

be conducted according to the following criteria:

- Challenge testing must be conducted on a full-scale filter element identical in material and construction to the filter elements proposed for use in full-scale treatment facilities.

- Challenge testing must be conducted using *Cryptosporidium* oocysts or a surrogate which is removed no more efficiently than *Cryptosporidium* oocysts. The organism or surrogate used during challenge testing is referred to as the challenge particulate. The concentration of the challenge particulate must be determined using a method capable of discretely quantifying the specific organism or surrogate used in the test, i.e., gross water quality measurements such as turbidity cannot be used.

- The maximum allowable feed water concentration used during a challenge test is based on the detection limit of the challenge particulate in the filtrate and calculated using one of the following equations.

For bag filters:

$$\text{Maximum Feed Concentration} = 3.16 \times 10^3 \times (\text{Filtrate Detection Limit})$$

For cartridge filters:

$$\text{Maximum Feed Concentration} = 3.16 \times 10^4 \times (\text{Filtrate Detection Limit})$$

This will allow the demonstration of up to 3.5 log removal for bag filters and 4.5 log removal for cartridge filters during challenge testing if the challenge particulate is removed to the detection limit.

- Challenge testing must be conducted at the maximum design flow rate specified by the manufacturer.

- Each filter must be tested for a duration sufficient to reach 100% of the terminal pressure drop, a parameter specified by the manufacturer which establishes the end of the useful life of the filter. In order to achieve terminal pressure drop during the test, it will be necessary to add particulate matter to the test solution, such as fine carbon test dust or bentonite clay particles.

- Each filter must be challenged with the challenge particulate during three periods over the filtration cycle: within 2 hours of start-up after a new bag or cartridge filter has been installed, when the pressure drop is between 45 and 55% of the terminal pressure drop, and at the end of the run after the pressure drop has reached 100% of the terminal pressure drop.

- Removal efficiency of a bag or cartridge filtration process is determined from the results of the challenge test, and expressed in terms of log removal values as defined by the following equation:

$$\text{LRV} = \text{LOG}_{10}(C_f) - \text{LOG}_{10}(C_p)$$

where LRV = log removal value demonstrated during challenge testing; C_f = the feed concentration used during the challenge test; and C_p = the filtrate concentration observed during the challenge test. For this equation to be valid, equivalent units must be used for the feed and filtrate concentrations. If the challenge particulate is not detected in the filtrate, then the term C_p is set equal to the detection limit. An LRV is calculated for each filter evaluated during the test.

- In order to receive treatment credit for *Cryptosporidium* under this

proposed rule, challenge testing must demonstrate a removal efficiency of 2 log or greater for bag filtration and 3 log or greater for cartridge filtration. If fewer than twenty filters are tested, then removal efficiency of the process is set equal to the lowest of the representative LRVs among the various filters tested. If twenty or more filters are tested, then removal efficiency of the process is set equal to the 10th percentile of the representative LRVs among the various filters tested. The percentile is defined by $[i/(n+1)]$ where i is the rank of n individual data points ordered lowest to highest. It may be necessary to calculate the 10th percentile using linear interpolation.

- Any significant modification to the filtration unit (e.g., changes to the filtration media, changes to the configuration of the filtration media, significant modifications to the sealing system) would require additional challenge testing to demonstrate removal efficiency of the modified unit.

b. *How was this proposal developed?*

The Stage 2 M-DBP Agreement in Principle recommended that EPA develop criteria for awarding *Cryptosporidium* removal credits of 1 log for bag filters and 2 log for cartridge filters. Today's proposal is consistent with the Agreement.

A limited amount of published data are available regarding the removal efficiency of bag and cartridge filters with respect to *Cryptosporidium* oocysts or suitable surrogates. The relevant studies identified in the literature are summarized in Table IV-18.

TABLE IV-18.—RESULTS FROM STUDIES OF *Cryptosporidium* OR SURROGATE REMOVAL BY BAG AND CARTRIDGE FILTERS

Process	Log removal	Organism/surrogate	Reference
Bag and cartridge filtration in series.	1.1 to 2.1	3 to 6 μm spheres	NSF 2001a.
Cartridge filtration	3.5 (average)	<i>Cryptosporidium</i>	Enriquez et al. 1999.
Cartridge filtration	3.3 (average)	<i>Cryptosporidium</i>	Roessler, 1998.
Cartridge filtration	1.1 to 3.3	<i>Cryptosporidium</i>	Schaub et al. 1993.
Cartridge filtration	0.5 to 3.6	5.7 μm spheres	Long, 1983.
Cartridge filtration	2.3 to 2.8	<i>Cryptosporidium</i>	Ciardelli, 1996a.
Cartridge filtration	2.7 to 3.7	<i>Cryptosporidium</i>	Ciardelli, 1996b.
Prefilter and bag filter in series	1.9 to 3.2	3.7 μm spheres	NSF 2001b.
Bag filtration	~3.0	<i>Cryptosporidium</i>	Cornwell and LeChevallier, 2002.
Bag filtration	0.5 to 3.6	<i>Cryptosporidium</i>	Li et al. 1997.
Bag filtration	0.5 to 2.0	4.5 μm spheres	Goodrich et al. 1995.

These data demonstrate highly variable removal performance for these processes, ranging from 0.5 log to 3.6 log for both bag and cartridge filtration. Results of these studies also show no correlation between the pore size rating established by the manufacturer and the

removal efficiency of a filtration device. In a study evaluating two cartridge filters, both with a pore size rating of 3 μm , a 2 log difference in *Cryptosporidium* oocyst removal was observed between the two filters (Schaub *et al.* 1993). Another study

evaluated seventeen cartridge filters with a range of pore size ratings from 1 μm to 10 μm and found no correlation with removal efficiency (Long, 1983). Li *et al.* (1997) evaluated three bag filters with similar pore size ratings and observed a 3 log difference in