Appendix A: Information in Support of Volume 1

Table 1 List of Sponsored Substances in the Six Petroleum HPV Categories Using Predictive Toxicity Modeling

- Aromatic Extracts
- Crude Oil
- Gas Oils
- Heavy Fuel Oils
- Lubricating Oil Basestocks
- Waxes and Related Products

Table A1.1 Nomenclature used throughout this document.

Figure 1 Number of Paraffin Isomers and Approximate Boiling Range of Categories - adapted from "Petroleum Chemistry and Refining" J. G. Speight (Editor) Taylor & Francis, 1998.

Figure 2 Relationship of Boiling Range to Petroleum Substance Composition - adapted from "Petroleum Chemistry and Refining" J. G. Speight (Editor) Taylor & Francis, 1998.

Examples from "Characteristics of Spilled Oils, Fuels, and Petroleum Products: 1. Composition and Properties of Selected Oils", EPA/600/R-03/072, July 2003

Figure 10.2 PAH Distribution for West Texas Intermediate Crude Oil
Table 10.18 PAH Distribution for West Texas Intermediate Crude Oil

Figure 11.1 PAH Distribution for Fuel Oil No 2 (Diesel)
Table 11.18 PAH Distribution for Fuel Oil No 2 (Diesel)

Figure 13.2 PAH Distribution of HFO 6303 (Bunker C)
Table 13.18 PAH Distribution of HFO 6303 (Bunker C)

Figure III: 2-6 Refinery Process Chart – from OSHA Instruction TED 1.15 CH-1, Office of Science and Technology Assessment, May 24, 1996.

Table III: 2-3 Overview of Petroleum Refining Processes – from OSHA Instruction TED 1.15 CH-1, Office of Science and Technology Assessment, May 24, 1996.

Table 1

Category	**Aromatic Extracts**
CasNumber	64742036
Substance	Extracts (petroleum), light naphthenic distillate solvent
Definition	A complex combination of hydrocarbons obtained as the extract from a solvent extraction process. It consists predominantly of aromatic hydrocarbons having carbon numbers predominantly in the range of C15 through C30. This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Aromatic Extracts**
CasNumber	64742047
Substance	Extracts (petroleum), heavy paraffinic distillate solvent
Definition	A complex combination of hydrocarbons obtained as the extract from a solvent extraction process. It consists predominantly of aromatic hydrocarbons having carbon numbers predominantly in the range of C20 through C50. This stream is likely to contain 5 wt. % or more of 4- to 6 membered condensed ring aromatic hydrocarbons
Category	**Aromatic Extracts**
CasNumber	64742058
Substance	Extracts (petroleum), light paraffinic distillate solvent
Definition	A complex combination of hydrocarbons obtained as the extract from a solvent extraction process. It consists predominantly of aromatic hydrocarbons having carbon numbers predominantly in the range of C15 through C30. This stream is likely to contain 5 wt. % or more of 4- to 6 membered condensed ring aromatic hydrocarbons.
Category	**Aromatic Extracts**
CasNumber	64742105
Substance	Extracts (petroleum), residual oil solvent
Definition	A complex combination of hydrocarbons obtained as the extract from a solvent extraction process. It consists predominantly of aromatic hydrocarbons having carbon numbers predominantly higher than C25.
Category	**Aromatic Extracts**
CasNumber	64742116
Substance	Extracts (petroleum), heavy naphthenic distillate solvent
Definition	A complex combination of hydrocarbons obtained as the extract from a solvent extraction process. It consists predominantly of aromatic hydrocarbons having carbon numbers predominantly in the range of C20 through C50. This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.

Category	**Crude Oil**
CasNumber	8002059
Substance	Petroleum
Definition	A complex combination of hydrocarbons. It consists predominantly of aliphatic, alicyclic and aromatic hydrocarbons. It may also contain small amounts of nitrogen, oxygen and sulfur compounds. This category encompasses light, medium, and heavy petroleums, as well as the oils extracted from tar sands. Hydrocarbonaceous materials requiring major chemical changes for their recovery or conversion to petroleum refinery feedstocks such as crude shale oils, upgrade shale oils and liquid coal fuels are not included in this definition.
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741431
Substance	Gas oils (petroleum), straight-run
Definition	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741442
Substance	Distillates (petroleum), straight-run middle
Definition	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C20 and boiling in the range of 205°C to 345°C (401°F to 653°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741497
Substance	Condensates (petroleum), vacuum tower
Definition	A complex combination of hydrocarbons produced as the lowest boiling stream in the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741588
Substance	Gas oils (petroleum), light vacuum
Definition	A complex combination of hydrocarbons produced by the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C13 through C30 and boiling in the range of approximately 230°C to 450°C (446°F to 842°F).

Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741599
Substance	Distillates (petroleum), light catalytic cracked
Definition	A complex combination of hydrocarbons produced by the distillation of products from a catalytic cracking process. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C25 and boiling in the range of approximately 150°C to 400°C (302°F to 752°F). It contains a relatively large proportion of bicyclic aromatic hydrocarbons.
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741602
Substance	Distillates (petroleum), intermediate catalytic cracked
Definition	A complex combination of hydrocarbons produced by the distillation of products from a catalytic cracking process. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C 30 and boiling in the range of approximately 205°C to 450°C (401°F to 842°F). It contains a relatively large proportion of tricyclic aromatic hydrocarbons.
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741771
Substance	Distillates (petroleum), light hydrocracked
Definition	A complex combination of hydrocarbons from distillation of the products from a hydrocracking process. It consists predominantly of saturated hydrocarbons having carbon numbers predominantly in the range of C1O through C18, and boiling in the range of approximately 160°C to 320°C (320°F to 608°F)
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741828
Substance	Distillates (petroleum), light thermal cracked
Definition	A complex combination of hydrocarbons from the distillation of the products from a thermal cracking process. It consists predominantly of unsaturated hydrocarbons having carbon numbers predominantly in the range of C10 through C22 and boiling in the range of approximately 160°C to 370°C (320°F to 698°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741862
Substance	Distillates (petroleum), sweetened middle
Definition	A complex combination of hydrocarbons obtained by subjecting a petroleum distillate to a sweetening process to convert mercaptans or to remove acidic impurities. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 150°C to 345°C (302°F to 653°F).

Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741908
Substance	Gas oils (petroleum), solvent-refined
Definition	A complex combination of hydrocarbons obtained as the raffinate from a solvent extraction process. It consists predominantly of aliphatic hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64741919
Substance	Distillates (petroleum), solvent-refined middle
Definition	A complex combination of hydrocarbons obtained as the raffinate from a solvent extraction process. It consists predominantly of aliphatic hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 150°C to 345°C (302°F to 653°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64742296
Substance	Gas oils (petroleum), chemically neutralized
Definition	A complex combination of hydrocarbons produced by a treating process to remove acidic materials. It consists of hydrocarbons having carbon numbers predominantly in the range of C13 through C25 and boiling in the range of approximately 230°C to 400 °C (446°F to 752°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64742309
Substance	Distillates (petroleum), chemically-neutralized middle
Definition	A complex combination of hydrocarbons produced by a treating process to remove acidic materials. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C20 and boiling in the range of approximately 205°C to 345°C (401°F to 653°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64742387
Substance	Distillates (petroleum), clay-treated middle
Definition	A complex combination of hydrocarbons resulting from treatment of a petroleum fraction with natural or modified clay, usually in a percolation process to remove the trace amounts of polar compounds and impurities present. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 150°C to 345°C (302°F to 653°F).

Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64742467
Substance	Distillates (petroleum), hydrotreated middle
Definition	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64742729
Substance	Distillates, petroleum, catalytic dewaxed, middle
Definition	
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64742796
Substance	Gas oils (petroleum), hydrodesulfurized
Definition	A complex combination of hydrocarbons obtained from a petroleum stock by treating with hydrogen to convert organic sulfur to hydrogen sulfide which is removed. It consists predominantly of hydrocarbons having carbon numbers predominately in the range of C13 through C25 and boiling in the range of approximately 230°C to 400°C (446°F to 752°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64742809
Substance	Distillates (petroleum), hydrodesulfurized middle
Definition	A complex combination of hydrocarbons obtained from a petroleum stock by treating with hydrogen to convert organic sulfur to hydrogen sulfide which is removed. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C25 and boiling in the range of approximately 205°C to 400°C (401°F to 752°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	64742876
Substance	Gas oils (petroleum), hydrodesulfurized light vacuum
Definition	A complex combination of hydrocarbons obtained from a catalytic hydrodesulfurization process. It consists of hydrocarbons having carbon numbers predominantly in the range of C13 through C30 and boiling in the range of approximately 230°C to 450°C (446°F to 842°F).

Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68333255
Substance	Distillates (petroleum), hydrodesulfurized light catalytic cracked
Definition	A complex combination of hydrorcarbons obtained by treating light catalytic cracked distillates with hydrogen to convert organic sulfur to hydrogen sulfide which is removed. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C25 and boiling in the range of approximately 150°C to 400°C (302°F to 752°F). It contains a relatively large proportion of bicyclic aromatic hydrocarbons.
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68333880
Substance	Aromatic Hydrocarbons, C9-17
Definition	NONE
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68334305
Substance	Fuels, diesel
Definition	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C20 and boiling in the range of approximately 163° to 357°C (325°F to 675°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68476302
Substance	Fuel oil, no. 2
Definition	A distillate oil having a minimum viscosity of 32.6 SUS at 37.7°C (100°F) to a maximum of 37.9 SUS at 37.7°C (100°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68476313
Substance	Fuel oil, no. 4
Definition	A distillate oil having minimum viscosity of 45 SUS at 37.7 °C (100°F) to a maximum of 125 SUS at 37.7°C (100°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68476346
Substance	Fuels, diesel, no. 2
Definition	A distillate oil having a minimum viscosity of 32.6 SUS at 37.7°C (100°F) to a maximum of 40.1 SUS at 37.7°C (100°F).

Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68477316
Substance	Distillates (petroleum), catalytic reformer fractionator residue, low-boiling
Definition	The complex combination of hydrocarbons from the distillation of catalytic reformer fractionator residue. It boils approximately below 288°C (550°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68814879
Substance	Distillates (petroleum), full-range straight-run middle
Definition	A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C9 through C25 and boiling in the range of approximately 150°C to 400°C (320°F to 752°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68915968
Substance	Distillates (petroleum), heavy straight-run
Definition	A complex combination of hydrocarbons produced by the atmospheric distillation of crude oil. It boils in the range of approximately 288°C to 471°C (550°F to 880°F).
Category	**Gas Oils (Diesel Fuels/Heating Oils)**
CasNumber	68915979
Substance	Gas oils (petroleum), straight-run, high-boiling
Definition	A complex combination of hydrocarbons produced by the atmospheric distillation of crude oil. It boils in the range of approximately 282°C to 349°C (540°F to 660°F).
Category	**Heavy Fuel Oils**
CasNumber	64741453
Substance	Residues (petroleum), atm. tower
Definition	A complex residuum from the atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly greater than C20 and boiling above approximately 350 °C (662°F). This stream is likely to contain 5 wt % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	64741577
Substance	Gas oils (petroleum), heavy vacuum
Definition	A complex combination of hydrocarbons produced by the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and boiling in the range of approximately 350°C to 600°C (662°F to 1112°F). This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.

Category	**Heavy Fuel Oils**
CasNumber	64741613
Substance	Distillates (petroleum), heavy catalytic cracked
Definition	A complex combination of hydrocarbons produced by the distillation of products from a catalytic cracking process. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C35 and boiling in the range of approximately 260 °C to 500°C (500°F to 932°F). This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	64741624
Substance	Clarified oils (petroleum), catalytic cracked
Definition	A complex combination of hydrocarbons produced as the residual fraction from distillation of the products from a catalytic cracking process. It consists of hydrocarbons having carbon numbers predominantly greater than C20 and boiling above approximately 350°C (662°F). This stream is likely to contain 5 wt % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	64741679
Substance	Residues (petroleum), catalytic reformer fractionator
Definition	A complex combination of hydrocarbons produced as the residual fraction from distillation of the product from a catalytic reforming process. It consists of predominantly aromatic hydrocarbons having carbon numbers predominantly in the range of C10 through C25 and boiling in the range of approximately 160 °C to 400°C (320°F to 725°F). This stream is likely to contain 5 wt. % or more of 4- or 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	64741759
Substance	Residues (petroleum), hydrocracked
Definition	A complex combination of hydrocarbons produced as the residual fraction from distillation of the products of a hydrocracking process. It consists of hydrocarbons having carbon numbers predominantly greater than C20 and boiling above approximately 350°C (662°F).
Category	**Heavy Fuel Oils**
CasNumber	64741806
Substance	Residues (petroleum), thermal cracked
Definition	A complex combination of hydrocarbons produced as the residual fraction from distillation of the product from a thermal cracking process. It consists predominantly of unsaturated hydrocarbons having carbon numbers predominantly greater than C20 and boiling above approximately 350°C (662°F). This stream is likely to contain 5 wt % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.

Category	**Heavy Fuel Oils**
CasNumber	64741817
Substance	Distillates (petroleum), heavy thermal cracked
Definition	A complex combination of hydrocarbons from the distillation of the products from a thermal cracking process. It consists predominantly of unsaturated hydrocarbons having carbon numbers predominantly in the range of C15 through C36 and boiling in the range of approximately 260°C to 480°C (500°F to 896°F). This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	64742592
Substance	Gas oils (petroleum), hydrotreated vacuum
Definition	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C13 through C50 and boiling in the range of approximately 230°C to 600°C (446°F to 1112°F). This stream is likely to contain 5 wt % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	64742785
Substance	Residues (petroleum), hydrodesulfurized atmospheric tower
Definition	A complex combination of hydrocarbons obtained by treating an atmospheric tower residuum with hydrogen in the presence of a catalyst under conditions primarily to remove organic sulfur compounds. It consists of hydrocarbons having carbon numbers predominantly greater than C20 and boiling above approximately 350°C (662°F). This stream is likely to contain 5 wt % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	64742865
Substance	Gas oils (petroleum), hydrodesulfurized heavy vacuum
Definition	A complex combination of hydrocarbons obtained from a catalytic hydrodesulfurization process. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and boiling in the range of approximately 350°C to 600°C (662°F to 1112°F). This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	68187586
Substance	Pitch, petroleum, arom.
Definition	The residue from the distillation of thermal cracked or steam-cracked residuum and/or catalytic cracked clarified oil with a softening point from 40.degree.C to 180.degree.C (104.degree.F to 356.degree.F). Composed primarily of a complex combination of three or more membered condensed ring aromatic hydrocarbons.

Category	**Heavy Fuel Oils**
CasNumber	68333222
Substance	Residues (petroleum), atmospheric
Definition	A complex residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly greater than C11 and boiling above approximately 200°C (392°F). This stream is likely to contain 5 wt.% or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	68333266
Substance	Clarified oils (petroleum), hydrodesulfurized catalytic cracked
Definition	A complex combination of hydrocarbons obtained by treating catalytic cracked clarified oil with hydrogen to convert organic sulfur to hydrogen sulfide which is removed. It consists of hydrocarbons having carbon numbers predominantly greater than C20 and boiling above approximately 350°C (662°F). This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	68333277
Substance	Distillates (petroleum), hydrodesulfurized intermediate catalytic cracked
Definition	A complex combination of hydrocarbons obtained by treating intermediate catalytic cracked distillates with hydrogen to convert organic sulfur to hydrogen sulfide which is removed. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C30 and boiling in the range of approximately 205°C to 450°C (401°F to 842°F). It contains a relatively large proportion of tricyclic aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	68410004
Substance	Distillates (petroleum), crude oil
Definition	A complex combination of hydrocarbons produced by distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C50 and boiling in the range of approximately 205°C to greater than 495°C (401°F to above 923°F).
Category	**Heavy Fuel Oils**
CasNumber	68476324
Substance	Fuel oil, residues-straight-run gas oils, high-sulfur
Definition	NONE

Category	**Heavy Fuel Oils**
CasNumber	68476335
Substance	Fuel oil, residual
Definition	The liquid product from various refinery streams, usually residues. The composition is complex and varies with the source of the crude oil.
Category	**Heavy Fuel Oils**
CasNumber	68478137
Substance	Residues (petroleum), catalytic reformer fractionator residue distn.
Definition	A complex residuum from the distillation of catalytic reformer fractionator residue. It boils approximately above 399°C (750°F).
Category	**Heavy Fuel Oils**
CasNumber	68478171
Substance	Residues (petroleum), heavy coker gas oil and vacuum gas oil
Definition	A complex combination of hydrocarbons produced as the residual fraction from the distillation of heavy coker gas oil and vacuum gas oil. It predominantly consists of hydrocarbons having carbon numbers predominantly greater than C13 and boiling above approximately 230°C (446°F).
Category	**Heavy Fuel Oils**
CasNumber	68512629
Substance	Residues (petroleum), light vacuum
Definition	A complex residuum from the vacuum distillation of the residuum from the atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly greater than C13 and boiling above approximately 230°C (446°F).
Category	**Heavy Fuel Oils**
CasNumber	68553004
Substance	Fuel oil, no. 6
Definition	A distillate oil having a minimum viscosity of 900 SUS at 37.7°C (100°F) to a maximum of 9000 SUS at 37.7°C (100°F).
Category	**Heavy Fuel Oils**
CasNumber	68607307
Substance	Residues (petroleum), topping plant, low-sulfur
Definition	A low-sulfur complex combination of hydrocarbons produced as the residual fraction from the topping plant distillation of crude oil. It is the residuum after the straight-run gasoline cut, kerosene cut and gas oil cut have been removed.

Category	**Heavy Fuel Oils**
CasNumber	68783084
Substance	Gas oils (petroleum), heavy atmospheric
Definition	A complex combination of hydrocarbons obtained by the distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C7 through C35 and boiling in the range of approximately 121°C to 510°C (250°F to 950°F).
Category	**Heavy Fuel Oils**
CasNumber	68783131
Substance	*Residures (petroleum) coker scrubber condensed-ring-aromatic-containing
Definition	A very complex combination of hydrocarbons produced as the residual fraction from the distillation of vacuum residuum and the products from a thermal cracking process. It consists predominantly of hydrocarbons having carbon numbers predominantly greater than C20 and boiling above approximately 350°C (662°F). This stream is likely to contain 5 wt. % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	68955271
Substance	Distillates (petroleum), petroleum residues vacuum
Definition	A complex combination of hydrocarbons produced by the vacuum distillation of the residuum from the atmospheric distillation of crude oil.
Category	**Heavy Fuel Oils**
CasNumber	70592766
Substance	Distillates (petroleum), intermediate vacuum
Definition	A complex combination of hydrocarbons produced by the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C14 through C42 and boiling in the range of approximately 250°C to 545°C (482°F to 1013°F) . This stream is likely to contain 5 wt.% or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	70592777
Substance	Distillates (petroleum), light vacuum
Definition	A complex combination of hydrocarbons produced by the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C11 through C35 and boiling in the range of approximately 250°C to 545°C (482°F to 1013°F).

Category	**Heavy Fuel Oils**
CasNumber	70592788
Substance	Distillates (petroleum), vacuum
Definition	A complex combination of hydrocarbons produced by the vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C50 and boiling in the range of approximately 270°C to 600°C (518°F to 1112°F). This stream is likely to contain 5 wt.% or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	70592799
Substance	Residues (petroleum), atm. tower, light
Definition	A complex residuum from the atmospheric distllation of crude oil. It consists of hydrocarbons having carbon numbers predominantly greater than C11 and boiling above approximately 200°C (392°F). This stream is likely to contain 5 wt % or more of 4- to 6-membered condensed ring aromatic hydrocarbons.
Category	**Heavy Fuel Oils**
CasNumber	70913858
Substance	Residues (petroleum), solvent-extd. vacuum distilled atm. residuum
Definition	A complex residuum produced by the solvent extraction of the vacuum distillate of the complex residuum from the atmospheric distillation of crude oil.
Category	**Heavy Fuel Oils**
CasNumber	70955178
Substance	Aromatic hydrocarbons, C12-20
Definition	A complex combination of hydrocarbons obtained from the distillation of biphenyl and naphthalene feedstocks. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C12 through C20, such as alkylbenzenes, alkylnaphthalenes, indans, fluorenes, acenaphthalenes, phenanthrenes and anthracenes, and boiling in the range of approximately 282.degree.C to 427.degree.C (540.degree.F to 800.degree.F).
Category	**Lubricating Oil Basestocks**
CasNumber	8042475
Substance	White mineral oil (petroleum)
Definition	A highly refined petroleum mineral oil consisting of a complex combination of hydrocarbons obtained from the intensive treatment of a petroleum fraction with sulfuric acid and oleum, or by hydrogenation, or by a combination of hydrogenation and acid treatment. Additional washing and treating steps may be included in the processing operation. It consists of saturated hydrocarbons having carbon numbers predominantly in the range of C15 through C50.

Category	**Lubricating Oil Basestocks**
CasNumber	64741500
Substance	Distillates (petroleum), light paraffinic
Definition	A complex combination of hydrocarbons produced by vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100 °F (19cSt at 40 °C). It contains a relatively large proportion of saturated aliphatic hydrocarbons normally present in this distillation range of crude oil.
Category	**Lubricating Oil Basestocks**
CasNumber	64741511
Substance	Distillates (petroleum), heavy paraffinic
Definition	A complex combination of hydrocarbons produced by vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of at least 100 SUS at 100°F (19cSt at 40°C). It contains a relatively large proportion of saturated aliphatic hydrocarbons.
Category	**Lubricating Oil Basestocks**
CasNumber	64741522
Substance	Distillates (petroleum), light naphthenic
Definition	A complex combination of hydrocarbons produced by vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64741533
Substance	Distillates (petroleum), heavy naphthenic
Definition	A complex combination of hydrocarbons produced by vacuum distillation of the residuum from atmospheric distillation of crude oil. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of at least 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64741760
Substance	Distillates (petroleum), heavy hydrocracked
Definition	A complex combination of hydrocarbons from the distillation of the products from a hydrocracking process. It consists predominantly of saturated hydrocarbons having carbon numbers in the range of C15-C39 and boiling in the range of approximately 260°C to 600°C (500°F to 1112°F)

Category	**Lubricating Oil Basestocks**
CasNumber	64741884
Substance	Distillates (petroleum), solvent-refined heavy paraffinic
Definition	A complex combination of hydrocarbons obtained as the raffinate from a solvent extraction process. It consists predominantly of saturated hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of at least 100 SUS at 100°F (19cSt at 40°C).
Category	**Lubricating Oil Basestocks**
CasNumber	64741895
Substance	Distillates (petroleum), solvent-refined light paraffinic
Definition	A complex combination of hydrocarbons obtained as the raffinate from a solvent extraction process. It consists predominantly of saturated hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C).
Category	**Lubricating Oil Basestocks**
CasNumber	64741953
Substance	Residual oils (petroleum), solvent deasphalted
Definition	A complex combination of hydrocarbons obtained as the solvent soluble fraction from C3 - C4 solvent deasphalting of a residuum. It consists of hydrocarbons having carbon numbers predominantly higher than C25 and boiling above approximately 400°C (752°F).
Category	**Lubricating Oil Basestocks**
CasNumber	64741964
Substance	Distillates (petroleum), solvent-refined heavy naphthenic
Definition	A complex combination of hydrocarbons obtained as the raffinate from a solvent extraction process. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of at least 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64741975
Substance	Distillates (petroleum), solvent-refined light naphthenic
Definition	A complex combination of hydrocarbons obtained as the raffinate from a solvent extraction process. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19 cSt at 40°C). It contains relatively few normal paraffins.

Category	**Lubricating Oil Basestocks**
CasNumber	64742014
Substance	Residual oils (petroleum), solvent-refined
Definition	A complex combination of hydrocarbons obtained as the solvent insoluble fraction from solvent refining of a residuum using a polar organic solvent such as phenol or furfural. It consists of hydrocarbons having carbon numbers predominantly higher than C25 and boiling above approximately 400°C (752°F).
Category	**Lubricating Oil Basestocks**
CasNumber	64742183
Substance	Distillates (petroleum), acid-treated heavy naphthenic
Definition	A complex combination of hydrocarbons obtained as a raffinate from a sulfuric acid treating process. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of at least 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64742194
Substance	Distillates (petroleum), acid-treated light naphthenic
Definition	A complex combination of hydrocarbons obtained as a raffinate from a sulfuric acid treating process. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64742343
Substance	Distillates (petroleum), chemically neutralized heavy naphthenic
Definition	A complex combination of hydrocarbons produced by a treating process to remove acidic materials. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of at least 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64742354
Substance	Distillates (petroleum), chemically neutralized light naphthenic
Definition	A complex combination of hydrocarbons produced by a treating process to remove acidic materials. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.

Category	**Lubricating Oil Basestocks**
CasNumber	64742376
Substance	Distillates (petroleum), clay-treated light paraffinic
Definition	A complex combination of hydrocarbons resulting from treatment of a petroleum fraction with natural or modified clay in either a contacting or percolation process to remove the trace amounts of polar compounds and impurities present. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C). It contains a relatively large proportion of saturated hydrocarbons.
Category	**Lubricating Oil Basestocks**
CasNumber	64742445
Substance	Clay treated heavy naphthenic distillate
Definition	A complex combination of hydrocarbons resulting from treatment of a petroleum fraction with natural or modified clay in either a contacting or percolation process to remove the trace amounts of polar compounds and impurities present. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of at least 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64742525
Substance	Distillates (petroleum), hydrotreated heavy naphthenic
Definition	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil of at least 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64742536
Substance	Distillates (petroleum), hydrotreated light naphthenic
Definition	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.

Category	**Lubricating Oil Basestocks**
CasNumber	64742547
Substance	Distillates (petroleum), hydrotreated heavy paraffinic
Definition	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil of at least 100 SUS at 100°F (19cSt at 40°C). It contains a relatively large proportion of saturated hydrocarbons.
Category	**Lubricating Oil Basestocks**
CasNumber	64742558
Substance	Distillates (petroleum), hydrotreated light paraffinic
Definition	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C). It contains a relatively large proportion of saturated hydrocarbons.
Category	**Lubricating Oil Basestocks**
CasNumber	64742569
Substance	Distillates (petroleum), solvent-dewaxed light paraffinic
Definition	A complex combination of hydrocarbons obtained by removal of normal paraffins from a petroleum fraction by solvent crystallization. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C).
Category	**Lubricating Oil Basestocks**
CasNumber	64742570
Substance	Residual oils (petroleum), hydrotreated
Definition	A complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon numbers predominantly greater than C25 and boiling above approximately 400°C (752°F).
Category	**Lubricating Oil Basestocks**
CasNumber	64742581
Substance	Lubricating oils, petroleum, hydrotreated, spent
Definition	A complex combination of hydrocarbons obtained by treating a spent lube oil with hydrogen in the presence of a catalyst. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C15 through C50.

Category	**Lubricating Oil Basestocks**
CasNumber	64742627
Substance	Residual oils (petroleum), solvent-dewaxed
Definition	A complex combination of hydrocarbons obtained by removal of long, branched chain hydrocarbons from a residual oil by solvent crystallization. It consists of hydrocarbons having carbon numbers predominantly greater than C25 and boiling above approximately 400°C (752°F).
Category	**Lubricating Oil Basestocks**
CasNumber	64742638
Substance	Distillates (petroleum), solvent-dewaxed heavy naphthenic
Definition	A complex combination of hydrocarbon obtained by removal of normal paraffins from a petroleum fraction by solvent crystallization. It consists of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil of not less than 100 SUS at 100°F (19cSt at 40°C). It contains relatively few normal paraffins.
Category	**Lubricating Oil Basestocks**
CasNumber	64742650
Substance	Distillates (petroleum), solvent-dewaxed heavy paraffinic
Definition	A complex combination of hydrocarbons obtained by removal of normal paraffins from a petroleum fraction by solvent crystallization. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity not less than 100 SUS at 100°F (19cSt at 40°C).
Category	**Lubricating Oil Basestocks**
CasNumber	64742672
Substance	Foots oil (petroleum)
Definition	A complex combination of hydrocarbons obtained as the oil fraction from a solvent deoiling or a wax sweating process. It consists predominantly of branched chain hydrocarbons having carbon numbers predominantly in the range of C20 through C50.
Category	**Lubricating Oil Basestocks**
CasNumber	64742707
Substance	Paraffin oils (petroleum), catalytic dewaxed heavy
Definition	A complex combination of hydrocarbons obtained from a catalytic dewaxing process. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of at least 100 SUS at 100°F (19cSt at 40°C).

Category	**Lubricating Oil Basestocks**
CasNumber	64742718
Substance	Paraffin oils (petroleum), catalytic dewaxed light
Definition	A complex combination of hydrocarbons obtained from a catalytic dewaxing process. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil with a viscosity of less than 100 SUS at 100°F (19cSt at 40°C).
Category	**Lubricating Oil Basestocks**
CasNumber	72623837
Substance	Lubricating oils (petroleum), C>25, hydrotreated bright stock-based
Definition	A complex combination of hydrocarbons obtained by treating solvent deasphalted residual oil with hydrogen in the presence of a catalyst in two stages with dewaxing carried out between stages. It consists predominantly of hydrocarbons having carbon numbers predominantly greater than C25 and produces a finished oil with a viscosity of approximately 440cSt at 40°C. It contains a relatively large proportion of saturated hydrocarbons.
Category	**Lubricating Oil Basestocks**
CasNumber	72623848
Substance	Lubricating oils, (petroleum) C15-30, hydrotreated neutral oil based solvent
Definition	
Category	**Lubricating Oil Basestocks**
CasNumber	72623859
Substance	Lubricating oils (petroleum), C20-50, hydrotreated neutral oil-based, high-viscosity
Definition	A complex combination of hydrocarbons obtained by treating light vacuum gas oil, heavy vacuum gas oil, and solvent deasphalted residual oil with hydrogen in the presence of a catalyst in a two stage process with dewaxing being carried out between the two stages. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil having a viscosity of approximately 112cSt at 40°C. It contains a relatively large proportion of saturated hydrocarbons.
Category	**Lubricating Oil Basestocks**
CasNumber	72623860
Substance	Lubricating oils (petroleum), C15-30, hydrotreated neutral oil-based
Definition	A complex combination of hydrocarbons obtained by treating light vacuum gas oil and heavy vacuum gas oil with hydrogen in the presence of a catalyst in a two stage process with dewaxing being carried out between the two stages. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C15 through C30 and produces a finished oil having a viscosity of approximately 15cSt at 40°C. It contains a relatively large proportion of saturated hydrocarbons.

Category	**Lubricating Oil Basestocks**
CasNumber	72623871
Substance	Lubricating oils (petroleum), C20-50, hydrotreated neutral oil-based
Definition	A complex combination of hydrocarbons obtained by treating light vacuum gas oil, heavy vacuum gas oil and solvent deasphalted residual oil with hydrogen in the presence of a catalyst in a two stage process with dewaxing being carried out between the two stages. It consists predominantly of hydrocarbons having carbon numbers predominantly in the range of C20 through C50 and produces a finished oil with a viscosity of approximately 32cSt at 40°C. It contains a relatively large proportion of saturated hydrocarbons.
Category	**Waxes and Related Products**
CasNumber	8002742
Substance	Paraffin waxes and Hydrocarbon waxes
Definition	A complex combination of hydrocarbons obtained from petroleum fractions by solvent crystallization (solvent deoiling) or by the sweating process. It consists predominantly of straight chain hydrocarbons having carbon numbers predominantly greater than C20.
Category	**Waxes and Related Products**
CasNumber	8009038
Substance	Petrolatum
Definition	A complex combination of hydrocarbons obtained as a semi-solid from dewaxing paraffinic residual oil. It consists predominantly of saturated crystalline and liquid hydrocarbons having carbon numbers predominantly greater than C25.
Category	**Waxes and Related Products**
CasNumber	63231607
Substance	Paraffin waxes and hydrocarbon waxes, microcryst.
Definition	A complex combination of long, branched chain hydrocarbons obtained from residual oils by solvent crystallization. It consists predominantly of saturated straight and branched chain hydrocarbons predominantly greater than C35.
Category	**Waxes and Related Products**
CasNumber	64742423
Substance	Hydrocarbon waxes (petroleum), clay-treated microcryst.
Definition	A complex combination of hydrocarbons obtained by treatment of a petroleum microcrystalline wax fraction with natural or modified clay in either a contacting or percolation process to remove the trace amounts of polar compounds and impurities present. It consists predominantly of long branched chain hydrocarbons having carbon numbers predominantly in the range of C25 through C50.

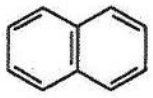
Category	**Waxes and Related Products**
CasNumber	64742434
Substance	Paraffin waxes (petroleum), clay-treated
Definition	A complex combination of hydrocarbons obtained by treatment of a petroleum wax fraction with natural or modified clay in either a contacting or percolation process to remove the trace amounts of polar compounds and impurities present. It consists predominantly of straight chain saturated hydrocarbons having carbon numbers in the range of C20 through C50.
Category	**Waxes and Related Products**
CasNumber	64742514
Substance	Paraffin waxes (petroleum), hydrotreated
Definition	A complex combination of hydrocarbons obtained by treating a petroleum wax with hydrogen in the presence of a catalyst. It consists predominantly of straight chain paraffinic hydrocarbons having carbon numbers predominantly in the range of about C20 through C50.
Category	**Waxes and Related Products**
CasNumber	64742605
Substance	Hydrocarbon waxes (petroleum), hydrotreated microcryst.
Definition	A complex combination of hydrocarbons obtained by treating a petroleum microcrystalline wax with hydrogen in the presence of a catalyst. It consists predominantly of long, branched chain hydrocarbons having carbon numbers predominantly in the range of C25 through C50.
Category	**Waxes and Related Products**
CasNumber	64742616
Substance	Slack wax (petroleum)
Definition	A complex combination of hydrocarbons obtained from a petroleum fraction by solvent crystallization (solvent dewaxing) or as a distillation fraction from a very waxy crude. It consists predominantly of saturated straight and branched chain hydrocarbons having carbon numbers predominantly greater than C20.

A1.1 Nomenclature

For purposes of clarity and consistency, the PAC TG has used the definitions of the following terms throughout this project.

Polycyclic Aromatic Hydrocarbon (PAH)

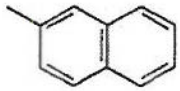
A fused aromatic-ring compound consisting only of carbon and hydrogen. Similar compounds include chrysene, pyrene, benzo[a]pyrene, perylene, etc. Naphthalene, the simplest PAH consists of two fused benzene rings:



The "ultimate" PAH is graphite, an inert material comprised of parallel sheets of fused benzene rings in an "infinite" array (API, 2002).

PAHs most commonly encountered in the environment contain two to seven fused benzene rings, although PAHs with a greater number of rings are also found in most PAH-containing materials, though usually at lower levels than the 2-6 membered ring species. The majority of the PAHs found in crude oil and petroleum streams have alkyl-substituents, with from one to twenty carbons, or even higher, depending on the boiling range of the petroleum stream (Altgelt and Boduszynski, 1994).

These compounds are referred to as "branched" or "alkylated" PAHs. Methylnaphthalene is the simplest example of an alkylated PAH: there are two possible isomers, 1-methyl and 2-methyl. 2-

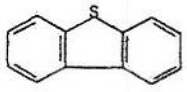


methylnaphthalene is shown below:

Polycyclic aromatic compound (PAC)

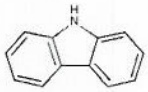
PAC is a more inclusive term than PAH. PAC includes PAHs, alkylated PAHs, and those multi-ringed aromatic molecules in which one or more atoms of a heteroatom such as nitrogen, oxygen or sulfur replaces a corresponding number of carbon atoms in a ring system. The PACs with heteroatoms can be grouped according to the heteroatom they contain. In general, the PAC categories contain only one heteroatom, although some having more than one type of heteroatom can be found at very low levels in some materials. As with PAHs, the majority of the PACs found in crude oil and petroleum streams have alkyl-substituents, with from one to twenty carbons, or even higher, depending on the boiling range of the petroleum stream.

S-PACs – are unalkylated and alkylated PACs in which the heteroatom is sulfur. These include the thiophenes and their benzologues (with additional aromatic rings fused to the thiophene structure).
Dibenzothiophene is an example of an S-PAC:

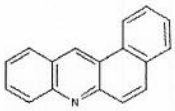


A1.1 Nomenclature (continued)

N-PACs- are unalkylated and alkylated PACs in which the heteroatom is nitrogen. These are the pyrrolic (five-membered ring aromatic) and pyridinic (six-membered ring aromatic) structures and their benzologues. Carbazoles, referred to as non-basic N-PACs, are N-PACs with a dibenzopyrrole system:



Due to their behavior as weak bases, N-PACs containing a quinoline nucleus are referred to as "basic N-PACs". Benz[a]acridine is an example of a basic N-PAC:



If the heteroatom is oxygen, the part of the structures containing the heteroatom is usually either a furan or a dioxane. Certain keto-structures, such as quinones, also can be found in some crude oils.

Polynuclear Aromatic (PNA)

This term is an obsolete term that is not recognized as valid by either the International Union on Pure and Applied Chemistry or the American Chemical Society. Historically, the term was used to describe the multi-ringed aromatic hydrocarbons now called PAHs.

Figure 1

Number of Paraffin Isomers and Approximate Boiling Range of Categories

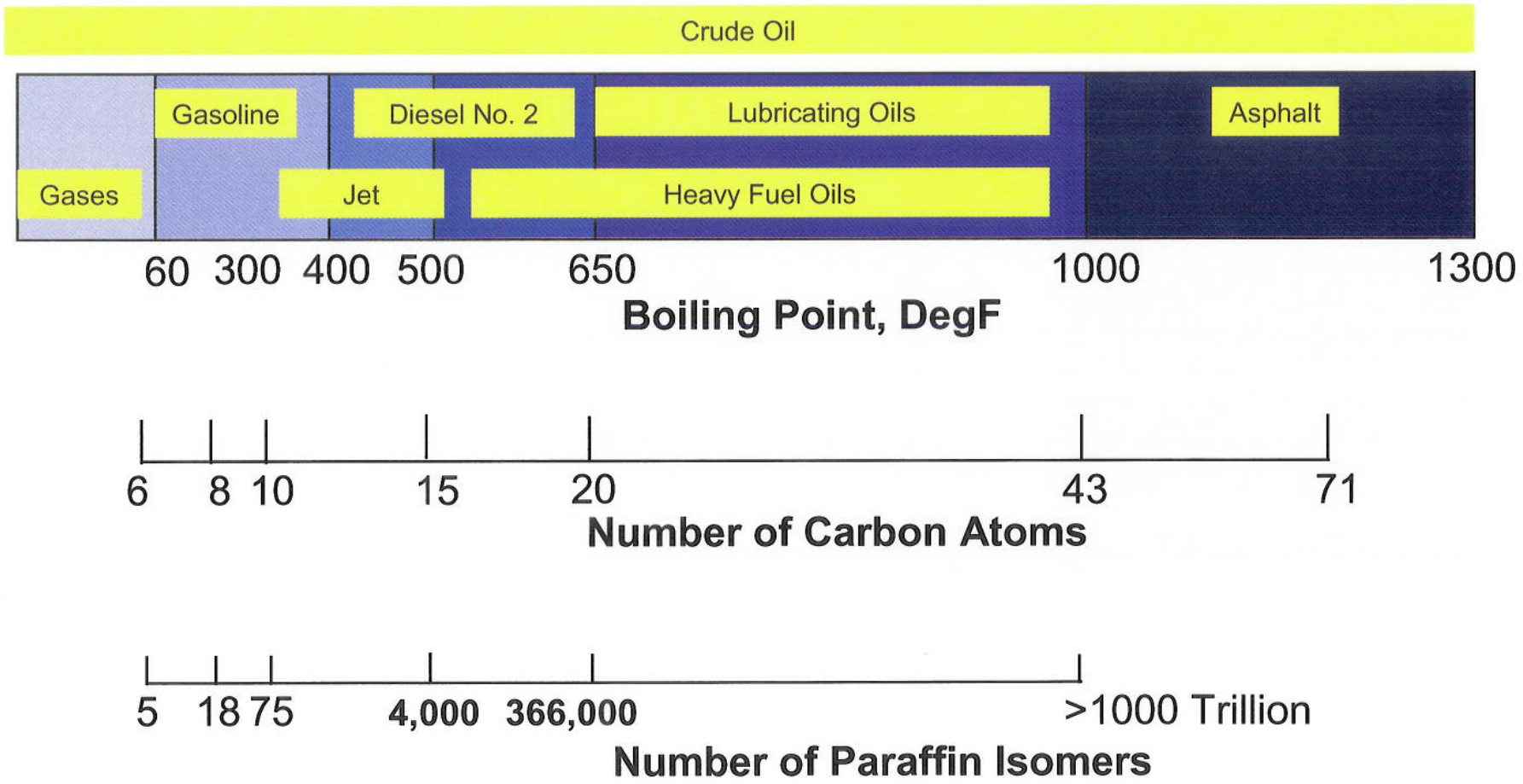
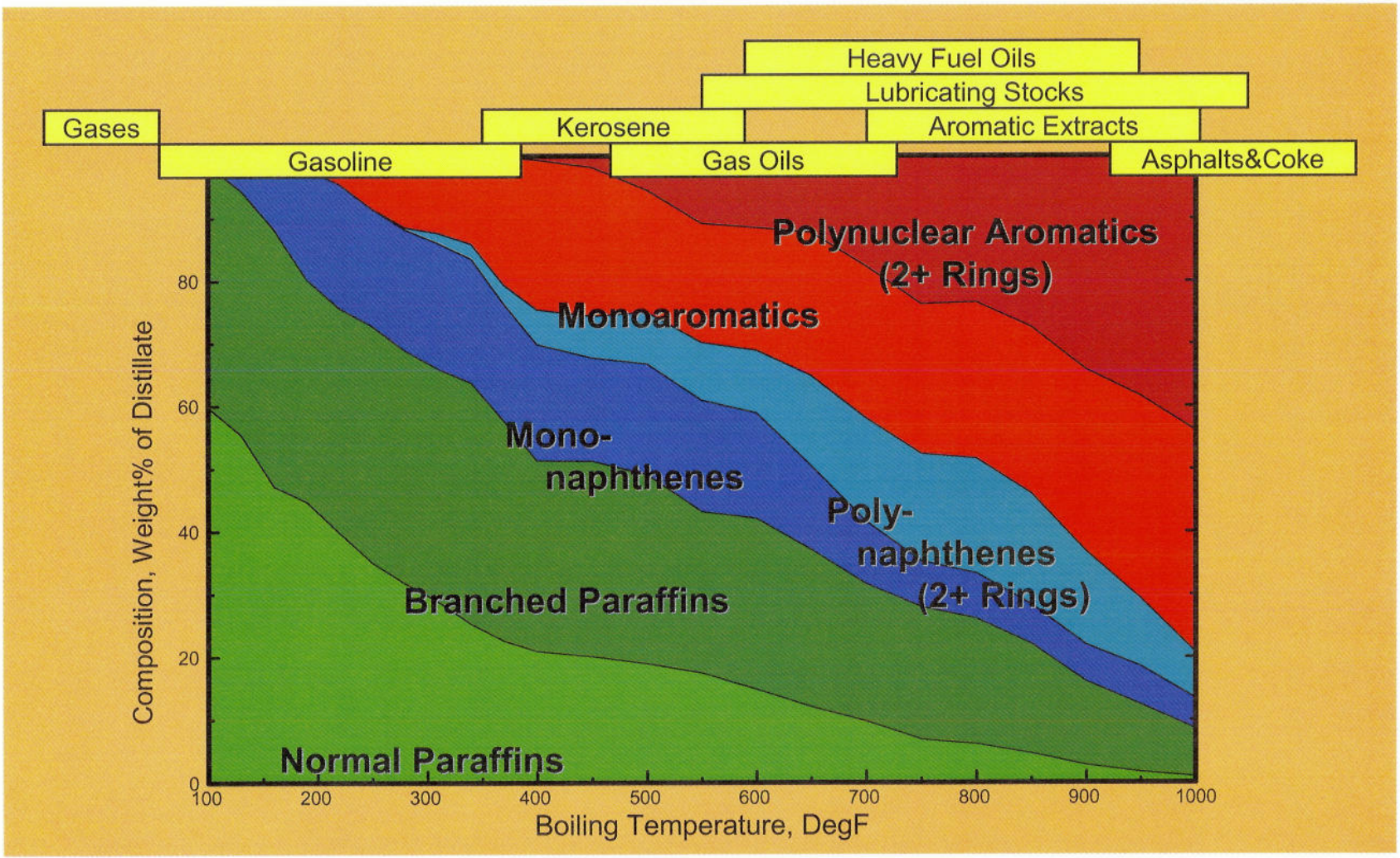


Figure 2

Relationship of Boiling Range to Petroleum Substance Composition



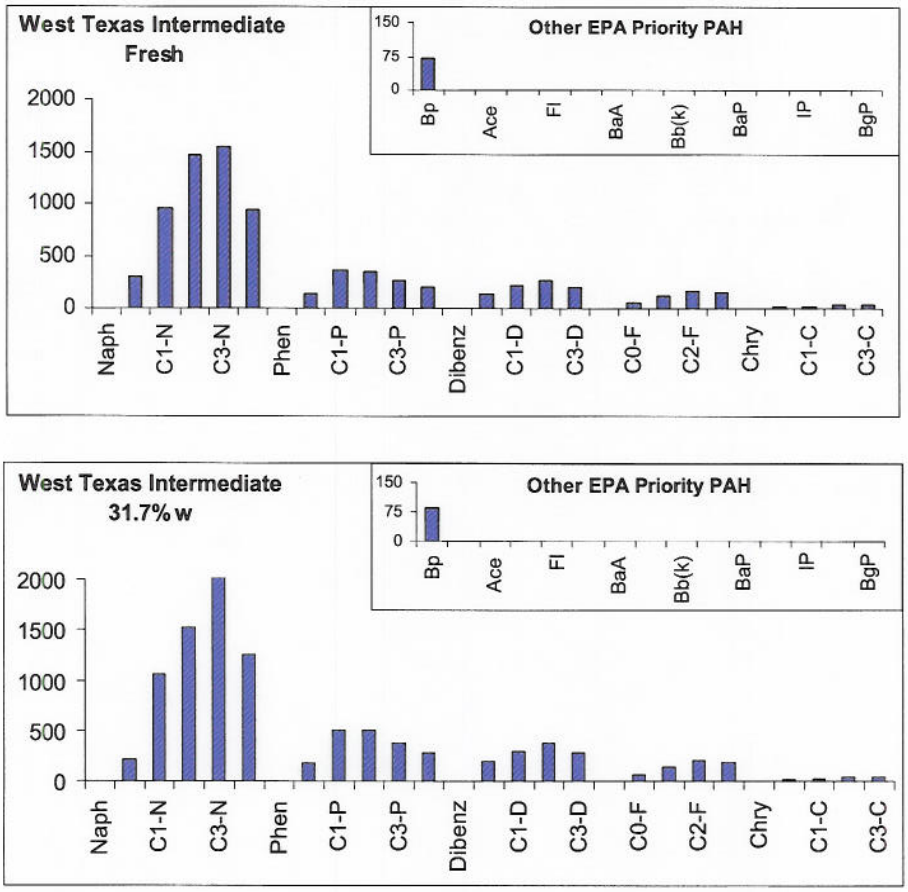


Figure 10.2 PAH Distribution for West Texas Intermediate crude oil (μg/g oil)

10.18 PAH Distribution

Alkylated PAH		Concentration (µg/g oil) 0% weathered	31.7% weathered
Naphthalene			
	C0-N	292.6	212.8
	C1-N	951.6	1056.6
	C2-N	1451.7	1517.0
	C3-N	1546.3	2025.8
	C4-N	929.5	1257.2
	Sum	**5172**	**6069**
Phenanthrene			
	C0-P	125.2	176.6
	C1-P	358.9	505.3
	C2-P	350.6	510.9
	C3-P	264.5	372.6
	C4-P	196.2	278.7
	Sum	**1295**	**1844**
Dibenzothiophene			
	C0-D	139.0	194.6
	C1-D	207.1	293.1
	C2-D	268.4	377.6
	C3-D	201.2	279.8
	Sum	**826**	**1145**
Fluorene			
	C0-F	48.9	63.0
	C1-F	108.6	141.3
	C2-F	160.7	208.8
	C3-F	140.2	186.5
	Sum	**458**	**600**
Chrysene			
	C0-C	13.5	19.3
	C1-C	22.5	31.8
	C2-C	32.7	47.5
	C3-C	31.4	47.0
	Sum	**100**	**146**
TOTAL		7841	9804
2-m-N/1-m-N		1.27	1.22
(3+2-m/phen)/(4-/9-+1m-phen)		0.72	0.71
4-m:2/3m:1-m-DBT		1:0.94:0.46	1:0.95:0.46
Other PAHs			
Biphenyl		68.45	82.79
Acenaphthylene		11.08	14.09
Acenaphthene		8.84	11.47
Anthracene		1.00	1.87
Fluoranthene		2.12	3.12
Pyrene		6.72	10.22
Benz(a)anthracene		1.24	1.50
Benzo(b)fluoranthene		1.37	1.75
Benzo(k)fluoranthene		0.37	0.37
Benzo(e)pyrene		3.48	5.24
Benzo(a)pyrene		0.25	0.33
Perylene		0.12	0.20
Indeno(1,2,3cd)pyrene		0.18	0.25
Dibenz(a,h)anthracene		0.18	0.25
Benzo(ghi)perylene		0.50	0.69
TOTAL		**106**	**135**

PAH Distribution for West Texas Intermediate crude oil

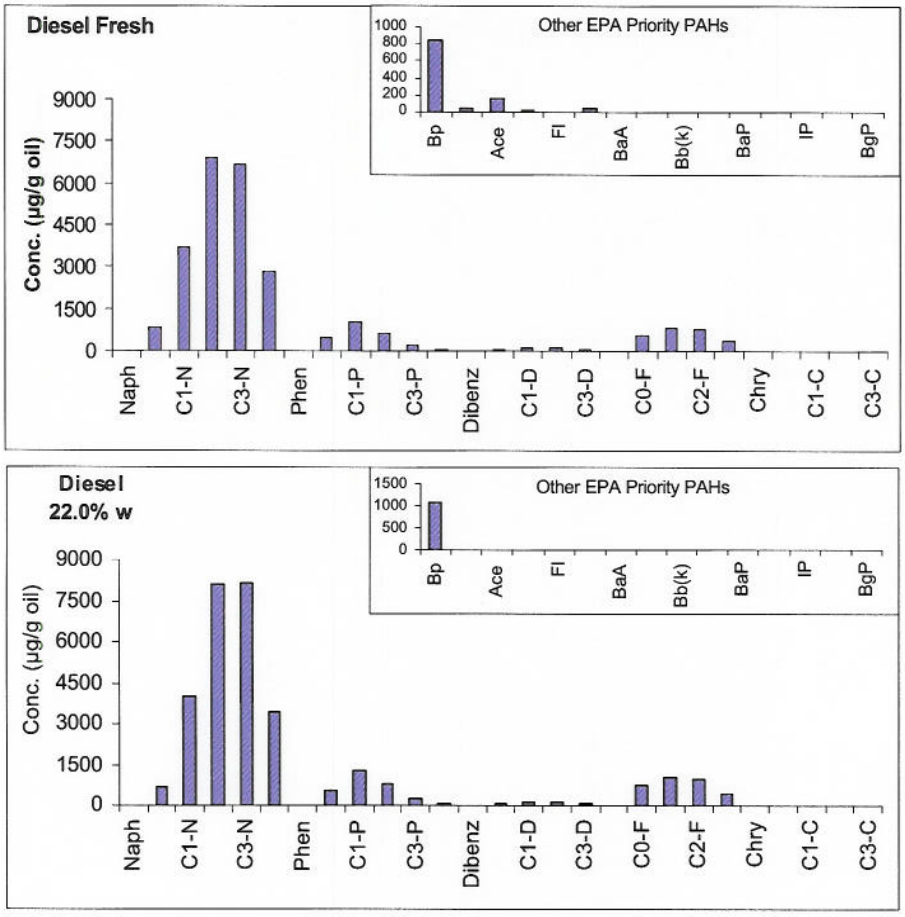


Figure 11.1 PAH Distribution for Fuel Oil No. 2 (Diesel) (µg/g oil)

11.18 PAH Distribution

Alkylated PAH		Concentration (µg/g oil) 0% weathered	22.0% weathered
Naphthalene			
	C0-N	820	677
	C1-N	3664	3968
	C2-N	6927	8101
	C3-N	6636	8163
	C4-N	2805	3427
	Sum	**20852**	**24337**
Phenanthrene			
	C0-P	437	557
	C1-P	1000	1262
	C2-P	617	769
	C3-P	185	237
	C4-P	53	65
	Sum	**2293**	**2890**
Dibenzothiophene			
	C0-D	65	82
	C1-D	110	137
	C2-D	99	123
	C3-D	38	50
	Sum	**312**	**392**
Fluorene			
	C0-F	567	713
	C1-F	799	1025
	C2-F	756	961
	C3-F	360	458
	Sum	**2481**	**3157**
Chrysene			
	C0-C	0.02	0.03
	C1-C	0.03	0.04
	C2-C	0.04	0.04
	C3-C	0.00	0.00
	Sum	0.09	0.12
TOTAL		**25938**	**30776**
2-m-N/1-m-N		1.56	1.53
(3+2-m/phen)/(4-/9-+1m-phen)		1.50	1.52
4-m:2/3m:1-m-DBT		1 : 0.35 : 0.16	1 : 0.36 : 0.17
Other PAHs			
Biphenyl		839.73	1072.40
Acenaphthylene		34.87	42.29
Acenaphthene		153.55	187.34
Anthracene		13.08	14.09
Fluoranthene		6.60	8.48
Pyrene		30.88	38.84
Benz(a)anthracene		0.25	0.28
Benzo(b)fluoranthene		0.00	0.00
Benzo(k)fluoranthene		0.00	0.00
Benzo(e)pyrene		0.00	0.00
Benzo(a)pyrene		0.00	0.00
Perylene		0.00	0.00
Indeno(1,2,3cd)pyrene		0.00	0.00
Dibenz(a,h)anthracene		0.00	0.00
Benzo(ghi)perylene		0.00	0.00
TOTAL		**1080**	**1364**

PAH Distribution for Fuel Oil No. 2 (Diesel)

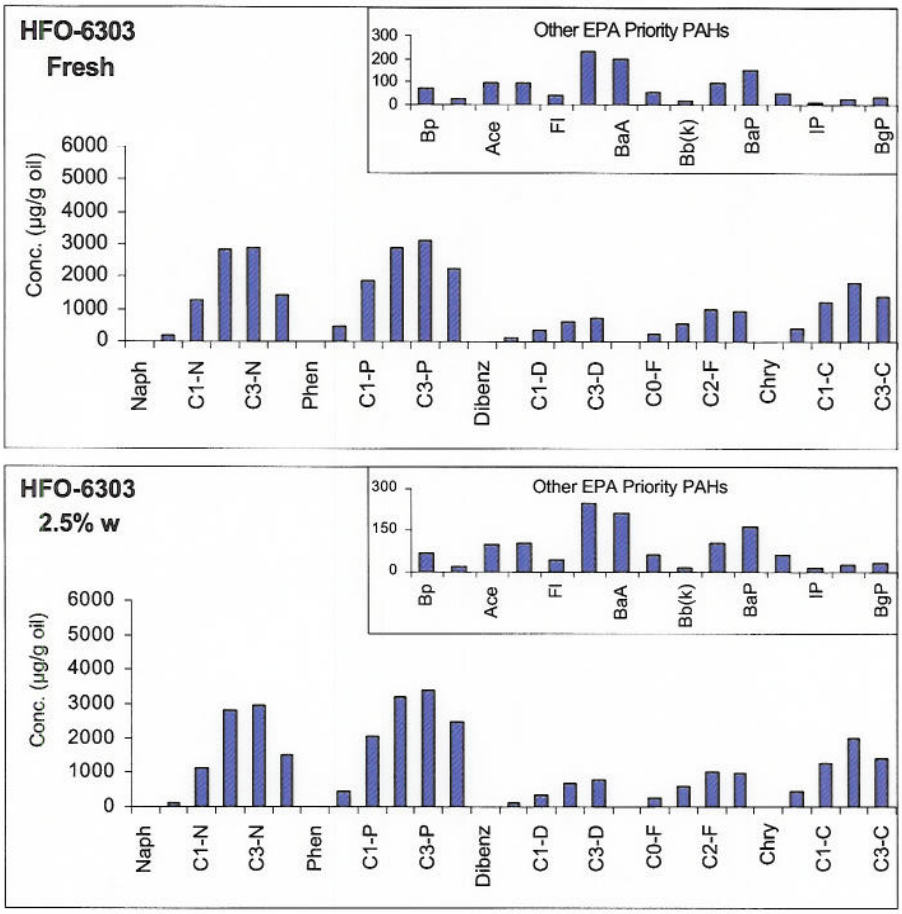
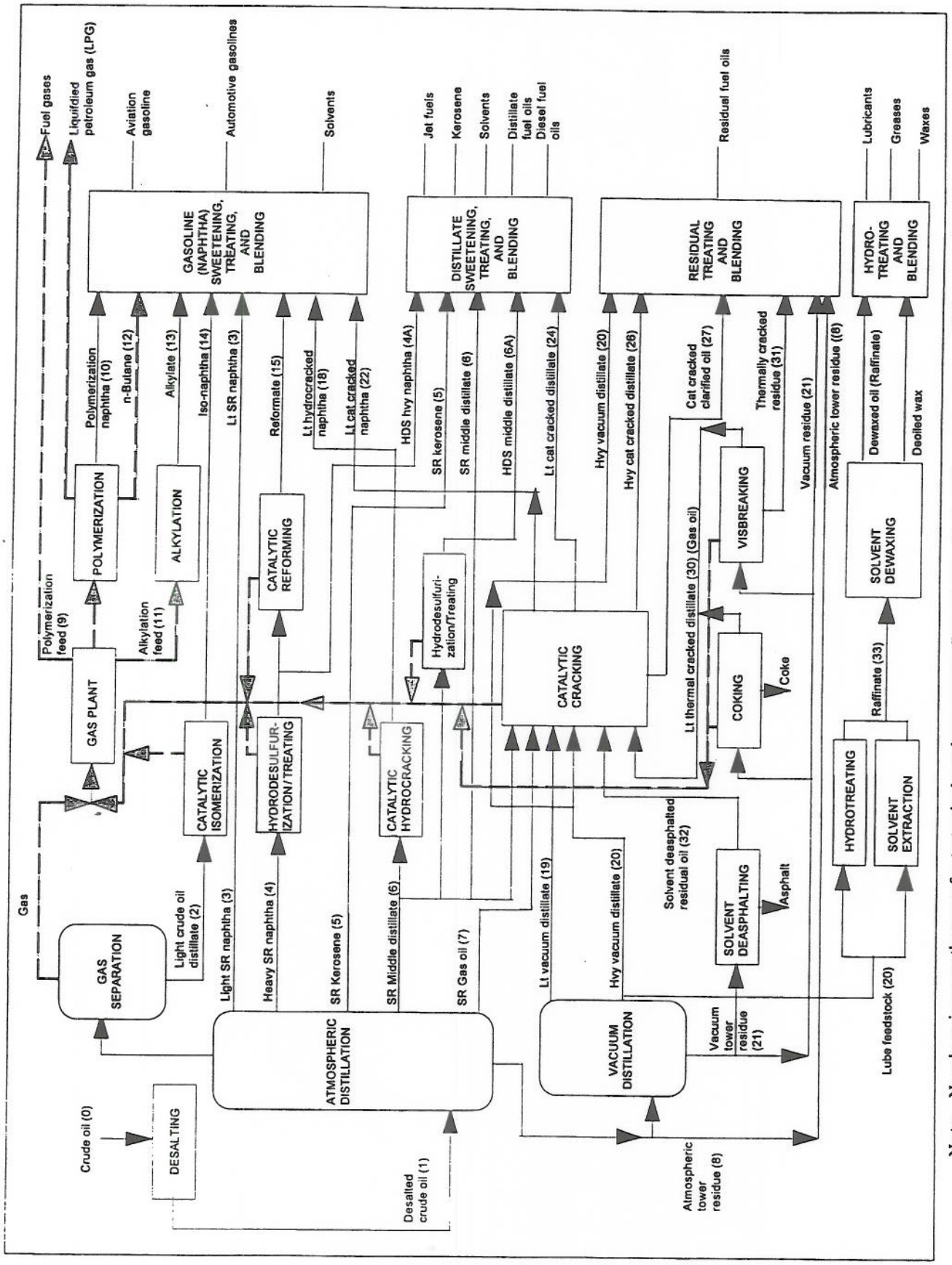


Figure 13.2 PAH Distribution for HFO 6303 (Bunker C) (µg/g oil)

13.18 PAH Distribution

	Concentration (µg/g oil)	
Alkylated PAH	0% weathered	2.5% weathered
Naphthalene		
C0-N	140	89
C1-N	1250	1091
C2-N	2861	2806
C3-N	2886	2956
C4-N	1422	1509
Sum	8558	8450
Phenanthrene		
C0-P	422	458
C1-P	1870	2029
C2-P	2910	3171
C3-P	3107	3376
C4-P	2211	2459
Sum	10520	11492
Dibenzothiophene		
C0-D	108	115
C1-D	315	335
C2-D	620	665
C3-D	701	766
Sum	1744	1881
Fluorene		
C0-F	224	233
C1-F	565	600
C2-F	978	1015
C3-F	936	963
Sum	2703	2811
Chrysene		
C0-C	376	415
C1-C	1173	1274
C2-C	1806	1961
C3-C	1379	1397
Sum	4733	5047
TOTAL	**28258**	**29682**
2-m-N/1-m-N	1.86	1.83
(3+2-m/phen)/(4-/9-+1m-phen)	1.39	1.4
4-m:2/3m:1-m-DBT	1 : 1.01 : 0.37	1 : 1.03 : 0.37
Other PAHs		
Biphenyl	69.22	66.79
Acenaphthylene	19.74	19.87
Acenaphthene	92.54	93.24
Anthracene	95.99	99.34
Fluoranthene	41.09	44.52
Pyrene	226.28	247.88
Benz(a)anthracene	198.27	210.88
Benzo(b)fluoranthene	53.42	57.21
Benzo(k)fluoranthene	11.84	13.29
Benzo(e)pyrene	93.03	99.94
Benzo(a)pyrene	151.14	164.81
Perylene	48.37	57.33
Indeno(1,2,3cd)pyrene	9.50	10.10
Dibenz(a,h)anthracene	21.84	24.30
Benzo(ghi)perylene	28.62	29.92
TOTAL	**1161**	**1239**

PAH Distribution for HFO 6303 (Bunker C)



Note: Numbers in parentheses refer to typical product process flow routes. Dashed lines are gases; solid lines are liquids.

Figure III:2-6 Refinery Process Chart

Table III:2-3 **OVERVIEW OF PETROLEUM REFINING PROCESSES**

Process name	*Action*	*Method*	*Purpose*	*Feedstock(s)*	*Product(s)*
FRACTIONATION PROCESSES					
Atmospheric distillation	Separation	Thermal	Separate fractions	Desalted crude oil	Gas, gas oil, distillate, residual
Vacuum distillation	Separation	Thermal	Separate w/o cracking	Atmospheric tower residual	Gas oil, lube stock, residual
CONVERSION PROCESSES—DECOMPOSITION					
Catalytic cracking	Alteration	Catalytic	Upgrade gasoline	Gas oil, coke distillate	Gasoline, petrochemical feedstock
Coking	Polymerize	Thermal	Convert vacuum residuals	Residual,heavy oil, tar	Naphtha, gas oil, coke
Hydrocracking	Hydrogenate	Catalytic	Convert to lighter HCs	Gas oil, cracked oil, residual	Lighter, higher-quality products
*Hydrogen Steam Reforming	Decompose	Thermal/cat.	Produce hydrogen	Desulfurized gas, O_2, steam	Hydrogen, CO, CO_2
*Steam Cracking	Decompose	Thermal	Crack large molecules	Atm tower hvy fuel/distillate	Cracked naphtha, coke,residual
Visbreaking	Decompose	Thermal	Reduce viscosity	Atmospheric tower residual	Distillate, tar
CONVERSION PROCESSES—UNIFICATION					
Alkylation	Combining	Catalytic	Unite olefins & isoparaffins	Tower isobutane/crckr olefin	Iso-octane (alkylate)
Grease compounding	Combining	Thermal	Combine soaps & oils	Lube oil, fatty acid, alky metal	Lubricating grease
Polymerization	Polymerize	Catalytic	Unite 2 or more olefins	Cracker olefins	High-octane naphtha, petrochemical stocks
CONVERSION PROCESSES—ALTERATION or REARRANGEMENT					
Catalytic reforming	Alteration/ dehydration	Catalytic	Upgrade low-octane naphtha	Coker/hydrocracker naphtha	High oct. reformate/aromatic
Isomerization	Rearrange	Catalytic	Convert strght chain to branch	Butane, pentane, hexane	Isobutane/pentane/hexane