6.21 Prime Urethane Carpet Cushion (Version "A")

four exposures were conducted to different compositions representing this product type. Exposure data for the series of mixtures are summarized in Table 44. Exposure concentration data for each of the four exposures are provided in Tables 45 - 48.

The initial exposure at the high end of the concentration range (Table 45) resulted in a respiratory depression of 55%, consistent with (but slightly above) that which would have resulted from the measured average concentration of BHT or 1,4-dimethylpiperazine alone. There appeared to be little or no additive effect of the two irritants. When the BHT was removed from the exposure mixture (Table 46), the measured respiratory depression was 22%. Removal of both potential irritants (BHT and 1,4-dimethylpiperazine, Table 47) from the mixture did not result in significant irritation response, indicating that any irritation experienced from the initial mixture was due to the presence of one or both of these compounds.

Testing at the low end of the target concentration range (Table 48) did not result in a significant irritation response. Neither of the suspected irritants were present at levels which would be expected to cause significant irritation. The exposure concentrations of BHT and 1,4-dimethylpiperazine used in this test were approximately 20 and 6 times higher, respectively, than the peak concentrations measured in chamber tests of this type of cushion conducted at CPSC.

Figures B-88 through B-91 in Appendix B show the respiratory response (as a percent of baseline) vs. time for each group of animals, as well as the exposure concentration (as ppm propane, based on total hydrocarbon analyzer measurements. In the initial exposure (Figure B-88), a rapid respiratory depression was observed, with some attenuation (recovery toward baseline) during exposure. This is consistent with the responses observed for both BHT and 1,4-dimethylpiperazine. For the second exposure (Figure B-89), however, there was a nearly immediate respiratory depression which was more sustained during the exposure period.

Appendix D provides the measured concentrations of the individual components in the exposure atmospheres, at different time points during the exposure. These analyses were done using the solid sorbent sampling and GC/MS analysis methodology described in Section 3.1.3, and with application of the analytical responses outlined in Table 12. Variation in these measurements increases for the compounds at lower concentrations, which would be expected.

6.2.2 Prime urethane carpet cushion (Version "B")

Three exposures were conducted to different compositions representing this product type. Exposure data for the series of mixtures are summarized in Table 49. Exposure concentration data for each of the exposures are provided in Tables 50 - 52.

The initial exposure at the high end of the concentration range (Table 50) resulted in a respiratory depression of 38%. This is below the sum of the predicted respiratory depression for the Task 1 irritants included in the mixture, but consistent with that response which would have resulted from the measured average concentration of BHT alone. When the BHT was removed from the exposure mixture (Table 51), no significant irritation was observed, despite the presence of a level of 1,3-dichloro-2-propanol above that which would be predicted to cause significant irritation from the Task 1 regression line.

Testing at the low end of the target concentration range (Table 52) did not result in a significant irritation response. This was despite a level of 1,3-dichloro-2-propanol above that which would be predicted to cause significant irritation from the Task 1 regression line. The exposure concentration of BHT used in this test was approximately 20 times higher than the peak concentration measured in chamber tests of this type of cushion conducted at CPSC.

Figures B-92 through B-94 in Appendix B show the respiratory response (as a percent of baseline) vs. time for each group of animals, as well as the exposure concentration (as ppm propane, based on total hydrocarbon analyzer measurements. For the initial exposure (Figure B-92), respiratory depression began almost immediately, but continued into the exposure before plateauing near the end of exposure.

Appendix D provides the measured concentrations of the individual components in the exposure atmospheres, at different time points during the exposure. These analyses were done using the solid sorbent sampling and GC/MSD analysis methodology described in Section 3.1.3, and with application of the analytical responses outlined in Table 12.

6.2.3 Sponge rubber carpet cushion

Six exposures were conducted to different compositions representing this product type. Exposure data for the series of mixtures are summarized in Table 53. Exposure concentration data for each of the exposures are provided in Tables 54 - 59.

The initial exposure at the high end of the concentration range (Table 54) resulted in a respiratory depression of 42%. This is below the predicted respiratory depression for the measured concentration of 2-methylnaphthalene, the only Task 1 irritant included in the mixture. When the 2-methylnaphthalene was removed from the exposure mixture (Table 55), a respiratory depression of 17% was measured. 1,4-Dimethylnaphthalene was suspected as a contributor to this irritation, since it is chemically similar to 2-methylnaphthalene. Removal of both substituted naphthalenes from the test mixture (Table 56) resulted in no significant irritation, suggesting that these compounds contributed to the observed irritation in the initial test.

The first test at the low end of the target concentration range (Table 57) resulted in a respiratory depression of 36%, consistent with the respiratory depression predicted from the 2-methylnaphthalene alone. An additional exposure was conducted at half of the original low end target concentration. Again, a significant response was determined (Table 58), with the respiratory depression of 15% consistent with the respiratory depression predicted from the 2-methylnaphthalene alone. A final exposure, at ¼ of the original low end target concentration (Table 59), was not found to cause a significant irritation response. The highest exposure concentration of 2-methylnaphthalene which did not cause respiratory irritation in the synthesized mixture testing was approximately 15 times greater than the highest chamber concentrations measured in chamber tests of this sponge rubber carpet cushion conducted at CPSC.

Figures B-95 through B-100 in Appendix B show the respiratory response (as a percent of baseline) vs. time for each group of animals, as well as the exposure concentration (as ppm propane, based on total hydrocarbon analyzer measurements. In all cases, the exposures which exhibited a positive sensory irritation response for this mixture were found to have some immediate respiratory depression at the beginning of exposure, with a continued decrease in respiratory rate as the exposure continued.

Appendix D provides the measured concentrations of the individual components in the exposure atmospheres, at different time points during the exposure. These analyses were done using the solid sorbent sampling and GC/MSD analysis methodology described in Section 3.1.3, and with application of the analytical responses outlined in Table 12.

6.2.4 Bonded urethane carpet cushion

Three exposures were conducted to different compositions representing this product type. Exposure data for the series of mixtures are summarized in Table 60. Exposure concentration data for each of the exposures are provided in Tables 61 - 63.

The initial exposure at the high end of the concentration range (Table 61) resulted in a respiratory depression of 36%. This is above the predicted respiratory depression for the measured concentration of BHT, the only Task 1 irritant included in the mixture. When the BHT was removed from the exposure mixture (Table 62), no significant irritation resulted, suggesting that it was responsible for the observed irritation in the initial test.

Testing at the low end of the target concentration range (Table 63) was not found to cause a significant irritation response. The exposure concentration of BHT used in this test was approximately 25 times higher than the peak concentration measured in chamber tests of bonded urethane cushions conducted at CPSC.

figures B-101 through B-103 in Appendix B show the respiratory response (as a percent of baseline) vs. time for each group of animals, as well as the exposure concentration (as ppm propane, based on total hydrocarbon analyzer measurements. In the initial exposure (Figure B-88), respiratory depression began upon initiation of the exposure, and plateaued during the first half of the exposure period before recovering slightly over the second half of the exposure. This response is consistent with those observed for exposures to BHT.

Appendix D provides the measured concentrations of the individual components in the exposure atmospheres, at different time points during the exposure. These analyses were done using the solid sorbent sampling and GC/MS analysis methodology described in Section 3.1.3, and with application of the analytical responses outlined in Table 12.

6.2.5 Styrene-butadiene latex rubber (SBR) backed carpet

Two exposures were conducted to different compositions representing this product type. Exposure data for the pair of mixtures are summarized in Table 64. Exposure concentration data for each of the exposures are provided in Tables 65 - 66.

The initial exposure at the high end of the concentration range (Table 65) resulted in no significant irritation. 4-Phenylcyclohexene, the only Task 1 irritant included in this mixture, was below a concentration expected to result in irritation; however, dodecanol was not able to be generated in this mixture. An additional test was done with decanol substituted for dodecanol as a long-chain alcohol often identified in emissions from this product type (Table 66); this test also found no significant irritation. With the exception of dodecanol, exposure concentrations of the muxture compounds were approximately 100 times higher than peak concentrations measured in chamber tests of SBR carpets.

Figures B-104 and B-105 in Appendix B show the respiratory response (as a percent of baseline) vs. time for each group of animals, as well as the exposure concentration (as ppm propane) based on total hydrocarbon analyzer measurements.

Appendix D provides the measured concentrations of the individual components in the exposure atmospheres, at different time points during the exposure. These analyses were done using the solid sorbent sampling and GC/MS analysis methodology described in Section 3.1.3, and with application of the analytical responses outlined in Table 12.

62.6 "Complaint system 'A'"

Four exposures were conducted to compositions representing this product type, including two repeated exposures. Exposure data for the series of mixtures are summarized in Table 67.

Exposure concentration data for each of the exposures are provided in Tables 68 - 71.

The initial exposure at the high end of the concentration range (Table 68) resulted in a respiratory depression of 18%. A repeat of this test, under similar conditions, resulted in a 20% respiratory depression (Table 69). Both results are below the predicted respiratory depression for the measured concentrations of BHT, based on Task 1 testing. When the BHT was removed from the exposure mixture (Tables 70-71), no significant irritation response was measured. This suggests that the BHT contributed to the initial irritation observed. The presence of o-hydroxybiphenyl in some of these exposures will be noted; this was due to its presence in the original desired test mixture. Difficulty in the generation of this vapor led to it being excluded from the test mixture; however, it continued to be detected in some of the exposures. The repeat tests confirm that any observed irritation was independent of the presence of this compound.

Figures B-106 through B-109 in Appendix B show the respiratory response (as a percent of baseline) vs. time for each group of animals, as well as the exposure concentration (as ppm propane) based on total hydrocarbon analyzer measurements. It should be noted that in the second ("repeat") exposure to the test mixture (Figure B-107) a "spike" in the exposure concentration was observed. This was attributed to an adjustment to the exposure generation system, which temporarily blocked the BHT vapor stream from contributing to the mixture. There appears to have been some slight effect on the response due to this "spike:" an attentuation in response which began prior to the "spike" reversed following re-introduction of BHT vapor to the mixture. This provides some further evidence that BHT is the principal contributor to the irritation observed.

Appendix D provides the measured concentrations of the individual components in the exposure atmospheres, at different time points during the exposure. These analyses were done using the solid sorbent sampling and GC/MS analysis methodology described in Section 3.1.3, and with application of the analytical responses outlined in Table 12.

6.2.7 "Complaint system 'B'"

Two exposures were conducted to different compositions representing this product type. Exposure data for the pair of mixtures are summarized in Table 72. Exposure concentration data for each of the exposures are provided in Tables 73 - 74.

The initial exposure at the high end of the concentration range (Table 73) resulted in a respiratory depression of 26%. This is consistent with the predicted respiratory depression for the measured concentration of BHT, the only Task 1 irritant included in the mixture. When the BHT was removed from the exposure mixture (Table 74), no significant irritation resulted, suggesting that it contributed to the observed irritation in the initial test.

Some diiculty in the analysis of 4-morpholine ethanamine was observed in the evaluation of the compound (see Section 3.1.3 and Table 42) and during these tests. This compound was observed to co-elute with BHT, and inconsistent recovery from the sorbent media was also observed, The concentration data for this compound should be interpreted in light of these analytical difficulties.

Figures B-l 10 and B-l 11 in Appendix B show the respiratory response (as a percent of baseline) vs. time for each group of animals, as well as the exposure concentration (as ppm propane) based on total hydrocarbon analyzer measurements. In the initial exposure (Figure B-98), respiratory depression began upon initiation of the exposure, and attenuated over the second half of the exposure. The exposure concentration was also observed to decay during the second half of the exposure, although this was after the recovery from the maximum respiratory depression had begun, This response is consistent with those observed for exposures to BHT.

Appendix D provides the measured concentrations of the individual components in the exposure atmospheres, at different time points during the exposure. These analyses were done using the solid sorbent sampling and GC/MS analysis methodology described in Section 3.1.3, and with application of the analytical responses outlined in Table 12.

7.0 QUALITY CONTROL

7.0 QUALITY CONTROL

7.1 Duplicate Exposure Testing

7.1.1 Task 1

Aithough exposure-response characteristics are often sufficient to ensure the adequacy of irritation data, some exposure testing was conducted in duplicate to provide an estimate of the reproducibility of the irritation due to a given test atmosphere. An initial goal of 10% duplication of positive irritation responses was set in the project Work Plan.

A total of 58 Task 1 tests which were found to result in a positive irritation response. Of these, six tests could be classified as exposure duplicates, based on the measured exposure concentrations, The duplicate exposures are summarized in Table 75.

The precision of the exposure data are expressed in Table 75 as a percent relative deviation. In cases where paired data are compared, an estimate of the percent deviation is calculated as the percent relative mean deviation, which is defined as:

$$\%RMD = (X - x_1)/X$$

where X = mean of the two values, and x, is the lesser of the two values. For the case where three values are compared, the percent relative standard deviation is used to determine the precision of these measurements. This is defined by:

$$\%RSD = SIX$$

where S is the (sample) standard deviation of the data, and X is the mean measured value.

The precision of the measured respiratory depression for duplicate tests under Task 1 ranged from 1% to 20% RMD. In all cases, there was less than 11% difference between responses for any tests at similar exposure concentrations. A difference of 11% was chosen in the current study as a maximum expected difference in response of two sets of animals to identical exposure concentrations, based on the use of 12% as a minimum for a positive response [4], and previous data for formaldehyde exposures [28] (see the discussion of defined mixture testing). In that study, Kane and Alarie showed concentration-response relationships for formaldehyde and acrolein, which showed 10% or greater variability in response to virtually identical chemical concentrations,

7.1.2 Task 2

A total of 14 defined mixture tests, and 11 synthesized mixture tests, were classified as positive responses for sensory irritation. Of these tests, only one represented conditions which were duplicated, less than the target of 10% rate of duplication. Constraints on available completion time near the end of the project did not allow further duplicate exposures to be pursued. However, a negative response was duplicated in this series of tests. These data are shown in Table 76. For both tests, nearly identical results were detemined.

The combined Task 1 and Task 2 duplicate testing included 83 tests classified as positive for sensory irritation, with 7 conditions duplicated among the positive tests, for a total rate of 8%.

7.2 Positive Controls

A further control on the respiratory irritation data generated was included in the test design. Positive controls for sensory and pulmonary irritation were completed.

7.2.1 Sensory iritation: formaldehyde

Vapors of formaldehyde were generated by sublimation of solid paraformaldehyde, using the flask methodology described in Section 3.1.2. Five exposures were conducted to this compound, all of which were determined to result in sensory irritation. These exposures were used to generate an estimate of the sensory irritation characteristics of this compound. Exposure data are summarized in Table 77.

Figure 30 shows the maximum respiratory depression vs. the exposure concentration (log scale) for the exposures to formaldehyde, where concentration is measured in $\mu g/m^3$; the same data are plotted for concentration as ppm in Figure 31. Regression of the data results in a correlation coefficient (r^2) of 0.795, with the RD_{50} calculated to be 12.9 mg/m^3 (10.5 ppm), the RD_{20} 1.2 mg/m^3 (0.9 ppm) and the RD,, determined to be 0.6 mg/m^3 (0.5 ppm). The slope of the regression line is 28.7; the slope of the regression line of response vs. logarithm of exposure concentration in ppm is also 28.7.

These data may be compared with published data for formaldehyde, which indicate an RD_{50} value of 3.9 mg/m^3 (3.2 ppm), with a 95% confidence limit of 1.8 - 8.2 mg/m^3 (1.5 - 6.7 ppm) [28]. In this reference, a steeper slope of the regression line of response vs. logarithm of exposure concentration in ppm was predicted (45.7). The predicted response based on the published regression line is shown in Figure 31. Although the current data results in an RD_{50} outside the published confidence limit, it should be noted that interlaboratory differences in RD_{50} often differ by factors of at least 2 [29]. Also, a total of 11 compounds were identified in reference 5 as having

published RD_{50} values for Swiss-Webster mice from different literature sources. Although the exposure conditions may have differed between the different tests compared, the highest published RD_{50} values for a given compound tested more than once ranged from 1.1 to 6.3 times the lowest published value. The 3.3-fold difference noted in the current study is therefore not unreasonable compared to other interlaboratry data.

Figures B112 - B116 show the average respiratory frequency of the group of mice (as a percent of the baseline frequency of the group) exposed to each concentration of formaldehyde tested, as well as the exposure concentration (based on sampling and analysis for formaldehyde, using chromotropic acid analysis). The onset of sensory irritation was immediate for all exposures to this compound, with some recovery of the response toward baseline during the exposure. Rapid recovery toward baseline frequency at the end of the exposure period was also observed.

7.2.2 Pulmonary iritation: nitrogen dioxide

A single exposure to 10 ppm nitrogen dioxide was conducted, as a control on the pulmonary irritation response. This exposure was found to produce the pulmonary irritation waveform change, near the end of the 60 minute exposure. A full determination of the RD_{TC50} was not pursued; since none of the exposures during the study were classified as pulmonary irritation. This is probably related to the observation that many pulmonary irritants also will cause sensory irritation, at lower concentrations than those which will result in pulmonary irritation [7].

8.0 RECOMMENDATIONS FOR FURTHER STUDY

8.0 RECOMMENDATIONS FOR FURTHER STUDY

Although the data generated in the current report are to be used by CPSC staff to generate a "screening-level" assessment of human risk for irritation due to exposure to these compounds and mixtures, other research directions are also indicated, and discussed below.

8.1 Interaction of Irritating Compounds

A broader study of the interaction between different irritants could be undertaken, along the lines of the defined mixture testing conducted under Task 2. For a study of this type to be useful, the confidence range for irritation caused by the individual components of any mixture would need to be established, and the mixtures themselves would need to be generated within tight tolerances of the target levels. An expanded scope of exposures would also benefit a study of this type, to establish interaction effects over a wider concentration range.

8.2 Irritation Caused by Individual Chemicals

Work aimed at the identification and purification of an irritant receptor preparation(s) from the trigeminal nerve would be essential for fully understanding the mechanism underlying the sensory irritation response. Additionally, comparisons of the mouse response to human responses would be improved (particularly if human receptor fractions could be prepared), and an *in-vitro* assay for sensory irritation could be developed. Another benefit of using a receptor preparation is the potential for an assay of increased sensitivity; **i.e.,** less chemical would be required to elicit a response.

Once any irritant receptors have been identified, further study could evaluate the manner in which these receptors both interact with irritating compounds and transmit this interaction through the trigeminus to the brain. Evaluation of the interaction between irritant receptors and irritating compounds would also aid in the understanding of any interactions between irritating compounds in more complex mixtures. Also, the effect of exposure to irritants on the expression and regulation of these receptors might explain how pre-exposure to an irritating atmosphere could affect subsequent perception of irritation (either sensitization, desensitization, or no change).

8.3 irritation and Indoor Air

Additional irritation testing could improve the understanding of how different variables may modify the development of irritation during indoor air exposures. For example, it is not clear if there are any sensitization (or desensitization) effects which may result from pre-exposure to irritating compounds at different levels. A study could be designed which exposes animals to different levels of irritants, and evaluates any changes in the irritation response due to these exposures. for example, animals could be exposed to sub-threshold levels of irritants for some defined period, and an exposure-response curve generated to evaluate the effect of the pre-exposure on the irritant response. Also, the change in the irritant response over time for animals exposed to the same levels of chemicals could be tested; for example, the same group of animals could be repeatedly exposed to the RD,, level of an irritant for several individual exposures over the course of several days. The relevance of these studies to indoor air is that there may be a pre-sensitization component to human complaints of irritation.

9.0 REFERENCES

9.0 REFERENCES

1. Nielsen, P.A., Jensen, L.K., Eng, K., Bastholm, P., Hugod, C., Husemoen, T., Molhave, L., and Wolkoff, P. *Indoor Air* 4:146-153 *(1994)*

2. Mølhave L., Z. Liu, A.H. Jørgensen, O.F. Pedersen, and SK. Kjærgaard: Sensory and physiological effects on humans of combined exposures to air temperatures and volatile organic compounds. *Indoor Air 3:* 155-169 *(1993)*

3. Amdur, M.O., J. Doull, and C.D. Klaassen, eds. *Casarett and Doull's Toxicology. New* York: Pergamon Press, 1991.

4. American Society for Testing and Materials: *Standard Tesf Mefhod for Esfimafing Sensory Irritancy of Airborne Chemicals*. ASTM Designation E 981-84. Philadelphia: American Society for Testing and Materials, 1984.

5. Schaper, M.: Development of a Database for Sensory Irritants and Its Use in Establishing Occupational Exposure Limits. *Am. Ind. Hyg. Assoc. J. 54(9)*:488-544 *(1993)*

6. Alarie, Y.C.: Sensory Irritation by Airborne Chemicals. *CRC Critical Reviews in Toxicology. 2: 299-363 (1973)*

7. Alarie, Y. "Toxicological evaluation of airborne chemical irritants and allergens using respiratory reflex reactions." In *Symposium on Inhalafion Toxicology and Technology.* pp. 207-231. Ann Arbor Publishers, Michigan (1981)

8. Gagnaire, F. S. Azim, P. Simon, B. Cossec, P. Bonnet, and J. DeCeaurriz. Sensory and pulmonary irritation of aliphatic amines in mice: a structure-activity relationship study. *J. Appl. Toxicol.* 13(2), *129-135 (1993)*

9. Nielsen, G.D. and M. Yamagiwa. Structure-activity relationships of irritating aliphatic amines. Receptor activation mechanisms and predicted industrial exposure limits. *Chem. Biol. Interact.* 71(2-3), *223-4 (1989)*

10. Nielsen G.D. and A.M. Vingaard. Sensory irritation and pulmonary irritation of C3-C7 n-alkylamines: mechanisms of receptor activation. *Pharmacol. Toxicol.* 63(4), *293-304 (1988)*

11. Ferguson, J.S., M. Schaper, M.F. Stock, D.A. Weyel, and Y. Alarie. Sensory and pulmonary irritation with exposure to methyl isocyanate. *Toxicol. Appl. Pharmacol. 82, 329-335 (1986)*

12 Black, M.S.: "Environmental Chamber Technology for the Study of Volatile Organic Compound Emissions from Manufactured Products." Paper presented at Indoor Air '90. Toronto, Canada. 1990. Vol. 3, pp. 713-718.

13. Hodgson, A.T., J.D. Wooley, and J.M Daisey. '*Volatile Organic Chemical Emissions for Carpets: Final Report." Prepared for U.S. Consumer Product Safety Commission under interagency agreement number CPSC-IAG-90-1252. Lawrence Berkeley Laboratory report LBL-31916, Berkeley, CA: Lawrence Berkeley Laboratory. (1992)

14. Muller, W.J. and M.S. Black: Sensory irritation in mice exposed to emissions from indoor products. *Am. Ind. Hyg. Assoc. J. 56: 794-803, 1995*

15. Anderson, R.C.: (1993) "Toxic Emissions From Carpets." Paper presented at Indoor Air '93. Helsinki, Finland. 1993. Vol. 1, pp. 651-656.

16. Hansen, L.F., G.D. Nielsen, J Tøttrup, A. Abildgaard, O.F. Dahl Jensen, M.K. Hansen, and 0. Nielsen: Biological Determination of Emission of Irritants From Paint. and Lacquer. *Indoor Air 2*:95-110 *(1991)*

17. Wolkoff, P, G.D. Nielsen, L.F. Hansen, 0. Albrecthsen, C.R. Johansen, J.H. Heinig, K. Schmidt, C. Franck, and P.A. Nielsen: "Controlled Human Reactions to Building Materials in Climatic Chambers. Part II. VOC Measurements, Mouse Bioassay and Decipol Evaluation in the 1-2 mg/m^3 TVOC/Tenax range." Paper presented at Indoor Air '90. Ottawa, Canada. 1990. Vol. 1, pp. 331-336.

18. Nielsen, G.D.: Mechanisms of Activation of the Sensory Irritant Receptor by Airborne Chemicals. *Crit. Rev. Toxicol. 21(3)*:183-208 *(1991)*

19. Weyel, D.A., and R.B Schaffer. Pulmonary and sensory irritation of diphenylmethane-4,4'- and dicyclohexylmethane-4,4'-diisocyanate. *Toxicol. Appl. Pharmacol. 77(3)*: *427-*433 (1985)

20. Alarie, Y., J.S. Ferguson, M.F. Stock, D.A. Weyel, and M. Schaper. Sensory and pulmonary irritation of methyl isocyanate in mice and pulmonary irritation and possible cyanidelike effects of methyl isocyanate in guinea pigs. *Env. Health Persp. 72: 159-167* (1987)

21. Miller, R.R., R.L. Letts, W.J. Potts, and M.J. McKenna. Improved methodology for generating controlled test atmospheres. *Am. Ind. Hyg. Assoc. J. 47: 844-846 (1980)*

22. Environmental Protection Agency: *Compendium of Methods For the Determination of Air Pollutants in Indoor Air* by W.T. Winberry, L. Forehand, N. Murphy, Barbara Phinne, A. Evans. (EPA Rpt 600/4-90/010). Washington, D.C.: Environmental Protection Agency. (1990)

23. American Society for Testing and Materials: Standard Guide *for Small-scale Environmental Chamber Determinations of Organic Emissions From Indoor Materials/products.* ASTM Designation D 5116-90. Philadelphia: American Society for Testing and Materials. (1990)

24. National Institute for Occupational Safety and Health: Manual *of Analytical Methods* by R. Kendall, ed. (NIOSH Pub. 84-100). Washington, D.C.: Government Printing Office (1990)

25. Environmental Protection Agency: Compendium *of Methods For fhe Determination of Toxic Organic Compounds in Ambient Air* by W.T. Winberry, N.T. Murphy, and R.M. Riggan. (EPA Rpt 600/4-89/017). Washington, D.C.: Environmental Protection Agency (1988)

26. Alarie, Y. Dose-response analysis in animal studies: prediction of human responses. *Env. Health Persp. 42: 9-73 (I 981)*

27. Kane, L.E., C.S. Barrow, and Y. Alarie. A short-term test to predict acceptable levels of exposure to airborne sensory initants. *Am. Ind. Hyg. Assoc. J. 40: 207-229 (1979)*

28. Kane, L.E. and Y. Alarie: Sensory irritation to Formaldehyde and Acrolein During Single and Repeated Exposures in Mice. *Am. Ind. Hyg. Assoc. J. 38*:509-522 (1 *977)*

29. Bos, P.M.J., A. Zwart, P.G.J. Reuzel, and P.C. Bragt: Evaluation of the sensory irritation test for the assessment of occupational health risk. CRC *Crit. Rev. Toxicol. 21*(6): *423-*450 (1992)

CHAPTER 10.0

DATA TABLES

TABLE 1

VOLATILE ORGANIC COMPOUNDS IDENTIFIED IN CARPET AND CARPET CUSHION AS CANDIDATES FOR RESPIRATORY IRRITATION TESTING

Chemical Name	CAS number	Boiling Point (°C)	Molecular weight	Density (g/ml) at 20 °C, I atm	Physical State at 20 °C, 1 atm	Lower Explosive Limit
1,2,3-Trichloropropane	96- 18-4	156.0	147.43	1.39	liquid	
N, N-Dimet hylacrylamide	2680-03-7	80.5	99.13	0.96	liquid	
1,4-Dimethylpiperazine	106-58-I	131.5	114.19	0.84	liquid	
N,N-Dimethylbenzylamine	103-83-3	183.5	135.21	0.90	liquid	
N, N-Dimet hylacetamide	127-I 9-5	164.0	87.12	0.94	liquid	1.8% at 100 °C
2-Methyleneglutaronitrile	1572-52-7	103.0	106.13	0.98	liquid	
2,6-Di-*tert*-butyl-4-methylphenol (BHT)	128-37-O	265.0	220.34	1.05	solid	
Benzothiazole	95-I 6-9	231 .O	135.18	I .24	liquid	
2-Ethylhexanoic acid	149-57-5	228.0	144.21	0.90	liquid	1.04% at 135 °C
4-Phenylcyclohexene	4994-I 6-5	250.0	158.23	0.99	liquid	
1,3-Dichloro-2-propanol	96-23- 1	174.3	128.99	1.35	liquid	
I-Dodecanol	112-53-8	261 .O	186.33	0.82	solid	
c-Caprolactam	105-60-2	180.0	113.16	not found	solid	

Chemical Name	CAS number	Boiling Point (°C)	Molecular weight	Density (g/ml) at 20 °C, 1 atm	Physical State at 20 °C, 1 atm	Lower Explosive Limit
Limonene	138-86-3	176.0	136.23	0.84	liquid	
2-Methylnaphthalene	91-57-6	241.5	142.20	1.00	solid	
Adiponitrile	111-69-3	295.0	108.14	0.95	liquid	1.7%
Octamethylcyclotetrasiloxane	556-67-2	175 - 176	296.62	0.96	liquid	
Nonanal (Nonyl aldehyde)	124-19-6	93.0@ 23 in. Hg	142.24	0.83	liquid	
Phenyl ether	101-84-8	259.0	170.20	1.07	liquid	
2-Phenylphenol	90-43-7	282.0	170.20	not found	solid	
Decamethylcyclopentasiloxane	541-02-6	210.0	370.80	0.96	liquid	
Vinyl acetate	108-05-4	72.7	86.09	0.93	liquid	
N,N-Dimethylformamide	68-12-2	153.0	73.09	0.94	liquid	
1-Dodecene	112-41-4	213.0	168.32	0.76	liquid	
2-Methylpropene (Isobutylene)	115-11-7	-6.9	56.06	0.59	gas	
Allylbenzene	300-57-2	156.5	118.18	0.89	liquid	
Benyl acetate	140-11-4	206.0	150.18	1.04	liquid	
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	6846-50-0	280.0	286.41	0.94	liquid	

TABLE 2

VOLATILE ORGANIC COMPOUNDS TESTED FOR RESPIRATORY IRRITATION IN CURRENT STUDY

Chemical Name	Generation methodology used
1,2,3-Trichloropropane	J-tube
N,N-Dimethylacrylamide	J-tube
1,4-Dimethylpiperazine	J-tube
N,N-Dimethylbenzylamine	J-tube
N.N-Dimethylacetamide	J-tube
2-Methyleneglutaronitrile	J-tube
2,6-Di-*tert*-butyl-4-methylphenol (BHT)	Flask
Benzothiazole	J-tube
2-Ethylhexanoic acid	J-tube
4-Phenylcyclohexene	J-tube
1,3-Dichloro-2-propanol	J-tube
1-Dodecanol	J-tube
ε-Caprolactam	Flask
Limonene	J-tube
2-Methylnaphthalene	Flask
Adiponitrile	J-tube
Octamethylcyclotetrasiloxane	J-tube

TABLE 3

TEST SYSTEMS EVALUATED TO CREATE SYNTHESIZED EXPOSURE MIXTURES

Prime Urethane Carpet Cushion (Version "A")
Prime Urethane Carpet Cushion (Version "B")
Sponge Rubber Carpet Cushion
Bonded Urethane Carpet Cushion
Styrene-Butadiene Latex Rubber (SBR) backed Carpet
"Complaint System 'A'"
"Complaint System 'B'"

TABLE 4

CONCENTRATIONS OF INDIVIDUAL COMPOUNDS MEASURED IN CHAMBER TESTS AND TARGET CONCENTRATIONS FOR SYNTHESIZED MIXTURES FROM PRIME URETHANE CARPET CUSHION (VERSION "A"),

Compound	Concentration Range (mg/m^3)	
	Detected in Chamber Tests	Target for Synthesized Mixture
BHT	0.1 - 0.2	5 - 20
1,4-Dimethylpiperazine*	0.015 - 0.5	3 - 15
1,1,1-Trichloroethane*	0.02 - 0.05	1 - 4
C_6 - C_8 Dinitrile (Adiponitrile used)	0.05 - 0.15	3 - 15
Styrene*	0.01 - 0.1	1 - 4
D_3 - D_5 cyclosiloxanes (Octamethylcyclotetrasiloxane used)	0.01 - 0.03	0.5 - 2

*Decayed rapidly in chamber tests.

TABLE 5

CONCENTRATIONS OF INDIVIDUAL COMPOUNDS MEASURED IN CHAMBER TESTS AND TARGET CONCENTRATIONS FOR SYNTHESIZED MIXTURES FROM PRIME URETHANE CARPET CUSHION (VERSION "B")

Compound	Concentration Range (mg/m^3)	
	Detected in Chamber Tests	Target for Synthesized Mixture
BHT	0.1 - 0.2	5 - 20
N,N-Dimethylacrylamide	0.05 - 0.2	3 - 15
1,2,3-Trichloropropane*	0.001 - 0.2	1 - 5
N,N-Dimethylformamide*	0.001 - 0.1	0.5 - 2
N,N-Dimethylacetamide*	0.005 - 0.05	0.5 - 2
D_3 - D_5 cyclosiloxanes (Octamethylcyclotetrasiloxane used)	6.005 - 0.15	1 - 5
1,3-Dichloro-2-propanol	0.01 - 0.1	1 - 5

*Decayed rapidly in chamber tests.

TABLE6

CONCENTRATIONS OF INDIVIDUAL COMPOUNDS MEASURED IN CHAMBER TESTS AND TARGET CONCENTRATIONS FOR SYNTHESIZED MIXTURES FROM SPONGE RUBBER CARPET CUSHION

Compound	Concentration Range (mg/m^3)	
	Detected in Chamber Tests	Target for Synthesized Mixture
N,N-Dimethylformamide*	0.001 - 0.05	0.1 - 0.5
N,N-Dimethylacetamide*	0.001 - 0.06	0.5 - 2
Toluene*	[illegible]	0.2 - I
C_{10} - C_{14} Alkanes (Undecane used)	0.05 - 0.2	5 - 20
C_4 - C_7 alkylbenzenes (I ,2,4-Trimethylbenzene used)	0.05 - 0.2	5 - 20
I- or 2-Methylnaphthalene (2-Methylnaphthalene used)	0.03 - 0.07	2 - 8
C_2 - C_4 Alkylnaphthalenes (1,4-Dimethylnaphthalene used)	0.05 - 0.2	5 - 20
Diphenyl ether	0.01 - 0.02	0.5 - 2

*Decayed rapidly in chamber tests.

TABLE7

CONCENTRATIONS OF INDIVIDUAL COMPOUNDS MEASURED IN CHAMBER TESTS AND TARGET CONCENTRATIONS FOR SYNTHESIZED MIXTURES FROM BONDED URETHANE CARPET CUSHION

Compound	Concentration Range (mg/m^3)	
	Detected in Chamber Tests	Target for Synthesized Mixture
BHT	0.1 - 0.2	5 - 20
C_6 - C_8 dinitriles (Adiponitrile used)	0.005 - 0.015	0.2 - 1.0
C_{11} - C_{15} diolefins (Undecene and Tridecene used)	0.5 - 1.0	10-50
C_9 - C_{14} alkanes* (Decane used)	0.02 - 0.2	0.5 - 2'
N,N-Dimethylacetamide	0.1 - 0.25	5-20
TXIB	0.01 - 0.025	0.5 - 2

*Decayed rapidly in chamber tests.

TABLE 8

CONCENTRATIONS OF INDIVIDUAL COMPOUNDS MEASURED IN CHAMBER TESTS AND TARGET CONCENTRATIONS FOR SYNTHESIZED MIXTURES FROM STYRENE-BUTADIENE LATEX RUBBER (SBR) BACKED CARPET

Compound	Concentration Range (mg/m^3)	
	Detected in Chamber Tests	Target for Synthesized Mixture
4-Phenylcyclohexene	0.001 - 0.05	1 - 5
4-Vinylcyclohexene*	0.001 - 0.04	0.5 - 2
Styrene*	0.001 - 0.12	1 - 5
Toluene*	0.001 - 0.93	2 - 10
fsooctane	0.001 - 0.05	0.5 - 2
Acetic acid	0.001 - 0.26	2-10
C_2 - C_3 Alkylbenzenes (Propylbentene used)	0.001 - 0.06	0.5 - 2
C_{10} - C_{12} Alcohols (Decanol used)	0.001 - 0.14	1 - 5
Cvclohexanol	0.001 - 0.11	1 - 5
C_{11} - C_{13} Alkanes (Undecane used)	0.001 - 0.12	1 -5

*Decayed rapidly in chamber tests.

TABLE 9

CONCENTRATIONS OF INDIVIDUAL COMPOUNDS MEASURED IN CHAMBER TESTS AND TARGET CONCENTRATIONS FOR SYNTHESIZED MIXTURES FROM "COMPLAINT SYSTEM 'A"'

Compound	Concentration Range (mg/m^3)	
	Detected in Chamber Tests	Target for Synthesized Mixture
BHT	0.015 - 0.35	5 - 20
Phenol	0.01 - 0.02	0.5 - 2
N,N-Dimethylacetamide	0.01 - 0.02	0.5 - 2
Nonanal	0.001 - 0.01	0.2 - 1
3-Methylcyclohexanol	0.01 - 0.02	0.5 - 2
C_3-alkylbenzene (1,2,4-Trimethylbenzene used)	0.01 - 0.02	0.5 - 2
$C_{,,}$ - C_{12} alkenes (Undecene used)	0.02 - 0.15	5 - 20
C_9 - C_{11} alkanes (Decane used)	0.005 - 0.02	0.5 - 2

TABLE10

CONCENTRATIONS OF INDIVIDUAL COMPOUNDS MEASURED IN CHAMBERTESTSANDTARGET CONCENTRATIONSFOR SYNTHESIZED MIXTURES FROM "COMPLAINT SYSTEM'B"'

Compound	Concentration Range (mg/m^3)	
	Detected in Chamber Tests	Target for Synthesized Mixture
BHT	0.02 - 0.3	5 - 20
lsobomvl acetate	0.01 - 0.02	0.5 - 2
N,N-Dimethylacetamide	0.005 - 0.02	0.5 - 2
C_{11} - C_{12} alkenes (Undecene used)	0.01 - 0.05	1 - 5
4-Morpholine ethanamine	0.001 - 0.02	0.5 - 2

Chemical name	CAS #	Percent Recovery (%RSD)	Sensitivity (relative to toluene) (%RSD)	Breakthrough volume (L)
2-Methylnaphthalene	91-57-6	88.1 (16.0)	61.7 (7.6)	> 18
Hexanedinitrile (Adiponitrile)	11 l-69-3	92.0 (7.2)	58.7 (3.2)	> 18
Octamethylcyclotetrasiloxane	556-67-2	102.3 (8.7)	87.7 (29.2)	≈ 18*

*Breakthrough possible under standard 18L sampling conditions. Sampling volume reduced during irritation testing.

TABLE 12

ANALYTICAL CHARACTERISTICS OF ADDITIONAL CHEMICALS USED IN SYNTHESIZED MIXTURE TESTS

Chemical name	CAS #	Percent Recovery (%RSD)	Sensitivity (relative to toluene) (%RSD)	Breakthrough volume (L)
1,1,1-Trichloroethane	71-55-6	98.0 (1.1)	44.6 (1.7)	< 18
Styrene	100-42-5	99.7 (4.8)	96.7 (1.3)	> 18
N, N-Dimethylformamide	68-12-2	94.6 (2.3)	46.7 (17.1)	718
Toluene	108-88-3	99.8 (1.3)	100.0 (1.3)	718
Undecane	1120-21-4	93.6 (5.1)	141.6 (1.3)	718
1,2,4-Trimethylbenzene	95-63-6	99.9 (2.2)	109.7 (0.6)	718
1,4-Dimethylnaphthalene	571-58-4	81.5 (20.7)	84.7 (12.1)	718
Diphenyl ether	101-84-8	95.3 (14.6)	104.5 (7.7)	718
Undecene	821-95-4	101.0 (2.5)	134.7 (3.6)	718
Tridecene	2437-56-l	76.4 (5.4)	94.1 (14.4)	718
Decane	124-18-5	96.5 (3.6)	158.0 (2.0)	718
TXIB	6846-50-o	81.8 (9.9)	117.9 (15.3)	718
4-Vinylcyclohexene	100-40-3	97.1 (1.2)	101.2 (0.9)	718
Isooctane	540-84-l	87.3 (5.2)	115.4 (1.9)	718

Chemical name	CAS #	Percent Recovery (%RSD)	Sensitivity (relative to toluene) (%RSD)	Breakthrough volume (L)
Acetic acid	64-19-7	54.1 (89.5)	20.0 (32.3)	< 18*
Propylbenzene	103-65-I	97.8 (4.4)	115.8 (0.1)	> 18
Decanol	112-30-I	79.4 (5.1)	69.5 (19.1)	> 18
Cyclohexanol	108-93-o	100.6 (6.0)	98.7 (3.2)	> 18
Phenol	108-95-2	82.8 (3.4)	62.5 (6.6)	not evaluated
Nonanal	124-19-6	85.2 (5.3)	76.9 (I 3.3)	> 18
3-Methylcyclohexanol	591-23-I	102.0 (1.8)	106.7 (4.0)	> 18
Isobomyl acetate	125-12-2	103.0 (8.0)	116.2 (3.4)	> 18
4-Morpholine ethanamine	2038-03-I	140.3 (105.9)	12.4 (91.4)	< 18*

*Breakthrough possible under standard 18 L sampling conditions. Sampling volume reduced during irritation testing.

TABLE 13

SUMMARY OF EXPOSURE-RESPONSE DATA FOR TARGET COMPOUNDS

Chemical Name	RD_{50} (mg/m^3)	RD_{20} (mg/m^3)	RD_{12} (mg/m^3)	r^2	Slope of log(exposure concentration) vs. response regression line	Number of Exposures used to calculate RD_{50}
1,2,3-Trichloropropane	118.8	15.3	8.9	0.733	33.7	8
N,N-Dimethylacrylamide	233.8	31.8	18.7	0.849	34.6	4
1,4-Dimethylpiperazine	19.8	4.1	2.7	0.785	44.1	5
N,N-Dimethylbenzylamine	291.8	41.4	24.6	0.993	35.4	4
N,N-Dimethylacetamide	No significant RD at 440 mg/m^3					
2-Methyleneglutaronitrile	105.3	17.4	10.7	0.721	38.3	4
2,6-Di-*tert*-butyl-4-methylphenol (BHT)	11.5	6.4	5.4	0.824	117.7	7
Benzothiazole	235.4	34.4	20.6	0.931	35.9	4
2-Ethylhexanoic acid	No significant RD at 199 mg/m^3					
4-Phenylcyclohexene	318.8	59.6	38.1	0.912	41.2	8
1,3-Dichloro-2-propanol	129.5	5.4	2.3	0.874	21.7	6
1-Dodecanol	No significant RD at 0.5 mg/m^3					
ε-Caprolactam	No significant RD at 13.5 mg/m^3					

Chemical Name	RD_{50} (mg/m^3)	RD_{20} (mg/m^3)	RD_{12} (mg/m^3)	r^2	Slope of log(exposure concentration) vs. response regression line	Number of Exposures used to calculate RD_{50}
Limonene (Dipentene)	No significant RD at 76.4 mg/m^3					
2-Methylnaphthalene	7.8	2.5	1.8	0.874	60.3	6
Adiponitrile (Hexane dinitrile)	No significant RD at 8.2 mg/m^3					
Octamethylcyclotetrasiloxane	No significant RD at 303 mg/m^3					

TABLE14

TARGET COMPOUNDS RANKED IN ORDER OF INCREASING RD_{50} (DECREASINGORDEROFPOTENCY)

Chemical Name	RD_{50} (ppm)	RD_{50} (mg/m^3)
Compounds with positive sensory irritation response		
2,6-Di-*tert*-butyl-4-methylphenol (BHT)	1.3	11.7
2-Methylnaphthalene	1.3	7.8
1,4-Dimethylpiperazine	4.2	*19.8*
Formaldehyde*	10.5	12.9
1,2,3-Trichloropropane	19.7	118.8
2-Methyleneglutaronitrile	24.3	105.3
1,3-Dichloro-2-propanol	24.5	*129.5*
Benzothiazole	42.6	235.4
4-Phenylcyclohexene	*49.3*	318.8
N, N-Dimethylbenzylamine	52.8	291.8
N,N-Dimethylacrylamide	57.7	233.8
Maximum concentration tested for compounds without posifive sensory irritation response		
I-Dodecanol	0.1	0.5
Adiponitrile (Hexane dinitrile)	1.9	8.2
e-Caprolactam	2.9	13.5
Limonene	13.7	76.4
Octamethylcyclotetrasiloxane	25.0	303
2-Ethylhexanoic acid	33.7	*199*
N,N-Dimethylacetamide	123.5	440

*Tested as positive control for sensory irritation.

TABLE15

PREDICTED HUMAN RESPONSES AT DIFFERENT MULTIPLES OF THE RD_{50} IN M I C E *

Multiple of RD_{50}	Predicted response
10	Severe injury, possibly lethal
1	Intolerable to humans
0.1	Some sensory irritation
0.01	No sensory irritation
0.001	No effect of any kind on the respiratory system

*Taken from Reference 26.

TABLE16

TARGET COMPOUNDS WITH POSITIVE IRRITATION RESPONSE, RANKED IN ORDER OF INCREASING RD_{20} (DECREASING ORDER OF POTENCY)

Chemical Name	RD_{20} (ppm)	$RD_{,,}$ (mg/m^3)
2-Methylnaphthalene	0.4	2.5
2,6-Di-*tert*-butyl-4-methylphenol (BHT)	0.7	6.4
Formaldehyde*	0.9	1.2
1,4-Dimethylpiperazine	0.9	4.1
1,3-Dichloro-2-propanol	1.0	5.4
1,2,3-Trichloropropane	2.5	15.3
2-Methyleneglutaronitrile	4.0	17.4
Benzothiazole	6.2	34.4
N,N-Dimethylbenzylamine	7.5	41.4
N,N-Dimethylacrylamide	7.8	31.8
4-Phenylcyclohexene	9.2	59.6

'Tested as positive control for sensory irritation.

TABLE 17

TARGET COMPOUNDS RANKED IN ORDER OF INCREASING $RD_{,,}$ (DECREASING ORDER OF THRESHOLD LEVEL)

Chemical Name	RD_{12} (ppm)	RD_{12} (mg/m^3)
2-Methylnaphthalene	0.3	1.8
1,3-Dichloro-2-propanol	0.4	2.3
Formaldehyde*	0.5	0.6
1,4-Dimethylpiperazine	0.6	2.7
2,6-Di-*tert*-butyl-4-methylphenol (BHT)	0.6	5.6
1,2,3-Trichloropropane	1.5	8.9
2-Methyleneglutaronitrile	2.5	10.7
Benzothiazole	3.7	20.6
N,N-Dimethylbenzylamine	4.4	24.6
N,N-Dimethylacrylamide	4.6	18.7
4-Phenylcyclohexene	5.9	38.1

*Tested as positive control for sensory irritation.

TABLE18

SUMMARYEXPOSUREDATA FOR 1,2,3-TRICHLOROPROPANE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
09/15/95	27.0	5.3	99.0	14.6
02/17/95	34.1	7.6	99.5	21.6
04/20/95	46.5	8.4	99.6	49.4
02/16/95	59.7	16.1	98.6	47.7
03/06/95	62.1	5.9	98.4	52.9
02/16/95	211.7	7.3	98.9	51.0
01/16/95	391.8	21.3	100.0	67.7
04/20/95	576.5	1.7	100.0	71 .o

TABLE 19

SUMMARY EXPOSURE DATA FOR N,N-DIMETHYLACRYLAMIDE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
02/28/95	43.6	3.5	73.7	16.4"
04/18/95	52.6	6.3	99.9	21.0
02/28/95	71.9	7.9	66.6	39.0
01/19/95	197.3	7.1	100.0	55.2
03/01/95	399.6	3.8	100.0	50.2

'Respiratory depression not accompanied by SI or PI waveform change, response not considered significant.

TABLE20

SUMMARY EXPOSURE DATA FOR 1,4-DIMETHYLPIPERAZINE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
04/19/95	6.2	3.4	**92.9**	14.4
02/21/95	8.3	5.2	**100.0**	38.6
02/20/95	11.8	6.6	**99.2**	46.4
02/21/95	26.5	6.7	100.0	65.2
01/20/95	72.0	8.9	99.6	66.7
01/20/95	239.0	7.8	98.6	**75.2***

'Exposure discontinued after 8 minutes due to single animal reaching >80% respiratory depression. Data not used in calculations of RD_{50} and RD,

TABLE 21

SUMMARY EXPOSURE DATA FOR N,N-DIMETHYLBENZYLAMINE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
02/23/95	24.4	10.5	90.7	10.8"
02/27/95	46.0	9.6	100.0	23.1
02/22/95	93.1	11.4	98.1	31.6
02123195	270.1	8.9	98.8	46.9
01/24/95	907.3	8.6	99.6	68.8

"Respiratory depression not considered significant.

TABLE 22

SUMMARYEXPOSUREDATAFORN,N-DIMETHYLACETAMIDE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
01/25/95	440	11.6	**100.0**	6.3"

*Respiratory depression not considered significant.

TABLE23

SUMMARY EXPOSURE DATA FOR 2-METHYLENEGLUTARONITRILE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
02/09/95 I	18.4	3.1	99.6	16.9*
02/13/95	31.5	6.7	99.8	29.4
02/10/95	49.7	2.9	99.8	39.9
01/27/95	80.3	4.0	NA**	39.5
03/07/95	103.7	13.9	99.9	55.3

*Respiratory depression not accompanied by SI or PI waveform change, response not considered significant. Data not used in calculations of RD_{50} and RD_{12}.
**Data not available, GC/MSD data not retrievable.

TABLE24

SUMMARYEXPOSUREDATA FOR 2,6-DI-*tert*-BUTYL-4-METHYLPHENOL (BHT)

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
11/06/95	7.1	19.6	98.9	34.5
04/24/95	7.4	5.2	69.2	25.4
02/07/95	7.4	10.5	83.5	20.7
02/08/95	10.7	17.2	89.5	50.1
01/31/95	10.7	14.4	75.7	45.5
09/15/95	10.9	10.2	92.0	43.6
04/25/95	12.0	12.7	92.8	54.5
02/06/95**	2.2"	18.1	40. 9	5.7*
03/08/95**	5.5**	7.7	33.7	13.4
03/08/95**	8.2"	6.8	22.6	23.4

*Respiratory depression not considered significant.
** Exposures rejectd due to presence of confounding irritants in exposure atmosphere; not included in data analyses.

TABLE 25

SUMMARY EXPOSURE DATA FOR BENZOTHIAZOLE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
02/14/95	25.9	9.6	98.5	*16.7*
02/1 *5195*	*47.1*	*5.5*	*98.0*	*21.2*
02/14/95	80.5	*7.6*	*95.9*	*37.0*
02/01/95	*149.8*	*30.0*	100.0	*41.8*

TABLE26

SUMMARY EXPOSURE DATA FOR 2-ETHYLHEXANOIC ACID

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
02/02/95	198.5	31.2	96.9	17.3*

*Respiratory depression not accompanied by SI or PI waveform change, response not considered significant.

TABLE27

SUMMARY EXPOSURE DATA FOR 4-PHENYLCYCLOHEXENE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
09/29/95	22.5	4.6	87.8	11.8"
11/13/95	42.4	12.4	99.7	16.4
03/16/95	57.7	7.4	100.0	19.2
03121195	87.5	2.6	93.8	25.7
03/16/95	115	6.0	98.6	25.8
03/20/95	138	10.3	97.6	33.8
03/20/95	142	6.7	94.4	36.9
03/21/95	150	4.2	94.3	39.1
07/05/95	195	2.0	92.5	43.4

"Respiratory depression not considered significant.

TABLE28

SUMMARY EXPOSURE DATA FOR 1,3-DICHLORO-2-PROPANOL

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
03/23/95	*13.3*	*11.6*	80.8	31.0
06/20/95	*95.5*	*4.6*	98.6	*52.6*
03/22/95	*117.3*	*13.2*	*86.9*	*40.0*
03/22/95	*269.2*	*10.8*	78.8	52.9
03/24/95	*551.8*	*8.7*	94.5	65.8
06/21 /95	961.6	*6.2*	98.3	72.0

TABLE29

SUMMARY EXPOSURE DATA FOR 1-DODECANOL

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
03/27/95	*0.5*	*9.4*	*95.3*	13.6*

*Respiratory depression not accompanied by SI or PI waveform change, response not considered significant.

TABLE30

SUMMARYEXPOSURE DATA FOR ε-CAPROLACTAM

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
06/22/95	*13.5*	*3.7*	*100.0*	9.0*

*Respiratory depression not considered significant

TABLE31

SUMMARY EXPOSURE DATA FOR LIMONENE (DIPENTENE)

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
04/17/95	*76.4*	*10.0*	*78.1*	3.8*

*Respiratory depression not considered significant.

TABLE32

SUMMARY EXPOSURE DATA FOR 2-METHYLNAPHTHALENE

Exposure Date	. Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
04111195	*2.6*	*3.9*	100.0	6.8*
04/12/95	*4.5*	*4.9*	*100.0*	*29.7*
06/29/95	*4.4*	*1.7*	*100.0*	*30.1*
06130195	*6.1*	*0.9*	*100.0*	*50.3*
04/12/95	*7.4*	*3.3*	*99.9*	*55.9*
04/07/95	*12.4*	*1.9*	*96.1*	*64.4*
04/13/95	*20.9*	*7.0*	*99.9*	*70.6*
04/04/95	*41.1*	*4.4*	*99.6*	68.2**
04/03/95	*81.7*	*3.0*	*99.0*	62.2**

'Respiratory depression not considered significant.
**Respiratory depression may have occurred above 'maximum- concentration; these points not used in RD, determination.

TABLE 33

SUMMARYEXPOSURE DATA FOR ADIPONITRILE (HEXANE DINITRILE)

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
04/27/95	8.2	6.8	100.0	6.5*

'Respiratory depression not considered significant.

TABLE34

SUMMARY EXPOSURE DATA FOR OCTAMETHYLCYCLOTETRASILOXANE

Exposure Date	Average Exposure Concentration (mg/m^3)	Precision of Exposure Concentration (%RSD)	Average level of target compound as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
07/11/95	303	2.5	99.6	3.5*

*Respiratory depression not considered significant.

TABLE 35

TARGET LEVELS FOR MIXTURE TESTS OF 2,6-DI-*tert*-4-BUTYL-METHYLPHENOL (BHT) AND 1,4-DIMETHYLPIPERAZINE

Exposure Number	2,6-Di-*tert*-4-butyl-methylphenol (BHT)		1,4-Dimethylpiperazine	
	Target Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)	Target Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)
1	6.4	20	4.1	20
2	5.2	10'	7.0	30
3	7.7	30	2.5	10*
4	5.2	IO'	2.5	10*
5	9.4	40	nd**	NS†
6	nd**	NS†	11.8	40

*Respiratory depression not considered significant.
**nd denotes non-detectable levels of compound.
†NS denotes respiratory depression not significant (<1 2%).

TABLE 36

TARGET LEVELS FOR MIXTURE TESTS INVOLVING 2,6-DI-*tert*-4-BUTYL-METHYLPHENOL (BHT), 1,4-DIMETHYLPIPERAZINE, AND 4-PHENYLCYCLOHEXENE

Exposure Number	2,6-Di-*tert*-4-butyl-methylphenol (BHT)		1,4-Dimethylpiperazine		4-Phenylcyclohexene	
	Target Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)	Target Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)	Target Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)
1	5.6	13	2.9	33	40.3	13
2	4.9	7*	2.1	7*	28.8	7*
3	6.4	20	nd**	NS†	59.6	20
4	nd**	NS†	4.1	20	59.6	20
5	6.4	20	4.1	20	nd**	NS'
6	9.4	40	nd**	NS†	nd**	NS†
7	nd**	NS†	11.8	40	nd**	NS'
8	nd**	NS†	nd**	NS†	182	40

*Respiratory depression not considered significant.
● **nd denotes non-detectable levels of compound.
† NS denotes respiratory depression not significant (<12%).

TABLE 37

TARGET LEVELS FOR MIXTURE TESTS INVOLVING 2,6-Di-*tert*-4-BUTYL-METHYLPHENOL (BHT), N,N-DIMETHYLACRYLAMIDE, AND 1,2,3-TRICHLOROPROPANE

Exposure Number	2,6-Di-*tert*-4-butyl-methylphenol (BHT)		N,N-Dimethylacrylamide		1,2,3-Trichloropropane	
	Target Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)	Target Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)	Target Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)
1	5.8	15	22.8	15	10.9	15
2	4.9	7	13.4	7	6.3	7
3	7.0	25	nd**	NS†	21.6	25
4	nd**	NS†	44.3	25	21.6	25
5	7.0	25	44.3	25	nd**	NS†
6	11.5	50	nd**	NS†	nd**	NS†
7	nd**	NS†	234	50	nd**	NS†
8	nd**	NS†	nd**	NS†	119	50

*Respiratory depression not considered significant.
**nd denotes non-detectable levels of compound.
†NS denotes respiratory depression not significant (<12%).

TABLE 38

SUMMARY EXPOSURE DATA FOR MIXTURE TESTING OF BINARY MIXTURES OF 2,6-DI-*tert*-4-BUTYL-METHYLPHENOL (BHT) AND 1,4-DIMETHYLPIPERAZINE

Exposure Number	Exposure Date	2,6-Di-*tert*-4-butyl-methylphenol (BHT)		1,4-Dimethylpiperazine		Sum of expected respiratory depression (based on Task 1 testing)	Actual respiratory depression (% of baseline)
		Measured Average Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)	Measured Average Concentration (mg/m^3)	Expected respiratory depression (based on Task 1 testing)		
1A	05/08/95	1.2	< 12*	20.1	50	50	55
1B	05/11/95	1.6	< 12*	10.1	37	37	26
2	05/12/95	9.5	41	7.8	32	73	55
3	05/17/95	4.5	2*	10.6	38	40	33
4	05/18/95	7.7	29	7.1	31	60	19
5	02/08/95	10.7	47	nd**	< 12*	47	50
6	02/20/95	nd**	< 12*	11.8	40	40	46

'Respiratory depression not considered significant.
- *nd denotes non-detectable levels of compound.

TABLE 39

SUPPLEMENTAL EXPOSURE DATA FOR BINARY MIXTURES OF 2,6-DI-*tert*-4-BUTYL-METHYLPHENOL (BHT) AND 1,4-DIMETHYLPIPERAZINE

Exposure Number	Exposure Date	Average Exposure Concentration (ppm as propane)	Precision of Exposure Concentration (%RSD)	Average level of target compounds as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
1A	05/08/95	9.6	31.5	84.6	55.0
1B	05/11/95	4.4	15.3	100.0	25.7
2	05/12/95	12.4	23.9	86.7	55.2
3	05/17/95	6.6	6.9	87.1	33.4
4	05/18/95	6.3	15.8	53.0	18.9

TABLE 40

SUMMARY EXPOSURE DATA FOR MIXTURE TESTING OF TERNARY MIXTURES OF 2,6-DI-*tert*-4-BUTYL-METHYLPHENOL (BHT), 1,4-DIMETHYLPIPERAZINE, AND 4-PHENYLCYCLOHEXENE

Exposure Number	Exposure Date	2,6-Di-*tert*-4-butyl-methylphenol (BHT)		1,4-Dimethylpiperazine		4-Phenylcyclohexene		Sum of expected RD (based on Task 1 testing)	Actual RD (% of baseline)
		Measured Average Conc. (mg/m^3)	Expected RD (based on Task 1 testing)	Measured Average Conc. (mg/m^3)	Expected RD (based on Task 1 testing)	Measured Average Conc. (mg/m^3)	Expected RD (based on Task 1 testing)		
1	07/19/95	5.6	13	7.4	31	8.8	< 12*	44	12
2	07/21/95	3.9	< 12*	5.9	27	2.2	< 12*	27	15
3	07/18/95	5.8	15	4.7	22	23.1	3*	40	22
4	07/17/95	nd**	< 12*	9.8	37	25.0	4*	41	28
5A	05/08/95	1.2	< 12*	20.1	50	nd**	< 12*	50	55
5B	05/11/95	1.6	< 12*	10.1	37	nd**	< 12*	37	26
6	02/08/95	10.7	46	nd**	< 12*	nd**	< 12*	46	50
7	02/20/95	nd**	< 12*	11.8	40	nd**	< 12*	40	46
8	07/05/95	nd**	< 12*	nd**	< 12*	184	40	40	43

*Respiratory depression not considered significant.
**nd denotes non-detectable levels of compound.

TABLE 41

SUPPLEMENTAL EXPOSURE DATA FOR TERNARY MIXTURES OF 2,6-DI-*tert*-4-BUTYL-METHYLPHENOL (BHT), 1,4-DIMETHYLPIPERAZINE, AND 4-PHENYLCYCLOHEXENE

Exposure Number	Exposure Date	Average Exposure Concentration (ppm as propane)	Precision of Exposure Concentration (%RSD)	Average level of target compounds as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
1	07/19/95	12.4	5.4	89.9	12.3
2	07/21/95	7.0	2.5	95.4	15.2
3	07/18/95	29.6	8.4	83.4	22.4
4	07/17/95	32.5	2.4	93.5	28.4

TABLE 42

SUMMARY EXPOSURE DATA FOR MIXTURE TESTING OF TERNARY MIXTURES OF 2,6-DI-*tert*-4-BUTYL-METHYLPHENOL (BHT), N,N-DIMETHYLACRYLAMIDE, AND 1,2,3-TRICHLOROPROPANE

Exposure Number	Exposure Date	2,6-Di-*tert*-4-butyl-methylphenol (BHT)		N,N-Dimethyl-acrylamide		1,2,3-Trichloropropane		Sum of expected RD (based on Task 1 testing)	Actual RD (% of baseline)
		Measured Average Conc. (mg/m^3)	Expected RD (based on Task 1 testing)	Measured Average Conc. (mg/m^3)	Expected RD (based on Task 1 testing)	Measured Average Conc. (mg/m^3)	Expected RD (based on Task 1 testing)		
1	06/01/95	4.6	4*	41.5	24	17.0	21	49	55
2	06/02/95	3.9	< 12*	36.0	22	12.8	17	39	26
3	06/06/95	7.1	26	30.5	19	17.3	22	67	12
4	06/07/95	nd**	< 12*	53.7	28	19.2	23	51	33
5	06/05/95	5.3	11*	55.3	28	nd**	< 12*	39	32
6	04/25/95	12.0	52	nd**	< 12*	nd**	< 12*	52	55
7	03/01/95	nd**	< 12*	197	47	nd**	< 12*	47	50
8	02/16/95	nd**	< 12*	nd**	< 12*	212	58	58	51

'Respiratory depression not considered significant.

- *nd denotes nondetectable levels of compound.

TABLE 43

SUPPLEMENTAL EXPOSURE DATA FOR TERNARY MIXTURES OF 2,6-DI-*tert*-4-BUTYL-METHYLPHENOL (BHT), N,N-DIMETHYLACRYLAMIDE, AND 1,2,3-TRICHLOROPROPANE

Exposure Number	Exposure Date	Average Exposure Concentration (ppm as propane)	Precision of Exposure Concentration (%RSD)	Average level of target compounds as % of total exposure concentration	Maximum Respiratory Depression (% below Baseline)
1	06/01/95	8.5	8.0	99.8	55.0
2	06/02/95	5.9	3.4	96.0	25.7
3	06/06/95	7.6	8.7	99.8	12.4
4.	06/07/95	19.0	4.2	99.9	32.6
5	06/05/95	21.6	4.0	100.0	31.9

TABLE44

SUMMARYEXPOSUREDATAFOR
PRIME URETHANE "A" SYNTHESIZED MIXTURES

Exposure Conditions	Exposure Date	Maximum Respiratory Depression (% below Baseline)	Average Exposure Concentration (ppm as propane)	Precision of Exposure Concentration (%RSD)
Test Mixture	08/31/95	48.5	25.0	3.4
lest Mixture without BHT	09/04/95	21.8	13.1	11.2
Test Mixture without BHT or 1,4-Dimethylpiperazine	09/11/95	5.9*	6.5	39.3
Low concentration Test Mixture	11/16/95	11.3*	7.8	13.4

*Respiratory depression not considered significant

TABLE45

SUMMARY CONCENTRATION DATA FOR
EXPOSURE TO PRIME URETHANE "A" TEST MIXTURE

Compound	Concentration Range (mg/m^3)		Predicted %RD (based on Task 1 data)
	Target	Average Conc. Detected	
BHT	5 - 20	10.2	44.1
1,4-Dimethylpiperazine	3 - 15	14.8	44.4
1,1,1-Trichloroethane	1 - 4	7.0	---
Adiponitrile	3 - 15	2.2	--
Styrene	1 - 4	5.9	---
Octamethykyclotetrasiloxane	0.5 - 2	3.2	---
Other	---	2.5 (Toluene equivalents)	--

Other compounds identified (*in* decreasing order *of* concentration): Ether, Ethyl acetate, Substituted methanonaphthalene, Isooctane, Methanol, Hexane, 1,1-Dichloroethene, Hexamethylcyclotrisiloxane, Benzene.

TABLE46

SUMMARY CONCENTRATION DATA FOR EXPOSURE TO PRIME URETHANE "A" TEST MIXTURE WITHBHTREMOVED

Compound	Concentration Range (mg/m^3)		Predicted %RD (based on Task 1 data)
	Target	Average Conc. Detected	
BHT	0	nd	---
11,4-Dimethylpiperazine,1, I-Trichloroethane	3-1-4 15	16.3 9.7	46.3 ...
Adiponitrile	3-15	0.4	---
Styrene	1-4	6.5	---
Octamethylcyclotetrasiloxane	0.5-2	4.4	---
Other	--	5.6 (Toluene equivalents)	---

Other compounds identified (in decreasing order of concentration): Methanol, Pyrazine, Ether, 1,1-Dichloroethane, Isooctane, Ethyl acetate, Acetone, Hexane, Benzene.

TABLE47

SUMMARY CONCENTRATION DATA FOR EXPOSURE TO PRIME URETHANE "A" TEST MIXTURE WITH BHT AND 1,4-DIMETHYLPIPERAZINE REMOVED

Compound	Concentration Range (mg/m^3)		Predicted %RD (based on Task 1 data)
	Target	Average Conc. Detected	
BHT	0	nd	---
1,4-Dimethylpiperazine	0	nd	---
1,1,1-Trichloroethane	'I - 4	2.7	---
Adiponitrile	3 - 15	3.3	---
Styrene	1 - 4	4.7	---
Octamethylcyclotetrasiloxane	0.5 - 2	0.9	---
Other	---	nd	---

TABLE48

SUMMARY CONCENTRATION DATA FOR EXPOSURE TO LOW CONCENTRATION PRIME URETHANE "A" TEST MIXTURE

Compound	Concentration Range (mg/m^3)		Predicted %RD (based on Task 1 data)
	Target	Average Conc. Detected	
BHT	5 - 20	4.6	3.4
1,4-Dimethylpiperazine	3 - 15	2.0	6.1
1,1,1-Trichloroethane	1 -4	1.3	---
Adiponitrile	3 - 15	0.4	---
Styrene	1 - 4	1.7	---
Octamethylcyclotetrasiioxane	0.5 - 2	2.6	---
Other (listed below)	---	0.7 (Toluene equivalents)	---

Other mmpounds identified (in decreasing order of concentration): Methanonaphthalene.

TABLE49

SUMMARYEXPOSUREDATAFOR
PRIME URETHANE "B" SYNTHESIZED MIXTURES

Exposure Conditions	Exposure Date	Maximum Respiratory Depression (% below Baseline)	Average Exposure Concentration (ppm as propane)	Precision of Exposure Concentration (%RSD)
Test Mixture	08/28/95	37.9	25.3	10.5
Test Mixture without BHT	09/04/95	9.3*	17.4	4.9
low concentration Test Mixture	10/17/95	7.1'	9.1	7.9

*Respiratory depression not considered significant.

TABLE 50

SUJVJMARYCONCENTRATIONDATAFOREXPOSURETO PRIME URETHANE "B" TEST MIXTURE

Compound	Concentration Range (mg/m^3)		Predicted %RD (based on Task 1 data)
	Target	Average Conc. Detected	
BHT	5 - 20	8.7	36.0
N,N-Dimethylacrylamide	3 - 15	6.2	---
1,2,3-Trichloropropane	1 - 5	6.2	6.7
N,N-Dimethylformamide	0.5 - 2	1.0	---
N,N-Dimethylacetamide	0.5 - 2	0.8	---
Octamethylcyclotetrsiloxane	1 - 5	4.7	---
1,3-Dichloro-2-propanol	1 - 5	1.9	10.2
Other (listed below)	---	2.3 (Toluene equivalents)	---

Other compounds identified (in decreasing order of concentration): Substiiuted methanonaphthalene and/or Cyclopropa[a]naphthalene, Ethyl acetate, Acetyl chloride, 1-Chloro-2-propanone, Ether, Toluene, Chloromethyloxirane.

TABLE51

SUMMARY CONCENTRATION DATA FOR EXPOSURE TO PRIME URETHANE "B" TEST MIXTURE WITH BHT REMOVED

Compound	Concentration Range (mg/m^3)		Predicted %RD (based on Task 1 data)
	Target	Average Conc. Detected	
BHT	0	nd	---
N,N-Dimethylacrylamide	3 - 15	16.8	10.4
1,2,3-Trichloropropane	1 - 5	7.7	9.9
N,N-Dimethyiformamide	0.5 - 2	3.5	---
N,N-Dimethylacetamide	0.5 - 2	4.0	--
Octamethylcyclotetrasiloxane	1 - 5	6.7	-a-
1,3-Dichloro-2-propanol	1 - 5	5.8	20.7
Other (listed below)	---	0.3 (Toluene equivalents)	---

Other compounds identified (ii decreasing order of concentration): (Chloromethyl)oxirane.