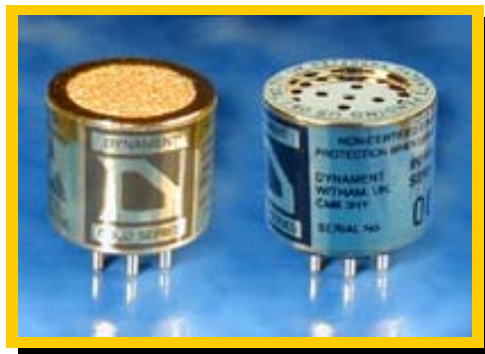


**Application Note AN6**

**MINIATURE INFRARED  
GAS SENSORS  
GOLD SERIES**

UK Patent App. No. 2372099A  
USA Patent App. No. 09/783,711  
World Patents Pending

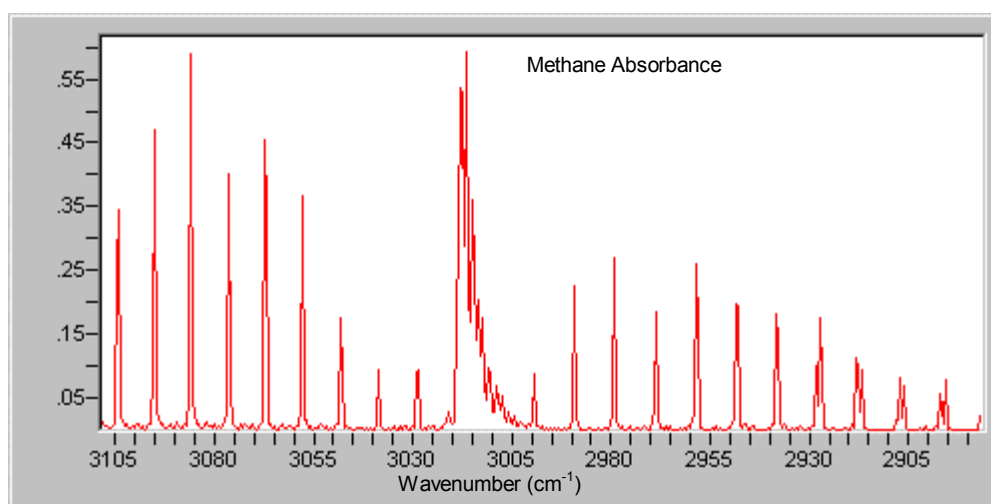
**RELATIVE RESPONSES**

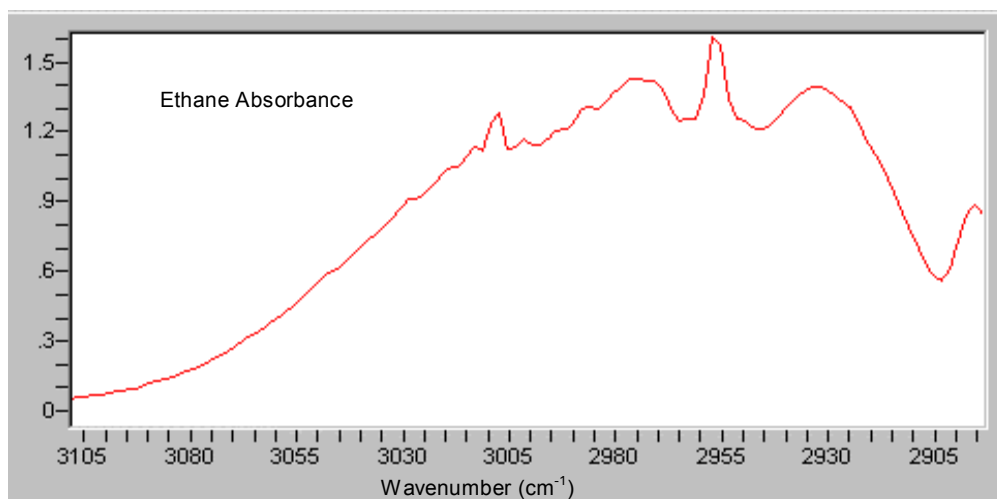
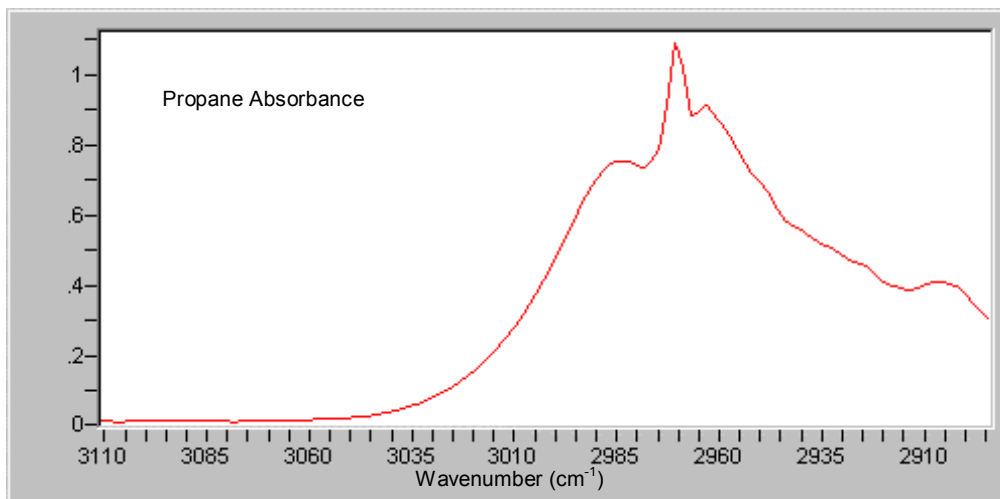


The MSH-HC sensors essentially respond to aliphatic C-H bonds, although olefinic and some other C-H bonds are also detected, as discussed in our application note AN0004 "Infrared Spectroscopy". We continue to gather data on various gases in order to examine the relative responses when compared to %l levels of standard alkanes (methane being the norm) and also linearity characteristics. If required, the linearity can be optimised for specific gases by a change to one or both of the linearisation constants used in the linearisation software.

Referencing to methane:

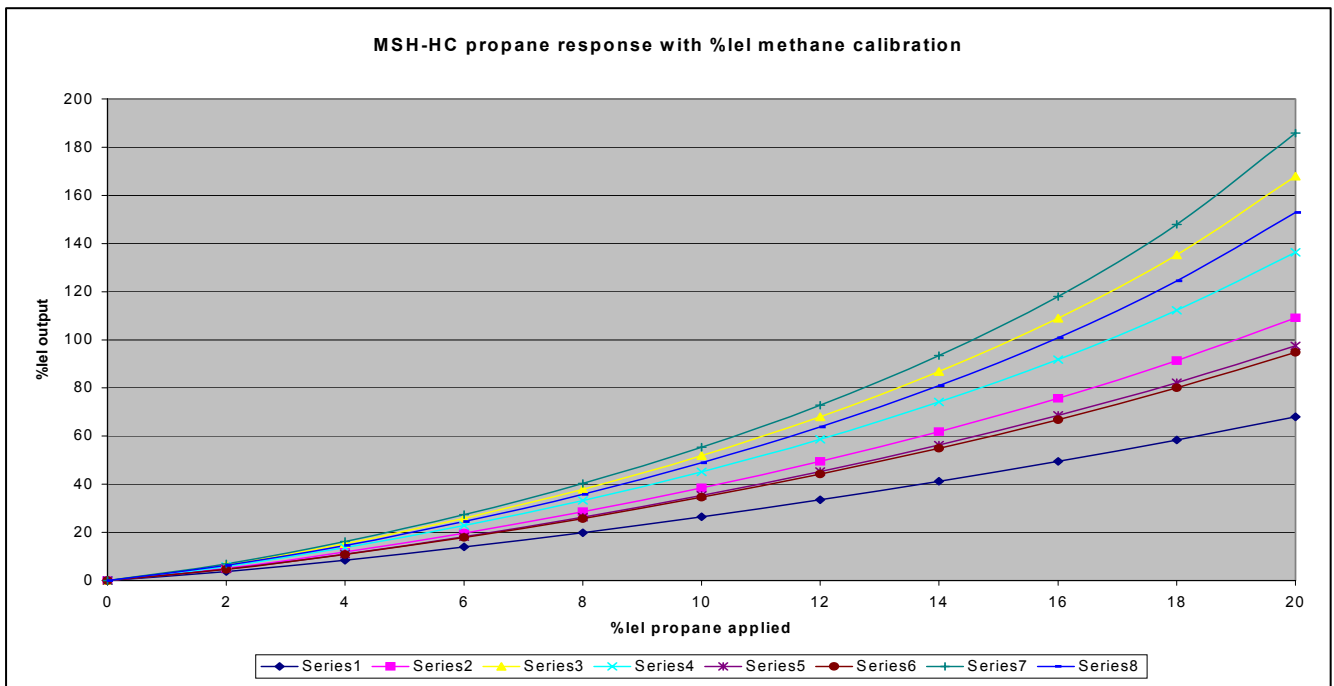
If we look at the IR spectra of the simple alkane range then it is clear that methane is the exception:





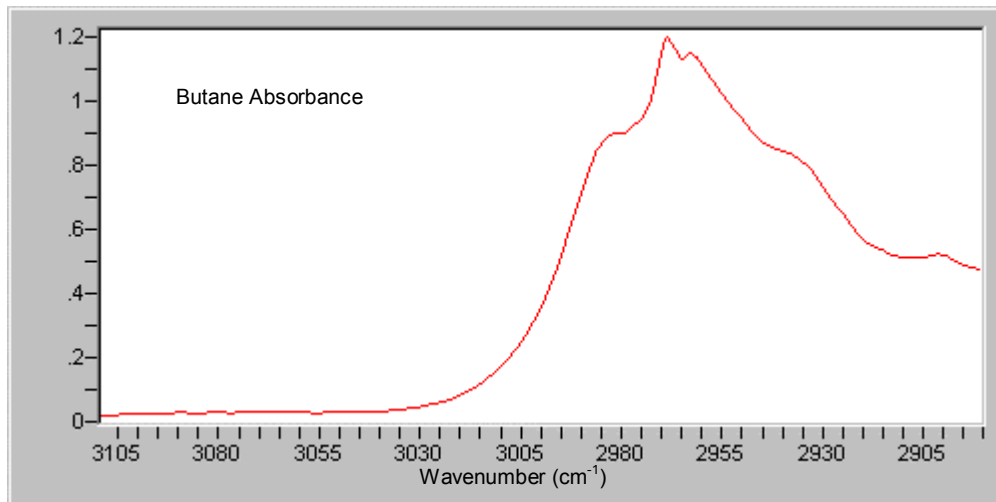
The methane spectrum has a comb like structure, which means that many of the wavelengths within the optical passband of the detector are not contributing to an absorbance signal. This is as opposed to a continuum absorbance band such as for ethane, propane, etc in the optical passband of the detector where all the wavelengths tend to contribute to the signal. The result of this is a variance in the linearity coefficients, which derive the gas concentration.

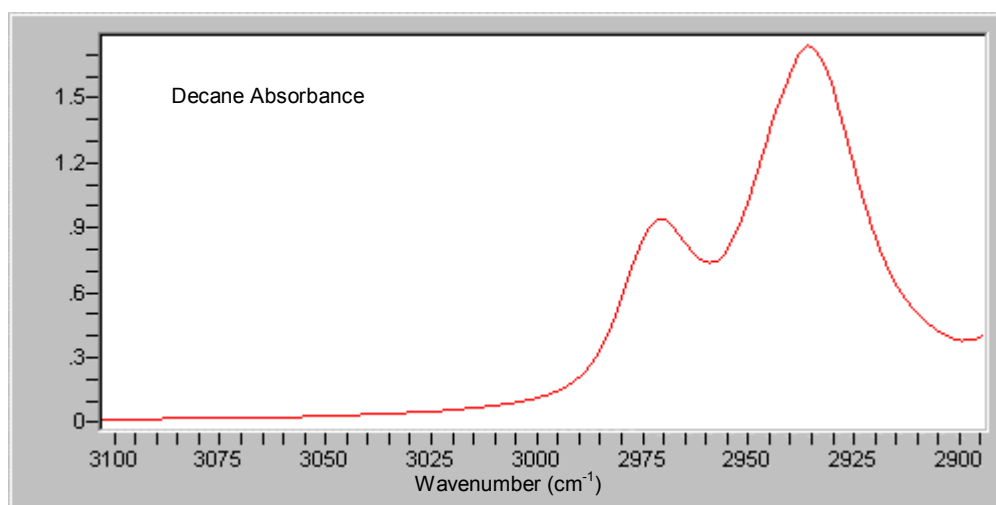
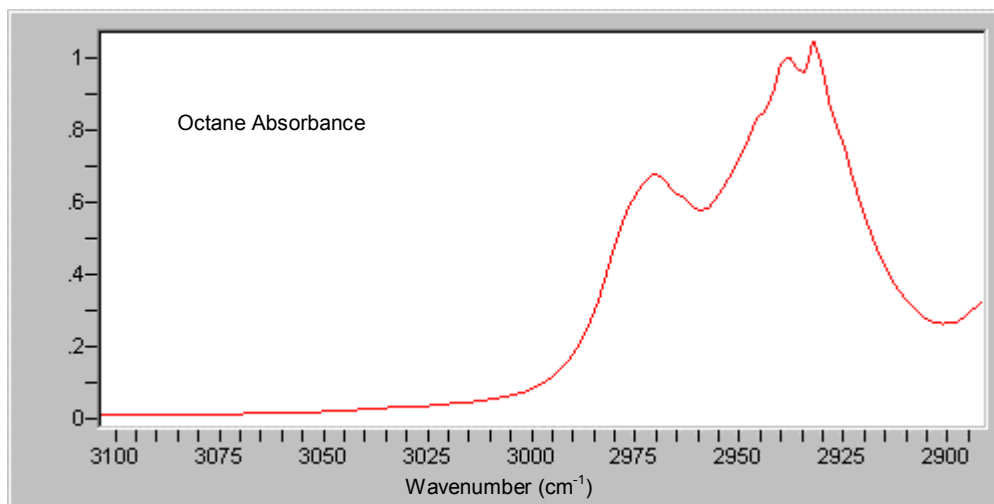
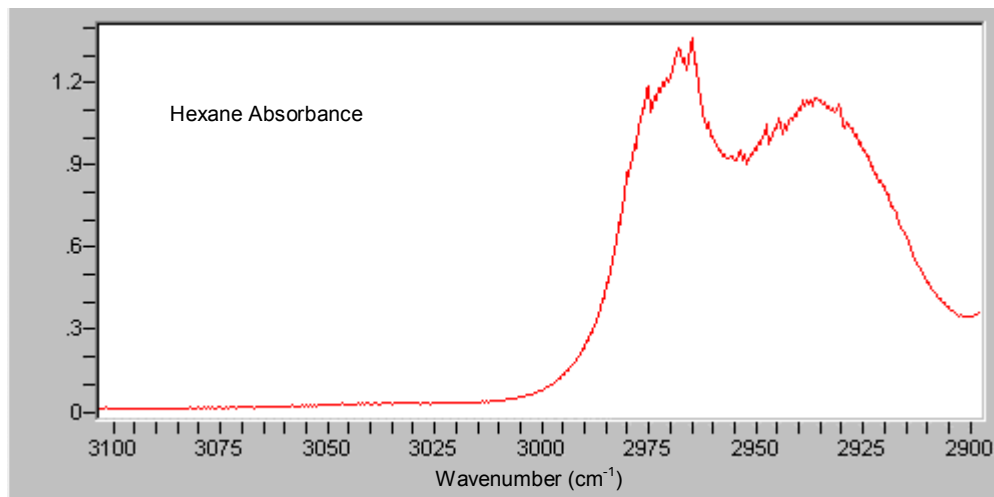
If a group of sensors was calibrated on a %l methane scale and exposed to %l levels of propane, as an example heavier alkane, then the nonlinearity and over-sensitivity is typically as shown below. The deviations increase with increasing gas concentration and the spread of values from sensor to sensor is caused by the individual span factors. It is clear that the relative response is also a function of the gas concentration:



Referencing to higher saturated alkanes:

As we consider heavier alkanes then as the carbon number increases the C-H bonds increases at typically twice the number. The absorbance maximum for the C-H stretch tends to move to slightly longer wavelengths (lower wavenumber) as the carbon number increases which results in a slight increase in sensitivity with increasing carbon number for the MSH-HC sensor:

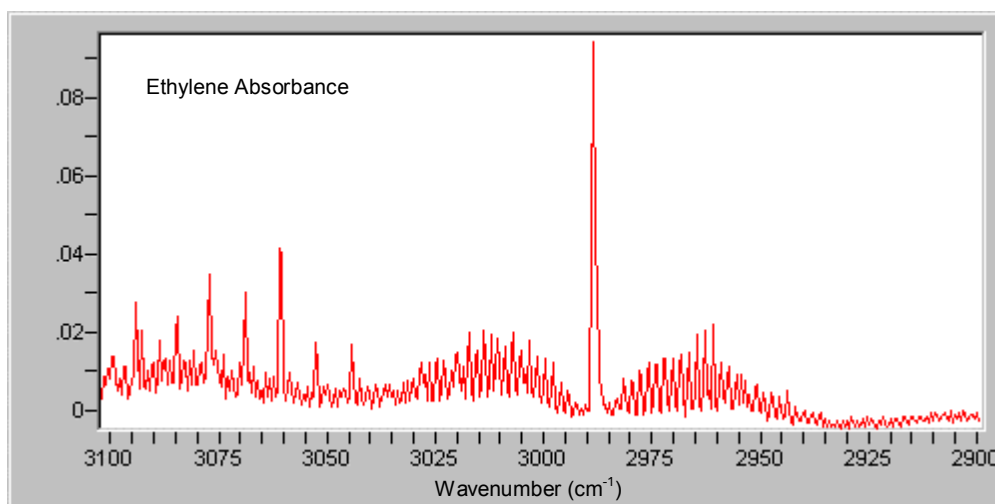




However, the lower explosive level tends to decrease as the carbon number increases and we find that in %lel terms there is a more direct equivalence between the responses to heavier hydrocarbons in those terms, with the increasing sensitivity offsetting the lower concentration for the same %lel. Equally, linearity remains quite consistent when comparing a propane calibration with heavier alkane exposures. This is again largely due to the similarity in the spectra for the heavier alkanes within the region used by the sensor and reflects in the commonality of linearisation coefficients.

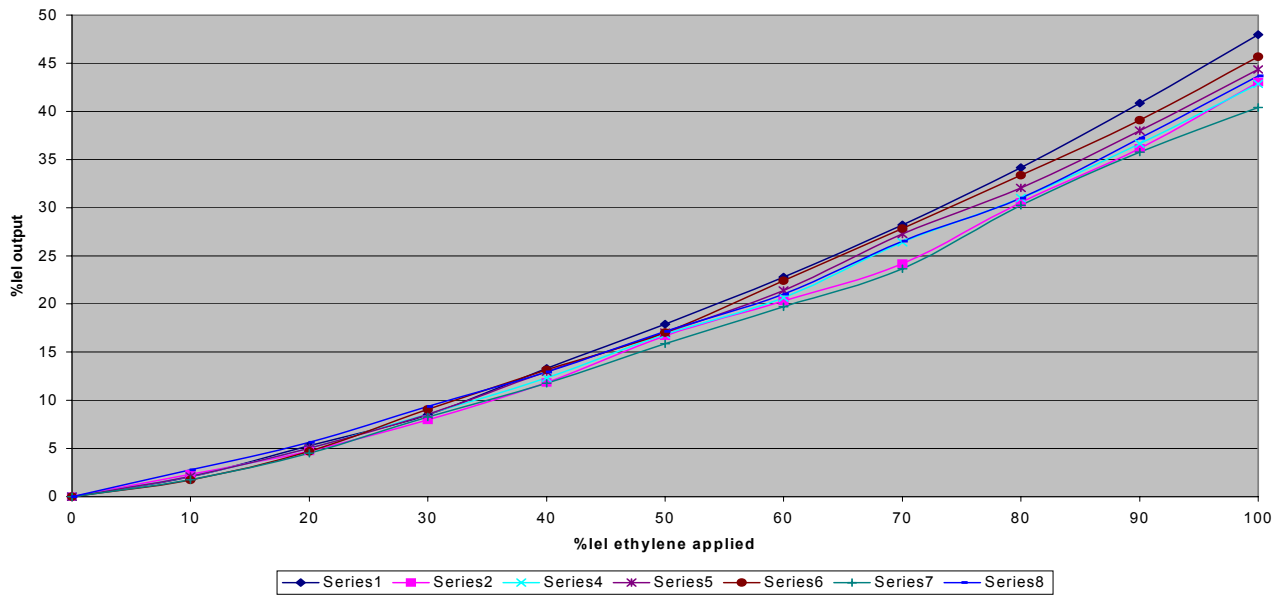
For the heavier saturated alkanes the power term in the linearisation expression is close to unity as a consequence of the strong absorbance continuum in the spectral region used by the sensor. If the continuum completely enveloped the optical bandwidth of the sensor then one would expect the power term to be unity. The associated exponential term correlates to the commonality between the heavier alkanes. See our application note AN0003 "Signal Extraction" for a discussion on the signal linearisation technique. In general, saturated alkanes and other molecules containing saturated aliphatic groups will have similar spectral features within the bandwidth of the sensor and therefore a reasonable correlation in linearity should be expected between them. This then leads to a more simple relative response treatment where a propane scale could be linearly adjusted to meet the target molecule and linearity can be maintained in %lel terms.

Ethylene has a complex absorbance spectrum which is generally weaker than the standard alkane C-H stretch. The response of the sensor to ethylene in %lel terms is therefore weaker than that for methane, which has the same number of C-H bonds. As in the case for methane, the ethylene spectrum shows that there are many wavelengths within the optical passband of the sensor which do not contribute to the signal:



The ethylene response relative to methane is quite interesting in that it is around 50% that of methane in %lel terms and the lel of ethylene is a little over half that of methane. There is also some nonlinearity as shown below. If the ethylene response is linearised fully then it appears that the power term is actually unity, which is surprising in view of the fact that there is not a large continuum in the ethylene spectrum within the bandwidth of the sensor.

MSH-HC Ethylene response with %lel methane calibration



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