3M

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Understanding P-Series Particulate Filters

SUMMARY

42 CFR 84 incorporated "worst case" test parameters for P-series filters to ensure that the filters would perform at least as well in the workplace as they do in the laboratory. Subsequent laboratory testing by NIOSH has revealed that **all** P-series filters will eventually experience a decrease in filter efficiency when subjected to DOP oil testing beyond the current NIOSH loading requirements. Since a reduction in filter efficiency may not always be accompanied by an increase in breathing resistance, NIOSH requested each manufacturer of P-series filters to establish service time recommendations.

NIOSH DOP test concentrations are 50 to 100 times greater than oil mist concentrations typically found in the workplace. Therefore, it is not appropriate to assume the time a P-series filter lasts under NIOSH laboratory testing conditions will reasonably predict filter service life in the workplace. In addition, most workplace environments that contain oil aerosols also contain solid contaminants. Solid aerosols tend to build up and form a "cake" on the filter, which increases both filter efficiency and breathing resistance. Taking these "real world" issues into account, the following time use limitation is recommended for 3M P-series filters:

If filter becomes damaged, soiled, or breathing becomes difficult, leave the contaminated area and dispose of the filter. If used in environments containing only oil aerosols, dispose of filter after 40 hours of use or 30 days, whichever is first.

Filters changed according to the 3M P-series filter time use limitation will perform at or above their certified efficiency.

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INTRODUCTION

Protection provided by respirators used to reduce worker exposure to particulate contaminants is determined by a combination of wear time, face seal leakage, and filter efficiency. Wear time can be maximized through training about the need for proper respirator use, coupled with selecting respirators that are comfortable and easy to breathe through. Face seal leakage can be minimized through training on proper fitting methods and application of fit tests. The optimal filter efficiency is selected based on the contaminants found in the workplace.

NIOSH has implemented new negative pressure air purifying particulate filter certification tests which address filter efficiency. 42 CFR Part 84 created three new series of respirators: N, R, and P. Each series is offered in three efficiency levels: 95%, 99%, and 99.97%.[1] By incorporating "worst case" testing parameters the new test procedures were intended to ensure that filter efficiency in workplace settings would always meet or exceed certified efficiency levels, provided that users followed recommended use instructions.

Subsequent NIOSH laboratory testing has revealed that **all** P-series filters can eventually experience at least some decrease in filter efficiency when loaded with sufficient amounts of dioctyl phthalate oil. In light of this new information NIOSH requested all manufacturers of P-series filters to include service time recommendations as part of the use instructions.

42 CFR PART 84 CERTIFICATION TESTS

When NIOSH implemented the 42 CFR Part 84 particulate filter testing methods they incorporated test parameters which, based on current knowledge, presented "worst case" conditions for filters. These parameters include using the most penetrating particle size, challenging test agents, and high filter loading requirements. "Worst case" test conditions were desired to ensure that the filters would perform at least as well in the workplace as they do in the laboratory.

In the past NIOSH tested certain classes of filters against typical workplace contaminants, such as silica dust and lead fume. Under 42 CFR 84 all filters are challenged with laboratory generated aerosols, which are the most difficult size to capture: particles with approximately 0.3 μm mass median aerodynamic diameter (MMAD). Particles both smaller and larger than this size are captured at a higher efficiency, and most aerosols found in the workplace are larger than 0.3 μm MMAD.[2] By testing with the most penetrating particle size it can be reliably predicted that filters will perform at their certified efficiency level (95%, 99%, or 99.97%) or better when used against aerosols present in the workplace.

Under 42 CFR 84 the test aerosol used depends on the filter classification: the N-series filters are tested with solid sodium chloride (NaCl) particles, and R- and P-series filters with dioctyl phthalate (DOP), an oil. Solid aerosols tend to build up and form a "cake" on the filter which increases both the filter's efficiency and its breathing resistance, indicating when the filter needs to be changed. In contrast, it is thought that DOP oil droplets tend to spread out across the filter fibers or "wet" the fibers. With certain electrostatic filters this may mask some of the electrostatic charge on the filter fibers and potentially result in a decrease in filter efficiency.

The DOP test is made more challenging by use of a particularly high concentration (100 mg/m^3) for an oil mist. As a result, from a filter efficiency perspective, the DOP loading test is more discriminating than the NaCl test. Therefore, N-series filters are approved for protection against non-oil aerosols only, and R- and P-series filters are approved for both oil and non-oil aerosols.

Another important aspect of 42 CFR 84 is that all filters now undergo heavy loading with the NaCl and DOP test aerosols during certification testing. N- and R-series filters are loaded to 200 mg. Filter performance must exceed the efficiency level desired for certification (95%, 99%, or 99.97%) at all times during the test. P-series filters are loaded to at least 200 mg. If the efficiency of the filter is decreasing at 200 mg then the test continues until the filter efficiency stabilizes. At the end of the certification test the filter efficiency for **all** NIOSH certified P-series filters is stable and exceeds the filter efficiency category.

NIOSH USER'S GUIDE

In addition to subjecting filters to severe testing requirements, NIOSH has recommended time use restrictions for filters in "NIOSH Guide to the Selection and Use of Particulate Respirators Certified under 42 CFR Part 84."[3] In this guide, NIOSH states that "all filters should be replaced whenever they are damaged, soiled, or causing noticeably increased breathing resistance." Additional limitations, specific to the filter series, may also apply. For example, if oil aerosols are present, R-series filters must be changed after 8 hours of use or after loaded with 200 mg of aerosol.

The User's Guide states that "Use and reuse of the P-series filters would be subject only to considerations of hygiene, damage, and increased breathing resistance." While the NIOSH test conditions represent "worst case," later NIOSH laboratory testing revealed that **all** P-series filters, both electrostatic and mechanical filters, will eventually experience a decrease in filter efficiency when subjected to DOP testing beyond the current NIOSH loading requirements. The mechanism believed to cause a decrease in efficiency for electrostatic filters is discussed above. The mechanism by which filter efficiency decreases for mechanical filters is not known at this time.

NIOSH testing has also indicated that a reduction in filter efficiency may not always be accompanied by an increase in breathing resistance. In light of this new information, NIOSH published a "Respirator User Notice"[4] to notify end users that time use restrictions would be recommended for P-series filters. In the "Respirator User Notice" NIOSH stated that "This reduction in filter efficiency varies significantly from model to model and NIOSH can not make a single filter change recommendation that is appropriate for all models. Therefore, NIOSH has requested each manufacturer of P-series filters to establish service time recommendations as part of their instructions."

P-SERIES TIME USE LIMITATION

In response to NIOSH's request, the following time use limitation is recommended for all 3M P-series filters:

If filter becomes damaged, soiled, or breathing becomes difficult, leave the contaminated area and dispose of the filter. If used in environments containing only oil aerosols, dispose of filter after 40 hours of use or 30 days, whichever is first.

As discussed above, if a filter is used in environments containing non-oil aerosols, the filter will cake and efficiency will increase. This increase in efficiency is accompanied by an increase in breathing resistance which can help signal the wearer to change the filter. Atmospheres that contain both oil and non-oil aerosols will most likely result in filter caking from the non-oil aerosol. Therefore, the P-series time use limitation reverts to *dispose of the filter when it becomes damaged, soiled, or difficult to breathe through* if the filter is used in environments that contain no oil aerosols, or if the filter is used in environments that contain a mixture of oil and non-oil aerosols. Only if a P-series filter is used in an environment that contains only oil aerosols does the full time use limitation apply.

THE "REAL WORLD" PERSPECTIVE

By creating N-, R-, and P-series filters, NIOSH has compelled end users to consider the presence of oil aerosols in the environment when selecting a respirator. The NIOSH User's Guide states that R- or P- series respirators are to be used if oil aerosols are present. (For guidance on which contaminants may be considered to be an oil, see Technical Data Bulletin #129.[5]) In most atmospheres containing oil aerosols respirators are worn for protection from contaminants other than oil. For example, in the textile industry oil aerosols may be generated from looming machines, but respirators may be used to reduce exposures to cotton dust. In foundries where parting oils are sprayed on molds, respirators are worn to protect workers from silica dust. And in the food processing industry where food grade oils are aerosolized, grain dust may be the primary exposure for which respirators are being worn.

All of these environments contain oil and, according to wording in NIOSH approvals, would necessitate using an R- or P-series filter. They would also be environments where solid particles are likely to cause filter caking, increasing filter efficiency and breathing resistance, which would indicate when the filter or respirator should be changed. Following the NIOSH time restrictions, R-series filters should be disposed of if they become damaged, soiled, or difficult to breathe through. Additionally, they should be changed after no more than 8 hours of use or after 200 mg loading. Based on the 3M P-series time use limitation P-series filters should be changed when the filter becomes damaged, soiled, or difficult to breathe through.

Because oil aerosols are seldom the primary contaminant in the environment there has been limited documentation of oil concentrations in the workplace. However, recent concern over the health effects of metal working fluids, many of which would be considered oils, has prompted an extensive survey of oil exposures at three auto parts manufacturing facilities.[6] Each of the facilities had thousands of metal working machines. Investigators collected 403 personal, 6 to 8

hour time averaged samples of workers exposed to metal working fluids. The mean total exposure was 0.7 mg/m^3 with average particle sizes ranging from 3.6 to 8.2 μm MMAD (well above the most penetrating particle size of 0.3 μm MMAD) by operation for exposed workers.

Based on the above metal working fluid survey, a typical oil mist exposure is unlikely to exceed 2 mg/m^3 as compared to the DOP aerosol concentration of 100 mg/m^3 (50 to 100 times greater than oil mist concentrations typically found in the workplace) used by NIOSH. Therefore, it is not appropriate to assume the time a P-series filter lasts under NIOSH laboratory testing conditions will reasonably predict filter service life in the workplace. A more meaningful interpretation would be to assume a worker is continuously exposed to 2 mg/m^3 of oil while working at a moderate rate. This worker would breathe about 10 m^3 of air over an eight-hour day. Under these circumstances it would take 10 days of continuous use to reach 200 mg loading of oil. This is the **minimum** filter loading used by NIOSH in certification tests for P-series filters. By following the 3M time use limitation on P-series filters, the worker would have replaced his filters after no more than 5 days (40 hours) - well before any potential decrease in filter efficiency.

There are few, if any, workplace environments that contain oil aerosols with no other contaminants. Neither 3M nor NIOSH has been able to locate an oil-only environment. Therefore, in most industrial environments it is expected that non-oil particles will cake the filter and increase filter efficiency keeping it well above the certified level. In oil-only environments, a potential for a gradual drop in filter efficiency may exist, but filters changed according to the 3M P-series filter time use limitation will perform at or above their certified efficiency.

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