INALAB, INC.

3615 HARDING AVE. • SUITE 308 • HONOLULU, HAWAII 96816
(808) 735-0422 • FAX (808) 735-0047

TECHNICAL EXPERTS CONSULTING IN
ENVIRONMENTAL • FORENSIC • OCCUPATIONAL AND LABORATORY SERVICES

INALAB, INC.

Mr. Bertil Werjefelt
Post Office Box 5011
Kaneohe, Hawaii 96744

14 May 1998

Dear Bertil,

I have reviewed the FAA documentation of the oxygen generator testing conducted by the Fire Safety Section of the FAA Technical Center in Atlantic City on November 6 and 7, 1996. This documentation relates to the investigation of the ValuJet 592 accident in Florida on 11 May 1996.

My first impression after having critically reviewed the information provided was that it is of insufficient depth and scope to evaluate completely. This is specifically true with respect to the evaluation of overall "quality" of the data provided within the submission.

With this submission, we have received incomplete and missing data regarding the specifics of each "test", "run" or trial. I am not inferring that the data does not exist only that it has not been presented in the documentation I have obtained for review.

In some cases exceedingly simple observations are absent (the time of day) and in others serious omissions are evident, e.g., trial 5, what happened to the "three" expended oxygen canisters. The methods and materials employed for each "test" have not been clearly defined. Additionally, perhaps more disturbingly, the submission appears to contain data, which has yet to be "evaluated".

Normally scientists use data for specific and well-defined purposes; e.g., the experiment is designed to test a certain hypotheses. This is the foundation of the "scientific method". What is their hypothesis? It appears to be left undefined (or worse yet undetermined). Once the experiment has been completed, the data is clearly defined and validated, conclusions are drawn on the basis of the information (data) gathered, limitations are examined and generally professional opinions are generated.

I see no professional opinions in this submission. I believe these simulations took place approximately 18 months ago. The government obviously spent a good deal of money and time generating the results. I am at a loss to explain why there is no interpretation of them.

What I do see is a hodge-podge of data, ill-defined, under characterized, hanging out there like "bait" for curious observers.

I'm wondering what conclusions the FAA intends to develop on the basis of this these heterogeneous results.

Without conclusions, without professional opinions, without predictions, the experiment has no intrinsic value. As such, it is difficult to comment on the validity of data, which has no clearly defined purpose.

Under the limitations described above, I have the following observations to make:

We are not given any insight into the "mix" of selection of oxygen generators. What was, for instance, the rationale behind the selection of the Douglas vs. the Boeing design for "activation"? Was one larger than the other with perhaps a higher heat (BTU) output? The oxygen generators employed are not clearly (except in some cases, serial nos. and in other cases, "2 outlet" or "4 outlet", etc.) described in detail. What were the physical, material, and geometrical differences between the generators? What is the rationale behind the investigator's mixed selection (it was my understanding the Douglas design was involved in the ValuJet accident) and packing order? Why was the Boeing generator used for the first "activator" in trial 1, but Douglas generators used for the next seven trials? In the FAA investigator's opinion, how does the "overall" selection of generator type, capacities, and geometry correspond to what is known of the real accident and the circumstances surrounding it?

There is no indication as to "HOW" the initiator generators were actually "activated". This is a serious problem with respect to experimental design. Are they suggesting that the oxygen generators on the ValuJet were activated by human intervention? How else might they be activated? Why were no trials involving dropping, shaking or crushing employed? Again there is no explanation or interpretation given for the selected mechanism or mode of activation (in this case, human intervention).

The actual initiation of the three fires is not fully described. For instance, did the "fuel" (presumably the polyethylene bubble plastic covering or cardboard) actually ignite first or did associated oxygen canisters adjacent to, above and below, etc., activate, producing additional BTU's, driving the ultimate plateau temperature higher prior to combustion of the fuel? Alternatively, did both occur simultaneously? Once melted, but not burned, was the polyethylene bubble wrap reused in subsequent trials?

What was the rationale behind the "abundance" of oxidizer available for the simulation? Each simulation employed between 24 to 28 oxygen canisters of (largely) undefined design and capacity. Based on the theoretical BTU (a measure of heat generated per unit of mass of combustible material) output of each canister (left undefined), what ultimate temperature would be expected if all 28 oxygen canisters fired spontaneously without the presence of fuel? What effects would larger amounts of fuel (acting as a heat sink) decreasing the oxidizer / fuel ratio, have on the possibility of ignition. We believe it would substantially lower the probability of ignition.

The material nature of the fuel is not described in detail. What exactly is it? What are its chemical, physical and fire properties? What is the ignition point for the each material type of fuel, what mass of fuel was employed, what geometrical arrangement was employed. Were there any other fuels present directly or indirectly, e.g., was the cardboard impregnated with wax or did the polymer (in the bubble wrap) contain volatile plasticizers? What were the ambient temperatures at the time of the experiments? What time of day was it? Why wasn't a chronological record of the sequence of each trial, time interval in between each trial, or total length of each trial including setup, calibration and experimental simulation, presented?

Although eight (8) trials were run by the FAA investigators, quantitative data is presented for only three of the trials. Why? The trials, which did not result in fire, were of no interest? Only certain results were worth recording? Trial 5 actually consisted of four sub-trials 3 of which failed to ignite the "fuel". What happened to the failed generators before the last trial (of the 4) which resulted in a fire? Was this simulation (trial 5) allowed to cool down to ambient temperature before additional attempts were made to activate new canisters? Were the exhausted generators "left" in the box? We have no indication of what occurred with respect to these issues.

There was no mention of "smoke" generation, its quantity, its character, its material composition. We have one "tracing" beginning at 17 minutes and labeled "Cargo". Where is the rest of the tracing? What is this smoke sensor "sensing", particulate matter, optical density, gasses, or all three? Was the resulting fire "cleanly" burning with an abundance of oxidizer and fuel limited? We suspect so. Was the smoke sooty, aromatic in nature, "white" or black? When did the smoke first appear with respect to the initiation of the "fire"? We have no indication of these observations being recorded in the documentation submitted. These would obviously play a significant role in assumptions developed regarding the "detectability" of the subsequent fire on-board the ValuJet flight prior to or after takeoff. Considering the resources available, the presence of smoke 6 minutes into the flight and the oxygen canister theory of fire initiation we question why there were no tests conducted to ascertain how long it takes for smoke to penetrate into the cockpit/passenger cabin from the forward cargo hold?

Why weren't oxygen canister "shell" temperatures of the activator "oxygen generator" measured to determine if their ultimate temperature rise was sufficient to reach the ignition temperature of the "fuel" used in the simulation? Was this indeed accomplished at some time prior to the field simulations?

Temperature measuring sites are not defined. For example, we have no idea what "Ceiling temperature" refers to. Is this an ultimate temperature rise plateau or a thermocouple physically placed on the "ceiling" of the box or cargo hold. It is not specified. The same holds true for the other temperature measurement sensors.

What was the purpose for the oxygen sensor (which never did detect the presence of oxygen throughout the experiment)? How is it that no oxygen was ever present? Where was this sensor placed, in a vacuum? And what about the common "magical" misconception that the presence of oxygen alone somehow lowers the fundamental thermodynamic barrier for combustion to occur. We see no mention of this mysterious (but fatally flawed) underground assumption here. This assumption has, in the past, been promoted to somehow buttress the misconception that the oxygen canisters, in and of themselves" are dangerous and (I've even heard) "flammable".

There are no indications of the calibration states of the sensors employed. How, when and to what standard, were the thermocouples calibrated and "checked" for accuracy and proper response?

What was the purpose for the carbon dioxide (an indicator gas of combustion, when carbon burns in the presence of oxygen, carbon dioxide gas is generated) monitoring? Why was the carbon dioxide barely detectable (human breath contains more carbon dioxide that was determined in the 11-6-96 simulation). Why don't we have oxygen and carbon dioxide measurements for 11-7-96 simulation? Why are gases monitored for only one experiment? Is it because the results are confusing and difficult to interpret? Are the oxygen and carbon dioxide sensors working properly, calibrated properly? In a major fire, carbon dioxide levels typically "displace" air, causing death by suffocation, etc. Why the low levels in this instance? Could the charts have been accidentally mislabeled?

According to my understanding of the NTSB and the FAA records, the accident flight lasted 9-10 minutes. Before this, the Cockpit Voice Recorder (CVR) indicates at least 23-24 minutes elapsed from push back from the gate until take off. Sometime before this, the oxygen canisters were loaded on the aircraft. The pilots noted they had smoke in the cockpit and the cabin 6 minutes into the flight.

Although difficult to determine from the information I have reviewed, it appears that of the three fires graphically charted, two give us some indication of timing. Timing in this instance is defined from the point of "manual" oxygen canister activation to that of maximum temperature. The third (trial 5) cannot be used with any reliability due to the uncertainty in its design, canister activation and subsequent fire generation. On the basis of the two (out of 8 trials) it appears that temperatures reach suitable autoignition points for many materials approximately 8 minutes into the scenario, with maximum temperatures about 16 minutes after canister activation. This time interval appears to be either too short (for the fire to have started on the ground, awaiting take off) or too long if generated by the hypothetical cargo shift or air turbulence to apply to the ValuJet accident.

Working backwards from when smoke was noted in the cabin, when would the oxygen canister have to be activated to give this result? Under circumstances, would it have activated? Taxiing on the runway? Doubtful. Severe turbulence in flight? Possibly. But

fire initiation in flight by the oxygen canister mechanism (by the FAA results and our own) does not appear to allow enough time to fit the eyewitness information. Had a canister initiated the fire during rough handling when loading, one would expected a major fire before take-off (no smoke was noted on board by those personnel or seen coming from the plane at takeoff and the plane was still on the ground at the airport for about half an hour after the oxygen canisters were loaded).

I stand by my original comments regarding the most probable source of the fire (electrical) and hope that this brief review of the FAA submission sheds more light than confusion on the issue. In my opinion, on the basis of the review of data presented to us, the FAA/NTSB simulations fail, to a reasonable degree of scientific certainty, to demonstrate that the oxygen canisters could have created such a calamitous fire as the one observed on the ValuJet flight.

Since we have no opinion from the FAA regarding their interpretation of these results, it is premature to comment on the validity of "their" position, whatever it may ultimately become.

Bertil, I spent about four hours reviewing the data and assembling this response. My work schedule is so severe, and the economy is so bleak that I cannot afford to put in anymore *pro bono* work on this project. I am spending this time purely in the interest of promoting good science and a rationale basis for the valid interpretation of these analytical results.

The opinions expressed in this response are my own and do not represent the interests or avocation of any other group or third party.

Sincerely,

Mark Hagadone, Ph.D., DABFE
President / Technical Director
INALAB, Inc.