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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

INCIDENT INVESTIGATION TEAM

Nine Mile Point Nuclear Power Plant

Information Meeting

Nuclear Regulatory Commission

The Woodmont Building

Room W-100

8120 Woodmont Avenue

Bethesda, Maryland

Tuesday, September 3, 1991

The meeting in the above-entitled matter convened, pursuant to notice, in closed session at 9:30 a.m.

PARTICIPANTS:

JACK ROSENTHAL, NRT/ITT Team Leader

FRANK ASHE, NRT/ITT Team

JOSE IBARRA, NRC/IIT TEAM

WALTER JENSEN, NRC/IIT Team

MICHAEL JORDAN, NRC/IIT TEAM

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RUDI MACHILEK, Exide Electronics
WAYMON RANSOM, Exide Electronics
KYLE TERRY, Niagara Mohawk
KERRY JOHNSON, Failure Prevention, Inc.

PROCEEDINGS

[9:30 a.m.]

MR. JORDAN: Good morning, gentleman. My name is Michael Jordan. I'm out of Region III with the NRC. It is September 3, 1991. We're conducting an investigation of an event that happened at Nine Mile Point on August 13, 1991.

MR. IBARRA: I'm Jose Ibarra and I'm part of the IIT Team, Instrument and Controls.

MR. MACHILEK: I'm Rudi Machilek. I'm Director of the Technical Group of the Technology Center.

MR. HESS: D.J. Hess, Director-Customer Support Operations for Exide Electronics.

MR. RANSOM: Waymon Ransom, Customer Support Engineer for the Western Region.

MR. GRADY: Michael Grady, Manager of Technical Support.

MR. STONER: Jim Stoner, Consultant with the IIT Team.

MR. ROSENTHAL: Jack Rosenthal. I'm the IIT Team Leader. Sitting next to me is Frank Ashe, who I look at as my central focus for this meeting.

MR. ASHE: Frank Ashe, IIT Team member from the Office of Nuclear Reactor Regulations.

MR. TERRY: I'm Kyle Terry. I'm Vice President of Nuclear Engineering for Niagra Mohawk.

MR. JOHNSON: I'm Kerry Johnson, Vice President of Failure Prevention, Incorporated.

MR. POHIDA: Tom Pohida from Instrumentation and Controls Branch, member of the IIT Team.

MR. ROSENTHAL: Rudi, I think that we really have to rely on you. What we had related was that we wanted to understand, truly understand the system, rather than guessing and that the best thing to do is to do it top-down on what's the system, what was its intent, how does it work, and get progressively deeper into what makes this thing trip a lot, what makes the thing run, with a lot of focus on the A-13 card cage.

MR. MACHILEK: All right. Where do you want me to start? Basically, as you know, the uninterruptible power systems originally, if you go back in time, and I have to go back in time a little because we are talking about ten-year-old equipment that we're dealing with here.

Originally, the purpose of the UPS was an uninterruptible power supply, meaning that if your utility power went away, there was an alternate power source which takes its place. It carries you through a scenario where the utility goes away and then later on comes back again.

It also had some elements of power conditioning, which means that it took the spikes and the switching transients and so on out of the actual critical power supply

which was supplied by the utility.

Later on, our customers and we in the industry found that the actual load which was connected to the critical bus was the subject of protection. That means the person who operated a piece of equipment which was powered by the UPS, his prime concern was the power on the terminals, actually where he was receiving power rather than what the UPS was doing or something else.

The explanation of UPS then became an uninterruptible power system. If you really look at a UPS, what it was supposed to prevent is if you have a power station, like an atomic power plant, the power is pretty good. Normally, a failure in the power station itself, if you're talking about generating stations of the old type, steam power plants, coal-fired and so on, there were rarely incidents of losing the whole power supply; for instance, if an atomic power plant goes down.

The operations were from the transmission of the power from the generating plant to the actual users input, and then the distribution of power down to the terminals of the equipment which was supposed to be protected.

So our whole focus as time went on was to safeguard the power not only from the standpoint of having a power conversion module or a box sitting there, but examining the whole system, recognizing the fact that all

the maintenance and fail operations in a distribution system still exist, coming off the UPS like they did exist before coming off the power plant, except the scope was reduced to exclude all the transmissions and the outside elements from there.

What we did after that was to actually start supplying uninterruptible power systems, meaning that we took responsibility for the design of the system from the actual utility power input to a user's distribution system, to include the supply circuitry to the UPS, the UPS itself, its bypass circuitry, the maintenance of all those elements, and then, of course, the coordination of the downstream distribution to the actual user of the equipment.

The reason why I was saying all that is that at the time ten years ago, whoever designed the system was not designing an uninterruptible power system. Switchgear was purchased, a UPS was purchased, and all kinds of installation effects were done. On the end, you had something there which was considered to be adequate at the time.

The equipment was purchased as being best commercial grade. There was no special requirement for it in enhanced meantime between failure or availability. Usually, if we sell UPS systems or if they are specified by militaries or by nuclear power plants and so on, a percent

availability of power is specified. For instance, 99.9 would be a 99.9 percent of the time you have to somewhat guarantee that the power will be there. Six nines is about it; 99.9999, which basically gives you 18 seconds of actual power loss per year. So maybe every 15 years you can afford to lose the power for a little noticeable time.

Of course, you will understand that in order to achieve that, you have to go beyond the box, the actual power converter. You have to examine the input switchgear, the bypass switchgear, and, last but not least, the downstream switchgear with it.

The high reliability equipment avoids two things. Number one, single point failure mechanisms; that means any circuit which would bring the whole system down, and the system, we are talking only about the power conversion box and the bypass circuitry, and the circuit which would be vulnerable or which would cause by its failure as a single point to bring the whole system down should be avoided.

Number two, in good UPS systems design, you do not want to rely on anything to happen in the case of a corrective emergency situation, which has not actually happened already in operation. In other words, you do not want to say if something happens, this relay has to switch or that breaker has to change state or whatever.

If you depend on that to happen, there's a certain

risk. If I may digress for a moment, if you would rob a bank and you run off to your getaway car, of course, you wonder is it going to start or is it not going to start. On the other hand, if it's already running, then the risk of does it start or not start is falling away and it becomes a certainty that the car is starting because it's already running.

In this spirit, we are usually avoiding -- and as a matter of fact, the latest changes which are proposed to be done in the A-27 was in that spirit, that if I have to switch the K-5 relay, for instance, why don't I only switch it at the times where if it doesn't work, it wouldn't cause me a load loss, that it would be an inconvenience and so on. I'm just telling you where we are coming from in this respect.

The fact that the A-27, for instance, the new one or the one which was generated by the Navy, came from that kind of investigation. Somebody said, hey, what happens if a power supply fails. You go to bypass. What if there is no bypass? Usually you have to differentiate here between one failure, does it survive the failure of one component, does it survive the failure of two components that fail at the same time and what is the probability of that, what if there are three things happening at the same time, what is the probability of that, because last, not least, all those

questions can be answered with a big sign, which is dollars.

Of course, if you compete for an order; for instance, the equipment for the Nine Mile Plant, it's a complicated situation. They cannot give you a Cadillac if all you want to go is from here to there and you call it transportation. See what I mean?

So we have to understand here that the equipment which was installed was not the highest scrutinized equipment, such that it would go into high military or high-risk military installations or installations which specify the percentage of availability and the quality which has to be maintained to that end.

So from about 1972, we introduced the Series 3000, which the new equipment that is the subject of our discussion here is part of it. The Series 3000 was developed, if you want, between 1968 and 1972. The first system of that sort went into operation in the spring of 1972 at Philadelphia Electric in Philadelphia; not in the power plant itself, but in the office in the building they have downtown. It is still running. It is still there.

It is the system we have the longest in service, about 19 years now. I think if there's a question on what is the failure rate and what is the availability of power and how vulnerable is the equipment, I believe that installation would be the most indicative of that 3000

circuitry.

The 3000 was improved. The problem was that it used to be that the development time of a piece of apparatus was maybe one year and the lifetime of the design was maybe ten years. Now the design time is maybe two years and the lifetime is minus one year. That means as soon as you come up with a piece of equipment, enough technology has been made available that you almost can say whatever new I'm introducing is obsolete at the time, unless you don't know about the other thing yet.

So in that spirit, we had a Series 250 and a Series 300, 315, a Mark I, a Mark I-and-a-half, a Mark I-and-three-quarters, and then a Mark II, and then we had -- from then on it became a little erratic because customers had specific needs or specific circumstances and we went more into the design of systems rather than the power conversion module.

In that spirit, we made changes, improvements, if you want, to meet certain specific requirements. The Mark II design was actually the one where we entered the era of systems rather than supply and made changes in the circuitry which had nothing to do with improving the circuitry itself, but had something to do with the operations effect of what we were doing.

For instance, some customers said if a module went

to bypass that it should not come back automatically ever. They wanted to go there and investigate what caused it and fix it or do whatever. The other customers said, gee, I don't really care about all that; if I have a glitch in the power and the power restores to normal, I want to come back and I don't want to have that much to do.

So we had two versions already. One had automatic re-transfer and the other had manual re-transfer. The Mark II-U was a design which consolidated all the features which were different for various customers into one universal design. In other words, with the universal board, you can select if you want to come back automatic and manual. You have all kinds of features in there which we don't advertise to be selectable, but they are there to aid us to come up with a board which meets everybody, and yet we can sell it to you as a custom piece of equipment because we can adjust it, but we don't have to make special production runs.

The reliability of the circuitry is better, of course, because it's done over and over the same thing. For instance, we came up with the Mark II-U selectable for 50 and 60 Hertz. So you can stick it into international units as well as domestic ones. You will never run it at 50 Hertz.

But if you want to test for clock failure, you can actually switch a little switch and the inside of the unit

gets programmed for 50 Hertz, and yet you have 60, the clock, of course, goes to hell, but the effects of it we can demonstrate.

In our design, anything failing in one module only effects that one module. If you have a bypass, it will go to bypass. If you have a parallel module, such as a redundant one, the redundant one will take over without any ill effects. We call it selective tripping. That means any failure within the module only effects the module. It does not effect the output bus.

If you do not have a redundant module which works with the one that you have on-line, then, of course, the utility has to take its place. So the utility in this case is the redundancy to the UPS. If the UPS fails, it will go to bypass, the bypass being the utility.

There is a misconception, of course, if you want a reasonable assumption that once you are in the power blend itself, that you'll never lose utility power or the utility power is highly, highly reliable there. The module itself was designed to have a meantime between failures of 20,000 hours.

In other words, every 20,000 hours, if you operate the equipment for an infinite amount of time, then, as an average, every 20,000 hours you would have a failure, which does not mean that you will not have a failure until 20,000

hours have passed.

As you know, if you have a dice, the probability for infinite amount of throws is that you have each one, one to six, come up exactly at the same one-sixth of the time. Of course, if you only throw the dice ten times, you will find that distribution is not true. So we are talking about probabilities here. We're talking about MPTF.

So we have to expect that you may not have a failure in five years, but you may have three in two months. We don't know. It's the quality of the components and the design intent is of that sort. So every 20,000 hours, if you want, as an average, for an infinite period of time, you would have a need -- now, this 20,000 hours is only failures of components which would actually effect the output of the module itself.

If a meter goes bad or what have you, which has no effect on the operation, we do not consider that a failure in that sense. Now, if the UPS fails for an internal component failure, blowing of fuses or a malfunction of whatever sort, there is a mechanism in place where it shifts the critical bus over to the alternate redundant source.

The redundant source can be a diesel plant which is already up. The redundant source can be a utility, such as in your case, or the redundant source can be another UPS which was running in parallel with the one you already have,

and if one fails, the other one simply takes over and you wouldn't even know anything was going on.

Now, in case the UPS fails, the UPS module fails itself and, as a second failure at the same time, the utility isn't there either, then, of course, we're talking about a double failure. The meantime between failures of that to happen is calculated at 100,000 hours if the utility has an MPTF for 3,000 hours. That means if the utility doesn't fail more often than to generate 3,000 hours MPTF, then every 100,000 hours, if you operate the equipment an infinite amount of time, you will have a load loss.

Why do I say that? Because if you have only one module and it quits and you have only one bypass and it's not there, then, of course, if the sky breaks, all the sparrows out there, you have nothing to work anymore.

Now, in the case of the incident, if I may refer to the incident, you'll know what happened here. We had that situation happen. The UPS tripped, became unavailable for the user and the bypass wasn't there either simply because its quality has to be a certain one in order to be labelled in existence. It's frequency has to be within half-a-Hertz.

Its voltage has to be at least within ten percent, plus or minus, of the mean voltage which the system is adjusted to. Of course, it has to be in sync with the

output of the UPS module. If any one of these three conditions are not there, then the bypass is considered not available. The reason for that is if you would switch to such a bypass, let's say you're out of sync and you will switch anyway, you are suffering a phase hot.

That means instantaneously you would see a huge change in frequency in an extremely short period of time, where the FTD would be substantial. Any piece of equipment downstream which is of the computer type which would be sensitive to fast frequency changes would either have a data problem, it's output would be unusable, or else it would even be physically damaged, such as it was in the case if you go back ten years when the equipment was not able to do this kind of thing.

Now, most of the users say that no power is better than bad power. In other words, if I have no power, well, equipment stops functioning and if I have bad power it gets damaged. Single phasing, for instance, if you lose one phase, was considered a serious problem because you're rotating all the motors and so on, drives, what have you, a lot of the three-phase pieces of equipment suffered.

So a lot of installations do have protection, that the circuit breakers actually open if you lose a phase. What that would have done any good, of course, is because the power supplies would not have seen a reduction in

voltage on Phase B when you had the incident. It would have a seen a loss. We demonstrated it even was bad batteries on the power supply and actual loss of the bypass power was not detrimental.

It was a reduction in the voltage which really caused us to go down. We did not consider that in the design. Tell you that plain and honest. A loss of voltage on one phase, a reduction of voltage on one phase was not considered in the design of the UPS. It was designed for a loss of either one of the two supplies. If the UPS output was lost, then, of course, you transfer. If you didn't have a bypass at the time, bad luck, you go down.

It is designed to do that. If you lose both, if you lose the UPS module, you do not have a redundant one and your bypass is not available as defined, then you will lose your load. So in the design application of the UPS, it had to be considered that every 100,000 hours average over an infinite period of time, I will lose that load.

That simple. Now, the question is was that fact considered in the application of the module and since it did happen, why was everybody upset. You have to look at it from that point of view. Yes, we had five units around in there for roughly five years, so we have 25 equipment years of operation. How many times did we go down? We did go down once and the circumstance was really one that the

equipment wasn't designed for.

Should it have been designed for -- well, a lot of should-it-have's we can discuss until we're blue in the face here.

MR. ROSENTHAL: Let me just interrupt. What is hung on the UPS, on what loadings, etcetera, is a subject for the IIT, but I don't consider it a subject for this meeting.

MR. MACHILEK: No, no.

MR. ROSENTHAL: Just so we get agreement here.

MR. MACHILEK: I'm simply saying it in the relationship of what can be expected. If you have four passengers, you cannot have a two-seater sports car. In that relationship, I am simply saying that the severity of having that scenario happen, which was expected to happen based on the design criteria of the system, needs to be taken into consideration here.

The only reason why I'm saying that, if we would only be having a 10,000 or a 15,000 hour operating here, then we would be extremely disturbed here. The only reason I was making that dissertation was to say what is expected, and I believe this was the equation, what was the design criteria of the equipment, what is it expected to do.

Now, if the utility goes away, of course, the rectifier portion is not all that important of the UPS

because you have a battery there as a redundant DC supply for the inverter to operate. So the actual loss, disturbance of the input to the UPS, number one, it's much broader.

You can risk a plus or minus three Hertz of deviation in the frequency and the rectifier would still run. You can have a plus-ten minus-fifteen percent voltage deviation and you can actually have an actual outage, or if the rectifier itself breaks, all those considerations are of little concern to the inverter as long as the battery is there.

If the battery is not there, and now we're talking about two failures again, the UPS would go down. The same way the little UPS, which we consider the power supply, which is basically of the same design as the large one, we have a little UPS within the big UPS. If you lose the supply to an UPS and you lose your secondary or redundant power to it, which is the battery, the output goes bonkers. It goes away.

This is the reason why you bought the UPS in the first place. You are well aware of that, that if the battery plant would go away and you have a power glitch, you've had it, you lose your load. Unfortunately, of course, the little UPS which is supplying the control power, which was at the time of the same design as the big one,

doing the same job, suffers the same shortcomings.

All I want to say, that the normal operation of the UPS is utility power goes through the rectifier, it's been rectified, supplied to the inverter, the inverter inverts it and out comes the AC on the other end. The rectifier itself is redundant in the meaning that the battery power takes its place, not requiring a switching, though.

Normally, the battery is simply floating. It's in parallel with the rectifier output and who supplies power to the inverter simply determines who has the instantaneously higher voltage at one particular moment. So whichever voltage of the two, the battery or the rectifier is higher in any one instant, this source will supply the power.

Of course, if one source fails, then -- now, you can lose your battery as long as the AC and still nothing happens. If you can restore the battery power, of course, you're in good shape again. I've seen instances where, for instance, auctioneering diodes, such as we have, were paralleled with circuit breakers, that in case that one -- now, an SCR fails always short, always meaning until one fails open.

I've only had one diode open failure in the over 42 years I'm working with static power equipment, but it happened one time. No matter if you work 60 years, your

whole life on something, if it happens one time, that one time is considered a 100 percent of the failure. How come you did not consider that.

Of course, the question is why don't we have circuit breakers parallel to the auctioneering diodes. Well, we don't expect the auctioneering diode to fail open. Otherwise, you would have the parallel breaker, you get in a RAM, and we do have in a RAM that the auctioneering diode is, in fact, there and it's in good shape, it goes to the circuit breaker and you maintain power.

So what you expect, you design for. If you can afford to design for it depends now on the probability and if you want to spend the money. If it once happens in 60 years, do you want to really install it, maintain it, and do all these good things. Well a lot of people say no way, forget it.

But you only have one spare tire in your car. Why don't you have two? Well, how many times did you have a blowout on two tires at the same time? Never. None of us have, right? But it could happen, right?

So in that spirit, we have now the battery as a redundant power supply to the rectifier. Is it an absolute 100 percent true that you never lose DC power? No. You can only reduce probabilities, you cannot reduce the risk and son on.

Now, once you have the inverter, unfortunately the inverter has to be -- I think we covered the basic operation. As long as you have AC and battery, you have an inverter, as long as you have a bypass, whatever happens, you go to bypass. So far, the load is not being effected by anything.

MR. ROSENTHAL: I follow the -- if you lose the rectifier, you go on the battery, etcetera. As I understand the design objective, it's that no single failure of the battery or the rectifier will cause the normal UPS to go down. On going to bypass on loss of the inverter, I think we're going to have to -- that's a design objective, I take it, but I think we want to see drawings and, as the morning progresses, truly understand that.

MR. MACHILEK: Okay.

MR. ROSENTHAL: You'll get to that. Go ahead. You're doing terrific.

MR. MACHILEK: Now, as long as we understand that the loss of the rectifier portion, or half of the box, really, would bother us little if we confide in ourselves to the existence of single failures.

As far as the inverter is concerned, of course -- yes, sir?

MR. ROSENTHAL: Sorry. There are signals from the card cage to the SCRs on the rectifier side.

MR. MACHILEK: Correct. There are three circuit boards, commonly known as A-30, A-1, 2 and 3, which control the rectifier. If you go back in time between 1972 and 1976, we had two card cages. One was in the rectifier, and the rectifier was a separate cabinet, physically divided, and you had an inverter at another card cage; of course, constant cost reductions and looking to make the whole equipment to be smaller in footprint and so on.

Last, not least, the least amount of components you use is the most reliable unit, because we have the failure, MPTF is calculating by the count of equipment, of components. We combined the card cage into one and designed the UPS that it behaves much like a three-phase generator would. The only difference is that it has the absolutely constant frequency on the output. The output frequency does not change with loading at all.

It's just to explain the differences between a three-phase generator. The impedance, of course, the output impedance is higher, 16 to 18 percent versus maybe eight percent in the generator. Other than that, it is phase-to-phase control, not as the static equipment was if you go back in time prior to 1968.

So as far as we are now concerned, let's say the AC goes away, the battery is powering the inverter. Now the question is is the bypass power going away at the same time

the input power to the UPS goes away or is it not.

If the bypass power and the UPS input power go away at the same time, then, in a sense, you do not really have redundant bypass power. You simply have a UPS sitting there without a bypass and you are back to your 20,000 hours MPTF, because the 100,000 hours we only realize by having the utility.

In order to overcome that, if you are a user, if you are out in the plant somewhere taking utility power, you would come from different substations. You would come from -- if the two substations go together in the same high voltage line, of course, again, you can only go that far until you make tradeoffs. If you have substations and you have cables coming in, of course, you try to have separate cables. You have redundancy, as much as you can afford.

Let's take the case where the bypass power is coming from another source. You lose your source to the UPS. You go on battery. The other source is available. Then what happens is that you run on battery at the design which you had at the time ten years ago.

You run on battery until the battery was depleted, which would never happen in your case because you have a battery charger which is keeping the DC bus alive, unless the battery charger also is supplied by the same utility source which supplies the UPS in the first place. But let's

not -- let's say the DC stays put.

Then you would simply run on battery. You would not have any need for the bypass source until the bypass source comes back. That is the designed intent of it.

MR. ROSENTHAL: Let's stop this again. For now, let's assume that all the logic was up and running throughout the entire event. Let's assume that.

MR. MACHILEK: Yes.

MR. ROSENTHAL: We believe that on the normal and on the maintenance supply, for sometime between six and nine cycles, the voltage went to about -- somewhat more than half of its normal voltage, then went to zero for three cycles, and then was back up after a total of 12 cycles.

I think that the relay time that we were looking at in the switchyard and in the plant are a little bit off by a few cycles. So for six to nine cycles, you saw a degraded voltage on the normal input and on the maintenance bus.

Let's assume that the electronics power source is good.

MR. MACHILEK: Logic power.

MR. ROSENTHAL: Yes. The logic power. What should I design the UPS to --

MR. MACHILEK: To keep running.

MR. ROSENTHAL: And it would --

MR. MACHILEK: The inverter would keep on supplying power from the battery.

MR. ROSENTHAL: From the 5100 battery. What would the rectifier do for that small period of time.

MR. MACHILEK: Just sitting there being phased off.

MR. ROSENTHAL: Phased off by the logic.

MR. MACHILEK: That's correct.

MR. ROSENTHAL: Then when it saw the voltage good again --

MR. MACHILEK: The voltage comes good again, it recognizes that fact, it waits for a little under ten seconds to make sure -- see, if you have a utility switching, sometimes it comes back suddenly and you have about -- you deal with the supplies of networks coming.

So it makes sure that the AC, in fact, is stable and is back. It synchronizes to it and then walks the load back up. It means it increases the load gradually over about three seconds or thereabouts.

The reason why that feature was put in is if you come from a diesel generator, because more often than not, if a utility fails, a diesel plant starts up and the diesel doesn't want to see a sudden in-rush or increase of power. So we are ramping the load up on the rectifier.

Once that has taken place, you are back into

normal operation like you had before. Regardless of how short an outage or disturbance you have on the input, you end up with about 14 seconds non-availability of the rectifier.

So your large station battery will always see a 14-second discharge period, even if your disturbance was only nine cycles or six cycles or whatever it is. But the inverter simply doesn't care. It doesn't know. The logic often cannot differentiate if the DC power is coming from the rectifier or the battery.

It can only determine that DC is available within the window, as we call it, between the maximum and minimum battery voltage which exists on the DC link. So the inverter would sit there and run.

Now, since you lost your bypass power, the way the power supply input is configured on the units you have, the K-5 relay, the infamous K-5 would have switched over and would have put the logic on the inverter output. Now, that switch-over should or was, by design, done that the battery would not really be required to be there.

MR. ROSENTHAL: The little battery.

MR. MACHILEK: The little battery, yes. That means there is enough capacity in the power supplies to switch you over, to carry you over. The battery, of course, was there, still there, because we believed that the little

UPS is powering the pickups. That's our philosophy.

Yes, we are the only ones in the industry which has a control power battery. The rest of our competition, if you should lose all the power, you do not know what happened simply because you would not have any light indication and, number two, we have enough power in the battery that if everything goes bad, it still has enough power to open all the circuit breakers.

So we believe and I believe very strongly today that that battery is a very important feature; not for a single component failure or a failure, but if you have a more specific scenario which not one failure or two or three, but simply accumulation of failures, you never want to see. You don't want an aircraft to go down with 300 people on it, you know. It happens.

So in that spirit, I believe we do have -- we maintain the light indications, so if you come after this scenario, that you see or you can determine what happened. That feature failed during that event. That means on the end of the scenario, we did not realize the information we should have had. Namely, what caused the trip for the UPS.

When we got the first call of what happened, we never expected that the batteries were dead. That was not a consideration. We learned that after we got the site. But only in the investigations we did up to that point was

considering that the battery was in good shape.

We tried to find a scenario, either a multiplicity, happenings never seen before, to theorize of how could we possibly, and there we go now into circuitry of the A-21 board, how could we possibly get a lamp indication on the A-14, which is the meter panel, how can we possibly get no indication on the A-21, and that was really the focus of our intent to find out what happened was -- to assume all that.

When I talked to -- and I don't have a record of who was on the conference call, the very first one we got after the event, and people wanted to have a quick -- you know, what happened, tell me, tell me now, not tomorrow, not in half-an-hour, right now I want to know.

So we stuck our heads together. Well, we were on the conference call and we said, gee, in order to get a latch-to-latch and the lamp's not lit and the other lamp which comes on at the same time is, what possibly could cause it. So our first input was no way. The lamps had to be there, somebody had to push the button and reset it.

If you push that button, you reset all of the lights which were lit, reported lit, together with the ones which were reported not lit. They call come on at the same time, they all reset with the same button. So you cannot reset 15 lamps and have the other two lit. It doesn't work

that way.

So we said, gee, you know, since the lamps on the A-14 were still lit and the lamps on the A-21 were not, the lamps had to go away somehow. How can the lamps go away? Well, the only -- component failures were ruled out. You cannot have the same component failures on five modules and five modules are doing the same thing at the same time.

So we just said, hey, you know, to have a chip here or there or something went bad, forget it. There was no repair required. That means all units went on-line by simply being restarted.

Then Mr. Bill Zuke, I think some of you have mentioned, he says, you know, Rudi, he said there is something like an SCR latch-up, there is something which can latch-up the logic without getting actually a signal to do so. We looked into that while we were still on the conference call and said, well, how can that happen; we have a printer circuit board which is about 16-inches long or thereabouts, there is a ribbon going from here to there, I would have to have -- and I think the test showed ten volts, but we thought between five and six volts. I made that statement on the phone.

If I had a voltage difference on that ribbon from here to here of at least five volts, we thought at the time, it could happen. But what would not have happened is that

the latches would latch. You would have to have a trip and you would have -- after the trip, the lamps would have gone away and you wouldn't have known what was going on.

Let's say the SCR latch-up time was staying put. Then you had to switch down or off the controls, the control power supplies completely in order to get an outage. But there was no report of such a shutting down of the control modules, the control logic.

Matter of fact, it's not something you can easily overlook because, number one, you have to shut the module down or, if it's already down, you have to wait for the DC link to bleed off. If you restart the unit while the DC link is still up, you'll probably have a combination failure. So you wait for the DC to come down to about 30 volts. Then you can restart the unit.

So it's not something you can do in the haste of going through a scenario and forget about it. So we took the transcript and we searched it and there was no mention. When we came to decide, we questioned the personnel, we said was the logic reset. Why do we have to reset the logic, we pushed the reset button. I said, well, what did you do after you pushed the reset button. Well, we started the unit back up and it came back up.

So there was no resetting taking place. For that reason, we discarded the idea of the SCR latch-up of the

gates, which is the trip signal and what gave you the lamps on the A-14. All this was going through in haste. We were still on the conference call. I said, gee, folks, I cannot really -- all I'm saying here is we're just trying to, off the top of our heads, find a scenario which could cause the peculiar -- if it would have been a commercial situation, we would have said you're all full of -- you know.

The lamps were there. You just didn't -- you know -- you just reset it and then you thought, gee, God, I should have done this and that. But this wasn't the case. We were talking about reliable personnel, we were talking about more than one team which looked at it, so we did not consider -- we took as a fact that the A-21 lamps were not there.

The only other way, if the SCR latch-up can be discarded now, is, well, what else is there peculiar to the lamps. They all power with five volts. The only five volts in the whole system is to power these lamps. It comes from a five-volt power supply on the A-21.

So if, on all five units, the five volts would have gone away and stayed away for the whole period of time three teams looked at it, and then after pushing the button, all of a sudden they were there again, we just -- not reasonably, with any academics and even practical reasoning, we could come to a conclusion that that would be a

possibility.

So this is where we were. My statement, and I think it's on the transcript of the last meeting, was, folks, I have to consider it academic, it doesn't really do me any good to search for it for another ten years because we will never find out.

There is no way I know of, and if there are any experts elsewhere which can look at it, you're never too old to learn. But what I have to my command in the development lab in the Systems Test Department, I just can't do it for you. If I cannot duplicate a failure, no explanation would suffice. Show me, don't tell me, and I cannot do that.

For that reason, I suggest that to -- I don't know to what extent there is a need for explanation of the incident down to an understanding. This is where we ended up, that I said, you know, at this point, I say to myself let the powers to be and the experts will look into that some more.

All I was interested now is in how can I help you to improve the situation, not to prevent a scenario like this and give you a guarantee in writing and my paycheck, although it's not that big, but simply say what could we have or what would we do, what can I do today to help you, us, in order to improve the situation.

What I said to myself, well, the philosophy of an

UPS, as I explained at the beginning of my dissertation here, is not to ask for something to work which doesn't work before an incident, but take the risk away.

For that reason, I was suggesting the change of the A-27 board to say let me -- you always have to start on the bypass because the inverter isn't there. So if we say inverter preferred, it was a bad choice of words. You have to have the preferred supply to be the bypass or some others, like -- the other ones, you have to use a DC converter off the battery. But it has to be other than the output of the UPS.

Now, the battery supply in the commercial systems is not that reliable that we can work off the DC to power our power supplies. In your case, different story. So what I say to myself, if that K-5 would switch right away after the inverter is brought up and becomes available, you've got to switch at one time or the other.

Either you stay on bypass and you switch when you need it or you go and switch right away, then you stay there. This was the reason why I suggested the change, that the K-5 were not working would be -- the importance of it would diminish; again, not as a single point failure, together with a dead battery, two failures you've got to have, two or three.

You've got to lose the power for a reason, the

transformer failed, you had a bad battery, and to decide why to switch at that period of time. So I can take that risk away. I can say, okay, I have the getaway car running, ready.

Now, you would have detected the bad battery because if you started up the unit and you wanted to go from bypass to UPS, you may or may not. Chances are that you would not have to take the -- unfortunately, the problem is that you cannot detect the battery, you cannot measure a dead battery unless you discharge it.

The open circuit voltage can stay up to roughly two volts per cell, even on a very poor battery. You have to put some load to it and see how fast the battery voltage collapses.

Normally, we are doing that twice a year. In our commercial contracted maintenance procedures, we go in twice a year, every six months. We go on maintenance bypass. That means we switch the load actually around the whole UPS and go through and check out everything. So we never had in the past a battery which wasn't load tested either twice a year or at least once a year, because some customers objected to the twice a year for the simple reason that they did not want to come off the UPS twice a year.

They said once a year we have a general maintenance period. Some during a long weekend, they had

from 2:00 in the morning on Saturday till maybe Sunday. There was always some window where we could go in.

We never could at these installations -- and customers get over-confident. Nothing has happened to them for three years to say, well, why should I shut down twice a year. This is basically the way that the situation is still.

Now, can you design -- okay. As far as what you see in the manual was already describing the Navy style, unfortunately. We switched over, as I told you, to the Navy style, which is redundant power supplies. The fact that it's a relay K-1 and not K-5 is to keep off that -- somewhere I have a schematic with me on that -- which has two pairs of power supplies. Here it is. See, one, two, three, four power supplies and the relay is a K-1 relay.

It's the same battery still, everything is still --but this is actually the power supply plan which was described in the manual which was supplied in 1985, and I think my colleagues here from Field Service can go into why it wasn't the right one.

MR. ROSENTHAL: I read this manual twice over the weekend and I'm not sure that I was reading the right manual.

MR. MACHILEK: On Page 210, you have a description of the -- see, this one says here 817 K-1.

MR. ROSENTHAL: Right.

MR. MACHILEK: This is not your power supply.

MR. ROSENTHAL: So what is the manual for what's in the plant?

MR. MACHILEK: This is what it should read.

MR. ROSENTHAL: And who else has copies of this?

MR. MACHILEK: Angela Freeman.

MR. HESS: This is the one you sent up to Niagra Mohawk, right?

MR. MACHILEK: Yes.

MR. HESS: She's in our Engineering Department. Clarify your question, Jack. I don't think we got your question.

MR. ROSENTHAL: So Niagra Mohawk had a manual.

MR. HESS: That's correct.

MR. ROSENTHAL: Which I think is this manual, or a copy of it.

MR. HESS: I haven't seen it. Do you want me to take a look at it?

MR. MACHILEK: This is a copy of the manual that I brought and made a copy of.

MR. HESS: Okay.

MR. MACHILEK: This is the one which Mike gave me when I went up.

MR. HESS: Then this is the 1985 manual.

MR. MACHILEK: That's the 1985 manual.

MR. HESS: Okay.

MR. MACHILEK: You have to explain if it's needed here or why the 1985 got into that.

MR. ROSENTHAL: What we're going to be talking about today is the manual for the units that are in there and the drawings for what's really there.

MR. MACHILEK: Yes. The drawings --

MR. ROSENTHAL: And I don't know if Niagra Mohawk had them. They have them now, I assume.

MR. MACHILEK: When I came to Niagra Mohawk, Bob brought in a whole stack of drawings because you guys or somebody wanted them. I looked at that stack and said, you know, what are you doing with all these drawings and he said, well, these are the ones we have to give to you people and to the institute and what have you, so many copies.

So I said, you mind if I look at it, and we looked through the drawings and about two-thirds of them were not even the same equipment. They were 100-KW modules and God knows what. I conferred with him and said, you know, is the documentation I have in hand the proper documentation, and the answer was yes, that it was, except for some items which we could not recover. There was in 1985 a request from the plant to resupply a set of drawings.

The problem was that the original drawings which

were generated were not around no more. So we only had prints. The manual was there. So what somebody in that department which is filling the request for documentation just simply took the 1985 manual and sent it on to you. So what you have there was what we did build, in fact, in 1985.

MR. HESS: We don't know what they have on-site from the original units. Were you able to locate anything on the site?

MR. MACHILEK: In order to find out what the manual says exactly which was supplied was the units, we would have to rely on the plant to hopefully have one around somewhere.

MR. ROSENTHAL: Over the weekend, reading the thing I realized -- it looked like a generic manual where it said if you're a 60-KW, but if you're 100-KW you'll have an extra transformer. I can follow through. And that doesn't -- okay, fine. But then I get to very specifics where it looks like you get a logic trip if the SCR firing logic, without lighting some of the other lights.

For something like that, you've got to know whether that is the manual or a generic manual when you get into specifics like that, or maybe -- but you do have the drawings with you of the actual installed units, right?

MR. MACHILEK: The drawings which were drawn on-site, identical to what the unit is. The manual does not

reflect that.

MR. ROSENTHAL: And you've got copies of the drawings with you.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Good. Why don't we take a five-minute break.

[Recess.]

MR. ROSENTHAL: As an intro to where we are going, I have 90 percent confidence that the design changes that have been proposed make the machine less suspectable to spikes on AC supplies, et cetera. We recognize that we can't reduplicate the event short of throwing a crowbar across a major transformer in the plant. What we were doing up at the site was really simulations at best.

When you toggled off the AC supply to the control logic you did see a little spike on the output of the supply even with fresh batteries. So it is of interest to us to learn as much as we can about the logic response of the unit so we can fully appreciate what we are fixing and what vulnerabilities might still be there.

With that, let me give you back the floor.

MR. MACHILEK: What may be of value here is to speak a moment about what a battery is doing.

MR. ROSENTHAL: What kind of battery?

MR. MACHILEK: Any battery. What you just

described as having a little spike on it is what we refer to as a crack of the whip. If I may approach the board.

What you have on a lead acid battery is basically your open circuit voltage would be 2 volts per cell. Your charge voltage is 2.5 to 2.17 volts per cell. This is the constant voltage which comes out of the rectifier. It doesn't work like that on a standard UPS. The reason why I discuss it like a standards UPS is because the power supply of the little UPS behaves like that. If you loose the charge voltage, automatically the battery voltage drops down to 2 volts per cell. Unfortunately, it drops down a little farther and recovers to 2 volts per cell. We call this a crack of the whip.

The reason for that is that the series impedance was the battery. If you look at free flowing circuit, you have a little resister and a conductor and then you have your internal battery, your EMF, and then you have a little leakage, conductor, a resistor, and there is another leakage capacitor.

As soon as you have a charge curve in demand from the actual battery cell, you are deducting the voltage drop of the series impedance. If you go inside, you have a little plate, and then you have a little connection going up to the post and from the post there is a leak, which manifests itself in the sudden voltage drop and the spike.

It recovers and stays basically at 2 volts per cell and then slowly decreases in voltage.

This behavior would include the large station battery as well. In your case, the reason why it is different is because you have another rectifier which really keeps the voltage. So you are not dropping down on the large station battery. You will not drop down to 2 volts as long as the other rectifier is keeping the flow voltage up.

We have two rectifiers in your case on the large station battery.

MR. ROSENTHAL: Right. There is a separate rectifier.

MR. MACHILEK: There is a separate rectifier which is on the other side of the auctioneering diode.

MR. ROSENTHAL: I don't know what its capacity is, but I think that is moot.

MR. MACHILEK: It is of no consequence here.

The only difference in operation is that you would stay up at 2.15, because the other charger supplies flow voltage, whereas if you only had your own rectifier you would lose that source. So you have a redundant rectifier, if you will, installed in your system.

MR. ROSENTHAL: Our concerns with respect to this event is that these spikes are short in time compared to the time it takes relays to move and the shunt trips, et cetera.

I don't know what the time scales of something like this with a spike is compared to the CMOS logic, which I take it is running at 180 kilohertz.

MR. MACHILEK: The power supply is monitored. The CMOS logic is not affected by voltages below 16-1/2 volts. If you would have gone with that spike below you would have gotten an alarm which says your power supply is -- as a matter of fact, it would shut down on you. In UPS design you have to take the crack of the whip into consideration in your window for the maximum/minimum voltage you can allow the battery to operate, which includes the crack of the whip, of course. Otherwise all the UPS would go down as soon as you had discharge.

MR. ROSENTHAL: Do you want to go on or do you have a plan for today?

MR. MACHILEK: No. I'm here to explain or describe or theorize anything you may want to hear.

MR. IBARRA: Can we go into the details of what that battery was supposed to do?

MR. ASHE: So far Rudi has given us a broad overview of a very simplified diagram that we have here. Maybe as best you can understand or perhaps some of your people understand the actual wire connections to that diagram, I think we can then move on to the details of the A27 panel.

MR. MACHILEK: The only difference here is that you have another rectifier sitting here, AC/DC.

MR. ROSENTHAL: That's external to your scope of supply.

MR. MACHILEK: Correct. The idea here was that your own station battery is keeping the battery floating and the rectifier of the UPS is prohibited from recharging the battery.

MR. ASHE: How is the actual wiring done here, here and out here? Is it delta? Is it Y? Is it grounded? Is it ungrounded? The actual Nine Mile Point installation.

MR. MACHILEK: The input is a delta, Y, double delta with the Y, and the delta on the secondary. The input is a three-wire ungrounded. The only grounded three-wire system I know of is in Japan, which they call a wild leg delta. They are grounding one phase actually of the delta. I have never seen it in the United States or Canada.

MR. ASHE: So these are three wires, ungrounded delta input.

MR. MACHILEK: Ungrounded delta input.

MR. ASHE: Fine. That's that one. Let's move to this one.

MR. MACHILEK: This transformer is a delta -- I don't know if I brought it or not.

I did not bring it, but that is also an ungrounded

delta.

MR. ASHE: And the output?

MR. MACHILEK: The output is a Y with a floating neutral. We ship it as a floating neutral. It is up to the systems engineering, which would be Stone and Webster in this case, to determine if that should be grounded and where.

Generally the reason why we stay out of that is because of what codes you have to meet. NEC 250 basically tells you that a power source to a building can only be grounded at one point. In other words, if you come into a building and you have a delta Y transformer, which most of the building entrance transformers are, you have a wire directly ground via neutral point to what they call electrode or the main grounding point.

If you have an UPS, then you can consider that UPS as separately derived power only if you never parallel the two sources. Unfortunately, on a static transfer you do parallel the two sources. By code you cannot ground that system here separately. You cannot have two ground points and parallel the two systems or you are violating the code. Therefore you have to take this ground point here, this neutral point, and bring it over to this one. This is to meet the codes.

If the ground electrode is connected to a ground

grid or a main grounding distribution system meeting the definition of the National Electric Code, then you can of course connect that point to that system which is considered to be the electrode.

MR. ASHE: I think what you said is that the output is a delta from the inverter.

MR. MACHILEK: Correct.

MR. ASHE: That ground is a straight piece of wire that goes back to here.

MR. MACHILEK: This doesn't matter. Since this is a delta transformer, you are isolated.

MR. ASHE: But how is the Nine Mile Point installation, as best you understand it?

MR. MACHILEK: What we have here is another transformer. This is this transformer here. This transformer has to come to here. Due to UPS output it is no longer your building entrance transformer; it is now this transformer which constitutes the alternative source. Therefore the neutral point of this one and the neutral point of this one have to be connected together and grounded only at one point, either here or here or somewhere in between. It doesn't matter.

MR. ASHE: You are saying the output here is grounded back here with respect to this transformer.

MR. MACHILEK: These two neutral points have to be

connected together and grounded once. Whether here or here or anywhere else, to the best of my knowledge and interpretation of NEC, is immaterial.

MR. ASHE: To the best of your knowledge, how is it done at Nine Mile Point?

MR. MACHILEK: This one is connected to this one and this one is grounded.

MR. ASHE: All right.

MR. STONER: Let me clarify something. I thought you indicated that the AC source inputs were a delta.

MR. MACHILEK: Yes, sir.

MR. STONER: According to the utility drawings, the inputs are grounded Y's on the low side, which are the source inputs both --

MR. MACHILEK: Then whoever did these drawings didn't know what it was.

MR. STONER: You have verified that it's a delta.

MR. MACHILEK: I have known since 1962 they are delta Y transformers.

MR. STONER: Inside your inverter, you mean?

MR. MACHILEK: Absolutely.

MR. STONER: I'm sorry. I'm talking about the source to the inverter.

MR. MACHILEK: I wouldn't know.

MR. STONER: So you were speaking of the

transformer in your UPS.

MR. MACHILEK: Yes.

MR. STONER: Fine. That's what I wanted to clarify.

MR. MACHILEK: I have no knowledge of what goes on upstream from there.

MR. STONER: There is no drawing here. This is the drawing only for the customers' transformer.

MR. MACHILEK: If you start from the 375 or whatever high voltage line that is, you have three transformers before you get to this.

MR. STONER: I just wanted to be sure that we were talking about the same thing.

MR. MACHILEK: We are not. This is the transformer which actually is within the UPS, within the box, and there are only three connection points.

MR. ROSENTHAL: That makes sense, because you go delta Y, delta Y, delta Y. So you have got Nine Mile's Y feeding your delta.

MR. MACHILEK: We coiled the transformer distribution downstream only to that end, to assure ourselves that the phase that was the ground on the high voltage always was the phase that was the ground on the last one of the transformers.

MR. ASHE: Did you actually take it all the way

back up, though?

MR. MACHILEK: Yes, sir.

MR. ASHE: You did?

MR. MACHILEK: At least as good as you can establish from the drawings.

MR. ASHE: So the 575 is between A and C phase or B and C phase or A and B phase?

MR. MACHILEK: Correct, 200 volts to neutral, or 199.6, or whatever. It is basically 200 volts. They dropped down to 80 kilovolts. We took that ratio. If you follow the whole distribution of all the transformers, you end up with the same 200 to 80. That was the basis for asking for the adjustment of the rheostat or VRAC.

MR. ASHE: Most of the loads as far as you know were 120 volt loads. So when you say 120 volt out here, three phase, what you are really saying is between a phase and neutral.

MR. MACHILEK: I don't think you have a four wire distribution off the UPS.

MR. ASHE: For example, 1A, which powers a lot of instruments loads. Isn't that 120 volts?

MR. MACHILEK: Yes, but you have a transformer in between the UPS and that load.

MR. ASHE: What does this 208 mean, between where and where?

MR. MACHILEK: Phase to phase. If it would be a four wire system, it would be 120/208.

MR. ASHE: That is the way it is taken and used and then you go through a transformer if you need 120; is that the way it works?

MR. MACHILEK: That is correct. Or you could wire the Y out and use it as a neutral.

MR. ASHE: Wouldn't it be easier to do that?

MR. MACHILEK: Our system allows you to work it as a three wire system or a four wire system, floating or neutral ground. We don't know how it is being used, so we give you all the options.

MR. ASHE: If they have a ground and a neutral here, is that the same point? At this point. A ground and a neutral.

MR. MACHILEK: The ground and the neutral can never be the same point except as executed in accordance with NEC. That means the neutral is white and ground is green. If you have a distribution box on the wall, this is where the ground and the neutral can be connected together because that point is considered to be the point of the ground electrode. But you are not allowed to connect the neutral and the ground together in the box.

MR. ASHE: Your box has a neutral.

MR. MACHILEK: My box has a neutral and it has a

safety ground, which goes basically to the cabinet.

MR. ASHE: The neutral in your box connects where in your box?

MR. MACHILEK: Nowhere. As shipped, it doesn't connect anywhere. It is up to the systems designer, the one who determines what the whole power system incorporating the UPS looks like to establish if he has to ground the neutral or bring the neutral to another point which is grounded or let them float. We have floating neutrals in cases where all the loads are step-down transformers, like on 480 volts. We distribute three phases and then we step down all the loads to 120 or 208 isolation transformers, which only secondarily have an isolated ground for that system. The reason we do that is because in large computer centers you do not want a common ground between different missions or operations, and you isolate it that way.

MR. ASHE: Do you have a ground lug in your box?

MR. MACHILEK: Yes.

MR. ASHE: That connects where?

MR. MACHILEK: We don't connect it. Somebody connects it.

MR. ASHE: But it is inside your box?

MR. MACHILEK: Correct.

MR. ASHE: Connecting where inside your box?

MR. MACHILEK: To the neutral of the transformer.

That means you have the transformer and out comes one, two, three, four terminals.

MR. ASHE: I got you.

MR. MACHILEK: Unless we have a turnkey job, meaning we are also the installers, we do not get anywhere near telling you how to do things. The installer usually is responsible for the codeworthiness of what he is doing.

MR. ASHE: Very good.

MR. ROSENTHAL: Ultimately I want to learn what the logic is.

MR. ASHE: I think we need to go to the A27 board and go through some of the details of how this unit isolates when that DC power supply drops down and show the signals why it isolates: CB1, CB2, CB3, all of them. And through the details of the A27.

MR. MACHILEK: Then we need A27.

MR. ROSENTHAL: We will need copies of these prints. I leave it up to you guys to designate those things you consider proprietary or not. We will protect the proprietary but we still want a copy.

MR. MACHILEK: This is A27, which was supplied with the unit. The wiring of it was exactly like that.

MR. ASHE: Maybe I asked for the wrong thing. We clearly understand this guy. No problem. What I think Jack is interested in is the downstream logic down here and

showing how it sends the signal.

MR. ROSENTHAL: Or you could start here and work backwards.

I take it that you energized the shunt trip coils on CB1, CB2, CB3 to shed the loads.

MR. MACHILEK: You have to get A21.

MR. ASHE: When this voltage out here drops below a certain value, we want to show how it isolates this guy, this guy, and this guy.

MR. ROSENTHAL: Help me on this drawing a little bit. You energize the shunt trip to trip the breakers, right?

MR. MACHILEK: Correct.

MR. ROSENTHAL: These contacts here, the two K1's, two K2's and two K3's, come from the 40 volts.

MR. MACHILEK: It's right here.

MR. ROSENTHAL: It's not these?

MR. MACHILEK: No.

MR. ROSENTHAL: What is the difference between this K1 and that K1? These are different relays, aren't they? Or is in fact the same relay shown in two places?

MR. MACHILEK: No.

You will see here a dotted line.

MR. ROSENTHAL: Right.

MR. MACHILEK: That dotted line is describing what

we call the A27A1 board. That relay on the A27A1 is associated with its conduct on the A27A1. These relays here, which are not within the confines of the printed circuit boards, are actually hard mounted on the A27 panel.

So the K1 here and that K1 associate together.

MR. ROSENTHAL: So these are to the motor operators.

MR. MACHILEK: You can take a scissors and cut that.

MR. ROSENTHAL: I understand that.

In order to open up CB1, CB2 and CB3 --

MR. MACHILEK: Shunt trip it.

MR. ROSENTHAL: Which means that you close these contacts, which takes the 40 volts from here.

MR. MACHILEK: And dumps it on the shunt trip coils.

MR. ROSENTHAL: Are there other sources of electricity to the shunt coil?

MR. MACHILEK: No, sir.

MR. ROSENTHAL: If that is the case, then you open CB1, CB2, CB3 by closing these contacts, which means that you do something to these relays.

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: You change the state of these relays.

MR. MACHILEK: Correct.

MR. ROSENTHAL: I am sort of like working it backwards at this point. These relays are sitting at plus 20 volts here and going off to something off this page.

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: I don't know if these are normally open or normally closed, but when you make up the logic to change these states, you trip. So what goes off this page if I am working it backwards?

MR. ASHE: Would it be easier to work it the other way, though?

MR. ROSENTHAL: I'll leave it up to you. Would it be better to work it backwards or forwards?

Similarly, I want to look at CB4 and the logic that makes CB4 work. If you want to go from the front back or from the back front, it is up to you.

MR. MACHILEK: This is what we call the top schematic. This gives you all the wiring which is between the printed circuit board. A13 is the card cage, and load division panel, and then the power supply panel A27 is probably somewhere right here. This is the A27 which we are talking about.

MR. ROSENTHAL: For the transcript, what are we looking at?

MR. MACHILEK: We are looking at what we call the

top schematic diagram, Drawing No. D-110711102-77223.

The CB3 has its three main contacts, phase A,B,C.

As you will see, the neutral comes directly from the output transformer neutral and is brought out to a terminal which is marked N. What you want to do with it is up to the user at this point.

The phase A,B,C, now we do have high-speed fuses on the output. The reason why they are are there, if you should have a short in the transformer itself, then one of those fuses will go if you try to transfer at the same time because then the power from the other side would go in.

MR. ROSENTHAL: But those fuses didn't blow.

MR. MACHILEK: No. You have got a motor operator. All the motor operator is doing is simply mechanically closing and opening the circuit breaker much the same you would do it manually.

We have a shunt recoil. Energizing of the shunt recoil will trip the break open.

Then we have auxiliary conducts, which are two types, two normally opened and two normally closed, and as you see, we are only using the two normally opened ones.

In order to find out what the shunt tripper is powering we have to follow wire 595 and 589. This 595 and 589 go to a plug, which is called A27P1. We should go directly to the A27P1 plug. Unfortunately we don't have the

wire numbers on it. A27P1, 9 and 15.

MR. ROSENTHAL: So we are talking about K3 that we just followed and CB3. So we now went from CB3, the AC output of the aux, and we followed that back to --

MR. MACHILEK: Which means that you are coming from plus 20, which if it is energized goes through the coil, comes back and here and goes to the minus 20. So we put 40 volts DC directly without any other interference and put the trip voltage on here.

You will find a similar situation true for the input in the battery breaker.

MR. ROSENTHAL: So now I have to make up the logic for K1, K2 and K3.

MR. MACHILEK: That is correct.

MR. ROSENTHAL: They are sitting on plus 20 volts and then they go off this board.

MR. MACHILEK: Since this is the A27A1, we have to identify the plug. The plug is at J2, 9, 12 and 15. So we go to A27P2, plug 2 and jack 2. There is always a plug and a jack. And 9, 12 and 15. There is 9; there is 12; and there is 15. BBTR, OBTR, IBTR -- well, the "R" you have to leave of. The signal is BBT, IBT and OBT. "R" simply says it's a relay.

MR. ASHE: Okay. We are going to go back up stream.

MR. MACHILEK: Then 15 is 273; 12 is 272; and 9 is 274, and 274 was OBT, and there is IBT, and 15 is BBT. That should jibe with what we have here.

MR. ROSENTHAL: Let me stop for a second. We were looking at Drawing No. 110611334.

MR. MACHILEK: Correct.

MR. ROSENTHAL: Now we are going backwards.

MR. MACHILEK: Now we have to follow those three wires as they go into that wire bundle here, come up here, and go to 272, 273, and --

MR. HESS: I think it's 274, not 774. It's 274, which is right.

MR. MACHILEK: Now we have to take A13, the motherboard. If we take those three, 9, 12 and 15, we established that 9 is K3, 12 is K1, and 15 is K2. What we were saying here was that corresponds with plus 20.

MR. ROSENTHAL: These are just small relays with 100 or 200 millisecond strobe time or something like that?

MR. MACHILEK: Correct. Because we are switching a total of probably 2 milliamps at the outside.

MR. HESS: You are on J3.

MR. MACHILEK: It says here A13P3, and since the plug goes into a jack we have to look for an A13J3 on the A13 motherboard. A13 is the card cage and everything is plugged into the motherboard. Those connections are now

made through OBT, right here, IBT, and BBT.

Now you are on your own because you have to follow the printed circuit. The BBT, for instance, goes to the A1; the IBT goes to the A1 right besides it; and the OBT goes --

MR. HESS: It goes nowhere because it didn't shadow well.

MR. MACHILEK: Wait a minute. Let's go slowly.

MR. HESS: We'll find it.

MR. MACHILEK: Let's get the A1 and the A20.

MR. ROSENTHAL: So that goes to the motherboard and then on to the individual cards?

MR. MACHILEK: That is correct.

MR. HESS: This one here, Rudi, is IBT and then this one is IBR, and this is pin 11 on the A20, which is the OBR.

MR. MACHILEK: Right here. The input breaker, IBT, goes to A12; the battery breaker goes to A13; this goes to A20, pin 11. We are there.

A1, 2 and 3 incorporate the shunt trip, right here; input breaker shunt trip goes to a transistor driver output. This is the output of that logic against ground. In other words, we take the plus 20 volts and go directly over a transistor driver to ground. The controller is telling you once the K3 is closed and other conditions are

correct there are other conditions which are tripping that relay.

MR. ROSENTHAL: Here we are going to find all the logic that causes ultimately CB1 to open.

MR. MACHILEK: The same thing should be true from No. 3. There you have a transistor driver; ground against plus 20 powers that relay. The same as you will see under A20.

MR. ASHE: Can we back up and see what saturates this guy right here? Obviously if this guy goes to saturation, you pick up the relay. Can we show reduced voltage out here causes this guy to saturate?

MR. MACHILEK: You would have to go to A21. The question is what portion of the circuity tells this transistor to saturate, right?

MR. ROSENTHAL: Right. In normal operation, and also we can think in terms of reduced voltage.

MR. ASHE: Obviously we are saturating this guy, so we bring this guy. The collector here goes down to ground to protect the relay. What I think we want to establish in this drawing trace here is when this guy goes low we want to show how we saturate that transistor.

It may be easier to work this way. There must be something here that comes back into the front side of this transistor over here.

MR. MACHILEK: Let's trace it. We are bringing it over to J4. A27 J4; A27P4. We have the minus 20; we have ground.

MR. ASHE: J4-8. Rudi, you come over here and you come straight over on a line to the A30 bypass panel.

MR. ROSENTHAL: Let's take a five-minute break.

[Recess.]

MR. ROSENTHAL: We are now on the record. Frank Ashe.

MR. ASHE: Before we went off the record we had saturated Q1 on drawing number D-11007116877223. We were attempting to see how Q1 was saturated by tracing the signals upstream of Q1. Rudy, do you want to take over now?

MR. MACHILEK: We went to the other end for a moment and said the plus one to the ground and the minus one is distributed throughout the cage door on the areas. On the A18 board we have the plus one at the ground and the minus one and monitoring it over high position regulator. There is some adjustment for the three points and will come out with PSF. The PSF signal is brought over to the A21 PSF.

MR. ROSENTHAL: What is the function of PSF?

MR. MACHILEK: PSF, it monitors the control voltage to be within maximum of 19 volts I believe, and a minimum of 16. That's the adjustment range of that

monitoring.

MR. ASHE: Excuse me. Is that monitoring both sides there, plus with respect to neutral and minus with respect to the --

MR. MACHILEK: Minus, plus. If either one of the two would for instance go below 16 and one-half volts it would issue a PSF signal which would go over -- comes in here -- and switches the latch but uses a Q output which does two things. Number one, it brings the light on the A21 board which says power supply failed. Number two, on a separate circuit over a gate which simply detects also the frequency and the voltage on the frequency. It is just we use the same one for both.

MR. ASHE: That's AND gate there.

MR. MACHILEK: Right.

MR. ASHE: How do you get this guy again?

MR. MACHILEK: This one it gets from PSF comes up here and sets the latch.

MR. ASHE: Right. We got that one.

MR. MACHILEK: We got this one.

MR. ASHE: That's one signal going to the --

MR. MACHILEK: This is one signal.

MR. ASHE: How do we get this guy?

MR. RANSOM: They are just together because there are not enough inputs on this gate over here. Either one

of these going --

MR. MACHILEK: Either one of the two. This is not this plus two, it's either the one or the two.

MR. ASHE: That's a NAND, n-a-n-d.

MR. MACHILEK: Either one, yes. Giving you number one the light, which is the light on the A14 which says logic failed, and giving you the trip signal over to the number three to the --

MR. ROSENTHAL: Trip light on A14.

MR. ASHE: This is SSTR and has to go back over here somewhere.

MR. MACHILEK: The SSTR --

MR. ROSENTHAL: It changes SSTR from high to low or the other way.

MR. MACHILEK: And the SSTR --

MR. ASHE: This drawing right here somewhere, right?

MR. MACHILEK: No, the SSTR should go directly -- you have to trace that back. The transfer from one point to the next.

MR. ROSENTHAL: From here we decided that it had to go to that transistor, C1.

MR. MACHILEK: C1, yes. SSTR, goes to the trip relays -- you have to trace it because I don't know how it comes in. The SSTR goes to the -- we have to locate the

mother board and comes out --

MR. HESS: The mother board on the top print.

MR. MACHILEK: It comes out of the A1 off the A21 and I think it goes to the

MR. ROSENTHAL: The A23 and the A21.

MR. MACHILEK: It gives you a leg off and gives you this CB 1, 2 and 3 trip.

MR. ROSENTHAL: That corresponds to Q1 going to ground.

MR. ASHE: You have it to SST1 here but we have to make the relationship between this guy and Q1 saturated. Then, if we can do that, that's it.

MR. ROSENTHAL: No, because this is monitoring the voltage; right?

MR. ASHE: Yes. The Q1 has to saturate it, so that has to --

MR. ROSENTHAL: We have to get to Q1.

MR. ASHE: Right.

MR. ROSENTHAL: Also, this should have lit -- what other thing should it have lit?

MR. HESS: It also ties over to B 834.

MR. MACHILEK: Yes.

MR. HESS: This is 163, wrong one.

MR. MACHILEK: We still have to come over to the A1 board. I can't understand where this SSTR comes over

here. I have to get the signal -- therefore, I have to come in here somewhere, and I cannot spot it. Where is the --

MR. HESS: It also goes under the TB bar too.

MR. ROSENTHAL: Isn't this PIN 23 on some connector?

MR. HESS: That would be the plug in connector, Jack. Is that the A21 card that you have?

MR. ROSENTHAL: Yes. It's the A21. A13, A21 card.

MR. HESS: That comes off and it would come off on J8 which is the SSTR command.

MR. ROSENTHAL: It says 23 here.

MR. HESS: That's PIN 23.

MR. ROSENTHAL: PIN 23 on connector J8?

MR. HESS: No. That's the plug in PIN.

MR. ROSENTHAL: Right.

MR. HESS: You plug the board in and that comes off that -- that coincides with this PIN right here. That comes off the board on an SSTR which comes off of here, which is J8. J8 is over here, which is right -- that's SSTR right there.

MR. ASHE: That comes in here somewhere.

MR. HESS: Yes.

MR. ASHE: Is that what it does?

MR. HESS: It doesn't show a wire coming off of

it.

MR. MACHILEK: We have three latches here now, one for each breaker.

MR. HESS: That's right.

MR. MACHILEK: We have to set the latches, it's that simple. This is UPS okay -- input breaker closed, okay. This is logic command. The shunt trips --

MR. ASHE: Basically, all we need to do is make a relationship between SSTR and over here somewhere.

MR. MACHILEK: Yes.

MR. ASHE: It looks like by the way of this thing over here.

MR. MACHILEK: Yes.

MR. HESS: SSTR also comes off the A13 P5 connector which is right there.

MR. IBARRA: Hold it. That's a PIN number, right? Isn't that a PIN number there?

MR. HESS: What breaker are you looking for, Bernie?

MR. MACHILEK: We have to get a signal to trip those three characters, CP1, CP2 and CP3.

MR. HESS: There's SSTR, off the TB1. As you look here it's tied in there. It's tied in there and it's tied in there.

MR. MACHILEK: What way are they going?

MR. HESS: That come back up -- that follows the 648.

MR. MACHILEK: That means with this three there, that's why I came --

MR. HESS: That's right.

MR. MACHILEK: How do they come in here now?

MR. HESS: You find it on that side. In fact, I found it on the mother board up here. Let me fold this out here.

MR. MACHILEK: You have to see where we come back. That means we get the SSTR --

MR. HESS: You tie SSTR, so SSTR ties over here on the A34 card here.

MR. MACHILEK: Yes, this is fine. That's where the transfer, but we also have to go -- this is the one that I am looking for. Where does it go.

MR. HESS: It goes in right there.

MR. MACHILEK: SSTR on 13 of P5.

MR. HESS: P5 13, mother board. You want mother board?

MR. MACHILEK: Yes.

MR. HESS: Five. SSTR.

MR. MACHILEK: SSTR, right.

MR. HESS: There is also an SSTR connection off of the A21 card.

MR. MACHILEK: This is the A21. I am looking at

the A1. We have to split it somewhere. It goes to the A21 -- it comes from the A21. It goes on to what --

MR. HESS: Down here we split it up, off here. You split coming down.

MR. MACHILEK: I don't know how we did it here. I don't know how we did it.

MR. ASHE: Would it be better if we go off the record and try to figure this out.

MR. ROSENTHAL: There's a lot of blank space on the tape right now. Other than wrestling papers and people going on.

MR. ASHE: We can stop it. Let's stop it.

MR. ROSENTHAL: Let's go off the record.

[Discussion off the record.]

MR. ROSENTHAL: Okay, let's go. Do you have it?

MR. MACHILEK: It changes the mother board from an SSTR to a UPT. The question was, where is it happening?

MR. ROSENTHAL: We are back on and Rudy is talking.

MR. MACHILEK: The SSTR on the A21 which is over here, goes from here to the A20 boards. On the A20 board it comes in on -- where does it change to --

MR. RANSOM: Right here on A21 it's STR. That is right where it changes, right there.

MR. MACHILEK: SSTR PIN 23, all right, is

statically connected in 53 on the A20. You see that is called a UPT.

MR. ROSENTHAL: Now we have UPT --

MR. MACHILEK: It's the same --

MR. ROSENTHAL: On drawing D-110071196.

MR. MACHILEK: This is where it comes in and trips. It trips the output breaker if other conditions can also trip it, right? Either one of those ones is tripping it, and one of those is the UPT. Also, it comes in on the K1 as a UPT and trips number 1B input breaker at the same point. Breaker and input breaker is tripped on UPT signal off the A1 and off the output breaker.

MR. ROSENTHAL: By design then, we have now followed through that a low voltage on the control power supply should--MR. MACHILEK: No, low voltage on the logic bus.

MR. ROSENTHAL: On the logic bus should result in tripping of --

MR. MACHILEK: Tripping of all three breakers.

MR. ROSENTHAL: Right. Now, we go to --

MR. MACHILEK: It also goes to the A34 -- do we have an A34. What we have to show here now is that -- is it SSTR or SSTR comes in the A34 and does all kinds of things now.

MR. ASHE: Such as?

MR. MACHILEK: Well, we should end up in a gate in a logic that says that if a bus is available -- this is a trip signal. If a bus is available -- let me see how we are going to do that. Transfer ready to bypass and this one comes from either -- now we have to tie it into the SSTR, okay? That means we have to walk ourselves --

MR. HESS: We have to walk ourselves all the way through.

MR. MACHILEK: Which one is it which we are getting down here. This one -- this, if closed, and coming out of here, go over to the 4066 and if it is selected, and coming through there.

MR. ROSENTHAL: That's if the selected, you mean the auto select? -

MR. MACHILEK: A lot of conditions have to be -- number one, it checks if the CB4 got to be open in the first place, okay? That means that if somebody goes and goes to CB4 for instance, it would disable everything. If the CB4 is open and if the bypass sensing -- BC CA is showing that number one, the voltage is within the window and the frequency is okay and we are coming I believe from -- we are in sync -- now we have to bypass -- that is reset -- the way this is drawn out you can't -- coming up there and this is in the UV/OV transfer -- which transfer are we looking for, UPS, right?

If we get an UPS -- this is the UPS --

MR. HESS: That's an output.

MR. MACHILEK: This is the output.

MR. HESS: Here is your SSTR right up through here, Rudy. That comes up through the --

MR. MACHILEK: The TP25 --

MR. RANSOM: I think what it does is, it comes in through here.

MR. MACHILEK: Yes, I am trying to find my way through here.

MR. RANSOM: Right here it's saying okay, we want to trip the breaker but we are looking to see if --

MR. MACHILEK: We need a command to the -- I am looking for the command to the CB4. If I get a one here I got a static switch on, all right? This one is giving me the conditions if the bypass breaker is in fact open if I don't have a load down. This is in the input, and this is the output.

MR. RANSOM: Right here is the critical bus sensing. We are also looking at the bypass fault sensing back through here. This signal down here is going to try to hold off this signal if we are at tolerance, and this signal is the signal that comes off of here which comes back to your SSTR.

MR. MACHILEK: Okay. Here we go.

MR. RANSOM: It comes back through to your SSTR.

MR. MACHILEK: Yes, 4066.

MR. RANSOM: That is going to hold it off if your bypass is not available or not in sync with your critical bus.

MR. ASHE: In terms of time, how long does it take it to make up its mind?

MR. MACHILEK: One hundred-twelve micro seconds.

MR. ASHE: Once it makes up its mind that you are out of tolerance.

MR. MACHILEK: Yes.

MR. ASHE: How long does it hold there?

MR. MACHILEK: How long does it hold there?

MR. ASHE: Right.

MR. MACHILEK: It holds there until the bypass breaker has closed. The bypass breaker tells them it is closed then we remove the signal. In other words, the CB3 does not go open until the CB4 is closed unless bypass is not available and the CB4 is open.

MR. ASHE: Once it decides that the bypass is not available --

MR. MACHILEK: Once it is not available --

MR. ASHE: Very quickly.

MR. MACHILEK: If it decides the bypass is not available you will never get a transfer signal out of here.

MR. ASHE: What I am saying is, what is the minimum time it can hold that?

MR. MACHILEK: That is not available?

MR. ASHE: Suppose that one instance of time the bypass isn't available but for whatever reason it creeps back up and readjusts, and everything comes back.

MR. MACHILEK: Once it becomes available --

MR. ASHE: Right. Right away?

MR. MACHILEK: Then you get it a sync signal, okay sync signal, and then it waits until it is synced. Once the sync is confirmed, then you get the third condition which says that you are in sync which allows you to advance a command. You are checking the voltage, okay, making sure that the voltage is within plus - minus ten percent.

MR. ASHE: Right.

MR. MACHILEK: You are checking the frequency which says the frequency is within one-half a hertz. If these two conditions are right, then you wait until it is synced. If you have a sync confirmation, that means that if you are within seven degrees of each other -- okay -- then you release the third condition and from then on it takes you 120 micro seconds to close the static switch.

If you takes you one-half hour to sync, then you know that it simply isn't -- that the conditions are not given.

MR. ASHE: How long -- it resets immediately.

MR. MACHILEK: There is no reset. It is not the light, it is simply a gate.

MR. ASHE: I understand. If you come back in sync such that your criteria met, it will permit --

MR. MACHILEK: Immediately to transfer.

MR. ASHE: Right.

MR. MACHILEK: If the transfer is still desired. That means -- you know what I mean.

MR. ASHE: Right.

MR. MACHILEK: If you get an SSTR and all the other conditions are right, you have 120 micro seconds and you are on bypass.

MR. ASHE: I am asking all these questions really, because I think these units went out of sync just prior -- after the transformer fault. That's why it wouldn't transfer. They locked out.

MR. MACHILEK: No.

MR. ASHE: Just prior.

MR. MACHILEK: You lost voltage.

MR. ASHE: The question could be asked why didn't they transfer. Why didn't they transfer to maintenance when you had a maintenance good. What I think happened was, when we got the fault these units picked that the maintenance supply was no good, it locked out the transfer and it held

that lock out because it wasn't any good. The voltage decayed and the unit tripped out. That's why they lost the bus. Is that a fair assessment of it?

MR. MACHILEK: I would suggest to go the other way. The UPS was running. The voltage suffered a decline of the phase speed, which means that it is phasing off. No problem. It's running on battery now. The bypass voltage now suffers a decrease in voltage which causes the power supply to go out of limits.

MR. ASHE: Right.

MR. MACHILEK: Which issues the trip signal. But the fact that the voltage has to decrease first before you get the trip signal means that it is assured that the bypass wasn't there at the time you got your trip signal.

MR. ASHE: That's right. You are actually saying the same thing. The units lost sync prior to tripping.

MR. MACHILEK: What does this have to do with sync?

MR. ASHE: To me it lost sync prior to tripping. That's why --

MR. MACHILEK: You did not lose sync. The voltage decreased.

MR. RANSOM: What do you call losing sync, locking out?

MR. ASHE: Prior to the event you were probably in

sync, and by in sync your three criteria -- difference criteria --

MR. MACHILEK: Delta --

MR. ASHE: Your maintenance supply were met so it will permit a transfer.

MR. MACHILEK: Right.

MR. ASHE: When the B phase fault occurred, I think the electronics picked this up right away and said hey, this maintenance source is no good. I cannot do transfer.

MR. MACHILEK: Right.

MR. ASHE: Subsequent to that, the voltage decayed and isolated the unit.

MR. MACHILEK: It happened at same time. It's the same voltage. It's the same voltage. I suggest the Delta V is really the one which locked them out because as the voltage decayed there is no reason to go out of sync. A phase B reaction of voltage does not change the frequency of the --

MR. ASHE: Right.

MR. MACHILEK: Therefore, if you were in sync --

MR. ASHE: It was amplitude.

MR. MACHILEK: Yes.

MR. ASHE: Yes, voltage difference.

MR. MACHILEK: The amplitude locked yourselves

out.

MR. ASHE: Right.

MR. MACHILEK: As soon as you passed the ten percent -- as soon as you decrease below 90 percent it said no more transfer.

MR. ASHE: I guess what I am trying to get to is the order which this occurred. I am saying I think, these units lost sync prior to tripping.

MR. MACHILEK: Why do you say lost sync?

MR. ASHE: Because I think your electronics picked it up --

MR. MACHILEK: Why should it lose sync?

MR. ASHE: Let me say --

MR. MACHILEK: You have one voltage and you have --

MR. ASHE: I'm sorry.

MR. MACHILEK: You have another voltage. Why should it lose sync?

MR. ASHE: I am saying that I think we are having problems with the word "sync", what sync means. It blocked the transfer prior to the unit trip.

MR. MACHILEK: Correct.

MR. ASHE: Okay. So, we are saying the same thing.

MR. ROSENTHAL: By the way, this no longer looks

like a 60 cycle sine wave because it has all the crap on it now.

MR. MACHILEK: It doesn't matter. As long as this coincides, that's all it looks at.

MR. ROSENTHAL: Right.

MR. ASHE: A signal was generated to preclude transfer prior to the unit's tripping?

MR. MACHILEK: Right. Prior, we mean may be a circle or -- right. The time constant it takes for the output capacities of the power supply to --

MR. ROSENTHAL: Let me go back to CB3. We took that as an example where we said that you had to apply voltage to the shunt coil to open this nice big break.

MR. MACHILEK: Correct.

MR. ROSENTHAL: You had to apply that early enough, before the power supplies went dead, or there wouldn't have been any power to in fact open CB3.

MR. MACHILEK: That is correct.

MR. ROSENTHAL: I am advised that that is typically maybe like five cycles that you had to apply the current to the shunt coil.

MR. STONER: Do you know how long it is for that breaker?

MR. MACHILEK: It takes about 50 milliseconds for the blades to actually open. A few cycles, I would say, at

least two or three cycles. It wouldn't matter.

MR. ROSENTHAL: Two to five to --

MR. MACHILEK: Right.

MR. ROSENTHAL: To a 48 volt nominal coil you normally apply 40 to it. You had to put some sensible voltage on that, or that breaker wouldn't have opened -- which we know it did -- for a couple of cycles.

MR. MACHILEK: Right.

MR. ROSENTHAL: When we were following the under voltage sensor we didn't see any latches, right? They were all large gates.

MR. MACHILEK: No. The power supply which isn't latched -- if you lose the power supplies then you do not latch.

MR. ROSENTHAL: It was PSS --

MR. MACHILEK: If you lose the voltage it causes --

MR. ROSENTHAL: It's coming in but there's no latches here.

MR. MACHILEK: Oh yes, sure.

MR. ROSENTHAL: I'm sorry, that's a latch. We just decided on a micro second level.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Nano seconds and this RC here, micro seconds. These lights then --

MR. MACHILEK: They come immediately after the latch has been --

MR. ROSENTHAL: Right. We got some of them on some of the units. I remember seen an under voltage/over voltage load.

MR. ASHE: That's right.

MR. MACHILEK: Different --

MR. ASHE: He's referring to the as-found data which I think Wayman is familiar with. Perhaps as recorded data than as-found.

MR. MACHILEK: What we do not know is how fast the voltage actually decayed from the 200 kilovolts to the 80. It just didn't close that --

MR. ASHE: Wouldn't the oscillograph on a high side show some rate there?

MR. STONER: I don't think you can take that as an indication of what was happening on the low side.

MR. MACHILEK: There was some decay time I assume, right when the transformer failed.

MR. STONER: Decay time?

MR. MACHILEK: Of the actual voltage.

MR. ASHE: Reduction in voltage.

MR. STONER: The reduction was almost instantaneous.

MR. MACHILEK: Almost instantaneous.

MR. STONER: Constant.

MR. ASHE: Physical insight, and I am not an --

MR. MACHILEK: You do have --

MR. ASHE: Three-quarters of the cycle I think it dropped ten percent, and when you got four fault current flowing to the step function down --

MR. MACHILEK: We did the three test.

MR. ASHE: Repeatedly. We demonstrated these units.

MR. MACHILEK: You know, it was the -- there is enough capacity in the output of the power supplies --

MR. ASHE: That's a question that I had. Do we have a blow up diagram of the power supplies in here?

MR. MACHILEK: No.

MR. ASHE: That is a transistorized regulator.

MR. MACHILEK: It's a linear power supply. It is not a switch power supply or anything like that. It's simply a --

MR. ASHE: Transistor regulated.

MR. MACHILEK: Yes. It's a transistor regulated filtered power supply.

MR. ROSENTHAL: You just decided that you have to squelch Q1, Q2 and Q3 in order to make those circuit breakers pop.

MR. MACHILEK: In order to make the circuit

breakers.

MR. ROSENTHAL: You have to do that --

MR. MACHILEK: You have to have enough --

MR. ROSENTHAL: Cycles.

MR. MACHILEK: You have to -- consider here that the shunt trip, even if the 40 volts decay considerably, the shunt trip still would be effective, you know. The trip comes from the fact that the logic cannot stand anything less than six and one-half volts. You can shunt trip with considerably less voltage -- the current goes up, okay?

MR. ASHE: What was the design intent of that trip to isolate like this? Obviously, the logic would reduce voltage and cannot function properly. Would it destroy the unit or would it do something else?

MR. MACHILEK: It would cost you probably eight fuses.

MR. ASHE: A few SCR's or a few other proponents?

MR. MACHILEK: It shouldn't. It should not.

MR. ASHE: If the fuses act faster than --

MR. MACHILEK: The current limiting fuses protecting the semiconductors -- the switching SCR's -- it is really a question of who is protecting whom, you know.

MR. ASHE: Are the fuses thermal?

MR. MACHILEK: The fuses are fast acting. Instantaneous.

MR. ASHE: Fast acting thermal, right?
MR. MACHILEK: Instantaneous. They have --
MR. ASHE: They are faster than SCR's is what you are saying.
MR. MACHILEK: They should protect the SCR.
MR. ROSENTHAL: We followed one circuit to the power transistor that I raised earlier and we can start on the next one.
MR. ASHE: Would it be helpful if you perhaps trace it out beforehand, do you think?
MR. MACHILEK: What do you want to trace, to be exact.
MR. ASHE: I think what he was trying to say was that he wants to go through every way you can get isolation from the -- CB1, CB2, CB3 isolated. We traced one. We know for a fact that when the DC voltage was dropped it repeatedly tripped on all of the units.
MR. MACHILEK: It is relatively easy. Why I am saying that is, you have to get an SSTR -- from here on we know what happens, which is tested.
MR. ASHE: That's right.
MR. MACHILEK: Once we got a logic output here we tripped --
MR. ASHE: Right.
MR. MACHILEK: The question is, how many ways can

we do that, right?

MR. ASHE: Right. That's three --

MR. MACHILEK: We can do that one, two, three, four, five, six, seven ways. Any inputs to that gate here will --

Basically what we have to say is how many of those inputs are trip --

MR. ASHE: Triggered.

MR. MACHILEK: I did a working analysis, and if you permit me to just -- we said you have all the inputs which are latched. This is the trip sequence initiation which is all what you see down there, okay?

MR. ASHE: Okay.

MR. MACHILEK: Then we have beside the A21 we have other inputs which can actually trip the units, okay. Now, what I say then, since I didn't have any lamps which told me what it was, I tried to establish for instance the AC under voltage -- if you go down there -- I rule out as being a possible source because it's ten second time delayed and it seems that the whole thing was only --

MR. ASHE: Cycles.

MR. MACHILEK: Seven or ten cycles or 12 cycles. This would never have come into the picture. The overload is ten minutes time delayed so we can rule these two out, okay? Rule out because the event only lasted 200

milliseconds, so no way. Those ones, logic failed, frequency failed and fuse failed would have required a repair. You don't get any of those without having logic elements going bad on you.

MR. ASHE: The point is, you can't bring the unit back up with some of that stuff wrong.

MR. MACHILEK: No way, because you have to fix something. You have to change or fix whatever. I say to rule out all down stores and store it without repair. That means you push the down store button which no reset and no latches, and it was back in operation. It was just a matter of getting that latch reset.

I say over temperature needs reset of thermal relays in the legs. That means the over temperature comes from thermal relays which are all mounted on the heat sinks of the switching legs. In order to get rid of that you have to push in the button to reset the over temperature.

MR. ASHE: That's important. If the unit trips out on over temperature, it will not reset itself automatically.

MR. MACHILEK: No.

MR. ASHE: You have to manually go there and push it in.

MR. MACHILEK: Reset. Once they are all reset, then you can reset it --

MR. ASHE: If it trips out on over temperature though, does it open all the breakers, CB1, CB2 and CB3?

MR. MACHILEK: Oh yes, it's a trip signal that comes out the same. We rule that out because nobody said anywhere that they had to go in and set thermal relays, okay? Circuit board interlock, that's another one which comes. If the circuit boards are not all plugged in properly then we have one circuit which simply runs in and out and one out the other -- if it's not plugged in it doesn't let you start up. In other words, if you go and pull a printed circuit card while the unit is running you get an instantaneous trip signal. I ruled that one out because it wouldn't reset.

That left me with the logic power supply fail alarm before this. I say suspect, because it is direct connection to the maintenance source which could explain the simultaneous fail in all five UPS systems.

MR. ASHE: All right now, key question.

MR. MACHILEK: That was only a logic deduction, and I am --

MR. ASHE: These are the only guys that can give you the kind of isolation that was actually experienced?

MR. MACHILEK: Right.

MR. ASHE: Those are the only ones. There are no more.

MR. MACHILEK: No, sir. I tell you here which ones are latched and which ones are not latched. Also, what is doing what. For instance you see this latched one is giving you a trip. The alarm reset, of course, acts on over flows. It is important that if you push the alarm you cannot reset one of the three different sources of trips.

MR. ROSENTHAL: In the manual, I thought that I saw if the SCR legs aren't firing right or aren't getting the right instructions to fire, then I would get a light.

MR. MACHILEK: Then you get fuse blowings and you get a fuse fail alarm and trip. You cannot restart the unit without fixing it. Big time maintenance -- intervention you have to make. Everything worked fine. Later on some atmospheric or phenomena which I cannot find anybody to give me a rationale I can test against to duplicate against.

This was all done prior to knowing anything about the batteries, okay? As soon as I learned the way the dead battery is, I said gee, maybe I am on the right way with my determination. I would have gone in -- as soon as I saw the manual I thought we got it. Then I looked at the A27 and confirmed that it was exactly like the module, there was no help here.

Unfortunately or fortunately -- whatever you want to put it -- every circuit worked the way it was assigned to work. It shouldn't have done all of that.

MR. ROSENTHAL: At the same time that PSV is coming down -- whatever that you run to this chip --

MR. MACHILEK: No, this works on 12.

MR. ROSENTHAL: Okay.

MR. MACHILEK: Only the lamp is on the 12 volts.

MR. ROSENTHAL: The five volts to the lamp is coming down --

MR. MACHILEK: See, this --

MR. ROSENTHAL: This latch is coming down.

MR. MACHILEK: No, it works on 12 volts.

MR. ROSENTHAL: But the 12 volts is coming down too, isn't it?

MR. MACHILEK: No.

MR. ROSENTHAL: Where did this 12 volts come from?

MR. MACHILEK: It wouldn't latch if I don't put -- if there is no voltage there. We know it latched. Otherwise, it wouldn't get a trip which is latched and requires a reset.

MR. ROSENTHAL: Play that again. I apologize. Just repeat what you just said.

MR. MACHILEK: The lamp works on five volts, only the lamp. The latch going through to the A14 and to the trip is a completely different circuit. If you lose the five volts you lose the lamp, but the rest of the circuit still works.

MR. ROSENTHAL: We are assuming by virtue of knowledge of our design -- your knowledge --

MR. MACHILEK: We know by knowledge that the latches latched.

MR. ROSENTHAL: How?

MR. MACHILEK: Because the lamps, which are on the A14 -- these two lamps here -- there is one lamp here which says trip. There is one lamp here which says logic. This is both red. These two lamps, they are coming off here.

MR. ROSENTHAL: Which says inverter logic type A14.

MR. MACHILEK: On A14 and then we have a trip light on the A14. Trip light on A14, these are the two lights. These two lights, they can only stay on and requiring reset if the latches -- which latches were, I don't know because we didn't have the corresponding --

MR. ROSENTHAL: There is no latch over here. The latches are simply these RS --

MR. MACHILEK: Simply those RS latches, yes.

MR. ASHE: What is the explanation? What if the unit had no logic lamp, this guy here, and no trip --

MR. MACHILEK: After it had tripped -- after it had physically tripped -- which means an SSTR logic came out of here, the two lamps came on and were on, were stored. None of these lamps got lit.

MR. ASHE: One-D unit is different, in that there was no logic lamp on the data sheet only for the 1D.

MR. ROSENTHAL: Let me back up a little bit. Based on our interviews they go down in one UPS. I am still not sure what was done on the first UPS. They then decide to manually close CB4, and it's our understanding then that the -- they dispersed and don't hit any more switches, they just closed the other CB4's.

I am not sure exactly what was done, and I think my guys may know better than me, on the first of those units. But then the other units, I think that they adjusted CB4 so that the data recording which is about two hours in the event and then reconstructed on the others -- on the four others -- ought to be pretty good and little bit -- we could argue all day what on the first one.

Which is the first one they go to, Frank? Is it 1C or Id?

MR. ASHE: One C.

MR. ROSENTHAL: One C.

MR. MACHILEK: One C, after ram reset and normal start sequence system operated without need for a UPS. One D, same thing. One A, after a ram reset normal start up stayed one, closing to CB1 input breaker caused upstream breaker in the panel to trip. That happened twice in a row, so they decided that there was something wrong in the

rectifier section of the UPS and it was left on bypass.

A worker request, 162319 was issued for its repair.

MR. ROSENTHAL: Since then we know it was the actual breaker.

MR. MACHILEK: Then there comes UPS 1B after a ram reset and normal start sequence, the UPS power conversion module operated without need for a repair. The retransfer from bypass did not work because of a defective CB3. Work request 138173 was issued for that repair. None of the two dissimilarities with the other three had anything to do with the actual event, because the CB3 being flaky was known --

MR. ROSENTHAL: Beforehand.

MR. MACHILEK: Beforehand, and the charger breaking doesn't matter.

MR. ROSENTHAL: Can I take an aside. These are nice sized breakers, all right?

MR. MACHILEK: Yes.

MR. ROSENTHAL: Either they were flaky beforehand, or we broke them in the course of testing. I know the plant manager talked like you are breaking my units by testing them. It seems to me that these breakers ought to be good for many cycles.

MR. MACHILEK: Two hundred-fifty.

MR. ROSENTHAL: Two hundred-fifty cycles.

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: They are not. Or, they saw a fair number of cycles over the years.

MR. MACHILEK: Or, they are just not holding up the way we expect them to.

MR. ASHE: When you say --

MR. ROSENTHAL: We were there on one occasion when the thing tripped on over temperature. We were just standing in front of the unit and it tripped out. That over temperature is on the SCR leg heat sink, as I understand it.

MR. MACHILEK: Are you talking about the scenario when I was there when we tested? We broke a gate and then we got an over temperature.

MR. ROSENTHAL: That wasn't a trip. It wasn't a trip. Maybe it was the next day. We were just there.

MR. MACHILEK: We were 18 20 board. We got an over temperature and we couldn't reset it.

MR. ROSENTHAL: This was another time.

MR. MACHILEK: Another time, okay.

MR. ROSENTHAL: Subsequent. The thing just tripped out, and I assume it -- it was in auto reset and it must have cooled down and sometime goes back on to --

MR. MACHILEK: If you had an over temperature you have to reset. If you get an over temperature and none of

the button needs resetting then you probably have a U4 chip failing on the A20 boards. That's a guess. It might be a U6, either one of the two.

MR. ROSENTHAL: What I am wondering is, if over time this unit has automatically switched to its maintenance supply as designed and is in the auto reset mode and switches itself back onto the preferred AC --

MR. MACHILEK: If that would happen, you would get a stored alarm that says that happened. In order to get rid of the horn you have to physically push the one silence button. Otherwise, the unit will sit there and blare at you. You have a guard in that room, or somebody must hear if that alarm goes off.

MR. ROSENTHAL: Why wasn't the horn blowing when we were tripping the units out, Frank, when we were intentionally tripping the units?

MR. ASHE: It was sometime.

MR. ROSENTHAL: It was.

MR. ASHE: Sure.

MR. MACHILEK: You say sometime?

MR. ASHE: Yes, sometimes it was.

MR. MACHILEK: Each time you should get an alarm.

MR. ASHE: Maybe it was each time. Most times --

MR. ROSENTHAL: Do you recall hearing a horn.

MR. ASHE: Yes, lots of times.

MR. ROSENTHAL: That systems guy is pretty good at hitting the button.

MR. ASHE: You have to push the button to silence the horn. I can't say -- most of the time when the unit tripped out there was a horn. That's the way I recall it.

MR. MACHILEK: I believe the units you have being built ten years ago, if you got an alarm and you silenced the horn button prior to resetting the alarms -- all right? The lights, you have to reset separately. You silence the horn and then you reset the lamps.

MR. ASHE: Right.

MR. MACHILEK: If you silence the horn and then other alarm came along before you reset the lights, you did not get the horn again. Today, you do on the new equipment, okay? If you silence the horn and another alarm comes the horn comes on again, okay? At that time it was not going that way.

MR. ASHE: Cycling the breakers 250 times, is that full load cycle?

MR. MACHILEK: It doesn't really matter, they mechanically fall apart.

MR. ASHE: Making and breaking is not the problem with that. What is the real problem here?

MR. MACHILEK: The real problem is that a breaker -- historically, okay -- is not intended to be switched a

lot. If you have a lot of switching you use a contact where you lose control means. So, a breaker basically is designed to stay put for a long period of time such as the branch distribution of whatever you have, okay?

If you have a situation like a bypass breaker like the CB3, there comes a customer who wants to see 50 switchings in test in the factory and wants to see 50 more once it is in store. That means you are exposing -- you are doing so much testing that only -- for instance, on surface security, 6.2 megawatt, 20 modules large system, okay.

I made then change all the fuses after we were doing a finish testing, because we had to show five circuit tests in the factory and five short circuit tests on the -- each time you subject a fuse to near melting current it degrades itself, it compromises itself. After one or two months beyond the normal current all of a sudden the fuse goes and you don't know why.

I had this problem. You see, we started the units up and I had what they call modality failures, I lost fuse here and there. With 20 units like almost every day a fuse, I had them change all the fuses. Circuit breakers ditto -- we exercised this General Electric Circuit breakers. We had 52 breakers there, we had to service all 52 breakers after we were doing testing.

There is a mechanical exercising of a breaker with

no other -- sometimes doing something to the breaker, okay, molded case breaker specifically.

MR. ROSENTHAL: These aren't molded case.

MR. MACHILEK: They are molded case.

MR. ROSENTHAL: Let me see if I got this. We were following how does CB3 trip, and we decided that you had to close K3 and K3 had to close because Q1 saturated, and Q1 saturated off an SSTR signal on this drawing; that the trip light on A14 came on; that the inverter logic light on A14 came on that is consistent; but that, none of these lights came on. I thought that we got an under voltage, over voltage light on one of them.

MR. MACHILEK: That was on the A34 board which is the transfer board.

MR. HESS: That's the horizontal.

MR. MACHILEK: The horizontal, yes.

MR. ROSENTHAL: Okay. At some point let's go to that board and see what turns on that light.

MR. MACHILEK: Which one is that?

MR. ASHE: The OV/UV.

MR. ROSENTHAL: The OV/UV, the horizontal lights on the upper left-hand side. We can take a break. Let's go off the record.

[Discussion off the record.]

MR. ROSENTHAL: Can somebody explain just the

normal path to light these lights, because I am really a nuclear engineer and this is not --

MR. MACHILEK: Okay.

MR. ROSENTHAL: I got five volts here to an LED.

MR. MACHILEK: That is correct. You get -- this is the 12 volt power supply.

MR. ROSENTHAL: I have five volts, right, and five volts may be in fact degrading volts, right?

MR. MACHILEK: Yes.

MR. ROSENTHAL: Plus five though the LED, through the diode to ground -- how? It has to come back through here -- no. This is now changed state, right?

MR. MACHILEK: Yes. As long as the latch is on, the light is on.

MR. ROSENTHAL: Right. This PIN goes from high to zero?

MR. MACHILEK: That's right. That is correct.

MR. ROSENTHAL: This is an inverter?

MR. POHIDA: Buffer.

MR. ROSENTHAL: Just a buffer, okay. Then, what is switch one?

MR. MACHILEK: If you put a ground on the --

MR. ROSENTHAL: Is this a lamp test?

MR. MACHILEK: Yes.

MR. ROSENTHAL: That's the lamp test. Now, what

is the story with -- I am sitting at -- this switch is normally in this position. I have plus 20, the voltage dropped here across the zenar and across the transistor and plus 12.

MR. MACHILEK: This is at the 20 volts level.

MR. ROSENTHAL: That's at 20 and this is at 12 -- this K1 -- energizer.

MR. ASHE: This is the collector on up through here and that's normally closed, right through here. When this guy saturates K1 --

MR. ROSENTHAL: Which means that contact is open.

MR. ASHE: All that's doing is just monitoring the 20 volt supply, it looks like to me. What is it doing other than that?

MR. POHIDA: I think it might just be a delay, monitoring and then also a delay.

MR. MACHILEK: All this is doing is, you are de-energize K1 if you are testing the lamps.

MR. POHIDA: Right, that's all it does.

MR. MACHILEK: That's all it does.

MR. ASHE: It breaks that and returns back and puts this whole thing back into circuit. The only way to change this guys state is through here, isn't it?

MR. MACHILEK: Yes.

MR. ASHE: That's ground, so this point has to

raise or lower in order to get this guy to change in the normal.

MR. POHIDA: It just gets around through K1.

MR. ASHE: All it really is doing though, K1 never changed state and nothing happened down here.

MR. MACHILEK: Your main -- you prevent a reset if you lamp test, right?

MR. ROSENTHAL: In this case the plus 12 is decreasing.

MR. ASHE: I don't know where you get these plus 12 and plus 5 decreasing.

MR. ROSENTHAL: If the 20 is coming down --

MR. POHIDA: I think you may not lose your 12 immediately. Is there a voltage regulator -- a voltage regulator could hold the voltage about a minute and one-half.

MR. RANSOM: It will hold it down to about 13.

MR. POHIDA: You won't necessarily lose your 12 immediately.

MR. MACHILEK: We know we went below 16.5 but we don't know how far.

MR. ROSENTHAL: The one constant here is the voltage across the zenar.

MR. MACHILEK: If that whole circuit wouldn't be in there I don't know why -- all they do is they disconnect

the --this is shown in a discharge position and that means that it is normally open. If he pushes the lamp button he grounds the reset, right?

MR. ROSENTHAL: I guess the question is, what would have happened --

MR. MACHILEK: That's the lamp button. This prevents you from unstoring the lamps if you make a lamp test.

MR. ROSENTHAL: The only issue that we heard postulated was did K1 -- did this relay change state.

MR. MACHILEK: It didn't unlatch the latches, because we would have lost the lamps which are held by the latches.

MR. ASHE: Actually, the only purpose of that relay is after you do a lamp test --

MR. MACHILEK: If you have an alarm when you do a lamp test you don't want to unlatch the latches because after you let the lamp test go you want to have the same alarm still there.

MR. ASHE: It seems like if you are going to try to build an argument around here that some kind of way you reset these guys due to this decay of voltage here, then why didn't you reset these guys up here when they originated?

MR. ROSENTHAL: That's what the two of them are saying. There is no other latches up there on these.

MR. MACHILEK: No, sir. This goes directly to the lamp and to the ground. You have the A14 to show them?

MR. HESS: Right here. You want the print?

MR. MACHILEK: Yes.

MR. MACHILEK: Which one was it, UPS trip, right?

MR. ROSENTHAL: In order for that light to be on two hours later, I need the logic to not have changed state and the power to have been restored.

MR. ASHE: Right.

MR. ROSENTHAL: I need the logic -- for 200 milliseconds you need the power back to 200 milliseconds. I need the logic not to have changed state.

MR. ASHE: Right, okay.

MR. ROSENTHAL: When I get down on the 12 volt level here with the regulated power supply, are we postulating that this 12 volt in fact didn't degrade in the course of the 200 milliseconds.

MR. MACHILEK: I had hoped that the generator logic during this subsequent tests, that we will get an abnormal lamp indication pattern of some sort.

MR. ASHE: To suggest something is wrong with --

MR. MACHILEK: I had hoped, because I was --

MR. ASHE: Possible explanation. It didn't happen.

MR. MACHILEK: No, we couldn't make it happen,

let's put it that way.

MR. ROSENTHAL: Unfortunately, if I had it to do over again, I think I would have gotten 12 dual trace oscilloscopes from the plant when we were doing this test and we didn't, for better or worse.

MR. IBARRA: Do you mean the tests that you all have done?

MR. ROSENTHAL: Up at Nine Mile.

MR. MACHILEK: We tried to reset out of -- I don't know if we took the logic off for a long period of time, I don't know. If the logic was -- we turned the logic down to like 50 volts and let it sit there.

MR. ASHE: That's right.

MR. MACHILEK: For a considerable period of time.

MR. ASHE: That was done on 1C and 1D.

MR. MACHILEK: Tried to have a transient behavior off it.

MR. ROSENTHAL: Frank, you saw a test in which they had fresh batteries and lifted the 110 volt AC lead.

MR. ASHE: Fresh batteries and they switched.

MR. ROSENTHAL: It was a test in which the logic was living on the fresh batteries a couple of minutes.

MR. ASHE: No. There was some decrease of 120 volts down to the break fault in which the power supply no longer regulates, which is about 96. Up until about 96

volts the power supply tends to regulate pretty -- very good -- and held it up there 19, 20 or something. Below 96 volts it dropped off very rapidly.

With fresh batteries it tended to stabilize and still hold it up but it was decreasing, but it still held it up.

MR. MACHILEK: It goes from 2.15 down to two volts per cell. You cannot have more than open circuit voltage on the discharging battery.

MR. ASHE: That was the question that I wanted to ask. How much current does it take at 20 volts to drop this logic; does anybody have any idea?

MR. MACHILEK: Oh, yes, sir. I measured that when I got back. When the unit was not running and wasn't energized, the positive through 1.14 -- between 1.14 and 1.17 amps. The negative had .283 or three-tenths of an amp. When the unit was running the positive through 4.44 amps and that was under no load. The negative through 1.084 amps and then we loaded the module full load. The positive stayed at 4.44 amps and the negative went from .084 to .092, which means that loading or not loading the module has no bearing on that.

MR. ASHE: Could you go back to the no load case. You first started off with no loaded it was 1.1 -- something. Positive was what?

MR. MACHILEK: With the unit not running.

MR. ASHE: Yes.

MR. MACHILEK: One point one four.

MR. ASHE: One point one four.

MR. MACHILEK: Amps positive and .283 on the negative.

MR. ASHE: Okay. Then, you went with the unit running.

MR. MACHILEK: Yes. We started the unit up under no load, and through the output was 4.44 amps on the positive and 1.084 on the negative.

MR. ASHE: Then, running.

MR. MACHILEK: Then, with loaded --

MR. ASHE: Loaded.

MR. MACHILEK: With loaded it had the same current on the positive and the negative was 1.092. I don't know that anything had changed. the question is, what would have happened --

That's the lamp button.

The relay, I placed it at really K-5 and found -- per the data sheets, it should drop off between 65 and 20 percent, which means between 78 and 24 volts. Once we saw on the lower end, I believe 45 volts were lost.

The 120 volts, if we applied a ratio of 200 kilovolts to 80 kilovolts, somehow we can theorize that the

120 volts went down to 50. The one relay we tested was at 45. So it would have stayed in at 50. The power supply input lost regulation at 96 volts and it would trip itself off at 84 volts.

Considering all the tolerances, it could trip between 86 and 78 volts, depending on the control feature, depending on the tolerance of the control. On the output, the 16.5 volts is adjustable between 17.3 and 15.7. The last observed state on the C unit, it tripped at 16.9.

MR. ASHE: How often is that adjustment made? You have no idea?

MR. MACHILEK: We check that adjustment at every PM, at every maintenance, preventative maintenance check. I don't know how steady -- does it change?

MR. RANSOM: No.

MR. ROSENTHAL: What do you mean by every preventative maintenance check?

MR. MACHILEK: Under normal -- if we have a maintenance contract.

MR. ROSENTHAL: What I'd like to do, whenever you're ready, is to take one of the lights that did go on and see how that would go on by design.

MR. ASHE: Right now. He wants to --

MR. ROSENTHAL: I'm sorry. It went to the D?

MR. ASHE: No, no. We went through all of how you

get to CB-1, CB-2 and CB-3.

MR. ROSENTHAL: Which is the UPS that they went to first?

MR. ASHE: 1-C.

MR. ROSENTHAL: 1-C, not 1-D.

MR. ASHE: In testing.

MR. ROSENTHAL: No, no. When they --

MR. ASHE: 1-D.

MR. ROSENTHAL: 1-D.

MR. ASHE: Yes.

MR. ROSENTHAL: So let's go look at 1-C and some light was reported lit. 1-A, 1-B, 1-C. And then let's follow that backwards.

MR. ASHE: Which is what we've already done, I think.

MR. ROSENTHAL: No. Wasn't any of these lights lit? Not these. On the other -- on the horizontal -- there's a --

MR. ASHE: On the A-34.

MR. ROSENTHAL: On the A-34 board, there is some light that gets lit.

MR. ASHE: Is that UV/OV?

MR. ROSENTHAL: UV/OV.

MR. ASHE: The as-found data, I gave that to you the other day. You have it. No. The as-found data sheet,

which really is right there, too. It's the same thing. It's 1-C.

MR. ROSENTHAL: 1-C, 1-G. So the OV/UV light on --

MR. MACHILEK: On C, on D and on G.

MR. ROSENTHAL: Okay. So why don't we go to that light on the A-34 board and see what turns that on. If somebody has a better suggestion, I'll listen.

MR. HESS: We're here. Go ahead.

MR. ROSENTHAL: No, no. We'll do it.

MR. MACHILEK: If you look at 1-D, you'll see OV/UV. Wouldn't that suggest that this one is on A-34? That would be A-21, right?

MR. RANSOM: That is an alarm on A-34.

MR. MACHILEK: This would indicate that it did, in fact.

MR. TERRY: But that's a suspect, Rudi. I think it would be better to go any of the other four.

MR. JOHNSON: It obviously didn't transfer, because they did it manually.

MR. TERRY: That's just strictly recollection.

MR. MACHILEK: You've got the A-34?

MR. HESS: Where were we? Out put OV/UV?

MR. MACHILEK: OV/UV. It comes from a rectifier here. Simply a level detector, that's all it is,

adjustable. BCCA/AB and we're feeding that into a level detector, come out to the lamp.

MR. ASHE: What's feeding in here now?

MR. HESS: Critical bus loads.

MR. ASHE: What is that? I mean what senses that? Just a resistor --

MR. MACHILEK: Voltage transformer.

MR. ASHE: A voltage transformer.

MR. MACHILEK: Direct input from the voltage transformer.

MR. ASHE: Okay. Direct input from the transformer. That's really simple then.

MR. MACHILEK: Yes. It's pretty straightforward. You do the same with critical bus and bypass and compare the two and that is the difference.

MR. ASHE: How the hell does that get there?

MR. MACHILEK: You come in through the --

MR. ASHE: I'm coming through there, through here, I've got you. Okay. I've got you. Through the base of this and then the collector. Okay.

MR. HESS: I saw it before.

MR. MACHILEK: They are difficult to follow.

MR. ASHE: Is the rest of these things like this, just pretty much --

MR. MACHILEK: Yes.

MR. ASHE: Through these amplifiers and gates?

MR. MACHILEK: There is no complicated circuitry involved, none which might be considered in today's computer age, microprocessors.

MR. ASHE: This would be lost, though, if this condition corrected from here.

MR. MACHILEK: If it works, yes.

MR. ASHE: In other words, whatever triggers this input, if that goes back to the norm, this light goes out.

MR. MACHILEK: It might be broke, I don't know.

MR. RANSOM: The critical bus goes bad. So that's why they came down and saw the lights on, because that condition existed.

MR. ASHE: I don't know if I followed you.

MR. MACHILEK: If the maintenance bypass goes away, this goes away. Of course, you have a voltage difference, right?

MR. ASHE: Right.

MR. MACHILEK: More than plus/minus.

MR. ASHE: You're saying go away, but you don't mean that. If the maintenance bus has degraded.

MR. MACHILEK: Same thing. If it goes down to 50 volts from 120.

MR. ASHE: Okay. Right. Your point was what, now?

MR. RANSOM: When the unit shut down, it flipped off. It didn't close the bypass breaker.

MR. ASHE: Right.

MR. RANSOM: Which meant your critical bus voltage was zero volts. So if you're looking at the critical bus and the bypass switch then returned, you have the voltage difference.

MR. ASHE: I've got you.

MR. MACHILEK: Each time you have a discrepancy between the presence of the two voltages, yes, you get that lamp.

MR. ASHE: So in theory, that should have been on all five units.

MR. MACHILEK: Depending on when you looked at it because it's not latched. It's just a lamp. As soon as you bring the unit up and the output becomes available --

MR. ROSENTHAL: This data was taken at two hours into the event.

MR. MACHILEK: Consider the following. There were three different teams going down in a two-hour period. They all did something, right? They first ones did something, the second ones did something, the third ones did something.

Now, if you take all the accounts and you really go through with a fine-toothed comb, then selectively you can say that one makes sense, it's probably good, this one

doesn't make sense, it's probably no good. Now, as soon as you do a selectivity in what is believable and what not, then you have to say I believe nothing or I believe everything.

But you cannot make a point either way in order to support yourself or convince yourself of something, saying, yes, you know, this is probably the right thing which was recorded here, this one doesn't make sense, it's probably not right.

We are talking about idiosyncrasies here, something which we believe cannot happen, but yet we accept that it did happen. With the knowledge and experience we have, we'd walk away from it and say, hey, forget it, it never can happen. But all we can say is to the best of our knowledge and ability, to analyze it or to duplicate it. We cannot make it happen.

MR. ROSENTHAL: Frank, the OV/UV on the A-34, the horizontal strip of lights, doesn't latch.

MR. MACHILEK: No, sir. It's not an alarm. It's only an indication. It's a status indication.

MR. ROSENTHAL: Okay. Is it possible that people are confusing OV/UV on the A-34 board with the under-voltage with the lights on the A-21 board? There's an under-voltage fast and an over-voltage light. Those are separate LEDs on the A-21 board, right?

MR. MACHILEK: Okay. The under-voltage fast is not in operation. It's only for parallel units. The ACO voltage would lock, yes, sir, but it doesn't trip.

MR. ROSENTHAL: But it doesn't --

MR. ASHE: Wait a minute. Why do you say it doesn't trip?

MR. MACHILEK: It would transfer, right?

MR. ASHE: It looks like to me it sends a signal to the same place.

MR. ROSENTHAL: If I detect an under-voltage here --

MR. ASHE: I'm sorry. He's right. You're right, you're right. No, it doesn't go to the same place. It doesn't trip the unit. Over-voltage doesn't trip the unit.

MR. ROSENTHAL: Wait a minute. Over-voltage -- I'm sorry. Over here, here, here, this gate, this buffer, over here, up here, to here. Okay. It gives you a light.

MR. MACHILEK: It gives you two lights.

MR. HESS: That's the trip over here. It gives you light over here.

MR. ROSENTHAL: That's a trip light and that's a logic light, but here is the actual trip. I'm sorry, I'm being slow.

MR. MACHILEK: But you will get a transfer on the A-34, which again cranks into the one because it opens the

CB-3 eventually, the output after you have confirmation that the CB-4 has failed.

MR. ASHE: If you put full amp load on the three D-cell batteries, what is the load --

MR. MACHILEK: It goes through immediately and from then on it decreases commensurate with the state of charge. It's fully charged.

MR. ASHE: But you've actually tested it.

MR. MACHILEK: Well, I hope they did. They put new batteries in it and let it run for a while.

MR. ASHE: No, no, no, no, no, no. I'm saying outside the unit, we reconfigure 3 D-cell battery packs, just like the plus or minus 20. Take an oscilloscope or something, put a full amp load on there and watch the voltage. Nobody's done a test like that, to your knowledge, right?

MR. MACHILEK: No.

MR. ASHE: But they should be able to have full amps in a very short period of time, no problem, right, fully charged?

MR. MACHILEK: It should hold it for a minute.

MR. ROSENTHAL: I'm sorry. The under -- you said one of these is not on that unit, under-voltage or over-voltage?

MR. HESS: I think you're talking about the

parallel lights, the AC/UV fast.

MR. MACHILEK: What about it?

MR. ROSENTHAL: It's not on the units there.

MR. MACHILEK: No, sir. No. This is only for parallel operation.

MR. ASHE: The under-voltage is the one that's not there. They only thing they've got is the over-voltage.

MR. ROSENTHAL: Could this have been on? What would have made the over-voltage?

MR. MACHILEK: Well, we had the other problem. We had a decrease in voltage, not an increase. I don't think if you short a transformer you'll get much of an over-voltage on it.

MR. ROSENTHAL: Okay. Let's pick another light that they're reporting. OV/UV doesn't latch.

MR. MACHILEK: It's a status indication.

MR. ROSENTHAL: OV/UV transfer. Voltage difference.

MR. ASHE: Am I saying something wrong here? I'm not saying anything wrong, right?

MR. MACHILEK: No. If you have -- I don't understand -- we have a transfer?

MR. ASHE: Transfer went on the same diagram.

MR. RANSOM: It does latch.

MR. ASHE: Wait a minute. It does? Okay. All

right. He's right.

MR. MACHILEK: That latch is the -- if you do transfer, you maintain that.

MR. RANSOM: It won't stop the unit from running, though.

MR. MACHILEK: No, no, no, no.

MR. ROSENTHAL: OV/UV transfer.

MR. MACHILEK: If it helps the statement, you can take the A-34 out of the module and the module runs. It's strictly a bypass control. It has nothing to do with the operation of the module itself.

MR. ASHE: I think what Jack is trying to get to is a possible explanation for these lights. I think that's where he's going with this.

MR. MACHILEK: On the A-34, the only lamps which you want to have stored is that a transfer has taken place or a transfer command was given. The rest are status indications, saying that one voltage or one frequency is different from another one. But if that condition would go away, then the lamp would go away.

MR. ASHE: Why didn't this show up on all the units, then?

MR. MACHILEK: It depends when you look at it, what the exact situation was. Was the maintenance voltage there or was it not there. Of course, once you try -- once

a module goes on the internal oscillator, then it drifts away from the bypass. Different speeds, it can stay there or it can drift off. It's really hard to say.

MR. ASHE: These reset bus tables, they're just dual in-line pin ICs, right?

MR. MACHILEK: Which ones?

MR. ASHE: The reset bus tables, they're latching --

MR. MACHILEK: Latches, yes.

MR. ASHE: How many, eight pin, 16-pin, dual in-line pin? How many is on a one --

MR. MACHILEK: Twelve.

MR. ASHE: Twelve on one guide, right? Close, some number thereabouts.

MR. RANSOM: Twelve of the actual devices?

MR. ASHE: No, no.

MR. RANSOM: It would have to be 14 or 16.

MR. ASHE: Sixteen. In terms of reset modules on that device, there's probably four.

MR. MACHILEK: Yes.

MR. RANSOM: Yes. Sounds about right.

MR. ROSENTHAL: What's the voltage difference?

MR. MACHILEK: It means that the output voltage of the module, that the bypass voltage and the critical voltage is different from each other.

MR. ROSENTHAL: Does that latch?

MR. MACHILEK: No, no, no. It's an indicator. It's like two volt meters to tell you what they are doing.

MR. ROSENTHAL: The voltage difference is that light.

MR. MACHILEK: Yes. It comes and goes as the situation changes.

MR. RANSOM: These two phases.

MR. ASHE: So that's AB phase, right?

MR. MACHILEK: AB and -- all three, sum it up, put an average to it and look at the DC signal, the level to take that.

MR. ROSENTHAL: They are saying that when they went down to look at two amps, they saw an OV/UV light, and we're saying that there's no latch, it's got nothing to do with what happened at T-zero.

MR. MACHILEK: Right. It's only an assumption to do at the time you look at the light.

MR. ROSENTHAL: The voltage difference, same story, right? And the OV/UV transfer does latch.

MR. MACHILEK: It will tell you that you did, in fact, get a transfer signal, which is strange, though, because if you do get a transfer signal, if the transfer is not executed, then you get a transfer fail alarm, which wasn't there.

It's almost as wierd as if you switch the lights on in your car and the horn comes on.

MR. ROSENTHAL: I had something like that and the stalk to the multi-function lever switch is a cable that runs down inside the steering column, and it had abraded the insulation and depending on just where the vibrations were and whatnot, as you turned this on north, it would occasionally -- the wipers would come on when you turned the lights on, etcetera.

They had to pull the steering wheel. It cost me 100 bucks for a guy to pull it apart to put a piece of tape on it because they addresed the leads wrong. That was an inadvertant or a sneak circuit, right? And what's the parallel here?

MR. MACHILEK: I don't know.

MR. ROSENTHAL: But there's a sneak circuit.

MR. MACHILEK: But if we want to investigate for a possible problem of that sort, it would be -- what my problem is, it's an atomic power plant and all the things have -- it was a multiple happening at the same time. Any one of the happenings by itself would not have done anything.

The shorting of the transformer would not have bothered anybody. The batteries dead, by themselves, wouldn't have bothered anybody either. You see what I mean?

MR. ASHE: Let's backup now.

MR. MACHILEK: What was the coincidence of the dead battery and the loss of the Phase B. If you would have lost A or C, nothing would have happened. So dual failure. It's inconsistencies in the reporting of lamps.

MR. ASHE: Let's flip that around. Let's say fully charged batteries and take the same scenario.

MR. MACHILEK: Nothing happens. I wish I could throw a --

MR. ASHE: Are you saying with fully charged batteries, the same Phase B short, this unit would have stayed up, the five units would have stayed up.

MR. MACHILEK: Yes. For the 12 cycles or whatever it was, for sure. But this can be tested. This can be proven. It's not -- we don't have to rely on anybody's opinion here. This is very provable.

The only suggestion I felt was a good one is to switch the relay coil.

MR. ASHE: Correct.

MR. MACHILEK: So that I'm going to inverter right away and I prevent switching later on. Are we covering all the bases with that? No, we don't, because if you lose one power supply and you do not have a bypass at the time, it's not in sync or God knows what, then you still would lose the load. See what I mean?

I want to make this 100 percent clear. That change improved the situation as far as that scenario is concerned.

MR. ASHE: Sure.

MR. MACHILEK: A different scenario with different combinations of problems at the same time could still get you in trouble.

MR. ASHE: Yes. The fix is also dependent on the inverter's voltage either being there or not there.

MR. MACHILEK: Also, I want to mention that if the AC/DC converter in the other unit goes bad, you've had it. You see what I mean? You lose it right away. Single point failure. Just damned lucky that it never happened. Now, we are not talking about --

MR. ROSENTHAL: We have had individual 1-E inverter, the losses of the --

MR. MACHILEK: If you lose the power supply, and this is why we never considered a AC/DC converter, for that reason. It's a single point failure. We could not qualify it with the Army, Navy or Air Force because we can't get away from this single point failure syndrome.

If you lose that AC/DC converter, the logic goes away and you crash and you lose your output load.

MR. ASHE: You mean the Army has none of these other kind of inverters?

MR. MACHILEK: The old ones.

MR. ASHE: No, no, no, no. The one with the DC converter on it.

MR. MACHILEK: No, I don't say that. I said we could not qualify it.

MR. ASHE: In your case.

MR. MACHILEK: Yes.

MR. ASHE: In your case.

MR. MACHILEK: No. The Army has a lot of things, but so does everybody else because a lot of things are being purchased on the open market by a local distributor, low bid.

MR. ASHE: It's bench stuff, right?

MR. MACHILEK: One of the reasons why the armed forces particularly liked this type of equipment was because everybody can fix it and we teach you how to. We have a course which teaches you every circuit down to the component leave, not only the subassembly level.

That means if you really want to understand our particular system, come down to Raleigh and go to school. Every circuit, every component, we teach you what it's doing, why it's doing it, and how it is doing it and what it is. We have no secrets there at all.

MR. ASHE: Some of the people from NOM now have gone down to the school you're talking about, right?

MR. GRADY: We haven't been able to find out who they were.

MR. ASHE: Okay.

MR. MACHILEK: The ones which are still around haven't been there. But if you really want to understand it, you'll need two weeks -- a three-week course and you'll know as much as we do.

MR. ROSENTHAL: Let me take an aside before I come back to this. We have seen random failures of converters which we have attributed to pre-conditioning due to temperature. But you don't expect five to all go at the same time due to that sort of problem.

Nevertheless, since we're thinking about the logic, let's talk about temperature for just a second. The over-temperature trips of this unit, I take it, are really on the heat sink temperature.

MR. MACHILEK: Right.

MR. ROSENTHAL: The chips there are -- they're not mil spec ships, they're just chips, high quality chips.

MR. MACHILEK: 70 degrees C logic.

MR. ROSENTHAL: 70 C?

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: Centigrade.

MR. MACHILEK: Yes.

MR. ROSENTHAL: 70.

MR. MACHILEK: 70. Which means that if you have a 40 degree C inlet temperature and a 15 degree C internal device, this is what our design criteria is. You have 55 degree logic. Because that unit is that tightly packaged, we have a separate blower on the controller itself.

MR. ROSENTHAL: On the card cage.

MR. MACHILEK: Yes. Which the other units do not have. Only the single cabinet has that and the 60-KW is the only one we have in a single cabinet. Once you go to the 100-KW, you have two cabinets. It's much looser packaged.

The problem with the 60-KW is that you need an air exchange. You have to get the PTUs away from the module. It has a tendency that the air does not want to readily come out and simply dissipate. So we specify if we install it or if somebody asks, three times an hour air exchange, which isn't all that much.

The Army, for instance, or the Navy, if they don't use air conditioning, they have a plenum on top and suck the unit, exhaust the -- and the plenum has a little blower which makes up for the static pressure which is generated. But the reason why you don't get the heat out of the units is because there is really nothing which makes the heat come out.

Simply the temperature difference between the inlet and the outlet, the blowers which are in there are

really not blowing, if you want, or transporting the heat away from the unit.

MR. ROSENTHAL: Now, the little batteries, the four-year is based on 77 --

MR. MACHILEK: 77 degree format, yes, sir.

MR. ROSENTHAL: And it's hotter than that in there, isn't it?

MR. MACHILEK: Well, depending on the inlet air temperature. One evening we were there, I would say it had probably 80 degrees in there.

MR. ASHE: 80 degrees in where? Where the batteries are located?

MR. MACHILEK: In the room itself.

MR. ASHE: I was in that room and I would say it was over 100 degrees in the room itself. I think that was their problem at that time. The chillers or something like that. Most times, it was probably --

MR. IBARRA: It was hotter than 80 at any time.

MR. MACHILEK: But you have a 15 degree C internal device. The filters were immaculately clean, so I don't know if they have been recently changed.

MR. ROSENTHAL: Apparently that is in the PM program.

MR. MACHILEK: Yes. They were really -- I mean, there was not a speck of dust in any of them. That was the

first thing, when I felt the one panel, I said to myself maybe that I had filter obstruction. There was none.

MR. ROSENTHAL: Whether it was the original design intent or not, to me, is irrelevant. What I'm seeing is that for certain scenarios, the little batteries do play an important role.

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: And I don't have your design change memorized, but I am under the impression that they would continue to play as important a role, if not more important.

MR. MACHILEK: Shouldn't play a more important role now. The reason why I'm saying that, while you're on bypass, you've got to have the load on bypass before you start up the inverter. So the load is on bypass and so is your power supply. Now you are ready to transfer. You bring up the module and run it.

As soon as the inverter output voltage becomes available, it switches over. If you cope while you are switching over, no problem because it's on purpose. So you just have to fix it and then switch it over.

Once you are on inverter output, you don't need the battery no more.

MR. ASHE: You go to the face plate. You take that little switch and you put it in auto restart. Now the

unit goes off the inverter. For whatever reason, it transfers.

MR. MACHILEK: Okay.

MR. ASHE: You're in auto restart.

MR. MACHILEK: Yes, sir.

MR. ASHE: It's going to try to go back.

MR. MACHILEK: Okay.

MR. ASHE: The batteries have got to play a role.

MR. MACHILEK: Then you stay on bypass, you get in a RAM.

MR. ASHE: You know about it if it did make it.

MR. MACHILEK: Yes, but it doesn't bother you. You do not lose the load.

MR. ASHE: If the batteries were dead --

MR. MACHILEK: You're on bypass already, right?

MR. ROSENTHAL: No. He's saying you're sitting running with dead batteries. You now have a fault in the inverter. Your logic has to stay up long enough to execute the transfer to the maintenance supply.

MR. MACHILEK: But the UPS does not fail in decreasing its output voltage.

MR. ASHE: It has to go down to some value, right? Wouldn't it go down to some value?

MR. MACHILEK: If an UPS trips, it's gone.

MR. ROSENTHAL: At least it's more apparent

failure modes.

MR. ASHE: What's the purpose of auto restart and three tries to go back onto the inverter, then?

MR. MACHILEK: This is if you want to go from the UPS to bypass.

MR. ASHE: No, no, no, no, no. Auto restart means you're going from the maintenance supply back to the inverter, right?

MR. MACHILEK: Okay.

MR. ASHE: I'm putting you in the same scenario as you starting up the inverter.

MR. MACHILEK: Yes, sir.

MR. ASHE: Now, how do you get around the batteries?

MR. MACHILEK: You're on bypass, okay?

MR. ASHE: Yes.

MR. MACHILEK: You want to auto restart.

MR. ASHE: Right.

MR. MACHILEK: Now you give a command to go back to UPS.

MR. ASHE: Right.

MR. MACHILEK: You have no logic to do it with.

MR. ASHE: Are you saying the inverter output is going to come up instantaneously?

MR. MACHILEK: No. Whenever it comes up, you

switch over to inverter. If it doesn't come up, then you don't.

MR. ASHE: No. But the thing is it's not going to come up instantaneously. It's going to be a ramp-up, right?

MR. MACHILEK: Okay.

MR. ASHE: So that's going to put you right back to where you were starting up.

MR. MACHILEK: No. You're going upwards in voltage, you don't come down.

MR. ASHE: Yes. I know you're going up, but there is a latch-up before that K-5 is going to pick up. It's got to be.

MR. MACHILEK: Yes, but the K-5 is on bypass all the time.

MR. ASHE: K-5 is deenergized the way it is now, right?

MR. MACHILEK: The supply to the power supplies comes from the bypass.

MR. ASHE: Yes, but when you flip to -- when you deenergize K-5, you reroute to supply. K-5 is deenergized. When you energize, it's from the inverter, right?

MR. MACHILEK: Correct.

MR. ASHE: So it means that when you're coming up, unless the inverter brings it up instantaneously, the battery is going to have to hold it a little bit while it's

making the switch, right? Wait a minute. Am I making myself clear? Is that right?

MR. RANSOM: I understand what you're saying. You transfer it off-line to an auto restart. The module shuts off. As the inverter tries to come up, as the inverter's making potential as it goes through the neutral point, the relay is going to try to pick up, at which point the batteries have to be there to handle the switch-over, just like if you had a utility failure previously. Then the control batteries will trip off. We tested it with the control batteries. We put the .6 volt back in and tried it.

But, like you were saying, you were in bypass, so at that point, all you then have to do is find the -- it tries to come up and when it goes to switch over and shuts down again. You know there's a problem at that point, but you're not jeopardizing your load because you're in bypass.

MR. ASHE: Right. But I observed most of the units, as I observed, were in the auto restart mode, for whatever reason.

MR. MACHILEK: It wouldn't bother you.

MR. ROSENTHAL: When we were looking at whatever drawing has the power supplies on it, the logic power supplies, and we were looking at the battery discharge light and the continuity battery discharge off-light or whatever you call it, it's clear to us that that really isn't

monitoring the battery while it's in standby, but rather simply what's happening to the battery if the power supply fails.

MR. MACHILEK: It really monitors the power supply.

MR. ROSENTHAL: It monitors the power supply. Okay. So if they --

MR. MACHILEK: Once the power supply is gone, then it monitors the battery.

MR. ROSENTHAL: Yes, yes. Well, I'm sure that these will be the most watched batteries in the nuclear industry. Okay. But they're running at some elevated temperature relative to that which you would associate with their four-year life.

What kind of advice can you provide them on what to do with the batteries and when to change them out?

MR. GRADY: If you do a full-blown maintenance program on the system, then that's something you would check. We are shifting through our paper right now, so bear with us for a second.

MR. MACHILEK: Our contracted maintenance programs, we do it every half-a-year, check the batteries.

MR. ASHE: Every six months, check it out. What do you do, a load test on it?

MR. MACHILEK: Yes.

MR. ASHE: Actual load test. That means you pull them, do a load test and if it passes, you put it back.

MR. MACHILEK: Correct.

MR. ASHE: Okay.

MR. MACHILEK: There is unfortunately no other way.

MR. ASHE: I'm just trying to understand.

MR. MACHILEK: We have a lot of installations, rather than go through a load test, we exchange the batteries every half-a-year.

MR. ASHE: Frankly, I think that's --

MR. MACHILEK: It cost you less money to stick in six D-cells.

MR. ASHE: Yes. Then it's a replacement program rather than testing.

MR. ROSENTHAL: Okay. Well, look. This is a very expensive meeting and we have all the people here. How can we learn the most about this thing, what's -- did we decide -- okay. Let me go back to the basics.

I decided that the -- we know that the circuit breakers changed states, CB-1, 2, 3, and we decided that you had to change K-1, 2, 3 on that first drawing we looked at. That was the only way to do that. Then we decided that that meant that you had to change the state of Q-1, Q-2, Q-3 on the third drawing that we looked at.

MR. MACHILEK: Right.

MR. ROSENTHAL: Then we followed back one way of changing the state of those power transistors was by detecting a low voltage on the output of the larger power supply, and we traced that all the way back.

MR. MACHILEK: Right.

MR. ROSENTHAL: Let's go back to Q-1, Q-2, Q-3 and say how else does this change its state, unless somebody else has a better idea.

MR. MACHILEK: How many ways are there to turn on a transistor who is between ground and the voltage.

MR. ROSENTHAL: Where's the drawing? We've got it out here on the table someplace. If you could advise me on a better thing to do with the next few hours, let me know.

MR. MACHILEK: The fact that the signal which made it happen was latched and confirmed, I see -- it did turn on, right? The breakers tripped as a response to it.

MR. ASHE: Right. I think what he wants to do, though, is to back up. What other ways can we get that other -- we know we can get it on loss of logic DC power, if the power decreases below the trip set point.

How else can Q-1 be turned off is what he's trying to get to, I think.

MR. MACHILEK: Turned off, you mean tripped?

MR. ASHE: Well, the thing is -- I think we agree

-- we had to saturate these guys to pick up the relay coil. Normally, they're sitting there, they're all cut off, and then we trace through everything. But now what I think he wants to do is how many other ways, other than low DC logic power, can this thing be saturated. So do you want to trace all of those guys?

MR. MACHILEK: All those ones which go in here.

MR. ASHE: Right. But I think he wants to trace it to everything on the drawing.

MR. ROSENTHAL: Is there a remote load dump? I read it in your manual.

MR. MACHILEK: No, no, no. The load dump is --

MR. ROSENTHAL: Like for a computer.

MR. MACHILEK: -- if you want to dump your load.

MR. ROSENTHAL: Right. But it would be -- right. But it is not installed on this unit.

MR. ASHE: Are you going to let us have a copy of that?

MR. MACHILEK: Well, they've changed it around.

MR. ASHE: That's right. By the way, you have a final report, though, addressing most of this stuff.

MR. MACHILEK: Yes. Yes.

MR. ASHE: That's all right.

MR. ROSENTHAL: I think what we will do is we will ask Nine Mile for a report from Exide.

MR. ASHE: That's already done. It will be finalized within the next day or so.

MR. ROSENTHAL: Okay.

MR. ASHE: Basically, that chart with all of those chips on there will be in that report, right?

MR. MACHILEK: Yes.

MR. ASHE: That's the key, I think, to what is really -- what we're going through.

MR. ROSENTHAL: If we just trace that out. Input breaker control, that's a physical switch on the breaker, unlike the -- is it racked in?

MR. MACHILEK: Input breaker, it would be a toggle switch which would be in here, which would automatically switch the breaker on. Yours is manual.

MR. ROSENTHAL: Battery breaker control, and you don't have it here.

MR. MACHILEK: No. It's manual.

MR. ROSENTHAL: I'm sorry. So this is like a universal board, as you were saying earlier.

MR. MACHILEK: Yes.

MR. ROSENTHAL: So are these contacts now floating?

MR. MACHILEK: It depends.

MR. ROSENTHAL: Tied higher, tied lower.

MR. MACHILEK: Yes. Whatever the circuit will

take. You cannot make it work without that. It depends if the signal is lower or higher.

MR. ROSENTHAL: What is this RCR-TCA-27?

MR. MACHILEK: This is an output that comes from --

MR. ROSENTHAL: It goes into that.

MR. MACHILEK: It's a remote switch on the A-14.

MR. ROSENTHAL: So you don't have it.

MR. MACHILEK: No.

MR. ROSENTHAL: We just traced this one.

MR. MACHILEK: Yes.

MR. ROSENTHAL: REM. Local A-14.

MR. ASHE: What is that remote used for?

MR. MACHILEK: This is if you want to remove it from a remote location.

MR. ROSENTHAL: You see your big computer burning up. Local A-14. Local A-14. What does LCL stand for?

MR. ASHE: LCL?

MR. MACHILEK: I think this is a local UPS off switch. A-14, yes.

MR. HESS: Yes. It's UPS off right there. And that's if you had -- the remote is off the A-30, you put remote switch off.

MR. MACHILEK: Yes. We don't have it.

MR. HESS: Local is the A-14 front meter panel

where you can press UPS off, and that's on the pictures that I just gave back.

MR. MACHILEK: The UPS on is the other button.

MR. HESS: There's a remote button for UPS on the A-30, as you had a remote off.

MR. MACHILEK: But we don't have it. Two buttons.

MR. HESS: Two buttons, on and off.

MR. ROSENTHAL: So are some of those not used, unconnected, floating?

MR. MACHILEK: Yes.

MR. ROSENTHAL: Is this all C-MOSS or --

MR. MACHILEK: Yes.

MR. ROSENTHAL: So you have some C-MOSS inputs floating.

MR. MACHILEK: Except the transistors on the output.

MR. ROSENTHAL: Do you run into problems with having C-MOSS floating, oscillations or --

MR. MACHILEK: Well, they are protected. They are -- I don't think we have any loose gates, if this is what -- for instance, this is a gate input and it's protected.

MR. ROSENTHAL: So anything that's not used is --

MR. MACHILEK: Yes. It should be a point higher and have a protection capacity against ground.

MR. ROSENTHAL: Wait a minute. Now what we're

saying is that the only way that you pop open CB-1, 2 and 3, is from here -- is from the --

MR. MACHILEK: UPT.

MR. ROSENTHAL: -- UPT which --

MR. MACHILEK: Which comes from this --

MR. ROSENTHAL: And UPT is SSTR. It changes names, but it's a physical wire on the back plate.

MR. MACHILEK: Yes.

MR. HESS: From A-21 to A-24, it changes. SSTR, UPT.

MR. ROSENTHAL: Okay. Now we decided that the under-voltage to this gate should have seen an under-voltage and tripped it. Which one was that?

MR. MACHILEK: Power supply failed.

MR. ROSENTHAL: FR is frequency?

MR. MACHILEK: Clock failure.

MR. ROSENTHAL: Clock failure.

MR. MACHILEK: Which is --

MR. ROSENTHAL: Okay. It's right there. Clock failure. Fuse failed. But we know that that --

MR. MACHILEK: They require repair if that would happen.

MR. ROSENTHAL: OTA.

MR. MACHILEK: The OTA goes -- it's not stored, because you have to reset the buttons.

MR. ROSENTHAL: FU is --

MR. MACHILEK: Fuse.

MR. ROSENTHAL: Fuse blown. WF is a --

MR. MACHILEK: It's freq failure.

MR. ROSENTHAL: Frequency fail.

MR. MACHILEK: That requires a board change if that happens.

MR. ROSENTHAL: AC over-voltage.

MR. MACHILEK: Yes. That's a legitimate -- by the way, AC over-voltage does trip.

MR. HESS: I thought we said it didn't.

MR. MACHILEK: Yes.

MR. HESS: I thought we traced out how it didn't trip.

MR. MACHILEK: Well, let's trace it again, because I remember where voltage was tripping on me.

MR. HESS: Over-voltage.

MR. MACHILEK: Over-voltage comes up here, comes there, comes there, all right. Over-voltage and power supply failure comes in at the same one.

MR. ASHE: That's coming in through here. It's a lamp through here. It's not the same.

MR. ROSENTHAL: Where is that over-voltage?

MR. MACHILEK: I just thought it was.

MR. ROSENTHAL: Over-voltage. Where are you

measuring the over-voltage?

MR. MACHILEK: On the output of the module. If the regulator goes haywire and you know your voltage goes up.

MR. ROSENTHAL: Logic failed.

MR. MACHILEK: Logic failed is a summary -- anything you get --

MR. ASHE: Wait a minute. Why doesn't that go --

MR. MACHILEK: See, all of these go in here. All of those are tripping, either/or. That means any one of those is tripping. In other words --

MR. ASHE: Maybe you're right on over-voltage. Let's go back to over-voltage. AC over-voltage --

MR. MACHILEK: Over-voltage comes out here, here, goes here, and trips.

MR. ASHE: Provided this is met up, right?

MR. MACHILEK: No, no. It says either/or. It doesn't matter.

MR. ROSENTHAL: What is this 12-bit -- Bit 12, 60 Hertz.

MR. MACHILEK: Which one is that? This is from the down circuit. This would trip you if it comes in. It results in a low under-voltage on the output of the module. The voltage control oscillator is going haywire of you miss the 12-count. You trip the unit before you see it on the

output. It should go directly up to the trip without any -- or is it. No, no, no, no, no, no. It goes over the -- it goes over the -- it depends on what the over-load is doing.

Yes. This goes up to the countdown. That's where they stuck it. This is only the 11 bits for the timing circuit. So you have the 1, 2 and 2-seconds timer. This should be a frequency -- it's 94 Hertz, going down to the timer. That's not what I thought it was. They're summing that together on the FRs.

MR. ROSENTHAL: I know we've been over this three or four times. I'm sorry. Okay. Here I've got chips, right?

MR. MACHILEK: Latches, yes.

MR. ROSENTHAL: Latches. And that itself takes 12 volts.

MR. MACHILEK: Right.

MR. ROSENTHAL: Which is coming from this power supply here, right?

MR. MACHILEK: Right.

MR. ROSENTHAL: We have 20 volts, plus 20, degrading here.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Do we know anything about the plus-12 volts here?

MR. MACHILEK: Well, as soon as the 20 volts

degraded to 16.5, we shut down the module.

MR. ROSENTHAL: By design.

MR. MACHILEK: Yes.

MR. ROSENTHAL: But in the time being, what was happening to the 12 volts here?

MR. MACHILEK: Which time being?

MR. IBARRA: The time it shuts down and --

MR. MACHILEK: The time the unit shuts down?

MR. ASHE: I think he's talking the time that the voltage degrades from whatever it's --

MR. MACHILEK: If you start out at 12 and go to 16.5?

MR. ROSENTHAL: Right.

MR. MACHILEK: It's almost instantaneously. As long as the power supply holds the voltage up, it's there, right? Once the power supply quits, you go on discharge from two more cells and from then on, since the batteries were pretty much dead, it decreased to .64 or something like that.

But to shut the unit down, you can blink your eyes fast enough to -- it's just, clink, and it's gone.

MR. POHIDA: Is the unit powered back up?

MR. ROSENTHAL: After 200 milliseconds.

MR. POHIDA: Is there any consideration on power-up states, like what the modes will be of all these latches

on power-up?

MR. MACHILEK: You have to push the reset button. If you don't reset the latches, you cannot restart the unit.

MR. POHIDA: Even if you lose power.

MR. MACHILEK: Even if you lose --

MR. POHIDA: The outputs won't toggle.

MR. MACHILEK: The outputs won't toggle. No, sir. Except if you switch off the logic.

MR. POHIDA: That's what you may have done. When the 20 volts came down, if it got below, what did you say, 13 volts?

MR. MACHILEK: 16.5.

MR. POHIDA: When do the 12-volt supplies start to --

MR. MACHILEK: We don't monitor the 12-volts.

MR. TERRY: Rudi, doesn't that K-1 -- that's what I'm asking about, that K-1. That K-1 relay --

MR. MACHILEK: That K-1 is there --

MR. TERRY: They'll reset the latches.

MR. MACHILEK: Well, it's there not to reset the latches if you do a lamp test.

MR. TERRY: But if it loses power, it will reset those latches. That's why I asked about that.

MR. POHIDA: Well, what if you did lose your 12 volts?

MR. MACHILEK: If you lost your 12 volts --

MR. POHIDA: What is the power-up condition of all of the latches?

MR. MACHILEK: If you lost the 12 volts, then the latches would -- no. You have to apply a -- you have to reset. As long as you do not reset, they stay where they are. They are bi-stable. They're not like a computer. If you lose the logic, you lose the memory or anything like that. It's like a toggle switch.

MR. ROSENTHAL: We could just pull a manual and look up the 4044s.

MR. MACHILEK: Yes.

MR. POHIDA: So they'll power-up as they power-down. Wait. Let me --

MR. ROSENTHAL: In order to -- I'm sorry I'm being redundant again. I thought earlier this morning we decided that you have to apply power to the shunt coils for two to five cycles in order to make the breakers change state.

MR. MACHILEK: Right.

MR. ROSENTHAL: And there has to be some reasonable voltage. That gives us a hint then about the condition of the logic, that the logic had to change state to initiate an open signal and there had to be enough voltage and enough power left to actually open the shunt coils, trip the shunts. Right?

MR. MACHILEK: We are not collapsing all the valves. They are linear power supplies.

MR. ROSENTHAL: It's a sub-component that you purchase.

MR. MACHILEK: Yes. It's a chip.

MR. ROSENTHAL: Do we know the -- but if we go to look up 4044 in a manual --

MR. MACHILEK: We can review it, but I don't have it here. I can get parts lists of all the components. That's no problem.

MR. POHIDA: You said earlier that you probably did not lose the 12 volts.

MR. MACHILEK: I do not believe you lost 12 volts.

MR. POHIDA: But we did diminish the 20.

MR. MACHILEK: The 20 -- we know that it ran to a 16.5, yes, sir.

MR. POHIDA: Is that a voltage regulator?

MR. MACHILEK: It's a voltage regulator.

MR. POHIDA: How fast can that act to correct for the 20 volts being pulled down?

MR. MACHILEK: I don't know.

MR. POHIDA: What I'm wondering is the 12 volts may have also dropped instantaneously.

MR. MACHILEK: It's possible.

MR. POHIDA: You lost your logic. The voltage

regulator, you just can't -- I don't think you can just put a sine wave into it and get --

MR. MACHILEK: We maintained the latches because the light stayed on and they are held by the latches.

MR. POHIDA: Did all of them stay on?

MR. MACHILEK: Yes.

MR. POHIDA: All the latches?

MR. MACHILEK: No, no. These two. Why they didn't --

MR. POHIDA: I'm not 100 percent familiar with the event, but it seems as though you could have problems if your 12-volt supply and your five-volt supply -- well, the five-volt just runs the LEDs, I guess, but moreso the logic. If you have your 12 volts dipping down and then coming back up, you say you will not lose the latches.

MR. MACHILEK: Well, I don't --

MR. POHIDA: I think you might.

MR. MACHILEK: If you remove the power, you would have to -- you have to ground the --

MR. POHIDA: You're also losing your inputs.

MR. MACHILEK: In order to re-circuit, you have to ground the S terminal. If you don't, you simply don't notice it. If you lose the 20 volts altogether -- I have to look at the data sheet.

MR. POHIDA: I don't know which latches were held,

which ones weren't. The other thing that --

MR. MACHILEK: You're familiar with the 4044s.

MR. POHIDA: The other thing that bothers me --

MR. ASHE: The 4044, that's the standard. Radio Shack or any of these places have probably got the same transistors as these guys do.

MR. HESS: Jack, you asked me earlier about some of the things that we should talk about for Niagra Mohawk and what they should be looking at. Then you went on to another piece. Did you want to revisit that or did you want to hold on that?

MR. MACHILEK: If it helps, five units were running for five years. We had one scenario we cannot fully explain. With normal maintenance, which we are doing for the industry as a whole, applied to it, we can say with high probability that we will not have any problem.

I don't know what much we can do else. If we had an inordinate amount of failures, normal operation, whatever, I don't know. I can probably see a concern, but it's really not there.

I would suggest it's none of my business, but to look at the other aspects of the obligation of the unit, classification of it, the maintenance level. These units turned out to be a hell of a lot more important than what they are perceived as.

So there's a lot of things which can be done. A maintenance bypass can be installed. The units can be half-yearly checked all the way through. We have roughly two-and-a-half-thousand units sitting out there in the field. We have a good reputation in the marketplace. We're not junk sellers. We usually don't even participate in low-dollar type deals.

MR. ASHE: Let me ask you something. How many units like this were -- do you have a handle on that --

MR. MACHILEK: We estimate around 700 prior to the shipment of the five here.

MR. ASHE: 75 KVA ratings.

MR. MACHILEK: No, sir. They all have the same logic. They all have the same -- the commonality is what the armed forces like, from 60-KW all the way up to 1000 or 800-KW. They all have the same logic, same circuitry, same everything; 68 percent commonality.

MR. ROSENTHAL: I know that the Reporter would like to take a break. So why don't we take a break and then when we get back, I guess the issues are, one, what could be done with respect to these units, that's one thing; two, a little bit more information on where else they're used and then by that time, maybe we'll come up with some more bright ideas.

[Recess.]

MR. ROSENTHAL: Your nickel.

MR. HESS: I'm sorry. I was waiting for Frank to say go ahead and do your thing. What I'd like to do is put in the record some recommendations that we have for Niagra Mohawk, and we'll follow this up with Niagra Mohawk in a full report to them shortly.

Under recommendations, I'd like to put number one, Niagra Mohawk is aware that the current UPS systems represents technology that is over ten years old. Exide Electronics' current UPS systems represent three technological advances and represents state-of-the-art power protection. It is our recommendation that Niagra consider replacement of the present systems with our present designs.

Recommendation number two, if Niagra Mohawk chooses to have Exide Electronics maintain the UPS systems at Nine Mile Point, we recommend our Powercare Preferred Service Package that covers all facets of maintenance, seven-by-24 emergency service, preventive maintenance inspections and modifications and parts.

Number three, if Niagra Mohawk chooses to continue maintaining this equipment, the following recommendations are applicable. Section A, inspect logic power control battery condition at least once every year. B, perform an annual preventive maintenance on UPS modules per manufacturer's recommendations or have manufacturer perform

an annual site acceptance test.

C, obtain necessary product and technical knowledge through an ongoing training program for Niagra Mohawk maintenance personnel. Exide Electronics can supply formal technical training programs at the Niagra Mohawk facility or at the manufacturer's training center in Raleigh.

D, as-built systems schematics diagrams must be maintained with equipment. These documents take precedent over any other manual, text or verbal communications and should be referenced during maintenance procedures. E, we've got to replace all DC input filter capacitors in each module. F, Exide Electronics stands ready to fully support Niagra Mohawk in any service requirements. Niagra Mohawk can call 1-800-84-Exide for service support should this be required.

G, our last recommendation is peripheral equipment that directly impacts the UPS operations should also be under manufacturer's recommended maintenance programs. End recommendations.

MR. ROSENTHAL: Are you worried about the circuit breakers based on what you know now?

MR. HESS: Not knowing -- yes. I would have to say yes. We're concerned about them. We can't tell how many times they've been worked. The only way to really go

in there would be to have somebody come in and take them out, and I believe they're all sealed. No. They come apart, don't they? They're just molded case. Have them looked at and/or replaced. Throw them away probably would be the best thing to do and put new ones in, knowing what we know today from this meeting.

MR. ROSENTHAL: Rudi, we wanted to give you the floor. Where are these units used? You have to expansive in terms of the same logic or similar enough logic, independent of the power rating.

MR. MACHILEK: About 700 we've come up with. They have identical logic. I wish you come to our plant and as you go through the production line, you see the same card cage being used. Sixty-eight percent of the subassemblies are commonality.

MR. ROSENTHAL: And at other nuclear power plants?

MR. MACHILEK: Well, the only ones I was personally aware of was Yankee Atomic and Duke.

MR. ROSENTHAL: Yankee Atomic and Duke. But how do we go about having to check your --

MR. HESS: We'll run a list. We can look through our users list and determine which facilities have our equipment.

MR. ROSENTHAL: I'd appreciate it if you'd do that in general. That assumes you can.

MR. HESS: Sure.

MR. ROSENTHAL: Those that are non-nuclear you can delete from that list.

MR. HESS: Understood. You want a strict nuclear application only.

MR. ROSENTHAL: Right. Now, I recognize that you may not know the application.

MR. HESS: That's true and chances are we probably don't.

MR. ROSENTHAL: With the understanding that the UPS may run the security computer or the UPS may run lights or whatnot, you may now know that, but I think we need to have that fairly fast.

MR. HESS: Do you want that faxed to you?

MR. ROSENTHAL: Yes, please. We'll give you our fax number.

MR. HESS: Okay.

MR. ROSENTHAL: So now we're back to drawings. Are we? I'm down to either there's a sneak circuit or we understand it. One or the other.

MR. ASHE: Maybe what we need to do -- what about let's go over some of the timing as possibly related to the event or what happened to the units. Can we do something like that?

MR. MACHILEK: In what respect, timing?

MR. ASHE: Maybe what we need to do is suggest -- just start with the guards and see how they generate a time base.

MR. MACHILEK: It has nothing to do with nothing.

MR. ASHE: Has nothing to do with nothing.

MR. MACHILEK: There were no problems with the switching, with the power. All the time clock is doing is it determines what sequence of filing of SCRs. All units started up. There was no repair, there was no damage. If a clock fails, you would know it. You have -- well, you wouldn't really because we have what we call a clock watching circuit and as soon as we lose a beat, we are ready to shut down. We don't wait on a disaster to happen in the first place.

MR. ASHE: All right. How do you shut down?

MR. MACHILEK: On a clock fail.

MR. ASHE: All right. Maybe we need to go on that. When you shut down, what do you do? You open the CB breaker?

MR. MACHILEK: Same thing. SSTR.

MR. ROSENTHAL: But don't you --

MR. MACHILEK: The clock fails and there is --

MR. ASHE: Right. All that part is the same. What about up here?

MR. ROSENTHAL: But don't you turn the SCRs off

even faster than ultimately the circuit breakers will open?

MR. MACHILEK: If you don't turn an SCR on or off at the exact precise time, you blow a fuse. You blow a fuse because you would have a direct shortcircuit of positive and negative on the battery. What you do is you simply switch the parallel voltage on and off, and then you do the same thing negative and you feed the transformers on the output.

MR. ROSENTHAL: In the manual, you said you've got like a 12-step --

MR. MACHILEK: Yes. The transformers which are -- two of them -- and if you had an imbalance of the positive and the negative, you would have a saturation effect, DC saturation, and you would blow just about anything. If you are a fraction of a millisecond off, you blow. Like we used to say, when you are power switching, you are always a millisecond away from disaster.

There was no problem in the power train in the conversion of the DC to AC.

MR. ROSENTHAL: Yes. We understand that nothing failed and the units were restarted, etcetera, but it might be useful to educate us a little bit. In this event, the SCRs were turned off, right?

MR. MACHILEK: You simply turn all SCRs off. You have to turn them off with a leg-off command.

MR. ROSENTHAL: Which comes from --

MR. MACHILEK: Are we just passing time or --

MR. ROSENTHAL: I'm just trying to understand.

MR. MACHILEK: -- do we want to have some analysis of the event.

MR. ASHE: Could we take about two minutes and just go over the gating of the SCRs in general. I think that would be helpful. I agree with you. I don't think this is so much relatable to the event.

MR. MACHILEK: GFM.

MR. ASHE: You have a GFM? A-9.

MR. MACHILEK: We would really have to go through the circuitry big time.

MR. ASHE: But I think we can just illustrate the format a little bit without really going through a detailed timing diagram and so forth.

MR. MACHILEK: Basically, what we have is six -- we have 12 switching legs.

MR. ASHE: All right.

MR. MACHILEK: Now, as you know, you can only turn off an SCR if you have interrupted forward current. In order to interrupt this forward current, you have to push current backwards against the direction of current flow. The way you are doing that is you are charging the capacitor and you have accommodation SCR, a static switching element. You should turn on and dump the capacitor charge backwards

through the SCR and you turn it off.

Then, of course, in the next cycle, you have to charge up the capacitor again.

MR. ASHE: All right.

MR. MACHILEK: The gate firing modules, as you see, you have -- it comes from the logic which turns on the various -- you have the main resistors and you have the accommodation, accommodating resistors. Each one is simply taking the capacitor charge. The main -- this goes directly -- the connection out of here is feeding directly into the --

MR. ASHE: Okay. I think we can --

MR. MACHILEK: We would have to have the right schematic.

MR. ASHE: We'll look for the schematic. So pulse comes out of here and goes into the gate zone.

MR. MACHILEK: You have the gate command coming here.

MR. ASHE: Which comes from the -- okay.

MR. MACHILEK: The leg switch-off -- see the leg switch-off commands.

MR. ASHE: Yes.

MR. MACHILEK: All the legs are getting a zero here which turns off the main SCR. At this point, you have a discharge capacitor. The accommodation SCR is turned on.

The charge is done through the main SCR, which is turned off, and you do not get any more gate commands.

MR. ASHE: Okay.

MR. MACHILEK: Should one of the leg switch-offs not execute, you blow the fuse. You see on the leg, you are directly between plus and minus DC. The two SCRs aren't serious. Should they ever turn on at the same time, for whatever reason, you have a shortcircuit positive.

You have a leg fuse which blows and the leg fuse is not on here. The leg fuse is -- one, two, three, four, five, six, one per leg pair.

MR. ASHE: Right there, yes.

MR. MACHILEK: You have the accommodating capacitors, the chokes, accommodating chokes, and diodes, standard leg, designed from the 1950s.

MR. ASHE: What is this guy doing here now?

MR. MACHILEK: This is the gate circuit.

MR. ASHE: Yes. This one right here. I know this is the gate that goes in and --

MR. MACHILEK: Between gate and the five-six gives you the firing circuit and this comes right out here. Similar, you have a gate against here and then the same thing, you have the accommodating SCR three, four and one and two.

The sequence in which the gate comes in up here,

comes directly out of the A-8 pin.

MR. ASHE: Eight and nine.

MR. MACHILEK: As you see, it's straight logic, nothing --

MR. ASHE: What kind of gate voltages are we talking about here?

MR. MACHILEK: I believe it's 12, but I -- what we used ten years ago.

MR. ASHE: I think that's a broad overview of --

MR. MACHILEK: Yes. It basically agrees with the control oscillator, with the countdown circuits.

MR. ASHE: Is it actually discrete control or is it --

MR. MACHILEK: Or discrete.

MR. ASHE: It's discrete crystal control.

MR. MACHILEK: Discrete crystal control.

MR. ROSENTHAL: This goes to a logic fail.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Is that covered?

MR. MACHILEK: This is the one from the guard watcher.

MR. ROSENTHAL: Twelve bits, whatever?

MR. MACHILEK: No. The 12-bit is simply used as a timing signal for the timers, all these timers. See all these timers here, they are run by the 12-bit circuit.

Now, in order to explain all that, you need timing diagrams.

MR. ASHE: Yes. They're too involved.

MR. MACHILEK: They give you the sequence of it.

MR. ASHE: I think that's an overview of how it's really working.

MR. MACHILEK: There it is. There's the crystal sitting right here, 1.47 megahertz, and then it goes through the countdown circuits. We're counting it down until we get the 60 hertz. We are watching the countdown, comparing it against the standard and if we have discrepancies, then we shut down on clock failure.

MR. ASHE: What is this 100 --

MR. MACHILEK: This is 1.47 megahertz crystal. We're just counting it down.

MR. ASHE: Something that is relatable to this is how does this thing bump up or change the frequency?

MR. MACHILEK: It doesn't and cannot.

MR. ASHE: We saw it.

MR. MACHILEK: There's a crystal control, oscillator which is influenced by the circuit.

MR. ASHE: Right. How does that -- just go through that, because I think that was somewhat relatable to the event.

MR. MACHILEK: What the crystal control oscillator

is doing, the voltage controller oscillator is doing, it takes the synchromat and corrects it to be in concern with it.

MR. ASHE: How does it do that? Through voltage?

MR. MACHILEK: It's voltage-controlled. The voltage level is established by the frequency of the voltage converter from the bypass directly compared to the frequency which comes out of the countdown circuits of the clock. And it corrects -- I'll show you how it corrects for the incidents.

MR. ASHE: It does that in a period of what, about 30 or 40 seconds or so, depending on the ranges?

MR. MACHILEK: It does it -- no, no. It does it every 737,000 hertz level.

MR. ASHE: What kind of band is this thing operated in? For example, if you lose more than a few hertz, it won't bring it back into sync anyway, will it?

MR. MACHILEK: Yes. If you are 180 degrees other phase, it brings it back.

MR. ASHE: No, no, no, no. Supposing the frequency, for some reason, goes down to --

MR. MACHILEK: Internally?

MR. ASHE: No, no, no. The unit works fine. The maintenance supply --

MR. MACHILEK: If the sync frequency is going .5

hertz, we disconnect the sync.

MR. ASHE: So you lock out really.

MR. MACHILEK: You disconnect from the sync, yes. We no longer let you influence us.

MR. ASHE: So it only rises and falls by that amount basically, because otherwise it --

MR. MACHILEK: Plus/minus .5 hertz, that's it.

MR. ROSENTHAL: Based on your knowledge of the design, number one, you know that the SCRs were fired as designed for however long --

MR. MACHILEK: If one gets a little out of step, you blow down right away.

MR. ROSENTHAL: And you would know failures of --

MR. MACHILEK: There was no repair, no readjustment, at least not reported.

MR. ROSENTHAL: And that's both from the rectifier and the --

MR. MACHILEK: And the worst -- the only repair which -- two repair orders have been issued, one for the circuit breaker on one unit, and I don't know what the -- the rectifier -- it was a breaker problem.

MR. ASHE: What is the maintenance cost you're talking about on one of these units per year?

MR. HESS: The maintenance contract or the actual cost?

MR. ASHE: The actual cost. Well, contract cost for one unit.

MR. HESS: For one unit, it could vary from -- you're talking about full coverage? There's a whole --

MR. ASHE: Full coverage.

MR. HESS: Full coverage.

MR. ASHE: Ballpark figure.

MR. HESS: Three to 5K a year. Now, that depends -- that could be a guesstimate.

MR. IBARRA: Per unit.

MR. HESS: Per unit, yes. It would be per unit and that would be depending on what spares were maintained on-site.

MR. GRADY: That would include parts.

MR. HESS: Yes. What we normally do is a customer has a spare parts package and then we work from that spare parts package and replenish that to them underneath the contract. So they have an ever present supply of parts.

MR. ROSENTHAL: When the AC input, normal input degrades, as I understand the design, you turn off the SCRs in the rectifier.

MR. MACHILEK: Correct.

MR. ROSENTHAL: At some point in this scenario, this event, the SCR is -- were the SCRs on the inverter turned off?

MR. MACHILEK: No.
MR. ROSENTHAL: No.
MR. MACHILEK: Only when it shut down.
MR. ROSENTHAL: It was only following --
MR. MACHILEK: You got the leg-off command. Leg switch-off.
MR. ROSENTHAL: And it gets the leg switch-off --
MR. MACHILEK: Simultaneously on all 12 legs.
MR. ROSENTHAL: From where does it get it?
MR. MACHILEK: From --
MR. ASHE: You knew he was going to ask that.
MR. MACHILEK: It's on eight or nine.
MR. HESS: It ties in. It's over there on 12 and it's tied in on the nine. This is the nine right there.
MR. MACHILEK: It's 20.
MR. HESS: Yes. Which is tied in across down the back here.
MR. MACHILEK: It basically takes it -- if we get an under-voltage -- there's the UPT, which is the -- see the UPT? That's the same one which is coming out, this one here, the UPT. It switches off to three breakers, comes in here, and it gives you a leg-off command, which is transmitted directly to the K-5 module.
MR. ROSENTHAL: Let me see if I can get this right. Because the fuses weren't blown and because the SCRs

were not damaged, in the inverter, you know that it got a leg switch-off. The leg switch-off came from which drawing? From here, which gets its input from --

MR. MACHILEK: UPT.

MR. ROSENTHAL: One is UPT, which is the same --

MR. MACHILEK: Yes.

MR. ROSENTHAL: -- which is the output of SSTR.

MR. MACHILEK: UPS trip.

MR. ROSENTHAL: From the UPS trip or --

MR. MACHILEK: Do you see UV?

MR. ROSENTHAL: I'm sorry.

MR. MACHILEK: Output voltage low. In your case, not used. This is only used on a parallel circuit.

MR. ROSENTHAL: Okay. Or --

MR. MACHILEK: That's it. UPT is the only thing which gives you a leg-off.

MR. ROSENTHAL: Okay. So that had to be --

MR. MACHILEK: Yes. Everything is consistent with operation.

MR. ROSENTHAL: But that's an independent way of -- okay -- or supporting.

MR. MACHILEK: I understand.

MR. ROSENTHAL: Okay. So now let me try to verbalize it.

MR. MACHILEK: Sure.

MR. ROSENTHAL: And then you verbalize it better. It is my current understanding that, by design, the rectifier would turn off -- would be shut down on seeing bad input, that the inverter would be turned off by an SSTR signal only, and that same signal would end up opening CB-1, CB-2, and CB-3.

MR. MACHILEK: And give a transfer command.

MR. ROSENTHAL: To the --

MR. MACHILEK: To the A-34 transfer circuit.

MR. ROSENTHAL: To the transfer circuit.

MR. MACHILEK: The transfer circuit makes a decision if or if not to execute that, depending on three conditions; bypass frequency, voltage and sync.

MR. ROSENTHAL: But we know that that was also effected by the original fault.

MR. MACHILEK: Correct. We would not expect the maintenance voltage to be there, because it wasn't.

MR. ROSENTHAL: We follow back the SSTR signal and we decided that that had -- that the only probably way, other than a sneak circuit or something we don't understand, is that that would have come from a power supply failure input and then we followed that back to power -- to the logic power supplies which we know were powered off B-phase and saw the --

MR. MACHILEK: Yes. Or that can be a verified

test that duplicated --

MR. ROSENTHAL: The one thing that we don't understand then --

MR. MACHILEK: Is the discrepancy with the --

MR. ROSENTHAL: Discrepancy with the lights. On the lights, we decided that the under-voltage UV does not latch. So that the observation of that light was the time that somebody wrote down what they saw, which was at roughly two hours -- two or three hours -- two hours into the event.

MR. MACHILEK: I would really consider that as a status indication rather than an alarm.

MR. ROSENTHAL: And that the voltage difference light does not latch as the UV -- OV/UV, but that the OV/UV transfer light does latch and may have -- and we don't know if that latched and lit at time T-zero or five, ten, 20 minutes or an hour into the event.

MR. MACHILEK: Right.

MR. ROSENTHAL: Go on. What else do we know?

MR. MACHILEK: We know that we didn't have to make a repair or adjustment and the units started up after the alarms were reset.

MR. ROSENTHAL: Right. Let's break.

[Recess.]

MR. ROSENTHAL: Let's go back to UPS. What we decided was it is not single failure-proof.

MR. MACHILEK: It is, because the power supplies are a single point failure -- not a single point failure. You've got to have something else to happen; namely, the maintenance has to get lost at the same time.

MR. ROSENTHAL: But we did decide that there are lots of redundancy in it. For example, if you lose the rectifier, you have the battery.

MR. MACHILEK: Correct.

MR. ROSENTHAL: And if you lose the inverter itself, you have the maintenance.

MR. MACHILEK: Bypass.

MR. ROSENTHAL: Bypass. So although it's -- so there is a level of redundancy there.

MR. MACHILEK: The only time your redundancy gets lost is if the redundant is if the primary source fails at the same time.

MR. ROSENTHAL: Wait a minute. Given the loss of power supply, including the battery, with the dead battery, if the maintenance supply had been good --

MR. MACHILEK: Nothing would have happened.

MR. ROSENTHAL: Then it would have -- what would have happened?

MR. MACHILEK: What would have happened? Nothing, because the power supplies would have to be maintained and you wouldn't know a thing.

MR. ROSENTHAL: If there was some other fault in the power supplies --

MR. MACHILEK: If there's another fault in the power supplies, it would --

MR. ROSENTHAL: Or the card cage or something.

MR. MACHILEK: Then the UPS would have shut down. It would have transferred to maintenance. It transferred many times over the years, right?

MR. ROSENTHAL: Yes.

MR. MACHILEK: And certainly the batteries didn't go bad. So the dead batteries, by itself, if nothing else happens with it, something specific happens with it, you would never in your life would have known that you have dead batteries.

MR. ROSENTHAL: Okay.

MR. MACHILEK: Given the assumption that nobody would have checked it. Now, we have to recognize it is difficult to test, check or make a major investigation on the modules since you have no way to power a flow. So I don't -- probably, out of my own, I probably -- given the difficulty to shut down a module and maybe not even getting permission to do it, it is considered that maintenance at times is falling short because of it.

I have to give you an example on the first Boeing installation we did in Vienna, not far from here, and we

wanted to perform the first preventative maintenance, half-a-year after installation, and we were told no way in the world are they going to go off the UPS. We have to wait. Well, three years later we had the first PM. Nobody wanted to let the load get off the UPS. So if you want an enforced maintenance deficiency because of that.

And users are paranoid. Once you have an UPS installed, you have a computer operation going, they simply don't let you get off the UPS, period.

MR. ROSENTHAL: We have discussed how do we know that the batteries were not -- were discharged or not charged at the time of the event rather than after the event.

MR. MACHILEK: It was not a matter of --

MR. ROSENTHAL: But I'd like to hear your verbalization of why you believe the batteries were no good at time T-zero.

MR. MACHILEK: Because of the amount of time it was operating in the elevated temperature environment, experts were indicating that the batteries probably were no longer batteries after one-and-a-half years after installation.

I hope it was confirmed that all five batteries were dead. Not that they couldn't get charged, they were simply incapable to hold a charge.

MR. TERRY: There was one that was -- plus 20. It was half. The plus 20 volts.

MR. MACHILEK: The plus was good?

MR. TERRY: Yes.

MR. ASHE: Which unit was that, do you recall?

MR. TERRY: Gulf.

MR. ASHE: And you actually load tested that?

MR. TERRY: No. That's measured voltage.

MR. ASHE: No-load voltage. That doesn't -- was the load test -- it wasn't load tested, was it?

MR. TERRY: No. I'm just talking about the as-found voltage.

MR. ASHE: Okay. No-load voltage will certainly come up and that --

MR. ROSENTHAL: But the as-found no-load voltage measured roughly a week after the event was after the power supplies had been re-powered three to five days earlier and, hence, are effectively on a triple charge, are on a charger.

MR. HESS: Yes.

MR. ASHE: Is there a blow-up diagram for the power supply, PS-1 and PS-2? Do we have that someplace to show the internals of that?

MR. MACHILEK: No. It's a purchased product. All of our drawings shows only the information necessary to procure it. We don't fix it or service it if it's broke.

We simply replace it.

MR. ASHE: Well, how do we know what's in there?

MR. HESS: When you order one, it comes with a small diagram inside the box, if I remember correctly.

MR. ASHE: You don't retain any of the diagrams like that?

MR. HESS: They're in the purchase part of it.

MR. MACHILEK: We don't fix it. It's what we call a non-repair subassembly.

MR. ASHE: What happens to the old unit you take out then?

MR. HESS: Throw it away.

MR. ASHE: Who do you purchase that from, do you recall?

MR. HESS: I knew you'd ask that question and there's been a couple different vendors. Economate. We have a list of vendors. Would you like --

MR. GRADY: We have a drawing that lists the vendors in the specs.

MR. ASHE: For the power supplies.

MR. MACHILEK: Yes. We can send that to you.

MR. ROSENTHAL: Okay. That might be helpful. Because if those power supplies have, let's say, big capacitors inside there, they have finite lives also.

MR. ASHE: I'm not certain that that's really

true. This power supply appeared to act more as a transistorized regulator rather than a capacity guide.

MR. MACHILEK: It's a series -- it's a linear series regulator, transistor regulator with filter capacitors on the output. The DC is being filtered because it is --

MR. ASHE: Right.

MR. MACHILEK: That's why the capacitors are there.

MR. ASHE: The output is across the capacitor.

MR. MACHILEK: Absolutely. Yes, sir. Otherwise we wouldn't survive with the power you had there, not even on the normal charges. Capacitors are holding you up right now.

MR. ASHE: Okay.

MR. ROSENTHAL: I'm sorry. K-5 flips from one state to the other.

MR. MACHILEK: The capacitor --

MR. ROSENTHAL: The capacitor and the power supply is what's holding you up.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Then I guess it would be good to know what --

MR. ASHE: So you have seen the diagram and you know that's the way it is.

MR. MACHILEK: No. I don't see the diagram. The power supply. Same power supplies which are on the pan which --

MR. ASHE: When you say on the output, what I'm saying -- to me, what that means is between plus and the neutral, you're saying that output is across the capacitor.

MR. MACHILEK: Correct.

MR. ROSENTHAL: That's another age-related problem. Did you want to review the --

MR. ASHE: I'm saying the internals. The internals. It didn't seem like the data was suggesting that to me.

MR. HESS: As soon as we get back, we'll get you -
-

MR. ASHE: You can do that, from the internals, I'm saying. The internals. I'm talking about the one from the inside of the power supply.

MR. HESS: In fact, I think it's on the back of the power supply now, they've gotten it. I saw one where it was actually glued onto the back of it.

MR. ASHE: And you have one of those laying around someplace, you think, or might?

MR. MACHILEK: At the plant.

MR. HESS: Let us take care of that. Let us get one.

MR. TERRY: Are you just talking about filter capacitors across the power pack? They're external.

MR. HESS: No. They're internal.

MR. HESS: We will take that as an action item and get you a copy of the schematic of the power supply itself, not the subassembly, which we already have.

MR. ROSENTHAL: We know that large tantalum type capacitors, batteries, are age-related components. The chips, hypothetically, have an infinite life. What other components are there which you would consider age-related?

MR. MACHILEK: DC electrolytic capacitors which are on the main DC bus.

MR. HESS: That was called out in the recommendations.

MR. ROSENTHAL: Go on.

MR. MACHILEK: That's it.

MR. HESS: Age-related like that.

MR. MACHILEK: Nothing else has a shelf or operating life.

MR. ROSENTHAL: Wear-related rather than age-related.

MR. ASHE: The diodes, you said that's a chip, too? Is that just -- that takes the 20 volts?

MR. MACHILEK: Yes, yes. The output regulators which are little chips.

MR. ASHE: Is that just a resistive voltage --
MR. MACHILEK: It's a transistor series regulator.
MR. ROSENTHAL: That's a 7812. We could look that up.
MR. MACHILEK: Yes. They're all over the place.
MR. ROSENTHAL: What were you going to say?
MR. ASHE: I was going to ask Rudi to characterize the whole thing very simply, starting from the transformer rectifier, downstream propagation to the power supply, trip of the units.
MR. MACHILEK: Okay. The loss of Phase B voltage translated itself over the areas Delta Y transformers to show up as a Phase II voltage reduction all the way through, including the 100-volt switch we use for control.
The effects of the voltage reduction on the rectifier input was that the rectifier phased off. The inverter continued to operate on the main station battery. The supply to the control power supplies reduced itself from 120 to roughly 50 volts. The drop-out voltage was, I believe, 45 on those relays. So we did not switch over, which starved the input to the power supplies and they lost regulation, reduced the output DC voltage and the batteries, which were not able to hold up, decreased their voltage on the load to below 16.5 volts, which caused an UPS trip signal to be issued, which was properly executed.

The transfer to bypass signal was not processed because the bypass was not of the quality acceptable to the circuit, and the load was lost.

MR. ROSENTHAL: Break.

[Recess.]

MR. MACHILEK: It can be shown that if you, for instance, simply take the power supply pan, the A-27, and you supply it with voltage and you monitored the load of the power supplies with four-amp and one-amp, respectively, which is the normal draw, then you can really demonstrate what would happen.

If you reduced the input voltage to the power supplies, was switched to power supply availability from one input to the other, all that can be duplicated and shown what's going to happen. The draw is a constant draw. So even if you simply put a resistor float on here which draws about four amps or thereabouts, draws about one amp or thereabouts, then you can direct it to break it. And what will happen is given the capacity of the battery and the discharge current of four and one amps, you can directly calculate or get from the manufacturer the voltage decay over time, and whenever you hit 16.5 volts, that time, you will be able to support the operation of the UPS without any other supply.

You will see, if you do that, that it is

considerably longer than the 12 cycles of voltage we're actually experiencing. Given that, which can be demonstrated, tested and shown, you can make the conclusion that if the batteries would have been good, you would not know that anything happened.

MR. ROSENTHAL: I think that's it.

[Whereupon, at 5:10 p.m., the meeting was concluded.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission

in the matter of:

NAME OF PROCEEDING: Nine Mile

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Mary C. Lail

Official Reporter
Ann Riley & Associates, Ltd.

07-4593-91

OFFICIAL TRANSCRIPT OF PROCEEDINGS

Agency: U.S. Nuclear Regulatory Commission
Incident Investigation Team

Title: Nine Mile Point Nuclear Power
Plant Information Meeting

Docket No.

LOCATION: Bethesda, Maryland

DATE: Tuesday, September 3, 1991 **PAGES:** 1 - 175

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

INCIDENT INVESTIGATION TEAM

Nine Mile Point Nuclear Power Plant

Information Meeting

Nuclear Regulatory Commission

The Woodmont Building

Room W-100

8120 Woodmont Avenue

Bethesda, Maryland

Tuesday, September 3, 1991

The meeting in the above-entitled matter convened, pursuant to notice, in closed session at 9:30 a.m.

PARTICIPANTS:

JACK ROSENTHAL, NRT/ITT Team Leader

FRANK ASHE, NRT/ITT Team

JOSE IBARRA, NRC/IIT TEAM

WALTER JENSEN, NRC/IIT Team

MICHAEL JORDAN, NRC/IIT TEAM

JOHN KAUFFMAN, NRC/IIT Team

TOM POHIDA, NRC/ITT Team

JIM STONER, NRC/IIT Team

BILL VATTER, NRC/IIT Team

MICHAEL GRADY, Exide Electronics

D. J. HESS, Exide Electronics

RUDI MACHILEK, Exide Electronics
WAYMON RANSOM, Exide Electronics
KYLE TERRY, Niagara Mohawk
KERRY JOHNSON, Failure Prevention, Inc.

P R O C E E D I N G S

[9:30 a.m.]

MR. JORDAN: Good morning, gentleman. My name is Michael Jordan. I'm out of Region III with the NRC. It is September 3, 1991. We're conducting an investigation of an event that happened at Nine Mile Point on August 13, 1991.

MR. IBARRA: I'm Jose Ibarra and I'm part of the IIT Team, Instrument and Controls.

MR. MACHILEK: I'm Rudi Machilek. I'm Director of the Technical Group of the Technology Center.

MR. HESS: D.J. Hess, Director-Customer Support Operations for Exide Electronics.

MR. RANSOM: Waymon Ransom, Customer Support Engineer for the Western Region.

MR. GRADY: Michael Grady, Manager of Technical Support.

MR. STONER: Jim Stoner, Consultant with the IIT Team.

MR. ROSENTHAL: Jack Rosenthal. I'm the IIT Team Leader. Sitting next to me is Frank Ashe, who I look at as my central focus for this meeting.

MR. ASHE: Frank Ashe, IIT Team member from the Office of Nuclear Reactor Regulations.

MR. TERRY: I'm Kyle Terry. I'm Vice President of Nuclear Engineering for Niagra Mohawk.

MR. JOHNSON: I'm Kerry Johnson, Vice President of Failure Prevention, Incorporated.

MR. POHIDA: Tom Pohida from Instrumentation and Controls Branch, member of the IIT Team.

MR. ROSENTHAL: Rudi, I think that we really have to rely on you. What we had related was that we wanted to understand, truly understand the system, rather than guessing and that the best thing to do is to do it top-down on what's the system, what was its intent, how does it work, and get progressively deeper into what makes this thing trip a lot, what makes the thing run, with a lot of focus on the A-13 card cage.

MR. MACHILEK: All right. Where do you want me to start? Basically, as you know, the uninterruptible power systems originally, if you go back in time, and I have to go back in time a little because we are talking about ten-year-old equipment that we're dealing with here.

Originally, the purpose of the UPS was an uninterruptible power supply, meaning that if your utility power went away, there was an alternate power source which takes its place. It carries you through a scenario where the utility goes away and then later on comes back again.

It also had some elements of power conditioning, which means that it took the spikes and the switching transients and so on out of the actual critical power supply

which was supplied by the utility.

Later on, our customers and we in the industry found that the actual load which was connected to the critical bus was the subject of protection. That means the person who operated a piece of equipment which was powered by the UPS, his prime concern was the power on the terminals, actually where he was receiving power rather than what the UPS was doing or something else.

The explanation of UPS then became an uninterruptible power system. If you really look at a UPS, what it was supposed to prevent is if you have a power station, like an atomic power plant, the power is pretty good. Normally, a failure in the power station itself, if you're talking about generating stations of the old type, steam power plants, coal-fired and so on, there were rarely incidents of losing the whole power supply; for instance, if an atomic power plant goes down.

The operations were from the transmission of the power from the generating plant to the actual users input, and then the distribution of power down to the terminals of the equipment which was supposed to be protected.

So our whole focus as time went on was to safeguard the power not only from the standpoint of having a power conversion module or a box sitting there, but examining the whole system, recognizing the fact that all

the maintenance and fail operations in a distribution system still exist, coming off the UPS like they did exist before coming off the power plant, except the scope was reduced to exclude all the transmissions and the outside elements from there.

What we did after that was to actually start supplying uninterruptible power systems, meaning that we took responsibility for the design of the system from the actual utility power input to a user's distribution system, to include the supply circuitry to the UPS, the UPS itself, its bypass circuitry, the maintenance of all those elements, and then, of course, the coordination of the downstream distribution to the actual user of the equipment.

The reason why I was saying all that is that at the time ten years ago, whoever designed the system was not designing an uninterruptible power system. Switchgear was purchased, a UPS was purchased, and all kinds of installation effects were done. On the end, you had something there which was considered to be adequate at the time.

The equipment was purchased as being best commercial grade. There was no special requirement for it in enhanced meantime between failure or availability. Usually, if we sell UPS systems or if they are specified by militaries or by nuclear power plants and so on, a percent

availability of power is specified. For instance, 99.9 would be a 99.9 percent of the time you have to somewhat guarantee that the power will be there. Six nines is about it; 99.9999, which basically gives you 18 seconds of actual power loss per year. So maybe every 15 years you can afford to lose the power for a little noticeable time.

Of course, you will understand that in order to achieve that, you have to go beyond the box, the actual power converter. You have to examine the input switchgear, the bypass switchgear, and, last but not least, the downstream switchgear with it.

The high reliability equipment avoids two things. Number one, single point failure mechanisms; that means any circuit which would bring the whole system down, and the system, we are talking only about the power conversion box and the bypass circuitry, and the circuit which would be vulnerable or which would cause by its failure as a single point to bring the whole system down should be avoided.

Number two, in good UPS systems design, you do not want to rely on anything to happen in the case of a corrective emergency situation, which has not actually happened already in operation. In other words, you do not want to say if something happens, this relay has to switch or that breaker has to change state or whatever.

If you depend on that to happen, there's a certain

risk. If I may digress for a moment, if you would rob a bank and you run off to your getaway car, of course, you wonder is it going to start or is it not going to start. On the other hand, if it's already running, then the risk of does it start or not start is falling away and it becomes a certainty that the car is starting because it's already running.

In this spirit, we are usually avoiding -- and as a matter of fact, the latest changes which are proposed to be done in the A-27 was in that spirit, that if I have to switch the K-5 relay, for instance, why don't I only switch it at the times where if it doesn't work, it wouldn't cause me a load loss, that it would be an inconvenience and so on. I'm just telling you where we are coming from in this respect.

The fact that the A-27, for instance, the new one or the one which was generated by the Navy, came from that kind of investigation. Somebody said, hey, what happens if a power supply fails. You go to bypass. What if there is no bypass? Usually you have to differentiate here between one failure, does it survive the failure of one component, does it survive the failure of two components that fail at the same time and what is the probability of that, what if there are three things happening at the same time, what is the probability of that, because last, not least, all those

questions can be answered with a big sign, which is dollars.

Of course, if you compete for an order; for instance, the equipment for the Nine Mile Plant, it's a complicated situation. They cannot give you a Cadillac if all you want to go is from here to there and you call it transportation. See what I mean?

So we have to understand here that the equipment which was installed was not the highest scrutinized equipment, such that it would go into high military or high-risk military installations or installations which specify the percentage of availability and the quality which has to be maintained to that end.

So from about 1972, we introduced the Series 3000, which the new equipment that is the subject of our discussion here is part of it. The Series 3000 was developed, if you want, between 1968 and 1972. The first system of that sort went into operation in the spring of 1972 at Philadelphia Electric in Philadelphia; not in the power plant itself, but in the office in the building they have downtown. It is still running. It is still there.

It is the system we have the longest in service, about 19 years now. I think if there's a question on what is the failure rate and what is the availability of power and how vulnerable is the equipment, I believe that installation would be the most indicative of that 3000

circuitry.

The 3000 was improved. The problem was that it used to be that the development time of a piece of apparatus was maybe one year and the lifetime of the design was maybe ten years. Now the design time is maybe two years and the lifetime is minus one year. That means as soon as you come up with a piece of equipment, enough technology has been made available that you almost can say whatever new I'm introducing is obsolete at the time, unless you don't know about the other thing yet.

So in that spirit, we had a Series 250 and a Series 300, 315, a Mark I, a Mark I-and-a-half, a Mark I-and-three-quarters, and then a Mark II, and then we had -- from then on it became a little erratic because customers had specific needs or specific circumstances and we went more into the design of systems rather than the power conversion module.

In that spirit, we made changes, improvements, if you want, to meet certain specific requirements. The Mark II design was actually the one where we entered the era of systems rather than supply and made changes in the circuitry which had nothing to do with improving the circuitry itself, but had something to do with the operations effect of what we were doing.

For instance, some customers said if a module went

to bypass that it should not come back automatically ever. They wanted to go there and investigate what caused it and fix it or do whatever. The other customers said, gee, I don't really care about all that; if I have a glitch in the power and the power restores to normal, I want to come back and I don't want to have that much to do.

So we had two versions already. One had automatic re-transfer and the other had manual re-transfer. The Mark II-U was a design which consolidated all the features which were different for various customers into one universal design. In other words, with the universal board, you can select if you want to come back automatic and manual. You have all kinds of features in there which we don't advertise to be selectable, but they are there to aid us to come up with a board which meets everybody, and yet we can sell it to you as a custom piece of equipment because we can adjust it, but we don't have to make special production runs.

The reliability of the circuitry is better, of course, because it's done over and over the same thing. For instance, we came up with the Mark II-U selectable for 50 and 60 Hertz. So you can stick it into international units as well as domestic ones. You will never run it at 50 Hertz.

But if you want to test for clock failure, you can actually switch a little switch and the inside of the unit

gets programmed for 50 Hertz, and yet you have 60, the clock, of course, goes to hell, but the effects of it we can demonstrate.

In our design, anything failing in one module only effects that one module. If you have a bypass, it will go to bypass. If you have a parallel module, such as a redundant one, the redundant one will take over without any ill effects. We call it selective tripping. That means any failure within the module only effects the module. It does not effect the output bus.

If you do not have a redundant module which works with the one that you have on-line, then, of course, the utility has to take its place. So the utility in this case is the redundancy to the UPS. If the UPS fails, it will go to bypass, the bypass being the utility.

There is a misconception, of course, if you want a reasonable assumption that once you are in the power blend itself, that you'll never lose utility power or the utility power is highly, highly reliable there. The module itself was designed to have a meantime between failures of 20,000 hours.

In other words, every 20,000 hours, if you operate the equipment for an infinite amount of time, then, as an average, every 20,000 hours you would have a failure, which does not mean that you will not have a failure until 20,000

hours have passed.

As you know, if you have a dice, the probability for infinite amount of throws is that you have each one, one to six, come up exactly at the same one-sixth of the time. Of course, if you only throw the dice ten times, you will find that distribution is not true. So we are talking about probabilities here. We're talking about MPTF.

So we have to expect that you may not have a failure in five years, but you may have three in two months. We don't know. It's the quality of the components and the design intent is of that sort. So every 20,000 hours, if you want, as an average, for an infinite period of time, you would have a need -- now, this 20,000 hours is only failures of components which would actually effect the output of the module itself.

If a meter goes bad or what have you, which has no effect on the operation, we do not consider that a failure in that sense. Now, if the UPS fails for an internal component failure, blowing of fuses or a malfunction of whatever sort, there is a mechanism in place where it shifts the critical bus over to the alternate redundant source.

The redundant source can be a diesel plant which is already up. The redundant source can be a utility, such as in your case, or the redundant source can be another UPS which was running in parallel with the one you already have,

and if one fails, the other one simply takes over and you wouldn't even know anything was going on.

Now, in case the UPS fails, the UPS module fails itself and, as a second failure at the same time, the utility isn't there either, then, of course, we're talking about a double failure. The meantime between failures of that to happen is calculated at 100,000 hours if the utility has an MPTF for 3,000 hours. That means if the utility doesn't fail more often than to generate 3,000 hours MPTF, then every 100,000 hours, if you operate the equipment an infinite amount of time, you will have a load loss.

Why do I say that? Because if you have only one module and it quits and you have only one bypass and it's not there, then, of course, if the sky breaks, all the sparrows out there, you have nothing to work anymore.

Now, in the case of the incident, if I may refer to the incident, you'll know what happened here. We had that situation happen. The UPS tripped, became unavailable for the user and the bypass wasn't there either simply because its quality has to be a certain one in order to be labelled in existence. It's frequency has to be within half-a-Hertz.

Its voltage has to be at least within ten percent, plus or minus, of the mean voltage which the system is adjusted to. Of course, it has to be in sync with the

output of the UPS module. If any one of these three conditions are not there, then the bypass is considered not available. The reason for that is if you would switch to such a bypass, let's say you're out of sync and you will switch anyway, you are suffering a phase hot.

That means instantaneously you would see a huge change in frequency in an extremely short period of time, where the FTD would be substantial. Any piece of equipment downstream which is of the computer type which would be sensitive to fast frequency changes would either have a data problem, it's output would be unusable, or else it would even be physically damaged, such as it was in the case if you go back ten years when the equipment was not able to do this kind of thing.

Now, most of the users say that no power is better than bad power. In other words, if I have no power, well, equipment stops functioning and if I have bad power it gets damaged. Single phasing, for instance, if you lose one phase, was considered a serious problem because you're rotating all the motors and so on, drives, what have you, a lot of the three-phase pieces of equipment suffered.

So a lot of installations do have protection, that the circuit breakers actually open if you lose a phase. What that would have done any good, of course, is because the power supplies would not have seen a reduction in

voltage on Phase B when you had the incident. It would have a seen a loss. We demonstrated it even was bad batteries on the power supply and actual loss of the bypass power was not detrimental.

It was a reduction in the voltage which really caused us to go down. We did not consider that in the design. Tell you that plain and honest. A loss of voltage on one phase, a reduction of voltage on one phase was not considered in the design of the UPS. It was designed for a loss of either one of the two supplies. If the UPS output was lost, then, of course, you transfer. If you didn't have a bypass at the time, bad luck, you go down.

It is designed to do that. If you lose both, if you lose the UPS module, you do not have a redundant one and your bypass is not available as defined, then you will lose your load. So in the design application of the UPS, it had to be considered that every 100,000 hours average over an infinite period of time, I will lose that load.

That simple. Now, the question is was that fact considered in the application of the module and since it did happen, why was everybody upset. You have to look at it from that point of view. Yes, we had five units around in there for roughly five years, so we have 25 equipment years of operation. How many times did we go down? We did go down once and the circumstance was really one that the

equipment wasn't designed for.

Should it have been designed for -- well, a lot of should-it-have's we can discuss until we're blue in the face here.

MR. ROSENTHAL: Let me just interrupt. What is hung on the UPS, on what loadings, etcetera, is a subject for the IIT, but I don't consider it a subject for this meeting.

MR. MACHILEK: No, no.

MR. ROSENTHAL: Just so we get agreement here.

MR. MACHILEK: I'm simply saying it in the relationship of what can be expected. If you have four passengers, you cannot have a two-seater sports car. In that relationship, I am simply saying that the severity of having that scenario happen, which was expected to happen based on the design criteria of the system, needs to be taken into consideration here.

The only reason why I'm saying that, if we would only be having a 10,000 or a 15,000 hour operating here, then we would be extremely disturbed here. The only reason I was making that dissertation was to say what is expected, and I believe this was the equation, what was the design criteria of the equipment, what is it expected to do.

Now, if the utility goes away, of course, the rectifier portion is not all that important of the UPS

because you have a battery there as a redundant DC supply for the inverter to operate. So the actual loss, disturbance of the input to the UPS, number one, it's much broader.

You can risk a plus or minus three Hertz of deviation in the frequency and the rectifier would still run. You can have a plus-ten minus-fifteen percent voltage deviation and you can actually have an actual outage, or if the rectifier itself breaks, all those considerations are of little concern to the inverter as long as the battery is there.

If the battery is not there, and now we're talking about two failures again, the UPS would go down. The same way the little UPS, which we consider the power supply, which is basically of the same design as the large one, we have a little UPS within the big UPS. If you lose the supply to an UPS and you lose your secondary or redundant power to it, which is the battery, the output goes bonkers. It goes away.

This is the reason why you bought the UPS in the first place. You are well aware of that, that if the battery plant would go away and you have a power glitch, you've had it, you lose your load. Unfortunately, of course, the little UPS which is supplying the control power, which was at the time of the same design as the big one,

doing the same job, suffers the same shortcomings.

All I want to say, that the normal operation of the UPS is utility power goes through the rectifier, it's been rectified, supplied to the inverter, the inverter inverts it and out comes the AC on the other end. The rectifier itself is redundant in the meaning that the battery power takes its place, not requiring a switching, though.

Normally, the battery is simply floating. It's in parallel with the rectifier output and who supplies power to the inverter simply determines who has the instantaneously higher voltage at one particular moment. So whichever voltage of the two, the battery or the rectifier is higher in any one instant, this source will supply the power.

Of course, if one source fails, then -- now, you can lose your battery as long as the AC and still nothing happens. If you can restore the battery power, of course, you're in good shape again. I've seen instances where, for instance, auctioneering diodes, such as we have, were paralleled with circuit breakers, that in case that one -- now, an SCR fails always short, always meaning until one fails open.

I've only had one diode open failure in the over 42 years I'm working with static power equipment, but it happened one time. No matter if you work 60 years, your

whole life on something, if it happens one time, that one time is considered a 100 percent of the failure. How come you did not consider that.

Of course, the question is why don't we have circuit breakers parallel to the auctioneering diodes. Well, we don't expect the auctioneering diode to fail open. Otherwise, you would have the parallel breaker, you get in a RAM, and we do have in a RAM that the auctioneering diode is, in fact, there and it's in good shape, it goes to the circuit breaker and you maintain power.

So what you expect, you design for. If you can afford to design for it depends now on the probability and if you want to spend the money. If it once happens in 60 years, do you want to really install it, maintain it, and do all these good things. Well a lot of people say no way, forget it.

But you only have one spare tire in your car. Why don't you have two? Well, how many times did you have a blowout on two tires at the same time? Never. None of us have, right? But it could happen, right?

So in that spirit, we have now the battery as a redundant power supply to the rectifier. Is it an absolute 100 percent true that you never lose DC power? No. You can only reduce probabilities, you cannot reduce the risk and son on.

Now, once you have the inverter, unfortunately the inverter has to be -- I think we covered the basic operation. As long as you have AC and battery, you have an inverter, as long as you have a bypass, whatever happens, you go to bypass. So far, the load is not being effected by anything.

MR. ROSENTHAL: I follow the -- if you lose the rectifier, you go on the battery, etcetera. As I understand the design objective, it's that no single failure of the battery or the rectifier will cause the normal UPS to go down. On going to bypass on loss of the inverter, I think we're going to have to -- that's a design objective, I take it, but I think we want to see drawings and, as the morning progresses, truly understand that.

MR. MACHILEK: Okay.

MR. ROSENTHAL: You'll get to that. Go ahead. You're doing terrific.

MR. MACHILEK: Now, as long as we understand that the loss of the rectifier portion, or half of the box, really, would bother us little if we confide in ourselves to the existence of single failures.

As far as the inverter is concerned, of course -- yes, sir?

MR. ROSENTHAL: Sorry. There are signals from the card cage to the SCRs on the rectifier side.

MR. MACHILEK: Correct. There are three circuit boards, commonly known as A-30, A-1, 2 and 3, which control the rectifier. If you go back in time between 1972 and 1976, we had two card cages. One was in the rectifier, and the rectifier was a separate cabinet, physically divided, and you had an inverter at another card cage; of course, constant cost reductions and looking to make the whole equipment to be smaller in footprint and so on.

Last, not least, the least amount of components you use is the most reliable unit, because we have the failure, MPTF is calculating by the count of equipment, of components. We combined the card cage into one and designed the UPS that it behaves much like a three-phase generator would. The only difference is that it has the absolutely constant frequency on the output. The output frequency does not change with loading at all.

It's just to explain the differences between a three-phase generator. The impedance, of course, the output impedance is higher, 16 to 18 percent versus maybe eight percent in the generator. Other than that, it is phase-to-phase control, not as the static equipment was if you go back in time prior to 1968.

So as far as we are now concerned, let's say the AC goes away, the battery is powering the inverter. Now the question is is the bypass power going away at the same time

the input power to the UPS goes away or is it not.

If the bypass power and the UPS input power go away at the same time, then, in a sense, you do not really have redundant bypass power. You simply have a UPS sitting there without a bypass and you are back to your 20,000 hours MPTF, because the 100,000 hours we only realize by having the utility.

In order to overcome that, if you are a user, if you are out in the plant somewhere taking utility power, you would come from different substations. You would come from -- if the two substations go together in the same high voltage line, of course, again, you can only go that far until you make tradeoffs. If you have substations and you have cables coming in, of course, you try to have separate cables. You have redundancy, as much as you can afford.

Let's take the case where the bypass power is coming from another source. You lose your source to the UPS. You go on battery. The other source is available. Then what happens is that you run on battery at the design which you had at the time ten years ago.

You run on battery until the battery was depleted, which would never happen in your case because you have a battery charger which is keeping the DC bus alive, unless the battery charger also is supplied by the same utility source which supplies the UPS in the first place. But let's

not -- let's say the DC stays put.

Then you would simply run on battery. You would not have any need for the bypass source until the bypass source comes back. That is the designed intent of it.

MR. ROSENTHAL: Let's stop this again. For now, let's assume that all the logic was up and running throughout the entire event. Let's assume that.

MR. MACHILEK: Yes.

MR. ROSENTHAL: We believe that on the normal and on the maintenance supply, for sometime between six and nine cycles, the voltage went to about -- somewhat more than half of its normal voltage, then went to zero for three cycles, and then was back up after a total of 12 cycles.

I think that the relay time that we were looking at in the switchyard and in the plant are a little bit off by a few cycles. So for six to nine cycles, you saw a degraded voltage on the normal input and on the maintenance bus.

Let's assume that the electronics power source is good.

MR. MACHILEK: Logic power.

MR. ROSENTHAL: Yes. The logic power. What should I design the UPS to --

MR. MACHILEK: To keep running.

MR. ROSENTHAL: And it would --

MR. MACHILEK: The inverter would keep on supplying power from the battery.

MR. ROSENTHAL: From the 5100 battery. What would the rectifier do for that small period of time.

MR. MACHILEK: Just sitting there being phased off.

MR. ROSENTHAL: Phased off by the logic.

MR. MACHILEK: That's correct.

MR. ROSENTHAL: Then when it saw the voltage good again --

MR. MACHILEK: The voltage comes good again, it recognizes that fact, it waits for a little under ten seconds to make sure -- see, if you have a utility switching, sometimes it comes back suddenly and you have about -- you deal with the supplies of networks coming.

So it makes sure that the AC, in fact, is stable and is back. It synchronizes to it and then walks the load back up. It means it increases the load gradually over about three seconds or thereabouts.

The reason why that feature was put in is if you come from a diesel generator, because more often than not, if a utility fails, a diesel plant starts up and the diesel doesn't want to see a sudden in-rush or increase of power. So we are ramping the load up on the rectifier.

Once that has taken place, you are back into

normal operation like you had before. Regardless of how short an outage or disturbance you have on the input, you end up with about 14 seconds non-availability of the rectifier.

So your large station battery will always see a 14-second discharge period, even if your disturbance was only nine cycles or six cycles or whatever it is. But the inverter simply doesn't care. It doesn't know. The logic often cannot differentiate if the DC power is coming from the rectifier or the battery.

It can only determine that DC is available within the window, as we call it, between the maximum and minimum battery voltage which exists on the DC link. So the inverter would sit there and run.

Now, since you lost your bypass power, the way the power supply input is configured on the units you have, the K-5 relay, the infamous K-5 would have switched over and would have put the logic on the inverter output. Now, that switch-over should or was, by design, done that the battery would not really be required to be there.

MR. ROSENTHAL: The little battery.

MR. MACHILEK: The little battery, yes. That means there is enough capacity in the power supplies to switch you over, to carry you over. The battery, of course, was there, still there, because we believed that the little

UPS is powering the pickups. That's our philosophy.

Yes, we are the only ones in the industry which has a control power battery. The rest of our competition, if you should lose all the power, you do not know what happened simply because you would not have any light indication and, number two, we have enough power in the battery that if everything goes bad, it still has enough power to open all the circuit breakers.

So we believe and I believe very strongly today that that battery is a very important feature; not for a single component failure or a failure, but if you have a more specific scenario which not one failure or two or three, but simply accumulation of failures, you never want to see. You don't want an aircraft to go down with 300 people on it, you know. It happens.

So in that spirit, I believe we do have -- we maintain the light indications, so if you come after this scenario, that you see or you can determine what happened. That feature failed during that event. That means on the end of the scenario, we did not realize the information we should have had. Namely, what caused the trip for the UPS.

When we got the first call of what happened, we never expected that the batteries were dead. That was not a consideration. We learned that after we got the site. But only in the investigations we did up to that point was

considering that the battery was in good shape.

We tried to find a scenario, either a multiplicity, happenings never seen before, to theorize of how could we possibly, and there we go now into circuitry of the A-21 board, how could we possibly get a lamp indication on the A-14, which is the meter panel, how can we possibly get no indication on the A-21, and that was really the focus of our intent to find out what happened was -- to assume all that.

When I talked to -- and I don't have a record of who was on the conference call, the very first one we got after the event, and people wanted to have a quick -- you know, what happened, tell me, tell me now, not tomorrow, not in half-an-hour, right now I want to know.

So we stuck our heads together. Well, we were on the conference call and we said, gee, in order to get a latch-to-latch and the lamp's not lit and the other lamp which comes on at the same time is, what possibly could cause it. So our first input was no way. The lamps had to be there, somebody had to push the button and reset it.

If you push that button, you reset all of the lights which were lit, reported lit, together with the ones which were reported not lit. They call come on at the same time, they all reset with the same button. So you cannot reset 15 lamps and have the other two lit. It doesn't work

that way.

So we said, gee, you know, since the lamps on the A-14 were still lit and the lamps on the A-21 were not, the lamps had to go away somehow. How can the lamps go away? Well, the only -- component failures were ruled out. You cannot have the same component failures on five modules and five modules are doing the same thing at the same time.

So we just said, hey, you know, to have a chip here or there or something went bad, forget it. There was no repair required. That means all units went on-line by simply being restarted.

Then Mr. Bill Zuke, I think some of you have mentioned, he says, you know, Rudi, he said there is something like an SCR latch-up, there is something which can latch-up the logic without getting actually a signal to do so. We looked into that while we were still on the conference call and said, well, how can that happen; we have a printer circuit board which is about 16-inches long or thereabouts, there is a ribbon going from here to there, I would have to have -- and I think the test showed ten volts, but we thought between five and six volts. I made that statement on the phone.

If I had a voltage difference on that ribbon from here to here of at least five volts, we thought at the time, it could happen. But what would not have happened is that

the latches would latch. You would have to have a trip and you would have -- after the trip, the lamps would have gone away and you wouldn't have known what was going on.

Let's say the SCR latch-up time was staying put. Then you had to switch down or off the controls, the control power supplies completely in order to get an outage. But there was no report of such a shutting down of the control modules, the control logic.

Matter of fact, it's not something you can easily overlook because, number one, you have to shut the module down or, if it's already down, you have to wait for the DC link to bleed off. If you restart the unit while the DC link is still up, you'll probably have a combination failure. So you wait for the DC to come down to about 30 volts. Then you can restart the unit.

So it's not something you can do in the haste of going through a scenario and forget about it. So we took the transcript and we searched it and there was no mention. When we came to decide, we questioned the personnel, we said was the logic reset. Why do we have to reset the logic, we pushed the reset button. I said, well, what did you do after you pushed the reset button. Well, we started the unit back up and it came back up.

So there was no resetting taking place. For that reason, we discarded the idea of the SCR latch-up of the

gates, which is the trip signal and what gave you the lamps on the A-14. All this was going through in haste. We were still on the conference call. I said, gee, folks, I cannot really -- all I'm saying here is we're just trying to, off the top of our heads, find a scenario which could cause the peculiar -- if it would have been a commercial situation, we would have said you're all full of -- you know.

The lamps were there. You just didn't -- you know -- you just reset it and then you thought, gee, God, I should have done this and that. But this wasn't the case. We were talking about reliable personnel, we were talking about more than one team which looked at it, so we did not consider -- we took as a fact that the A-21 lamps were not there.

The only other way, if the SCR latch-up can be discarded now, is, well, what else is there peculiar to the lamps. They all power with five volts. The only five volts in the whole system is to power these lamps. It comes from a five-volt power supply on the A-21.

So if, on all five units, the five volts would have gone away and stayed away for the whole period of time three teams looked at it, and then after pushing the button, all of a sudden they were there again, we just -- not reasonably, with any academics and even practical reasoning, we could come to a conclusion that that would be a

possibility.

So this is where we were. My statement, and I think it's on the transcript of the last meeting, was, folks, I have to consider it academic, it doesn't really do me any good to search for it for another ten years because we will never find out.

There is no way I know of, and if there are any experts elsewhere which can look at it, you're never too old to learn. But what I have to my command in the development lab in the Systems Test Department, I just can't do it for you. If I cannot duplicate a failure, no explanation would suffice. Show me, don't tell me, and I cannot do that.

For that reason, I suggest that to -- I don't know to what extent there is a need for explanation of the incident down to an understanding. This is where we ended up, that I said, you know, at this point, I say to myself let the powers to be and the experts will look into that some more.

All I was interested now is in how can I help you to improve the situation, not to prevent a scenario like this and give you a guarantee in writing and my paycheck, although it's not that big, but simply say what could we have or what would we do, what can I do today to help you, us, in order to improve the situation.

What I said to myself, well, the philosophy of an

UPS, as I explained at the beginning of my dissertation here, is not to ask for something to work which doesn't work before an incident, but take the risk away.

For that reason, I was suggesting the change of the A-27 board to say let me -- you always have to start on the bypass because the inverter isn't there. So if we say inverter preferred, it was a bad choice of words. You have to have the preferred supply to be the bypass or some others, like -- the other ones, you have to use a DC converter off the battery. But it has to be other than the output of the UPS.

Now, the battery supply in the commercial systems is not that reliable that we can work off the DC to power our power supplies. In your case, different story. So what I say to myself, if that K-5 would switch right away after the inverter is brought up and becomes available, you've got to switch at one time or the other.

Either you stay on bypass and you switch when you need it or you go and switch right away, then you stay there. This was the reason why I suggested the change, that the K-5 were not working would be -- the importance of it would diminish; again, not as a single point failure, together with a dead battery, two failures you've got to have, two or three.

You've got to lose the power for a reason, the

transformer failed, you had a bad battery, and to decide why to switch at that period of time. So I can take that risk away. I can say, okay, I have the getaway car running, ready.

Now, you would have detected the bad battery because if you started up the unit and you wanted to go from bypass to UPS, you may or may not. Chances are that you would not have to take the -- unfortunately, the problem is that you cannot detect the battery, you cannot measure a dead battery unless you discharge it.

The open circuit voltage can stay up to roughly two volts per cell, even on a very poor battery. You have to put some load to it and see how fast the battery voltage collapses.

Normally, we are doing that twice a year. In our commercial contracted maintenance procedures, we go in twice a year, every six months. We go on maintenance bypass. That means we switch the load actually around the whole UPS and go through and check out everything. So we never had in the past a battery which wasn't load tested either twice a year or at least once a year, because some customers objected to the twice a year for the simple reason that they did not want to come off the UPS twice a year.

They said once a year we have a general maintenance period. Some during a long weekend, they had

from 2:00 in the morning on Saturday till maybe Sunday. There was always some window where we could go in.

We never could at these installations -- and customers get over-confident. Nothing has happened to them for three years to say, well, why should I shut down twice a year. This is basically the way that the situation is still.

Now, can you design -- okay. As far as what you see in the manual was already describing the Navy style, unfortunately. We switched over, as I told you, to the Navy style, which is redundant power supplies. The fact that it's a relay K-1 and not K-5 is to keep off that -- somewhere I have a schematic with me on that -- which has two pairs of power supplies. Here it is. See, one, two, three, four power supplies and the relay is a K-1 relay.

It's the same battery still, everything is still --but this is actually the power supply plan which was described in the manual which was supplied in 1985, and I think my colleagues here from Field Service can go into why it wasn't the right one.

MR. ROSENTHAL: I read this manual twice over the weekend and I'm not sure that I was reading the right manual.

MR. MACHILEK: On Page 210, you have a description of the -- see, this one says here 817 K-1.

MR. ROSENTHAL: Right.
MR. MACHILEK: This is not your power supply.
MR. ROSENTHAL: So what is the manual for what's in the plant?
MR. MACHILEK: This is what it should read.
MR. ROSENTHAL: And who else has copies of this?
MR. MACHILEK: Angela Freeman.
MR. HESS: This is the one you sent up to Niagra Mohawk, right?
MR. MACHILEK: Yes.
MR. HESS: She's in our Engineering Department. Clarify your question, Jack. I don't think we got your question.
MR. ROSENTHAL: So Niagra Mohawk had a manual.
MR. HESS: That's correct.
MR. ROSENTHAL: Which I think is this manual, or a copy of it.
MR. HESS: I haven't seen it. Do you want me to take a look at it?
MR. MACHILEK: This is a copy of the manual that I brought and made a copy of.
MR. HESS: Okay.
MR. MACHILEK: This is the one which Mike gave me when I went up.
MR. HESS: Then this is the 1985 manual.

MR. MACHILEK: That's the 1985 manual.

MR. HESS: Okay.

MR. MACHILEK: You have to explain if it's needed here or why the 1985 got into that.

MR. ROSENTHAL: What we're going to be talking about today is the manual for the units that are in there and the drawings for what's really there.

MR. MACHILEK: Yes. The drawings --

MR. ROSENTHAL: And I don't know if Niagra Mohawk had them. They have them now, I assume.

MR. MACHILEK: When I came to Niagra Mohawk, Bob brought in a whole stack of drawings because you guys or somebody wanted them. I looked at that stack and said, you know, what are you doing with all these drawings and he said, well, these are the ones we have to give to you people and to the institute and what have you, so many copies.

So I said, you mind if I look at it, and we looked through the drawings and about two-thirds of them were not even the same equipment. They were 100-KW modules and God knows what. I conferred with him and said, you know, is the documentation I have in hand the proper documentation, and the answer was yes, that it was, except for some items which we could not recover. There was in 1985 a request from the plant to resupply a set of drawings.

The problem was that the original drawings which

were generated were not around no more. So we only had prints. The manual was there. So what somebody in that department which is filling the request for documentation just simply took the 1985 manual and sent it on to you. So what you have there was what we did build, in fact, in 1985.

MR. HESS: We don't know what they have on-site from the original units. Were you able to locate anything on the site?

MR. MACHILEK: In order to find out what the manual says exactly which was supplied was the units, we would have to rely on the plant to hopefully have one around somewhere.

MR. ROSENTHAL: Over the weekend, reading the thing I realized -- it looked like a generic manual where it said if you're a 60-KW, but if you're 100-KW you'll have an extra transformer. I can follow through. And that doesn't -- okay, fine. But then I get to very specifics where it looks like you get a logic trip if the SCR firing logic, without lighting some of the other lights.

For something like that, you've got to know whether that is the manual or a generic manual when you get into specifics like that, or maybe -- but you do have the drawings with you of the actual installed units, right?

MR. MACHILEK: The drawings which were drawn on-site, identical to what the unit is. The manual does not

reflect that.

MR. ROSENTHAL: And you've got copies of the drawings with you.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Good. Why don't we take a five-minute break.

[Recess.]

MR. ROSENTHAL: As an intro to where we are going, I have 90 percent confidence that the design changes that have been proposed make the machine less suspectable to spikes on AC supplies, et cetera. We recognize that we can't reduplicate the event short of throwing a crowbar across a major transformer in the plant. What we were doing up at the site was really simulations at best.

When you toggled off the AC supply to the control logic you did see a little spike on the output of the supply even with fresh batteries. So it is of interest to us to learn as much as we can about the logic response of the unit so we can fully appreciate what we are fixing and what vulnerabilities might still be there.

With that, let me give you back the floor.

MR. MACHILEK: What may be of value here is to speak a moment about what a battery is doing.

MR. ROSENTHAL: What kind of battery?

MR. MACHILEK: Any battery. What you just

described as having a little spike on it is what we refer to as a crack of the whip. If I may approach the board.

What you have on a lead acid battery is basically your open circuit voltage would be 2 volts per cell. Your charge voltage is 2.5 to 2.17 volts per cell. This is the constant voltage which comes out of the rectifier. It doesn't work like that on a standard UPS. The reason why I discuss it like a standards UPS is because the power supply of the little UPS behaves like that. If you loose the charge voltage, automatically the battery voltage drops down to 2 volts per cell. Unfortunately, it drops down a little farther and recovers to 2 volts per cell. We call this a crack of the whip.

The reason for that is that the series impedance was the battery. If you look at free flowing circuit, you have a little resister and a conductor and then you have your internal battery, your EMF, and then you have a little leakage, conductor, a resistor, and there is another leakage capacitor.

As soon as you have a charge curve in demand from the actual battery cell, you are deducting the voltage drop of the series impedance. If you go inside, you have a little plate, and then you have a little connection going up to the post and from the post there is a leak, which manifests itself in the sudden voltage drop and the spike.

It recovers and stays basically at 2 volts per cell and then slowly decreases in voltage.

This behavior would include the large station battery as well. In your case, the reason why it is different is because you have another rectifier which really keeps the voltage. So you are not dropping down on the large station battery. You will not drop down to 2 volts as long as the other rectifier is keeping the flow voltage up.

We have two rectifiers in your case on the large station battery.

MR. ROSENTHAL: Right. There is a separate rectifier.

MR. MACHILEK: There is a separate rectifier which is on the other side of the auctioneering diode.

MR. ROSENTHAL: I don't know what its capacity is, but I think that is moot.

MR. MACHILEK: It is of no consequence here.

The only difference in operation is that you would stay up at 2.15, because the other charger supplies flow voltage, whereas if you only had your own rectifier you would lose that source. So you have a redundant rectifier, if you will, installed in your system.

MR. ROSENTHAL: Our concerns with respect to this event is that these spikes are short in time compared to the time it takes relays to move and the shunt trips, et cetera.

I don't know what the time scales of something like this with a spike is compared to the CMOS logic, which I take it is running at 180 kilohertz.

MR. MACHILEK: The power supply is monitored. The CMOS logic is not affected by voltages below 16-1/2 volts. If you would have gone with that spike below you would have gotten an alarm which says your power supply is -- as a matter of fact, it would shut down on you. In UPS design you have to take the crack of the whip into consideration in your window for the maximum/minimum voltage you can allow the battery to operate, which includes the crack of the whip, of course. Otherwise all the UPS would go down as soon as you had discharge.

MR. ROSENTHAL: Do you want to go on or do you have a plan for today?

MR. MACHILEK: No. I'm here to explain or describe or theorize anything you may want to hear.

MR. IBARRA: Can we go into the details of what that battery was supposed to do?

MR. ASHE: So far Rudi has given us a broad overview of a very simplified diagram that we have here. Maybe as best you can understand or perhaps some of your people understand the actual wire connections to that diagram, I think we can then move on to the details of the A27 panel.

MR. MACHILEK: The only difference here is that you have another rectifier sitting here, AC/DC.

MR. ROSENTHAL: That's external to your scope of supply.

MR. MACHILEK: Correct. The idea here was that your own station battery is keeping the battery floating and the rectifier of the UPS is prohibited from recharging the battery.

MR. ASHE: How is the actual wiring done here, here and out here? Is it delta? Is it Y? Is it grounded? Is it ungrounded? The actual Nine Mile Point installation.

MR. MACHILEK: The input is a delta, Y, double delta with the Y, and the delta on the secondary. The input is a three-wire ungrounded. The only grounded three-wire system I know of is in Japan, which they call a wild leg delta. They are grounding one phase actually of the delta. I have never seen it in the United States or Canada.

MR. ASHE: So these are three wires, ungrounded delta input.

MR. MACHILEK: Ungrounded delta input.

MR. ASHE: Fine. That's that one. Let's move to this one.

MR. MACHILEK: This transformer is a delta -- I don't know if I brought it or not.

I did not bring it, but that is also an ungrounded

delta.

MR. ASHE: And the output?

MR. MACHILEK: The output is a Y with a floating neutral. We ship it as a floating neutral. It is up to the systems engineering, which would be Stone and Webster in this case, to determine if that should be grounded and where.

Generally the reason why we stay out of that is because of what codes you have to meet. NEC 250 basically tells you that a power source to a building can only be grounded at one point. In other words, if you come into a building and you have a delta Y transformer, which most of the building entrance transformers are, you have a wire directly ground via neutral point to what they call electrode or the main grounding point.

If you have an UPS, then you can consider that UPS as separately derived power only if you never parallel the two sources. Unfortunately, on a static transfer you do parallel the two sources. By code you cannot ground that system here separately. You cannot have two ground points and parallel the two systems or you are violating the code. Therefore you have to take this ground point here, this neutral point, and bring it over to this one. This is to meet the codes.

If the ground electrode is connected to a ground

grid or a main grounding distribution system meeting the definition of the National Electric Code, then you can of course connect that point to that system which is considered to be the electrode.

MR. ASHE: I think what you said is that the output is a delta from the inverter.

MR. MACHILEK: Correct.

MR. ASHE: That ground is a straight piece of wire that goes back to here.

MR. MACHILEK: This doesn't matter. Since this is a delta transformer, you are isolated.

MR. ASHE: But how is the Nine Mile Point installation, as best you understand it?

MR. MACHILEK: What we have here is another transformer. This is this transformer here. This transformer has to come to here. Due to UPS output it is no longer your building entrance transformer; it is now this transformer which constitutes the alternative source. Therefore the neutral point of this one and the neutral point of this one have to be connected together and grounded only at one point, either here or here or somewhere in between. It doesn't matter.

MR. ASHE: You are saying the output here is grounded back here with respect to this transformer.

MR. MACHILEK: These two neutral points have to be

connected together and grounded once. Whether here or here or anywhere else, to the best of my knowledge and interpretation of NEC, is immaterial.

MR. ASHE: To the best of your knowledge, how is it done at Nine Mile Point?

MR. MACHILEK: This one is connected to this one and this one is grounded.

MR. ASHE: All right.

MR. STONER: Let me clarify something. I thought you indicated that the AC source inputs were a delta.

MR. MACHILEK: Yes, sir.

MR. STONER: According to the utility drawings, the inputs are grounded Y's on the low side, which are the source inputs both --

MR. MACHILEK: Then whoever did these drawings didn't know what it was.

MR. STONER: You have verified that it's a delta.

MR. MACHILEK: I have known since 1962 they are delta Y transformers.

MR. STONER: Inside your inverter, you mean?

MR. MACHILEK: Absolutely.

MR. STONER: I'm sorry. I'm talking about the source to the inverter.

MR. MACHILEK: I wouldn't know.

MR. STONER: So you were speaking of the

transformer in your UPS.

MR. MACHILEK: Yes.

MR. STONER: Fine. That's what I wanted to clarify.

MR. MACHILEK: I have no knowledge of what goes on upstream from there.

MR. STONER: There is no drawing here. This is the drawing only for the customers' transformer.

MR. MACHILEK: If you start from the 375 or whatever high voltage line that is, you have three transformers before you get to this.

MR. STONER: I just wanted to be sure that we were talking about the same thing.

MR. MACHILEK: We are not. This is the transformer which actually is within the UPS, within the box, and there are only three connection points.

MR. ROSENTHAL: That makes sense, because you go delta Y, delta Y, delta Y. So you have got Nine Mile's Y feeding your delta.

MR. MACHILEK: We coiled the transformer distribution downstream only to that end, to assure ourselves that the phase that was the ground on the high voltage always was the phase that was the ground on the last one of the transformers.

MR. ASHE: Did you actually take it all the way

back up, though?

MR. MACHILEK: Yes, sir.

MR. ASHE: You did?

MR. MACHILEK: At least as good as you can establish from the drawings.

MR. ASHE: So the 575 is between A and C phase or B and C phase or A and B phase?

MR. MACHILEK: Correct, 200 volts to neutral, or 199.6, or whatever. It is basically 200 volts. They dropped down to 80 kilovolts. We took that ratio. If you follow the whole distribution of all the transformers, you end up with the same 200 to 80. That was the basis for asking for the adjustment of the rheostat or VRAC.

MR. ASHE: Most of the loads as far as you know were 120 volt loads. So when you say 120 volt out here, three phase, what you are really saying is between a phase and neutral.

MR. MACHILEK: I don't think you have a four wire distribution off the UPS.

MR. ASHE: For example, 1A, which powers a lot of instruments loads. Isn't that 120 volts?

MR. MACHILEK: Yes, but you have a transformer in between the UPS and that load.

MR. ASHE: What does this 208 mean, between where and where?

MR. MACHILEK: Phase to phase. If it would be a four wire system, it would be 120/208.

MR. ASHE: That is the way it is taken and used and then you go through a transformer if you need 120; is that the way it works?

MR. MACHILEK: That is correct. Or you could wire the Y out and use it as a neutral.

MR. ASHE: Wouldn't it be easier to do that?

MR. MACHILEK: Our system allows you to work it as a three wire system or a four wire system, floating or neutral ground. We don't know how it is being used, so we give you all the options.

MR. ASHE: If they have a ground and a neutral here, is that the same point? At this point. A ground and a neutral.

MR. MACHILEK: The ground and the neutral can never be the same point except as executed in accordance with NEC. That means the neutral is white and ground is green. If you have a distribution box on the wall, this is where the ground and the neutral can be connected together because that point is considered to be the point of the ground electrode. But you are not allowed to connect the neutral and the ground together in the box.

MR. ASHE: Your box has a neutral.

MR. MACHILEK: My box has a neutral and it has a

safety ground, which goes basically to the cabinet.

MR. ASHE: The neutral in your box connects where in your box?

MR. MACHILEK: Nowhere. As shipped, it doesn't connect anywhere. It is up to the systems designer, the one who determines what the whole power system incorporating the UPS looks like to establish if he has to ground the neutral or bring the neutral to another point which is grounded or let them float. We have floating neutrals in cases where all the loads are step-down transformers, like on 480 volts. We distribute three phases and then we step down all the loads to 120 or 208 isolation transformers, which only secondarily have an isolated ground for that system. The reason we do that is because in large computer centers you do not want a common ground between different missions or operations, and you isolate it that way.

MR. ASHE: Do you have a ground lug in your box?

MR. MACHILEK: Yes.

MR. ASHE: That connects where?

MR. MACHILEK: We don't connect it. Somebody connects it.

MR. ASHE: But it is inside your box?

MR. MACHILEK: Correct.

MR. ASHE: Connecting where inside your box?

MR. MACHILEK: To the neutral of the transformer.

That means you have the transformer and out comes one, two, three, four terminals.

MR. ASHE: I got you.

MR. MACHILEK: Unless we have a turnkey job, meaning we are also the installers, we do not get anywhere near telling you how to do things. The installer usually is responsible for the codeworthiness of what he is doing.

MR. ASHE: Very good.

MR. ROSENTHAL: Ultimately I want to learn what the logic is.

MR. ASHE: I think we need to go to the A27 board and go through some of the details of how this unit isolates when that DC power supply drops down and show the signals why it isolates: CB1, CB2, CB3, all of them. And through the details of the A27.

MR. MACHILEK: Then we need A27.

MR. ROSENTHAL: We will need copies of these prints. I leave it up to you guys to designate those things you consider proprietary or not. We will protect the proprietary but we still want a copy.

MR. MACHILEK: This is A27, which was supplied with the unit. The wiring of it was exactly like that.

MR. ASHE: Maybe I asked for the wrong thing. We clearly understand this guy. No problem. What I think Jack is interested in is the downstream logic down here and

showing how it sends the signal.

MR. ROSENTHAL: Or you could start here and work backwards.

I take it that you energized the shunt trip coils on CB1, CB2, CB3 to shed the loads.

MR. MACHILEK: You have to get A21.

MR. ASHE: When this voltage out here drops below a certain value, we want to show how it isolates this guy, this guy, this guy, and this guy.

MR. ROSENTHAL: Help me on this drawing a little bit. You energize the shunt trip to trip the breakers, right?

MR. MACHILEK: Correct.

MR. ROSENTHAL: These contacts here, the two K1's, two K2's and two K3's, come from the 40 volts.

MR. MACHILEK: It's right here.

MR. ROSENTHAL: It's not these?

MR. MACHILEK: No.

MR. ROSENTHAL: What is the difference between this K1 and that K1? These are different relays, aren't they? Or is in fact the same relay shown in two places?

MR. MACHILEK: No.

You will see here a dotted line.

MR. ROSENTHAL: Right.

MR. MACHILEK: That dotted line is describing what

we call the A27A1 board. That relay on the A27A1 is associated with its conduct on the A27A1. These relays here, which are not within the confines of the printed circuit boards, are actually hard mounted on the A27 panel.

So the K1 here and that K1 associate together.

MR. ROSENTHAL: So these are to the motor operators.

MR. MACHILEK: You can take a scissors and cut that.

MR. ROSENTHAL: I understand that.

In order to open up CB1, CB2 and CB3 --

MR. MACHILEK: Shunt trip it.

MR. ROSENTHAL: Which means that you close these contacts, which takes the 40 volts from here.

MR. MACHILEK: And dumps it on the shunt trip coils.

MR. ROSENTHAL: Are there other sources of electricity to the shunt coil?

MR. MACHILEK: No, sir.

MR. ROSENTHAL: If that is the case, then you open CB1, CB2, CB3 by closing these contacts, which means that you do something to these relays.

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: You change the state of these relays.

MR. MACHILEK: Correct.

MR. ROSENTHAL: I am sort of like working it backwards at this point. These relays are sitting at plus 20 volts here and going off to something off this page.

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: I don't know if these are normally open or normally closed, but when you make up the logic to change these states, you trip. So what goes off this page if I am working it backwards?

MR. ASHE: Would it be easier to work it the other way, though?

MR. ROSENTHAL: I'll leave it up to you. Would it be better to work it backwards or forwards?

Similarly, I want to look at CB4 and the logic that makes CB4 work. If you want to go from the front back or from the back front, it is up to you.

MR. MACHILEK: This is what we call the top schematic. This gives you all the wiring which is between the printed circuit board. A13 is the card cage, and load division panel, and then the power supply panel A27 is probably somewhere right here. This is the A27 which we are talking about.

MR. ROSENTHAL: For the transcript, what are we looking at?

MR. MACHILEK: We are looking at what we call the

top schematic diagram, Drawing No. D-110711102-77223.

The CB3 has its three main contacts, phase A,B,C.

As you will see, the neutral comes directly from the output transformer neutral and is brought out to a terminal which is marked N. What you want to do with it is up to the user at this point.

The phase A,B,C, now we do have high-speed fuses on the output. The reason why they are are there, if you should have a short in the transformer itself, then one of those fuses will go if you try to transfer at the same time because then the power from the other side would go in.

MR. ROSENTHAL: But those fuses didn't blow.

MR. MACHILEK: No. You have got a motor operator. All the motor operator is doing is simply mechanically closing and opening the circuit breaker much the same you would do it manually.

We have a shunt recoil. Energizing of the shunt recoil will trip the break open.

Then we have auxiliary conducts, which are two types, two normally opened and two normally closed, and as you see, we are only using the two normally opened ones.

In order to find out what the shunt tripper is powering we have to follow wire 595 and 589. This 595 and 589 go to a plug, which is called A27P1. We should go directly to the A27P1 plug. Unfortunately we don't have the

wire numbers on it. A27P1, 9 and 15.

MR. ROSENTHAL: So we are talking about K3 that we just followed and CB3. So we now went from CB3, the AC output of the aux, and we followed that back to --

MR. MACHILEK: Which means that you are coming from plus 20, which if it is energized goes through the coil, comes back and here and goes to the minus 20. So we put 40 volts DC directly without any other interference and put the trip voltage on here.

You will find a similar situation true for the input in the battery breaker.

MR. ROSENTHAL: So now I have to make up the logic for K1, K2 and K3.

MR. MACHILEK: That is correct.

MR. ROSENTHAL: They are sitting on plus 20 volts and then they go off this board.

MR. MACHILEK: Since this is the A27A1, we have to identify the plug. The plug is at J2, 9, 12 and 15. So we go to A27P2, plug 2 and jack 2. There is always a plug and a jack. And 9, 12 and 15. There is 9; there is 12; and there is 15. BBTR, OBTR, IBTR -- well, the "R" you have to leave of. The signal is BBT, IBT and OBT. "R" simply says it's a relay.

MR. ASHE: Okay. We are going to go back up stream.

MR. MACHILEK: Then 15 is 273; 12 is 272; and 9 is 274, and 274 was OBT, and there is IBT, and 15 is BBT. That should jibe with what we have here.

MR. ROSENTHAL: Let me stop for a second. We were looking at Drawing No. 110611334.

MR. MACHILEK: Correct.

MR. ROSENTHAL: Now we are going backwards.

MR. MACHILEK: Now we have to follow those three wires as they go into that wire bundle here, come up here, and go to 272, 273, and --

MR. HESS: I think it's 274, not 774. It's 274, which is right.

MR. MACHILEK: Now we have to take A13, the motherboard. If we take those three, 9, 12 and 15, we established that 9 is K3, 12 is K1, and 15 is K2. What we were saying here was that corresponds with plus 20.

MR. ROSENTHAL: These are just small relays with 100 or 200 millisecond strobe time or something like that?

MR. MACHILEK: Correct. Because we are switching a total of probably 2 milliamps at the outside.

MR. HESS: You are on J3.

MR. MACHILEK: It says here A13P3, and since the plug goes into a jack we have to look for an A13J3 on the A13 motherboard. A13 is the card cage and everything is plugged into the motherboard. Those connections are now

made through OBT, right here, IBT, and BBT.

Now you are on your own because you have to follow the printed circuit. The BBT, for instance, goes to the A1; the IBT goes to the A1 right besides it; and the OBT goes --

MR. HESS: It goes nowhere because it didn't shadow well.

MR. MACHILEK: Wait a minute. Let's go slowly.

MR. HESS: We'll find it.

MR. MACHILEK: Let's get the A1 and the A20.

MR. ROSENTHAL: So that goes to the motherboard and then on to the individual cards?

MR. MACHILEK: That is correct.

MR. HESS: This one here, Rudi, is IBT and then this one is IBR, and this is pin 11 on the A20, which is the OBR.

MR. MACHILEK: Right here. The input breaker, IBT, goes to A12; the battery breaker goes to A13; this goes to A20, pin 11. We are there.

A1, 2 and 3 incorporate the shunt trip, right here; input breaker shunt trip goes to a transistor driver output. This is the output of that logic against ground. In other words, we take the plus 20 volts and go directly over a transistor driver to ground. The controller is telling you once the K3 is closed and other conditions are

correct there are other conditions which are tripping that relay.

MR. ROSENTHAL: Here we are going to find all the logic that causes ultimately CB1 to open.

MR. MACHILEK: The same thing should be true from No. 3. There you have a transistor driver; ground against plus 20 powers that relay. The same as you will see under A20.

MR. ASHE: Can we back up and see what saturates this guy right here? Obviously if this guy goes to saturation, you pick up the relay. Can we show reduced voltage out here causes this guy to saturate?

MR. MACHILEK: You would have to go to A21. The question is what portion of the circuity tells this transistor to saturate, right?

MR. ROSENTHAL: Right. In normal operation, and also we can think in terms of reduced voltage.

MR. ASHE: Obviously we are saturating this guy, so we bring this guy. The collector here goes down to ground to protect the relay. What I think we want to establish in this drawing trace here is when this guy goes low we want to show how we saturate that transistor.

It may be easier to work this way. There must be something here that comes back into the front side of this transistor over here.

MR. MACHILEK: Let's trace it. We are bringing it over to J4. A27 J4; A27P4. We have the minus 20; we have ground.

MR. ASHE: J4-8. Rudi, you come over here and you come straight over on a line to the A30 bypass panel.

MR. ROSENTHAL: Let's take a five-minute break.

[Recess.]

MR. ROSENTHAL: We are now on the record. Frank Ashe.

MR. ASHE: Before we went off the record we had saturated Q1 on drawing number D-11007116877223. We were attempting to see how Q1 was saturated by tracing the signals upstream of Q1. Rudy, do you want to take over now?

MR. MACHILEK: We went to the other end for a moment and said the plus one to the ground and the minus one is distributed throughout the cage door on the areas. On the A18 board we have the plus one at the ground and the minus one and monitoring it over high position regulator. There is some adjustment for the three points and will come out with PSF. The PSF signal is brought over to the A21 PSF.

MR. ROSENTHAL: What is the function of PSF?

MR. MACHILEK: PSF, it monitors the control voltage to be within maximum of 19 volts I believe, and a minimum of 16. That's the adjustment range of that

monitoring.

MR. ASHE: Excuse me. Is that monitoring both sides there, plus with respect to neutral and minus with respect to the --

MR. MACHILEK: Minus, plus. If either one of the two would for instance go below 16 and one-half volts it would issue a PSF signal which would go over -- comes in here -- and switches the latch but uses a Q output which does two things. Number one, it brings the light on the A21 board which says power supply failed. Number two, on a separate circuit over a gate which simply detects also the frequency and the voltage on the frequency. It is just we use the same one for both.

MR. ASHE: That's AND gate there.

MR. MACHILEK: Right.

MR. ASHE: How do you get this guy again?

MR. MACHILEK: This one it gets from PSF comes up here and sets the latch.

MR. ASHE: Right. We got that one.

MR. MACHILEK: We got this one.

MR. ASHE: That's one signal going to the --

MR. MACHILEK: This is one signal.

MR. ASHE: How do we get this guy?

MR. RANSOM: They are just together because there are not enough inputs on this gate over here. Either one

of these going --

MR. MACHILEK: Either one of the two. This is not this plus two, it's either the one or the two.

MR. ASHE: That's a NAND, n-a-n-d.

MR. MACHILEK: Either one, yes. Giving you number one the light, which is the light on the A14 which says logic failed, and giving you the trip signal over to the number three to the --

MR. ROSENTHAL: Trip light on A14.

MR. ASHE: This is SSTR and has to go back over here somewhere.

MR. MACHILEK: The SSTR --

MR. ROSENTHAL: It changes SSTR from high to low or the other way.

MR. MACHILEK: And the SSTR --

MR. ASHE: This drawing right here somewhere, right?

MR. MACHILEK: No, the SSTR should go directly -- you have to trace that back. The transfer from one point to the next.

MR. ROSENTHAL: From here we decided that it had to go to that transistor, C1.

MR. MACHILEK: C1, yes. SSTR, goes to the trip relays -- you have to trace it because I don't know how it comes in. The SSTR goes to the -- we have to locate the

mother board and comes out --

MR. HESS: The mother board on the top print.

MR. MACHILEK: It comes out of the A1 off the A21 and I think it goes to the

MR. ROSENTHAL: The A23 and the A21.

MR. MACHILEK: It gives you a leg off and gives you this CB 1, 2 and 3 trip.

MR. ROSENTHAL: That corresponds to Q1 going to ground.

MR. ASHE: You have it to SST1 here but we have to make the relationship between this guy and Q1 saturated. Then, if we can do that, that's it.

MR. ROSENTHAL: No, because this is monitoring the voltage; right?

MR. ASHE: Yes. The Q1 has to saturate it, so that has to --

MR. ROSENTHAL: We have to get to Q1.

MR. ASHE: Right.

MR. ROSENTHAL: Also, this should have lit -- what other thing should it have lit?

MR. HESS: It also ties over to B 834.

MR. MACHILEK: Yes.

MR. HESS: This is 163, wrong one.

MR. MACHILEK: We still have to come over to the A1 board. I can't understand where this SSTR comes over

here. I have to get the signal -- therefore, I have to come in here somewhere, and I cannot spot it. Where is the --

MR. HESS: It also goes under the TB bar too.

MR. ROSENTHAL: Isn't this PIN 23 on some connector?

MR. HESS: That would be the plug in connector, Jack. Is that the A21 card that you have?

MR. ROSENTHAL: Yes. It's the A21. A13, A21 card.

MR. HESS: That comes off and it would come off on J8 which is the SSTR command.

MR. ROSENTHAL: It says 23 here.

MR. HESS: That's PIN 23.

MR. ROSENTHAL: PIN 23 on connector J8?

MR. HESS: No. That's the plug in PIN.

MR. ROSENTHAL: Right.

MR. HESS: You plug the board in and that comes off that -- that coincides with this PIN right here. That comes off the board on an SSTR which comes off of here, which is J8. J8 is over here, which is right -- that's SSTR right there.

MR. ASHE: That comes in here somewhere.

MR. HESS: Yes.

MR. ASHE: Is that what it does?

MR. HESS: It doesn't show a wire coming off of

it.

MR. MACHILEK: We have three latches here now, one for each breaker.

MR. HESS: That's right.

MR. MACHILEK: We have to set the latches, it's that simple. This is UPS okay -- input breaker closed, okay. This is logic command. The shunt trips --

MR. ASHE: Basically, all we need to do is make a relationship between SSTR and over here somewhere.

MR. MACHILEK: Yes.

MR. ASHE: It looks like by the way of this thing over here.

MR. MACHILEK: Yes.

MR. HESS: SSTR also comes off the A13 P5 connector which is right there.

MR. IBARRA: Hold it. That's a PIN number, right? Isn't that a PIN number there?

MR. HESS: What breaker are you looking for, Bernie?

MR. MACHILEK: We have to get a signal to trip those three characters, CP1, CP2 and CP3.

MR. HESS: There's SSTR, off the TB1. As you look here it's tied in there. It's tied in there and it's tied in there.

MR. MACHILEK: What way are they going?

MR. HESS: That come back up -- that follows the 648. MR. MACHILEK: That means with this three there, that's why I came --

MR. HESS: That's right.

MR. MACHILEK: How do they come in here now?

MR. HESS: You find it on that side. In fact, I found it on the mother board up here. Let me fold this out here.

MR. MACHILEK: You have to see where we come back. That means we get the SSTR --

MR. HESS: You tie SSTR, so SSTR ties over here on the A34 card here.

MR. MACHILEK: Yes, this is fine. That's where the transfer, but we also have to go -- this is the one that I am looking for. Where does it go.

MR. HESS: It goes in right there.

MR. MACHILEK: SSTR on 13 of P5.

MR. HESS: P5 13, mother board. You want mother board?

MR. MACHILEK: Yes.

MR. HESS: Five. SSTR.

MR. MACHILEK: SSTR, right.

MR. HESS: There is also an SSTR connection off of the A21 card.

MR. MACHILEK: This is the A21. I am looking at

the A1. We have to split it somewhere. It goes to the A21 -- it comes from the A21. It goes on to what --

MR. HESS: Down here we split it up, off here. You split coming down.

MR. MACHILEK: I don't know how we did it here. I don't know how we did it.

MR. ASHE: Would it be better if we go off the record and try to figure this out.

MR. ROSENTHAL: There's a lot of blank space on the tape right now. Other than wrestling papers and people going on.

MR. ASHE: We can stop it. Let's stop it.

MR. ROSENTHAL: Let's go off the record.

[Discussion off the record.]

MR. ROSENTHAL: Okay, let's go. Do you have it?

MR. MACHILEK: It changes the mother board from an SSTR to a UPT. The question was, where is it happening?

MR. ROSENTHAL: We are back on and Rudy is talking.

MR. MACHILEK: The SSTR on the A21 which is over here, goes from here to the A20 boards. On the A20 board it comes in on -- where does it change to --

MR. RANSOM: Right here on A21 it's STR. That is right where it changes, right there.

MR. MACHILEK: SSTR PIN 23, all right, is

statically connected in 53 on the A20. You see that is called a UPT.

MR. ROSENTHAL: Now we have UPT --

MR. MACHILEK: It's the same --

MR. ROSENTHAL: On drawing D-110071196.

MR. MACHILEK: This is where it comes in and trips. It trips the output breaker if other conditions can also trip it, right? Either one of those ones is tripping it, and one of those is the UPT. Also, it comes in on the K1 as a UPT and trips number 1B input breaker at the same point. Breaker and input breaker is tripped on UPT signal off the A1 and off the output breaker.

MR. ROSENTHAL: By design then, we have now followed through that a low voltage on the control power supply should--MR. MACHILEK: No, low voltage on the logic bus.

MR. ROSENTHAL: On the logic bus should result in tripping of --

MR. MACHILEK: Tripping of all three breakers.

MR. ROSENTHAL: Right. Now, we go to --

MR. MACHILEK: It also goes to the A34 -- do we have an A34. What we have to show here now is that -- is it SSTR or SSTR comes in the A34 and does all kinds of things now.

MR. ASHE: Such as?

MR. MACHILEK: Well, we should end up in a gate in a logic that says that if a bus is available -- this is a trip signal. If a bus is available -- let me see how we are going to do that. Transfer ready to bypass and this one comes from either -- now we have to tie it into the SSTR, okay? That means we have to walk ourselves --

MR. HESS: We have to walk ourselves all the way through.

MR. MACHILEK: Which one is it which we are getting down here. This one -- this, if closed, and coming out of here, go over to the 4066 and if it is selected, and coming through there.

MR. ROSENTHAL: That's if the selected, you mean the auto select?

MR. MACHILEK: A lot of conditions have to be -- number one, it checks if the CB4 got to be open in the first place, okay? That means that if somebody goes and goes to CB4 for instance, it would disable everything. If the CB4 is open and if the bypass sensing -- BC CA is showing that number one, the voltage is within the window and the frequency is okay and we are coming I believe from -- we are in sync -- now we have to bypass -- that is reset -- the way this is drawn out you can't -- coming up there and this is in the UV/OV transfer -- which transfer are we looking for, UPS, right?

If we get an UPS -- this is the UPS --

MR. HESS: That's an output.

MR. MACHILEK: This is the output.

MR. HESS: Here is your SSTR right up through here, Rudy. That comes up through the --

MR. MACHILEK: The TP25 --

MR. RANSOM: I think what it does is, it comes in through here.

MR. MACHILEK: Yes, I am trying to find my way through here.

MR. RANSOM: Right here it's saying okay, we want to trip the breaker but we are looking to see if --

MR. MACHILEK: We need a command to the -- I am looking for the command to the CB4. If I get a one here I got a static switch on, all right? This one is giving me the conditions if the bypass breaker is in fact open if I don't have a load down. This is in the input, and this is the output.

MR. RANSOM: Right here is the critical bus sensing. We are also looking at the bypass fault sensing back through here. This signal down here is going to try to hold off this signal if we are at tolerance, and this signal is the signal that comes off of here which comes back to your SSTR.

MR. MACHILEK: Okay. Here we go.

MR. RANSOM: It comes back through to your SSTR.

MR. MACHILEK: Yes, 4066.

MR. RANSOM: That is going to hold it off if your bypass is not available or not in sync with your critical bus.

MR. ASHE: In terms of time, how long does it take it to make up its mind?

MR. MACHILEK: One hundred-twelve micro seconds.

MR. ASHE: Once it makes up its mind that you are out of tolerance.

MR. MACHILEK: Yes.

MR. ASHE: How long does it hold there?

MR. MACHILEK: How long does it hold there?

MR. ASHE: Right.

MR. MACHILEK: It holds there until the bypass breaker has closed. The bypass breaker tells them it is closed then we remove the signal. In other words, the CB3 does not go open until the CB4 is closed unless bypass is not available and the CB4 is open.

MR. ASHE: Once it decides that the bypass is not available --

MR. MACHILEK: Once it is not available --

MR. ASHE: Very quickly.

MR. MACHILEK: If it decides the bypass is not available you will never get a transfer signal out of here.

MR. ASHE: What I am saying is, what is the minimum time it can hold that?

MR. MACHILEK: That is not available?

MR. ASHE: Suppose that one instance of time the bypass isn't available but for whatever reason it creeps back up and readjusts, and everything comes back.

MR. MACHILEK: Once it becomes available --

MR. ASHE: Right. Right away?

MR. MACHILEK: Then you get it a sync signal, okay sync signal, and then it waits until it is synced. Once the sync is confirmed, then you get the third condition which says that you are in sync which allows you to advance a command. You are checking the voltage, okay, making sure that the voltage is within plus - minus ten percent.

MR. ASHE: Right.

MR. MACHILEK: You are checking the frequency which says the frequency is within one-half a hertz. If these two conditions are right, then you wait until it is synced. If you have a sync confirmation, that means that if you are within seven degrees of each other -- okay -- then you release the third condition and from then on it takes you 120 micro seconds to close the static switch.

If you takes you one-half hour to sync, then you know that it simply isn't -- that the conditions are not given.

MR. ASHE: How long -- it resets immediately.

MR. MACHILEK: There is no reset. It is not the light, it is simply a gate.

MR. ASHE: I understand. If you come back in sync such that your criteria met, it will permit --

MR. MACHILEK: Immediately to transfer.

MR. ASHE: Right.

MR. MACHILEK: If the transfer is still desired. That means -- you know what I mean.

MR. ASHE: Right.

MR. MACHILEK: If you get an SSTR and all the other conditions are right, you have 120 micro seconds and you are on bypass.

MR. ASHE: I am asking all these questions really, because I think these units went out of sync just prior -- after the transformer fault. That's why it wouldn't transfer. They locked out.

MR. MACHILEK: No.

MR. ASHE: Just prior.

MR. MACHILEK: You lost voltage.

MR. ASHE: The question could be asked why didn't they transfer. Why didn't they transfer to maintenance when you had a maintenance good. What I think happened was, when we got the fault these units picked that the maintenance supply was no good, it locked out the transfer and it held

that lock out because it wasn't any good. The voltage decayed and the unit tripped out. That's why they lost the bus. Is that a fair assessment of it?

MR. MACHILEK: I would suggest to go the other way. The UPS was running. The voltage suffered a decline of the phase speed, which means that it is phasing off. No problem. It's running on battery now. The bypass voltage now suffers a decrease in voltage which causes the power supply to go out of limits.

MR. ASHE: Right.

MR. MACHILEK: Which issues the trip signal. But the fact that the voltage has to decrease first before you get the trip signal means that it is assured that the bypass wasn't there at the time you got your trip signal.

MR. ASHE: That's right. You are actually saying the same thing. The units lost sync prior to tripping.

MR. MACHILEK: What does this have to do with sync?

MR. ASHE: To me it lost sync prior to tripping. That's why --

MR. MACHILEK: You did not lose sync. The voltage decreased.

MR. RANSOM: What do you call losing sync, locking out?

MR. ASHE: Prior to the event you were probably in

sync, and by in sync your three criteria -- difference criteria --

MR. MACHILEK: Delta --

MR. ASHE: Your maintenance supply were met so it will permit a transfer.

MR. MACHILEK: Right.

MR. ASHE: When the B phase fault occurred, I think the electronics picked this up right away and said hey, this maintenance source is no good. I cannot do transfer.

MR. MACHILEK: Right.

MR. ASHE: Subsequent to that, the voltage decayed and isolated the unit.

MR. MACHILEK: It happened at same time. It's the same voltage. It's the same voltage. I suggest the Delta V is really the one which locked them out because as the voltage decayed there is no reason to go out of sync. A phase B reaction of voltage does not change the frequency of the --

MR. ASHE: Right.

MR. MACHILEK: Therefore, if you were in sync --

MR. ASHE: It was amplitude.

MR. MACHILEK: Yes.

MR. ASHE: Yes, voltage difference.

MR. MACHILEK: The amplitude locked yourselves

out.

MR. ASHE: Right.

MR. MACHILEK: As soon as you passed the ten percent -- as soon as you decrease below 90 percent it said no more transfer.

MR. ASHE: I guess what I am trying to get to is the order which this occurred. I am saying I think, these units lost sync prior to tripping.

MR. MACHILEK: Why do you say lost sync?

MR. ASHE: Because I think your electronics picked it up --

MR. MACHILEK: Why should it lose sync?

MR. ASHE: Let me say --

MR. MACHILEK: You have one voltage and you have --

MR. ASHE: I'm sorry.

MR. MACHILEK: You have another voltage. Why should it lose sync?

MR. ASHE: I am saying that I think we are having problems with the word "sync", what sync means. It blocked the transfer prior to the unit trip.

MR. MACHILEK: Correct.

MR. ASHE: Okay. So, we are saying the same thing.

MR. ROSENTHAL: By the way, this no longer looks

like a 60 cycle sine wave because it has all the crap on it now.

MR. MACHILEK: It doesn't matter. As long as this coincides, that's all it looks at.

MR. ROSENTHAL: Right.

MR. ASHE: A signal was generated to preclude transfer prior to the unit's tripping?

MR. MACHILEK: Right. Prior, we mean may be a circle or -- right. The time constant it takes for the output capacities of the power supply to --

MR. ROSENTHAL: Let me go back to CB3. We took that as an example where we said that you had to apply voltage to the shunt coil to open this nice big break.

MR. MACHILEK: Correct.

MR. ROSENTHAL: You had to apply that early enough, before the power supplies went dead, or there wouldn't have been any power to in fact open CB3.

MR. MACHILEK: That is correct.

MR. ROSENTHAL: I am advised that that is typically maybe like five cycles that you had to apply the current to the shunt coil.

MR. STONER: Do you know how long it is for that breaker?

MR. MACHILEK: It takes about 50 milliseconds for the blades to actually open. A few cycles, I would say, at

least two or three cycles. It wouldn't matter.

MR. ROSENTHAL: Two to five to --

MR. MACHILEK: Right.

MR. ROSENTHAL: To a 48 volt nominal coil you normally apply 40 to it. You had to put some sensible voltage on that, or that breaker wouldn't have opened -- which we know it did -- for a couple of cycles.

MR. MACHILEK: Right.

MR. ROSENTHAL: When we were following the under voltage sensor we didn't see any latches, right? They were all large gates.

MR. MACHILEK: No. The power supply which isn't latched -- if you lose the power supplies then you do not latch.

MR. ROSENTHAL: It was PSS --

MR. MACHILEK: If you lose the voltage it causes --

MR. ROSENTHAL: It's coming in but there's no latches here.

MR. MACHILEK: Oh yes, sure.

MR. ROSENTHAL: I'm sorry, that's a latch. We just decided on a micro second level.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Nano seconds and this RC here, micro seconds. These lights then --

MR. MACHILEK: They come immediately after the latch has been --

MR. ROSENTHAL: Right. We got some of them on some of the units. I remember seen an under voltage/over voltage load.

MR. ASHE: That's right.

MR. MACHILEK: Different --

MR. ASHE: He's referring to the as-found data which I think Wayman is familiar with. Perhaps as recorded data than as-found.

MR. MACHILEK: What we do not know is how fast the voltage actually decayed from the 200 kilovolts to the 80. It just didn't close that --

MR. ASHE: Wouldn't the oscillograph on a high side show some rate there?

MR. STONER: I don't think you can take that as an indication of what was happening on the low side.

MR. MACHILEK: There was some decay time I assume, right when the transformer failed.

MR. STONER: Decay time?

MR. MACHILEK: Of the actual voltage.

MR. ASHE: Reduction in voltage.

MR. STONER: The reduction was almost instantaneous.

MR. MACHILEK: Almost instantaneous.

MR. STONER: Constant.

MR. ASHE: Physical insight, and I am not an --

MR. MACHILEK: You do have --

MR. ASHE: Three-quarters of the cycle I think it dropped ten percent, and when you got four fault current flowing to the step function down --

MR. MACHILEK: We did the three test.

MR. ASHE: Repeatedly. We demonstrated these units.

MR. MACHILEK: You know, it was the -- there is enough capacity in the output of the power supplies --

MR. ASHE: That's a question that I had. Do we have a blow up diagram of the power supplies in here?

MR. MACHILEK: No.

MR. ASHE: That is a transistorized regulator.

MR. MACHILEK: It's a linear power supply. It is not a switch power supply or anything like that. It's simply a --

MR. ASHE: Transistor regulated.

MR. MACHILEK: Yes. It's a transistor regulated filtered power supply.

MR. ROSENTHAL: You just decided that you have to squelch Q1, Q2 and Q3 in order to make those circuit breakers pop.

MR. MACHILEK: In order to make the circuit

breakers.

MR. ROSENTHAL: You have to do that --

MR. MACHILEK: You have to have enough --

MR. ROSENTHAL: Cycles.

MR. MACHILEK: You have to -- consider here that the shunt trip, even if the 40 volts decay considerably, the shunt trip still would be effective, you know. The trip comes from the fact that the logic cannot stand anything less than six and one-half volts. You can shunt trip with considerably less voltage -- the current goes up, okay?

MR. ASHE: What was the design intent of that trip to isolate like this? Obviously, the logic would reduce voltage and cannot function properly. Would it destroy the unit or would it do something else?

MR. MACHILEK: It would cost you probably eight fuses.

MR. ASHE: A few SCR's or a few other proponents?

MR. MACHILEK: It shouldn't. It should not.

MR. ASHE: If the fuses act faster than --

MR. MACHILEK: The current limiting fuses protecting the semiconductors -- the switching SCR's -- it is really a question of who is protecting whom, you know.

MR. ASHE: Are the fuses thermal?

MR. MACHILEK: The fuses are fast acting. Instantaneous.

MR. ASHE: Fast acting thermal, right?

MR. MACHILEK: Instantaneous. They have --

MR. ASHE: They are faster than SCR's is what you are saying.

MR. MACHILEK: They should protect the SCR.

MR. ROSENTHAL: We followed one circuit to the power transistor that I raised earlier and we can start on the next one.

MR. ASHE: Would it be helpful if you perhaps trace it out beforehand, do you think?

MR. MACHILEK: What do you want to trace, to be exact.

MR. ASHE: I think what he was trying to say was that he wants to go through every way you can get isolation from the -- CB1, CB2, CB3 isolated. We traced one. We know for a fact that when the DC voltage was dropped it repeatedly tripped on all of the units.

MR. MACHILEK: It is relatively easy. Why I am saying that is, you have to get an SSTR -- from here on we know what happens, which is tested.

MR. ASHE: That's right.

MR. MACHILEK: Once we got a logic output here we tripped --

MR. ASHE: Right.

MR. MACHILEK: The question is, how many ways can

we do that, right?

MR. ASHE: Right. That's three --

MR. MACHILEK: We can do that one, two, three, four, five, six, seven ways. Any inputs to that gate here will --

Basically what we have to say is how many of those inputs are trip --

MR. ASHE: Triggered.

MR. MACHILEK: I did a working analysis, and if you permit me to just -- we said you have all the inputs which are latched. This is the trip sequence initiation which is all what you see down there, okay?

MR. ASHE: Okay.

MR. MACHILEK: Then we have beside the A21 we have other inputs which can actually trip the units, okay. Now, what I say then, since I didn't have any lamps which told me what it was, I tried to establish for instance the AC under voltage -- if you go down there -- I rule out as being a possible source because it's ten second time delayed and it seems that the whole thing was only --

MR. ASHE: Cycles.

MR. MACHILEK: Seven or ten cycles or 12 cycles. This would never have come into the picture. The overload is ten minutes time delayed so we can rule these two out, okay? Rule out because the event only lasted 200

milliseconds, so no way. Those ones, logic failed, frequency failed and fuse failed would have required a repair. You don't get any of those without having logic elements going bad on you.

MR. ASHE: The point is, you can't bring the unit back up with some of that stuff wrong.

MR. MACHILEK: No way, because you have to fix something. You have to change or fix whatever. I say to rule out all down stores and store it without repair. That means you push the down store button which no reset and no latches, and it was back in operation. It was just a matter of getting that latch reset.

I say over temperature needs reset of thermal relays in the legs. That means the over temperature comes from thermal relays which are all mounted on the heat sinks of the switching legs. In order to get rid of that you have to push in the button to reset the over temperature.

MR. ASHE: That's important. If the unit trips out on over temperature, it will not reset itself automatically.

MR. MACHILEK: No.

MR. ASHE: You have to manually go there and push it in.

MR. MACHILEK: Reset. Once they are all reset, then you can reset it --

MR. ASHE: If it trips out on over temperature though, does it open all the breakers, CB1, CB2 and CB3?

MR. MACHILEK: Oh yes, it's a trip signal that comes out the same. We rule that out because nobody said anywhere that they had to go in and set thermal relays, okay? Circuit board interlock, that's another one which comes. If the circuit boards are not all plugged in properly then we have one circuit which simply runs in and out and one out the other -- if it's not plugged in it doesn't let you start up. In other words, if you go and pull a printed circuit card while the unit is running you get an instantaneous trip signal. I ruled that one out because it wouldn't reset.

That left me with the logic power supply fail alarm before this. I say suspect, because it is direct connection to the maintenance source which could explain the simultaneous fail in all five UPS systems.

MR. ASHE: All right now, key question.

MR. MACHILEK: That was only a logic deduction, and I am --

MR. ASHE: These are the only guys that can give you the kind of isolation that was actually experienced?

MR. MACHILEK: Right.

MR. ASHE: Those are the only ones. There are no more.

MR. MACHILEK: No, sir. I tell you here which ones are latched and which ones are not latched. Also, what is doing what. For instance you see this latched one is giving you a trip. The alarm reset, of course, acts on over flows. It is important that if you push the alarm you cannot reset one of the three different sources of trips.

MR. ROSENTHAL: In the manual, I thought that I saw if the SCR legs aren't firing right or aren't getting the right instructions to fire, then I would get a light.

MR. MACHILEK: Then you get fuse blowings and you get a fuse fail alarm and trip. You cannot restart the unit without fixing it. Big time maintenance -- intervention you have to make. Everything worked fine. Later on some atmospheric or phenomena which I cannot find anybody to give me a rationale I can test against to duplicate against.

This was all done prior to knowing anything about the batteries, okay? As soon as I learned the way the dead battery is, I said gee, maybe I am on the right way with my determination. I would have gone in -- as soon as I saw the manual I thought we got it. Then I looked at the A27 and confirmed that it was exactly like the module, there was no help here.

Unfortunately or fortunately -- whatever you want to put it -- every circuit worked the way it was assigned to work. It shouldn't have done all of that.

MR. ROSENTHAL: At the same time that PSV is coming down -- whatever that you run to this chip --

MR. MACHILEK: No, this works on 12.

MR. ROSENTHAL: Okay.

MR. MACHILEK: Only the lamp is on the 12 volts.

MR. ROSENTHAL: The five volts to the lamp is coming down --

MR. MACHILEK: See, this --

MR. ROSENTHAL: This latch is coming down.

MR. MACHILEK: No, it works on 12 volts.

MR. ROSENTHAL: But the 12 volts is coming down too, isn't it?

MR. MACHILEK: No.

MR. ROSENTHAL: Where did this 12 volts come from?

MR. MACHILEK: It wouldn't latch if I don't put -- if there is no voltage there. We know it latched. Otherwise, it wouldn't get a trip which is latched and requires a reset.

MR. ROSENTHAL: Play that again. I apologize. Just repeat what you just said.

MR. MACHILEK: The lamp works on five volts, only the lamp. The latch going through to the A14 and to the trip is a completely different circuit. If you lose the five volts you lose the lamp, but the rest of the circuit still works.

MR. ROSENTHAL: We are assuming by virtue of knowledge of our design -- your knowledge --

MR. MACHILEK: We know by knowledge that the latches latched.

MR. ROSENTHAL: How?

MR. MACHILEK: Because the lamps, which are on the A14 -- these two lamps here -- there is one lamp here which says trip. There is one lamp here which says logic. This is both red. These two lamps, they are coming off here.

MR. ROSENTHAL: Which says inverter logic type A14.

MR. MACHILEK: On A14 and then we have a trip light on the A14. Trip light on A14, these are the two lights. These two lights, they can only stay on and requiring reset if the latches -- which latches were, I don't know because we didn't have the corresponding --

MR. ROSENTHAL: There is no latch over here. The latches are simply these RS --

MR. MACHILEK: Simply those RS latches, yes.

MR. ASHE: What is the explanation? What if the unit had no logic lamp, this guy here, and no trip --

MR. MACHILEK: After it had tripped -- after it had physically tripped -- which means an SSTR logic came out of here, the two lamps came on and were on, were stored. None of these lamps got lit.

MR. ASHE: One-D unit is different, in that there was no logic lamp on the data sheet only for the 1D.

MR. ROSENTHAL: Let me back up a little bit. Based on our interviews they go down in one UPS. I am still not sure what was done on the first UPS. They then decide to manually close CB4, and it's our understanding then that the -- they dispersed and don't hit any more switches, they just closed the other CB4's.

I am not sure exactly what was done, and I think my guys may know better than me, on the first of those units. But then the other units, I think that they adjusted CB4 so that the data recording which is about two hours in the event and then reconstructed on the others -- on the four others -- ought to be pretty good and little bit -- we could argue all day what on the first one.

Which is the first one they go to, Frank? Is it 1C or Id?

MR. ASHE: One C.

MR. ROSENTHAL: One C.

MR. MACHILEK: One C, after ram reset and normal start sequence system operated without need for a UPS. One D, same thing. One A, after a ram reset normal start up stayed one, closing to CB1 input breaker caused upstream breaker in the panel to trip. That happened twice in a row, so they decided that there was something wrong in the

rectifier section of the UPS and it was left on bypass.

A worker request, 162319 was issued for its repair.

MR. ROSENTHAL: Since then we know it was the actual breaker.

MR. MACHILEK: Then there comes UPS 1B after a ram reset and normal start sequence, the UPS power conversion module operated without need for a repair. The retransfer from bypass did not work because of a defective CB3. Work request 138173 was issued for that repair. None of the two dissimilarities with the other three had anything to do with the actual event, because the CB3 being flaky was known --

MR. ROSENTHAL: Beforehand.

MR. MACHILEK: Beforehand, and the charger breaking doesn't matter.

MR. ROSENTHAL: Can I take an aside. These are nice sized breakers, all right?

MR. MACHILEK: Yes.

MR. ROSENTHAL: Either they were flaky beforehand, or we broke them in the course of testing. I know the plant manager talked like you are breaking my units by testing them. It seems to me that these breakers ought to be good for many cycles.

MR. MACHILEK: Two hundred-fifty.

MR. ROSENTHAL: Two hundred-fifty cycles.

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: They are not. Or, they saw a fair number of cycles over the years.

MR. MACHILEK: Or, they are just not holding up the way we expect them to.

MR. ASHE: When you say --

MR. ROSENTHAL: We were there on one occasion when the thing tripped on over temperature. We were just standing in front of the unit and it tripped out. That over temperature is on the SCR leg heat sink, as I understand it.

MR. MACHILEK: Are you talking about the scenario when I was there when we tested? We broke a gate and then we got an over temperature.

MR. ROSENTHAL: That wasn't a trip. It wasn't a trip. Maybe it was the next day. We were just there.

MR. MACHILEK: We were 18 20 board. We got an over temperature and we couldn't reset it.

MR. ROSENTHAL: This was another time.

MR. MACHILEK: Another time, okay.

MR. ROSENTHAL: Subsequent. The thing just tripped out, and I assume it -- it was in auto reset and it must have cooled down and sometime goes back on to --

MR. MACHILEK: If you had an over temperature you have to reset. If you get an over temperature and none of

the button needs resetting then you probably have a U4 chip failing on the A20 boards. That's a guess. It might be a U6, either one of the two.

MR. ROSENTHAL: What I am wondering is, if over time this unit has automatically switched to its maintenance supply as designed and is in the auto reset mode and switches itself back onto the preferred AC --

MR. MACHILEK: If that would happen, you would get a stored alarm that says that happened. In order to get rid of the horn you have to physically push the one silence button. Otherwise, the unit will sit there and blare at you. You have a guard in that room, or somebody must hear if that alarm goes off.

MR. ROSENTHAL: Why wasn't the horn blowing when we were tripping the units out, Frank, when we were intentionally tripping the units?

MR. ASHE: It was sometime.

MR. ROSENTHAL: It was.

MR. ASHE: Sure.

MR. MACHILEK: You say sometime?

MR. ASHE: Yes, sometimes it was.

MR. MACHILEK: Each time you should get an alarm.

MR. ASHE: Maybe it was each time. Most times --

MR. ROSENTHAL: Do you recall hearing a horn.

MR. ASHE: Yes, lots of times.

MR. ROSENTHAL: That systems guy is pretty good at hitting the button.

MR. ASHE: You have to push the button to silence the horn. I can't say -- most of the time when the unit tripped out there was a horn. That's the way I recall it.

MR. MACHILEK: I believe the units you have being built ten years ago, if you got an alarm and you silenced the horn button prior to resetting the alarms -- all right? The lights, you have to reset separately. You silence the horn and then you reset the lamps.

MR. ASHE: Right.

MR. MACHILEK: If you silence the horn and then other alarm came along before you reset the lights, you did not get the horn again. Today, you do on the new equipment, okay? If you silence the horn and another alarm comes the horn comes on again, okay? At that time it was not going that way.

MR. ASHE: Cycling the breakers 250 times, is that full load cycle?

MR. MACHILEK: It doesn't really matter, they mechanically fall apart.

MR. ASHE: Making and breaking is not the problem with that. What is the real problem here?

MR. MACHILEK: The real problem is that a breaker -- historically, okay -- is not intended to be switched a

lot. If you have a lot of switching you use a contact where you lose control means. So, a breaker basically is designed to stay put for a long period of time such as the branch distribution of whatever you have, okay?

If you have a situation like a bypass breaker like the CB3, there comes a customer who wants to see 50 switchings in test in the factory and wants to see 50 more once it is in store. That means you are exposing -- you are doing so much testing that only -- for instance, on surface security, 6.2 megawatt, 20 modules large system, okay.

I made then change all the fuses after we were doing a finish testing, because we had to show five circuit tests in the factory and five short circuit tests on the -- each time you subject a fuse to near melting current it degrades itself, it compromises itself. After one or two months beyond the normal current all of a sudden the fuse goes and you don't know why.

I had this problem. You see, we started the units up and I had what they call modality failures, I lost fuse here and there. With 20 units like almost every day a fuse, I had them change all the fuses. Circuit breakers ditto -- we exercised this General Electric Circuit breakers. We had 52 breakers there, we had to service all 52 breakers after we were doing testing.

There is a mechanical exercising of a breaker with

no other -- sometimes doing something to the breaker, okay, molded case breaker specifically.

MR. ROSENTHAL: These aren't molded case.

MR. MACHILEK: They are molded case.

MR. ROSENTHAL: Let me see if I got this. We were following how does CB3 trip, and we decided that you had to close K3 and K3 had to close because Q1 saturated, and Q1 saturated off an SSTR signal on this drawing; that the trip light on A14 came on; that the inverter logic light on A14 came on that is consistent; but that, none of these lights came on. I thought that we got an under voltage, over voltage light on one of them.

MR. MACHILEK: That was on the A34 board which is the transfer board.

MR. HESS: That's the horizontal.

MR. MACHILEK: The horizontal, yes.

MR. ROSENTHAL: Okay. At some point let's go to that board and see what turns on that light.

MR. MACHILEK: Which one is that?

MR. ASHE: The OV/UV.

MR. ROSENTHAL: The OV/UV, the horizontal lights on the upper left-hand side. We can take a break. Let's go off the record.

[Discussion off the record.]

MR. ROSENTHAL: Can somebody explain just the

normal path to light these lights, because I am really a nuclear engineer and this is not --

MR. MACHILEK: Okay.

MR. ROSENTHAL: I got five volts here to an LED.

MR. MACHILEK: That is correct. You get -- this is the 12 volt power supply.

MR. ROSENTHAL: I have five volts, right, and five volts may be in fact degrading volts, right?

MR. MACHILEK: Yes.

MR. ROSENTHAL: Plus five though the LED, through the diode to ground -- how? It has to come back through here -- no. This is now changed state, right?

MR. MACHILEK: Yes. As long as the latch is on, the light is on.

MR. ROSENTHAL: Right. This PIN goes from high to zero?

MR. MACHILEK: That's right. That is correct.

MR. ROSENTHAL: This is an inverter?

MR. POHIDA: Buffer.

MR. ROSENTHAL: Just a buffer, okay. Then, what is switch one?

MR. MACHILEK: If you put a ground on the --

MR. ROSENTHAL: Is this a lamp test?

MR. MACHILEK: Yes.

MR. ROSENTHAL: That's the lamp test. Now, what

is the story with -- I am sitting at -- this switch is normally in this position. I have plus 20, the voltage dropped here across the zenar and across the transistor and plus 12.

MR. MACHILEK: This is at the 20 volts level.

MR. ROSENTHAL: That's at 20 and this is at 12 -- this K1 -- energizer.

MR. ASHE: This is the collector on up through here and that's normally closed, right through here. When this guy saturates K1 --

MR. ROSENTHAL: Which means that contact is open.

MR. ASHE: All that's doing is just monitoring the 20 volt supply, it looks like to me. What is it doing other than that?

MR. POHIDA: I think it might just be a delay, monitoring and then also a delay.

MR. MACHILEK: All this is doing is, you are de-energize K1 if you are testing the lamps.

MR. POHIDA: Right, that's all it does.

MR. MACHILEK: That's all it does.

MR. ASHE: It breaks that and returns back and puts this whole thing back into circuit. The only way to change this guys state is through here, isn't it?

MR. MACHILEK: Yes.

MR. ASHE: That's ground, so this point has to

raise or lower in order to get this guy to change in the normal.

MR. POHIDA: It just gets around through K1.

MR. ASHE: All it really is doing though, K1 never changed state and nothing happened down here.

MR. MACHILEK: Your main -- you prevent a reset if you lamp test, right?

MR. ROSENTHAL: In this case the plus 12 is decreasing.

MR. ASHE: I don't know where you get these plus 12 and plus 5 decreasing.

MR. ROSENTHAL: If the 20 is coming down --

MR. POHIDA: I think you may not lose your 12 immediately. Is there a voltage regulator -- a voltage regulator could hold the voltage about a minute and one-half.

MR. RANSOM: It will hold it down to about 13.

MR. POHIDA: You won't necessarily lose your 12 immediately.

MR. MACHILEK: We know we went below 16.5 but we don't know how far.

MR. ROSENTHAL: The one constant here is the voltage across the zenar.

MR. MACHILEK: If that whole circuit wouldn't be in there I don't know why -- all they do is they disconnect

the --this is shown in a discharge position and that means that it is normally open. If he pushes the lamp button he grounds the reset, right?

MR. ROSENTHAL: I guess the question is, what would have happened --

MR. MACHILEK: That's the lamp button. This prevents you from unstoring the lamps if you make a lamp test.

MR. ROSENTHAL: The only issue that we heard postulated was did K1 -- did this relay change state.

MR. MACHILEK: It didn't unlatch the latches, because we would have lost the lamps which are held by the latches.

MR. ASHE: Actually, the only purpose of that relay is after you do a lamp test --

MR. MACHILEK: If you have an alarm when you do a lamp test you don't want to unlatch the latches because after you let the lamp test go you want to have the same alarm still there.

MR. ASHE: It seems like if you are going to try to build an argument around here that some kind of way you reset these guys due to this decay of voltage here, then why didn't you reset these guys up here when they originated?

MR. ROSENTHAL: That's what the two of them are saying. There is no other latches up there on these.

MR. MACHILEK: No, sir. This goes directly to the lamp and to the ground. You have the A14 to show them?

MR. HESS: Right here. You want the print?

MR. MACHILEK: Yes.

MR. MACHILEK: Which one was it, UPS trip, right?

MR. ROSENTHAL: In order for that light to be on two hours later, I need the logic to not have changed state and the power to have been restored.

MR. ASHE: Right.

MR. ROSENTHAL: I need the logic -- for 200 milliseconds you need the power back to 200 milliseconds. I need the logic not to have changed state.

MR. ASHE: Right, okay.

MR. ROSENTHAL: When I get down on the 12 volt level here with the regulated power supply, are we postulating that this 12 volt in fact didn't degrade in the course of the 200 milliseconds.

MR. MACHILEK: I had hoped that the generator logic during this subsequent tests, that we will get an abnormal lamp indication pattern of some sort.

MR. ASHE: To suggest something is wrong with --

MR. MACHILEK: I had hoped, because I was --

MR. ASHE: Possible explanation. It didn't happen.

MR. MACHILEK: No, we couldn't make it happen,

let's put it that way.

MR. ROSENTHAL: Unfortunately, if I had it to do over again, I think I would have gotten 12 dual trace oscilloscopes from the plant when we were doing this test and we didn't, for better or worse.

MR. IBARRA: Do you mean the tests that you all have done?

MR. ROSENTHAL: Up at Nine Mile.

MR. MACHILEK: We tried to reset out of -- I don't know if we took the logic off for a long period of time, I don't know. If the logic was -- we turned the logic down to like 50 volts and let it sit there.

MR. ASHE: That's right.

MR. MACHILEK: For a considerable period of time.

MR. ASHE: That was done on 1C and 1D.

MR. MACHILEK: Tried to have a transient behavior off it.

MR. ROSENTHAL: Frank, you saw a test in which they had fresh batteries and lifted the 110 volt AC lead.

MR. ASHE: Fresh batteries and they switched.

MR. ROSENTHAL: It was a test in which the logic was living on the fresh batteries a couple of minutes.

MR. ASHE: No. There was some decrease of 120 volts down to the break fault in which the power supply no longer regulates, which is about 96. Up until about 96

volts the power supply tends to regulate pretty -- very good -- and held it up there 19, 20 or something. Below 96 volts it dropped off very rapidly.

With fresh batteries it tended to stabilize and still hold it up but it was decreasing, but it still held it up.

MR. MACHILEK: It goes from 2.15 down to two volts per cell. You cannot have more than open circuit voltage on the discharging battery.

MR. ASHE: That was the question that I wanted to ask. How much current does it take at 20 volts to drop this logic; does anybody have any idea?

MR. MACHILEK: Oh, yes, sir. I measured that when I got back. When the unit was not running and wasn't energized, the positive through 1.14 -- between 1.14 and 1.17 amps. The negative had .283 or three-tenths of an amp. When the unit was running the positive through 4.44 amps and that was under no load. The negative through 1.084 amps and then we loaded the module full load. The positive stayed at 4.44 amps and the negative went from .084 to .092, which means that loading or not loading the module has no bearing on that.

MR. ASHE: Could you go back to the no load case. You first started off with no loaded it was 1.1 -- something. Positive was what?

MR. MACHILEK: With the unit not running.

MR. ASHE: Yes.

MR. MACHILEK: One point one four.

MR. ASHE: One point one four.

MR. MACHILEK: Amps positive and .283 on the negative.

MR. ASHE: Okay. Then, you went with the unit running.

MR. MACHILEK: Yes. We started the unit up under no load, and through the output was 4.44 amps on the positive and 1.084 on the negative.

MR. ASHE: Then, running.

MR. MACHILEK: Then, with loaded --

MR. ASHE: Loaded.

MR. MACHILEK: With loaded it had the same current on the positive and the negative was 1.092. I don't know that anything had changed. the question is, what would have happened --

That's the lamp button.

The relay, I placed it at really K-5 and found -- per the data sheets, it should drop off between 65 and 20 percent, which means between 78 and 24 volts. Once we saw on the lower end, I believe 45 volts were lost.

The 120 volts, if we applied a ratio of 200 kilovolts to 80 kilovolts, somehow we can theorize that the

120 volts went down to 50. The one relay we tested was at 45. So it would have stayed in at 50. The power supply input lost regulation at 96 volts and it would trip itself off at 84 volts.

Considering all the tolerances, it could trip between 86 and 78 volts, depending on the control feature, depending on the tolerance of the control. On the output, the 16.5 volts is adjustable between 17.3 and 15.7. The last observed state on the C unit, it tripped at 16.9.

MR. ASHE: How often is that adjustment made? You have no idea?

MR. MACHILEK: We check that adjustment at every PM, at every maintenance, preventative maintenance check. I don't know how steady -- does it change?

MR. RANSOM: No.

MR. ROSENTHAL: What do you mean by every preventative maintenance check?

MR. MACHILEK: Under normal -- if we have a maintenance contract.

MR. ROSENTHAL: What I'd like to do, whenever you're ready, is to take one of the lights that did go on and see how that would go on by design.

MR. ASHE: Right now. He wants to --

MR. ROSENTHAL: I'm sorry. It went to the D?

MR. ASHE: No, no. We went through all of how you

get to CB-1, CB-2 and CB-3.

MR. ROSENTHAL: Which is the UPS that they went to first?

MR. ASHE: 1-C.

MR. ROSENTHAL: 1-C, not 1-D.

MR. ASHE: In testing.

MR. ROSENTHAL: No, no. When they --

MR. ASHE: 1-D.

MR. ROSENTHAL: 1-D.

MR. ASHE: Yes.

MR. ROSENTHAL: So let's go look at 1-C and some light was reported lit. 1-A, 1-B, 1-C. And then let's follow that backwards.

MR. ASHE: Which is what we've already done, I think.

MR. ROSENTHAL: No. Wasn't any of these lights lit? Not these. On the other -- on the horizontal -- there's a --

MR. ASHE: On the A-34.

MR. ROSENTHAL: On the A-34 board, there is some light that gets lit.

MR. ASHE: Is that UV/OV?

MR. ROSENTHAL: UV/OV.

MR. ASHE: The as-found data, I gave that to you the other day. You have it. No. The as-found data sheet,

which really is right there, too. It's the same thing. It's 1-C.

MR. ROSENTHAL: 1-C, 1-G. So the OV/UV light on --

MR. MACHILEK: On C, on D and on G.

MR. ROSENTHAL: Okay. So why don't we go to that light on the A-34 board and see what turns that on. If somebody has a better suggestion, I'll listen.

MR. HESS: We're here. Go ahead.

MR. ROSENTHAL: No, no. We'll do it.

MR. MACHILEK: If you look at 1-D, you'll see OV/UV. Wouldn't that suggest that this one is on A-34? That would be A-21, right?

MR. RANSOM: That is an alarm on A-34.

MR. MACHILEK: This would indicate that it did, in fact.

MR. TERRY: But that's a suspect, Rudi. I think it would be better to go any of the other four.

MR. JOHNSON: It obviously didn't transfer, because they did it manually.

MR. TERRY: That's just strictly recollection.

MR. MACHILEK: You've got the A-34?

MR. HESS: Where were we? Out put OV/UV?

MR. MACHILEK: OV/UV. It comes from a rectifier here. Simply a level detector, that's all it is,

adjustable. BCCA/AB and we're feeding that into a level detector, come out to the lamp.

MR. ASHE: What's feeding in here now?

MR. HESS: Critical bus loads.

MR. ASHE: What is that? I mean what senses that? Just a resistor --

MR. MACHILEK: Voltage transformer.

MR. ASHE: A voltage transformer.

MR. MACHILEK: Direct input from the voltage transformer.

MR. ASHE: Okay. Direct input from the transformer. That's really simple then.

MR. MACHILEK: Yes. It's pretty straightforward. You do the same with critical bus and bypass and compare the two and that is the difference.

MR. ASHE: How the hell does that get there?

MR. MACHILEK: You come in through the --

MR. ASHE: I'm coming through there, through here, I've got you. Okay. I've got you. Through the base of this and then the collector. Okay.

MR. HESS: I saw it before.

MR. MACHILEK: They are difficult to follow.

MR. ASHE: Is the rest of these things like this, just pretty much --

MR. MACHILEK: Yes.

MR. ASHE: Through these amplifiers and gates?

MR. MACHILEK: There is no complicated circuitry involved, none which might be considered in today's computer age, microprocessors.

MR. ASHE: This would be lost, though, if this condition corrected from here.

MR. MACHILEK: If it works, yes.

MR. ASHE: In other words, whatever triggers this input, if that goes back to the norm, this light goes out.

MR. MACHILEK: It might be broke, I don't know.

MR. RANSOM: The critical bus goes bad. So that's why they came down and saw the lights on, because that condition existed.

MR. ASHE: I don't know if I followed you.

MR. MACHILEK: If the maintenance bypass goes away, this goes away. Of course, you have a voltage difference, right?

MR. ASHE: Right.

MR. MACHILEK: More than plus/minus.

MR. ASHE: You're saying go away, but you don't mean that. If the maintenance bus has degraded.

MR. MACHILEK: Same thing. If it goes down to 50 volts from 120.

MR. ASHE: Okay. Right. Your point was what, now?

MR. RANSOM: When the unit shut down, it flipped off. It didn't close the bypass breaker.

MR. ASHE: Right.

MR. RANSOM: Which meant your critical bus voltage was zero volts. So if you're looking at the critical bus and the bypass switch then returned, you have the voltage difference.

MR. ASHE: I've got you.

MR. MACHILEK: Each time you have a discrepancy between the presence of the two voltages, yes, you get that lamp.

MR. ASHE: So in theory, that should have been on all five units.

MR. MACHILEK: Depending on when you looked at it because it's not latched. It's just a lamp. As soon as you bring the unit up and the output becomes available --

MR. ROSENTHAL: This data was taken at two hours into the event.

MR. MACHILEK: Consider the following. There were three different teams going down in a two-hour period. They all did something, right? They first ones did something, the second ones did something, the third ones did something.

Now, if you take all the accounts and you really go through with a fine-toothed comb, then selectively you can say that one makes sense, it's probably good, this one

doesn't make sense, it's probably no good. Now, as soon as you do a selectivity in what is believable and what not, then you have to say I believe nothing or I believe everything.

But you cannot make a point either way in order to support yourself or convince yourself of something, saying, yes, you know, this is probably the right thing which was recorded here, this one doesn't make sense, it's probably not right.

We are talking about idiosyncrasies here, something which we believe cannot happen, but yet we accept that it did happen. With the knowledge and experience we have, we'd walk away from it and say, hey, forget it, it never can happen. But all we can say is to the best of our knowledge and ability, to analyze it or to duplicate it. We cannot make it happen.

MR. ROSENTHAL: Frank, the OV/UV on the A-34, the horizontal strip of lights, doesn't latch.

MR. MACHILEK: No, sir. It's not an alarm. It's only an indication. It's a status indication.

MR. ROSENTHAL: Okay. Is it possible that people are confusing OV/UV on the A-34 board with the under-voltage with the lights on the A-21 board? There's an under-voltage fast and an over-voltage light. Those are separate LEDs on the A-21 board, right?

MR. MACHILEK: Okay. The under-voltage fast is not in operation. It's only for parallel units. The ACO voltage would lock, yes, sir, but it doesn't trip.

MR. ROSENTHAL: But it doesn't --

MR. ASHE: Wait a minute. Why do you say it doesn't trip?

MR. MACHILEK: It would transfer, right?

MR. ASHE: It looks like to me it sends a signal to the same place.

MR. ROSENTHAL: If I detect an under-voltage here --

MR. ASHE: I'm sorry. He's right. You're right, you're right. No, it doesn't go to the same place. It doesn't trip the unit. Over-voltage doesn't trip the unit.

MR. ROSENTHAL: Wait a minute. Over-voltage -- I'm sorry. Over here, here, here, this gate, this buffer, over here, up here, to here. Okay. It gives you a light.

MR. MACHILEK: It gives you two lights.

MR. HESS: That's the trip over here. It gives you light over here.

MR. ROSENTHAL: That's a trip light and that's a logic light, but here is the actual trip. I'm sorry, I'm being slow.

MR. MACHILEK: But you will get a transfer on the A-34, which again cranks into the one because it opens the

CB-3 eventually, the output after you have confirmation that the CB-4 has failed.

MR. ASHE: If you put full amp load on the three D-cell batteries, what is the load --

MR. MACHILEK: It goes through immediately and from then on it decreases commensurate with the state of charge. It's fully charged.

MR. ASHE: But you've actually tested it.

MR. MACHILEK: Well, I hope they did. They put new batteries in it and let it run for a while.

MR. ASHE: No, no, no, no, no, no. I'm saying outside the unit, we reconfigure 3 D-cell battery packs, just like the plus or minus 20. Take an oscilloscope or something, put a full amp load on there and watch the voltage. Nobody's done a test like that, to your knowledge, right?

MR. MACHILEK: No.

MR. ASHE: But they should be able to have full amps in a very short period of time, no problem, right, fully charged?

MR. MACHILEK: It should hold it for a minute.

MR. ROSENTHAL: I'm sorry. The under -- you said one of these is not on that unit, under-voltage or over-voltage?

MR. HESS: I think you're talking about the

parallel lights, the AC/UV fast.

MR. MACHILEK: What about it?

MR. ROSENTHAL: It's not on the units there.

MR. MACHILEK: No, sir. No. This is only for parallel operation.

MR. ASHE: The under-voltage is the one that's not there. They only thing they've got is the over-voltage.

MR. ROSENTHAL: Could this have been on? What would have made the over-voltage?

MR. MACHILEK: Well, we had the other problem. We had a decrease in voltage, not an increase. I don't think if you short a transformer you'll get much of an over-voltage on it.

MR. ROSENTHAL: Okay. Let's pick another light that they're reporting. OV/UV doesn't latch.

MR. MACHILEK: It's a status indication.

MR. ROSENTHAL: OV/UV transfer. Voltage difference.

MR. ASHE: Am I saying something wrong here? I'm not saying anything wrong, right?

MR. MACHILEK: No. If you have -- I don't understand -- we have a transfer?

MR. ASHE: Transfer went on the same diagram.

MR. RANSOM: It does latch.

MR. ASHE: Wait a minute. It does? Okay. All

right. He's right.

MR. MACHILEK: That latch is the -- if you do transfer, you maintain that.

MR. RANSOM: It won't stop the unit from running, though.

MR. MACHILEK: No, no, no, no.

MR. ROSENTHAL: OV/UV transfer.

MR. MACHILEK: If it helps the statement, you can take the A-34 out of the module and the module runs. It's strictly a bypass control. It has nothing to do with the operation of the module itself.

MR. ASHE: I think what Jack is trying to get to is a possible explanation for these lights. I think that's where he's going with this.

MR. MACHILEK: On the A-34, the only lamps which you want to have stored is that a transfer has taken place or a transfer command was given. The rest are status indications, saying that one voltage or one frequency is different from another one. But if that condition would go away, then the lamp would go away.

MR. ASHE: Why didn't this show up on all the units, then?

MR. MACHILEK: It depends when you look at it, what the exact situation was. Was the maintenance voltage there or was it not there. Of course, once you try -- once

a module goes on the internal oscillator, then it drifts away from the bypass. Different speeds, it can stay there or it can drift off. It's really hard to say.

MR. ASHE: These reset bus tables, they're just dual in-line pin ICs, right?

MR. MACHILEK: Which ones?

MR. ASHE: The reset bus tables, they're latching --

MR. MACHILEK: Latches, yes.

MR. ASHE: How many, eight pin, 16-pin, dual in-line pin? How many is on a one --

MR. MACHILEK: Twelve.

MR. ASHE: Twelve on one guide, right? Close, some number thereabouts.

MR. RANSOM: Twelve of the actual devices?

MR. ASHE: No, no.

MR. RANSOM: It would have to be 14 or 16.

MR. ASHE: Sixteen. In terms of reset modules on that device, there's probably four.

MR. MACHILEK: Yes.

MR. RANSOM: Yes. Sounds about right.

MR. ROSENTHAL: What's the voltage difference?

MR. MACHILEK: It means that the output voltage of the module, that the bypass voltage and the critical voltage is different from each other.

MR. ROSENTHAL: Does that latch?

MR. MACHILEK: No, no, no. It's an indicator. It's like two volt meters to tell you what they are doing.

MR. ROSENTHAL: The voltage difference is that light.

MR. MACHILEK: Yes. It comes and goes as the situation changes.

MR. RANSOM: These two phases.

MR. ASHE: So that's AB phase, right?

MR. MACHILEK: AB and -- all three, sum it up, put an average to it and look at the DC signal, the level to take that.

MR. ROSENTHAL: They are saying that when they went down to look at two amps, they saw an OV/UV light, and we're saying that there's no latch, it's got nothing to do with what happened at T-zero.

MR. MACHILEK: Right. It's only an assumption to do at the time you look at the light.

MR. ROSENTHAL: The voltage difference, same story, right? And the OV/UV transfer does latch.

MR. MACHILEK: It will tell you that you did, in fact, get a transfer signal, which is strange, though, because if you do get a transfer signal, if the transfer is not executed, then you get a transfer fail alarm, which wasn't there.

It's almost as wierd as if you switch the lights on in your car and the horn comes on.

MR. ROSENTHAL: I had something like that and the stalk to the multi-function lever switch is a cable that runs down inside the steering column, and it had abraded the insulation and depending on just where the vibrations were and whatnot, as you turned this on north, it would occasionally -- the wipers would come on when you turned the lights on, etcetera.

They had to pull the steering wheel. It cost me 100 bucks for a guy to pull it apart to put a piece of tape on it because they addresed the leads wrong. That was an inadvertant or a sneak circuit, right? And what's the parallel here?

MR. MACHILEK: I don't know.

MR. ROSENTHAL: But there's a sneak circuit.

MR. MACHILEK: But if we want to investigate for a possible problem of that sort, it would be -- what my problem is, it's an atomic power plant and all the things have -- it was a multiple happening at the same time. Any one of the happenings by itself would not have done anything.

The shorting of the transformer would not have bothered anybody. The batteries dead, by themselves, wouldn't have bothered anybody either. You see what I mean?

MR. ASHE: Let's backup now.

MR. MACHILEK: What was the coincidence of the dead battery and the loss of the Phase B. If you would have lost A or C, nothing would have happened. So dual failure. It's inconsistencies in the reporting of lamps.

MR. ASHE: Let's flip that around. Let's say fully charged batteries and take the same scenario.

MR. MACHILEK: Nothing happens. I wish I could throw a --

MR. ASHE: Are you saying with fully charged batteries, the same Phase B short, this unit would have stayed up, the five units would have stayed up.

MR. MACHILEK: Yes. For the 12 cycles or whatever it was, for sure. But this can be tested. This can be proven. It's not -- we don't have to rely on anybody's opinion here. This is very provable.

The only suggestion I felt was a good one is to switch the relay coil.

MR. ASHE: Correct.

MR. MACHILEK: So that I'm going to inverter right away and I prevent switching later on. Are we covering all the bases with that? No, we don't, because if you lose one power supply and you do not have a bypass at the time, it's not in sync or God knows what, then you still would lose the load. See what I mean?

I want to make this 100 percent clear. That change improved the situation as far as that scenario is concerned.

MR. ASHE: Sure.

MR. MACHILEK: A different scenario with different combinations of problems at the same time could still get you in trouble.

MR. ASHE: Yes. The fix is also dependent on the inverter's voltage either being there or not there.

MR. MACHILEK: Also, I want to mention that if the AC/DC converter in the other unit goes bad, you've had it. You see what I mean? You lose it right away. Single point failure. Just damned lucky that it never happened. Now, we are not talking about --

MR. ROSENTHAL: We have had individual 1-E inverter, the losses of the --

MR. MACHILEK: If you lose the power supply, and this is why we never considered a AC/DC converter, for that reason. It's a single point failure. We could not qualify it with the Army, Navy or Air Force because we can't get away from this single point failure syndrome.

If you lose that AC/DC converter, the logic goes away and you crash and you lose your output load.

MR. ASHE: You mean the Army has none of these other kind of inverters?

MR. MACHILEK: The old ones.

MR. ASHE: No, no, no, no. The one with the DC converter on it.

MR. MACHILEK: No, I don't say that. I said we could not qualify it.

MR. ASHE: In your case.

MR. MACHILEK: Yes.

MR. ASHE: In your case.

MR. MACHILEK: No. The Army has a lot of things, but so does everybody else because a lot of things are being purchased on the open market by a local distributor, low bid.

MR. ASHE: It's bench stuff, right?

MR. MACHILEK: One of the reasons why the armed forces particularly liked this type of equipment was because everybody can fix it and we teach you how to. We have a course which teaches you every circuit down to the component leave, not only the subassembly level.

That means if you really want to understand our particular system, come down to Raleigh and go to school. Every circuit, every component, we teach you what it's doing, why it's doing it, and how it is doing it and what it is. We have no secrets there at all.

MR. ASHE: Some of the people from NOM now have gone down to the school you're talking about, right?

MR. GRADY: We haven't been able to find out who they were.

MR. ASHE: Okay.

MR. MACHILEK: The ones which are still around haven't been there. But if you really want to understand it, you'll need two weeks -- a three-week course and you'll know as much as we do.

MR. ROSENTHAL: Let me take an aside before I come back to this. We have seen random failures of converters which we have attributed to pre-conditioning due to temperature. But you don't expect five to all go at the same time due to that sort of problem.

Nevertheless, since we're thinking about the logic, let's talk about temperature for just a second. The over-temperature trips of this unit, I take it, are really on the heat sink temperature.

MR. MACHILEK: Right.

MR. ROSENTHAL: The chips there are -- they're not mil spec ships, they're just chips, high quality chips.

MR. MACHILEK: 70 degrees C logic.

MR. ROSENTHAL: 70 C?

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: Centigrade.

MR. MACHILEK: Yes.

MR. ROSENTHAL: 70.

MR. MACHILEK: 70. Which means that if you have a 40 degree C inlet temperature and a 15 degree C internal device, this is what our design criteria is. You have 55 degree logic. Because that unit is that tightly packaged, we have a separate blower on the controller itself.

MR. ROSENTHAL: On the card cage.

MR. MACHILEK: Yes. Which the other units do not have. Only the single cabinet has that and the 60-KW is the only one we have in a single cabinet. Once you go to the 100-KW, you have two cabinets. It's much looser packaged.

The problem with the 60-KW is that you need an air exchange. You have to get the PTUs away from the module. It has a tendency that the air does not want to readily come out and simply dissipate. So we specify if we install it or if somebody asks, three times an hour air exchange, which isn't all that much.

The Army, for instance, or the Navy, if they don't use air conditioning, they have a plenum on top and suck the unit, exhaust the -- and the plenum has a little blower which makes up for the static pressure which is generated. But the reason why you don't get the heat out of the units is because there is really nothing which makes the heat come out.

Simply the temperature difference between the inlet and the outlet, the blowers which are in there are

really not blowing, if you want, or transporting the heat away from the unit.

MR. ROSENTHAL: Now, the little batteries, the four-year is based on 77 --

MR. MACHILEK: 77 degree format, yes, sir.

MR. ROSENTHAL: And it's hotter than that in there, isn't it?

MR. MACHILEK: Well, depending on the inlet air temperature. One evening we were there, I would say it had probably 80 degrees in there.

MR. ASHE: 80 degrees in where? Where the batteries are located?

MR. MACHILEK: In the room itself.

MR. ASHE: I was in that room and I would say it was over 100 degrees in the room itself. I think that was their problem at that time. The chillers or something like that. Most times, it was probably --

MR. IBARRA: It was hotter than 80 at any time.

MR. MACHILEK: But you have a 15 degree C internal device. The filters were immaculately clean, so I don't know if they have been recently changed.

MR. ROSENTHAL: Apparently that is in the PM program.

MR. MACHILEK: Yes. They were really -- I mean, there was not a speck of dust in any of them. That was the

first thing, when I felt the one panel, I said to myself maybe that I had filter obstruction. There was none.

MR. ROSENTHAL: Whether it was the original design intent or not, to me, is irrelevant. What I'm seeing is that for certain scenarios, the little batteries do play an important role.

MR. MACHILEK: Yes, sir.

MR. ROSENTHAL: And I don't have your design change memorized, but I am under the impression that they would continue to play as important a role, if not more important.

MR. MACHILEK: Shouldn't play a more important role now. The reason why I'm saying that, while you're on bypass, you've got to have the load on bypass before you start up the inverter. So the load is on bypass and so is your power supply. Now you are ready to transfer. You bring up the module and run it.

As soon as the inverter output voltage becomes available, it switches over. If you cope while you are switching over, no problem because it's on purpose. So you just have to fix it and then switch it over.

Once you are on inverter output, you don't need the battery no more.

MR. ASHE: You go to the face plate. You take that little switch and you put it in auto restart. Now the

unit goes off the inverter. For whatever reason, it transfers.

MR. MACHILEK: Okay.

MR. ASHE: You're in auto restart.

MR. MACHILEK: Yes, sir.

MR. ASHE: It's going to try to go back.

MR. MACHILEK: Okay.

MR. ASHE: The batteries have got to play a role.

MR. MACHILEK: Then you stay on bypass, you get in a RAM.

MR. ASHE: You know about it if it did make it.

MR. MACHILEK: Yes, but it doesn't bother you. You do not lose the load.

MR. ASHE: If the batteries were dead --

MR. MACHILEK: You're on bypass already, right?

MR. ROSENTHAL: No. He's saying you're sitting running with dead batteries. You now have a fault in the inverter. Your logic has to stay up long enough to execute the transfer to the maintenance supply.

MR. MACHILEK: But the UPS does not fail in decreasing its output voltage.

MR. ASHE: It has to go down to some value, right? Wouldn't it go down to some value?

MR. MACHILEK: If an UPS trips, it's gone.

MR. ROSENTHAL: At least it's more apparent

failure modes.

MR. ASHE: What's the purpose of auto restart and three tries to go back onto the inverter, then?

MR. MACHILEK: This is if you want to go from the UPS to bypass.

MR. ASHE: No, no, no, no, no. Auto restart means you're going from the maintenance supply back to the inverter, right?

MR. MACHILEK: Okay.

MR. ASHE: I'm putting you in the same scenario as you starting up the inverter.

MR. MACHILEK: Yes, sir.

MR. ASHE: Now, how do you get around the batteries?

MR. MACHILEK: You're on bypass, okay?

MR. ASHE: Yes.

MR. MACHILEK: You want to auto restart.

MR. ASHE: Right.

MR. MACHILEK: Now you give a command to go back to UPS.

MR. ASHE: Right.

MR. MACHILEK: You have no logic to do it with.

MR. ASHE: Are you saying the inverter output is going to come up instantaneously?

MR. MACHILEK: No. Whenever it comes up, you

switch over to inverter. If it doesn't come up, then you don't.

MR. ASHE: No. But the thing is it's not going to come up instantaneously. It's going to be a ramp-up, right?

MR. MACHILEK: Okay.

MR. ASHE: So that's going to put you right back to where you were starting up.

MR. MACHILEK: No. You're going upwards in voltage, you don't come down.

MR. ASHE: Yes. I know you're going up, but there is a latch-up before that K-5 is going to pick up. It's got to be.

MR. MACHILEK: Yes, but the K-5 is on bypass all the time.

MR. ASHE: K-5 is deenergized the way it is now, right?

MR. MACHILEK: The supply to the power supplies comes from the bypass.

MR. ASHE: Yes, but when you flip to -- when you deenergize K-5, you reroute to supply. K-5 is deenergized. When you energize, it's from the inverter, right?

MR. MACHILEK: Correct.

MR. ASHE: So it means that when you're coming up, unless the inverter brings it up instantaneously, the battery is going to have to hold it a little bit while it's

making the switch, right? Wait a minute. Am I making myself clear? Is that right?

MR. RANSOM: I understand what you're saying. You transfer it off-line to an auto restart. The module shuts off. As the inverter tries to come up, as the inverter's making potential as it goes through the neutral point, the relay is going to try to pick up, at which point the batteries have to be there to handle the switch-over, just like if you had a utility failure previously. Then the control batteries will trip off. We tested it with the control batteries. We put the .6 volt back in and tried it.

But, like you were saying, you were in bypass, so at that point, all you then have to do is find the -- it tries to come up and when it goes to switch over and shuts down again. You know there's a problem at that point, but you're not jeopardizing your load because you're in bypass.

MR. ASHE: Right. But I observed most of the units, as I observed, were in the auto restart mode, for whatever reason.

MR. MACHILEK: It wouldn't bother you.

MR. ROSENTHAL: When we were looking at whatever drawing has the power supplies on it, the logic power supplies, and we were looking at the battery discharge light and the continuity battery discharge off-light or whatever you call it, it's clear to us that that really isn't

monitoring the battery while it's in standby, but rather simply what's happening to the battery if the power supply fails.

MR. MACHILEK: It really monitors the power supply.

MR. ROSENTHAL: It monitors the power supply. Okay. So if they --

MR. MACHILEK: Once the power supply is gone, then it monitors the battery.

MR. ROSENTHAL: Yes, yes. Well, I'm sure that these will be the most watched batteries in the nuclear industry. Okay. But they're running at some elevated temperature relative to that which you would associate with their four-year life.

What kind of advice can you provide them on what to do with the batteries and when to change them out?

MR. GRADY: If you do a full-blown maintenance program on the system, then that's something you would check. We are shifting through our paper right now, so bear with us for a second.

MR. MACHILEK: Our contracted maintenance programs, we do it every half-a-year, check the batteries.

MR. ASHE: Every six months, check it out. What do you do, a load test on it?

MR. MACHILEK: Yes.

MR. ASHE: Actual load test. That means you pull them, do a load test and if it passes, you put it back.

MR. MACHILEK: Correct.

MR. ASHE: Okay.

MR. MACHILEK: There is unfortunately no other way.

MR. ASHE: I'm just trying to understand.

MR. MACHILEK: We have a lot of installations, rather than go through a load test, we exchange the batteries every half-a-year.

MR. ASHE: Frankly, I think that's --

MR. MACHILEK: It cost you less money to stick in six D-cells.

MR. ASHE: Yes. Then it's a replacement program rather than testing.

MR. ROSENTHAL: Okay. Well, look. This is a very expensive meeting and we have all the people here. How can we learn the most about this thing, what's -- did we decide -- okay. Let me go back to the basics.

I decided that the -- we know that the circuit breakers changed states, CB-1, 2, 3, and we decided that you had to change K-1, 2, 3 on that first drawing we looked at. That was the only way to do that. Then we decided that that meant that you had to change the state of Q-1, Q-2, Q-3 on the third drawing that we looked at.

MR. MACHILEK: Right.

MR. ROSENTHAL: Then we followed back one way of changing the state of those power transistors was by detecting a low voltage on the output of the larger power supply, and we traced that all the way back.

MR. MACHILEK: Right.

MR. ROSENTHAL: Let's go back to Q-1, Q-2, Q-3 and say how else does this change its state, unless somebody else has a better idea.

MR. MACHILEK: How many ways are there to turn on a transistor who is between ground and the voltage.

MR. ROSENTHAL: Where's the drawing? We've got it out here on the table someplace. If you could advise me on a better thing to do with the next few hours, let me know.

MR. MACHILEK: The fact that the signal which made it happen was latched and confirmed, I see -- it did turn on, right? The breakers tripped as a response to it.

MR. ASHE: Right. I think what he wants to do, though, is to back up. What other ways can we get that other -- we know we can get it on loss of logic DC power, if the power decreases below the trip set point.

How else can Q-1 be turned off is what he's trying to get to, I think.

MR. MACHILEK: Turned off, you mean tripped?

MR. ASHE: Well, the thing is -- I think we agree

-- we had to saturate these guys to pick up the relay coil. Normally, they're sitting there, they're all cut off, and then we trace through everything. But now what I think he wants to do is how many other ways, other than low DC logic power, can this thing be saturated. So do you want to trace all of those guys?

MR. MACHILEK: All those ones which go in here.

MR. ASHE: Right. But I think he wants to trace it to everything on the drawing.

MR. ROSENTHAL: Is there a remote load dump? I read it in your manual.

MR. MACHILEK: No, no, no. The load dump is --

MR. ROSENTHAL: Like for a computer.

MR. MACHILEK: -- if you want to dump your load.

MR. ROSENTHAL: Right. But it would be -- right. But it is not installed on this unit.

MR. ASHE: Are you going to let us have a copy of that?

MR. MACHILEK: Well, they've changed it around.

MR. ASHE: That's right. By the way, you have a final report, though, addressing most of this stuff.

MR. MACHILEK: Yes. Yes.

MR. ASHE: That's all right.

MR. ROSENTHAL: I think what we will do is we will ask Nine Mile for a report from Exide.

MR. ASHE: That's already done. It will be finalized within the next day or so.

MR. ROSENTHAL: Okay.

MR. ASHE: Basically, that chart with all of those chips on there will be in that report, right?

MR. MACHILEK: Yes.

MR. ASHE: That's the key, I think, to what is really -- what we're going through.

MR. ROSENTHAL: If we just trace that out. Input breaker control, that's a physical switch on the breaker, unlike the -- is it racked in?

MR. MACHILEK: Input breaker, it would be a toggle switch which would be in here, which would automatically switch the breaker on. Yours is manual.

MR. ROSENTHAL: Battery breaker control, and you don't have it here.

MR. MACHILEK: No. It's manual.

MR. ROSENTHAL: I'm sorry. So this is like a universal board, as you were saying earlier.

MR. MACHILEK: Yes.

MR. ROSENTHAL: So are these contacts now floating?

MR. MACHILEK: It depends.

MR. ROSENTHAL: Tied higher, tied lower.

MR. MACHILEK: Yes. Whatever the circuit will

take. You cannot make it work without that. It depends if the signal is lower or higher.

MR. ROSENTHAL: What is this RCR-TCA-27?

MR. MACHILEK: This is an output that comes from --

MR. ROSENTHAL: It goes into that.

MR. MACHILEK: It's a remote switch on the A-14.

MR. ROSENTHAL: So you don't have it.

MR. MACHILEK: No.

MR. ROSENTHAL: We just traced this one.

MR. MACHILEK: Yes.

MR. ROSENTHAL: REM. Local A-14.

MR. ASHE: What is that remote used for?

MR. MACHILEK: This is if you want to remove it from a remote location.

MR. ROSENTHAL: You see your big computer burning up. Local A-14. Local A-14. What does LCL stand for?

MR. ASHE: LCL?

MR. MACHILEK: I think this is a local UPS off switch. A-14, yes.

MR. HESS: Yes. It's UPS off right there. And that's if you had -- the remote is off the A-30, you put remote switch off.

MR. MACHILEK: Yes. We don't have it.

MR. HESS: Local is the A-14 front meter panel

where you can press UPS off, and that's on the pictures that I just gave back.

MR. MACHILEK: The UPS on is the other button.

MR. HESS: There's a remote button for UPS on the A-30, as you had a remote off.

MR. MACHILEK: But we don't have it. Two buttons.

MR. HESS: Two buttons, on and off.

MR. ROSENTHAL: So are some of those not used, unconnected, floating?

MR. MACHILEK: Yes.

MR. ROSENTHAL: Is this all C-MOSS or --

MR. MACHILEK: Yes.

MR. ROSENTHAL: So you have some C-MOSS inputs floating.

MR. MACHILEK: Except the transistors on the output.

MR. ROSENTHAL: Do you run into problems with having C-MOSS floating, oscillations or --

MR. MACHILEK: Well, they are protected. They are -- I don't think we have any loose gates, if this is what -- for instance, this is a gate input and it's protected.

MR. ROSENTHAL: So anything that's not used is --

MR. MACHILEK: Yes. It should be a point higher and have a protection capacity against ground.

MR. ROSENTHAL: Wait a minute. Now what we're

saying is that the only way that you pop open CB-1, 2 and 3, is from here -- is from the --

MR. MACHILEK: UPT.

MR. ROSENTHAL: -- UPT which --

MR. MACHILEK: Which comes from this --

MR. ROSENTHAL: And UPT is SSTR. It changes names, but it's a physical wire on the back plate.

MR. MACHILEK: Yes.

MR. HESS: From A-21 to A-24, it changes. SSTR, UPT.

MR. ROSENTHAL: Okay. Now we decided that the under-voltage to this gate should have seen an under-voltage and tripped it. Which one was that?

MR. MACHILEK: Power supply failed.

MR. ROSENTHAL: FR is frequency?

MR. MACHILEK: Clock failure.

MR. ROSENTHAL: Clock failure.

MR. MACHILEK: Which is --

MR. ROSENTHAL: Okay. It's right there. Clock failure. Fuse failed. But we know that that --

MR. MACHILEK: They require repair if that would happen.

MR. ROSENTHAL: OTA.

MR. MACHILEK: The OTA goes -- it's not stored, because you have to reset the buttons.

MR. ROSENTHAL: FU is --

MR. MACHILEK: Fuse.

MR. ROSENTHAL: Fuse blown. WF is a --

MR. MACHILEK: It's freq failure.

MR. ROSENTHAL: Frequency fail.

MR. MACHILEK: That requires a board change if that happens.

MR. ROSENTHAL: AC over-voltage.

MR. MACHILEK: Yes. That's a legitimate -- by the way, AC over-voltage does trip.

MR. HESS: I thought we said it didn't.

MR. MACHILEK: Yes.

MR. HESS: I thought we traced out how it didn't trip.

MR. MACHILEK: Well, let's trace it again, because I remember where voltage was tripping on me.

MR. HESS: Over-voltage.

MR. MACHILEK: Over-voltage comes up here, comes there, comes there, all right. Over-voltage and power supply failure comes in at the same one.

MR. ASHE: That's coming in through here. It's a lamp through here. It's not the same.

MR. ROSENTHAL: Where is that over-voltage?

MR. MACHILEK: I just thought it was.

MR. ROSENTHAL: Over-voltage. Where are you

measuring the over-voltage?

MR. MACHILEK: On the output of the module. If the regulator goes haywire and you know your voltage goes up.

MR. ROSENTHAL: Logic failed.

MR. MACHILEK: Logic failed is a summary -- anything you get --

MR. ASHE: Wait a minute. Why doesn't that go --

MR. MACHILEK: See, all of these go in here. All of those are tripping, either/or. That means any one of those is tripping. In other words --

MR. ASHE: Maybe you're right on over-voltage. Let's go back to over-voltage. AC over-voltage --

MR. MACHILEK: Over-voltage comes out here, here, goes here, and trips.

MR. ASHE: Provided this is met up, right?

MR. MACHILEK: No, no. It says either/or. It doesn't matter.

MR. ROSENTHAL: What is this 12-bit -- Bit 12, 60 Hertz.

MR. MACHILEK: Which one is that? This is from the down circuit. This would trip you if it comes in. It results in a low under-voltage on the output of the module. The voltage control oscillator is going haywire of you miss the 12-count. You trip the unit before you see it on the

output. It should go directly up to the trip without any -- or is it. No, no, no, no, no, no. It goes over the -- it goes over the -- it depends on what the over-load is doing.

Yes. This goes up to the countdown. That's where they stuck it. This is only the 11 bits for the timing circuit. So you have the 1, 2 and 2-seconds timer. This should be a frequency -- it's 94 Hertz, going down to the timer. That's not what I thought it was. They're summing that together on the FRs.

MR. ROSENTHAL: I know we've been over this three or four times. I'm sorry. Okay. Here I've got chips, right?

MR. MACHILEK: Latches, yes.

MR. ROSENTHAL: Latches. And that itself takes 12 volts.

MR. MACHILEK: Right.

MR. ROSENTHAL: Which is coming from this power supply here, right?

MR. MACHILEK: Right.

MR. ROSENTHAL: We have 20 volts, plus 20, degrading here.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Do we know anything about the plus-12 volts here?

MR. MACHILEK: Well, as soon as the 20 volts

degraded to 16.5, we shut down the module.

MR. ROSENTHAL: By design.

MR. MACHILEK: Yes.

MR. ROSENTHAL: But in the time being, what was happening to the 12 volts here?

MR. MACHILEK: Which time being?

MR. IBARRA: The time it shuts down and --

MR. MACHILEK: The time the unit shuts down?

MR. ASHE: I think he's talking the time that the voltage degrades from whatever it's --

MR. MACHILEK: If you start out at 12 and go to 16.5?

MR. ROSENTHAL: Right.

MR. MACHILEK: It's almost instantaneously. As long as the power supply holds the voltage up, it's there, right? Once the power supply quits, you go on discharge from two more cells and from then on, since the batteries were pretty much dead, it decreased to .64 or something like that.

But to shut the unit down, you can blink your eyes fast enough to -- it's just, clink, and it's gone.

MR. POHIDA: Is the unit powered back up?

MR. ROSENTHAL: After 200 milliseconds.

MR. POHIDA: Is there any consideration on power-up states, like what the modes will be of all these latches

on power-up?

MR. MACHILEK: You have to push the reset button. If you don't reset the latches, you cannot restart the unit.

MR. POHIDA: Even if you lose power.

MR. MACHILEK: Even if you lose --

MR. POHIDA: The outputs won't toggle.

MR. MACHILEK: The outputs won't toggle. No, sir. Except if you switch off the logic.

MR. POHIDA: That's what you may have done. When the 20 volts came down, if it got below, what did you say, 13 volts?

MR. MACHILEK: 16.5.

MR. POHIDA: When do the 12-volt supplies start to --

MR. MACHILEK: We don't monitor the 12-volts.

MR. TERRY: Rudi, doesn't that K-1 -- that's what I'm asking about, that K-1. That K-1 relay --

MR. MACHILEK: That K-1 is there --

MR. TERRY: They'll reset the latches.

MR. MACHILEK: Well, it's there not to reset the latches if you do a lamp test.

MR. TERRY: But if it loses power, it will reset those latches. That's why I asked about that.

MR. POHIDA: Well, what if you did lose your 12 volts?

MR. MACHILEK: If you lost your 12 volts --

MR. POHIDA: What is the power-up condition of all of the latches?

MR. MACHILEK: If you lost the 12 volts, then the latches would -- no. You have to apply a -- you have to reset. As long as you do not reset, they stay where they are. They are bi-stable. They're not like a computer. If you lose the logic, you lose the memory or anything like that. It's like a toggle switch.

MR. ROSENTHAL: We could just pull a manual and look up the 4044s.

MR. MACHILEK: Yes.

MR. POHIDA: So they'll power-up as they power-down. Wait. Let me --

MR. ROSENTHAL: In order to -- I'm sorry I'm being redundant again. I thought earlier this morning we decided that you have to apply power to the shunt coils for two to five cycles in order to make the breakers change state.

MR. MACHILEK: Right.

MR. ROSENTHAL: And there has to be some reasonable voltage. That gives us a hint then about the condition of the logic, that the logic had to change state to initiate an open signal and there had to be enough voltage and enough power left to actually open the shunt coils, trip the shunts. Right?

MR. MACHILEK: We are not collapsing all the valves. They are linear power supplies.

MR. ROSENTHAL: It's a sub-component that you purchase.

MR. MACHILEK: Yes. It's a chip.

MR. ROSENTHAL: Do we know the -- but if we go to look up 4044 in a manual --

MR. MACHILEK: We can review it, but I don't have it here. I can get parts lists of all the components. That's no problem.

MR. POHIDA: You said earlier that you probably did not lose the 12 volts.

MR. MACHILEK: I do not believe you lost 12 volts.

MR. POHIDA: But we did diminish the 20.

MR. MACHILEK: The 20 -- we know that it ran to a 16.5, yes, sir.

MR. POHIDA: Is that a voltage regulator?

MR. MACHILEK: It's a voltage regulator.

MR. POHIDA: How fast can that act to correct for the 20 volts being pulled down?

MR. MACHILEK: I don't know.

MR. POHIDA: What I'm wondering is the 12 volts may have also dropped instantaneously.

MR. MACHILEK: It's possible.

MR. POHIDA: You lost your logic. The voltage

regulator, you just can't -- I don't think you can just put a sine wave into it and get --

MR. MACHILEK: We maintained the latches because the light stayed on and they are held by the latches.

MR. POHIDA: Did all of them stay on?

MR. MACHILEK: Yes.

MR. POHIDA: All the latches?

MR. MACHILEK: No, no. These two. Why they didn't --

MR. POHIDA: I'm not 100 percent familiar with the event, but it seems as though you could have problems if your 12-volt supply and your five-volt supply -- well, the five-volt just runs the LEDs, I guess, but moreso the logic. If you have your 12 volts dipping down and then coming back up, you say you will not lose the latches.

MR. MACHILEK: Well, I don't --

MR. POHIDA: I think you might.

MR. MACHILEK: If you remove the power, you would have to -- you have to ground the --

MR. POHIDA: You're also losing your inputs.

MR. MACHILEK: In order to re-circuit, you have to ground the S terminal. If you don't, you simply don't notice it. If you lose the 20 volts altogether -- I have to look at the data sheet.

MR. POHIDA: I don't know which latches were held,

which ones weren't. The other thing that --

MR. MACHILEK: You're familiar with the 4044s.

MR. POHIDA: The other thing that bothers me --

MR. ASHE: The 4044, that's the standard. Radio Shack or any of these places have probably got the same transistors as these guys do.

MR. HESS: Jack, you asked me earlier about some of the things that we should talk about for Niagra Mohawk and what they should be looking at. Then you went on to another piece. Did you want to revisit that or did you want to hold on that?

MR. MACHILEK: If it helps, five units were running for five years. We had one scenario we cannot fully explain. With normal maintenance, which we are doing for the industry as a whole, applied to it, we can say with high probability that we will not have any problem.

I don't know what much we can do else. If we had an inordinate amount of failures, normal operation, whatever, I don't know. I can probably see a concern, but it's really not there.

I would suggest it's none of my business, but to look at the other aspects of the obligation of the unit, classification of it, the maintenance level. These units turned out to be a hell of a lot more important than what they are perceived as.

So there's a lot of things which can be done. A maintenance bypass can be installed. The units can be half-yearly checked all the way through. We have roughly two-and-a-half-thousand units sitting out there in the field. We have a good reputation in the marketplace. We're not junk sellers. We usually don't even participate in low-dollar type deals.

MR. ASHE: Let me ask you something. How many units like this were -- do you have a handle on that --

MR. MACHILEK: We estimate around 700 prior to the shipment of the five here.

MR. ASHE: 75 KVA ratings.

MR. MACHILEK: No, sir. They all have the same logic. They all have the same -- the commonality is what the armed forces like, from 60-KW all the way up to 1000 or 800-KW. They all have the same logic, same circuitry, same everything; 68 percent commonality.

MR. ROSENTHAL: I know that the Reporter would like to take a break. So why don't we take a break and then when we get back, I guess the issues are, one, what could be done with respect to these units, that's one thing; two, a little bit more information on where else they're used and then by that time, maybe we'll come up with some more bright ideas.

[Recess.]

MR. ROSENTHAL: Your nickel.

MR. HESS: I'm sorry. I was waiting for Frank to say go ahead and do your thing. What I'd like to do is put in the record some recommendations that we have for Niagra Mohawk, and we'll follow this up with Niagra Mohawk in a full report to them shortly.

Under recommendations, I'd like to put number one, Niagra Mohawk is aware that the current UPS systems represents technology that is over ten years old. Exide Electronics' current UPS systems represent three technological advances and represents state-of-the-art power protection. It is our recommendation that Niagra consider replacement of the present systems with our present designs.

Recommendation number two, if Niagra Mohawk chooses to have Exide Electronics maintain the UPS systems at Nine Mile Point, we recommend our Powercare Preferred Service Package that covers all facets of maintenance, seven-by-24 emergency service, preventive maintenance inspections and modifications and parts.

Number three, if Niagra Mohawk chooses to continue maintaining this equipment, the following recommendations are applicable. Section A, inspect logic power control battery condition at least once every year. B, perform an annual preventive maintenance on UPS modules per manufacturer's recommendations or have manufacturer perform

an annual site acceptance test.

C, obtain necessary product and technical knowledge through an ongoing training program for Niagra Mohawk maintenance personnel. Exide Electronics can supply formal technical training programs at the Niagra Mohawk facility or at the manufacturer's training center in Raleigh.

D, as-built systems schematics diagrams must be maintained with equipment. These documents take precedent over any other manual, text or verbal communications and should be referenced during maintenance procedures. E, we've got to replace all DC input filter capacitors in each module. F, Exide Electronics stands ready to fully support Niagra Mohawk in any service requirements. Niagra Mohawk can call 1-800-84-Exide for service support should this be required.

G, our last recommendation is peripheral equipment that directly impacts the UPS operations should also be under manufacturer's recommended maintenance programs. End recommendations.

MR. ROSENTHAL: Are you worried about the circuit breakers based on what you know now?

MR. HESS: Not knowing -- yes. I would have to say yes. We're concerned about them. We can't tell how many times they've been worked. The only way to really go

in there would be to have somebody come in and take them out, and I believe they're all sealed. No. They come apart, don't they? They're just molded case. Have them looked at and/or replaced. Throw them away probably would be the best thing to do and put new ones in, knowing what we know today from this meeting.

MR. ROSENTHAL: Rudi, we wanted to give you the floor. Where are these units used? You have to expansive in terms of the same logic or similar enough logic, independent of the power rating.

MR. MACHILEK: About 700 we've come up with. They have identical logic. I wish you come to our plant and as you go through the production line, you see the same card cage being used. Sixty-eight percent of the subassemblies are commonality.

MR. ROSENTHAL: And at other nuclear power plants?

MR. MACHILEK: Well, the only ones I was personally aware of was Yankee Atomic and Duke.

MR. ROSENTHAL: Yankee Atomic and Duke. But how do we go about having to check your --

MR. HESS: We'll run a list. We can look through our users list and determine which facilities have our equipment.

MR. ROSENTHAL: I'd appreciate it if you'd do that in general. That assumes you can.

MR. HESS: Sure.

MR. ROSENTHAL: Those that are non-nuclear you can delete from that list.

MR. HESS: Understood. You want a strict nuclear application only.

MR. ROSENTHAL: Right. Now, I recognize that you may not know the application.

MR. HESS: That's true and chances are we probably don't.

MR. ROSENTHAL: With the understanding that the UPS may run the security computer or the UPS may run lights or whatnot, you may now know that, but I think we need to have that fairly fast.

MR. HESS: Do you want that faxed to you?

MR. ROSENTHAL: Yes, please. We'll give you our fax number.

MR. HESS: Okay.

MR. ROSENTHAL: So now we're back to drawings. Are we? I'm down to either there's a sneak circuit or we understand it. One or the other.

MR. ASHE: Maybe what we need to do -- what about let's go over some of the timing as possibly related to the event or what happened to the units. Can we do something like that?

MR. MACHILEK: In what respect, timing?

MR. ASHE: Maybe what we need to do is suggest -- just start with the guards and see how they generate a time base.

MR. MACHILEK: It has nothing to do with nothing.

MR. ASHE: Has nothing to do with nothing.

MR. MACHILEK: There were no problems with the switching, with the power. All the time clock is doing is it determines what sequence of filing of SCRs. All units started up. There was no repair, there was no damage. If a clock fails, you would know it. You have -- well, you wouldn't really because we have what we call a clock watching circuit and as soon as we lose a beat, we are ready to shut down. We don't wait on a disaster to happen in the first place.

MR. ASHE: All right. How do you shut down?

MR. MACHILEK: On a clock fail.

MR. ASHE: All right. Maybe we need to go on that. When you shut down, what do you do? You open the CB breaker?

MR. MACHILEK: Same thing. SSTR.

MR. ROSENTHAL: But don't you --

MR. MACHILEK: The clock fails and there is --

MR. ASHE: Right. All that part is the same. What about up here?

MR. ROSENTHAL: But don't you turn the SCRs off

even faster than ultimately the circuit breakers will open?

MR. MACHILEK: If you don't turn an SCR on or off at the exact precise time, you blow a fuse. You blow a fuse because you would have a direct shortcircuit of positive and negative on the battery. What you do is you simply switch the parallel voltage on and off, and then you do the same thing negative and you feed the transformers on the output.

MR. ROSENTHAL: In the manual, you said you've got like a 12-step --

MR. MACHILEK: Yes. The transformers which are -- two of them -- and if you had an imbalance of the positive and the negative, you would have a saturation effect, DC saturation, and you would blow just about anything. If you are a fraction of a millisecond off, you blow. Like we used to say, when you are power switching, you are always a millisecond away from disaster.

There was no problem in the power train in the conversion of the DC to AC.

MR. ROSENTHAL: Yes. We understand that nothing failed and the units were restarted, etcetera, but it might be useful to educate us a little bit. In this event, the SCRs were turned off, right?

MR. MACHILEK: You simply turn all SCRs off. You have to turn them off with a leg-off command.

MR. ROSENTHAL: Which comes from --

MR. MACHILEK: Are we just passing time or --

MR. ROSENTHAL: I'm just trying to understand.

MR. MACHILEK: -- do we want to have some analysis of the event.

MR. ASHE: Could we take about two minutes and just go over the gating of the SCRs in general. I think that would be helpful. I agree with you. I don't think this is so much relatable to the event.

MR. MACHILEK: GFM.

MR. ASHE: You have a GFM? A-9.

MR. MACHILEK: We would really have to go through the circuitry big time.

MR. ASHE: But I think we can just illustrate the format a little bit without really going through a detailed timing diagram and so forth.

MR. MACHILEK: Basically, what we have is six -- we have 12 switching legs.

MR. ASHE: All right.

MR. MACHILEK: Now, as you know, you can only turn off an SCR if you have interrupted forward current. In order to interrupt this forward current, you have to push current backwards against the direction of current flow. The way you are doing that is you are charging the capacitor and you have accommodation SCR, a static switching element. You should turn on and dump the capacitor charge backwards

through the SCR and you turn it off.

Then, of course, in the next cycle, you have to charge up the capacitor again.

MR. ASHE: All right.

MR. MACHILEK: The gate firing modules, as you see, you have -- it comes from the logic which turns on the various -- you have the main resistors and you have the accommodation, accommodating resistors. Each one is simply taking the capacitor charge. The main -- this goes directly -- the connection out of here is feeding directly into the --

MR. ASHE: Okay. I think we can --

MR. MACHILEK: We would have to have the right schematic.

MR. ASHE: We'll look for the schematic. So pulse comes out of here and goes into the gate zone.

MR. MACHILEK: You have the gate command coming here.

MR. ASHE: Which comes from the -- okay.

MR. MACHILEK: The leg switch-off -- see the leg switch-off commands.

MR. ASHE: Yes.

MR. MACHILEK: All the legs are getting a zero here which turns off the main SCR. At this point, you have a discharge capacitor. The accommodation SCR is turned on.

The charge is done through the main SCR, which is turned off, and you do not get any more gate commands.

MR. ASHE: Okay.

MR. MACHILEK: Should one of the leg switch-offs not execute, you blow the fuse. You see on the leg, you are directly between plus and minus DC. The two SCRs aren't serious. Should they ever turn on at the same time, for whatever reason, you have a shortcircuit positive.

You have a leg fuse which blows and the leg fuse is not on here. The leg fuse is -- one, two, three, four, five, six, one per leg pair.

MR. ASHE: Right there, yes.

MR. MACHILEK: You have the accommodating capacitors, the chokes, accommodating chokes, and diodes, standard leg, designed from the 1950s.

MR. ASHE: What is this guy doing here now?

MR. MACHILEK: This is the gate circuit.

MR. ASHE: Yes. This one right here. I know this is the gate that goes in and --

MR. MACHILEK: Between gate and the five-six gives you the firing circuit and this comes right out here. Similar, you have a gate against here and then the same thing, you have the accommodating SCR three, four and one and two.

The sequence in which the gate comes in up here,

comes directly out of the A-8 pin.

MR. ASHE: Eight and nine.

MR. MACHILEK: As you see, it's straight logic, nothing --

MR. ASHE: What kind of gate voltages are we talking about here?

MR. MACHILEK: I believe it's 12, but I -- what we used ten years ago.

MR. ASHE: I think that's a broad overview of --

MR. MACHILEK: Yes. It basically agrees with the control oscillator, with the countdown circuits.

MR. ASHE: Is it actually discrete control or is it --

MR. MACHILEK: Or discrete.

MR. ASHE: It's discrete crystal control.

MR. MACHILEK: Discrete crystal control.

MR. ROSENTHAL: This goes to a logic fail.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Is that covered?

MR. MACHILEK: This is the one from the guard watcher.

MR. ROSENTHAL: Twelve bits, whatever?

MR. MACHILEK: No. The 12-bit is simply used as a timing signal for the timers, all these timers. See all these timers here, they are run by the 12-bit circuit.

Now, in order to explain all that, you need timing diagrams.

MR. ASHE: Yes. They're too involved.

MR. MACHILEK: They give you the sequence of it.

MR. ASHE: I think that's an overview of how it's really working.

MR. MACHILEK: There it is. There's the crystal sitting right here, 1.47 megahertz, and then it goes through the countdown circuits. We're counting it down until we get the 60 hertz. We are watching the countdown, comparing it against the standard and if we have discrepancies, then we shut down on clock failure.

MR. ASHE: What is this 100 --

MR. MACHILEK: This is 1.47 megahertz crystal. We're just counting it down.

MR. ASHE: Something that is relatable to this is how does this thing bump up or change the frequency?

MR. MACHILEK: It doesn't and cannot.

MR. ASHE: We saw it.

MR. MACHILEK: There's a crystal control, oscillator which is influenced by the circuit.

MR. ASHE: Right. How does that -- just go through that, because I think that was somewhat relatable to the event.

MR. MACHILEK: What the crystal control oscillator

is doing, the voltage controller oscillator is doing, it takes the synchromat and corrects it to be in concern with it.

MR. ASHE: How does it do that? Through voltage?

MR. MACHILEK: It's voltage-controlled. The voltage level is established by the frequency of the voltage converter from the bypass directly compared to the frequency which comes out of the countdown circuits of the clock. And it corrects -- I'll show you how it corrects for the incidents.

MR. ASHE: It does that in a period of what, about 30 or 40 seconds or so, depending on the ranges?

MR. MACHILEK: It does it -- no, no. It does it every 737,000 hertz level.

MR. ASHE: What kind of band is this thing operated in? For example, if you lose more than a few hertz, it won't bring it back into sync anyway, will it?

MR. MACHILEK: Yes. If you are 180 degrees other phase, it brings it back.

MR. ASHE: No, no, no, no. Supposing the frequency, for some reason, goes down to --

MR. MACHILEK: Internally?

MR. ASHE: No, no, no. The unit works fine. The maintenance supply --

MR. MACHILEK: If the sync frequency is going .5

hertz, we disconnect the sync.

MR. ASHE: So you lock out really.

MR. MACHILEK: You disconnect from the sync, yes. We no longer let you influence us.

MR. ASHE: So it only rises and falls by that amount basically, because otherwise it --

MR. MACHILEK: Plus/minus .5 hertz, that's it.

MR. ROSENTHAL: Based on your knowledge of the design, number one, you know that the SCRs were fired as designed for however long --

MR. MACHILEK: If one gets a little out of step, you blow down right away.

MR. ROSENTHAL: And you would know failures of --

MR. MACHILEK: There was no repair, no readjustment, at least not reported.

MR. ROSENTHAL: And that's both from the rectifier and the --

MR. MACHILEK: And the worst -- the only repair which -- two repair orders have been issued, one for the circuit breaker on one unit, and I don't know what the -- the rectifier -- it was a breaker problem.

MR. ASHE: What is the maintenance cost you're talking about on one of these units per year?

MR. HESS: The maintenance contract or the actual cost?

MR. ASHE: The actual cost. Well, contract cost for one unit.

MR. HESS: For one unit, it could vary from -- you're talking about full coverage? There's a whole --

MR. ASHE: Full coverage.

MR. HESS: Full coverage.

MR. ASHE: Ballpark figure.

MR. HESS: Three to 5K a year. Now, that depends -- that could be a guesstimate.

MR. IBARRA: Per unit.

MR. HESS: Per unit, yes. It would be per unit and that would be depending on what spares were maintained on-site.

MR. GRADY: That would include parts.

MR. HESS: Yes. What we normally do is a customer has a spare parts package and then we work from that spare parts package and replenish that to them underneath the contract. So they have an ever present supply of parts.

MR. ROSENTHAL: When the AC input, normal input degrades, as I understand the design, you turn off the SCRs in the rectifier.

MR. MACHILEK: Correct.

MR. ROSENTHAL: At some point in this scenario, this event, the SCR is -- were the SCRs on the inverter turned off?

MR. MACHILEK: No.

MR. ROSENTHAL: No.

MR. MACHILEK: Only when it shut down.

MR. ROSENTHAL: It was only following --

MR. MACHILEK: You got the leg-off command. Leg switch-off.

MR. ROSENTHAL: And it gets the leg switch-off --

MR. MACHILEK: Simultaneously on all 12 legs.

MR. ROSENTHAL: From where does it get it?

MR. MACHILEK: From --

MR. ASHE: You knew he was going to ask that.

MR. MACHILEK: It's on eight or nine.

MR. HESS: It ties in. It's over there on 12 and it's tied in on the nine. This is the nine right there.

MR. MACHILEK: It's 20.

MR. HESS: Yes. Which is tied in across down the back here.

MR. MACHILEK: It basically takes it -- if we get an under-voltage -- there's the UPT, which is the -- see the UPT? That's the same one which is coming out, this one here, the UPT. It switches off to three breakers, comes in here, and it gives you a leg-off command, which is transmitted directly to the K-5 module.

MR. ROSENTHAL: Let me see if I can get this right. Because the fuses weren't blown and because the SCRs

were not damaged, in the inverter, you know that it got a leg switch-off. The leg switch-off came from which drawing? From here, which gets its input from --

MR. MACHILEK: UPT.

MR. ROSENTHAL: One is UPT, which is the same --

MR. MACHILEK: Yes.

MR. ROSENTHAL: -- which is the output of SSTR.

MR. MACHILEK: UPS trip.

MR. ROSENTHAL: From the UPS trip or --

MR. MACHILEK: Do you see UV?

MR. ROSENTHAL: I'm sorry.

MR. MACHILEK: Output voltage low. In your case, not used. This is only used on a parallel circuit.

MR. ROSENTHAL: Okay. Or --

MR. MACHILEK: That's it. UPT is the only thing which gives you a leg-off.

MR. ROSENTHAL: Okay. So that had to be --

MR. MACHILEK: Yes. Everything is consistent with operation.

MR. ROSENTHAL: But that's an independent way of -- okay -- or supporting.

MR. MACHILEK: I understand.

MR. ROSENTHAL: Okay. So now let me try to verbalize it.

MR. MACHILEK: Sure.

MR. ROSENTHAL: And then you verbalize it better. It is my current understanding that, by design, the rectifier would turn off -- would be shut down on seeing bad input, that the inverter would be turned off by an SSTR signal only, and that same signal would end up opening CB-1, CB-2, and CB-3.

MR. MACHILEK: And give a transfer command.

MR. ROSENTHAL: To the --

MR. MACHILEK: To the A-34 transfer circuit.

MR. ROSENTHAL: To the transfer circuit.

MR. MACHILEK: The transfer circuit makes a decision if or if not to execute that, depending on three conditions; bypass frequency, voltage and sync.

MR. ROSENTHAL: But we know that that was also effected by the original fault.

MR. MACHILEK: Correct. We would not expect the maintenance voltage to be there, because it wasn't.

MR. ROSENTHAL: We follow back the SSTR signal and we decided that that had -- that the only probably way, other than a sneak circuit or something we don't understand, is that that would have come from a power supply failure input and then we followed that back to power -- to the logic power supplies which we know were powered off B-phase and saw the --

MR. MACHILEK: Yes. Or that can be a verified

test that duplicated --

MR. ROSENTHAL: The one thing that we don't understand then --

MR. MACHILEK: Is the discrepancy with the --

MR. ROSENTHAL: Discrepancy with the lights. On the lights, we decided that the under-voltage UV does not latch. So that the observation of that light was the time that somebody wrote down what they saw, which was at roughly two hours -- two or three hours -- two hours into the event.

MR. MACHILEK: I would really consider that as a status indication rather than an alarm.

MR. ROSENTHAL: And that the voltage difference light does not latch as the UV -- OV/UV, but that the OV/UV transfer light does latch and may have -- and we don't know if that latched and lit at time T-zero or five, ten, 20 minutes or an hour into the event.

MR. MACHILEK: Right.

MR. ROSENTHAL: Go on. What else do we know?

MR. MACHILEK: We know that we didn't have to make a repair or adjustment and the units started up after the alarms were reset.

MR. ROSENTHAL: Right. Let's break.

[Recess.]

MR. ROSENTHAL: Let's go back to UPS. What we decided was it is not single failure-proof.

MR. MACHILEK: It is, because the power supplies are a single point failure -- not a single point failure. You've got to have something else to happen; namely, the maintenance has to get lost at the same time.

MR. ROSENTHAL: But we did decide that there are lots of redundancy in it. For example, if you lose the rectifier, you have the battery.

MR. MACHILEK: Correct.

MR. ROSENTHAL: And if you lose the inverter itself, you have the maintenance.

MR. MACHILEK: Bypass.

MR. ROSENTHAL: Bypass. So although it's -- so there is a level of redundancy there.

MR. MACHILEK: The only time your redundancy gets lost is if the redundant is if the primary source fails at the same time.

MR. ROSENTHAL: Wait a minute. Given the loss of power supply, including the battery, with the dead battery, if the maintenance supply had been good --

MR. MACHILEK: Nothing would have happened.

MR. ROSENTHAL: Then it would have -- what would have happened?

MR. MACHILEK: What would have happened? Nothing, because the power supplies would have to be maintained and you wouldn't know a thing.

MR. ROSENTHAL: If there was some other fault in the power supplies --

MR. MACHILEK: If there's another fault in the power supplies, it would --

MR. ROSENTHAL: Or the card cage or something.

MR. MACHILEK: Then the UPS would have shut down. It would have transferred to maintenance. It transferred many times over the years, right?

MR. ROSENTHAL: Yes.

MR. MACHILEK: And certainly the batteries didn't go bad. So the dead batteries, by itself, if nothing else happens with it, something specific happens with it, you would never in your life would have known that you have dead batteries.

MR. ROSENTHAL: Okay.

MR. MACHILEK: Given the assumption that nobody would have checked it. Now, we have to recognize it is difficult to test, check or make a major investigation on the modules since you have no way to power a flow. So I don't -- probably, out of my own, I probably -- given the difficulty to shut down a module and maybe not even getting permission to do it, it is considered that maintenance at times is falling short because of it.

I have to give you an example on the first Boeing installation we did in Vienna, not far from here, and we

wanted to perform the first preventative maintenance, half-a-year after installation, and we were told no way in the world are they going to go off the UPS. We have to wait. Well, three years later we had the first PM. Nobody wanted to let the load get off the UPS. So if you want an enforced maintenance deficiency because of that.

And users are paranoid. Once you have an UPS installed, you have a computer operation going, they simply don't let you get off the UPS, period.

MR. ROSENTHAL: We have discussed how do we know that the batteries were not -- were discharged or not charged at the time of the event rather than after the event.

MR. MACHILEK: It was not a matter of --

MR. ROSENTHAL: But I'd like to hear your verbalization of why you believe the batteries were no good at time T-zero.

MR. MACHILEK: Because of the amount of time it was operating in the elevated temperature environment, experts were indicating that the batteries probably were no longer batteries after one-and-a-half years after installation.

I hope it was confirmed that all five batteries were dead. Not that they couldn't get charged, they were simply incapable to hold a charge.

MR. TERRY: There was one that was -- plus 20. It was half. The plus 20 volts.

MR. MACHILEK: The plus was good?

MR. TERRY: Yes.

MR. ASHE: Which unit was that, do you recall?

MR. TERRY: Gulf.

MR. ASHE: And you actually load tested that?

MR. TERRY: No. That's measured voltage.

MR. ASHE: No-load voltage. That doesn't -- was the load test -- it wasn't load tested, was it?

MR. TERRY: No. I'm just talking about the as-found voltage.

MR. ASHE: Okay. No-load voltage will certainly come up and that --

MR. ROSENTHAL: But the as-found no-load voltage measured roughly a week after the event was after the power supplies had been re-powered three to five days earlier and, hence, are effectively on a triple charge, are on a charger.

MR. HESS: Yes.

MR. ASHE: Is there a blow-up diagram for the power supply, PS-1 and PS-2? Do we have that someplace to show the internals of that?

MR. MACHILEK: No. It's a purchased product. All of our drawings shows only the information necessary to procure it. We don't fix it or service it if it's broke.

We simply replace it.

MR. ASHE: Well, how do we know what's in there?

MR. HESS: When you order one, it comes with a small diagram inside the box, if I remember correctly.

MR. ASHE: You don't retain any of the diagrams like that?

MR. HESS: They're in the purchase part of it.

MR. MACHILEK: We don't fix it. It's what we call a non-repair subassembly.

MR. ASHE: What happens to the old unit you take out then?

MR. HESS: Throw it away.

MR. ASHE: Who do you purchase that from, do you recall?

MR. HESS: I knew you'd ask that question and there's been a couple different vendors. Economate. We have a list of vendors. Would you like --

MR. GRADY: We have a drawing that lists the vendors in the specs.

MR. ASHE: For the power supplies.

MR. MACHILEK: Yes. We can send that to you.

MR. ROSENTHAL: Okay. That might be helpful. Because if those power supplies have, let's say, big capacitors inside there, they have finite lives also.

MR. ASHE: I'm not certain that that's really

true. This power supply appeared to act more as a transistorized regulator rather than a capacity guide.

MR. MACHILEK: It's a series -- it's a linear series regulator, transistor regulator with filter capacitors on the output. The DC is being filtered because it is --

MR. ASHE: Right.

MR. MACHILEK: That's why the capacitors are there.

MR. ASHE: The output is across the capacitor.

MR. MACHILEK: Absolutely. Yes, sir. Otherwise we wouldn't survive with the power you had there, not even on the normal charges. Capacitors are holding you up right now.

MR. ASHE: Okay.

MR. ROSENTHAL: I'm sorry. K-5 flips from one state to the other.

MR. MACHILEK: The capacitor --

MR. ROSENTHAL: The capacitor and the power supply is what's holding you up.

MR. MACHILEK: Yes.

MR. ROSENTHAL: Then I guess it would be good to know what --

MR. ASHE: So you have seen the diagram and you know that's the way it is.

MR. MACHILEK: No. I don't see the diagram. The power supply. Same power supplies which are on the pan which --

MR. ASHE: When you say on the output, what I'm saying -- to me, what that means is between plus and the neutral, you're saying that output is across the capacitor.

MR. MACHILEK: Correct.

MR. ROSENTHAL: That's another age-related problem. Did you want to review the --

MR. ASHE: I'm saying the internals. The internals. It didn't seem like the data was suggesting that to me.

MR. HESS: As soon as we get back, we'll get you --

MR. ASHE: You can do that, from the internals, I'm saying. The internals. I'm talking about the one from the inside of the power supply.

MR. HESS: In fact, I think it's on the back of the power supply now, they've gotten it. I saw one where it was actually glued onto the back of it.

MR. ASHE: And you have one of those laying around someplace, you think, or might?

MR. MACHILEK: At the plant.

MR. HESS: Let us take care of that. Let us get one.

MR. TERRY: Are you just talking about filter capacitors across the power pack? They're external.

MR. HESS: No. They're internal.

MR. HESS: We will take that as an action item and get you a copy of the schematic of the power supply itself, not the subassembly, which we already have.

MR. ROSENTHAL: We know that large tantalum type capacitors, batteries, are age-related components. The chips, hypothetically, have an infinite life. What other components are there which you would consider age-related?

MR. MACHILEK: DC electrolytic capacitors which are on the main DC bus.

MR. HESS: That was called out in the recommendations.

MR. ROSENTHAL: Go on.

MR. MACHILEK: That's it.

MR. HESS: Age-related like that.

MR. MACHILEK: Nothing else has a shelf or operating life.

MR. ROSENTHAL: Wear-related rather than age-related.

MR. ASHE: The diodes, you said that's a chip, too? Is that just -- that takes the 20 volts?

MR. MACHILEK: Yes, yes. The output regulators which are little chips.

MR. ASHE: Is that just a resistive voltage --

MR. MACHILEK: It's a transistor series regulator.

MR. ROSENTHAL: That's a 7812. We could look that up.

MR. MACHILEK: Yes. They're all over the place.

MR. ROSENTHAL: What were you going to say?

MR. ASHE: I was going to ask Rudi to characterize the whole thing very simply, starting from the transformer rectifier, downstream propagation to the power supply, trip of the units.

MR. MACHILEK: Okay. The loss of Phase B voltage translated itself over the areas Delta Y transformers to show up as a Phase II voltage reduction all the way through, including the 100-volt switch we use for control.

The effects of the voltage reduction on the rectifier input was that the rectifier phased off. The inverter continued to operate on the main station battery. The supply to the control power supplies reduced itself from 120 to roughly 50 volts. The drop-out voltage was, I believe, 45 on those relays. So we did not switch over, which starved the input to the power supplies and they lost regulation, reduced the output DC voltage and the batteries, which were not able to hold up, decreased their voltage on the load to below 16.5 volts, which caused an UPS trip signal to be issued, which was properly executed.

The transfer to bypass signal was not processed because the bypass was not of the quality acceptable to the circuit, and the load was lost.

MR. ROSENTHAL: Break.

[Recess.]

MR. MACHILEK: It can be shown that if you, for instance, simply take the power supply pan, the A-27, and you supply it with voltage and you monitored the load of the power supplies with four-amp and one-amp, respectively, which is the normal draw, then you can really demonstrate what would happen.

If you reduced the input voltage to the power supplies, was switched to power supply availability from one input to the other, all that can be duplicated and shown what's going to happen. The draw is a constant draw. So even if you simply put a resistor float on here which draws about four amps or thereabouts, draws about one amp or thereabouts, then you can direct it to break it. And what will happen is given the capacity of the battery and the discharge current of four and one amps, you can directly calculate or get from the manufacturer the voltage decay over time, and whenever you hit 16.5 volts, that time, you will be able to support the operation of the UPS without any other supply.

You will see, if you do that, that it is

considerably longer than the 12 cycles of voltage we're actually experiencing. Given that, which can be demonstrated, tested and shown, you can make the conclusion that if the batteries would have been good, you would not know that anything happened.

MR. ROSENTHAL: I think that's it.

[Whereupon, at 5:10 p.m., the meeting was concluded.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission

in the matter of:

NAME OF PROCEEDING: Nine Mile

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Mary C. Lark

Official Reporter
Ann Riley & Associates, Ltd.