

## Determination of Aromatic Hydrocarbons in Jet Fuel by LC-RID According to ASTM D6379 / IP436 using a Two-column Set

### ■ Introduction

The test method presented here is applicable to the determination of mono- and di-aromatic hydrocarbon content in aviation fuels and middle distillates with boiling points in the range of 50° C to 300° C in accordance with ASTM D6379 and IP436. This application is relevant to some of the most commonly-used aviation fuels, such as Jet A and Jet A-1. The accurate determination of the aromatic content of fuels is critical to assessing their quality and combustion characteristics. These parameters are crucial to ensuring aviation safety and compliance with environmental regulations.

This methodology presents an alternative to ASTM D1319. Though ASTM D1319 has enjoyed widespread use, it relies on the use of a fluorescent dye which was discontinued, and the replacement no longer produces reliable results, particularly for middle distillates. As such, many laboratories are exploring alternative methods, including ASTM D6379 / IP436, for determination of the total aromatics in kerosene and jet fuels.

This application news demonstrates the use of the Shimadzu Prominence™ HPLC for the determination of mono- and di-aromatic hydrocarbons in aviation fuel and other middle distillates in compliance with parameters set out in ASTM D6379 and IP436. Due to the use of a two-column set, the instrument is also in compliance with ASTM D6591 with minimal changes to the instrument configuration.



Prominence™ HPLC System

### ■ Experimental Design

#### Instrument

Shimadzu Prominence HPLC

- LC-20AD HPLC Pump
- DGU-20A<sub>3R</sub> Degasser
- SIL-20AC Autosampler
- CTO-20A Column Oven with 6-port 2-position valve
- RID-20A Refractive Index Detector

#### Software

LabSolutions™ LC/GC

#### Columns

1. Shim-pack™ GIST NH<sub>2</sub> 4.6×250 mm, 5 μm (P/N 227-30302-08)
2. Shim-pack™ GIS CN 4.6×150 mm, 5 μm (P/N 227-30263-06)

#### Reagents

Mobile Phase: Heptane, HPLC Grade

#### Standards

ASTM D-6379 Kit from AccuStandard®

- System Resolution Standard: cyclohexane (10 mg/mL), *o*-xylene (0.5 mg/mL), 1-methyl naphthalene (0.05 mg/mL) in *n*-heptane
- Four (4) calibration standards as shown in Table 1.

#### Valve Operation

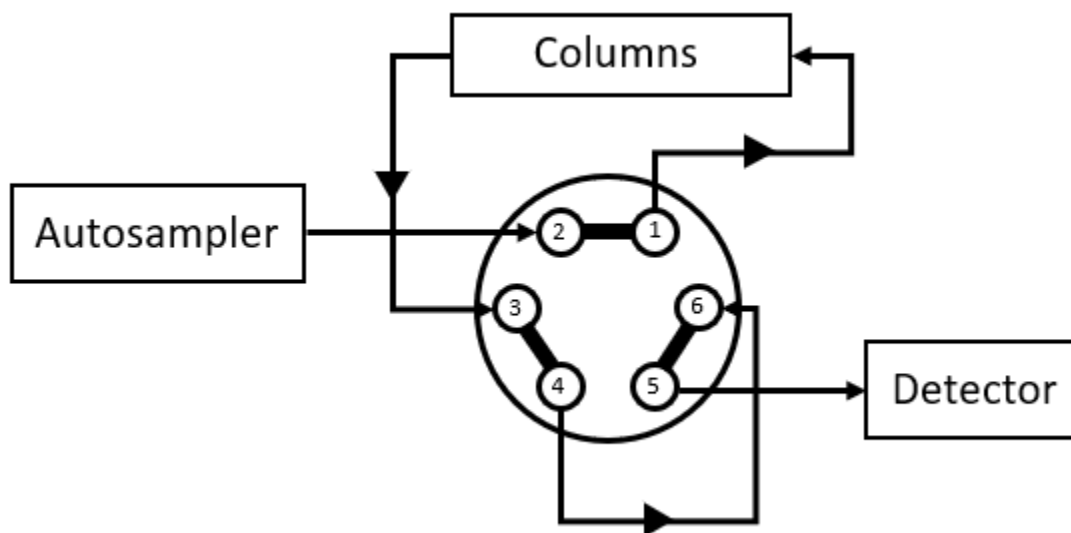
This system contains a 6-port, 2-position valve within the analytical line and is operated in the 1 → 6 position (Fig. 1). The valve is not actuated for this method but is included because other methods such as ASTM D6591 / IP391 can be run on the same system and require a valve switch for back-flushing of more retained compounds such as tri-aromatic hydrocarbons.

#### Analytical Conditions

- Mobile phase flow rate: 1 mL / min
- Injection volume: 1 μL
- Column temperature: 35° C
- RID temperature: 35° C

**Table 1:** Standard analytes and concentrations

Analyte	Standard 1 (mg/mL)	Standard 2 (mg/mL)	Standard 3 (mg/mL)	Standard 4 (mg/mL)
Cyclohexane	5	2	0.5	0.1
<i>o</i> -Xylene	15	5	1	0.1
1-Methylnaphthalene	5	1	0.2	0.05



**Figure 1:** Simplified flow schematic of the HPLC used for this application

### ■ Results

An injection of the system resolution standard (SRS) demonstrated method-appropriate resolution of the three component peaks (Fig. 2). Cyclohexane, a proxy for saturated compounds of samples, eluted at 5.10 minutes, whereas *o*-Xylene, a proxy for mono-aromatic hydrocarbons (MAHs), eluted at 6.56 minutes. Finally, 1-Methylnaphthalene eluted at 8.02 minutes and serves as a proxy for di-aromatic hydrocarbons (DAHs). The resolution of cyclohexane and *o*-Xylene was 8.9, which exceeds both the ASTM and the IP standards of 5 and 5.7, respectively.

Calibration curves generated for the compounds and at concentrations outlined in Table 1 were linear, with  $r^2$  values of 0.9999 for both *o*-Xylene and 1-Methylnaphthalene (Figs. 3 and 4).

To assess precision, three replicate injections were made of Standard 2. The RSDs for retention times of the peaks and peak areas were less than 0.5% and 0.3%, respectively.

A sample of Jet A fuel, obtained from the fuel depot at a local airport, was diluted 1:10 in heptane and injected to assess the efficacy of this instrument on real samples. An example chromatogram is provided in Figure 5. The separation of the saturates, MAHs, and DAHs is sufficient for quantitation per ASTM D6379.

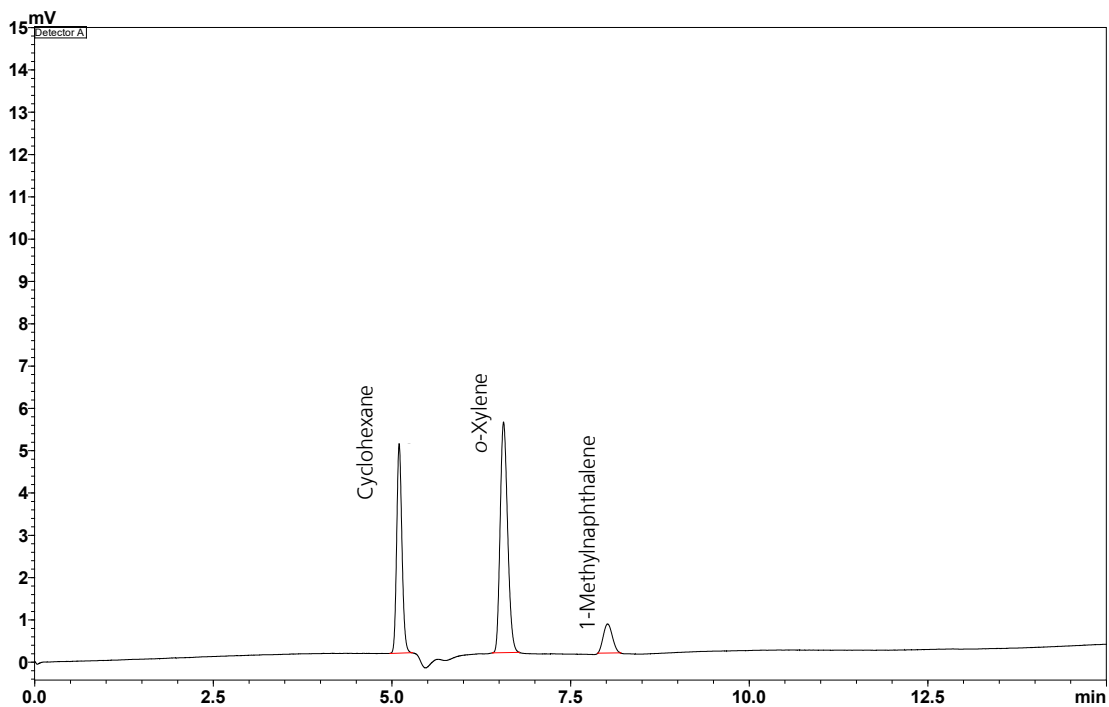


Figure 2: Chromatogram resulting from injection of the System Resolution Standard

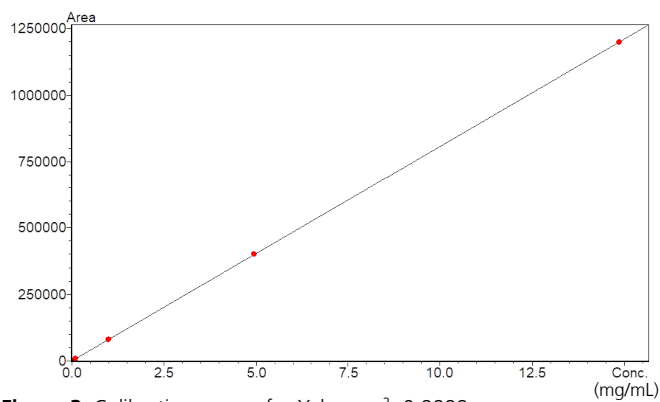


Figure 3: Calibration curve of o-Xylene.  $r^2=0.9999$

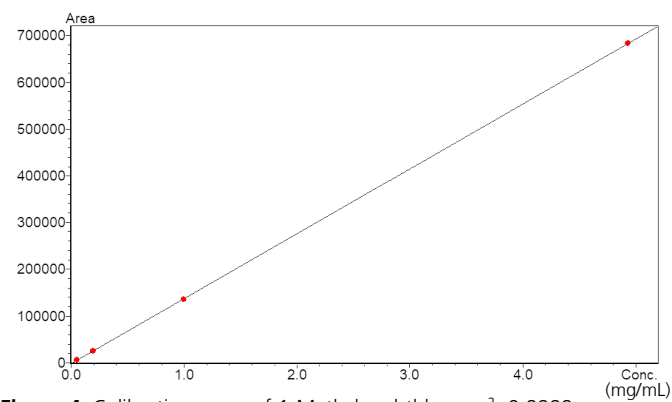


Figure 4: Calibration curve of 1-Methylnaphthalene.  $r^2=0.9999$

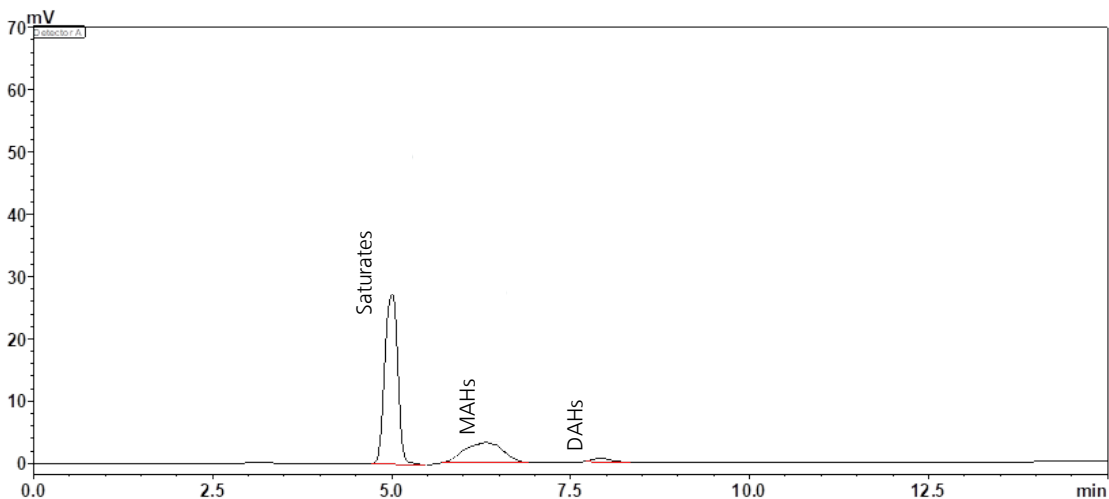


Figure 5: Injection of Jet A diluted 1:10 in heptane

### ■ Discussion and Conclusions

This application news demonstrates the detection and quantitation of MAH and DAH using a Prominence HPLC, as well as method compliance for ASTM D6379 / IP436. Coefficients for the calibration curves with  $r^2$  values greater than 0.9999 indicate a strong linear response of these compounds and exceed the requirements of the method.

The two-column set used in this application maintains minimal analysis times and ensures compliance with resolution standards set by ASTM D6379 and IP 436 of 5 and 5.7, respectively. Additionally, the two-column set provides a robust solution that minimizes column reconditioning or replacement. Finally, the set is also in compliance with ASTM D6591, allowing a single instrument to be used for both methods without modification.

Results generated by this method on both system check standards and real samples demonstrate its acceptability as an alternative to ASTM D1319, which has become difficult to apply to middle distillates due to the unsuitability of the fluorescent dye used in the method.

### ■ References

- ASTM D1319-18, Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption, ASTM International, West Conshohocken, PA, 2018, [www.astm.org](http://www.astm.org)
- ASTM D6591-18, Standard Test Method for Determination of Aromatic Hydrocarbon Types in Middle Distillates—High Performance Liquid Chromatography Method with Refractive Index Detection, ASTM International, West Conshohocken, PA, 2018, [www.astm.org](http://www.astm.org)
- ASTM D6379-11, Standard Test Method for Determination of Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates—High Performance Liquid Chromatography Method with Refractive Index Detection, ASTM International, West Conshohocken, PA, 2011, [www.astm.org](http://www.astm.org)

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