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VOLVO

Volvo Aero Corporation

Mr. Thomas R Conroy
Investigator in Charge
Major Investigations Division, (AS-10)
National Transportation Safety Board
490 L'Enfant Plaza East, S.W.
Washington, DC 20594

Your reference	Our reference	Telephone indialling	Date
Your **Letter,** May 6,1997.	9400-0022	[redacted]	05/29/97

Dear Mr. Conroy,

Please find enclosed, by DHL, the proposal of corrections in Mr. B Andersson's testimony at the Public Hearing in Atlanta, March 26 - 28,1997 regarding the Investigation of Pensacola accident, that We Think is necessary for a correct picture of his testimony.
There are some misunderstandings because of use of wrong word in the script.
You will have the whole paper work sent to you by DHL including the original of this letter that will be faxed to you prior to the May 30, 1997.
I do hope this is the correct way to handle it.

Sincerely

[redacted]

Lennart Thoren
Party Spokesman,
Quality Manager
Aero Engines Services Division.

cc: **Mr. B** Andersson, Volvo **Aero** Corporation

BERTIL ANDERSSON, QUALITY MANAGER, DISCS AND MILITARY, VOLVO AERO CORPORATION, TROLLHATTAN, SWEDEN

Whereupon,

BERTIL ANDERSSON,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows:

MR. HAUETER: Mr. Andersson, for the record, could you provide your full name and place of employment?

THE WITNESS: My name is Mr. Bertil Andersson. I work at Volvo Aero Corporation, Trollhattan, Sweden.

MR. HAUETER: And could you provide your background in engineering aviation?

THE WITNESS: My background is Quality Manager for seven years now in manufacturing. And before that, I was Supervisor both manufacturing and quality. I work in Quality Assurance, and I am a Mechanical Engineer.

MR. HAUETER: What year did you get your Mechanical Engineering degree?

THE WITNESS: Excuse me?

MR. HAUETER: What year did you receive your

degree in engineering? What year? How long have you had it?

since 1986

THE WITNESS: Oh, ~~'86.~~

MR. HAUETER: Eighty-six.

THE WITNESS: Yes.

MR. HAUETER: Okay. And Mr. Anderson -- George Anderson will be doing the questions. Thank you, sir.

MR. ANDERSON: Good morning, Mr. Andersson.

THE WITNESS: Good morning, ~~George~~ Mr Anderson

MR. ANDERSON: We want to continue to talk about the manufacturing procedures and controls involved at Volvo. And before we proceed with that, I wanted to ask you several other questions about your background.

The first question was, have you worked for any other company in your career as an engineer, other than Volvo?

THE WITNESS: No, I always worked at Volvo Aero Corporation.

MR. ANDERSON: Okay. And has your employment in the last several years been focused in the area of titanium rotating parts?

THE WITNESS: Yes.

MR. ANDERSON: And could you tell us

basically what the general progression was? In other words, what was your first introduction to the titanium rotating part and how did you progress to your present position?

THE WITNESS: Oh, the first time I worked as an inspector on the titanium part. And then I was involved in the manufacturing of it. And back in late '95, as a Quality Manager for Discs. So that is my area and experiences of titanium parts.-- titanium parts since 1976, sir.

MR. ANDERSON: And part of that experience involves writing procedures for the shop processes. Is that correct?

THE WITNESS: Yes.

MR. ANDERSON: I see. My first question would be to ask you to provide to the Board an overview of the manufacturing process that is involved in the sequence of drilling, boring, and honing the tierod and counter weight holes at the time that the accident hub was produced.

THE WITNESS: Okay. Back in '89, we produced this hub starting by rough drilling operation. Rough drilling is ~~that we -- means~~ that ~~we~~ leave more than .01" one ~~10 mils~~ on the surface for additional ~~remover and fine~~ machining. In the drilling operation, we work

with what we call the cool channel drill. ~~It's~~ right through the hole and ~~overlook~~ the hole, visually.

And after that, we move the part to another machine, doing a fine ~~bolting~~ and a single point ~~bolting~~ operation, doing fine ~~bolting~~ of the holes, and ended up by honing the holes to the ~~finer~~ dimension.

MR. ANDERSON: And could you explain in some detail on the reasoning behind the, first of all, drilling the hole and then following it with the two steps of boring, I believe, you mentioned.

THE WITNESS: Yes. The reason why we were ~~boring~~ a hole is to open up the hole. And ~~that we use [illegible]~~ that time we used ~~cool~~ channel drill, as I said before. And I would go through them on paper here. And we open up 24 hole for the tierod holes and 24 holes for the -- holes by this cool channel drill. And we do that in an NC control machine.

MR. ANDERSON: Would you say again the type of machine, Mr. Andersson?

THE WITNESS: The NC control.

MR. ANDERSON: An NC.

THE WITNESS: Yes.

MR. ANDERSON: Numerically controlled machine. Thank you. Next, I would ask that you give a more detailed physical description -- I'll say that

again. I ask that you give a more detailed physical description of the coolant channel drill, which was the drill in use at the time. And we have two exhibits, 8L and 8M to assist you on the view graph.

(Slide shown.)

THE WITNESS: If you look at the drill up here, it's the standard drill. It's a high-speed standard drill that we use today. Down here is a cool channel with the braced tip, carbide tip on a steel shaft, with two holes up in there, where the coolant is coming down through the drill and feed it out near the cutting edge of the drill. That is for getting the coolants as close to the cutting edge as possible, to reduce the heat of the machining.

And I think you have a slide of the machine.

(Slide shown.)

THE WITNESS: As you see here, this is the head of the machine. The drill is down is held by a fixture and here. The part -- you see the part from the rear. You have the fixture holding here at the table, and this is in a cabinet when the machine is opened up just for taking picture. Here is able to see how the coolant flow down and also the coolant corning down through the drill.

So that's the coolant around the part, When we

drilling it.

MR. ANDERSON: While that is on the screen --

THE WITNESS: I -- you have to speak --

CHAIRMAN GOGLIA: Would you pull the microphone closer?

MR. ANDERSON: While that is the screen, would you discuss the use of coolant on when the coolant channel drill is in use? By that, I mean, was there coolant channel -- or was there coolant flowing through the drill itself and also as indicated in the picture, coolant flowing onto the surface, which is more conventional?

THE WITNESS: Yes, that's correct. I said, through this drill is coming down to the cutting edge. And also we have a lot of -- we don't use ~~organizers~~ in the picture, because you haven't seen anything in the pictures there. But flowing over the part. You see both ~~have two channels~~ down through the drill, ~~the coolant~~, and the flooding all over the part to cool it down. And the purpose with the flood up here is to get rid of the chips coming up from the hole.

MR. ANDERSON: I understand. And the technique used in terms of the speed and feed for this drill and the stroke used -- in other words, was it a continuing drilling process?

THE WITNESS: This was a continued drilling process, yes ~~yeah~~.

MR. ANDERSON: And it was approximate 2.9 to 3 inches depth was the hole?

THE WITNESS: Yes, 3 inches depth. Yes ~~Yeah~~.

MR. ANDERSON: And also the -- if we could go back to the previous slide, could you describe the nature of the tip on the coolant channel drill? Was it different from a conventional drill?

THE WITNESS: This tape is a carnitive drill. tip carbide You look at a ~~tape~~ tip that is ~~braced~~ brazed to the steel -- the steel ~~shelf~~ shaft you have here. You also see that through that drill, the feeding of coolant is coming down there and out of two holes here, close to the cutting edge.

So, that is the design of that drill. And the purpose is to get the coolant down to the cutting area to cool that down.

MR. ANDERSON: Mr. Andersson, in your opinion, at the time this drill was used, what was the reasoning -- the engineering reasoning for selecting it over a conventional what we would perhaps call a high-speed steel drill?

THE WITNESS: We choose to use this drill, because we had a problem at that time with a banana hole or bent hole that was not ~~straight~~ straight. Those drills

would give us a ~~stride~~ straight hole, and we would get rid of problems with activities related to -- we were not able to clean the surface, ~~of~~, but this drill will drill a very straight hole.

MR. ANDERSON: So you're saying that the coolant channel drill was a -- performed better in maintaining drilling tolerances. Is that correct?

THE WITNESS: Yes.

MR. ANDERSON: What was the procedure used at that time to sharpen the drill and also to determine when did the machine operator determine when it was dull?

THE WITNESS: At that time, the procedure was that the operator had to -- after one part, ~~it changed~~ ~~it~~. So 24 holes, then he changed it. The sharpening of the tool was to a drilling of the tool. And the resharpening was made by the ***same*** people, in the resharpening area. And it was a half numerically controlled machine who sharpened it or resharpened the drill at that time.

MR. ANDERSON: And ***so*** the sharpening was accomplished after the drilling of 24 holes?

THE WITNESS: Yes.

MR. ANDERSON: And the -- do you have any estimate of the life of this particular type of drill?

THE WITNESS: No, I don't have that.

MR. ANDERSON: Going back to that period, the coolant channel drill was eventually discontinued for a time and then brought back again. Could you describe some of the issues that were encountered? First of all, were you involved in those changes?

THE WITNESS: No, I was not personally involved in those changes. But the changes was close, because of, when we used the coolant channel drill, in some cases, we have problem with size probably the over ——— of the hole. Look at over size ——— of the hole. So, we went back to the type of high-speed drill that you have on the top of this picture. It's working more strident straighter than the first high-speed drill was that were used back in '84.

MR. ANDERSON: Yes.

THE WITNESS: And it also solved the problem with over size ——— at that time.

MR. ANDERSON: At the time the accident hub was produced, were any records kept of the drill replacements on the machine? In other words, any records of any discrepancies or malfunctioning?

THE WITNESS: Of a tool?

MR. ANDERSON: Of an individual drill? If a drill was not -- in other words, if a drill was not functioning properly, if it did not drill a proper

hole, was this -- records kept of this?

THE WITNESS: The only information we have is from the shop traveler, and the operator will -- if there was some problem with the drill, that drilling process, he would have brought down some information about that, from the shop traveler.

MR. ANDERSON: When the coolant channel drill was discontinued shortly after the 1989 time period, was the process in terms of drilling speed in our revolutions per minute and the advance rate of the drill bit in terms of millimeters per revolution changed or did the rates remain the same?

THE WITNESS: Do you mean from the high speed to the coolant channel drill?

MR. ANDERSON: In comparison. In other words, the coolant channel drill had a set of speeds and feeds, which are published in our report, the Powerplant Chairman's Report. But when that drill was changed back to a high-speed steel drill, were the speeds and/or feeds changed?

THE WITNESS: Oh, yes. We have another speed and feed for the high-speed drill than we have for the coolant channel drill. That's correct.

MR. ANDERSON: Could you explain to us some of the methodology that went into setting those speeds?

THE WITNESS: When we set the speeds, we have a system we're -- we do testing the drill prior to using it in the manufacturing. For instance, the coolant channel drill that we had used back in '89, we test about 700 holes. From those tests, we put together the cutting data related -- the cutting speed and feed based on data from those holes.

So we used the cutting data that is giving us a good hole, a good surface finish, giving us a good proper and assure lifetime enough drilling 24 holes. So that way, we work for putting -- setting our cutting data. And we do that all the time.

MR. ANDERSON: And in establishing these work processes, obviously, this line was set up some time prior to 1981. Do you remember if the drilling processes for the initial manufacturer of the hub were evaluated by Pratt & Whitney?

THE WITNESS: Yes.

MR. ANDERSON: Under their engineering source approval process?

THE WITNESS: Yes.

MR. ANDERSON: Can you tell us what was involved there?

THE WITNESS: Back in '84 when we get the first approval for this part's drilling, we send them pictures, photos -- pictures of the holes, showing what

type of metallurgic structure we have on the surface of the hole. And we also give them all the cutting data, all the operating drawing sheets, and then they approve that process from the results of that.

MR. ANDERSON: At that time, were you aware of the microstructure -- the potential for microstructural damage? That is to say, damage that would occur to the metal, but not leave a visual signature without further testing?

THE WITNESS: No, we weren't aware of that.

DR. LOEB: Before we go further, I just want to follow up on -- I don't know whether you're going to get to it or not. On the tests -- on these 7 or 800 tests that were done, in determining the feed and speeds of the drilling, did you do any -- did Volvo do any inspections, such as either blue etch or sectioning and putting the sections under SEM to look and, in fact, determine what the microstructure looked like during those tests or as a part of those tests?

THE WITNESS: We made some blue etch tests. We didn't make any cut up of the holes.

DR. LOEB: And at any time during these tests with the varying speeds and feeds, did you see any blue etch indications that looked different from the rest of the --

THE WITNESS: No, we didn't see it.

DR. LOEB: So at no time did you see anything that would lead you to the point that you may want to go further and section and look under an SEM?

THE WITNESS: Yes, that's right.

DR. LOEB: All right. Thank you.

MR. ANDERSON: We'll talk just a little bit later about the blue etch inspection under both the engineering source approval and the general quality control oversight system, which is an important part, of course, of the manufacturing process.

But before we get to that, I would like to ask, Mr. Andersson, about the actual training of the operator producing the holes. Could you briefly explain to us the background, first of all, of a machine operator and what they are taught as far as operating the drill and the bore?

THE WITNESS: All our operators back in '89 was trained to what we call the workmanship -- of industrial workmanship. They were trained ~~for~~ by having -- we call it, a the father will that follow of them the first year through the shops and work to[redacted] with them. We also have what we call a driving license, +Zen ~~that we tell them.~~ They have to go through special courses, make some tests, and then they would be

approved to work by their own in the machines.

It normally takes about one, one and a half year at that time. Then they are trained to work by their own. We have also the operation sheet that we're trained to understand [redacted] they were trained also to report everything that was coming up during manufacturing of the operations, even something that was not in non-conformance, but something that they had to remark on.

MR. ANDERSON: When the operator would see an error or felt that an error had been made, what was the procedure for him to bring it to the attention of either a foreman or a technical -- something with more technical oversight?

THE WITNESS: Yes. As soon as he was aware that there was something in non-conformance or he had something abnormal coming up in his operation, he had to stop that operation, and he had to contact the manufacturing engineer who is responsible, for that part. And the manufacturing engineer would get together with the quality people in that shop. Go through the part and look at the part. Ask the operator what happened. Ask him to describe it. Ask him to describe the abnormality or the non-conformance in his way. And then they were able to make a decision if there is a

non-conformance.

If there is a non-conformance, we have to put it in the MRB system together with Pratt & Whitney. Pratt & Whitney would have to review and give us approval for that before we move the part forward in production.

MR. ANDERSON: I see. Before we go to the inspection, the operator took care of changing their own equipment on the machines. In other words, the machines were set up by the operator?

THE WITNESS: Yes, that's correct.

MR. ANDERSON: And at this time, was your quality system certified under ISO-9001?

THE WITNESS: No, we were certified back in 27 of December 1995.

MR. ANDERSON: At what point in time, approximately, did that process change begin? When did you start --

THE WITNESS: We changed our quality system, you mean?

MR. ANDERSON: Yes.

THE WITNESS: We changed the quality system back in 1992.

MR. ANDERSON: Okay, 1992. I would like to call your attention, please, to Exhibit 8B-1.

THE WITNESS: You said 8 --

MR. ANDERSON: Eight-B-1 and the title is Volvo Hub Front Drill Process History.

THE WITNESS: Yes.

MR. ANDERSON: On the first page of this, we have a -- essentially an instruction drawing. Could you explain to the Board basically the key or the outstanding features of the hole, such as how it is located, the surface finish required on this drawing, and any other features that contribute to describing the hole?

THE WITNESS: Okay. On the section ~~page H~~ H-H to the left of the drawing, you have the dimension of 23 holes, who would be the tierod holes. Then you also ~~show -- and that is~~ see 1 hole that is the location hole. the top of it -- the true position at ~~that time~~ for the holes at is .4 millimeter. And that's equal split 24 holes. We drill that hole to 12.2 millimeter, and they have ~~total runs~~ a tolerance of +.3 mm for plus three tenths of a millimeter.

If you look at the bottom of the section, HH, you see one hole of those 24 which would be single point boring up to another dimension that is for the location through the continuous processing of the part.

You also see a small ~~--~~ section in the middle of the drawing, you will see a small picture showing a hole

with diameter 11.0 plus five tenths of a related tolerance. Those are the holes called the tierod holes.

The surface finish call out in the bottom of the drawing, in the middle, and says 1.6 Ra ~~array~~, as we have in Europe. That is your 63AA ~~6300~~. You will also see that we have operation drawing number, the issue number in the bottom left is ~~was~~ important. We also on the top of it have the type of machine, the material we use. So they are aware of what type of material they're working.

As you also can see, we have stamps on the drawings showing that this is titanium part, we handle in a special way. All the parts and all the operation performed on the part is stamped critical.

MR. ANDERSON: Very good. On page 2 -- actually, it is sheet ref 4 ~~404~~. That would be the second page of the exhibit. We have -- just show the or describe the purpose of that sheet as an operation sequence?

THE WITNESS: Yes. This is to give the information to the operator, which tool he will use. It says he should ~~could~~ use it. He will use a center drill with a special number on it. And then you have the drills, the bore, mill cuts ~~tabs~~, and a column ~~difference~~ with all

the drilling number on the drill and the number of the -- the part number of the drill, I would say.

MR. ANDERSON: And finally, the addendum 1 or page 3 to the exhibit, would you explain the content of this chart and explain, perhaps, since the coolant channel used in the beginning of 1988, some of the other drill events here?

THE WITNESS: First, we started in '84. We have a high-speed standard drill. And you were able to see the speed on the meter. And back in the beginning of '88, we changed it to the coolant channel. And in 1990, we changed to another cool channel drill, called the Sandvik Delta drill, who is the supplier's name of the drill.

We also changed the speed at that time and the feed for the coolant drill type. We went back in September 1990 to high-speed drill. I will go back to the point three there in exhibit. We use the Sandvik Delta drill in two directions.

MR. ANDERSON: Would you explain --

THE WITNESS: That means that we drill half of the hole in one direction. Turn the part around in the machine and drill from the other direction, to reduce the problem with the oversize and to reduce the problem if the hole was bent away.

MR. ANDERSON: So it was not a problem --

THE WITNESS: So the hole was not ***so*** deep when we drill them that way.

MR. ANDERSON: I understand. Could you discuss the variations in speed? We see initially using what would be a baseline of a high-speed steel drill --

THE WITNESS: Yes.

MR. ANDERSON: -- starting in 1984, speeds of 300 rpm. And we see the speeds increasing, which would lead us to believe that perhaps the newer drills would cut faster and that might have been the reason for their introduction.

THE WITNESS: Well, the reason why we increase the speed here is that the coolant channel drill of the carbide drill is working with high speed. ~~That~~ This was coming out from the -- to get the most sufficient cutting data out from it and get the most -- because we want -- we will not have a too dull drill after 24 holes, because they we have to ~~scrap~~ the drill instead of resharpening. So, we will have the drill as good as possible through all the 24 holes. And that's the reason why we try to put the right cutting data in, and the hole -- ~~the~~ carbide data is used at a higher rate of cutting speed.

MR. ANDERSON: That as we're talking about increasing the cutting speeds, the -- perhaps the reason for the carbide being more effective, to higher speeds is that it is more resistent to heat buildup.

THE WITNESS: Yes.

MR. ANDERSON: And so would it be fair to characterize the amount of heat buildup in the coolant channel drill is higher than perhaps the standard high-speed steel drill?

THE WITNESS: No, because we -- at that time, we were able to -- using the high speed, the chips moved away faster from the area.

MR. ANDERSON: I see.

THE WITNESS: That means that you will have the area as cool as possible. If you decrease the speed by using carbide, it will heat up the area. So, it's necessary to have this higher level of speed to get rid of the heat in the area. The heat is going away from the cutting edge by the chips.

MR. ANDERSON: So as long as the chips are moving along, the temperature should remain the same.

THE WITNESS: Yes.

MR. ANDERSON: I understand.

THE WITNESS: And also at the time we feed the coolant down to the cutting edge.

MR. **ANDERSON:** Could you describe the malfunctions as far as chip clearance? In some cases, what is known as pecking was used where the drill would be withdrawn every *so* many millimeters during the drilling process. And I understand in some of the uses of the coolant channel, the plunge technique was used, where the drill was advanced continuously through the material until the hole was through the metal.

THE WITNESS: When we use the high-speed steel drill, we flood the coolant over the part. We're not able to flood it down to the ~~coolant~~ cutting edge -- ~~cutting edge~~. That means that we had to retract the drill each 5 millimeter, and that is in the machine's computer control system and the machine's doing that.

When we **use** the coolant channel drill, the flooding, the coolant coming down and coming out from near the cutting edge. And we will flood these chips out from the cutting edge, together with the coolant coming out there. So we don't need to have that retraction for the reason when using the coolant channel drill. Do **you** understand?

MR. ANDERSON: Yes.

THE WITNESS: Okay.

MR. ANDERSON: Yes.

THE WITNESS: Thank you.

MR. ANDERSON: The coolant channel drill has essentially got a dual stream, is what you're saying. The coolant flowing down through the two holes in the drill and also the conventional pattern of spray on the top of the part. Is that correct?

THE WITNESS: Yeah.

MR. ANDERSON: I would like to change to a different area, still related to the manufacturing process, dealing with the inspection systems, which, of course, are at least several significant inspection processes involved with inspecting the holes, both during the time that they're manufactured and after the part is ready to be shipped from Volvo.

Could you give an overview of the inspection system, starting at the manufacturing point? In other words, what processes are involved?

THE WITNESS: I think you have an exhibit showing our quality system down there. This is a way that our system controls the part today. We have the requirements coming down this way from the company management, customer, authorities, coming through the quality system. And we have that through the --agreement assigned, purchasing, manufacturing and shipping of the part, which means that control by the contract, specifications. drawings, purchase orders, operations -- and release of

the documentation. This is a very general picture of the system.

Then I will --

DR. LOEB: Could you identify for the record this Exhibit Number, please?

MR. ANDERSON: It's 8N, 8-November. And he will be talking about 8N through Q.

THE WITNESS: And then I -- 8Q, please?

(Slide shown.)

THE WITNESS: If you look at that picture over here, you see --'f will also tell you the system that we changed back in '92, the system prior to that is very equal. The only thing is that they have changed the name of some of the manual. We have in more detail explained the responsibilities for some of the operators and for the management also.

So, I just use that first picture showing the system. If we look at how we control the part when -- we look at the purchase order. We have the business contract between Pratt & Whitney and Volvo. The business contract is like an umbrella over all purchase orders. But in the purchase order, we have part and system requirements.

We also have requirements for -- operation of authorities coming to us, because the requirements from

FAA are coming through Pratt & Whitney to Volvo. We have what we call our system that I showed earlier, who handles the raw material, semi-finished part, unfinished part. Also gives us strict guidelines and requirements for personnel involved in everything, how they should work and what they should do in each step.

MR. ANDERSON: Okay. So, the -- you've shown the outline of the flow of communication. Could you talk a little more about the flow of communication between Volvo and Pratt & Whitney as far as the documents that would be in use? By that, I mean, what quality systems?

THE WITNESS: Okay. Up here, basically, we have requirements pointed out in the QA 6076 and then a lot of other requirements coming down the same way. The raw material for rotating parts is released to Volvo by the MCL at Pratt & Whitney. So, we buy the raw material from an approved supplier, approved by Pratt & Whitney.

We machine the part to the requirements that's coming down this way. And that means that we have all this in our system and we have the system basically from this QA 6076. And for this part, we also have the ESA system working or from the 370. This means that we have to have Pratt & Whitney to approve all the processes and

the whole process of the manufacturing from that we start the first operation until we ship the part. They approve everything for what we're doing with the part, our manufacturing and sheet inspection plans.

MR. ANDERSON: Yes. I think we can remove that slide now. What I would like to do with that as an overview is to talk, Mr. Andersson, about the individual inspection criteria for this hole, because that is really where the difficulties in this particular accident occurred. The first exhibit is 11-C for you, which is the Pratt & Whitney VIS standard or visual inspection standard.

The first thing I would like to ask you to explain is basically how an inspector conducting a visual inspection of the hole during the initial stages of inspection would -- what he would look -- he or she would look for in deciding whether that hole met the visual standards of this specification.

THE WITNESS: She or he would look for a certain finish. He would look at the VIS and he would look or she would look for different type of damage to surface, i.e. the -- scratch from the gaging tools. And you have the requirements in the 61 -- chapter 6.1 general limits. There's at VIS- least 454.

This was released later than '89, but they

are similar to the prior one. It was 277

MR. ANDERSON: Yes. If we turn to page 2 of 13, we have a series of definitions, which are, of course, extremely important in communicating within the quality and inspection system, the nature of a defect. Could you go down and talk about the ones that seemed -- we will later see, seemed to be associated with the accident disc. I would suggest that burnish marks, chatter marks, and perhaps pickup would be worth commenting on.

THE WITNESS: What we are looking at in the inspection is chatter marks and tool marks, from the inspection, bad portion from the shop traveler. The chatter marks is closest spaced to marks caused by the vibration of the cutting tool, deviation of that. The tool mark is deviation from normal surface plan, usually appearing as an undercut. Also defined as a deviated tool line. That is the definition of this tool.

MR. ANDERSON: Yes. And I guess a more specific question would be how would the inspector distinguish between a chatter mark and just a scratch?

THE WITNESS: The chatter mark is vibration over a its a pattern over the surface. It looks down on the surface. And it looks like a surface on an

orange when you look at it.

MR. ANDERSON: Okay. Having reviewed these -- and I might just add also, bring your attention to the superficial imperfection, which is an imperfection which disrupts the surface and appears smooth edged, but does not penetrate the surface roughture -- or excuse me, surface roughness texture. Taking these into consideration, how would you relate them to the condition described on the accident hole? Would any of these apply?

THE WITNESS: You mean if any one of these would fit into the accident hub?

MR. ANDERSON: Yes.

THE WITNESS: No, I don't think so.

MR. ANDERSON: Then what you're saying that probably none of these would apply to the origin sites pointed out on what was later seen in this section --

THE WITNESS: Yes.

MR. ANDERSON: -- after the accident?

THE WITNESS: In a visual inspection, you would not.

MR. ANDERSON: These would not occur?

THE WITNESS: No.

MR. ANDERSON: Mr. Andersson, moving to page 3, please, we are still, of course, talking about

inspecting holes. And would you enlighten us as to the nature of a water discoloration, which is described here as light grey or light brown in color, what would be the nature of that kind of discoloration and titanium?

THE WITNESS: You have to explain that question.

MR. ANDERSON: Yes. On page three in the column --

THE WITNESS: Yes, I follow that, but, - you have to explain that question.

MR. ANDERSON: Okay. When there is described an acceptable imperfection, one of those acceptable imperfections is called or described as a water discoloration, light grey or light brown in color.

THE WITNESS: Yes.

MR. ANDERSON: What is the likely cause of that type of a discoloration in your experience?

THE WITNESS: It can come from the cleaning, and process it self from the ~~person~~ -- for instance, from the coolant used.

MR. ANDERSON: Moving ahead, the page 9 of the Pratt & Whitney VIS 454 standard. We have a list of limitations and acceptable limits. We have on the fourth row down, the description nicks, dents, scratches, and tool marks. Could you read the acceptable limits, please?

THE WITNESS: The acceptable limits would provide, a substance -- so it's not to irritate the surface.

MR. ANDERSON: Is this the method by which Volvo inspectors measured the surface finish of these holes?

THE WITNESS: It's not -- we are not able to use it down in the holes, because the stilus is not designed that way. We use a comparison and look down the hole, just at the finish. If we have any problem, we use a surface finish machine, the surface.

MR. ANDERSON: So would you -- what would be the frequency of doing a special inspection on surface finish?

THE WITNESS: If you have any marks, if you look at the surface and see that it's something , because we are looking at a very smooth surface on the holes. Like a mirror, to a mirror. So anything that is coming up from the surface showing a normal surface , it would be handled -- try to the surface or look at for comparison.

MR. ANDERSON: Would the -- what process would be to follow to repair a failure of the surface

finish of this hole?

THE WITNESS: We have possibility to go back and do some what we call polishing in planning the hole, and see if that would be removed, the scratch from the mark in the hole.

MR. ANDERSON: And we will look at the manufacturing records in a minute, but would -- what would be the record in Volvo's manufacturing process of blending or --

THE WITNESS: It would be in -- you would find an extra operation, put it in for that blending, if there would be something like that.

MR. ANDERSON: So that if the manufacturing record did not have a record of any blending repairs, would it be safe to say that the hole was drilled without any imperfections --

THE WITNESS: Yes.

MR. ANDERSON: -- that would fail VIS?

THE WITNESS: Yes. For the VIS, yes.

MR. ANDERSON: Okay. You can put the VIS 454 back in the pile. And I would like to turn next to the fluorescent penetrant inspection as used at Volvo on the hub. This would be Exhibit 11-Echo, E.

THE WITNESS: Exhibit L-11?

MR. ANDERSON: E as in echo. Mr. Andersson,

have you got 11-E?

THE WITNESS: Yes.

MR. ANDERSON: I believe this is a familiar document.

THE WITNESS: It is.

MR. ANDERSON: Could you describe the nature of this document for the Board?

THE WITNESS: If you look at the Exhibits 11, you will first find an operations list. With that list that we get the signature from, approved by Pratt & Whitney, all the change showing that this had been approved. It's using a rough information about -- or like I say, a brief information about the way we're machining the part.

And the first four pages showing when we do assembly of some of the hubs, the hubs that we will ship out as directly to the assembly line of Pratt & Whitney. Otherwise, we use just the second operation sequence list we're doing an assembly of, for spare parts, for instance.

MR. ANDERSON: I understand. Could you turn so we have a record here of the -- of essentially a batch of hubs that included the accident hub. Is that correct?

THE WITNESS: Yes.

MR. ANDERSON: And so if we are to know what happened to the hub during manufacture, we would look at this record, would we not?

THE WITNESS: Yes. On the first -- okay --

MR. ANDERSON: Is that correct?

THE WITNESS: Yes.

MR. ANDERSON: So, if we could turn to page 12 of the Exhibit, please. And I would like to ask you about several items on this page, but for the benefit of the people who are not familiar with the codes, perhaps I would ask you to describe what's going on here, but essentially, as we read down this list, we have several write-ups, one of which deals with another hub. That comment and 1'11 quote is, "Tool mark on bolt face due to wrong tooling. Applies to serial number 32977." That is not the accident hub.

THE WITNESS: Yeah.

MR. ANDERSON: Can you tell who made that -- tell us, who made that remark and --

THE WITNESS: That is a remark from one operator to another. It was on line that they had to observe that from this rough machining.

MR. ANDERSON: And does this constitute a failure of an inspection under VIS 454 or is it simply a remark?

THE WITNESS: It's simply a remark.

MR. ANDERSON: In other words, the process is finished or is not yet finished and ready for inspection?

THE WITNESS: It's not yet finished. It's semi-finished.

MR. ANDERSON: It is not yet finished.

THE WITNESS: Yes.

MR. ANDERSON: Moving ahead, can you read the one that refers to the accident hub, R32971, please?

THE WITNESS: Yes. We have this -- as you call a code is 110. It's means that you have to -- it's in the operation 110 that the remarks ~~remote~~ is coming from. The two holes, then you have the diameasure, says that it fits oversize. It also says that it has some chatter marks in the two holes. Applies to serial number RV2971. That is also remark made from the operation to an operator further down the line. It's not a finished surface at that time.

MR. ANDERSON: So, if I understand you correctly, Mr. Andersson, the person making this remark was the operator of the drill?

THE WITNESS: Yes.

MR. ANDERSON: And he was --

THE WITNESS: That's a person -- it was an

operator for the fine boring.

MR. ANDERSON: For the fine boring.

THE WITNESS: Yes.

MR. ANDERSON: Okay. So that he was communicating with who?

THE WITNESS: With the honing -- operating the honing operation.

MR. ANDERSON: Okay. And what would have been the disposition? How would this have worked out?

THE WITNESS: Because it's -- because this is not a finished hole, the disposition is going to be made on the finished hole, after the honing operation.

MR. ANDERSON: So that because there appears to be no further remarks dealing with chatter marks, that they were cleared during the honing?

THE WITNESS: Yes.

MR. ANDERSON: And *so*, therefore, we could conclude because of the nature of honing, that these marks were not very deep?

THE WITNESS: No, that's correct.

MR. ANDERSON: Would that be a correct assumption?

THE WITNESS: Yes.

MR. ANDERSON: I believe I would like to return the witness to the Chair.

DR. LOEB: Excuse me, I would like to just clarify an issue. Is it then your understanding, Mr. Andersson, that the honing process removed the chatter marks?

THE WITNESS: Yeah. The chatter mark we are talking about is very, very slight to the surface. It's just something that you see, because the surface -- so, you have a fine surface finish in the fine boring. So you are able to see very small variations of chatter structure that would be removed by the honing.

DR. LOEB: The chatter marks if they were still there, if there was still a notation that chatter marks, after the honing, then this would not be acceptable. Is that correct?

THE WITNESS: That's correct.

DR. LOEB: And, particularly, in the hole, in the bore --

THE WITNESS: Yes, that's correct. Just look at the hole.

DR. LOEB: Okay. So, that the assumption is that the honing removed the chatter marks.

THE WITNESS: Yes.

DR. LOEB: But there is no indication -- positive indication on this form that that's the case.

There is -- we're going by the absence of any further mention on the form that we're assuming that the -- that the honing removed the chatter marks.

THE WITNESS: Well, if you don't see any in the fine inspection, the visual inspection, and if they're not, the operator in the honing operation has not signed up and make any remarks of chatter marks, there was no chatter marks of the honing operation.

DR. LOEB: Do you think it would improve the system somewhat if it was a requirement to actually address something in a more positive fashion? In other words, stating chatter marks removed or not found after honing?

THE WITNESS: We have changed the system after this accident. So that today, we do that, because we need -- we have a feeling that we have to have the person's signature, who verified that everything has been taken care of in the proper way.

DR. LOEB: Thank you.

THE WITNESS: Yes.

MR. ANDERSON: At this time, I would like to turn the questioning back to the Chair, Mr. Goglia, for perhaps a break.

CHAIRMAN GOGLIA: At this time, I would like to take a break and 15 minutes.

(Whereupon, a short recess was taken.)

CHAIRMAN GOGLIA: On the record. Can everybody take their seats and we can reconvene?

(Pause.)

CHAIRMAN GOGLIA: The questioning of Mr. Andersson will continue.

MR. ANDERSON: Mr. Andersson, can you hear me? We're having a little trouble --

THE WITNESS: Oh, yes.

MR. ANDERSON: -- adjusting the gain on the microphone. Is that satisfactory?

THE WITNESS: Yes. Thank you.

MR. ANDERSON: We were talking about Exhibit 11-E. The title of that exhibit is the English Translation of Volvo's Manufacturing Records on Hub, Serial Number 32971. We had begun to explain. We had asked Mr. Andersson to explain the meaning of several remarks made in what a part of this document that is referred to sometimes as a shop traveler here in the United States. The meaning of that is generally that this document travels with the part and it serves as an in-process record of things that are done to that part, inspections that are performed on that part, during the intermediate steps and the manufacturing process.

Is this a correct characterization --

THE WITNESS: Yes, it is.

MR. ANDERSON: -- of this document?

THE WITNESS: Yes.

MR. ANDERSON: So we were --

THE WITNESS: It also gives you information about what type of machines -- and drawings also. It gives the requirements of the operation step.

MR. ANDERSON: Yes. Your comment is that in addition to those items, the processes are described, each step of the process. So, when a code is given on a page, one can go to a previous listing of those processes, such as step 110 is boring, I believe.

THE WITNESS: Yes.

MR. ANDERSON: The boring of the hole, which follows drillings.

THE WITNESS: Yes.

MR. ANDERSON: And these are important distinctions, because we're going to be talking about remarks are made at an intermediate point. And we will eventually get to the end of the process where the issue of inspection sign offs would be appropriate to describe.

We were on page 12 of the exhibit.

THE WITNESS: Yes.

MR. ANDERSON: And we had talked about the

chatter marks. Did you have any more comments on that particular write-up?

THE WITNESS: No.

MR. ANDERSON: Do you know, is there any way for you, as being familiar with these forms, to know who made this write-up?

THE WITNESS: The write-up from the operation 110 was made by the operator who performed that operation.

MR. ANDERSON: And how would we know who that person was at this point?

THE WITNESS: On the page 10, if you look at operations 110, you will see that the operations has this employee number and the signature who performed that operation to the right.

MR. ANDERSON: And can we determine who that is by a number or by the --

THE WITNESS: By a number.

MR. ANDERSON: -- initials?

THE WITNESS: By the number, employee number.

MR. ANDERSON: Okay. Could you please read this comment into the record, Mr. Anderson, the comment after the 110 inspector's remark? On page 12, I'm sorry.

THE WITNESS: It says that it's two holes,

the dimension 12.117 millimeters plus 0.035 and one hole .13, .095 is plus 0.08. One of the dimensions, the first 12.117 is for a carbide hole. And the second one is for one of the tierod holes.

It also said below that, some chatter marks in the two holes applies to serial number R32971. Some chatter marks -- very small chatter marks.

MR. ANDERSON: And even though it is not written, we can correctly state that the dimensions are given in millimeters?

THE WITNESS: Yes.

MR. ANDERSON: Thank you. If we could turn, please, to page 28. You're on page 28?

THE WITNESS: Yes.

MR. ANDERSON: We have another remark, this one being of more direct interest. Certainly, has been seen by a number of people with the investigation. Could you interpret -- give us your interpretation from the Swedish code 50 there.

THE WITNESS: Okay. First, what we're looking at is page 28. It's an inspection record. The remarks in code 50, remarks related to VIS observation. It's not related to BEA process. And he has made a remark that on serial number R32971, is machining marks in hole diameter 13.145, located 180 degree from serial

number marking. He also, to the right, has put out that this remark was noted down to the -- in the traveler or on the traveler, with address to the inspection department 473, who is the final VIS inspection department, because this was not reason for rejection due to standards in the BEA. So you have to -- to cause them to make a decision if it was approved or not -- acceptable or not. I would use that word.

MR. ANDERSON: Yes. So, if I understand correctly, the person making this comment on this document was the blue etch inspector.

THE WITNESS: Yes, that's correct.

MR. ANDERSON: But that blue etch inspector was not recording the results of his blue etch inspection? This is not --

THE WITNESS: No, this is not a blue etch indication. No, that's true. That is an observation he made on the surface.

MR. ANDERSON: So, the blue etch inspector was merely making an observation to perhaps VIS 454?

THE WITNESS: Yes.

MR. ANDERSON: And so his comment was to the person who is responsible for conducting the visual inspection, which is department, what, 454?

THE WITNESS: Four seven three, yeah.

MR. ANDERSON: Four seven three.

THE WITNESS: At that time.

MR. ANDERSON: And it was whose responsibility to conduct a visual inspection of this finding?

THE WITNESS: That was the visual inspector. He had to look at the hole at that time, look at if there was any surface finish texture, damage to the texture of the surface, and make a decision that was acceptable or not. And his decision, we will discuss it later.

MR. ANDERSON: And he would have used the criteria that we had discussed previous in VIS 454. Is that correct?

THE WITNESS: Yes, that's correct.

MR. ANDERSON: Were there any other inspection criteria that would be used in conjunction with this remark?

THE WITNESS: Not for the inspection, no.

MR. ANDERSON: Would FPI have been an issue here?

THE WITNESS: No, because this doesn't -- didn't anything in the FPI.

MR. ANDERSON: I understand. Can you take us

to the sign off of the inspector -- of the visual inspector and show us where that is in the record?

THE WITNESS: Yes. If you look at page 19.

MR. ANDERSON: Nineteen.

THE WITNESS: Yes.

MR. ANDERSON: And on page 19 that is code 230, which --

THE WITNESS: The code, yes, 230 is operations. It's a number for the inspection.

MR. ANDERSON: And can you tell me which inspection is it? Is this the last visual inspection or is it second to last?

THE WITNESS: Of the hole, it's the last one.

MR. ANDERSON: It is the last visual inspection?

THE WITNESS: Yes.

MR. ANDERSON: And can you show how this form of this write up or sign off occurred here?

THE WITNESS: On the code 21, which is the second code on this inspection record --

MR. ANDERSON: Yes.

THE WITNESS: -- you would find that he has signed off by a dash, I would call it. That's -- the remarks from the early operation had been taken care of and fall within the -- meeting all the requirements

that is on the part. Or their remarks prior to this operation has been removed by later operations between this remarks and the fine inspection.

As in this case, the chatter marks removed by the honing.

MR. ANDERSON: Yes.

THE WITNESS: You also have on page 26 --

MR. ANDERSON: Okay. I'm on page 26.

THE WITNESS: Twenty-six, you have it?

MR. ANDERSON: Yes.

THE WITNESS: Okay. As *you* can see, the code 1991 is the VIS inspection. The first code there indicates that the operator should look at all the surface on the part, including your holes. And if there was any remarks, it should be written down there. So it's shown that it's no remarks related to the VIS inspection, to the surface finish of the part.

MR. ANDERSON: So that the final inspector's stamp that we would expect to see would then have been carried forward to another page? Is there one more step in the sign-off process from page 26?

THE WITNESS: In that operation?

MR. ANDERSON: yes.

THE WITNESS: No. The only sign you would see is on the traveler for the --

MR. ANDERSON: Okay.

THE WITNESS: -- for that operation. You will see his sign off and approve that.

MR. ANDERSON: But we see other sign offs on earlier documents, such as page 10, where we have each operation signed off. And we go to page 230 -- I'm sorry, operation 230 -- this was operation 230.

THE WITNESS: Two thirty, yes.

MR. ANDERSON: Yes. And we see an inspector's stamp after that line. Would that constitute his approval and signify that this part had passed his inspection?

THE WITNESS: Yes.

MR. ANDERSON: And, therefore, it -- he is saying that this part met all the standards --

THE WITNESS: At that time, yes.

MR. ANDERSON: -- at that time in VIS 454?

THE WITNESS: Yes. I will correct *you* there, because at that time, it was 217 used, but this is a similar one and older one than of 454.

MR. ANDERSON: Okay. The VIS --

THE WITNESS: Seven, seven.

MR. ANDERSON: -- 77, Pratt & Whitney VIS standard.

THE WITNESS: Yes. It was working -- was in

'89, but they are equal.

MR. ANDERSON: Do you remember approximately when the standards changed?

THE WITNESS: Nineteen ninety.

MR. ANDERSON: Nineteen ninety. So, shortly after --

THE WITNESS: Yes.

MR. ANDERSON: -- the accident hub was produced. Do you remember the significant -- any significant changes between the two documents --

THE WITNESS: No.

MR. ANDERSON: -- that relate to holes?

THE WITNESS: No.

MR. ANDERSON: Page 27 --

CHAIRMAN GOGLIA: George, before you change, I have one question for Mr. Andersson, and it's on page 26. When you're referring to this inspection that was performed on the entire part and there's no comments, I'm familiar with some work that was done here in the United States to determine the probability of detection, POD, for persons performing visual inspections. And I will ask the FAA for the exact numbers of this later. But I believe here in the United States, there's an 80 percent probability of detection. Has Volvo or are *you* aware of any work,

similar work that would determine what the likely probability of detection would be for this inspector performing this task?

THE WITNESS: Volvo has by ourselves make tests of visual inspection. And I have been involved in that. And we say that something close to 90, 94 percent.

CHAIRMAN GOGLIA: Okay. Thank you.

THE WITNESS: That was back in late '70s, we made that test.

MR. ANDERSON: Page 27.

THE WITNESS: Yes.

MR. ANDERSON: On line 79, we have an English translation, but I would ask you to retranslate, again, the item or the write up there or the comment, please?

THE WITNESS: Once again, then, this is not a -- the notice is not related to the FPI. This is not an FPI indication that's filled out here. The inspector who is a her, she noted down that in one of the holes has what you call -- what she called a hole in the radius -- on this part, R32971. That is also something -- a note which she passed to the final inspector who is in the same area.

MR. ANDERSON: And can you read, for the record, what it said?

THE WITNESS: It said that hole in the red is a one-piece one hole. She's showed a very brief explanation of the -- she saw something abnormal in one of the radius. She looked like it at hole -- not an FPI indication. A very small hole then.

MR. ANDERSON: So, it would be a surface imperfection?

THE WITNESS: Yeah.

MR. ANDERSON: And the method of describing it as in the radius, could you explain further the meaning of that?

THE WITNESS: That means that is not in the hole itself under H of the hole to the surface.

MR. ANDERSON: I see. So, in other words, if that were an edge, described as an edge of the hole, this imperfection was along that edge?

THE WITNESS: Yes. And we do not really know if it is related to these holes, because there are several holes on this hub.

MR. ANDERSON: Yes. There was --

THE WITNESS: She is not pointing out any of the tierod or the ~~carbide~~ counterweight holes here.

MR. ANDERSON: I would like to ask a question at this point of this process. Is it normal for the people making these notations during manufacture not to

specifically locate the hole?

THE WITNESS: At that time, I would say that this is where normal notes made by the inspector -- as a note if they have been related to the FPI. So, ~~it~~ if was an indication from the FPI, which we wrote in a complete -- it would be explained and probably it would have a map showing where ~~of~~ on the part -- in which area of the part the FPI indication had been shown up. But just the remark would be like this.

MR. ANDERSON: So, in general, in summing up, in discussing all these remarks -- these three remarks that we've looked at, would they be characterized as remarks to aid the inspection process as opposed to observations by the individual inspectors?

THE WITNESS: Yes, to making them observe and being more observant, look at those certain areas.

MR. ANDERSON: In other words, if these remarks were not present, the inspection process would work correctly without them?

THE WITNESS: Yes.

MR. ANDERSON: Is that a correct statement?

THE WITNESS: Yes.

MR. ANDERSON: I would like to turn --

DR. LOEB: George, excuse me, I would like to just clarify, because I'm not certain I understand.

The remarks were made for whom to take a further look to make --

THE WITNESS: For the final inspection.

DR. LOEB: For the final inspection.

THE WITNESS: Yes, because the people in the FPI or the people in the blue etch is not -- has not the criteria for the VIS requirements. They have the criteria for FPI or BEA process.

DR. LOEB: Now, how do we know that, in fact, the final inspector looked at these particular indications and ruled them out for himself?

THE WITNESS: Because we have a code, as I told you, a code 21 will take care of that. And when he marked that code out, he said he had taken care of all the remarks on the ~~sheek~~ shop traveler and prior inspection records, because those was part of the report to the inspector, final inspection area.

DR. LOEB: We just have to assume, though, that those particular remarks were, in fact, noticed and addressed, because we don't have anything that is specific to them noted by the final inspector. Just that this -- is that correct or am I incorrect?

THE WITNESS: I would say that those are very specific noted to the final inspection, because you would find a sign on the traveler -- for operation 230

to be of service on notes early in the production. If you look at the ship traveler, page 10, you will across, behind the words "KON" on the operation 230, that's to indicate that he has to take care of notes made prior to that to different operations observations -- operator's observations.

DR. LOEB: Okay. All right. Thank you.

THE WITNESS: Okay.

MR. ANDERSON: I'd like to turn -- just before we leave this subject, I would like to say again that a visual inspector performing the final visual inspection on this part would have a set of instructions. Is that correct?

THE WITNESS: Yeah.

MR. ANDERSON: And would it be fair to say that those instructions would include the direction to inspect each hole?

THE WITNESS: Yes. It includes to inspect each hole.

MR. ANDERSON: Yes. So that if no hint, if you will, were given as to where possible damage might be, the inspector would still inspect each area of the hub?

THE WITNESS: Yes.

MR. ANDERSON: I'm sorry, I'm using the term

disc, but hub is more correct.

THE WITNESS: That's correct.

MR. ANDERSON: I would like to turn --

CHAIRMAN GOGLIA: Before we escape that, are there any inspection aids used at this time, such as a baroscope or something to allow a visual inspection inside a deep hole?

THE WITNESS: Not -- we don't use baroscope for those holes, no. We use mirrors. We use the stylus. It's possible to use comparisons for surface finish and we use different live sources that is supposed to --

CHAIRMAN GOGLIA: Okay.

THE WITNESS: The problem is when you use a baroscope in this hole, you could be -- ~~bare~~ make damage to the surface finish and you also would be fooled by looking down in the mirror. And the angle and the light would be coming down in the wrong way to the surface and hit it, and when you look back, as I told you earlier, it's like a mirror down there, because of the surface finish. So, it really don't help you. It could really fool you to make mistakes to use a baroscope down there.

CHAIRMAN GOGLIA: Thank you.

MR. ANDERSON: I would like to turn to the

third of inspection that the hub receives, which is the blue etch anodizer or BEA process. Could you, so to speak, describe the general BEA process for those who are not familiar with it?

THE WITNESS: The BEA process was developed back in the 1970s by Pratt & Whitney. And the purpose is to detect the different type of structure damage to material IC forge laps, grain segregation. The process was developed for controlling of the variation prior to the manufacturing ~~for~~ of the forging -- in that process. The process is not developed for looking at damage that could be caused by a manufacturing in the beginning.

Since that, they have been developing the process. So, they are looking for other things today, but in the beginning, the process was developed for looking for variation from the forging -- on the forgings.

MR. ANDERSON: Yes, could you -- we understand the purpose.

THE WITNESS: Yes.

MR. ANDERSON: Could you describe the physical nature of this process? In other words, basically without naming every step, just how one goes about applying this blue etch anodize and what it looks like roughly when you are ready to inspect. What does

the inspector see?

THE WITNESS: Okay. The blue etch anodizer is first you clean the part and then you anodize the part and it will go dark blue -- and the inspection, look at the part at that time and see that it's -- the whole part is dark blue. And then they do stripping in the process step. And after that, you're looking at the surfaces, looking like slightly grey, some color to the blue, and from that, you will find variation from white to dark blue in the surface, if there is any abnormalities.

MR. ANDERSON: So, if I could characterize again, that the test that the inspector is performing is on a surface which has been anodized and that that anodized, based on the condition of the material or the titanium beneath it, gives different patterns?

THE WITNESS: Yes, that's correct.

MR. ANDERSON: As opposed to other inspection methods where you either identify a crack or have some sort of indication. The blue etch anodized process is directed at having an inspector look for patterns in this coating that is applied to the part. Is that a correct characterization.

THE WITNESS: Characterization, yes, that gives a pattern.

MR. ANDERSON: And how many conditions of failure does this blue etch anodize -- you have named, I believe, grain segregation, which is a metallurgical condition?

THE WITNESS: Yes, hard alpha, which is also something coming from the forging. The ~~grey-areas~~ grain size, segregations, forging ~~depths~~ laps.

MR. ANDERSON: And of those three discrepancies, the first is a physical discrepancy, is it not? It is a physical discrepancy. It could show up under other types of tests, forging laps?

THE WITNESS: Forging laps, yeah.

MR. ANDERSON: The other two, the grain segregation and the hard alpha are not detectable, is it not true, by the other process?

THE WITNESS: That's true.

MR. ANDERSON: So, that the BEA is the only test capable of detecting those -- at least two of the three situations.

THE WITNESS: Yes. As we look at the part, yes.

MR. ANDERSON: The indications after the accident on this hub, perhaps led Volvo and Pratt & Whitney maybe to reevaluate the potential for this process. Are you aware of any changes in the

application of the blue etch process?

THE WITNESS: Well, during the tests that we have run at Volvo together with Pratt & Whitney, we have been able to see that the variation of color counter is not always showing up so strongly as this standard showed earlier. So, the standard has changed now to more take care of even a variation from the ~~manufacturer~~ normal blue/gray color surface related to the manufacturing.

MR. ANDERSON: And what kind of testing or studies have led to this type of actions?

THE WITNESS: During investigation of this accident at Volvo, we have produced more than 300 holes with different types of drillings. We have prepared the tools to create -- try to create similar damage that we are looking at on the accident hub. We have been able to create something who looks rather similar on just a few of those holes. So, it's very extremely real -- extremely difficult to create damage like this, even if you try to.

MR. ANDERSON: Yes.

THE WITNESS: And what we're seeing **by** the blue etch is that the variation is very **small** from the grey-blue surface, if you look at ~~the~~ angles of material **hard work**, ~~hard area, very lucrative area~~. So, that ***is*** what we are tightening **up** the standards today.

MR. ANDERSON: Mr. Andersson, you have testified that Volvo drilled over 300 holes to attempt to duplicate the microstructural change that we see on the accident hub. Can you characterize in your opinion what that microstructural change is caused by?

THE WITNESS: If you look at that hole -- specifically, this hole and look at the surface as has been testimony earlier here, the surface finish is within +- the requirements. It seems that the only possibility to create this type of damage to the surface is by a very strong chip packing, because you're looking at a very local area of the hole and the chip packing occurs just for a few seconds and then the chip's coming up, burn away from the holes and leave that signature. And you're also looking at the surface that was very smeared. A lot of layers made out.

So, it's strong chip packing, local chip packing, or for few chips try to go over the margin of the drill instead of pulling up the chip ~~shell~~ canal that ~~it~~ created this type of damage.

MR. ANDERSON: Have you confidence that this was the mechanism by which your duplicate damage was caused?

THE WITNESS: This is the only time when we tried to duplicate it with other changes of drill. Can

drills be without any coolant? And without any success, we have used the coolant channel drill, 24 hole without any coolant, increase the speed for 28 percentage, with no damage at all in the hole.

So, this is the only time when we have this similar damage. We have not been able to create any identical damage like this, but a similar damage. Very -- and the smearing seems to be related to that the heat -- the transportation of the heat from the area when the chips squeeze to the surface is so poor in titanium.

So, when you heat the local overheated area once again, it starts smearing that area out of the hole. That's the reason why you look at the pictures early here, and see that it's very local and it's smeared and it's a very hard layer with a lot of smeared surface, with different structuring also.

The old --

MR. ANDERSON: Is it -

THE WITNESS: Yes?

MR. ANDERSON: I have an overhead slide here demonstrating what you're describing as far as chip packing.

(Slide shown.)

MR. ANDERSON: Is this the phenomena that you

are referring to?

THE WITNESS: Yes, I was trying to explain. If you look at the chip channels coming up here, normally this goes in the channel. It does not call no problem. And at the time the coolant up here, it forces the chip up through the channel.

It seems, if you look at the damage on the hole, one of the chips or part of this chips had been trying to go over this margin -- have been forced over the margin. And when they hit that margin and also they hit the wall of the hole, increase the heat very rapidly also, I would say, just within a few seconds. You increase the heat enough to -- and the chip that is heated up would be very hard and have smearing material on the wall or the surface, which leaves a signature on the surface from the rough machining, the drilling operation.

MR. ANDERSON: I might comment -- thank you -- that the exhibit has not been assigned a number yet -- because of requests to get the rights to show it, and we will introduce it later.

You've mentioned several times that the -- that heat was involved in the change or the effect on the titanium. Would you suggest that heat is an integral part of changing the microstructure as opposed

to the mechanical caring of the chip along the wall?

THE WITNESS: If you look at the chip, if the chip would be hard enough to create this damage, that it would be heated up to be that hard, so it's able to create the damage. And you also are able to look at the structure just behind the surface and you can see some change in the structure to show that they have been heated up.

MR. ANDERSON: The reason I ask that question, Mr. Andersson, is that we realized that after the hole is drilled, that there is further material removed from the hole. And are we to accept the fact that the chip packaging in the event that occurs there affects the material as deep as the hole when it's expanded?

THE WITNESS: As I said before, during our 300 holes tests, we have just been able to create some similar damage that is shown here in the fan hub. And the variation depth is very big. The variations from just a few hundredths of a millimeter to close to ~~hundred~~ one millimeter in the rough machine surface. So, if you have the best conditions, it could be -- even if you have ~~them~~ we move a little further much in the material ~~flight~~ later operations, there would still be small things that are left on the surface.

MR. ANDERSON: Is this -- yes. Is it also possible during this chip packaging that -- and I don't think you mentioned the effect of the coolant. It's possible to exclude the coolant in these local areas of the drill sides, just because there's no room.

THE WITNESS: Yes.

MR. ANDERSON: So, that takes away the possibility that the coolant is aiding and keeping the chips cool.

THE WITNESS: Yes.

MR. ANDERSON: But it is also possible in extreme and rare circumstances, that a chip is small enough and hot enough to spark or burst into be consumed? Is in a small flash?

THE WITNESS: I think *so*, yes.

MR. ANDERSON: Is this a sort of thing that may happen occasionally with drilling large holes in titanium?

THE WITNESS: No, I don't think so, because from what we have learned here, it's very extremely difficult to create the damage similar to that.

MR. ANDERSON: Yes.

THE WITNESS: So, I don't think that is something that is normal.

MR. ANDERSON: Would you characterize the

accident hub's anomaly, the microstructural change as a relatively rare event?

THE WITNESS: It's a very extremely rare event, yes.

MR. ANDERSON: So, it would be extremely rare in the sense that it has not been seen, at least in Volvo?

THE WITNESS: Yeah

MR. ANDERSON: As far as the follow up recommendations, you were doing 300 holes and you were looking to duplicate the process. This led to changes or proposed changes in the blue etch process. Can you tell us what -- physically what change in that process it led to, as we speak today?

THE WITNESS: The change in the process is that we have ad pictures showing up, ~~filling~~ Filled holes, that we call it, holes that are showing up in the two pieces. Pictures showing this type of damage in the standards. We also have put to the lesson learned words that tells us that the variation of color is not only blue and white, it's also variations of grey, blue scale of color.

MR. ANDERSON: How many for the blue etched inspector -- under this new system, how many new patterns or pictures, standards are now used?

THE WITNESS: Four new pictures.

MR. ANDERSON: So, there are four new pictures. Are they very much the same? What are they based on? Are they based on the actual physical, one of the 300 or four of the 300 holes that you sectioned?

THE WITNESS: One of -- two of the -- three -- excuse me. Three of the 300 holes that we have produced at Volvo, yes.

MR. ANDERSON: Okay. And did you use --

THE WITNESS: And we handed over those pictures to Pratt & Whitney.

MR. ANDERSON: And did I understand you to say that there is also a visual -- an addition to the visual inspector's duties here to detect perhaps a visual indication of this condition?

THE WITNESS: No, not on the visual.

MR. ANDERSON: So, there is no --

THE WITNESS: Just a BEA.

MR. ANDERSON: It is believed that there is no visual way to detect.

THE WITNESS: That's correct.

MR. ANDERSON: And the reason I ask that is, as we look at the earlier pictures and the one behind the table, we do see a visual indication of the two origin sites.

THE WITNESS: Yes. If you look at that hole -- and that hole has been around for close to 14,000 cycles, you have this variation of color, because this is a whole layer there than in the normal section.

So, from what we have seen at Volvo, if you look at a part -- as a new part, in the surface finish, you were not able to see any variation by visual inspection of the holes.

MR. ANDERSON: What type of drill -- was one type of drill used to create all 300?

THE WITNESS: No, we have tried -- we have used all the different types of drills that we had used at Volvo since '84 up to today.

MR. ANDERSON: And was there any correlation between the type of drill and the ability to create the damage?

THE WITNESS: No, there wasn't.

MR. ANDERSON: My other question would be, in your professional opinion, is the new standards that are -- that have been developed have a high probability of identifying this microstructural change or is it still possible that this microstructural change, if it meets all other inspection criteria, cannot be detected?

THE WITNESS: I would say that the change that we have together with Pratt & Whitney made the blue etch will take care of this type of variation in the structure. I have a very high confidence for that process.

MR. ANDERSON: And what makes you confident of the process?

THE WITNESS: Because I know that we now have the pictures. We have also a lot of lessons learned. We have all people -- the inspectors have been able to look at this tape of samples that we have shown. We have shown the samples also from the inspection of Pratt & Whitney. So, we have a very high confidence for the process, because of that and the new pictures, the new words, and lessons learned, and so on take care of this type of variations that we were looking at in 1989 without understanding what it was.

MR. ANDERSON: So, the new understanding as a result of the information from the accident, as well as the experiments done in drilling holes, give you a high confidence that any future rare events of altered microstructure will be detected --

THE WITNESS: By the blue etch.

MR. ANDERSON: -- by the blue etch inspector.

THE WITNESS: Yes.

DR. LOEB: George, if I could just follow up on one question. Is that dependent -- is that strongly dependent upon the inspectors having these pictures?

THE WITNESS: Yes, and also the training of the inspector. So, there's always a human in there.

DR. LOEB: So if they see something in the blue etch, but there isn't a picture that looks like that and has some -- and it has been identified as a microstructural defect, what do they do with that then? In other words, if they see a blue etch -- some sort of difference in the blue etch, but there is no picture that identifies it as a specific defect, how is that --

THE WITNESS: But in the standard -- part of the standard. It's all variation, and the grey-blue color or grey color, white. And earlier, it was white and blue. So, all variations to the normal surface conditions will give signal there is something on the surface.

DR. LOEB: And so if it doesn't look like one of the pictures, then what will happen?

THE WITNESS: Because you have the word -- written words in the standards telling that you have to take care of all variations today.

DR. LOEB: But what will happen then? What will the steps be taken?

THE WITNESS: The inspector will have to call down the level 3. The level 3 is the specialist approved and trained by Pratt & Whitney. He will go down there. They will make a replica on this local area. Evaluate it, if there is a metallurgic damage. If there is something on the surface he's not sure of, they would do the -- the next step is to re-etch the part.

If there still is variation of discoloration, we reject the part and we have to within 24 hours give that information to Pratt & Whitney and inform them about they have rejected parts up on the blue etch.

DR. LOEB: If there is -- if the part is rejected or they re-blue etch it and that same indication shows up, is there an automatic process to section it and look at it then under an SEM or some other technique?

THE WITNESS: If the part were -- we will cut it up and section it.

DR. LOEB: Always?

THE WITNESS: We would always do that to understand what we're looking at.

DR. LOEB: Okay. Thank you.

THE WITNESS: Because there would always be a lab report coming up from that. A replica was shown

there is something abnormal on the surface.

DR. LOEB: Okay. Thank you.

MR. ANDERSON: The inspection process for blue etch, I think has been -- we've pretty well covered, but I would like to turn to the other protection, which is proper drilling procedures. During this experimentation, did Volvo come up with any change or any recommended change to their -- to your processes that would reduce the probability of creating the condition? That is to say, perhaps modify the way the chips are handled. In other words, have your drilling procedures changed as a result of the -- what you have learned from the accident?

THE WITNESS: The drilling procedure that we use at Volvo today is that high speed steel drill specially designed for titanium, very small margin, and very different type of relief, angle zone. And the speed and feed and everything -- we have not been able to create any type of damage by using that tool. So, no, we're not suppose to change anything in the process --

MR. ANDERSON: I understand.

THE WITNESS: -- of speed and feed and drilling. What we have changed is that we have more specific training operators to be more -- evaluation of

the chip's color and so on, because that is the only way they have the possibility to see if anything happened down there in the hole.

MR. ANDERSON: So, is it fair to say that at the present time, there is no higher probability of creating this condition with any of the types of drills that have been in general use at Volvo and perhaps at other manufacturers?

THE WITNESS: If you look at both the coolant channel drill, both types of the coolant channel drill, and the high speed drill that we use, and use in those drill by normal conditions, flowing down the coolant through the channel, flood over the part, we have not been able to create any damage of deformation to the holes.

MR. ANDERSON: I understand. So, that there are essentially no changes to the manufacturing or drilling process as a result of --

THE WITNESS: That's correct.

MR. ANDERSON: Does Volvo produce drilled holes in other titanium products for other manufacturers other than Pratt & Whitney?

THE WITNESS: Yes, we do.

MR. ANDERSON: Are these parts subject to the blue etch anodize inspection process?

THE WITNESS: Yes, they are.

MR. ANDERSON: Is this true with all of them?

THE WITNESS: Yes. That is a normal way of handling the titanium parts, rotating parts. We always do the blue etch.

MR. ANDERSON: And so this new standard will be applied to other parts, other than this particular part manufacturer?

THE WITNESS: Our operations and inspectors out there are trained to the new standards, to the knowledge that they have today. So, yes.

MR. ANDERSON: Yes. We talked about the blue etch process. And I would like to return briefly to cover the engineering source approval process, as far as the specific details with the accident hub. More specifically, we have an exhibit here that shows the exact transaction that authorized the use of the coolant channel drill. And I would like to present Exhibit 6-8-1.

THE WITNESS: What exhibit? Say that again? Six --

MR. ANDERSON: I'm sorry, Exhibit 8G is the first one.

THE WITNESS: Eight-G.

MR. ANDERSON: The Exhibit 8G -- excuse me --

is a rather bulky document, page 26. You're on page 26. Can you explain the circumstances and the activity being accomplished by this form?

THE WITNESS: Okay. What we're looking at is page 26. There is a process of a record. That is a record that we have to send in to Pratt & Whitney each time we do any changes on the rotating parts, manufacturing to Pratt & Whitney. It's to explain what ~~that~~ we canceled and replaced by another drill. And it also tells that that is an operation. Operation 80 was a rough drilling operation. And we have the normal or the new drill and we also explain that this drill -- the drawing of that drill is enclosed ~~in close~~ to this.

We also explained that the feed, speed, and coolant are the same as approved method.

MR. ANDERSON: So that, essentially, this document was part of the engineering source approval. Is that correct?

THE WITNESS: Yes.

MR. ANDERSON: And that process in general was to communicate to the engineering authority at Pratt & Whitney significant changes -- and I'll use that word, because it's used in this document. There are three types of changes. There's a first submittal. There's a significant change. And there's an

insignificant change.

In this case, the marking was insignificant. Could you tell me who filled in that block, insignificant?

THE WITNESS: That is a decision made by Pratt & Whitney engineering of the quality.

MR. ANDERSON: Was that --

THE WITNESS: But this was Pratt & Whitney.

MR. ANDERSON: Was that Mr. McCarter's signature at the bottom?

THE WITNESS: It could be Mr. McCarter, yes.

MR. ANDERSON: Yes. And what was his position at this time?

THE WITNESS: He was at Volvo as a quality guy. And this approval had been sent in by McCarter -- had sent in and discussed it with the people at Pratt & Whitney prior to approving that at Volvo.

MR. ANDERSON: So, he made the decision that this was an insignificant change. Is that correct?

THE WITNESS: I don't think that -- Tom McCarter made it by himself. He made it together with engineering and other --

MR. ANDERSON: No, I understand.

THE WITNESS: -- people.

MR. ANDERSON: But I'm just saying, I'm

trying to establish that he was the individual that put the marking on the form.

THE WITNESS: Yeah, it seemed so.

MR. ANDERSON: Yeah. I understand that he is not -- that he is working in conjunction with his engineering personnel and we'll discuss that. So is this, indeed, the coolant channel drill that we have described before as being in use at the tine the accident hub was drilled?

THE WITNESS: It should be. Yeah, it is.

MR. ANDERSON: So, yes, it would be the same. It may not be the same diameter. I would want to check that, but it would certainly be the same --

THE WITNESS: It is the same drill.

MR. ANDERSON: -- physical description having the carbide cutting edges and the coolant holes.

THE WITNESS: Yes.

MR. ANDERSON: So, at the time of the accident, you were visited by several inspectors to look at the process. And one of the findings by the FAA, which is in this exhibit -- this same exhibit, was that there seemed to be some difficulty with the engineering source approval, ESA, process. Was this particular record, in your opinion, filled out improperly?

THE WITNESS: Oh, yes.

MR. ANDERSON: I don't mean in the sense that it was classified as insignificant, but was there any other error in the way it was processed?

THE WITNESS: The process was working. The ESA process was showing up.

MR. ANDERSON: So, that in your opinion, you and Volvo had communicated your intent to change to the coolant channel drill to Pratt & Whitney?

THE WITNESS: Oh, yes, as we always do.

MR. ANDERSON: Yes. One other question on this form. Going back up to the description, they talk about speed, feed, and coolant are the same as the approved method. Is that not an error, that aren't the described speeds for the coolant channel somewhat higher than the high speed steel that was in use prior?

THE WITNESS: Together with this process approval record, they will have all the operation drawing sheet showing all the feed and speed. So, if there is a written error, I don't show that, because we are looking at the feed and speed is based on this 700 test that we run. And by that, we mean that the process shown or approved that it's a good process.

So, that could be the word that we mean here. But remember, that behind this process approved record

is both the old or that would be in use at that time and the new document that we will use approved by this document. So, in that document, you will see all operating drawing sheets, feed, and speed, and tooling, and also --

MR. ANDERSON: I understand.

THE WITNESS: So, that is not misleading information. No, I don't think so.

MR. ANDERSON: But I think if we read this document as it stands, that portion would appear to be an error.

THE WITNESS: Yes. But you had to look at the whole packs of paper that was in that.

MR. ANDERSON: Yes, which is not all present.

THE WITNESS: Yes.

MR. ANDERSON: Page 29, I believe, talks about predrilling. And it's -- I would simply ask in passing, is this telling us that the predrilling was used on the tie bolt or the counterweight holes?

THE WITNESS: It's just said that you change the information to another page -- to another operation drawing.

MR. ANDERSON: It is not a predrilling that applies to the counterweight holes?

THE WITNESS: It is a predrilling, but it is

not removed or something like that, but it tells -- to change to another page of the package of paper.

MR. ANDERSON: I understand.

THE WITNESS: Yes.

MR. ANDERSON: Immediately after the accident, details were known as far as the metallurgy of the hub. Volvo took some action to identify some blue etch indications. Could you describe how that was undertaken?

THE WITNESS: First of all, we didn't try to identify any blue etch indication. We weren't able to do that, because all the blue etch indication historically have been taken care of prior to that So, what we are talking about is notifications or -- yeah, notification from the blue etch inspectors that he has seen something on the surface related to the holes and reported that down the road, so to speak, and down to the final inspector to make a decision.

We were able to look at, oh, the 2,400 parts that we have produced. And we identified eight more hubs. Two of them were scrapped at Volvo prior to shipping. One of the six hubs has only a notification from the FPI, who has similar notes, as we were discussing earlier here.

So, there's another five parts out there with

notification from the blue etch inspector, there was something in the holes similar to what we have seen on this accident hub. And those were identified, I think it was 13 or 14 of July, and we gave that report over to Pratt & Whitney and they took care of it immediately.

MR. ANDERSON: Yes. So, those were obtained, the ones that were in service. And was any discrepancy found in any of those in service?

THE WITNESS: No. No metallurgic damage in none of the six.

MR. ANDERSON: Have you since that event, gone and looked at the rest of the records of hubs and identified any other indications in the travelers, which know you have told are not blue etch? That you know -- unfortunately, that terminology has gotten into the record at various points. But they are either visual or FPI type indications.

THE WITNESS: The notes from the FPI was not an indication. It was a remark from the FPI.

MR. ANDERSON: Yes, yes.

THE WITNESS: So, you have to understand that indication is something that the part will never leave that operation, if they have an indication.

MR. ANDERSON: Exactly. So --

THE WITNESS: So, what we're looking at and discuss here is notification of remarks.

MR. ANDERSON: So, I need to correct myself and say they would --

THE WITNESS: Yes.

MR. ANDERSON: -- be limited to the visual criteria or visual criteria that were not understood and passed on to the visual inspector?

THE WITNESS: Yes, that's correct.

MR. ANDERSON: After that initial inventory, if you will, were any other hubs identified as perhaps being at higher risk or --

THE WITNESS: We have created what we call a method. When we put all the 200 -- 2,400 hubs and we had identified together with Pratt & Whitney other hubs that -- known to Pratt & Whitney and they have informed the operators about those serial numbers.

MR. ANDERSON: And how many, approximately?

THE WITNESS: It was -- ~~with shoes~~ at the time -- we're back in August '96 now. *And* we were focusing at that time on just the coolant channel drill. So, ~~with shoes~~ -- all the coolant channel drill was 720, including the fail, ed ones And then in late October, beginning of November, with by the method we would use going through all the information, we identify 258.

And that means that 140 of those that we find at that time ~~has been added to the other~~ were in that first group of 720, and ~~because~~ the other ~~118 pieces per~~ 118 hubs were added to the first group of 720. ~~total~~ 858

MR. ANDERSON: So, essentially, they would be considered to be at somewhat higher risk. If we go back to the assumption that this is a rare event, then those hubs would be the ones considered the most at risk, because of some sort of observation?

THE WITNESS: That this is a maybe. Perhaps, yeah.

MR. ANDERSON: Yes. But would it be -- would you conclude that given the inability of blue etch anodize inspection to detect this anomaly up till fairly recently, would allow the possibility that a similar damaged hub could have been produced?

THE WITNESS: The possibility is there, yes.

MR. ANDERSON: Yes, the possibility is there. I'm not suggesting that it is high, as those that had some indication, but because it's a rare event and because there is or was no way to positively inspect for his condition.

THE WITNESS: That's true.

MR. ANDERSON: I would like to just shift to another product of the documentation system between Volvo and Pratt & Whitney, and that is the Exhibit 11-

D. Do you have Exhibit 11-D?

THE WITNESS: Yes.

MR. ANDERSON: Here we have as we interpret it, an example of a form used to report a supplier's report of non-conformance or a brief -- and the acronym is SRON. It is a United Technologies, Pratt & Whitney form. And we interpret this as being part of the material review board system, which jointly operates between Pratt & Whitney and Volvo to maintain in accordance with the aviation regulations, the quality and the integrity of the manufacturing process.

Could you tell us -- we find that this particular part of this hub is mentioned for a non-conformance. It is not a non-conformance that is related to the hole that we have been discussing, but could you describe the non-conformance here?

THE WITNESS: If you look at the item number A, page 1 of this exhibit, you would the serial number 32971, as the fourth serial number at the top of that. And that is related to the diameter outside the hub, the turning diameter. You don't have a good picture in the hub here. It's related to diameter out here, in this area. It is not related to any holes.

MR. ANDERSON: I may have another -- is that sufficient?

THE WITNESS: We use that. That's okay. You would also on page 2 be able to look at item A and also find the same serial number. It is also diameter out in this area. It's in this area of the hub, not related to the holes at all.

MR. ANDERSON: And can you describe the condition that caused this discrepancy?

THE WITNESS: If you look at item A on page 1, it says that the diameter is adjusted to blueprint requirements of the tumbling, operation 220. The parts are tested and are subject to in entirety. So, there is in attachment page 1, which noted in here, to explain if there isn't -- there probably isn't over or around the size of the dimension -- diameter.

MR. ANDERSON: Yes. And I call your attention to page 2, investigation and follow up is going on in purpose to find out why this diameter is not all a shrink, is calculated. So, am I reading that correctly?

THE WITNESS: Page 2?

MR. ANDERSON: Yes. In the second --

THE WITNESS: Item A?

MR. ANDERSON: Item A, yes.

THE WITNESS: It is also diameter. It says that it's two ten thousandths of an inch over max.

MR. ANDERSON: And could you read the first part where it says "compensation in process sheet?"

THE WITNESS: The compensation process sheet, because of shrinking diameter, the part did not shrink as much as calculated. That means that during machining of the part, you had to take care of the variation of heat on the part, the titanium, and it's working up and down, and the diameter is increased and decreased because of the heat. And because of that variation here, it's not as normal or as calculated during the process of the turning of the diameter.

So, that's the reason why they, on the final part, have this deviation or non conformance. That is rather normal that we have to take care of variation from Shop pinning, tumbling, and processes between the -- the operation was rather early in the steps of the manufacturing of the part and to the final dimensions. And sometimes we don't now why it don't work. The calculations are wrong or something like that for some part. You will have this oversize or under size because of that.

MR. ANDERSON: I understand. And in talking through this, we are essentially going through the material board process here that looked at a part, found it had shortcomings. In this case, they were

dimensional shortcomings and took action to correct them. And if I read it correctly, it appears that the part was delivered meeting the blueprint specification. Is that a correct statement?

THE WITNESS: Well, on the first page, yes. On the second page, there still was an oversize of two ten thousands of a diameter. On the part -- from Volvo. But they accept it on the SIGN

MR. ANDERSON: Yes, but I also see just reading below, that -- oh, I'm sorry. That's for a second part that's being discussed.

THE WITNESS: Yes.

MR. ANDERSON: So, yes, so that we can conclude by saying that the part -- the material review board concluded that the part was functional, even though the dimension was two thousandths --

THE WITNESS: Two ten thousandths.

MR. ANDERSON: -- two ten thousandths out of or oversized.

THE WITNESS: Yes.

MR. ANDERSON: That's the last question I have, Mr. Andersson. Mr. Chairman.

CHAIRMAN GOGLIA: We will proceed to the parties. The Federal Aviation Administration?

MR. DONNER: We have no questions. Thank

you, Mr. Chairman.

CHAIRMAN GOGLIA: Pratt & Whitney?

MR. YOUNG: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Air Line Pilots Association?

MR. MCCARTHY: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: McDonnell Douglas?

MR. STEELHAMMER: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Delta Air Lines?

MR. VALEIKA: Yes, we have one question. The blue etch procedure at the time of this disc inspection, just to clarify a point, was not used to find any type of machining mechanical process induced errors. It was strictly used to see if there was a problem with the base material after it's drilled. Is that correct or not correct?

THE WITNESS: The only in process that was related to the specification is the overheated of an area by grinding, for instance, or polishing.

MR. VALEIKA: So, but -- I heard you basically say the blue etch procedure then at that time -- not today, but then, are basically -- there was no action taken based on any of the blue edge findings, but there was action taken based on the visual findings of the hole and the various comments that Mr. Anderson

referred to?

THE WITNESS: Yes, because it was not blue etch findings. It was an observation by the blue etch inspector.

MR. VALEIKA: But just explain that to me? The blue etch didn't show anything at all?

THE WITNESS: That's correct.

MR. VALEIKA: That's all I have. Thank you.

CHAIRMAN GOGLIA: Volvo?

MR. THOREN: No more questions.

CHAIRMAN GOGLIA: Okay. We'll bring it up to the panel here. I think Mr. Loeb -- Dr. Loeb has a question.

DR. LOEB: Yes, I have a couple of questions, but I want to follow up on the last question that was asked by Mr. Valeika. The blue -- your answer to this question, I believe, was the blue etch didn't show anything.

THE WITNESS: Yes, that's correct, because then you have had the note in there. The code 40 in that operation -- in that inspector record.

DR. LOEB: Would it be correct to say that there was nothing detected by the inspector in the blue etch anodized process?

THE WITNESS: Isn't that the same, because

the operation --

DR. LOEB: Well --

THE WITNESS: -- depending on what the inspector --

DR. LOEB: Is it -- I mean, is it the same? And the reason I'm asking is because if the situation were the way it were today and the additional pictures made available, that same blue etch process may have been identified at that point as something to be concerned about today when it was not at that time. Is that correct?

THE WITNESS: During the test -- during the test here at Volvo, we have been trying to understand the blue etch -- the way the blue etch working. And unfortunately, it seems that sometimes the blue etch could be interfered by ~~documentation~~ contamination -- and especially when we Look at the smear surface like we're looking here. The layers could be -- could include, for instance, iron, which gives grey color instead of dark blue indication. And the grey color -- that's the reason why we have add this words to the standard today and showing that all variation, even in the grey color --

DR. LOEB: I --

THE WITNESS: We have samples that we -- the

first etch operation and the test is to finish anything -- that people are looking at the part, looking down at the holes, so a good hole -- as I thought, we would cut the hole in two pieces, re-etch the part, and some very local area was dark the second time. But the first time when we look at that hole, we were able to look at the variation of the grey color. That's the reason why we put that statement out in the EIS 30 today.

DR. LOEB: And so I'm going to ask you again. If the conditions that exist today had existed -- the statement, the pictures, and so forth, had they existed then, then it is possible that that blue etch may have indicated something to the inspector that it wouldn't have at that time?

THE WITNESS: Yes.

DR. LOEB: I just wanted to clarify that. Now, just a couple of questions regarding the change approvals and so forth. It's my understanding and I just wanted to make sure that I'm clear on this, that any change from a type of drill bit to another drill, any change in the feed or speed, you would get Pratt & Whitney's approval for that?

THE WITNESS: Yes. All the change -- even if a change machine from another machine is standing behind that, beside that machine, change from machine A

to B, we had to approve that by Pratt.

DR. LOEB: Regardless of whether it was a significant or insignificant change, you would get the --

THE WITNESS: We always sign all that document.

DR. LOEB: Now, would the FAA -- do you know whether the FAA would be notified about any of those changes?

THE WITNESS: I'm not able to answer that question, because we're not working the FAA.

DR. LOEB: Okay. That's fair enough. Can you describe very briefly, the changes -- the differences in the process that would take place between a change that was significant versus a change that was insignificant?

THE WITNESS: Repeat that again?

DR. LOEB: Yes. What are the differences that would occur in the process if that were a significant change rather than an insignificant change?

THE WITNESS: I think this question that a better witness should answer on, because they make the decision things can change.

DR. LOEB: That's fine. So, you would be more comfortable with them answering that?

THE WITNESS: Yes.

DR. LOEB: Okay. Thank you. I don't have anything further.

CHAIRMAN GOGLIA: Mr. Haueter?

MR. HAUETER: Just a few. One, just for the record, this part is designed by Pratt & Whitney. Is not designed by Volvo.

THE WITNESS: No, it's designed by Pratt & Whitney.

MR. HAUETER: It's designed by Pratt & Whitney. When you first starting making the part, Pratt & Whitney provided all the specifications to be used in the --

THE WITNESS: Yes, they did.

MR. HAUETER: Okay. Was there any FAA involvement?

THE WITNESS: Well, as I told you earlier, we were working with Pratt & Whitney requirements -- and we are -- all the information, all requirements coming through Pratt & Whitney to Volvo.

MR. HAUETER: Did the FAA ever do inspections of your facility to --

THE WITNESS: No, but the Swedish authorities does twice a year.

MR. HAUETER: There were no FAA inspections

of your facility or production?

THE WITNESS: Not in manufacturing.

MR. HAUETER: You mentioned you drilled numerous holes in other samples. And I want to check on this. Looking at the chip packing phenomenon, once again, how deep does this go into the material?

THE WITNESS: We have had about 20 different holes created by chip damage, was the only time when we had something similar to what we're looking at in the hub. The depth of those 20 damages had variation from a few hundredths of a millimeter down to close to one millimeter. We don't know why this variation, because the signal that we get from the machine that we use -- is the same signal.

MR. HAUETER: And the machine used, this is a computer controlled machine.

THE WITNESS: Yes, it is. And we continue to test at Volvo now. And we are suppose to in late May or beginning of June have that testing finished.

MR. HAUETER: How much operator involvement is there in this process?

THE WITNESS: The operator have the possibility to look at the chips, he starts the machine. The machines really control -- he changes the tool, but he changed the tool in the magazine behind

the machine. So, the machine is picking up the tool from the magazine. So, the influence from the operator is very little.

MR. HAUETER: Minimal.

THE WITNESS: Yes, minimal. He is very important to look at the operation going on, listen if there is any special noise coming out from the machine. But as I explained, when we look at the picture, there's a closing cabinet around. So, it's not so noisy out there --

MR. HAUETER: Can the machine itself note whether there is a binding, drilling, or whether there's a problem? Does it have a back feed?

THE WITNESS: Today, we are incorporating that in some of the machines. And we had made the first incorporation back in March '96. Before that, we didn't have that equipment on the machines, no.

MR. HAUETER: Real quickly, looking at Exhibit 11-E, page 15, this is not necessarily the accident part, but I note at the bottom, there's a comment.

THE WITNESS: Will you give me the page once again, please?

MR. HAUETER: Page 15 of 11-E. Can you describe what's happening here? The dimensions -- I'm

trying to read this -- is that there were parts sent to Pratt & Whitney for examination? I don't understand.

THE WITNESS: If you look at those, those was the findings that you're looking at of these runs. When you look at this run, you will find the same dimensions in this run. So, the area here, we have noted down the dimension, the variation, and what it is. And then we put it on a -- and send it over to Pratt & Whitney for -- or approval as it is.

MR. HAUETER: Is there a Pratt & Whitney representative on site to make that determination or do you have to ship it back to the U.S.?

THE WITNESS: I have to ship it back to U.S.

MR. HAUETER: For their examination. And what was the case of these two parts, why did they need to be examined again by Pratt & Whitney?

THE WITNESS: Because of the oversize and the dimension of the oversize.

MR. HAUETER: Okay.

THE WITNESS: Remember, that those notes on the back side of the page 15 here is in millimeter.

MR. HAUETER: Yes.

THE WITNESS: And you also -- in that note, you also will find that the part have been sent to ~~center~~ crib. It's in a locked area that would keep the part as a

non-conformance, until this position had been made by Pratt & Whitney.

MR. HAUETER: That's all the questions I have. Thank you.

CHAIRMAN GOGLIA: Mr. Conroy?

MR. CONROY: Yes, sir. One or two more questions on 11-E, which Mr. Haueter just addressed. And this me retrace a little bit of ground, but I would like to be clear on this. This entire document, English translation of Volvo's manufacturing records on hub serial number 32971, as the title reads, we call the traveler. Is that true of this entire document? Does it travel with that hub?

THE WITNESS: Yeah.

MR. CONROY: On page 12 that Mr. Anderson addressed, some chatter marks -- and you had talked about that at some length earlier this morning -- was a comment regarding two drill holes. Is that correct?

THE WITNESS: That comment is in the single point boring operation.

MR. CONROY: I'm sorry?

THE WITNESS: That comment is made in the single point boring operation.

MR. CONROY: Okay.

THE WITNESS: That he had some chatter marks

on that surface.

MR. CONROY: All right. And we talked about -- Mr. Anderson asked you some questions regarding quality assurance inspections following those comments. What would be the last quality assurance inspection indication in this traveler regarding those comments?

THE WITNESS: Two hundred and thirty.

MR. CONROY: I'm sorry, I didn't hear your last sentence?

THE WITNESS: Two hundred and thirty. The operation coded 230.

MR. CONROY: Is that on page 10?

THE WITNESS: Page 10, yes.

MR. CONROY: All right. And we have a quality assurance stamp in that line. Is that correct?

THE WITNESS: Yes, that's correct.

MR. CONROY: Now, I noticed there are no comments there, and you discussed that, I think, briefly. When would comments, if ever, be appropriate regarding that action?

THE WITNESS: If he as an inspector did identify anything that is not within the requirements, he put those notes down on the inspection records. And then we have to discuss that or send the variations,

non-conformance to Pratt & Whitney for evaluation ~~to reactivities.~~

MR. CONROY: I'm sorry, your last sentence?

THE WITNESS: We have to send them to Pratt & Whitney for evaluation.

MR. CONROY: I see. Does that QA stamp indicate that the bore -- correction -- that the holes, the drill holes that were commented on in the first comments regarding chatter marks, passed his inspection?

THE WITNESS: Yes. And you don't find any notes in the inspection records. So, yes, they were approved to the standards.

MR. CONROY: Could there still be any indications in that, in those drill holes and meet inspection qualifications?

THE WITNESS: If you look at the surface finish and say that -- I would say the variation could be there, but not to the -- not a reason for a reactive part to the VIS specification.

MR. CONROY: Your last sentence, sir?

THE WITNESS: There was not -- there could be something in that hole, but not reason for ~~rejection~~ rejection That was approved by the or accepted by the VIS standard.

MR. CONROY: Okay.

THE WITNESS: Did you understand what I mean?

MR. CONROY: I think so. Are there documents that tell how much -- you mentioned it could be something.

THE WITNESS: If this is acceptable, you don't find any -- you will not find a note on it.

MR. CONROY: I guess my question is, are there objective criteria that say how much is acceptable?

THE WITNESS: In the VIS standard it is, yes.

MR. CONROY: And by that, I can assume that his stamp indicates that we are within an acceptable level.

THE WITNESS: Yes.

MR. CONROY: Now, you mentioned if he were required to make a comment, it would then go on back to Pratt & Whitney. Is that correct? If he found it unacceptable?

THE WITNESS: If there is anything who is not acceptable to the standard, to the drawings -- we have to go to Pratt & Whitney to get that approval or rejection.

MR. CONROY: Is there a Pratt & Whitney representative at Volvo or would you go to Pratt & Whitney in Connecticut?

THE WITNESS: We go to Pratt & Whitney in Connecticut.

MR. CONROY: Okay. Thank you very much.

CHAIRMAN GOGLIA: Are there any further questions from the parties? Okay. Hearing none -- oh, Mr. Eindler.

MR. EINDLER: My name is Erik Eindler, and I represent the Swedish Board of Accident Investigation. Would you summarize the situation that Volvo and Pratt & Whitney and maybe the aviation world know more about the titanium alloy machining inspection today than -- after the accident than before the accident?

THE WITNESS: Yes, I will do that. We have shared information with the companies we work together with. And I know that Pratt & Whitney have shared the information to other companies, too, that we have lesson learned -- during the investigation at Volvo about the machining of titanium, the type of damage we are looking at, and so on. And also the BEA process.

MR. EINDLER: That means that also Volvo's routine instructions and Pratt & Whitney instructions regarding inspection has changed as a result of --

THE WITNESS: Regarding the BEA inspection, yes.

MR. EINDLER: What about -- do you have to

calibrate the judgment of inspectors to define to approve or not to approve surface imperfections? Sometimes, it's difficult to -- just to read in the paper to define an imperfection. Sometimes, you need to physically look at the piece and the imperfections. Do you regularly calibrate that with the Pratt inspectors?

THE WITNESS: Yes, we do -- that, we do, sure. And we also have very similar -- the same as both sides of the -- *so*, we use as a standard, looking at the surface, and we always do that. We have a lot of questions between each other about look at this piece, part. We have something that we would all ship out and they give their response on that question. That is a continuing going on between Pratt & Whitney and Volvo.

MR. EINDLER: Okay. So, does that mean that you have the feeling that a Pratt & Whitney inspector would judge about the same as your inspectors in your shop?

THE WITNESS: Today, yes.

MR. EINDLER: Or today, and, of course, the time of the manufacture?

THE WITNESS: Oh, yes. Yes.

MR. EINDLER: Okay. Thank you, Mr. Chairman.

No more questions.

CHAIRMAN GOGLIA: Again, I'll go to the parties. Any further questions? Hearing none, then, Mr. Andersson, we will release you.

THE WITNESS: Thank you.

CHAIRMAN GOGLIA: Thank you very much for your testimony.

THE WITNESS: Thank you, Mr. Chairman.

(Witness excused.)

CHAIRMAN GOGLIA: And we'll call our next witness, Mr. Scussell. A little housekeeping issue here. We are running behind schedule, which we have a very aggressive witness list for these three days. So, the likelihood of us reconvening after dinner is high. So, if you -- if anyone needs to be excused, if we need to change the parties' spokesman, we will be very flexible in that. Just, I believe, we all should make plans to be here late. Thank you.

(Witness testimony continues on the next page.)