TABLE 74

Summary of Interactions Between 2,5-Dimethylpyrrole (DMP) and S and O Compounds in No. 2 Diesel Fuel[1]

Compound A (ppm)	Compound B (ppm)	Storage Time (days)	Type of Interaction[3]	Significance of Test[4]
DMP[2] (750)	Decanoic Acid (100)	14	None	
DMP (750)	Decanoic Acid (100)	28	None	
DMP (750)	Decanoic Acid (100)	56	None	
DMP (750)	Benzylphenyl Sulfide (3000)	14	None	
DMP (750)	Benzylphenyl Sulfide (3000)	28	None	
DMP (750)	p-Thiocresol (3000)	7	Negative	Significant($t = 60$; $p = 05$)
DMP (750)	p-Thiocresol (3000)	14	Negative	Highly Significant ($t = 13.0$; $p < .005$)
DMP (750)	p-Thiocresol (3000)	28	Negative	Highly Significant ($t = 19.1$; $p < .005$)
DMP (750)	Thiophenol (3000)	7	Negative	Highly Significant ($t = 11.1$; $p < .005$)
DMP (750)	Thiophenol (3000)	14	Negative	Highly Significant ($t = 71.0$; $p < .005$)
DMP (750)	Thiophenol (3000)	28	Negative	Highly Significant ($t = 28.3$; $p < .005$)
DMP (750)	Dodecanethiol (3000)	14	None	
DMP (750)	Dodecanethiol (3000)	28	Positive	Not Significant
DMP (750)	2,6-Di-t-Butylphenol (100)	14	None	
DMP (750)	2,6-Di-t-Butylphenol (100)	28	None	
DMP (750)	Pyrrole-2-carboxaldehyde (100)	7	None	
DMP (750)	Pyrrole-2-carboxaldehyde (100)	14		
DMP (750)	p-Toluenesulfonic Acid[5]	14	None	
DMP (750)	p-Toluenesulfonic Acid[5]	28	None	
Pyrrole (1350)	Pyrrole-2-Carboxaldehyde (100)	14	None	
Pyrrole (1350)	Pyrrole-2-Carboxaldehyde (100)	28	Negative	Not Significant
2-Methylindole (750)	n-Decanoic Acid (100)	28	None	
2-Methylindole (750)	n-Decanoic Acid (100)	56	Negative	Doubtful

[1]Storage at 43.3 °C (110° F).
[2]DMP = 2,5-dimethylpyrrole.
[3]"Positive" interaction, two compounds together give more sediment than sum of same compounds tested separately; "negative", two compounds together give less than sum of same compounds separately.
[4]Students "t" test
[5]Saturated solution

Taken from Reference No. 39

TABLE 75
Interaction Studies With DMP[1] And Aromatic Sulfur Compounds[2]

Fuel	Sulfur Compound	S	Total Sediment (mg/100 cc)[3]						
			7 Days	14 Days	28 Days	56 Days	80 Days	112 Days	128 Days
No. 2 Diesel	None	--	24.7	85.6	245.8	362.0	422.6	--	600.0
	Thiophenol	3000	13.1	14.4	70.7	160.0	166.5	191.1	
	Thiophenol	1000		22.4	55.5				
	Thiophenol	500	12.4	36.4					
	Thiophenol	100	20.5	41.6					
	p-Thiocresol	3000	12.6	20.3	62.4				
	p-Toluenesulfonic Acid	[4]	--	71.5	233.4				
JP-8 Jet	None	--	--	61.3	140.5	253.7			
	p-Thiocresol	3000	--	--	58.8	83.9			
	Thiophenol	3000	--	49.8	88.4				
	p-Toluenesulfonic Acid	[4]		59.8	168.1[5]				
Decane	None	--	--	44.1	102.0				
	p-Toluenesulfonic Acid	[4]	--	53.2[5]	125.9[5]				

[1]DMP = 2,5-Dimethylpyrrole; added as 750 ppm N.
[2]Stored at 43.3 °C (110° F).
[3]Sum of Insoluble plus adherent deposits; ave. of 3 or 4 replicates.
[4]Saturated solution (>3000 ppm S).
[5]This represents a statistically significant (Student's test) positive interaction.

Taken from Reference No. 39

TABLE 76

Effects of n-Decanoic Acid on Sediment Formation with 2,5-Dimethylpyrrole (DMP) in Various Model Fuel Systems[1]

FUEL	STORAGE TEMP (°F)	ppm R CO_2H[3]	Total Sediment[2] (mg/100cc) After 14 Days	28 Days	50 Days
No. 2 Diesel	72	---	18.6	42.6	-----
		100	16.1	46.1	-----
	110	---	88.5	245.8	380.1
		100	88.0	245.0	500.0
JP-8 Jet	72	---	7.0	-----	-----
		100	12.7	-----	-----
	110	---	61.3	140.5	253.7
		100	84.7	227.0	432.9
n-Decane[4]	72	---	18.3	38.1	-----
		100	69.2	103.9	-----
	110	---	44.1	101.5	-----
		100	92.8	225.2	375.0

[1]DMP present at 750 ppm N.
[2]Sum of insoluble and adherent sediments, adjusted for blanks.
[3]RCO_2H=n-decanoic acid; ppm on oxygen basis.
[4]Purified over silica gel and activated alumina.

Taken from Reference No. 39

TABLE 77

Effects of Hydrocarbon Types on Sediment Formation With 2,5-Dimethylpyrrole (DMP)[1]

Base Fuel	Hydrocarbon Added	Vol. % Added	Total Sediment (mg/100 ml)[2] After 14 Days	28 Days	56 Days
No. 2 Diesel	None	--	217.5	572.8	795.8
	s-Butylbenzene	15	176.1	833.3	-----
	Cyclohexane	20	152.0	888.0	-----
JP-8 Jet	None	--	108.5	313.7	586.3
	s-Butylbenzene	15	93.5	313.2	630.5
	1-Dodecene	5	112.0	311.2	685.5
	a-Methylstyrene	5	118.1	327.8	676.0

[1]DMP Level: 1500 ppm N; storage temp: 43.3 °C (110 ° F).

[2]Avg. of 2 or more replicates; "total sediments" is sum of insoluble and adherent sediments.

Taken from Reference No. 39

TABLE 78

Effects of Diolefins on Sediment Formation with DMP[1]

Base Fuel	Olefin Added	Vol % Added	Sediment (mg/100 cc)[2] After 28 Days		
			Insoluble	Adherent	Total
No. 2 Diesel	None	--	65.3	180.5	245.8
	1,7-Octadiene	2	106.2	10.4	117.0
	1,3-Octadiene	2	56.8	3.0	59.8
	2,4-Octadiene	2	153.4	5.5	158.9
	2,6-Octadiene	2	178.9	8.7	187.6
	2,5-Dimethyl-2,4-hexadiene	2	121.0	8.0	129.0
JP-8 Jet	None	--	6.6	133.9	140.5
	1,7-Octadiene	2	14.6	127.1	141.7
	1,3-Octadiene	2	33.1	98.6	131.7
	2,4-Octadiene	2	16.5	124.7	141.2
	2,5-Dimethyl-2,4-hexadiene	2	56.2	80.2	136.8
n-Decane[3]	None	--	28.3	73.7	102.0
	1,7-Octadiene	2	15.8	102.5	118.3
	1,3-Octadiene	2	11.2	91.6	102.8

[1]750 ppm DMP (N basis) in all cases; storage temperature 43.3 °C (110 °F)
[2]Avg. of 3 replicates.
[3]Dried and purified over activated silica gel and alumina.

Taken from Reference No. 39

TABLE 79

Temperature Study With 2,5-Dimethylpyrrole (DMP)

Replicate	DMP (ppm N)	Time (Days)	Fuel	Temperature °F	°C	°K	Total Sediment (mg/100 cc)[1] Repl.	Mean (X)	Std. Dev. (S)	S/X(%)	E_{ACT} (Kcal/Mole)
1		14	Diesel Blank	150			2.0	1.7	.29	16.9	
2		"					1.5				
3		"					1.5				
1	1500	14	Diesel	74	23.3	296.3	42.7	42.9	.92	2.1	
2	"	"					42.1				
3	"	"					43.9				
1	1500	14	Diesel	115	46.1	319.1	158.3	195.4	35.2	18.0	
2	"	"					199.8				
3	"	"					228.2				
1	1500	14	Diesel[2]	155	68.3	341.3	373.2	375.4	22.3	6.2	10.7
2	"	"					342.2				
1	750	14	Diesel	74	23.3	296.3	27.1	23.5	3.9	16.6	
2	"	"					26.6				
3	"	"					19.7				
4	"	"					20.5				
1	750	14	Diesel	110	43.3	316.3	59.9	85.7	32.5	38.0	10.9
2	"	"					106.3				
3	"	"					120.6				
4	"	"					56.1				
1	1500	14	Jet	74	23.3	296.3	20.8	19.7	1.06	5.4	
2	"	"					19.5				
3	"	"					18.7				
1	1500	14	Jet	115	46.1	319.1	38.4	135.4	4.88	3.6	
2	"	"					129.8				
3	"	"					138.0				
1	1500	14	Jet	155	68.3	341.3	307.0	324.0	15.9	4.9	14.4
2	"	"					338.4				
3	"	"					326.5				
1	750	14	Decane	74	23.3	296.3	17.7	18.3	0.94	5.1	8.4
2	"	"					19.0				
1	750	14	Decane	110	43.3	316.3	45.4	44.1	1.8	4.1	
2	"	"					42.8				
1	750	28	Decane	74	23.3	296.3	38.8	38.6	0.35	0.9	9.6
2	"	"					38.3				
1	750	28	Decane	110	43.3	316.3	102.0	102.0	0	0	
2	"	"					102.0				

[1]Sum of insoluble plus adherent sediments, corrected for blank; no blank correction for jet or decane.

[2]Two replicates only.

from Reference No. 39

TABLE 80

Effects of Dissolved Oxygen on Sediment Formation with DMP

Fuel	ppm DMP[2]	Storage Conditions		Total Sediment (mg / 100 cc)[1]		
		Temperature (°F)	Time (Days)	Deoxygenated[3]	Untreated	Air Saturated[4]
No. 2 Diesel[5]	750	110	14	1.1	85.6	81.7
JP-8 Jet[5]	750	110	14	43.7	61.3	64.1
Decane[7]	2000	74	15	0.5	4.5	5.5
Decane[7]	2000	74	30	1.0	8.0	9.5
Decane[7]	2000	74	60	3.5	16.5	18.0

[1] Sum of insoluble plus adherent sediments; storage in dark.
[2] N basis (wt/vol).
[3] Achieved by sparging with high purity nitrogen; contain < 1 ppm O_2.
[4] Air sparged, previously determined as about 70 ppm O_2.
[5] Six replicates.
[6] Three replicates.
[7] Two replicates

Taken from Reference No. 39

TABLE 81

Effects of Metal Surfaces on Sediment Formation with DMP[1]

Metal[2]	Fuel	Sediment (mg/100 cc) After 7 Days				Sediment (mg/100 cc) After 14 Days			
		Metal Surface	Insol	Adherent	Total	Metal Surface	Insol	Adherent	Total
None	No. 2 Diesel	–	24.1	0.6	24.7	--	57.2	28.4	85.6
None	JP-8 Jet	--	--	--	--	--	7.3	54.0	61.3
Copper	No. 2 Diesel	0.3	22.5	0.7	23.5	1.7	67.0	3.1	71.8
Steel[3]	No. 2 Diesel	0.3	20.6	0.7	21.6	--	--	--	--
Coated Steel[4]	No. 2 Diesel	--	--	--	--	0.6	51.0	1.4	53.0
Copper	JP-8 Jet	0.2	14.3	0.8	15.3	3.0	36.9	1.6	41.5
Steel[3]	JP-8 Jet	0.1	10.9	1.4	11.4	--	--	--	--
Coated Steel[4]	JP-8 Jet					4.3	33.4	1.9	39.6

[1]DMP present at 750 ppm N (wt/vol); storage at 43.3 °C (110°F) in dark; 3 replicates at 14 days; 2 replicates at 7 days.
[2]Two strips 20 mm x 50 mm added to each sample.
[3]Cold rolled steel plate.
[4]Tin plated.

Taken from Reference No. 39

TABLE 82

Effects Of Water On Sediment Formation With DMP In Various Fuels Stored At Ambient Temperature[1]

Fuel	Water Level[2] (ppm)	Total Sediment[3] (mg/100 cc) 28 Days	56 Days
No. 2 Diesel	<10	34.7	92.8
	71	47.0	–
	79	44.0	125.0
	99	81.9	220.8
	131	62.2	292.5
	169	110.6	336.0
JP-8 Jet	1	20.1	63.6
	<10	19.2	55.9
	6	18.0	62.1
	52	36.0	108
	83	20.1	64.5
Decane	4.4	28.6	61.5
	4.7	29.0	71.6
	6.7	38.5	--
	16.8	25.8	62.6

[1]DMP present at 750 ppm N levels; storage in dark at ambient temperature.
[2]As determined by Karl Fischer titration.
[3]Sum of insoluble plus adherent deposits; ave. of 3 replicates.

Taken from Reference No. 39

TABLE 83

Color Tests for Pyrroles and Indoles Stored in Jet Fuel and No. 2 Diesel at 43.3 °C (110 °F)

			ASTM D1500 Color							
			No. 2 Diesel				JP-8			
Replicate	Nitrogen Compounds	PPM Added[1]	Start	14 Days	28 Days	56 Days	Start	14 Days	28 Days	56 Days
1	None	---	0.5	0.5	0.5	0.5	0.0	0.0	0.5	0.5
2	None	---	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.5
1	DMP[2]	1500	0.5	3.5	4.0	[5]	0.0	3.0	3.5	2.5
2	DMP[2]	1500	0.5	4.0	4.0		0.0	3.0	3.5	2.5
1	DMP[2]	750	0.5	3.0	3.5		0.0	2.0	2.0	2.0
2	DMP[2]	750	0.5	3.0	3.0		0.0	2.0	2.5	2.0
1	DMP[2]	150	0.5	2.0	2.0		0.0	1.5	1.5	1.5
2	DMP[2]	150	0.5	1.5	1.5		0.0	1.0	2.0	1.5
1	2-Methylindole	1500	0.5	0.5	1.0		0.0	0.5	1.5	1.0
2	2-Methylindole	1500	0.5	0.5	1.0		0.0	0.5	1.5	1.0
1	2-Methylindole	750	0.5	0.5	1.0		0.0	0.5	1.5	0.5
2	2-Methylindole	750	0.5	0.5	1.0		0.0	0.5	1.0	1.5
1	2-Methylindole	150	0.5	0.5	0.5		0.0	0.5	1.0	1.0
2	2-Methylindole	150	0.5	0.5	0.5		0.0	0.5	1.0	2.0
1	3-Methylindole	1500	0.5	0.5	1.0		0.0	1.0	3.0	3.0
2	3-Methylindole	1500	0.5	0.5	1.0		0.0	1.0	2.5	3.0
1	3-Methylindole	750	0.5	0.5	0.5		0.0	0.5	2.0	2.5
2	3-Methylindole	750	0.5	0.5	1.0		0.0	0.5	2.0	2.0
1	3-Methylindole	150	0.5	0.5	0.5		0.0	0.5	0.5	1.5
2	3-Methylindole	150	0.5	0.5	0.5		0.0	0.5	0.5	1.0
1	Indole	1500	0.5	0.5	0.5	0.5	NT[3]			
2	Indole	1500	0.5	0.5	0.5	0.5				

[1]Nitrogen basis
[2]DMP = 2,5-dimethylpyrrole
[3]NT= Not tested in JP-8
[4]Too dark to measure
[5]Colors with DMP are generally too dark to measure by 56 days

Ta' om Reference No. 39

TABLE 83

Color Tests for Pyrroles and Indoles Stored in Jet Fuel and No. 2 Diesel at 43.3 °C (110 °F) --continued

Replicate	Nitrogen Compounds	PPM Added[1]	ASTM D1500 Color							
			No. 2 Diesel				JP-8			
			Start	14 Days	28 Days	56 Days	Start	14 Days	28 Days	56 Days
1	Pyrrole	1500	0.5	0.5	0.5	0.5	NT[3]			
2	Pyrrole	1500	0.5	0.5	0.5	0.5				
1	1,2,5-trimethylpyrrole	1500	0.5	2.0	---	---	NT[3]			
2	1,2,5-trimethylpyrrole	1500	0.5	2.0	---	---				
1	1,2,5-trimethylpyrrole	150	0.5	2.0	---	---	NT[3]			
2	1,2,5-trimethylpyrrole	150	0.5	2.0	---	---				
1	1,2,5-trimethylpyrrole	1500	0.5	2.5	2.5	---	NT[3]			
2	1,2,5-trimethylpyrrole	1500	0.5	2.5	2.5	---				
1	1-methylpyrrole	1500	0.5	0.5	0.5	0.5	NT[3]			
2	1-methylpyrrole	1500	0.5	0.5	0.5	0.5				
1	1-phenylpyrrole	1500	0.5	0.5	0.5	0.5	NT[3]			
2	1-phenylpyrrole	1500	0.5	0.5	0.5	0.5				
1	2,4-dimethyl-3-ethylpyrrole	1500	0.5	[4]	[4]	[4]				
2	2,4-dimethyl-3-ethylpyrrole	1500	0.5	[4]	[4]	[4]				

[1]Nitrogen basis
[2]DMP = 2,5-dimethylpyrrole
[3]NT= Not tested in JP-8
[4]Too dark to measure
[5]Colors with DMP are generally too dark to measure by 56 days

Taken from Reference No. 39

TABLE 84

Studies with 2,5-Dimethylpyrrole (DMP) in No. 2 Diesel Fuel at Various Times and Temperatures

Level Added (ppm)[1]	Storage Temp (°F)	Storage Time (Days)	Averaged Sediment Values (mg/100 cc)			
			No. of Replicates	Insol.	Adherent	Total
750	110	7	8	24.1	0.6	24.7
1500	110	14	5	51.6	141.2	192.8
750			15	57.2	28.4	85.6
150			--	18.1	5.8	23.9
1500	110	28	7	115.1	254.9	370.0
750			6	65.3	180.5	245.8
150			12	31.9	9.0	40.9
1500	110	56	4	559.6	236.1	795.8
750			4	205.7	156.3	362.0
150			7	24.1	50.4	74.5
750	110	80	4	359.4	63.2	422.6
150			4	82.4	7.1	89.5
1500	74	14	3	35.9	7.0	42.9
750			2	26.1	0.8	26.9
1500	155	14	2	215.0	160.4	375.4

[1]Nitrogen basis

Taken from Reference No. 39

TABLE 85

Insoluble, Adherent And Total Sediments From Fuels Containing Pyrroles And Indoles After Storage at 43.3 °C (110 °F)

Nitrogen Compounds	Level (ppm)[1]	Sediment (mg/100cc)[2] 14 Days Insol	14 Days Adherent	14 Days Total	28 Days Insol	28 Days Adherent	28 Days Total	56 Days Insol	56 Days Adherent	56 Days Total
				Normal Decane[3]						
2,5-Dimethylpyrrole	750	35.0	9.1	44.1	28.3	73.7	102.0	---	---	---
				JP-8						
2,5-Dimethylpyrrole	1500	19.6	88.9	108.5	11.1	302.6	313.7	138.1	448.2	586.3
	750	7.3	54.0	61.3	6.6	133.9	140.5	5.4	248.3	253.7
	150	0	0.8	0.8	.5	17.8	18.3	3.6	37.6	41.2
2-Methylindole	1500	TRACE	TRACE	TRACE	1.9	12.7	14.6	0.5	25.4	25.9
	750	0.4	0	0.4	3.6	7.8	11.4	2.5	12.4	14.9
	150	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE	0.5	0.5
3-Methylindole	1500	1.0	3.0	4.0	0.9	.10	1.0	0.3	TRACE	0.3
	750	1.1	TRACE	1.1	0.8	.10	0.9	0.2	0.7	0.9
	150	0	0	0	.09	.10	1.0	0.5	0.1	0.6
				No. 2 Diesel						
2,5-Dimethylpyrrole	1500	51.6	141.2	192.8	115.1	254.9	370.0	559.6	236.1	795.8
	750	57.2	28.4	85.6	65.3	180.5	245.8	205.7	156.3	362.0
	150	18.1	5.8	23.9	31.9	9.0	40.9	24.1	50.4	74.5
2-Methylindole	1500	TRACE	TRACE	TRACE	1.1	11.9	13.0	1.0	25.4	26.4
	750	0	0.4	0.4	2.8	7.0	9.8	2.5	12.5	15.0
	150	4.5	15.5	20.0	5.0	TRACE	5.0	0.2	3.0	3.2
3-Methylindole	1500	0.7	0	0.7	0.1	0.5	0.5	0.5	4.0	4.5
	750	0.2	0	0.2	0.1	0.1	0.2	0.9	0.8	1.7
	150	0	0	0	0.1	0.1	0.2	0.4	0.7	1.1

[1] Nitrogen basis; ppm = mg/100 cc.
[2] Average of 2-10 replicates, diesels corrected for blank, blank corrections: 14-day 0; 28 day 0.5; 56-day 0.5.
[3] Purified over silica gel and activated alumina.

Taken from Reference No. 39

TABLE 85

Insoluble, Adherent And Total Sediments From Fuels Containing Pyrroles And Indoles After Storage at 43.3 °C (110 °F) -- continued

Nitrogen Compounds	Level (ppm)[1]	Sediment (mg/100cc)[2] 14 Days Insol	14 Days Adherent	14 Days Total	28 Days Insol	28 Days Adherent	28 Days Total	56 Days Insol	56 Days Adherent	56 Days Total
				No. 2 Diesel						
Pyrrole	1500	0	0.7	0.7	3.0	TRACE	3.0	0.5	TRACE	0.5
Indole	1500	0	TRACE	TRACE	0.4	1.0	1.4	TRACE	1.0	1.0
1-Methylpyrrole	1500	0	0	0	0	0	0	0	0	0
1-Phenylpyrrole	1500	0	0	0	0	0	0	0	0	0
2,4-Dimethyl-3-ethylpyrrole	1500	14.5	5.3	19.8	10.3	16.0	26.3	---	---	---
1,2,5-trimethylpyrrole	1500	67.8	19.8	82.6	---	---	---	474.0	352.0	826.0
	750				92.3	24.8	117.1			
	150	10.2	5.8	16.0	24.0	4.4	28.4	9.1	25.1	34.6

[1] Nitrogen basis: ppm = mg/100 cc.
[2] Average of 2-10 replicates, diesels corrected for blank, blank corrections: 14-day 0; 28 day 0.5; 56-day 0.5.
[3] Purified over silica gel and activated alumina.

Taken from Reference No. 39

TABLE 96
ASTM Color Test Results for Various Nitrogen Compounds Stored in No. 2 Diesel Fuel at 43.3 °C (110 °F)

Replicate	Nitrogen Compound[1]	ASTM D1500 Color			
		Start	14 Days	28 Days	56 Days
1	None	0.5	0.5	0.5	0.5
2	None	0.5	0.5	0.5	0.5
1	Benzimidazole[2]	---	---	---	---
2	Benzimidazole[2]	---	---	---	---
1	7-Azaindole	0.5	0.5	0.5	1.5
2	7-Azaindole	0.5	0.5	0.5	1.5
1	3-Methylpyrazole	0.5	0.5	0.5	0.5
2	3-Methylpyrazole	0.5	0.5	0.5	1.0
1	2-Methylpiperazine	0.5	0.5	0.5	0.5
2	2-Methylpiperazine	0.5	0.5	1.0	0.5
1	3-Methylpyridazine	0.5	1.0	1.0	1.0
2	3-Methylpyridazine	0.5	1.0	1.0	1.0
1	2-Methylpyrazine	0.5	0.5	0.5	0.5
2	2-Methylpyrazine	0.5	0.5	0.5	0.5
1	Quinaldine[3]	0.5	0.5	1.0	2.5
2	Quinaldine[3]	0.5	0.5	1.0	2.0
1	m-Tolylnitrile	0.5	0.5	0.5	0.5
2	m-Tolylnitrile	0.5	0.5	0.5	0.5
1	n-Undecylcyanide	0.5	0.5	0.5	0.5
2	n-Undecylcyanide	0.5	0.5	0.5	0.5
1	2-Methylbenzoxazole	0.5	0.5	1.0	0.5
2	2-Methylbenzoxazole	0.5	0.5	1.0	0.5
1	2-Methylbenzothiazole	0.5	0.5	1.0	0.5
2	2-Methylbenzothiazole	0.5	1.0	1.0	0.5

[1]All added at 1500 ppm N.
[2]Insoluble in No. 2 diesel.
[3]Quinaldine = 2-methylquinoline.

Taken from Reference No. 39

TABLE 87

Insoluble, Adherent and Total Sediments[1] for Various Nitrogen Compounds Stored in No. 2 Diesel at 43.3 °C (110 ° F)

Nitrogen Compound[2]	28 Days			56 Days			112 Days		
	Insol.	Adherent	Total	Insol.	Adherent	Total	Insol.	Adherent	Total
3-Methylpyrazole[3]	0	0	0	0	0.7	0.7	0	1.0	1.0
4-Methylpyrazole[3]	0	0	0	0	0	0	0	0.2	0.2
3,5-Dimethylpyrazole[4]	0	0	0	TRACE	TRACE	TRACE	4.8	120.5	125.3
Pyrazine	0	0	0	0	0	0	0	0	0
2-Methylpyrazine[3]	0	1.4	1.4	0	1.1	1.1	---	---	---
2,3-Dimethylpyrazine	0	0	0	TRACE	TRACE	TRACE	0	0.7	0.7
2,5-Dimethylpyrazine	0	0	0	TRACE	TRACE	TRACE	0	2.0	2.0
2,6-Dimethylpyrazine	0	0	0	0	0	0	0	0.6	0.6
2-Methylpiperazine	0.2	4.3	4.5	1.9	5.0	6.9	---	---	---
1-Methylpiperazine	0	0	0	TRACE	TRACE	TRACE	2.1	3.0	5.1
N,N-Dimethylpiperazine	0	0	0	0	0	0	0.4	0.8	1.2
2,5-Dimethylpiperazine	0	0	0	0	TRACE	TRACE	0.3	17.6	17.9
2,6-Dimethylpiperazine	0	0	0	0	TRACE	TRACE	0.2	24.1	24.3
2-Methylpiperidine	0	0	0	0	0	0	2.8	10.4	13.2
3-Methylpiperidine	0	0	0	0	0	0	6.2	9.5	15.7
2,6-Dimethylpiperidine	0	0	0	0	0	0	1.0	2.8	3.8
3,5-Dimethylpiperidine	0	0	0	0	0	0	0	2.1	2.1
Pyrrolidine	0	0	0	0	0	0	0	0	0
1-Methylpyrrolidine	0	0	0	0	TRACE	TRACE	2.9	20.9	23.8
2,5-Dimethylpyrrolidine	0	0	0	0	TRACE	TRACE	1.0	10.5	11.5
Quinoline	0	0	0	0	0	0	0	0	0
Isoquinoline	0	0	0	0	0	0	0	0	0
3-Methylquinoline[3]	0.3	1.5	1.8	0	4.7	4.7	---	---	---
1,2-Dihydro-2,2,4-trimethylquinoline	---	---	---	14.5	2.1	16.6	---	---	---
7-Azaindole[4]	0.3	0.7	1.0	0	8.7	8.7	---	---	---
2-Methylbenzoxazole	0	0	0	0	0	0	0	TRACE	TRACE
2-Methylbenzothiazole	0	0	0	0	0	0	0	TRACE	TRACE
3-Methylpyridazine	0	4.2	4.2	0	4.0	4.0	---	---	---
n-Undecylcyanide	0	0	0	0	TRACE	TRACE	0	TRACE	TRACE
Triethylamine	0	0	0	0	0	0	0	0	0
m-Tolylnitrile	0	0	0	0	0	0	0	TRACE	TRACE

[1]Sediments average of 3 replicates unless otherwise noted.
[2]Compounds added at 1500 ppm N level (wt/vol).
[3]Average of 2 replicates.
[4]Average of 6 replicates.

Tal[illegible]m Reference No. 39

TABLE 88

Effect of Metal Deactivator on Action of Copper on Stability of Jet Fuel[1]

Condition	Metal Deactivator[2] mg./100 ml.	260 °C (500 °F). Steam Jet Gum.mg./100 ml.									Soluble Cu[3], ppm, after 7 Months
		1 Month			3 Months			7 Months			
		Sol.	Insol.	Total	Sol.	Insol.	Total	Sol.	Insol.	Total	
No metal present	0	1.4	1.7	3.1	9.9	1.9	11.8	6.9	8.1	15.0	0.0
	5	2.6	2.2	4.8	7.1	3.6	10.7	7.8	7.3	15.1	---
Steel strip											
0.007% Cu	0	1.3	2.3	3.6	3.9	4.0	7.9	12.4	10.5	22.9	---
	5	1.9	2.6	4.5	2.0	3.1	5.1	7.8	6.6	14.4	---
0.043% Cu	0	---	---	---	---	---	---	10.1	7.9	18.0	---
	5	---	---	---	---	---	---	6.9	8.2	15.1	---
0.092% Cu	0	4.3	2.6	6.9	9.9	5.1	15.0	18.3	12.2	30.5	0.3
	5	2.2	1.8	4.0	6.4	3.4	9.8	8.1	7.8	15.9	--
Copper wire											
0.1[4]	0	28.9	6.3	35.2	31.0	14.4	45.4	46.1	27.1	76.2	0.6
	5	2.2	1.6	3.8	57.5	13.1	70.6	71.0	29.0	100.0	2.3
1.0[5]	0	20.0	6.4	26.4	43.6	12.1	55.7	45.9	30.2	76.1	0.3
	5	3.4	3.7	7.1	102.5	34.2	136.7	88.5	29.2	117.7	2.4
Soluble copper, 10 ppm, (as copper naphthenate)	0	87.8	20.5	108.3	118.7	20.4	139.1	111.8	26.6	138.4	1.9
	5	27.6	10.3	37.9	108.4	33.8	142.2	71.6	28.3	99.9	2.6

[1] Aging conditions: 43.3 °C (110 °F)., 1 atm. air, F/A = 0.5. Composite JP - 4 fuel, 1.0 mg. gum/100 ml.
[2] N,N-Disalicylidene-1,2-propanediamine.
[3] Determined on filtered sample.
[4] Equivalent to storage in drum having 10% copper surface.
[5] Equivalent to storage in drum having 100% copper surface.

Taken from Reference No. 79

TABLE 89

Effect of Concentration of Metal Deactivator in Composite JP-4 Blend Containing Varying Amounts of Soluble Copper[1]

Metal Deactivator[2] Concn., mg./100 ml.	Soluble Copper[3] Concn., ppm	Stoichiometric Ratio Deactivator-Copper	500 ° F., Steam Jet Gum, mg./100 ml.						
			Original	2 Months			9 Months		
			Total	Sol.	Insol.	Total	Sol.	Insol.	Total
0.0	0	--	4.3	4.1	1.6	5.7	8.8	5.9	14.7
0.443	0	--	3.8	3.9	2.0	5.9	4.2	4.4	8.6
4.43	0	--	3.6	3.5	1.1	4.6	3.7	4.7	8.4
8.9	0	--	4.1	3.5	1.4	4.9	3.5	4.5	8.0
0.0	1	0.0	--	23.8	7.9	31.7	24.4	10.2	34.6
0.443	1	1.0	--	12.8	5.6	18.6	10.0	8.2	18.2
0.66	1	1.5	4.0	5.2	1.8	7.0	8.8	8.9	17.7
0.89	1	2.0	4.6	4.9	1.7	6.6	10.3	7.2	17.5
0.0	10	0.0	7.9	38.6	9.8	43.4	32.4	12.6	45.0
4.43	10	1.0	--	32.6	8.4	41.0	26.1	17.1	43.2
6.6	10	1.5	4.9	6.2	2.6	8.8	13.3	9.6	22.9
8.9	10	2.0	5.5	6.2	1.9	8.1	19.8	11.3	31.1

[1] Aging conditions: 43.3 °C (110 °F)., 1 atm. air,F/A = 0.5
[2] N,N'-disalicylidene-1,2-propanediamine
[3] Added as copper naphthenate.

Taken from Reference No. 79

TABLE 90

Effect of Dispersants on Rate of Gum Formation in Composite Jet Fuel Blends[1]

Fuel	Additive[2], 10 mg./100 ml.	500 ° F Steam Jet Gum, mg./dl. 1 Week Sol.	1 Week Insol.	1 Week Total	4 Weeks Sol.	4 Weeks Insol.	4 Weeks Total	7 Weeks Sol.	7 Weeks Insol.	7 Weeks Total
Composite JP-3 type blend, 10.5 mg. gum	None	15.9	10.6	26.5	19.6	11.2	30.8			
		14.4	11.8	26.2	26.1	13.0	39.1			
	a	39.6	16.1	55.7	34.6	15.2	49.8			
	b	51.5	7.2	58.7	33.0	10.5	43.5			
	c	18.7	11.0	29.7	31.9	15.0	46.9			
	d	15.4	8.5	23.9	30.1	13.4	43.5		No data	
	e	30.8	7.2	38.0	23.0	14.2	37.2			
	f	23.0	7.8	30.8	38.9	11.6	50.5			
	g	19.1	5.1	24.2	23.6	9.6	33.2			
	h	46.5	11.2	57.7	26.6	11.5	38.1			
	i	30.3	10.7	41.0	26.2	15.4	41.6			
Composite JP-4 type blend, 1.0 mg. gum	None	9.4	6.3	15.7	11.2	20.7	31.9	26.6	19.7	46.3
	j	7.7	5.0	12.7	20.4	11.9	32.3	25.0	11.3	36.3
	k	7.8	3.1	10.9	21.2	10.3	31.5	24.8	17.2	42.0
	l	5.8	4.0	9.8	18.6	9.5	28.1	25.5	13.3	38.8
	m	9.2	1.8	11.0	15.1	13.0	28.1	22.7	12.3	35.0
	None	--	--	--	--	--	--	25.5	12.8	38.3
	n	--	--	--	--	--	--	27.5	14.2	41.7
	o	--	--	--	--	--	--	44.3	22.1	66.4
Composite JP-4 type blend, 2.0 mg.gum	None	--	--	5.4	7.2	2.8	10.0	4.8	7.7	12.5
		--	--	5.9	4.5	3.0	7.5	7.9	7.0	14.9
	m[3]	21.9	2.6	24.5	23.3	3.6	26.9	24.0	4.7	27.8
	p[4]	29.5	2.5	32.0	36.0	2.6	38.6	33.2	5.2	38.4

[1] Aging conditions: 70 ° C., 1 atm. air, F/A = 0.5
[2] Experimental and commercially available dispersants, not further identified.
[3] Initial gum = 19.4 mg./100 ml.
[4] Initial gum = 35.2 mg./100 ml.

Taken from Reference No. 79

TABLE 91
Summary of Thermal Stability Breakpoints of JP-7 Jet Fuel Stored in Presence of Fuel System Materials

Specimen	Breakpoint (°F) after 130 °F (54.4 °C) storage for periods indicated			
	Fresh	16 weeks	35 weeks	1 year
None (cold storage)	625	—	—	—
None (cold storage)	>675	—	—	—
None	—	625	650	650
None	>675	650	650	>675
None, wet	—	>675	625	550
Steel	>675	625	600	675
Rusted steel	>675	675	500	550
Rusted steel, wet	>675	>675	600	600
Stainless steel	>675	675	650	575
Aluminum (6061)	>675	675	625	600
Aluminum (5052)	>675	675	675	600
Brass	>675	575	≤375	525
Brass, wet	625	≤475	—	525
Bronze	>675	≤475	—	550
Hose liner, Buna N rubber[1]	625	≤375	—	≤350
Hose liner, Buna N rubber[1]	650	≤400	—	400
Coupling gaskets	>675	450	—	≤350
Coating, furan type	>675	650	625	675
Coating, epoxy type	>675	675	625	600
Plug valve grease	>675	>675	600	675
Filter-separator element	650	625	600	625

[1] From different manufacturers

Taken from Reference No. 57