Training Guidelines for the Fire Debris Analyst

Lesson Plan (Module) 3

Date: December 2004 **Instructor:** Qualified Instructor

Subject: Refinery Process **Total Time:** 8 hours

Learning Objectives

- Demonstrate a basic understanding of the process of refining petroleum products from crude oil
- Describe and evaluate domestic and foreign sources of crude oil used in petroleum product manufacturing
- Describe the distillation process of crude oil in terms of the categories of products recovered
- Describe the general physical and chemical properties of each distillation fraction
- Relate these fractions to commercially available petroleum products and their use
- Describe other physical separation techniques used in refinery processes
- Describe the chemical conversion processes of cracking, alkylation, reformation, and others, used to increase yield and improve specifications of fuel and specialty products

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Suggested Reading

1. Petroleum Refining: Technology and Economics, James H. Gary, and Handwerk, Glen E., Marcel Dekker Inc., 4th edition, 2001, ISBN: 0824704827
2. Chemistry of Catalytic Processes, McGraw-Hill Chemical Engineering series, Gates, Bruce et al, McGraw-Hill College, ISBN: 0070229872
3. The Chemistry and Technology of Petroleum , Speight, James G., Marcel Dekker Inc; 2nd/Rev edition, 1991, ISBN: 0824784812
4. *Petroleum (Refinery Process, Survey), and Petroleum Products*, Kirk-Othmer Encyclopedia of Chemical Technology, Concise, Kirk, Raymond E. and Othmer, Donald F. (Editors), Wiley-Interscience, 4th edition, 2003, ISBN: 0471646865
5. Chromatography in Petroleum Analysis, Altgelt, K., Marcel Dekker Inc;1979 ISBN: 082476790X
6. "Petroleum: Its composition, analysis and processing", King, Richard W., Occupational Medicine: State of the Art Reviews, Vol. 3 (3), July-September 1988, pages 409-430.
7. "The Implications of refining operations to the characterization and analysis of arson accelerants", Thornton, J. I. and Fukayama, B., Arson Analysis Newsletter, Part I.

Physical Separation, May 1-16, Part II. Chemical Conversions, Treating Processes, and Subsidiary Processes, August 1-16, 1979.
8. Petroleum Refining in Non-Technical Language, Leffler, William L., PennWell Corp., Tulsa, 3rd edition, 2000, ISBN: 087814776-4

Introduction

This lesson will provide a brief history of the petroleum refining industry, crude oil sources, and a basic understanding of the processes of refining petroleum from crude oil. The student should gain an insight of how the raw product is manipulated to create products for a variety of purposes. The student should also learn the physical and chemical characteristics of the categories of petroleum products to assist in the identification of a specific product encountered in a forensic fire debris case.

Outline

1. Crude Oil Sources and Composition
    a. Domestic
    b. Foreign
    c. Miscellaneous sources, e.g. shale, tar sands, recycled
    d. Varied amounts of hydrocarbons, sulfur, nitrogen, oxygen, trace metal
    e. “Sweet” vs “Sour”

2. Refining Processes
    a. Desalting
    b. Various physical separations processes
    c. Distillation fractions
    d. Physical and chemical properties of distillation fractions
    e. Various chemical conversion processes
    f. Increasing yield
    g. Improving specifications, i.e. octane, cetane
    h. Additive packages
    i. Blending

3. Relating Refinery Fractions to Commercially Available Products

4. Distribution
    a. Pipeline
    b. Tankers
    c. Trucks
    d. Storage
    e. Exchange agreements

5. Obtaining Specific Product Information

Teaching Aids

Handout
PowerPoint presentation
Interpretation of MSDS, other manufacturer product information
Refinery tour (real or virtual)

Summary

Knowledge of the varied properties of crude oil and of the various methods used to process crude oil to obtain the many specific petroleum products will assist the fire debris analyst in interpreting chromatographic results and comparing evidentiary samples to commercially available products.

Test Questions

1. The cracking process is a chemical conversion process to convert saturated hydrocarbons to aromatic compounds. True or **False**
   *The **reformation** process is a chemical conversion process to convert saturated hydrocarbons to aromatic compounds.*

2. Sweet crude oil has a sulfur content below .9 wt percent. True or **False**
   *Sweet crude oil has a sulfur content below **.5** wt percent.*

3. Most modern refinery operations accomplish desalting by mixing the crude oil with water and allowing salts to settle in the bottom layer of brine. True or **False**
   *Most modern refinery operations accomplish desalting by **high voltage electrostatic separations. Settlement is an older technique.***

4. Kerosene is an example of a blended petroleum product. True or **False**
   *Kerosene is an example of a **straight run distillation** petroleum product.*

5. The purpose of alkylation is to create products to blend into gasoline for the purpose of improving ignition quality. **True** or False

6. Crude oil from different regions contains paraffins, cycloparaffins, olefins, and aromatics which vary in percent amount present depending on the region of origin. True or **False**

Crude oil from different regions contains paraffins, cycloparaffins, no olefins, and aromatics which vary in percent amount present depending on the region of origin.

7. Isopars are a light to medium straight run petroleum distillation product. True or **False**
Isopars are a light to heavy specialty petroleum product.

8. Mineral spirits used as dry cleaning fluid is called Stoddard solvent. **True** or False

9. Small amounts of isopentane and butane might have been added to gasoline to make a car easier to start in cold weather. **True** or False

10. Crudes of older geologic age generally contain higher quantities of normal paraffins. **True** or False

11. Aviation gas and JP-4 are chemically similar products used by the aviation industry. True or **False**
Av gas is a light range petroleum product while JP is heavy range petroleum product.

12. Light straight run gasoline is a mixture of C5-C15 hydrocarbons. True or **False**
C5-C11

13. Kerosene was patented by Canadian geologist Abraham Gesner in 1854. **True** or False

14. In the distillation process, crude oil is preheated to 425 F. True or **False**
In the distillation process, crude oil is preheated to 600 F by counter current heat exchangers or either to 700-750 F in a fired furnace, and introduced near the bottom on a distillation column, where steam is introduced.

15. For all questions above answered False, correct the statement to make the statement true.

16. List 5 refinery processes used to physically separate crude oil. Briefly describe how the processes accomplish separation.

17. List 5 refinery process used to chemically separate crude oil. Briefly describe how the processes accomplish separation.

18. List the 6 primary straight run products which result from fractional distillation of crude oil. For 3 of these, list 3 common commercially available products.

19. Explain octane numbers.

20. List 5 major compounds in gasoline.