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Good Morning, I ‘m delighted to be here. And here is anywhere. I used to think, as many of you probably think, that 75 is really old. But since the alternative is not too hot I’ve changed my mind. Yes, I am 75 going on 90.

One of the advantages of having someone as old as me on the podium is that I can give you a living history lesson about the Art and perhaps the science of Reliability and its relationship to maintenance. I’ll try to do that but perhaps I can do more because as I have seen events unfold over the years I could step back and see trends that others, who are younger, may not see. This is not a put- down because you can read about what has happened which I suspect most of you do. But for me this rather special oversight of history can be projected into the future, a future that you may shape and certainly encounter.

My first job out of college as a Chemical Engineer was in a relatively small chemical plant that made and bottled reagent chemicals. They also made important chemicals, in bulk, such as DDT, which was effectively used to knock out mosquitoes and other flying insects that passed on some very bad diseases to people, like yellow fever. I was trained as a Chemical Engineer but I was very early made a maintenance shop supervisor. What an experience that was. Maintenance doesn’t really describe what we did; it needs adjectives. The entire job of my group was to fix machines, pipes and anything else that broke. So **expensive breakdown maintenance** is a more appropriate term for what we were instructed to do.

Since plant management was clearly focused on producing product there was no tolerance for taking time to find out why anything broke. So after a couple of years of this silliness, I joined the Army as a commissioned officer in the health area. The contrast was like a breath of fresh air because the U.S Military Services provide wonderful training and give young people a lot of responsibility. I became the post Sanitary Engineer on a military post in Virginia. I worked out of a hospital and was also in charge of Preventive Medicine. Are you beginning to see how I was developing?

Well, before you get too excited about the lessons I probably learned let me tell you what I did learn. We immunized babies and also adults going overseas. The idea was obviously to prevent illnesses. I'm sure you are familiar with that. However you may not be familiar with some other things that I did to prevent illness such as raising flies – you heard right --- I was raising flies and sending them in a hard shell pupae stage to 2nd Army Headquarters where they were allowed to develop into adults and were exposed to different insecticides so that the army could feed back to me what insecticide would be most effective to use during the summer months. I did a number of things like this that were truly preventive.

To summarize my Army career, I learned that training could be very effective when new things were learned and then applied in realistic circumstances. I also learned that young professionals should not have their education expensed but should be applied where their education and natural inclinations lean. Finally, I learned that if we are creative enough we could prevent bad things from happening.

After a couple of years I was discharged into the reserves and I returned to my previous company, but to a new recently built facility in Virginia. Where do you think they put me? Remember, I was a trained Chemical Engineer. I was again placed in maintenance and I soon graduated to an authority position. To me that meant I had some space to try my own ideas.

In 1957 I purchased a rather heavy electronic box, which I used to analyze equipment vibrations. Using this box, I was able to identify equipment problems before they caused us downtime. This is certainly old hat to you but in the 1950's it was a revelation. The early warning systems allowed us to prepare for the fix in a way that considerably reduced downtime and sometimes eliminated the need for it.

During this time I researched other nondestructive tools as they became available. With sonic equipment we were gauging the thickness of pipes and tubes and with infrared thermography we were identifying furnace and heater problems as well as the condition of our roofing systems. This was great fun. And since process uptime, and consequently revenues, was rising management was supporting my efforts although I had to constantly keep reminding them what our contribution was. As you know when something good is happening there are always many people standing in line to take credit for it.

In early 1960 I was sweet talked into a temporary move to another plant where I entered into a new world. This was my employer's largest facility at that time. It had three continuous and one batch polymer facility and a very large operation to produce various synthetic fiber products such as very strong yarn for tires and crimped yarns for carpets as well as specialty yarns for drives and conveyor belts.

My first assignment was to build a facility to make dies to extrude the polymers. It was my job to see to the building of the facility, the technology transfer from Italy for the manufacturing facility and the hiring and training of people to do the work. Remember I was a trained Chemical Engineer and although the assignment was interesting it was strictly mechanical.

I am not going to bore you with the particulars of this experience but I want to hit some highlights. Remember I am tracing the development of my career to project some learning for you. The best dies were manufactured in Japan and Germany at that time. Oh, did I tell you that the holes in these dies were very small, some so small they could not be seen with the naked eye and did I tell you that most of the holes in the dies were not round? Some were "Y"s and some were dumbbell shaped. Isn't that interesting? And all the holes in a die had to be exactly like the other fifty to a hundred other holes in the die and in the holes in the other dies. Well we learned how to produce them and we eventually became the best in the world. One story will help frame the larger picture I want to present.

We needed to acquire tools to make these holes but nobody sold tools that small at that time so we manufactured them on jeweler's lathes under microscopes. Each tool took an hour to make and we were able to make less than 10 holes with them and we had orders to produce thousands of holes. So I used two of my assets to correct this problem. One was an Engineer that had an insatiable curiosity and the other was Mechanical design genius that I had hired. I developed specifications for what we needed and gave it to the engineer and told him to find a machine that would make the tools in no more then 3 seconds. He spent a couple of months traveling throughout Western Europe and finally found something close to what we needed in Switzerland. Many of you will remember that at the time the Swiss were the leading watch manufacturers in the world.

He brought the machine back with him and my in-house Mechanical Design Genius modified it to fit our specifications and we began making each tool in 3 seconds.

As I stated before, I learned that I would get the best results from my technical resources if I used them in the areas that they were most interested in.

Soon after this I was promoted and became the head of Engineering, Maintenance and Utilities for that facility. You are right if you are wondering when I went back to my previous job. The answer is that I never returned. One can deduce that management really appreciated my performance. You see this was an important deduction that I also made. Let me tell you why. In this facility there were 20 producing cost centers. Each one had a supervisor who in turn had a cadre of production workers and a small group of maintenance workers whose job it was to fix problems quickly on the run when they were called upon to do it. This type of maintenance service was pretty common in the fiber industry at that time. This was not a very efficient use of labor because when the equipment was running smoothly the labor was idle.

I suggested that we develop software, remember this was the early 1970s, where production workers could request these jobs on handy workstations. The work requests would immediately go to a centralized computer that would prioritize the requests and direct a mechanic that had the needed skills to address the job. Since the computer would know where each of the maintenance craftsmen was working this would be a very efficient application of manpower.

The facility had over 3000 employees working at the time that had to be trained to input information needed into the input stations. So if an operator found that yarn was breaking and wrapping on a position on one of her stations she would input that information to the computer. The computer would be receiving requests from the entire facility and prioritizing them so that the jobs that would provide the greatest safety and financial return would be done first. Since the operator’s request also identified the skill needed the computer would select a person with the required skills and the shortest travel time to perform the task.

When the mechanic arrived at the position needing maintenance, he signed in to the input device that he had arrived. After completing the task he reported that the task was completed. If he used any materials he would also input these and the computer would automatically see that the supplies were replenished. Once the task was completed the operator would report to the computer the time when the position was restarted and production resumed.

Now we had captured the exact time that machine or machine position was down, the time it took for the mechanic to arrive, the elapsed time of the repair and the lost time, if any, to restart the machine or the problem position. And this was done with 1970 technology.

At the time I requested this be done it was a bold and perhaps seemingly outrageous move. I have found that a really good strategy for large ideas is to wrap them in a bold and outrageous package. If you have developed a reputation for materially helping to improve output and lower costs managements are very reluctant to turn you down. Boldness and Outrageousness opens dialogue while incremental improvements lose their luster very easily, if any luster was there in the first place.

You can see this on our political scene. Incremental improvement to social security, for example, is to raise the social security tax or increase the retirement benefit age. Bold and outrageous is to propose an entirely new scheme such as giving people ownership of part of their retirement invested in the financial markets. You may or may not agree with the proposal but you have to admit it has surely opened up the dialogue.

Later in my tenure at this facility I learned that in a fiber plant if you wanted to reduce production costs you must produce larger packages. So I recommended to my Engineers that we could perhaps spin a package that was double its present size or 60 pounds. We did it then transported these larger packages and loaded or creeled them on to drawtwisting machines. Each drawtwisting machine was producing seventy-two 5-pound packages at the time. I wanted the biggest package we could produce. My Mechanical Design Genius said that he believed he could design a 20-pound package. We also decided that instead of hauling the 20-pound bobbins to the next operation we would devise a conveying system that would become the creel for the next operations.

Remember what I said about Bold and Outrageous. This was a bold move. The Vice President wanted to support it because of its tremendous savings and his confidence in our abilities, but at the last minute he got cold feet and purchased thousands of 10-pound bobbins because his advisers were telling him that it would be impossible to develop a 20-pound bobbin that would not crush under the forces created by the Nylon yarn winding up on the flanged spools. Because of this design concern management decided to take the bobbin design away from us and give to the Central Engineering designers that had more experience with bobbin design. Because of the failure of their designs the VP purchased the 10-pound bobbins.

I asked my designer if he could make a 20-pound prototype bobbin that would work and not crush. His **first** prototype performed as we intended. This was a severe blow to the integrity of the Central Engineering management. I believe that the Central Engineering bobbin designers had developed paradigms of what would work and what would not work where as my designer was a mechanical expert that had not designed a bobbin before so he had no built in restraints. Keep this in mind because paradigms are extremely powerful and although they can sometimes provide order they can also provide obstacles.

While all this design work was going on I had grown my Maintenance Engineering staff to about 12 engineers of different disciplines. This group of fine professionals entered into the world of Failure Analysis among other things. First they gathered information about methods and techniques that was being used in the aircraft industry. These techniques used probabilities to forecast failure events but I thought ‘why do that when I had plenty of actual failures to study and we could generate real information’. As a result my young engineers began to develop methodologies of our own. I provided encouragement and some direction and I proudly observed as they developed and tested nuance after nuance, continually honing our methods.

Applying all the methods of Reliability Engineering that we assembled and developed resulted in our plant polymer and fiber processes operating at a very high level of onstream time. For example our four-polymer processes were on stream an average of 98% of the time for the 10 years that we kept records. Many people manipulate uptime figures by excluding times they feel that were not responsible for or by other ways but my figures always accounted for every incident of downtime and for every hour of the year.

This was a remarkable achievement but I learned one or two important human concepts:

1. It is difficult for most people to accept large ideas and big accomplishments. It is like throwing a $10,000 bill on the ground of a busy street and people see it but no one picks it up because they cannot accept that it is real.

2. When large achievements are made only really great managers and executives will acknowledge the originator. Some are afraid to give that much attention to someone else. Many others are reluctant to acknowledge the originator of the idea because they are afraid of alienating the support group that worked on the accomplishment.

Well, because of my track record the corporation decided to move me to their R&D operations at their central headquarters with the object in mind to continue the development of this new technology and spread it to the rest of the corporation. I refused to move on the basis that the company had three producing facilities where I was and that was a better laboratory than the pristine facilities at the home office. They bought my argument.

In 1972 the Reliability Center was established to further develop Reliability Concepts and to spread these Concepts to the entire corporation. I directed and managed this operation. In the years that followed we continued our development of Reliability Techniques and we consulted and introduced our methods into most of the company's chemical plants in the United States.

This is some of what I learned in those years:

- Challenge Parochial Pride to develop innovative approaches to improve performance. One way to do it is to suggest that in lieu of their application outsiders will be brought in to help.

- Managers often lean on a confidant who usually has his own agenda. If performance is improving the confidant may be needed as a competent sounding board for the Manager. If performance has been deteriorating it may be that the Manager is getting poor advice.

- Everyone has an agenda. Their agenda may or may not conflict with the goals of the management. Steady improvement in facility

performance is a good indicator that individual agendas support the Managers goals. Steady deterioration in performance is a clear marker that they do not.

- Some employees like to know the rules and are quite content to follow them. Others need space and responsibility, with accountability, to perform. Take a lesson from the armed services and provide excellent and realistic training, responsibility with accountability and great support. That is a formula for success but only give it to the people who need space.

I think if I talk any more I will bore you if I haven't done that already so allow me wind up so I can then shut up.

I worked in the USA when Maintenance was totally Repair and Replace or Rebuilt activities. And it was very expensive. Reflecting back it was probably a good thing. Remember this was about 5 or 6 years after World War II and millions of men and many women had returned from the war and they needed to work. Our inefficiencies provided that employment.

Remember another important factor. With the Marshal Plan after World War II we diverted money to rebuild Western Europe countries such as Germany and also Japan. In those days there was criticism that we were helping to rebuild our enemies.

As we moved into the Predicted Maintenance era and started to gain efficiencies we were expanding our markets both in the USA and in Europe and the Far East. As our population grew we used the evolving manpower to staff the new and expanded industries that were develop to meet the market demands.

As I look back it sure seems to me that there was always a master plan that drove events to help all nations to grow and seek peace.

Today our maintenance efforts are beginning to develop toward Prevention through Proaction. You know I was using that word long before it made it into Webster's Collegiate Dictionary.

In the 1950s I studied all the routine jobs that our shift mechanics in the various crafts performed. I found a chain that drove a feeder that broke

just about every shift and was routinely replaced. I found that very cheap sewer sampling pumps were being replaced routinely every week. I found a very large conveyor system that kept dropping material from its ore-carrying belt. The ore that dropped hit the emergency shutdown cords just about every hour and people had to be dispatched to restart the conveyer. These are a just few examples but I found that these miner cost incidents occur in every operation.

I became a million mile flyer many years ago and I have been in hundreds of manufacturing operations and I have seen miner mishaps like those examples I gave that routinely cost great money. On further observation as we developed and honed root cause analysis we found that these small occurrences made a major contribution to the much larger more expensive mishaps such as equipment wrecks, fires, explosions and major process upsets.

You may not realize it yet but I am leading up to something. I just hope I can convey it properly to you. I also began to realize that human beings are not very good at recognizing where our largest costs emanate from. You see when we have a large explosion like the ones that recently occurred in Texas City we all can appreciate that the company will be hit with a rather large cost. But if we amortize this cost over 10 years it is very likely not our largest cost. What is our largest cost over that same 10 year period are those small mishaps that really don't cost much when they occur. But because they are so small a cost there is no driving force to remove their cause.

What is missing is our ability to recognize frequency. A minor incident that occurs every hour or every shift or every week amounts to really big money. A minor failure that costs $100 to correct but occurs on every eight-hour shift will cost hundreds of thousands of dollars each year. What's more, if we learn to do root cause analysis and eliminate their causes we will prevent the bigger mishaps from occurring. The smaller mishaps may not be directly related to the larger ones but their elimination reduces the noise in our systems and builds in discipline in the way we do things.

If I project what I have seen in my lifetime I believe that the use of Root Cause Analysis will intensify as industries, banks, healthcare and government see its usefulness in bettering our society. I believe that the

use of Root Cause Analysis to only satisfy compliance to laws and/or standards will eventually get the bad name it deserves.

Further out I believe that eventually Predictive Maintenance will yield to true Root Cause Analysis and be displaced by it. I probably will not see it but it will come.

This has been fun for me and it has also been an honor to present my thoughts to you so I thank you and pray that God will continue to guide our path.