**APPENDIX B.3**

**RAF PROJECT SAFETY COMMITTEE**

**HAZARDOUS MATERIALS AND DEVICES**

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DO NOT WRITE IN THIS BLOCK

Project: \_\_\_NOMADSS\_\_\_ Installation Period: 8 Apr – 22 May 2013

Aircraft: \_\_\_\_C-130\_\_\_\_\_\_\_ Beginning Date: \_\_1 Jun 2013\_\_\_\_\_\_

Instrument Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Ending Date: \_\_15 Jul 2013\_\_\_\_\_

1. Instrument: \_\_Fast-response Ozone\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. Function: \_\_high rate ozone for fluxes and mixing ratios\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Principal Investigator: \_\_Andrew Weinheimer, Teresa Campos, and Frank Flocke\_\_\_\_\_\_

 Address: \_\_RAF\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Telephone: \_\_x1048\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. Instrument Operator(s): \_Andrew Weinheimer, Frank Flocke, Teresa Campos, David Knapp, Denise Montzka, Daniel Stechman, and Melodye Rooney

5. Is this instrument commercially produced? \_No\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. If so, please list name and address of manufacturer:

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. Please list serial number of the instrument:

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Please attach a copy of the manufacturer’s instruction manual for the device. If this is not possible, attach a copy of those pages of the instruction manual which describe the principles of operation, hazard warnings, safety features, and safety rules.

8. If the instrument is not commercially produced, please provide information requested below:

 Designed by: B. Ridley, after Don Stedman, et al

 Organization: \_NCAR\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Address: \_RAF\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Telephone: \_x1048\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Built by: \_Pollack, Campos, Weinheimer, and CARI Group\_\_\_\_\_\_\_\_\_\_\_

 Organization: \_\_NCAR\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Address: \_\_RAF\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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9. Describe principles of operation, hazard warnings, safety features:

 Quantifies ozone via chemiluminescent reaction with highly concentrated nitric oxide

(NO).

Hazards: 1) NO is a very toxic gas; although not flammable itself, it is an oxidizer and

accelerates an existing fire. MSDS is included. Precautions have been taken minimize

the risk of crew exposure to unsafe levels of NO, as described in #25. 2) Instrument uses

dry ice as a coolant prior to and during flights. About 5 lbs are used for a 9 hr flight.

10. If the instrument is commercially produced, has it been modified? \_\_\_\_No\_\_\_\_\_\_\_\_\_\_\_

11. If modified, describe the modification.

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**All investigators please answer the following:**

12. Does the instrument contain, use, or produce:

 Radioactive materials \_No\_\_\_\_\_ Compressed gases \_\_Yes\_\_\_\_

 Other ionizing radiation \_No\_\_\_\_\_ Non-ionizing radiation \_\_No\_\_\_\_

 Flammable liquids \_No\_\_\_\_\_ Laser \_\_No\_\_\_\_

 Radar \_No\_\_\_\_\_ Flammable gases \_\_No\_\_\_\_

 Explosive materials \_No\_\_\_\_\_ Toxic materials \_\_Yes\_\_\_\_

13. If any of the categories were checked, specify the material below (for example, amount, energy levels, physical form, etc.).

 We carry 500 psi of 99.7% NO in a compressed gas cylinder having 0.44 L internal volume. Breathable compressed air cylinders, pressurized to 2000 psi or less will also be flown as part of this installation. Approximately 5 lb. dry ice is used to cool the optical detector.

14. Please list all other chemicals you will use on board this aircraft in your experiment.

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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15. If your experiment consumes or discharges materials, will you need to carry additional materials on board? None for research flights. We will need to ferry spare NO lecture bottles to the ground base of operations. A sealed, vented vessel has been constructed to safely transport these materials on the research aircraft during ferry flights.

16. What and how much extra materials will you need to carry?

 \_None for research flights. A quantity of 4 lecture bottles of NO will be ferried to the remote base of operations. \_\_\_\_\_\_\_\_\_\_\_\_\_

17. What kind of container will you need to carry these materials?

 \_\_We have fabricated a sealed, vented containment vessel to safely transport lecture bottles during ferry flights.\_\_\_\_\_\_

18. If the device utilizes a laser, please classify the laser according to ANSI Z 136.1-1973 (circle one).

Class: I II III IV

1. If your laser will be operating at a wavelength that is not eye safe, what procedures will

 be established to minimize the danger to yourself and other project participants?

 \_\_\_\_\_\_please attached a separate document covering this question\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

20. If you are using compressed gas cylinders, what is the maximum pressure expected for each cylinder type?

 \_\_500 psig pure NO, 2000 psig synthetic air\_

21. Will you be re-filling any compressed gas cylinders yourself, either at JeffCO or during the field deployment?

 \_\_No\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

22. Are there any other hazards associated with the instrument itself, the required ground support equipment or the experiment which have not so far been covered in this questionnaire?

 1) Nitric Oxide (NO) Properties:

–Corrosive and toxic, an oxidant that can act as a fire accelerant

–Permissible Exposure Limit (8-hours) is 25 ppm

–The human odor threshold is 0.3-1.0 ppm, smells like nitric acid or chlorine bleach

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2) Ground ops: We will be exchanging the NO cylinder at a rate of 2-3 times per project. This activity will be conducted on a non-flight day by two trained professional staff and outside in a well-ventilated area. Our routine procedures are contained in the attached document and include a complete description of the steps required to exchange NO lecture bottles mounted inside the containment vessel.

23. How would you describe the probability of an accident resulting from the presence and use of your instrument on board the NCAR aircraft?

 \_\_\_\_\_\_\_Low probability, if precautions discussed in #25, below are implemented.

24. How would you describe the severity of such an accident?

 Safe use on research aircraft requires a vented containment vessel, cabin monitors, and crew briefing on properties and proper procedures. Without procedures detailed in #25, such an accident could be quite severe if clearly defined routine and emergency procedures are not followed. With precautions and proper procedures, the risk of accidental exposure is extremely low.

25. What precautions will you take to decrease the probability and the severity of an accident? If any documented safety procedures from your home facility or university are available, please attach a copy of said materials to this form.

 NO safety features, safe handling precautions and procedures:

1) The NO compressed gas cylinder is housed in a containment vessel to prevent leakage of NO into the cabin in the event of cylinder valve or regulator failure. When installed on the aircraft, the containment vessel is vented to allow contents release to air outside the aircraft cabin.

2) It has also been designed to contain the entire cylinder contents, even if the vent is completely blocked. Before installation on the aircraft, the containment vessel leak rate is measured to ensure that it can hold 45 psi of positive pressure without detectable pressure loss. (Test pressure = 30 psig x safety factor of 1.5.)

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3) A flow restrictor has been installed inside the vessel to guarantee that in the event of line rupture, crew exposure cannot exceed 8-hr safety limit (max flow rate into the 2400 cu ft cabin volume will not exceed 2.3 ppmv).

4) All wetted components consist of materials compatible with NO.

5) Manual shut off valve at vent port allows removal from aircraft as a sealed unit.

6) Easily understandable manual emergency shutdown procedures will be attached to the rack.

7) Pressure relief valves prevent overpressurization of components both internal and external to the containment vessel.

8) Computer control program monitors and displays NO flow and pressure; quick shutdown button allows quick, safe shutdown by untrained crew.

9) NO alarms are mounted at the cylinder and at the instrument to provide crew warning

of unanticipated problems. Crew will be identified to interpret the alarm warnings.

10) Loss of research power automatically closes all valves.

11) NO will not be allowed to flow during ground operations without active exhaust pumping away from traffic around the aircraft. Exhaust hose will be vented a safe distance away from ground operations.

12) During research flight operations, NO will not be allowed to flow during pre-flight. The procedure for turning on NO flow requires that pre-flight engine start be first initiated. At flight’s end, NO flow will be automatically stopped at a preprogrammed altitude to allow complete flushing of all plumbing prior to landing. In the event NO is not purged from the system prior to engines being turned off, our operators will make arrangements with Project Manager and ground operations staff to initiate instrument purge of NO on the ground, with other crew either confined inside the cabin, or remaining a safe distance away during the 0.3 hour required to complete the purge process. Research power and operator access will be required to complete this non-routine purging operation.

Cryogenic CO2 handling procedures:

1. Operators will use gloves to prevent cryogenic burns while handling dry ice.

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 Date Signature of principal investigator or operator

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 Printed name of principal investigator or operator

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Reviewed by

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Date