

TABLE 51
Existent Gum Values¹
for Diesel Fuels Stored in
100 BBL Tanks at Ambient Conditions

Storage Interval, months	mg/100 ml.			
	Fuel A ²	Fuel B ²	Fuel C ²	Fuel D ²
1	2.3	8.3	5.9	14.3
2	1.4	9.5	10.4	14.9
3	7.5	5.9	12.1	21.9
4	6.1	12.7	11.9	22.1
5	2.5	5.5	11.0	18.3
6	3.3 (3.2)	12.7 (6.6)	13.0 (5.4)	21.5 (14.6)
7	4.3	14.6	14.8	21.0
8	3.9	15.7	17.1	20.4
9	4.4	11.7	19.5	27.7
10	3.6	17.3	16.3	25.7
11	3.9	25.7	20.0	33.1
12	4.6 (8.4)	15.2 (26.0)	20.7 (6.2)	35.5 (13.4)
15	3.8	12.7	21.5	33.0
18	3.9 (1.8)	7.7 (10.0)	18.6 (5.0)	25.5 (14.2)
21	6.1	13.4	21.2	26.8
24	7.7 (5.6)	13.9 (9.0)	24.0 (8.6)	27.3 (15.0)

¹Values shown were averages of top, middle and bottom samples. Those values shown in parenthesis are the laboratory control sample results.

²Diesel fuels meeting Fed. Spec. VV-F-800a.

Taken from Reference No. 70

TABLE 52
Accelerated Stability Values¹ For Four Specification Diesel Fuels

Storage Interval, months	mg/100 ml			
	Fuel A ²	Fuel B ²	Fuel C ²	Fuel D ²
1	0	0.1	0.1	0.7
2	0	0.1	0.1	0.5
3	0.2	0.1	0.1	0.6
4	0.3	0.3	0.3	0.7
5	0.3	0.1	0	3.0
6	0.1(0)	0.1(0)	0.2(0)	0.6(0.6)
7	0	0	0.1	0.7
8	0.1	0.2	0.5	0.2
9	0.1	0	0.2	0.6
10	0	0.1	0.4	0.6
11	0.2	0.2	0.3	0.6
12	1.3(0.3)	0.1(0.1)	0.4(0.1)	1.1(1.1)
15	0.2	0.2	0.8	1.2
18	0.3(0.3)	0.3(0.1)	1.0(0.2)	1.4(1.8)
21	0.2	0.1	1.5	2.4
24	0.1(0)	0.1(0.1)	0.4(0.2)	0.9(0.8)

¹Values shown were averages of top, middle, and bottom samples from 100-bbl steel tanks.

Those values shown in parenthesis are the laboratory control sample results.

²Diesel fuels meeting Federal Specification VV-F-800a.

Taken from Reference No. 7D

TABLE 53

43.3 °C (110 °F) Storage Test on Ten No. 2 Diesel Fuels¹, (gum, mg/100ml)

Initial			4th Week			8th Week			16th Week			32nd Week		
Soluble	Insol	Precip.	Soluble	Insol	Precip.	Soluble	Insol	Precip.	Soluble	Insol	Precip.	Soluble	Insol	Precip.
4.2	0	0	A-5.2 ²	1.2	0.1	A-6.9	0.2	0.6	A-7.2	1.7	0.3	A-9.8	1.8	0.1
			B-5.7			B-6.7			B-7.2			B-10.0		
3.4	0	0	A-3.4	1.5	1.0	A-1.6	0.7	0.3	A-3.2	0.8	0.1	A-3.0	0.5	0.2
			B-2.5			B-2.2			B-3.4			B-3.1		
2.2	0	0	A-2.5	0.5	0	A-2.1	0.7	0.7	A-3.8	0.8	0.2	A-6.6	1.2	0.4
			B-2.3			B-2.3			B-3.8			B-7.6		
3.4	0	0	A-3.1	0.5	0.1	A-11.1	1.7	0.6	A-33.1	3.4	0.6	A-54.7	4.1	0.6
			B-3.3			B-11.6			B-31.3			B-49.1		
8.1	0	0	A-11.2	0.4	0.2	A-12.2	0.3	0.3	A-13.4	0.1	0.6	A-15.6	0.5	0.4
			B-11.1			B-11.5			B-13.0			B-17.7		
5.2	0	0	A-4.9	0.8	0.1	A-5.3	0.7	0.4	A-8.1	1.1	0.7	A-8.9	1.3	0.4
			B-5.0			B-5.9			B-7.6			B-9.8		
4.7	0	0	A-7.1	0.3	0.3	A-6.5	0.5	0.8	A-9.9	0.6	0.8	A-13.4	1.1	0.8
			B-6.5			B-6.5			B-8.9			B-12.9		
3.5	0	0	A-2.1	0.7	0.1	A-4.2	0.7	0.3	A-4.2	0.3	0.8	A-6.0	1.3	0.2
			B-2.2			B-4.4			B-4.7			B-5.9		
3.1	0	0	A-4.6	0.8	0.1	A-7.0	0.8	0	A-10.5	1.3	0.1	A-12.8	2.3	2.1
			B-4.4			B-7.1			B-11.1			B-13.8		
6.5	0	0	A-9.8	1.2	0.5	A-13.8	1.3	0.3	A-19.0	2.5	0.4	A-22.0	3.7	0.5
			B-9.7			B-13.6			B-19.3			B-23.9		

¹ Diesel fuels, petroleum, from 10 military bases across United States² A, B - two independent determinations of soluble gum.

Taken from Reference No. 10

TABLE 54

Data for Test Fuels After Zero Weeks Storage at 43.3 °C (110 °F)

Test Fuel No.	1 ¹	2 ²	3 ²	4 ²	5 ³	6 ³	7 ⁴	8 ⁵
Average Filterable Insolubles, mg / 100 ml	0.2	0.1	0.2	0.3	0.1	0.4	< 0.1	0.2
Average Steam Jet Gum, D 381, mg / 100 ml	90.2	10.0	2.0	10.1	⁶	62.5	0.4	6.8
Color, D 1500	5.0	1.5	0.5	3.5	2.5	5.5	5	3.0

¹ Light cycle oil² Blended No. 2 heating oil without additives³ Specially blended experimental heating oil⁴ Straight run North Slope Diesel⁵ Finished product No. 2 Diesel⁶ No data available

Taken from Reference No. 111

TABLE 55

Data for Test Fuels After Four Weeks Storage at 43.3 °C (110 °F)

Test Fuel No.	1 ¹	2 ²	3 ²	4 ²	5 ³	6 ³	7 ⁴	8 ⁵
Average Filterable Insolubles, mg / 100 ml	1.8	0.1	0.2	1.2	1.0	1.0	0.1	0.2
Average Adherent Insolubles, mg / 100 ml	0.8	0.3	0.4	0.3	0.9	0.9	0.4	0.3
Total Insolubles, mg / 100 ml	2.6	0.4	0.6	1.5	1.9	1.9	0.5	0.5
Average Steam Jet Gum, D 381, mg / 100 ml	60.4	3.6	3.5	6.1	7.9	53.6	0.9	6.7
Total Gum, mg / 100 ml	63.0	4.0	4.1	7.6	9.8	55.5	1.4	7.2

¹ Light cycle oil² Blended No. 2 heating oil without additives³ Specially blended experimental heating oil⁴ Straight run North Slope Diesel⁵ Finished product No. 2 Diesel

Taken from Reference No. 111

Data for Test Fuels After Eight Weeks Storage at 43.3 °C (110 °F)

Test Fuel No.	1 ¹	2 ²	3 ²	4 ²	5 ³	6 ³	7 ⁴	8 ⁵
Average Filterable Insolubles, mg / 100 ml	2.1	0.2	0.1	1.1	0.4	2.4	0.1	0.2
Average Adherent Insolubles, mg / 100 ml	3.4	0.3	0.1	0.6	1.4	3.9	0.1	0.1
Total Insolubles, mg / 100 ml	5.5	0.5	0.2	1.7	1.8	6.3	0.2	0.3
Average Steam Jet Gum, D 381, mg / 100 ml	87.8	11.2	8.4	12.0	10.7	101.1	3.1	7.1
Total Gum, mg / 100 ml	93.3	11.7	8.6	13.7	12.5	107.4	3.3	7.4

¹Light cycle oil

²Blended No. 2 heating oil without additives

³Specially blended experimental heating oil

⁴Straight run North Slope Diesel

⁵Finished product No. 2 Diesel

Taken from Reference No. 111

TABLE 57

Data for Test Fuels After Twelve Weeks Storage at 43.3 °C (110 °F)

Test Fuel No.	1 ¹	2 ²	3 ²	4 ²	5 ³	6 ³	7 ⁴	8 ⁵
Average Filterable Insolubles, mg / 100 ml	1.8	0.3	0.3	1.3	0.4	2.1	0.1	0.2
Average Adherent Insolubles, mg / 100 ml	4.5	0.7	0.5	0.8	2.1	7.0	0.1	0.6
Total Insolubles, mg / 100 ml	6.3	1.0	—	2.1	2.5	9.1	—	—
Average Steam Jet Gum, D 381, mg / 100 ml	77.4	11.5	3.1	9.4	15.8	100.8	1.4	10.8
Total Gum, mg / 100 ml	83.7	12.5	—	11.5	18.3	109.9	—	—

¹Light cycle oil

²Blended No. 2 heating oil without additives

³Specially blended experimental heating oil

⁴Straight run North Slope Diesel

⁵Finished product No. 2 Diesel

⁶No data available

Taken from Reference No. 111

TABLE 58

Data for Test Fuels After Eighteen Weeks Storage at 43.3 °C (110 °F)

Test Fuel No.	1 ¹	2 ²	3 ²	4 ²	5 ³	6 ³	7 ⁴	8 ⁵
Average Filterable Insolubles, mg / 100 ml	1.5	0.2	0.7	1.6	0.4	1.5	0.8	0.7
Average Adherent Insolubles, mg / 100 ml	7.0	1.4	0.4	1.5	3.2	9.4	0.1	0.1
Total Insolubles, mg / 100 ml	8.5	1.6	1.1	3.1	3.6	10.9	0.9	0.8
Average Steam Jet Gum, D 381, mg / 100 ml	99.8	33.7	5.5	15.1	20.5	118.2	3.5	12.2
Total Gum, mg / 100 ml	106.3	35.3	6.6	18.2	24.1	129.1	4.4	13.0

¹Light cycle oil²Blended No. 2 heating oil without additives³Specialty blended experimental heating oil⁴Straight run North Slope Diesel⁵Finished product No. 2 Diesel

Taken from Reference No. 111

TABLE 59

Data for Test Fuels After Twenty-Four Weeks Storage at 43.3 °C (110 °F)

Test Fuel No.	1 ¹	2 ²	3 ²	4 ²	5 ³	6 ³	7 ⁴	8 ⁵
Average Filterable Insolubles, mg / 100 ml	0.7	0.3	1.2	1.4	0.2	0.4	0.1	0.3
Average Adherent Insolubles, mg / 100 ml	7.9	2.2	0.4	1.6	4.1	11.2	0.4	0.4
Total Insolubles, mg / 100 ml	8.6	2.5	1.6	3.0	4.3	11.6	0.5	0.7
Average Steam Jet Gum, D 381, mg / 100 ml	108.1	16.7	11.3	16.9	21.4	176.4	3.3	11.2
Total Gum, mg / 100 ml	116.7	19.2	12.9	19.9	25.7	188.0	3.8	11.9

¹Light cycle oil²Blended No. 2 heating oil without additives³Specialty blended experimental heating oil⁴Straight run North Slope Diesel⁵Finished product No. 2 Diesel

Taken from Reference No. 111

TABLE 60

Data for Test Fuels Aged at 150 °C (302 °F)

Test Fuel No.	1 ¹	2 ²	3 ²	4 ²	5 ³	6 ³	7 ⁴	8 ⁵								
	1.5 hr. 3.0 hr.	1.5 hr. 3.0 hr.	1.5 hr. 3.0 hr.	1.5 hr. 3.0 hr.	1.5 hr. 3.0 hr.	1.5 hr. 3.0 hr.	1.5 hr. 3.0 hr.	1.5 hr. 3.0 hr.								
Filterable Insolubles, D 2276 (mod) Glass Fiber mg / 100 ml	10.06	11.40	0.51	2.54	3.12	3.38	1.12	4.68	8.5	7.7	13.64	13.46	0.68	3.98	1.74	3.96
Adherent Insolubles, D 381, mg / 100 ml	1.2	1.6	0.5	1.1	0.3	1.2	0.7	1.1	1.6	1.7	1.0	1.1	0.6	0.9	0.4	0.8
Total Insolubles, mg / 100 ml	11.3	13.0	1.0	3.6	3.4	3.5	1.8	5.7	10.1	9.4	14.6	14.5	1.3	4.9	2.1	4.8
Steam Jet Gum, D 381, mg / 100 ml	117.4	138.8	13.9	25.2	8.0	4.7	12.5	14.3	15.1	16.8	168.8	204.7	3.3	4.5	9.5	11.7
Total Gum, mg / 100 ml	128.7	151.8	14.9	28.8	11.4	8.2	14.3	20.0	25.2	26.2	181.4	219.2	4.6	9.4	11.6	16.5

¹Light cycle oil²Blended No. 2 heating oil without additives³Specialty blended experimental heating oil

Taken from Reference No. 111

⁴Straight run North Slope Diesel⁵Finished product No. 2 Diesel

TABLE 61

Data for Test Fuels Aged at 80 °C (176 °F)

Test Fuel No.	1 ¹			2 ²			3 ²			4 ²		
	3 Days	7 Days	14 Days	3 Days	7 Days	14 Days	3 Days	7 Days	14 Days	3 Days	7 Days	14 Days
Filterable Insolubles mg / 100 ml	0.6	2.0	3.4	<0.1	0.1	0.3	<0.1	0.6	1.0	0.2	0.6	1.2
Adherent Insolubles, D 381 mg / 100 ml	0.3	0.7	1.3	0.2	0.5	0.3	0.2	0.8	0.6	0.2	0.4	0.6
Total Insolubles, mg / 100 ml	0.9	2.7	4.7	0.3	0.6	0.6	0.3	1.4	1.6	0.4	1.0	1.8
Steam Jet Gum, D 381, mg / 100 ml	35.3	95.9	116.0	6.2	6.1	12.1	4.3	3.5	17.4	6.3	7.4	17.3
Total Gum, mg / 100 ml	36.2	98.6	120.7	6.4	6.7	12.7	4.5	4.9	19.0	6.7	8.4	19.1
	5 ³			6 ³			7 ⁴			8 ⁵		
	3 Days	7 Days	14 Days	3 Days	7 Days	14 Days	3 Days	7 Days	14 Days	3 Days	7 Days	14 Days
Filterable Insolubles mg / 100 ml	0.5	0.5	3.8	2.8	6.1	12.2	<0.1	0.1	0.9	0.5	0.1	1.5
Adherent Insolubles, D 381 mg / 100 ml	0.6	1.7	2.5	0.6	2.5	2.2	0.2	<0.1	0.7	0.1	<0.1	0.2
Total Insolubles, mg / 100 ml	1.1	2.2	6.3	3.4	8.6	14.4	0.3	0.1	1.6	0.6	0.1	1.7
Steam Jet Gum, D 381, mg / 100 ml	15.6	24.6	20.0	117.1	182.4	233.8	1.7	1.5	12.7	9.3	8.0	14.1
Total Gum, mg / 100 ml	16.7	26.8	26.3	120.5	191.0	248.2	1.9	1.6	14.3	9.9	8.1	15.8

¹Light cycle oil²Blended No. 2 heating oil without additives³Specialty blended experimental heating oil

Taken from Reference No. 111

TABLE 62
ASTM Method D 2274 Test Data for Test Fuels

Test Fuel No.	1 ¹	2 ²	3 ²	4 ²	5 ³	6 ³	7 ⁴	8 ⁵
Filterable Insolubles, mg / 100 ml	2.8	0.2	0.7	0.3	1.9	10.1	0.1	0.4
Adherent Insolubles, mg / 100 ml	0.8	0.3	0.3	0.4	0.9	2.3	0.1	0.1
Total Insolubles, mg / 100 ml	3.6	0.5	1.0	0.7	2.8	12.4	0.2	0.5
Steam Jet Gum, D 381, mg / 100 ml	6	6	16.6	139.9	16.3	271.8	5.3	5.7
Total Gum, mg / 100 ml	---	---	17.6	140.6	19.1	294.2	5.5	6.2

¹Light cycle oil
²Blended No. 2 heating oil without additives
³Specialty blended experimental heating oil
⁴Straight run North Slope Diesel
⁵Finished product No. 2 Diesel
⁶Steam jet gum not obtained; sample accidentally destroyed

Taken from Reference No. 111

TABLE 63

Data for Test Fuels After Four, Eight, and Twelve Weeks Storage in Erlenmeyer Flask at 43.3 °C (110 °F)

Test Fuel No.	2 ¹		4 ¹		7 ²		8 ³	
	Vented	Nonvented	Vented	Nonvented	Vented	Nonvented	Vented	Nonvented
Filterable Insolubles, mg / 100 ml (4/8 Weeks) (12 Weeks)	0.4/0.1 0.2	0.2/0.1 0.1	1.0/1.7 2.3	0.9/1.9 2.4	<0.1/< 0.1 <0.1	<0.1/0.1 <0.1	<0.1/0.2 0.3	0.1/0.4 0.3
Adherent Insolubles, mg / 100 ml (4/8 Weeks) (12 Weeks)	0.2/0.6 1.1	0.1/1.7 1.6	0.4/1.0 1.3	0.3/0.8 1.3	<0.1/< 0.1 <0.1	<0.1/< 0.1 <0.1	0.1/0.4 0.1	0.1/0.1 0.1
Total Insolubles mg / 100 ml (4/8 Weeks) (12 Weeks)	0.6/0.7 1.3	0.3/1.8 1.7	0.5/2.7 3.6	1.2/2.7 3.7	0.2/0.2 0.2	0.2/0.2 0.2	0.2/0.6 0.4	0.2/0.5 0.4
Steam Jet Gum, D 381 mg / 100 ml (4/8 Weeks) (12 Weeks)	16.1/23.2 26.7	6.0/27.1 18.4	14.2/15.7 15.5	13.0/29.2 12.8	8.5/4.3 9.3	5.1/7.0 3.4	12.9/8.6 17.5	3.7/15.9 14.7
Total Gum, mg / 100 ml (4/8 Weeks) (12 Weeks)	16.7/23.9 28.0	6.3/28.9 20.1	14.7/18.4 19.1	14.2/31.9 16.5	8.7/4.5 9.5	6.3/7.2 3.6	13.1/9.2 17.9	3.9/16.4 15.1

¹Blended No. 2 heating oil without additives²Straight run North Slope Diesel³Finished product No. 2 Diesel

Taken from Reference No. 111

Data for Test Fuels After Four, Eight, and Twelve Weeks Storage in Wheaton Bottles at 43.3 °C (110 °F)

Test Fuel No.	2 ¹			4 ¹			7 ²			8 ³		
	Vented	Nonvented		Vented	Nonvented		Vented	Nonvented		Vented	Nonvented	
Filterable Insolubles, mg / 100 ml (4/8 Weeks) (12 Weeks)	0.1/0.2 0.3	0.2/0.2 0.2		1.2/1.1 1.3	0.7/1.3 1.6		0.1/0.1 0.1	<0.1/< 0.1 <0.1		0.2/0.2 0.2	0.2/0.3 0.2	
Adherent Insolubles, mg / 100 ml (4/8 Weeks) (12 Weeks)	0.3/0.3 0.7	0.1/0.4 0.8		0.3/0.6 0.8	0.2/0.3 0.8		0.4/0.1 4	<0.1/0.1 <0.1		0.3/0.1 4	0.1/< 0.1 0.1	
Total Insolubles mg / 100 ml (4/8 Weeks) (12 Weeks)	0.4/0.5 1.0	0.3/0.6 1.0		1.5/1.7 2.1	0.9/1.6 2.4		0.5/0.2 ---	0.2/0.2 0.2		0.5/0.3 ---	0.3/0.4 0.3	
Steam Jet Gum, D 381 mg / 100 ml (4/8 Weeks) (12 Weeks)	3.6/11.2 11.5	4.5/8.4 30.1		6.1/12.0 9.4	7.8/12.1 26.0		0.9/3.1 1.4	7.1/14.1 8.0		6.7/7.1 10.8	14.6/25.0 19.5	
Total Gum, mg / 100 ml (4/8 Weeks) (12 Weeks)	4.0/11.7 12.5	4.8/9.0 31.1		7.6/13.7 11.5	8.7/13.7 20.4		1.4/3.3 ---	7.3/14.3 8.2		7.2/7.5 ---	14.9/25.4 19.6	

¹Blended No. 2 heating oil without additives

²Straight run North Slope Diesel

³Finished product No. 2 Diesel

⁴No data available; sample accidentally destroyed

Taken from Reference No. 111

Data for Test Fuels After Four, Eight, and Twelve Weeks Storage in Culture Bottles at 43.3 °C (110 °F)

Blended No. 2 heating oil without additives

2Straight run North Slope Diesel

Finished product No. 2 Diesel

Taken from Reference No. 111

TABLE 66
Deposit from Diesel Fuel Spiked with
Nitrogen Compounds¹

Spiking compound	Deposit ² (g/mm ²) x 10 ⁷
Control (no spike)	8.0 ± 0.2
Pyrrole	19.6 ± 3.6
N-Methylpyrrole	34.9 ± 0.3
2-Pyrrolidone	20.7 ± 3.5
1,2,5-Trimethylpyrrole	15.1 ± 3.5
Indole	19.6 ± 0.2
N-Methylindole	21.3 ± 3.2
2-Methylindole	22.9 ± 3.8
3-Methylindole	17.3 ± 3.1
Indoline	19.1 ± 0.8
N-Ethylcarbazole	23.5 ± 1.2
Pyridine	21.9 ± 2.3
2-Acetylpyridine	21.0 ± 4.6
2-Methylpyridine	13.6 ± 0.8
4-Methylpyridine	17.0 ± 0.6
2-Ethylpyridine	11.8 ± 0.9
2,6-Dimethylpyridine	18.7 ± 4.8
2,4,6-Trimethylpyridine	18.1 ± 2.1
Quinoline	15.8 ± 1.2
2,4-Dimethylquinoline	21.5 ± 0.9
7,8-Benzoquinoline	15.1 ± 1.0
8-Hydroxyquinoline	17.2 ± 0.1

¹ Aged at 121 °C (249.8 °F).

² Gum deposited on microscope cover slip.

Taken from Reference No. 143

TABLE 67

Sediment Formation with Various Pyrroles and
Indoles after Storage at 43.3 °C (110 °F) in Various Test Fuels¹

Nitrogen Compound	Level	Total Sediment (mg / 100 cc) ²					
	Added (ppm N) ³	7 Days	14 Days	28 Days	56 Days	80 Days	112 Days
Normal Decane							
2,5-Dimethylpyrrole (DMP)	750	--	44.1	102.0	--	--	--
Jet Fuel							
DMP	1500	--	108.5	313.7	586.3	--	--
	750	--	61.3	140.5	260.8	327.9	--
	150	--	0.8	18.3	41.2	--	--
1,2,5-Trimethylpyrrole (TMP)	750	--	33.3	103.9	219.0	--	--
	150	--	7.7	13.5	21.6	--	--
2-Methylindole	1500	--	TRACE	14.6	25.9	--	--
	750	--	0.4	11.4	14.9	--	--
	150	--	0	TRACE	0.5	--	--
3-Methylindole	1500	--	4.0	1.0	0.3	--	--
	750	--	1.1	0.9	0.9	--	--
	150	--	0.1	1.0	0.5	--	--
No. 2 Diesel							
DMP	1500	--	192.8	397.0	795.8	--	--
	750	24.7	85.6	245.8	362.0	422.6	--
	150	--	23.9	40.9	74.5	89.5	--
TMP	1500	--	82.6	--	--	--	--
	750	--	--	117.1	--	--	--
	150	--	16.0	28.4	66.9	--	--
2,4-Dimethyl-3-ethylpyrrole	1500	--	19.8	26.3	--	--	--
Pyrrole	1500	--	0.7	3.0	1.0	--	--
1-Phenylpyrrole	1500	--	--	0	0	--	--
1-Methylpyrrole	1500	--	0	0	0.7	--	4
2-Methylindole	1500	--	TRACE	13.0	26.4	--	--
	750	--	0.4	9.8	15.0	--	--
	150	--	2.0	5.0	3.2	--	--
3-Methylindole	1500	--	0.7	0.5	4.5	--	--
	750	--	0.2	0.2	1.7	--	--
	150	--	0	0.1	1.1	--	--
Indole	1500	--	TRACE	1.4	1.0	--	--
1,2-Dimethylindole	1500	--	0	0	0	--	2.9
2,3-Dimethylindole	1500	--	0	TRACE	6.4	--	22.0
2,5-Dimethylindole	1500	--	0	TRACE	3.2	--	8.6
Carbazole	1500	--	0	0	0	--	--

¹ Dark storage; average of 2-10 replicates.

² Sum of insoluble and adherent sediments corrected for blanks (diesel only); blank correction: 14-day 0, 28-day 0.5; 56-day 0.5 mg / 100 cc.

³ Based on Nitrogen, i.e. 150 ppm means 150 ppm Nitrogen not 150 ppm pyrrole; wt/volume basis, i.e. 150 ppm mg N/100 cc diluent.

⁴ Yields about 9 mg / 100 cc on 120 days' storage.

TABLE 68
Effects of Various Alkylated Nitrogen Heterocycles on
Sediment Formation in No. 2 Diesel Fuel¹

Nitrogen Compound ³	Total Sediment (mg/100 cc) After ²		
	28 Days	56 Days	112 Days
Pyrazole			
3-Methyl ⁴	Trace	1.0	1.0
4-Methyl	0	0	0.2
3,5-Dimethyl ⁴	0	Trace	80.9
Pyrazine			
2-Methyl ⁵	0	1.0	—
2,3-Dimethyl	0	Trace	0.7
2,5-Dimethyl	0	Trace	2.0
2,6-Dimethyl	0	Trace	0.6
Pyrrolidine			
N-Methyl ⁵	0	0	30.0
2,5-Dimethyl	0	Trace	11.5
Piperazine			
N-Methyl	0	0	5.1
N,N-Dimethyl	0	0	1.2
2-Methyl	4.0	7.0	—
2,5-Dimethyl	0	Trace	17.9
2,6-Dimethyl	0	Trace	24.3
Quinoline	0	0	0
Quinaldine			
2-Methyl (Quinaldine)	1.8	4.0	5.0
2,6-Dimethyl	0	Trace	5.7
1,2-Dihydro-2,2,4-trimethyl	Trace	16.6	—
Piperidine			
2-Methyl	Trace	Trace	13.2
3-Methyl	Trace	Trace	15.7
2,5-Dimethyl	0	0	2.1
2,6-Dimethyl	0	0	3.8
Misc. Heterocycles			
7-Azaindole	0.3	8.7	—
2-Methylbenzoxazole	0	Trace	Trace
2-Methylbenzothiazole	0	Trace	Trace
3-Methylpyridazine	4.2	4.0	—
Non-Heterocyclic N Compounds			
n-Undecylcyanide	0	0	Trace
Trloctylamine	0	0	0
m-Tolynitrile	0	0	Trace

¹Storage at 43.3 °C (110 ° F) in dark

²Sum of Insoluble plus adherent sediment; corrected for blank; average of 3 replicates unless otherwise noted.

³Added at 1500 ppm N level (wt/vol).

⁴5 replicates.

⁵5 replicates.

taken from Reference No. 39

TABLE 69
Accelerated Storage Tests of Fuels With Added Sulfur Compounds¹

Sulfur Compound ²	Total Sediment ³ (mg/100 ml) in Fuel					
	No. 2 Diesel			JP-8 Jet Fuel		
	28 Day	56 Day	160 Day	28 Day	56 Day	160 Day
Benzylphenyl Sulfide	0	0	0	0	0	0
Benzyl Disulfide	0	0	0	0	0	0
t-Butyl Sulfide	-	-	-	0	0	0
Dodecanethiol	0	0	0	-	-	-
Thlanaphthene	0	0	0	-	-	-
p-Thiocresol	0	0	20.7	-	-	-
p-Toluenesulfonic Acid	15.5	1609.6	-	20.0	-	-

¹Storage at 43.3 °C (110°F).

²Present at 3000 ppm S level (wt/vol).

³Sum of insoluble and adherent deposits; average of 3 replicates.

Taken from Reference No. 39

TABLE 70

Nitrogen-Nitrogen Interaction Studies with Pyrroles During 43.3 °C (110°F) Storage in No. 2 Diesel And JP-8 Jet Fuels

Nitrogen Compound	Level Added (ppm N) ¹	Fuel	Total Sediment (mg/100 ml) ²			
			14 Days	28 Days	56 Days	73 Days
2,5-Dimethylpyrrole (DMP)	150	No. 2 Diesel	23.9	46.9	74.5	97.1 ³
2,5-Dimethylpyrrole (DMP)	750		85.6	245.8	362.0	410.0 ³
2,5-Dimethylpyrrole (DMP)	150	JP-8	--	18.3	--	53.7 ³
2,5-Dimethylpyrrole (DMP)	750		--	140.5	--	330.7 ³
1,2,5-Trimethylpyrrole (TMP)	150	Diesel	16.0	28.4	34.6	--
1,2,5-Trimethylpyrrole (TMP)	750		--	117.1	--	--
1,2,5-Trimethylpyrrole (TMP)	150	JP-8	--	13.5	--	--
Pyrrole	1500	Diesel	--	3.0	5.0 ⁴	6.0 ⁴
1-Methylpyrrole	1500	Diesel	--	0	0.7	--
DMP	150	Diesel	64.9	98.1	164.3	--
Plus TMP	150		--	--	--	--
DMP	150	JP-8	--	56.3	--	--
Plus TMP	150		--	--	--	--
DMP	150	Diesel	--	21.8	57.2	71.2
Plus Pyrrole ⁵	1350		--	--	--	--
DMP	150	Diesel	--	31.3	--	--
Plus 1-Methylpyrrole	1350		--	--	--	--

¹WT/vol basis

²Sum of insoluble plus adherent; corrected for solvent blanks; average of 3 replicates unless otherwise noted.

³Extrapolated.

⁴Estimated.

⁵Six replicates.

Taken from Reference No. 39

TABLE 71
Interactions Involving Pyrroles, Indoles And Other Nitrogen Compounds In 43.3 ° C (110 ° F) Storage

Nitrogen Compound ¹	Level Added (ppm N) ²	Fuel	Total Sediment (mg/100 ml) ³				
			14 Days	28 Days	56 Days	73 Days	
2-Methylindole	1500	No. 2 Diesel	—	13.0	26.4	19.5 ³	
	750		0.4	9.8	15.0	27.0 ³	
3-Methylindole	750	JP-8	—	11.4	—	—	
	1500	Diesel	—	0.5	4.5	—	
	750		—	0.2	1.7	—	
Tricetylamine	1500	Diesel	0	0	0	0	
		JP-8	—	0	0	0	
Tripropylamine	1500	Diesel	0	0	0	0	
		JP-8	—	0	0	0	
Isaquinoline	1500	Diesel	0	0	0	0	
		JP-8	—	0	0	0	
DMP	150	Diesel	—	15.0 ⁴	27.3 ⁴	—	
Plus 2-Methylindole	1350						
DMP	750	Diesel	91.7	103.3	—	83.3	
Plus 2-Methylindole	750						
DMP	750	JP-8	—	139.7	—	441.0	
Plus 2-Methylindole	750						
2-Methylindole	750	Diesel	—	0.2 ⁵	0.3 ⁵	—	
Plus 3-Methylindole	750						
DMP	150	Diesel	—	48.2 ⁴	94.0 ⁴	—	
Plus 3-Methylindole	1350						
DMP	150	Diesel	—	54.9 ⁴	127.5 ⁴	—	
Plus Isoquinoline	1350						
DMP	150	JP-8	—	32.9	—	94.3	
Plus Isoquinoline	1350						
DMP	150	Diesel	—	49.8 ⁴	115.8 ⁴	—	
Plus Triethylamine	1350						
DMP	150	JP-8	—	17.5	—	—	
Plus Triethylamine	1350						
DMP	150	Diesel	—	38.9	—	97.4	
Plus Tripropylamine	1350						
DMP	150	JP-8	—	17.8	—	62.7	
Plus Tripropylamine	1350						
TMP	150	Diesel	—	35.5 ⁴	—	67.8	
Plus Isoquinoline	1350						

¹See Tables 67 or 70 for sediment from DMP and TMP tested alone. Levels are on N basis [wt%/vol].

²Average of 3 replicates unless otherwise noted; total sediment is sum of insoluble plus adherent.

³Extrapolated.

⁴Six replicates.

⁵Two replicates.

Taken from Reference No. 39

TABLE 72
Summary of N-N Interaction Studies¹

Fuel	Compound A	Compound B	Time (Days)	Type ²	Significance ³
No. 2 Diesel	DMP	TMP	14	Pos.	Highly significant
			28	Pos.	Significant
			56	Pos.	Highly significant
Diesel	DMP	1-Methylpyrrole	28	Neg.	Significant
Diesel	DMP	Pyrrole	28	Neg.	Highly significant
			56	Neg.	Significant
			17	Neg.	Highly significant
Diesel	DMP ⁴	2-Methylindole ⁴	28	Neg.	Highly significant
Diesel	DMP ⁵	2-Methylindole ⁵	56	Neg.	Significant
			14	None	—
			28	Neg.	Significant
Diesel	DMP	3-Methylindole	73	Neg.	Highly significant
			28	Pos.	Doubtful
			50	Pos.	Significant
Diesel	DMP	Triethylamine	28	Pos.	Doubtful
			56	Pos.	Significant
			28	None	—
Diesel	DMP	Tripropylamine	73	None	—
			28	Pos.	Doubtful
			73	Pos.	Highly significant
Diesel	TMP	Isoquinoline	28	Pos.	Highly significant
			73	Pos.	Highly significant
			28	Neg.	Highly significant
Diesel	2-Methylindole	3-Methylindole	56	Neg.	Highly significant
			28	Pos.	Highly significant
			73	Pos.	Highly significant
JP-8	DMP	TMP	28	Pos.	—
JP-8	DMP	2-Methylindole	28	None	Doubtful
			73	Pos.	—
			28	None	—
JP-8	DMP	Tripropylamine	73	Pos.	Doubtful
			28	Pos.	Highly significant
			73	Pos.	Highly significant
JP-8	DMP	Isoquinoline	28	Pos.	—
			73	Pos.	—
			28	None	—

¹Three or more replicates; 43.3 °C (110 °F) storage; DMP = 2,5-dimethylpyrrole, TMP = 1,2,5-trimethylpyrrole

²Pos = "positive" interaction, two compounds together give more sediment than sum of same compounds tested separately; neg = "negative", two compounds together give less than sum of same compounds separately

³Students' "t" test

⁴DMP at 150 ppm N; 2-methylindole at 1350 ppm N.

⁵Both at 750 ppm N.

en from Reference No. 39

TABLE 73

Interactions Between Nitrogen Compounds And Various Sulfur And Oxygen Compounds
In No. 2 Diesel Fuel¹

Nitrogen Compound (ppm N)	Sulfur or Oxygen Compound (ppm S or O)	Total Sediment (mg/100 cc) ³			
		7 Days	14 Days	28 Days	56 Days
DMP ² (750)	--	24.7	85.6	245.8	362.0
--	n-Decanoic Acid (100)	0	0	0	0
DMP (750)	Pyrrole-2-carboxaldehyde (100)	9.2			
Pyrrole (1500)	--	--	0.7	3.0	Trace
Pyrrole (1350)	Pyrrole-2-carboxaldehyde (100)	--	Trace	Trace	15.0
2-Methylindole (750)	--	--	0.4	9.8	Trace
2-Methylindole (750)	--	--	--	3.0	Trace
--	n-Decanoic Acid (100)	0	0	0	0
DMP (750)	2,6-Di- <i>t</i> -butylphenol (100)	--	107.7	293.5	--
DMP (750)	2,6-Di- <i>t</i> -butylphenol (100)	--	90.2	256.0	376.5
--	n-Decanoic Acid (100)	0	0	0	160.0
DMP (750)	Thiophenol (3000)	13.1	14.4	70.7	
--	Thiophenol (3000)	0	0	0	
DMP (750)	p-Thiocresol (3000)	12.6	20.3	62.4	
--	p-Thiocresol (3000)	0	0	0	
DMP (750)	Pyrrole-2-carboxaldehyde (100)	0	0	0	0
--	Benzylphenyl Sulfide (3000)	0	0	0	--
DMP (750)	Benzylphenyl Sulfide (3000)	--	95.6	216.1	0
--	n-Dodecanethiol (3000)	0	0	0	--
DMP (750)	n-Dodecanethiol (3000)	--	71.6	373.2	--
--	p-Toluenesulfonic Acid ⁴	0	0	15.5	--
DMP (750)	p-Toluenesulfonic Acid ⁴	--	71.5	233.4	--

¹Storage at 43.3 °C (110 °F).²DMP = 2,5-Dimethylpyrrole³Sum of insoluble plus adherent sediment; average of 3 replicates.⁴Solubility problems; saturated solution was employed.

Taken from Reference No. 39