schedule at +140°F T2										
52	7107	60	+140	117.5	70	234 - 246	236	240			
53	8800	105				377 - 401	391	397	.297 - .413	.381	(.415)
54	9452	140				483 - 511	500	505	.812 - .908	.886	(.927)
55	9850	170				571 - 603	586	592			
56	10145	200				601 - 663	640	638	1.339 - 1.455	1.425	(1.467)
57	10245	200	+140	117.5	70	-40 to -60 of 56	-45	-45			
	LDS Schedule - Lower Range										
58	7749	76	+60	117.5	-10	-247 to -193 of 61	-211	-214			
59	7966	93			0	-197 to -153 of 61	-170	-165			
60	8515	121			15	-123 to -83 of 61	-96	-98			
61	9012	152	+60	117.5	30	268 - 390	380	381			

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL UNIT CALIBRATION (cont.) S/N 93747

TEST POINT	NG RPM	P3 PSIA	T2 °F	PAS DEG	LDS DEG	NEW PART Wf LIMITS	PRE TEST	POST TEST	NEW PART Vg LIMITS	PRE TEST	POST TEST
	LDS Schedule - Lower Range (cont.)										
62	9529	192	60	117.5	50	+160 to +206 of 61	+187	+166			
63	9828	216			60	+268 to +340 of 61	+291	(+261)			
64	9012	152	60	117.5	30	370 - 390	+378	+375			
	LDS Schedule - Upper Range										
65	9058	152	60	117.5	60	384 - 388	386	385			
66	9435	185			70	+79 to +131 of 65	+96	+88			
67	9845	228	60	117.5	80	+132 to +201 of 65	+144	+132			

Np Servo Reset Schedule - Uptrim

TEST POINT	P3 PSIA	T2 °F	PAS DEG	LDS DEG	ACCEPTANCE Wf LIMITS	ACCEPTANCE RPM LIMITS	PRE TEST	POST TEST
68	200	60	117.5	15	595 - 605	9443 - 9887	9566	9559
	Np Servo Reset Schedule - Downstream							
69	70	60	117.5	50	172 - 178	7472 max	7190	6917

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL TEST CALIBRATION (cont.) S/N 93747

TEST POINT				
	High Pressure Relief Valve			
70	POUT New Part Limits	PRE TEST	POST TEST	
	880 - 905	905	(907)	
	Np Servo Hysteresis			
	Torque Motor Current - New Part Limits	PRE TEST	POST TEST	
71	10 M.A. Max	8.3	5.4	
	Ng Overspeed Shutoff RPM New Parts Limits	PRE TEST	POST TEST	
72	10,800 - 11,090	10,968	10,952	

TEST POINT	PAS TORQUE (IN. LBS)			
	PAS RANGE	NEW PART LIMITS	PRE TEST	POST TEST
73	0 to 23.5 Degrees	25 Max. - 0 Min.	9	7.2
74	23.5 to 120 Degrees	15 Max. - 0 Min.	5	5.7
75	120 to 130 Degrees	25 Max. - 0 Min.	6	15.7
	LDS TORQUE			
	LDS RANGE	NEW PART LIMITS	PRE TEST	POST TEST
76	-10° to 80° to -10°	15 Max. - 0 Min.	6	5

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL UNIT CALIBRATION (cont.) S/N 93747

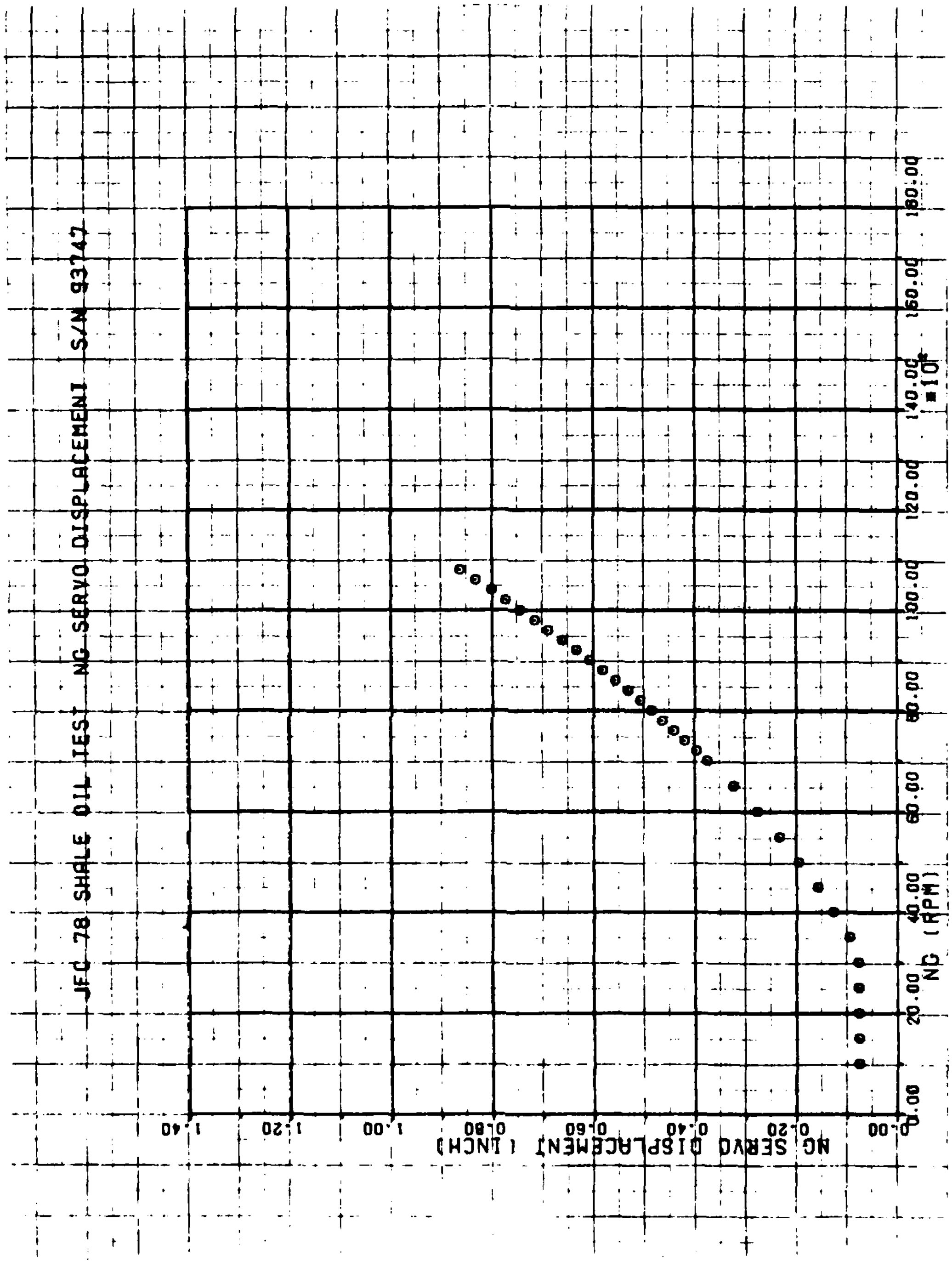
TEST POINT				
	EXTERNAL LEAKAGE			
	NEW PART LIMITS Wf		PRE TEST	POST TEST
77	External	0	0	0
78	Overboard Drain	7.55 cc/5 min.	0	0
	INSULATION RESISTANCE			
	NEW PART LIMIT		PRE TEST	POST TEST
79	10 Megohm Min.		*	1000 +
	ELECTRICAL CONTINUITY			
	NEW PART LIMIT		PRE TEST	POST TEST
80	No Shorts		OK	OK
	TORQUE MOTOR LOCKOUT			
	PAS RANGE	NEW PART LIMIT	PRE TEST	POST TEST
81	127° to 41°	Locked out No Wf	0	0
82	28.5° to 117.5°	T.M. Functioning OK	OK	OK

TABLE 3

SUMMARY OF PRE AND POST SHALE OIL TEST CALIBRATION (cont.) S/N 93747

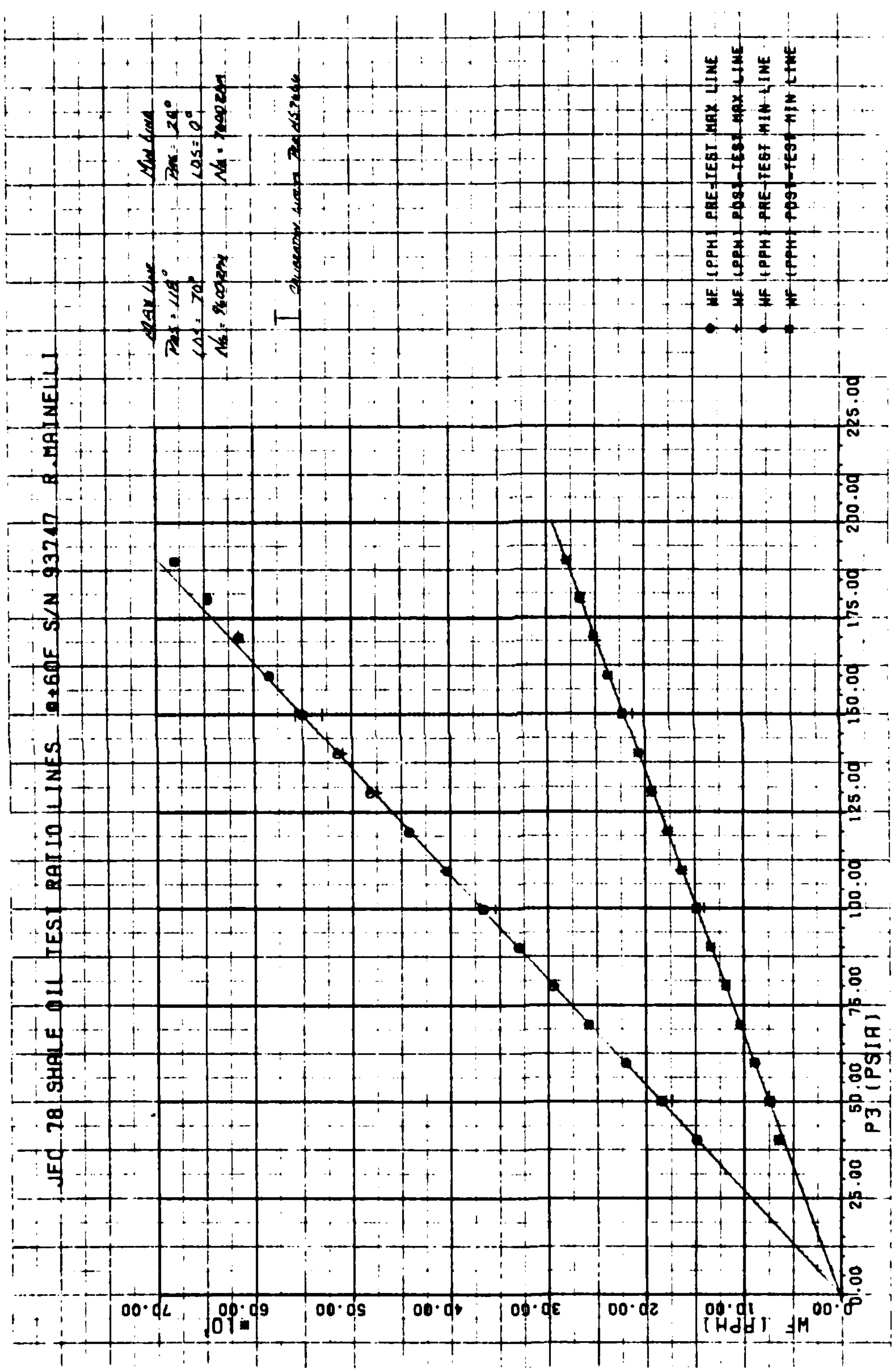
TEST POINT	SHUTOFF FUNCTION AND VAPOR VENT	PRE TEST	POST TEST
	New Part Limits		
83	Control Shutoff 5^{o} PAS Minimum	14.7	15.0
84	Flow when Shutoff 1 cc/min	0	0
85	Control out of Shutoff 5^{o} PAS Minimum	15.1	15.5
86	Control Flow at 26^{o} PAS 135 - 145	142	147
87	PAS for Vapor Vent 125^{o} - 127^{o}	126.9	127.3

* These points not run.



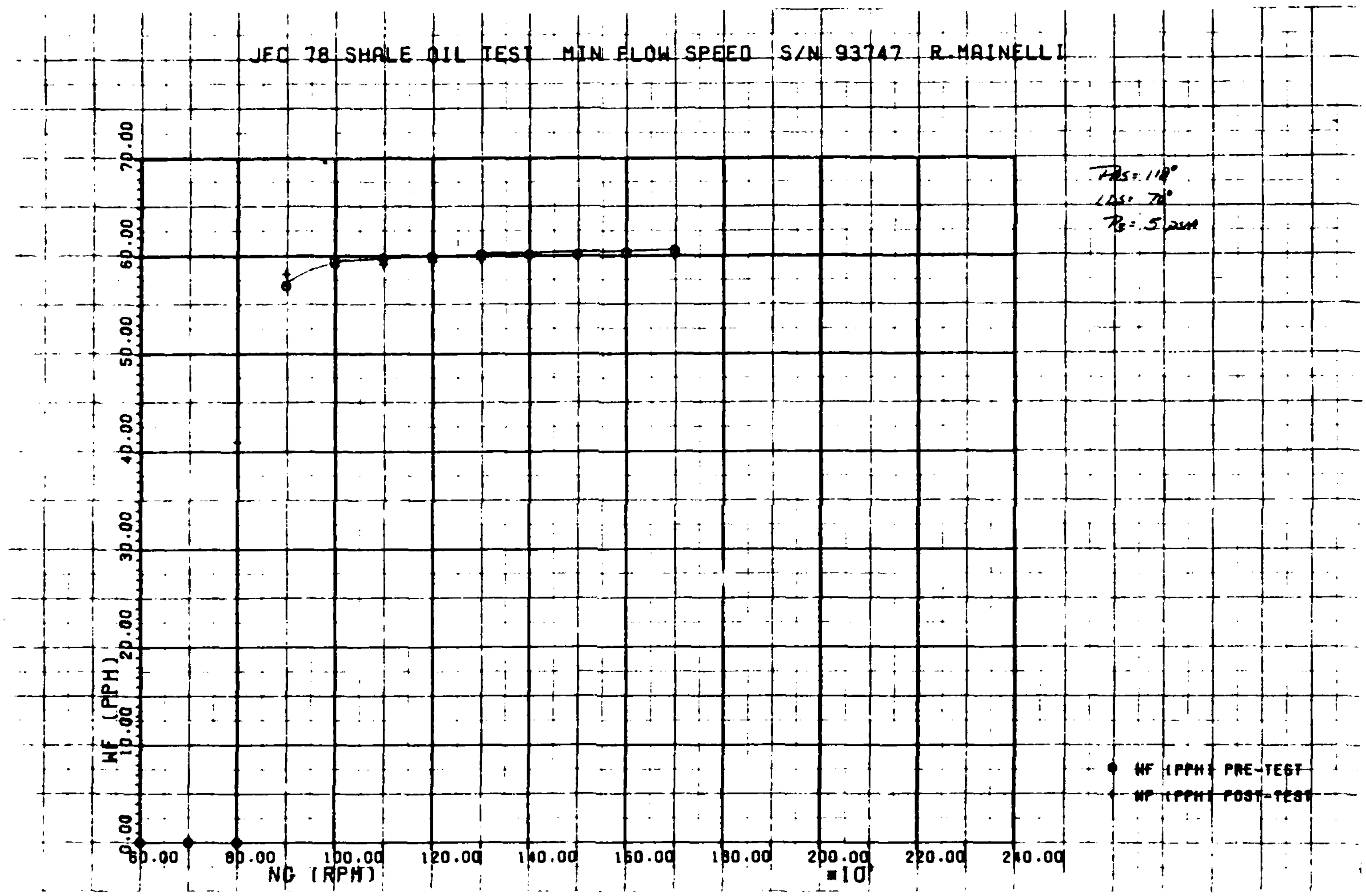
SPEED SERVO CALIBRATION

FIGURE 23



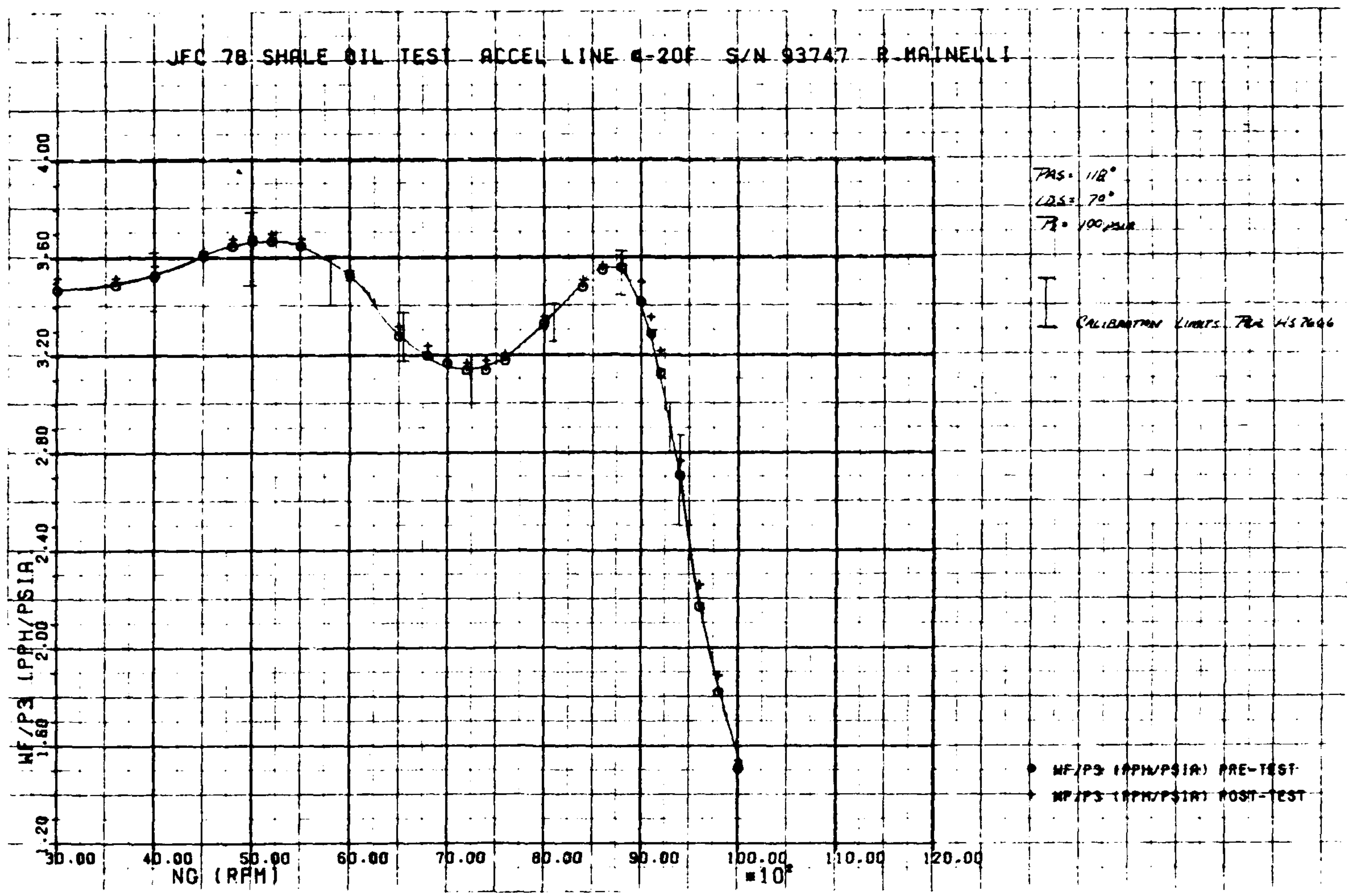
Wf VS P3 RATIO LINES

FIGURE 24



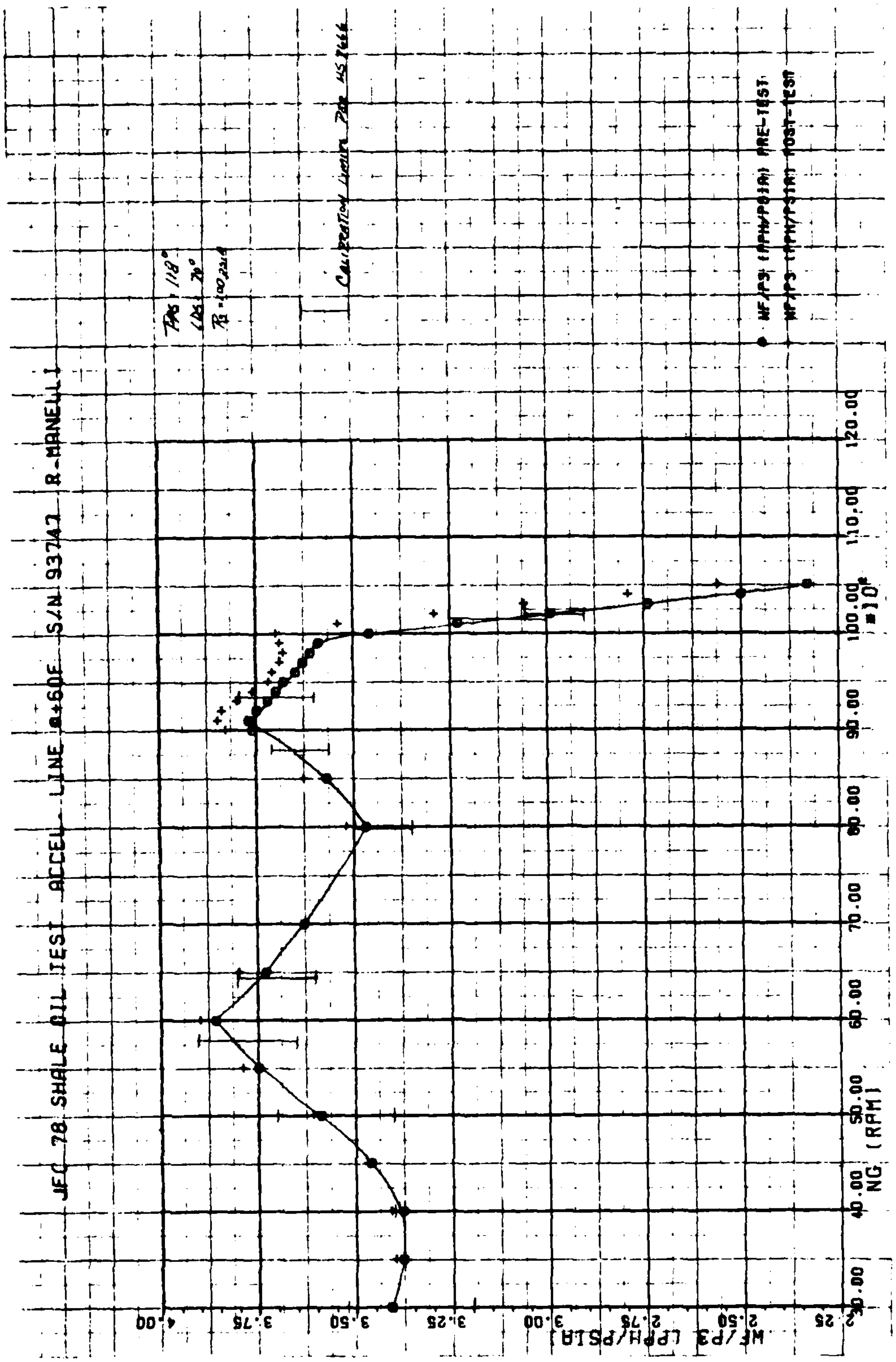
PUMP SPEED TO PRODUCE MIN FLOW

FIGURE 25



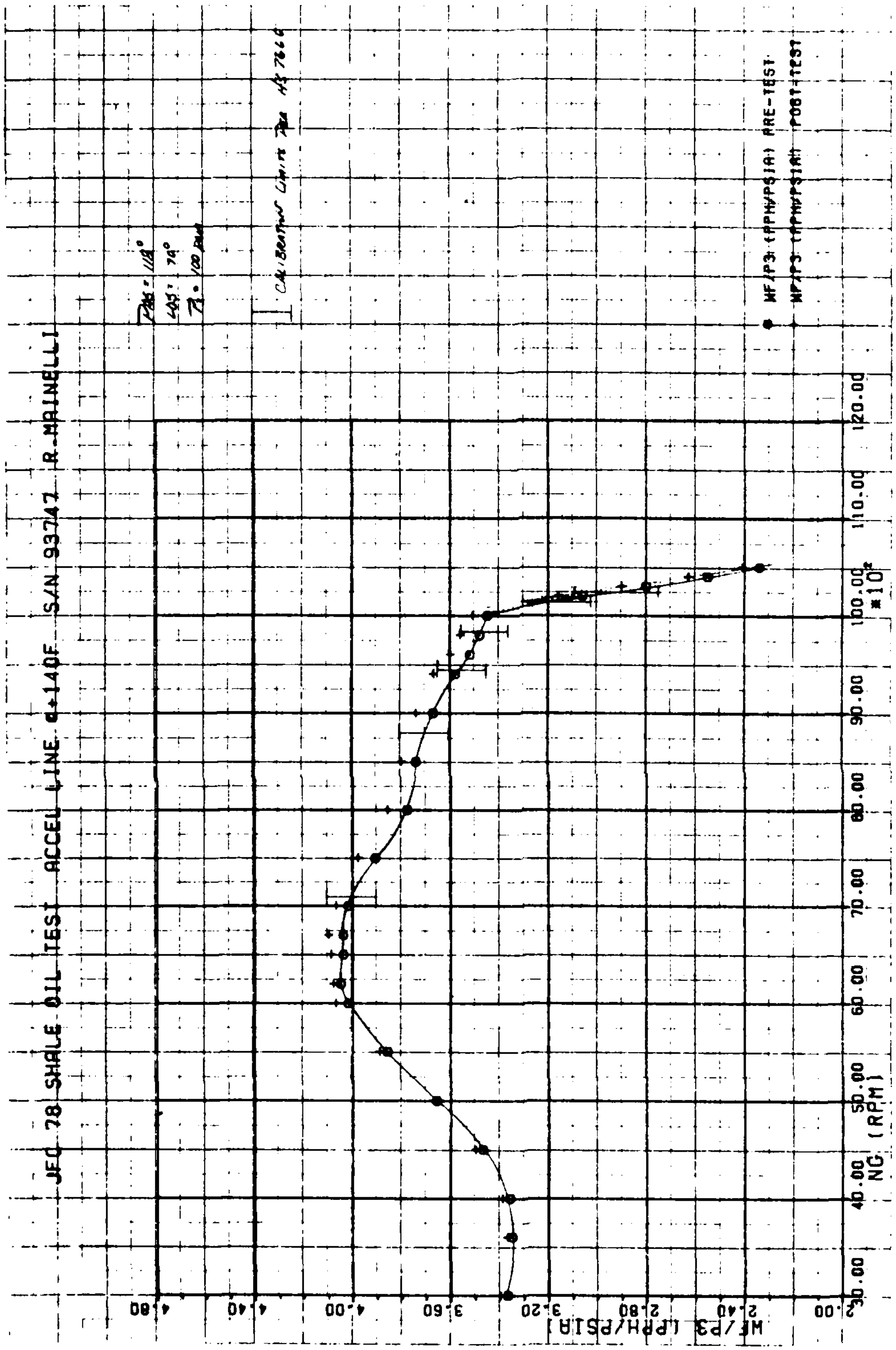
ACCELERATION SCHEDULE 9-20°F)

FIGURE 26



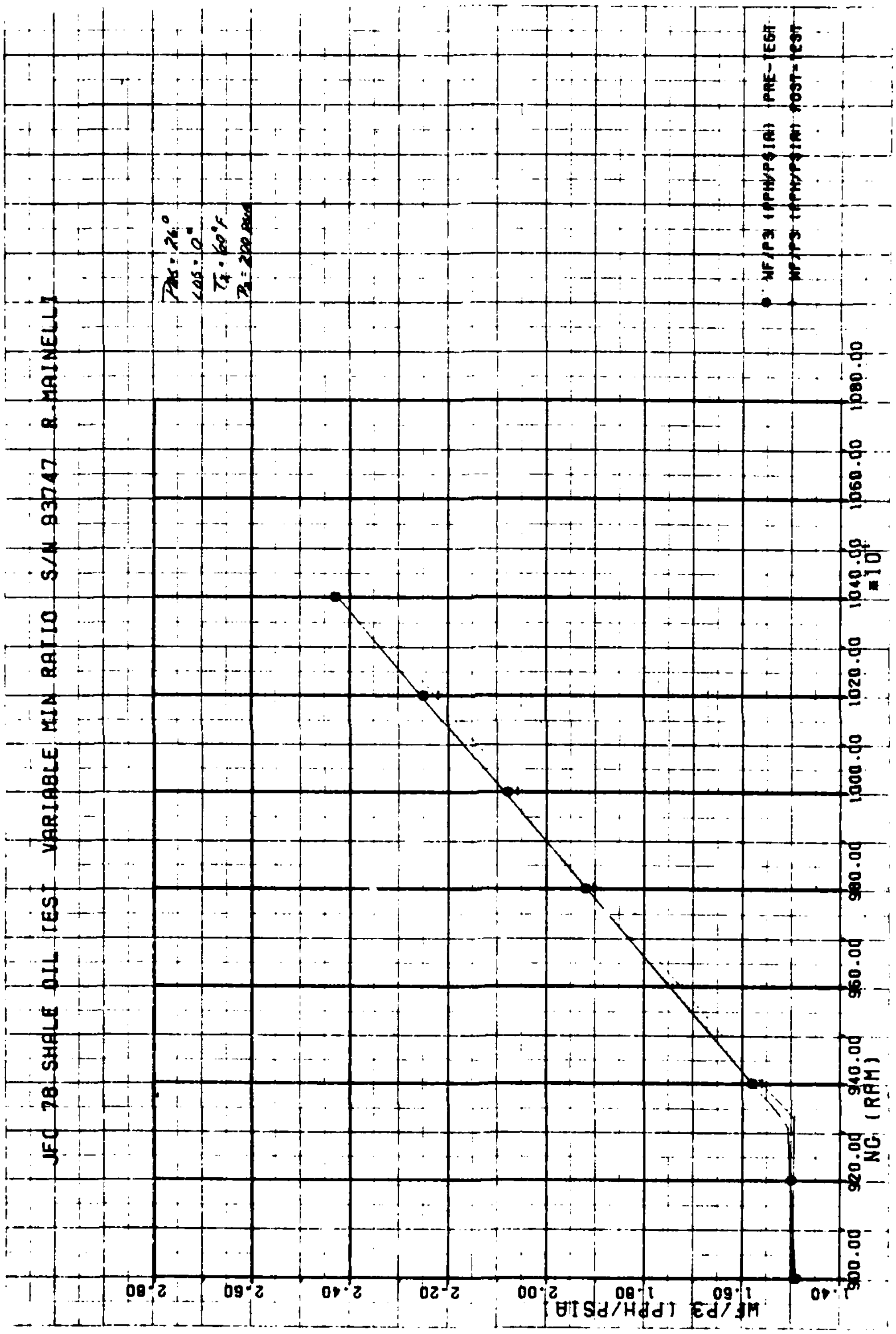
ACCELERATION SCHEDULE ($60^{\circ}F$)

FIGURE 27



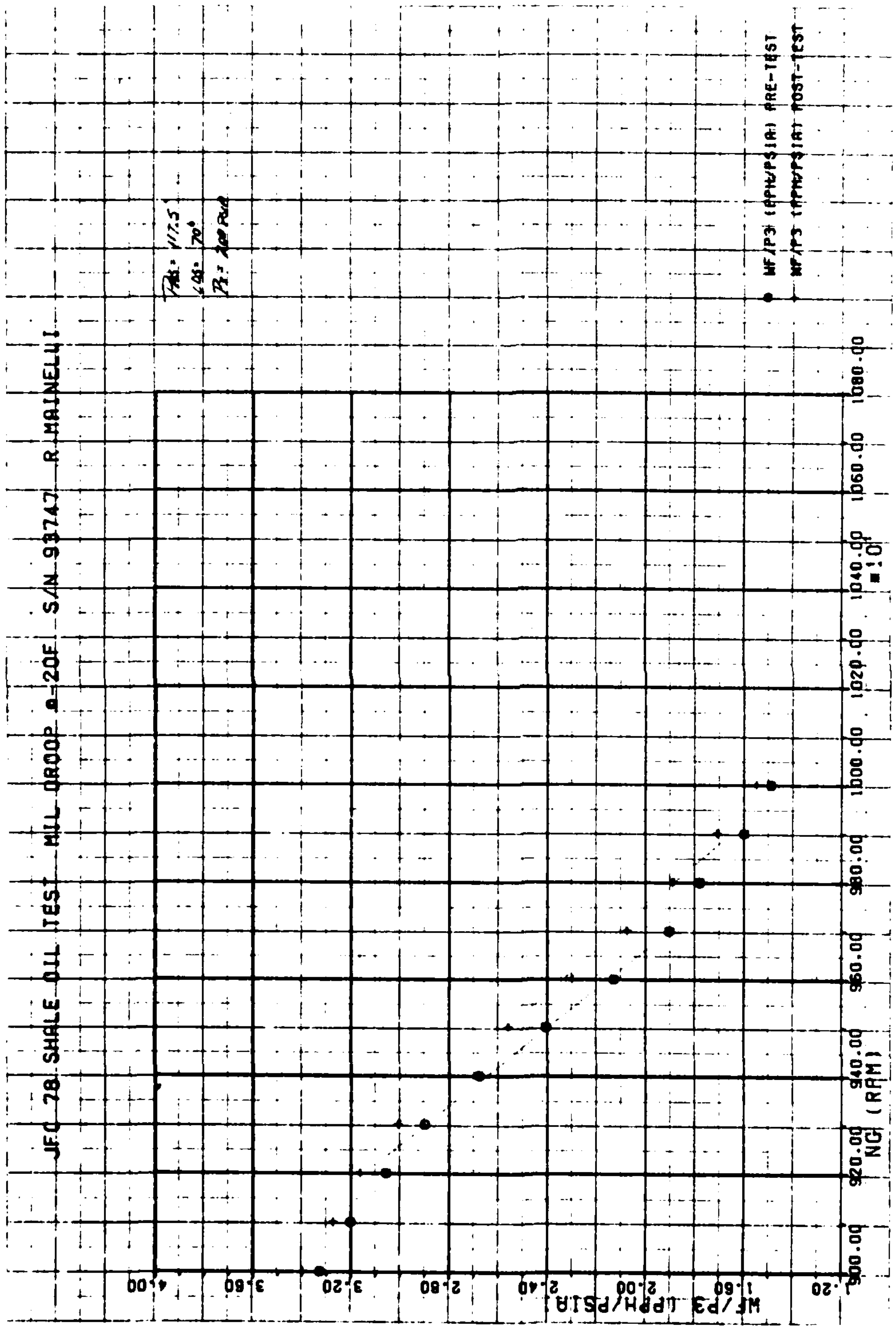
ACCELERATION SCHEDULE (140°F)

FIGURE 28



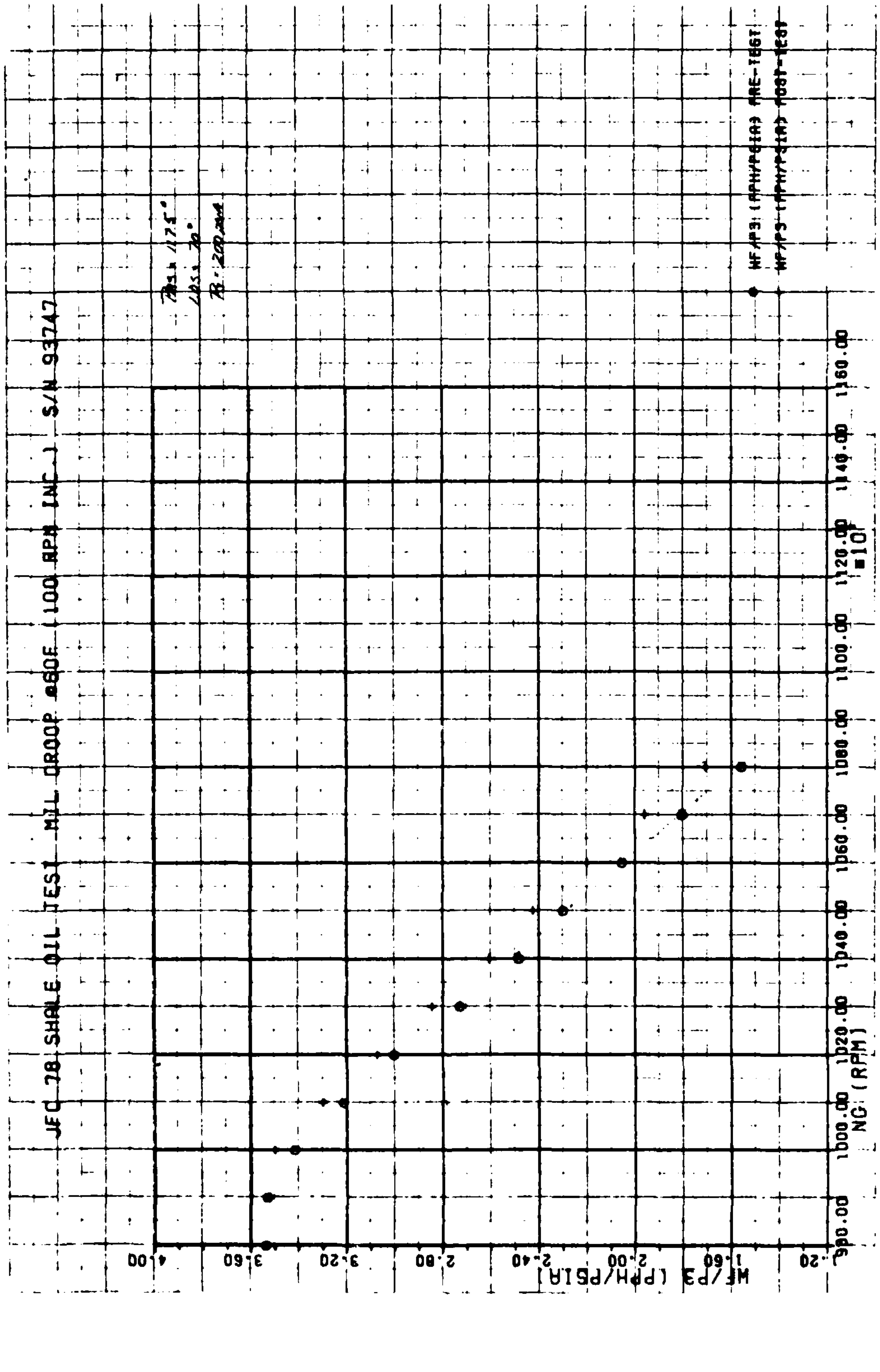
VARIABLE MIN RATIO

FIGURE 29



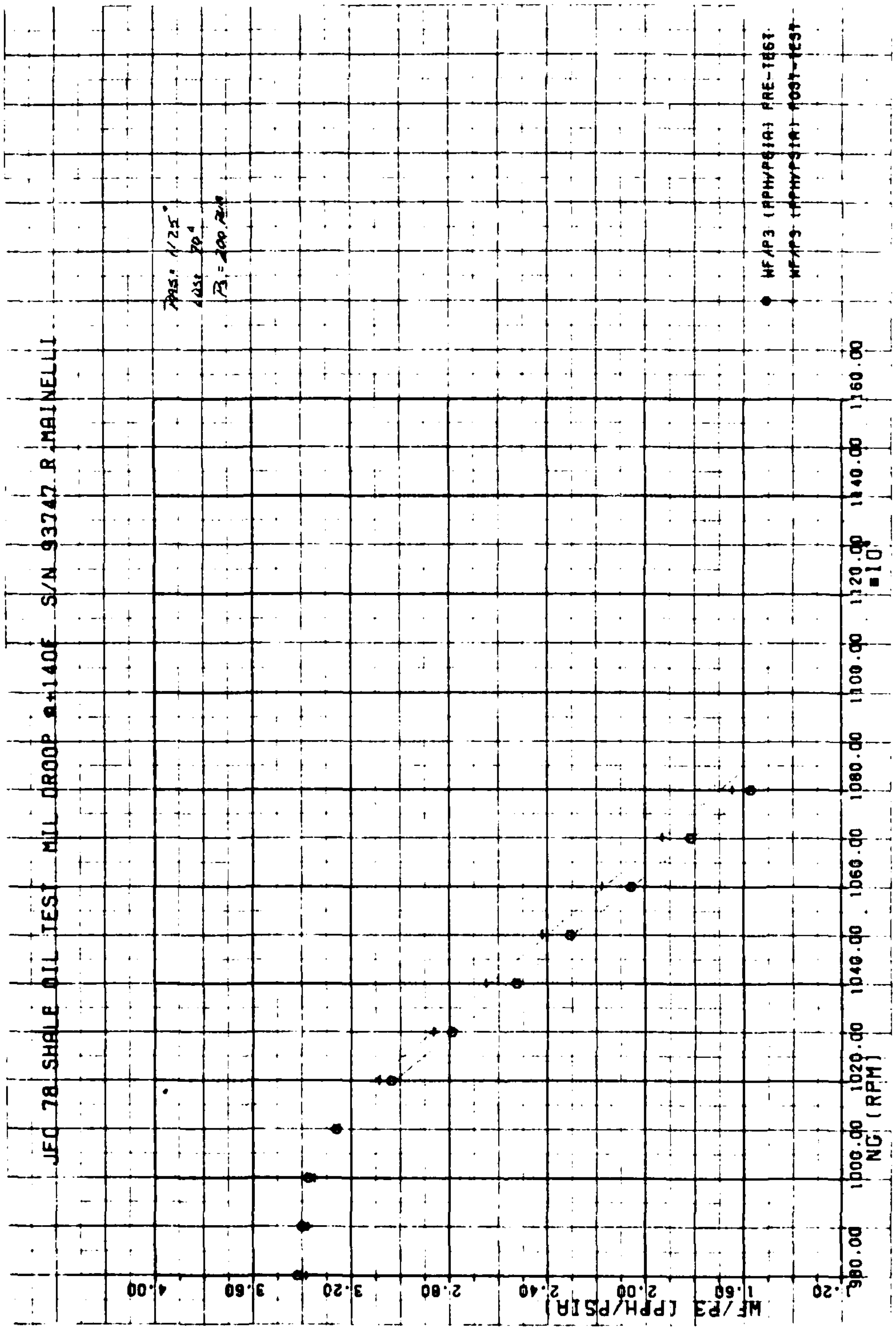
MILITARY GOVERNOR DROOP (-20^{o}F)

FIGURE 30



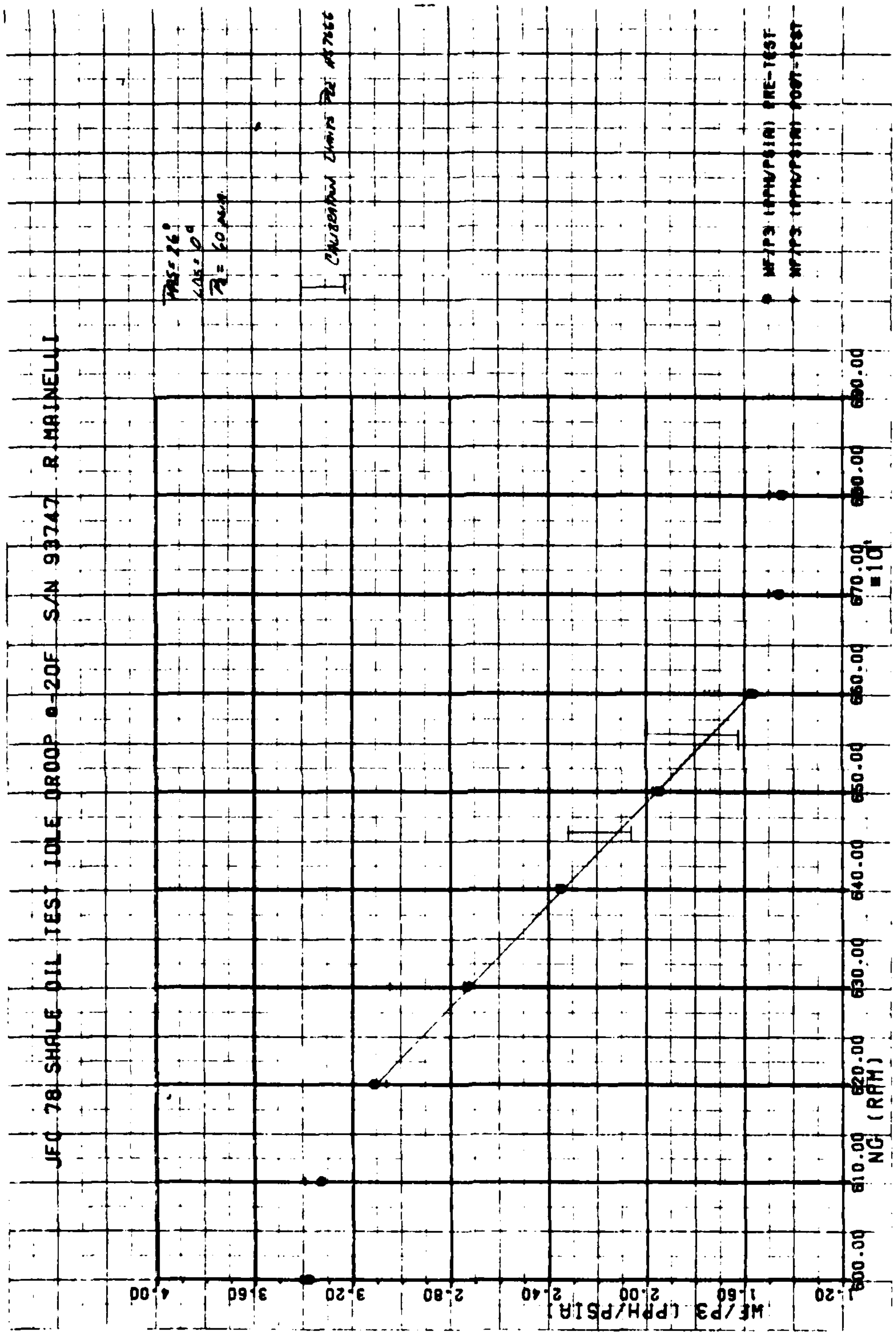
MILITARY GOVERNOR DROOP (60°F)

FIGURE 31



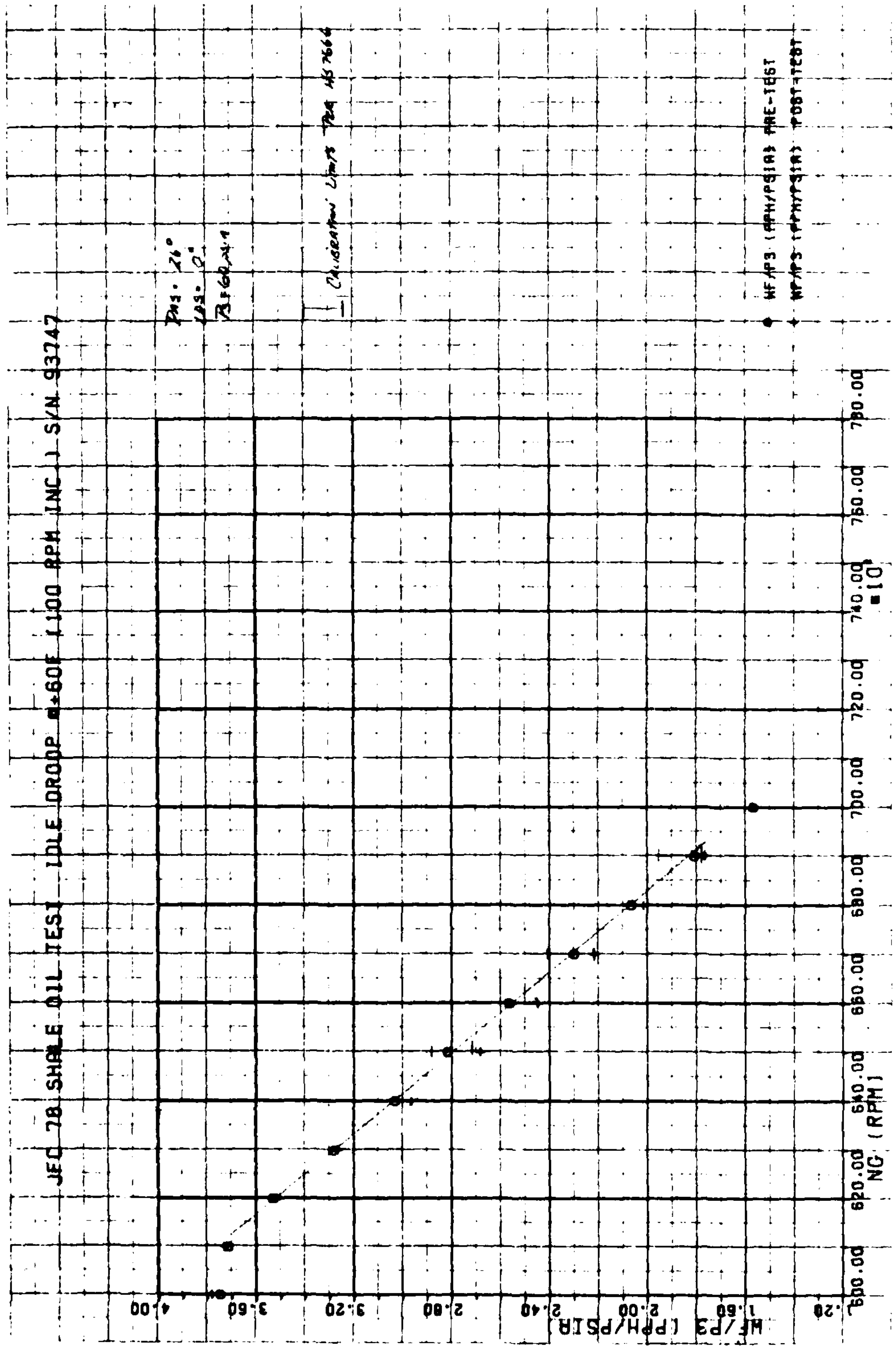
MILITARY GOVERNOR DROOP (140°F)

FIGURE 32



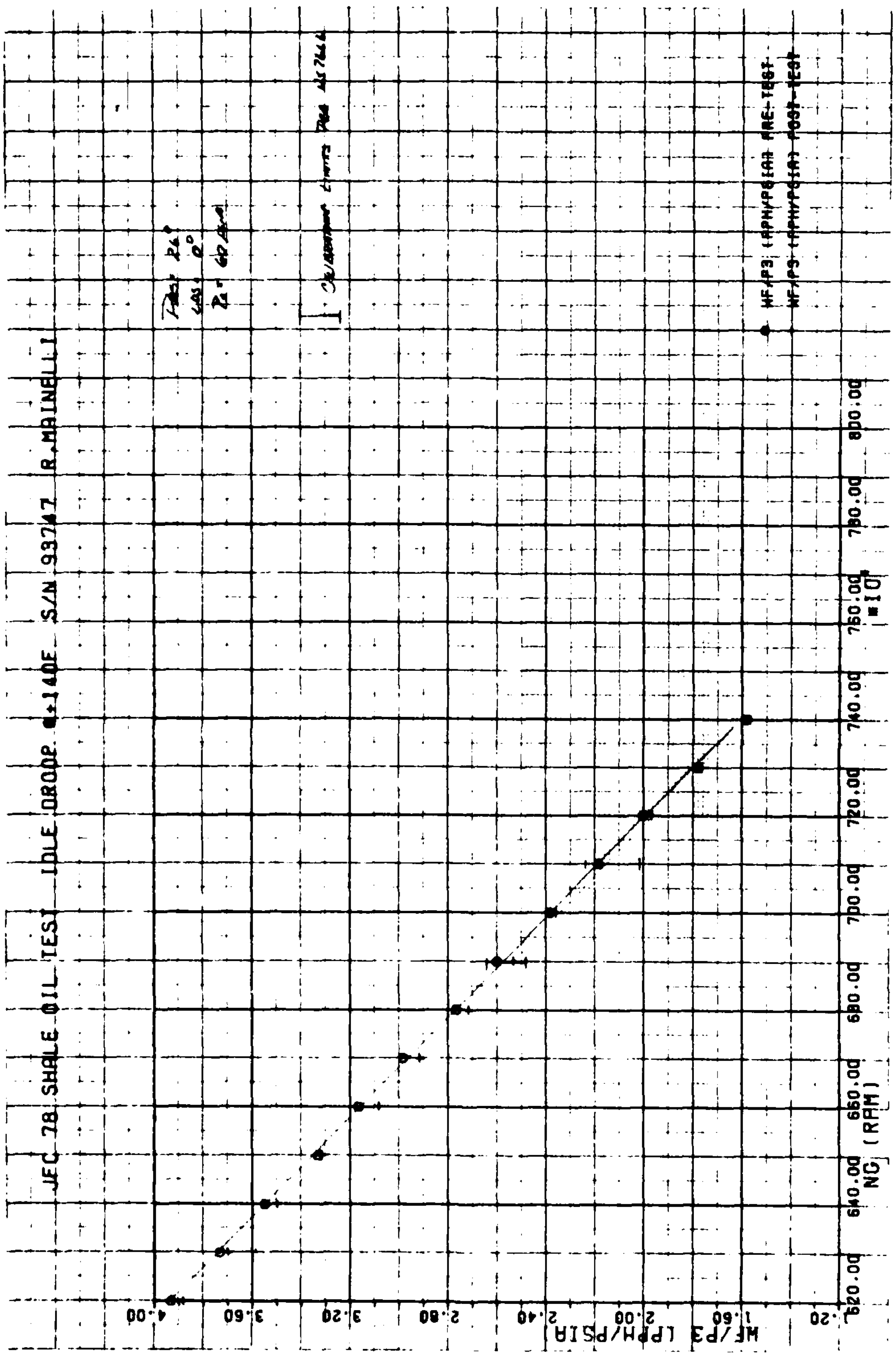
IDLE GOVERNOR DROOP (-20°F)

FIGURE 33



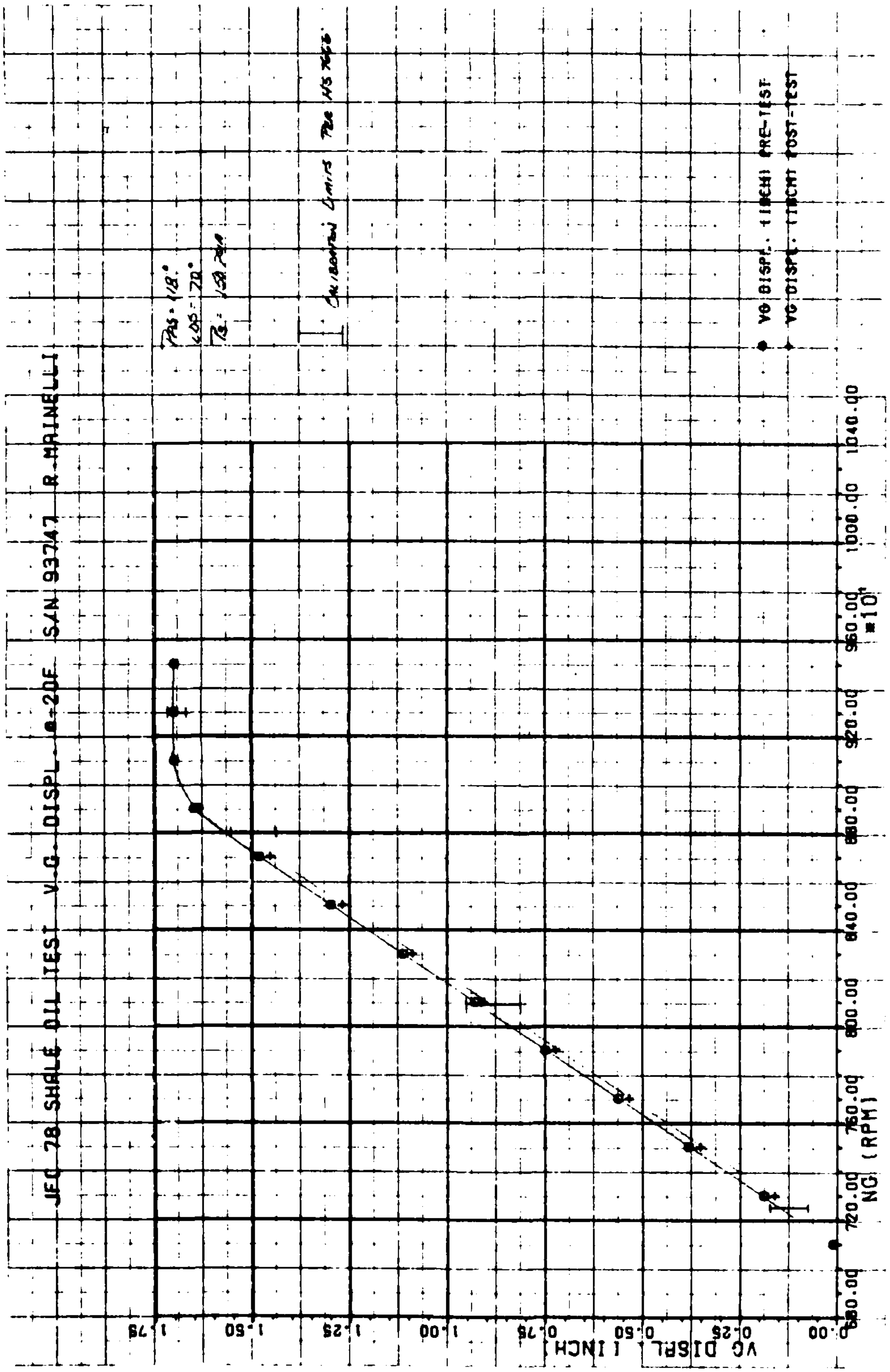
IDLE GOVERNOR DROOP (+60°F)

FIGURE 34



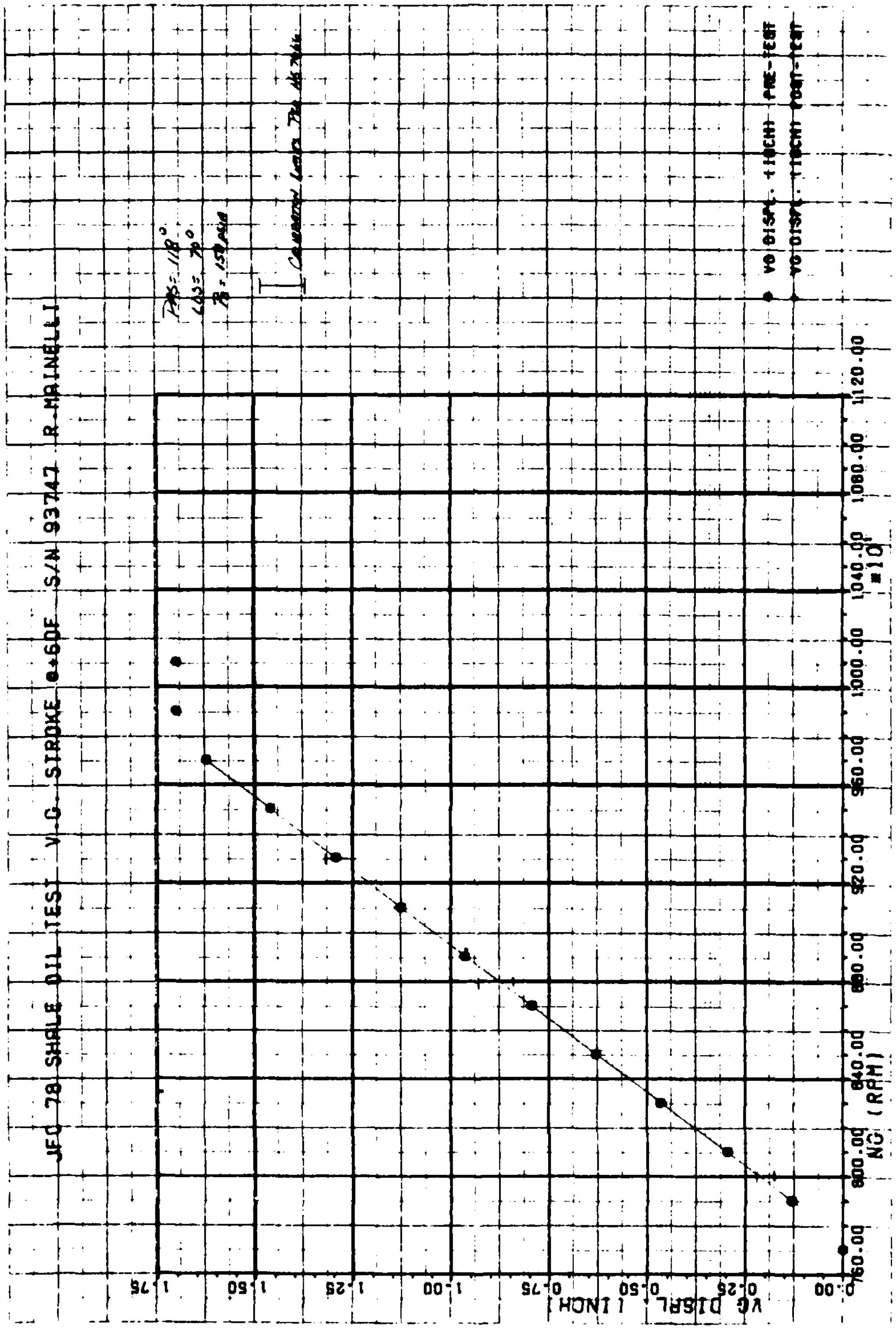
IDLE GOVERNOR DROOP (140°F)

FIGURE 35



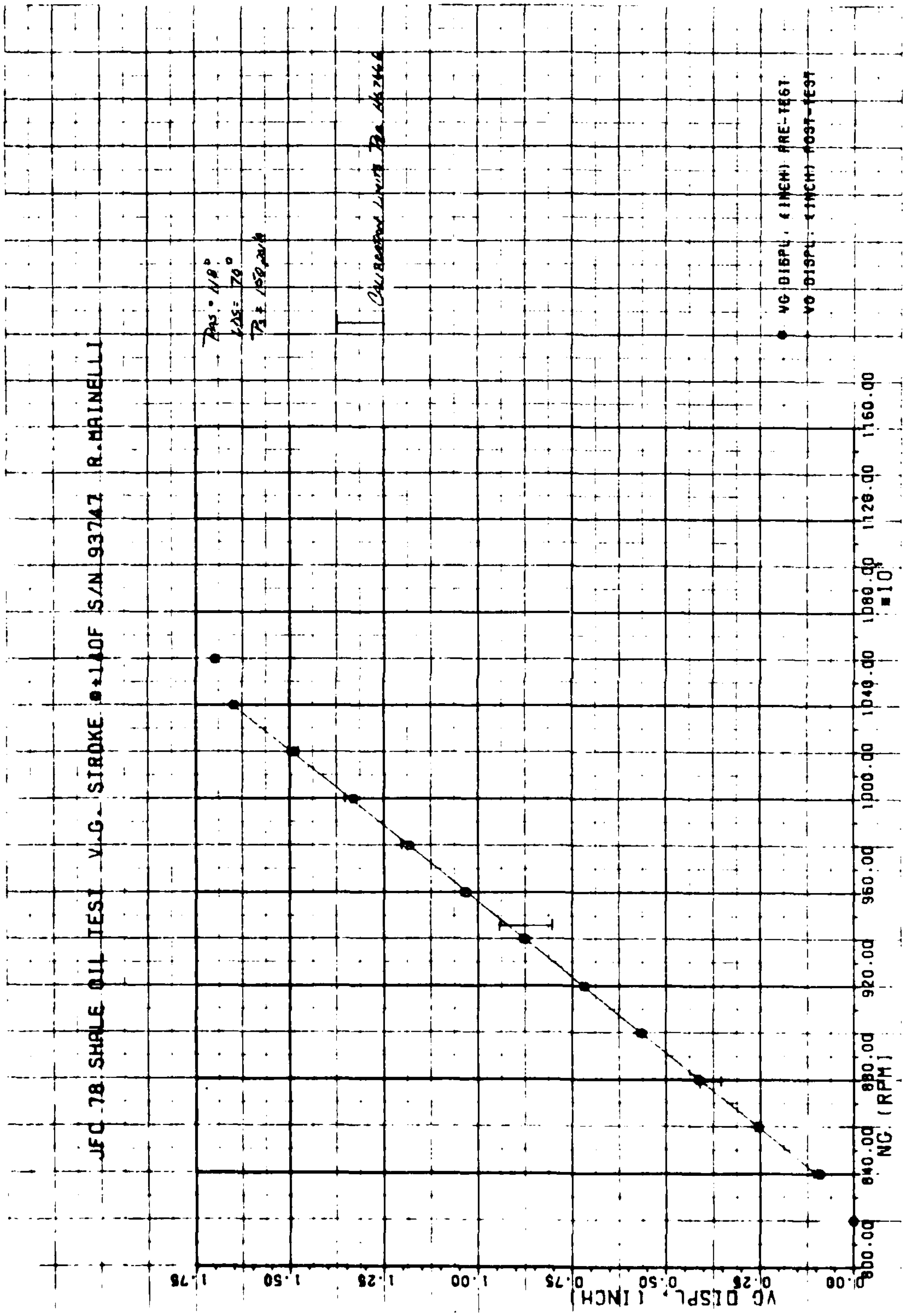
VANE ACTUATOR DISPLACEMENT (-20°F)

FIGURE 36



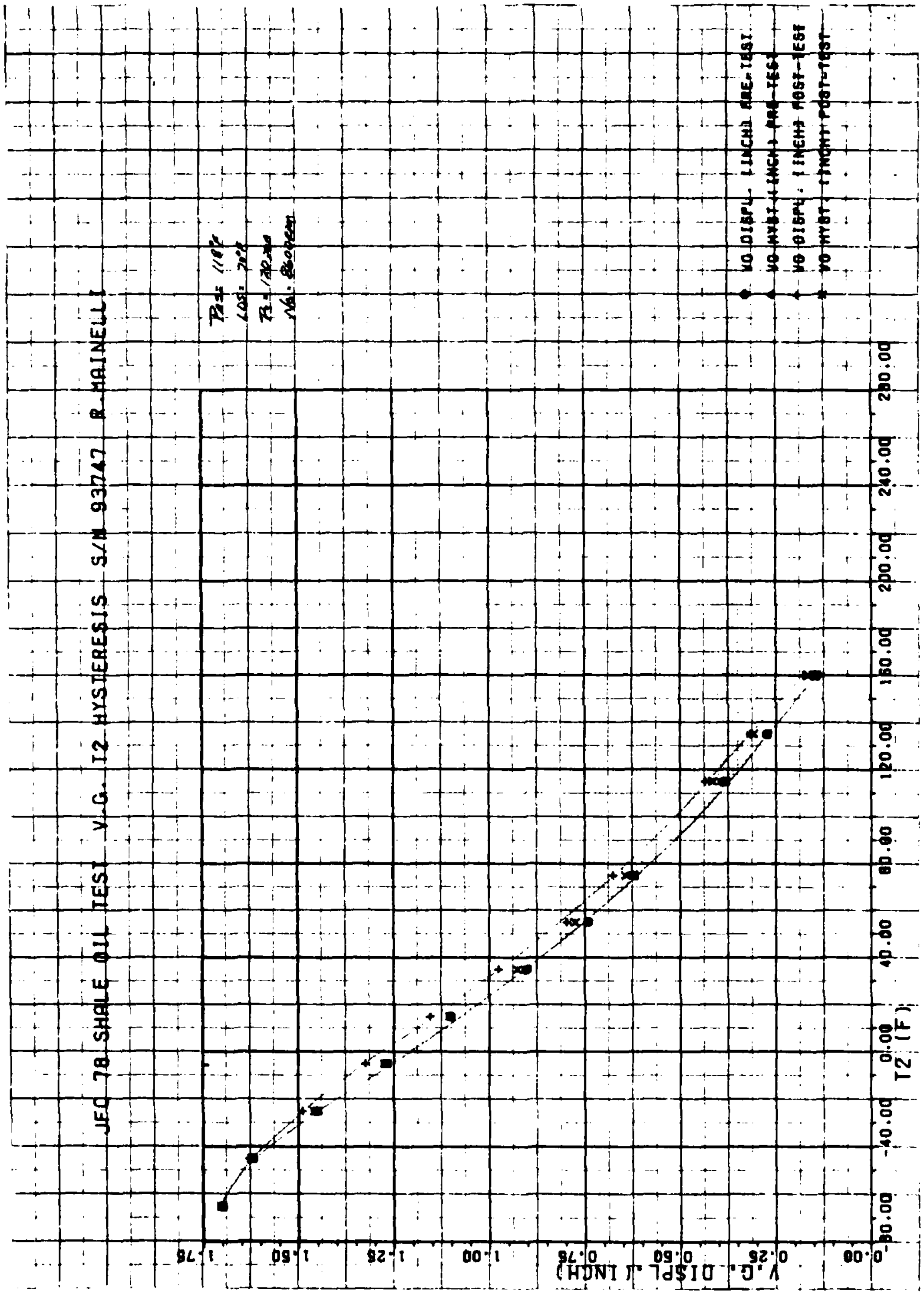
VANE ACTUATOR DISPLACEMENT (60°F)

FIGURE 37



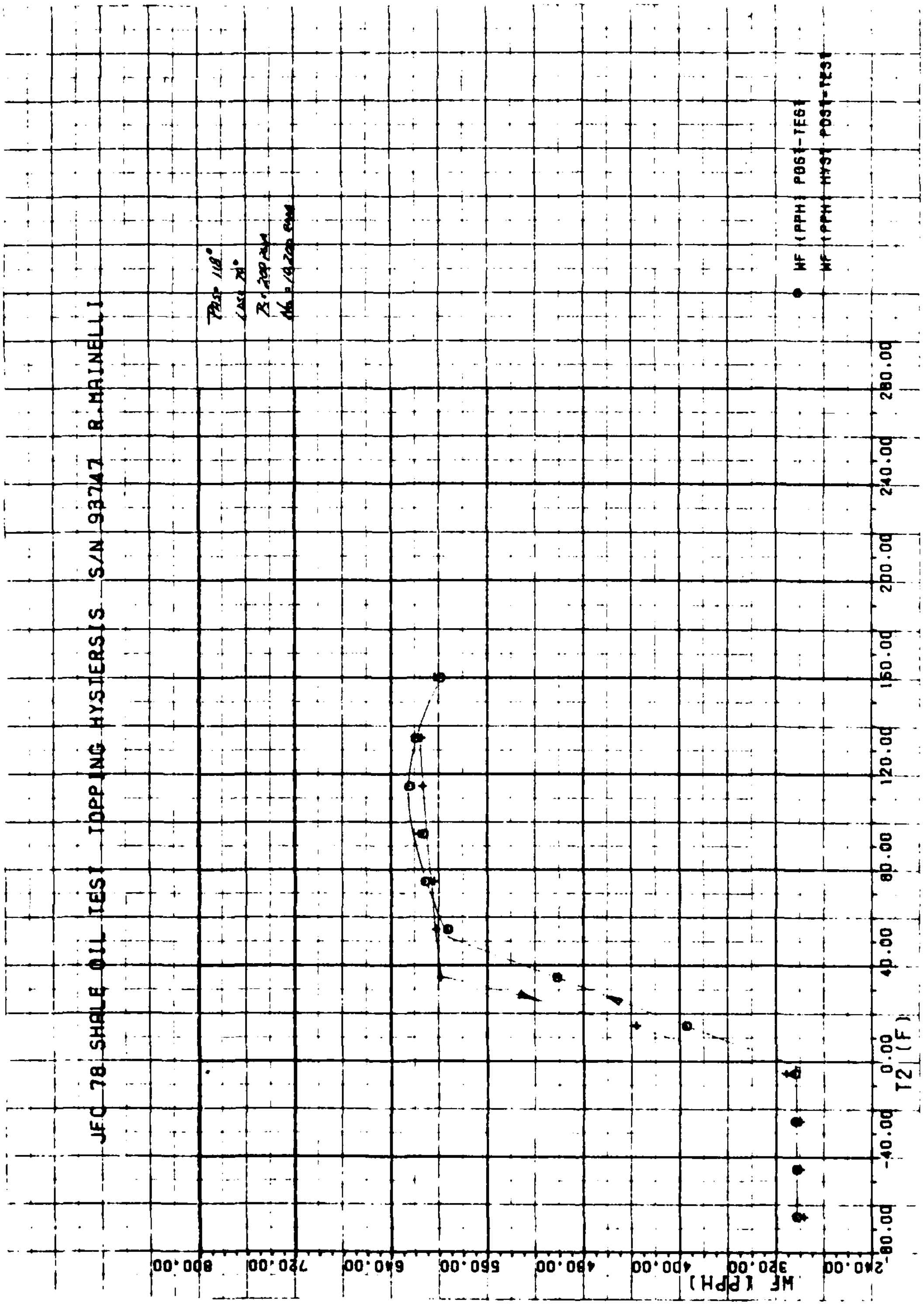
VANE ACTUATOR DISPLACEMENT (140°F)

FIGURE 38



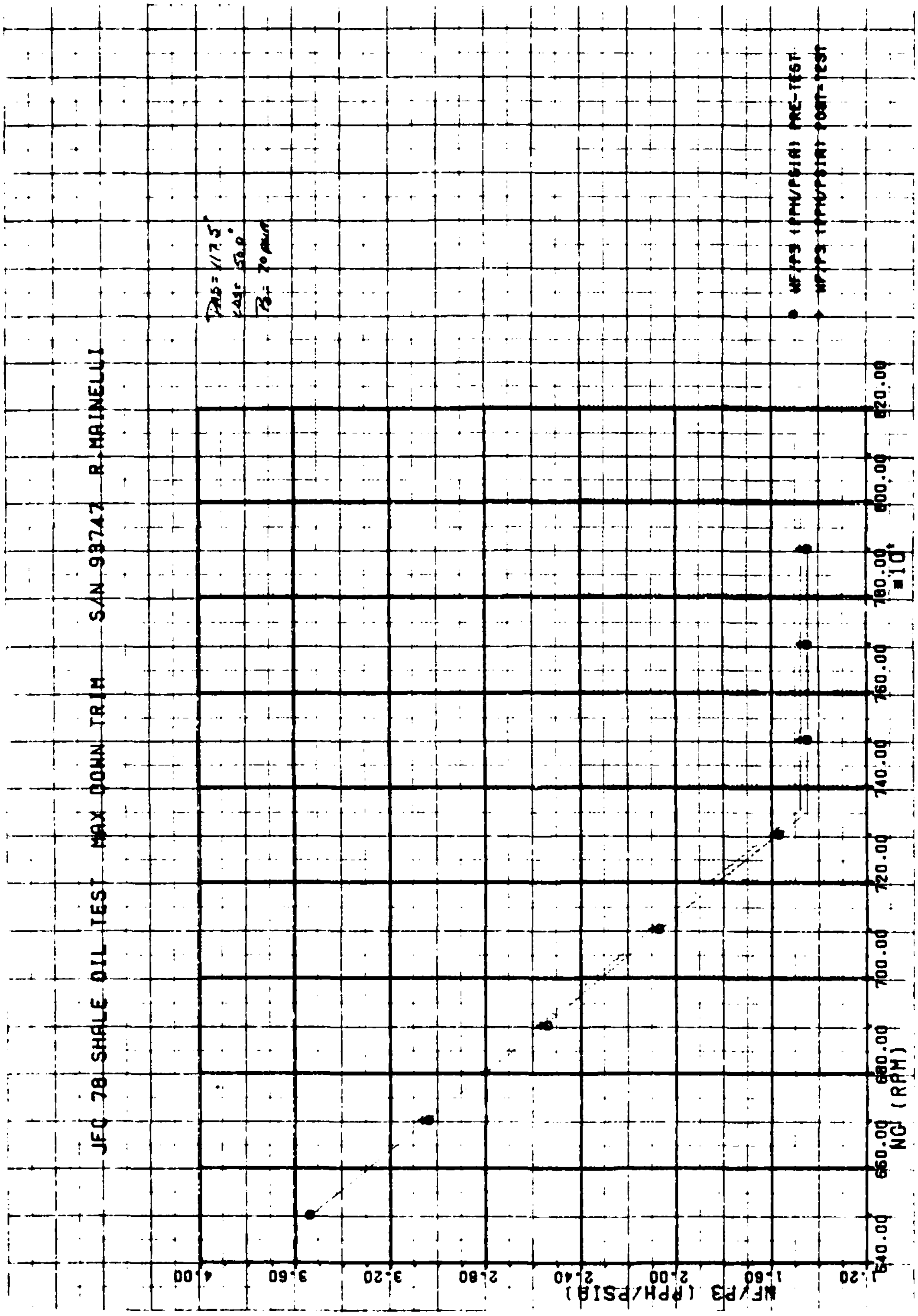
TEMPERATURE BIAS OF VANE SCHEDULE WITH HYSTERISIS

FIGURE 39



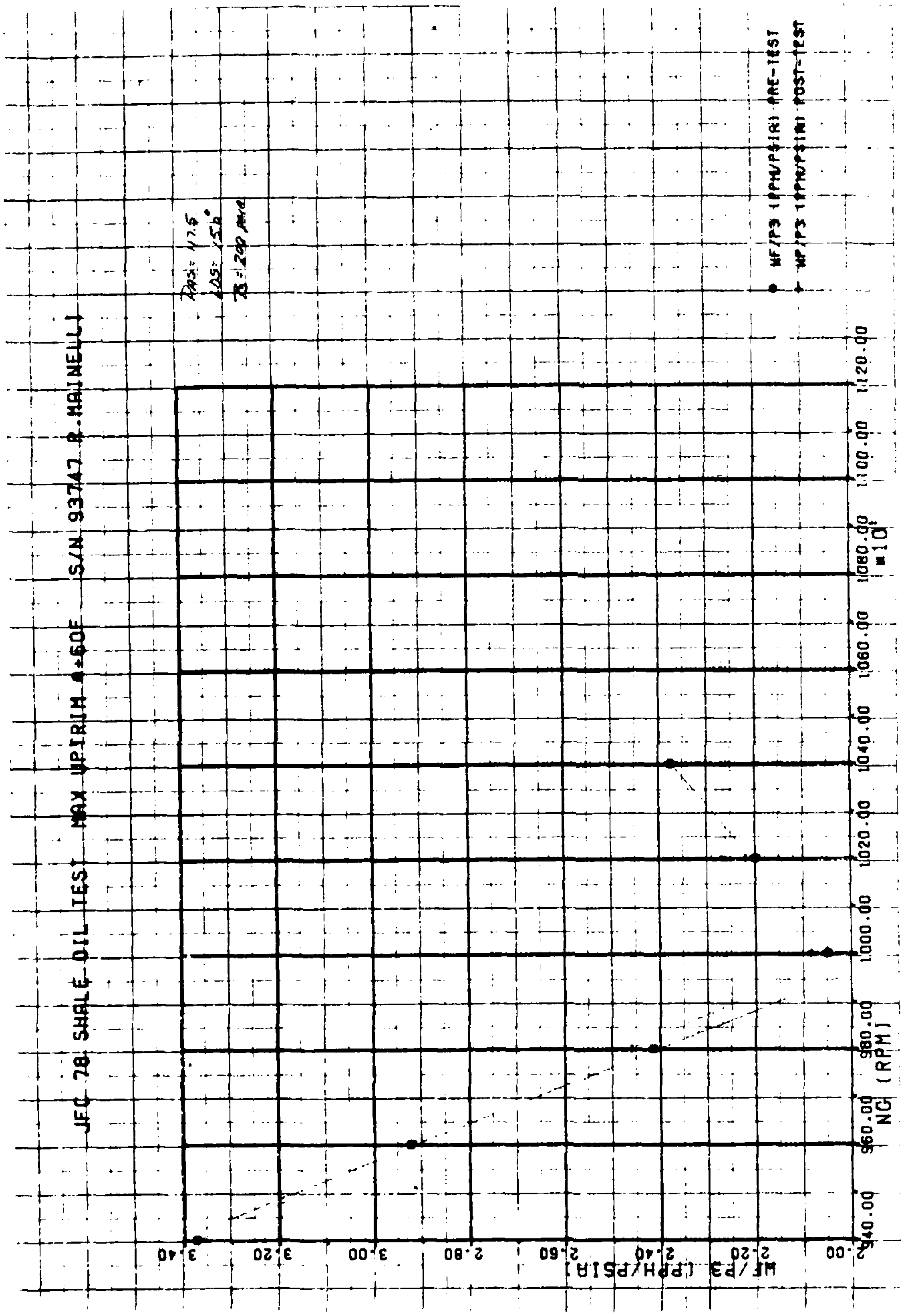
TEMPERATURE BIAS OF TOPPING SCHEDULE WITH HYSTERISIS

FIGURE 40



MAX ELECTRICAL DOWN TRIM

FIGURE 41



MAX ELECTRICAL UPTRIM

FIGURE 42

APPENDIX D-10

DISASSEMBLY AND INSPECTION REPORT

After completion of the post-test definition data the fuel control was disassembled and hardware examined. Pre and post test experimental inspection reports are included as figures 43 and 44. All hardware was in good condition and the fuel control will be reassembled without replacement or rework. Wear appeared consistant with endurance tests run in JP4 and iso octane. No direct comparison is possible since no endurance tests of this length (300 hours) have been run in clean fuel using the JFC 78. Control qualification tests have been considered which consist of 420 hours of accelerated cyclic endurance (1 minute cycles). These tests were run with iso-octane containing military specification contamination. Addition control hardware has been examined after long term engine endurance tests of 1250 hours and 1900 hours. Hardware from all these tests exhibited similar, but more severe, wear than that observed in this test.

Photographs of the hardware showing signs of wear are included in figures 45 to 46. This wear is not considered excessive and did not result in significant shifts in fuel control performance. A varnish type deposit was observed on some of the hardware. Quantities were not sufficient to be analyzed and did not effect control performance, however, increased quantities of this deposit might cause fuel control shifts and increased hysteresis. These deposits were found on the following hardware: pressure regulating valve, flyweight toes, flyweight wear pad, and the pilot valve lever. In addition the AMS 7445 cam follower balls and the carbide flyweight toe wear pad were discolored by a deposit or surface distress which had no apparent depth with 20x magnification. These deposits have been noted on other JFC 78 controls. This discoloration had no apparent adverse effects on performance or durability.

HS F-182E 7/81

HAMILTON STANDARD

EXPERIMENTAL INSPECTION REPORT

COPIES:

1. **Engineer** Roy Mainelli
2. **Government** ____
3. **Exp. Assy** ____

(sign to verify inspection)

Pre ~~**After**~~ PRE-TEST **ENDURANCE**

Fuel Control **Assembly**

Parts List 763700-3

Experimental No. ____

Assy Record No. S/N 93747

Insp. Date 4/10/81

Test No. ____

Sheet No. ____

Test Date ____

No. of Pages 1

Page No. 1

JFC 78-4 500 Hrs. Shale Oil Test

Part No.	Part Name	Qty	Condition of Part	Dispositi
763700-3	Fuel Control	1	The parts for this test have been visually	
			inpsected and are acceptable, some parts	
			have slight wear from previous testing as	
			listed below.	
767124-1	Latching Valve	1	Nicks on flat face.	
	Piston			
766313-20	P2 Regulator Valve		[illegible]	
			[illegible]	
737897-4	Seat Check Valve	1	Light scoring on half ball	
751176-2	Injector Tube	1	Nick on lip of the retaining pin slot	
			anodize missing on two spots on O.D. of	
			tube.	
738021-3	Idle Reset Lever	1	Nicks near hole for pin.	
765452-1	Speed Servo Piston	1	Anodize worn off piston	
755242-1	Power Spindle (PAS)	1	Electrofilm worn off on shutoff cam	
738045-14	Lever	1	Worn spot - no depth	

FIGURE 43

IS F-182E 7/81

HAMILTON STANDARD

EXPERIMENTAL INSPECTION REPORT

COPIES:

1. Engineer Roy Mainelli
2. Government
3. Exp. Assy
(sign to verify inspection)

~~Pre~~ After] POST TEST ENDURANCE

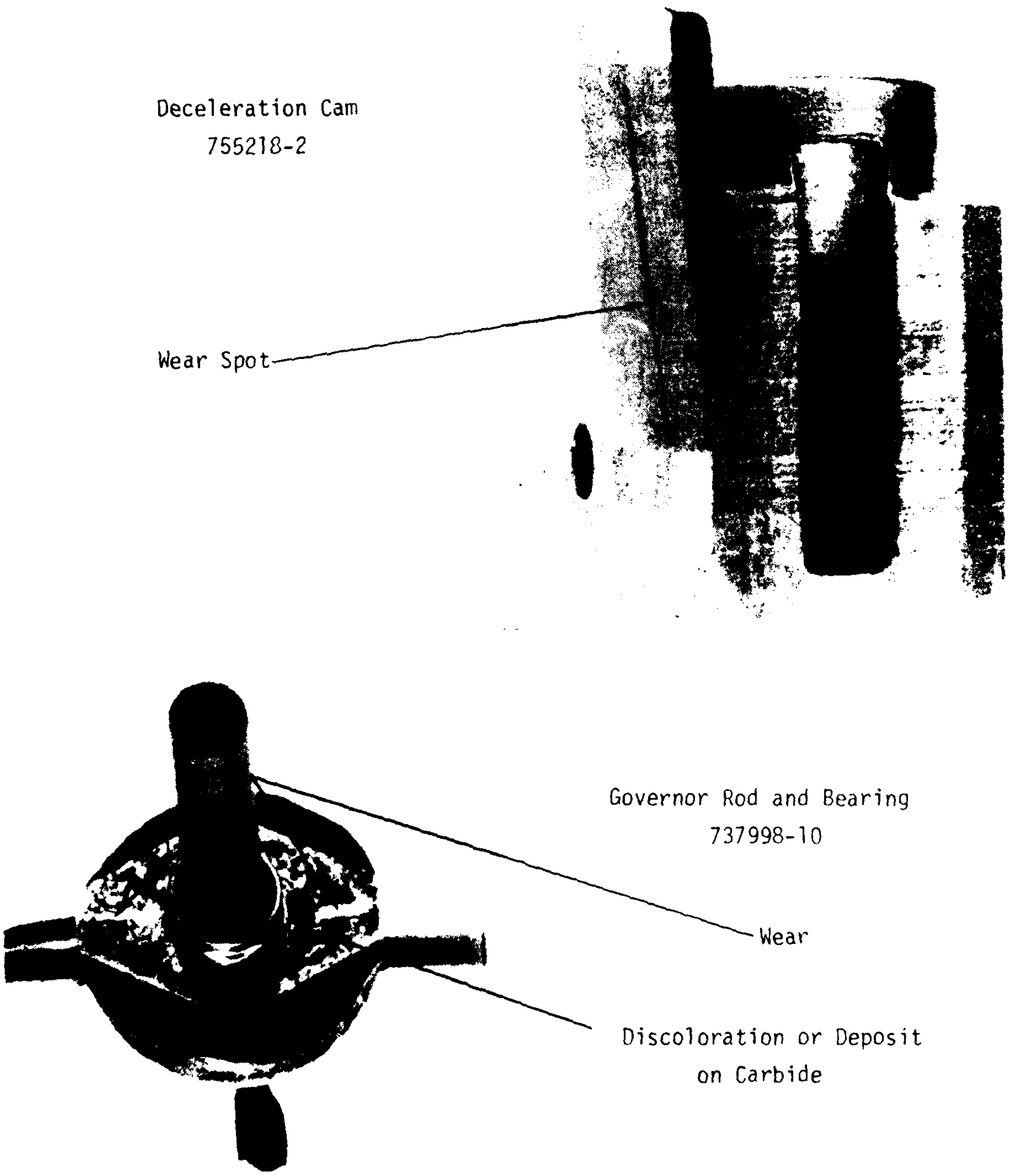
Fuel Control Assembly
Parts List 763700-3
Experimental No.
Assy Record No. S/N 93747
Insp. Date 9/2/81

Test No.
Sheet No.
Test Date
No. of Pages 1
Page No. 1

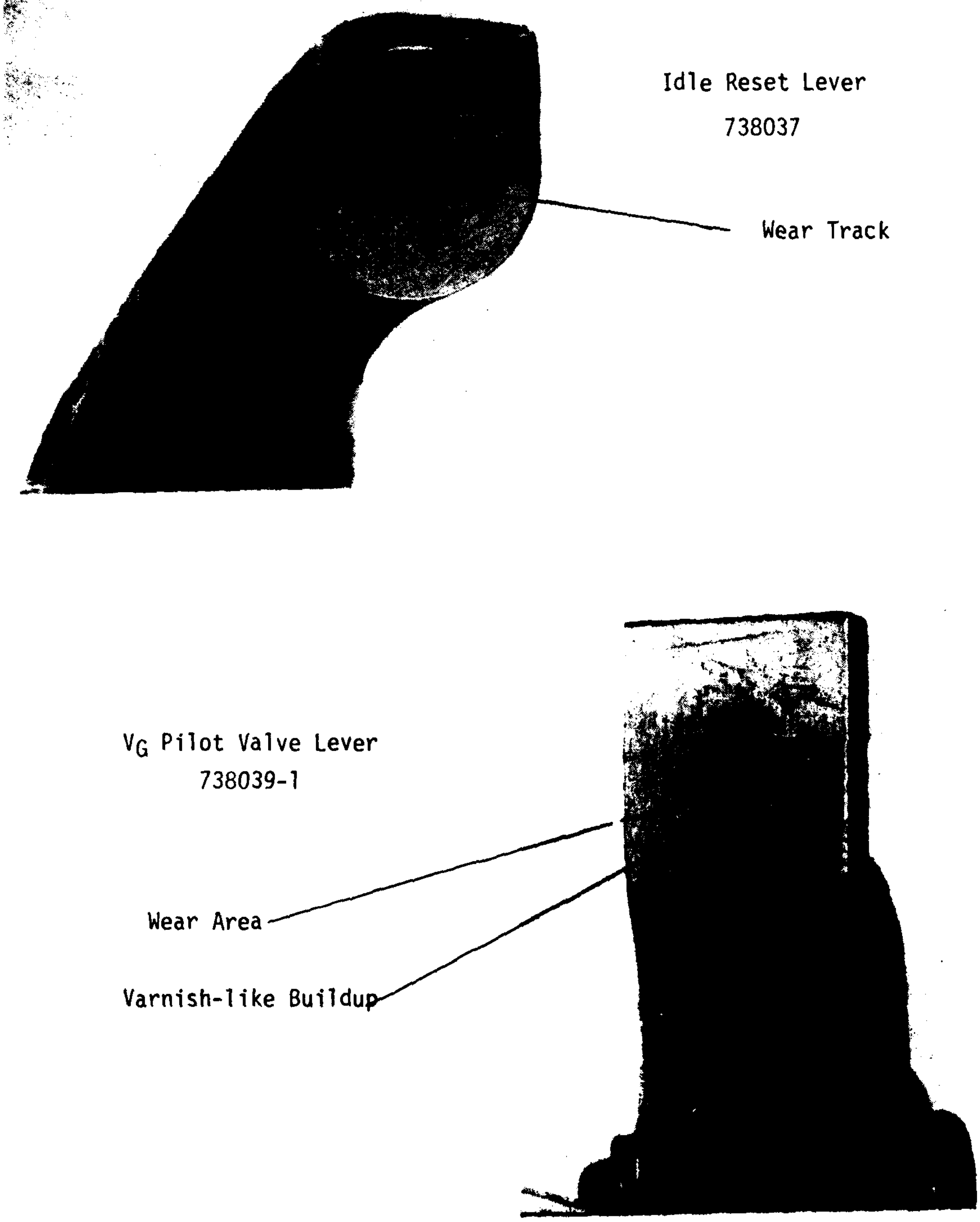
JFC 78 500 Hrs. Shale Oil Test

Part No.	Part Name	Qty	Condition of Part	Dispositic
738039-1	Lever, Pilot Valve		Slight Wear and Some Deposit	
765428-1	Sleeve, Lockout		Dent in Ball Seat Area	
755242-1	Spindle and Insert,		Slight Wear on Shut-Off Cam	
	Power			
764462-1	Flyweight, Speed		Deposit on Flyweight Toes	
	Governor			
757697-2	Gear, Speed Governor		Light Wear on Teeth	
755218-2	Cam, Decel		Slight Wear Flat	
737998-10	Governor Rod and		Slight Wear and Discolored	
	Bearing			
766380-1	Valve and Sleeve,		Cut Seal	
	Shutoff Ball		Discolored	
732994-2	Lever and Roller,		Corrosion on Roller	
	Droop			
738001-1	Lever, Idle Reset		Slight Wear on Pad	
751056-7	Pump Cam Ring, (Shaft Spline)		Slight Deposits	

FIGURE 44


Deceleration Cam
755218-2
Wear Spot
Governor Rod and Bearing
737998-10
Wear
Discoloration or Deposit
on Carbide

Figure


Idle Reset Lever
738037
Wear Track
V_G Pilot Valve Lever
738039-1
Wear Area
Varnish-like Buildup

Figure

APPENDIX E

No. 1 Identification of Critical Fuel System Components

No. 2 Existing Engine Qualification Procedures

No. 3 NATO Standard Engine Laboratory Test-Edition June 80

No. 4 Fuel System Components Qualification Procedures

No. 5 Environmental Protection Agency Heavy-Duty Diesel Engine Exhaust Emissions Certification and Test Procedures

APPENDIX E-1

IDENTIFICATION OF CRITICAL FUEL SYSTEM COMPONENTS

A. INTRODUCTION

This appendix presents a compilation of the critical diesel engine fuel system components which could be adversely affected by an alternative fuel (e.g., a coal or shale-derived diesel fuel) whose physical and/or chemical characteristics differ from the engine's intended fuel. Specifically, engine-mounted "fuel-wetted" components are identified. Non-fuel-wetted components such as valves, pistons, piston rings, etc., are not addressed nor are components which could be indirectly affected by a fuel change (e.g., electrical system components). Vehicle-related fuel-wetted components such as fuel tanks, fuel supply lines, and ancillary equipment are not addressed,

Any identification of "critical" fuel system components involves a number of assumptions to define the meaning of the term critical. The approach was to highlight components which are generally considered to be sensitive to changes in fuel parameters such as lubricity, aromaticity, sulfur content, gum content, impurities, and related parameters and characteristics. In this respect, the components of concern are those involving close tolerances, are known to contain elastomeric (or similarly sensitive) materials which contact fuel, operate in a high temperature environment, or are a particularly necessary unit to engine operation. Components which were found to belong to these categories include fuel injection equipment, fuel pumps, fuel filters and strainers, non-metallic fuel lines (e.g., hoses), fuel solenoid valves, and manifold heaters (which are a collection of these components).

The approach utilized to present this information is to describe for each engine model, its operating characteristics, the vehicles in which it is used, and to list the specific fuel critical components (complete with its part number and/or model designation and manufacturer or source of supply).

The information was obtained from the various engine manufacturers and/or the applicable engine Army technical manual. Where TACOM or a similar entity is listed as the manufacturer, they are the controlling source of supply for the item within the military system.

B. ARMY DESIGNED ENGINES

1. AVDS-1790 Series

a. Powerplant characteristics

The AVDS-1790 Series engines are 12-cylinder, 90 degree, V-type, four-stroke cycle, air-cooled, and turbosupercharged. Selected engine characteristics and performance data are shown in Table A-1.

TABLE A-1, SELECTED AVDS-1790 SERIES ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	1790 in^3
Weight, dry (with accessories) Model 2A Models 2C&2D Model 2DR	 4685 lb 4876 lb 4925 lb
Compression ratio	16:1
Horsepower, net	642 bhp at 2400 rpm
Torque, net	1585 lb-ft at 1800 rpm
Speed Governed, full load Governed, no load Idle	 2400 rpm 2640 rpm 700 rpm
Bore	5.750 in
Stroke	5.750 in
Fuel	VV-F-800, Grade DF-2

b. Engine/Vehicle Matches

Table A-2 shows the M-Series vehicles which contain the AVDS-1790 Series engines under consideration, per the appropriate technical manuals.

TABLE A-2, APPARENT AVDS-1790 SERIES ENGINE/VEHICLE MATCHES

Engine Model	M-Series Vehicle Designation
AVDS-1790-2A	M48A3,M60,M60A1,M728
AVDS-1790-2C	M48A5,M60,M60A1,M60A1(RISE), M60A2,M60A3,M48A2AVLB,M60A1AVLB, M48A5AVLB,M728
AVDS-1790-2D	M48A5,M60,M60A1,M60A1(RISE), M60A2,M60A3,M48A2AVLB,M60A1AVLB, M48A5AVLB,M728
AVDS-1790-2DR	M88A1

Table A-3 shows the M-Series vehicles in current use (confirmed by TACOM) which contain Teledyne-Continental-Motors-built AVDS-1790 series engines. The 1790-2 is no longer built and the 2A is built only on special order. The 2C, 2D, and 2DR models are current production items. Vehicles with the 2A engine are being converted to 2C's or 2D's when in for overhaul. The M48A5 vehicles are being retrofitted with 2C's or 2D's; most will be retrofitted with 2D's (if the electrical system can handle the amperage, a 2C is used, otherwise a 2D is used).

TABLE A-3, THE AVDS-1790 SERIES ENGINES MATCHED TO IN-SERVICE M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
AVDS-1790-2	
AVDS-1790-2A	M48A5, M60A1, M60A2, M728
AVDS-1790-2C	M60A3, M60A1RISE, M48A5*
AVDS-1790-2D	M48A5*, M60A1*, M60A2*, M728
AVDS-1790-2DR	M88A1

*Vehicles being retrofitted with listed engine.

The major distinctions between models are as follows:

● AVDS-1790-2: (Army No. 8725265)	supplied with air-cooled generator and associated accessory drive.
● AVDS-1790-2A: (Army No. 10912450)	supplied with air-cooled generator and associated accessory drive
● AVDS-1790-2C: (Army No. 11682700)	supplied with oil-cooled alternator and associated accessory drive.
● AVDS-1790-2D: (Army No. 11684000)	supplied with air-cooled generator and associated accessory drive.
● AVDS-1790-2DR: (Army No. 11684150)	supplied with air-cooled generator and associated accessory drive and an auxiliary power take-off drive.

c. Fuel System Components Identification

Figure A-1 shows a schematic of the main fuel system. Figure A-2 shows a schematic of the manifold air induction heater system. Figure A-3 shows a schematic of the smoke generating system. Table A-4 lists the vendor or source of supply for the primary fuel system components and their respective part and/or model designation; differences between models are so noted. Table A-5 identifies fuel system hoses and tubes for the 1790-2A model while Table A-6 lists similar data for the other engine models.

TABLE A-4, IDENTIFICATION OF AVDS-1790 SERIES PRIMARY FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (model number)
Fuel Injection Pump ● Model 2A ● Models 2C, 2D, & 2DR	American Bosch	 ● 10912447 (PSB-12BT) ● 11684129-1 (PSB-12BT)
Fuel Nozzle & Holder Assembly	American Bosch	10912452

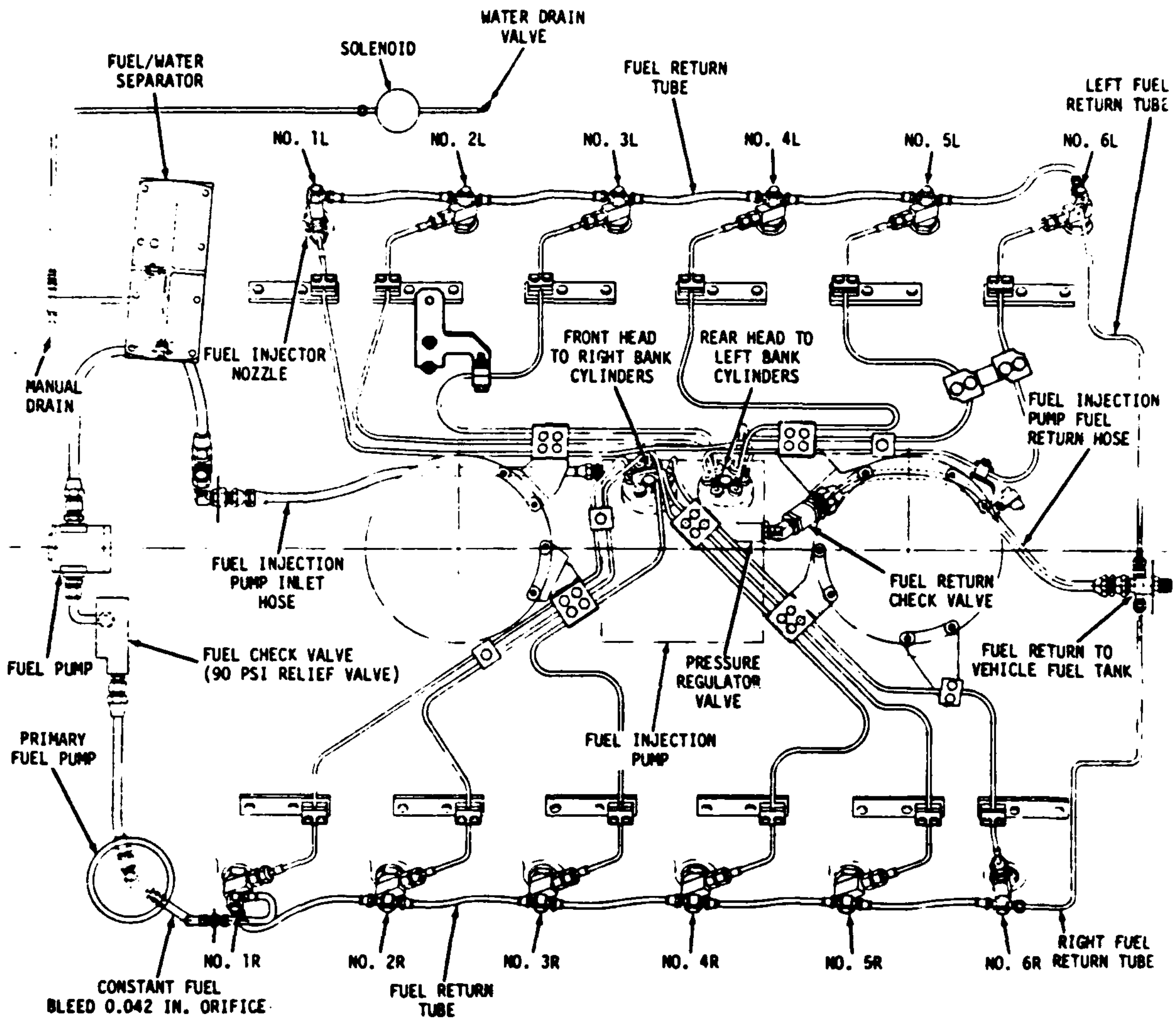


FIGURE A-1, THE AVDS-1790 SERIES PRIMARY FUEL SYSTEM

Source TM9-2815-220-34

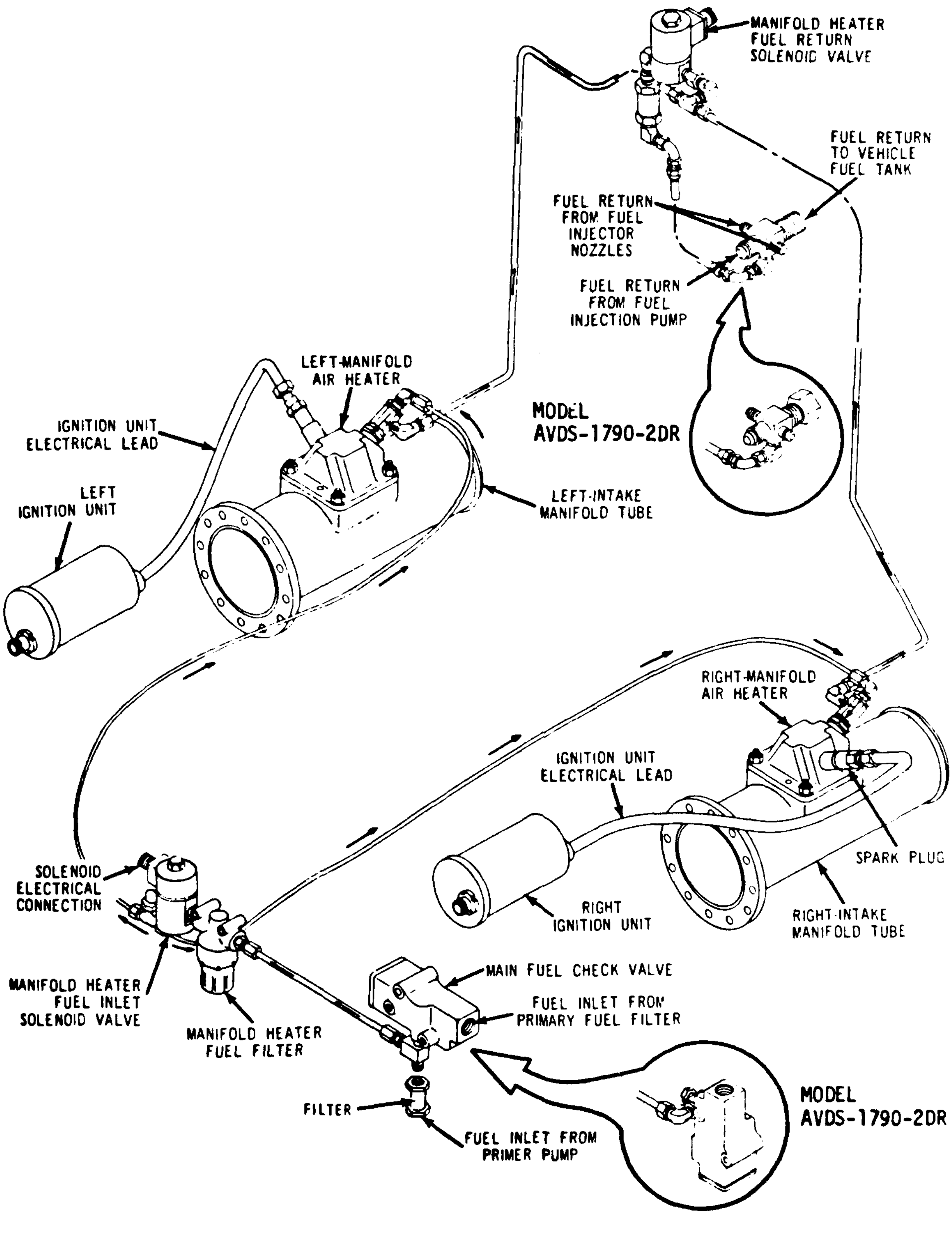


FIGURE A-2, THE AVDS-1790 SERIES FLAME HEATER FUEL SYSTEM

Source: TM9-2815-220-34

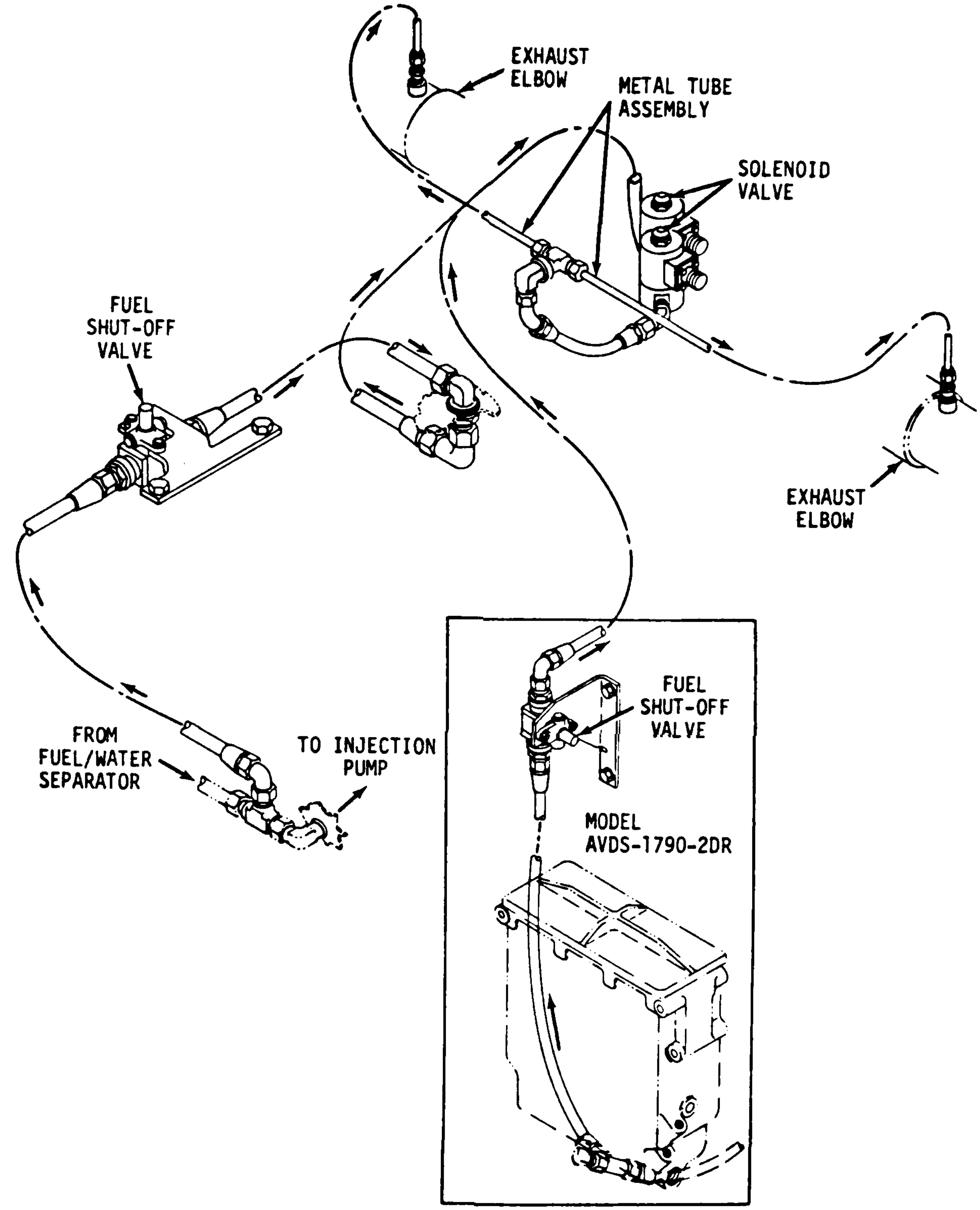


FIGURE A-3, THE AVDS-1790 SERIES SMOKE GENERATING FUEL SYSTEM
Source: TM9-2815-220-34

TABLE A-4, IDENTIFICATION OF AVDS-1790 SERIES PRIMARY FUEL SYSTEM COMPONENTS (Cont.)

Component	Vendor/Source	Part Number (model number)
Fuel Supply Pump ● Model 2A ● Models 2C&2D ● Model 2DR	Viking	● 10882763 (FV492) ● 10882763-1 (FV492-4C ● 8761431-1 (FV492-4D
Primary Fuel Filter ● Model 2A ● Models 2C,2D& 2DR	● Fram or Purolator ● Bendix Filter Div.	● 8395476 (2949 or 664479) ● 11668617 (054615-02)
Primary Fuel Filter Parts Kit ● Model 2A ● Models 2C,2D& 2DR	TACOM	● 5702757 ● 5704487
Fuel/Water Separator Filter ● Model 2A ● Models 2C,2D& 2DR	● Keene Corp. Filtration Div. ● Facet Filter Products	● 11602063 ● 11602063
Fuel/Water Separator Filter Parts Kit	TACOM	5702738
Secondary Fuel Filter (Model 2A only)*	Fram	8764641(FBM1126)
Secondary Fuel Filter Parts Kit (Model 2A only)*	TACOM	5702690
Water Separator Solenoid Valve	Skinner Electric Valve Div	11668627

TABLE A-4, IDENTIFICATION OF AVDS-1790 SERIES PRIMARY FUEL SYSTEM COMPONENTS (Cont.)

Component	Vendor/Source	Part Number (model number)
Manifold Air Heater Nozzle Assembly ● Model 2A ● Models 2C,2D& 2DR	TACOM	● 7335555 ● 12254278
Flame Heater Solenoid Valve	Skinner Electric Valve Div	7062194
Flame Heater Fuel Filter ● Model 2A ● Models 2C,2D& 2DR	● Military Standard ● Bendix Filter Div	● 51085-1 ● 11668619
Smoke Generator Solenoid Valve	Skinner Electric Valve Div	11668627

TABLE A-5, IDENTIFICATION OF AVDS-1790-2A FUEL SYSTEM HOSES AND PLASTIC TUBES

Hose/Tube Description	Vendor/Source	Part Number
Hose Assembly-Fuel Return, Cylinders 5&6	TACOM	10951341-2
Hose Assembly-Fuel Return, Cylinders 1-2, 2-3,3-4,4-5	TACOM	10951341-1
Tube Assembly-Fuel Injection Pump To Bulkhead Elbow	TACOM	8761510
Hose Assembly Teflon-Fuel Injection Return	TACOM	10882940

TABLE A-5, IDENTIFICATION OF AVDS-1790-2A FUEL SYSTEM HOSES AND PLASTIC TUBES (Cont.)

Hose/Tube Description	Vendor/Source	Part Number
Hose Assembly-Water Separator Fuel Filter Outlet Elbow To Bulk-Head Elbow	Military Standard	28741-8-0300
Hose Assembly-Fuel Pump Outlet To Water Separator Fuel Filter Inlet	Military Standard	28741-8-0134
Hose Assembly, Rubber-Primary Fuel Filter Outlet To Check Valve Inlet	Military Standard	28741-8-0204
Hose Assembly, Rubber-Fuel Pump Outlet Adapter To Secondary Fuel Filter Inlet	Military Standard	28741-8-0260
Hose Assembly, Rubber-Secondary Fuel Filter Outlet Elbow To Bulk-Head Elbow	Military Standard	28741-8-0340
Plastic Tubing-7.125", Part Of Check Valve To Flame Heater Fuel Filter Tube Assembly	TACOM	7017826
Plastic Tubing-75", Part Of Right Bank Solenoid Valve Tee To Flame Heater Nozzle Tube Assembly	The Polymer Corp	(NS4H)

TABLE A-6, IDENTIFICATION OF AVDS-1790-2C,-2D, AND-2DR
FUEL SYSTEM HOSES AND PLASTIC TUBES

Hose Description	Vendor/Source	Part Number
Hose Assembly-10 Intercylinder Connector And 1 Fuel Return Connecting No. 6 Cylinder, Left Bank, And Elbow Tube	Military Standard	MS52104C4-0074
Hose Assembly-Fuel Return Connecting No. 6 Cylinder, Right Bank, And Elbow Tube	Military Standard	MS5104C4-0090
Hose Assembly-Fuel Injection Pump Check Valve To Tee	Military Standard	MS8005H120A
Hose Assembly-Injection Pump Overflow Tee To Tube Nipple	Military Standard	MS8005H520A
Hose Assembly-Injection Pump Overflow Tee To Tube Cross	Military Standard	MS8005H060A
Hose Assembly-Fuel Injection Pump Check Valve To Bulkhead Cross Tee	TACOM	10882940
Hose Assembly-Water Separator Fuel Filter Outlet Elbow To Bulk-Head Elbow	Military Standard	MS28741-8-0300
Tube Assembly-Fuel Injection Pump Inlet To Bulkhead Elbow	TACOM	8761510
Hose Assembly-Primary Fuel Filter Outlet To Fuel Back Flow Valve Inlet	Military Standard	MS28741-8-0124

TABLE A-6, IDENTIFICATION OF AVDS-1790-2C,-2D, AND -2DR FUEL SYSTEM HOSES AND PLASTIC TUBES (Cont.)

Hose Description	Vendor/Source	Part Number
Hose Assembly-Primary Fuel Filter Outlet To Fuel Back Flow Valve Inlet**	TACOM	11684294
Hose Assembly-Fuel Back Flow Valve Outlet To Fuel Pump Inlet**	Military Standard	MS28741-8-0240
Hose Assembly-Fuel Pump Outlet To Water Separator Fuel Filter Inlet**	Military Standard	MS28741-8-0330
Hose Assembly-Fuel Pump Outlet To Water Separator Fuel Filter Inlet*	Military Standard	MS28741-8-0134
Hose Assembly-Flame Heater Solenoid Valve Outlet To Cross Tee	Military Standard	MS8005E086E180
Plastic Tube-60", Part Of Tube Assembly For Flame Heater (Part No. 10882779)	The Polymer Corp	(NS4H)
Plastic Tube-75", Part Of Tube Assembly (Part No. 10882780) For Flame Heater	The Polymer Corp	(NS4H)
Plastic Tube-7.12" Or 10.44", Check Valve To Flame Heater Filter Inlet, Part Of Tube Assembly (Part No. 10865122)	TACOM	7017826

*Models 2C and 2D only
**Model 2DR only

2. The LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, LDS-465-2 Multi-Fuel Engines

a. Powerplant Characteristics

The LD-465, LDT-465, and LDS-465 model "multi-fuel" engines are all four-stroke cycle, in-line, six-cylinder, and liquid cooled. The LD-465 models are naturally aspirated, and the LDS-465 and LDT-465 models are turbocharged. Selected engine characteristics and performance data are shown in Table A-7.

TABLE A-7, SELECTED LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, AND LDS-465-2 ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Characteristic \ Model	LD-465-1	LD-465-1C	LDT-465-1C	LDS-465-1	LDS-465-1A	LDS-465-2
Displacement	478 in^3	478 in^3	478 in^3	478 in^3	478 in^3	478 in^3
Weight	1614 lb	1614 lb	1650 lb	1561 lb	1650 lb	1633 lb
Compression Ratio	22:1	22:1	22:1	22:1	22:1	22:1
Gross Horsepower, Min (All Fuels)	126 hp at 2600 rpm	126 hp at 2600 rpm	130 hp at 2600 rpm	175 hp	175 hp at 2600 rpm	195 hp at 2800 rpm
Gross Torque, Min (All Fuels)	300 lb-ft at 1400 rpm	300 lb-ft at 1400 rpm	305 lb-ft at 1500 rpm	425 lb-ft at 2000 rpm	425 lb-ft at 2000 rpm	425 lb-ft at 2000 rpm
Speed (rpm)						
Governed, Full Load	2600-2650	2600-2650	2600-2650	2600-2650	2600-2650	2800-2850
Governed, No Load	2850-2900	2850-2900	2850-2900	2850-2900	2850-2900	3050-3100
Idle	650-700	650-770	*	650-770	650-700	650-700
Bore	4.56 in	4.56 in	4.56 in	4.56 in	4.56 in	4.56 in

*Early production models are 650-700 rpm; late production models are 800-350 rpm.

TABLE A-7, SELECTED LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, AND LDS-465-2 ENGINE CHARACTERISTICS AND PERFORMANCE DATA (CONT.)

Model / Characteristics	LD-465-1	LD-465-1C	LDT-465-1C	LDS-465-1	LDS-465-1A	LDS-465-2
Stroke	4.87 in	4.87 in	4.87 in	4.87 in	4.87 in	4.87 in
Fuel*	Primary Fuels: VV-F-800, Grades DF-A, DF-1, and DF-2; MIL-T-5624, Grade JP-5 Alternate I Fuels: MIL-F-16884; MIL-F-24397; commercial diesel fuel (ASTM D975), Grades 1-D and 2-D; aviation turbine fuel-kerosene type; MIL-T-38219, Grade JP-7; commercial aviation turbine fuel (ASTM D1655)-Jet A and Jet A-1; MIL-G-5572, AVGAS 80/87; commercial gasoline (leaded, low-lead, or unleaded) with RON L 89 or anti-knock index L 85; any mixture of Primary and/or Alternate I fuels.					

*There is a list of Alternate II fuels that may be used when blended with diesel fuel as well as emergency fuels that may be used. TM9-2815-210-34 contains additional information.

b. Engine/Vehicle Matches

Table A-8 shows the M-Series vehicles (as indicated by TACOM) which contain the subject multi-fuel engines. Although White Motors Inc. has built most of the models, Teledyne Continental Motors has built some.

TABLE A-8, THE LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, AND LDS-465-2 ENGINES MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
LD-465-1* LD-465-1C* LDT-465-1C*	M35A2,M35A2C,M36A2,M44A2,M45A2,M45A2C, M46A2,M46A2C,M49A2C,M50A2,M50A3,M109A2, M185A3,M275A2,M292A2,M292A5,M342A2,M751A2, M756A2,M763,M764

*The engine model used depended on the build date of the truck. The vehicles are collectively known as the M44A2 series (2-1/2-ton trucks).

TABLE A-8, THE LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, AND LDS-465-2 ENGINES MATCHED TO M-SERIES VEHICLES (Cont.)

Engine Model	M-Series Vehicle Designation
LDS-465-1* LDS-465-1A*	M40A2C,M51A2,M52A2,M54A2,M54A2C,M55A2, M61A2,M63A2,M63A2C,M246A2,M291A2,M291A2C, M291A2D,M328E2,M543A2,M738E2,M748A2
LDS-465-2**	M656,M757,M791

* The engine model used depended on the build date of the truck. The vehicles are collectively known as the M39A2 series (5-ton trucks).

**The vehicles are collectively known as the M656 series (8x8 5-ton trucks).

c. Fuel System Components Identification

The main fuel system is similar to that of the LDS-427-2 (see Figure A-7) consisting of a fuel injection pump assembly, fuel injector nozzle and holder assembly, fuel transfer pump, fuel filter(s), and fuel hoses/tubes. There have been three different manifold air heater systems used (see Figures A-3, A-4,A-5, and A-6). The side mounted solenoid controlled unit was used on the LDS-465-1. The top mounted, uncovered unit was used on the LD-465-1 and early production models of the LDS-465-1A and LD-465-1C. The top mounted, covered unit was used on the LDT-465-1C, LDS-465-2 and late production models of the LD-465-1C and LDS-465-1A.

Table A-9 identifies the fuel injection pump assemblies used on the subject multi-fuel engines. Table A-10 illustrates the differences between the models (note that Table A-10 also lists the fuel pump model used on the previously discussed LDS-427-2 engine.)

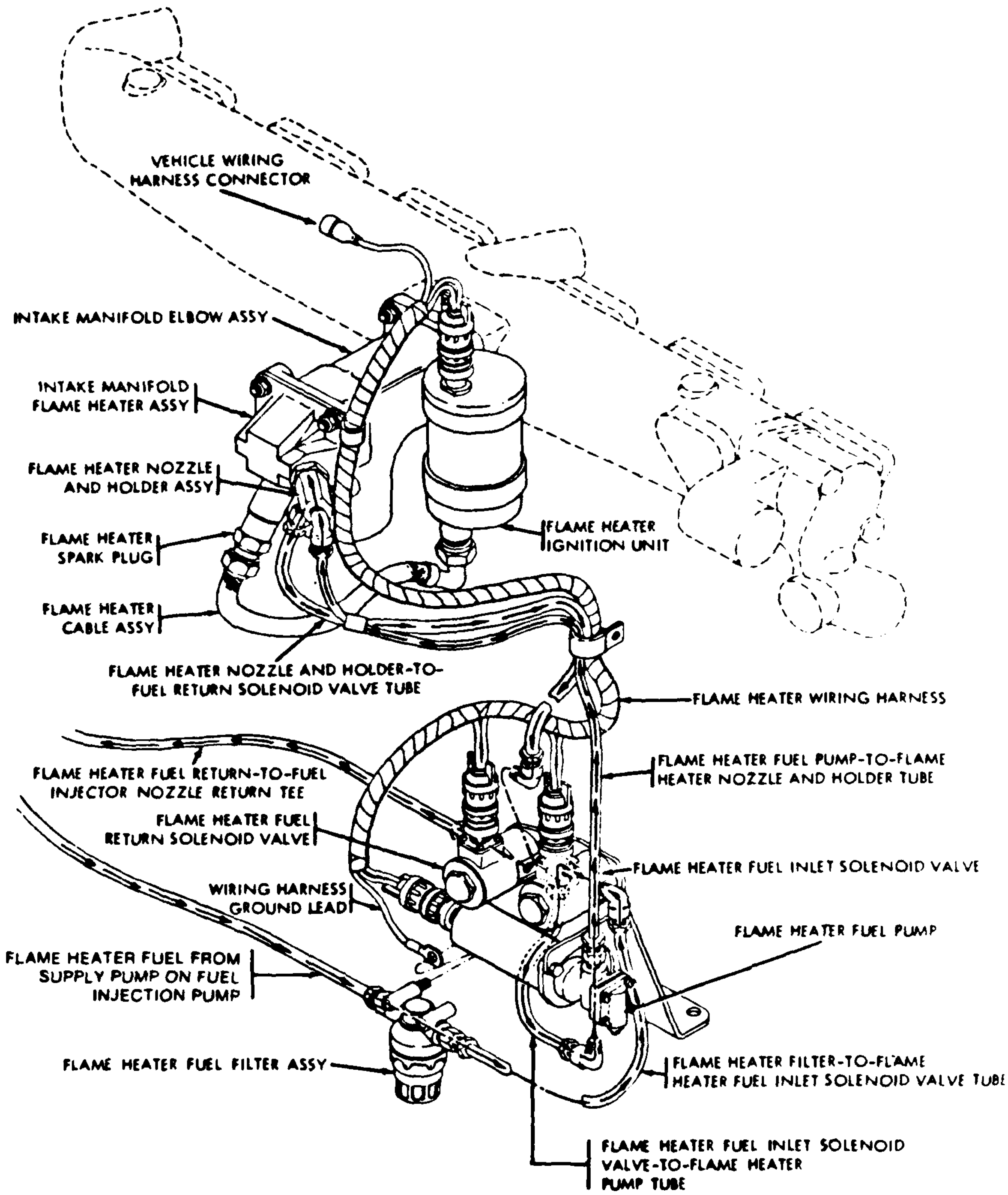


FIGURE A-4, THE FLAME HEATER FUEL SYSTEM FOR THE LDS-465-1 ENGINE - SIDE MOUNTED, SOLENOID CONTROLLED

Source: TM9-2815-210-34

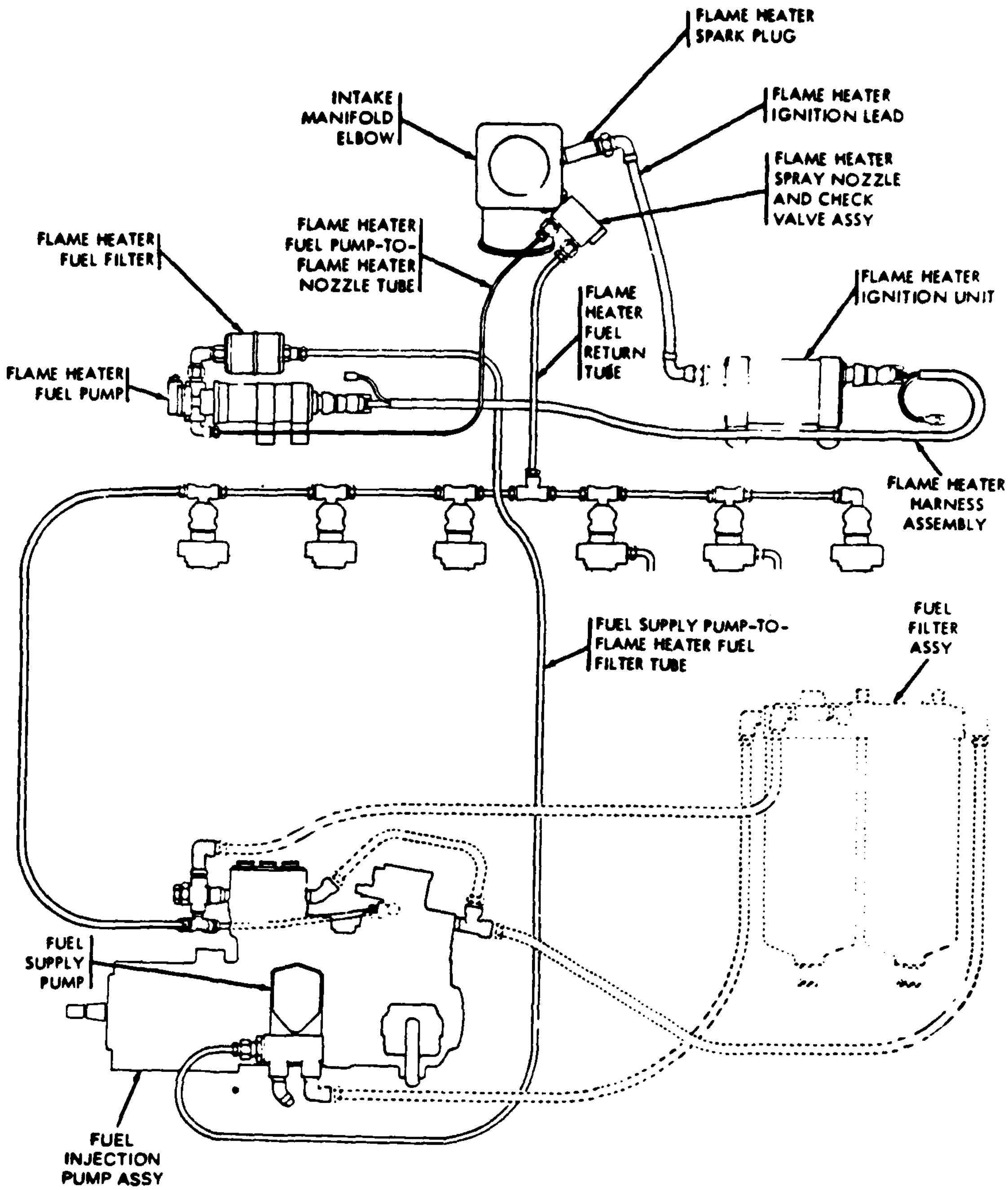


FIGURE A-5, THE FLAME HEATER FUEL SYSTEM FOR THE LD-465-1, LD-465-1C AND LDS-465-1A ENGINES - TOP MOUNTED, UNCOVERED
Source: TM9-2815-210-34

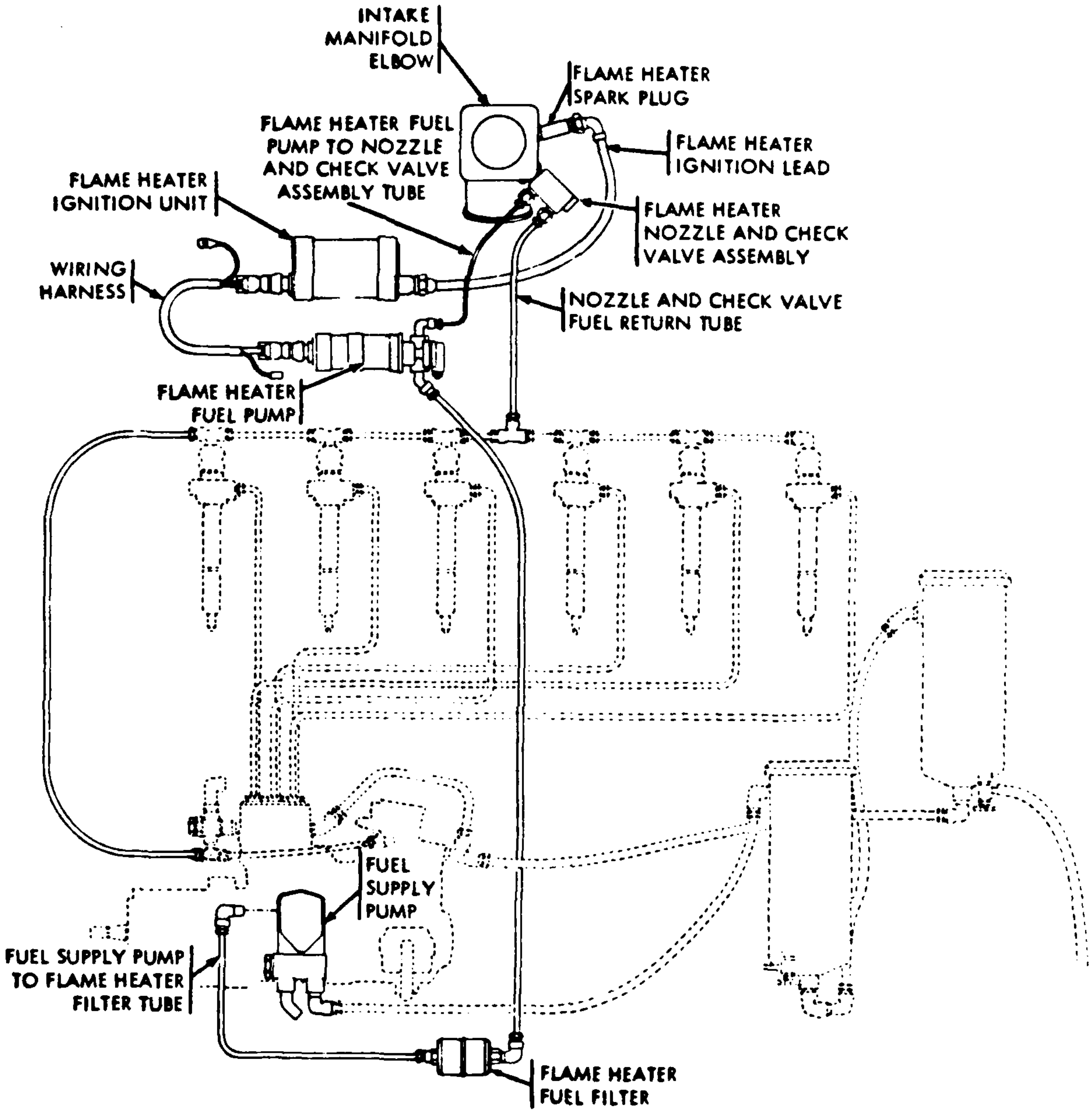


FIGURE A-6, THE FLAME HEATER FUEL SYSTEM FOR THE LDT-465-1C, LDS-465-2, LD-465-1C AND LDS-465-1A ENGINES - TOP MOUNTED, COVERED
Source: TM9-2815-210-34

TABLE A-9, IDENTIFICATION OF LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, AND LDS-465-2 FUEL INJECTION PUMP ASSEMBLIES

Engine Model	Vendor/Source	Part Number (Model Number)
LD-465-1 LD-465-1C LDT-465-1C	American Bosch	10935261* (PSB6A90EH5337A)
LDS-465-1	American Bosch	10935270 (PSB6A90EH5327B)
LDS-465-1A	American Bosch	1095116 (PSB6A90EH5828A)
LDS-465-2	American Bosch	11641906 (PSB6A90EH5371G)

*Some engine models had been assigned different part numbers to retain engine identity.

TABLE A-10, DIFFERENCES BETWEEN FUEL INJECTION PUMP ASSEMBLY MODELS FOR THE MULTI-FUEL ENGINES

Engine Mode / Port Description	LDS-465-2	LDS-465-1A	LD-465-1 & LD-465-1C	LDT-465-1C	LDS-465-1	LDS-427-2
Fuel Supply Pump With Fuel Pressure Relief Valve.	X				X	
Engine Mounted Fuel Filters After Fuel Supply Pump:						
• 2 Filters	X	X	X	X		X
• 1 Filter					X	
Fuel Density Compensator Type:						
• Diaphragm					X	
• Piston	X	X	X	X		
Fuel Line Type:						
• Hose					X	X
• Plastic Tubing	X	X	X	X	X	X
Oil Filter In Pump Housing					X	X
Throttle Operating Lever Type:						
• 1 Piece		X	X	X	X	X
• 2 Piece	X					

TABLE A-10, DIFFERENCES BETWEEN FUEL INJECTION PUMP ASSEMBLY MODELS FOR THE MULTI-FUEL ENGINES (Cont.)

Port Description / Engine Mode	LDS-465-2	LDS-465-1A	LD-465-1 & LD-465-1C	LDT-465-1C	LDS-465-1	LDS-427-2
Overflow Valve Body Orifice At Fuel Inlet Seal, Inside Diameter:						
• 0.280 (approx)	X	X	X	X		X
• 0.085 (approx)					X	
Fulcrum Lever Assembled With Low Speed Fuel Adjusting Setscrew (Droop Screw).	X	X		X	X	X
Governor Equipped With Torque Control Link For Automatic Transmission Application.	X					
Governor Housing Oil Drail To Oil Pan By External Hose.					X	
Fuel Shutoff Type:						
• Manual		X	X	X	X	X
• Electrical	X					
Throttle Lever Mounting Position:						
• Up	X					X
• Down		X	X	X	X	
Governor Speed Range:						
• 700-2600		X	X	X	X	
• 700-2800	X					
• 600-2800						X
• 800-2600				X		
Timing Device Spring Rates:						
• 69.0 lbs/in. (SP9041).		X			X	X
• 55.1 lbs/in. (SP9043).			X			
• 102.5 lbs/in. (SP857-3).	X					

Table A-11 identifies the fuel supply pumps used on the subject multi-fuel engines.

TABLE A-11, IDENTIFICATION OF LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, AND LDS-465-2 FUEL SUPPLY PUMPS*

Engine Model	Vendor/Source	Part Number (Model Number)
LD-465-1 LD-465-1C LDT-465-1C LDS-465-1A	American Bosch	10947558 (SGB25C25)*
LDS-465-1 LDS-465-2	American Bosch	10947153 (SGB25C23)

*The fuel supply pumps are part of the fuel injection pump assembly.

Table A-12 identifies the fuel injector nozzle and holder assemblies for the subject multi-fuel engines.

TABLE A-12, IDENTIFICATION OF LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, AND LDS-465-2 FUEL INJECTOR NOZZLE AND HOLDER ASSEMBLIES

Engine Model	Vendor/ Source	Nozzle and Holder Assembly Part Number	Nozzle Assembly Part Number
LD-465-1 LD-465-1C LDT-465-1C LDS-465-1	American Bosch	7748863	7748882
LDS-465-1A	American Bosch	10935284	10935272
LDS-465-2	American Bosch	11641806	11641889

Table A-13 identifies the primary fuel system fuel filters used on the multi-fuel engines.

TABLE A-13, IDENTIFICATION OF LD-465-1, LD-465-1C, LDT-465-1C, LDS-465-1, LDS-465-1A, AND LDS-465-2 PRIMARY FUEL SYSTEM FUEL FILTERS

Engine Model	Vendor/ Source	Part Number (Model Number)	Replacement Kit Part Number
LD-465-1 LD-465-1C LDT-465-1C LDS-465-1A	Purolator	11609954 (PR-161-4) 11610298*	5702776
LDS-465-1	Purolator	10935266 33435*	5702684
LDS-465-2	TACOM	11610297** 11610298*	5702776

*Element only.
**Unit contains two identical fuel filters (primary and secondary).

Table A-14 identifies the plastic fuel tubes and hoses used on the multi-fuel engines primary fuel system.

TABLE A-14, IDENTIFICATION OF HOSES AND PLASTIC TUBES FOR THE MULTI-FUEL ENGINES PRIMARY FUEL SYSTEM BY ENGINE MODEL

Engine Model	Tube Location	Part Number
LD-465-1 LD-465-1C LDT-465-1C LDS-465-1 LDS-465-1A LDS-465-2	No. 1 Cylinder Injector Nozzle Fuel Return Tee To Injection Pump Over-Flow Valve	11609976-9*
	Fuel Injector Nozzle Fuel Return, Cylinder No's. 1-2, 2-3, 4-5, and 5-6	11609976-1*
	Fuel Injector Nozzle Fuel Return, Cylinders 3 and 4	11609976-16*

*The plastic tubes are fabricated from tubing part number 11609976 (source is TACOM).
**The plastic tubes are fabricated from tubing part number 10861278 (source is TACOM).

TABLE A-14, IDENTIFICATION OF HOSES AND PLASTIC TUBES FOR THE MULTI-FUEL ENGINES PRIMARY FUEL SYSTEM BY ENGINE MODEL (Cont.)

Engine Model	Tube Location	Part Number
LD-465-1 LD-465-1C LDT-465-1C LDS-465-1 LDS-465-1A	Injection Overflow To Filter Inlet Tee	10951185-4**
	Fuel Supply Pump To Filter Inlet	10951185-6**
	Final Filter To Compensator	10951185-2**
LDS-465-1	Fuel Injector Nozzle Fuel Return, Cylinders No. 3 and 4	11609976-2*
	Fuel Filter Outlet To Compensator Inlet	10951185-11**
LDS-465-2	Primary Fuel Filter Outlet To Final Fuel Filter Inlet	10951185-6**
	Final Fuel Filter To Compensator	10951185-14**
	Fuel Supply Pump To Primary Fuel Filter	10951185-4**
LDS-465-1	Hose Assembly-Fuel Filter Outlet Elbow To Fuel Control Housing Inlet Tee	10935237-1
	Hose Assembly-Fuel Injection Supply Pump Outlet Elbow To Fuel Filter Inlet Elbow	10935237-2

*The plastic tubes are fabricated from tubing part number 11609976 (source is TACOM).

**The plastic tubes are fabricated from tubing part number 10861278 (source is TACOM).

Table A-15 identifies the critical fuel system components within the flame heater (cold-start) system for the subject multi-fuel engines.

TABLE A-15, IDENTIFICATION OF CRITICAL FLAME HEATER COMPONENTS FOR THE MULTI-FUEL ENGINES BY ENGINE MODEL

Engine Model	Component	Vendor/Source	Part Number
LD-465-1 LD-465-1C LDT-465-1C LDS-465-1 LDS-465-1A	Fuel Pump-Electric	Bendix-Scintilla Div.	10951192
	Fuel Filter Assembly	TACOM	10935646
	Flow Control Nozzle And Valve ● Nozzle Supply & Return Filters(2)	TACOM TACOM	11641827 11610365
	Plastic Tube-Flame Heater Nozzle Fuel Return	TACOM	11609976-8*
	Plastic Tube-Fuel Injector Supply Pump To Flame Heater Filter	TACOM	11609976-17*
	Plastic Tube-Flame Heater Fuel Pump To Flame Heater Nozzle	TACOM	11609977-4**
LD-465-1C LDT-365-1C LDS-465-1 LDS-465-1A LDS-465-2	Fuel Pump-Electric	Bendix-Scintilla Div.	10951192
	Fuel Filter Assembly	TACOM	10935646
	Flow Control Nozzle And Valve ● Nozzle Supply & Return Filters(2)	TACOM TACOM	11641827 11610365
	Plastic Tube-Flame Heater Fuel Pump To Flame Heater Nozzle	TACOM	11609977-7**
	Plastic Tube-Flame Heater Fuel Pump To Flame Heater Nozzle	TACOM	11609977-6**

*The plastic tubes are fabricated from tubing part number 11609976 (source is TACOM).

**The plastic tubes are fabricated from tubing part number 11609977.

TABLE A-15, IDENTIFICATION OF CRITICAL FLAME HEATER COMPONENTS FOR THE MULTI-FUEL ENGINES BY ENGINE MODEL (Cont.)

Engine Model	Component	Vendor/Source	Part Number
(Cont. - LD-465-1C LDT-465-1C LDS-465-1 LDS-465-1A LDS-465-2	Plastic Tube-Flame Heater Fuel Nozzle Fuel Return To Cylinder Nos. 3&4 Injector Nozzle Fuel Return Tee	TACOM	11609976-7*
	Plastic Tube-Flame Heater Fuel Nozzle Return To Cylinder Nos. 3&4 Injector Nozzle Fuel Return Tee	TACOM	11609976-24*
	Plastic Tube-Flame Heater Fuel Filter To Flame Heater Pump	TACOM	11609976-23*
	Plastic Tube-Flame Heater Fuel Filter To Flame Heater Pump	TACOM	11609976-25*
	Plastic Tube-Fuel Injector Supply Pump To Flame Heater Fuel Filter	TACOM	11609976-26
	Plastic Tube-Fuel Injector Supply Pump To Flame Heater Fuel Filter	TACOM	11609976-5
	Plastic Tube-Fuel Injector Supply Pump To Flame Heater Fuel Filter	TACOM	11609976-6
LDS-465-1	Fuel Pump-Electric	Bendix-Scintilla Div.	7748874
	Fuel Filter Assembly ● Element	Military Standard Bendix-Filter Div.	MS51085-1 A26422

*The plastic tubes are fabricated from tubing part number 11609976 (source is TACOM).

**The plastic tubes are fabricated from tubing part number 11609977.

TABLE A-15, IDENTIFICATION OF CRITICAL FLAME HEATER COMPONENTS FOR THE MULTI-FUEL ENGINES BY ENGINE MODEL (Cont.)

Engine Model	Component	Vendor/Source	Part Number
(Cont. LDS-465-1)	Flow Control Nozzle and Valve • Nozzle Supply & Return Filters(2)	TACOM TACOM	11641827 11610365
	Solenoid Valves (2)	TACOM	7062194
	Plastic Tube-Flame Heater Fuel Return To Solenoid Valve	TACOM	11609976-9*
	Plastic Tube-Flame Heater Fuel Supply Solenoid Valve To Flame Heater Fuel Supply Pump	TACOM	11609976-3*
	Plastic Tube-Flame Heater Fuel Return Solenoid Valve To Fuel Injector Nozzle Return Tube Tee	TACOM	11609976-11*
	Plastic Tube-Fuel Injector Pump To Flame Heater Fuel Filter	TACOM	11609976-14*
	Plastic Tube-Flame Heater Fuel Filter To Solenoid Valve	TACOM	11609976-4*
	Plastic Tube-Flame Heater Fuel Pump To Flame Heater Nozzle	TACOM	11609977-3**

*The plastic tubes are fabricated from tubing part number 11609976 (source is TACOM).

**The plastic tubes are fabricated from tubing part number 11609977.

3. The LDS-427-2 Multi-Fuel Engine

a. Powerplant Characteristics

The LDS-427-2 "Multi-fuel" engines are four-stroke cycle, in-line, six-cylinder, overhead valve, turbosupercharged, and liquid cooled. Selected engine characteristics and performance data are shown in Table A-16.

TABLE A-16, SELECTED LDS-427-2 ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	427 in^3
Weight, Dry (With Accessories)	1500 lb
Compression Ratio	20:1
Horsepower, Net (Less Accessories) Diesel Fuel (VV-F-800) CI Fuel (MIL-F-45121) Gasoline (MIL-G-3056)	 130 hp at 2600 rpm 118 hp at 2600 rpm 103 hp at 2600 rpm
Torque, Net (Less Accessories) Diesel Fuel (VV-F-800) CI Fuel (MIL-F-45121) Gasoline (MIL-G-3056)	 340 lb-ft at 1400 rpm 310 lb-ft at 1400 rpm 290 lb-ft at 1400 rpm
Speed Governed, Full Load Governed, No Load Idle	 2600 to 2650 rpm 2750 to 2850 rpm 650 to 700 rpm
Bore	4.31 in
Stroke	4.87 in
Fuel	Diesel Fuel (VV-F-800) Compression Ignition (MIL-F-46005) Gasoline* (MIL-G-3056)

*High octane gasoline is not usable.

b. Engine/Vehicle Matches

Table A-17 shows the M-Series vehicles (as indicated by TACOM) which contain Teledyne-Continental-Motors-built LDS-427-2 "multi-fuel" engines. The LDS-427-2 is no longer built, but vehicles with these engines are suspected to still be in the current fleet.

TABLE A-17, THE LDS-427-2 ENGINE MATCHED
TO M-SERIES VEHICLES*

Engine Model	M-Series Vehicle Designation
LDS-427-2	M35A1,M44A1,M45A1,M46A1, M46A1C,M49A1C,M50A1,M109A2, M185A2,M275A1,M292A1, M292A4

*The listed vehicles are all 2-1/2 ton trucks known collectively as the M44A1 series.

c. Fuel System Components Identification

Figure A-7 shows a schematic of the main fuel system. Figure A-8 shows a schematic of the manifold air induction heater system. Table A-18 lists the vendor(s) or source of supply for the primary fuel system components and their respective part or model designation. Table A-19 identifies the fuel system hoses and plastic lines.

TABLE A-18, IDENTIFICATION OF LDS-427-2
PRIMARY FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Injection Pump Assembly • Early Model(G) • Late Model(G) • Rebuild Model(G)	American Bosch	• 7748899 (PSB-6A) • 10935295(PSB6A85EH5250D) • 11640900
Fuel Supply Pump*		7748851(SGB25C15)
Fuel Injector Nozzle Assembly		7748863(KT-7824)
Primary Fuel Filter/ Secondary Fuel Filter (Units Are Identical)	Purolator	11609954(PR-161-4)
Primary & Secondary Fuel Filter Parts Kit	TACOM	5702776
Flame Heater Assembly (Sparkplug, Nozzle, etc.)	Bendix-Scintilla Div.	7748871(10-187565-6)

*An integral component of the fuel injection pump assembly.

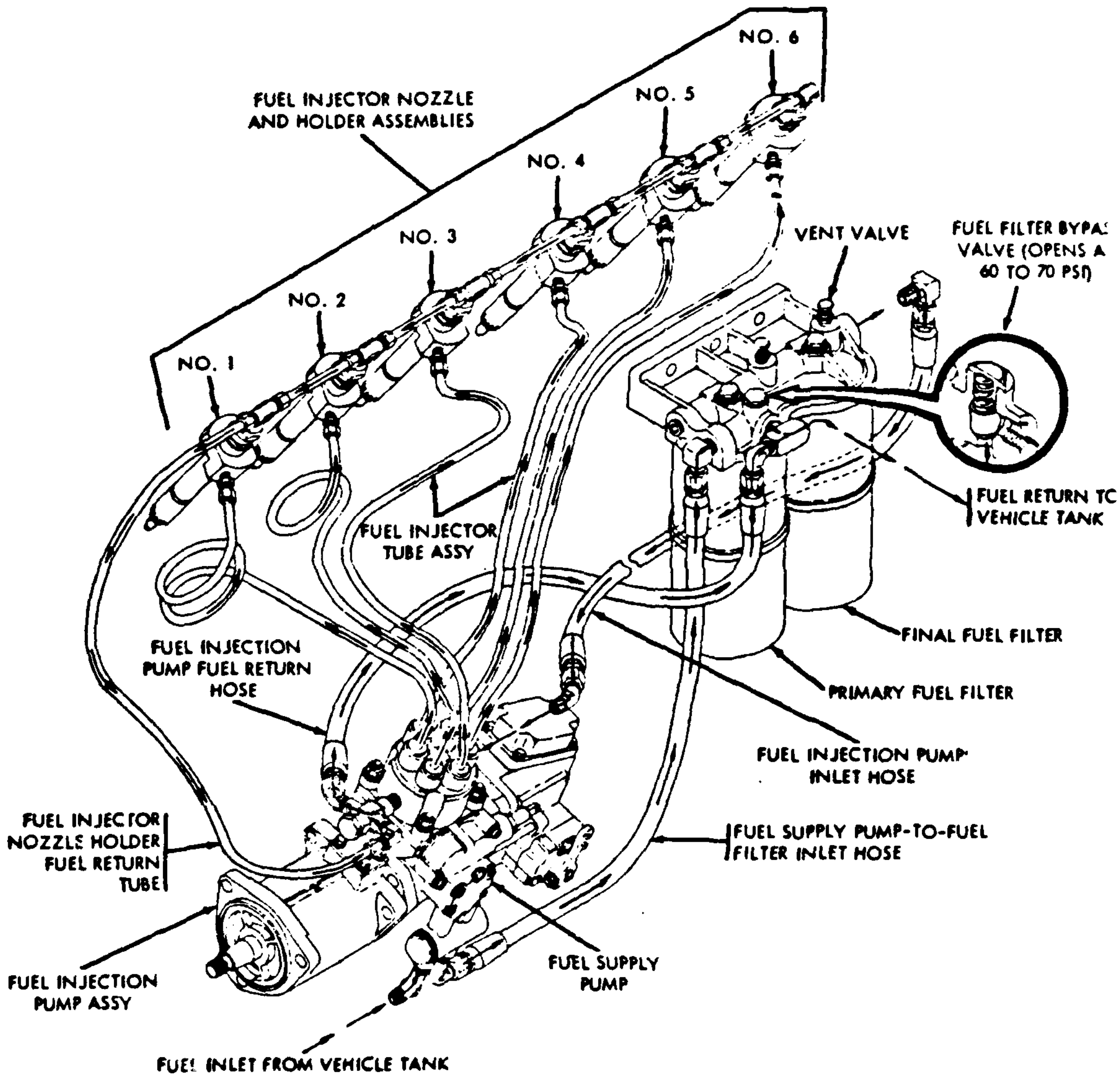


FIGURE A-7, THE LDS-427-2 PRIMARY FUEL SYSTEM

Source: TM9-2815-204-35

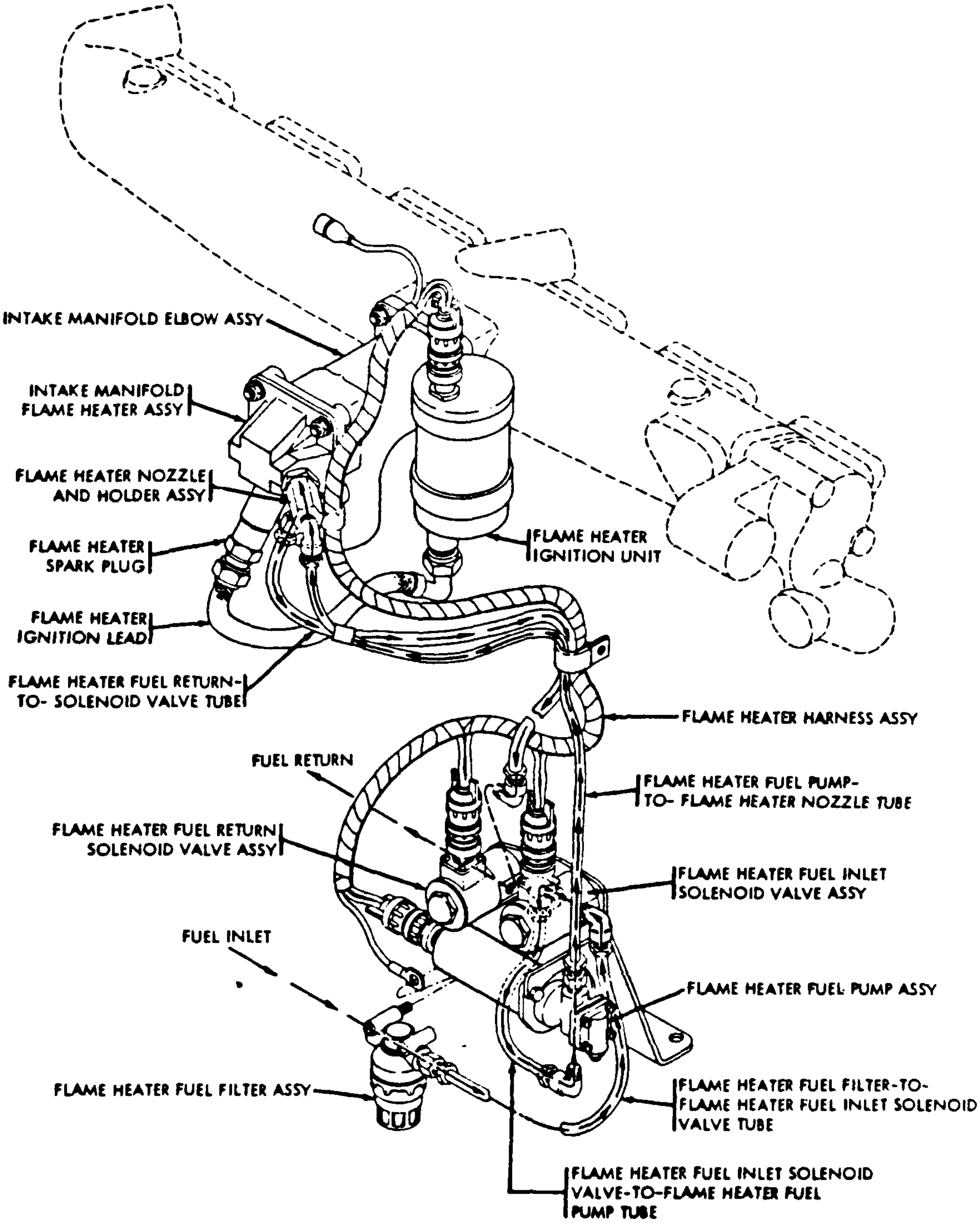


FIGURE A-8, THE LDS-427-2 FLAME HEATER
FUEL SYSTEM
Source: TM9-2815-204-35

TABLE A-18, IDENTIFICATION OF LSD-427-2
PRIMARY FUEL SYSTEM COMPONENTS (Cont.)

Component	Vendor/Source	Part Number (Model Number)
Flame Heater Fuel Pump (Electric)	Bendix-Scintilla Div.	10951192(10-207317)
Flame Heater Solenoid Valves(2)	TACOM	7062194
Flame Heater Fuel Filter Assembly	Military Standard	MS51085-1

*An integral component of the fuel injection pump assembly.

TABLE A-19, IDENTIFICATION OF LDS-427-2
FUEL SYSTEM HOSES AND PLASTIC TUBES

Hose/Tube Location	Vendor/Source	Part Number
Hose Assembly-Fuel Pump To Fuel Filter Inlet	TACOM	10912422
Hose Assembly-Fuel Injection Supply To Filter Outlet And Pump Overflow And Fuel Return To Filter Outlet	TACOM	10912422-1
Plastic Tube-Fuel Return To Injection Pump Overflow Valve (27")	TACOM	11609976*
Plastic Tube-Fuel Return, 4 Lines (5")	TACOM	11609976*
Plastic Tube-Fuel Return (5-3/8")	TACOM	11609976*
Plastic Tube-Injection Overflow To Filter Inlet Tee (3")	TACOM	10861278*
Plastic Tube-Fuel Supply Pump To Filter Inlet (26")	TACOM	10861278*

*The plastic tubes described are fabricated from tubing of the listed part number.

TABLE A-19, IDENTIFICATION OF LDS-427-2 FUEL SYSTEM HOSES AND PLASTIC TUBES (Cont.)

Hose/Tube Location	Vendor/Source	Part Number
Plastic Tube-Final To Compensator (27-1/2")	TACOM	10861278*
Plastic Tube-Flame Heater Pump To Nozzle (27")	TACOM	11609977*
Plastic Tube-Flame Heater Solenoid To Pump (6-3/4")	TACOM	11609976*
Plastic Tube-Flame Heater Filter To Valve (7-1/2")	TACOM	11609976*
Plastic Tube-Flame Heater Fuel Return To Valve (27")	TACOM	11609976*
Plastic Tube-Flame Heater Nozzle Fuel Return (23")	TACOM	11609976*
Plastic Tube-Flame Heater Pump Supply To Filter (48-1/2")	TACOM	11609976*
Plastic Tube-Flame Heater Pump To Heater Nozzle (23")	TACOM	11609977*

*The plastic tubes described are fabricated from tubing of the listed part number.

C. COMMERCIALLY DESIGNED ENGINES

1. The 3-53: Detroit Diesel Allison (DDA)

a. Powerplant Characteristics

The DDA 3-53 engines are three-cylinder, in-line, two-stroke cycle, and water cooled. Air for scavenging and combustion is supplied through an air cleaner by a blower. Selected engine characteristics and performance data are shown in Table A-20.

TABLE A-20, SELECTED DDA 3-53 ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	159 in^3
Compression ratio	21:1
Horsepower, gross	90 to 98 bhp at 2800 rpm
Torque, gross	190 lb-ft at 1750 rpm (min)
Speed	
Governed, full load	2785 to 2835 rpm
Governed, no load	2940 to 2990 rpm
Idle	575 to 625 rpm
Bore	3.875 in.
Stroke	4.5 in.
Fuel	VV-F-800, Grade DF-2

b. Engine/Vehicle Matches

Table A-21 shows the M-Series vehicles which contain the DDA-3-53 engine.

TABLE A-21, THE DDA 3-53 ENGINE MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
3-53	M561, M792

c. Fuel System Component Identification

Figure A-9 shows a schematic of the primary fuel system. The schematic is also typical of the primary fuel systems for the

DDA designed engines to be discussed subsequently. Table A-22 lists the vendor or source of supply for the primary fuel system components and their respective part numbers and/or model designations. Table A-23 identifies the fuel system hoses.

TABLE 22, IDENTIFICATION OF DDA 3-53 FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Injector Assembly	Detroit Diesel Allison	5228783 (N31)
Filter element within fuel injector body assembly (also part of parts kit Part No. 5228701)	TACOM	5247880
Fuel Supply Pump Assembly	Detroit Diesel Allison	5199560
Primary Fuel Filter ● filter element	Detroit Diesel Allison	5575824 ● 5575032
Secondary Fuel Filter ● filter element	Detroit Diesel Allison	5574533 ● 5574508
Fuel Filter Assembly ● filter element	Military Standard ● TACOM	MS51085-1 ● 8328647
Flame Heater Fuel Pump Assembly	Detroit Diesel Allison	5142748
Flame Heater Fuel Nozzle Assembly	Detroit Diesel Allison	5232519
Flame Heater Fuel Filter Assembly	Detroit Diesel Allison	5140410
Flame Heater Fuel Solenoid Valve, Supply Pump Shut-off	TACOM	7062194
Fuel Pump - Fuel Tank, Electric	Military Standard	MS51321-2

TABLE A-23, IDENTIFICATION OF DDA 3-53 FUEL SYSTEM HOSES

Hose Description	Vendor/Source	Part Number
Hose Assembly - Filter to Pump Bracket	TACOM	11595166-1
Hose Assembly - Tractor to Carrier Ambulance, Fuel Line	TACOM	11660051-1
Hose - Flame Heater	Detroit Diesel Allison	5120970
Hose - Flame Heater Pump	Detroit Diesel Allison	5145666

2. THE 6V-53 AND 6V-53T: DETROIT DIESEL ALLISON (DDA)

a. Powerplant Characteristics

The 6V-53 and 6V-53T engines are six-cylinder, V-type, 2-stroke cycle and liquid cooled. The 6V-53 incorporates a blower to provide scavenging air and the 6V-53T is turbocharged. Table A-24 presents selected engine characteristics and performance data.

TABLE A-24, SELECTED DDA 6V-53 AND 6V-53T ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	318 in^3
Compression ratio	
6V53	21:1
6V53T	17.5:1
Horsepower, Gross	
6V53	210 hp at 2800 rpm
6V53T	300 hp at 2800 rpm
Torque, Gross	
6V53	420 lb-ft at 1600 rpm (min)
6V53T	556 lb-ft at 2200 rpm (min)
Speed	
Governed, full load	2800 rpm
Governed, no load	2950 to 3000 rpm
Idle	550 to 600 rpm

TABLE A-24, SELECTED DDA 6V-53 AND 6V-53T ENGINE CHARACTERISTICS AND PERFORMANCE DATA (CONT.)

Bore	3.875 in.
Stroke	4.5 in.
Fuel	VV-F-800

b. Engine/Vehicle Matches

Table A-25 shows the M-Series vehicles which contain the DDA 6V-53 or 6V-53T engines.

TABLE A-25, THE DDA 6V-53 AND 6V-53T ENGINES MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
6V-53	M106A1, M113A1, M125A1, M132A1, M548, M577A1, M667, XM727, M730, M741, XM806E1
6V-53T	M551, M551A1

c. Fuel System Component Identification

The fuel system for each engine is similar to that shown for the DDA 3-53 (Figure A-9). Table A-26 lists, for each engine, the vendor or source of supply for the primary fuel system components and their respective part number and/or model designation. Differences between engine models are noted. Table A-27 identifies the fuel system components for the flame heater unit equipped with an accumulator, and Table A-28 presents similar information for the flame heater unit equipped with an air pump. The primary difference between the accumulator and air pump configurations is that the air pump replaces the accumulator, hand pump, and pressure gage. Figures A-10 and A-11 illustrate the two systems.

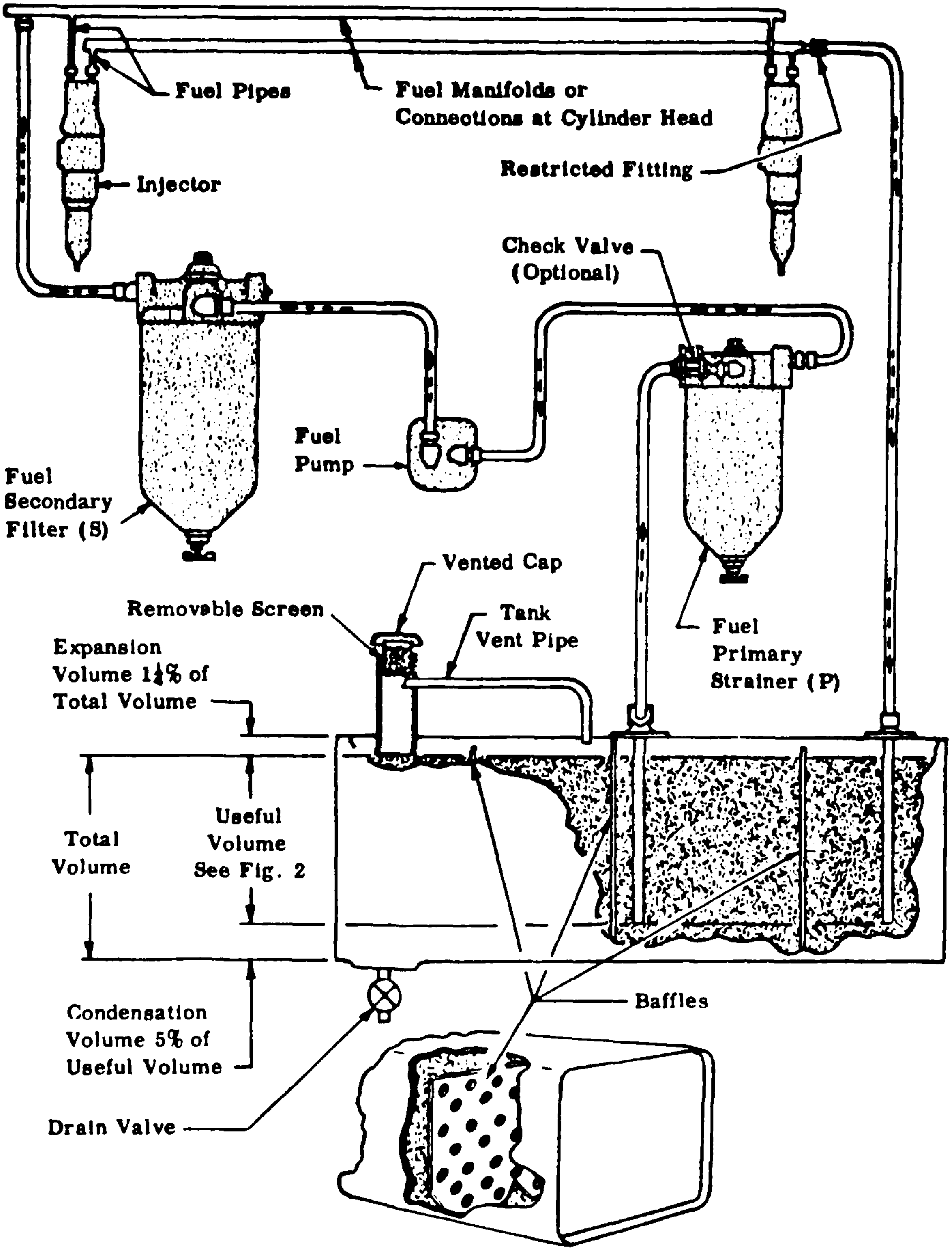


FIGURE A-9, A TYPICAL DETROIT DIESEL ALLISON PRIMARY FUEL SYSTEM SCHEMATIC
Source: Detroit Diesel Allison, Engineering Bulletin No. 21

TABLE A-26, IDENTIFICATION OF DDA 6V-53 AND 6V-53T FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Injector Assembly ● 6V53 ● 6V53T	Detroit Diesel Allison	● 5228774(M50) ● 5228770(N70)
Filter Element within Fuel Injector Body Assembly (Also Part of Parts Kit Part No. 5228701)	Detroit Deisel Allison	5228587
Fuel Supply Pump Assembly	Detroit Diesel Allison	5198876
Primary Fuel Filter ● Filter Element	AC Div. of GMC	5575824 ● 5575032
Secondary Fuel Filter ● Filter Element	AC Div. of GMC	5574533 ● 5574508

TABLE A-27, IDENTIFICATION OF COMPONENTS FOR THE ACCUMULATOR TYPE FLAME HEATER FUEL SYSTEM: 6V-53 AND 6V-53T ENGINES

Component	Vendor/Source	Part Number
Accumulator	Detroit Diesel Allison	5132524
Hand Pump	Detroit Diesel Allison	5110760
Fuel Nozzle ● Filter Strainer Element*	Detroit Diesel Allison	5232195 ● 5228373
Fuel Solenoid Valve	Honeywell, Inc. - Skinner Valve Div.	5132525

*Within Air Box Assembly

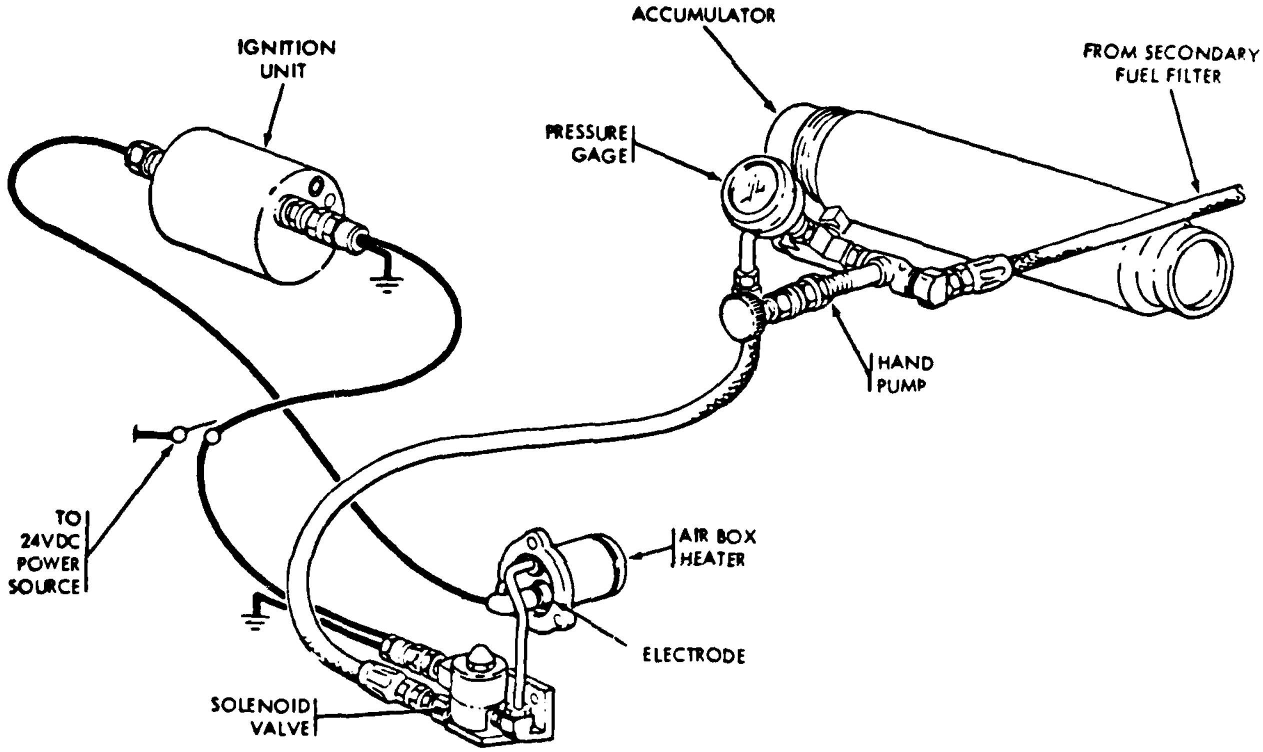


FIGURE A-10, THE ACCUMULATOR-TYPE FLAME HEATER FUEL SYSTEM FOR THE DDA 6V-53 AND 6V-53T ENGINES

Source: TM9-2815-205-34

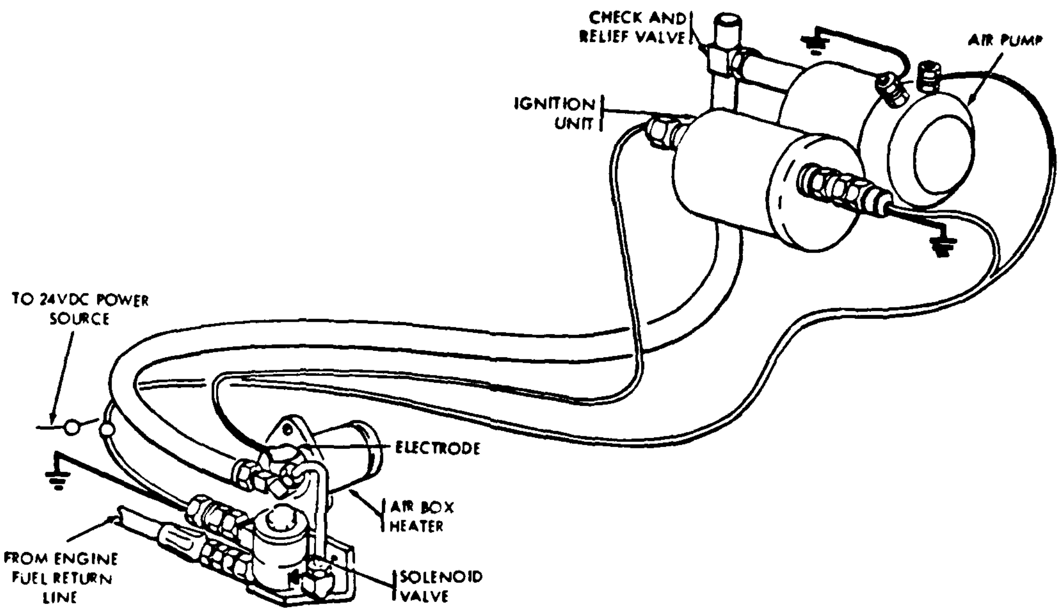


FIGURE A-11, THE AIR-PUMP-TYPE FLAME HEATER FUEL SYSTEM FOR THE 6V-53 AND 6V-53T ENGINES

Source: TM9-2815-205-34

TABLE A-28, IDENTIFICATION OF COMPONENTS FOR THE AIR PUMP-TYPE FLAME HEATER FUEL SYSTEM: 6V-53 AND 6V-53T ENGINES

Component	Vendor/Source	Part Number
Fuel Pump Assembly	Detroit Diesel Allison	5142748
Fuel Nozzle	Detroit Diesel Allison	5232650
Fuel Solenoid Valve	Honeywell, Inc. - Skinner Valve Div.	5132525

Table A-29 identifies the fuel system hoses used on the 6V-53 and 6V-53T engines.

TABLE A-29, IDENTIFICATION OF 6V-53 AND 6V-53T FUEL SYSTEM HOSES

Hose Description	Vendor/Source	Part Number
Hose Assembly - Fuel Inlet	Detroit Diesel Allison	5131375
Hose Assembly - Fuel Inlet, Cylinder Head, Left Bank	Detroit Diesel Allison	5131517
Hose Assembly - Fuel Pump to Filter	Detroit Diesel Allison	5131507 (Fabricate From 5131311)
Hose Assembly - Fuel Strainer to Pump	Detroit Diesel Allison	5142003
Hose Assembly · Fuel Filter to Cylinder Head, Right Bank	Detroit Diesel Allison	5131576
Hose Assembly - Valve to Fuel Pump, Return Tube (Flame Heater)	Detroit Diesel Allison	5147883
Hose - Accumulator to Valve (Flame Heater w/Accumulator)	Detroit Diesel Allison	5132614

TABLE A-29, IDENTIFICATION OF 6V-53 AND 6V-53T FUEL SYSTEM HOSES (CONT.)

Hose Description	Vendor/Source	Part Number
Hose Assembly - Pump Inlet (Flame Heater w/Accumulator)	Detroit Diesel Allison	5132612
Hose Assembly - Pump to Accumulator (Flame Heater w/Accumulator)	Detroit Diesel Allison	5132599

3. The 8V-71T: Detroit Diesel Allison (DDA)

a. Powerplant Characteristics

The 8V-71T engines are eight cylinder, V-type, two-stroke cycle, liquid cooled, and turbocharged. Table A-30 presents selected engine characteristics and performance data. Two models are in use, 7083-7398 and 7083-7399; the differences are slight and will be noted where appropriate.

TABLE A-30, SELECTED 8V-71T ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	567.4 in^3
Compression ratio	17:1
Horsepower, Net	345 bhp at 2300 rpm
Speed Idle: Dual Range Governor Single Range Governer Full Load: Dual Range Governor Single Range Governor	 550 to 600 rpm 550 to 600 rpm 1200 to 2300 rpm 2300 rpm
Bore	4.25 in.
Stroke	5.0 in.
Fuel	VV-F-800, Grade 2-D

b. Engine/Vehicle Matches

Table A-31 shows the M-Series vehicles which contain the DDA 8V-71T engine.

TABLE A-31, THE 8V-71T ENGINE MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
8V-71T	M108, M109, M109A1, M109A2, M109A3, M110, M110A1, M110A2, M578

c. Fuel System Component Identification

The fuel system for the 8V-71T is similar to that shown for the 3-53 (Figure A-9). Table A-32 lists the vendor or source of supply for the fuel system components (including the flame heater system) and their respective part numbers and/or model designations. The flame heater fuel system is shown in Figure A-12. Table A-33 identifies the 8V-71T fuel system hoses.

TABLE A-32, IDENTIFICATION OF 8V-71T FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Injector Assembly	Diesel Equipment Division of GMC	5228524 (S80)
Filter Element Within Fuel Injector Body Assembly (Part of Parts Kit)	Detroit Diesel Engine Division of GMC	5228587
Fuel Supply Pump Assembly	Detroit Diesel (Engine Division of GMC)	5100305
Primary Fuel Filter ● Filter Element	AC Division of GMC	5575824 ● 5575032
Secondary Fuel Filter ● Filter Element	AC Division of GMC ● AC Division of GMC	5574533 ● 5574508
Flame Heater Fuel Pump	John S. Barnes	10921624

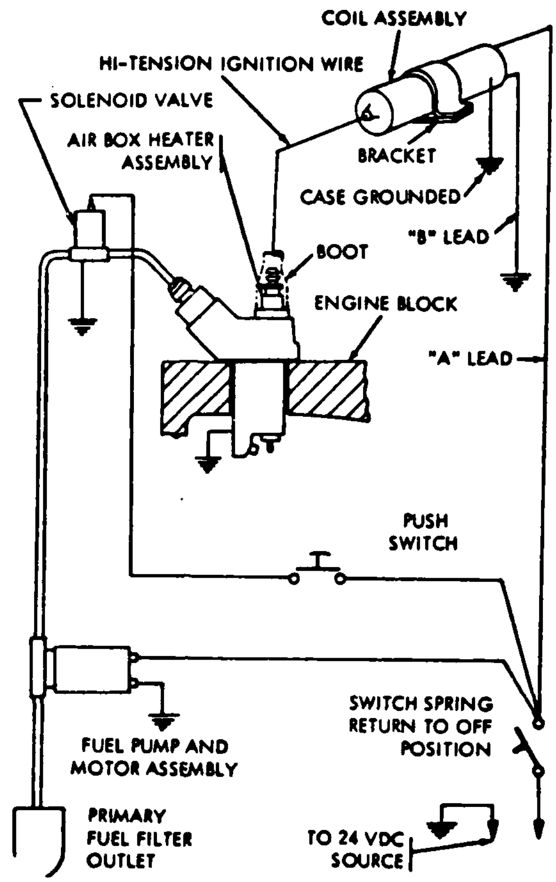


FIGURE A-12, THE FLAME HEATER FUEL (AND ELECTRICAL) SYSTEM FOR THE 8V-71T ENGINE
Source: TM9-2815-202-34

TABLE A-32, IDENTIFICATION OF 8V-71T FUEL SYSTEM COMPONENTS (CONT.)

Component	Vendor/Source	Part Number (Model Number)
Flame Heater Fuel Nozzle ● Filter Element (Within Air Box Assembly)	Detroit Diesel Engine Division of GMC ● TACOM	5232195 ● 5247880
Flame Heater Fuel Solenoid Valve	General Controls	10914604

TABLE A-33, IDENTIFICATION OF 8V-71T FUEL SYSTEM HOSES

Hose Description	Vendor/Source	Part Number
Hose Assembly, Rubber-Fuel Drain Crossover*	Detroit Diesel Engine Division	5130695
Hose Assembly, Rubber-Fuel Drain Crossover*	Detroit Diesel Engine Division	5130696
Hose Assembly - Fuel Drain Crossover*	Detroit Diesel Engine Division	5130691
Hose Assembly - Fuel Drain Crossover*	Detroit Diesel Engine Division	5130688
Hose Assembly, Rubber-Strainer to Fuel Pump**	Detroit Diesel Engine Division	5130687
Hose Assembly - Filter to Cylinder Head**	Detroit Diesel Engine Division	5130689
Hose Assembly - Fuel Pump to Filter*	Detroit Diesel Engine Division	5130690
Hose Assembly, Rubber-Flame Heater Pump Inlet	Detroit Diesel Engine Division	5131576

* 8V-71T Model 7083-7399
** 8V-71T Model 7083-7398

4. The 12V-71T: Detroit Diesel Allison (DDA)

a. Powerplant Characteristics

The 12V-71T engines are twelve cylinder, V-type, two-stroke cycle, liquid cooled and turbocharged. Table A-34 presents selected engine characteristics and performance data.

TABLE A-34, SELECTED 12V-71T ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	852 $in.^3$
Compression ratio	17:1
Horsepower, Gross	600 bhp at 2500 rpm
Torque, Gross	1470 lb-ft at 1600 rpm
Speed full load w/apply pressure* no load w/apply pressure* full load without no load without	 2475 to 2525 rpm 2650 to 2700 rpm 1500 rpm 1700 rpm
Bore	4.25 in
Stroke	5.0 in
Fuel	VV-F-800, Grade 2-D

*With a hydraulic pressure of 200 psi applied to the governor.

b. Engine/Vehicle Matches

Table A-35 shows the M-Series vehicles which contain the 12V-71T engine.

TABLE A-35, THE 12V-71T ENGINE MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
12V-71T	M746

c. Fuel System Component Identification

Table A-36 lists the vendor or source of supply for the fuel system components. Table A-37 identifies the fuel system hoses.

TABLE A-36, IDENTIFICATION OF 12V-71T FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Injector Assembly	Detroit Diesel Engine Division	5228780 (N80)
Filter Element Within Fuel Injector Body Assembly (Also Part of Parts Kit, Part No. 5228701)	Detroit Diesel Engine Division	5228587
Fuel Supply Pump Assembly	Detroit Diesel Engine Division	5146699
Fuel Filter ● Filter Element	AC Division of GMC ● GMC	6436947 (T75) ● 6436719
Fuel Strainer ● Filter Element	AC Division of GMC ● Detroit Diesel Engine Division	6438799 ● 5574980

TABLE A-37, IDENTIFICATION OF 12V-71T FUEL SYSTEM HOSES

Hose Description	Vendor/Source	Part Number
Hose - Filter Outlet to Right Bank Head	Detroit Diesel Engine Division	5136633
Hose - Pump Outlet to Filter Inlet	Detroit Diesel Engine Division	5143620
Hose - Fuel Strainer to Pump Inlet	Detroit Diesel Engine Division	5134436
Hose - Crossover	Detroit Diesel Engine Division	5133168
Hose - Front Filter Outlet to Left Bank Fuel Inlet	Detroit Diesel Engine Division	5143623

5. The 8V-92 and 8V-92TA: Detroit Deisel Allison (DDA)

a. Powerplant Characteristics

The 8V-92T and 8V-92TA engines are eight cylinder, V-type, two-stroke cycle, liquid cooled and turbocharged. The TA model has an aftercooler. Table A-38 presents selected engine characteristics and performance data.

TABLE A-38, SELECTED 8V-92T AND 8V-92TA ENGINE CHARACTERISTICS AND PERFORMANCE DATA*

Displacement	736 in^3
Compression, Ratio	17:1
Horsepower	430 hp at 2100 rpm
Speed Full Load Idle	 2100 rpm 600 rpm
Bore	4.84 in
Stroke	5.0 in
Weight, day	2,345 lb.

*There is a slight change in performance between models because the aftercooler allows for a slightly greater quantity of fuel to be consumed.

b. Engine/Vehicle Matches

Table A-39 shows the M-Series vehicles which contain the 8V-92T engine. The first 100 M911 vehicles built had the 8V-92T, the rest incorporate the 8V-92TA. Differences between models are slight.

TABLE A-39, THE 8V-92T AND 8V-92TA ENGINES MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
8V-92	M911*
8V-92TA	M911, M977**, M985**, M978**, M983**, M984

*The first 100 vehicles produced had the noted engine.

**Vehicles are not yet built; scheduled for early 1982 introduction.

c. Fuel System Component Identification

Table A-40 lists the vendor or source of supply and the corresponding part or model designations for the fuel system components. Future versions of the 8V-9TA may incorporate a flame heater system (a development program is under way).

TABLE A-40, IDENTIFICATION OF 8V-92T AND 8V-92TA FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Injector Assembly	Detroit Diesel Engine Division	5229400 (9280)
Filter Element Within Fuel Injector Body Assembly (Also Part of Parts Kit Part No. 5228701)	Detroit Diesel Engine Division	5228587
Fuel Supply Pump Assembly ● Pump Repair Kit	Detroit Diesel Engine Division	5199735 ● 5199560
Fuel Filter Assembly ● Filter Element	AC Division of GMC	6436957 (T75) ● 6436719
Fuel Strainer Assembly ● Filter Element	AC Division of GMC	6438799 ● 5574980

TABLE A-40, IDENTIFICATION OF 8V-92T AND 8V-92TA FUEL SYSTEM COMPONENTS (CONT.)

Component	Vendor/Source	Part Number (Model Number)
Spin-On Fuel Filter Assembly*	AC Division of GMC	25010778
Spin-On Fuel Strainer Assembly*	AC Division of GMC	25010776

*Is found on some engines in place of the "replaceable" type units.

6. The V8-300: Cummins Engine Company

a. Powerplant Characteristics

The V8-300 engines are eight cylinder, four-stroke cycle, V-type and liquid cooled. Table A-41 presents selected engine characteristics and performance data.

TABLE A-41, SELECTED V8-300 ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	785 in^3
Weight, dry	2250 lb.
Compression ratio	17:1
Horsepower, Gross	300 hp at 3000 rpm
Speed Governed, no load	3000 - 3300 rpm 650 rpm

b. Engine/Vehicle Matches

Table A-42 shows the M-Series vehicles which contain the V8-300 engine.

TABLE A-42, THE V-8-300 ENGINE MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
V8-300	M123A1C, M123E2

c. Fuel System Component Identification

Table A-43 lists the vendor or source of supply for the fuel system components.

TABLE A-43, IDENTIFICATION OF V8-300 FUEL SYSTEM COMPONENTS

Components	Vendor/Source	Part Number (Model Number)
Fuel Injector Assembly ● Plunger Body Screen	Cummins Engine Company Defense Products ● Cummins Engine Company	BM97421 (PTC) ● 136042
Fuel Pump Assembly ● Filter Element Within Pump Assembly	Cummins Engine Company Defense Products ● Cummins Engine Company	BM97400 AR50828 (PTG) ● 146483
Fuel Supply Pump*	Cummins Engine Company Defense Products	AR50101
Fuel Solenoid Valve*	Cummins Engine Company Defense Products	BM69979
Triple Stage Fuel Filter ● Filter Element (2) ● Fuel Strainer (1)	TACOM ● GMC ● Cummins Engine Company	10947525 ● 5577945 ● BM49891
Hose Assembly - Filter to Pump	TACOM	10946173-2

*Integral with fuel pump assembly

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DEVELOPMENT OF ACCELERATED FUEL-ENGINES QUALIFICATION PROCEDURE--F
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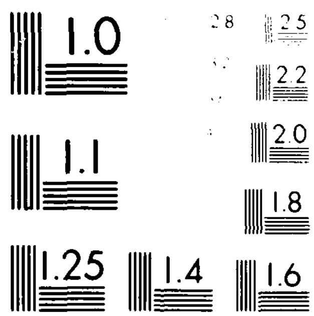
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7. The NTC-400: Cummins Engine Company

a. Powerplant Characteristics

The NTC-400 engines are six cylinder, in-line, four-stroke cycle, liquid cooled, and turbocharged. Table A-44 presents selected engine characteristics and performance data.

TABLE A-44, SELECTED NTC-400 ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	855 in^3
Weight, dry	2600 lbs.
Compression ratio	13.5:1
Horsepower	400 hp at 2100 rpm
Torque, max	1150 lb-ft at 1500 rpm
Speed Governed, Full Load Governed, No Load Governed, idle	 2100 rpm 2400 rpm 600 rpm
Bore	5.5 in
Stroke	6.0 in

b. Engine/Vehicle Matches

Table A-45 shows the M-Series vehicles which contain the NTC-400 engine. The vehicles are not considered to be tactical vehicles, but are listed due to the availability of information.

TABLE A-45, THE NTC-400 ENGINE MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
NTC-400	M915, M916, M917, M918, M919, M920

c. Fuel System Component Identification

Table A-46 lists the vendor or source of supply for the fuel system components. The fuel supply system is illustrated by Figure A-13.

TABLE A-46, IDENTIFICATION OF NTC-400 FUEL SYSTEM COMPONENTS

Components	Vendor/Source	Part Number (Model Number)
Fuel Injector Assembly	Cummins Engine Company Defense Products	3013738 (PTD)
● Fuel Strainer Element Within Injector Assembly	● Cummins Engine Company	● 3008706
Fuel Pump Assembly	Cummins Engine Company Defense Products	30041883257 (PTG-AFC)
● Filter Screen Assembly Within Pump Assembly	● Cummins Engine Company	● 146483
Fuel Supply Pump*	Cummins Engine Company Defense Products	BM97502
Fuel Solenoid Valve*	Cummins Engine Company Defense Products	BM69985
Fuel Filter	Cummins Engine Company Defense Products	156172

*Integral With Fuel Pump Assembly

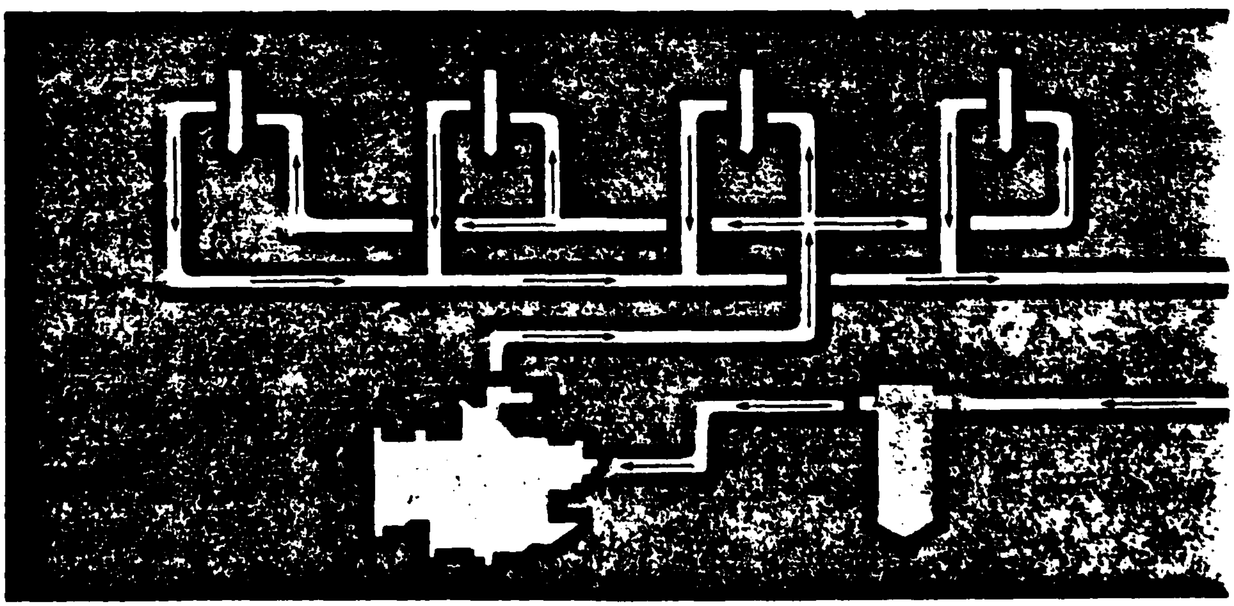


FIGURE A-13, THE TYPICAL CUMMINS FUEL SUPPLY SYSTEM
Source: Cummins Engine Co. Bulletin 952580

8. The NHC-250: Cummins Engine Company

a. Powerplant Characteristics

The NHC-250 engines are six cylinder, in-line, and naturally aspirated. Table A-47 presents selected engine characteristics and performance data.

TABLE A-47, SELECTED NHC-250 ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	855 in^3
Weight, Dry	2500 lb.
Compression Ratio	15.8:1
Horsepower, Gross	240 hp at 2100 rpm
Torque, Peak	658 lb-ft at 1500 rpm
Speed Governed, Full Load Governed, No Load Idle	 2100 rpm 2400 rpm 600 rpm
Bore	5.5 in
Stroke	6.0 in
Fuel	VV-F-800

b. Engine/Vehicle Matches

Table A-48 shows the M-Series vehicles which contain the NHC-250 engines.

TABLE A-48, THE NHC-250 ENGINE MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
NHC-250*	M813, M813A1, M814, M815, M816, M817, M818, M819, M820, M821

*The listed vehicles are collectively referred to as the M809 series.

c. Fuel System Component Identification

Table A-49 lists the vendor or source of supply and corresponding part or model designation for the fuel system components. The fuel supply system is similar to the NTC-400 (see Figure A-13).

TABLE A-49, IDENTIFICATION OF NHC-250 FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Pump Assembly • Filter Element Within Pump	Cummins Engine Company Defense Products • Cummins Engine Company	AR-51322-3096 (PTG) • 146483
Fuel Injector Assembly • Plunger Body Screen	Cummins Engine Company Defense Products • Cummins Engine Company	AR-40126 (PTD) • 174298
Fuel Supply Pump*	Cummins Engine Company Defense Products	AR-51306
Fuel Solenoid Valve*	Cummins Engine Company	AR-51328
Fuel Filter/Water Separator Assembly	Cummins Engine Company Fleetguard	256-546
Fuel Hoses	Wire Braid Seamless Rubber (Butyl N Rubber) Wire Fabric Reinforced or Extruded Nylon or Teflon With at Least One Braid Cover**	

* Integral with pump assembly
** Source unavailable. Hoses are cut from one piece as needed.

9. The VTA-903T: Cummins Engine Company

a. Powerplant Characteristics

The VTA-903-T engines are eight-cylinder, V-type, four-stroke cycle, liquid cooled, and turbocharged (with aftercooling). Table A-50 presents selected engine characteristics and performance data.

TABLE A-50, SELECTED VTA-930-T ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	903 in^3
Weight, Dry	2450 lb.
Compression Ratio	15.5:1
Horsepower, Net	500 bhp at 2600 rpm
Torque, Net	963 lb-ft at 1800 rpm
Speed Governed, Full Load Governed, No Load Idle	 2600 rpm 2960 rpm 600 rpm
Bore	5.5 in
Stroke	4.75 in
Fuel	VV-F-800

b. Engine/Vehicle Matches

The VTA-903-T engines will be incorporated into the M2 and M3 Infantry Fighting Vehicles, currently in production.

c. Fuel System Component Identification

Table A-51 lists the vendor or source of supply and the corresponding part or model designation for the fuel system components.

TABLE A-51, IDENTIFICATION OF VTA-903-T PRIMARY FUEL SYSTEM COMPONENTS

Components	Vendor/Source	Part Number (Model Number)
Fuel Pump Assembly ● Filter Element Within Pump Assembly	Cummins Engine Company Defense Products ● Cummins Engine Company	(PTG-AFC) ● 146483
Fuel Injector Assembly ● Plunger Body Screen	Cummins Engine Company Defense Products	(PTD)

TABLE A-51, IDENTIFICATION OF VTA-903-T PRIMARY FUEL SYSTEM COMPONENTS (CONT.)

Component	Vendor/Source	Part Number (Model Number)
Fuel Supply Pump*	Cummins Engine Company Defense Products	AR-51306
Fuel Solenoid Valve	Cummins Engine Company Defense Products	AR-51328
Fuel/Water Separator	Cummins Engine Company Fleetguard	11664680

*Integral with fuel pump assembly

10. The D333C and 3306: Caterpillar Tractor Company

a. Powerplant Characteristics

The D333C and 3306 engines are six cylinder, in-line, four-stroke cycle, liquid cooled and turbocharged. Table A-52 presents selected engine characteristics and performance data for the 3306 engine which is or will replace the D333C engines when an overhaul is required.

TABLE A-52, SELECTED 3306 ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	638 in^3
Weight, Dry	1900 lb.
Compression Ratio	17.5:1
Horsepower	218 hp at 2200 rpm
Torque, Net	578 lb-ft at 1550 rpm
Speed Governed, Full Load Governed, No Load Idle	 2200 rpm 2355 rpm 750 rpm
Bore	4.75 in
Stroke	6.0 in
Fuel	VV-F-800

b. Engine/Vehicle Matches

Table A-53 shows the M-Series vehicles which contain the D333C engine.

TABLE A-53, THE D333C AND 3306 ENGINES MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Vehicle Designation
D333C and 3306	M520, M553, M559, M877

c. Fuel System Component Identification

The fuel supply system is illustrated in Figure A-14. Table A-54 lists the vendor or source of supply for the fuel system components for the D333C and 3306 engines.

TABLE A-54, IDENTIFICATION OF D333C AND 3306 FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Injection Pump Assembly		
• D333C	• Caterpillar Tractor Company	• 559076
• 3306	• Caterpillar Tractor Company	• 8N8336
Fuel Injector Nozzle Assembly		
• D333C - parts kit	• Caterpillar Tractor Company	• 7S8722 -7S9891
• 3306	• Caterpillar Tractor Company	• 8N4698
Fuel Transfer Pump		
• D333C	• Caterpillar Tractor Company	• 4N4878 or 7L543
• 3306	• Caterpillar Tractor Company	• 4N4878

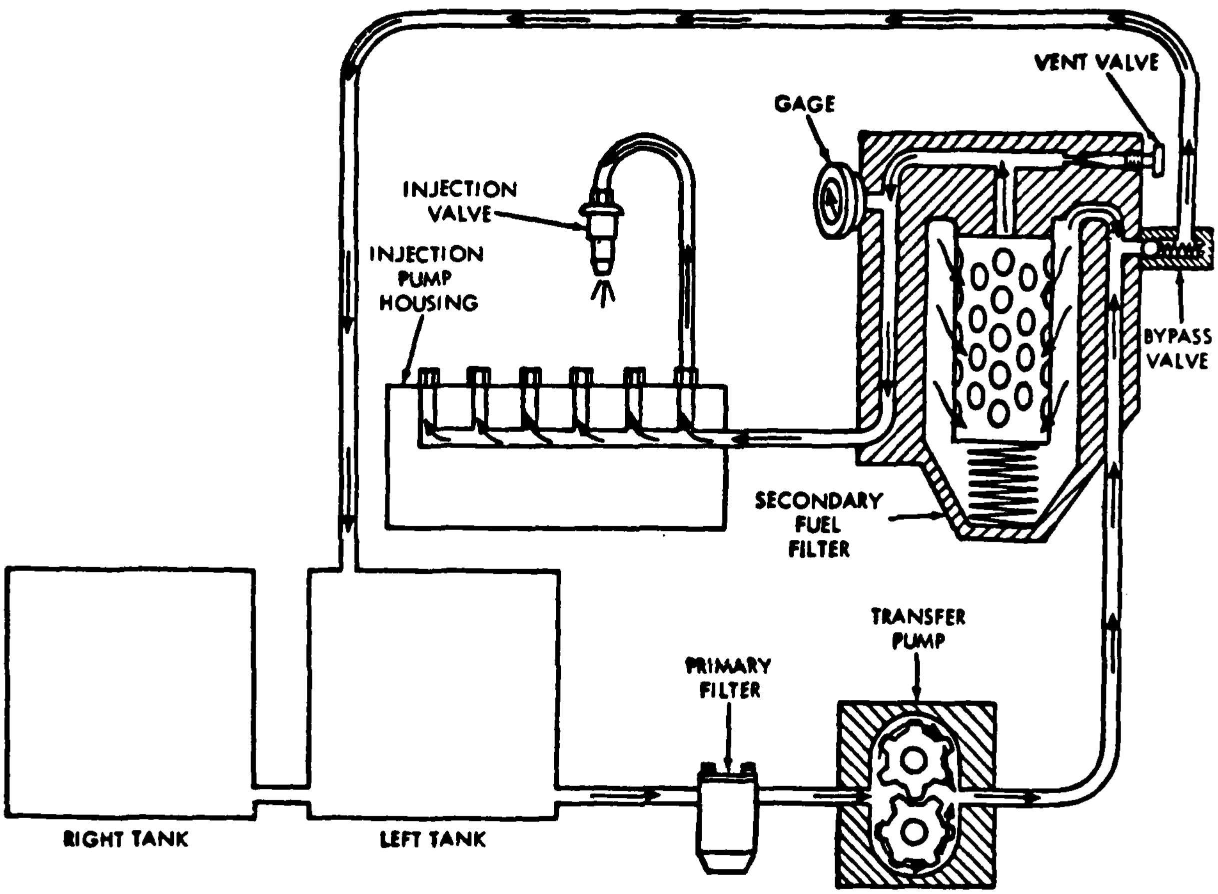


FIGURE A-14, THE D333C PRIMARY FUEL SYSTEM
Source: TM9-2320-233-34

TABLE A-54, IDENTIFICATION OF D333C AND 3306 FUEL SYSTEM COMPONENTS (CONT.)

Component	Vendor/Source	Part Number (Model Number)
Primary Fuel Filter		
• D333C - Filter Element	• TACOM - TACOM	• 11634237-1 -11634639-1
• 3306	• Michigan Dynamics, Inc. or Beaden Screens or Purolator or Ohio Fabricators	• 9M2341
Secondary Fuel Filter		
• D333C	• Caterpillar Tractor Company	• 1P2299
• 3306	• Fram or Champion Labs, Inc. or Purolator or Automotive Products, Ltd.	• 1P2299
Fuel Solenoid Valve		
• D333C	• Caterpillar Tractor Company	• 5R1762
• 3306	• Delco-Remy	• 2N2385
Fuel Priming Pump		
• D333C	• TACOM	11634233 (9H2256)
Fuel Return Hose		
• D333C	• Caterpillar Tractor Company	• 9S9339
• 3360		• *

*Part number unknown, but is a fabric reinforced rubber.

11. The ENDT-673: Mack Trucks, Inc.

a. Powerplant Characteristics

The ENDT-673 engines are six-cylinder, in-line, four-stroke cycle, liquid cooled and turbocharged. Table A-55 presents selected engine characteristics and performance data.

TABLE A-55, SELECTED ENDT-673 ENGINE CHARACTERISTICS AND PERFORMANCE DATA

Displacement	672 in^3
Compression Ratio	16.59:1
Horsepower	205 bhp at 2100 rpm
Speed Governed, Full Load Governed, No Load Governed, Idle	 2100 rpm 2200 rpm 550 to 575 rpm
Bore	4.875 in
Stroke	6.0 in
Fuel	VV-F-800

b. Engine/Vehicle Matches

Table A-56 shows the M-Series vehicles which contain the ENDT-673. The ENDT-673 is no longer built and only limited numbers are in the active fleet (approximately 500 vehicles in 1974).

TABLE A-56, THE ENDT-673 ENGINE MATCHED TO M-SERIES VEHICLES

Engine Model	M-Series Designation
ENDT-673	M51A1, M52A1, M54A1, M54A1C, M55A1, M291A1, M543A1, M748A1

c. Fuel System Component Identification

Figure A-15 illustrates the fuel supply system. Table A-57 identifies the primary fuel system components by vendor or source and part or model designation. Table A-58 lists similar information for the flame heater fuel system.

TABLE A-57, IDENTIFICATION OF ENDT-673 FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number (Model Number)
Fuel Injection Pump Nozzle Assembly	Mack Truck Engine Division	736GB221
Fuel Injection Pump	American Bosch	313GC-4127* (APE-6BB90Q)
Hand Primer Pump Assembly	Mack Truck - Diesel Engine Division	3125B18
Fuel Transfer Pump	Mack Truck - Diesel Engine Division	319GC110
Primary Fuel Filter ● Fuel Filter Element	Mack Truck - Diesel Engine Division ● Mack Truck	483GBA334 ● 237GB16
Secondary Fuel Filter ● Fuel Filter Element	Mack Truck - Diesel Engine Division ● Mack Truck	483GB319A ● 237GB13
Hoses (3) ● Fuel Filter Air Ble ● Filter to Fuel Emergency Shut-Off Valve ● Filter to Primer Pump	Mack Truck - Diesel Engine Division (all components)	 ● 36RUA3117P12 ● 36RUA3132P9 ● 36RUA3132P44

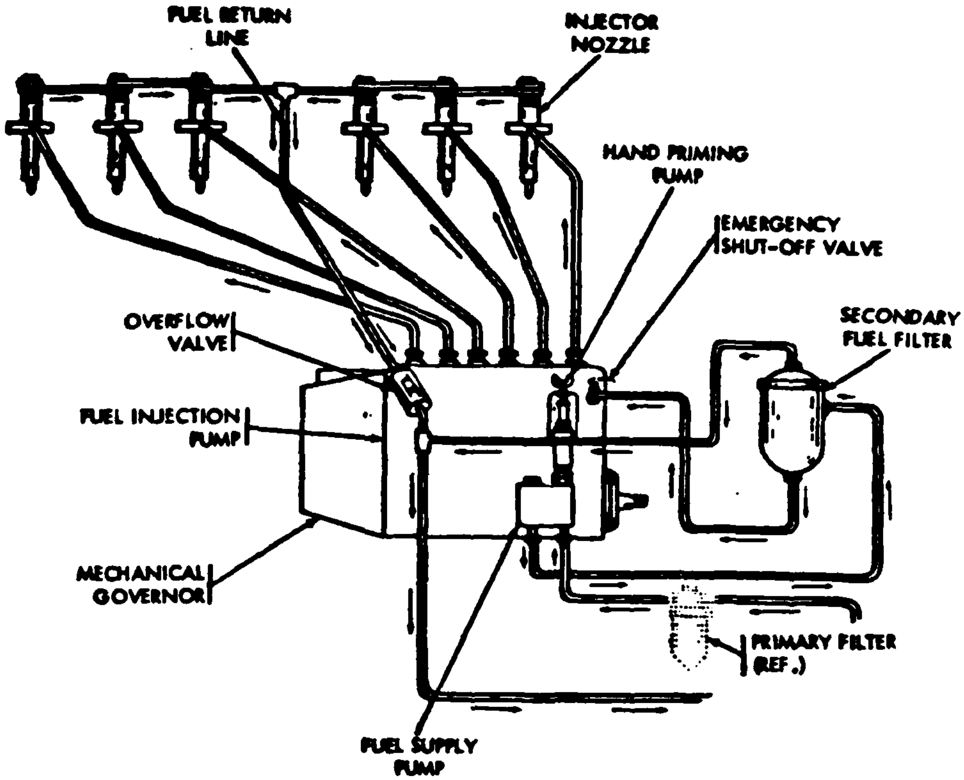


FIGURE A-15, THE ENDT-673 PRIMARY FUEL SYSTEM

Source: TM9-2815-207-35

TABLE A-58, IDENTIFICATION OF ENDT-673 FLAME HEATER FUEL SYSTEM COMPONENTS

Component	Vendor/Source	Part Number
Fuel Nozzle	Mack Truck - Diesel Engine Division	115GC16
Fuel Pump Assembly	Lear Siegler, Inc. Power Equipment Division	RG16705-3
Fuel Solenoid Valve	Mack Truck - Diesel Engine Division	689GC21
Hose Assembly, Rubber-Fuel Supply	Mack Truck - Diesel Engine Division	36RUA3117P29
Hose Assembly, Rubber-Fuel Supply Inlet	Mack Truck - Diesel Engine Division	36RUA3117P8
Hose Assembly, Rubber-Heater Pump Outlet	Mack Truck - Diesel Engine Division	36RUA3117P18
Hose Assembly, Rubber-Overflow Solenoid Outlet	Mack Truck - Diesel Engine Division	36RUA3117P10

APPENDIX E-2

EXISTING ENGINE QUALIFICATION PROCEDURES

A. INTRODUCTION

This appendix contains information in some detail regarding the tests and test procedures currently or recently used at the direction of the Army to qualify production diesel engines for use in existing Army M-Series combat and tactical vehicles. The information is presented in two sections. The first section discusses the qualification tests and test procedures associated with Army designed engines (i.e., the AVDS-1790 series of engines and the multi-fuel engines). The second section presents similar information for engines of commercial design. This approach was primarily utilized as a matter of convenience. That is, the Army designed engines tend to be qualified similarly amongst models while the commercially designed engines display a mild variance. For this reason, detailed test procedures are presented for all commercially designed engines where the information was available. For the Army designed engines, detailed information is presented for each engine type or where the procedures differed to an appreciable degree.

Also presented in this appendix is information concerning some diesel engined vehicles which are currently in the procurement process. Their status regarding engine qualification testing (endurance type tests) is stated.

B. ARMY DESIGNED ENGINES

1. AVDS-1790 Series

MIL-E-62177 (AT), 9 March 1977, establishes the performance, design, test manufacture and acceptance requirements for the AVDS-1790 series engines. The engine qualification steps described are design, pre-production, and initial production qualification. The specific procurement document can waive any or all of the qualification steps. In the absence of a waiver, the various required qualification inspections are as shown in Table B-1. The fuels to be used during all engine testing must be in accordance with Grade DF-2 of Federal Specifications VV-F-800. Engine lubricating oil used for the various tests must be in accordance with the seasonal requirements of MIL-L-2104 (for -10°F to 115°F) and MIL-L-46167 (for -65°F to 0°F).

As Table B-1 shows, regardless of whether the procuring activity calls for design qualification, pre-production, or only initial production qualification testing, an engine break-in test must be conducted. The engine break-in test is conducted according to the schedule shown in Table B-2. During the engine break-in test, torque and horsepower curves are produced for the 1800 to 2400 rpm engine speeds at the full power control arm setting. The following data are recorded during the runs:

- full power control arm setting governed speed
- minimum power control arm setting governed speed
- speed range
- gross horsepower
- gross torque
- fuel consumption
- exhaust smoke density
- oil pressure
- oil temperature
- oil consumption

Also, during break-in period 8 the oil consumption is measured (during the initial production test only, the time is extended to 120 minutes to verify stable oil consumption data).

TABLE B-1, AVDS-1790 SERIES QUALIFICATION INSPECTIONS

Requirement Description	Design Qualification Sample	Preproduction Sample	Initial Production Sample
Speed Ranges	X	X	X
Governor	X	X	X
Gross Horsepower	X	X	X
Torque	X	X	X
Fuel Consumption	X	X	X
Exhaust Smoke Density	X	X	X
Oil Consumption	X	X	X
Oil Pressure	X	X	X
Air Pressure	X	X	X
Air Leakage	X	X	X
Submergence	X	X	X
Water Contamination	X	X	X
Flame Heater	X	X	X
Cycle Endurance	X		
NATO Endurance			X
Break-In	X	X	X
Weight	X	X	X
Starting at Extreme Temperatures		X	
High Temperature Operation	X		
Humidity Conditions			
Elevation		X	
Grades and Slopes		X	
Materials			
Greases			
Oil Seals			
Product Marking	X	X	X
Name Plates	X	X	X
Workmanship	X	X	X
Interchangeability of Parts			
Protective Coatings			

TABLE B-2, AVDS-1790 SERIES ENGINE BREAK-IN TEST SCHEDULE

RUN NO.	TIME (MIN.)	RPM	TORQUE (LB-FT)
1	10	700	warm-up
2	15	1000	85
3	15	1400	440
4	20	1800	837
5	20	2200	1024
6	20	2400	1092
7	30	2400	1202
8*	30	2400	Full Power Control Arm Setting
9	5	2400	
10	5	2200	
11	5	2000	
12**	5	1800	

*After run no. 8, check for low idle at 675-725 rpm and adjust if necessary. Visually inspect for air, exhaust, oil and fuel leaks. Check governor high idle speed. This shall not exceed 2640 rpm (no load-water off). If adjustment is required, recheck horsepower at 2400 rpm and full power control arm setting. Governor must be resealed after adjustment.

**Borescope inspect cylinders, pistons, and valves after completion of test.

The following performance tests (see Table B-1) can be run as part of the break-in test or separately:

- speed ranges
- governor
- gross horsepower
- torque
- fuel consumption
- exhaust smoke density
- oil pressure and temperature
- engine leakage check
- engine pressure drop
- submersion
- water contamination
- flame heater

Regarding endurance related qualification tests, Table B-1 shows two of interest. There is a cycle endurance test conducted as part of the design qualification process and the NATO 400-hour endurance test conducted as part of the initial production qualification process.

The engine selected for the cycle endurance test (during the design qualification process only) is put through 20 cycles as shown in Table B-3. The following data is recorded during the test at the end of each 10-minute or longer period and just prior to stopping:

- Engine speed
- Engine power
- Intake manifold pressure
- Exhaust manifold pressure
- Lubricating oil pressure, gallery
- Crankcase pressure
- Lubricating oil temperature, sump
- Blowby
- Fuel flow
- Fuel pressure after secondary filters
- Fuel temperature at secondary fuel filter
- Air temperature at air cleaner inlet

TABLE B-3, AVDS-1790 SERIES CYCLE ENDURANCE TEST SCHEDULE

Period No.	Length of Period Minutes	Gross HP	RPM	Period No.	Length of Period Minutes	Gross HP	RPM
1	Start	0	0	47	30	300	1600
2	5		Idle	48	5		Idle
3	5	300	1600	49	30	750	2400
4	120	600	2000	50	5		Idle
5	5	300	1600	51	5		Stop
6	5		Idle	52	5		Idle
7	5		Stop	53	15	460	1800
8	5		Idle	54	5		Idle
9	5	300	1600	55	5		Stop
10	25	720	2200	56	30	550	1900
11	5		Idle	57	5		Idle
12	50	650	2100	58	35	460	1800
13	5		Idle	59	5		Idle
14	5		Stop	60	20	550	1900
15	5		Idle	61	5		Idle
16	15	200	1400	62	15	200	1400
17	5		Idle	63	5		Idle
18	5		Stop	64	5	300	1600
19	5	200	1400	65	5		Idle
20	5		Idle	66	5		Stop
21	30	200	1400	67	40	300	1600
22	5		Idle	68	5		Idle
23	25	600	2000	69	20	460	1800
24	5		Idle	70	5		Idle
25	5		Stop	71	10	200	1400
26	100	600	2000	72	5		Idle
27	5		Idle	73	5		Stop
28	5		Stop	74	5	300	1600
29	5		Idle	75	5		Idle
30	15	750	2400	76	30	300	1600
31	5		Idle	77	5		Idle
32	15	650	2100	78	15	750	2400
33	5		Idle	79	5		Idle
34	5	300	1600	80	5		Stop
35	5		Idle	81	10	750	2400
36	5		Stop	82	5		Idle
37	5		Idle	83	25	550	1900
38	5	300	1600	84	5		Idle
39	5		Idle	85	15	300	1600
40	30	750	2400	86	5		Idle
41	5	460	1800	87	70	750	2400
42	60	750	2400	88	5		Idle
43	5		Idle	89	5	200	1400
44	5		Stop	90	30		Idle
45	5	300	1600	91			Stop
46	5		Idle				

- Test cell ambient air temperature
- Specific oil consumption at periods No's. 42 and 87
- Barometric pressure of test cell - once each 4 hour period
- Exhaust smoke density - once each 50 hour period, plus or minus 5 hours
- Generator/Alternator, volts and amps

After completion of the cycle endurance test, the engine must be capable of producing 90 percent of its original power.

One of the first ten engines produced is selected for the 400-hour NATO endurance test (see Table B-1). The engine selected is first broken-in (see Table B-2), then put through a pre-test performance run from which a corrected performance test curve (torque, horsepower, BSFC, and smoke number vs. engine speed) is plotted from a minimum of seven speed settings in both ascending and descending order. The speeds to be run include 1200, 1400, 1600, 1800, 2000, 2200, and 2400 rpm. Data are recorded at 85, 70, 50, and 25 percent of the full power control arm setting. The endurance test consists of four 100-hour periods. Each 100-hour period consists of twenty 5-hour cycles where each cycle consists of the schedule shown in Table B-4.

TABLE B-4, AVDS-1790 SERIES 5-HOUR ENDURANCE TEST SCHEDULE

Period	Engine Speed (rpm)	Power*	Endurance Hours
1	Idle	0	0.5
2	2000	100	1.0
3	2400	0	0.5
4	1800	85	1.0
5	2400	50	0.5
6	2400	100	1.0
7	1200	25	0.5
Total Endurance			5.0

*In percent of full power control arm setting gross horsepower at respective speed.

The following data are recorded at the end of test periods 2, 3, 4, and 6 (see Table B-4):

- Engine speed
- Engine power
- Intake manifold pressure
- Exhaust manifold pressure
- Lubricating oil pressure, gallery
- Crankcase pressure
- Lubricating oil temperature, sump
- Blowby
- Fuel flow
- Fuel pressure after secondary filters
- Fuel temperature at secondary fuel filter
- Air temperature at air cleaner inlet
- Test cell ambient air temperature
- Oil consumption
- Barometric pressure of test cell - once each 4 hour period
- Exhaust smoke density - once each 100 hour period, plus or minus 5 hours
- Generator/Alternator, volts and amps

At completion of each 100-hour period, the engine is operated at 2400 rpm and full power control arm setting; the fuel flow is checked and adjusted to within 2 lb/hr of that observed during the pre-test performance check. At the end of the endurance run the engine is subjected to a post-test performance test (following the same procedure used for the pre-test performance check) and the engine must develop 90 percent of its original power. The engine is then disassembled and inspected.

During engine production, various quality control measures are conducted. A specific requirement is a 50-hour quality control test. The procedure is as shown in Table B-5. Also, every production engine is given a break-in test per the schedule shown in Table B-2.

TABLE B-5, AVDS-1790 SERIES 50-HOUR QUALITY CONTROL TEST SCHEDULE

Run No.	Time (Min.)	Control Arm Power Setting*	Engine Speed (rpm)
1	60	1/2**	2000
2	30	Minimum	700
3	40	Full	2400
4	30	Minimum	700
5	120	1/2**	2000
6	30	Minimum	700
7	120	Full	2400
8	60	Minimum	700
9	300	Full	2400
10	60	Minimum	700
11	300	Full	2400
12	60	Minimum	700
13	300	Full	2400
14	60	Minimum	700
15	300	Full	2400
16	60	Minimum	700
17	300	Full	2400
18	60	Minimum	700
19	300	Full	2400
20	60	Minimum	700
21	300	Full	2400

*For the AVDS-1790-2C engine, the even numbered runs use a control arm power setting of "As Required" in place of "Minimum" and an engine speed of 900-925 rpm in place of 700 rpm.

**One-half of the full power control arm setting gross horsepower at 2000 rpm.

2. LD-465-1 and LD-465-1C

MIL-E-62106 (AT) describes the tests and test procedures used to qualify the LD-465-1 and LD-465-1C multi-fuel engines. The range of the various requires tests is illustrated in Table B-6.

TABLE B-6, LD-465-1 AND LD-465-1C QUALIFICATION INSPECTIONS

Test	Initial Engine	Acceptance	Control
Operational test	X		
Performance tests	X		
Temperature tests	X		
Cold starting test	X		
High temperature starting test	X		
Oil cooling test	X		
Electromagnetic compatibility test	X		
Grades and slope test	X		
Speed range & governor test	X	X	X
Brake horsepower & torque test	X	X	X
Exhaust smoke density test	X	X	X
Fuel consumption, oil consumption, and oil pressure check	X		
Fuel consumption and oil pressure check		X	X
Power check	X		
Coolant temperature rise test	X	X	X
Manifold heater check	X	X	X
Starter check	X	X	X
Generator and alternator test	X	X	X
Air compressor test	X	X	X
Submersion requirements & contamination test	X		
Steam & water jet cleaning test	X		
Production engine break-in run	X	X	X
Corrections and reassembly	X	X	X
Fifty hour quality control test			X
Selection of test sample			X
Control test failure & correction			X
Disposition of engine			X
Control test conditions			X
Atmospheric conditions			X
Pre-test warm-up			X
Temperatures			X
Engine cooling			X
Operating temperatures			X
Accessories			X

The engine must perform as specified using fuels conforming to VV-F-800, MIL-G-3056 referee grade, VV-6-76 with a maximum octane rating of 83 MON and 91 RON, MIL-F-45121, and MIL-F-46005. During the production break-in run, diesel fuel grade DF-1 of VV-F-800 and VV-6-76 (gasoline) with a maximum octane rating of 83 MON and 91 RON are used as indicated in the test procedure. During the 50-hour quality control test grade DF-1 of VV-F-800 and VV-6-76 with a maximum octane rating of 83 MON and 91 RON are used. For the 500-hour endurance test, compression ignition fuel conforming to MIL-F-45121 is used. For the power run, the following fuels are used when performed in conjunction with the 500-hour endurance run:

- diesel fuel: grade DF-1 of VV-F-800
- compression ignition fuel: MIL-F-45121
- referee grade gasoline: MIL-G-3056 (with exceptions as noted in Table B-7)

TABLE B-7, EXCEPTIONS TO MIL-G-3056:
REFEREE GRADE GASOLINE

Test/Property	Test/Limit
Distillation:	ASTM D216
10% Evaporated	140-158°F.
50% Evaporated	194-239°F.
90% Evaporated	275-356°F.
Residue % Maximum	2.0
Reid Vapor Pressure	6-8
Octane No. Motor Method	83-85
Octane No. Research Method	91-93
Gum, mg/100 ml, Unwashed residue Max	4
Sulfur, percent	0.10-0.15(1)
Corrosiveness (122°F) maximum	ASTM No. 1
Tetraethyl lead ml/gal	2.5-3.00
Oxidation Inhibitor lbs/1000 bbls.(2)	30

(1) This sulfur level may be obtained by the addition of ditertiary butyl disulfide.

(2) Oxidation inhibitor shall be composed of 50% N, N^1 disecondary butyl-paraphenylenediamine and 50% N, n butyl-p-aminophenol. (Dupont No. 22 or No. 5, UOP No. 4 or Tenamene No. 1 meets this requirements.)

When performed in conjunction with the 50-hour quality control test, the power run fuels are grade DF-1 of VV-F-800 and gasoline grade I of MIL-G-46015.

Engine lubricating oil must be in accordance with the seasonal requirements of MIL-L-2104 (for -10°F to 115°F) and MIL-L-10295 (for -65°F to 20°F). Lube oil used during engine build-up and during the production break-in run is left to the engine manufacturer. The referee grade lube oil used during the 500-hour endurance run is Cities Service Oil Company grade OE-30, CDL-139 (government designation MB-901). Lube oil conforming to grade 2 of MIL-L-21260 can be used during the 50-hour run.

Every engine produced is broken-in according to the schedule shown in Table B-8. During each test period, the following data is recorded:

- Coolant temperatures
- Oil sump temperature
- Gallery oil pressure
- Observed brake horsepower
- Engine speed
- Period duration
- Starter cranking speed and terminal voltage
- Air compressor delivery
- Generator or alternator output

Also, the following data is recorded during periods 8 through 15 (in addition to the above):

- Intake air temperature before turbo-supercharger
- Torque (observed corrected)
- Brake horsepower (observed; corrected)
- Fuel consumption
- Specific fuel consumption
- Air pressure at inlet to engine
- Exhaust smoke density (diesel fuel only)
- Governed speed, full load and no load rpm (period 8 and 9 only)
- Fuel temperature at primary fuel filter inlet
- Fuel temperature at fuel flow measuring instrument
- Correction factor

TABLE B-8, LD-465-1 AND LD-465-1C PRODUCTION ENGINE BREAK-IN SCHEDULE

Period	Duration	Engine Speed	BHP (except as noted)	Fuel	Min. Eng. Coolant Temp. IN	OUT
1 Prelube	1 min. minimum	Prelube	Idle	Diesel	130	160
2	30	1000	15			
3 Re-torque heads & set valve lash immediately after period three	15	1200	15	Diesel	130	160
4	15	1600	33	Diesel	130	160
5	30	2000	64	Diesel	130	160
6	30	2400	110	Diesel	130	160
7	15	2600	125-135	Diesel	130	160
8 Adjust full power position and set Governor	As Req'd	2600	126-131	Diesel		200
9 Set unloaded Governor speed	As Req'd	2850-2900	No load			200
10 Power Check	As Req'd	1400	300-330	Diesel		200
11 Set idle speed and check manifold heater	As Req'd	650-700	Idle	Diesel	130	160
12 Run as required to convert fuel system to gasoline (see Note 2)	As Req'd			Gasoline	130	160
13 Power Check	As Req'd	2600	126-136	Gasoline		200
14 Power Check	As Req'd	1400	300 lb-ft min.	Gasoline		200
15 Record idle after stabilization	5	650-700	Idle	Gasoline	[illegible]	160
16 Re-torque heads & set valve lash immed.						
17 Run as req'd to convert fuel system to diesel (see Note 2)	As Req'd			Diesel	130	160
18 Same as 15		650-700	Idle	Diesel	130	160

NOTE: (1) For fuel, 3.2.3.9.1 for lubricating oil, 3.2.2.7

(2) Time and method to purge fuel system to be approved by Government inspector. A maximum of 3 percent residual fuel after purging is permissible.

(3) Re-torque cylinder head studs and re-set valve lash per drawing 10935504 a detail of engineering parts list, immediately following periods 3 and 15.

Periods 8 through 15 of the engine break-in test procedure must be run without stopping the engine. If engine adjustments are required during the power-check portion, then periods 8 through 15 must be re-run after stable operating conditions are obtained. The power-check test indicated in Table B-8 is performed according to the schedule shown in Table B-9.

Every engine produced is inspected for defects as shown in Table B-10.

TABLE B-9, LD-465-1 AND LD-465-1C POWER CHECK TEST SCHEDULE

Period	Engine Speed	Load	Fuel	Minimum Coolant Outlet Temperature
1	2600	Full Power	VV-F-800 DF-1	200°F
2	2400	Full Power	VV-F-800 DF-1	200°F
3	2200	Full Power	VV-F-800 DF-1	200°F
4	2000	Full Power	VV-F-800 DF-1	200°F
5	1800	Full Power	VV-F-800 DF-1	200°F
6	1600	Full Power	VV-F-800 DF-1	200°F
7	1400	Full Power	VV-F-800 DF-1	200°F
8	1200	Full Power	VV-F-800 DF-1	200°F
Switch fuel to compression ignition fuel MIL-T-45121.				
9	2600	Full Power	MIL-F-45121	200°F
10	2400	Full Power	MIL-F-45121	200°F
11	2200	Full Power	MIL-F-45121	200°F
12	2000	Full Power	MIL-F-45121	200°F
13	1800	Full Power	MIL-F-45121	200°F
14	1600	Full Power	MIL-F-45121	200°F
15	1400	Full Power	MIL-F-45121	200°F
16	1200	Full Power	MIL-F-45121	200°F
Switch fuel to gasoline, MIL-G-3056 Referee Grade				
17	2600	Full Power	Gasoline	200°F
18	2400	Full Power	Gasoline	200°F
19	2200	Full Power	Gasoline	200°F
20	2000	Full Power	Gasoline	200°F
21	1800	Full Power	Gasoline	200°F
22	1600	Full Power	Gasoline	200°F
23	1400	Full Power	Gasoline	200°F
24	1200	Full Power	Gasoline	200°F

TABLE B-10, LD-465-1 AND LD-465-1C
REQUIRED EXAMINATIONS

Characteristics	Defects
Valve tappet clearance, each	Intake and exhaust valves improperly adjusted
*Oil sump, fuel and oil filters	Dirt, chips and foreign particles, due to production
Fuel, oil, and coolant leaks	Leakage
Fuel lines	Damaged, rubbing or improperly supported
Governor	Malfunction, not sealed
Torque on cylinder heat bolts, intake and exhaust manifold flange bolts	Improper torque
Crankshaft	Excessive or restrictive end play
Engine	Malfunction
Fuel system components	Malfunction - damage or leaks, etc.
Fuel injection system, timing and components	Malfunction, improper adjustment
Injection pump support bracket	Improperly installed
Linkage	Improper adjusted
Minor assemblies	Omitted
Engine	Improper adjustment or installation of components
Fuel lines, hose vents, shut-off valve	Improperly assembled or installed
Painting	Spots missed, sags or runs
Workmanship	Not following good practice, improper installation or adjustment of components

*Do not remove or inspect secondary fuel filter.

One of the initial production engines is furnished for a 500-hour endurance run (not to exceed 575 hours) to be conducted on compression ignition fuel (MIL-F-45121) and consisting of four 125-hour cycles. The 125-hour cycle schedule is shown in Table B-11. (Note: periods 1 and 2 are deleted during cycle 2, 3, and 4.)

TABLE B-11, LD-465 AND LD-465-1C
125-HOUR ENDURANCE SCHEDULE

Period	Length (hrs)	Engine Speed (rpm)	Percent Load	Period	Length (hrs)	Engine Speed (rpm)	Percent Load
1*				34	1	650	0
2**				35	2	2000	50
3	2	650	0	36	4	2000	100
4	5	1400	75	37	1	650	0
5	1	650	0	38	4	2200	75
6	5	2000	75	39	4	2200	100
7	1	650	0	40	1	650	0
8	5	2200	75	41	2.5	2600	75
9	1	650	0	42	4	2600	100
10	5	2600	75	43	1	650	0
11	1	650	0	44	.75	2600	100
12	2	1800	50	45	.25	650	0
13	2	1800	100	46	.75	2600	100
14	1	650	0	47	.25	650	0
15	2	2000	50	48	.75	2600	100
16	2	2000	75	49	.25	650	0
17	1	650	0	50	.75	2600	100
18	2	2200	75	51	.25	650	0
19	2	2200	100	52	.75	2600	100
20	1	650	0	53	.25	650	0
21	3	2600	75	54	.75	2600	100
22	3	2600	100	55	.25	650	0
23	2	650	0	56	2	1800	50
24	5	1400	75	57	2	1800	100
25	1	650	0	58	1	650	0
26	5	2000	75	59	2	2000	50
27	1	650	0	60	1	650	0
28	5	2200	75	61	2	2600	100
29	1	650	0	62	1	650	0
30	5	2600	75	63	4	2600	75
31	1	650	0	64	2	2600	100
32	2	1800	50	65	.5	2850	0
33	2	1800	100	66**			

*Break-in Run
**Power-Check

Prior to the endurance run, the engine is broken-in by running periods 1 through 7 of the schedule shown in Table B-8. The endurance test is conducted by completing four 125-hour cycles. The final 125 hours are run with an intake air temperature of 140°F at an ambient air temperature of 115°F (± 5°F). At the conclusion of the endurance run, the engine must meet all performance requirements except the engine can develop not less than 95 percent of its power output at period 66 (of Table B-11). Also, there can be no evidence of abnormal wear of internal engine components.

During engine production, the first ten engines produced, every second engine of the next 100 produced, and every twentieth engine of the next 200 produced are dismantled and inspected after the break-in and acceptance tests are conducted (see Table B-12). The engines are then reassembled and subjected to another break-in test.

Fifty-hour quality control tests are also conducted during engine production at the rate of one per month when production is 100 units or less and two per month when production is greater than 100 units per month. The 50-hour quality control test schedule is shown in Table B-13. The engine is examined for defects per Table B-10 and acceptance tests are conducted. The following data are recorded at the end of each operation:

- Engine speed
- Observed brake horsepower
- Observed torque
- Air pressure at inlet to engine
- Fuel pressure at primary filter inlet
- Fuel supply pressure at inlet to engine driven supply pump
- Lubricating oil pressure, main gallery and piston cooling gallery
- Coolant pressure at cylinder block drain cock, water pump inlet and engine coolant outlet
- Lubricating oil temperature in oil sump
- Fuel temperature at primary filter inlet
- Coolant temperature rise - inlet to outlet
- Air temperature at air cleaner inlet
- Cell ambient air temperature
- Fuel temp at fuel measuring device
- Exhaust temperature port and manifold outlet
- Fuel flow
- Brake specific fuel consumption
- Oil consumption

* Exhaust smoke density (during period 1 and 7 only)
* Generator output
* Air delivery
* Crankcase blowby

TABLE B-12, LD-465-1 AND LD-465-1C ENGINE DISASSEMBLY INSPECTIONS

• Oil contamination. • Dirt, chips or foreign matter in the engine block, oil passages, oil pan, filters, and secondary drive case. NOTE: Do not remove or inspect the secondary fuel filter. • Main bearing bolt torque. • Connecting rod bolt torque. • Vibration damper bolt torque. • Fuel injectors and nozzles for dribbling, improper spray pattern, plugged nozzles or other malfunction. • Cylinder compression pressure (maximum of 25 psi variation between cylinders). • Scuffing, scoring, or galling of bearings, pistons, cylinders, cam lobes, tappets or other components. • Burning of pistons or valves, broken piston rings and valve seats, or worn valve faces. • Leakage of gaskets or seals. • Casting flash and obstructions in cylinder block and cylinder head water jacket passages (removal of core plugs and necessary assemblies required for visual inspection). • Any defects having no bearing on function, safety, interchangeability or life, but which are considered departure from good workmanship will be noted in writing. • Valve tappet clearance, each valve. • Governor adjustment. • Torque on cylinder head nuts, intake and exhaust manifold bolts. • Crankshaft end play. • Injection pump timing and adjustment.

TABLE B-13, LD-465-1 AND LD-465-1C 50-HOUR QUALITY CONTROL TEST SCHEDULE

Period	Time (hrs)	LDS-465 Speed (rpm)	Power Position (% of full power)	Fuel
1*				Diesel fuel, VV-F-800 Grade F-1 shall be used during periods 1 through 6
2	5	1400	50	
3	5	1400	75	
4	5	2600	75	
5	5	1400	100	
6	30	2600	100	
7**				

*Break-in schedule

**Periods 1 through 8 and 9 through 16 of the power-check test are conducted on diesel fuel and gasoline respectively.

3. LDT-465-1C

ATPD-2046, 17 February 1972, describes the tests and test procedures used to qualify the LDT-465-1C engines. The tests required and procedures used are nearly identical to those described for the LD-465-1 and LD-465-1C multi-fuel engines (see previous section, B.2). The primary differences arise because the LDT-465-1C engine is turbocharged whereas the LD-465-1 and LD-465-1C engines are not, and engine characteristics between the LD and LDT engines differ slightly. Thus, the primary difference in the procedures will be the engine settings (e.g., speed and load) at which test periods are run, performance tests are conducted, and/or data is recorded. In some cases, the required fuel for a test procedure is different from that described for the LD engines.

Fuels required for qualification of the LDT-465-1C are varied. During the production break-in run, diesel fuel conforming to grade DF-1 of VV-F-800 and gasoline conforming to VV-G-76 (with a maximum octane rating of 83 MON and 91 RON) are used. During the 50-hour quality control test grade DF-1 of VV-F-800 and gasoline conforming to MIL-G-46015 or VV-G-76 (with a maximum octane rating of 83 MON and 91 RON) is used. For the 500-hour endurance test, grade DF-1 of VV-F-800 is used. For the power run, the following fuels are used when performed in conjunction with the 500-hour endurance run:

- Grade DF-1 of VV-F-800
- Referee grade gasoline conforming to grade 1 of MIL-G-46015 (with exceptions as noted in Table B-14).

When performed in conjunction with the 50-hour quality control test, grade DF-1 of VV-F-800 and gasoline conforming to grade 1 of MIL-G-46015 are used.

TABLE B-14, EXCEPTIONS TO MIL-G-46015: REFEREE TO GRADE GASOLINE

Test/Property	Test/Limit
Distillation:	ASTM D216
10% Evaporated	140-158°F
50% Evaporated	194-239°F

TABLE B-14, EXCEPTIONS TO MIL-G-46015: REFEREE TO GRADE GASOLINE (CONT.)

Test/Property	Test/Limit
90% Evaporated	275-356°F
Residue % Maximum	2.0
Reid Vapor Pressure	6-8
Octane No. Motor Method	83-85
Octane No. Research Method	91-93
Gum, mg/100ml, Unwashed residue Max	4
Sulfur, percent	0.10-0.15(1)
Corrosiveness (122°F) maximum	ASTM No. 1
Tetraethyl lead ml/gal	2.5-3.00
Oxidation Inhibitor lbs/1000 bbls.(2)	30

(1) This sulfur level may be obtained by the addition of di-tertiary butyl disulfide.

(2) Oxidation inhibitor shall be composed of 50% N, N[1] disecondary butyl-paraphenylenediamine and 50% N, n butyl, p-aminophenol. (Dupont No. 22 or No. 5, UOP No. 4 or Tenamene No. 1 meets this requirement.)

Engine lubricating oil must conform to the seasonal requirements of MIL-L-2104 (for -10°F to 115°F) and MIL-L-10295 (for -65°F to 20°F). Lube oil used during engine assembly and production break-in runs are left to the discretion of the engine manufacturer. The referee grade lube oil used for the 500-hour endurance and 50-hour quality control runs is Humble Oil and Refining Company grade OE/HDO-30 (government designation MC-23).

The range of the various required qualification tests are described in Table B-15 (for production engines.

TABLE B-15, LDT-465-1C QUALIFICATION INSPECTIONS

Test	Initial Engine	Acceptance	Control
Operational tests	X		
Performance tests	X		
Temperature tests	X		
Cold starting tests	X		
High temperature starting tests	X		
Oil cooling test	X		
Electromagnetic compatibility tests	X		
Grades and slope tests	X		
Speed range & governor test	X	X	X
Brake horsepower & torque test	X	X	X
Exhaust smoke density test	X	X	X
Fuel consumption, oil consumption, and oil pressure check	X		X
Fuel consumption and oil pressure check		X	X
Supercharging check		X	X
Power check and supercharger test	X		
Coolant temperature rise test	X	X	X
Manifold heater check	X	X	X
Starter check	X	X	X
Alternator test	X	X	X
Air compressor test	X	X	X
Submersion requirements and contamination test	X		
Steam and water jet cleaning test	X		
Fifty hour quality control test			X
Selection of test sample			X
Control test failure and correction			X
Disposition of engine			X
Control test conditions			X
Atmospheric conditions			X
Pre-test warm-up			X
Temperatures			X
Operating temperatures			X
Accessories			X

Every engine produced is subjected to a break-in test procedure according to the schedule shown in Table B-16. One notable addition to the procedure for this break-in test (from that for the LD engines) is that during the pre-lubrication step (period 1 of

Table B-16), lube oil must also be delivered to the turbocharger unit. During each period of the break-in schedule, the following data are recorded:

- Coolant temperature (at engine inlet and outlet)
- Oil sump temperature
- Gallery oil pressure
- Observed brake horsepower
- Engine speed
- Period duration
- Starter cranking speed and terminal voltage (after completion of break-in run)
- Air compressor delivery (record once at 1500 and 2600 rpm)
- Alternator output (record once at 1500 and 2600 rpm engine speed)

During the power check portion of the break-in schedule (periods 10, 14, and 15 of Table B-16), the following data are recorded:

- Coolant temperature
- Oil sump temperature
- Gallery oil pressure
- Observed brake horsepower
- Engine speed
- Period duration
- Intake air temperature before turbo supercharger
- Torque (observed)
- Fuel consumption
- Specific fuel consumption
- Intake manifold pressure after turbo supercharger
- Exhaust smoke density (diesel fuel only)
- Governed speed, full load and no load RPM (period 8 and 9 only)
- Fuel temperature at transfer pump inlet
- Fuel temperature at fuel flow measuring instrument
- Intake air pressure depression across the air cleaner and intake air hose (intake air pick up to be within 2 inches of turbo inlet)

TABLE B-16, LDT-465-1C PRODUCTION ENGINE BREAK-IN SCHEDULE

Period		Duration	Engine Speed	BHP (except as noted)	Fuel	Min.Eng. Coolant Temp. In	Out
1	Prelube	1 min. minimum	Prelube	Idle	Diesel		
2		30	1000	15			
3		15	1200	15	Diesel	130	160
4		15	1600	33	Diesel	130	160
5		30	2000	64	Diesel	130	160
6	Re-torque heads & set valve lash immediately after period 6	30	2400	110	Diesel		
7		15	2600	125-135	Diesel	130	160
8	Set governor and full power position	As Req'd	2600	64.0 lbs/hr max. (130 to 140 bhp)	Diesel		200
9	Set unloaded governor speed	As Req'd	2850-2900	No load	Diesel		200
10	Power check (see Note 4)	As Req'd	1500	37.5 lbs/ max. (305 to 355 lbs-ft)	Diesel		200
11	Set droop screw (see Note 5)	As Req'd	1200	29.0 to 30.0 lbs/hr	Diesel	130	160
12	Set idle and check manifold heater	As Req'd	650-700	Idle	Diesel	130	160
13	Run as required to convert fuel system to gasoline system (see Notes 1 and 2)	As Req'd			Gasoline	130	160

TABLE B-16, LDT-465-1C PRODUCTION ENGINE BREAK-IN SCHEDULE (CONT.)

Period		Duration	Engine Speed	BHP (except as noted)	Fuel	Min.Eng. Coolant Temp. In	Out
14	Power Check	As Req'd	2600	130 to 145	Gaso-line		200
15	Power Check	As Req'd	1500	305 lb-ft min.	Gaso-line		200
16	Record idle after stabili-zation Re-torque heads & set valve lash im-mediately after period 16. (see Notes 2 & 3)	5	600	Idle	Gaso-line	130	160
17	Run as req'd to convert fuel sys-tem to diesel (see Note 12)	As Req'd			Diesel	130	160
18	Same as 16	5	650-700	Idle	Diesel	130	160

NOTE: (1) Time and method to purge fuel system to be approved by Government inspector. A maximum of 3 percent diesel fuel in the gasoline after purging is permissible.

(2) Periods 13 through 18 required only for engines selected for the 50 hour control test.

(3) Re-torque cylinder head studs and re-set valve lash per Drawing 10935504 immediately following periods 6 and 16. If periods 13 through 18 are not run, re-torque immediately following period 12.

(4) Specified fuel rate to be obtained by adjustment of smoke limiting cam only.

(5) Specified fuel rate to be obtained by adjustment of droop screw only.

Periods 8 through 16 are made without stopping the engine. If adjustments are required during the power check periods, then periods 8 through 15 must be re-run after stable operating conditions are obtained.

The power check test indicated in Table B-16 is performed according to the schedule shown in Table B-17.

TABLE B-17, LDT-465-1C POWER CHECK TEST SCHEDULE

Period	Engine Speed	Load	Fuel	Minimum Coolant Outlet Temperature
1	2600	Full Power	VV-F-800 DF-1	200°F
2	2400	Full Power	VV-F-300 DF-1	200°F
3	2200	Full Power	VV-F-800 DF-1	200°F
4	2000	Full Power	VV-F-800 DF-1	200°F
5	1800	Full Power	VV-F-800 DF-1	200°F
6	1600	Full Power	VV-F-800 DF-1	200°F
7	1400	Full Power	VV-F-800 DF-1	200°F
8	1200	Full Power	VV-F-800 DF-1	200°F
Switch fuel to gasoline, MIL-G-46015				
9	2600	Full Power	MIL-G-46015	200°F
10	2400	Full Power	MIL-G-46015	200°F
11	2200	Full Power	MIL-G-46015	200°F
12	2000	Full Power	MIL-G-46015	200°F
13	1800	Full Power	MIL-G-46015	200°F
14	1600	Full Power	MIL-G-46015	200°F
15	1400	Full Power	MIL-G-46015	200°F
16	1200	Full Power	MIL-G-46015	200°F

Every production engine is also checked for defects as shown in Table B-18.

TABLE B-18, LDT-465-1C REQUIRED EXAMINATIONS

Valve tappet clearance, each valve	Intake and exhaust valves improperly adjusted
*Oil sump, fuel and oil filters	Dirt, chips and foreign particles, due to production
Fuel, oil, and coolant leaks	Leakage
Fuel lines	Damaged, rubbing or improperly supported
Governor	Malfunction, not sealed

TABLE B-18, LDT-465-1C REQUIRED EXAMINATIONS (CONT.)

Torque on cylinder head bolts, intake and exhaust manifold flange bolts	Improper torque
Crankshaft	Excessive or restrictive end play
Engine	Malfunction
Fuel system components	Malfunction - damage or leaks, etc.
Fuel injection system, timing and components	Malfunction - improper adjustment
Injection pump support bracket	Improperly installed
Linkage	Improperly adjusted
Minor assemblies	Omitted
Engine	Improper adjustment or installation of components
Fuel lines, hose, vents, shut-off valve	Improperly assembled or installed
Painting	Spots missed, sags or runs
Workmanship	Not following good practice, improper installation or adjustment of components

*Do not remove or inspect secondary fuel filter.

One of the initial engines produced is furnished for a 500-hour endurance run (not to exceed 575 hours) to be conducted on grade DF-1 of VV-F-800 (except during the power test portion when both DF-1 and gasoline conforming to MIL-G-46015 are used). The 500-hour endurance test consists of four 125-hour cycles. The schedule for the 125-hour cycle is shown in Table B-19 (Note: periods 1 and 2 are deleted during cycles 2, 3, and 4). The final cycle is run with an intake air temperature of 140°F at an ambient air temperature of 115°F (+5°F). At the conclusion of the endurance run, the engine must meet all performance requirements except the engine can develop not less than 95 percent of its power output at period 66 (Table B-18). Also, there can be no evidence of abnormal wear of internal engine components.

During engine production, the first ten engines produced, and every second engine of the next 100 produced, and every twentieth engine of the enxt 200 produced are dismantled and inspected after the break-in and acceptance tests have been conducted (see Table B-20). The engines are then reassembled and subjected to another break-in test.

TABLE B-19, LDT-465-1C 125-HOUR ENDURANCE SCHEDULE (CONT.)

Period	Time (hrs)	Engine Speed (rpm)	Percent Load
47	.25	650	0
48	.75	2600	100
49	.25	650	0
50	.75	2600	100
51	.25	650	0
52	.75	2600	100
53	.25	650	0
54	.75	2600	100
55	.25	650	0
56	2	1800	50
57	2	1800	100
58	1	650	0
59	2	2000	50
60	1	650	0
61	2	2600	100
62	1	650	0
63	4	2600	75
64	2	2600	100
65	.5	2850	0
66**			

* Break-in run
** Power check

4. The Remaining Multi-Fuel Engines

The military specification or purchase description document which describes the tests and test procedures used to qualify the remaining multi-fuel engines are as follows:

- MIL-E-46778: LDS-427-2
- DAPD-292F: LDS-465-1 and LDS-465-1A
- ATPD-2024A: LDS-465-2

It is notable that ATPD-2024A (for the LDS-465-2 engine) has been cancelled. Also, the LDS-427-2 engine has not been produced for a number of years.

The qualification tests and test procedures described in these above mentioned military specifications and purchase description documents are nearly identical to those already described for the LD-465-1 and LD-465-1C [MIL-E-62106(AT)] and LDT-465-1C (ATPD-2046) engines. Therefore, they will not be repeated here. The primary difference in the procedures (from those already described) will be minor changes in the engine settings (e.g., speed and load) at

TABLE B-19, LDT-465-1C 125-HOUR ENDURANCE SCHEDULE

Period	Time (hrs)	Engine Speed (rpm)	Percent Load
1*			
2**			
3	2	650	0
4	5	1400	75
5	1	650	0
6	5	2000	75
7	1	650	0
8	5	2200	75
9	1	650	0
10	5	2600	75
11	1	650	0
12	2	1800	50
13	2	1800	100
14	1	650	0
15	2	2000	50
16	2	2000	75
17	1	650	0
18	2	2200	75
19	2	2200	100
20	1	650	0
21	3	2600	75
22	3	2600	100
23	2	650	0
24	5	1400	75
25	1	650	0
26	5	2000	75
27	1	650	0
28	5	2200	75
29	1	650	0
30	5	2600	75
31	1	650	0
32	2	1800	50
33	2	1800	100
34	1	650	0
35	2	2000	50
36	4	2000	100
37	1	650	0
38	4	2200	75
39	4	2200	100
40	1	650	0
41	2.5	2600	75
42	4	2600	100
43	1	650	0
44	.75	2600	100
45	.25	650	0
46	.75	2600	100

* Break-in run
** Power check

TABLE B-20, LDT-465-1C ENGINE DISASSEMBLY INSPECTIONS

- Oil contamination
- Dirt, chips or foreign matter in the engine block, oil passages, oil pan, filters, and secondary drive case.
  NOTE: Do not remove or inspect the secondary fuel filter.
- Main bearing bolt torque
- Connecting rod bolt torque
- Vibration damper bolt torque
- Fuel injectors and nozzles for dribbling, improper spray pattern, plugged nozzles or other malfunction
- Cylinder compression pressure (maximum of 25 psi variation between cylinders)
- Scuffing, scoring, or galling of bearings, pistons, cylinders, cam lobes, tappets or other components
- Burning of pistons or valves, broken piston rings and valve seats, or worn valve faces.
- Leakage of gaskets or seals
- Casting flash and obstructions in cylinder block and cylinder head water jacket passages (removal of core plugs and necessary assemblies required for visual inspection)
- Any defects having no bearing on function, safety, interchangeability or life, but which are considered departure from good workmanship will be noted in writing.
- Valve tappet clearance, each valve
- Governor adjustment
- Torque on cylinder heat nuts, intake and exhaust manifold bolts, and turbocharger mounting bolts
- Crankshaft end play
- Injection pump timing and adjustment

which test periods are run, performance tests are conducted, and/or data is recorded. In some cases, the required fuel for a specific test procedure is different. If the reader is specifically interested in a test or test procedure, then consult the above stated military specification or purchase document for the engine of interest.

Fifty hour quality control tests are also conducted during engine production at the rate of one per month when production is 100 units or less per month and two per month when production is greater than 100 units per month. The 50-hour quality control test schedule is shown in Table B-21. The engine is examined for defects per Table B-18 and submitted to acceptance tests.

TABLE B-21, LDT-465-1C 50-HOUR QUALITY CONTROL TEST SCHEDULE

Period	Time (hrs)	LDS-465 Speed (rpm)	Power Position (% of full power)	Fuel
1*				Diesel fuel,
2	5	1400	50	VV-F-800
3	5	1400	75	Grade F-1 shall
4	5	2600	75	be used during
5	5	1400	100	periods 1
6	30	2600	100	through 6
7**				

*Break-in schedule
**Periods 1 through 8 and 9 through 16 of the power-check test are conducted on diesel fuel and gasoline respectively.

The following data are recorded:

- Engine speed
- Observed brake horsepower
- Observed torque
- Air pressure at inlet to engine
- Fuel pressure at primary filter inlet
- Fuel supply pressure at inlet to engine driven supply pump
- Lubricating oil pressure, main gallery and piston cooling gallery
- Coolant pressure at cylinder block drain cock, water pump inlet and engine coolant outlet
- Lubricating oil temperature in oil sump
- Fuel temperature at primary filter inlet
- Coolant temperature rise - inlet to outlet
- Air temperature at air cleaner inlet
- Cell ambient air temperature
- Fuel temperature at fuel measuring device

C. COMMERCIALLY DESIGNED ENGINES

1. Detroit Diesel Allison 3-53

MIL-E-62045B(AT), 14 May 1973, describes the reliability, endurance, and performance tests used to qualify the DDA 3-53 engine. The engine is also required to comply with the applicable Health, Education, and Welfare Regulations governing control of exhaust emissions from new motor vehicle engines in effect on the date of manufacture. The range of the various required qualification inspections as well as the location for the test is shown in Table B-22. All testing is conducted using fuel conforming to grade DF-2 of Federal specification VV-F-800. Engine lubricating oil used for the various tests must be in accordance with the seasonal requirements of MIL-L-2104 (for -10°F to 115°F) and MIL-L-10295 (for -65°F to 0°F). Type II lube oil of MIL-L-21260 can be used during engine assembly and during the production break-in runs. Referee lube oil grade MB901 of MIL-L-2104 is used during the engine endurance test. In addition to the engine specific tests listed in Table B-22, a vehicle reliability test is required in which the 3-53 engine must demonstrate its durability in 20,000 miles of wheeled vehicle operation without overhaul or major failure. Major failure is defined as:

- Main bearing and connecting rod bolt broken, stripped threads, scored, and damage that may cause subsequent failure
- Broken, scuffed, and burned pistons
- Cylinder bore scuffed, scored, and galling

The first engine produced is subjected to a variety of examinations (see Table B-23) as well as performance tests such as:

- Oil consumption
- Cold starting
- High temperature starting
- Humidity conditions and coolant temperatures
- Elevation
- Grades and slopes
- Steam and water jet cleaning

- Exhaust temperature port and manifold outlet
- Fuel flow
- Brake specific fuel consumption
- Oil consumption
- Exhaust smoke density - (during period 1 and 7 only)
- Alternator output
- Air delivery
- Crankcase blowby

TABLE B-22, DDA 3-53 QUALIFICATION INSPECTIONS AND TEST LOCATION

Test Requirement Description	Place of Manufacture	Government Laboratory
First production inspection and testing		X
Endurance test		X
Failure		X
Power check	X	X
Engine shutdown		X
Engine warm-up period		X
Test hours		X
Data		X
Warning and shutdown		X
Servicing		X
Test temperature		X
Performance test	X	X
Oil consumption test	X	X
Cold starting	X	X
High temperature starting	X	X
Humidity conditions and coolant temperatures	X	X
Elevation test		X
Grades and slopes test		X
Steam and water jet cleaning test		X
Examinations	X	
Production engine test	X	
Tear-down inspection	X	
Corrections and reassembly	X	
Speed range check	X	
Governor check	X	
Brake horsepower check	X	
Oil pressure check	X	
Airbox heater check	X	
Fifty-hour control test	X	
Temperatures	X	
Torque and brake horsepower check	X	
Exhaust smoke density check	X	
Fuel consumption check	X	
Radio noise suppression test	X	
Inspection for preparation of delivery	X	

TABLE B-23, REQUIRED EXAMINATIONS OF DDA 3-53 ENGINE DURING ENDURANCE TEST

Characteristic	Major Defect	Method of Inspection
Valve tappet clearance each valve	Exhaust valves improperly adjusted	Gage
Oil sump, fuel and oil filters	Dirt, chips, and foreign particles, due to production	Visual and functional
Fuel, oil, and coolant leaks	Leakage	Visual
Fuel lines	Damaged	Visual and functional
Governor	Malfunction	Visual and functional
Torque on cylinder head bolts, exhaust manifold flange bolts, vibration damper	Improper torque	Torque wrench
Crankshaft	Excessive or restrictive play	Gage and functional
Engine	Malfunction	Functional
Fuel system components	Malfunction, damage or leaks, etc.	Visual and functional
Fuel, injection system, timing and components	Malfunction, improper adjustment	Gage
Coolant system	Malfunction non-conformance	Functional
Airbox pressure	Less than limits	Gage
Crankcase pressure	Exceeds limits	Gage
Linkage	Improperly adjusted	Visual
Minor assemblies	Omitted	Visual

TABLE B-23, REQUIRED EXAMINATIONS OF DDA 3-53 ENGINE DURING ENDURANCE TEST - (CONT.)

Characteristic	Major Defect	Method of Inspection
Engine	Improper adjustment or installation of components	Visual and Functional
Fuel lines, hose, vents, shut-off valve	Improper assembly or installation	Visual
Painting	Improper application	Visual
Workmanship	Not following good practice, improper installation or adjustment of components	Visual and functional

The first production engine is also subjected to a 400 hour endurance test whose schedule consists of four periods of 100 hours each where each 100 hour period consists of 20, 5 hour schedules. Table B-24 describes the 5 hour schedule.

TABLE B-24, DDA 3-53 5 HOUR ENDURANCE TEST SCHEDULE

Period	Percent Rate Speed	Percent Load	Endurance Hours
1	Idle	0	0.5
2	Max. Torque	100	1.0
3	100	0	0.5
4	75	85	1.0
5	100	50	0.5
6	100	100	1.0
7	50	25	0.5
	Total Endurance		5.0

Before the start of the endurance run and after 100 hours of endurance time, power checks are conducted at full load and various engine speeds in both ascending and descending order after the engine has stabilized for a sufficient time (about 20 minutes). The engine can be shut down after completion of any period in the 5 hour schedule, but a cool-down run is required after periods 2, 4, and 5. A 1/2 hour warm-up is required following any shutdown and prior to continuation of the endurance run; during the period, the loads and speeds are progressively increased to the values shown in period 5. The following data are recorded during the last 5 minutes of each schedule period and during power checks:

- Engine speed
- Observed brake horsepower and/or torque
- Fuel flow
- Test cell ambient temperature and barometric pressure
- Engine oil gallery and sump temperatures and pressure
- Fuel secondary filter out and spill back temperatures and pressures
- Air cleaner inlet temperature
- Air inlet pressure
- Air cleaner restriction
- Coolant engine inlet and outlet temperatures and pressures
- Exhaust port temperatures
- Exhaust manifold pressure
- Crankcase pressure
- Fuel, transfer pump, inlet pressure
- Oil consumption
- Exhaust smoke density

After the final performance test, the engine is completely dismantled and inspected. The engine must conform to all performance requirements with the exception that the power and torque be not less than 95% of initial readings without readjustment of the injection system. Also, there can be no evidence of abnormal wear of internal engine components.

Every production engine is given a break-in run (MIL-E-62045B(AT) does not describe the break-in schedule) and the engines are checked for speed range, governor operation, maximum brake horsepower, minimum oil pressure and oil pressure limits, and airbox heater operability. The first ten production engines and every other engine of the next ten are then completely dismantled and inspected. These tests are known as acceptance tests.

During engine production, 50-hour quality control testing is performed. One engine per month when production is less than 100 and two engines per month when production is greater than 100 are selected for the 50-hour tests. The tests follow the schedule shown in Table B-25, after the normal break-in and performance check tests (as described for the endurance test procedure) are conducted. Additional performance check testing is conducted after the 50-hour test schedule is completed.

TABLE B-25, DDA 3-53 60-HOUR QUALITY CONTROL TEST SCHEDULE

Period	Time (Hours)	Engine Speed (rpm)	Horsepower (bhp)
1	5	1600	30
2	5	2000	58
3	5	2800	73
4	5	2400	84
5	30	2800	90

2. Detroit Diesel Allison 6V-53

MIL-E-62140(AT), 27 August 1971, describes the endurance and performance tests used to qualify the DDA 6V53 engine. The range of the various required qualification inspections as well as the location for the test is shown in Table B-26.

TABLE B-26, DDA 6V QUALIFICATION INSPECTIONS AND TEST LOCATION

Requirement Description	Place of Manufacture	Government Laboratory
First production engine test		X
Endurance test		X
Cold starting		X
High temperature starting		X
Slope test		X
Power check test		X
Servicing		X
Elevation test		X
High temperature operational test		X
Steam and water jet cleaning test		X
Radio noise suppression test		
Examination:	X	
Production break-in run	X	
Tear down inspection	X	
Corrections and reassembly	X	
Acceptance tests:	X	
50-hour control test	X	
Selection of test sample	X	
Control test failure	X	
Performance	X	
Corrections	X	
Disposition of engine	X	

Fuel for testing, except endurance testing, is grade DF-2 of Federal specification VV-F-800. Endurance testing is conducted using referee grade diesel fuel. The referee grade diesel fuel has properties as shown in Table B-27 (using method No. 340-T of Federal Test Method Standard No. 791). The various testing is conducted using lubricating oil conforming to the seasonal requirements of MIL-L-2104 (for -10°F to 115°F) and MIL-L-10295 (for -65°F to 0°F); the engine manufacturer can use oil of his own selection for engine assembly and during the break in test, or oil conforming to grade 2 of MIL-L-21260.

TABLE B-27, PROPERTIES OF REFEREE GRADE DIESEL FUEL

Parameter	Specification
Flash point, minimum, °F	100 or legal
Pour point, maximum, °F	20
Water and sediment, by volume, maximum percent	0.05
Distillation, 50% evaporated, minimum, °F	500
90% evaporated, °F	600 - 640
end point, °F	650 - 690
Kinematic viscosity, centistokes, at 100°F	1.6 to 4.5
Sulfur*, percent	0.95 - 1.05
Corrosion	pass
Alkali and mineral acids	none
Cetane number	40 to 45

*Must be natural sulfur

Each engine selected for testing must meet the examination requirements of Table B-28 as well as performance tests (following a break-in run) such as:

- speed range
- governor setting
- brake horsepower
- torque
- oil pressure

The first production engine (after break-in and examination) must successfully complete the 500 hour endurance test described in Table B-29, operating on the referee diesel fuel described in Table B-27. During the endurance test, power check tests are conducted (as noted in Table B-29) following the schedule shown in Table B-30. The following data are recorded after each hour of operation and at the completion of each period prior to stopping the engine:

- Engine speed
- Observed brake horsepower
- Observed torque
- Air box pressure
- Fuel pressure after secondary filter
- Fuel supply pressure at inlet to engine driven supply pump
- Lubricating oil pressure
- Lubricating oil temperature in oil sump
- Fuel temperature after secondary filter
- Coolant temperature - Engine inlet and outlet
- Air temperature at air inlet
- Cell ambient air temperature
- Exhaust temperature
- Fuel flow
- Brake specific fuel consumption
- Specific oil consumption
- Exhaust smoke density

TABLE B-28, REQUIRED EXAMINATIONS OF DDA 6V-53 ENGINE

Characteristic	Defect	Method of Inspection
Valve tappet clearance, each valve	Exhaust valves improperly adjusted	Gage
Oil sump, fuel and oil filters	Dirt, chips and foreign particles, due to production	Visual & functional
Fuel, oil, and coolant leaks	Leakage	Visual
Fuel lines	Damaged	Visual & functional
Governor	Malfunction	Visual & functional
Torque on cylinder head bolts, intake and exhaust manifold flange bolts, vibration damper	Improper torque	Torque wench
Crankshaft	Excessive or restrictive end play	Gage & functional

TABLE E-28, REQUIRED EXAMINATIONS OF DDA 6V-53 ENGINE (CONT.)

Characteristics	Defect	Method of Inspection
Engine	Malfunction	Functional
Fuel System Components	Malfunction - damage or leaks, etc.	Visual & Functional
Fuel Injection System, Timing and Components	Malfunction, improper adjustment	Gage
Air Cleaner	Malfunction	Functional
Air Box Pressure	Exceeds Limits	Gage
Crankcase Pressure	Exceeds Limits	Gage
Linkage	Improperly Adjusted	Visual
Minor Assemblies	Omitted	Visual
Engine	Improper Adjustment or Installation of Components	Visual & Functional
Fuel Lines, Hose, Vents, Shut-Off Valve	Improper Assembly or Installation	Visual
Painting	Improper Application	Visual
Workmanship	Not Following Good Practice, Improper Installation or Adjustment of Components	Visual & Functional

TABLE B-29, DDA 6V-53 500-HOUR ENDURANCE TEST SCHEDULE

Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed	Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed
1				45	1	500 rpm	0
2	2	500 rpm	0	46	5	75 pct	75
3	5	50 pct	75	47	1	500 rpm	0
4	1	500 rpm	0	48	5	85 pct	75
5	5	75 pct	75	49	1	500 rpm	0
6	1	500 rpm	0	50	5	100 pct	75
7	5	85 pct	75	51	2	500 rpm	0
8	1	500 rpm	0	52	5	50 pct	75
9	5	100 pct	75	53	1	500 rpm	0
10	2	500 rpm	0	54	5	75 pct	75
11	5	50 pct	75	55	1	500 rpm	0
12	1	500 rpm	0	56	5	85 pct	75
13	5	75 pct	75	57	1	500 rpm	0
14	1	500 rpm	0	58	5	100 pct	75
15	5	85 pct	75	59	2	500 rpm	0
16	1	500 rpm	0	60	5	50 pct	75
17	5	100 pct	75	61	1	500 rpm	0
18	2	500 rpm	0	62	5	75 pct	75
19	5	50 pct	75	63	1	500 rpm	0
20	1	500 rpm	0	64	5	85 pct	75
21	5	75 pct	75	65	1	500 rpm	0
22	1	500 rpm	0	66	5	100 pct	75
23	5	85 pct	75	67		(powertest)	
24	1	500 rpm	0	68	2	50 pct	50
25	5	100 pct	75	69	1	500 rpm	0
26	2	500 rpm	0	70	2	58.4 pct	100
27	5	50 pct	75	71	2	58.4 pct	50
28	1	500 rpm	0	72	1	500 rpm	0
29	5	75 pct	75	73	2	58.4 pct	100
30	1	500 rpm	0	74	2	58.4 pct	50
31	5	85 pct	75	75	1	500 rpm	0
32	1	500 rpm	0	76	2	58.4 pct	100
33	5	100 pct	75	77	2	58.4 pct	50
34		(powertest)		78	1	500 rpm	0
35	2	500 rpm	0	79	2	58.4 pct	100
36	5	50 pct	75	80	2	58.4 pct	50
37	1	500 rpm	0	81	1	500 rpm	0
38	5	75 pct	75	82	2	58.4 pct	100
39	1	500 rpm	0	83	2	58.4 pct	50
40	5	85 pct	75	84	1	500 rpm	0
41	1	500 rpm	0	85	2	58.4 pct	100
42	5	100 pct	75	86	2	58.4 pct	50
43	2	500 rpm	0	87	1	500 rpm	0
44	5	50 pct	75	88	2	58.4 pct	100

TABLE B-29, DDA 6V-53 500-HOUR ENDURANCE TEST SCHEDULE (CONT.)

Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed	Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed
89	2	58.4 pct	50	133	1	500 rpm	0
90	1	500 rpm	0	134	4	85 pct	100
91	2	58.4 pct	100	135	1	500 rpm	0
92	2	58.4 pct	50	136	4	85 pct	75
93	1	500 rpm	0	137	1	500 rpm	0
94	2	58.4 pct	100	138	4	85 pct	100
95	2	58.4 pct	50	139	1	500 rpm	0
96	1	500 rpm	0	140	4	85 pct	75
97	2	58.4 pct	100	141	1	500 rpm	0
98	2	58.4 pct	50	142	4	85 pct	100
99	1	500 rpm	0	143	1	500 rpm	0
100	2	58.4 pct	100	144	4	500 rpm	75
101	2	58.4 pct	50	145	1	500 rpm	0
102	1	500 rpm	0	146	4	100 pct	100
103	2	58.4 pct	100	147	1	500 rpm	0
104	2	75 pct	50	148	4	100 pct	100
105	1	500 rpm	0	149	1	500 rpm	0
106	2	75 pct	100	150	4	100 pct	100
107	4	75 pct	50	151	1	500 rpm	0
108	1	500 rpm	0	152	4	100 pct	75
109	4	75 pct	50	153	1	500 rpm	0
110	1	500 rpm	0	154	4	100 pct	100
111	4	75 pct	50	155	1	500 rpm	0
112	1	500 rpm	0	156	4	100 pct	75
113	4	75 pct	100	157	1	500 rpm	0
114	1	500 rpm	0	158	4	100 pct	100
115	4	75 pct	50	159	1	500 rpm	0
116	1	500 rpm	0	160	4	100 pct	75
117	4	75 pct	100	161	1	500 rpm	0
118	1	500 rpm	0	162		(powertest)	
119	4	75 pct	50	163	4	100 pct	100
120	1	500 rpm	0	164	1	500 rpm	0
121		(powertest)		165	4	100 pct	75
122	4	75 pct	100	166	1	500 rpm	0
123	1	500 rpm	0	167	3	100 pct	75
124	4	75 pct	50	168	1	500 rpm	0
125	1	500 rpm	0	169	3	100 pct	100
126	4	85 pct	100	170	3	100 pct	75
127	1	500 rpm	0	171	1	500 rpm	0
128	4	85 pct	75	172	3	105 pct	100
129	1	500 rpm	0	173	3	100 pct	75
130	4	85 pct	100	174	1	500 rpm	0
131	1	500 rpm	0	175	3	100 pct	100
132	4	85 pct	75	176	3	100 pct	75

TABLE B-29, DDA 6V-53 500-HOUR ENDURANCE TEST SCHEDULE (CONT.)

Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed	Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed
177	1	500 rpm	0	213	0.25	500 rpm	0
178	3	100 pct	100	214	0.25	100 pct	75
179	3	100 pct	75	215	0.25	500 rpm	0
180	1	500 rpm	0	216	0.75	100 pct	100
181	2	100 pct	100	217	0.25	500 rpm	0
182	2	75 pct	75	218	0.75	100 pct	100
183	1	500 rpm	0	219	0.25	500 rpm	0
184	2	85 pct	100	220	0.75	100 pct	100
185	2	100 pct	100	221	0.25	500 rpm	0
186	1	500 rpm	0	222	0.75	100 pct	100
187	2	75 pct	75	223	0.25	500 rpm	0
188	2.75	75 pct	100	224	0.75	100 pct	100
189	2.75	85 pct	75	225	0.25	500 rpm	0
190	2.5	85 pct	100	226	0.75	100 pct	100
191	2.5	85 pct	75	227	0.25	500 rpm	0
192	2.5	100 pct	100	228	0.75	100 pct	100
193	2.5	100 pct	75	229	0.25	500 rpm	0
194	2.5	100 pct	100	230	0.75	100 pct	100
195	2.5	100 pct	75	231	0.25	500 rpm	0
196	0.75	100 pct	100	232	0.75	100 pct	100
197	0.25	500 rpm	0	233	0.25	500 rpm	0
198	0.75	100 pct	100	234	0.75	100 pct	100
199	0.25	500 rpm	0	235	0.25	500 rpm	0
200	0.75	100 pct	100	236	0.75	100 pct	100
201	0.25	500 rpm	0	237	0.25	500 rpm	0
202	0.75	100 pct	75	238	0.75	100 pct	100
203	0.25	500 rpm	0	239	0.25	500 rpm	0
204	0.75	500 rpm	100	240	0.75	100 pct	100
205	0.24	500 rpm	0	241	0.25	500 rpm	0
206	0.75	100 pct	100	242	0.75	100 pct	100
207	0.25	500 rpm	0	243	0.25	500 rpm	0
208	0.75	100 pct	100	244	0.75	100 pct	100
209	0.25	500 rpm	0	245	0.25	500 rpm	0
210	0.75	100 pct	100	246	0.50	110 pct	0
211	0.25	500 rpm	0	247		(powertest)	
212	0.75	100 pct	75				

Note 1 - Cylinder head temperatures are allowed to vary with load except for test period numbers 147, 166, 203, and 239 where they may not exceed limits recommended by the engine manufacturer.

Note 2 - Coolant temperature is to be maintained at 180°F for test periods 1 through 204 (except during power tests) and at 210°F for test periods 205 through 246.

TABLE B-30, DDA 6V-53 POWER CHECK TEST SCHEDULE

Period	Engine Speed (rpm)	Rack Position
1	1600	Full
2	2000	Full
3	2400	Full
4	2800	Full

At the conclusion of the endurance run, the engine must develop no less than 90 percent of its rated power. The engine is then dismantled and inspected.

The first ten production engines and every second engine of the next ten (after break-in) are dismantled and inspected to the extent necessary to verify the following:

- Oil contamination
- Dirt, chips or foreign matter in the engine block, oil pan, filters and accessory drive case
- Main bearing bolt torque
- Connecting rod bolt torque
- Cylinder bore scuffing, scoring, galling, etc.
- Piston scuffing and burning

The engines are then reassembled and put through the previously described power check test.

During engine production, a 50-hour quality control test is performed. One engine per month when production is less than 100 units and two engines per month when production is greater than 100 units are selected for the 50-hour tests. The test schedule is as shown in Table B-31, after the normal break-in is conducted. Additional power check testing is conducted after the 50-hour test schedule is complete. Finally, the engine is reinspected (per Table B-28) after the performance requirements for the following are verified:

- Speed range
- Governor setting
- Brake horsepower
- Torque

TABLE B-31, DDA 6V-53 50-HOUR QUALITY CONTROL TEST SCHEDULE

Test Period	Time (Hours)	Engine Speed (rpm)	Rack Position (% of full rack)
1	5	1600	50
2	5	2000	75
3	5	2800	75
4	5	2400	100
5	30	2800	100

- Exhaust smoke density
- Fuel consumption
- Oil consumption
- Oil pressure
- Limiting operating temperatures

3. Detroit Diesel Allison 6V-53T

MIL-E-52395A, 10 March 1976, describes the tests used to qualify the DDA 6V-53T engine. Fuel for all testing conforms to grade DF-2 of Federal specification VV-F-800, except for endurance testing. Endurance test fuel has properties as shown in Table B-32 (using method No. 340.3 of Federal Test Method Standard No. 791).

Engine lubricating oil used for the various tests must be in accordance with the seasonal requirements of MIL-L-2104 (for -10°F to 115°F) and MIL-L-46167 (for -65°F to 0°F). The engine manufacturer may use oil of his own selection for the engine assembly and break-in runs, or oil conforming to grade 2 of MIL-L-21260 can be used.

The first production engine is subjected to an engine break-in (schedule not defined) and is then checked for the following (this test is called an acceptance test)

- Speed range
- Governor setting
- Brake Horsepower

* Torque
* Exhaust smoke density
* Oil pressure

TABLE B-32, PROPERTIES OF REFEREE GRADE DIESEL FUEL

Parameter	Specification
Flash point, minimum, $^{\circ}F$	100 or legal
Pour point, maximum, $^{\circ}F$	20
Water and sediment, by volume, maximum percent	0.05
Distillation, 50% evaporated, minimum, $^{\circ}F$	500
90% evaporated, $^{\circ}F$	600 - 640
end point, $^{\circ}F$	650 - 690
Kinematic viscosity, centistokes, at $100^{\circ}F$	1.6 to 4.5
Sulfur*, percent	0.95 - 1.05
Corrosion	pass
Alkali and mineral acids	none
Cetane number	40 to 45

*Must be natural sulfur

The engine must also be the examination requirements shown in Table B-33. The following tests are then conducted:

* Starting tests (hot and cold soak)
* Slope
* 400 hour endurance
* Power check
* Elevation
* High temperature
* Steam and water cleaning
* Electromagnetic compatibility
* Teardown

The endurance test is the 400 hour NATO cycle procedure which consists of four periods of 100 hours each where each 100 hour period is made up of twenty 5-hour schedules as shown in Table B-34. After the endurance run, a power check test is conducted (also with the referee diesel fuel) per the schedule in Table B-35. Subsequent to the endurance run, the engine must conform to all performance requirements except it must develop no less than 90 percent of its initial power output with a maximum smoke density not to exceed a No. 3 (light gray using a Robert Bosch EFAW 68 smoke meter or equivalent) without an engine tune-up and 95 percent of its initial power output after an engine tune-up. Also, there must be no evidence of abnormal wear of internal engine components.

TABLE B-33, REQUIRED EXAMINATIONS OF DDA 6V-53T

Characteristic	Defect	Method of Inspection
Valve tappet clearance, each valve	Exhaust valves improperly adjusted	Gage
Oil sump, fuel and oil filters	Dirt, chips and foreign particles, due to production	Visual & functional
Fuel, oil, and coolant leaks	Leakage	Visual
Fuel lines	Damaged	Visual & functional
Governor	Malfunction	Visual & functional
Torque on cylinder head bolts, intake and exhaust manifold flange bolts, vibration damper	Improper torque	Torque wench
Crankshaft	Excessive or restrictive end play	Gage & functional
Engine	Malfunction	Functional
Fuel System Components	Malfunction - damage or leaks, etc.	Visual & Functional
Fuel Injection System, Timing and Components	Malfunction, improper adjustment	Gage
Air Cleaner	Malfunction	Functional
Air Box Pressure	Exceeds Limits	Gage
Crankcase Pressure	Exceeds Limits	Gage
Linkage	Improperly Adjusted	Visual
Minor Assemblies	Omitted	Visual

TABLE B-33, REQUIRED EXAMINATIONS OF DDA 6V-53T ENGINE (CONT.)

Characteristics	Defect	Method of Inspection
Engine	Improper Adjustment or Installation of Components	Visual & Functional
Fuel Lines, Hose, Vents, Shut-Off Valve	Improper Assembly or Installation	Visual
Painting	Improper Application	Visual
Workmanship	Not Following Good Practice, Improper Installation or Adjustment of Components	Visual & Functional

TABLE B-34, DDA 6V-53T 5-HOUR ENDURANCE SCHEDULE

Period	Percent Rated Speed	Percent Load	Endurance Hours
1	Idle	0	0.5
2	Max Torque	100	1.0
3	100	0	0.5
4	75	85	1.0
5	100	50	0.5
6	100	100	1.0
7	50	25	0.5
Total Endurance			5.0

TABLE B-35, DDA 6V-53T POWER CHECK TEST SCHEDULE

Period	Engine Speed	Rack Position
1	1800	Full
2	2000	Full
3	2400	Full
4	2600	Full
5	2800	Full

During engine production, the first ten engines produced and every second engine of the next ten (after the break-in run) are disassembled and inspected to the extent necessary to determine the following:

- Oil contamination
- Dirt, chips or foreign matter in the engine block, oil pan, filters, and accessory drive case
- Main bearing bolt torque
- Connecting rod bolt torque
- Cylinder bore scuffing, scoring, galling, etc.
- Piston scuffing and burning

They are then reassembled and once again put through a break-in run.

During engine production, an additional quality control test is performed, called a 50-hour control test. One engine per month is selected when production is less than 100 units per month, and two units per month are selected when production is greater than 100 units per month. The selected engines are broken-in, examined, and acceptance tested and then put through the 50-hour control test per the schedule shown in Table B-36. During the 50-hour quality control test, the engine is evaluated for adherence to the following performance requirements:

- Limiting operating temperature
- Speed range

TABLE B-36, DDA 6V-53T 50-HOUR QUALITY CONTROL TEST SCHEDULE

PERIOD	TIME (HRS.)	ENGINE SPEED (RPM)	% OF RACK POSITION
1	5	1000	50
2	5	2300	75
3	5	2800	75
4	5	2500	100
5	30	2800	100

- Governor setting
- Brake horsepower
- Torque
- Exhaust smoke density
- Fuel consumption
- Oil consumption
- Oil pressure
- Turbocharging

Additionally, the following data are required to be recorded:

- Engine speed
- Observed brake horsepower
- Observed torque
- Air box pressure
- Fuel pressure after secondary filter
- Lubricating oil pressure
- Lubricating oil temperature in oil sump
- Fuel temperature after secondary filter
- Coolant temperature - engine outlet
- Air temperature at turbocharger
- Cell ambient air temperature
- Exhaust temperature (after turbocharger)
- Fuel flow
- Brake specific fuel consumption
- Specific oil consumption
- Exhaust smoke density
- Barometer pressure during power check test

Finally, the engine is disassembled and inspected, reassembled, and shipped as a production engine (pending a successful inspection).

4. Detroit Diesel Allison 8V-71T

MIL-E-46796(MO), as amended 6 December 1973, describes the tests used to qualify the DDA 8V-71T engine. Three general tests are conducted, first production, acceptance, and 50-hour quality control testing. Table B-37 lists the tests required. All testing, except endurance testing, is conducted

TABLE B-37 , ENGINE TESTS REQUIRED FOR QUALIFYING THE 8V-71T

TEST	FIRST PRODUCTION	ACCEPTANCE	CONTROL
Break-in run	X	X	
Acceptance (power check)	X	X	
Starting tests	X		
Slope	X		
Submersion	X		
500-hour endurance	X		
Power check	X		
Elevation	X		
High temperature	X		
Steam and water cleaning	X		
Radio supression	X		
Control (50 hour)			X

using fuel conforming to grade 2 of Federal specification VV-F-800. Endurance test fuel is of a referee grade (using method No. 340-T of Federal Test Method Standard No. 791 having properties as shown in Table B-38.

TABLE B-38,PROPERTIES OF REFEREE GRADE DIESEL FUEL

Parameter	Specification
Flash point, minimum, ^{o}F	100 or legal
Pour point, maximum, ^{o}F	20
Water and sediment, by volume, maximum percent	0.05

TABLE B-38, PROPERTIES OF REFEREE GRADE DIESEL FUEL (CONT.)

Parameter	Specification
Distillation, 50% evaporated, minimum, °F 90% evaporated, °F end point, °F	500 600-640 650-690
Kinematic viscosity, centistokes, at 100°F	1.6 to 4.5
Sulfur*, percent	0.95-1.05
Corrosion	pass
Alkali and mineral acids	none
Cetane number	40 to 45

*Must be natural sulfur

Engine lubricating oil used for the various tests must be in accordance with the seasonal requirements of MIL-L-2104 (for -10°F to 115°F) and MIL-L-10295 (for -65°F to 0°F). The engine manufacturer may use oil of his own selection during engine assembly and break-in, or oil conforming to grade 2 of MIL-L-21260. During the endurance test, the lube oil must be Cities Service Oil Company designation as shown in Table B-39 .

TABLE B-39, REFEREE GRADE LUBE OIL DESIGNATION

GRADE	GOVERNMENT DESIGNATION	MANUFACTURER'S DESIGNATION
10	MB 2	CHL-140
30	MB 1	CHL-139
50	None	None

Engines are selected for examination in accordance with inspection level II of MIL-STD-105. Table B-40 describes the required examinations.

TABLE B-40 REQUIRED EXAMINATIONS OF DDA 8V-71T ENGINES

CATEGORIES	DEFECTS	GAGE OR OTHER METHOD OF INSPECTION
Valve tappet clearance, each valve	Intake and exhaust valves improperly adjusted.	Gage
Oil sump, fuel and oil filters	Dirt, chips and foreign particles, due to production.	Visual and functional
Fuel, oil and coolant leaks	Leakage	Visual
Fuel lines	Damaged	Visual and functional
Governor	Malfunction	Visual and functional
Torque on cylinder head bolts, intake and exhaust manifold flange bolts, vibration damper	Improper torque	Torque wrench
Crankshaft	Excessive or restrictive end play	Gage and functional
Engine	Malfunction	Functional
Fuel system components	Malfunction - damage or leaks, etc.	Visual and functional
Fuel injection system, timing and components	Malfunction, improper adjustment	Visual and functional
Air Cleaner	Malfunction	Functional
Linkage	Improperly adjusted	Visual
Minor assemblies	Omitted	Visual
Engine	Improper adjustment or installation of components	Visual and functional
Fuel lines, hose, vents, shutoff valve	Improper assembly or installation	Visual
Painting	Improper application	Visual
Workmanship	Not following good practice, improper installation or adjustment of components	Visual

The first production engine is submitted to the tests indicated in Table B-37. The endurance test is conducted in accordance with Table B-41. The power check tests indicated in Table B-41 are conducted according to the schedule shown in Table B-42. During the power check test, compliance with the following

TABLE B-41 DDA 8V-71T 500-HOUR ENDURANCE TEST SCHEDULE

Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed	Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed
1				45	1	500 rpm	0
2	2	500 rpm	0	46	5	75 pct	75
3	5	50 pct	75	47	1	500 rpm	0
4	1	500 rpm	0	48	5	85 pct	75
5	5	75 pct	75	49	1	500 rpm	0
6	1	500 rpm	0	50	5	100 pct	75
7	5	85 pct	75	51	2	500 rpm	0
8	1	500 rpm	0	52	5	50 pct	75
9	5	100 pct	75	53	1	500 rpm	0
10	2	500 rpm	0	54	5	75 pct	75
11	5	50 pct	75	55	1	500 rpm	0
12	1	500 rpm	0	56	5	85 pct	75
13	5	75 pct	75	57	1	500 rpm	0
14	1	500 rpm	0	58	5	100 pct	75
15	5	85 pct	75	59	2	500 rpm	0
16	1	500 rpm	0	60	5	50 pct	75
17	5	100 pct	75	61	1	500 rpm	0
18	2	500 rpm	0	62	5	75 pct	75
19	5	50 pct	75	63	1	500 rpm	0
20	1	500 rpm	0	64	5	85 pct	75
21	5	75 pct	75	65	1	500 rpm	0
22	1	500 rpm	0	66	5	100 pct	75
23	5	85 pct	75	67		(powertest)	
24	1	500 rpm	0	68	2	50 pct	50
25	5	100 pct	75	69	1	500 rpm	0
26	2	500 rpm	0	70	2	58.4 pct	100
27	5	50 pct	75	71	2	58.4 pct	50
28	1	500 rpm	0	72	1	500 rpm	0
29	5	75 pct	75	73	2	58.4 pct	100
30	1	500 rpm	0	74	2	58.4 pct	50
31	5	85 pct	75	75	1	500 rpm	0
32	1	500 rpm	0	76	2	58.4 pct	100
33	5	100 pct	75	77	2	58.4 pct	50
34		(powertest)		78	1	500 rpm	0
35	2	500 rpm	0	79	2	58.4 pct	100
36	5	50 pct	75	80	2	58.4 pct	50
37	1	500 rpm	0	81	1	500 rpm	0
38	5	75 pct	75	82	2	58.4 pct	100
39	1	500 rpm	0	83	2	58.4 pct	50
40	5	85 pct	75	84	1	500 rpm	0
41	1	500 rpm	0	85	2	58.4 pct	100
42	5	100 pct	75	86	2	58.4 pct	50
43	2	500 rpm	0	87	1	500 rpm	0
44	5	50 pct	75	88	2	58.4 pct	100

TABLE B-41 DDA 8V-71T 500-HOUR ENDURANCE TEST SCHEDULE (Continued)

Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed	Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed
89	2	58.4 pct	50	133	1	500 rpm	0
90	1	500 rpm	0	134	4	85 pct	100
91	2	58.4 pct	100	135	1	500 rpm	0
92	2	58.4 pct	50	136	4	85 pct	75
93	1	500 rpm	0	137	1	500 rpm	0
94	2	58.4 pct	100	138	4	85 pct	100
95	2	58.4 pct	50	139	1	500 rpm	0
96	1	500 rpm	0	140	4	85 pct	75
97	2	58.4 pct	100	141	1	500 rpm	0
98	2	58.4 pct	50	142	4	85 pct	100
99	1	500 rpm	0	143	1	500 rpm	0
100	2	58.4 pct	100	144	4	500 rpm	75
101	2	58.4 pct	50	145	1	500 rpm	0
102	1	500 rpm	0	146	4	100 pct	100
103	2	58.4 pct	100	147	1	500 rpm	0
104	2	75 pct	50	148	4	100 pct	100
105	1	500 rpm	0	149	1	500 rpm	0
106	2	75 pct	100	150	4	100 pct	100
107	4	75 pct	50	151	1	500 rpm	0
108	1	500 rpm	0	152	4	100 pct	75
109	4	75 pct	50	153	1	500 rpm	0
110	1	500 rpm	0	154	4	100 pct	100
111	4	75 pct	50	155	1	500 rpm	0
112	1	500 rpm	0	156	4	100 pct	75
113	4	75 pct	100	157	1	500 rpm	0
114	1	500 rpm	0	158	4	100 pct	100
115	4	75 pct	50	159	1	500 rpm	0
116	1	500 rpm	0	160	4	100 pct	75
117	4	75 pct	100	161	1	500 rpm	0
118	1	500 rpm	0	162		(powertest)	
119	4	75 pct	50	163	4	100 pct	100
120	1	500 rpm	0	164	1	500 rpm	0
121		(powertest)		165	4	100 pct	75
122	4	75 pct	100	166	1	500 rpm	0
123	1	500 rpm	0	167	3	100 pct	75
124	4	75 pct	50	168	1	500 rpm	0
125	1	500 rpm	0	169	3	100 pct	100
126	4	85 pct	100	170	3	100 pct	75
127	1	500 rpm	0	171	1	500 rpm	0
128	4	85 pct	75	172	3	105 pct	100
129	1	500 rpm	0	173	3	100 pct	75
130	4	85 pct	100	174	1	500 rpm	0
131	1	500 rpm	0	175	3	100 pct	100
132	4	85 pct	75	176	3	100 pct	75

TABLE B-41 DDA 8V-71T 500-HOUR ENDURANCE TEST SCHEDULE (Continued)

Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed	Test Period No.	Time (Hours)	Engine Speed or Percent of Max. Rated Speed (rpm)	Percent of Full Rack Load at Indicated Speed
177	1	500 rpm	0	213	0.25	500 rpm	0
178	3	100 pct	100	214	0.25	100 pct	75
179	3	100 pct	75	215	0.25	500 rpm	0
180	1	500 rpm	0	216	0.75	100 pct	100
181	2	100 pct	100	217	0.25	500 rpm	0
182	2	75 pct	75	218	0.75	100 pct	100
183	1	500 rpm	0	219	0.25	500 rpm	0
184	2	85 pct	100	220	0.75	100 pct	100
185	2	100 pct	100	221	0.25	500 rpm	0
186	1	500 rpm	0	222	0.75	100 pct	100
187	2	75 pct	75	223	0.25	500 rpm	0
188	2.75	75 pct	100	224	0.75	100 pct	100
189	2.75	85 pct	75	225	0.25	500 rpm	0
190	2.5	85 pct	100	226	0.75	100 pct	100
191	2.5	85 pct	75	227	0.25	500 rpm	0
192	2.5	100 pct	100	228	0.75	100 pct	100
193	2.5	100 pct	75	229	0.25	500 rpm	0
[illegible]4	2.5	100 pct	100	230	0.75	100 pct	100
195	2.5	100 pct	75	231	0.25	500 rpm	0
196	0.75	100 pct	100	232	0.75	100 pct	100
197	0.25	500 rpm	0	233	0.25	500 rpm	0
198	0.75	100 pct	100	234	0.75	100 pct	100
199	0.25	500 rpm	0	235	0.25	500 rpm	0
200	0.75	100 pct	100	236	0.75	100 pct	100
201	0.25	500 rpm	0	237	0.25	500 rpm	0
202	0.75	100 pct	75	238	0.75	100 pct	100
203	0.25	500 rpm	0	239	0.25	500 rpm	0
204	0.75	500 rpm	100	240	0.75	100 pct	100
205	0.24	500 rpm	0	241	0.25	500 rpm	0
206	0.75	100 pct	100	242	0.75	100 pct	100
207	0.25	500 rpm	0	243	0.25	500 rpm	0
208	0.75	100 pct	100	244	0.75	100 pct	100
209	0.25	500 rpm	0	245	0.25	500 rpm	0
210	0.75	100 pct	100	246	0.50	110 pct	0
211	0.25	500 rpm	0	247		(powertest)	
212	0.75	100 pct	75				

Note 1 - Cylinder head temperatures are allowed to vary with load except for test period numbers 147, 166, 203, and 239 where they may not exceed limits recommended by the engine manufacturer.

Note 2 - Coolant temperature is to be maintained at 180°F for test periods 1 through 204 (except during power tests) and at 210°F for test periods 205 through 246.

TABLE B-42 , DDA 8V-71T POWER CHECK TEST SCHEDULE

PERIOD	ENGINE SPEED	RACK POSITION
1	1200	Full
2	1400	Full
3	1800	Full
4	2100	Full
5	2300	Full

performance requirements are established:

- Speed range
- Governor speeds
- Brake horsepower
- Torque
- Exhaust smoke density
- Fuel consumption
- Oil consumption
- Oil pressure
- Supercharging
- Engine life

Through the course of the endurance test, the following data are recorded at the end of each hour of operation, at the completion of each period, and just prior to stopping the engine:

- Engine speed
- Observed brake horsepower
- Observed torque
- Intake manifold pressure, after turbocharger
- Exhaust manifold pressure, before turbocharger
- Fuel pressure after secondary filter
- Fuel supply pressure at transfer pump
- Lubrication oil pressure, gallery
- Crankcase pressure
- Lubricating oil temperature (sump)
- Lubricating oil temperature inlet, gallery
- Fuel temperature after secondary filter
- Air temperature at air cleaner inlet
- Air temperature at air box
- Coolant temperature inlet and outlet
- Exhaust temperature before and after turbocharger
- Test cell ambient air temperature
- Blowby

- Fuel flow
- Specific fuel consumption
- Specific oil consumption (at power check'
- Barometric pressure of test cell - once each 4-hour period.
- Exhaust smoke density

During the endurance test, compliance is established with the same performance requirements as listed above for the power check test. At the conclusion of the endurance test, the engine must comply with all performance requirements except the engine need develop only 90 percent of its initial power output with a maximum smoke density as shown in Table B-43.

TABLE B-43, MAXIMUM ALLOWABLE EXHAUST SMOKE DENSITY, 8V-71T

ENGINE SPEED (rpm)	VISUAL NO.	METER NO.*
1000	3	6
1400	3	5
2600	1	4

*The meter reading has precedence over the visual reading.

The first ten engines and every second of the next ten are submitted to a power-check test (see Table B-42) then disassembled and inspected. All engines are submitted for acceptance testing (which includes a power-check test) and must be in compliance with the following:

- Speed range
- Governor setting
- Brake horsepower
- Torque
- Exhaust smoke density
- Oil pressure

During engine production, 50-hour quality control testing is performed (the engines selected are also examined per Table B-40). After the engine is broken in, it is tested under the schedule shown in Table B-44 .

TABLE B-44 , 8V-71T 50-HOUR QUALITY CONTROL TEST SCHEDULE

PERIOD	TIME (HRS.)	SPEED (RPM)	RACK POSITION (% OF FULL)
1	5	1400	50
2	5	1800	75
3	5	2300	75
4	5	2100	100
5	30	2300	100

The following data are recorded during the test with the engine stabilized:

- Engine speed
- Observed brake horsepower
- Observed torque
- Intake manifold pressure, after turbocharger
- Fuel pressure after secondary filter
- Fuel supply pressure at inlet to engine driven supply pump
- Lubricating oil pressure
- Lubricating oil temperature in oil sump
- Fuel temperature after secondary filter
- Coolant temperature -- Engine inlet and outlet
- Air temperature at air inlet
- Cell ambient air temperature
- Exhaust temperature, after turbocharger
- Fuel flow
- Brake specific fuel consumption
- Specific oil consumption
- Exhaust smoke density

Subsequent to the 50-hour quality control test, a power check test is performed per the schedule shown in Table B-42 .

5. Detroit Diesel Allison 12V71T

MIL-E-62146(AT), 31 July 1972, describes the tests used to qualify the DDA 12V71T engine. The engine is also required to comply with the applicable exhaust emissions and smoke regulations set forth by the U.S. Environmental Protection Agency. The range of the various required tests are summarized in Table B-45.

TABLE B-45, ENGINE TESTS REQUIRED FOR QUALIFYING THE 12V-71T

TEST	INITIAL PRODUCTION	ACCEPTANCE	CONTROL
Initial Production (Endurance)	X		
Speed Range	X		
Governor	X	X	X
Brake Horsepower	X	X	X
Torque	X	X	X
Exhaust Smoke Density	X	X	X
Engine Emission	X		X
Fuel Consumption	X		X
Oil Consumption	X		X
Oil Pressure	X	X	X
Air Box Pressure	X	X	X
Air Induction			X
Restriction	X		X
Exhaust Back Pressure	X		X
Operating Temperature	X		X
Oil Cooling Temperature	X		X
Rise			
Starting	X		
Elevation Conditions	X		
Grades and Slopes	X		
Leakage	X	X	X
Submersion	X		
Steam & Water Jet Cleaning	X		
Production Break-in	X	X	
Fifty-Hour Run			X

Testing, including endurance testing, is conducted using fuel conforming to grade DF-2 of Federal specification VV-F-800. However, the engine is also required to operate at reduced output on fuel conforming to grade 2 of MIL-T-5161. Engine lubricating oil must be in accordance with the seasonal requirements of MIL-L-2104 (for $-10^{o}F$ to $125^{o}F$) and MIL-L-10295 (for $-65^{o}F$ to $10^{o}F$). The engine manufacturer may use his own lube oil during engine assembly and break-in.

One of the first ten engines produced is subjected to a variety of tests (see Table B-45) and in addition is inspected for defects per Table B-46 .

TABLE B-46 , REQUIRED EXAMINATIONS OF DDA 12V71T ENGINES

CHARACTERISTIC	DEFECT	METHOD OF INSPECTION
Valve clearance, each valve	Intake and exhaust valves improperly adjusted	Gage
Oil sump, fuel and oil filters	Dirt, chips and foreign particles, due to production	Visual
Fuel, oil and coolant leaks	Leakage	Visual
Fuel lines	Damaged, rubbing or improperly supported	Visual
Governor	Malfunction	Visual & Functional
Torque on cylinder head bolts, intake and exhaust manifold flange bolts	Improper torque	Gage
Crankshaft	Excessive or restrictive	Gage & Functional
Fuel system components	Malfunction - damage or leaks, etc.	Visual & Functional
Fuel injection system, timing and components	Malfunction, improper adjustment	Visual & Functional
Injection pump support bracket	Improperly installed	Visual
Linkage	Improper adjustment	Visual
Minor assemblies	Omitted	Visual
Engine	Improper adjustment or installation of components	Visual & Functional
Fuel lines, hose, vents shut-off valve	Improperly assembled or installed	Visual
Painting	Spots missed, sags or runs	Visual
Workmanship	Not following good practice, improper installation or adjustment of components	Visual, Gage & Functional

Included in the test is a 400-hour endurance test which consists of four periods of 100 hours each. Each 100-hour period consists of twenty 5-hour schedules as shown in Table

TABLE B-47, DDA GV-53-T 5-HOUR ENDURANCE SCHEDULE

Period	Percent Rated Speed	Percent Load	Endurance Hours
1	Idle	0	0.5
2	Max Torque	100	1.0
3	100	0	0.5
4	75	85	1.0
5	100	50	0.5
6	100	100	1.0
7	50	25	0.5
Total Endurance			5.0

To ensure compliance with the various performance specifications, the engine is submitted to a power check test before each 100-hour test cycle. The power checks are performed at full load and engine speeds of 1400, 1600, 1800, 2100, 2300, and 2500 rpm, in both ascending and descending order. Data for the following are obtained for each engine speed (after engine stabilization):

- Speed range & governor
- Brake horsepower and torque
- Exhaust smoke density
- Fuel consumption
- Oil consumption & oil
- Pressure
- Air box pressure

Also, following the pre-endurance test power check, part load data is obtained at each of the speeds above plus 85, 70, 50, and 25 percent of full load for each speed. During the endurance test the engine can be shut down after completion of any period in the 5-hour schedule (see Table B-47), but a cool down is required after periods 2, 4, and 5. A one-half hour warm-up is required following any shut-down and prior to continuation of the endurance run. At the conclusion of the endurance run and associated tests, the engine is disassembled to the extent required to perform the following inspections:

- Oil contamination
- Dirt, chips or foreign matter in the engine block, oil pan, filters, and accessory drive case
- Main bearings bolt torque
- Connecting rod bolt torque
- Cylinder bore scuffing, scoring, and galling
- Piston scuffing, scoring, and burning
- Excessive wear

Every production engine is inspected for defect per Table B-46, given a break-in run, and the following tests are conducted (see Table B-45).

- Governor
- Brake horsepower
- Torque
- Exhaust smoke density
- Oil pressure
- Air box pressure
- Leakage

During engine production, 50-hour quality control testing is conducted. One engine per month when production is less than 100 and two engines per month when production is greater than 100 are selected for the 50-hour tests. The engines are examined for defects per Table B-46, and tested in accordance with the schedule shown in Table B-48 (Table B-45 indicates other, specific tests which are conducted).

TABLE B-48 , 12V-71T 50-HOUR QUALITY CONTROL TEST SCHEDULE

PERIOD	TIME (HRS.)	ENGINE SPEED (RPM)	POWER LEVEL
1	1	2000	0.5 load
2	0.5	600	Idle
3	1.5	2500	Full load
4	0.5	600	Idle
5	2	2000	0.5 load
6	0.5	600	Idle
7	2	2500	Full load
8	1	600	Idle
9	5	2500	Full load
10	1	600	Idle
11	5	2500	Full load
12	1	600	Idle
13	5	2500	Full load
14	1	600	Idle
15	5	2500	Full load
16	1	600	Idle
17	5	2500	Full load
18	1	600	Idle
19	5	2500	Full load
20	1	600	Idle
21	5	2500	Full load

6. Detroit Diesel Allison 8V-92T and 8V-92TA for M911 Vehicles

MIL-PD-T-911 is the purchase description document which is used for procuring the M911 vehicles. A copy of the subject document was not obtained through the course of this research effort, however, the contents of the document were revealed through discussions with Detroit Diesel Allison and TACOM personnel. The required tests, in fact, are similar to those called out in MIL-T-PD-977, (M977, M978, M983, M984, and M985 vehicles which will contain the 8V-92TA) which will be discussed next.

MIL-PD-T-911 specifically requires that the engine selected be a commercially proven item and conform to U.S. Environmental Protection Agency emission standards. Further, the engine is required to pass the 400-hour NATO endurance test (see sections of this appendix for a description of the procedures, e.g., section B.5). Various vehicle durability tests are required, examples of which are similar to MIL-T-PD-977 to be described next.

7. Detroit Diesel Allison 8V-92TA For M977, M978, M983, M984, and M985 Vehicles

M-T-PD-977 is the purchase description document which is used to procure the M977, M978, M983, M984, and M985 vehicles (which will enter the fleet in early 1982).

The purchase description document specifies that the engine selected be a commercially proven item and conform to Federal (U.S.) emission standards (the 8V-92TA has been selected). The engine specific qualification requirements contained in MIL-T-PD-977 are summarized as follows:

- The engine must be a commercially proven item.
- The engine must meet U.S. E.P.A. emissions regulations
- The engine must meet the 400-hour NATO test which includes operation with high sulfur diesel fuel (1± .05%).

The 400-hour NATO test for the 8V-92TA engine for this procurement is reportedly in progress. Appendix C of this report contains an official description of the NATO test procedure being used. Briefly, the endurance test consists of four 100-hour cycles where each 100-hour cycle is composed of ten 10-hour schedules. The 10-hour schedule is shown in Table B-49.

TABLE B-49, DDA 8V-92TA 10-HOUR ENDURANCE TEST CYCLE

Period	Percent Rated Speed	Percent Load	Endurance Hours
1	Idle	0	0.5
2	100	100	2.0
3	*	0	0.5
4	75	100	1.0
5	Idle to 100	0-100 (4-6 min.)	2.0
6	60	100	0.5
7	Idle	0	0.5
8	**	70	0.5
9	Max Torque	100	2.0
10	60	50	0.5
Total Endurance			10

*Governed speed at full throttle and minimum load
**Full throttle and 70% load

Various vehicle tests will be conducted among which are initial production and acceptance testing.

The initial protection test includes a detailed inspection of the vehicle (including its engine), and durability tests at selected Army Proving Grounds. MIL-T-PD-977 contains details of the number of vehicles, terrain, and courses involved.

8. Caterpillar Tracter Company 333C and 3306 Engines

MIL-E-6113B(AT), 23 April 1976, describes the tests used to qualify the CAT 3306 engine. A previous version of the specification, MIL-E-62133A(AT), 15 January 1971, was used to qualify the Cat 333C engine. Since the 3306 specification was esentially unchanged from the 333C specification, and the engines are similar (the 3306 is a replacement engine for existing GOER vehicles containing a 333C engine in need of replacement), the remaining discussion will be specific to the 3306 engine and MIL-E-62133B(AT). The engine is also required to comply with the U.S. Environmental Protection Agency regulations governing control of exhaust emissions from new motor vehicle engines in effect on the date of manufacture. In addition to the engine specific tests, a vehicle test is called for (at the time of vehicle procurement and as part of the vehicle qualification testing) to determine mean time between failures (MTBF), durability and maintainability factors for the engine.

With respect to engine qualification testing, the range of the various required qualification inspections as well as the location of the test is shown in Table B-50. All testing is conducted using fuel conforming to grade 2 of Federal specification VV-F-800. Engine lubricating oil used for the various tests must be in accordance with the seasonal requirements of MIL-L-2104 (for $-10^{\circ}F$ to $125^{\circ}F$) and MIL-L-46167 (for $-65^{\circ}F$ to $10^{\circ}F$). The engine manufacturer may use lube oil of his own selection during engine assembly and break-in.

TABLE B-50, 3306 QUALIFICATION INSPECTIONS AND TEST LOCATION

TEST REQUIREMENT DESCRIPTION	INITIAL PRODUCTION	ACCEPTANCE	CONTROL
Break-in	X	X	
Acceptance	X	X	
Initial production (endurance)	X		
Speed range & governor	X	X	X
Brake horsepower & torque	X	X	X
Exhaust smoke density	X	X	X
Fuel consumption	X	X	X
Oil consumption	X		X
Oil pressure	X	X	X
Supercharging	X		X
Air restriction	X		X
Exhaust back pressure	X		X
Operating temperatures	X		X
Cooling system	X		X
Environment	X		
Cold starting	X		
Elevation	X		
Leakage	X	X	X
Grades & Slope	X		
Steam & jet cleaning	X		
Air pollution	X		
Radio interference suppression	X		

One of the first ten engines produced is subjected to a variety of examinations (see Table B-51) as well as tests (see Table B-50) including a 400-hour endurance test. The endurance test consists of a total of 400-hours divided into four periods of 100-hours each. Each 100-hour period consists of twenty 5-hour endurance schedules (see Table B-52).

TABLE B-51, REQUIRED EXAMINATIONS OF 3306 ENGINES

CHARACTERISTIC: DEFECT	METHOD OF INSPECTION
Valve tappet clearance (each valve): intake and exhaust valves improperly adjusted.	Visual and functional
Fuel, oil and coolant leaks: leakage	Visual
Governor: malfunction; not sealed	Visual and functional
Torque on accessible cylinder head bolts, intake and exhaust manifold flange bolts that can be reached without breaking seals or removing cover: improper torque.	Visual and functional
Crankshaft: excessive or restrictive end play.	Visual and functional
Fuel system components: malfunction; damage; leaks	Visual and functional
Fuel injection system timing and components: malfunction; improper adjustment.	Visual and functional
Fuel lines: damaged; rubbing; improper support.	Visual
Injection pump support bracket: improperly installed.	Visual
Linkage: improper adjustment	Visual and functional
Minor assemblies: omitted.	Visual
Engine: improper adjustment or installation of components.	Visual and functional
Fuel lines, hose, vents, shut-off valve: improperly assembled or installed.	Visual and functional
Oil sump, fuel and oil filters: dirt, chips, and foreign particles, due to production.	Visual
Painting: spots missed; sags or runs	Visual

TABLE B-52, 3306 5-HOUR ENDURANCE TEST SCHEDULE

Period	Percent Rated Speed	Percent Load	Endurance Hours
1	Idle	0	0.5
2	Max Torque	100	1.0
3	100	0	0.5
4	75	85	1.0
5	100	50	0.5
6	100	100	1.0
7	50	25	0.5
Total Endurance			5.0

During the endurance test, power-check tests are conducted to assure conformance to the following performance parameters:

- Speed range
- Brake horsepower
- Torque
- Exhaust smoke density
- Fuel consumption
- Oil pressure
- Supercharger pressure

The power check tests are performed at full-load and engine speeds of 1550, 1700, 1800, 1900, 2000, 2100, and 2200 rpm in both ascending and descending order. Data is recorded at each engine setting. In addition, following the pre-endurance run power-check test, part load data is obtained at each of the above listed engine speeds at 85, 70, 50, and 25% of full load. During the endurance run, the engine can be shut-down after completion of any period in the 5-hour schedule (see Table B-52), but a cool-down run is required after periods 2, 4, and 5. A one-half hour warm-up is required following any shut-down and prior to continuation of the endurance run. The following data is recorded during the last five minutes of each schedule period and power-check tests:

- Engine speed
- Observed brake horsepower and/or torque

- Fuel flow
- Test cell ambient temperature and barometric pressure
- Engine oil gallery and sump temperature and pressure
- Fuel secondary filter out and spill back temperature and pressures
- Air cleaner inlet temperature
- Air intake manifold pressure
- Air cleaner restriction
- Coolant engine inlet and outlet temperatures and pressures
- Exhaust port temperatures
- Exhaust manifold pressure
- Crankcase pressure
- Fuel, transfer pump, inlet pressure
- Oil consumption will be calculated on basis of oil added to the engine as necessary during the endurance run.
- Exhaust smoke density (power-check only)

At the conclusion of the endurance run, the engine must conform to all performance requirements except that power and torque can not be less than 95 percent of initial readings without readjustment of the injection system. A compression check is made of all cylinders (variation between cylinders can not be more than 50 psi at 4000 rpm). Also, there can be no abnormal wear of internal engine components.

Every production engine is given a break-in run and the engines are tested per Table B-50, and examined per Table B-51. These tests are known as acceptance tests.

During engine production, 50-hour quality control testing is performed. Engines are selected at the rate of one per month when production is less than 100 and two per month when production is greater than 100. The tests follow the schedules shown in Table B-53.

TABLE B-53, 3306 50-HOUR QUALITY CONTROL TEST SCHEDULE

Period	Time (hrs)	Speed (rpm)	Percent of Full Rack Load At Indicated Speed
1 (Engine must have completed acceptance & inspection tests)			
2	5	1550	50
3	5	1800	75
4	5	2000	75
5	5	2100	100
6	30	2200	100

After the 50-hour quality control test, the engine is given a compression check (variation between cylinders can be no more than 50 psi at 4000 rpm) and disassembled to the extent necessary to determine the following:

- Oil contamination
- Dirt, chips or foreign matter in the engine block, oil pan, filters and accessory drive case.
- Main bearings bolt torque, head bolt torque, intake and exhaust manifold flange bolts, and vibrator damper.
- Connecting rod bolt torque.
- Cylinder bore scuffing, scoring, and galling.
- Piston scuffing, scoring and burning.
- Excessive wear.

9. Cummins Engine Company NHC-250

ATPD-2023B has been used, in part, to qualify the Cummins NHC-250 which was specified as a commercially proven engine. The purchase description refers primarily to vehicle tests (from a druability or endurance perspective), but some engine specific tests are described. Also, the purchase description requires various fuels to be tested, while only VV-F-800 fuel was used in qualifying the NHC-250. The document was originally intended for procuring a replacement engine for the M39 series trucks with multi-fuel engines.

Sources at TACOM state that the NHC-250 did successfully pass a 500-hour enduranct test. A description of the 500-hour endurance procedure and associated tests has been described previously (see, for example, Table B-29 and Section B.2).

TACOM is presently in the process of writing a specification for the NHC-250. Also, a new procurement is in progress to replace the M809 series; the new series will be called the M939.

10. Cummins Engine Company V8-300

MIL-E-52396(MO) describes the procedures used to qualify the V8-300 engine. The specification has been cancelled as of 15 July 1975. The engine was, however, qualified via the 500-hour endurance procedure and related tests. Section B.2 presents a good discussion of the various test procedures associated with the 500-hour endurance test.

11. Cummins Engine Company VTA-903T

The VTA-903-T is the engine selected to go in the M2 and M3 vehicles. The engine has recently completed the NATO 400-hour endurance test.

12. Cummins Engine Company NTC-400

MIL-T-PD-9156 is the purchase description used to procure M915 Series vehicles. These vehicles are not considered combat or tactical. An engine draability (i.e., NATO 400-hour test) test was not required.

APPENDIX E-3

NATO STANDARD ENGINE LABORATORY TEST-EDITION JUNE 80

CHAPTER 1

PURPOSE AND APPLICABILITY

SECTION 1-1 - PURPOSE

The purpose of this document is to define a test method and standard conditions to enable all NATO countries to conduct tests using an identical method or to analyse the tests conducted in the laboratories of other NATO countries on the basis of this method.

The method described below is independent of existing national test methods, which may be used for supplementary testing.

When an engine has met the requirements of the tests under the present code, its power rating should be indicated as follows : "Power rating .... Kw (... metric HP) at .... r.p.m., in accordance with NATO code AEP 5. Edition June 1980".

SECTION 1-2 - APPLICABILITY

These test conditions apply to all service vehicle (combat and transport) propulsion Diesel and gasoline engines.

NOTE : SI units will be used.

CHAPTER 2

TEST REQUIREMENTS

SECTION 2-1 - GENERAL COMPOSITION AND ORDER OF TEST

2.1.1. Engine reception.

Running-in in accordance with manufacturer's instructions.

Performance test, complete (full and part loads).

Endurance test.

Performance test, complete (full and part loads).

Disassembly, inspection and measurement.

Report.

NOTES : (1) Engine measurements may be carried out before running-in.

(2) The manufacturer is responsible for defining the running-in programme and the engine should have been run-in before it is submitted for testing.

.../...

(3) In so far as possible, the manufacturer's drawings and technical data will be supplied with the engine, to assist inspection and measurement of components.

(4) It is normal practice for the engine to be given a preliminary performance test immediately after receipt, to check acceptability.

(5) The initial, if accomplished, and final inspection of the engine should be carried out by the same inspection team using the same gauges.

2.1.2. During performance and durability testing, the following variables will be monitored :

a - Main values
Speed
Torque (engine output shaft)

b - Ambient conditions
Temperature of ambient air
Atmospheric pressure
Humidity

c - Air and gases
Inlet air temperature
Induction or cylinder inlet depression
Inlet air flow (performance test only)
Air temperature and pressure in the inlet manifold
Exhaust temperature
Exhaust back-pressure
Gas temperatures at points influencing fuel control (if required)

d - *Lubrication and cooling*
Oil temperatures and pressures
Temperatures into and out of external coolers
Flow rates of fluids to cooling devices external to the engine (for heat rejection calculations)(during performance tests only)
Oil consumption (during endurance tests only)

e - Fuel
Fuel temperature
Fuel consumption

f - Miscellaneous
Blow-by
Smoke density

2.1.3. <u>Regulated parameters</u>

Outlet liquid coolant temperatures :
96°C ± 3°C

Induction depression at rated power :
12,5 ± 2,5 mbar

Exhaust back pressure at rated power :
40 mbar ± 5

Fuel temperature at injection pump inlet :
30°C ± 3°C

.../...

2.1.4. TEST CONDITIONS

Measuring is to be done in normal and stable operating conditions.

The temperature of the air entering the engine (ambient air) is to be measured at a maximum distance of 0,15 m from the air filter inlet or, if there is no filter, 0,15 m from the air inlet nozzle. The thermometer or thermocouple must be protected against heat radiation and be located directly in the air jet. Testing must be carried out in an adequate number of positions to give a representative inlet temperature.

Once an output speed has been selected for measurement purposes, its value must not vary by more than $\pm$ *1* % or $\pm$ *10* r.p.m. (whichever of these limits is the higher) during measurement.

The readings for brake load, fuel consumption and inlet air temperature are to be taken simultaneously, the value recorded being the average of two stabilized results, obtained in succession with brake load and fuel consumption differing by less than 2 %.

When a device fitted with an automatic starting system is used for measuring speed and consumption, the duration of measurement must be at least 30 seconds ; if the measuring device is manually operated, the duration must be at least 60 seconds.

The exhaust gas outlet temperature must be measured at a point downstream and less than 100 mm from the flange (s) of the exhaust manifold (s).

Lubricant temperature is to be measured at the inlet and outlet of the heat exchanger if there is one. Otherwise it must be take preferably in the lubrication system, or, failing this, in the crank case. The measuring point will be specified in the test report.

Fuel temperature must be read at the injection pump inlet, or carburettor inlet.

Cooling condition for air cooled engine will be in accordance with manufacturers specification.

measured

Auxiliary power take-offs may be loaded and mesured if desired

2.1.5. MEASUREMENT ACCURACY

- TORQUE

  The torque must be accurate within $\pm$ 0,5 % of the highest value to be measured.

- OUTPUT SPEED

  Measurement must be accurate to within $\pm$ 0,5 %.

- FUEL CONSUMPTION

  $\pm$ 1 % for all apparatus used.

.../...

- TEMPERATURES

  Intake air ± 1°C.

- PRESSURE

  Atmospheric pressure ± 0,7 mbar
  Air and gas pressure ± 50 mbar
  Induction and exhaust pressure and depression ± 0,250 mbar
  Pressure of other fluids ± 250 mbar

SECTION 2-2 - DEFINITION OF ENGINE

Engines will be equipped only with such auxiliary equipment as is strictly essential to their operation (see table of auxiliary equipment at Annex A).

SECTION 2-3 - PERFORMANCE TEST

The performance test maximum load curve will be plotted from measurements taken at a minimum of five speed settings, the fifth setting being the rated speed.

For each setting, the engine should be run for a sufficient time to allow the operating parameters to stabilize.

Part-load data is to be recorded at the same pre-selected speed as was used for the full-load test. The part loads for each speed point are to be calculated at least for 85 %, 70 %, 50 % and 25 % of the full load at the given speed.

During this test, the smoke emission as measured on the Robert BOSCH Scale (or equivalent) shall not exceed 1.5.

No correction factor will be applied and the test results must include air temperature and atmospheric pressure.

The inlet air temperature shall be maintained as close as possible to 25°C.

SECTION 2-4 - ENDURANCE TEST

2.4.1. The endurance test duration is 400 hours, divided into four periods of 100 hours each. At the completion of each period, the engine shall be submitted to a full-load performance check.

.../...

2.4.2. Normal maintenance and adjustment will be permissible after each 100 hour test period.

2.4.3. Engine oil and filters shall be changed after each 100 hour period.

2.4.4. The coolant outlet temperature is to be held at 96°C $\pm$ 3°C or a higher temperature if proposed by the manufacturer. The coolant is to be water plus antifreeze in egal volume.

2.4.5. The engine oil temperature is to be measured in the lubrication system. The temperature measurement location shall be specified.

2.4.6. The four 100 hour periods which make up the endurance test are to be carried out with the reference fuel defined in Chapter 3.

2.4.7. Each 100 hour period is to comprise ten 10 hour cycles. Each 10 hour cycle will be carried out in accordance with the programme (section 2-5).

2.4.8. Data will be recorded during the last five minutes of each of the sub-cycles included in the basic 10 hours cycle, with the exception of sub-cycle 5.

2.4.9. No interruptions are permitted during any of the sub-cycles, but the engine may be switched off on completion of any sub-cycle.

SECTION 2-5 - PROGRAMME OF 10 HOUR CYCLE

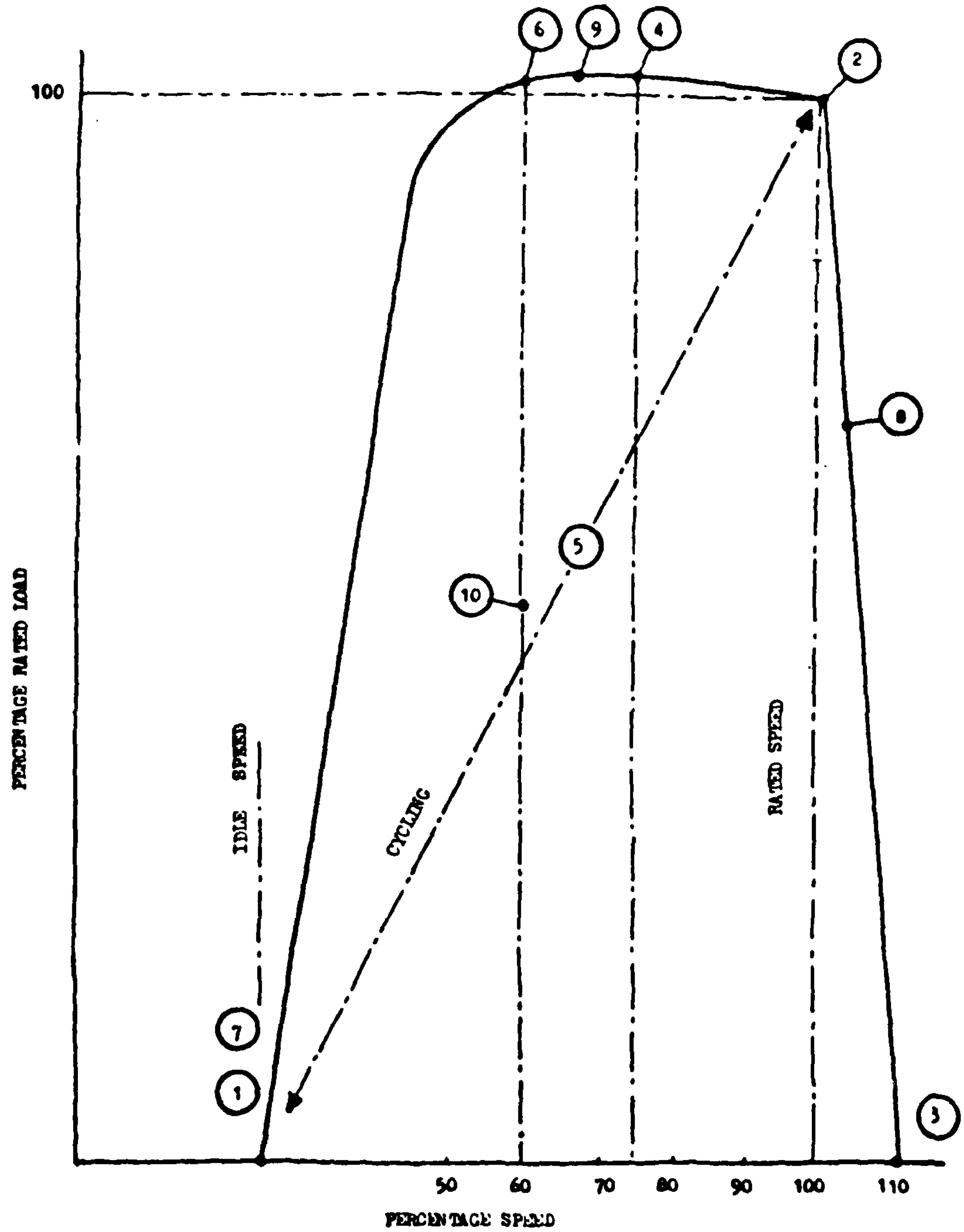
Sub Cycle	% Rated Speed	% Load (3)	Duration in hours
1	IDLE	0	½
2	100	100	2
3	governed speed (1)	0	½
4	75	100	1
5	IDLE ⟷ 100	0 ⟷ 100 4 MIN 6 MIN	2
6	60	100	½
7	IDLE	0	½
8	governed speed (2)	70 (3)	½
9	Max torque speed	100	2
10	60	50 (3)	½
		Total	10

NOTES :

(1) The speed shall be that attained with the engine at full throttle and with minimum load (residual brake load).

(2) The speed shall be the steady speed of the engine at full throttle and 70 % load.

(3) Part loads (70 and 50 %) shall be taken from the initial performance test.



GRAPHICAL PRESENTATION OF 10 HOUR CYCLE

CHAPTER 3

FUELS AND LUBRICANTS AND ANTIFREEZES

301 Engines are to be tested on Reference Fuels and Lubricants and antifreezes as specified by the relevant NATO Authority.

CHAPTER 4

DEFINITION OF TEST FAILURE

401 A major failure is a failure of any part or component of the engine assembly that leads to a final stoppage of the test or that brings about as loss of power which cannot be rectified to give at least 95 % of rated power.

Any major failure will lead to termination of the test and any retest must start at 0 hour.

Major failures and corrective action are to be reported to the proper National Authority.

402 A minor failure is a defect which leads to a loss of power or degradation of the operation of the engine and which it is possible to remedy within the scope of normal maintenance and adjustment. If 95 % of the rated power cannot be obtained after normal maintenance then the test will be terminated. The minor failures and the measures taken to overcome them must be included in the report.

403 The suitability of an engine for NATO AEP5 Approval is to be the responsibility of the National Authorities after completion of the 400 hours test and consideration of the final condition of the engine.

ANNEXE A

DETAILS OF PRODUCTION AUXILIARY EQUIPMENT

(To be included as applicable)

Inlet system	
Inlet manifold	Yes
Air filter	
Inlet silencer	Optional
Blowby gas recirculation intake ...	
Exhaust system	
Manifold	Yes
Piping	
Silencer	Test bench equipment
Exhaust pipes	
Fuel feed pump	Yes
Carburettor	Yes (details of adjustment will be specified)
Ignition system	
Distributor	Yes
Spark-plugs	Yes
Coils	Yes
Suppressor	Yes
Fuel injection equipment	
Prefilter	Yes or test bench equipment
Filter	
Pumo	Yes
High-pressure pipes	Yes
Injector	Yes
Regulator	Yes

AD-A113 532 SOUTHWEST RESEARCH INST SAN ANTONIO TX ARMY FUELS AN--ETC F/G 15/?
DEVELOPMENT OF ACCELERATED FUEL-ENGINES QUALIFICATION PROCEDURE--F?
DEC 81 J A RUSSELL, J P CUELLAR, J C TYLER DAAK70-80-C-0001

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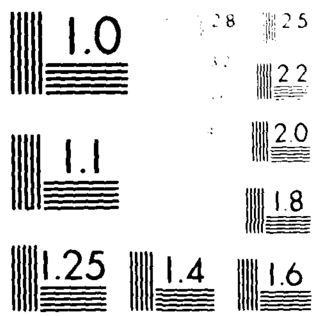

1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

Liquid cooling equipment	
Radiator	No
Fan	No
Water pump	Yes
Thermostat	Yes
Air cooling equipment	
Streamlining	Yes
Blower	Yes
Temperature regulating device	Yes
Electrical equipment	If necessary
Supercharging equipment	
Compressor driven directly or indirectly by the engine and/or exhaust gas	Yes
Charge cooler	Yes
Cooling pump or fan .... (engine driven)	Yes
Device for regulating flow of cooling fluid	Yes

ANNEX B

INFORMATION TO BE INCLUDED IN TEST REPORT

A complete report covering all the tests, servicing, maintenance, rectification of faults and the condition of the engine at the strip examination including the measurements of the principal wearing parts will be compiled.

The report will also include the following :

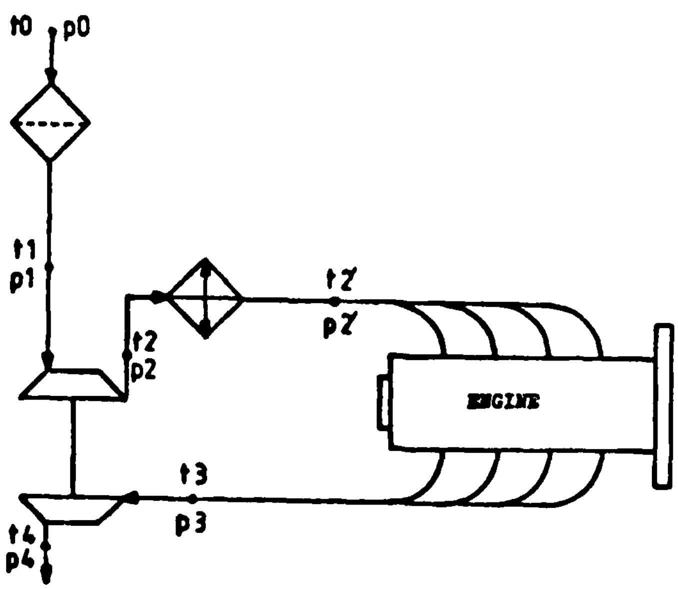
1. A statement of the build standard of the engine, with drawings and a parts list.
2. Photographs of the engine from four different views.
3. Photographs of the test installation at least four different views.
4. A list of equipment fitted to the engine.
5. Sample test sheets and a summary with a list of faults and the remedial action taken.
   Full load performance data will be show in the format indicated.
6. An engine condition report at end of test with photographs of the condition of major parts such as pistons, bearings, valves, camshafts, crankshafts, cylinder bores together with any other components of interest.
7. A history chart of lubricating oil used during the endurance tests.
8. Analysis of new and used lubricating oil, the latter to be taken at approximately 100 hours intervals.
9. Fuel analysis.
10. Any other relevant data.

ENGINE Type	N°.	Place date
FULL CHARGE PERFORMANCES INITIAL ☐ FINAL ☐		Reference
FUEL :	OIL type	BRAKE type
Volume mass kg/dm³	grade	

AMBIENT	t0	°C								
	p0	mbar								
PERFORMANCE	n	rpm								
	M	m.daN								
	P	kW								
	pme	bar								
FUEL	Cs/Csfc	g/kWh								
	Qc	mm³/cycle								
	qm	kg/h								
OIL	tH	°C								
	pH	bar								
WATER	te	°C								
	ts	°C								
INLET	t1	°C								
	p0 - p1	mbar								
	t2	°C								
	p2	bar								
	t2'	°C								
	p2 - p2'	mbar								
EXHAUST	t3	°C								
	p3	bar								
	t4	°C								
	p4 - p0	mbar								
	Smoke	Bosch								
BLOW - BY		[illegible]								

DEFINITION OF SHORTS

- t0 : ambient temperature
- p0 : ambient pressure
- n : engine speed
- M : engine torque
- P : output power
- pme/bmep: brake mean effective pressure
- Cs/bsfc : specific fuel consumption
- Qc : volume of fuel par injection
- qm : mass fuel flow per hour
- tH : oil temperature
- pH : oil pressure
- te : coolant temperature into engine
- ts : coolant temperature out of engine
- t1 : air temperature after filter (or compressor inlet)
- p0 - p1 : inlet depression
- t2 : compressor discharge temperature
- p2 : compressor discharge pressure
- t2' :air temperature after charge cooler
- p2 - p2': pressure of across charge cooler
- t3 : exhaust gaz temperature (turbine inlet)
- p3 : exhaust gaz pressure (turbine inlet)
- t4 : turbine discharge temperature
- p4 - p0 : Exhaust back pressure



APPENDIX E-4

FUEL SYSTEM COMPONENTS QUALIFICATION PROCEDURES

A. INTRODUCTION

The use of an alternative fuel (instead of the specified) fuel) in an existing diesel engine as in the present fleet of M-Series vehicles can quickly result in problems with critical fuel system components. The types of critically affected components include (not necessarily in order of importance) fuel injection equipment, fuel metering and supply pumps, fuel filters, fuel hoses as well as other components.

It is important to remember that the long term use of an alternative fuel can affect other engine components as well. Examples include pistons, piston rings, cylinder liners, valves, bearings and others. These types of engine-related components were considered to be beyond the scope of this project and thus were not explicitly addressed. However, it should be recognized that these components are indeed affected by changes in fuels and fuel characteristics.

The following describes the types of tests, as related by fuel system component manufacturers, to either quality check their products or certify their applicability to a given fuel. In some cases military or other specifications govern the procedure or lend guidance.

B. FUEL INJECTION EQUIPMENT

1. In-Line Fuel Pumps/Injectors/Nozzles

Most test procedures for inline injection type pumps (e.g., American Bosch and Caterpillar, see Figure D-1) are fairly similar and involve test stand operation of the fuel supply system (pump, injectors and nozzles). The typical test involves operation using the lightest grade fuel anticipated. The pump must be mounted exactly as on the engine (same side load on input shaft, if any) and the pump will be calibrated at various times during the testing. The duration of the testing is from 1000 to 2500 hours at an injection line pressure up to 33% over maximum design operation pressure at rated pump speed. The pump is typically cycled between 90 percent of full discharge and 10 percent no discharge at the rate of nine seconds on and one second off. The fuel temperature is maintained at 170°F and is checked every 100 hours for signs of oxidation(the fuel should be changed every 500 hours). Special attention is drawn to signs of leakage during operation at the idle condition. With respect to materials, immersion tests are conducted with fuel temperature maintained at 200°F to 300°F. The injection pump must be operational at the end of the test and be within ± 2 percent of its rated fuel delivery. A test of 1000 hours duration is considered sufficient to predict wear likely to be encountered in 10,000 hours of engine operation.

2. Unit Injectors and Supply Pumps

For engine/fuel systems which rely on unit injectors (see Figure D-2), the flow capacity of the fuel pump is important to satisfactory operation. If the physical properties of a new fuel are such that the pump cannot maintain its rated capacity at rated pressure, engine performance will suffer. In many cases where unit injectors are used, the fuel pump is of a gear type (see Figure D-3), driven directly by the engine. A fuel regulator maintains system pressure and the amount of fuel which is returned to the tank.

For a new fuel, Detroit Diesel Allison (DDA) suggests that a

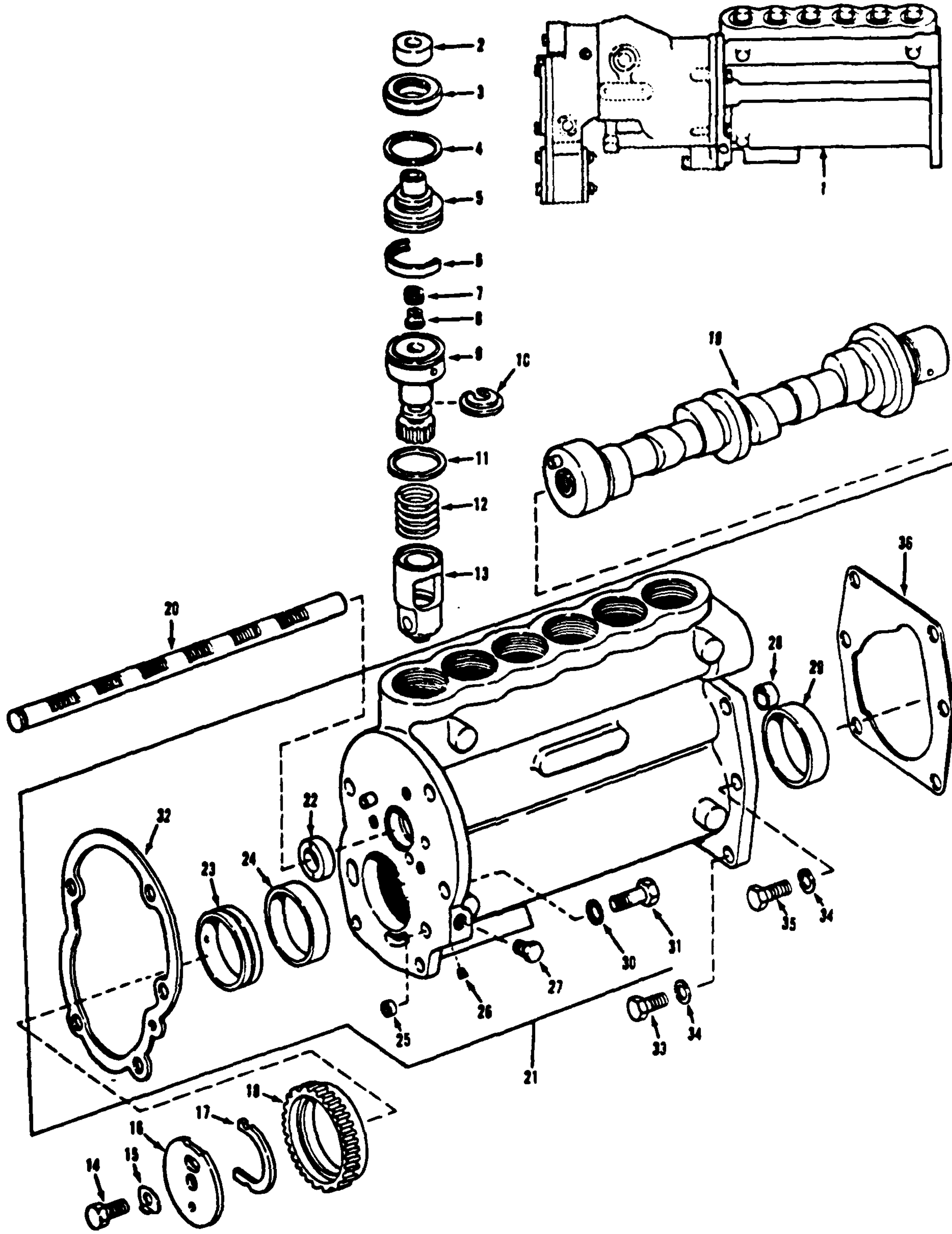


FIGURE D-1 CATERPILLAR INLINE FUEL INJECTION PUMP
AS ON THE D333C ENGINE
SOURCE: TM9-2320-233-34P

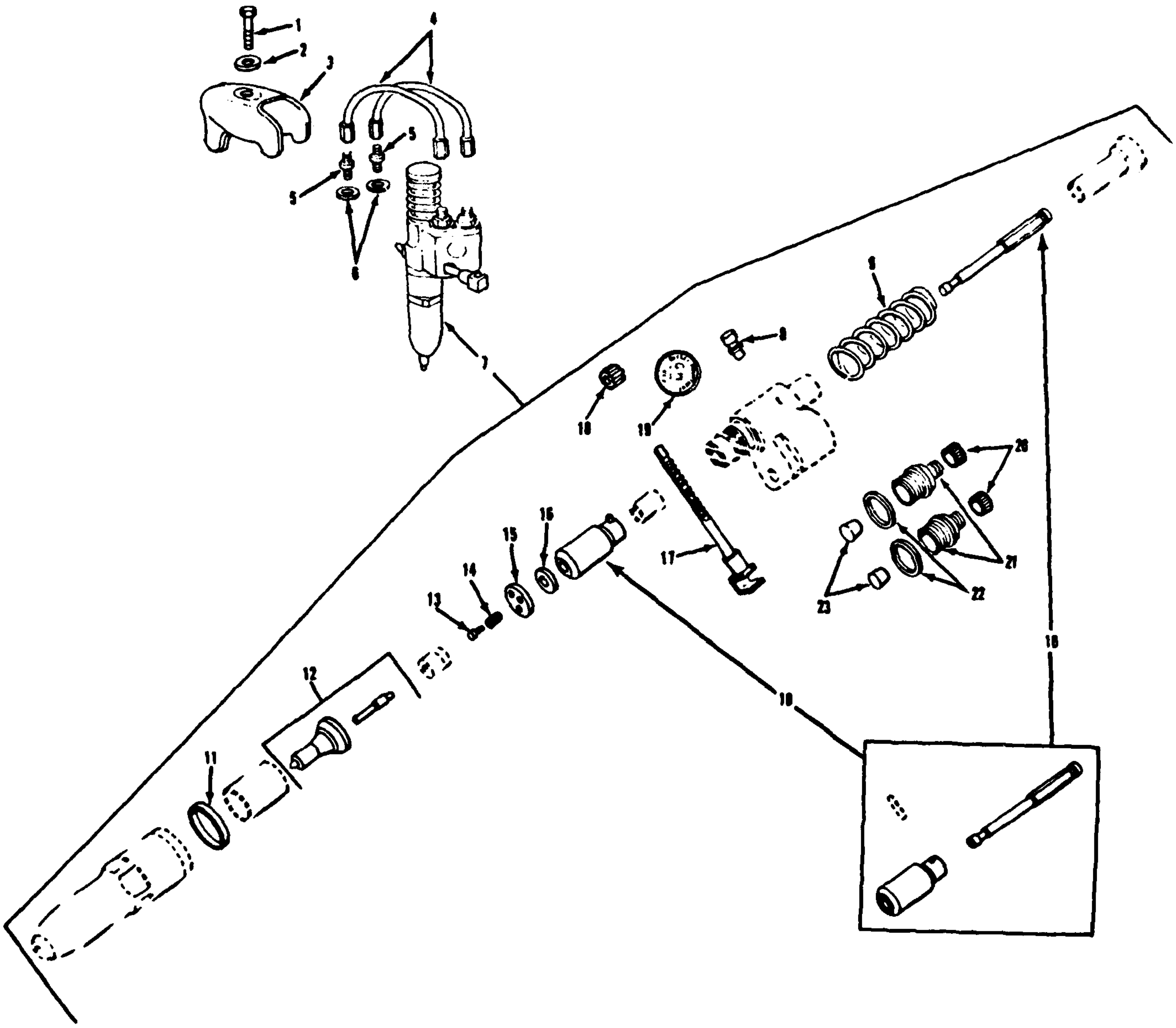


FIGURE D-2, DETROIT DIESEL ALLISON UNIT INJECTOR
AS ON THE 6V-53 AND 6V-53T ENGINES
SOURCE: TM9-2815-205-34P

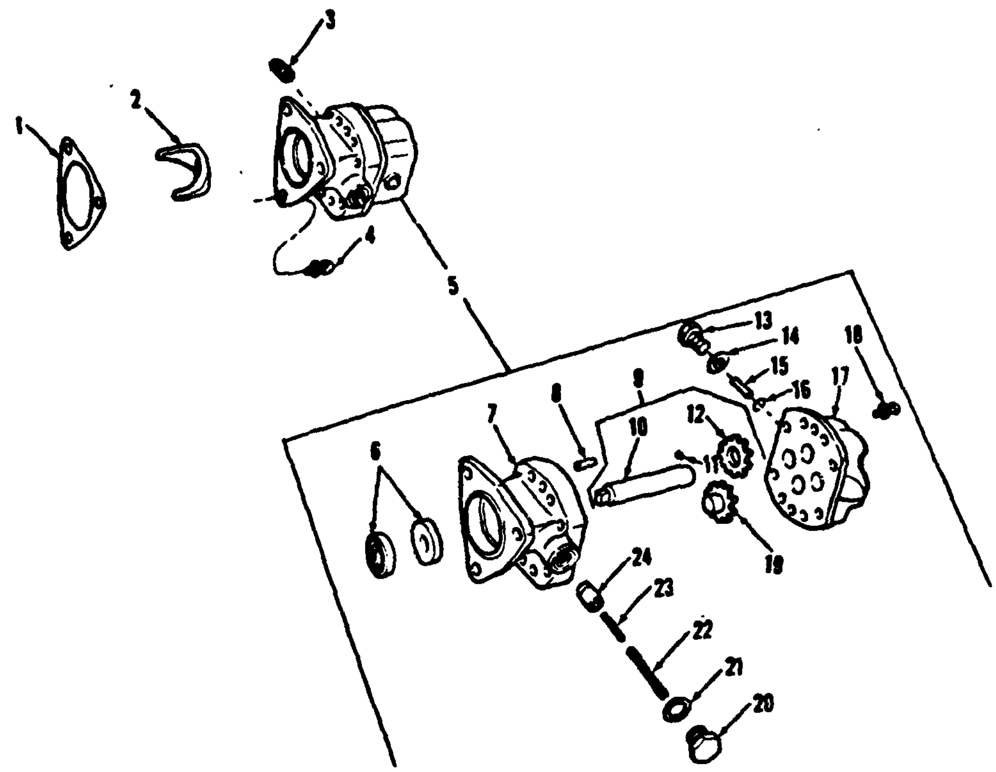


Figure B-24. Fuel pump assembly details.

FIGURE D-3, FUEL SUPPLY PUMP AS ON THE DETROIT DIESEL
ALLISON 12V-71T ENGINES
SOURCE: TM9-2815-217-34

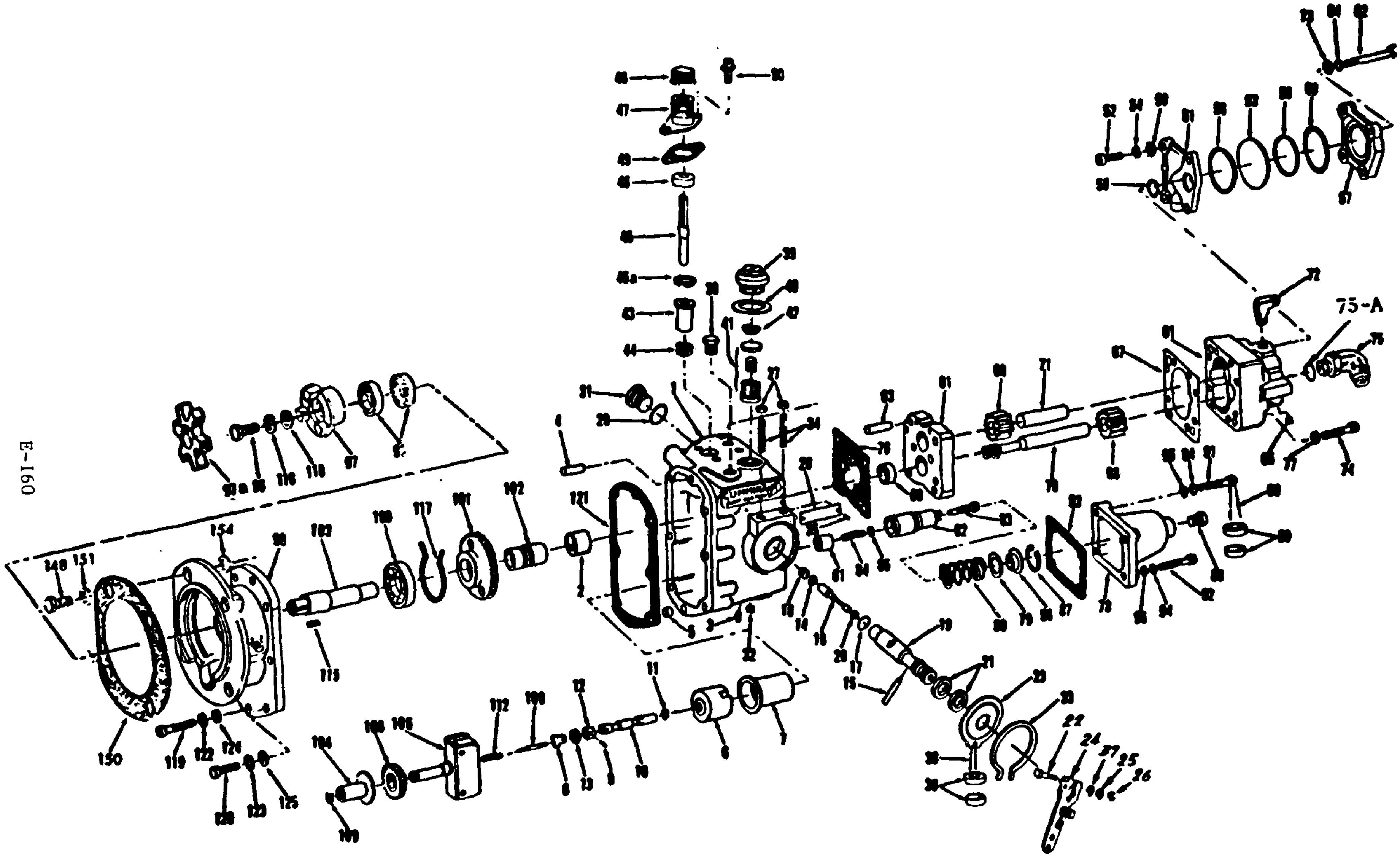


FIGURE D-4, THE CUMMINS PTG TYPE FUEL PUMP ASSEMBLY AS ON THE CUMMINS BUILT ENGINES
SOURCE: CUMMINS ENGINE COMPANY

1000 hour bench test of the pump (operating at rated capacity and pressure with the fuel in question) can be used to predict this operating lifetime of the pump. The seals used in the pump should then be checked for dimensional changes (swelling or shrinkage). Visual observation of the interior of the pump should reveal no corrosion or pitting.

DDA also suggests that unit fuel injector/nozzle assemblies can be bench tested. They should be placed in a mock-up of the fuel system and cycled for 1000 hours. The fuel can be heated (typically to 176°F) during the 100 hour test. If the fuel is heated, it should be checked for oxidation every 100 hours and changed every 500 hours. The injectors should be cycled from 100% delivery to zero delivery for time periods of 9 seconds and 1 second, respectively. At the end of the test the injectors are evaluated according to standard repair shop test procedures. The factors most critical are fuel retention, pop-off pressure, leakage and dribble. The internal components of the injector can be evaluated for compatibility by immersion in the test fuel. The fuel can be heated and the test duration should be at least 200 hours. Typical adverse results are corrosion, rusting, or deposit formation. After the fuel injector/nozzle assembly is bench-tested, the nozzles must be in good working condition. They should have valve opening pressures within specifications, not leak, and retain their rated flow capacity (measured at 10,000 psi live pressure). The fuel-passages in the nozzles should be clean and show no sign of corrosion, erosion or cavitation.

3. The Cummins PT Fuel System

Engineers at Cummins Engine Company feel that the best (and quickest) way to test their fuel system (see Figure D-4) is to conduct an engine endurance test. The test should be at least 500 hours at rated speed and load. Their opinion is that an engine durability test is most realistic and will discover problems in the fuel system which may not be uncovered in a bench-type fuel system test. This is particularly so in the case of the injectors. That is, many injector problems are combustion related and are thus best revealed by monitoring changes in engine operation such as smoke, fuel consumption and power output.

Cummins does, however, suggest a procedure for bench testing their pump on a new fuel, if such an approach is desired. They suggest a 500 hour bench test at constant speed and with fuel output near maximum. The internal parts should be measured before and after the test. The fuel pump bearings are especially critical and any leakage from the seals at the pump driveshaft is an indication of bearing wear. A good measure of pump deterioration due to wear is to check the calibration curve at intervals during the test and subsequent to the test. Pump elastomers can be tested separately by immersion in the test fuel at an elevated ambient temperature (the exact temperature depends on the fuel). The Cummins personnel contacted feel confident that a 500 hour test can provide reliable wear data for their fuel injection pump.

With respect to the Cummins fuel injectors, it is again Cummins' opinion that an engine operational test is more realistic for evaluating a new fuel. An important indicator of injector wear is the clearance between the plunger and barrel. This is measured using an air leakage test developed by Cummins for this purpose (the amount of leaking air can be correlated with plunger and barrel wear). No-load operation is considered to be the worst condition for operation of the injectors; this is the condition under which injector leakage is best observed. Scuffing and scoring of the plunger and barrel can be observed by visual inspection. Cummins suggests that the type of tests conducted and factors to be concerned about should be dependent on the fuel being used. For example, attention should be given to signs of increased clearances, scoring and scuffing if the fuel has low lubricity and/or viscosity. High fuel sulfur content or acidity is likely to cause corrosion and thus the test procedure should reflect the worst operating conditions for which these fuel properties are a problem. Also, fuels with low hydrogen content or high viscosity can cause injector nozzle coking and some fuels deteriorate rapidly at elevated temperatures (thus they should be tested at those temperatures).

C. FUEL SUPPLY PUMPS

1. Gear Pumps

Gear type fuel pumps, as made by Viking, Inc. are durability tested with anticipated fuels via 1000 to 2000 hour tests. The pumps are operated at the flow and pressure specified for a given pump speed and test fuel viscosity. The Facet personnel contacted feel that such a durability test provides enough data to judge critical wear rates and gives a good indication of pump life. Viking notes that it is necessary to determine flow capacity and pressure at a given pump speed for a standard fuel which matches the viscosity of the test fuel(in order to establish a baseline since the pump will naturally have different output characteristics). Heating, cooling or blending may be necessary to achieve the proper fuel physical properties.

Viking tests pump seals by immersion in the test fuel using standard SAE tests.

2. Solenoid Pumps

Solenoid operated electric transfer pumps, as made by Facet, are typically tested for a new fuel via the following:

- Output tests are conducted to establish the maximum flowrate for a given head.
- The pump is tested for resistance to vibration/shock and salt spray (MIL-P-45328).
- A calibration curve is established.
- Dielectric strength is established.
- A 3300 hour endurance test is conducted. The pump is stopped for 10 minutes, four times per 24 hours.
- Immersion tests are conducted for fuel sensitive materials.

D. FUEL FILTERS AND FUEL/WATER SEPARATORS

1. Facet-Type Filters

Facet Enterprises, Inc. fuel filters (see Figure D-5) are typically tested by performing 100 hour immersion tests with materials compatibility the prime concern. Tests are also conducted for filtering efficiency, clean pressure drop, and capacity (maximum flowrate at maximum allowable pressure drop), as well as a proof pressure test at 90 psi (for unit integrity). The various tests are followed by disassembling the unit for inspection. A joint SAE/ASTM effort is currently under way to develop a new procedure.

2. AC Type Filters

Fuel filters from the AC Corporation (see Figure D-6) are tested in a variety of ways to measure a number of different fuel filter parameters. The most basic tests are called filter performance tests and are summarized as follows:

- Single Pass Efficiency - This test establishes the micron rating of the filter as measured by the percentage removal of a given class of test beads. The test beads are assumed to have a normal distribution within a class and are grouped according to size range.
- Leakage Under Pressure - In this test, the filter is subjected to the highest pressure anticipated during operation while on an engine. The pressure is constant and is maintained for a sufficient time to observe any leaks.
- Differential Pressure at Rated Flow - In this test, the pressure drop across the filter element is measured at rated flow (of the filter unit) to establish a clean filter pressure drop. The magnitude of the pressure drop is dependent on the fuel used, the temperature of the fuel and the configuration of the filter housing. Monitoring of the pressure drop during operation gives an indication of the contaminant loading of the filter element.

The life of a filter is defined by AC as its capacity to hold a contaminant. Life determination is made using tests

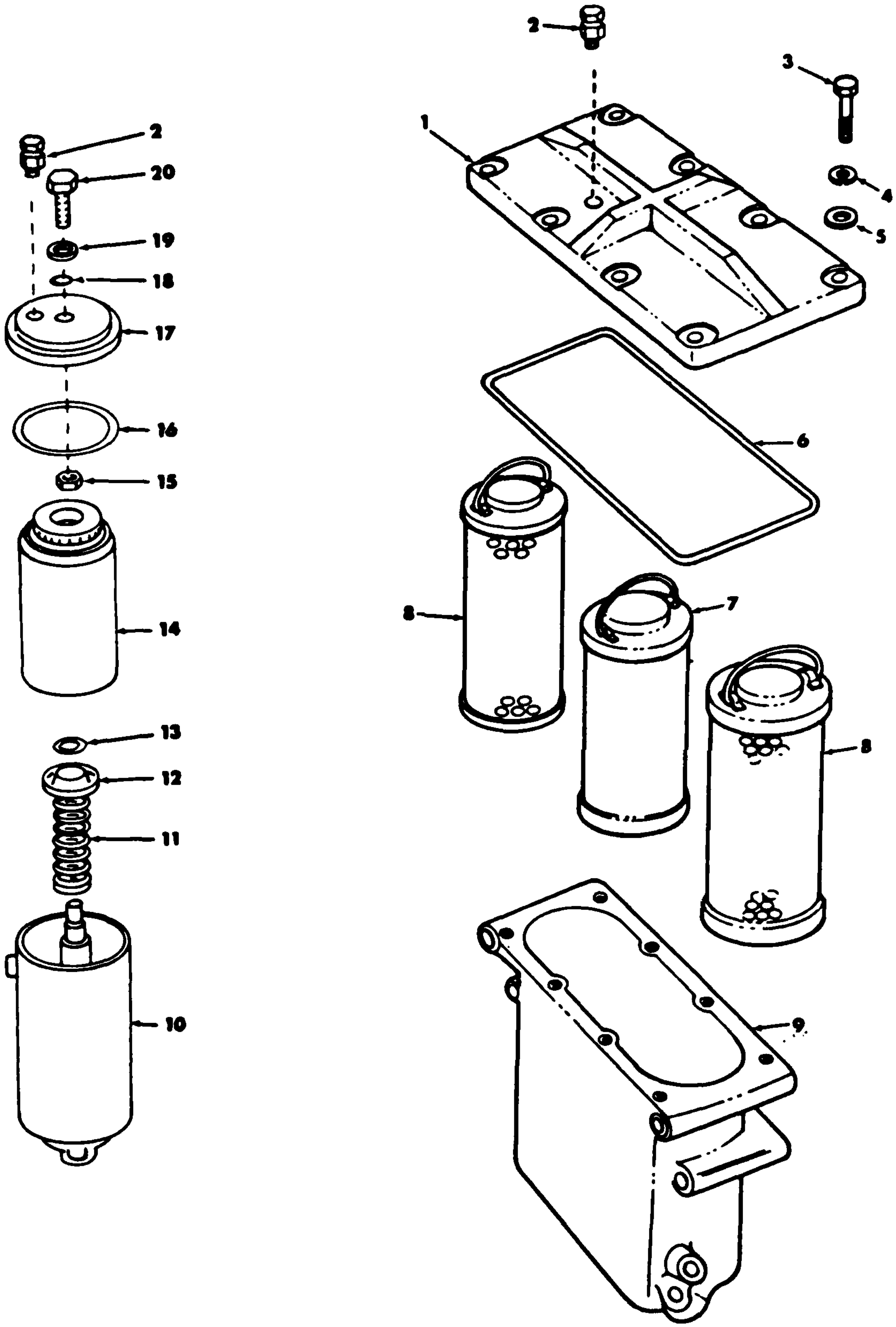


FIGURE D-5, PRIMARY AND WATER SEPARATOR FUEL FILTERS
AS ON THE AVDS-1790-2D ENGINES
SOURCE: TM-9-2815-220-34P

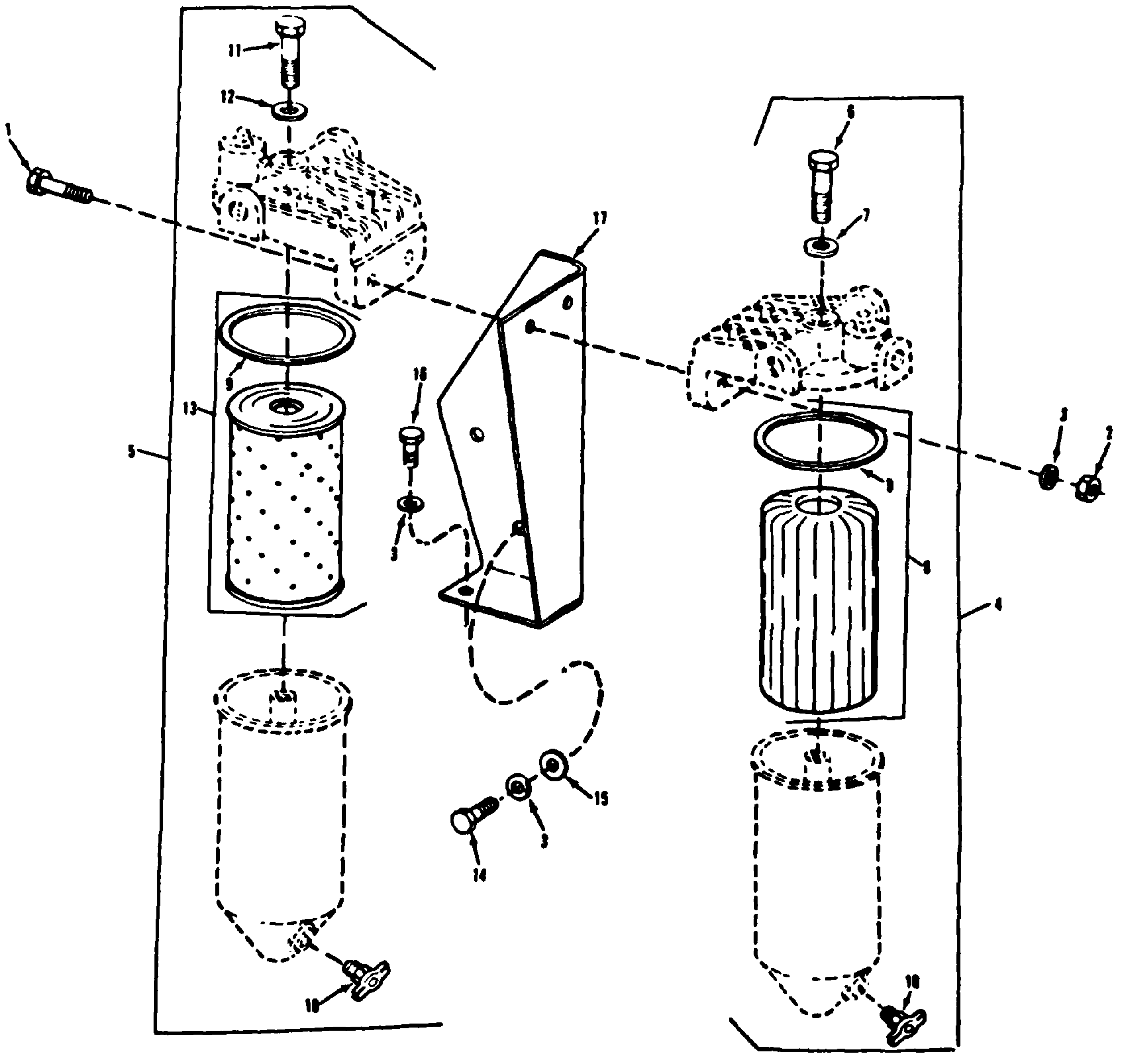


FIGURE D-6, AC CORPORATION PRIMARY AND SECONDARY FUEL FILTERS AS ON THE 6V-53 AND 6V-53T ENGINES

SOURCE: TM9-2815-205-34P

conforming to SAE Recommended Practice J905-- Fuel Filter Test Method. The contaminant used to determine filter life in SAE J905 is AC Fine Test Dust (Table D-1 gives the size distribution).

A number of tests are conducted to measure the structural integrity of the unit and evaluate the materials compatibility of the fuel filter element. The following is a description of these tests:

- Temperature Cycling - A filter is immersed in test fluid while the temperature is varied from 65°C to -35°C at a rate of 15°C/hr. The filter is maintained at the temperature extremes for 6 hours during each cycle. A total of 5 cycles are completed, after which the filter is subjected to the performance tests described previously.
- Chemical Exposure - The filter is typically immersed in materials such as water, unleaded gasoline, Gasohol, 10% MTBE, in gasoline (methyl tertiary butyl ether), 10% isopropyl alcohol in gasoline, and 100% Stoddard's Solvent. After contact with the filter element for 100 hours, inspection of the filter is conducted. Items of particular concern include deterioration of the element, corrosion of the housing and separation of the element from the housing due to deterioration of the binder.
- Low Pressure Testing - This test procedure evaluates whether any physical damage has occurred to a filter element after being exposed to certain test fluids or after non-destructive tests. The filter is submerged approximately 1 inch below the surface of a test fluid and air under 2-4 inches of water pressure is introduced to one side of the filter. (This pressure is low enough to prevent forcing the air through the filter element). If bubbles are observed rising in the fluid, some damage has occured to the filter element or perhaps the element has loosened from the housing. Separation of the paper at folded seams, tears, and holes are

all common failures.

- Destructive Testing - Disassembly of the filter may sometimes yield pertinent information. Examination of a sample of the filter element under a microscope after disassembly is a good method to identify contaminants held by the element. However, it is not used very often as the other techniques are generally more effective.

3. Fleetguard (Cummins) Type Filter

Fleetguard (Cummins) fuel/water separators are not endurance tested per se, but are pressure and vibration tested. Tests are coordinated with SAE filter tests (J905). Immersion tests of the filtering elements are conducted as are contaminant removal tests using a test dust such as AC Fine Test Dust (see Tables D-1 and D-2) in calibration fluid. The dust test is used to estimate the half-life pressure drop of the separator (a typical test will add dust to a 28 liter system at the rate of 8 grams every 5 minutes). A common test routine is as follows:

- conduct clean filter water removal test
- add dust to create half-life pressure drop
- conduct water removal test

The Fleetguard unit was tested by MERADCOM in 1970. Internally, Cummins presently follows some of the tests described in MIL-F-8901E.

TABLE D-1. SIZE DISTRIBUTION OF AC TEST DUST

AC COARSE		AC FINE	
Size Distribution (Microns)	Percent By Weight	Size Distribution (Microns)	Percent By Weight
0-5	12	0-5	39
5-10	12	5-10	18
10-20	14	10-20	16
20-40	23	20-40	18
40-80	30	40-80	9
80-200	9		

TABLE D-2 SIZE DISTRIBUTION OF BLACK IRON OXIDE

Size Distribution (Microns)	Percent By Weight
0-.25	47.8
.25-.50	29.9
.50-1.0	16.4
1-2	3
2-3	0.8
3-4	0.3
4-5	0.7
5-7.5	0.8
7.5-10	0.3

Facet fuel/water spearators are tested similarly to the Fleetguard unit.

E. MANIFOLD (FLAME) AIR HEATERS

1. System Description

Engine flame heaters (see Figure D-7) are sometimes used as a cold-start aid to heat the air in the intake manifold just prior to and during engine cranking. The principle behind their operation is that an open flame in the intake manifold will provide enough heat to raise the intake air temperature sufficiently to facilitate engine starting. This procedure works despite dilution of the air with combustion gases from the flame. The fuel used is that carried by the vehicle though an auxiliary fuel could be used. Ignition is usually accomplished by spraying the fuel past an open, continuous electrical spark.

Flame heaters are usually specified by the engine manufacturer as a collection of components rather than a single unit. The components of flame heaters which come into contact with the fuel are as follows:

- Fuel lines
- Fuel filter
- Fuel pump
- Solenoid valve
- Flame heater housing
- Ignition electrodes

Of these components, the fuel lines and filters are the same type as covered in sections D and F respectively, of this appendix. Therefore, they will not be discussed any further in this section.

2. Fuel Pumps

The fuel pumps are typically small electric pumps using vane or solenoid type construction. Three performance specifications are indicated for these pumps:

- Maximum pressure - determined by restricting the output and measuring the pressure between the pump and the restriction.
- Inlet suction - determined by restricting the inlet line and measuring the amount of vacuum the pump can generate.

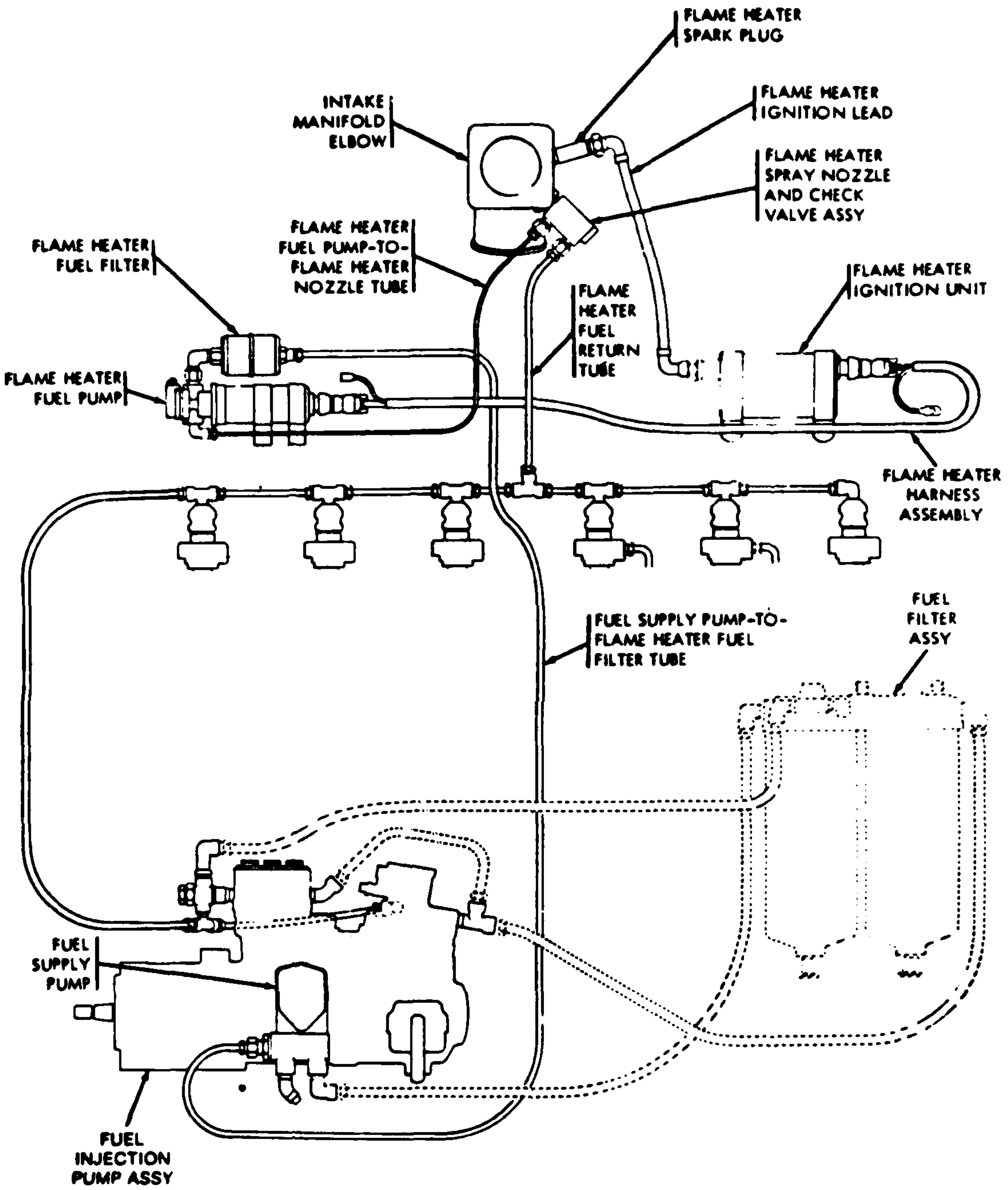


FIGURE D-7, FLAME HEATER SYSTEM AS ON THE LD-465-1 ENGINES
SOURCE: TM9-2815-210-34

- Maximum flow - determined by measuring the volumetric flow rate of the pump under conditions of no restriction.

These performance specifications are the measures by which it is determined whether or not a pump is satisfactory for use. A typical test for such fuel pumps is to measure the performance specifications of the pump. Also, 1000 to 2000 hour durability tests are conducted at flow rates and output pressures typical of ordinary operation. During this time, the pump can run almost continuously (it is not cycled). Fuel heating should be avoided as it makes the test less appropriate for this application. At the end of the test, the three performance specifications indicated above are measured again to determine whether the pump has deteriorated. Past and current experience indicates that the 1000 to 2000 hour time period is sufficient to predict pump life. It also indicates compatibility of pump seals and gaskets. Visual inspection of the interior of the pump is made to detect any corrosion which may have occurred. The pump is also subjected to salt-spray and vibration-shock tests which may uncover a weakness created by the fuel.

3. Solenoid Valves

Testing of the solenoid valve typically involves circulation of test fuel for up to 1000 hours at flow rates and pressure drops used for current fuels typical of use. A quick determination with good confidence can be made after 70 hours. At the end of the test, the solenoid is pressure tested at the maximum specified operating pressure to check for leaks. The seals are checked for deterioration, swelling or shrinking. Visual checks of the interior of the housing are made for indications of corrosion.

4. Housing Unit

The flame heater housing contains the fuel spray nozzle and the ignition electrodes. The problems which are likely to develop with this unit are corrosion of the fuel passage, coking of the nozzle, and fouling of the electrodes. The units are tested by cycling the flame heater at an ambient temperature of $0^{o}F$ ($-18^{o}C$). Time is allowed between ignitions for the nozzle and electrodes to return to ambient temperature. The number of repetitions should be at least 200 to 300 and more if abnormal deposits exist or a fuel-related malfunction occurs.

F. FUEL LINES/HOSES

1. Generic Type Tests

Fuel lines and hoses can be tested two ways to determine their compatibility with a new fuel. The assembled hose can be subjected to a variety of tests after exposure to a fuel, or it can be disassembled and its component parts tested individually for their tolerance to a given fuel. This section will be divided into two parts reflecting these two distinctions.

2. Whole Hose Tests

a. Conditioning

The hose assembly is immersed in the test fuel for 70 hours or longer. The temperature during the test is ambient up to 300°F, depending on the fuel. The majority of any dimensional changes due to swelling or shrinking will have occurred by the end of 70 hours. There are a variety of physical tests which the hose assembly is put through which are described in the remainder of this section.

b. High Temperature Circulation

An alternative to conditioning is a high temperature circulation test. Fuel is circulated through the hose for 50 hours at 50 to 75 psi pressure. The temperature can be as high as 300°F, depending on the fuel used.

c. Dimensional Changes

Immediately after the hose has been removed from the fuel, it is dried; and changes in wall thickness, overall diameter, and length are measured and compared to the original valves.

d. Length Change Under Pressure

Two lines are marked on the hose exactly 10 inches apart. The hose is then pressurized to 50 percent of its burst pressure. The rate of increase of pressure is 1000 psi-per minute. A linear measurement check is made 2 minutes after the final pressure has been reached. The average change in length, expressed in percent, is calculated from three test specimens. This average should not be more than $\pm$ 4 percent.

e. Proof Pressure

The hose is subjected to its proof pressure (typically twice the operating pressure) for at least 30 seconds. No leakage, rupture or detachment from fittings is allowed.

f. Leakage

The hose is subjected to a pressure of 70% of the minimum burst pressure (typically 4 times operating pressure) for 5 minutes, followed by 5 minutes at no pressure, and then 5 minutes at the 70% burst pressure. Any leakage, rupture or detachment from its fittings is a failure.

g. Minimum Burst Pressure

The hose is subjected to increasing pressure at a rate of 5000 to 10000 psi per minute till it fails. Any leakage, rupture or detachment from a fitting is considered a failure. Average burst pressure from three specimens is calculated and compared to the minimum burst pressure for that hose.

h. Cold Flex

The hose and test mandrel is conditioned for 70 hours at $-67^{O}F$, $\pm$ $3.6^{O}F$ ambient air temperature. Each test specimen is tested by bending it around a mandrel until the full length of hose is in contact with the mandrel circumference, then straightening the hose and bending it in the reverse direction about the mandrel circumference. Each bend is accomplished at a substantially uniform rate in 12 $\pm$ 3 seconds. The mandrel radius is specified for each hose. The hose is then subjected to the proof pressure test (part e, above).

i. Fire

The hose has $200^{O}F$ oil circulating through it while bent. The hose is subjected to a temperature of $2000^{O}F$. The hose must last from 5 to 15 minutes depending on its application.

j. Stress Degradation

The hose is subjected to $400^{O}F$ ambient air for 24 hours. Four cycles of the Leakage Test (part f) are performed. Any leakage, rupture or detachment from fittings is a failure.

k. Permeation

A hose is capped at both ends and weighed. The hose is then subjected to a temperature applicable with its application (up to $300^{O}F$). The weight of the hose assembly is checked after 24, 70, and 168 hours to determine weight lost with time.

3. Hose Component Tests

a. Conditioning

Various test

ment and outer coating are immersed in the test fuel at temperatures up to 300°F for 70 hours. The most commonly used temperature is 212°F.

b. Volume Increase

Within 5 minutes of removal of the specimen from the fuel, it is dried and measured for volume increase. The volume change must be done in accordance with Federal Test Method Standard No. 601, method 6211.

c. Elongation

Elongation must also be measured within 5 minutes of removing the sample from the test fuel. The measurements must be done in accordance with Federal Test Method Standard No. 601, method 4121.

d. Tensile Strength

Tensile strength is determined within 5 minutes of removal of the specimen from the test fuel and conducted in accordance with Federal Test Method Standard No. 601, method 4111.

e. Aging

The test specimens are immersed in the test fuel at ambient temperature from as little as 168 hours to as long as 1000 hours. This test can serve as conditioning for the specimen. Physical property tests (such as parts b,c, and d above) are then conducted.

G. OTHER COMPONENTS

1. Personnel Heaters

Personnel heaters, as made by the Southwind division of Stewart-Warner, are subjected to vibration, shock, salt spray, cold start, and endurance tests. The endurance test is typically composed of an 800 hour endurance run at temperatures ranging from -55°F to 90°F. The test schedule is composed of 200 hours at ambient temperatures on No. 2 diesel fuel, 100 hours at -25°F on No. 1 diesel fuel, and 100 hours at -65°F on arctic grade diesel fuel. The test is repeated for a total of 800 hours and the entire test is conducted under conditions of 20 minutes on and 10 minutes off.

2. Valves

Ball valves, such as those made by Dynaquip Controls, must typically conform to MSS (Manufacturers Standards Society) and ANSI (American National Standards Institute) requirements. The primary test for final acceptance is for shell and seat leakage. The test procedure (as used by Dunaquip) using clean dry air or gaseous nitrogen is as follows:

- Clamp the valve to be tested in the fixture.
- Position the handle to approximately 45° or the 1/2 open position. Apply 80.0 psig minimum pressure to both end connections.
- Submerge the pressurized valve under water. Air bubbles adhering to the exterior of the valve should be mechanically removed.
- Observe the valve for 15 seconds. Any bubbles coming from any area of the valve during this time shall be cause for rejection. If the source of the bubble is unknown and may be the result of air entrapped on the valve exterior, the observation period must be repeated.
- Close the valve.
- Apply 80.0 psig minimum to one end connection and vent the other to atmosphere.
- Observe the tubing end for 15 seconds. Any bubbles exiting the tubing shall be cause for rejection.

- Repeat the two previous steps with pressure and venting to test valve reversed.
- Shut off the air pressure, raise the test valve from the water and remove from the test fixture.
- Each valve shall be thoroughly dried with clean dry air and then opened for packaging.

APPENDIX E-5

ENVIRONMENTAL PROTECTION AGENCY HEAVY-DUTY DIESEL ENGINE EXHAUST EMISSIONS CERTIFICATION AND TEST PROCEDURES

A. INTRODUCTION

All heavy-duty vehicles and heavy-duty engines intended for use in heavy-duty vehicles must meet exhaust emission standards as outlined in the Federal Code of Regulations, Title 40, Part 86 - Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines: Certification and Test Procedures. The following is a collection of selected excerpts from the Federal Code of Regulations which describe the testing required in order for heavy-duty engine or vehicle to obtain Environmental Protection Agency (EPA) certification.

B. EPA HEAVY DUTY DIESEL ENGINE DURABILITY TESTING REQUIREMENTS AND PROCEDURES

For any engine family which is undergoing EPA exhaust emissions certification, some engines must undergo durability testing. This test is basically a 1000 hour test run at rated speed and load. Exhaust emissions and smoke are measured at 125 hour intervals. Engine operating conditions are the same as specified for exhaust emissions testing. The following outlines how engines are selected and how the test is conducted.

(i) One engine from each engine-system combination shall be tested. At each test point, either the complete gaseous emission test or the complete smoke test may be conducted first. Within each combination, the engine which features the highest fuel feed per stroke, primarily at rated speed and secondarily at the speed of maximum rated torque, will usually be selected for durability testing. In the case where more than one engine in an engine-system combination has the highest fuel feed per stroke, the engine with the highest maximum rated horsepower will usually be selected for durability testing. If an engine-system combination includes both military and nonmilitary engines, then the nonmilitary engine with the highest maximum rated horsepower will usually be selected for durability testing.

(ii) A manufacturer may elect to operate and test additional engines to represent any engine-system combination. The additional engines must be of the same model and fuel system as the engine selected in accordance with the provisions of paragraph (i) of this section. Notice of an intent to test additional engines shall be given to the EPA Administrator not later than 30 days following notification of the test fleet selection. Deterioration factors calculated for each engine-system combination shall be applied separately to military and nonmilitary engines within the same engine-system combination.

Any manufacturer whose projected sales for the model year in which certification is sought is less than

(1) 2000 gasoline-fueled light-duty vehicles, or

(2) 2000 Diesel light-duty vehicles, or

(3) 2000 gasoline-fueled light-duty trucks, or

(4) 2000 Diesel light-duty trucks, or

(5) 700 gasoline-fueled heavy-duty engines, or

(6) 200 Diesel heavy-duty engines, may request a reduction in the number of test vehicles (or engines) determined in accordance with the foregoing provisions of this section. The EPA Administrator may agree to such lesser number as he determines would meet the objectives of this procedure.

Durability-data engines. Durability-data engines shall be operated and tested as follows: Each durability-data engine shall be operated, with all emission control systems installed and operating, for 1,000 hours. Emission tests shall be conducted at zero hours and at each 125-hour interval.

A break-in procedure, not to exceed 20 hours, may be run if approved in writing in advance by the Administrator. This procedure would be run after the zero-hour test, and the hours accumulated would not be counted as part of the service accumulation.

Before service accumulation can begin, the following criteria must be met. Failure to comply with these requirements shall invalidate all test data submitted for an engine.

(i) Each engine shall produce at least 95 percent of the maximum horsepower, corrected to rating conditions, at 95 to 100 percent of the rated speed.

(ii) The fuel rate at maximum horsepower shall be within manufacturer's specifications.

(iii) The zero-hour test data shall be provided to the Administrator (except for those engines for which the zero-hour test requirement has been waived) and the engine shall be made available for such testing as the EPA Administrator may require.

During service accumulation, hours can be credited toward the required service accumulation hours when the following criteria are met. If these criteria cannot be met, engine operation shall be discontinued and the EPA Administrator shall be notified immediately.

(i) Each engine shall produce at least 95 percent of the maximum horsepower, at 95 to 100 percent of the rated speed, observed during zero-hour testing. Horsepower values shall be corrected to the rating conditions.

(ii) The engine shall be operated at 75 percent of the inlet and exhaust restrictions specified except that the tolerance will be $\pm$ 3 inches of water and $\pm$ 0.5 inches of Hg, respectively.

The results of each emission test shall be air posted to the Administrator within 72 hours of test completion (or delivered within 5 working days). The manufacturer shall furnish to the Administrator an explanation for voiding any test. The Administrator will determine if voiding the test was appropriate based upon the explanation given by the manufacturer for the voided tests. If a manufacturer conducts multiple tests (not to exceed three valid tests) at any test point, the number of tests must be the same at each point. The data obtained from all valid tests shall be used in the calculation of the deterioration factor. Tests between test points may be conducted as required by the Administrator. Data from all tests (including voided tests) shall be air posted to the Administrator within 72 hours (or delivered within 5 working days). In addition, all test data shall be compiled and provided to the Administrator. Where the Administrator conducts a test on a durability-data engine at a prescribed test point, the results of that test will be used in the calculation of the deterioration factor.

The results of all emission tests shall be recorded and reported to the Administrator using two places to the right of the decimal point. These numbers shall be rounded in accordance with the "Rounding Off Method" specified in ASTM E29-67.

Once a manufacturer begins to operate an emission-data or durability-data engine, he shall continue to run the engine to 125 hours or 1,000 hours respectively. Discontinuation of an engine shall be allowed only with the prior written consent of the Administrator.

The Administrator may elect to operate and test any test engine during all or any part of the service accumulation and testing procedure. In such cases, the manufacturer shall provide the engine(s) to the Administrator with all information necessary to conduct the testing.

C. EMISSION STANDARDS FOR 1977 AND LATER DIESEL HEAVY-DUTY ENGINES

The opacity of smoke emissions from new 1977 and later model year Diesel heavy-duty engines shall not exceed:

(i) 20 percent during the engine acceleration mode.

(ii) 15 percent during the engine lugging mode.

(iii) 50 percent during the peaks in either mode.

Exhaust gaseous emissions from new 1977 and later model year Diesel heavy-duty engines shall not exceed:

(i) Hydrocarbons plus oxides of nitrogen (as NO_2). 16 grams per brake horsepower hour.

(ii) Carbon monoxide. 40 grams per brake horsepower hour.

D. TEST PROCEDURE TO MEASURE SMOKE EMISSIONS OPACITY

The test consists of a prescribed sequence of engine operating conditions of an engine dynamometer with continuous examination of the exhaust gases. The test is applicable equally to controlled engines equipped with means for preventing, controlling, or eliminating smoke emissions and to uncontrolled engines.

The test is designed to determine the opacity of smoke in exhaust emissions during those engine operating conditions which tend to promote smoke from diesel-powered vehicles.

The test procedure begins with a warm engine which is then run through preloading and preconditioning operations. After an idling period, the engine is operated through acceleration and lugging modes during which smoke emission measurements are made to compare with the standards. The engine is then returned to the idle condition and the acceleration and lugging modes are repeated. Three sequences of acceleration and lugging constitute the full set of operating conditions for smoke emission measurement.

1. Diesel Fuel Specifications

The Diesel fuels employed shall be clean and bright, with pour and cloud points adequate for operability. The fuels may contain nonmetallic additives as follows: Cetane improper, metal deactivator, antioxidant, dehazer, antirust, pour depressant, dye, and dispersant.

Fuel meeting the following specifications, or substantially equivalent specifications, shall be used in exhaust emission testing. The grade of fuel recommended by the engine manufacturer, commercially designated as "Type 1-D" or "Type 2-D" shall be used.

Item	ASTM Test Method No.	Type 1-D	Type 2-D
Cetane	D613	48-54	42-50
Distillation Range	D86		
IBP, °F		330-390	340-400
10 percent point, °F		370-430	400-460
50 percent point, °F		410-480	470-540
90 percent point, °F		460-520	550-610
EP, °F		500-560	580-660
Gravity, °API	D287	40-44	33-37
Total sulfur, percent	D129 or D2622	0.05-0.20	0.2-0.5
Hydrocarbon composition	D1139		
Aromatics, percent		8-15	27 (Min.)
Paraffins, Naphthenes, Olefins		Remainder	Remainder
Flash point, °F (Min.)	D93	120	130
Viscosity, centistokes	D445	1.6-2.0	2.0-3.2

2. Dynamometer Operation Cycle for Smoke Emission Tests

(a) The following sequence of operations shall be performed during engine dynamometer testing of smoke emissions, starting with the dynamometer preloading determined and the engine preconditioned.

(1) Idle mode. The engine is caused to idle for 5 to 5.5 minutes at the manufacturer's recommended low idle speed. The dynamometer controls shall be set to provide minimum load by turning the load switch to the "off" position or by adjusting the controls to the minimum load position.

(2) Acceleration mode.

(i) The engine speed shall be increased to 200 ± 50 r.p.m. above the manufacturer's recommended low idle speed within 3 seconds.

(ii) Immediately upon completion of the mode specified in paragraph (a)(2)(i) of this section, the throttle shall be moved rapidly to, and held in, the fully-open position. The inertia of the engine and the dynamometer, or alternately a preselected dynamometer load, shall be used to control the acceleration of the engine so that the speed increases to 85 percent of the rated speed in 5 ± 1.5 seconds. This acceleration shall be linear within 100 r.p.m.

(iii) After the engine reaches the speed required in paragraph (a)(2)(ii) of this section, the throttle shall be moved rapidly to, and held in, the fully-closed position. Immediately after the throttle is closed, the preselected load required to perform the acceleration in paragraph (a)(2)(iv) of this section shall be applied.

(iv) When the engine decelerates to the maximum torque speed or 60 percent of rated speed (within 50 r.p.m.), whichever is higher, the throttle shall be moved rapidly to, and held in, the fully-open position. The preselected dynamometer load which was applied during the preceding transition period shall be used to control the acceleration of the engine so that the speed increases to at least 95 percent of the rated speed in 10 ± 2 seconds.

(3) Lugging mode.

(i) Immediately upon completion of the preceding acceleration mode, the dynamometer controls shall be adjusted to permit the engine to develop maximum horsepower at rated speed. This transition period shall be 50 to 60 seconds in duration. During the last ten seconds of this period, the engine speed shall be maintained within 50 r.p.m. of the rated speed, and the power (corrected, if necessary, to rating conditions) shall be no less than 95 percent of the maximum horsepower developed during zero-hour testing.

(ii) With the throttle remaining in the fully-open position, the dynamometer controls shall be adjusted gradually so that the engine speed is reduced to the maximum torque speed or to 60 percent of the rated speed (within 50 r.p.m.), whichever is higher. This lugging operation shall be performed smoothly over a period of 35 ± 5 seconds. The rate of slowing of the engine shall be linear, within 100 r.p.m.

(4) Engine unloading. Immediately after completion of the preceding lugging mode, the dynamometer and engine controls shall be returned to the idle position described in paragraph (a)(1) of this section. The engine must be at the low idle condition within one minute after completion of the lugging mode.

(b) The procedures described in paragraphs (a)(1) through (a)(4) of this section shall be repeated until three consecutive valid cycles have been completed. If three valid cycles have not been completed after a total of six consecutive cycles have been run, the engine shall be preconditioned by operation at maximum horsepower at rated speed for 10 minutes before the test sequence is repeated.

3. Dynamometer and Engine Equipment

The following equipment shall be used for smoke emission testing of engines on engine dynamometers.

(a) An engine dynamometer with adequate characteristics to perform the test cycle.

(b) An engine cooling system having sufficient capacity to maintain the engine at normal operating temperatures during conduct of the prescribed engine tests.

(c) A noninsulated exhaust system extending 15 ± 5 feet from the exhaust manifold, or the crossover junction in the case of Vee engines, and presenting an exhaust back pressure within ± 0.2 inch Hg. of the upper limit at maximum rated horsepower, as established by the engine manufacturer in his sales and service literature for vehicle application. A conventional automotive muffler of a size and type commonly used with the engine being tested shall be employed in the exhaust system during smoke emission testing. The terminal 2 feet of the exhaust pipe shall be circular cross section and be free of elbows and bends. The end of the pipe shall be cut off squarely. The terminal 2 feet of the exhaust pipe shall have a diameter in accordance with the engine being tested, as specified below.

Maximum Rated Horsepower	Exhaust Pipe Diameter (Inches)
Less than 101	2
101 to 200	3
201 to 300	4
301 or more	5

(d) An engine air inlet system presenting an air inlet restriction within $\pm$ 1 inch of water of the upper limit for the engine operating condition which results in maximum air flow, as established by the engine manufacturer in his sales and service literature, for the engine being tested.

4. Smoke Measurement

(a) Equipment. The following equipment shall be used in the system:

(1) Adapter - the smokemeter optical unit may be mounted on a fixed or movable frame. The normal unrestricted shape of the exhaust plume shall not be modified by the adapter, the meter, or any ventilator system used to remove the exhaust from the test site.

(2) Smokemeter (light extinction meter) - continuous recording, full-flow light obscuration meter. It shall be positioned near the end of the exhaust pipe so that a built-in light beam traverses the exhaust smoke plume which issues from the pipe at right angles to the axis of the plume.

(3) Recorder - a continuous recorder, with variable chart speed over a minimal range of 0.5 to 8.0 inches per minute (or equivalent) and an automatic marker indicating 1-second intervals shall be used for continuously recording the exhaust gas opacity, engine r.p.m. and throttle position.

5. Information to be Recorded

The following information shall be recorded with respect to each test:

(a) Test number

(b) Date and time of day.

(c) Instrument operator.

(d) Engine operator.

(e) Engine Identification numbers - Date of manufacture - Number of hours of operation accumulated on engine - Engine family - Exhaust pipe diameter - Fuel injector type - Maximum measured fuel rate at maximum measured torque and horsepower - Air aspiration system - Low idle r.p.m. - Maximum governed r.p.m. - Maximum measured horsepower at r.p.m. - Maximum measured torque at r.p.m. - Exhaust system back pressure - Air inlet restriction.

(f) Smokemeter: Number - Zero control setting - Calibration control setting - Gain.

(g) Recorder chart: Identify zero traces - Calibration traces - Idle traces - Closed throttle trace, open throttle trace - Acceleration and lugdown test traces - Start and finish of each test.

(h) Ambient temperature in dynamometer testing room.

(i) Engine intake air temperature and humidity.

(j) Barometric pressure.

(k) Observed engine torque and speed during the steady-state test conditions.

6. Test Run

(a) The temperature of the air supplied to the engine shall be between 68°F. and 86°F. The observed barometric pressure shall be between 28.5 inches and 31 inches Hg. Higher air temperature or lower barometric pressure may be used, if desired, but no allowance will be made for possible increased smoke emissions because of such conditions.

(b) The governor and fuel system shall have been adjusted to provide engine performance at the levels specified by the engine manufacturer for maximum rated horsepower and maximum rated torque.

(c) The following steps shall be taken for each test:

(1) Start cooling system.

(2) Starting with a warmed engine, determine by experimentation the dynamometer inertia and dynamometer load required to perform the acceleration in the dynamometer cycle for smoke emission tests. In a manner appropriate for the dynamometer and controls being used, arrange to conduct the acceleration mode.

(3) Install smokemeter optical unit and connect it to the recorder. Connect the engine r.p.m. and torque sensing devices to the recorder.

(4) Turn on purge air to the optical unit of the smokemeter, if purge air is used.

(5) Check and record zero and span settings of the smokemeter recorder at a chart speed of approximately 1 inch per minute. (The optical unit shall be retracted from its position about the exhaust stream if the engine is left running.)

(6) Precondition the engine by operating it for 10 minutes at maximum rated horsepower.

(7) Proceed with the sequence of smoke emission measurements on the engine dynamometer.

(8) During the test sequence, continuously record smoke measurements, engine r.p.m., and throttle position at a minimum chart speed of 1 inch per minute during the idle mode and transitional periods and 8 inches per minute during the acceleration and lugging modes. The smokemeter zero and full scale recorder deflections may be rechecked during the idle mode of each test sequence. If either zero or full scale drift is in excess of 2 percent opacity, the smokemeter controls must be readjusted and the test must be repeated.

(9) Turn off engine.

(10) Check zero and reset if necessary and check span of the smokemeter recorder by inserting neutral density filters. If either zero or span drift is in excess of 2 percent opacity, the test results shall be invalidated.

E. TEST PROCEDURE TO MEASURE GASEOUS EXHAUST EMISSIONS

The test procedure begins with a warm engine and consists of a prescribed sequence of engine operating conditions on an engine dynamometer with continuous examination of the exhaust gases.

The test is designed to determine the brake-specific emissions of hydrocarbons, carbon monoxide and oxides of nitrogen when an engine is operated through a cycle which consists of three idle modes and five power modes at each of two speeds which span the typical operating range of Diesel engines. The procedure requires the determination of the concentration of each pollutant, the exhaust flow and the power output during each mode. The measured values are weighted and used to calculate the grams of each pollutant emitted per brake-horsepower hour.

When an engine is tested for exhaust emissions or is operated for durability testing on an engine dynamometer, the complete engine shall be tested with all standard accessories which might reasonably be expected to influence emissions to the atmosphere installed and functioning.

Except in cases of component malfunction or failure, all emission control systems installed on or incorporated in a new motor vehicle engine shall be functioning during all procedures in this subpart.

All emission control systems installed on or incorporated in a new motor vehicle engine shall be functioning during all test procedures in this subpart.

The grade of Diesel Fuel Specifications fuel used should be that recommended by the manufacturer. The properties of the fuel should lie within those indicated for commercial grades "Type 1-D" and "Type 2-D" presented previously in section C.

1. Dynamometer Procedure

(a) The following 13 mode cycle shall be followed in dynamometer operation tests of heavy-duty Diesel engines:

Mode No.	Engine Speed	Percent Load
1.............	Low idle.......	0
2.............	Intermediate...	2
3.............	do.........	25
4.............	do.........	50
5.............	do.........	75
6.............	do.........	100
7.............	Low idle.......	0
8.............	Rated..........	100
9.............	do.........	75
10.............	do.........	50
11.............	do.........	25
12.............	do.........	2
13.............	Low idle.......	0

(b) During each mode the specified speed shall be held to within 50 r.p.m. and the specified torque shall be held to within 2 percent of the maximum torque at the test speed. For example, the torque for mode 4 shall be between 48 and 52 percent of the maximum torque measured at the intermediate speed.

2. Sampling and Analytical Methods

(a) The determination of the carbon monoxide and nitric oxide concentrations shall be accomplished using sampling and analysis components as specified in sections 2.1 and 2.2 of the SAE Recommended Practice No. J177 titled "Measurement of Carbon Dioxide, Carbon Monoxide and Oxides of Nitrogen in Diesel Exhaust," dated June 1970. Other sampling and analysis components may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(b) The determination of the hydrocarbon concentrations shall be accomplished using sampling and analysis components as specified in sections 2.1 and 2.2 of SAE Recommended Practice No. J215 titled, "Continuous Hydrocarbon Analysis of Diesel Exhaust," dated November 1970.

(c) The determination of the intake airflow or exhaust flow shall be accomplished using SAE Recommended Practice No. J244 titled, "The Measurement of Intake or Exhaust Flow in Diesel Engines," dated May 1971.

3. Information to be Recorded

The following information shall be recorded:

(a) Test number.

(b) Date and time of day.

(c) Instrument operator.

(d) Engine operator.

(e) Engine identification numbers - date of manufacture - number of hours of operation accumulated on engine - engine family - exhaust pipe diameter - fuel injector type - low idle r.p.m., governed speed, maximum power and torque speeds - maximum horsepower and torque - fuel consumption at maximum power and torque - air aspiration system - exhaust system back pressure - air inlet restriction.

(f) All pertinent instrument information such as tuning - gain - serial numbers - detector numbers - range.

(g) Recorder chart. Identify zero traces - calibration or span traces - emission concentration traces for each test mode - start and finish of each test.

(h) Ambient temperature in dynamometer testing room.

(i) Engine intake air temperature and humidity for each mode.

(j) Barometric pressure.

(k) Observed engine torque for each mode.

(l) Intake airflow or exhaust flow for each mode.

(m) Fuel flow and temperature for each mode.

4. Calibration and Instrument Checks

Calibration and instrument checks shall be performed according to section 2.3.1 of SAE Recommended Practice No. J177, dated November 1970, except that the instrument zeros need not be checked after each analysis but as necessary to maintain test validity. Calibration and checks of other instruments used for the test shall be performed as necessary according to good practice.

5. Test Run

(a) The temperature of the air supplied to the engine shall be between 68°F and 86°F. The fuel temperature at the pump inlet shall be 100°F ± 10°F. The observed barometric pressure shall be between 28.5 inches and 31 inches Hg. Higher air temperature or lower barometric pressure may be used, if desired, but no allowance shall be made for increased emissions because of such conditions.

(b) The governor and fuel system shall have been adjusted to provide engine performance at the levels specified by the engine manufacturer for maximum rated horsepower and maximum rated torque.

(c) The following steps shall be taken for each test.

(1) Install instrumentation and sample probes as required.

(2) Start cooling system.

(3) Start the engine, warm it up and precondition it by running it at rated speed and maximum horsepower for 10 minutes or until all temperatures and pressures have reached equilibrium.

(4) Determine by experimentation the maximum torque at rated speed and intermediate speed to calculate the torque values for the specified test modes.

(5) Zero and span the emission analyzers on each range used during the test run.

(6) Operate the engine for 10 minutes in each mode, completing engine speed and load changes in the first minute. If a delay of more than 10 minutes occurs between the end of one mode and the start of the next mode, discontinue the sequence and repeat the test from Mode No. 1. Record the response of the analyzers on a strip chart recorder for the full 10 minutes with exhaust gas flowing through the analyzers at least during the last 5 minutes. Record the engine speed and load, intake air temperature and restriction, exhaust back pressure, fuel flow and air or exhaust flow during the last 5 minutes of each mode, making certain that the speed and load requirements are met during the last minute of each mode. Fuel flow during idle or 2 percent load conditions may be determined just prior to or immediately following the dynamometer sequence, if longer times are required for accurate measurements.

F. EMISSION STANDARDS FOR 1984 AND LATER DIESEL HEAVY DUTY ENGINES

The emission standards which heavy-duty diesel engines must meet in 1984 reflect a change in the test procedures. While the smoke emissions opacity standards are retained as before (along with the procedures used to measure them), new more stringent hydrocarbon (HC) and carbon monoxide (CO) standards will go into effect as well as a separate oxides of nitrogen (NOx) standard. A new transient test procedure is specified to measure these exhaust emissions.

1984 Heavy Duty Diesel Engine Emission Standards

The opacity of smoke emissions from new 1984 and later model year diesel heavy-duty engines shall not exceed:

(i) 20 percent during the engine acceleration mode.

(ii) 15 percent during the engine lugging mode.

(iii) 50 percent during the peaks in either mode.

No crankcase emissions shall be discharged into the ambient atmosphere from any new 1984 model year naturally-aspirated diesel heavy duty engine. This provision does not apply to turbocharged engines.

Exhaust emissions from new 1984 model year diesel heavy-duty engines using the transient text procedure shall not exceed the following:

(i) Hydrocarbons - 1.3 grams per brake horsepower hour.

(ii) Carbon Monoxide - 15.5 grams per brake horsepower hour.

(iii) Oxides of Nitrogen - 10.7 grams per brake horsepower hour.

G. TRANSIENT TEST PROCEDURE TO MEASURE 1984 MODEL YEAR HEAVY DUTY DIESEL ENGINE EMISSIONS

The transient test procedure is conducted in two halves - a cold-start portion and a hot-start portion. Each is identical and takes exactly 20 minutes to run. A 20 minute soak period separates the cold-start and hot-start portions. The engine oil must be at ambient temperature before a cold-start portion can be begun.

Emissions during the transient test are analyzed directly and integrated over the cold-start and hot-start portions. This allows weighting of the emissions according to the number of cold-starts vs. hot-starts found in the field. A ratio of 1:7 is used for the number of cold-starts to hot-starts. Accordingly, the mass of a pollutant emitted over each of the two cycle segments and the work done by the engine during the two segments are calculated; the hot/cold weighting is applied to the resulting grams and the BHP·hrs; and a final calculation yields a weighted g/BHP·hr emission result for that pollutant.

The fuels acceptable for testing and the equipment required for testing are the same as before with the exception that the engine dynamometer must be capable of duplicating the load requirements of the transient cycle.

H. FUTURE HEAVY DUTY DIESEL ENGINE EMISSIONS TESTS AND STANDARDS

By the 1985 model year, EPA hopes to propose and promulgate regulations governing particulate emissions from heavy-duty diesel engines. The transient test procedure may be changed to be completely compatible with measurement of particulates. The promulgation of particulate regulations will only require the addition of some new equipment and no replacement of newly-purchased equipment necessary for conducting the transient test procedure.

Another change being incorporated into the revised test procedures being introduced for the 1984 model year heavy-duty engines is a redefinition of "useful life." The new definition of "useful life" for heavy-duty diesel engines is 10 years, 100,000 miles or 3000 hours of operation, whichever occurs first. This definition is felt to be (by EPA) more representative for heavy-duty engines and vehicles than the light-duty, 5 years or 50,000 mile definition previously used.

DEPARTMENT OF DEFENSE

DEFENSE DOCUMENTATION CTR
CAMERON STATION 12
ALEXANDRIA VA 22314

DEPT OF DEFENSE
ATTN: DASD(MRAL)-LM(MR DYCKMAN) 1
WASHINGTON DC 20301

COMMANDER
DEFENSE LOGISTICS AGY
ATTN DLA-SME (MRS P MCLAIN) 1
CAMERON STATION
ALEXANDRIA VA 22314

COMMANDER
DEFENSE FUEL SUPPLY CTR
ATTN: DFSC-T (MR. MARTIN) 1
CAMERON STA
ALEXANDRIA VA 22314

COMMANDER
DEFENSE GENERAL SUPPLY CTR
ATTN: DGSC-SSA 1
RICHMOND VA 23297

DOD
OFC OF SEC OF DEF
ATTN USD (R&E) 1
WASHINGTON, DC 20301

DOD
ATTN. OASD (MRA&L)-TD 1
PENTAGON, 3C841
WASHINGTON DC 20301

DEFENSE ADVANCED RES PROJ AGENCY
DEFENSE SCIENCES OFC 1
1400 WILSON BLVD
ARLINGTON VA 22209

DEPARTMENT OF THE ARMY

HQ, DEPT OF ARMY
ATTN: DALO-TSE (COL ARNAUD)
DALO-AV 1
DALO-SMZ-E 1
DAMA-CSS-P (DR BRYANT) 1
DAMA-ARZ (DR CHURCH) 1
DAMA-SMZ 1
WASHINGTON DC 20310

CDR
U.S. ARMY MOBILITY EQUIPMENT
R&D COMMAND
Attn: DRDME-GL 10
FORT BELVOIR VA 22060

CDR
US ARMY MATERIEL DEVEL&READINESS
COMMAND
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WARREN MI 48090

DIRECTOR
US ARMY MATERIEL SYSTEMS
ANALYSIS AGENCY
ATTN DRXSY-CM 1
DRXSY-S 1
DRXSY-L 1
ABERDEEN PROVING GROUND MD 21005

DIRECTOR
APPLIED TECHNOLOGY LAB
U.S. ARMY R&T LAB (AVRADCOM)
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DAVDL-ATL-ASV (MR CARPER) 1
FORT EUSTIS VA 23604

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APO SEATTLE 98733

HQ, DEPT. OF ARMY
ATTN: DAEN-RDZ-B 1
WASHINGTON, DC 20310

CDR
US ARMY RES & STDZN GROUP
(EUROPE)
ATTN DRXSN-UK-RA 1
BOX 65
FPO NEW YORK 09510

HQ, US ARMY AVIATION R&D CMD
ATTN DRDAV-GT (MR R LEWIS) 1
DRDAV-D (MR CRAWFORD) 1
DRDAV-N (MR BORGMAN) 1
DRDAV-E (MR LONG) 1
4300 GOODFELLOW BLVD
ST LOUIS MO 63120

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AFLG-POP 1
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WARREN MI 48090

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US ARMY EUROPE & SEVENTH ARMY
ATTN AEAGC-FMD 1
APO NY 09403

PROJ MGR, PATRIOT PROJ OFC
ATTN DRCPM-MD-T-G 1
US ARMY DARCOM
REDSTONE ARSENAL AL 35809

CDR
THEATER ARMY MATERIAL MGMT
CENTER (200TH)
DIRECTORATE FOR PETROL MGMT
ATTN AEAGD-MM-PT-Q (MR PINZOLA) 1
ZWEIBRUCKEN
APO NY 09052

CDR
US ARMY RESEARCH OFC
ATTN DRXRO-ZC 1
DRXRO-EG (DR SINGLETON) 1
DRXRO-CB (DR GHIRARDELLI) 1
P O BOX 12211
RSCH TRIANGLE PARK NC 27709

DIR
US ARMY R&T LAB (AVRADCOM)
ATTN DAVDL-AS (MR D WILSTED) 1
NASA/AMES RSCH CTR
MAIL STP 207-5
MOFFIT FIELD CA 94035

CDR
TOBYHANNA ARMY DEPOT
ATTN SDSTO-TP-S 1
TOBYHANNA PA 18466

DIR
US ARMY MATERIALS & MECHANICS
RSCH CTR
ATTN DRXMR-EM 1
DRXMR-R 1
DRXMR-T 1
WATERTOWN MA 02172

CDR
US ARMY DEPOT SYSTEMS CMD
ATTN DRSDS 1
CHAMBERSBURG PA 17201

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US ARMY WATERVLIET ARSENAL
ATTN SARWY-RDD 1
WATERVLIET NY 12189

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ATTN DALO-LEP 1
NEW CUMBERLAND ARMY DEPOT
NEW CUMBERLAND PA 17070

CDR
US ARMY GENERAL MATERIAL &
PETROLEUM ACTIVITY
ATTN STSGP-PW (MR PRICE) 1
SHARPE ARMY DEPOT
LATHROP CA 95330

CDR
US ARMY FOREIGN SCIENCE & TECH
CENTER
ATTN DRXST-MT1 1
FEDERAL BLDG
CHARLOTTESVILLE VA 22901

CDR
DARCOM MATERIEL READINESS
SUPPORT ACTIVITY (MRSA)
ATTN DRXMD-MD 1
LEXINGTON KY 40511

HQ, US ARMY T&E COMMAND
ATTN DRSTE-TO-O 1
ABERDEEN PROVING GROUND, MD 21005

HQ, US ARMY ARMAMENT R&D CMD
ATTN DRDAR-LC 1
DRDAR-SC 1
DRDAR-AC 1
DRDAR-QA 1
DOVER NJ 07801

HQ, US ARMY TROOP SUPPORT &
AVIATION MATERIAL READINESS
COMMAND
ATTN DRSTS-MEG (2) 1
DRCPO-PDE (LTC FOSTER) 1
4300 GOODFELLOW BLVD
ST LOUIS MO 63120

DEPARTMENT OF THE ARMY
CONSTRUCTION ENG RSCH LAB
ATTN CERL-EM 1
CERL-ZT 1
CERL-EH 1
P O BOX 4005
CHAMPAIGN IL 61820

DIR
US ARMY ARMAMENT R&D CMD
BALLISTIC RESEARCH LAB
ATTN DRDAR-BLV 1
DRDAR-BLP 1
ABERDEEN PROVING GROUND, MD 21005

HQ
US ARMY TRAINING & DOCTRINE CMD
ATTN ATDO-5 (COL MILLS) 1
FORT MONROE VA 23651

DIRECTOR
US ARMY RSCH & TECH LAB (AVRADCOM)
PROPULSION LABORATORY
ATTN DAVDL-PL-D (MR ACURIO) 1
21000 BROOKPARK ROAD
CLEVELAND OH 44135

CDR
US ARMY NATICK RES & DEV CMD
ATTN DRDNA-YEP (DR KAPLAN) 1
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BASE ATLANTIC
ATTN CODE P841 1
ALBANY GA 31704

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