

# Determination of the instrument detection limit of the TSQ 9610 triple quadrupole GC-MS/MS with Advanced Electron Ionization (AEI) source

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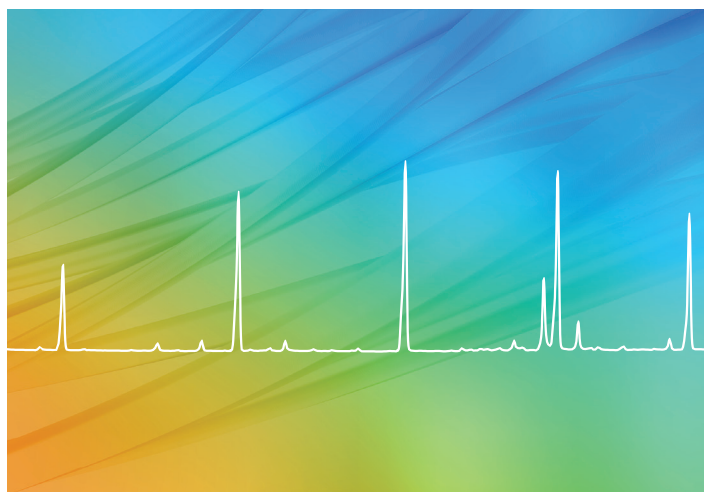
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## Introduction

To determine whether a GC-MS/MS system can meet the sensitivity requirements set by regulations in the application of choice, the detection limit of the instrument is used. Historically the signal-to-noise ratio (S/N) has been used to convey the detection limit. However, the advancements of MS technologies have resulted in reduction of noise and increase in sensitivity; this combined with lower bleed GC columns producing sharper peaks has caused signal-to-noise calculations to increase exponentially. On many GC triple quadrupole instruments, the added selectivity leads to much lower baseline noise with regions of chromatograms with zero noise. This renders the use of S/N inadequate for the measurement



of instrument detection limits. Therefore, a more accurate or statistically significant method of calculating the detection limit of an instrument is required.

## Instrument detection limit

To determine the instrument detection limit (IDL), the standard deviation of the response of multiple injections of an analyte of choice at a concentration close to the estimated detection limit is utilized. This approach gives a much more reliable limit of detection (LOD) value as it considers not only the signal intensity, but also the consistency of the response. Method detection limits (MDL) are firmly established with many regulatory bodies and can be defined in numerous ways.

According to the most recent U.S. Code of Federal Regulations,<sup>1</sup> MDL is defined as “the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.” This methodology can be seamlessly transferred when calculating IDL. Unlike MDL, the IDL uses solvent- standards containing a test chemical at concentrations that give a consistent response over several repeat injections (e.g., %RSD <10). Therefore, the IDL is a statistically rigorous method that uses the precision of a measurement at low analyte levels and accurately reflects the true detection limit of an instrument, ultimately defining how sensitive an analytical system is. The IDL can be determined by using the following equation.<sup>2</sup>

$$IDL = t \times \text{Amount} \times \%RSD$$

Where, t = student t-value for one-tailed distribution:  
for n = 8 injections; t = 2.998

Amount = amount of analyte (on-column)

%RSD = relative standard deviation of the response

During this study, the consistency in IDL for octafluoronaphthalene (OFN), a commonly used reference compound in GC-MS systems, was determined on the Thermo Scientific™ TSQ™ 9610 triple quadrupole GC-MS/MS system with NeverVent™ technology equipped with the Thermo Scientific™ Advanced Electron Ionization (AEI) source operating in EI mode. The AEI source is an electron ionization source where the filament is placed in-line with the direction of the ion beam. More details about this source can be found in Reference 3.

## Experimental

The TSQ 9610 system with a NeverVent AEI source coupled to a Thermo Scientific™ TRACE™ 1610 GC and a Thermo Scientific™ AS 1610 liquid autosampler. Experimental details are reported in Table 1. A 1 µL injection solution containing 1 fg/µL OFN in iso-octane was used for the experiment. A series of injections were made to perform this test, and the IDL was calculated from eight sequential replicate injections.

**Table 1. Experimental conditions for TSQ 9610 NeverVent AEI and TRACE 1610 GC**

AS 1610 autosampler	
Syringe	10 µL, 25 gauge, 50 mm length, cone tip (P/N 36500525)
Injection volume	1 µL
Pre-injection solvent and cycles	None
Sample rinses	3
Post-injection solvent and cycles	None
TRACE 1610 GC system	
Column	Thermo Scientific™ TraceGOLD™ TG-SQC, 15 m × 0.25 mm × 0.25 µm
Liner	Splitless liner single taper with wool, 4 mm i.d., 78.5 mm length (P/N 453A1925)
SSL mode	Splitless
Inlet temperature	220 °C
Split flow	50 mL/min
Splitless time	0.5 min
Septum purge flow	Constant flow of 5.0 mL/min
Carrier flow	Constant He flow of 1.2 mL/min
Oven program	45 °C (0.5 min), 40 °C/min to 190 °C (0 min)
TSQ 9610 GC-MS system	
MS transfer line temperature	250 °C
Ion source temperature	200 °C
Source type	Advanced Electron Ionization (AEI) with NeverVent technology
Ionization mode, electron energy	EI, 50 eV
Emission current	50 µA
Scan start	2.40 min
Precursor Ion	<i>m/z</i> 272
Product Ion	<i>m/z</i> 222
Collision energy	20 eV
Q1 resolution	Widest (2.5)
Q3 resolution	Widest (2.5)
Dwell time	0.2 s
Detector gain	2.10E+06

## Results and discussion

The TSQ 9610 NeverVent AEI system IDL was evaluated using sixteen sequential replicate injections of a 1 fg/µL octafluoronaphthalene standard in iso-octane. The peak area response trend over the 16 injections is shown in Figure 1. Stable area response over these injections was observed with %RSD of less than 7%.

The minimum %RSD over 8 consecutive injections was 4.1% and resulting in a calculated IDL of 0.12 fg. Figure 2 shows the overlay of eight injections. To verify the IDL, a standard of OFN at 0.1 fg was injected. Figure 3 shows the injection of this low-level standard that can be clearly detected on the system. The calculated peak-to-peak signal-to-noise ratio was 4 to 1.

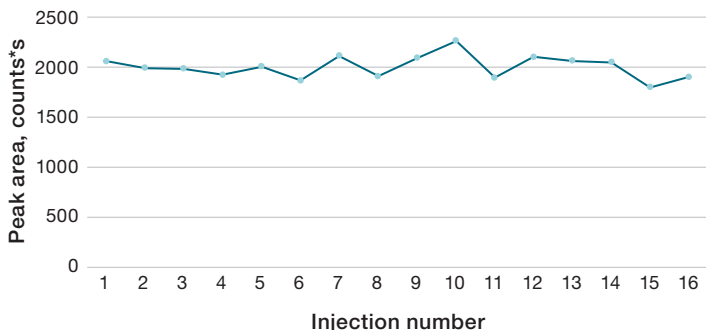


Figure 1. Absolute peak area responses over 16 injections

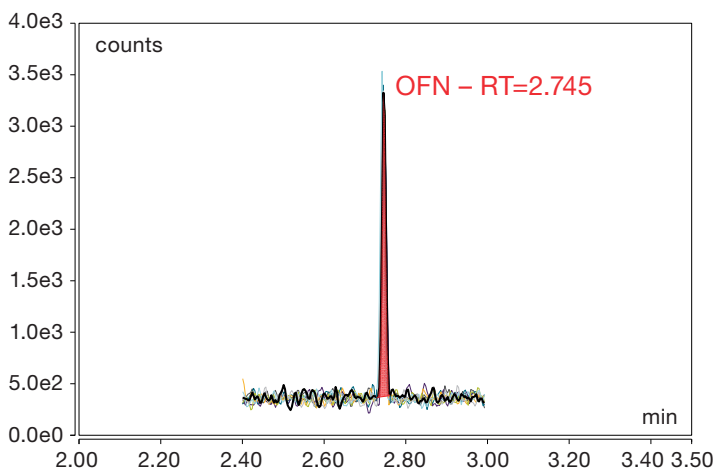


Figure 2. Overlay of eight consecutive 1 fg on-column OFN injections with %RSD of 4.1%. The calculated IDL is 0.12 fg.

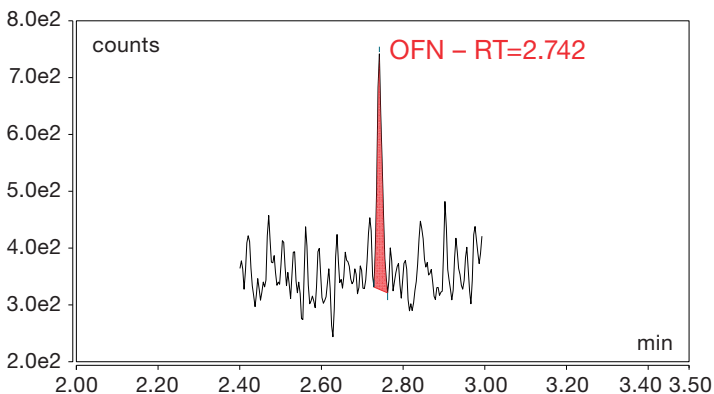


Figure 3. Chromatogram of 0.1 fg OFN on-column with a signal-to-noise ratio of 4 to 1

The TSQ 9610 GC-MS/MS system provides sensitive and consistent results due to innovative technologies. The off-axis ion source and unique s-shaped ion-guide create a curved path, which allows chemical and neutral noise to be kept to a minimum, thus enabling lower detection limits. This design ensures the quadrupoles on the system are protected from interferences and eliminates the need for any heating of the quadrupoles. The sensitivity to detect and amplify the low number of transmitted ions needed at this challenging analyte concentration is provided by the Thermo Scientific™ XLXR™ detector.

## Conclusion

The TSQ 9610 system with the AEI ion source exhibits outstandingly low instrument detection limits, ensuring confidence in your analysis. The use of a statistical method to determine the IDL demonstrates the consistent and sensitive detection that can be achieved at this challenging analyte concentration. The detection limits using a 1 fg on-column amount have been shown to be highly reproducible. The exceptionally sensitive XLXR detector, complemented by the innovative s-shaped ion guide, effectively reduces noise while maintaining maximum sensitivity, leading to IDLs below 0.3 fg on column.

## References

1. U.S. Code of Federal Regulations, 49 FR 43430, (Oct. 26, 1984); 50 FR 694, 696 (Jan. 4, 1985), as amended at 51 FR 23703 (June 30, 1986), [http://www.ecfr.gov/cgi-bin/text-idx?SID=efe93db42854f88dffcf66ba8de737e6&mc=true&node=ap40.23.136\\_17.b&rgn=div9](http://www.ecfr.gov/cgi-bin/text-idx?SID=efe93db42854f88dffcf66ba8de737e6&mc=true&node=ap40.23.136_17.b&rgn=div9)
2. International Union of Pure and Applied Chemists (IUPAC), [http://media.iupac.org/publications/analytical\\_compendium/Cha18sec437.pdf](http://media.iupac.org/publications/analytical_compendium/Cha18sec437.pdf)
3. Thermo Scientific. Technical Note 10597: Practical determination and validation of instrument detection limit for the Thermo Scientific ISQ 7000 Single Quadrupole GC-MS system with Advanced Electron Ionization source. <https://assets.thermofisher.com/TFS-Assets/CMD/Technical-Notes/tn-10597-gc-ms-idl-isq-7000-aei-tn10597-en.pdf>

Find out more at [thermofisher.com/TSQ9610](http://thermofisher.com/TSQ9610)

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