# Air Quality Index (AQI) Monitor Design

[Air Quality Index (AQI) Monitor Design 1](#_Toc52606482)

[AQI Standards 1](#_Toc52606483)

[Table of AQI Ranges and Color Codes 1](#_Toc52606484)

[Table of AQI Ranges and µg/m3 Measurements 1](#_Toc52606485)

[Time Averaging Measurements 2](#_Toc52606486)

## AQI Standards

### Table of AQI Ranges and Color Codes

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **AQI Range** | **AQI Category** | **AQI Color** | **Hex** | **R** | **G** | **B** |
| 0-50 | Good | Green | 00E400 | 0 | 228 | 0 |
| 51-100 | Moderate | Yellow | FFFF00 | 255 | 255 | 0 |
| 101-150 | Unhealthy for Sensitive Groups | Orange | FF7E00 | 255 | 126 | 0 |
| 151-200 | Unhealthy | Red | FF0000 | 255 | 0 | 0 |
| 201-300 | Very Unhealthy | Purple | 8F3F97 | 143 | 63 | 151 |
| 301-500 | Hazardous | Maroon | 7E0023 | 126 | 0 | 35 |

### Table of AQI Ranges and µg/m3 Measurements

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AQI Range** | **AQI Category** | **PM2.5 24hr µg/m3** | **AQI Factor** | **PM10.0 24 hr µg/m3** | **AQI Factor** |
| 0-50 | Good | 0-12 | 4.17 | 0-54 | 0.93 |
| 51-100 | Moderate | 12.1-35.4 | 2.10 | 55-154 | 0.49 |
| 101-150 | Unhealthy for Sensitive Groups | 35.5-55.4 | 2.46 | 155-254 | 0.49 |
| 151-200 | Unhealthy | 55.5-150.4 | 1.94 | 255-354 | 0.49 |
| 201-300 | Very Unhealthy | 150.5-250.4 | 1.01 | 355-424 | 1.43 |
| 301-500 | Hazardous | 250.5-500.4 | 1.26 | 425-604 | 1.11 |

The AQI ratings in the above table apply only to PM2.5 and PM10.0 measurements. There are no equivalent AQI ratings for smaller particle masses, but the Plantower device measures counts of particles at 0.3 µm, 0.5 µm, 1.0 µm, 2.5 µm, 5.0 µm and 10.0 µm and masses of particles per cubic meter at 1.0 µm, 2.5 µm and 10.0 µm. The latter mass measurements come in “standard” or laboratory adjusted measurements and “environment” or atmospheric measurements. These make different assumptions about how to convert the raw data and experimenters have determined that for typical use the environmental measures should be used. All of the raw data is available if you are creating your own measures that use different assumptions.

The sensors on the PM2.5 and the Clue do not give us the other AQI pollutant measures for ozone, CO, SO2 or NO2. For a complete AQI monitoring system, additional sensors, available from Sparkfun, can be integrated into a more complex device.

The guidance from AQI Technical Assistance Document published by the EPA (Sept 2018) provides information on how to calculate AQI across all of the pollutant measures, if they are available. The AQI is the highest value calculated for each pollutant by identifying the highest concentration among all of the monitors and truncate as follows:

* Ozone (ppm) – truncate to 3 decimal places
* PM2.5 (µg/m3) – truncate to 1 decimal place
* PM10 (µg/m3) – truncate to integer
* CO (ppm) – truncate to 1 decimal place
* SO2 (ppb) – truncate to integer
* NO2 (ppb) – truncate to integer

Using the breakpoints table, find the upper and lower

### Time Averaging Measurements

The standard for reporting on AQI Category from particulate measurements is a 24-hour average. That’s appropriate for general weather reporting to give a sense of the overall pollutant load in the air, but for a personal sensor shorter time averaging seems appropriate. The guidance from the EPA for shorter times is to use 12 hours for medium term averages and 3 hours for “real-time” reporting. A personal AQI monitor might also provide 1 hour and 5-minute averaging options.

In all cases, the time averaging should be available for display at any time so the monitor should be accumulating the data so that it can report the full time averaged statistic as well as providing historical trends for the day, week or month, if the sensor is kept running continuously.

For any of the time averaging and trend data handling it’s clear that the monitor must handle missing data.

Each ring represents an average for a time range:

Center of the circle = Real time average  
1st ring = Short-term average  
2nd ring = 30-minute average  
3rd ring = 1-hour average  
4th ring = 6-hour average  
5th ring = 24-hour average  
6th ring = 1-week average

Paper slides showing conversion from Plantower (PurpleAir) readings to EPA AQI

<http://lar.wsu.edu/nw-airquest/docs/20200610_meeting/NWAQ_20200611_1030_Hadley.pdf>

Purple Air website includes optional correction for PM2.5:

* LRAPA: (PM2.5 = 0.5PA-0.66)
* AQ&U (PM2.5 = 0.77PA +2.6)

Some polynomial fits are better than the linear fitted line.

Higher relative humidity increases the apparent size of particles and causes different counts than nephelometers which take samples and put them in standard RH environment.

The correlation between nephelometer and Plantower with PM2.5 counts is a sigmoidal curve

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