Selection of Suitable Instrument Ranges when Establishing an Air Quality Monitoring Network

In order to maximise the performance of an air quality monitoring station, careful selection of instrumentation is essential. One of the key issues is to have a good understanding of what pollutants need to be measured and at what concentrations. There are several different types of air quality monitoring, these include:

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Trace/Background Monitoring

This is performed in areas where there is no immediate source of pollutants, such as motor vehicles or industry and is aimed at obtaining "background" measurements for that region.

These stations typically measure a wide range of pollutants including PM10, PM2.5, O_3, CO, NOy, NO_2, NO, SO_2 and meteorological conditions.

Concentrations for CO are typically less than 100 ppb and often less than 1 ppb for all other gases. PM concentrations are also low, often less than 10 ug/m^3 for PM10 and 5 ug/m^3 for PM2.5.

This application calls for special trace monitoring analysers capable of measuring at these very low concentrations.

Compliance Monitoring

This is performed in urban locations but removed from any immediate source of pollutants and is aimed at providing a good understanding of typical pollutant concentrations in the broad area. A typical city of a population of around 5 million, may have anywhere between 10 to 30 of these monitoring stations depending on local topography and available funding.

These monitoring stations measure "criteria" pollutants, which are gases that include O_3, CO, NO_2, SO_2 and particulates such as PM10 and in some countries PM2.5.

The goal for these stations is to ensure that "typical" pollution concentrations don't exceed that countries standards and thus do not impact on the health and wellbeing of the population.

For instance the USEPA has established the following standards.

	Primary Standard
	Level
Carbon Monoxide	9 ppm (8 hr) 35 ppm (1 hr)
Nitrogen Dioxide	53 ppb (annual) 100 ppb (1 hour avg)
Ozone	75 ppb (8 hour avg) 120 ppb (1 hour avg)
Sulphur Dioxide	30 ppb (annual) 75 ppb (1 hr avg)
PM10	50 ug/m^3 (24 hr avg)
PM2.5	15 ug/m^3 (annual) 35 ug/m^3 (24 hr avg)

Compact street level monitoring stations

These small compact monitoring stations which are typically mounted on a pole provide some good basic information on street level concentrations and are ideal for installation in areas where space is at a premium and only indicative values are required.

The reason they are not installed more widely is that maintenance poses challenges and automatic daily calibrations are difficult to perform. They are also too small to allow for installation of high performance gas analysers and particulate monitors.

The goal for these stations is to provide a basic qualitative measure of street level air quality.

Roadside Monitoring

This is a specialised application where monitoring stations are installed close to roads and are aimed at providing a very good indication of pollutant concentrations inhaled by drivers or pedestrians in that location.

These monitoring stations are typically designed to measure emissions from traffic that include CO, NO_2, SO_2 and particulates (PM10 and PM2.5).

Hong Kong, a country with a significant and worsening

amount of traffic related pollution provides an excellent example of the anticipated concentrations that will be seen at these monitoring stations.

The maximum observed 1 hour concentrations in Hong Kong in 2011 from all monitoring stations including roadside stations were as follows:

Parameter	Maximum 1 hr concentration
O_3	161 ppb
CO	3.5 ppm
NO_2	272 ppb
SO_2	100 ppb
PM10	173 ug/m^3 (24hr avg)

It should also be noted that the USEPA have established a new one hour goal for NO_2 of 100 ppb directly aimed at reducing road side pollution health threats for millions of Americans." For the first time ever, we are working to prevent short-term exposures in high risk NO_2 zones like urban communities and areas near roadways," said EPA Administrator Lisa P. Jackson.

MOSCOW (Reuters) 9th Aug. 2010- Air quality levels in Moscow tumbled to an eight-year low on Wednesday as the Russian capital was blanketed in thick smoke from forest and peat fires, said Moscow's state agency for monitoring air pollution.

"Air pollution surged four to ten times (above the maximum safe levels) in the early morning hours, which is an new high," Elena Lezina, an expert at the Moscow state agency that monitors air pollution, told Reuters.

Note: Russian CO Air Quality Standard for CO is 3000 ug/m^3

Wide range vs small measurement range

The presumption that it is beneficial to have the widest possible measurement range for instruments, is not true as the following issues need to be considered.

Ambient Concentrations are typically less than 500 ppb (5 ppm for CO)

As illustrated above, both by USEPA Criteria pollutant limits and maximum 1 hour concentrations obtained in Hong Kong, ambient concentrations are nearly always less than 500ppb for O_3, NO_2 & SO_2 and less than 5 ppm for CO. PM10 concentrations rarely exceed 200 ug/m^3, except in exceptional circumstances such as forest fires.

For instance in the Russian forest fires of August 2010 air pollution was severe with extremely high CO concentrations, but the maximum CO concentration observed was less than 50ppm.

With the vast majority of air quality monitoring stations Ecotech have installed and configured the most common operating range configured are:

O_3	0-500 ppb
CO	0-5 ppm
NO_2	0-500 ppb
SO_2	0-500 ppb
PM10	0-1000 ug/m^3

Autoranging of Instruments

While the above concentrations are very typical of all monitoring environments for compliance and roadside monitoring, modern microprocessor based analysers such as the Ecotech Serinus have the ability of autoranging and are able to capture concentrations approximately 20 to 40 times greater than this if necessary. Which is more than sufficient for all ambient/roadside monitoring applications.

USEPA approved measurement ranges

The USEPA approves criteria pollutant analysers over prescribed ranges, hence even if the analysers have a wide range they must still be operated on the range specified below to meet USEPA approval. The same is also true for EN requirements.

The USEPA approves analysers across the following ranges:

O_3: 0-500 ppb

CO: 0-50 ppm

NO_2: 0-500ppb

SO_2: 0-500 ppb

Calibration of analysers

It is recommended by all manufacturers that analysers should be calibrated at multiple concentrations (typically 0, 20, 40, 60, 80%) of the measurement range every three months. It is also highly recommended that an overnight calibration check performed at 80% of the measurement range also be performed.

The aim of these calibrations is to perform them at the typical ambient concentrations measured in that location in order to achieve the great possible accuracy and precision for the measurement. If an overly high range such as 0-100 ppm (O_3, NO_2, SO_2) is configured in the analyser then in order to operate the analyser at this range over night span calibration checks would need to be performed at 80 ppm (80% of range) in order for this range to be acceptable. This would result in extremely poor precision and accuracy for concentrations measured below 1 ppm as the precision for instruments is typically between 0.5 to 1% of operating range.

Analyser Precision & Lower Detection Limit

If a measurement range for O_3, SO_2 and NO_2 was configured to be 0-100 ppm and 0-1000 ppm for CO then with a typical precision of 0.5% of the measurement range, the best precision and lower detection limit would be approximately:

O_3: 0.5 ppm

CO: 5 ppm

NO_2: 0.5 ppm

SO_2: 0.5 ppm

This is obviously far higher than concentrations observed in highly polluted roadside environments.

Toxic Levels of Criteria Pollutants

It is also noteworthy to discuss toxic concentrations of criteria pollutants. Many international organisations have established both Maximum Personnel Exposure Limits (PEL) , Short Term Exposure Limits (STELs) and ceiling limits (concentrations should never exceed this limit) to many gases including O_3, CO, NO_2 and SO_2. The levels listed below are not found in even heavily polluted ambient environments, they are only experienced in industrial application such as those immediately surrounding an ozone generator or immediately surrounding a furnace or in confined spaces where a combustion source is located.

Parameter	PEL	Other
NO_2	0.1 ppm (NIOSH)	5 ppm (immediately dangerous to life) ACGIH 1 ppm (15 minute short term exposure limit)
O_3	0.1 ppm (OSHA)	5 ppm (immediately dangerous to life) NIOSH 0.1 ppm (ceiling limit) NIOSH
SO_2	5 ppm (OSHA)	5 ppm (short term exposure limit) NIOSH
CO	50 ppm (OSHA)	200 ppm (Ceiling value)NIOSH

Conclusion

It is important when specifying instruments and instrument ranges for air quality monitoring that close attention be paid to typical expected maximum concentrations in order to choose analysers which have ranges suitable to measure these concentrations. While initially it would appear choosing instruments with the widest possible range would be ideal, doing this creates significant problems and should be avoided.

The selection of instrument with suitable measurement ranges is but a very small part of designing an air quality monitoring station/network. There are many other considerations as important if not more important which include; siting of the monitoring station, regular and auditable maintenance and calibration and data handling.

While it would be nice to assume that all data coming from monitoring stations is accurate and reliable, this is rarely the case, data needs to be sometimes adjusted for calibration drift, instrument faults, lost data due to power outages, manual data from some instruments needs to be imported into the air quality database and some data needs to be scaled appropriately. It is critical that whatever software is used to collect, validate and report on the data should allow for these functions. It should also provide a fully auditable database where any changes are logged and can be reviewed by management on a regular basis.

It is only by incorporating good practice and auditable procedures into operation of an air quality network that you can be ensured of high quality data. A laboratory that is accredited to ISO17025 is a good partner to help ensure that this happens.