### Subject Index

**A**

Absorption refining technique, 90

Acenaphthene, effect on sediment formation, 79

Acid effects
- on deposit formation, 83–84
- interaction with nitrogen and sulfur compounds, 84

Acid treating, 90

Additives (See also specific additive)
- combinations, 124–125
- effects on deposition in deoxygenated fuels, 106–107
- for high-temperature applications, 140
- reviews and surveys of, 122–123
- summary of effects, 127

Advanced aircraft fuel system simulator, 23–25
- comparison of steady-state deposit rates in, 53
- deoxygenation studies, 100–101
- deposit composition studies, 86–87
- schematic of, 24
- temperature effects in, 51–52

Advanced Fuel Research mini-reactor, 48

Advanced kinetic unit, 35–36
- Arrhenius plot for fuel deposition in, 57
- composition effects on deposition in deoxygenated fuels, 104–107
- deoxygenation studies in, 102–103
- metallic exposure effects on deposition, 116
- pressure effects in, 60
- schematic of, 36
- temperature effects in, 54, 57

AFDTA (See Aircraft fuel deposit test apparatus)

Afterburners, spraybar tests, 27

A-1 fuel
- acid-doped, deposition behavior, 83
- copper contaminated, breakpoint of, 113
- mild hydrotreatment vs. noble metal processing, 90–91

Aging effects, on thermal stability, 89–90

Aircraft
- commercial, fuel temperature, 133–136
- military, fuel temperature, 136–137

Aircraft fuel deposit test apparatus, 35, 37
- global reactions for chemical processes in, 68–69
- pressure effects on JP-5 fuel, 60
- schematic of, 37

Air-saturated fuels, pressure effects, 58–59

$n$-Alkanes, deposit formation, 75–76

Aluminum
- deposit thickness on JFTOT tubes, 118
- effects on deposition, 116–118
- heater tube deposits, 116
- in MEC deposits, 5

Anti-icing additives
- effects on deposition in deoxygenated fuels, 106–107
- effects on thermal stability, 151

Antioxidants
- cautions for, 151
- effects on deposition in deoxygenated fuels, 106–107
- JP-4 shale-derived fuel, 125
- thermal stability, 123

Antistatic inhibitors, 124

Apparent energy of activation, 59

Aromatics
- in $n$-dodecane, temperature oxidation data, 77
- removal, 90–91

ASTM standards
- Adjunct No. 12-416600-00: 15
- D 1655: 6, 15, 20, 42
- D 1660: 5, 15, 148
- D 1665: 5
- D 3241: 14, 17, 144, 148
- D 3241-88a: 118

Auger electron spectroscopy
- elemental composition of deposits, 86
- magnesium on heater tubes, 117–118

Autoxidation, 72–75
- flask oxidation studies, 74–75
- $n$-dodecane, 75
- paraffinic hydrocarbons, 73–74

AVTUR (See Kerosene-type aviation turbine fuels)
THERMAL OXIDATION STABILITY OF AVIATION TURBINE FUELS

B

Bender process
deposit formation after, 85
fuel characterization, 5
Benzothiophene, effect on metal
compound deposition, 84
Beryllium, effects on breakpoints, 116
Biomass-derived fuels, 144
Bureau of Mines, thermal stability review
(1962), 1-2
Bypass recirculation, environment at flight
idle, 10

C

Cadmium plating, effects on deposition,
116
Carbon deposition, test duration effects,
117
Cartridge brass, heater tube deposits, 116
CF6-50E engines, deposits on MEC, 4-5
CF6-80E engines, deposits on MEC, 4-5
Clay absorption, 90
Clay filtration
and high-temperature applications, 140
metals removal by, 115
Coal-derived fuels
vs. petroleum-derived JP-5, copper
pickup, 113
as petroleum replacements, 143
Coking rate, deoxygenation and, 103
Color standards (for deposits)
ASTM D 2276, 20
CRC/ASTM coker, 15
JFTOT, 17
Commercial aircraft, fuel temperatures,
133-136
Computerized fluid dynamics and
chemistry, thermal stability
modeling, 68
Concorde aircraft, fuel temperatures, 133
Coordinating Research Council, thermal
stability review (1979), 2-3
Copper
catalytic activity, 119-120
compounds, effects on deposition, 113
deposit thickness on JFTOT tubes, 118
dissolved in JP-4 fuels, 114
dissolved in JP-5 fuels, 114-115
effects on
breakpoints, 116
deposition in deoxygenated fuels,
106-107
JP-7 breakpoint, 113-114
kerosene oxidation rate, 114
thermal stability
coker tests, 113
JFTOT tests, 112-113
rig tests, 112
effects on spray patterns, 111
in MEC deposits, 5
mechanisms of action, 118-119
solubility, 115
in USSR static tests, 21
Copper contamination
JP-5 fuel, effects on
heat exchangers, 8
nozzles, 7-8, 111
JT3D/MC-6 and MC-7 engines, 2
summary of effects, 150
Copper/nickel, effect on deposition in
doxygenated fuels, 106
Corrosion inhibitors
effects on deposition in deoxygenated
fuels, 106-107
effects on thermal stability, 124
CRC/ASTM coker
comparisons
with JFTOT, 17
with STHTR, 16
description, 14-16
development, 3
dissolved metal effects on thermal
stability, 113-114
drawbacks, 16
flight test results, 4
gas driven, 44
high-temperature research coker, 43-44
for metal effects, 45
metallic exposure effects on deposition,
116
micro fuel coker, 45
modifications to, 43-45
modified fuel coker, 44
rating criteria, 15
research coker development and use,
19-20
as research tool, 16, 19-20
schematic of, 15
CRC/NAA simulator, temperature effects
in, 51
Cycloalkanes, inhibition of decane deposit
formation, 76

D

Decalin, as endothermic fuel, 141
Density, of thermal stability deposits, 67
Deoxygenated fuels
applications for, 108
deposits
additive effects, 107
characterization, 107
hydrocarbon effects, 104
interactions between added compounds, 107
metal effects, 106–107
nitrogen compound effects, 105–106
oxygen compound effects, 106
sulfur compound effects, 104–105
precautions for, 108
pressure effects, 58–59
Deoxygenation effects
Aero Propulsion studies, 100–101
Exxon studies, 101–103
high-temperature applications and, 140
NASA studies, 100
Shell Development studies, 99–100
summary of, 150
UTRC studies, 103
Deposit formation
in advanced kinetic unit, rate measurement, 35–36
n-alkanes, 75–76
and Bender process, 5, 85
carbon, test duration effects, 117
chemical mechanisms in, 91–94
ddeoxygenated fuel
additive effects, 107
hydrocarbon effects, 104
interactions between added compounds, 107, 150
metal effects, 106–107
nitrogen compound effects, 105–106
oxygen compound effects, 106
sulfur compound effects, 104–105
dodecosy free-radical intermediates, 78
dropoff at higher temperatures, 57–58
effects of acids, 83–84
exposure to metallic materials, 116–118
oxygen compounds, 83–84
polar fractions, 83–84
temperature, 51–58, 89–90, 149
on flow divider valves, 6–7
hetero atom-containing compounds in, 79–85
in JFTOT, pressure effects, 59
JP-5 fuel during extended duration tests, 63
mechanisms, 100
nitrogen compounds in, 81
pressure effects, 59
radioactively tagged compounds, 78–79
sulfur compounds in, 79–81
Deposition rate
in advanced kinetic unit, pressure effects, 60
flow velocity effects, 60–61
in fuel deposit test apparatus, flow rate effects, 62
heat transfer-related, 64–66
at higher temperatures, 57–58
JP-5 in AFDTA, pressure effects, 60
JP-5 in single tube heat exchanger (UTRC), 61
modeling, 68–69
prediction, 68
surface finish effects, 67–68
test duration effects, 63–64
two-step global kinetic mechanism for, 68
Deposits (See also specific deposit)
ASTM D1655 codes, 15
chemical structure, 87–89
color standards
CRC/ASTM coker, 15
JFTOT, 17
from contaminated MECs, 5
density measurements, 67
from deoxygenated fuels, characterization, 108
effects on fuel metering system, 3
heat exchangers, 3
nozzles, 3
elemental composition of, 85–87
in fuel system filters, 4
light reflectance meters for, 19
magnesium, 116–118
Micellar theory of, 66
morphology, 66–67
nitrogen concentration in, 88
sulfur concentration in, 88
thermal conductivity measurements, 67
thickness in fuel tank simulator, 30
optical interference techniques, 19
Dielectric strength, of metal deposits, 118
Diolefins, effect on n-decane deposit formation, 75
N,N′-Disalicylidine-1,2-ethanediamine, 123
N,N′-Disalicylidine-1,2-propanediamine effectiveness, 123
effects on fuel properties, 125–127
Dispersants
cautions for, 151
effects on thermal stability, 124
Disulfides, effect on metal compound deposition, 84

\textit{n-Dodecane}

- autoxidation, 75
- dodecoxy free-radical intermediates, 78
- temperature oxidation data for aromatics in, 77

Dodecoxy free-radical intermediates, 78

DTS-1 unit, 39

Duration of tests

- and carbon deposition, 117
- and deposition rate, 63–64

Dynamic testers (See specific tester)

\textbf{E}

Endothermic fuels, for high-temperature applications, 140–141

Energies of activation, 55–57, 59, 149

Engine component rigs

- afterburner spraybar tests, 27
- nozzle testers, 25–27
- single tube heat exchanger, 29–30

Engine gear pump, environment at flight idle, 10

Engine oil cooler, environment at flight idle, 10

Extraction methods, 90

Exxon wing tank testers (See Wing tank testers (Exxon))

\textbf{F}

Fatty acids, high-molecular-weight, 124

F100C aircraft, TOS flight tests, 3

F101 fuel nozzle, deposit formation, 6

F404 fuel nozzle fouling test results, 54

Field ionization mass spectrometry, chemical structure of deposits, 89

Filters

- color standard ASTM D 2276, 20
- CRC/ASTM coker, 15
- deposits in, 4
- environment at flight idle, 10
- JFTOT, 18–19
- sediment composition, 89

FIMS (See Field ionization mass spectrometry)

Flask oxidation studies, 74–75

- antioxidant effects, 125
- effects of dissolved metals on kerosenes, 114

Flask oxidation test

- description of, 46–47
- schematic of, 47

Fuel breakpoint

- dissolved metal effects, 116–118
- jet fuel thermal oxidation tester, 19, 42, 112–113

Fuel coking apparatus, 39

- chemical structure of deposits, 87–88
- flow rate effects, 61

Fuel deposit test apparatus

- copper effects on carbon deposition, 112
- design and use, 41–42
- flow rate effects studies, 61–62
- test duration effects on deposition rates, 63

Fuel environment, at flight idle

- (commercial aircraft), 10

Fuel flow, at flight idle (commercial aircraft), 10

Fuel injector nozzles (See Nozzles)

Fuel metering systems, effects of deposits, 3

Fuel oil additive 310, effects on fuel properties, 125–127

Fuel oil stabilizer 3, effects on fuel properties, 125–127

Fuel quality, and engine performance, 3–4

Fuel systems

- commercial airplanes, thermal environment of, 9–10
- filters (See Filters)
- generic subsonic airplane, 9
- simulators
  - advanced aircraft fuel system simulator, 23–25
  - GE4 fuel system simulator, 22–23

Flight idle, fuel environment at commercial aircraft, 10

Flight tests, 3–4

Flow divider values, deposit formation on, 6–7

Flow velocity effect on

- deposition rate, 60–61
- heat transfer, 60–61
- summary of, 149
- UTRC studies, 61–62

Fluorene, effects on deposit formation, 76–77

Fluorocarbon lubricity additives, 124

Free-radical inhibitors

- natural, 73
- synthetic, 73

Free radicals

- dodecoxy, intermediates in deposit formation, 78
- initiation, metals effects, 119

Fuel breakpoints

- dissolved metal effects, 116–118
- jet fuel thermal oxidation tester, 19, 42, 112–113

Fuel environment, at flight idle

- (commercial aircraft), 10

Fuel flow, at flight idle (commercial aircraft), 10

Fuel injector nozzles (See Nozzles)

Fuel metering systems, effects of deposits, 3

Fuel oil additive 310, effects on fuel properties, 125–127

Fuel oil stabilizer 3, effects on fuel properties, 125–127

Fuel quality, and engine performance, 3–4

Fuel systems

- commercial airplanes, thermal environment of, 9–10
- filters (See Filters)
- generic subsonic airplane, 9
- simulators
  - advanced aircraft fuel system simulator, 23–25
  - GE4 fuel system simulator, 22–23
half-engine-scale fuel system rig, 25
temperatures for supersonic aircraft, 134–136

Fuel tanks
environment at flight idle, 10
Exxon wing tank testers, 46–48
simulator, 30

Fuel temperatures (See also Temperature effects)
at combustor nozzle, 137
in commercial aircraft, 133–136
for Concorde aircraft, 133
at flight idle (commercial aircraft), 10
vs. flight time for heat exchangers, 5
in military aircraft, 136–137
for supersonic aircraft, 134–136

G
Gas driven fuel coker, 44
GE4 fuel system simulator, design and use, 22–23
GE-NZ apparatus
design and use, 25–27
F404 nozzle fouling results, 54
summary of nozzle-fouling regression results, 55
tests in, 52–53
Gold, deposit thickness on JFTOT tubes, 118
Gost Method 9144-79
description, 21
limits, 20
operational principle, 14
Gost Method 11802-66
description, 21
limits, 20
operational principle, 14
Gost Test 17751-79 for Specification RT Kerosene, N. 16564-71, 20

H
Half-engine-scale fuel system rig
description, 25
schematic of, 26
Heater tubes
additive tests, 125–126
deposits
chemical composition, 89
FIMS and HR/MS, 89
Hastelly C, 99
JFTOT, 18
Nichrome V, 100
surface effects summary, 150
surface finish effects, 67–68
Heat exchange effectiveness factor, 65
Heat exchangers
CF6-50E and CF6-80E engines, 5
deposition effects on heat transfer, 3
fuel temperature vs. flight time, 5
heat transfer deterioration, 8
Naval Air Propulsion Center, 65
single tube test rig, 29–30
testing, 8
Heat load, at flight idle (commercial aircraft), 10
Heat transfer
effects of copper, 112
copper-doped JP-5 fuel, 8
flow velocity, 60–61
pressure, 59
sulfur compounds, 80
single tube heat exchanger rig, 29–30
Heat transfer unit (Esso)
design and use, 39–41
flow diagram of, 40
heat transfer reference data for RAF-179-64, 56
heat transfer-related deposition, 64
temperature effects in, 53, 56
Heavy oil-derived fuels, 144
n-Hexadecane, decomposition, 141
Hexanoic acid, effect on nitrogen compound deposition, 84
High-resolution mass spectrometry, JFTOT heater tube deposits, 89
High-temperature requirements
in commercial aircraft, 133–136
in military aircraft, 136–137
High-temperature research fuel coker, 43–44
HR/MS (See High-resolution mass spectrometry)
Hydrocarbons
alicyclic, as endothermic fuel, 141
effects on deposition in deoxygenated fuels, 104
paraffinic, autoxidation, 73–74
pure, noncatalytic decomposition, 141
structure and deposition, 75–79
Hydrogenation, and JFTOT breakpoint, 91
Hydroperoxides
and copper presence, 119
decomposition, 73
effect on deposition in deoxygenated fuels, 106
formation during storage, 109
product breakdown, 77–78
summary of effects, 150
Hydrotreatment refining technique, 90–91, 151
for high-temperature applications, 140

I
Icing inhibitors, 124
Inconel 600, effect on deposition in deoxygenated fuels, 106
Indene, effect on n-decane deposit formation, 76
Injector feed-arm rig (Shell Thornton) design and use, 41
flow diagram of, 41
flow velocity effects in, 61
heat transfer-related deposition, 66
time-dependence of deposition in, 63–64
Injector nozzles (See Nozzles)
Ion-exchange cleanup, for metal removal, 115
IONOL, effects on fuel properties, 125–127
Iron
dissolved in JP-4 fuels, 114
effects on deposition in deoxygenated fuels, 106–107
JP-7 breakpoint, 113–114
kerosene oxidation rate, 114
mechanism of action, 119
solubility, 115
summary of effects, 150

J
J-57 engine
in F100C aircraft, 3
in fighter aircraft, 4
instability behavior, 2
TOS flight tests, 3–4
Jet fuel thermal oxidation tester
acid studies in, 83
additives to JP-4 fuel, evaluation, 124–125
breakpoints
hydrogenation and, 91
and metal contamination tests, 112–113
bulk heating step ahead of, 43
carbon burnoff in SS tubes, 43
coal-derived fuels, 143
comparison with CRC/ASTM coker, 17
copper mechanism of action, 119
deoxygenation studies, 100–101
diagram of, 18
elemental composition of deposits, 86
fiber optic modified, test duration effects, 64
flow velocity effects in, 61
fuel breakpoints, 19, 42
heater tube additive tests, 125–126
heater tube deposits, FIMS and HR/MS, 89
high temperature for, 42
for JP-7 fuels, 20
metal deactivator studies, 128–130
metallic exposure effects on deposition, 116–118
Millipore filters, 43
modifications to, 42–43
nitrogen compound studies in, 81
127-mm heater tube for, 43
optical techniques, 19
polar fraction studies, 83
pressure effects on JP-4 breakpoints, 59
problems with, 19
rating criteria, 17
rating relationships with JFTOT, 17
shale-derived fuels, 142–143
sulfur compound studies in, 80–81
tar sand and heavy oil-derived fuels, 144
test duration effects on deposition rates, 64
test parameters, 17
use of, 5
JFA-5 dispersant, 124
JFTOT (See Jet fuel thermal oxidation tester)
JP-4 fuels
high-temperature applications, 140
shale-derived
additives evaluation, 124–125
antioxidants evaluation, 124–127
shale-derived, antioxidant evaluation, 124–127
sources of dissolved metals in, 114
JP-5 fuels
in AFDTA, pressure effects, 60
vs. coal-derived fuels, copper pickup, 113
copper-contaminated
heat exchanger tests with, 8
nozzle tests with, 7–8, 111
deoxygenation effects, 102–103
deposit formation
during extended tests, 63
hydroperoxide effects, 106
nitrogen compound effects, 105–106
peroxide effects, 106
sulfur compound effects, 104–106
high-temperature applications, 140
pressure effects, 59
sources of dissolved metals in, 114
JP-7 fuels
breakpoint, dissolved metal effects, 113–114
deoxygenation effects, 103
fouling rates, 8
high-temperature applications, 140
JFTOT conditions for, 17
metals removal from, 115
research coker use for, 20
static testers for, 20–21
thermal stability, 8, 20
JT3D/MC-6 engine, instability problems, 2
JT3D/MC-7 engines, instability problems, 2

Kerosene fuels
CRC coker specification for, 16
dynamic tests for
Peoples Republic of China, 20
USSR, 20
high-temperature applications, 151
for high-temperature applications, 140
metallic exposure effects, 116
oxidation rate
copper effects, 114
iron effects, 114
pressure effects, 59
static tests in USSR, 20
thermal precipitation rating, 20
Kerosene-type aviation turbine fuels (AVTUR)
effect of nitrogen compounds, 82
heat transfer coefficient, test duration effects, 64–65
tests for nitrogen/sulfur compound effects, 46

L
L-605 (Haynes 25), heater tube deposits, 116
Large-scale thermal stability testers
advanced aircraft fuel system simulator, 23–25
GE4 fuel system simulators, 22–23
half-engine-scale fuel system rig, 25
priority list for, 23
Laser ionization mass analysis, metal deactivators, 129
Lead
dissolved in JP-4 fuels, 114
effects on breakpoints, 116
JP-7 breakpoint, 113–114
Light reflectance meters, deposit rating with, 19
Light scattering, phenyl sulfide role in particulate matter formation, 80
Lubricity additives, effects on thermal stability, 124

M
Mach number, and fuel stresses, 133–137
Magnesium compounds, effects on deposition, 113
Magnesium deposition
deposit thickness on JFTOT tubes, 118
migration, 116–118, 148
Main engine control
CF6-50E and CF6-80E engines, deposits on, 4–5
deposits analysis, 5
environment at flight idle, 10
Manifolds
fouling, 3
redesign, J-57 engine, 2
surface finish effects, 67–68
MEC (See Main engine control)
Mercaptans, conversion to disulfides, 5, 85
Metal concentrations
effects on thermal stability, 112
sources of dissolved metals in JP-4 fuels, 114
in JP-5 fuels, 114–115
Metal deactivators, 123
cautions for, 151
$N,N'$-disalicylidine-1,2-propanediamine effects, 128–130
laser ionization mass analysis, 129
mechanism of action, 127–128
secondary ion mass spectrometry, 130
X-ray photoelectron spectroscopy, 129–130
Metal effects
ASTM coker modification for, 45
coker tests, 113–114
on deposition in deoxygenated fuels, 106–107
engine component tests, 111–112
flask oxidation studies, 114
JFTOT tests, 112–113
rig tests, 112
summary of, 150
Metal passivators, 123, 151
Metals
dissolved, sources of, 114–115
mechanisms of action, 118–120
solubility, 115
Methylocyclohexane
catalytic decomposition studies, 141
dehydrogenation catalysts, 141
as endothermic fuel, 141, 151
Miceller theory, of deposits, 66
Microbiocides, 124
Micro fuel coker
description, 45
radioactively tagged compounds for
deposition studies, 79
Military aircraft, fuel temperatures,
136–137
Minex heat transfer rig
additives study, 123
calculation methods, 33–34
decay rates of heat transfer coefficients,
34
description, 33–35
flow diagram of, 33
revised version of, 34–35
Modeling, of thermal stability processes,
68–69
Modified fuel coker, 44
Monel 400, heater tube deposits, 116
Multiple tube testers
fuel deposit test apparatus, 41–42
heat transfer unit, 39–41
injector-feed-arm rig, 41

N
Naphthalenes
in heater tubes, 89
release of, 89
NASA Lewis Research Center single tube
rigs
deoxygenation studies in, 100
description, 38–39
heat transfer studies, 64
Naval Air Propulsion Center heat
exchanger, heat exchange
effectiveness factor, 65
Nickel
aluminized, heater tube deposits, 116
dissolved in JP-5 fuels, 115
Nickel 200, heater tube deposits, 116
Nitrogen compounds
effects on
deposit formation, 81
deposition in deoxygenated fuels,
105–106
interaction with acids and sulfur
compounds, 84
summary of effects, 150
tests in static devices, 82–83
Noble metal catalysts, refining with, 90–91
Nozzle fouling
by copper-contaminated JP-5 fuel, 7–8
by copper-generated solids, 111
flow-divider valve depositions, 3
F404 test results, 54
by high aromatic fuel blend, 7–8
test facility, 26–28
tests in GE-NZ apparatus, 52–53
Nozzles
combuster, fuel temperature at, 137
environment at flight idle, 10
T700 engine, 7
weighted temperature parameter, 6–7
Nozzle testers, 6–7, 25–27
F404/T700 test rig schematic, 28
GE-NZ, temperature effects in, 52–53

O
Oil cooler, environment at flight idle, 10
Olefins
effect on n-decane deposit formation, 75
removal, 90–91
Optical interference techniques, for deposit
thickness, 19
Oxidation, kerosenes, dissolved copper and
zinc effects, 114
Oxygen compounds
effects on
deposit formation, 83–84
deposition in deoxygenated fuels, 106
summary of effects, 150
Oxygen contents, reduced
Aero Propulsion studies, 100–101
Exxon studies, 101–103
NASA studies, 100
Shell Development studies, 99–100
UTRC studies, 103

P
Paraffin oxidation, 73–74
Peroxides, effect on deposition in
doxygenated fuels, 106
Petroleum replacements, 151
biomass-derived, 144
c Coal-derived fuels, 143–144
from heavy oils, 144
shale-derived fuels, 142–143
tar sand-derived fuels, 144
Phenols, in heater tubes, 89
Phenyl disulfide, effect on nitrogen compound deposition, 84
para-Phenylenediamine antioxidants, 123
Phillips Petroleum Co. 5-mL bomb technique, 45–46
Phosphorus-containing corrosion inhibitors, 124
Pipeline drag reducer additives, 124
Polar compounds
removal processes, 90
summary of effects, 151
Polar fractions, effect on deposit formation, 83–84
Prediction, deposition rates, 68
Preheater tubes
CRC/ASTM coker, 14
metal composition effects, 111
research coker, 19
Pressure, at flight idle (commercial aircraft), 10
Pressure effects
in advanced kinetic unit, 60
on air-saturated and deoxygenated fuels, 58–59
on deposit buildup, 59
general observations and recommendations, 60
on heat transfer, 59
in JFTOT, 59
on JP-5 fuel in AFDTA, 60
summary of, 149
on USAF special jet fuel with high thermal stability, 60
R
Radioactively tagged compounds, for deposition studies, 78–79
Rating criteria
CRC/ASTM coker, 15
jet fuel thermal oxidation tester, 17
summary of, 149
Rectangular flow tester (UTRC)
deoxygenation studies, 103
design and use, 48
flow rate effects, 61
Refining techniques, 90–91
Residence time, at flight idle, 10
S
Scanning electron microscopy, for deposit morphology, 66–67
Secondary ion mass spectrometry, metal deactivators, 130
Shale-derived fuels
JP-4
additives evaluation, 124–125
antioxidant evaluation, 124–127
as petroleum replacement, 142–143
Shell Development Company single tube rigs, 38
Silver, effects on breakpoints, 116
Simulators (See also specific simulator)
summary of, 148–149
Single tube heat exchanger (UTRC), flow rate effects, 61
Single tube heat transfer rig (Shell Thornton)
applications, 38
copper effects on heat transfer, 112
development, 35, 38
heat transfer coefficient deterioration in, 58
metal deactivator studies, 128–129
sulfur compound studies in, 80
temperature effects in, 55, 58
Single tube testers
advanced kinetic unit, 35–36
AFDTA, 35, 37
deposit composition studies, 86
description, 32–33
DTS-1 unit, 39
fuel coking apparatus, 39
heat exchanger test rig, 29–30
heat transfer rig (Shell Thornton), 16, 35, 38
comparison with CRC/ASTM coker, 16
heat transfer studies, 64–66
Minex heat transfer rig, 33–35
NASA Lewis Research Center apparatus, 38–39, 64
Shell Development Company apparatuses, 38
USSR, 39
Solubility, of metals, 115
Specification methods (See also specific method)
summary of, 148
table of, 14
types of tests, 13
Spraybar tests, for afterburners, 27
Spray patterns, copper contamination effects, 111
SR-71 reconnaissance aircraft, fuel stresses, 137
Stability
definition, 1
storage, 1
Stability—Continued
thermal oxidation (See Thermal oxidation stability)

Stainless steels
- type 304
  deposit thickness on JFTOT tubes, 118
  heater tube deposits, 116
- type 316
  deposit thickness on JFTOT tubes, 118
  heater tube deposits, 116
- type 446, heater tube deposits, 116

Static testers
- color standards for filters, 20
- deposits for Auger electron spectroscopy, 46
- flask oxidation test, 46-47
- Gost Method 9144-79, 14, 21
- Gost Method 11802-66, 14, 21
- for JP-7 fuels, 20
- nitrogen effects on AVTUR, 46
- Phillips 5-mL bomb technique, 45-46
- sulfur effects on AVTUR, 46
- thermal precipitation rating, 20

Steels, type 1015, heater tube deposits, 116

STHTR (See Single tube heat transfer rig (Shell Thornton))

Storage effects
- hydroperoxide formation, 109
  at low temperatures, 89-90

Storage stability, 1

Stress conditions, in aviation turbine engines, 8-11

Sulfides, effect on metal compound deposition, 84

Sulfur, in MEC deposits, 5

Sulfur compounds
- effects on deposition in deoxygenated fuels, 104-106
- interaction with nitrogen compounds and acids, 84
- role in deposit formation, 79-81
  summary of effects, 150

Sulfur dioxide, extraction, 90

Supersonic aircraft
- fuel temperatures, 133-136
  possible fuel system for, 136

Surface finish, deposition rate and, 67-68

Surface temperature, at flight idle, 10

SY2226 (China), 20

Tar sand-derived fuels, 144

Temperature effects (See also Fuel temperature)
in advanced aircraft fuel system simulator (USAF), 51-52
in advanced kinetic unit, 54, 57
in CRC/NAA simulator, 51
deposition rate dropoff, 57-58
fuel storage at low temperatures, 89-90
in GE-nozzle apparatus, 52-53
in heat transfer unit (Esso), 53, 56
at high velocities, 133
in single tube heat transfer rig (Shell Thornton), 55, 58
summary of, 149

Temperatures
- exterior surface (aircraft), 133
- radiation equilibrium surface, 134

T700 engine
- copper effects on nozzle flow rate, 111
- nozzle flow characteristics, 7
- nozzle fouling, 7-8

Test duration effects
- on carbon deposition, 117
- on deposition rate, 63-64

Tetralin, effect on sediment formation, 79

TF30 engines, fuel and wall temperatures, 9

Thermal conductivity, of deposits, 67

Thermally stable kerosene (U.S. MIL-T-25524c)
- CRC coker specification for, 16
- JFA-5 dispersant additive, 124
- JFTOT conditions for, 17

Thermal precipitation rating, for JP-7 fuels, 20

Thermal stability deposition (See Deposit formation)

Thermal stability processes
- aging, 89-90
- chemical, summary of, 150-151
- modeling, 68-69
- physical, summary of, 149-150

Titanium, effect on deposition in deoxygenated fuels, 106

TOS (See Thermal oxidation stability)

Tungsten, effects on breakpoints, 116

Two-step global kinetic mechanism, for deposition rate prediction, 68

U

U.S. Military specifications
- U.S. MIL-T-25524c: 17
- U.S. MIL-T-25524c: Amendment 2, 16

USAF special jet fuel with high thermal stability
metals removal from, 115
pressure effects, 60

V
Vanadium, effects on deposition in
deoxygenated fuels, 106–107

W
Weighted temperature parameter, 6–7, 52
Wing tank testers, 46–48
Wing tank testers (Exxon)
deoxygenation studies in, 101–102
description of, 46–48
nitrogen compound studies in, 81
sulfur compound studies in, 79–80

X
XB-70A aircraft, fuel stresses, 137
X-ray photoelectron spectroscopy, metal
deactivators, 129–130

Z
Zinc
dissolved in JP-4 fuels, 114
dissolved in JP-5 fuels, 115
effects on
  breakpoints, 116
  JP-7 breakpoint, 113–114
  thermal stability, coker tests, 113
mechanism of action, 119
solubility, 115