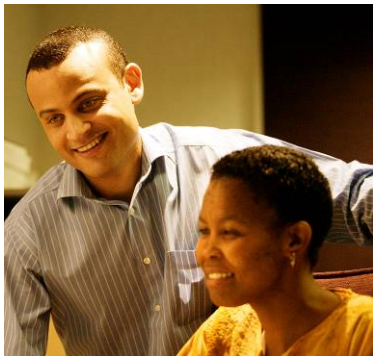


Sasol Synthetic Fuels
Coal to Liquids

Piet Roets
Manager Fuels, US CTL

ICAO Workshop - Aviation and Alternative Fuels

February 10 – 12, 2009

Overview

- Synthetic Fuels Industry in South Africa today
- Sasol Synthetic Fuels technology
- Sasol's CTL & GTL experience
- Approval Process for Sasol Fully Synthetic Jet Fuel
  - *Components*
  - *Properties (Def Stan 91-91)*
  - *Fit for Purpose Tests (Def Stan 91-91 Annex D)*
  - *Component tests*
  - *Research reports*
- Establishing a CTL industry is not without challenges
- Summary

Synthetic Fuels Industry in South Africa today

Sasol Synfuels

- *Coal-fed, supplemented with natural gas*
- *Capacity: 160 000 bpd crude oil equivalent*

Sasol II & III
160 000 bpd

PetroSA

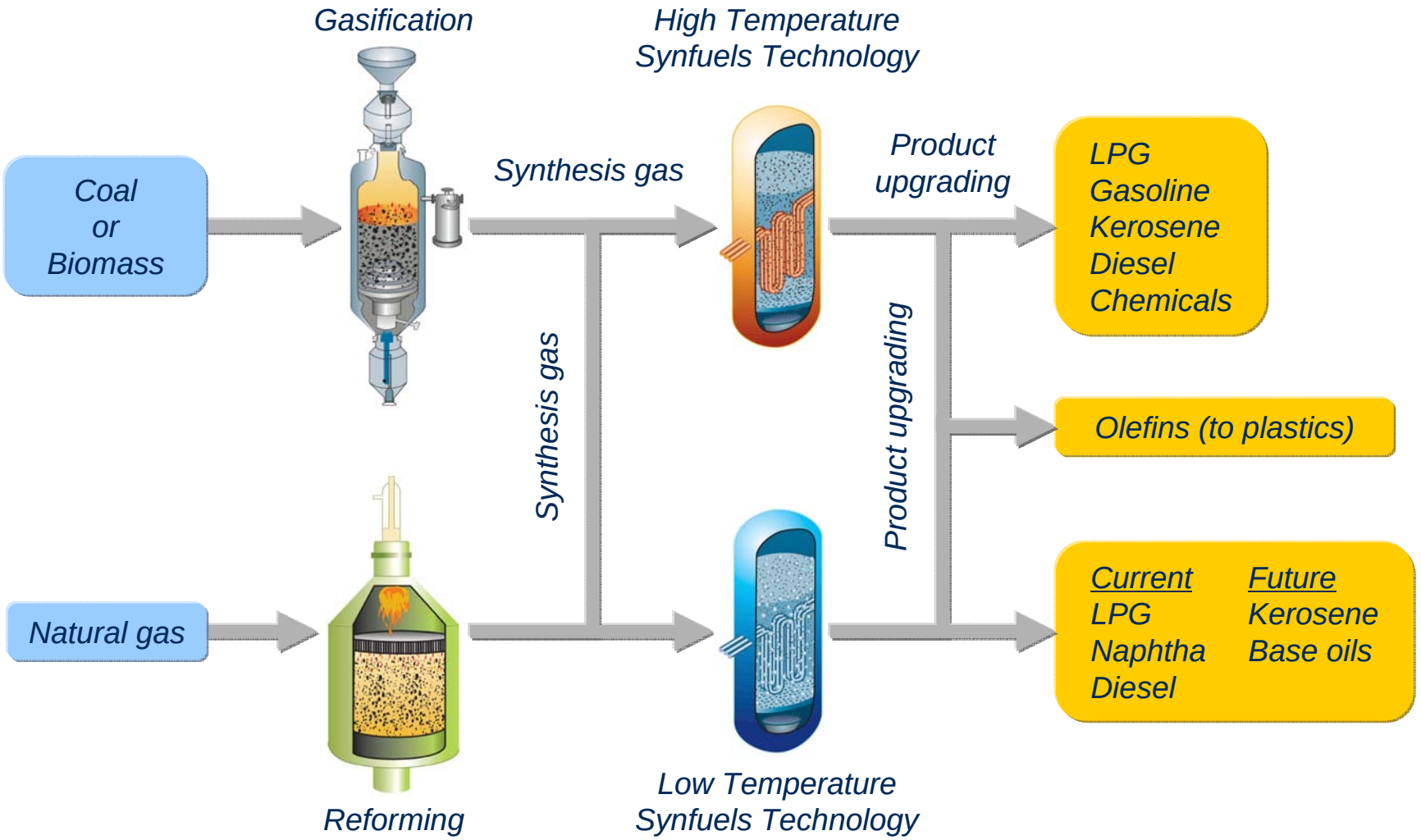
- *Natural gas-fed, some condensate*
- *Capacity: 45 000 bpd crude oil equivalent*

PetroSA
45 000 bpd

Total Capacity:
205 000 bpd (~ 10 million tpa) crude oil equivalent

Synfuels industry supplies ~30% of SA transport fuel consumption

Sasol Synthetic Fuels Technology



Product Slate

LPG

Naphtha

Gasoline

Kerosene

- ***Jet A1 / JP8***

Diesel

Base Oils

Chemicals

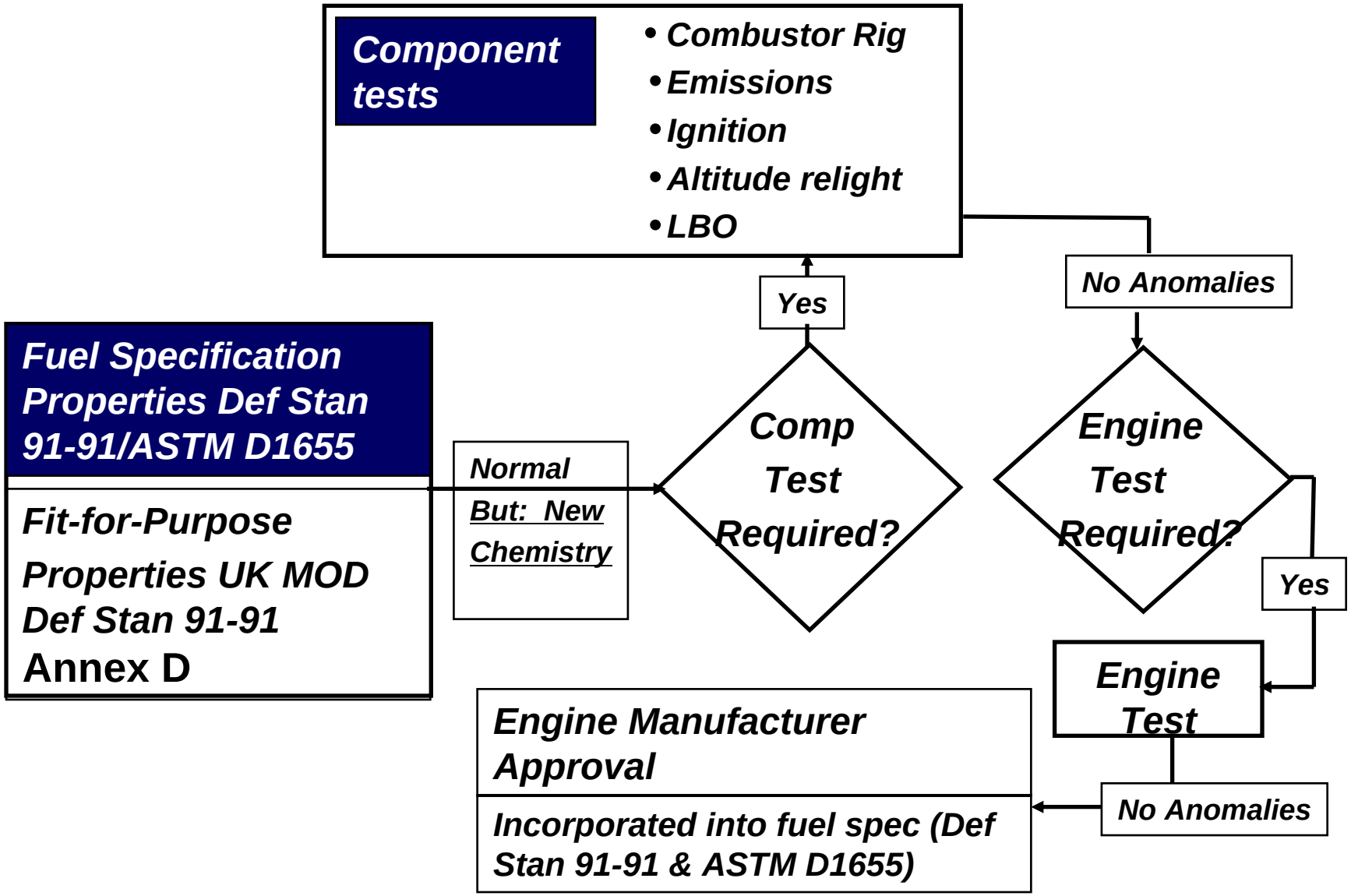
Sasol's CTL & GTL experience

Sasol is the leader in gas-and-coal to liquid technologies and their application

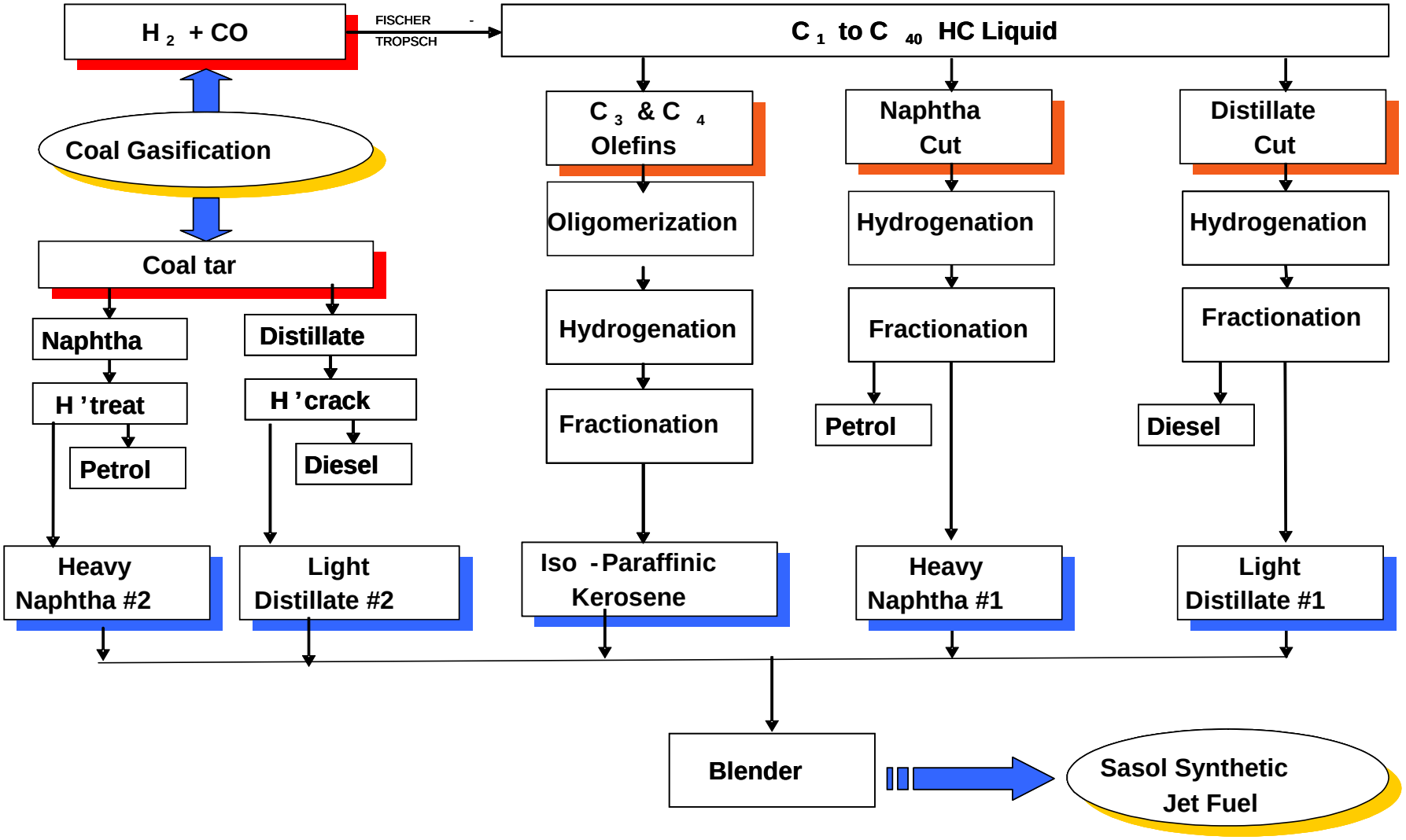
- *50 years experience in developing technology, designing and operating plants*
- *more than 1.5 billion barrels of synthetic fuels produced*
- *currently ~25% of South African fuel is derived mostly from coal*
- *South Africans drive and fly on coal – today*
- *Synthetic jet fuel blends in commercial use for last 10 years*
- *Sasol Fully Synthetic Jet Fuel first 100% synthesized jet fuel approved as commercial aviation turbine fuel (Def Stan 91-91)*
- *Writing Sasol Fully Synthetic Jet Fuel into ASTM D1655 as a specific approval is in process*

Sasol's technology offers a technically proven, commercially viable option - TODAY

Approval Process for Sasol Fully Synthetic Jet Fuel



Sasol Synthetic jet fuel components



Selected Fuel Specification Properties (Def Stan 91-91)

Property	**Test Method**	**Limit**	**FSJF blends**
Aromatics, vol%	D1319/IP156	8 – 25	7.2 – 16.9
Total Sulphur, mass%	IP336	0.3 max	<0.01
T10, ° C	D86/IP123	205 max	175 – 189
FBP, ° C	D86/IP123	300 max	245 – 279
Flash point, ° C	IP170	38 min	51 – 69
Density @ 15 ° C, kg/m3	D4052/IP365	775.0 – 840.0	0.776 – 0.802
Freezing point, ° C	D2386/IP16	-47 max	-55 to -61
Viscosity @ -20 ° C, cSt	D455/IP71	8.0 max	3.48 – 4.69
Smoke point, mm	D1322/IP57	25 min	25 – 40
Specific energy, kJ/kg	D4809	42.8 min	43.1 – 43.8

Sasol 100% synthesized jet fuel meets all commercial Jet A1 specifications

Fit for Purpose Tests (Def Stan 91-91 Annex D)

- **Physical properties vs. T**
  - *Density*
  - *Viscosity*
  - *Specific heat*
  - *Thermal conductivity*
  - *Bulk modulus*
  - *Surface tension*
- **Thermal stability**
- **Density vs. dielectric**
- **Lubricity**
- **Storage stability**
- **Hydrocarbon composition**
- **Trace materials**
  - *Organics*
  - *Inorganics*
  - *Metals*
- **Water separation**
- **Additives**
- **Materials compatibility**
  - *Elastomers*
  - *Metals*
  - *Other non-metals*

Sasol 100% synthesized jet fuel properties and characteristics indistinguishable from conventional jet fuel

Component tests

- **Endurance Engine Test**
  - *Evaluation of impact of Sasol FSJF on engine performance and operation*
  - *Fresh JT9-D engine*
  - *500 commercial cycles*
- **Combustor Rig Tests**
  - *Low-temperature atomization*
    - *Honeywell*
    - *Addressed APU start on cold-soaked fuel (-40C)*
- **Emissions**
  - *Pratt & Whitney Talon combustor*
- **Cold Start & altitude relight**
  - *Main engine: R-R Trent combustor*
- **Altitude Lean Blow Out**
  - *Honeywell combustor rig*

No degradation of engine performance

Combustion characteristics are normal for viscosity and boiling point distribution; synthetic hydrocarbons are not different

SwRI Reports submitted to UK MOD

EVALUATION OF SASOL SYNTHETIC KEROSENE FOR SUITABILITY AS JET FUEL

C. A. Moses
G. Wilson, III
Southwest Research Institute
6220 Culebra Road
San Antonio, TX USA

Piet Roets
Sasol Oil R&D
Sasolburg, Republic of South Africa

DECEMBER 2003

Report No. 08-04438-2

EVALUATION OF SASOL SYNTHETIC KEROSENE FOR SUITABILITY AS JET FUEL

PHASE II: ENGINE AND COMBUSTOR TESTS

Prepared by

Clifford A. Moses
Fuels and Lubricants Technology Department
Southwest Research Institute® (SwRI®)
6220 Culebra Road
San Antonio, TX 78238

Final Report
SwRI® Project No. 08-04438

Prepared for

Sasol Technology Fuels Research
1 Klasie Havenga Road
PO Box 1, Sasolburg
SOUTH AFRICA

September 2007

SOUTHWEST RESEARCH INSTITUTE®
SAN ANTONIO HOUSTON WASHINGTON, DC

UK MOD Def Stan 91-91 Issue 6

Ministry of Defence
Defence Standard 91-91

Issue 6 Publication Date 8 April 2008

Turbine Fuel, Aviation Kerosine Type,
Jet A-1
NATO Code: F-35
Joint Service Designation: AVTUR

IMPLEMENTATION DATE: 8 July 2008

D.4 Specific Approvals

D.4.2 Sasol Fully Synthetic Jet Fuel

D4.2.1 ***Sasol synthetic kerosene, see clause D.4.2.4, is currently the only fully synthetic jet fuel which has been approved for use.***

D.4.2.2 The aromatic content of Sasol fully synthetic fuel shall not be less than 8.0% nor greater than 25.0% by volume when using method IP 156, or less than 8.4% nor greater than 26.5% by volume when using method IP 436. The fuel shall exhibit a maximum wear scar diameter of 0.85 mm when tested by ASTM D5001. Analysis for these properties shall be made at the point of manufacture. These results shall be included on the batch certificate for the fuel.

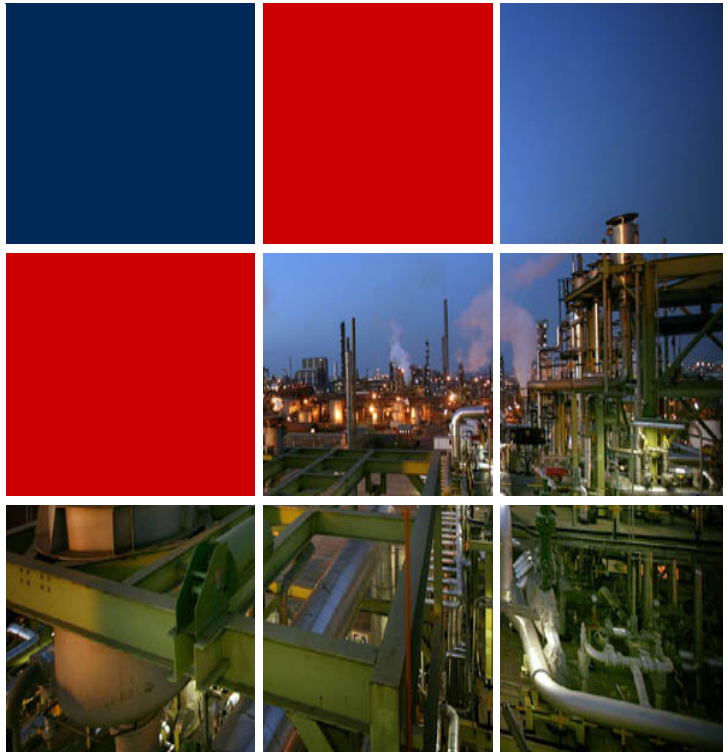
D.4.2.3 The flash point shall be no greater than 50° C. The boiling point distribution shall have a minimum slope defined by T50-T10 ≥ 20° C and T90-T10 ≥ 40° C when measured by IP 123 / ASTM D86.

D.4.2.4 ***Sasol fully synthetic kerosene is defined as that material blended from light distillate, heavy naphtha and iso-paraffinic kerosene streams manufactured at the Secunda plant*** as described in the SwRI reports number 08-04438 and 08-04438-2. The batch certificate for the fuel shall state that the fuel contains 100% synthetic components.

Establishing a CTL industry is not without challenges

The Challenges in the Global Market

- *World energy markets are volatile*
- *Competition for resources*
- *Investment decisions on large capital projects are risky*
- *Uncertainty of global Greenhouse Gas framework*
- *Objections to coal use*



The cost of projects are high

In summary

- *CTL has been demonstrated as source of jet fuel for the future*
- *CTL can be a significant part of a portfolio of measures to address future energy security*
- *Sasol leads GTL and CTL operations and development globally*
- *South Africa's government and economy are being handsomely rewarded for enabling a CTL industry*
- *A number of countries are at various stages of development of a CTL industry*
- *There is an urgent need for objective debate by decision makers to ensure sustainable energy solutions for the future*