U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

AD-A033 028

COMMITTEE ON FIRE TOXICOLOGY SIX-MONTH PROGRESS REPORT

NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL, WASHINGTON, D.C.

JULY 1976

SIX-MONTH PROGRESS REPORT

Committee on Fire Toxicology

Assembly of Life Sciences
National Research Council

National Academy of Sciences

Washington, D.C.

July 1976

NAS/ACT/P-843-1

BIBLIOGRAPHIC DATA SHEET

1. Report No. NAS/ACT/P-843-1

2.

3. Recipient's Accession No.

4. Title and Subtitle

Six-month progress report.

5. Report Date July 1976

6.

7. Author(s)

Committee on Fire Toxicology of the National Research Council

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

Advisory Center on Toxicology
National Research Council
2101 Constitution Ave. N.W.
Washington, D.C. 20418

10. Project/Task/Work Unit No.

11. Contract/Grant No.

N00014-75-C-[redacted] 0718 per DDC Correction

12. Sponsoring Organization Name and Address

National Aeronautics and Space Administration
Washington, D.C. 20546

13. Type of Report & Period Covered

6-month progress

14.

15. Supplementary Notes

16. Abstracts

The Committee has outlined desirable characteristics for a screening test for determining the toxicity of combustion and pyrolysis products.

17. Key Words and Document Analysis. 17a. Descriptors

Combustion products
Decomposition products
Smoke
Fires
Toxicity

17b. Identifiers/Open-Ended Terms

Fire toxicology

17c. COSATI Field/Group 13B

18. Availability Statement

Release unlimited

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 11

22. Price $3.50

NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

Prepared under Contract N00014-75-C-~~0178~~ 0718 between the National Academy of Sciences, Advisory Center on Toxicology and the Office of Naval Research.

Committee on Fire Toxicology

Charles F. Reinhardt, Chairman, E. I. duPont de Nemours and Company; Herbert H. Cornish, University of Michigan; Arthur B. DuBois, John B. Pierce Foundation Laboratory; Robert M. Fristrom, Johns Hopkins University; Jean H. Futrell, University of Utah; William E. Gibbs, Foster Grant Company, J. Douglas MacEwen, University of California, Irvine; Carl W. Walter, Harvard University Medical School; R. Brady Williamson, University of California, Berkeley.

NASA Liaison Representative: Thora Halstead

Staff Officer: Jack A. Winstead

Ralph C. Wands, Director
Advisory Center on Toxicology
National Academy of Sciences - National Research Council

SIX-MONTH PROGRESS REPORT

THE COMMITTEE ON FIRE TOXICOLOGY

At the request of the National Aeronautics and Space Administration, the Committee on Fire Toxicology has undertaken the task of reviewing the state-of-knowledge and methodology for testing the toxicity of polymeric materials in fires on aircraft, spacecraft and other transportation systems. Zapp et al.[22] reported on the toxicity of pyrolysis products as early as 1955. Numerous reports have been published on the toxicity of pyrolysis/combustion products and on methodology; however, most of these methods were designed for research and were not intended to be applicable for use as screening methods. A review of the methodologies used to study toxicities of combustion products of polymeric materials soon will be completed by this committee.[1-21]

Based on the literature review, presentations at the International Symposium on Toxicity and Physiology of Combustion Products, University of Utah, March 22-26, 1976, and presentations made to the Committee on April 7, 1976,* the Committee observes that acceptable screening tests to evaluate the relative toxicities of aircraft materials are not currently available, as all present methods have one or more shortcomings.

The Committee considers the following to be requirements for an optimum screening test for toxicity:

a. Materials should be evaluated under both pyrolysis and flaming modes. Two heat fluxes should be used for pyrolysis; one flux should be just below that which would produce flaming combustion, and the other should be just higher than the temperature at which pyrolysis starts. These burn conditions necessitate the evaluation of each material at three heat fluxes. The samples should be exposed to known heat fluxes; however, it is highly desirable to measure the surface temperature of the sample during combustion. Both gaseous and particulate combustion products should be mixed uniformly in the chamber atmosphere without being unduly subjected to surface condensation or adsorption.

b. The time of pyrolysis or combustion should be short compared with the animal exposure time.

* Presentations were made by M.M Birky, National Bureau of Standards; C.R. Crane, Federal Aviation Administration; H.H. Cornish, University of Michigan; D.P. Dressler, Harvard Medical School; R. Long, Natl. Fire Prevention and Control Administration; J. H. Petajan, University of Utah; and W.H. Rippstein, NASA

c. It is highly desirable to use one chamber for both combustion/pyrolysis and animal exposure. This not only approximates the real fire situation but prevents large losses of combustion particles and gases on the walls of any transfer apparatus. The animals must be protected from direct radiation from the burning material or the hot gases. This may be done with a radiation barrier and a satisfactory mixing device. The chamber should be airtight to prevent toxic gases from leaking into the laboratory; however, there should be a safety pressure relief diaphragm. The system must be easy to clean between runs.

d. A small rodent species such as the rat or mouse should be used as the animal model. Enough animals must be used at each exposure condition to give statistically valid results.

e. The exposure time should be in the range of 15-30 minutes, preferably 30 minutes. Exposure time should begin at the time pyrolysis or combustion products are released.

f. The temperature in the animal chamber should not exceed 35°C; however, the best means for controlling temperature has not been determined.

g. Incapacitation was considered to be the most important endpoint since it should be directly related to escape capability. The committee members have not yet agreed on the type of measurement to make. The shuttle box, running wheel, and leg-flexion paradigms were discussed. It was recommended that research should be conducted to compare methods for assessing incapacitation endpoints. Experimental animals should be held for 2 weeks post exposure and the number of deaths recorded. Visual observations of animal behavior and physical condition during and after exposure are considered extremely important; thus these should be done by a qualified investigator. Some type of quantitative test may be required to evaluate observations made by the investigator. Carboxy-hemoglobin should be measured in the animal at the end of the exposure. It is also highly desirable to measure the respiration rate and other physiologic parameters in at least one animal during the exposure. The smoke density in the animal chamber should be measured during the animal exposure.

h. In addition to temperature, carbon monoxide, carbon dioxide, humidity, and oxygen levels should be monitored in the chamber during animal exposure. The oxygen should be maintained above 16%. Other expected toxic degradation products such as hydrochloric acid or hydrogen cyanide should be monitored.

i. The amount of material combusted or pyrolyzed within the chamber should be determined. Dose should be expressed in mg/m^3 and should give an endpoint in 30 minutes.

j. Relative toxicity of materials should be determined by comparing test materials with reference materials, those in use or candidate materials, rather than attempting to make absolute toxicity evaluations.

Most current procedures for determining the toxicity of combustion products involve the transfer of the products; therefore, they do not meet requirement c. The official testing methods of Germany[12] and Japan[13] involve the transfer of combustion products and use combustion tubes rather than a radiant heat source. The method of Smith et al.[20] involves such a short transfer of gases that it may be interpreted to fulfill the requirement of not transferring combustion products; however, this procedure does not make use of a radiant heat source. The apparatus in use at the University of Utah[7,16] probably comes closest to meeting the equipment parameters outlined above; however, the number of animals exposed at one time should be increased.

The optimum screening test for toxicity in this progress report will require the development of a prototype test apparatus and experimental validation of the foregoing parameters for sensitivity and reproducibility. It is suggested that NASA may wish to consider the requirements listed above in setting up their evaluations of the toxicities of aircraft materials subjected to fire.

The Committee will require additional time for the preparation of a formal report. The report will include a detailed review of currently used methods for fire-toxicity testing and more detailed description of the optimum toxicity screening test. The test parameters may be modified after further study by the Committee.

References

1. Alarie, Y. C., E. Wilson, T. Civic, J.H. Magill, J. M. Funt, C. Barrow, and J. Frohliger. 1975. Sensory irritation evoked by polyurethane decomposition products. Combust. Toxicol. 2:139-150.

2. Barrow, C.S., Y. Alarie, and M. F. Stock. 1976. Sensory irritation evoked by the thermal decomposition products of plasticized polyvinyl chloride. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

3. Birky, M. M., A.W. Coats, S. E. Alderson, J.E. Brown, M. Paabo, and B. Pitt. 1976. Measurements and observations of the toxicological hazard of fire in a Metrorail interior mock-up. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

4. Carter, V.L., Jr., D.A. Bafus, H.P. Warrington, and E. S. Harris. 1974. The acute inhalation toxicity in rats from the pyrolysis products of four fluoropolymers. Toxicol. Appl. Pharmacol. 30:369-376.

5. Cornish, H.H., M.L. Barth, and K. L. Hahn. 1976. Comparative toxicology of plastics during thermodecomposition. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

6. Cornish, H.H., K.J. Hahn, and M.L. Barth. 1975. Experimental toxicology of pyrolysis and combustion hazards. Environ. Health Perspect. 11:191-196.

7. Einhorn, I.N. 1975. Physiological and toxicological aspects of smoke produced during the combustion of polymeric materials. Environ.Health Perspect. 11:163-189.

8. Gaume, J.G. 1976. Methods for evaluation of the cardio-respiratory response of rats in large-scale burn tests. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

9. Hilado, C.J. 1975. Evaluation of the NASA animal exposure chamber as a potential chamber for fire toxicity screening tests. Combust. Toxicol. 2:298-314.

10. Hofmann, H.Th., and H. Oettel. 1974. Relative toxicity of thermal decomposition products of expanded polystyrene. Combust. Toxicol. 1:236-249.

11. Jouany, J.-M., C. Boudene, and R. Truhaut. 1976. The physiogram as a method for the evaluation of toxicity of combustion products in controlled ventilation experiments. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

12. Kimmerle, G. 1974. Aspects and methodology for the evaluation of toxicological parameters during fire exposure. Combust. Toxicol. 1:4-51.

13. Kishitani, K., and K. Nakamura. 1974. Toxicities of combustion products. Combust. Toxicol. 1:104-123.

14. Montgomery, R.R., C.F. Reinhardt, and J. B. Terrill. 1975. Comments on fire toxicity. Combust. Toxicol. 2:179-212.

15. Moreci, A.P., J.A. Parker, and A. Furst. 1975. A study of the effects on mice of smoke and gases from controlled fires in simulated aircraft cabins. Combust. Toxicol. 2:34-63.

16. Petajan, J.H. 1976. An approach to the toxicology of combustion products of materials. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

17. Rider, E., K. Mohrmann, D. Drozdowski, and D. Hansen. 1976. An acute, comparative, inhalation bioassay for screening the toxicity of the emissions of construction and decorative products when heated. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

18. Sand, H.E., and H. Th. Hofmann. 1976. Evaluation of the acute toxicity hazard of combustion products given off by organic materials. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City,March 22-26.

19. Skornik, W.A., D.P. Dressler, and R. S. Robinson. 1976. The relationship between a scale-model laboratory bioassay method for the determination of smoke toxicity and a full-scale fire test. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

20. Smith, P.W., C.R. Crane, D. Sanders, J. Abbott, and B. Endecott. 1976. Material toxicology evaluation by direct animal exposure. Presented at the International Symposium on Toxicity and Physiology of Combustion Products, Univ. Utah, Salt Lake City, March 22-26.

21. Sumi, K., and Y. Tsuchiya. 1975. Toxicity of decomposition products. Combust. Toxicol. 2:213-225.

22. Zapp, J.A., Jr., G. Limperos, and K.C. Brinker. 1955. Toxicity of pyrolysis products of "Teflon" tetrafluoroethylene resin. Presented at American Industrial Hygiene Assoc. Annual Meeting, May.