

Fig. 1

Trade Name	Ignition Delay (ms)				
	Pure Isooctane	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane	9.52				
Base Oil 1		9.70	9.81	9.86	9.91
Base Oil 2		9.48	8.75	8.10	7.67
Base Oil 3		9.33	8.08	7.14	6.55
Base Oil 4		9.30	8.13	7.10	6.35
Base Oil 5		9.13	8.23	7.20	6.43
Base Oil 6		9.27	8.02	7.05	6.40
Base Oil 7		8.97	7.48	6.36	5.65
Base Oil 8		8.78	7.15	6.02	
Base Oil 9		8.82	6.89	5.67	4.94
Base Oil 10		8.77	6.75	5.47	4.79
Base Oil 11		8.72	6.71	5.41	4.72
Base Oil 12		8.25	6.19	4.99	4.34
Base Oil 13		8.53	6.07	4.75	4.15
Base Oil 14		7.93	5.10	3.98	3.37
Base Oil 15		6.99	4.53	3.66	3.14
Base Oil 16		6.15	4.35	3.57	3.07

Fig. 2

Trade Name	Combustion Delay (ms)				
	Pure Isooctane	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane	91.71				
Base Oil 1		92.19	89.43	84.06	78.77
Base Oil 2		91.22	80.75	70.21	61.95
Base Oil 3		90.44	78.02	65.60	55.56
Base Oil 4		91.99	81.03	70.86	61.18
Base Oil 5		90.41	82.69	72.34	64.88
Base Oil 6		89.70	74.43	60.06	49.57
Base Oil 7		86.66	67.21	51.78	39.88
Base Oil 8		85.29	64.59	46.44	
Base Oil 9		86.25	64.36	47.88	35.30
Base Oil 10		83.24	59.66	41.35	27.37
Base Oil 11		84.41	57.93	38.66	25.25
Base Oil 12		83.40	55.80	36.73	23.35
Base Oil 13		82.73	52.86	31.69	19.20
Base Oil 14		83.74	60.72	43.58	30.25
Base Oil 15		82.89	64.05	46.08	31.63
Base Oil 16		81.40	62.83	44.35	29.87

Fig. 3

Components added to Base Oil 1	Insoluble	Soluble
2 wt% Partial ester friction modifier		x
3 wt Organic polymeric friction modifier		x
20 wt% Polymethacrylate viscosity modifier		x
1.75 wt% Mixture of multi-ring phenolic antioxidant, octylated/butylated diphenylamine antioxidant and phenolic antioxidant		x
2.9 wt% Mixture of molybdenum dithiophosphate and 2 secondary zinc dithiophosphates		x
3 wt% High molecular weight polyalphaolefin	x	
1.7 wt% Mixture of calcium salicylates detergents	x	
0.5 wt% Overbased calcium sulfonate detergent	x	
0.5 wt% Neutral calcium sulfonate detergent	x	
0.5 wt% Borated polyisobutylene succinic anhydride polyamine dispersant	x	
0.5 wt% Non-borated polyisobutylene succinic anhydride polyamine dispersant	x	
2 wt% Polymethacrylate dispersant		x
2 wt% Polypropylene glycol stearyl ether		x
0.02 wt% 1,4-Dihydroxy anthraquinone		x

Fig. 4

Component Description	Component wt%
	Example 3
Polyalkyl methacrylate copolymer viscosity modifier	9.8
Mixture of molybdenum dithiophosphate and 2 secondary zinc dithiophosphates	2.2
Corrosion inhibitor, antioxidants, and partial ester friction modifier	2.27
Polypropylene glycol stearyl ether	0.95
Polymethacrylate dispersant	0.95
Diisobutyl adipate	83.83

Fig. 5

Test Method	Description	Example 3
D3427, Time to 0.0 Percent Air, min	Gas Bubble Sep Time, 50°C	2.2
D3427 Time to 0.1 Percent Air, min	Gas Bubble Sep Time, 50°C	1.5
D3427 Time to 0.2 Percent Air, min	Gas Bubble Sep Time, 50°C	1.2
D4052 Density at 40°C, G/ML	Density of Liquid Hydrocarbons by density meter (40°C)	0.9331
D4052 Density at 150°C, G/ML	Density of Liquid Hydrocarbons by Density Meter (150°C)	0.8418
D4052 Density of Liquids, 212°F, G/ML	Density of Liquid Hydrocarbons	0.8832
D445 Kinematic Viscosity, 40°C, MM2/S	Kinematic Viscosity at 40°C	17.05
D445 Kinematic Viscosity, 100°C, MM2/S	Kinematic Viscosity at 100°C	6.494
D445 Kinematic Viscosity at 150°C, MM2/S	Kinematic Viscosity at 150°C	3.63
D4683 High temperature High Shear Viscosity, CP	HTHS Tapered Bearing Visc Test	2.124
D4951 Molybdenum, Mass%	Add. Elements in New Lube Oils	0.081
D4951 Phosphorus, Mass%	Add. Elements in New Lube Oils	0.172
D4951 Zinc, Mass%	Add. Elements in New Lube Oils	0.126
D874 Sulfated Ash, Mass%	Sulfated Ash from Lubes	0.64
D892 Foaming Tendency Seq 1, ML	Foaming Characteristics of Lube Oils	30
D892 Foaming Tendency Seq 2, ML	Foaming Characteristics of Lube Oils	30
D892 Foaming Tendency Seq 3, ML	Foaming Characteristics of Lube Oils	35
D97 Pour Point of Petroleum Oils, C	Pour Point of Petroleum Oils	-39

Fig. 6

Component Name	Component wt%
	Example 4
Polyalkyl methacrylate copolymer visocisty modifier	9.8
Mixture of molybdenum dithiophosphate and 2 secondary zinc dithiophosphates	1.2
Corrosion inhibitor, antioxidants, and partial ester friction modifier	2.27
Polypropylene glycol stearyl ether	0.95
Polymethacrylate dispersant	0.95
Diisooctyl adipate	84.83

Fig. 7

Test Method	Description	Example 4
D445 Kinematic Viscosity, 40°C, MM2/S	Kinematic Viscosity at 40°C	44.48
D445 Kinematic Viscosity, 100°C, MM2/S	Kinematic Viscosity at 100°C	12.26
D5185 Molybdenum, Mass%		0.057
D5185 Phosphorus, Mass%		0.08
D5185 Zinc, Mass%		0.065

Fig. 8

Component Name	Component wt%	Component wt%
	Example 5	Example 6
Polyalkyl methacrylate copolymer viscosity modifier	9.8	9.8
Mixture of molybdenum dithiophosphate and 2 secondary zinc dithiophosphates	2.2	2.2
Corrosion inhibitor, antioxidants, and partial ester friction modifier	2.27	2.27
Polypropylene glycol stearyl ether	0.95	0.95
Polymethacrylate Dispersant	0.95	0.95
Diisohexyl adipate	83.83	
Diisononyl adipate		83.83

Fig. 9

Component Name	Component wt%	Component wt%
	Example 7	Example 8
Polyalkyl methacrylate copolymer viscosity modifier	9.8	9.8
Mixture of molybdenum dithiophosphate and 2 secondary zinc dithiophosphates	2.2	2.2
Corrosion inhibitor, antioxidants, and partial ester friction modifier	2.27	2.27
Polypropylene glycol stearyl ether	0.95	0.95
Polymethacrylate dispersant	0.95	0.45
Polyisobutylene succinimide dispersant		0.50
Diisooctyl adipate		83.83
Diisodecyl adipate	83.83	