ORAL HISTORY PROGRAM

Ruth Engel: A Woman Surmounting the Challenges of Refractories

2023

PREFACE

The following oral history is the result of recorded interviews with Ruth Engel conducted by Alexis Neumann on May 18th, 2022. This interview is part of the AIME Oral History Program.

ABSTRACT

Immigrating from Santiago, Chile, to the State of Michigan, Ruth Engel became interested in geology and pursued a career in the refractory industry. Venturing into the mill as a woman in men's clothes, Engel started her first steelmaking job at ARMCO. Being tried and tested in the mill, Engel overcame numerous challenges presented to her and learned the technical side of the industry. Engel took the knowledge she accumulated across industries and started her own consulting company. Evolving from steel refractories to aluminum and failure analysis, Engel grew her company by networking with industry professionals and professional societies AIST and AIME. Amidst consulting and society seminars, Engel encourages the future generation to learn about the refractory industry by going out into the field and getting their hands dirty.

Readers are asked to bear in mind that they are reading a transcript of the spoken word rather than written prose. The following transcript has been reviewed, edited, and approved by the narrator.

TABLE OF CONTENTS

PART 1

00:15 Introduction

Neumann:

This is Alexis Neumann from HarbisonWalker International, and I'm a member of AIST. I'm here at AISTech in Pittsburgh on May 18th with Ruth Engel of Refractory Consulting Services. This recording is part of AIME's Oral History Capture Program. So, let's start at the beginning. Tell me about where you grew up.

00:31 Goodbye Santiago – Leaving Chile for the United States

Engel:

Well, I grew up in Santiago, Chile, and went through most of my high school there. And in 1970, I came to the US as an exchange student first, [then] went back to Chile. It was only a six-month program, which was on purpose, so I would not lose my year so I could graduate with my class. I went back, and a few months later, actually three months later, [Salvador] Allende was elected. And the night of his election, we decided that — actually, my whole family left. I came to the States; they went to other places. One of the reasons was that one of his platform statements was that he was not going to allow any more brain drain and that if you got a university degree, you were not going to have a passport to leave. And really, none of us really wanted — not myself nor my friends wanted to find out if it was going to be true or not. Because if you find — if you wait long enough to find out if it is true, usually it's too late. So, most of us just packed up and left. Different countries, different places, and different times, but we left! Our parents or the rest of the family followed, or we all left together, depending on the situation. I came back to the United States at that time. That was an adventure to get the visa to get back into the country. But it was — finished up high school, went to university, and I've been here ever since.

Neumann:

You mentioned your visa. What steps did you have to go through to get into the States?

Engel:

Well, when I went into the embassy — because I was in Santiago, so we had the embassy, not the consulate — I went in for a tourist visa and was denied my visa. I couldn't get a student visa because the paperwork would have taken too long. You sit around and wait for it; they call you. I asked, "Why was I denied?" And they had the vice-consul, [he] actually came down and talk to me, and he told me that, point blank, that they didn't want people like me because I was going to change my visa to "not a student." He said, "You're going to stay around. You're not going to be just a tourist. Your plan is to stay." That was true. I mean, I'm not going to say that that was not true. I already knew that I was going to go back to high school, finish up, and try to go to university. I mean, I had to be accepted, but I argued with him about it; for several hours, really, we were standing off to the side and arguing back and forth in English. And finally, I got the feeling, just to get rid of me, he stamped my passport and said, "Here you go." And that's how I was able to come back to the States.

03:56 Hello Michigan – Arriving in A New Country & A New High School

Neumann:

That's fascinating. Once you got back to the States, what school did you attend?

Engel:

Well, I went to East Grand Rapids High School. And if you're wondering, President Ford went to East Grand Rapids High School. I was there, so from there, I went to the University of Michigan. I mean, I was already in Michigan. I only applied to one university. My SATs were pretty bad, but I went in as a foreigner, so it was not quite as stringent as for the people who lived in Michigan itself. Also, my transcripts and my grade point from Chile were very good, and in the US, it was decent. Pretty good too, but not nearly as good as from Chile. The other problem was that coming from one school system to another school system, I had big holes.

The Chilean school system had been organized by German immigrants, but my year was the last one of that of that system. They went from a German-organized school system and design to a US-style school system. It was many years ago, so they may have changed it again, I do not know. In any case, when I went through school, the whole country learned the same materials. Well, it was a minimum for each grade. In other words, when I was in seventh grade, I learned the same thing in my school as everybody else in the seventh grade in the country. So not just Santiago, but the whole country. So that meant there was really a pretty uniform minimum knowledge. As I said, it was the minimum; you could always add to it.

Also, there was a certain, you know, there was no, “Well, girls don’t do science,” or “Boys don’t do this.” There was none of that because we all learned the same thing. The only difference was that girls had Home-Ec and boys had shop. That was it. Everything else was the same.

06:21 International Disparities in Schooling – Adapting to the US Education System

Engel:

I went to school from about 1:30 in the afternoon to about 5:30 in the afternoon, five days a week. When I came to the US, I was behind in certain key areas in the sense that I [had] never seen things because of the number of subjects [12 or more, depending on grade] I had. But I did not feel like I was behind in how to study or things like that. Once you were in high school, you were supposed to be in school in the morning. Let's say, 7:00 to 12:00, and in the afternoon [there] would have been the elementary school in the same building. But we had a big earthquake, and my school was unsafe to use. We could not go there. So we were out for a while, and then we went, in the afternoon, to a boy’s school. Oh, I should have said it [school] is either a boy’s school or a girl’s school. I went to what is called – in this country, it would be a public school; we would use the term government school, but that was the minority. But nevertheless, it was gender segregated. So, the Minister of Education or whoever, I don't know, made arrangements for us to go use the building of a boy’s school. They went in the morning, and we went in the afternoon.

Your teachers come into the classroom, teach, and leave. But because you had all these different subjects, you didn't go in-depth into any of them. I come to the United States, and let's say in math, I had big holes. I didn't have any trigonometry when I got here. My classmates had seen it at least twice

already and things like that. It was catch-up time in many areas because it was going much more in-depth in any of the classes here than what I had dealt with before. So, I had to try to catch up; in some areas, I did, some areas, I didn't. I'm not going to say that I always did it, so that's another reason why my SATs were not very good.

08:52 Applications vs. Publications – Going to College in the US vs. Chile

Neumann:

But why were you only applying to one school? I think I applied to at least six or eight when I was —

Engel:

It never even crossed my mind to apply to more than one. I mean, the University of Michigan is known worldwide. I had heard about it in Chile. It had a reputation everywhere. And so, it just never even crossed my mind. I had filled out all the paperwork for taking exams and applying for the university system in Chile. Now, again, it's very different. What you did there is you take exams countrywide. They're given [at the same time] for the whole country. You have math and Spanish, obviously, and then some [other] subject matters. I don't even remember anymore, but if you have three or four things that you want to study, those you write down. You write down the acceptable universities. You have a choice, let's say, of three. And then, weeks or months later, they published the list informing you if you are going and where you're going, and what you're studying. And they're published in the newspaper with your name and what you will study and where you're going.

Neumann:

Oh, so everybody knows exactly what you're going to do.

Engel:

The whole country knows. Because as I said, the exams are given countrywide, and the lists are published, of course, countrywide. So yes, everybody knows. So, the idea of several universities just wasn't really even in my thought process.

10:40 My Time at the University of Michigan — How I Ended Up in Geology

Neumann:

Okay. What did you pursue when you were at Michigan?

Engel:

Well, I started out thinking that I would study physics because that's what I was going to study; that was one of my choices in Chile. I mean, [in] Chile, my choices were Chemical engineering, physics, and I don't remember what the third one was that I had put down. So, when I applied to the University of Michigan, you know, you have to write down what you want to do, and I wrote down physics. I would have made a lousy physicist. Engineering would have been better, just looking in hindsight. I have always been interested in geology. In Chile, I would not have been able to study it. I couldn't have gotten a degree in

it, I could have studied it, and the reason I couldn't have gotten my degree in it is because you have to do an internship over the summers that would have taken me out into the petroleum fields. Petroleum fields had nothing for women. I couldn't have done it. I couldn't have done my internships. Therefore, I couldn't have gotten my degree in geology. So that one was out. A couple of other things that I looked into were out because I would never have been able to be employed as a woman.

Again, it didn't cross my mind. At the University of Michigan, second semester, I took a course called Gem and Gem Materials, which is in the geology department. But it's for anybody; it's not a course that you take if you're going to major in it. After that, it suddenly dawned on me that I could actually study geology; I could go into it. So that's what I did. I took sequence courses backwards, which makes it difficult and quite challenging when you take second semester first and then the first semester of a sequence. But that's what it was. I did it in three years, so I was not going to mess around. It was a matter of economics, and I had enough credits from high school with AP. I went a semester to junior college, too, because I was done in the high school. Again, state of Michigan, thank you for saying you have to go two consecutive semesters. Now, it doesn't say that you start in the winter and then you do your spring semester. You can do it backwards and that's how I did it. It was consecutive; I fulfilled the requirement.

Neumann:

So, did you start in the spring, or did you start in the fall?

Engel:

I came in January for the first time as an exchange student. I started and went back to Chile in July. I was back in the States by the end of September, and I did September to December. So, I did two consecutive semesters in high school, fulfilled my requirement, and I got my high school degree. I mean, you do what you have to do. For the University of Michigan, I had to finish US History and take Government. I took those two in the high school just to fulfill all requirements.

14:24 The Wolverine Community – Professors Treating You Like a Colleague

Neumann:

Did you have any professors in college or any other students that were mentors to you?

Engel:

I would say at the university, there were not exactly mentors, but the professors you ended up — if you went into it, you were a colleague, you were not just a student studying geology. They knew you were going to be a colleague, and they treated you like a colleague, and they looked out for you like that. You know, it was a very different relationship than going, having a professor come in and give you a lecture or whatever. We would go to their houses; we knew their families. If there was an issue with some student, they would go to another student and say, "Hey, go and make sure that this person is doing okay. Keep an eye on them. They're having difficulties," whatever. That's why I say it was very much like that, at least at that time. I mean, no idea how it is now, and I haven't been back for a long time.

Neumann:

So it was like a community.

Engel:

Yeah, as I said, we all looked out for each other, and that's why I said we were not a student that was there. Once you went into the system as going into geology, getting your bachelor's in that or advanced degree, you were part of the system. You were a colleague. You were not considered — I mean, yeah, they had to teach you, and you didn't know as much, and they had to write recommendations and all those good things. Still, it was not like you were just another student coming through. I had a problem with one of my professors. So, I went to my advisor, and my advisor said, "Don't worry about it, I'll take care of it. Come back tomorrow to find out what the result is," you know, type of a deal.

16:33 My Drive for Graduate School – No Challenge in Working

Neumann:

After your undergrad, you went into grad school. What influenced your decision to go to grad school?

Engel:

Well, after my undergrad, I was going to take a break. I was married at that time. My husband was going for his PhD, and I was working, and I was getting very bored because being in a student environment, but not being a student — working really, the challenge isn't there. I was working in the geology department doing some data gathering and things like that. I was also working as a surveyor, so I was getting bored. So I went, put in my application for grad school, started [in] January, which, again, not a good way of starting grad school, but that's when I did, and went to grad school. But I was a lot happier having a challenge than being bored.

Neumann:

So you just enjoyed taking the hard way with school starting in January and fulfilling your credits.

Engel:

That's how it worked out. I was not going to wait through the winter semester, then the summer, to start with my graduate studies. I already knew a lot of the things; I already had taken a lot of the courses. Actually, going to the same university in the same department again gave me a different problem, and that is: what courses do I take that I haven't taken already that I want to take? I mean, there were courses in other areas within geology that I was not interested [in] at all, like the fossils, paleontology, things like that. So, I had to find things that I was semi-interested in, if nothing else, to fulfill my requirements. Again, no, I never went the easy way.

Neumann:

Did you prefer grad school or undergrad, looking back?

Engel:

Actually, [it] didn't make much of a difference because we were the same people, the same professors, the same TAs. You know, just a little bit more age [laughs] for all of us, but we just went through it and went — the biggest thing was that I did not have to take field camp again because I already had done that as an undergraduate. Most people, when they go into geology, either as an undergrad, or if you didn't do it then, as a graduate, you do field camp, which gives you a lot of credit hours, but it also takes up a whole summer.

Neumann:

Is there a lot of travel with field camp, or did you —

Engel:

Well, actually, the University of Michigan owns property in Jackson Hole, Wyoming, and they have a big, big camp there, which used to be an old Army camp. When I went there, the cabins were arranged in a right angle, and, as a good old fashion camp, the facilities for women, let's say, were rather limited. And that's giving them more credit than they deserved. We had a hot water heater, which was good for about two people. If you wanted to take a hot shower after that, you had only cold water because all the hot water had been used. There were a few toilets, and that was it. While on the other hand, the men's side had a whole shower house and a whole bathroom.

At that time, there was also an undergraduate course, a 100-level course, besides the 400-level, which was for people in geology. There was an even split between the number of males and females at the camp. So, the facilities for women were woefully inadequate, and they were— just didn't really keep track with time. I know that they have changed, and they have added since because I get the newsletter from the department. Some of my friends stayed in geology, so they are more active at the university level to see what things are going on. But that year, really, between the undergraduate course and the course for the people within geology was really an even split. I think there was one person more on one side than the other, but I mean, you couldn't have it more even than that. They already knew, but it became very obvious that it had to be addressed.

21:31 My Blue “Green Card” – Post-graduate Life as A Foreigner

Neumann:

After college, what was your first position?

Engel:

Well, I had to cool my heels for a while because I was done before my husband was. Actually, I ended up working with university professors and anybody who was giving presentations at big conferences. I would work with them on how to design their slides and would do illustrations for them, which was interesting because I often had arguments. I would say, "You can only have two ideas on a slide," which is still the case with PowerPoint. They wanted to put all their data on a slide, but nobody can read it, and it's just not a good idea. So, we would go back and forth, and I would work through that. Then I took some other courses. I had a job offer for analyzing Landsat, geology data, and other things. Landsats were satellites orbiting the Earth. But I couldn't take the position because it required clearance, security

clearance, and, as a foreigner, I couldn't get security clearance because those Landsat satellites were put up for the military, not really for geology or agronomy or anything else. So that's why I would've needed a security clearance, and I just couldn't get it. As I said, I was on a student visa at that point, and I had applied for a green card, which, by the way, at that time, was blue, not green. That was the first thing I said when they handed it to me: "This is not green."

Neumann: I

Your green card was blue?

Engel:

Yeah, at that time, it was like an 8 x 11 piece of paper with my picture on it. The background was totally blue. Then my first words were, "This is not green; why do they call it a green card?"

Neumann:

Did they say why it was blue?

Engel:

No, I said it at customs coming through. The system is: you have to go outside the country, or at least at that time, it was you have to be outside the country. You have to come in, and they will — at least I had a sealed envelope. I went through the paperwork at the consulate in Toronto, and I was living in Michigan, so Toronto was very convenient to go [to]. It was also one of the busiest consulates, which I did not realize, so it took over two years for me to get my green card, just the paperwork and the waiting and things like that. So, we came through Detroit; I gave the customs official a sealed envelope. He opened it up, signed it, and handed it to me for me to sign. That was my green card. As I said, it was just a piece of paper, really. At the bottom, it says, "Do not duplicate." Of course, we all duplicate it because if something happens, you need to be able to have all the documentation, the number, where it came from, when you got it, and all these other things. So what's the most efficient way of tracking, that is, you make a copy of it. But we couldn't admit to having done that, you know. That was in big red letters at the bottom: "Do not duplicate" and whatever the penalty would've been.

Neumann:

So you just nod and go, "Yeah, I'm not going to duplicate this at all."

Engel:

Exactly. Not only that, but nobody admitted it. But we all knew. I mean, everybody had to do it because you needed to keep track of it.

25:30 Job Searching in Ohio – Phone Interviews & Security Clearance Struggles

Engel:

After that, as I said, I worked as a surveyor at some point, and then we moved down to Ohio. My

husband got a job at Miami [University] of Ohio, and I knew that I could get a position in that area. Not in geology, I already knew that. But there would be materials sciences, which — we were working very close with engineering school, metallurgy, and materials science. Well, at that time, the building was a few yards from ours, they would come to the geology department to take classes, and we would take classes and use their equipment. So, it was always a back-and-forth. I never considered it to be a very solid boundary between the two departments. Yes, they did certain things that we did not do and the other way around. But there was lots of cooperation between the two departments.

We came down, as I said, to Southern Ohio, and [I] applied to many different areas like GE Aviation, which is close by in Evendale. They were interested, but the ones that really were interested was a place called Monsanto Laboratories, which was, again, in the US Defense Department. So, they couldn't even interview me in person; they had to interview me over the phone. Now you have to understand that, remember, this is in 1978. So doing an interview over the phone was definitely a highly unusual thing. But because I couldn't get security clearance, I couldn't even set foot on that facility for them to talk to me directly.

Neumann:

So, they interviewed you over the phone. They didn't— [crosstalk]

Engel:

Even though they couldn't hire me because I couldn't get the security clearance, they still really wanted to hire me. They went and looked at all possible ways of going around that issue, yes.

Neumann:

How did that conversation go? Just "Hey, we're really interested in you, but —"

Engel:

"We're really interested in you. We need a crystallographer; we need to do X-ray diffraction, analysis," this and that. They also told me some of the things they do. We all knew that they were doing a lot in the radioactive areas, research, things like that. That was one of the Superfund sites. Now, because they moved the laboratory, they closed the one in Miamisburg, Ohio, and moved it somewhere else. So, some things were known, let's say, of what they were working on. And he said, "We will look if we can find. We are really interested; we'll see if we can figure out a way to get around the security clearance issue that you're having." So that's how the conversation went.

28:33 My First Steelmaking Job at ARMCO – Supporting A Welding Product Plant in Brazil

Engel:

I sent an application to [the American Rolling Mill Company] at that time. Again, it's pre-computer, so you don't really know if they have an opening. You just sent resumes out to different companies at that point. ARMCO called me back, so we set up interviews. Actually, I was interviewed twice because the first time, not everybody was in town, so they asked me for the second time round on it, in their research department, and I started working for them. My start date was 1/1/79. Yeah, it's a holiday, but

it was 1/1, and actually, I was working at that time in welding products development of welding products. ARMCO, at that time, which became AK Steel and is Cliffs today, was the sole representative for Lincoln Electric, a huge welding company out of Cleveland. I mean, pretty much all big welding things worldwide; not [the] US representative, but outside the US, they were the representatives for Lincoln Electric. That was the reason for why we were working on that.

The other thing was that ARMCO had built a welding product plant in Brazil. In support of that, we needed to understand and know what was going on. There were two of us working on welding products within the refractory group. At that time, it was called Refractories and Graphite. [As for] research, there was a welding group at the ARMCO Research Center; they would do the testing of the material. But the welding product itself has bauxite, has some alloys, ferrous alloys in there, some fluorine, and things like that. So really, thinking back about it now, it's a slag. Yeah, it makes sense. You know, we were working with slag. But we had it, not the welding group, which worked on parameters [for] how you best weld, how you have to prepare the surfaces, what are the electrical issues that you can run into when welding, things like that. They did not have — and we did not have — that expertise either. So that's why we worked together. That program was going on until the end of '81. Because it was very basic research, we were running what is called full factorial experiments, which means [for] all the different variables we looked into, if you take it out, what is the effect of it, things like that. So, we looked at the variables, and the analysis comes in batches. We designed experiments; we made the product. While we were making product, really, there was no analysis for either my coworker or myself to do.

31:52 Venturing into the Mill – A Woman in Men's Clothing

Engel:

I started asking to go out into the mill, Middletown Works. If anybody was going to Middletown Works, I would say, "Can I come along?" Sometimes I could; sometimes, I couldn't. Which meant that I had to have safety clothes to go out to the mill, which was another challenge because I'm a small person, and most safety clothing at that time was men's extra-large, which was rather big on me. Actually, it made me unsafe to have that because it was way too big. The biggest thing, I was very lucky that my feet are the size they are. I know it sounds kind of odd, but I was able to wear the smallest men's metatarsals size that they make, which allowed me to go into the mill because if I would have had a smaller foot, I would not have been able to buy metatarsal shoes, which meant that I couldn't have gone out into the mill. That's it; it was as simple as that. My hard hat was always too big for me, again because, at that time, it was all for men. I put it on the smallest setting, but it was still too big for me.

Neumann:

What did you do for [fire-resistant] clothes? I mean, I know there's more options for women now for safety gear, but still not a wide range of what's available.

Engel:

We didn't really wear much, okay. First of all, I was on the finishing side of things, so I didn't need silvers. I did eventually get silvers when I moved into the hot melt side, but those were special ordered; they had to make them for me. And my first silver coat, they messed up, and they made it too long for me and too narrow, so I could not put it on even though it [was] special order. I had been waiting and waiting and waiting. I'd worked for several months, and I couldn't go out into the mill. I couldn't go [to]

certain areas and do work because I didn't have full silvers. So then, when they finally got in, and I discovered it was improperly sized, I was extremely upset, and they heard all very clearly how upset I was with it. They got me one in a couple of weeks, which was properly sized. But getting full silvers was quite a challenge.

Neumann:

It sounds like it definitely was a challenge.

Engel:

At that time, we wore jeans into the mill. Later on, we were in greens, but the pants we could pretty much get in any size or adjust, shorten, or take in; I mean, you can't make them longer. And the jacket, who cares because you're sometimes wearing very little clothes when it is in summertime, and they also need to fit over five layers of clothing for the wintertime. So, you need a lot of flexibility for that.

35:19 A Single Lady in Research – Being Tried & Tested in the Mill

Neumann:

When you started out at ARMCO, you were one of two professional women, correct?

Engel:

That is correct. Major integrated plant, I don't remember, 18,000 people working there. I could be totally wrong; I don't remember, really. But yes, the other lady was a lawyer. I don't think I ever met her. I met one of the corporate lawyers, but I don't know if she was the one that was hired already when I was hired in or not. Within research, after me, there were several other women that were hired. In the plant, let's say that the wallpaper was interesting. It was usually — I don't know if people would know today, but they were usually Playboy centerfolds.

Neumann:

With that, were there any challenges that you experienced?

Engel:

Well, I was young; I definitely did not know refractories that much. So, going out into the mill to work with it, I usually was tagging along with somebody. I had to do a quick study on certain things. I had to learn what is a reheat furnace, what is a soaking pit, I had no idea. "You need to go to soaking pits." Well, what do we do there? What is it? The same way with reheat and everything else. Because this was just completely new vocabulary, new areas, everything for me. I started out at the finishing end, soaking pits on down. We had soaking pits, and I was tested, like most new people. Especially when you're young, it doesn't matter what you are when you set out, and especially if you are as green as I was, you get tested. Some of it was whether you're going to do it again. [With one] soaking pit, we were tearing it out, and there was this big ladder, and I was asked some questions. So, they said, "Let's go down." And it's like three stories to climb down, and this long ladder, to get to the bottom of the soaking pit. They had dug out some things, and I knew there was — it didn't really matter what I thought about it. I knew I

was going to be going down that ladder regardless of what I thought. And off we went. People had quite a bit of patience, usually when I asked questions, probably very basic questions because, as I say, I had no idea.

Engel:

That's when I learned that iron and steel are two different things. I thought that they were the same thing. Fe, what do you mean? But there were a couple of challenges, and I would be forewarned sometimes [by] my boss that probably certain ideas or certain questions that I had, if I asked them, I was going to get challenged and very [told] that I did not know what I was talking about. And sometimes, that was true, but often it was not quite as bad. So, we would discuss how to handle it and what to say before I went into the mill. That helped, really, because, as I say, I had no idea what it was doing, what the equipment was that I was looking at, or why. I asked a lot of questions, sometimes in the group and sometimes in the mill, I was not afraid of them thinking that I was totally out to lunch. I did not know what I was doing, and people might as well know it upfront because otherwise, it can get you into more trouble. That way, they kind of weigh your suggestion. Sometimes it backfires. Sometimes you can sit out, and you can discuss things a lot more because they're trying to explain to you, and you can explain your ideas, and you can come to an agreement a lot simpler than trying to convince them that you are right or that they should do something.

39:47 Ladles Named After Me – Being Challenged on My Assumptions in the Mill

Neumann:

How do you think going out into the mill helped you with your first position?

Engel:

Oh, it definitely helped me. It challenged me in many ways. I needed to explain things to others; I needed to justify everything I did, which is actually not a bad idea. I mean, it gets tiresome. I am not going to say no because you have to think about "Why am I going to do that?" You have to actually analyze your position and consider the pros and cons before you venture out because you have to be ready for those questions. After a while, you don't get challenged anymore, but still, it's a good checkpoint. Is this really true? Are my assumptions correct? What are my assumptions? Because at a certain point, you make assumptions, and you may be wrong on it, or you may have forgotten or overlooked something. So having to go step by step or rethink or discuss it — hopefully discuss it before you go out there — it is useful because you actually have to formulate a lot of things, and you are ready for many questions, which you may or may not get. But at least you are able to explain yourself, justify your position, or be ready for counterpoints that sometimes you get—sometimes you don't.

So, it is quite useful, and that's really how— then later on if you write something up, you need to go through those things anyway because you have to be able to make a coherent picture of whatever it is. So, it really kind of prepares you for that, and actually, I miss it some, to be challenged on my assumptions, on my conclusions, because I'm afraid sometimes that I missed something that I just didn't take into consideration, something that may be obvious to somebody else. It's something that you really don't want to do. I mean, from [a] safety aspect and from just [a] product aspect, you want to be sure. You need to be able to ensure everybody's safety and that the product that you are working on is the right product. That you didn't add anything that shouldn't have been there. I mean, if you don't make

chemistry in steel, or you don't make properties, etc., etc., etc. You really don't want to have your name associated with a bad heat.

Neumann:

No, definitely not. Is there a particular challenge that you had that stands out in your mind?

Engel:

Early on, there was a challenge that there were, let's say, professionally and technically, the steel industry, and I assume others, too, have come a long way. I remember going into a meeting where they wanted to do what we would call now an emissivity spray, except at that time, the technology really did not exist yet, and the theory didn't either. So, what they were doing there was spraying some very expensive mud on the walls of the furnace. And I knew that. So, I challenged the presenter, and what I didn't realize was that by doing that, I was challenging some of the mill people, and it did not go over well, let's say.

But in general, I have had many a ladle named after me because if you run a trial in a unit, that unit gets your name while you're running the trial. So, everybody knows, if something goes wrong, who to talk to. I've had many ladles with my name on it, and there was one situation, not a ladle, where it didn't work out properly, but in general, it did. So yes, the one that I remember really is the one where they tried to insulate by putting some mud on furnace walls. Actually, it worked in the sense of insulation because it just would have closed the cracks. But they were giving it attributes that it definitely did not have to justify some of the stories they were telling about it.

44:47 Manmade Assemblages of Minerals – Using My Geology Degree in the Refractory Industry

Neumann:

How did your geology degree help you in the refractory industry?

Engel:

Well, refractories are manmade assemblages of minerals, and in geology, I have naturally occurring assemblages of minerals that are modified by water, steam, temperature, and pressure. In general, in steelmaking, we have all of those. Well, not water, hopefully, but we have all the alterations. Not with pressure, usually, most of our vessels are not pressurized, but it's pretty much the same thing. If you look at it in that way, there is no difference. You have reactions between all these different elements, and you study how they work out or why they work out and why things happen. And when I started out, many of the refractory people were actually geologists by training.

Neumann:

Did you have any mentors in your first role?

Engel:

My boss definitely made sure that I would be prepared before going out into the mill. When it came to

welding, he was not involved, really. I mean, he was involved in the sense of allowing us to work, he provided [the] lab, but it was really basic research. There was nothing written, very little written on submerged-arc welding fluxes, at least at that time. There was just not much really that he could provide with it, except maybe if we'd ruffled some feathers to take care of those. But otherwise, there was not much that he could do. Once I started with refractories and steel making, things like that, I had several people within the group that would take not just me, but also some of the other people, younger engineers, out to the mill, introduce them, show us what was important, what was critical, how to read the data sheet, what to pay attention [to], what to ignore, and a lot of other things. So, it wasn't a formal mentor system, but we were understudies for quite a while before we were allowed to be on our own out there in order to ensure that things worked smoothly, that we knew what was going on, that people in the mill knew that we knew what we were doing and things like that.

Neumann:

So, you were people in training before you moved on to—

Engel:

Oh yes, very much so.

47:50 Branching Out at ARMCO – Taking on New Positions in Steelmaking

Neumann:

What other positions did you hold at Armco?

Engel:

Well, I started out, as I said, working in welding. The titles we had were pretty much set out. Originally, every five years, you got a new title, type of idea, but in practice, it wasn't quite that rigorous [a] change. So, then I went from finishing end, and I started doing some of the hot side of steelmaking. I quickly discovered that most people within our group had a vessel or an area that they specialized in, and it seemed like nobody was doing electric furnaces for stainless. So, I ended up working a lot in what was ARMCO Baltimore at that time; it's been shut down for years. We had the horizontal cast that was installed when I was working there, went from stopper rods to slide gates in the ladles, and I learned a lot about stainless steel making. We were standing on a shanty next to the vessel doing calculations for additions on an adding machine. We would get the chemistry, and that's how I learned to do stainless; that was my training on how you make steel. I wouldn't be able to do it today, but I was pretty good at doing it then because I was in the habit of doing it. Then [I] went and did a lot of work in Butler, again in stainless, and with electrical steels that they make there. I did not work that much in the [Basic Oxygen Furnace] area. I did ladles in the BOF shops, but I did not do that much BOF for blast furnace work.

As I said, it just kind of expands; you walk in, some people move out. I ended up doing some open-hearth work where we first made steel, and then they shut them down for steel. Middletown Works was iron-poor, so they started making iron in the open hearth and putting iron in steel ladles. Makes for very interesting times: you find every hole/gap in the ladle. So yes, I dealt with a lot of breakouts at that point, more than I ever cared to. But it wasn't really breakout; they just kind of came out through the weep holes and things like that. Ingot, ingot stool work, all sorts of different things, and changes in

technology. As we went along, the technology on the steelmaking side and technology in refractories changed. You had to work through it. When I started out, the electric furnaces for stainless steel-making — not just stainless — were all [magnesia] chrome-lined. Later on, they went to [magnesia] carbon in carbon steel. For a long time, ARMCO did not go to mag carbon in stainless because the chrome in the stainless can react with the carbon, and we were afraid that we would destroy the brick because of that. But at some point, we took the plunge, and we all agreed we had to move on and put the mag carbon brick in the electric furnaces. So that's why I say it was equipment and refractories. You know, sometimes one pulls, the other pushes, or the other way around, you have a problem you have to solve, things like that.

51:50 "We Self-destructed Many Times" — Technical Challenges & Incremental Changes

Neumann:

So how was the transition from mag chrome to mag carbon?

Engel:

It was rather smooth, thankfully. I mean, except for the shells that suddenly became a lot warmer, which we knew, because we were using mag carbon in the BOF. Our group was working on both sides, carbon and stainless. The BOF lasers, those developments were ARMCO research developments. All the original patents are ARMCO patents. I was not directly involved in it, but my group was. Many, many things were developed, many things changed at that time. I was in the beginnings of the baby steps, how we can look at it, and of many technologies. Because I was in research, because of the fact that at that time we had big research, we were like most integrated mills at that time. I did not realize how great a learning experience it was until years later. When you're in the middle of it, that's what it is. You don't really think twice about it. Anything different? No, of course not. That's what you expect because that's what you see around you.

Neumann:

Right, you're so close up that it's hard to take a step back and see the whole view.

Engel:

Yes.

Neumann:

What are some of the biggest technical challenges that you faced while you were at ARMCO?

Engel:

Actually, some of it has been slide gates, for example. Degasser, a lot of things in degassers. Now, the carbon steel people use a degasser maybe half an hour, 20 minutes. When I started out, we had a [Dortmund Hoerder] degasser — they're gone, thank you; I don't miss them — where the nozzle or snorkel was in the molten steel a minimum of 60 minutes or longer.

Neumann:

60 minutes?

Engel:

Yes. We routinely would melt the can out, so we would lose the bottom section of our degasser and had to change it out. So that was a huge, huge challenge. How do you keep that snorkel cool enough after it's immersed in steel, 3000 degrees, whatever, for that length of time? And so, yes. We self-destructed many times. When I first started out, we also had an RH degasser in Middletown, and we did some changes to those snorkels. There were two of us working on it at that time, and [we] were able to actually increase the life considerably [with] some of the design changes we made to it. But yes, the snorkels were an absolutely immense issue. And again, going to back to Butler, their reheat furnaces are run at considerably higher temperatures by design, from most others to the point that we have tap holes in them, we tap slag out of them. Refractories don't like slags that much.

Neumann:

No, not really. Refractory doesn't prefer slag.

Engel:

Yes. So, you continue, you look at what the technology of refractories has to offer, what you can do, and make incremental changes. Sometimes, you can make a quantum step, but usually, it's incremental.

PART 2

00:31 My Work-life Balance – Bedtime Stories About Steelmaking & McDonald's

Neumann:

Your work has taken you all over the world. How do you balance work and home life with all of your traveling?

Engel:

Well, it's interesting. For many years, it was mainly domestic. I only went outside for a welding stint, where I was in France for that, and a couple of trips to Europe for technology issues. I usually was traveling to the plants and within the US, and, you know, I didn't give it much thought.

Engel:

Well, when the children were small, I was in Baltimore all the time, almost. So, I would call them at night, after I had eaten dinner usually, and would talk to them and give them a goodnight story. The goodnight stories usually were some aspect of steelmaking. Obviously, it wasn't straight chemistry and things like that because they knew nothing about chemistry**.** But you can really use your imagination and have little people bring in little grains of chrome or iron, which gets very hot and starts dripping between the fingers. Things like that, you can even go on, and so they actually, in practice, they ended

up learning how to make stainless. They didn't know that. Later on, once they were in high school and they learned some chemistry, they started realizing that that was what I did. They would ask me, "Were you telling us how to make steel?" I said, "Yeah, that's what I was doing." That was one of the things that was always there.

I had to organize them. My husband and I had to organize that the kids were taken care of, they would be picked up, there was food in the house to eat for everybody, etc. But I have two children; we never considered it to be a major showstopper or something like that. I mean, there were a couple of times when I couldn't travel because one of the kids was sick or something happened. But in general, that was not an issue, and the kids knew that I might come home and say, "I'm leaving in 2 hours; I need to pack," and that was it. They grew up with that. They did not really think about it as being different or being unusual.

Neumann:

So, they were just used to you traveling all the time, and it's just "Oh!"

Engel:

Yeah, that's part of what mother does, exactly. They knew because I was doing it since they were born. My husband was obviously in town, so if something needed to be taken care of, he could step in. And we did have help, because [for] one person who is working also full-time it is very difficult to take care—to do all the other things. But they knew that I would travel, to the point that at the beginning of the week, they would ask me if I was going to be in town or not.

Neumann:

Did they ever get excited about where you were traveling?

Engel:

When they were very little, they were excited that I traveled because they would go to McDonald's.

Neumann:

"Mom's out; that means we get McDonald's this week!"

Engel:

Yes, exactly. And they didn't get that when I was home.

04:41 ARMCO Open House – Introducing My Children to the Steel Mill as Babies

Engel:

The other big thing was ARMCO had an open house every so often, so my daughter was in the BOF shop when she was probably about two months old for an open house. No, obviously, she doesn't remember, but we used to kid that she was in the steel mill basically since birth, that she had to go into steel. She

did not – but because of that. But they had an open house, and my husband and I and the baby went along, and I introduced both of them to all the people I was working with and things like that. But having open houses at the steel mill really helped because then they could at least imagine what I was talking about. Remember, this was all before YouTube and things like that. They couldn't really relate when I would say it's big or very big or very hot or loud and noisy. You cannot really relate to it unless you have seen it.

For the open houses, not only would I bring them, but the school my kids went to was very accommodating. If ARMCO had an open house, they brought pretty much all the grades. We couldn't bring the really small young kids because it would be a safety issue. But we would bring everybody else, and let me tell you, not only that the kids remember, but the teachers still remember to this day going into the steel mill. That's another way how you get new people is exposing others to some of these areas, some of these industries. You really have no way of entering unless you find out that you have an open house or there is something going on. You can show that it's not The Flintstones**.**

Neumann:

Do you happen to know if any of them ended up in the steel industry?

Engel:

I know some went into science, but not necessarily the steel industry. I thought my son would, and actually, he lived in Chicago many times and asked me one time, "Can you get me into one of the steel mills around here?" So, I talked to some people, and although he was not doing steel, not at all, he wanted to continue from what he had seen and heard from all his life up to then. So, I was able to get him into one of the mills for an open house type of day. We have to show, not just tell, what we do.

07:57 Continuing My Career as an Independent Refractory Consultant

Neumann:

That's great. So, after ARMCO and AK Steel, what did you do next?

Engel:

Well, the refractories group was slowly dissolved, and their equipment was auctioned off**.** Test equipment. So [I] did a lot more process work, steel making. Again, it was mainly stainless and specialty steel. After that, well, we were "separated," which is the nice way of saying that I was fired in 2003. After that, I worked for ANH, meaning A is for AP Green Refractories Company, N is for North American Refractories Company, and H is for HarbisonWalker Refractories Company, and today it's HWI. For about a year, year and a half, working mainly in the — they were trying to get into the AOD [argon oxygen decarburization] business with fired dolomite brick. It did not work out, so we parted ways. At that point, I made my own company and have been working as an independent refractory consultant in the steel and in the heavy industry. Usually heavy industry, some of them have not been so heavy, but what we think of as heavy industries.

Neumann:

What inspired you to start your own consulting?

Engel:

I was not moving. I was not going to be moving. At that time, for me to work with ANH, it was taken for granted I was going to be working from home. So that's why I said, “Well, my choices are getting limited.” I was seeing other people doing consulting work. I said that sounds like a great way of doing things and continuing my career. And I went for it. That's why I did it. As I said, I couldn't move. I wouldn't move, let's say. Obviously, I could, but I'm centrally located. I said I have highways close by, and I have two airports. I don't need anything else.

10:36 My Company’s Evolution from Just Steel Refractories to Aluminum & Failure Analysis

Neumann:

So how has your company evolved over the years?

Engel:

Well, when I started out, I was working almost exclusively in steel. Either working for refractory companies and going into the steelworks or working with them solving some issues, or working for steel companies solving issues, again, refractories. Over the years, it has expanded, first when I started working in aluminum and then did some work with silicon for solar panels. That was in Canada, I was doing some of that work, and I've expanded ever since. I don't look for jobs. I do have a website, and I know that in some cases, they tell me, "We found you through your website, or we found you on LinkedIn." I'm not trying to advertise LinkedIn, but it does give you a platform to showcase your availability and knowledge. And, you know, so nowadays, I do go in for failure analysis. But I also work as an expert witness in legal cases, and there are a couple areas that I will not touch because they are just not something that I would feel comfortable doing. And I do quite a bit of insurance work because when a unit goes down, be it steel, be it glass, copper. Obviously, I've worked in all of those; there is a big insurance claim. It's industrial; it's a production loss.

Usually, that’s where the big numbers come in. It's not so much the refractory itself, but the production lost because they have to obviously make up for all of that. Insurance companies generally want to know why something happened. They do give you the time, and usually, the resources, to actually investigate the failure. What went wrong? Why did it happen? Because they don't want it to happen again. That's really what it comes down to. It's been quite interesting. I have, as I say, been in all of those; I've been in a lead melter, a recycler of – that was not insurance, they had refractory issues – recycler of car batteries, which contain lead. So, they have an electric furnace that charges used car batteries to recover the lead. The big issue there, of course, is safety, the environmental issue with lead fumes being – and that was a mag chrome lining, and they were in the middle of a big city. And That's about all I can tell you about. But it's been very interesting the different industries, and as I said before, you learn from one, and you apply it to others. How you look and how you approach it is quite different.

I've done much aluminum. What they call secondary aluminum, in other words, recycling, refining aluminum. It's not taking the bauxite and making it into aluminum or alumina. That's been interesting. I have had titanium smelting, copper smelting, many different things. The big issue is many of the industries, especially the smelting side, taking the ore and making it into a metal; each company

develops their own technology and equipment. So, in the steel, somebody says BOF, everybody knows pretty much what it looks like. You go to an engineering company, and you order the BOF. In many other areas, the company develops invents their own equipment and their own process, and it's all proprietary. So, to get information on basics, "Why did the refractory fail?" Well, I need to know your process. I need to know how you do these things. That becomes very challenging because you can't read up on anything. You can read up on the very, very basic studies of slags, of melting, of temperatures needed. But that's about all you can get because everything else is proprietary; it's not published, obviously.

15:27 The Impact of Networking in Consulting – A Sounding Board of Professionals

Neumann:

You mentioned your website and LinkedIn. How have networking and everybody you've met throughout your career impacted your company?

Engel:

They have because the people that I have met were mainly in the steel side because that's where I grew up. They obviously have impacted it considerably. I still work quite a bit in steel and things like that. If I get a call at 8:00 at night, I know that something bad happened somewhere. And I'm talking while I am making, putting together my suitcase, I don't know necessarily where I'm going, but I know I'm going to be going out very quickly. I do training seminars; these are scheduled, planned. My name is put forward because of all the networking. I'm considered part of this system. I'm trustworthy enough not only to come in, but to keep certain things, the propriety aspects, and Every company has a certain amount of proprietary information, [it] stays proprietary after I go, and things like that. That's how it has impacted, having all this networking, having all these things. A, I can ask questions; B, they will give me work. They will suggest my name. My name is put forward in many areas. Although I work in steel, they may suggest my name in other areas, like maybe a methanol plant or some other thing.

But then, when I write the report, sometimes I'm not too sure about something, so I will actually use my contacts as a sounding board. I mean, it's not using them, but we can discuss things. Is this because I'm not that familiar with the process or the industry or things? Is this logical; does this make sense? Because one of the things [you do] if you work in an office or you have other people to talk to is you bounce ideas off of them. You discuss things. If you work for yourself, you don't have that. So, you have to find people that you feel comfortable doing those things [with]. And most of us working on our own have certain people we will call or we will discuss things with because you can easily go down the wrong way if you're by yourself and you don't really have a check on your ideas. What you're thinking or how you're thinking about it.

18:27 How to Succeed in Refractories – Take It All In & Apply Your Knowledge

Neumann:

Do you have any advice for people who are starting out in the refractory industry like me?

Engel:

Actually, learn as much as you can about all the systems, about the more theoretical things. You may be working in steel, but you may be working in aluminum later on. The detail of the challenge will change [with] the different industries, but the overall challenges will not. You know, every industry will consume refractories. That's why they're called consumables, although the users usually don't like to think of it that way. It's just the details of what attacks, what are the nasties that they encounter, or why some materials are better than others. You will also find out suddenly that— you can take the knowledge from one industry and transfer it to another industry, what to look for, how to look for it, and what questions to ask. Especially when you are looking for "Why did it fail?" Or what to consider if you're going to make a recommendation. All of those things play together, and you will find some industries are stronger in some areas or some material uses than others. So you can transfer knowledge back and forth.

You also find that they pass each other. Aluminum was very strong for the basics of castables when I started out with castables because Alcoa was in it. Then they had some purges and lost some of the technical people. So, then the steel industry started using more monolithics, and they learned how to install them, how to heat them, and how to make sure that they made them. And aluminum had some other issues at that point. So, you keep going from seeing similar challenges from one industry to the other, and you can really learn from the different ones and apply them across the board. It's not a one-for-one, but you can readily use that knowledge, and it helps with the analysis of failure or what you recommend or how you look at things to go into different industries because their assumptions, basic assumptions of why things work, are different than what you came from. From experience, they know what works best in their thing, but sometimes there are other things or better things that they didn't consider because it is something they have never done before, something they've never used before.

Neumann:

So, it's something that's not really in their view.

Engel:

Exactly. It's a stretch to do that and things like that. I'm just thinking of, let's say, reverb furnaces in the aluminum side have some very interesting roof-sidewall, tie-in designs which when I saw them the first time, my first thing was, "Gee, that would be nice to put in a reheat furnace in a steel mill." You just look at designs, and you look at things and say, "Yeah, we can use that somewhere else."

22:12 Accumulating Ideas from Different Industries & Technical Changes in the Steel Industry

Neumann:

Oh, so being in different industries, you've actually been able to take ideas and concepts from, as you said, the aluminum industry and be able to apply them to the steel industry.

Engel:

Oh yeah. Let's say electric furnaces. The induction furnace people have moisture — because an induction furnace has moisture, the coils contain water. So, if you have molten metal [and] you have cracks in the lining, or there is a leak from the coil itself, you will have an explosion. So, they're very concerned about explosions, just like in a vessel where if you have water under the steel, you have an explosion. Exactly the same concept, except it's an induction furnace instead of a BOF or an electric

furnace. So, they monitor, they have the ability or the equipment for that. I have recommended it to many places in electric furnaces because water-cooled panels have the tendency of developing holes, and the holes leak. So, you can get moisture into either the refractory of the bottom or the sidewall, or you can get moisture underneath the steel. You don't want either one of those things to happen. There's cross-fertilization, but you have to learn they exist. It's not the case — it's a good idea, but if you don't know the equipment [it] exists, you can't apply it, you can't install it, you can't follow up on something like that.

Neumann:

Right. So, what are some of the most notable changes that you've seen throughout the steel industry?

Engel:

Much more technical. Much more technical than when I started out. It started out it was very much — if you would ask for properties or anything, it was very much an "I'll take good care of you" type. And now, I mean, that would just not make it. You definitely get technical information, be it on refractories be it on the steel itself. And they get tighter and tighter for everybody, not just that; the equipment has to work a certain way. You don't just get it and expect it to — "Well, it may or may not work," that doesn't fly anymore. That's why I say much more technical overall, everywhere.

Neumann:

Okay.

24:53 Refractory Consulting, Training & AIST Seminars

Neumann:

So, Ruth, you consult for a lot of different other industries outside of steel. Can you tell me a bit about some of those industries?

Engel:

I can tell you about some of them; a lot of it is proprietary. Let's see. Right now, my work includes an incinerator. It's from a paper mill, and they want to recover some of the energy from that. I have a copper smelter that broke out in 2011, and it is 2022 now. That's for an insurance case. I have a couple of lime kilns that I'm working on; they are having refractory issues. I cover many, many industries. It's been interesting because I started out in steel, of course, and people know me there and everything else, but with time and word of mouth, I guess, or my website, whatever, I'm getting questions and jobs from many areas, many different industries.

Neumann:

So, along with refractory help, do you also do any training or any other services?

Engel:

Yes, I do two types of training. One of them is where I go into a steel mill, and the other I've done is refractory manufacturers and suppliers. I will go in and put on training seminars on refractories to cover the topics they're interested in. Those are tailored to their needs — we agree on the topics, and we agree on what I should cover. And then I always, if it is a mill, I will go in ahead to make sure that I actually talk to the people on the floor to see what's going on, what are their concerns, what they perceive as their issues. Then I also do work with the AIST society on some of their training seminars. I don't put on the whole training seminar, but I participated as a trainer with some of them.

Neumann:

Which seminars have you been involved in?

Engel:

For the AIST, I've been involved with specialty steels; I did the electric furnace when they still had a refractory section in there, which they haven't had in many years, and AOD, and I always participate in ladles and secondary metallurgy.

27:35 Dental Implant Refractory Problems – Connecting Companies with Technical Knowledge

Neumann:

What is one of the weirdest things that you've seen in your time throughout this industry or other industries?

Engel:

Well, I guess that would be dental implants. I was coming from a steel mill. I'm driving along on the highway, I get this call, and it's this company, XYZ company. They said, "We are having refractory problems; we make dental implants." And I'm thinking to myself, this is old, very old technology, pretty much what could have changed? And I said, "Yes, I can go and see what you're doing," etc. What on earth can this be? So, I get there, and they have these little trays which look like ashtrays, the size of an ashtray, that they fill with teeth. They are the teeth that they put in the stem, and they screw into your jaw. I discovered that they're made out of zirconia, yttria-stabilized zirconia, and they put several of these ashtrays. They stack them up inside this little furnace, which is about the size of a microwave. And they did have refractory issues.

One of the big problems, which I did not realize for a long time, was — coming from an integrated steel mill or working with steel companies, which are big companies, even the smaller ones are big companies, we go and buy refractories from the refractory company. A manufacturer of refractories. A small user of refractories like this company or some of the induction furnace foundries they do not go to the manufacturer. They go through a distributor who sometimes just doesn’t have the technical knowledge needed or even the products which have the quality control needed for some of these linings. And so, this particular company was— I mean, how much refractory can you put in a microwave to fill in a hole? Not much. They could not really go out and buy or access the technical know-how. Besides, they didn't know whom to access. So, in this case, I made suggestions of what product and how to install it, but I also gave them access to one of the major insulating producers in the country and gave them the names of who to contact. So, although they're probably only buying, let's say, think of it as one

roll of insulating blanket. It was not blanket; it was vacuum boards. But still, they now had the means and the ability to actually get it. What we cut off or put in the dumpster would be sufficient to line this kiln. The quantities are just so small that a manufacturer will not talk to them.

Neumann:

That's interesting. So, you were able to kind of help them not only solve their problem but connect them to a supplier that can actually help them.

Engel:

In the future, they will have developed the connection, yes. The furnace was designed for the European code for cold phase temperatures, which is much lower than the US. Well, I don't think we have a code for the temperature for cold phase, but they had it. So, it needed to be highly insulating because it's a no-burn, so you have to be able to get very close. You don't touch it; you don't hold onto it. That would be too hot. It's not something that you necessarily think of. You think, "Of course, I will call XYZ company for this material," and that XYZ company is a manufacturer of that material, it's not a distributor. It's just something that, again, makes it interesting. How do you solve the issues going outside the US? What refractory companies do you have available; how reliable are they? What do you feel comfortable using? That's the other one is, of course, the customer also needs to be comfortable using certain materials, using certain products, and things like that.

30:03 Papers & Presentations – Getting Involved with AIST & AIME

Neumann:

That's interesting. When did you first get involved with AIST and with AIME?

Engel:

Well, not with the AIST; I got involved with the ISS [Iron and Steel Society], which is the forerunner of the AIST. For several years, I was not considered to go to any of the big conventions. At that time, the ISS, Iron and Steel Society, had divisions. There was the Electric Furnace Division, there was the Iron Making Division, and there was the Steelmaking Division, which was the BOFs. I guess we didn't make our steel in the electric furnaces. I was electric furnace mainly. As I said before, I didn't work much in the BOFs, so I didn't get to go. And it takes a while before you feel comfortable enough [to go] to a big convention where you may not know many people. I was attending the Ceramic Society conventions but not steelmaking. So, they had a special session on horizontal continuous casting. Must have been, I don't know, [19]84, [19]85, somewhere in there. Make it the second half of the eighties. I submitted an abstract to it. I didn't tell my boss, though. I just submitted an abstract because I was doing a lot of work on horizontal continuous casting because we had one in Baltimore. I was in Baltimore every week. Fridays, I might be in the office, maybe. But, you know, it was taken for granted. I was in Baltimore. I submitted an abstract that was accepted. Then I went and told my boss, "I'm going to be going to the Electric Furnace Conference; I'm giving a paper." So then I had to write the paper.

Neumann:

How did your boss react to that?

Engel:

He said, "Fine." I mean, he was very laid back about things.

Neumann:

He just so He just was like, "Oh, okay?"

Engel:

Okay. Well, the biggest challenge was getting the paper approved because, being a big company, before you put the paper out, you have to get a lot of sign-offs from different people, and you have to send it to legal. That was much more of a challenge because it takes time to get all of these things done, etc. I presented the paper; that was my first one, it was in Atlanta. I discovered at that meeting that there was no refractory committee. The way they had the papers, sessions, and everything was organized by different committees, just like they are now. I knew the BOF division had one; I knew the ironmaking [division] definitely had a refractory committee because people from our group were involved in those. That's why I say I knew the theory of it; I just had not participated. But nothing in the electric furnace, so I went then to — there was always a meeting of the board, and the whole Electric Furnace Division committee would have a meeting during the convention. And I went to that meeting. I crashed the meeting, basically, and I said, "Guys, you don't have a refractory committee; you don't have a refractory session." I basically volunteered to put one on, and during the big meeting, they said, "No, not interested." By the time I got back to the office, and that was several days, etc., they called me: "Please put one on if you can."

37:27 Starting A Refractory Committee – Putting Together Ladle Refractory Courses

Engel:

So, I don't know what happened after I left because I made my presentations, and then I left because I was not a member of the committee, of the division, or anything. For several years we were what was called an ad hoc committee. Then I had a few other people who helped me, like Mike Fox and some other people. Then, later on, we were made a regular committee, not ad hoc, but we became a committee within the Electric Furnace Division. Actually, I even went through the chairs, I was chair of the Electric Furnace Division because I was the chair of the committees, and that was on a rotation. I was chair, I think it was in Nashville when I was a chair of that conference. We had the conference in early November. It couldn't be late November because of Thanksgiving. So yes, that was how I got involved with it.

Then, once it became AIST, there was no refractory committee at the AIST. They took the different divisions, and there were several of us who said, “Oh, the AIME has a refractory, so we will — we expected it to be automatic, but it wasn't. So, it took several years of convincing. The people that were on the refractory committee, at least from the Electric Furnace [Division], several of us went into the ladle committee because they were doing quite a bit of refractory work. That was when we got really involved with ladle furnaces, [we] were having a lot of refractory issues. That's how the Secondary Ladle Refractory course got not started but resurrected because, under the ISS, we had a lot of training meetings. I put many a ladle refractory course together and put it on for them at that time. It was a one-

day course instead of several days, and we did not do planned visits or anything like that. It was interesting, and actually, the first one we did. We pretty much took my agenda because it was the first one under the new system, added some things, and keep modifying it so it keeps reflecting the needs of the industry.

40:23 Professional Societies – Where the Human & Technical Part of Industry Come Together

Neumann:

So how has membership benefited you in your career?

Engel:

Oh my. The context, the personal [relationships] that you develop. One thing is the papers, but that's the technical content. Really and truly, it's also the people. I can call anybody, or they will call me, and we can throw around ideas. We will discuss problems; we will talk. If there is a new way of doing things, if there is a new technology, somebody is using it. How is it really working? Not the official line that is put out for consumption, but how is it? What are the challenges? Because even if it is working, fantastic, there are always challenges. A lot of these things come — it just creates also friendship, many friendships for life. There are many people here whom I've known for 20 plus, many, many years. We will not keep track of what are you doing on a daily basis, but we know each other. We will make sure that everybody is taken care of, things are done if something needs to be done, things like that. So, the human part and the technical part both come together here in a beautiful way. It's very comfortable, very warm, and, as I said, can be very technical if you need it.

Neumann:

So, you've earned quite a few awards throughout your career, including — I'm going to go through all of them now. The 2021 [American Ceramic Society] Theodore J. Planje-St. Louis Refractories Award, [at] AISTech 2021, you won the Benjamin F. Fairless Award, and you were also a Distinguished Member and Fellow award. Then, going back to ISS in 1994, you won the Clarence E. Sims Award. So, can you tell me what all of these awards have meant to you?

Engel:

It really gave me a lot of satisfaction for these awards because, although I knew that my work was recognized and things like that — I mean, just talking to people, you get the sense, you get the feeling. But one is a personal type of recognition, the other one is a public recognition of things. There have been times when I felt that refractories are really ignored; often, they are. So, to have these kinds of, especially in the steel part, kind of awards means that refractories and the work and the contribution of those things is percolating up. It does have an impact, even though they may be neglected, and I might complain bitterly about that. It does give you a satisfaction. The Planje Award was also very nice; was extremely satisfying because within the refractories industry, worldwide really, it is an award that is recognized. Not coming from— well, by now, I am part of that system, but originally not coming from that — and leaning on many people to learn, asking many questions it means that not only did I learn it, but I contributed to the furthering of it. So that, again, is very satisfying.

44:50 "Take Them Out in the Field; Show Them What Refractories Are"

Neumann:

That's awesome. So how do you think we can attract more young people into the industry?

Engel:

I think that taking them out into the field, and I don't think that going to universities and looking at ceramic engineering, I don't think would be the answer because people who go into ceramic engineering have a certain mental image of what that means. That may mean a lot of them have the mental image of having superconductors or some very special niche kind of environment, very clean, very controlled. And I don't think I've ever been in an industry that has a very controlled environment. I think that going there, taking them out in the field and showing them what refractories are: it's people who like to play in sandboxes and get dirty. That's why you have so many, let's say, geologists in it because they go out in the field. The reason most of us got into geology was because we went hiking or rock climbing and were curious about what we were seeing around us. How did they form? What did they get to?

So again, I think that's more what you need if you're looking for somebody. I'm not saying that they shouldn't or that they should never consider that. But most of our environments are not controlled environments. Most of our environments are, "Oh, my God, what happened now?" The mindset of a very controlled environment will not work; will not be comfortable under those circumstances. That's why I say the people who played in the sandbox and got dirty, walked around in the rain because it was fun, not because they got caught in it, things like that, I think would probably be better served. The other thing is, right now, there are very few places where you can study refractories, so we have to expand our views. Ceramic engineering is, again, also [a] very small number of people. So, if we want to replenish the ranks, which we have to do anyway, we need to look at other areas. The oil industry is not going to be hiring every geologist that there is out there.

Neumann:

So, you should start knocking on the doors of some geology departments and saying, " Do you want to join refractories?"

Engel:

Yes, actually, yes. Because, you know, even during the "good old days," which all they really are is old days, the oil industry, which really had many, many geologists— And that's where I expected to work. I mean, I had, then, what today would be an internship; it was a summer job with Mobil Oil in Denver. Really, it's very cyclical, very similar to steel in that they have massive layoffs every so many years. So not everybody is quite as enchanted with that concept. But that's [where] you think you will be working, so you don't really think or consider other areas. That's something to keep in mind. I know that in practice [chemical engineers], many of them go into the steel industry. That's why I say it's different areas where you learn the basics, the theory that can be developed and applied into other areas. That's what it's going to be, anyway. For the rest of your life, you will be using your knowledge and stretching and going into new areas because nothing is static.

49:10 Advice for the Future Generation – Learn as Much as You Can in School & Ask Questions

Neumann:

What advice would you have for today's young leaders?

Engel:

Learn as much as you can while you're in school. You may not like it. I mean, some of my most useful courses were the ones I took because I had to fill my schedule, not because I was "interested in it." You will probably use it if it is within the general area, although you may not realize it at that time. You may not realize it later on that you're using it, except in hindsight, looking back. But the knowledge that you acquire, especially with the more theoretical things and more basic things, will be useful. It may not be directly applied, but you can use it. I have never found something; of a report I wrote or a study I did that I may never have issued where I did not learn something. I may not have finished writing it even, but I have always used the knowledge that I acquired. So, it doesn't go away; it just gets modified. That's what I would say. Get that, and then just put yourself out there, speak up, ask questions. Yes, some of them will be so-called "dumb questions" or very basic questions. Usually, what is thought of as a dumb question is a very basic question. You don't know. Just take it and go with it. You know, not all of us were born knowing everything.

Neumann:

So what do you like the most about refractories?

Engel:

The changes were continuous challenges of how we can destroy them and new ways of destroying them. There's always a new way; there is always something different from place to place, from time to time.

Neumann:

What do you think the biggest challenge would be for refractory engineers in the industry?

Engel:

Figuring out why something actually worked, trying to adapt it. We are always going to be chasing a hole. You know, you solve one, you will just make room for a new one. That's how it is; that keeps us in business, too. And accept that; accept that there is no final answer to anything because there will be new challenges, new ways of doing things. Therefore, there will be new ways of destroying the refractories. That's how it is. And learn the whys so that you can chase and fix a new hole.

52:15 Surmounting the Continuous Challenges of Refractories

Neumann:

So what has been your proudest achievement?

Engel:

I would say that to be recognized that I contribute to maintaining the steel industry, and actually, now it's other industries, too. But the other thing is that it's amazing how small the world is of refractories. Just because I work mainly in the US does not mean that is really the only place I am known. I can get calls from other places, "Hey, I am having this problem. How would you think about it?" And it changes. There are different constraints or different issues, which are non-refractory issues. Let's say disposal issues, what materials can be used for, what is available, what does your workforce do, the structure of expenses. There are many things that need to be considered, but the fact that I can pretty much go anywhere in the world, and there will be somebody in refractories if I need to, I can call on, or they will call on me. As I say, the family of the refractories people. Family not just of the steel but also the sub-family of refractory people.

Neumann:

What has made working in this field the most meaningful for you?

Engel:

Solving the problem. The problem in front of me, not the next [one]. Obviously, I don't know what the next one is, but being able to solve it and maintain continuity of things, teaching the new generations coming up, be it through the training seminars of the AIST or going into the mills and working with the people there. Even if I do just a failure analysis, I go on-site for that. I usually have somebody asking me, "Why is this? Why is that?" You just kind of work through it because none of us are going to be here forever, and the next generation or generations need to know and need to see. I find that there are fewer and fewer people who can — It's not that they cannot do it, it's that they are running so lean that they don't have the time often to explain because taking a person who has not worked in the area, [it] takes quite a bit of time to show them, to explain.

We have new tools now to be able to pass on some of that knowledge, but nevertheless, a lot of it is just spending time with them, taking them out, showing them examples in the field, not pictures, but in the field of what you look for, how you look at it, why, what questions to ask, all those things. And there are not that many people who are able to do it because the knowledge may not be there, or they're not able to do it because they don't have the time. They're not given the time to be able to do those things. And I was lucky; I had the people who took the time to take me out to the mill, to take me to the blast furnace, to take me to different places, and explain, and tell me, "You don't want to go there because X, Y, Z." Let's say [there] might be poisonous gases there, so you don't want to go there. I'll tell you if you need to go, what to look for, or take you into the pulpit, and you can look at the screens. This is what it means. Pay attention to these numbers; you don't care about those numbers." But it all takes time, and we don't always have the time these days anymore to do those things.

56:25 Concluding Remarks

Neumann:

All right, is there any other advice that you have for the audience or anything else you'd like to discuss?

Engel:

I think we pretty much covered most of it.

Neumann:

Well, thank you, Ruth. It's been great to hear about what a fascinating career you've had, and it's been a pleasure to spend this time with you. Thank you again for your willingness to share your story with AIME.

Engel:

Thank you for taking the time to interview me. And thank you for the AIME to put these things together because it's all time and people. We have to be cognizant that we don't have forever; we need the time, and we need to preserve some of these things. Thank you.