

Air Data Report 2023

Intro CO NO₂ O₃ Pb PM10 PM2.5 SO₂ AQD

One of the most critical responsibilities of the Air Quality Division is monitoring Oklahoma's Air Quality.

This report makes monitoring information available to the public in a consistent form that helps Oklahomans become more aware of the air they breathe.

Criteria Pollutants

This report covers the six criteria pollutants associated with the National Ambient Air Quality Standards (NAAQS). Factsheets for the criteria pollutants can be found [here](#).

CO - Carbon Monoxide

NO₂ - Nitrogen Dioxide

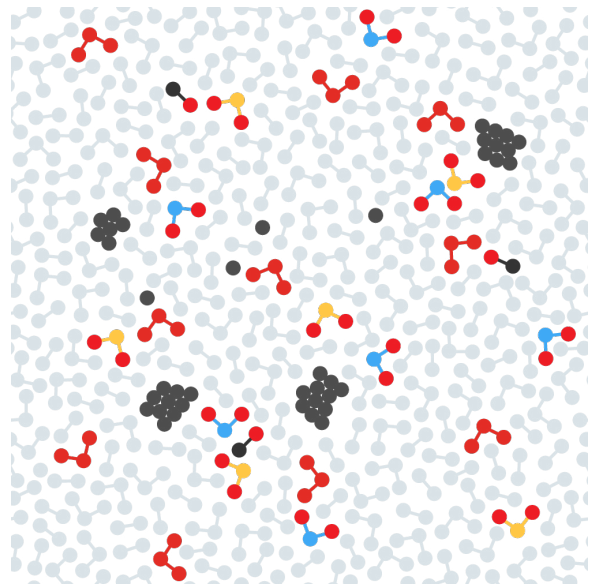
O₃ - Ozone

Pb - Lead

PM10 - Particulate Matter

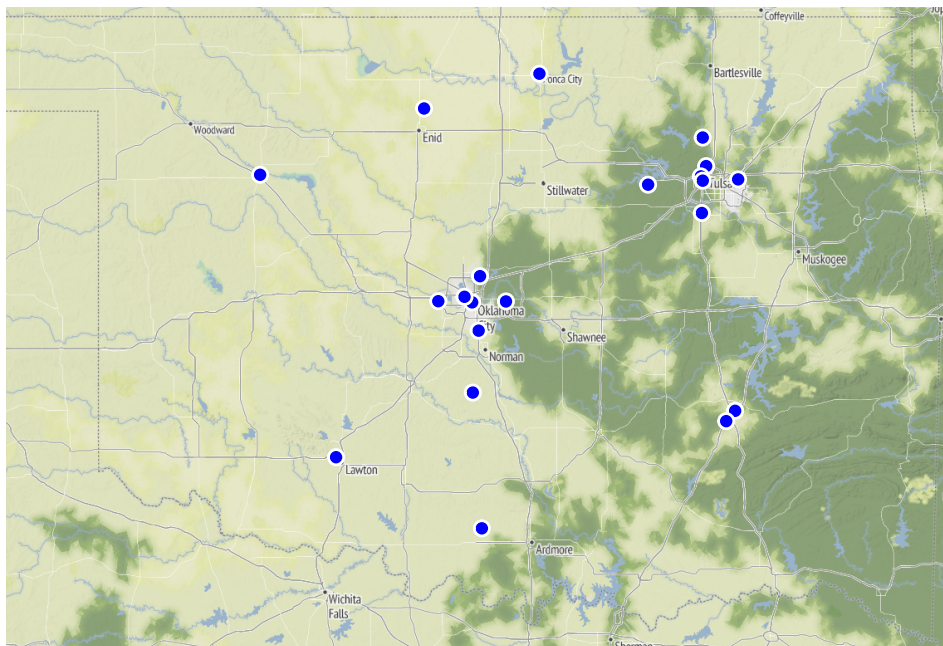
PM2.5 - Fine Particulate Matter

SO₂ - Sulfur Dioxide



DEQ Air Quality Monitoring

The Air Quality Division's monitoring staff measure criteria air pollutant concentrations at several sites across Oklahoma. This report includes data from 21 sites.



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National Ambient Air Quality Standards (NAAQS)

The Clean Air Act requires EPA to set ambient air quality standards for pollutants considered harmful to public health and the environment. They are called “criteria pollutants” because of the criteria developed to limit their emission. The **primary standards** provide public health protection, and the **secondary standards** provide public welfare protection against poor visibility and damage to crops, vegetation, and buildings.

Each NAAQS defines the maximum permissible concentrations for criteria pollutants. The standards are periodically revised by EPA to take into account new health research. The primary standard must be adequate to protect at-risk groups like children, those with lung diseases, and the elderly.

Pollutant		Standard	Averaging Time	Level	Form
Carbon Monoxide		Primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead		Primary and Secondary	Rolling 3 month average	0.15 µg/m ³	Not to be exceeded
Nitrogen Dioxide		Primary	1-hour	100 ppb	98th percentile (3 yr avg)
		Primary and Secondary	Annual	53 ppb	Annual mean
Ozone		Primary and Secondary	8-hour	0.070 ppm	Annual 4th-highest daily max 8-hour concentration (3 yr avg)
Particulate Matter	PM10	Primary and Secondary	24-hour	150 µg/m ³	Not to be exceeded more than once per year (3 yr avg)
	PM2.5	Primary	Annual	12 µg/m ³	Annual Mean (3 yr avg)
		Secondary	Annual	15 µg/m ³	Annual Mean (3 yr avg)
		Primary and Secondary	24-hour	35 µg/m ³	98th percentile (3 yr avg)
Sulfur Dioxide		Primary	1-hour	75 ppb	99th percentile of 1-hour daily max concentrations (3 yr avg)
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Units: ppm = parts per million ppb = parts per billion µg/m³ = micrograms per cubic meter

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CO - Carbon Monoxide

Carbon Monoxide (CO) is a colorless, odorless gas product of incomplete combustion. Complete combustion of hydrocarbon fuels, like wood and petroleum, forms water and carbon dioxide in the presence of oxygen. Insufficient oxygen produces toxic intermediates like carbon monoxide.

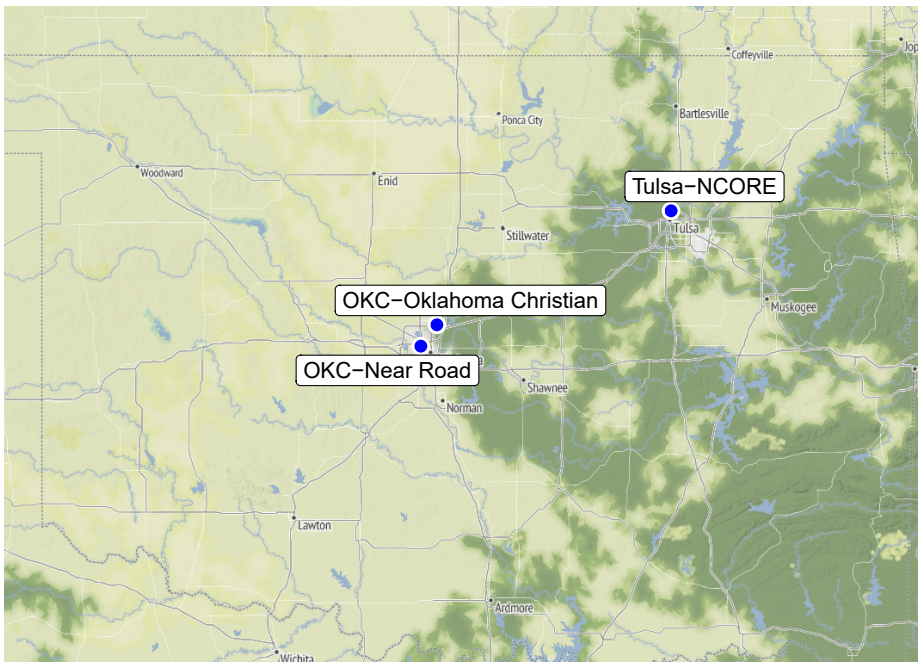


Catalytic converters reduce tailpipe CO emissions.

In the human body, CO reduces the oxygen-carrying capacity of the blood. Hemoglobin is the part of blood that carries oxygen. When carbon monoxide enters the bloodstream, it binds with a higher affinity to hemoglobin than oxygen. Even a small amount of carbon monoxide can displace needed oxygen and kill.

Most CO emissions come from mobile sources like cars and trucks. Manufacturers reduce mobile emissions by adding control devices like catalytic converters, which use platinum and other catalysts to convert toxic pollutants like CO into less toxic chemicals. In effect, the catalysts complete the combustion process.

There are two primary standards for carbon monoxide: one for an 8-hour average concentration of 9 parts per million (ppm) and another for a 1-hour average of 35 ppm. Oklahoma is in attainment with both standards.



CO Monitoring Sites

The CO network consists of three monitors: two in Oklahoma City and one in Tulsa. The CO monitors continuously sample air using a gas filter correlation method. The monitors report hourly values to determine compliance with the standards. Current data may be accessed [here](#).

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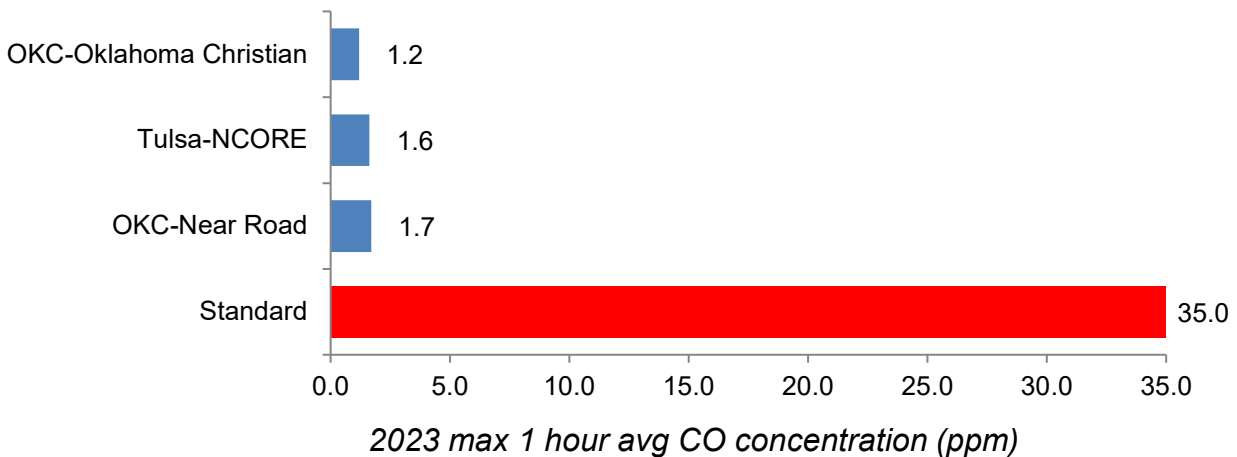
CO Data

Primary 1-hour Carbon Monoxide Standard = 35 ppm

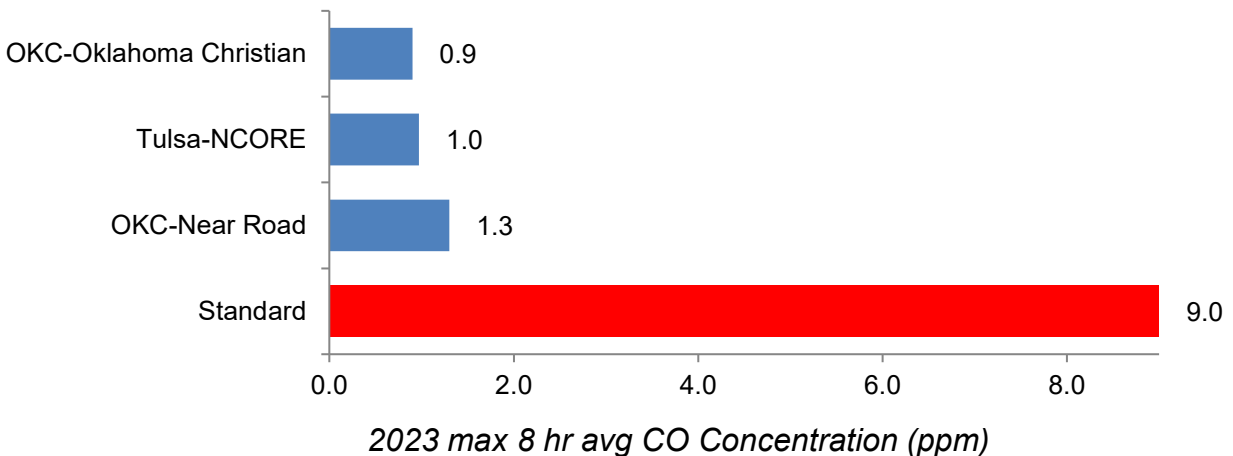
Primary 8-hour Carbon Monoxide Standard = 9 ppm

Oklahoma has exceedingly good air quality with CO values well below the NAAQS. CO levels have decreased from a national (8-hour) average of 8.9 ppm in 1980 to less than 2 ppm. Improved fuel burning efficiency of mobile sources will continue to be the major force in attainment of these standards.

2023 CO Values vs. 1 Hour NAAQS



2023 CO Values vs. 8 Hour NAAQS

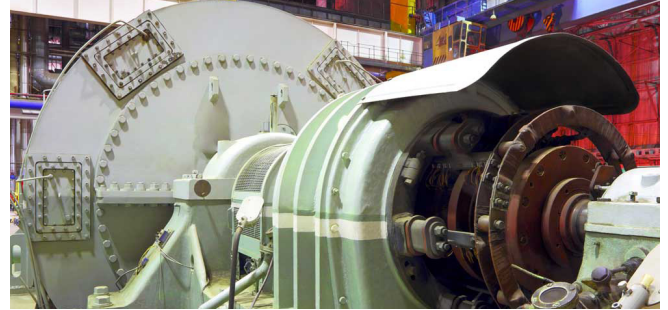


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NO₂ - Nitrogen Dioxide

Nitrogen Dioxide (NO₂) is one of a group of highly reactive gases known as “nitrogen oxides” (NO_x). There are many nitrogen oxides, but for regulatory purposes NO_x is the sum of nitric oxide (NO) and nitrogen dioxide (NO₂). Nitrogen oxides are combustion products and can come from engines and boilers.



Operating turbines with lower peak temperatures helps reduce NO_x emissions.

Nitrogen is abundant as N₂ in ambient air and is a constituent in varying forms in fuels. Nitrogen emissions can be controlled before, during, and after combustion. Pre-treatment removes nitrogen from fuels. Specialized low-NO_x burners use a controlled mix of air and fuel to minimize NO_x during combustion. Post-combustion treatment uses a catalyst to return nitrogen to a non-toxic form (N₂), the same as in ambient air.

NO and NO₂ are the two main constituents of NO_x and exist in a daytime equilibrium. NO can react with atmospheric oxygen to form NO₂, while solar radiation can breakdown NO₂ to again form NO and oxygen. The oxygen released from NO₂ can react with diatomic oxygen (O₂) to form ozone (O₃), so NO_x is one precursor to ozone pollution.

There are two federal standards for nitrogen dioxide: a 1-hour 100 parts per billion (ppb) primary standard and a 53 ppb annual mean primary/secondary standard. Oklahoma is in attainment with both standards.



NO₂ Monitoring Sites

The division monitors NO₂ at two sites in Oklahoma City and one site in Tulsa. The OKC Near Road site is next to the I-44 highway and Will Rogers Park so it can measure NO₂ emissions from mobile sources like cars and trucks. NO₂ measurements are made using a chemiluminescent (light-producing chemical reaction) method. Monitors report hourly values. Current data may be accessed [here](#).

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NO₂ Data

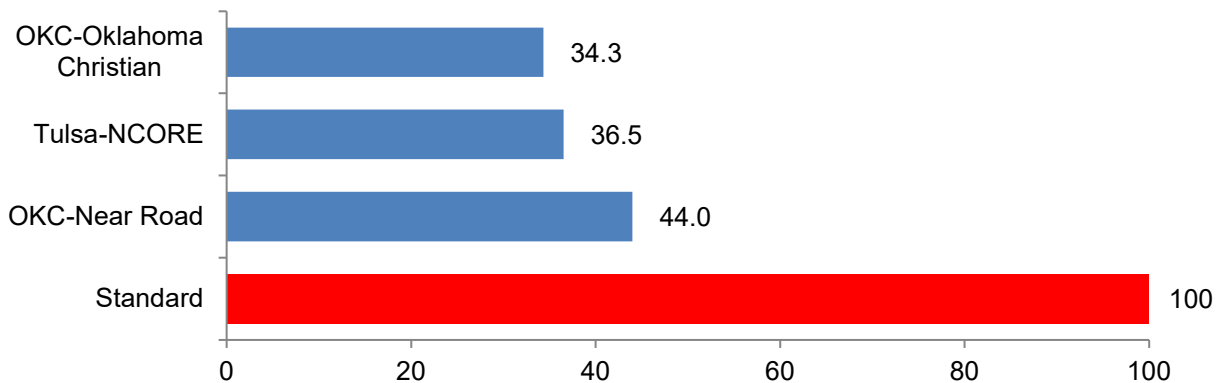
Primary 1-hour NO₂ Standard = 100 ppb

Primary/Secondary Annual Arithmetic Mean NO₂ Standard = 53 ppb

NO₂ concentrations continue to decrease as a result of a number of mobile source regulations for light- and heavy-duty vehicles. Implementation of these regulations is staggered over multiple years for manufacturers to design cleaner burning engines. Current air quality monitoring data does not reflect all the benefits of vehicles that meet these strict NO_x standards because many older vehicles remain. These reductions are even more significant because NO_x is a precursor to ozone, another air pollutant.

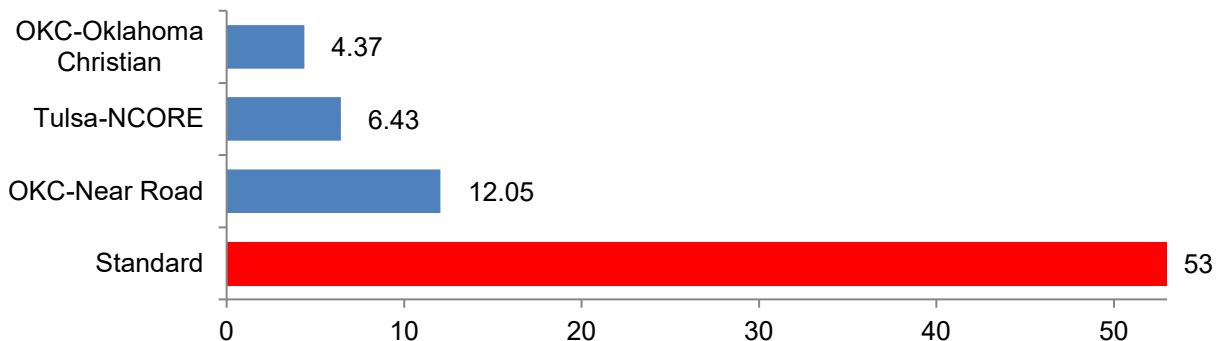
The 100 ppb standard is measured based on the 98th percentile of 1-hour daily maximum concentrations, averaged over three years. The 53 ppb standard is an annual mean.

2023 NO₂ values vs. 1 Hour NAAQS



3 yr avg (2021-23) 98th percentile 1 hr avg NO₂ concentration (ppb)

2023 NO₂ Values vs. Annual Arithmetic Mean NAAQS



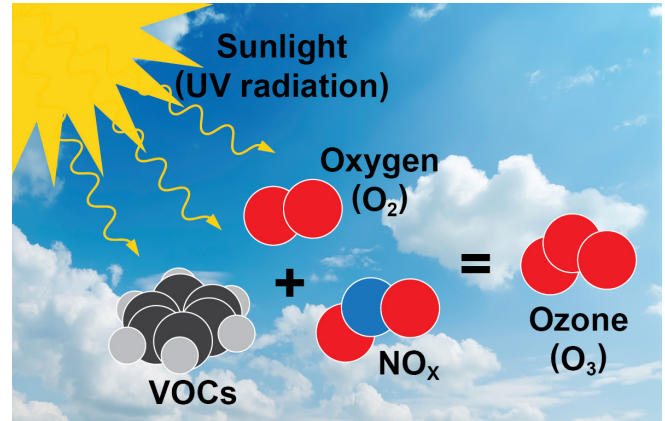
Annual Arithmetic Mean NO₂ concentration (ppb)

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O₃ - Ozone

Ozone (O₃) is a gas composed of three oxygen atoms, unlike the diatomic oxygen (O₂) we must breathe. Ozone is not usually emitted directly into the air. At ground-level, ozone is created by chemical reactions between diatomic oxygen (O₂), nitrogen oxides (NO_x), and volatile organic compounds (VOCs) in the presence of sunlight. NO_x and VOCs come from motor vehicle exhaust, industrial emissions, gasoline vapors, chemical solvents, and some natural sources.



Ozone forms in the atmosphere through chemical reactions between oxygen, precursor pollutants like VOCs and NO_x, and sunlight.

Ozone can be "good" or "bad" depending on its location in the atmosphere. The natural ozone layer in the upper atmosphere absorbs most of the sun's damaging ultraviolet radiation. Ground-level ozone in the lower atmosphere is considered "bad." Many urban areas tend to have high levels of "bad" ozone, but even rural areas can have high ozone because wind carries it and its precursor pollutants hundreds of miles away from their original sources.

There is one primary and one secondary federal standard for ozone, which have the same form: the fourth highest daily maximum 8-hour average of 0.070 parts per million (ppm), averaged over three years. While several Oklahoma sites measured recent exceedances of the standard, all are currently designated in attainment.



Ozone Monitoring Sites

The division monitors ozone at 13 sites across the state. These locations report data hourly and are the basis of the [Air Quality Health Advisory](#) program. Current data may be accessed [here](#).

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Ozone and Your Health

Ozone is a serious air quality problem in many parts of the United States. Even at low levels, ozone can cause negative health effects. People with lung diseases, children, older adults, and people who are active outdoors may be particularly sensitive to ozone. Numerous scientific studies have linked ozone pollution exposure to a variety of problems, including:

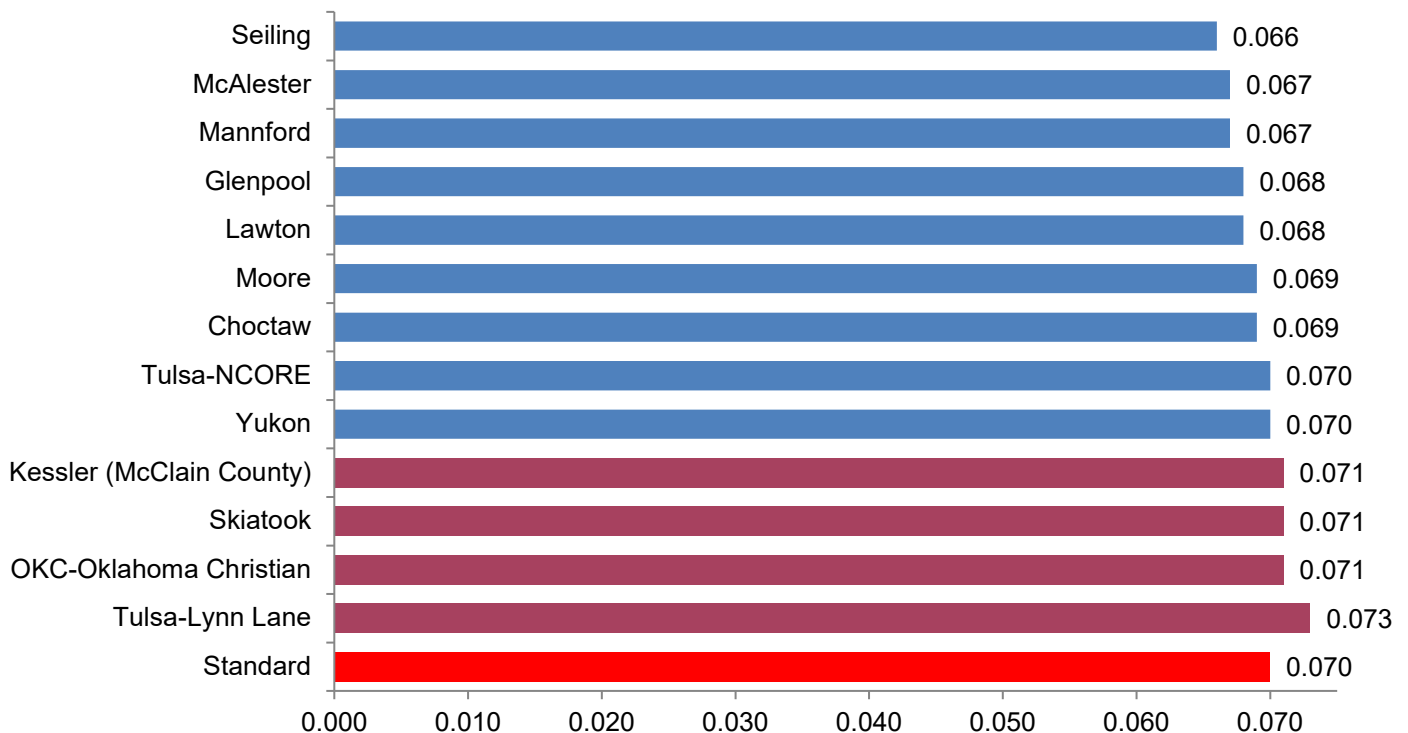
- respiratory system irritation
- aggravated asthma
- decreased lung function
- increased susceptibility to infection
- coughing or difficult breathing
- permanent lung damage

Ozone Data

Primary and Secondary Ozone Standard = 0.070 ppm (8-hour average)

To compare to the standard, 8-hour average concentrations are tracked, and the fourth-highest daily maximum is averaged across three consecutive years. Value above 0.0705 ppm (rounded to 0.071) are considered exceedances.

2023 Ozone Values vs. 8 Hour NAAQS



*3 yr avg ('21-'23) 4th highest daily max
8 hr avg Ozone concentration (ppm)*

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Pb - Lead

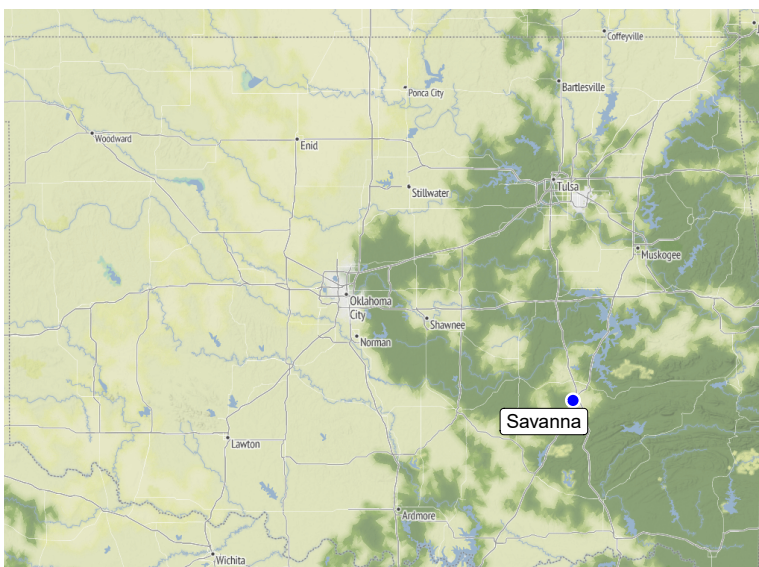
Lead (Pb) is a soft, dense metal found naturally in the environment and in manufactured products, from ancient plumbing pipes ("Pb" comes from the Latin plumbum) to modern applications like paints and anti-knock fuel additives. The major sources of lead air emissions have historically been motor vehicles (such as cars and trucks) and industrial sources.

Lead is a highly poisonous metal, interfering with many body processes such as development of the nervous system, in part by inhibiting the body's natural antioxidants. Lead's neurotoxicity is a serious concern for children, causing permanent learning and behavior disorders, anemia, and, in severe cases, seizures and death. Lead also accumulates in our bodies, stored along with calcium in bone. Pregnant women are at risk due to their bones releasing calcium with lead for the fetus, which reduces growth and increases the risk of premature birth.

As a result of federal regulatory efforts to remove lead from motor vehicle gasoline, nationwide lead emissions decreased by 99.6% (220,000 tons) from 1970 to 2011, and the average monitored lead concentration has decreased by 92% from 1980 to 2013. Today the highest levels of lead in air are usually found near lead smelters, absent in Oklahoma. Major sources of lead emissions to the air today are ore and metals processing and leaded aviation gasoline. For lead, there is one combined primary and secondary federal standard of 0.15 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) measured on a 3-month rolling average. Oklahoma is in attainment with the combined standard.



"Leaded gasoline" contained tetraethyl lead as a fuel additive. From the 1970s, leaded fuel was phased out due to health concerns and the "poisoning" (deactivation) of catalytic converters.



Lead Monitoring Site

The division monitors lead in Savanna. To measure lead, an air sampler pulls air for 24 hours across a glass fiber filter on a 6-day schedule. Samples are sent to an independent lab for analysis.

Most monitored lead values are so low they are under the instrument minimum detection limit, which itself is well below the standard and not a health concern.

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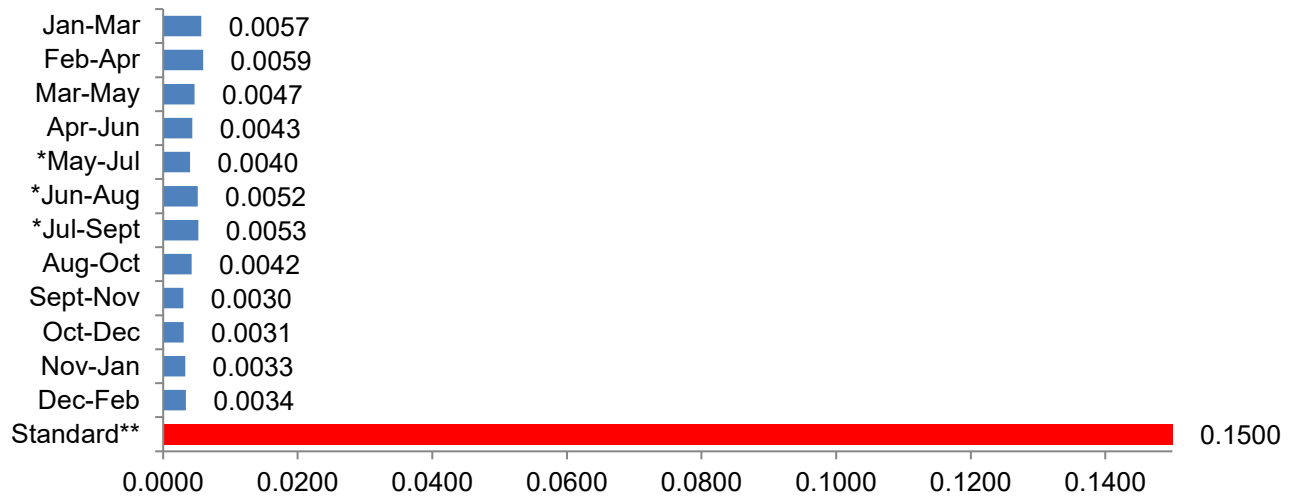
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Lead Data

Primary/Secondary Lead Standard = 0.15 µg/m³ (Rolling 3-month avg)

The primary and secondary standards are measured as total suspended particles (TSP) collected on a filter. Monitored lead concentrations in Oklahoma are well below the standards.

2023 Savanna Lead Values vs Rolling 3 month NAAQS



Rolling 3 month Lead avg (µg/m³)

*All data from July 2023 was invalid. Complete three-month averages cannot be calculated.

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PM10 - Particulate Matter

Particulate matter (PM) is a complex mixture of extremely small particles and liquid droplets. PM is made up of a number of components, including acids such as nitrates and sulfates, organic chemicals, metals, soil, and dust. Sources of particulate matter include construction sites, gravel/dirt roads, smokestacks, and fires. Many particles form in the atmosphere via chemical reactions of other pollutants like sulfur dioxide and nitrogen oxides, which are emitted from combustion sources like power plants and automobiles.



Rock crushers can spray water to control PM emissions.

Particle size is directly linked to health risk. The National Ambient Air Quality Standards (NAAQS) address particles that are 10 micrometers (μm) in diameter (**PM10**) or smaller because those particles pass through the throat and nose and can enter the lungs. The particles promote inflammation, induce coagulation, and oxidative stress. Long-term exposure contributes to more heart attacks and increased mortality rates. Different fire conditions produce different PM emissions, including toxic chemicals and volatile organic compounds (VOCs). Particles larger than 10 μm settle quickly and affect their immediate surroundings, while air currents transport smaller particles long distances, sometimes hundreds of miles.

Exposure to particulate matter can damage lung and heart function by irritating the airways and causing irregular heartbeats. PM settling on the ground or water contributes to acid rain damage and soil nutrient depletion. PM also reduces visibility (haze), which degrades scenic areas and can obscure transportation routes (e.g. wildfire smoke passing over a road).

There is one primary and secondary standard for PM10, which have the same form: a 24-hour average of 150 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) not to be exceeded more than once per year averaged over three years. Oklahoma is in attainment with both standards.



PM10 Monitoring Sites

The division monitors PM10 at sites across the state using a combination of continuous and filter-based samplers. One method takes continuous air samples and reports real-time PM10 values every hour (accessed online [here](#)). Other samplers pull air for 24 hours across a filter which is then sent later for analysis and not available in real-time. Some PM10 monitors (not shown on map) are not comparable to the NAAQS but are used for informational purposes. High values are usually the result of blowing dust from unpaved roads and emissions from nearby sources exacerbated by dry windy conditions

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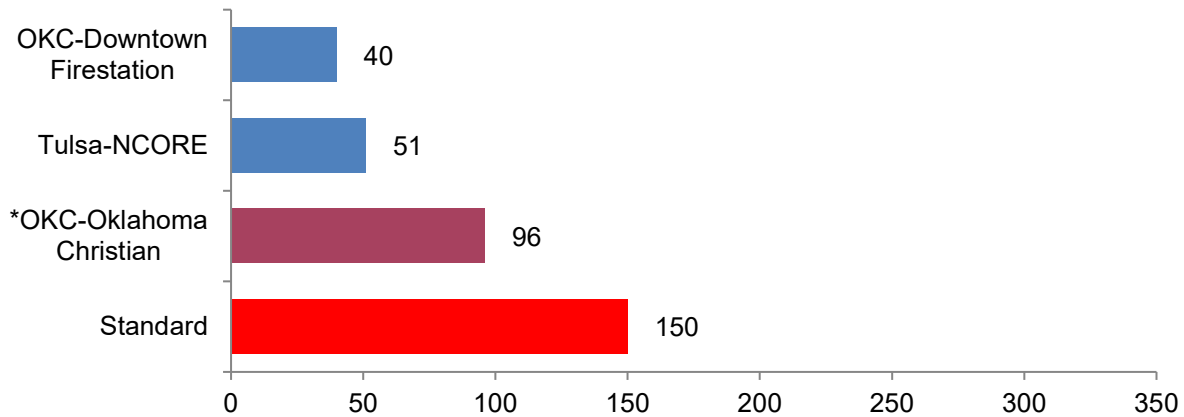
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PM10 Data

Primary and Secondary PM10 Standard = 150 ($\mu\text{g}/\text{m}^3$) (24-hour)

The NAAQS states the limit cannot be exceeded more than once per year over an average of 3 years. This means a violation would occur after four or more exceedances within three consecutive years.

2023 PM10 Values vs 24 Hour NAAQS



Max 24 hr avg PM10 concentration ($\mu\text{g}/\text{m}^3$)

*Over standard once in three years

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PM2.5 - Fine Particulate Matter

Particulate matter (PM) is a complex mixture of extremely small particles and liquid droplets. **PM2.5**, or **fine particulate matter**, is defined as particles 2.5 micrometers in diameter or smaller. Fine particles are constituents in smoke and haze. They can be directly emitted from sources like fires, or they can form when gases emitted from power plants, industries, and automobiles react in the air.



Wildfire smoke includes high amounts of PM. Prescribed fires help reduce fuel available for wildfires and can be managed to minimize smoke impacts. Photo courtesy of John Weir, Oklahoma State University.

Small particles less than 2.5 micrometers in diameter pose the greatest health risks because they travel farther and embed deeper into the lungs than large particles. Some fine particles even enter the bloodstream. PM2.5 exposure can affect both the lungs and heart. Numerous scientific studies have linked particle pollution to a variety of health problems, including:

- respiratory system irritation
- aggravated asthma
- decreased lung function
- irregular heartbeat
- coughing or difficult breathing
- nonfatal heart attacks

Though the purpose of the primary air quality standards is to protect public health, particulate matter, especially PM2.5, is believed to play a role in visibility. The emission and transport of particulate matter as it relates to visibility remain on the state and national agenda. There are four federal standards for PM2.5: identical primary and secondary standards for short term (24-hr) values of 35 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$), and separate annual primary ($9 \mu\text{g}/\text{m}^3$) and secondary ($15 \mu\text{g}/\text{m}^3$) standards. While some Oklahoma sites measured exceedances of the annual primary standard (subject to change), all sites are currently designated in attainment. DEQ is aware of an ongoing high data bias for some instruments.



PM2.5 Monitoring Sites

The division monitored PM2.5 at eleven locations in both highly populated areas and areas of specific concern. PM2.5 is monitored with two methods: a filter-based method (24-hr sampling on a Teflon filter taken on a daily, 3-day, or 6-day schedule) and a continuous sampling method (hourly reports). Current data may be accessed [here](#).

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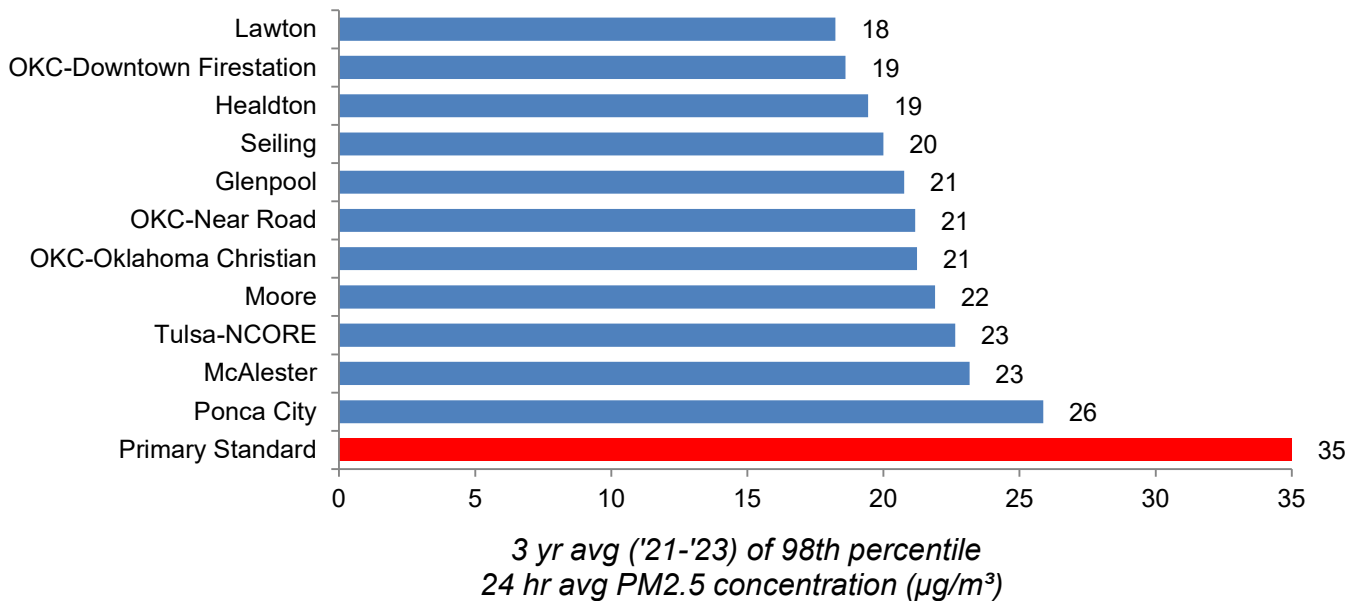
PM2.5 Data

Primary and Secondary PM2.5 24-hour standards: 35 µg/m³ (3 yr avg)

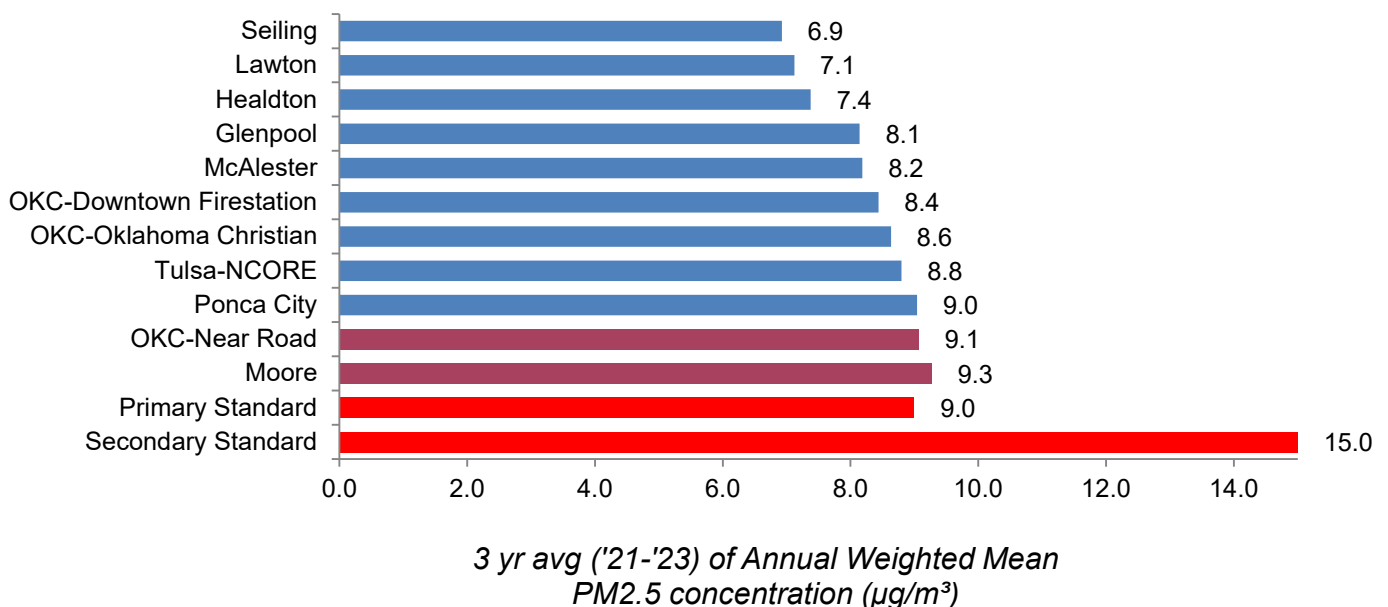
Primary Annual Arithmetic Mean PM2.5 standard: 9 µg/m³ (3 yr avg)

Secondary Annual Arithmetic Average PM2.5 standard: 15 µg/m³ (3 yr avg)

2023 PM2.5 Values vs. 24 Hour NAAQS



2023 PM2.5 Values vs. Annual Mean NAAQS



Note: Years 2021 and 2022 adjusted from previous reports. DEQ is aware of and has made corrections for an ongoing high data bias for some instruments. All data may be subject to change based on possible exceptional event demonstrations.

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SO₂ - Sulfur Dioxide

Sulfur dioxide (SO₂) is one of a group of highly reactive gases known as oxides of sulfur. The largest source of emissions is fossil fuel combustion at power plants and other industrial facilities. Sulfur is a natural constituent of both petroleum and coal deposits. Smaller SO₂ sources include industrial processes such as extracting metal from ore and the burning of high-sulfur fuels by locomotives, large ships, and non-road equipment.

Hydrogen sulfide (H₂S) is a poisonous sulfur compound and present at high concentrations in “sour” petroleum wells. Burning sour gas converts the H₂S into SO₂. H₂S can be removed from petroleum to meet low-sulfur fuel standards. Likewise, SO₂ limits for coal-burning facilities created an incentive to mine low-sulfur coal.

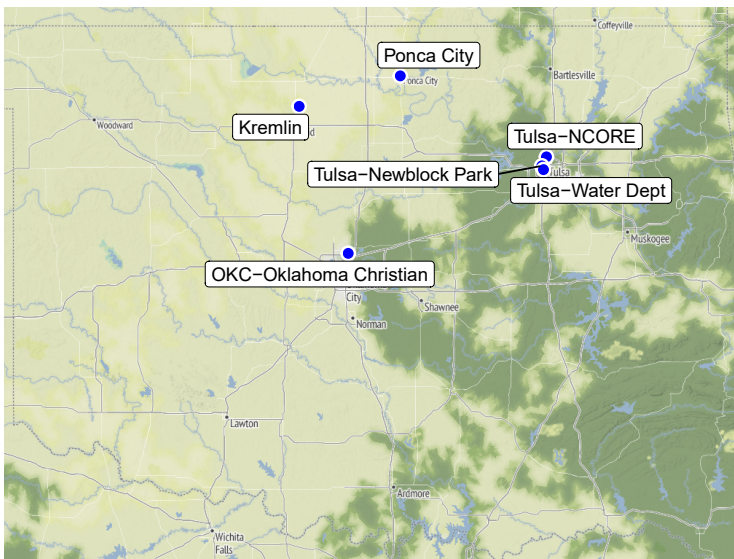
Sulfur dioxide has a strong odor at high levels and is easily absorbed when we breathe. SO₂ irritates the lungs, activates nerve reflexes, and causes injury to airway mucous membranes, which affects breathing. People with asthma can experience increased airway resistance when exercising under SO₂ concentrations of less than 0.1 ppm (100 ppb).

SO₂ is the major cause of acid rain because it dissolves in and acidifies atmospheric water. Acid rain damages buildings and statues by corroding minerals in limestone and marble. Acid rain also lowers the pH of (acidifies) forests, lakes, and streams, which harms aquatic wildlife.

There are two standards in place for sulfur dioxide: a primary 1-hour standard of 75 parts per billion (ppb) to protect human health, and a secondary 3-hour standard of 0.5 parts per million (ppm) to protect the environment and property. Oklahoma is in attainment with both standards.



Lime injection into exhaust gas helps absorb SO₂ before release from tall stacks.



SO₂ Monitoring Sites

The division monitors for sulfur dioxide at six sites in the state. The monitors measure SO₂ via pulsed fluorescence and report SO₂ concentrations on an hourly basis. The values are then used to determine compliance with the standard. Current data may be accessed [here](#).

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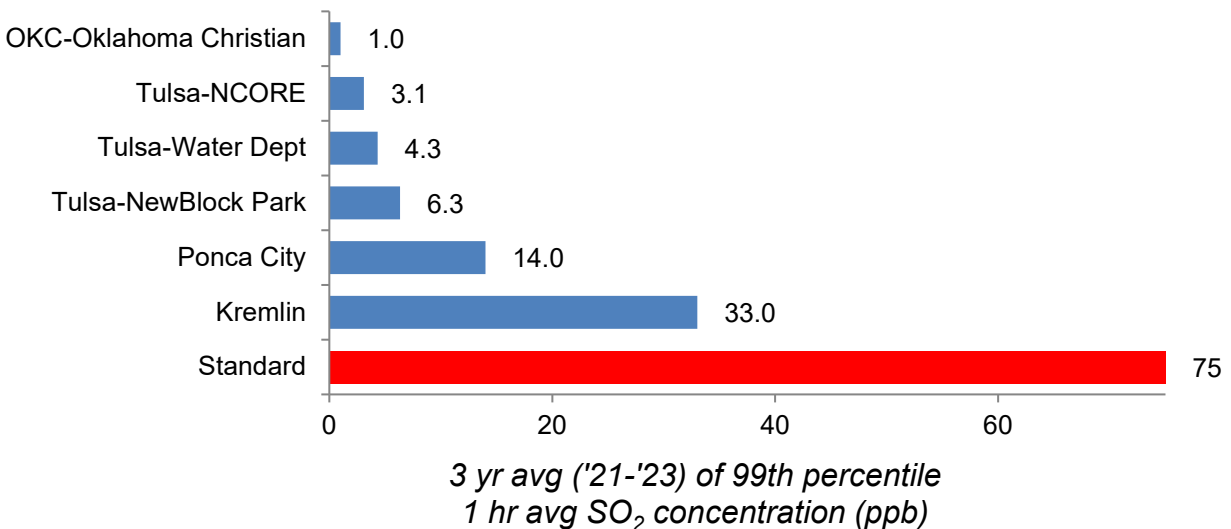
SO₂ Data

Primary SO₂ 1-hour standard: 75 ppb

Secondary SO₂ 3-hour standard: 0.5 ppm (= 500 ppb)

To attain the primary standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within the area must not exceed 75 ppb. The secondary standard is not to be exceeded more than once per year.

2023 SO₂ Values vs. 1 Hour NAAQS



2023 SO₂ Values vs. 3 Hour NAAQS

