>> Dr. Torrey: So, today we're going to talk about corrosion control systems on construction projects. And this is the seventh installment of the Corrosion Webinar Series. My name is Jessica Torrey, I'm a materials engineer here at the TSC in the Materials and Corrosion Laboratory. And I have several of my colleagues here from the Coatings and Cathodic Protection team. Just first off, aside, we have a new name. So, we had a reorganization here at the TSC in Denver, and as of October 1st, we are now called the Materials and Corrosion Laboratory. Our org code is 8540. We used to be part of the Materials Engineering and Research lab, as many of you are familiar with. And we are still housed in the same place, office is in the same place, everything the same except for our name. Our supervisor in our group is Bill Kepler. And we also got a few new members into our group. So, our group now has advice and expertise for construction materials in Reclamation facilities, specifically in the areas of protective coatings, corrosion and cathodic protection, polymeric and geosynthetic materials, composite materials. We now have Kevin Kelly in our group, who is in charge of environmental compliance and management. And we also have several of our team members who are able to do special examinations on normally inaccessible features. This means that they're on the rope team and the dive team. And so, we're able to offer those services to you for dive inspections or rope inspections. And one of the key functions of our group, in addition to our work in design and construction and inspections, is to perform research related to all these areas. And as I said, today we're going to talk about corrosion control systems. So, this means your protective coatings or your cathodic protection systems, and specifically as it relates to construction projects at Reclamation. So, we're first going to go through a little bit of a refresher and introduction to corrosion control systems. Talk about, then, our specifications. So, we'll go through our key components of our coatings specification as relates to construction projects. And as well our cathodic protection system specifications. Then we'll talk a little bit about training that's available for coatings and corrosion, or cathodic protection inspectors. We'll talk about the role of an inspector. This is typically on Reclamation projects, our CORs. And we'll talk about inspection tools, techniques, and some common problem areas for you to look out for if you are one of these people who's doing the government inspection job. What is a corrosion control system? The coating or protective coating or paint is the primary defense against corrosion. And then we also, in many cases, recommend cathodic protection, and this works in conjunction with the coating to protect the structure at any defects that are in the coating. The most effective corrosion protection system for buried and submerged structures involves a good bonded coating and cathodic protection. If any of you have seen any previous webinars or taken our class here in Denver, you've probably heard us say this many times. So, we like to recommend a good bonded coating and the cathodic protection. A refresher on paints and coatings, there's several different types of paints. Architectural paints—these would be what you would use in your house. We also use a lot of concrete sealers here at Reclamation. What we're going to focus on today is our coatings for corrosion protection. And these are primarily barrier coatings, which control the penetration of water and ions to the underlying metal surface. They need to have a strong bond or a strong adhesion to the substrate. And these paints are typically composed of a binder—which is a

polymeric material—a pigment and a filler, and then a solvent or something to dilute the coating for application. The types of barrier coatings, as I said—the types of protective coatings—barrier coatings are what we most commonly use here at Reclamation. Some examples of these are coal tar enamel, polyurethanes, epoxies, vinyls. We also have sacrificial coatings. You see sometimes zinc-rich coatings or metallizing, for example if you have galvanizing coatings on some of your steel structures. And then much less often, we see inhibitive coatings, which typically contain leads and chromates. And these are restricted materials, so we don't use them a lot on Reclamation structures. A refresher on cathodic protection systems—so, this is a technique that we use to control corrosion by making the cathode of an electric chemical cell. So, in the case of galvanic anode cathodic protection, this is also known as sacrificial anode cathodic protection, we use the natural voltage difference between two metals. So, we use one metal—for example a magnesium anode, which you see here in the picture—to protect the second metal, which is the steel of the structure. And the second type of cathodic protection is called impressed current cathodic protection. And this is where we use an external power source where the anodes are connected to the structure through a rectifier. If you need any more information on either the protective coatings or some basics on cathodic protection, we have some webinars that are available. And we also have a training here in Denver that's available. This is an example of a corrosion control system where we have both the coating and the cathodic protection. And as I said before, the coating is the main protective barrier, and then the cathodic protection protects the structure at defects in the coating. And there's four things that you will need for corrosion—the anode, cathode, metallic return path, and the electrolyte. And we can refer to this as our "ACME", a little acronym to remember this. And what the coating does is, basically provides a barrier between the steel structure and the electrolyte. So, it breaks that pathway. And then what the cathodic protection does is assigns your anode to an external metal and assigns your structure as the cathode. So, you get your corrosion on the sacrificial anode or on the impressed current anode and you protect your structure. So, that was a little refresher on coatings and cathodic protection. Now we're going to dive right into the specifications. If you've read any of our coatings or cathodic protection specifications, they're fairly long. So, we don't have time to go through everything. But here on this page, we'll start out with our coatings spec. And you can see the typical headers of sections that are in our coating spec. We do have a coating guide spec that's available on the website. These paragraphs here are typical. And we do tailor our spec, our coating spec, to the type of project and the needs of the project. Specifically, today, we're going to talk about two sections that you see highlighted in red. The Submittals section—so, these are things that we want the contractors to send and have approved by staff here in Denver, typically our TSC coatings staff. And then in the Execution section, we're going to talk about our contractor field quality testing. And this is where you'll see a lot of the language that deals with the inspection process itself. And just a note on the coatings specs, we do have separate spec sections for a lot of specialty coatings. So, even though you see the 09 96 20, we'll have a few different numerical designations if we have specialty coatings, for example for concrete or pipelines. Or vinyl and metallizing, they also have separate spec sections. In our Submittals

section, these are the—this is the information that we want the contractor to send to Denver and that should be approved. And part of the job of the government inspector is going to be to make sure that the contractor is actually using the products that are approved through the submittals. So, the first submittal that we ask for is our approval data. And this is where they send in either the brand name coating that's listed specifically in the coatings category section of the spec—and they'll need to send the manufacturer's product data sheet, the application data sheets, and the MSDS data sheets for approval by TSC. If they're trying to use a coating product that's designated as an equal product to anything in the coating category, so a non-brand name product, there's a few additional pieces of information that's required. And that's specifically showing where they've used this product successfully on similar types of products. Again, all the manufacturer's certifications, as well as performance certifications for that product. And then finally, if they're trying to match color or gloss of a specific paint, then they should send some paint chip samples as well. The next item for submittal is final approval data. And so, this is where we get the information on the specific batch numbers of the coating that's purchased for this project. And this allows us to go back—if there's any problems with that coating—to go back, look at the batch numbers, and go to the manufacturer and try and figure out what's wrong. If we got a poor batch or we got the wrong type of coating. Things like this. Next is the certification. We have two types of certifications. First, we have the contractor certifications. They need to be certified for the specific type of application that they're doing on a job, and the specific work that they're doing on a job. So, that could be for field application of that particular type of coating, for hazardous materials removal if they're doing that, or for the shop application if that's what's specified. And then we have manufacturer's product certifications. And this could be things like a materials suitability for use with potable water. Finally, we have documentation, which this is where we show that each applicator—so, each person who is applying the coating—has training or experience for that particular type of coating. And we ask for written evidence of that as a submittal. And then finally, the contractor quality testing data. And this is all the information that an inspector, a contractor's inspector, will collect in the field. Next, we're going to talk about the spec section on contractor field quality testing. So, this is where we define how the contractor's qualified personnel shall conduct tests. And this is often a third-party inspector. They do have to, and are required by the spec, to perform these tests in the presence of the COR, the Contracting Officer's Representative. This would be the government's coating inspector. So, this person should be able to understand and recognize and know all of the tests that need to be done and be able to recognize if we're getting good results. Some of the key inspection points that are outlined in this spec section—prior to abrasive blasting, we need to be able to witness the general condition of the surface. For example, compressed air quality. For example, general surface cleanliness. After abrasive blasting, the contractor should be testing for soluble salts, primarily chlorides. These can cause a lot of rust damage to a surface if they're not removed before the coating is applied. You need to test for surface profile. This would be using, for example, surface comparators or replica tape. And again, surface cleanliness to make sure that there's no residual blast media on the surface. After the final coat of material, again we're

going to test for the dry film thickness. And this should be tested for between each coat, so if the spec requires three layers of coating, then after each of those three layers, you'll want to test for the dry film thickness. As well, this is the point where you would do discontinuity or holiday testing. And then finally adhesion if it looks like there's problems with the coating. And I have some examples and some pictures of these later on in the presentation. The spec also requires that inspection devices be furnished by the contractor to the government inspector, if needed. Typically, the contractor's inspector will be performing the test, but the government inspector is also able to perform these tests and can ask for those devices from the contractor. This might include a holiday tester, a DFT gauge, and then the certified calibration plates or plastic shims. And then as well, in that section we talk about the contractor's report. And that should include things like the date of the work, description of the areas where the inspection was performed and the work was performed. Okay, so that's our coating specification. And as I said, it's quite extensive. So, this is a very brief summary. Now we're going to move into our cathodic protection specification. This is typically Section 26 42 10, although as with the coatings, we typically have—where we can have multiple spec sections in a spec package. For example, if we have different types of structures that we're protecting. On a given project, if we have a pipeline and some tanks and possibly some gates, then each of those might have their own spec section. And you would see it go 26 42 10, 26 42 11, etcetera. We do not have a guide spec for cathodic protection. And again, these paragraphs below are only typical, you may or may not see some of these in all specs. And it will change based on the design for a project. We typically design each of our—and write our specs particular to the design for that project. And again, we'll be talking about the Submittals section and the Contractor Field Quality Testing section. For cathodic protection, the first submittal that usually comes to us in Denver is the certification. We require a NACE Cathodic Protection Specialist certification, that's also known as a CP4 certification, for the person performing or directing the installation. So, not all of the people on site working with cathodic protection have to have the CP4, but there needs to be one person overseeing the job, going through the drawings, approving the design, and things like that, who has the CP4 certification. And we require that they submit that to us in Denver. We also ask for preconstruction drawings. A lot of times, we do the design and the drawings here in Denver, and then we often see the contractor just submit our own drawings back to us. But that's fine, that means they've hopefully reviewed them and are going to go with our design. We also ask for manufacturers' data sheets for system components. This is where we tend to reject a lot of submittals that come through our office. We see, a lot of times, the contractor just isn't, for example, using the right cable or doesn't have the proper weld material. And so, this is where we see a lot of back and forth between us and the contractor. And then, where applicable, we ask them to submit any information on interference mitigation. So, if there's other cathodic protection systems or other pipelines in the vicinity of the project that we're constructing, then they need to submit their plan on how to mitigate that potential interference there. And then, the next submittal we see is that final data. So, these are the actual as-built drawings and any other pertinent information for how the system was actually constructed. And then our testing data.

And that'll include testing equipment and any of the methods that they utilized, where they placed the reference electrodes for each of their tests, and then the results of these tests. And these results should be in conformance with the NACE cathodic protection criteria for that structure. So, contractor field quality testing. Again, this needs to be performed in the presence of the COR and is typically performed by the contractor's inspector. And this might include energizing a system, adjusting that system, testing the cathodic protection system. And this will depend on what type of system that we've installed, if it's a galvanic anode or impressed current system. Again, we specify that they need to inform the COR prior to the testing. All the equipment must be provided by the contractor. We ask that they, obviously, record and report all their readings, and that comes through to us in the submittal. We ask that they—for example, for an impressed current system—that they conduct the testing in at least two cycles. And this is often—it takes some time for a structure to polarize. So, the values, the protective potentials, will be changing up to a certain point. So, we ask that they do this in two cycles so that they can do any troubleshooting or adjustments and correct the problems. And these are as determined by the COR. COR has the right to ask them to further adjust the system, if necessary. And then they'll submit that final data after the last testing cycle, when they have met the NACE performance criteria. We may require additional testing. We don't often do this. Hopefully they'll try and meet the NACE criteria, and the systems are all designed to meet that criteria. But there is an option that we can require additional testing if they don't meet our standard criteria. Okay. So, that's our spec sections. Now I'll talk a little bit about training that's available for inspectors. There's a number of professional certifications that are out there. These are pretty extensive courses. NACE, the National Association of Corrosion Engineers, offers a Coating Inspector Program, a CIP program. And that has a Level 1 and 2, and then a peer review. The Levels 1 and 2 are both one-week classes. Many of us here in Denver have these certifications. And the peer review is actually sitting before a panel and basically answering questions as to your knowledge of coating application and inspection. SSPC, the Society for Protective Coatings also has a Protective Coating Inspector program that has three levels. They also offer a non-certificate online training program. That might be a place just to pretty easily get some information, fairly quickly. But this is, as I said, it's a non-certificate program. Then, on the cathodic protection side—again, NACE offers their CP Program. So, there's four levels. I—they're all—the first three all begin with a "T", and I never remember which one is which. So, we typically—you'll hear us say CP1, 2, 3, and 4. The CP4 Specialist certification, as I mentioned, is required for a person on the project, one of the contractor specialists who is overseeing all the cathodic protection work. And so, these are available—again, the Cathodic Protection Program, those are all one-week long trainings, each of those levels. NACE is based out of Houston, so most of the trainings are in Houston, but they do offer them around the country on occasions. I think the CIP class, they try and have Levels 1 and 2 once a year in Denver. There's one coming up here in April. Although, I got a notification that Level 2 was cancelled, so they might just be doing the Level 1 this year. But those—information on all of those are available at their website. And then, in addition to any certification training, you always want to make sure that you have the proper training for on-site

safety. Many of you are familiar with these certifications that are site-specific, such as fall protection. Possibly if you need rope access, confined space training, permit required confined space training. Lock out tag out program, now called the HECP program. And then, as well, be aware of the different hazards that can be on the job site and the protection that you're going to need. So, certain weather conditions, for example, you would never want to be out testing a cathodic protection system in a wet—in a lightning storm. Even if it's 10 miles away, there's a chance for pipelines of having a shock travel down that pipeline. So, want to be aware of that. Other physical hazards and possibly wildlife, for example, that might be on a project. And then, know your PPE. So, do you need safety shoes? Your hard hats, helmets, hearing protection? Often for coatings jobs—you can see Allen Skaja and I over here in our Tyvek suits, our protective suits, and our respirators, getting ready to start an application on a coatings job—coating repair for a cathodic protection installation. So, know what PPE you need and make sure that you're safe on the job. Now we're going to move into the role of the coatings inspectors. [background voice]. So, we have a question on who, in TSC I think maybe, has the certifications. So, everyone in our coatings group has either the NACE or SSPC certification. So, there's five of our staff and everyone has varying levels, but they all have the inspector certifications. In our cathodic protection program, three of us have the CP3 level certification. And then Chrissy, that CP2 level. So, we all have certifications here. And just to throw that out now while we're talking about it, we're all available to come, as well, as inspectors on a job.

>> Dr. Skaja: Roger just retired, but he has a CP4.

>> Dr. Torrey: Right, so yeah, we just lost Roger Turcotte to retirement from our cathodic protection group, and he was our CP4 specialist. And they're not easy certifications to get, and we are all trying for that CP4 level. So, hopefully a couple of us will be there before too long. So, moving into the role of the coatings inspector—just to clarify, before we go further in this, there's typically two inspectors on the job site. And I want to make sure that we're all on the same page as to which inspector we're going to be talking about. You typically have the contractor's inspector, and this is preferably a third-party inspector, although sometimes these are people that are, you know, they're hired by the contractor and then are actually staffed by the contractor. And these are—the contractor's inspector is the person or people that will perform all of the testing and reporting required by the specification. They should be NACE or SSPC certified and have experience with the particular type of infrastructure or equipment that's being coated, as well as the type of coating that's being used on the job. Having said that, that's ideal. It doesn't always happen that way. I think we all know that, you know, the contractor shows up on a job with an inspector and sometimes you just have to go with it, which is why it's so important to have the second inspector, which is the government inspector. This is typically a Reclamation employee. It can be a member of our TSC staff, we're available to do these inspections. It could also be the COR, for example. And this inspector will be observing all the tests performed by the contractor's inspector. They may also conduct their own testing. So, if they see that something's

not quite right, they disagree with the numbers that are coming out of a contractor's instrument, they can also perform their own testing. And at a minimum, the government inspector should be familiar with each of the tests required by the spec. So, you should be able to recognize a good versus bad data reading. You should know all the requirements in the spec and know if your DFT is meeting spec or not. And then, be competent with the testing devices and know how to properly calibrate them. Is there a question?

>> Dr. Merten: Yes, this next question is: What certification would be best for government inspectors for both cathodic and coatings?

>> Dr. Torrey: So, for cathodic protection, the Levels 1 and 2 are probably the best. Those are very heavily hands-on in the actual testing techniques. So, I understand they're a long time commitment, but if you could get to CP1 that would be great. As well, for the coatings, I'm going to look at my coatings colleagues here, but the Level 1 CIP training is very good. I've done that training just last year, and it is also a lot of hands-on. It's a full day doing applications and using all these types of equipment. And then four other days doing classroom work. And then both—all of them have a one-day exam at the end. So, I would say that, as an inspector, you could get the NACE Level 1 or 2. And as a—CP, the CP1 or 2. Those would be great. And we can, you know, we'd be happy to answer questions. As I said, many of us have been through those trainings. So, if you have specific questions on them, feel free to give us a call and we'd be happy to go more in-depth as to what would be expected at those trainings.

>> Dr. Merten: I would just add to that, that each of those trainings is gaining progressively more expertise. And it's—typically, that inspector will have progressively more experience. So, if you can get to the peer review level, or the CP4 level, that is essentially the point where you are deemed an expert, somebody who can be hired independently to perform that role.

>> Dr. Torrey: Okay. So, yeah. And those are really great trainings if you have the opportunity to get to them. Some of the roles of our coatings inspector—number one, observe. So, make sure you're there when the contractor's inspector is doing all their tests. Watch the application process, make sure that they're applying coatings correctly. Take note of anything that you see that's out of the ordinary or out of spec. You can also test to verify the contractors results if you deem that that's necessary. And then final, and possibly the most important—verify conformance to the specification. So, that's the main role of the inspector, is to make sure that the contractor is meeting the requirements that are outlined in the specification. And kind of common sense, but why use a coating inspector? And it's to ensure that you are getting a good quality coating job. Contractors—we've seen, I think all of my colleagues have seen situations where they try and cut corners or do some crazy things. So, having a coatings inspector on-site who's well trained really assures that you're getting that good product. Some of the risks that the inspector can help mitigate—poor surface prep or coating application. So, I think one of our tips, always, is that

90% of the coatings job is in the surface preparation. 10%, or something, in the application. So, make sure that these steps are followed through with in a proper manner. If they're not, you can have reduced coating service life or premature coating failure, which is bad. But then, the worst-case scenario, this leads to poor protection of your structure. And if you actually start losing metal off your structure, that's something that we don't want to be seeing. So, these are things that your inspector can help to ensure that you get a good product so that you are having good protection of your structure for the long term. Kind of went through some of these in the spec section, but here's our critical stages of a coating inspection, and some photos that you can see. For example, surface cleanliness and profile. You can see here, there's some pitting that remains on the surface. Ideally, this would be removed or filled before you have the coating application. Here's one of our staff using a replica tape to get a profile of this coating repair section. And having—you can use something like this, profile comparators. And this makes sure that you have a good enough angularity on your surface to get a good mechanical bond of your coating and good adhesion of your coating. Next, here's an image of a soluble salt test. This tests specifically for chlorides on a surface. There's a kit that you can buy. And you put some liquid in here, rub this onto the surface, and then there's a glass tube that I have in one of the following slides. You'll be able to see that you can—with a sponge in it. It'll pull up that liquid and it will tell you if you have chlorides on your surface. If chlorides remain underneath the coating, you can have some pretty serious problems with rust and premature rusting through your coating. Next is checking for thin spots. Make sure that the contractor does a stripe coat. And some of these you can see in these images here in the lower left corner. There's some pretty complex geometries here. Welds, for example, you also would like to see stripe coats over. Any crevices that you might have, you'd want them to be filled before your coating application. And just to make sure that they are meeting the coating thickness requirements in these hard to coat areas. And then, you would test that by doing a dry film thickness measurement, a DFT measurement, after each coat. So, as I said before, a spec requires two, three, four layers of a coating. And you would want to do that after each layer and confirm your DFT. And then finally, this is just one example of a tool for doing holiday testing. You moisten the sponge, run it over a surface. And with the electrical connection, it usually gives a—oops, sorry—an audio, little beep, for example, if they find a pinhole in your coating. These are, kind of, some examples of the critical stages of your inspections. And we'll go just a little bit more into that. Testing tools and techniques—on your surface prep side, one of the big things we see that we can see problems with is that the contractor fails to properly protect adjacent surfaces and equipment. So, you could get... spatter, I guess, or misting of your coating as it's being applied, onto to incorrect locations. And you want to make sure that they're taking measures to prevent that. Again, at sharp edges or irregular surfaces and pits, you want to make sure that they're grinding these out and removing these because they can cause further problems if you coat them without proper surface preparation. And again, general surface cleanliness. You want to make sure that after they do the abrasive blast step, that they then clean the surface so that it's free of the blast media. You want to make sure, before they coat, that there's no rust or other visible contaminants on the surface. This could

be, you know, if they have certain weather conditions where they could get flash rusting, for example. So, they blast it and maybe leave it overnight. And then the next morning, come in and want to coat, but there's some rust on the surface. You want to make sure that they don't start coating over that. And then, if there's oil or grease or contaminants like this as well, point those out. And then, as I mentioned before, that soluble salt contamination. And over here on the right, in the blue, these two little glass tubes, here, are examples of what the test kits look like. So, you would put the liquid in here, rub that onto the surface for a certain amount of time, and insert one of these tubes with the tip broken off. The liquid gets sucked up into the tube. And based on where this color change happens, will indicate the presence of chlorides on your surface and how much chlorides you have on your surface. And then there's ranges where you want to make sure that you don't go higher than certain levels of chlorides. And if you do find this, then they need to clean the surface again and remove those chlorides before they do their coating. And we mentioned surface profile. There's a bunch of images down here in the lower left on surface profile. Each type of coating typically has a mil target—a target mil profile. [laughing] I'm not saying that correctly. So, you might say that this coating needs a 2.5 mil profile. And what we mean by that is this kind of angularity that—the distances between peaks and valleys on your metal surface before you apply the coating. And you really need that to get a good mechanical adhesion of your coating to the surface. One of the ways to test that is with this tape, a replica tape. This one happens to be brand name, Testex. You can buy these in little rolls. You stick this onto your surface, use one of these little ball peen tools that come with the tape. Rub that on there and then use the micrometer to measure that profile and confirm that profile. There's—in the specs, there's many different standards that are listed for each of these surface conditions. So, this is an SSPC booklet that you can get as a comparator tool for surface profiles. There's ones for, for example, your rust condition on your surface cleanliness. And so, all of that information is included in the specification. And an inspector should be familiar with those different standards that are available. What standard is called out? For example, in some cases, you might only need this SP2 surface finish. Probably not, but [laughing]. But if that's called out in the spec, then you want to make sure that that's met. Whereas a lot of times you're down here more on, like a, you know, a white metal blast or something like what we would call—where you see very little rust and contamination on the surface, it looks like a very clean surface before they start coating. And you want to make sure you know which of those standards is called out in the spec, and then that the contractor meets those standards. Moving on to inspection tools and testing for the application process. There's certain environmental testing that you should be doing, or that you should be observing the contractor do before they coat. For example, your ambient and surface temperatures, the surface temperature of the structure, the relative humidity, the dew point, and the wind speed. And then many coatings have specific requirements that they cannot be applied unless environmental conditions meet certain requirements. Again, your dry film thickness testing. This should meet the spec for a chosen coating product. So again, your spec will say something like, we need coat number one to meet 6 mil to 8 mil thickness. The final DFT should be between 18 and 20 mils, or something like that. And you want to be familiar

with what's in the spec, and then make sure that the contractor meets those DFTs. And again, you should focus, try and focus on difficult to coat areas like some of those corners or edges or where they have welds, for example. Make sure that they're doing their stripe coats and fillers. Make sure that they meet that DFT in all these difficult areas, and that they're using filler materials on things such as rivets, seams, if they have skip welds, any irregular surfaces—pits, crevices, etcetera. And then, as well, there's also some other things that the inspector should be checking on. And these include things like recoat windows, making sure that the contractor's not exceeding the recoat window for a given coating product. Looking for other coating defects, things like amine blush, off-ratio application, contaminants, etcetera. And then the final inspection—again, you want to go and confirm the DFT and pay special attention to those difficult to coat areas. The final inspection is where the contractor inspector will be doing their holiday testing, looking for any pinholes in the coating. Look for, just any signs of visible damage. For example, over here there's—oops. Over here, there's some sags or drips, I guess, in the ceiling of a pipeline. So, look for things like that—runs, sags, blisters. And then if there is potentially a problem, you might ask for an adhesion test to be performed. And these are—you can't see the backside of this, but it's a little metal dolly that basically gets glued to a surface and then pulled straight off. And you see, in this case, that the adhesion was very poor on this particular coating. And certainly, if you see indications like this where you would already have rust starting, for example at rivets or at crevices, or you've noticed that they haven't filled in those areas. And then, finally, you want to make sure that the coating is not put into immersion service until it's fully cured. There are underwater cure coatings, but most of the coatings require a certain amount of cure time in atmospheric ambient conditions. Make sure the temperature requirements for that cure are met until they put that in service. Moving along into the cathodic protection inspector. Very similar to the coatings, the Reclamation CP inspector is typically the Project COR. And we're also trained and available at the TSC to come and be inspector for cathodic protection systems on your job site. Again, the role is to observe the installation and the testing of the cathodic protection system. This testing should be performed by the contractor's inspector. Verify that only approved materials are installed. One of the biggies that we always see is contractors try and use the improper cable for burial. There's very specific cable that's allowed for cathodic protection systems, both in the gauge and the sheathing on that cable. And, especially if it's meant for burial service, it's also much more expensive than what you would typically use for atmospheric exposure. And so, we see often, incorrect cables being used. And then, the COR and government inspector's job is to approve any troubleshooting that's required. Or defer this to the TSC staff for approval of any changes or troubleshooting that needs to be made with the CP system. As we said for the coatings, the CP inspector doesn't typically perform the testing themselves. Rather, they observe the testing that's performed by the contractor's hired inspector. This is both during energizing a system and testing a system. And then, these results all have to be submitted to the TSC by the contractor. Again, benefits of the knowledgeable inspector are assurance that you're getting a quality product. Assurance that your CP system is adequately protecting your structure. So, you don't want to install the system and spend all that

money and time to install the system, and then not have it meet protection criteria. Tools for the CP tests—some of the things that you want to make sure that the contractor has the proper tools for are—typically, we use copper/copper sulfate reference electrodes when we're testing cathodic protection systems. You can see a picture of that in the upper right. To make sure that the contractor calibrates this to an electrode that is not used in the field. So, we typically have one that we call our "truck electrode," it stays in the truck. It doesn't get used. And every day, we calibrate to that electrode. Your field electrode should be within 5 millivolts, and that's considered stable. And if that doesn't meet that, then they should re-prepare the electrode—dump out the solution, use distilled water, make sure that there's solid crystals that are remaining in the electrode, visible through that window. The second common piece of testing equipment for CP is your portable voltmeter. The big thing here is that you want to make sure it has a minimum impedance of 10 megaohms. Some of the less expensive, typically also smaller multimeters—that you would buy at a hardware store, for example—don't have this input impedance. And they can actually affect the measurements because the circuitry inside the device itself does not have enough impedance to give you accurate measurements of only your system. And again, in the middle here, photographs—those are two examples of, these happen to be Fluke multimeters, that we use here in our lab. And then finally, if you're working with an impressed current system, and especially for pipelines, then you'll have to interrupt the current to do the testing. And on pipelines, you want to make sure that if there are multiple rectifiers on the system, that all of the rectifiers affecting that area are interrupted simultaneously. So, this is really easy to do now, they have GPS-synchronized, time-synchronized interrupters. You set two or three of them up on the pipeline, and then you test the test stations in between them. During installation, things that you might want to look out for as an inspector are the metallurgical bonds. You can see an example up there in the upper left, like thermal welds or CAD welds. Typically, you would want to make sure that someone does a hammer test on these. Basically, it is what it says, you hit it with a hammer, and if it doesn't pop off, it's a good weld. And then, the other two things are electrical continuity and electrical isolation. So, in the other photograph you can see a kit for a flange or a joint where you would have isolation. The gasket, as well as the bolts, are isolated so that you do not have continuity across that joint or flange. In some cases, you want continuity. So, you want to just make sure you're familiar with what the spec calls for at that location. And that they're—if they require isolation, that they're doing an isolation test once they've installed it to make sure that that's what they're getting. Okay. As well, on a galvanic anode system—for example on gates, if you have a direct-mounted anode, you—once the anode is welded to the structure, typically you can use your multimeter and just test between the anode and the structure. Make sure you have good continuity there, as well. And then finally, once you're ready to energize your system and test your system, you want to check to make sure that it's meeting the NACE criteria for protection. And the big one here is your polarized potential, also known as your "instant OFF" potential. And for example, for steel, the NACE criteria is that it either must meet the minus 850 millivolt—this is using a copper sulfate reference electrode—or more negative. Or it must meet a minimum of a 100 millivolt shift more negative from the native potential. And

then at Reclamation, here at the TSC, we also recommend that the system not be energized more negative than minus 1,100 millivolts to a copper sulfate electrode, in order to avoid things like damaging your coating. That right there, that paragraph, it's like a whole day's training [laughing], typically, in our CP classes. And we do have a webinar that's available on cathodic protection system training, where we go a lot more in depth into those criteria. So, there is resources available if you want more information about that. The other things that you typically see a contractor testing for in certain types of systems are the current output from each anode. For example, there's a junction box over here, and each of these dials is a variable resistor. Each of these lines here is a shunt. And so, they can actually test across the shunt to get the current output from each anode, and then use the variable resistor that corresponds to that anode to adjust the current output as necessary. They'll also need to report rectifier settings, and then any adjustments that they make to the system. If they go through and test and they do not meet that criteria, they should record if they, for example, turn up or turn down their rectifier, things like this. Finally, this is our last slide. So, as well as all of the training offered—the certification training offered by these professional societies, such as NACE and SSPC—we have some TSC-sponsored training. We have a three-day Coatings and Corrosion School, which takes place in Denver, typically once a year. The next one hasn't—we haven't set a date for the next one yet. This is lectures and hands-on training, and it takes place here in our Coatings and Corrosion Labs. We also have these webinar series, twice per year, typically in the February-March timeframe and the June-July timeframe, depending on what my schedule is. You can email me, there's my email address. I'll put you on the mailing list and you'll get any further notices on the webinars. And there's the names—we now have seven webinars available, once I get this one processed and captioned and everything, and up on the website—those are available. And that final bullet is our TSC training website. As I said, right now, it's only on the intranet site, which means only DOI employees can access that. But hopefully very soon it will be pushed to the internet site, and then it's available, as well, for those of you outside. And that's, that link will get you to the PDF of the sides, and as well as videos of all the Corrosion Webinars. Finally, thank you for your attention. Here's all of our TSC Coatings and Corrosion staff. I am happy to announce that—well, I'm not happy to announce that Roger retired, but Roger did retire, we lost him last month. And I'm happy to announce that we're getting two new cathodic protection specialized staff here pretty soon. So, you'll see two new faces on this slide for the next webinar.