

perhaps an order of magnitude, that is likely to be without appreciable risks of deleterious noncancer effects during a lifetime." EPA derived the RfC from consideration of four chronic rat inhalation studies showing adverse pulmonary effects. The diesel RfC is based on a "no observable adverse effect" level of 144 $\mu\text{g}/\text{m}^3$ that is further reduced by applying uncertainty factors of 3 for interspecies extrapolation and 10 for human variations in sensitivity. The resulting RfC derived in the Diesel HAD is 5 $\mu\text{g}/\text{m}^3$ for diesel exhaust as measured by diesel PM. This RfC does not consider allergenic effects such as those associated with asthma or immunologic effects. There is growing evidence that diesel exhaust can exacerbate these effects, but the exposure-response data is presently lacking to derive an RfC. Again, this RfC is based on animal studies and is meant to estimate exposure that is unlikely to have deleterious effects on humans based on those studies alone.

The Diesel HAD also briefly summarizes health effects associated with ambient PM and the EPA's annual NAAQS for $\text{PM}_{2.5}$ of 15 $\mu\text{g}/\text{m}^3$. There is a much more extensive body of human data showing a wide spectrum of adverse health effects associated with exposure to ambient PM, of which diesel exhaust is an important component due to its large contribution to ambient concentrations. The RfC is not meant to say that 5 $\mu\text{g}/\text{m}^3$ provides adequate public health protection for ambient $\text{PM}_{2.5}$. There may be benefits to reducing diesel PM below 5 $\mu\text{g}/\text{m}^3$ since diesel PM is a major contributor to ambient $\text{PM}_{2.5}$. Recent epidemiologic studies of ambient $\text{PM}_{2.5}$ do not indicate a threshold of effects at low concentrations.³⁷

Also, as mentioned earlier in the health effects discussion for $\text{PM}_{2.5}$, there are a number of other health effects associated with PM in general, and motor vehicle exhaust including diesels in particular, that provide additional evidence for the need for significant emission reductions from nonroad diesel sources. For example, the Diesel HAD notes that acute or short-term exposure to diesel exhaust can cause acute irritation (e.g., eye, throat, bronchial), neurophysiological symptoms (e.g., lightheadedness, nausea), and respiratory symptoms (e.g., cough, phlegm). There is also evidence for an immunologic effect such as the

exacerbation of allergenic responses to know allergens and asthma-like symptoms. All of these health effects plus the designation of diesel exhaust as a likely human carcinogen provide ample health justification for control.

iii. Ambient Levels and Exposure to Diesel Exhaust PM

Because diesel PM is part of overall ambient PM and cannot be easily distinguished from overall PM, we do not have direct measurements of diesel PM in the ambient air. Ambient diesel PM concentrations are estimated instead using one of three approaches: (1) Ambient air quality modeling based on diesel PM emission inventories; (2) using elemental carbon concentrations in monitored data as surrogates; or (3) using the chemical mass balance (CMB) model in conjunction with ambient PM measurements. (Also, in addition to CMB, UNMIX/PMF have also been used). Estimates using these three approaches are described below. In addition, estimates developed using the first two approaches above are subjected to a statistical comparison to evaluate overall reasonableness of estimated concentrations. It is important to note that, while there are inconsistencies in some of these studies on the relative importance of gasoline and diesel PM, the studies which are discussed in the Diesel HAD all show that diesel PM is a significant contributor to overall ambient PM. Some of the studies differentiate nonroad from on-road diesel PM.

(1) Air Quality Modeling

In addition to the general ambient PM modeling conducted for this proposal, diesel PM concentrations specifically were recently estimated for 1996 as part of NATA. In this assessment, the PM inventory developed for the recent regulation promulgating 2007 heavy duty vehicle standards was used. Note that the nonroad inventory used in this modeling was based on an older version of the draft NONROAD Model which showed higher diesel PM than the current version. Ambient impacts of mobile source emissions were predicted using the Assessment System for Population Exposure Nationwide (ASPEN) dispersion model. Overall mean annual national levels for both on-road and nonroad diesels of 2.06 $\mu\text{g}/\text{m}^3$ diesel PM were calculated with a mean of 2.41 in urban counties and 0.74 in rural counties. These are ambient levels such as would be seen at monitors rather than the exposure levels discussed earlier. Over half of the diesel PM comes from nonroad diesels.

Diesel PM concentrations were also recently modeled across a representative urban area, Houston, for 1996, using the Industrial Source Complex Short Term (ISCST3) model. This modeling is designed to more specifically account for local traffic patterns including diesel truck traffic along specific roadways. The modeling in Houston suggests strong spatial gradients for Diesel PM and indicates that "hotspot" concentrations can be very high, up to 8 $\mu\text{g}/\text{m}^3$ at receptor versus a 3 $\mu\text{g}/\text{m}^3$ average in Houston. Such concentrations are above the RfC for diesel exhaust and indicate a potential for adverse health effects from chronic exposure to diesel PM. These results also suggest that PM from diesel vehicles makes a major contribution to total ambient PM concentrations. Such "hot spot" concentrations along certain roadways suggest the presence of both high localized exposures plus higher estimated average annual exposure levels for urban centers than what has been estimated in assessments such as NATA, which are designed to focus on regional and national scale averages. There are similar "hot spot" concentrations in the immediate vicinity of use of nonroad equipment such as in urban construction sites.

(2) Elemental Carbon Measurements

As mentioned before, the carbonaceous component is significant in ambient PM. The carbonaceous component consists of organic carbon and elemental carbon. Monitoring data on elemental carbon concentrations can be used as a surrogate to determine ambient diesel PM concentrations. Elemental carbon is a major component of diesel exhaust, contributing to approximately 60 to 80 percent of diesel particulate mass, depending on engine technology, fuel type, duty cycle, lube oil consumption, and state of engine maintenance. In most areas, diesel engine emissions are major contributors to elemental carbon in the ambient air, with other potential sources including gasoline exhaust, combustion of coal, oil, or wood (including forest fires), charbroiling, cigarette smoke, and road dust. Because of the large portion of elemental carbon in diesel particulate matter, and the fact that diesel exhaust is one of the major contributors to elemental carbon in most areas, ambient diesel PM concentrations can be bounded using elemental carbon measurements.

The measured mass of elemental carbon at a given site varies depending on the measurement technique used. Moreover, to estimate diesel PM concentration based on elemental

³⁷ EPA-SAB-Council-ADV-99-012, 1999. The Clean Air Act Amendments Section 812 Prospective Study of Costs and Benefits (1999): Advisory by the Health and Ecological Effects Subcommittee on Initial Assessments of Health and Ecological Effects, Part 1. July 28, 1999.