The levels of endotoxin discovered on the filters in this study were 2.27 EU/m^3 on the one filter from the first day and an average of 2.68 EU/m^3 from the filters from the second day. In the article by Viet, Buchan, and Stallones concerning the effects of endotoxin on pulmonary function, there were findings that suggest that workers exposed to a significant amount of endotoxin did have pulmonary effects.

Table 14: Endotoxin Study Comparison

	Minimum	Maximum	Average Exposure	Standard Deviation
Landscape Workers' Study	<0.03	4.14	1.84	1.44
Colorado Study (Viet et al., 2001)	4.40	744.40	54.24	3.27

Units in EU/m3

However, the values in this study are higher than the exposure levels found in the participating landscape workers breathable space. The levels found in this study were significantly lower than the findings of the Colorado study ($p<0.001$). The significant difference between these studies was instrumental in this study in the absence of vital data. It is clear from this difference that even if the afternoon PFT data had been contained from the second day, the likelihood of an acute shift in any of the participants would not have occurred strictly based on endotoxin exposure.

The Colorado was a more traditional agricultural study versus this study on the landscaping industry, thus explaining the difference in levels due to the environment needed to support endotoxin growth.

Another agriculture study published in 2001 considered endotoxin levels between 6400 and 10000 EU/m^3 to be significant in causing respiratory distress (Kirkhorn and Schenker, 2001). In addition to that study another researcher studied Swedish swine confinement buildings during the 1980s. In this study personal endotoxin exposures ranged from 0.02-1.12 µg/m^3 with a mean of 0.23 µg/m^3 and a standard deviation of 0.2 µg/m^3 (Donham et al., 1989).

According to the American Conference of Government Industrial Hygienist (ACGIH) established a suggested threshold level for cotton workers exposed to similar "…acute mucous membrane irritation…"(Viet et al., 2001) for 90 EU/m^3. Much like the fungal spore exposures, the presence of the irritant is apparent but the levels are low and not proven to cause respiratory difficulty or allergic reactions (Viet et al., 2001).

4.8 Respirator Design

The participating employees were asked to rate their experience with the selected N-100, half-face, disposable respirator. Seven of the questions were Likert-type questions with the remaining questions being short answer. The Likert-type scale questions ranged from 1 to 5 with 1 being disagree and 5 being agree with the corresponding statement. The participants responded to the questionnaire even if they were not chosen to wear a respirator on the first day to express their perceived comfort and the actual experience working and communicating with those wearing respirators. On the second day of data collection only those wearing respirators that were not selected to wear one on the first day completed a questionnaire.

The results of the Likert-type questions across the two days are represented in Table 15 (graphs of the responses can be found in Appendix E).

Table 15: Respirator Design Questionnaire Responses

	Mean Responses for Likert Type Questions (range 1-5)	Standard Deviations
The respirator was comfortable to wear	2.2	0.49
The respirator fit properly	2.89	0.51
The head straps are easy to adjust	4.2	0.46
I was able to communicate clearly to my fellow workers when wearing the Respirator	3.45	0.42
I was able to breathe normally while wearing the respirator	3.8	0.55
I felt that the respirator was necessary for the mulching task	2.7	0.58
I would voluntarily choose to wear a respirator again while mulching	2	0.52

The respirator used in this study was a Moldex N-100 half-face disposable respirator seen in Figure 6. The Moldex number for the specific respirator used is 2730N100, which is the medium/large non-oil particulate respirator.

Figure 6: Moldex N-100 Half-Face Disposable Respirator

One of the most common complaints from the participating landscape workers is that the nose piece did not fit properly and was not adjustable. Also, the respirator did not fit well, the Moldex material was not very flexible and did not mold to the user's face.

The employees described the design features that they were not satisfied with on the chosen respirator in this study. Some of the comments and the comments frequency among employees included the following (the entire list of comments can be found in Appendix F):

Table 16: Respirator Design Comments

Comment	Frequency of Comment (% respondents)
Nose piece unsatisfactory	66.7
Would not voluntarily wear a respirator	87.5
Liner of respirator bothersome	25
Respirator uncomfortable to wear	100
Respirator needs to be smaller overall	25
No changes needed to respirator	12.5

More specific individual comments from landscape workers include:

- Nose piece too tight (pinch); couldn't breath through his nose-kept breathing through his mouth; really gets humid (increase ventilation)
- Nose piece - wider; fix chin size
- Adjustable nose band; have it come down to chin, not all the way down the neck; non-fuzzy coating on inside (gets caught on beard stubble)
- Loosen nose piece

Five of the employees made it clear that the nose piece on the Moldex disposable respirator was not comfortable. Also, the shape and length of the respirator was not compatible with several of the users' faces, especially those with facial hair. In general, if the nose piece is adjustable, the material of the respirator more flexible and able to mold to the face, and the length of the respirator shortened the employees would be more satisfied with the product.

In a review of available respirators to try to meet the needs of the workers in this study, there are many different manufacturers and styles, but the selection becomes slim once the search is narrowed to N-100 respirators. The July 2002 Lab Safety Supply catalog and the 2002-2003 Fisher Scientific catalog were used for reference when reviewing available respirators. The 3M particulate respirator 2BD-38021, is another N-100 respirator that is currently available commercially. The 3M version also disposable and comes with adjustable nose piece.

4.8.1 Respirator Characteristics

The National Institute of Occupational Safety and Health (NIOSH) established guidelines that the disposable respirators must meet in order to receive the designation of N-100; however there are not specific characteristic guidelines laid out by NIOSH in the recent updates made to the N-100 specifications in 1995. The N-100 disposable respirators must block at least 99.9% of the particles and fit the user properly. NIOSH does not address physical design requirements, for example, head straps, exhale holes, etc in the updated guidelines.

After reviewing all available disposable respirators (not limited to N-100) there are several features that vary across manufactures and products. These features include nose pieces, head straps, exhale hole, and respirator material and overall shape. These all were covered on the respirator design questionnaire given to the landscape workers except a question concerning the exhale hole. Even though there was not a specific question there were a few comments concerning the exhale hole noted on the questionnaires.

The nose pieces on respirators vary in size and structure, whether the nose piece is adjustable or not adjustable and the length of the nose piece also varies. In this study the adjustable style appears to be preferred by the participants. Employees complained of the Moldex non adjustable nose piece pinched their noses' (66.7% of participants).

The number and placement of the head straps also varies among manufactures and styles of disposable respirators. The respirator used in this study had two straps; however, some styles only have one head strap. The employees seemed pleased with the

comfort and the location of the straps of the respirator used in this study. The participants polled in this study had a mean response value of 4.2 when ask if the head straps were easy to adjust (a score of 5 being strongly agree).

Other characteristics that tend to differ across disposable respirators include the exhale hole and the amount of structure build into the respirator. The exhale hole was a factor is this study and one of the participants noted that it should be larger in size. The exhale hole is not an integral component of all disposable respirators; many do not have this characteristic. The structure of the respirator varies from a flat "beak" looking shape which is designed to fit in one's pocket to the more traditional "dust mask" shape. In this study a more traditional shape was used, but even beyond the shape the structure can differ immensely across disposable respirators. The Moldex respirator used was not as flexible compared to other respirators providing similar protection. Moldex respirators have a unique cross hatching structure that makes the respirator more firm than many others.

4.9 Data Analysis

Since the number of participants is small (n=9) a non parametric means of statistical analysis was chosen. Chi-Squared is a common approximation for the Exact Fisher's Test. Studies with large sample sizes are easier to analyzed using Chi-Squared, but in this study since the sample size is small Chi-Squared is not a valid approximation (row sums <5) and the Fisher's Exact Test is used to analyze the data. The Fisher's Exact Test determines if there is any correlation between different independent factors in a study. The data of interest is organized into a two by two matrix and executed using the SAS statistical software.

The participants were divided into two different sets of groups initially, that is by age and duration of smoking. Using the median value for age (26 years of age) and the approximate median for the number of years the eight smokers have been smoking (7 years) the independent groups were established. The groups were compared against the responses to the Rylander's Questionnaire and their responses to the respirator design questionnaire.

The p-value of 0.05 was chosen (complying with NIOSH guidelines) to determine if the responses to the questionnaires were correlated to either age or smoking. After running all of the combinations in SAS, and observing the two-tailed p-values that were generated by the combinations, none of the groupings were determined to be significantly different. The two-tailed p-value was chosen because there was not any stated hypothesis on how the data would be correlated, so only if there was any correlation amongst the data was of interest. For example, it was not hypothesized that older participants were more likely to wear a respirator, thus when age was correlated with the likeliness to wear a respirator it was of interested whether it was older or younger participants that were highly correlated with this response and if this group's response was significantly different from the other age group.

In Tables 17 and 18 the table probabilities are shown for the different combinations represented in two-by-to matrices. The reported p-value is the two-tailed p-value for the combinations. The complete analysis can be found in appendix G.

Table 17: SAS P-values for Fisher's Exact Test (Respirator Design Questionnaire Responses)

Age vs. Respirator Design Responses	
Question #	P-value
1	1.0000
2	1.0000
3	1.0000
4	0.1667
5	0.1071
6	0.4643
7	1.0000

Smoking vs. Respirator Design Responses	
Question #	P-value
1	1.0000
2	1.0000
3	1.0000
4	1.0000
5	0.4286
6	1.0000
7	0.4286

Table 18: SAS P-values for Fisher's Exact Test (Rylander's Questionnaire Responses)

Age vs. Rylander's Responses	
Question #	P-value
1	1.0000
8	0.1667
12	0.4444
13	N/A
14	0.4444
15	1.0000
16	1.0000
18	0.5556
20	1.0000
25	N/A

Smoking vs. Rylander's Responses	
Question #	P-value
1	1.0000
8	0.4286
12	1.0000
13	N/A
14	1.0000
15	1.0000
16	1.0000
18	1.0000
20	1.0000
25	N/A

The questions that have a 'N/A' as a reported value were analyzed for significance, but since the data contained zeros for a complete column in all four cases there is no comparison that SAS will analyze and the columns are the same and not significantly different.

The p-value was set at 0.05 to establish significance, though none of the comparisons resulted in a significant finding there were three that resulted in relatively low p-values. All three comparisons were age related none of the smoking comparisons deem a significant p-value. The smallest two-tailed p-value was 0.1071 and resulted from the age of participants being compared to the response to question number five on the respirator design questionnaire. The question was "I was able to breathe normally while wearing the respirator:" In Table 10 is the matrix representing the age versus response to question number five. From Table 10, it was determined that the participants 26 or younger agreed that they were able to breathe normally while wearing the respirator.

Table 19: Matrix Representing Age versus Respirator Design Question Number Five

Age	Response		
Frequency	</=3	>3	Total
</=26	0	5	5
>26	2	1	3
Total	2	6	8

The other two combinations that resulted in p-values less than 0.2 (0.1667 for both) were also related to the age of the participants. The responses that resulted in these p-values were Respirator Design question number four and Rylander's question number eight. In Table 20 and 21 the raw matrices for these comparisons are shown.

Table 20: Matrix Representing Age versus Respirator Design Question Number Four

Table of Age by Response

Age	Response		
Frequency	</=3	>3	Total
</=26	3	2	5
>26	0	4	4
Total	3	6	9

Table 21: Matrix Representing Age versus Rylander's Question Number Eight

Table of Age by Response

Age	Response		
Frequency	NO	YES	Total
</=26	5	0	5
>26	2	2	4
Total	7	2	9

The participants that were 26 or younger tended to disagree with the statement made in the Respirator Design question, "I was able to communicate clearly to my fellow workers when wearing the Respirator." Three of the 5 participants 26 or younger either disagreed or were neutral about the statement in number four and 4 of the 4 workers older than 26 years of age agreed with the statement.

Rylander's question 8 concerns wearing breathing protection at work and the responses are summarized in Table 21. All 5 of the employees 26 or younger responded that they do not wear breathing protection at work; whereas half of the workers above 26 said they wear protection at work.