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DONALD J. TILLIAN
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is May 4, 2009. This interview with Don Tillian is being conducted at JSC for the JSC Facilities Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Rebecca Wright. Mr. Tillian begins today by talking about his educational and work experience.

TILLIAN: Let me give you a little background. First of all, I graduated from New Mexico State University [Las Cruces, New Mexico].

ROSS-NAZZAL: You went to New Mexico State? So did I. I got my master's there.

TILLIAN: I got a degree in Chemical Engineering in 1958. I went out to California. I worked for Douglas Aircraft from '58 to '61 in the materials and process group. Then, in 1961, I went to work for Ling-Temco-Vought in Dallas [Texas]. March of '64 I came down here to work for NASA JSC. I retired on the first of January, 1997, after 30-plus years, and I had several years of co-oping when I was out at White Sands [Test Facility], when I was out in Las Cruces.

So I put 35 years in with the government. I put five years in with the industry the first time. Then after the [Space] Shuttle [*Columbia*, STS-107] accident, I was called back to work by Boeing. A six month job now has turned in to over five and a half years.

ROSS-NAZZAL: Did you work on the Thermal Protection System [TPS]?

TILLIAN: Yes, I did. I worked on the Thermal Protection System development. I worked in that laboratory for quite a number of years, and I became the section head of the particular laboratory building of the Experimental Heat Transfer Section. Then I became a branch chief about three years before I retired.

I had a [number] of the facilities then. I had the arc jet in Building 222, the vibration acoustic facility in Building 49, and the structures test lab in Building 13. Also, Building 260, the radiant heat facility. At that time, they decided they wanted to combine them all into one organization. Then I retired.

ROSS-NAZZAL: Too much work? Too many hats?

TILLIAN: Well, I wanted to retire then. I had been around working for 30 or 40 years. So I thought I'd retired. Of course, this accident happened, the *Columbia* accident, and I thought I could help out. I've been working since then, working on the testing that we've been doing on the damaged tile and the repairs.

ROSS-NAZZAL: Great. You should be able to give us lots of information then about Building 222. Tell us about the history of that facility. What it was originally built for, and then how it was changed to support the Shuttle Program.

TILLIAN: Right. Well, let me go back a little way. In the beginning, there was a little facility building, a temporary building across the street, [Building] 262. That's where we started initially doing arc jet thermal testing of thermal protection materials, particularly the Apollo heat shield. Then, at that time, people recognized that we needed a larger facility. It was very small. It had a small nozzle. We could only test small samples. The idea was to build a larger facility. We could test larger material samples and test larger articles.

So they put into place a CFF [Construction of Facility] project. The facility was completed in 1967. It was put in place by the [U.S. Army] Corps of Engineers, the building itself, and AVCO Corporation provided the equipment—the arc heaters that heated the gas that we tested the materials in. They provided these chambers and the mechanism that placed the model in the stream. So that's how it all started.

The facility became operational in 1967. Its original intent was to test all manned spacecraft Thermal Protection Systems. When the Shuttle came along, we started doing work on the TPS materials. Looking at materials for potential Shuttle applications in 1969. We were looking at reusable surface installation, stuff we ended up with for the tiles, and also the carbon-carbon materials.

We did tests on these little samples. You have to understand the basic performance in 1969. Then, we had TPS material development contracts from '69 through about '72. At that time, Rockwell Downey was selected to build the Orbiter. It became the mainstream program.

At that time, since the government put a lot of money in these facilities, not only here at JSC, but at [NASA] Ames [Research Center, Moffett Field, California] and [NASA] Langley [Research Center, Hampton, Virginia]. We had the largest complex [of arc jet facilities] in the world at the time. The contractor was directed to test in government facilities. So in contrast to

Apollo, we did independent testing. The majority of Apollo testing was done by AVCO and North American Aviation, but we did independent testing to make sure everything was okay with the materials and special items.

Then we started hot and heavily supporting the Shuttle Orbiter TPS program in 1972, directly with Rockwell Downey. Of course, their supporting contractors—Lockheed provided the tile materials, and LTV up here provided the RCC [Reinforced Carbon-Carbon] materials that's used for the leading edge.

ROSS-NAZZAL: Tell us if you would, I think that there might be some people who don't know what an arc jet facility is. Can you explain that and how you test materials?

TILLIAN: An arc jet is—you have two electrodes, and you heat the air, you strike an electrical arc, you bring air in between these electrodes, heat it to very high temperatures, and then expand it through nozzles. You use that high-temperature air that's expanded through the nozzles to test your materials. It simulates the conditions of reentry. It's really an electric arc heater. You use an arc. It's sort of like lightning. You're passing gas through the arc, then heat it at these high temperatures of 10,000-plus degrees [Fahrenheit]. That's what you do. That technology started at Langley in the early '50s, '60s. Some of the original people that worked on that came from Langley, when we first started down here in 1963 in that small facility.

ROSS-NAZZAL: You mentioned in '69 they were working on some development contracts for the TPS. What were some of the different thoughts that they had for tile? Wasn't there an aluminum thought at one point?

TILLIAN: We were looking at an all-silica system that was developed by Lockheed Missile Space Company. Then, we were looking at mullite systems, which was alumina silicate that were being developed by McDonnell Douglas and also GE [General Electric] at the time. In fact, we initially did some screening tests with about 12 different contractors. Little samples. Then we narrowed it down to three, really: GE, McDonnell Douglas, and Lockheed, as far as the tile material that covered the bulk of the Shuttle. For the leading edge material on the leading edges and the nose-cap, there were two contractors working on that. That was LTV in Dallas and McDonnell Douglas in St. Louis [Missouri]. It turned out that LTV had the best materials.

ROSS-NAZZAL: Were there any significant changes done to [Building] 222 to support the Shuttle Program?

TILLIAN: Originally, the Corps of Engineers put it in, and then AVCO developed the heaters. In 1972, we had another CFF project. What we did was we put in another chamber, a ten-foot diameter chamber. We had an eight-foot diameter chamber. We put in a ten-foot diameter chamber, put in a new boiler, and the interconnecting piping that goes with it.

We also developed a set of channel nozzles. We developed a new technique where we tested large panels. (Two foot by two foot, and twelve [inches] by twelve [inches].) So we did change our nozzle systems. Of course, we kept the conical nozzles, but we also developed these channel nozzles, as well as getting new boilers and new updates to equipment.

Then in 1990, '91 we had another upgrade. Then again [we replaced] a boiler. We got an 80,000-pound-per-hour boiler. We got another chamber, a 12-foot diameter chamber. We also got an updated control system that controls the operations in the facility. The small eight-foot chamber that was originally there, we moved it to Building 262 to use in the radiant heat facility that we had. Before that, small radiant heat system was in an old command module boilerplate in [Building] 13, but we moved it down to Building 260, the heater system, and put in the original eight-foot diameter chamber that we got in ’67.

ROSS-NAZZAL: As you started working on the Space Shuttle in ’72, were you still working on Apollo issues through ’75, with the Skylab hardware and the ASTP [Apollo-Soyuz Test] Project?

TILLIAN: Very limited. We did a limited amount of tests. Primarily, at that point in time the Apollo material had been through flight tests, and we had been through a lunar landing. The issues were essentially resolved. There was very little that was done after that. So it was primarily Shuttle.

ROSS-NAZZAL: Will you tell us about some of the testing that you did from ’72 until the launch in ’81?

TILLIAN: First stuff we did, we evaluated the materials’ thermal stability. We evaluated its over-temperature capability and its basic thermal performance. We also then looked at specialized areas of the vehicle. We looked at singularities, penetrations, various seals, the nozzle areas, and the penetration doors, door sections. So we looked at the major design features during that period of time. We had samples made of the major design features, as well as the basic acreage materials. We did tests on the carbon-carbon leading edge materials. We also did life testing.

ROSS-NAZZAL: What is life testing?

TILLIAN: The Shuttle was designed for 100 missions, the external Thermal Protection System. So we did many, many hours of testing to accumulate 100 missions.

ROSS-NAZZAL: How long did that take to accumulate 100 missions?

TILLIAN: The material was being improved during that period of time, so we did it for multiple different materials. We started out with an LI-900 (nine-pound-per-cubic-foot material). Then we went to an LI-[2200] material that was used on the areas where we needed more durable material closer to the leading edges and around doors. Then, we went to FRCI [Fibrous Refractory Composite Insulation]-12, even a stronger material, more durable. Then later on, we went to an AETB [Alumina-Enhanced Thermal Barrier]-8, which was used for more impact-resistant. The most recent stuff, really that came about as a result after the accident, we looked at [was] BRI [Boeing Replacement Insulation]-18, which is a good, high-strength material.

So there's been an evolution of materials here, too. That's the lower surface. In the upper surface, we looked at the low temperature reusable surface installation tiles that just has the white coating versus the black coating with an [emittance agent] in it. We looked at the LI-[900] side material for the upper surface, and the FRSI, Flexible Reusable Surface Insulation, which is a material with a silicone adhesive on it. Then, we also looked at the Advanced Flexible Reusable Surface Insulation [AFRSI] that could even go to higher temperature, like up to about 1,200 degrees to 1,500 degrees. So there's been an improvement in materials as the program has matured, but the bulk of the Orbiter still contains LI-900 on that lower surface.

ROSS-NAZZAL: What challenges did densification present to you once they had discovered that the strength of the tiles wasn't hard enough? What challenges did that pose to you as you were testing?

TILLIAN: That was more primarily a structural thing, more structural testing to understand adherence problems. We did some tests on it to make sure there wasn't any difference in the thermal performance, but that's about all we did. It wasn't a big deal as far as thermal testing. We did a limited amount of testing. All of the tiles were densified, [and] everything we tested from then on was a densified, inner-mold line of the tile. We tested tiles in that fashion. The tile is densified and then [bonded] into a thin layer Strain Isolation Pad [SIP] and then to the aluminum structure. So we did some thermal testing, but the bulk of the testing was done with [the concerns] about structural issues, making sure it hung on there okay. Structural integrity.

ROSS-NAZZAL: You were studying the SIP as well?

TILLIAN: When we did test, we did tests as a complete system. We had the tile, and the tile had been densified, and then we had the Strain Isolation Pad, the SIP, and then we'd [had] the aluminum structure. We did the complete system.

ROSS-NAZZAL: Can you walk us through one of the tests that you did sometime in the ’70s? Or several, if you want to point out the different types. As you pointed out, there was an evolution of the tiles over the years. Can you walk us through how long a test took, how many people would be there? Give us some of those details in that building.

TILLIAN: Some of the life-testings took a long period of time. They might take several months to get through a life test. If it’s a design feature, usually those could be done in probably a week or less. Maybe two weeks at max, if there was some special design feature. We’d have to calibrate first and establish the test conditions with calibration models.

ROSS-NAZZAL: Can you tell us a little bit more about that?

TILLIAN: What we did is we’d have, in the channel nozzle, two cold plates, and in one plate we’d have [it instrumented] with heating rate sensors and pressure taps so we could understand the heating rate and pressure distributions. Then, we had to put in an instrumented tile. You’d have to remove one wall, put in an instrumented tile, and then run the test. That way we could understand the temperature response, pressure, and heating rate response. That’s what we did, [to] try and understand the conditions we were testing at, to simulate the flight conditions as best as we could on Earth.

ROSS-NAZZAL: How many people were typically involved in these different type of tests?

TILLIAN: That facility has been operating—in fact, it still is today—it's been essentially operating on a two-shift basis since the beginning of the Shuttle Program.

ROSS-NAZZAL: So 12-hour shifts?

TILLIAN: Eight-hour shifts. Right now, I believe there's [24] people. It's around 24 people. Twelve per shift. Usually, though, some of those people might be diverted to that other facility I was talking about, Building 260, where we do radiant heat tests. They're trained to operate in both facilities, both the arc jet, [Building] 222, and the radiant heat facility across the way there.

ROSS-NAZZAL: Are there any such people as test conductors and different technicians who work [there]?

TILLIAN: Right. During the test, there's mechanical technicians that work on putting the arc in, all of the mechanical work. Then we have a boiler operator that operates the boiler. We have electrical technicians to set up the instrumentation, the electrical systems in the facility, and also the computers. We have a contractor test conductor that operates our automatic data control system.

Then, we have, of course—it's been that way, it came from Langley—there's always a NASA test director. That facility is one of those that still has NASA people that are really involved with the test nowadays. They still have a NASA test director at all tests. It was that way when the people came from Langley, and we practiced it, and it's still in practice today.

ROSS-NAZZAL: Were you ever a test conductor during the Shuttle Program?

TILLIAN: Oh, yes. In the beginning, in our small facility, there were just three of us. That was in Building 262. There was myself, an electrical technician that ran the power supply and set up the electrical equipment, and one mechanical technician that set up the arc heater and all the mechanical systems. There was me. I was the test director, test conductor. That was it in the beginning. But then, when we moved into the large facility, of course we expanded to a larger number of people. Yes, I was a test director when we went over in the other facility, before I got into the management.

ROSS-NAZZAL: How long were you a test conductor in the newer building, in 222?

TILLIAN: Probably about eight to ten years, then I transferred. When the Shuttle Program got going pretty good, I became the TPS test program manager. I was responsible for all of the tests in all of the NASA facilities. Because we were not only doing tests at JSC, like I said, we were doing tests at Langley and at Ames, and there was tests going on—well, it didn't really have to do with thermal testing—but there were a lot of tests going on at Rockwell on the structural testing.

ROSS-NAZZAL: But you said JSC had the largest facility, is that correct?

TILLIAN: The largest complex is at Ames. Langley had a 20-megawatt facility, which has been subsequently deactivated. The ones that are in business today are JSC, our 10-megawatt facility, and the Ames complex out in California.

ROSS-NAZZAL: Would you share some of your recollections of being a test conductor with us on the Shuttle Program?

TILLIAN: It was exciting work. We were testing new materials. We didn't know what to expect. Some of the materials, when we were doing screening tests, some of them would just fall apart. When we got into the real Shuttle materials, after the screening activities, they were very durable as far as thermal protection. They hold on there pretty good.

The most spectacular test was when we did over-temp-check conditions, to see if the specimen would start to melt and glow and flow. We did that kind of testing on tiles. We also did the same thing on the carbon to see what temperature it could take. We also did the damage testing. Very limited damage testing in those days, but those were spectacular, too. The temperatures would get very hot, the materials would flow. We also did lost tile tests. Those were very spectacular. In one case we burned a hole right through the aluminum structure. That was a spectacular test.

ROSS-NAZZAL: This is all before STS-1?

TILLIAN: Yes.

ROSS-NAZZAL: Who did you share your results with? Did you share those with Max [Maxime A.] Faget or did they go all the way up to Chris [Christopher C.] Kraft?

TILLIAN: They would mostly be documented into branch reports, thermal design branch reports, or memorandum. We would provide those to Max Faget. At the time when I was a TPS test program manager, which was for about eight years there, until about '80, we had weekly noon meetings with the Orbiter program manager, [Aaron Cohen]. We would tell him everything we did. He wanted to know what we did, what we accomplished, not only in this facility, but all of the facilities in the country. We'd give a status of the schedule and what we accomplished and what the results were, in little summary briefings. That was called a noon briefing. The Orbiter program manager knew what we were doing. Of course, our division chief and Max Faget knew what we were doing.

ROSS-NAZZAL: The tiles were one of those sort of pacing items for the Orbiter. They were sort of the last thing to really work out all of the kinks. Did that create any problems for you in your facility? Were you having to work a lot of overtime to meet the demands of that first flight?

TILLIAN: No, it really didn't. It really wasn't a thermal issue as really a structural issue at that time. So we just kept going on. We didn't have any special issues that came about that we had to worry about.

ROSS-NAZZAL: On STS-1, they actually lost some tile. They reported that when they got up into orbit. Was your facility called upon to work some of those issues?

TILLIAN: No, because we had done some of that before STS-1. The management at the time, I believe, felt confident that they had a good handle on things, where these damages were on the STS-1. So there wasn't an issue at that time.

We did mostly post-test flight anomaly investigations. After the flight, you'd see some of these damages. Also, the inner tiles on STS-1, 2, 3, the gaps between the tiles, we noticed a lot of burning on top of the filler bar. There's a material down at the bottom, [where] we noticed burning there. We knew the excess heat was getting down there, so we had to develop gap fillers to put in there and cut down on that heating that was getting into the inner tile gaps, which could cause structural temperature gradient problems and over-temp conditions. So we did do that. We did mostly flight anomaly investigations after flights. We didn't do really real-time testing support until after the accident [*Columbia* accident, STS-107]. Of course, we've done quite a bit of that.

ROSS-NAZZAL: Would you tell us about that?

TILLIAN: As you know, after the accident, we went into a big damaged tile test program. Many different kinds of damages, so that they could validate their math models. They were very extensive, many, many models. Before the flight, we just did a few damaged test conditions, but these were many different type of test models and many different configurations. Some were [designed] specifically so they could develop their analytical models or verify their analytical models to use the data without these sophisticated math models they have these days.

We've done a lot of testing on that. Then we've done a lot of testing on repairs. The STA [Shuttle Tile Ablator]-54, the ablator repair in tiles, we've done a lot of testing on that material. Also, there was testing done on the overlay, which is a plate that covers the damaged area, if you have one. You have soft insulation that's held on by augurs that's attached to the top of the tile.

We've done a lot of that type of test. Then, as far as the LESS [Leading Edge Subsystem], those fellows have done a lot of testing on different methods to repair, including if it's damaged. If there's a hole all the way through, they've got these different types of plugs they've tested to cut flow from getting into there, if you have a hole right through the leading edge. That's been the primary emphasis since we've returned to flight.

We've done specific, real-time flight support. As you know, on STS-117, the blanket on the OMS [Orbital Maneuvering System] pod lifted up. There was a blanket that lifted up, a AFRSI blanket that exposed the underlying graphite epoxy on the structure. It was right next to the LI-[900] side tile interface. So we did a test during the flight, and they were looking at a repair option where they use the staples to staple with and the [pins]. We tested that configuration during the flight. We did that type of testing. Danny [John D.] Olivas, the astronaut, went out there and did a magnificent job of repairing the vehicle. Anyway, we tested the configuration that they were going to use, real-time.

Then, on STS-118, there was a damage on a tile. A small damage that went all the way down to the SIP, the filler bar configuration. We did some tests on that particular damage. Now they have that sophisticated imagery where they can determine the damaged areas and all of this stuff from on orbit. Then, we can simulate that and get the right geometry. We did that particular test, too, to show it wasn't an issue. Those were two direct [flight support]—STS-117 and 118—where we tested two flight anomalies real time.

Then, the other thing we did, on STS-123, they were looking at the STA-54. That's when the astronauts were trying to determine, they had this new type of gun, T-RAD [Tile Repair Ablator Dispenser], and they wanted to see how it would work and how it would apply these things. So they had tile samples out in the cargo bay, and they applied it on orbit. After they brought it back, we tested some of those specimens and made sure that they would perform thermally, and of course they do, because we had done earlier tests. But we verified that. We plan to do some more, of course.

ROSS-NAZZAL: Have you done any testing for this mission, [STS-125]? I know that they were initially concerned that there might have been some damage.

TILLIAN: No, we were prepared. They've had our facility in a ready mode the last several nights, in case there was a problem with that leading edge. So far, there hasn't been shown to be any issues that require testing from the imagery work that they've done, but they had the facility prepared.

ROSS-NAZZAL: When you provide this real time support, do hours change at the facility? Or are there any differences that you can note?

TILLIAN: We use the same test group, but people will just work long hours. There'll be extended hours until you get the job done.

ROSS-NAZZAL: Tell us a little bit about the post-flight anomalies. You mentioned that that's primarily what you did prior to the *Columbia* accident. Can you tell us about some of the missions that maybe stood out to you?

TILLIAN: Well, it's really the early ones: the development flight missions, STS-1 through 4. It's really those particular flights, the early development flights. Subsequent to that, then there were material changes that were going on, upgraded material changes. We looked at those type of things.

ROSS-NAZZAL: Can you tell us about some of those upgrades, in terms of the nose-cap or the different tiles, and what changes were made when?

TILLIAN: The nose-cap has really not changed much. There has not been very many changes to that material. Really, the change has been in the tile. When we went to stronger, more durable materials, like the AETB-8 and the BRI-18. BRI-18 was really developed after the *Columbia* accident. So we've done a lot of testing on that material, and that's being put around doors and hatch areas, penetrations, and areas that you need more durable material. Yes, we've done a lot of testing on the BRI-18. That's one thing I forgot to mention during this return to flight activity.

ROSS-NAZZAL: When you do testing on the RCC or the nose-cap or the FRSI—is that correct? Is that what you called it?

TILLIAN: Yes.

ROSS-NAZZAL: Is it different from testing the tiles in that facility, and if so, could you explain it?

TILLIAN: Well, the nose-cap and the leading edges are usually tested on a conical nozzle. It's mounted on the end of a sting, and you usually do that on a stagnation, with flow coming head-on into the material, because it's a leading edge. In the case of the FRSI, which requires low temperature, so those are usually tested in a channel nozzle [under] lower temperature conditions. Or on a wedge, it's inclined, so you don't get the high heating. We can test that on the wedge, too. But it's a big wedge, and it might be something that would accommodate a foot by foot or two foot by two foot sample. But it's a lot lower heating. It depends on the angle of attack that you have it in the flow.

So we did a lot of testing on that material, too, both the FRSI and AFRSI. There were some problems with the AFRSI after it was applied. I think it occurred on *Challenger*, probably STS-6. The original material, it was not coated, and we found that the fabric was ripping and exposing things. A coating was developed to apply on and stiffen the outer surface, and we did a lot of testing on that material. That was the result of a flight anomaly. We did things like that to improve the AFRSI that's on the upper surface on the vehicle.

Now, the low temperature reusable surface installation is used in a lot lower temperature areas, and we never incurred any problems there. Except in some cases where it was in a zone where the temperature was higher than it should be, and it got a little brown, the coating. So then they would just apply some of the higher-temperature material there. But the Advanced Flexible Reusable Insulation required the development of a coating to apply on top of it.

ROSS-NAZZAL: What type of coating is it?

TILLIAN: It's a ceramic fill. It's just filling in the voids in the fabric. It's a silica slip type material. Anyway we did that, and then, of course, there's been other, better coatings developed for the tile, too. Now, there's these TUFI [Toughened UniPiece Fibrous Insulation] coatings that are used in areas that require stronger material that's less impact-sensitive. There's some of that stuff that's been flown.

Those are the major things we looked at. It was the gap fillers, required in the high-pressure gradient areas, in the areas that we had burned filler bars, and the AFRSI that required a coating development. Then the AETB-8 was put on the back end of the vehicle where the rockets, when it would lift off, they would tear up the tile coating, so that material was developed for that particular area of application. The AETB-8, it's more durable. We did a lot of testing on [that]. Not only arc jet, but also radiant testing, which is not the subject of this particular activity right now. But we did both, arc jet and radiant. The arc jet, you get the flow conditions. With radiant, it's static. You just get the heat from a heater system. The arc jet is an active flow.

ROSS-NAZZAL: Could you tell us about the arc jet test facility in general? I understand, for instance, there's a control room, a data center, a laser room, a blockhouse. Can you give us some information about those facilities?

TILLIAN: First of all, if you go out in the arc jet area, the arc jet is coupled to a test chamber, okay? The test chamber then is coupled to a set of piping that goes to the ejectors. The ejectors are driven by this boiler that provides the steam, that provides the vacuum conditions. Now, the arc jet is ignited by the power supply, this ten mega-watt power-supply. It can operate at 5,000 volts, 2,000 amps. The power is provided to the arc heater. Then we have a gas yard, and we have these tanks out in the gas yard. Nitrogen-oxygen. We put nitrogen-oxygen that simulates air into the arc heater, and it's heated. It goes through the arc, and then expands through these nozzles to get the conditions that we want.

So really what you have there is you have a power supply area, you have the outside that has the ejectors that provide the vacuum, and the boiler that provides the steam for the ejectors. Then you have the trailers that provide the gas that are outside. They come into that building there, those arc heaters out there, those two test chambers. Then you have the control room, [where] you actually control the power and the gas that's going into this, and changing and making conditions to the power, the gas, the flow rates, and the power that's going in [the arc]. Then, they have very sophisticated cameras now that you can look at all these articles now and see what's going on, particularly when they're in the conical nozzle testing mode.

Then, you have the people there in that control room. They have to be isolated, because you got some dangerous things out there. You have a high-voltage, that arc. You have this vacuum that's pumping down this chamber. Then you have this gas system that's coming in at very high pressure through a set of controls. So you have high-pressure gas, you have vacuum, and you have electricity. That's why it's isolated. That's why people are not allowed out there. They're in the control room.

ROSS-NAZZAL: You mentioned that they have these sophisticated cameras. Do you recall when they started using cameras? Was that a switch?

TILLIAN: Some of the early cameras were not as sophisticated. They got those in the ’90s.

ROSS-NAZZAL: So you were always able to use cameras when you working on the Shuttle Program?

TILLIAN: Right. We have a little blockhouse between the two test chambers. If people wanted to get out there, there was a blockhouse, and you could view the test article through the windows. The chambers. But most of the time, there’s cameras that you can mount on the chamber and look down in there and see what’s going on. Video cameras. That’s been around for quite some time, but they’ve just gotten better with time.

ROSS-NAZZAL: Were there any major challenges that you encountered out in the facility?

TILLIAN: No, not really. It’s just that the facilities, as time goes on, they age. Then you always have to worry about the power supply. You have to limit the power supply capability. But now it’s been upgraded, so there’s no problem anymore. There’s not been any real major issues. The problem is that’s a facility requires maintenance. There’s a considerable amount of maintenance to keep the facility going.

ROSS-NAZZAL: Are you still using the same consoles and equipment that you were using in the ’60s, or have you upgraded to newer systems?

TILLIAN: In the '90s, when we had that CFF project in the '90s, we upgraded the consoles. When we went to the automatic control system. So that was all updated in the second CFF project in the '90s. There hasn't been anything really major since then, except there's been some upgrades to the power supply. We're using the same boiler that we last bought in the '90s. The basic equipment has not really changed since the '90s—'90, '91 was the last upgrade. Of course, I think it's going to require some changes for the future. Because it's been, what, 18 years now, and it's just going to need some upgrades. Particularly to support the new CEV [Crew Exploration Vehicle] Program. In fact, they've been testing some of the new CEV TPS materials. They've already started that.

ROSS-NAZZAL: When do you anticipate you'll start winding down with Shuttle? Do you think you'll still be working that last flight?

TILLIAN: I think you're going to have to require this particular arc jet until the very last flight, because you never know, [you might need] real-time support. You're going to have to have it around to do that. Now, as far as all the major work that we've resolved to this damaged tile testing that we've been doing, for the last four or five years, and all of these material repairs, I think all those will probably be completed this year. Most of the orbital Shuttle work is winding down. Now, it's ready if there's any flight anomalies. We could support flight anomalies real-time, or post, the after post-flight inspection. But most of the work that was required as a result of the accident I think will be finished up by the end of this year. All of the testing and all of the repairs for the RCC should be completed, and all of the testing for the tiles. So we are sort of winding down. Then there can always be some flight anomaly, and something after flight you expect might require some material change or something. But there's not very many flights left to go, as you know, and not much time. So the facility is intended to really continue to support the CEV Program [and] the materials for the CEV.

ROSS-NAZZAL: I think you've sort of touched on this, but it's a different way to approach the question. As the Shuttle has matured, we've gone from the operational flights to really more sophisticated flights. Have operations changed or has testing changed in any way in your facility?

TILLIAN: Not really. It's pretty well standardized, now, with our test configurations. We've gotten better imagery capability, diagnostic capability in the facility. Basic testing itself has not changed that much.

ROSS-NAZZAL: Is there any unique equipment in the facility that we haven't talked about that we should put on the record?

TILLIAN: Well, the unique equipment is that—and it's the only one in the agency—is those channel nozzle test fixtures there in test position number one. Those were developed specifically and tailored for the Shuttle, to get the Shuttle-type conditions. So those channel nozzles, they can accommodate a twelve [inches] by twelve [inches] model or a two-foot by two-foot model. Now, that was built specifically for Shuttle-type testing, for the test conditions by the Shuttle, not stagnation testing. So that is unique, that particular channel nozzle test fixtures. The ones at Ames are usually inclined planes. Nobody else has a channel nozzle test fixture that I know of, in the country, in fact. The arc heaters are optimized, but they're very similar to the arc heaters that Ames has. I think that's the major differences.

ROSS-NAZZAL: Who built these channel nozzles? Was that something built in-house? Or was that something you contracted out?

TILLIAN: I believe those were built per drawing. They were probably done by a contractor outside, but the work was probably originally turned over to Tech Services Division [of JSC]. They probably contracted that. They're stainless steel, so they probably had them built outside, I'm not sure.

ROSS-NAZZAL: I don't think that this question applies to you, but I'm just going to ask because it's on our core list of questions. Originally, the Space Shuttle was flying DoD [Department of Defense] flights. Did that have any impact on your facility at all?

TILLIAN: No.

ROSS-NAZZAL: I didn't think so.

TILLIAN: There's no difference.

ROSS-NAZZAL: I think you mentioned some of the main contractors who worked in your facility over the years, but can you list them for us?

TILLIAN: Originally, when the facility was first built, there was Brown & Root- Northrop. Then the second contractor team was Northrop only. Then the third was Lockheed. The fourth is the current one, ESCG [Engineering and Science Contract Group] Jacobs. So that's it.

ROSS-NAZZAL: Not too many. That's pretty easy. That's very good.

TILLIAN: That's not too many. Right.

ROSS-NAZZAL: That's very good. That's great. Is there anybody else you think we should talk to about this building? You seem like the expert on the building, but are there other people who you think we should talk to about the Shuttle and [Building] 222?

TILLIAN: There's only one other person that's been around since that period of time when I first started, and he works for ESCG. James [D.] Milhoan. He's pretty knowledgeable about that facility. He's been there continuously. I've moved on; I was down there, and I worked as test conductor and test director function, and then I became TPS test program manager, then I became the section head. Of course, I stayed down there during that period of time. Then, I took over the branch, but Jim has been down there continuously. He came to work in about 1967, when the facility was being built. I was here in '63 when we were still working that small facility. The very small team.

ROSS-NAZZAL: Great. Now, it looks like you've brought us some materials. I know that was one of the questions that we had.

TILLIAN: Let me show you what I've got here. First of all, I know this is not really facility, but this shows that we were really testing—this memorandum in 1969—this RPP [Reinforced Pyrolyzed Plastic] material, which is a forerunner of the RCC leading edge material.

ROSS-NAZZAL: Oh, great.

TILLIAN: The LESS. So this way we would report things, memorandum and test branch reports. This shows—and of course I wrote it—this shows the testing we did on an early version that eventually was used. This was '69. It's 40 years ago.

ROSS-NAZZAL: Isn't that amazing?

TILLIAN: Then, in '83, we had done a lot of testing already up to the first flight, the first development flights. We put out a paper jointly with folks at Rockwell [called "Orbiter TPS Development and Certification Testing at the NASA 10 MW Atmospheric Reentry Materials and Structures Evaluation Facility"]. Rockwell support [included W.C.] Rochelle and [H.H. Battley]. John [E.] Grimaud was the section head at the time, and myself, Bud [Linus P.] Murray, [Walter J.] Lueke, and Ted [T.M.] Heaton was Northrop. You can see there, there's the Northrop contract. He was head of the facilities at the Northrop contract down there at the time. That's 1983.

This shows you an abstract, and it's pretty detailed, and all of the different type of things we tested in that channel nozzle I was talking about. The conical nozzle. That's over in that other test position now, but we could switch them back to either chamber. It shows you a little layout of the facility and what the tile looks like. It talks about all of the systems in there. The test chambers, the cooling system, the gas system, power system, the arc heaters. Then test techniques, the way we tested things. These are sort of like stagnation flow testing. I got some better pictures of the shell. These didn't turn out too good. About these very test techniques.

ROSS-NAZZAL: Oh, some of these photos would be great. Yes, if you have some.

TILLIAN: This paper here is pretty good.

ROSS-NAZZAL: Yes, it looks like it's really detailed.

TILLIAN: It describes the facility as it existed then. This has been an update that has recently been done that describes what the facility looks like today. I can send you this thing electronically. This is really in color, I can send you this electronically. But this shows what the facility looks like. Here's the layout, this is in color. This view.

ROSS-NAZZAL: These are perfect materials.

TILLIAN: This shows the arc heater where you strike an arc. You can see the arc is being struck between the cathode and anode, and then you're injecting the gas, hitting it, going out through a nozzle, and your specimen is out here and you're testing it. Then this shows all of the systems that I was talking about, that you have to worry about. There's the control system inside the control room. Here's that power supply. This is another building outside, the test gas system, the chamber. These ejectors are outside. Those tall ejectors outside there.

When you go down there, you can see these. If you're going down in the day, that's what you would see. In this one chamber here, we have those channel nozzles that I was talking about. We just keep them on there permanently now. The channel nozzles here and the conical nozzles. We can change out the conical nozzles, by the way, all the way up from five inches up to forty inches in diameter.

This shows the test techniques. This is a channel that's just cut away. The conical nozzle. This shows a specimen in there.

This is a history. I wrote this history.

ROSS-NAZZAL: Oh, great.

TILLIAN: This shows when it started, like I was saying. When we started all of this stuff in 1967, was when this started being used. It was used for Apollo initially. But then Orbiter, like I said, we started testing in '69. Then we had that upgrade in '72 that I told you about. The first upgrade specifically for the Orbiter applications. Then we had another one in '90, '91. I was the section head down there at the time. This shows what we did. I just told you about, we changed out the chambers, and we got a new boiler. Not only the Shuttle, but we tested other programs, too, during that period of time. This sort of is an idea of what we've done.

ROSS-NAZZAL: Yes, these are great sources for the purposes of this nomination.

TILLIAN: This is what a report looks like today. This report I worked on with some of our NASA folks over there. This is a typical report. This is the one that they did the STS-123 DTO [Detailed Test Objective]. Okay? This is that repair material. This is what the astronauts applied in space.

ROSS-NAZZAL: That looks like that spray-on insulation.

TILLIAN: Right. Yes, right. It looks more like a red RTV [Room-Temperature Vulcanizing] material. Very close cousin to it, by the way. Anyway, this shows what the samples look like and what they looked like after they dispensed. Here's the arc heater we tested them in, that we did the test in. The simulation we did. This is the specimens. Before and after testing. You can see that they do the job.

ROSS-NAZZAL: Whoa. That looks like charcoal.

TILLIAN: Right, it does. That's the way it works. It takes the heat, converts it to char, soaks up the energy.

ROSS-NAZZAL: So is it almost like an ablative material?

TILLIAN: Yes, that's what it is. It's an ablative material. That's what it is. This we simulated. This is an example of a current-type report. But this just describes a test program. This one here will describe the facility. This one here, as it was in '83, and this is what we used to do when we first got into [testing].

ROSS-NAZZAL: Fantastic. Can we take these and scan them?

TILLIAN: Yes, you can have those.

ROSS-NAZZAL: Are you sure you don't want them back?

TILLIAN: No, I don't want them. I've got copies. I can send you a color version of this one. You want me to do that?

ROSS-NAZZAL: Sure.

TILLIAN: Because these are nicely colored.

ROSS-NAZZAL: I'll give you a card before I leave.

TILLIAN: This one here is in color, but I don't have a better one of this, unfortunately.

ROSS-NAZZAL: That's okay. Maybe we can see if we can find some of those photos.

TILLIAN: You can probably find that. You might be able to find this. I'll see if there's any other original copies. I don't know if there are anymore. It's hard to find stuff anymore.

ROSS-NAZZAL: Oh, sure. Well, that was from '83, so, more than 25 years ago.

TILLIAN: Then this one here, that's just a memorandum.

ROSS-NAZZAL: Oh, but these are great.

TILLIAN: That's the way we used to do it.

ROSS-NAZZAL: These are perfect. What we're trying to do is give people a sense of what happened in these facilities.

TILLIAN: You can see you used to report data by hand. I put a date on it.

ROSS-NAZZAL: This is how, after each test, what you would fill in here?

TILLIAN: Right, right. This here is just the model measurements, okay. The weight and the length. Any recession. Any weight losses. This here is weight, recession, and let's see, I have another thing here. Oh, yes. These are the test conditions: the heat flux, the pressure, the enthalpy, the surface temperature, test time. Then various calculations that I did. You can see, this is the old way of doing business. You don't do business this way anymore, but that's what I did on Apollo. Now it's all computer.

ROSS-NAZZAL: Oh, I'm sure.

TILLIAN: You can see it's very fancy stuff now.

ROSS-NAZZAL: Oh, yes, you're right. Lots of color and nice photos.

TILLIAN: That's old. That's forty years. That's the anniversary of Apollo 11.

ROSS-NAZZAL: Oh, yes, that's coming up. Is there anything else that we haven't touched on that you think we should know in terms of the building and the Space Shuttle Program? Or anything else that we should talk about?

TILLIAN: Oh, the other thing I should talk about, this facility, in supporting the Shuttle, it has probably done in excess of over 10,000 tests. That's a large number. This program has been going on for many years. We started in '69, that's forty years. So 10,000, not a large number with that many years. But it is large, because we were doing not only one of a kind type tests on these various penetrations, singularities, and special design features, we were doing life testing. That, like I said, took many, many tests. Every time you change the material, you got to do many hours of testing. It's in excess of over 10,000 tests.

In contrast, of course, that amount of testing was done on Apollo, but down here, at the time, since we were just looking at any gaps that the Apollo contractor had—North American at the time, or AVCO—we did maybe less than maybe 1,000 or less, maybe 2,000 at max. We didn't do any more than that, because it was just the independent assessment. This here, these tests were directly supporting either Lockheed, the material development. They were supporting Rockwell, who had the prime contract. They were directed to use NASA equipment facilities, or LTV, who was building the leading edge. So those were the three people we supported, primarily. Lockheed Missile and Space Company for the tiles in the development phases. Rockwell for the design issues. Of course, they were worried about life issues and also the material usability. Then LTV up in Dallas, who picked up the leading edge. That required a lot of life testing. Many, many hours.

ROSS-NAZZAL: Can you tell us a little bit more about that?

TILLIAN: Well, the thing with the leading edge, it's a carbon graphite substrate. The outer layer has been converted to a silicon carbide-type coating diffusion process that provides it the high-temperature capability. It provides the oxidation protection, because carbon will burn. Then they also infiltrated with different silica-type solutions to cut down on the substrate internal oxidation. So that material there is sensitive to oxidation. Where the tile, it's inert, it's pure silica, it's just sand, it's just low-density sand. So it don't convert. It won't burn, in other words. It won't oxidize. It will melt, of course, when you get high enough temperatures, like any material, but it don't burn or oxidize like the carbon [will].

The carbon is very sensitive. It's a very thin laminate. It's only three-eighths inches thick, and these tiles range anywhere from maybe an inch, three-quarters of an inch, up to two-and-a-half inches or better. It's an insulator. The LESS material that you have is a hot structure. It radiates heat, and then it requires all kinds of insulation systems internally to cut down on the heat before it gets to the Orbiter. Where the tile is a great insulator.

ROSS-NAZZAL: Has there been any change to the RCC at all over the Shuttle Program?

TILLIAN: They've been just trying to enhance the oxidation capability by these fillers, internal fillers. They call them enhancements. They call them AA-enhancements. So all of those things had to be tested, just to make sure that they work and that they did cut down on the oxidation so you could get the mission life.

ROSS-NAZZAL: Has that testing really been since the *Columbia* accident?

TILLIAN: No, no. That was done before. That was done up through about the early '90s. From the first flight on, we were really doing the heavy life testing. So a limited amount of life testing had been done before the first fight, and then we really got into a heavy amount of life testing after the first flight. During that period of time. Because the intent was to fly the Shuttle a hundred times.

ROSS-NAZZAL: Right, yes. Hasn't worked out that way.

TILLIAN: No, it hasn't. I guess the most they've got on them was 30-something, 35 or so.

ROSS-NAZZAL: Yes. What do you think is the greatest contribution of Building 222 to the Space Shuttle Program?

TILLIAN: I think that the greatest contribution is that it's been a place where you get a consistent set of data that you know your test conditions, you can support real-time flight anomalies. You're calibrated. You can then support any new material development, because we have a baseline. See, this is where the initial certification started. You got the database established here. Then you can compare everything from that initial database to when you make improvements. I think that's a good thing to have, because that way you're starting with the same facility, same test conditions, because when you go in a different facility, you never get exactly the same test conditions. Each one of them has unique characteristics. They're not all the same. So that way, you have a consistent set of data that you've used to certify this vehicle.

ROSS-NAZZAL: Rebecca, do you have any questions for Mr. Tillian?

WRIGHT: I have a couple. One, when you were describing the layout of the building and how the building is connected and coupled, would you consider it a risky place to work?

TILLIAN: No, because all that stuff is isolated from the control room. We don't have any of that stuff coming into the control room. We just have the controls in there. All of that stuff is isolated. That's why we have those thick window panes in the control room that's looking out there. We have all of these TV systems that are looking at systems. Then, these things are all locked out. Nobody goes into that when that arc's on, okay. We don't want anybody out there.

WRIGHT: So are there very stringent, specific procedures, safeties, everything?

TILLIAN: Yes, there is. You have to be very safety conscious in that facility. You have to keep them doors locked.

WRIGHT: Then, when we first sat down, you mentioned that you did some work at White Sands. Was it anywhere related to some of the work that you did here at JSC?

TILLIAN: No, [I] was a co-op. I was in a Climatic Laboratory where we just conditioned material in ovens. We were running hot and cold. In those old days, they'd have us co-ops out there by the rocket engine. They were going to test breaking up dry ice, packing it around rocket engines to cool them down in the cold desert air for firing the next morning. It was really climatic. You would use dry ice or other cold chambers to cool things down. But that was as a co-op at White Sands.

WRIGHT: That's very unique.

ROSS-NAZZAL: That is. I've never heard that story before.

TILLIAN: That's what you did in the old days. You didn't have these sophisticated vacuum cold chambers like Reagan [S.] Redman has over here in Building 7.

WRIGHT: You've seen from one level to the other. That's pretty interesting.

ROSS-NAZZAL: That is interesting. I just had one other thought for you. What do you think that the Space Shuttle would have been without Building 222?

TILLIAN: Well 222 was used to, really, in the beginning, to screen all of these materials. It covered the entire development and certification phase. I don't think you would feel as secure. I think because we have a consistent database from the beginning. I think we've done a pretty good job of simulating on the Earth, as well as we can, the entry-heating conditions that you experience. We're not exact, you can't simulate everything in the arc jet facility, but we can simulate the thermal conditions. So I think that's been its major contribution.

The electric arc [heater is] still [in use], after all of these years, all those technologies began at Langley in the late '50s, early '60s. Really the early '60s. After some 50 years, it's still the most effective means of getting a high-temperature air source to simulate entry-heating condition. Now, there's nothing else out there yet. So after all of these years, this is it right now. It's still the same. The work was really done by the Langley pioneers people that came down here from Langley. In fact, people that came down here from Langley worked in arc jet facilities up there. The original people, the original division chief, and all of these people that came down. Joe [Joseph N.] Kotanchik and Dave [David H.] Greenshields, my first section head, and John Grimaud, my second one. They all worked at those facilities up at Langley. They did the pioneering work up there to begin development of these things. They were atmospheric driven, and things like that, but they did the original arc heater work. Then, some of the contractors, of course, got heavily involved.

At one time in 1963, I ran a survey when I worked at LTV. There were over 45 arc heater facilities in the country at the time. That's because we were in the Cold War, in the space program, and these arc jets were not only used for supporting the manned space programs, they were used for DoD application, missiles. In fact, they did some of that work out at Douglas Aircraft. At that time there was 45. Today, there's, like I said, Ames, JSC, and McDonnell Douglas. There's a small facility up at McDonnell Douglas. There's three today. At one time, there was 45.

ROSS-NAZZAL: Is that because of the cost to run the facility?

TILLIAN: Well that's one thing. The large facilities ended up at NASA. They were small facilities. There were 45. A lot of them were small [facilities]. Right, it's the cost, and now, since the Cold War is over with, there's not that much effort going into development of new materials for ballistic missile applications. There was a lot of testing done during the Apollo era. Overall, there was probably over 10,000 tests in that short period of time. But multiple facilities were doing it, besides us and AVCO. The difference is that you had a greater demand. Now the demand is down, and of course, they're not exactly cheap to operate, either. These large ones aren't. The small ones are a lot cheaper, but there were a lot of them over at universities. Every aerospace firm, every aircraft company had one of these things. I knew that. There were a lot more aircraft companies, by the way, then. Now, you really have only two. Boeing and

Lockheed-Martin. Well, Northrop. There's really three, and before there was Chance Vought and Republic Aviation and Grumman and all of these other people that no longer exist.

A lot of universities were into this type of thing in the early days. Some of the DoD people who were involved—that's right, I forgot. There is one complex still left at Tullahoma [Arnold Engineering Development Center, Tennessee]. There's really four then. There's really Tullahoma. They support really the military applications these days, where Ames and JSC primarily support the manned spacecraft activities these days. Although, we did in the past, at some point in time, we did support some of the work that was done on various military applications, and we also supported the Atomic Energy Commission in the early days, prior to when we got into the Shuttle.

The work we did there, we were testing these nuclear systems. They were [encapsulated in] graphite. The concern was if there was a failure, and these capsules came back, these graphite canisters that contain these nuclear systems, if they burned up, what would happen? You didn't want them to hit a populated area. We did a lot of testing. There was a lot of testing required to do that. We did a lot of that work in the early '60s. It went into the '70s. In fact, I think we even did a test like that in the ten megawatt [facility] on a military application, SNAP one for the Poseidon submarines that are used for beacon purposes.

We did quite a lot of work along that line. Of course, Ames did some of that work, too. We supported the Atomic Energy Commission. Of course, we haven't done that recently, because there hasn't been any new developments. But you can see the arc jet has been used for various things. Not only just manned space program, but it's also had a strong use for military applications and for nuclear systems that are contained that might [fail when] taken into space.

We want to make sure that when they come back, they don't contaminate the atmosphere and people.

There was a lot of that type of testing that was done. Our arc jet down here, we did that testing in both the small facility and the ten megawatt. We supported various agencies. Of course, there's been various programs. There's a lot of programs, like the X-33, and X-38, and all of these other programs that never flew. The arc jet was used for the screening and development of those materials that were going to be used for those programs.

ROSS-NAZZAL: I did not know that.

TILLIAN: Yes, the ACRV [Assured Crew Return Vehicle], and all of these. There's a number of them. It's listed in one of these. I think I've got it listed.

ROSS-NAZZAL: Oh, in your history?

TILLIAN: Let's see if I got it in the history. I think I have it in the history here. Other proposals supported during this time: the Aeroassist Flight Experiment, the NASP [National AeroSpace Plane]—which maybe didn't fly—X-33, the crew return vehicle, X-38. So it was not only Shuttle in the '90s. There were also these other programs. They were looking at alternative methods. Of course, those never made it.

ROSS-NAZZAL: That's good to know.

TILLIAN: That's in that history, that section I've got back there. So you can see we not only supported the Shuttle. Really, this facility was used for all manned programs, and even unmanned, in some cases. Like I said, the nuclear work.

ROSS-NAZZAL: I think that gives a broader sense of what the facility was used for, not just Space Shuttle.

TILLIAN: Right, right.

ROSS-NAZZAL: That's great. Is there anything else that you think we should know that we might not have touched on? I think we've hit on all of the questions that we've come up with. The only other thought that I had is if you wanted to talk a little bit about Ames and Langley and how you worked in conjunction with them on Shuttle.

TILLIAN: All right. When we got into the Shuttle Program, because it was going to fly 100 missions, because it was such a large vehicle, there was very many design issues. We [worked] together as a team with Langley, Ames, also [NASA] Headquarters [Washington, DC], and ourselves. We developed a test program with the contractor, with Rockwell. There was so much work that it couldn't have all been done at one facility. It was impossible. So the work was split between the three facilities: Langley, JSC, and Ames. That was the case from about the early '70s, 1970 through up to about the first flight, '80 [or] so.

Subsequent after that, Langley deactivated their facility, because there was no longer a requirement because we had done all of the major design work, and they didn't have other programs to support. So that facility was deactivated, their 20 megawatt facility. But Ames also supports unmanned space programs, planetary missions and that type of thing, to Mars, unmanned. So they've been in an active role. They've also played an active role in developing new materials. They've had the capability maintained out there. Of course, they've been also participating on this new CEV Program along with JSC. So right now, in the new CEV Program, the testing has been done at Ames and JSC. This is just the start of it, okay.

ROSS-NAZZAL: When you were breaking up those projects, were you primarily each assigned a certain task, or were you all assigned the same task?

TILLIAN: No, we were assigned specific tests. Each one had different tests. I was a test program manager there. Then we all got together. We worked very effectively as a team. There was plenty of work, so there was no arguments. Everybody had plenty of work. When there's not much work, that's when people argue. Funding was adequate. The other thing that probably causes problems is funding. Everybody was funded at the time, so there was no problem. Everybody was willing to pitch in and support the program. Particularly since the management says that we were going to do this in government facilities, rather than contractor. We [didn't] want to build another multitude of facilities.

The team worked very effectively, and like I said, there was so much [that a] specific facility could accomplish [with] their capability. Those tests were devoted at that particular facility. In some cases there was some crossover, but each one got a certain number of tests. It worked very effectively. It was a very large program. Very large.

ROSS-NAZZAL: Do you recall what the funding was like in the early days?

TILLIAN: Gosh, I don't really remember the funding. I wouldn't even venture to guess, with so many facilities involved.

ROSS-NAZZAL: Sure. The different tests. You mentioned that each area had its own sort of specialization. What about JSC?

TILLIAN: Well JSC, it developed these conical nozzles, so they could get the flow conditions, and we could also get the lower temperature conditions required for the upper surfaces. These other facilities had these inclined planes at Langley. They could get some of the higher temperature conditions. Ames had high-powered facilities. So they could accommodate that type of testing, too. Each one had a capability that accommodates roughly the same size models. Although, I guess the largest models we tested in the arc jets were about two-foot by two-foot, which we have down here.

ROSS-NAZZAL: Well, I think we've sort of exhausted everything.

TILLIAN: Do you want me to send this item electronically, because this isn't in color? I'll see if I got anything else.

ROSS-NAZZAL: Sure. That would be fantastic. We appreciate you going through all of your materials and bringing them for us. Well, thank you so much.

TILLIAN: Right. Well, there's a lot more reports. There's hundreds of these things. Of course, a lot of old memorandum, but you don't want all of this old paper.

ROSS-NAZZAL: Well, we'll share them with the contractors, and we'll keep copies for ourselves, too. Thank you so much.

(Break in audio) [Tillian describes Building 262].

TILLIAN: [They said], "Well, we don't need that small facility anymore." People said, "Well, we could use this for other things." So they de-activated it. Took all of the equipment out: the arc heaters, the chambers, and the little small steam generators outside. That was all taken out, and today it is used by security. [Building] 262. But that was really the first operating facility on this site that was really running hot and heavy in '63.

WRIGHT: Why? Why was that the first one? Is it just happened to be the one that they prefer?

TILLIAN: Well, because of the temporary building. It was small, and the people from Langley really came down there, and I think they put it together mostly themselves, with some help from Tech Services. So that's how it all started, as a very small laboratory. That's essentially where it started. Today, though, now, all you got it just the shell of the building. That's where security has their stuff. I think they practice their shooting guns. But anyway, the only problem is it would have been nice to preserve, but the only problem is it's just the shell now.

WRIGHT: They moved it all.

TILLIAN: That was really the first operating facility. I've said some things to some people around here, and they said, "Well, it just don't have anything in it anymore."

ROSS-NAZZAL: It's lost its integrity.

TILLIAN: Right, it's lost its integrity.

WRIGHT: I know some of the facilities were housed off of the center site while the Center was being built, but this was right here?

TILLIAN: Yes, right here. The first one that was really operating as a laboratory. People were really worried about the heat shield on Apollo, so they wanted to get something going fast. A small facility. So they did it. When I came down and interviewed in November of '63, they were already running tests. They said, "Yes." Then I came down from LTV. Of course, when I came down three or four months later, I was running tests, and I was out there. The other guys, the Langley guys that would have been operating it, they were worried about developing this new facility, the ten megawatt, Building 222. They all went over there. I just ran tests over there [Building 262] with a couple of technicians. They were over there working, building this new facility, 222. Working with the [contractor], the Corps of Engineers. You know, the Corps of Engineers put in all of these buildings. They did a great job, I think. Because those things really did good with all these storms we've had. I mean, they did a good job here, right? In fact, I told them one day when I've seen some of them down here.

WRIGHT: That's pretty neat.

ROSS-NAZZAL: Yes, it is. We'll let you go then.

[End of interview]