MR R HILL questioned by MEMBERS OF THE BOARD:

MR HILL: I am the programme manager in cabin fire safety at the FAA's technical centre at ATLANTIC CITY and have been involved in fire safety research in aircraft for the past twenty years, and have participated in most of the major aircraft-transport aircraft fire investigations over the past ten years. We have done major research programmes over the past twenty years looking at aircraft cargo fires, their occurrence and their possible containment.

Cargo fires are very rare in transport aircraft. They have occurred more often in lower hold baggage compartments where the contents may not be as well controlled as they are in the upper lobe where it is shipping material, in that most of the fires that I know of in cargo compartments in aircraft, have occurred due to the transport of materials such as matches in baggage, or materials carried of a personal nature that could ignite.

Again they are very rare but there have been a few very catastrophic occurrences of cargo fires. The most catastrophic being the SAUDI L1011 in which 301 people were lost due to a cargo fire. So they do occur and they can become

/out ...

out of control.

CHAIRMAN: What is the materials in which they occur? Anything?

MR HILL: Most of the work that we have done has been based on looking at cargo fires in materials that normally would be carried as opposed to those that would be outside of those allowed in a cargo compartment. Most of the test work that has been done over the past twenty years has utilised strictly packing materials in cardboard boxes. And a fire initiated from just about any source spreading through packing material and cardboard boxes, can lead to catastrophic occurrences.

CHAIRMAN: What about the source of ignition? We know from reading the ICAO reports and from other published material in the journals, that fires in cargo holds have occurred through lighter fluid, cigarette lighters, through devices aimed at being warmed up in a hotel to curl a woman's hair - curling tongs are they called, with heating apparatus in the form of lighter fluid or something of that kind, nitric acid leaking out of its container and setting the container materials on fire, cardboard matches which are ignited through friction, lithium batteries even in the smallest size which have been roughly handled and which most extraordinarily and rarely have resulted in a minor explosion and fire - we know

about that sort of thing. What are the other sources of ignition? What causes these things to become alight?

MR HILL: All you need is enough energy to ignite whatever combustible material you have in the vicinity and it depends on what that material is as to how much energy you need to ignite it. There have been fires in the past, in fact in the past two to three years in cargo compartment holds from electrical overheats of aircraft systems igniting insulation blankets; from the overheating of a solid oxygen canister whereby the outer sheath of the canister reached a temperature in the range of 400-450° F and ignited plastic packing material, and the as a result of that an aircraft was completely lost on the ground. It was prior to loading of passengers. It was a DC-10 aircraft.

There are numerous chemicals that, when mixed together can ignite, or cause high enough temperatures to ignite other materials in the vicinity.

CHAIRMAN: There was a case of cleaning materials being mixed and of an aircraft becoming very warm. A passenger couldn't put his arm on an arm rest, if you recall that accident.

MR HILL: Yes, it was a DC-9 and the heat that was observed in the upper part of the aircraft was because

of a fire not necessarily the chemicals heating - the chemicals mixed, heated and ignited the cardboard container probably that was housing those chemicals, and then spread to some other materials. So most of the heat came from the fire and not the chemical reaction, but the chemical reaction is what caused the fire.

So there are numerous ways of igniting various materials and from what I have seen of the damage to the aircraft, both at the debris centre and from the photographs and from what I have heard, I do not consider the result inconsistent with a fire in typical cargo baggage type materials; packing materials. Cardboard and packing materials could produce enough heat and generate enough heat to produce the results that you see both at the debris centre and from the photographs.

The exact ignition source could be as small as a tiny arc which ignited a plastic, or could be a little bit larger and it could very possibly be some of the other modes of ignition that we have heard over the past four to five days, and I don't consider myself knowledgeable enough to be able to tell you exactly what the ignition source would have been in that case. But I am

not so sure that it is the important point as to what started the fire because in any investigation I think the major purpose is to determine how we can prevent this from happening again.

CHAIRMAN: Precisely.

MR HILL: And if we are to do that it is not so important as to the exact ignition source, as it is as to why it propagated, how it produced the results it did, and what we can do to prevent it from occurring no matter what the ignition source may be in the future.

CHAIRMAN: What about the fire fighting systems for a cargo hold of this nature, a B Class cargo hold?

MR HILL: I think that's answered by our AD in that the FAA believes that that is not an adequate method of trying to extinguish a fire in a compartment of that size and that nature.

CHAIRMAN: Is that a question for MR SLIFER rather?

MR HILL: I think he can tell you what we have come up with as the best available systems for present aircraft.

CHAIRMAN: Let me take a step back and ask you please to tell us something about the consequences that you have observed in cargo fires.

MR HILL: Over the years we have conducted numerous investigations including fire tests in large compartments, not quite as large as the compartment on the 747 in question, but up to the size of

5 000 cubic feet with packing material ignited, with a resistance heater per se; an iron that starts a barbecue, and in those tests the fires developed fairly rapidly and within three to five minutes from the time we ignited the packing material, we obtained what is called a "flash fire", that is where enough of the material had off gassed and produced combustible gasses at the ceiling, and ignited and flames rapidly progressed from one end of the compartment at the ceiling, to the other end, consuming the majority of the oxygen in that compartment. The temperatures at the ceilings generally range upwards to 2000°F and last for a period of time anywhere from thirty seconds to a few minutes, depending on how fast and violent this occurs and the amount of material in the compartment.

The fire then dies down from lack of oxygen and will reach an equilibrium point depending on how much air/oxygen is being induced back into the compartment. The fire can stay at a steady state smouldering condition for - the test we ran - as long as two hours, or if you induce enough oxygen back into the compartment, in the form of air, the fire can then go back into a flaming mode, and we did see in some of the tests where we were simulating what might have happened

in the SAUDI accident, where we got a definite cycling of the fire, where the fire would build up and then die down at a periodic time frame. As oxygen would be induced into the compartment, it would flame, it would burn up that oxygen, die down into a smouldering state, and then induce more oxygen into the compartment.

So exactly how a fire would burn in a compartment depends on a number of variables and I don't know that anyone could tell you exactly how this fire would have burned in that compartment.

CHAIRMAN: And the generation of smoke, have you anything to say about that?

MR HILL: The generation of smoke in a flash fire or even a flash-over where you ignite a number of other materials underneath, is very rapid and very dense and there have been instances in actual fires in aircraft where people could not see a few feet in front of them. In a test that we ran the light obscuration, that is the amount of light visible over one foot, went to zero almost immediately upon this flash fire in the entire compartment, and stayed there for the total two hours of the test.

CHAIRMAN: What was productive of that smoke? Packing materials?

MR HILL: The only thing we had in the test were packing

materials and cardboard. So that was what was making the smoke. Also the amount of material consumed at the end of two hours was very, very little and most of it was in the area that we started the fire. The outside of the rest of the boxes was scorched and a little burning but very, very little material consumed. Most of it is in the area where the fire starts.

CHAIRMAN: Could you explain the apparent reversal of the airflow? I gather that in ordinary circumstances the pressure in the passenger compartment, or passenger section, of the aircraft is slightly higher than that in the cargo section, so that there is a flow of air however slow and minute from the passenger section to the cargo section. But in order for smoke generated in the cargo section to reach the passenger section, that flow would have to be reversed.

MR HILL: That is correct.

CHAIRMAN: What causes that, Mr Hill?

MR HILL: If you get a large fire or in the case of a flash-over or flash fire, you develop a large pressure in the compartment and the amount of pressure of course would depend on how much temperature you heat the air up in that compartment. But that pressure would in most cases and especially in a flash fire condition, be enough to overcome the slight differential pressure and push smoke

into other areas of the compartment.

There have been instances in flight of fires in aircraft where this has occurred and one that comes to mine right off is AIR CANADA where the smoke propagated from the back of the aircraft up into the cockpit, in which case the cockpit crew had a hard time reading their instruments on approach. There have been a number of other incidents where aircraft have been lost where the pilots just could not see what was going on because of the dense smoke they had propagated up into the cockpit.

So it is very possible for smoke to flow against that pressure differential once you get a very, very large fire.

MR TOMPKINS: I just want to ask you Mr Hill, with the VARIG accident at ORLY AIRPORT and the PANAM accident at BOSTON, would they be examples of where the fire started at the rear of the aircraft and smoke propagated all the way up into the cockpit? You mentioned PANAM earlier. Do you remember the VARIG accident at all?

MR HILL: Yes, I remember the VARIG accident very well. Yes, it was concluded that the fire started in or around one of the aft lavatories; probably in the trash receptacle behind the wall and there

was very little fire fighting or they couldn't find the fire and smoke and fumes propagated from the passenger cabin, through the passenger cabin into the cockpit. It got very smoky in the cockpit and the crew had donned oxygen masks and in fact put the plane down in an onion field, I believe. That would be a very good example of that.

There are others. There is a 737 in ABU DHABI; a Gulf area aircraft where a fire in the lower cargo hold spread upwards and smoke propagated into the cockpit, and the aircraft ended up flying into the desert. There are cases where they got them onto the ground, and cases where they haven't.

MR TOMPKINS: Thank you.

MR WILKINSON: Mr Hill, just one quick question. You heard the temperature range as quoted in the main cargo deck area, being what - 200 to 700. In your experience are you surprised at this range of temperature?

MR HILL: No, not. You have to remember that the temperatures quoted in almost all cases, are temperatures that metal reached, not temperatures the air reached in the compartment. The air temperatures were probably much higher especially for short periods of time. Most of the materials that

we have temperatures quoted on, were behind insulation blankets. So their heating was not until those insulation blankets were removed due to fire or the fasteners failing and those falling. Most of the materials that we heard temperatures of are also cooled in some method by the outside air. So I would expect temperatures in that upper crown were much higher than that for periods of time, and they would be very consistent with the temperatures we have seen in tests.

CHAIRMAN: Could you tell us within the range of your experience, what can happen to the structure of the aircraft in the cargo fire when the matter being burned is packing materials?

MR HILL: I can only tell you that in the incidents that I have investigated of fires in cargo compartments - and again most of those fires, in fact all those fires have been lower lobe compartments where the structure is completely different - or in fires in cabins where we're impinging on similar type of material, that I do not conceive that what we see is in any opposing view to the tests that we have conducted, I have not seen any place where fires have burned through fuselage skin that's being cooled in flight, other than areas that are not getting that cooling effect like the air pressure bulk-

head. I have seen where an air pressure bulkhead has been weakened by ...

CHAIRMAN: It's called "torching". Is it?

MR HILL: Right. But I have not seen it happen on areas that are cooled by the outside air to be very consistent with what I saw here but other than that I am not a structures expert.

CHAIRMAN: I didn't mean to ask you what happened to the structure as a hole, I meant to ask you what happened to structural components like stringers and skin in vital areas.

MR HILL: Right. I have seen damage similar to this on other aircraft, yes.

CHAIRMAN: Can I ask you Mr Hill, what your view is of the probable origin within the range of possibilities, of the fire in this case?

MR HILL: It is my opinion that there was a small ignition source which could be of the range of a spark or arc onto packing material up to a small incendiary device. Anything in that range that could get the packing material burning and from there the fire to spread in what we have seen to be normal occurrence in packing-type fires.

CHAIRMAN: What would have led to the aircraft hitting the sea? I can't ask you to be specific but I can invite you to deal with the range of possibilities.

MR HILL: I think we have heard the range of possibilities and I wouldn't rule any of them out. I am not

a structural expert so I couldn't tell you whether the fire would have done enough structural damage. The fire certainly had enough heat in the upper area of the fuselage to do damage to some of the structure. It had enough heat to do some damage to some of the control cables. Again I am not an expert to tell you what that would do to the flyability of the aircraft and we have other experts who have been telling us that for the last few days. I would not rule out the possibility of smoke and fumes travelling up into the cockpit and either incapacitating or causing lack of visibility in the cockpit to the crew. That has happened in other aircraft accidents.

The SAUDI accident for one where the crew actually got the aircraft on the ground ...

CHAIRMAN: The SAUDI ARABIAN one are you talking about?

MR HILL: Right. Where the aircraft was landed with very, very little smoke or fumes or any in the cockpit at that time, it was documented that the crew had not put on oxygen masks at all throughout the entire incident.

CHAIRMAN: Nobody got out?

MR HILL: Stopped the aircraft and had radio contact to the tower telling them that they were going to initiate an evacuation, and nothing. No doors

opened and everyone was killed on the airplane; they never even got out of thier seats.

CHAIRMAN: It was reported at one stage was it not, that the cabin attendants had lost control of the passengers.

MR HILL: I don't believe that was ever borne out in fact. There was no evidence to indicate that. The evidence indicated that something very rapidly happened in the aircraft after landing that incapacitated all or most of the people on board.

CHAIRMAN: And just to avoid repetition but to get clarity, what do you say is the key issue we must look at in this investigation? Not the origin of fire you say, but what?

MR HILL: In my opinion the emphasis of any accident investigation from the standpoint of at least the FAA, is to make sure that accidents of that type do not happen again and in doing so we must determine the factors in that accident that we have to protect against, or we can protect against to make sure it does not occur again. In this case I think it comes down to knowing that there was a fire in the cargo compartment and this led to the final demise of the aircraft; that what can we do to prevent or control aircraft fires, and what do we have to do to the aircraft to make them withstand this type of fire.

CHAIRMAN: Yes, and what would your answer be on those two

propositions, Mr Hill?

MR HILL: Hopefully we have answered most of that in our AD for what we believe is possible with present aircraft, and we will be looking at in research what we can do in future aircraft to make them even safer.

CHAIRMAN: Thank you. Have you any other guidance for us at this stage before I call on MR SLIFER?

MR HILL: I just want to mention one thing that may be overlooked and I think WEST may bring it up, and that is the fact of the checklist for evacuation of smoke and it should be remembered if you follow the first checklist for a fire in the cargo compartment - that upper deck cargo compartment - the last words before it says to go to the next checklist says: "extinguish fire". Then if you have smoke in the main deck or in the passenger cabin, you follow the next checklist to evacuate the smoke. I do believe that those procedures are for getting smoke out of the aircraft when there is no fire and if you still have a fire, I don't believe anyone can tell you what the effect of following those procedures is going to be on a fire.

So those procedures are not for getting smoke out while a fire is in progress. It is too complicated; there hasn't been enough research

/and ...

and there are too many variables to come up with an exact procedure that would cover every possible fire scenario, to tell you how that procedure would affect the growth of the fire. So that procedure is just for getting smoke out after the fire has been extinguished.

CHAIRMAN: If the fire is still burning then by cracking the door you might be nourishing it with more oxygen.

MR HILL: You may be doing anything. I don't think there is enough documented evidence to say what it would do one way or the other. It may draw more smoke out of the cargo compartment and pass it over the passengers to get it out of the aircraft. There are all kinds of possibilities. But I think the key word in the first checklist is "extinguish fire". If you haven't done that, then you have a big problem.

CHAIRAN: Mr Hill, if anything else occurs to you, would you please tell us about it?

MR HILL: Yes, Mr Chairman. Thank you.

CHAIRMAN: May I ask MR SLIFER now to assist us, first of all on the certification of this Class B type of cargo hold and secondly, on fire-fighting systems.

MR W B SLIFER, questioned by MEMBERS OF THE BOARD:

MR SLIFER: It has involved the entire Class B concept on large aircraft.

CHAIRMAN: Can you speak up a bit please, Mr Slifer?

MR SLIFER: Yes, Mr Chairman. It has involved all of the Class B concept as applied to large cargo aircraft. I have been involved in this since 1972. The concepts that we have actually date back long before I was involved with it and it started with the concept that the compartments were relatively small compartments, and as they developed and as the cargo traffic developed in air commerce, the regulations attempted to change to address the new concerns; additional types of cargo compartments were added. At the same time they modified some of the earlier concepts and one of the changes that occurred was as Class B compartments grew in size, they also added an all freighter concept to the airplanes and simultaneously eliminated the requirement because packages were getting larger, that the personnel in the aircraft could move by hand all the cargo that was in it, because packages were growing in size. And as a result of that the development of the wand concept to extent the end of the nozzle to reach more remote areas in a compartment was accepted.

/At ...

At the time that these things occurred the certification and service experience that we had indicated that this was an acceptable concept; that you could apply the chemnical extinguishing which was present at that time, to remote areas where there might be a fire where you could not move the package itself and extinguish a fire based on that. But all of this was predicated upon the assumption that you reach those areas at a relatively early stage in the fire.

CHAIRMAN: What about an item of cargo two metres high with a fire on the other side of the person who is trying to extinguish it. How does he get the applicator to it?

MR SLIFER: If you look at the pallet arrangement that is in the air compartment here on the 747, those are easily two metres high, they are also quite wide. The concept was accepted by the FAA based on a lack of any other evidence or data from service experience, that the wand which was provided in this case, you could reach anywhere around or above to apply the extinguishment at that time. We have no service experience to show us that we could expect the larger fires with legal cargo.

CHAIRMAN: What is the position in your opinion, as far as the adequacy goes of the fire-fighting systems until your AD was published?

MR SLIFER: I was part of the FAA review team; that as a result of this accident we decided to examine the criteria and assumptions that we had made for certifying Class B cargo compartments in particular. And as a result of that, we concluded that what we had been doing was entirely inadequate, that it had not grown with what had occurred in realistic scenarios such as large cargo compartments.

As part of that process we met with several airport type fire-fighting experts, the ones that don't fly but are involved with many of the scenarios on the ground where there are aircraft crashes. And we learned a good many things there from them that we found that we had accepted based upon the history of aviation, that were really not acceptable concepts. And one of them was that if you taught a person how to use a tool, that because they knew how to use it they would be able to extinguish a fire. And as a result of that we felt and - it is part of the AD - that what we had previously was unacceptable, that this would take a person who has specialised training in fighting cargo fires. And according to the experts that we had consulted it was not just that they knew how, but they had demonstrated that ability in a real fire

scenario. Now that is not talking about building a fire in an airplane flying, but in a real scenario where they would demonstrate their ability to locate and extinguish the fire, and that includes low visibility conditions.

CHAIRMAN: Do you stand by the AD that was issued last week?

MR SLIFER: Yes. If you look at that AD you will see that there are two features - primary features you may call it. One is what we can do now, the rest is what it takes some time for manufacturers to be able to design and for the modification to be accomplished on existing aircraft. We believe that this is probably the best that can be possibly done with the technology that we have today on a reasonable basis. The initial phase of that AD addresses things that can be accomplished rightaway. The training of personnel; requiring those people as part of the crew to be present, depending upon the size of the compartment. Requiring the additional extinguishers to be present and located, and establishing that they do have communication means between that compartment and the flight deck so that they can keep each other informed of what is occurring.

The improved detection system is within the capabilities of occuring; the second phase which

adds a great deal more will give them an additional fire-fighting capability that when flames are open and present, that they can use what we call a "knock-down" system to provide an extinguishment there to control it to a level where the person can later go in and as necessary, perhaps have to fight it manually as was originally. This would take care of the open flames, large rapid-growth fires.

CHAIRMAN: Are you satisfied as to the economic viability of the AD? The cost of the operation?

/Yes, Mr Chairman

MR SLIFER: Yes Mr Chairman, I understand what you're saying. It's a little bit difficult. All we can talk to is what our estimates on costs are, and as you noticed in the AD, we felt that it would be in the area of about - for a large Jumbo-sized aircraft - of about 2.3 million US Dollars.

CHAIRMAN: Per aircraft?

MR SLIFER: Per aircraft, yes. Unfortunately we do not have exact detail. I think the manufacturers could better answer that question in terms of what the actual costs are. But that was based upon the industry's input back to them that it would be in the area of about 2.5 million Dollars per aircraft for a large Jumbo-type aircraft - wide body.

DR FUNATSU: Mr Slifer, I would like to know if FAA has recently certified a new type of airplane of the COMBI configuration after the HELDERBERG accident?

MR SLIFER: In September, I believe it was 1988, we approved on an end-term basis, one 757 COMBI aircraft which has a two-power arrangement with a cargo compartment located between the cockpit and the passenger compartment. That is the only aircraft that I'm aware of that has been approved. That particular aircraft had numerous additional features provided based upon our knowledge at that time, and the fact that the noticed proposed rule-making had been published and we could not comment as to what the

final AD would consist of, so on an interim basis that one airplane was accepted, that that airplane will have to meet the requirements of the AD to ever be re-admitted to certification operations in the UNITED STATES.

DR FUNATSU: Have you any other certification programmes for other new type COMBI airplanes?

MR SLIFER: There is currently undergoing a programme for the 747-400 COMBI aircraft, the first aircraft to be delivered to KLM. This airplane is due to be delivered in the very near future. At the time that they started talking to us about this, it was anticipated that the delivery of that aircraft would be earlier this year, and due to a number of unforeseen technical problems, the aircraft was not able to be delivered. The FAA established some interm guidelines which probably consist of - it's hard to put a percentage on it because there are a couple of the things that this aircraft will not have, that it will have to have if it is re-introduced to US operations, after the effective date of the second part of the AD. This aircraft has the knock-down system, it has an improved smoke detection system, it will be required to have the fire fighter set in accordance with the guidance that we've talked about. It has a communications system. It has the increased

portable fire fighting equipment; the additional protective garments for the fire fighters which was not previously ever required, the protective breathing part of the aircraft. The flight manual will require that this person who is the designated fire fighter - of which we do not call it that there - will have to do a 30-minute surveillance every 30 minutes; provide a total walk-through and look at the condition of the cargo relative to potential problem areas relative to fire. If there is a smoke alarm - false or otherwise - we'll require that there be continuous surveillance in the cargo compartment until approach to landing.

This aircraft would be close to meeting the requirements. It will not have the liner in it which would meet the new burn requirements. It would not have a thermal surveillance system or monitor system. I believe that those are the only two things that this aircraft would not have.

We are working on behalf of the FAA and the Dutch authorities on this, and have been working with them towards accepting this aircraft, but it has not yet been certified.

DR FUNATSU: Thank you very much, Mr Slifer.

CHAIRMAN: How many COMBI's are flying? Not the IRON CURTAIN ones.

MR SLIFER: I would probably have to go back and consult my records that I have, to know actually how many of them are flying. The reason I have difficulty in answering that question is, in some of the work we do we look to see how many are involved in the US fleet, and the rest is in the world fleet, the difference - and then an additional number is those that are actually flying versus those that are eligible to be converted - and I believe perhaps that 224 is the high number in terms of those that are actually operating, but I believe the number that are eligible to be operated is higher than that. I believe this number can be matched by just one of the major manufacturers in the UNITED STATES of aircraft that are currently operating, but maybe not in COMBI configuration.

CHAIRMAN: Has there been a fire like this in a COMBI before?

MR SLIFER: None to my knowledge, Sir.

CHAIRMAN: This one is unique as far as your knowledge goes?

MR SLIFER: Yes, Sir. As far as COMBI's.

CHAIRMAN: Mr Slifer, could you tell us what the possibilities are for the sequence of events that occurred after the fire warning bell sounded on the flight deck?

MR SLIFER: Well Mr Chairman, I can speculate on it based on some of my knowledge, and then there would have to be numerous scenarios that could have occurred.

As MR HILL indicated to you, if they followed the first checklist for fighting the fire and then proceeded without knowledge that the fire - or even with knowledge - that the fire was still into the second portion of that checklist, I could see many things that could happen, but I have no way of knowing that they did.

If you depressurise the airplane and were to shut down the airflow so that you can open up any of the doors to attempt to evacuate, the stabilisation of the pressures inside the aircraft would be disturbed. We have no engineering knowledge present to us in certification as to what the total effect of that can be. I've had some experience in non-certification work in some research work which indicates that you could expect almost anything. In some cases there were benefits to removing smoke; in other cases all it did was spread it around more within the aircraft.

We do know in some cases that it will drive smoke into areas even without the thermal source, that you wouldn't have expected the smoke to go. So to try to predict that on a large-bodied aircraft like a 747 would be very difficult. I would be concerned - and we had experience once before on

/another ...

another airplane in which two checklists were inadvertently combined, and one of them was a fire fighting procedure, and another one was the smoke evacuation procedure for the cockpit. And if a person followed the numerical sequence that had been in that one, it ruled would automatically draw the smoke immediately into that cockpit. It was a different aircraft; it had an openable window. That is a known condition, because there have been some observations made in testing by that manufacturer - not for that purpose - that that was not the right thing to do.

We feel very strongly that the AFM - and when I say the - it's an approved engineering document from which they build the operations manual. It's a very brief that in those cases, checklist functions should not be combined, and sometimes what appears clear at the time that you write something, later allows some explanation to clarify it, and that is oftentimes different.

But many people do not understand the complexity of air movement, particularly when you combine it with a thermal driver within the airplane. When I say "a thermal driver", some type of occurrence which is causing a great expansion of air and

/completely ...

completely changing the airflows that are within the airplane under normal conditions.

The 747 COMBI, under ambient temperature conditions within the airplane, has a tremendous amount of air which flows in the ceiling area above the passenger. It's not introduced there but it is present there, and it flows towards the aft of the airplane, such that there's a 2 to 3 ft wide air barrier between the aft corner and the aft passenger cargo barrier, in which a person could stand in that area, breathing in clear air, with 3 ft beyond that the density would be such that you could not see your hand in about 15 to 18 inches from your eyes.

And so the things that can occur within an aircraft and to try and speculate upon what all may have occurred in there, my assumptions normally would have to say is that the crew would follow the checklist as best they could. And it is possible, in the cockpit of the aircraft air is introduced at a much higher rate, but that is on the assumption that the air-conditioning packs are not turned down.

If the air-conditioning packs are turned off, then you're not introducing any air. You now have a static vessel and the thermal driver would drive

that smoke into each corner of the aircraft.

CHAIRMAN: I understand that there have been several fires started in aircraft toilets?

MR SLIFER: Yes, Sir.

CHAIRMAN: Have we anything to learn from that in this accident?

MR SLIFER: Well, the obvious ...

CHAIRMAN: I suppose unless you can reach it early enough it can run away?

MR SLIFER: That is the most obvious thing, that any fire that doesn't get extremely early attention, the concept in fire fighting that we have used in the FAA is N°1, prevention, both by trying to control the type of cargoes that are carried on aircraft, and by the design of the aircraft to eliminate fire ignition sources due to aircraft equipment.

The second one has been when for some reason that has failed, to provide means to a crew to attempt to counteract it at a very early date, the term that is used in fire fighting is to attempt to catch it at the insipid-fire stage, which is at the very beginning, so that you can take immediate action.

In one of our tests, to simulate what we felt would be a worse case - and you must remember this is a test condition, not a real fire scenario - and we

assumed that the flight engineer would be the individual who went back to fight the fire on a 747 - took him, without running, 2 minutes and 15 seconds to reach the cargo compartment. It took him an additional approximately 1 minute to don his protective breathing equipment, collect the portable extinguisher, enter through the barrier net - the cargo barrier net - and take the wand and go back to the point in the aft of the compartment where the fire was supposed to occur in a smoke-filled environment.

CHAIRMAN: Thank you, Mr Slifer.

MR DONNER: Mr Chairman ...

CHAIRMAN: Yes, Mr Donner?

Just one moment, Mr Slifer.

MR DONNER: I would just like to make another remark if I may?

CHAIRMAN: Yes?

MR DONNER: I would not like to leave you with the impression that the FAA is involved in some sort of struggle with BOEING concerning the certification of the 747-400. Throughout the process, even before the AD was published, we've been working closely with BOEING, and have had nothing but their complete co-operation.

And finally concerning the AD again, I believe we wouldn't have an AD without the efforts of your

Board, and without the efforts of MR VAN ZYL and his investigators.

CHAIRMAN: Thank you.

MR DONNER: Thank you.

CHAIRMAN: This accident is of world-wide significance.

MR DONNER: Yes Sir, it certainly is.

CHAIRMAN: Mr Southwood, there can be no question of cross-examination, but I'm sure that if you consult the members of the FAA as we have been doing, they'll assist you with any aspects you would like to develop.

SOUTHWOOD CANNOT CROSS EXAMINE BECAUSE HILL & DONNER WERE NOT SWORN IN

MR SOUTHWOOD: Yes, Sir.

MR HILL questioned by MR SOUTHWOOD:

MR SOUTHWOOD: I have one question that I would like to ask of MR HILL. Mr Chairman, and that is the significance of the so-called hot spot between body station - I think it's 1800 and 1820 at the level of 15R - in relation to the kind of cargo that he described - the fire from cardboard and wood.

How would you get a hot spot developing some distance away from the pallet at that particular spot?

MR HILL: Alright. All I can say about hot spots in general, and it would apply to that one in particular, is that when you have a fire in typical packing material - and we've run numerous tests over the years in boxes packed in a pallet-type style with various materials in the boxes that, depending on where the fire is initiated, you can get flames emanating at various positions on that pallet, that any type of damage to the side wall or the fuselage structure, can depend on the insulation blankets; on how they fall; on how a flame hits that insulation blanket; on when it impinges on the side wall; on how the pallet falls apart if it does fall apart, and it is not inconceivable that a fire from typical packing material could give you that

type of damage on the structure. It is also possible that you could have other methods of impinging flames from other types of materials on that area and get the same result.

So I can't give you an answer and say: Yes, it's from this, or it's from that, but it's not inconceivable it's from standard packing type material burning in ways we've seen it happen.

MR SOUTHWOOD: Are you satisfied Mr Hill, that the fire emanated from Pallet PR - that is the right front pallet - from a small fire?

MR HILL: I think all the evidence that I've seen indicates that the fire started on that side in the forward part of the compartment.

MR SOUTHWOOD: And it was a small fire? Or do you think it was a large fire?

MR HILL: It was a large fire that did the damage it did to the aircraft. I believe it was a smaller fire when it started and spread to a larger fire, yes, very rapidly.

MR SOUTHWOOD: Thank you, Mr Chairman.

MR HILL, questioned by MR CILLIERS:

MR CILLIERS: Mr Chairman, I have two questions. I would be grateful if MR HILL could just clarify what he had in mind.

The first was that you asked him Mr Chairman, in general terms, with the benefit of his experience of fires aboard airplanes, and understandably then he answered you in general terms.

But turning to the 747 in particular, I am instructed Mr Chairman, that firstly of course the ventilation systems and the airflow systems, differ from 'plane to 'plane according to its design, and that the 747 is the only 'plane which has the flight deck crew on a different level to the passenger deck, and one has more bulkheads between the cargo compartment here and the cockpit, than one would have on other 'planes, and so the differences can be listed and mounted.

And all I wanted to clarify, which is what I think is a fair comment on what MR HILL intended and did convey, but I do wish to clarify it, that his suggestion that smoke may have migrated as far as the cockpit, is not based on any specific study of

the airflow in this particular 'plane, with particular features, some of which I've mentioned, and that it is a general statement and is not specifically based on an analysis of this type of 'plane - the 747?

If MR HILL confirms that then ...

CHAIRMAN: Would you care to comment, Mr Hill?

MR HILL: Any of the information that I have put forward here is based on experience on numerous types of aircraft and not particularly 747's. I am not aware - I have not been involved that I can think of - of a fire on board a 747 in flight, where I can say that with certain air-conditioning systems working or not, that smoke propagated to the flight deck.

I have been involved in ground accidents, where fires have developed on the ground on 747's, were quite evident that flames or smoke and toxic gases have propagated fairly rapidly into the cockpit from other areas - a KOREAN AIRLINES 747 in KEMPO AIRPORT in SEOUL KOREA where there was a ground fire - so it depends on the airflow and whether the airflow systems are working or not, as to what is going to happen, whether the smoke is going to propagate into the cockpit or not,

or how long it would take, and I couldn't tell you whether it would or it wouldn't, without knowing all the conditions that were going on inside that aircraft at that particular time.

MR CILLIERS: I think that satisfies us on that score. We understand MR HILL saying that he hasn't made a specific study for this particular case in order to be able to give an opinion whether the smoke would or wouldn't have promoted itself, or been promoted into the cockpit.

The second question I can perhaps also put in broad terms.
I understood MR HILL to say that - and he said it on two occasions - that to his mind it was not inconceivable to get this type of fire from, what he called, standard packing materials, or that one would get it from other types of materials which would promote a fire.

Now I just want to ask MR HILL to confirm one thing, and that is that he has had some discussions with MR SOUTHEARD who is a fire expert, whose report is before you Mr Chairman, and that they have exchanged views, and in order to shorten the question as best I can, would MR HILL confirm that

he feels that he can neither confirm nor dispute the views which MR SOUTHEARD has put forward about the origin and the development of this fire.

CHAIRMAN: Yes. Mr Hill, would you care to comment on that? I don't know whether you've seen EXHIBIT "N"?

MR CILLIERS: To be fair to MR HILL, and not to ask him a question which may go beyond the province of his detailed knowledge, the conversations which he had with MR SOUTHEARD on an occasion when MR SOUTHEARD put his views to MR HILL, and MR HILL put his views to MR SOUTHEARD, and as I understand from MR SOUTHEARD, the upshot is that MR HILL feels that he can neither confirm nor dispute ...

CHAIRMAN: Mr Cilliers, you're cross-examining MR HILL. Can't you just ask him for advice?

MR CILLIERS: Yes. I just thought it would be shorter because MR SOUTHEARD is going to give evidence to say: Is it correct that he would neither confirm nor dispute MR SOUTHEARD's views, in which case we'll hear MR SOUTHEARD's views.

CHAIRMAN: Have you read EXHIBIT "N", Mr Hill?

MR HILL: Yes, I've read it.

CHAIRMAN: Would you care to comment on it?

MR HILL: All I can say is, repeat the advice I have given to you earlier and the fact that from what I see in the damage in the compartments, it is in my opinion not contradictory to burning packing

material in cargo, doing most of the damage - if not all of the damage I see in that compartment - and I cannot tell whether the ignition source would have been a small spark - matches - on and up to some kind of incendiary device and which would be consistent with what MR SOUTHEARD saw.

CHAIRMAN: Yes.

MR HILL: In fact, it could be.

MR HILL, questioned by MR PUCKRIN:

MR PUCKRIN: Mr Chairman, might I perhaps ask MR HILL to amplify an answer which he gave in answer to a question from yourself, Mr Chairman?

Mr Chairman, you asked MR HILL how he could perhaps explain the phenomenon whereby, because of a pressure differential between the maindeck cargo hold and the cabin, and particularly a lesser pressure in the maindeck cargo hold, smoke could gain ingress into the cabin. And MR HILL did answer you.

Perhaps I can ask MR HILL whether he would agree with my very amateurish quantification of the increase in volume of air in the maindeck cargo hold, and the proposition which I put is the following. That it's a corollary of BOYLE's law, that as a gas' temperature increases so its volume increases. That is a function of temperature absolute and the formulae is that the volume increases by $^{1}/_{273}$rd for every degree Centigrade increase. If one assumes an ambient temperature at 35 000 ft in the maindeck cargo hold of a few degrees Centigrade, and one appreciates that on all the evidence that we have, the gas temperature in the maindeck cargo hold at least near the cockpit voice recorder, was

in the order of say 200°C, the proposition is that there is an increase in volume of about 80%.

CHAIRMAN: Well Mr Hill, would you care to comment on the applicability of BOYLE's law?

MR HILL: Well I would assume that the volume of the aircraft doesn't increase, so I would assume that the pressure would go up. I think that is what we implied earlier that if we get a pressure increase in the compartment, and if that pressure increase was sufficient to overcome the differential pressure, then the airflow would reverse and go into the other part of the cabin.

MR PUCKRIN: Thank you, Mr Chairman.

MR HILL, questioned by MR ANTROBUS:

MR ANTROBUS: Mr Chairman, I think a question also addressed to MR HILL on the similar aspect of thermal expansion.

In the report there is a line under the heading of thermal expansion to the effect that the effect of thermal expansion was apparently not considered.

Now what is FAA's experience with thermal expansion? Is this not something which is commonly considered in the aspect of fire prevention and fire control within the ...

CHAIRMAN: I can't hear you, Mr Antrobus.

MR ANTROBUS: Sorry, Mr Chairman.

Mr Chairman, my question quite simply: Is not the problem of thermal expansion commonly considered by the FAA and by other persons responsible for safety in the aviation industry?

CHAIRMAN: Would you care to comment on that, Mr Hill?

MR HILL: I can't answer for certification. Maybe MR SLIFER can. But in tests where we run large fires, if you have a large fire, we see some thermal expansion. If you have a small fire and you utilise certain systems such as HALON systems, you can negate those systems - that problem.

/There ...

There has been some in-flight evidence that in operating with fires on board aircraft, if you utilise safety systems such as the HALON system in a lower load compartment, that you can control smoke through the normal ventilation system.

The SAUDI L10-11 accident is a very good example where the smoke and fumes were being controlled in flight, very definitely, utilising the aircraft's systems.

But depending on what systems work and what systems don't, when you have a fire it's very difficult to tell what is going to happen. You don't know what you have available for directing smoke in one way or another.

MR ANTROBUS: Thank you, Mr Chairman.

CHAIRMAN: Thank you.

Mr Donner, is there any other aspect on which you think you can help us with advice?

MR DONNER: No, Sir. Not at this time.

CHAIRMAN: Any other questions? Mr van Zyl?

MR VAN ZYL: No, thank you.

CHAIRMAN: Well Mr Donner, to you and your colleagues, our profound thanks. We're greatly indebted to you for your guidance and your assistance.

You represent one of the greatest authorities in the world in this aspect of aviation development, and we welcome your assistance which has been of great value to us.

MR DONNER: Thank you.

CHAIRMAN: Do you want to call any evidence, Mr Puckrin?