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Pam Cole: Hello. Welcome, everyone. I'm Pam Cole with Pacific Northwest National Laboratory and I'd like to welcome you today to DOE's Energy Codes Commentator Webinar Series, and this one is on energy code compliance for metal buildings. We do a webinar every Thursday every other month, so to speak, at the same time, so keep a watch out on energycodes.gov training space as we add new webinars. And if you have any new topics that you would like to, for us to review, more than happy. Send them in the way you register, or you can send them in through our help desk, and we'll provide those avenues as resources at the end. On the webinar we are gonna be talking about metal buildings, how to show compliance to metal buildings, and we're gonna demo COMcheck software, DOE's COMcheck software, go through some of the logistics of metal buildings that are in the software, and we have a presenter today that's actually very knowledgeable in metal buildings who's gonna walk you through some of the applications, some of the code requirements, and some of the things to be familiar with when you're dealing with metal buildings.

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They are their own really animal, and we do get a lot of questions for metal buildings through our help desk, and so we know this is pretty, topic that's of interest to a lot of people throughout the US. Metal buildings are built everywhere. We do have some learning objectives for today. What we'd like to achieve is learning how the building energy code defines a metal building, and then understanding the differences between an unconditioned, a conditioned, and a semi-heated spaces within these buildings. Also we want you to be able to provide how you can look up these assemblies. There are references in ASHRAE 90.1 and IECC provides references and so forth that we will discuss today, but there are lookup tables that are very important when it comes to metal buildings that you'll want to pay attention to. Those are gonna be very helpful for you as a resource. And then we also want you to know how to use COMcheck. This is not a COMcheck basics webinar today, but so we are really gonna focus on just metal buildings and those assemblies within the tool. I will go over some of the highlights of COMcheck and how to use it, but again we're gonna really focus on –

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some of the real fine-tuned things that are in COMcheck. So I

would like to introduce you to our first speaker, and his name is Dan Walker and he is the associate general manager for the Metal Building Manufacturers Association. And Dan, he's a native out of Cleveland, Ohio, and he's attended the Cleveland State University. He has a bachelors of science and civil engineering way back in 1996. He's a member of – I'm not gonna say it right but he's a manager of Tau Beta Pi engineering honor society, and his list really goes on and on and on. He is one of the experts when it comes to metal buildings and we're really appreciative that he's taken the time to help us today and to provide the information that he has. And so I just want to turn it right over to Dan, and if he has any more that he'd like say about himself – I mean he's with ASHRAE. He's IECC. He's really involved in the codes, and so I'm just gonna turn it over to him. He's a great presenter. So, Dan, I'm gonna let you go ahead.

Dan Walker: Okay, great. Thanks a lot, Pam. I really appreciate it. And I would just like to thank PNNL for hosting this webinar, and especially all the attendees that are logging in today.

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We have over 1100 people that have registered for this course, so no pressure. Primarily what we're gonna cover in this course, there are going to be three parts of it, as Pam said. So an introduction to metal building systems so you understand what they are, how to identify them in the field, and then what code provisions apply for metal buildings, and then we're gonna get into some prescriptive compliance methods, primarily dealing with insulation that's used in metal building systems because the insulation systems specific for metal buildings are really the defining factor that makes a metal building system what it is as defined by the codes, and I'll explain more of that later. And then as Pam said, she's going to get into some of the specifics about metal buildings with regard to the COMcheck software. I'll start with a really brief introduction to MBMA, or the Metal Building Manufacturers Association, and we're located in Cleveland, Ohio, as Pam said, since 1956. We started with 13 charter member companies and today we've got 43 members who produce the buildings. They are the fabricators of metal buildings. And then we have 71 –

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suppliers that supply all different sorts of parts and pieces to the industry that make metal buildings what they are. Our statistics program shows that metal buildings comprise about 45 percent of

the new low-rise non-residential construction, and that's for building that are below 60 feet in height, and not including the dormitories, hotels, and motels. And we estimate about 9,000 builder contractors across the country are involved in our industry, and we collect data on how many metal buildings are being built every year and it's about 28,000 projects per year. So a pretty significant number of metal buildings are going up, and that number continues to grow each year. So just a quick idea of what metal buildings are not just so that we don't have any confusion here. They are not pre-fabricated modular buildings. These buildings are erected on site. They're not erected in the factory and then delivered in a whole piece to a job site. They're actually erected on the ground just like a conventional steel building would be. They're also no longer pre-engineered buildings.

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I know the term pre-engineered is still used in the marketplace because it's sort of an identity for our industry, but the pre-engineered building market really stopped working that way in the 1970s when building codes really started coming in and every building that was used for commercial purposes needed to be custom designed by an engineer. And so our industry produces buildings that all 28,000 of those projects are custom engineered steel buildings, and no longer picked out of a catalog. And so the name pre-engineered is really a misnomer, and that's why we call them metal building systems. So to identify a metal building system from another type of construction, you'd see some things in the field when you look up at the framing that would give you some signs of what you're looking at. And many times the structural steel members are tapered. Typically frames are spaced about 25 feet apart per bay. The columns and beams can be tapered. They're not always tapered, but many times they are.

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The secondary framing is usually cold-formed steel made of purlins and girts. Sometimes there are C-shaped structural members. Sometimes they're Z-shaped members. They're oftentimes spaced about five feet apart, and then the roof is on the building. And the one thing about metal building systems is nearly always they have a metal roof on them, but they don't always have metal walls, and I'll show you some examples of metal buildings that don't have metal walls and you'll find that they're very hard to differentiate from other types of construction when you look from the outside. Another part of the metal building system is the

bracing, both lateral and stability bracing for structural members. Of course connections, screws, nuts, and bolts make up the parts of metal buildings, and then additional items that are provided by the supplier members of our association and that's for insulation, windows, doors, skylights, all the different parts and pieces that make it a complete building system. And so what I'm showing on the screen now is some metal building framing as a building is going up –

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and this is pretty typical of a metal building. If you look at them you see them going up this way. They're not always rectangular. They can be almost any shape or size building. They range everywhere from a couple thousand square feet up to a million square feet depending on the end use of the building, but when you see one going up this way, this is pretty much the way metal building systems look. They can also incorporate bar joists in the roofs. Most often it is steel purlins, like shown in the picture here, but they're very versatile structures and – but at the same time they really are no different than any other structural steel-framed building that you see, other than a few nuances that we're going to cover today. The energy codes in general, if I'm gonna talk about that in general, they differentiate construction types as the defining factor of what the code requirements are in terms of insulation especially. They also do it by climate zone and by the type of building that you have –

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whether it's a residential building or if it's a, what you call a commercial building or non-residential, or if it's an agricultural building, depending on how it's defined in the code. But those are the different ways that energy codes are defined. This is how metal buildings break down in the marketplace. About 14 percent of them are agricultural buildings. Roughly 20 percent go into manufacturing, about 40 percent into commercial, and then the rest are either community or some other type of buildings type. This is somewhat important because of the way that the codes identify them, and you see this commercial segment is about 40 percent, and that continues to grow all the time. That's retail buildings, office buildings, and includes warehouse as well. But you're going to see metal building systems appearing in code compliance situations for all sorts of buildings, including retail and office space, and it's not uncommon to have them used in that. So here are some examples of photographs of different types.

Manufacturing and distribution buildings, which are more traditional looking buildings, and agricultural you see here. But we also do a lot of recreational facilities –

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gymnasiums, practice facilities. A lot of NFL practice facilities are metal building systems. Many of the Olympic Games have been filmed in metal buildings. So they're just all over the place, and you have to know how to work with them with the codes. But oftentimes an entire school building can be a metal building, fire stations, aircraft hangars, all sorts. Now these are examples of buildings that you might not think were metal buildings when you look from the outside. And so for a building official really you need to get inside the building, take a look at the plans. You'll identify it pretty much right away if you pop the ceiling tiles and look at the roof framing. That's really the, kind of the giveaway that will tell you that you're looking at a metal building system because the framing, the cold-formed steel framing and the tapered frames or the fabricated steel frames are there and you know what you're dealing with. The energy codes define metal buildings in a number of different ways, and it's difficult to explain how they came about with this but it really works –

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because you have to differentiate a steel stud building from a metal building. They both use cold-formed steel. And wood framed is more obvious and mass wall buildings are more obvious because the construction is a different material, but metal buildings use the same material as a steel stud building but they have different requirements in the code. And so how they came to differentiate those requirements was to define the metal building. So metal building systems have metal roof and wall panels. The purlins are nominally spaced at five feet on center. That's the roof framing. The girts can be spaced as much as 52 inches on center for code compliance in energy, and then the metal building insulation is further defined as being compressed between the metal roof panel and the purlin or girt at the wall. Now not all the insulation is compressed in the modern codes, but that was the original definition of a metal building, so you don't get it confused with a steel-framed wall building. And then again a picture of the framing system that we have there with the tapered frames.

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And most of what I'm gonna talk about today is building envelope related stuff, because the mechanical systems, the power and lighting systems, the service water heating systems, these are the four areas that are really covered in ASHRAE 90.1 and the International Energy Conservation Code, but the differentiating thing for metal building systems is really in the building envelope section, and to be honest I'm not a mechanical expert so I won't be getting into any of that. I won't be getting into power and lighting, and so we won't deal with that. But we'll dive right into the building envelope provisions. So in terms of insulation we've got the drawing of the metal building shown on the right there. You have the roof framing, walls above grade, walls below grade, and floors with slab on grade, and these are the primary types that are covered by the building code. It's not just a metal building thing, but that's how insulation systems are defined in the code in terms of the requirements. You also have cool roof requirements, window and door and skylight requirements, air barriers and air leakage. So –

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the point I'm trying to get across here is that metal building systems are not exempt from really any of these. I mean they are just a building like any other type of building and so they have to meet all these same requirements in the code. And really the thing about metal building systems that is different in the code, and really the only thing, is the insulation section. And so every other part of the project, when you're talking about whole building air leakage or you're talking about the cool roof requirements or the requirements for ventilation, the requirements for air leakage of components like windows and doors, they have to meet the same requirements. The products may be a little bit different because they fit into a metal building, but they still have to meet all the same energy code requirements. So really it's the insulation systems that will look a little bit different. There are also different use types that we'll get into that metal buildings sometimes will fall into, like semi-heated. So the IECC, or International Energy Conservation Code, really points to ASHRAE 90.1, and most of the insulation requirements and a lot of the code provisions –

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in the IECC come out of the ASHRAE 90.1 committee where a lot of that work is done. They meet four times a year face-to-face and then they meet numerous times during the year on conference calls, so it affords a lot more time to debate what the requirements

should be and to do some research on those requirements than the IECC process does. But the nice thing is that those two things are usually pretty well aligned with each other. And IECC actually references 90.1 in a number of different places in the code, and in the building envelope section that we'll point out 90.1 is actually the first choice offered, and then IECC is another way to meet the code requirements. So we have two different types of codes here, the IECC and 90.1. The difference really between the two, at times they will be a little bit more different because they're developed under different cycles and so the 2015 IECC references –

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the 2013 ASHRAE 90.1, and then like I said before 90.1's requirements are developed first and then they're adopted into the IECC. And so there's a time lag there, so at times the IECC may get ahead of 90.1 in terms of its stringency, and there are times when it may fall behind. But both of the documents cover almost all the same things with the exception of semi-heated spaces, and semi-heated spaces is defined really only in ASHRAE 90.1, and so if you have warehouse buildings or you have manufacturing buildings that are going to contain these spaces that are semi-heated, you would use ASHRAE 90.1 for compliance for those in all likelihood if there's gonna be any heating or cooling at a low level. So again just different types of spaces that you deal with, and you have different requirements, and the reason I show this slide is that all of these still have to meet the code but they may have very different space heating and energy code compliance requirements depending on an agricultural building which may have none –

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so it may have less than the minimum required energy use per square foot for heating equipment, or you could have an aircraft hangar that maybe is semi-heated all the way up to a restaurant or a healthcare, religious building that could have different requirements. And then a lot of times you'll find them in office and warehouse applications where you may have a mixed use, where you have some conditioned space which could be contained inside the building, like in this case the office and the retail space for this building is included inside the building envelope, and so behind that, past those conditioned walls, is a semi-heated space in that building. And so you have two different space conditioning requirements in one building, and Pam would be able to show you how to handle that in COMcheck. Still make it simple. Even though you're in ASHRAE 90.1 you can still use COMcheck for

code compliance. It is not difficult at all. So we'll take a look at what the space conditioning requirements are.

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In 90.1, as I said before, you have semi-heated buildings, but in the International Energy Conservation Code there's no such thing there, and so you have, you do have a provision there called Low Energy Buildings and those are buildings that are exempt from the building thermal provisions if the peak design rate of energy use is less than 3.4 Btus per hour per square foot. And the way to look at that is that's the heating equipment capacity. Every piece of heating equipment has the number of Btus per hour that it can put out in terms of its heating capacity. If you take the heating capacity of the equipment and you divide it by the square footage of the space being served, you get a number. That's the 3.4 we're talking about as a lower end threshold, so if you exceed that 3.4 in the IECC with your heating equipment, then you're considered a conditioned space. And so conditioned spaces are any area or room within a building that has a heating or cooling equipment capacity divided by the square footage of the space being served of greater than or equal to 3.4.

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So what seems to be a confusing thing at first glance actually is fairly simple. It's all based on the capacity of the heating or cooling equipment that is serving the space, and that's by design. So ASHRAE 90.1 conversely, it has similar limits thankfully so you don't have to worry about different numbers, but they do have this thing called a semi-heated space, which is sort of a space that's somewhere in between unconditioned and conditioned, and the rule here is that the semi-heated spaces are heated only, but only to protect from freezing for the most part. So not to comfort levels, not to habitable space levels, so you're not heating to 68 degrees. The design temperature actually, if you look at whole building energy modeling, is about 50 degrees Fahrenheit, and so a worker in that space would have to wear a jacket to stay comfortable, but would still prevent freezing. The most important thing about semi-heated spaces is they are not cooled spaces. They are heated only –

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and they are heated to a lower equipment capacity. And I'll just make a comment on that. You know there are different climate zones throughout the United States, so we have actually nine

climate zones now, from climate zone zero all the way through climate zone eight in the most recent version of 90.1, and each climate zone has different heating needs. So the design temperature, the heating degree days and the cooling degree days in those zones are different. And so it will require a different amount of heating capacity to maintain that 50 degree temperature or that 68 degree temperature, depending on if you're a fully conditioned space or if you're a semi-heated space. And so the threshold on the upper end moves. The lower end threshold of 3.4 does not. So if you're below 3.4 Btus per hour per square foot, you do not have any energy requirements in terms of envelope. Now lighting still applies and other things still apply, but the building envelope and mechanical is gonna be dictated by that.

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But if you're between 3.4 and the upper threshold, then you are considered a semi-heated space. Above the upper threshold in the ASHRAE 90.1 standard and you're gonna be a conditioned space. Okay. That may seem a little more confusing, but I think if you think about Alaska and the amount of heat that it takes from a piece of equipment to heat a space to prevent it from freezing, you see that it would have to put out far more than 3.4 Btus per hour per square foot, but in Florida the piece of equipment would be minimally sized because it's not challenged by the temperature. In terms of compliance methods, all three, all two of these codes, IECC and ASHRAE 90.1, allow you to use different paths, and so the prescriptive path is the most simple path. It's really very cookie cutter. And then you've got the trade-off path which gives you a little more flexibility. That's where COMcheck comes in. And you've got the performance path. And today on this webinar we're really gonna cover the prescriptive path and the trade-off path.

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And I think those are really going to be the two most popular paths for low-rise metal buildings and probably for most low-rise buildings, although the performance path is always available if you have someone who's qualified to do an analysis. The performance path does require whole building hour by hour energy analysis, and I'm sure Pam and the folks at PNNL could explain how to do that in a separate session, but really the trade-off method is what we are gonna focus on here, and the prescriptive requirements, and that's, like I said, where COMcheck comes in. That's where you can do UA tradeoffs and U-factor substitutions, and it's fairly simple to do and that's really the focus of this webinar today. A prescriptive

path is always available to you. I will tell you that it is the easiest, but it's also the most limiting path and it just sort of depends on which version of the code that you're using, because these things are constantly in development and it just becomes sort of the benchmark for the other methods. But it is a bit more limiting, so I –

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I always encourage people to take a look at the trade-off path because it does give you a lot more options for what you're gonna provide in terms of building for your building owner. In the 2015 IECC we have air leakage provisions that are relatively new to some people because the 2015 IECC, now being probably the most referenced code across the United States at this point, has whole building testing requirements. They are 0.40 cfm per square foot, or you can do some other measures including air barrier sealing placement that complies with materials, materials that comply to 0.004 cfm per square foot, or assemblies with an air leakage rate of 0.04. Assembly air leakage testing has to be done in order to use that 0.04. If you don't have those assembly air leakage tests on the particular system that you're looking at – and now that assembly –

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is really a two-dimensional assembly. It's tested in a ten by ten frame, probably a ten by ten frame, so it does not encompass all the different joints of a building that could leak. And so that's why the 0.40 cfm per square foot is there. It's for people that want to run a whole building energy test. It does allow you to do the assembly testing, and we've done some of that in the metal building industry and I will show you some of those results in just a minute so you can use those assemblies for compliance. 90.1 takes a slightly different tack, and as I said before they're developed in concert with each other to some degree, but 90.1 gets developed first. And so in this case it's not quite as advanced as the IECC in terms of the air leakage there, but you do have the option to use materials with low air permeance the same rate, 0.004, or assemblies with an air leakage rate of 0.04. So all the seams, penetrations, and transitions –

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between materials have to be sealed in order to use that 0.004. If you have a material that qualifies as an air barrier material, anywhere that that material is disrupted in the building, or if it has

a seam in it or a joint in it, that has to be caulked and visually inspected. If something is going to be tested as an assembly, you're getting a little more information about the performance of that thing and it's undergone some sort of a rigorous protocol to show you that it can survive the pressure differentials. So that's kind of the difference between those two methods. In the 2015 IECC climate zone 2B is exempted from those requirements, and that's just an exemption that was created there for various reasons, but in 90.1-2013 there are a few other exemptions that are listed. Single wythe concrete masonry buildings in climate zone 2B again and semi-heated spaces in climate zones one through six are exempted.

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So climate zones seven and eight, if you have a semi-heated building, you still have to comply with one of those air leakage methods. This is a picture of one of a seams in a metal building. This particular one was actually at a sister laboratory of PNNL. This is from Oak Ridge National Laboratory, and this seam is a self-adhesive material. You peel and stick that and it will connect the two pieces together. These materials, these insulation materials, have a flexible air barrier on them, basically a vapor retarder, that also is an air barrier, and that has to be joined in some way in order to seal it up. And this is a, what we're talking about when we say if you don't have an assembly test for something, you would need to either run – you either would need to caulk or seal the seams. In this case they've chosen to use an adhesive seam, so I'm showing it here peeled back but that's as far as I could get it to go because there is adhesive underneath there that's keeping it from moving.

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And in that case it did a very good job of air sealing that building. But the other way to do that would be to have an assembly test. All the interfaces in the building need to be sealed. In this case, again, self-adhesive corners were done, so the tabs or the loose part of the insulation on the edges has that peel and stick and it's able to adhere on the walls. Any rips or tears obviously – now these are kinds of things that as a, in a prescriptive sense you're going to have to seal those things on visual inspection. If you did a whole building air leakage test, you would find whether or not those were big enough to worry about. If you meet the minimum requirements, I would still recommend that you patch all those tears, but in a code sense you would pass if you were less air leakage than the 0.04 required in the whole building air leakage test. And again penetrations that are sealed. And in the case here

on the left we have an unsealed penetration, and then on the right we have one that's been sealed with a putty that's made for that purpose as there were wires coming through a piece of conduit.

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I won't go on and on about the air leakage requirements. We've got a lot of material in here about that, but you'll have it in your handout. And we did some testing to see how the metal building system components, whether roof or wall components perform, and there is a test. This is sort of the list of tests that can be done to show compliance for metal buildings. Of course ASTM E 2357 is the – a test that shows that a material qualifies as an air barrier material. ASTM C – sorry, E 1677 is for low-rise framed building walls. 1680 and 283 are metal building sort of staples. The 1680 test is specific to metal buildings for metal roof panel systems for air leakage, and then 283 is a more common test used by other materials such as curtain walls, and those are the tests we used to show the air leakage again under 75 pascals, and we had to be better than 0.04.

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And so testing was done in 2011 at the NAHB Research Center by MBMA, and we tested a number of different systems to try to capture – and there's an example – of what one of those air leakage assemblies looks like, just for your information. So you put it in a frame, you do whatever sealing you're going to do, and then you come up with your result. And so we had pretty good results on all of the systems. Virtually everything we tested passed and so – I thought there was gonna be a chart in here, Pam. It's apparently not here. But we have a list of these available on the MBMA website at mbma.com. If you want to download that test we can get those to you and you can use those for compliance. So in the whole building application we're talking about the US Army Corps of Engineers test. They've got a limit to their test of 0.25 for whole building air leakage, that's cfm per square foot of the building, the five-sided box, and –

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when you look at the IECC, the value is 0.4 instead of 0.25, and so slightly different requirements. We did some testing on that same building where I showed the peel and stick membrane at Oak Ridge National Laboratory. This is an example of what a blower door test looks like. It's just put into a man door and the building is

pressurized. And we were able to, upon the construction of this building, it really performed pretty well to begin with. It was only 0.26 cfm per square foot. And then we did some retrofitting to close some of the obvious holes and to fix some of the little things in there. We actually got the building down to 0.12 cfm per square foot, which really is better than what the code requirement is. So it's entirely possible to do this with a little bit of care and a little bit of detailing. Let's get into some of the prescriptive code compliance items here. And so all the different parts of the building can be shown for compliance prescriptively –

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whether it's doors, windows, roofs, walls, you name it, and so the various different sections of the code that apply are shown here on the screen. So we have the roof assembly systems in IECC section 402.1.3, et cetera, et cetera. And so we'll go through some of these. These are for the R-value method. For the U-factor method it's a little simpler because there are some really concise tables there, and that's referenced in the slide as well. This is an example of the R-value table that's in the 2015 IECC, and I've got some highlights here to help sort of point out what's important to you here for metal buildings. All systems are included here. Insulation entirely above deck would be like a bar joist and metal deck type of roof where all the insulation, usually polyiso board, would be above the metal deck. The metal building definition is here for roofs, and then we have attic roofs and all other roofs.

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And then for walls we cut off the table a little bit there, but there are four wall types: mass, metal building, steel framed, and then wood framed and other. So going down the line and looking at a metal building, you can see the types of systems that get specified there, and there's some nomenclature that you're gonna need to know about what that means. We have ci's and LS's in there, and so the footnotes will be laid out here. Of course the tables is organized by climate one across the top horizontally, so you go climate zone one through eight in this case. Climate zone zero was added to the ASHRAE 90.1 in the last go around, not adopted by the IECC yet. But all the climate zones are, they're defined. From there you've got all other buildings in Group R. So Group R is residential buildings, whether they're commercial residential or homes, and then all other includes just about everything else that you can imagine, including commercial buildings. And again as I said –

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there is no semi-heated building in the IECC, so they don't have a special designation for that. Roof section is shown here. We have walls above grade, walls below grade, floors, slab-on-grade, and then opaque doors, which I mentioned earlier in the presentation. It's all how it's organized. Metal buildings have their own category, as I said. They're defined in the footnotes, and as we say here the assembly descriptions – and this is in the IECC, mind you, but it says the assembly descriptions can be found in ASHRAE 90.1 appendix A. And so you almost have to have ASHRAE 90.1 at this point to use the IECC for metal buildings so you can see how these assemblies are described, but prescriptively it's pretty obvious once you know what an LS is or what a ci is. You get to figure that out pretty easily. So in terms of the tables here for R-value compliance, as I said, we have LS standing for liner systems.

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LS, that's the designation that you see here, along with the insulation. So this first number, R-19, indicates the insulation that goes over the purlin. This is actually the second layer that's installed. The first layer goes and it's supported by some banding that goes in between the purlins. And you can see that this insulation in the lower area is uncompressed insulation so it has virtually its full R-value. This insulation that's laid on top of that in the second layer is compressed at the purlin where the metal roof panel comes across, and there's the standing seam roof clip and then the thermal spacer block that's in there. But that's where we see the definition of a metal building including that compressed insulation, so this is really what defines a metal building in the code. But that's what a liner system looks like. There is some banding that runs perpendicular to the purlins that's attached by screws, and then the insulation is laid on top of a vapor retarder and it's a very clean look. It almost looks sort of like a drop ceiling system in the building –

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but it makes a nice uniform look and really fills that space up with insulation. And prescriptively they're talking about fiberglass, and that's what's shown in the drawing here. That's what you need to know about these. LS is fiberglass insulation in the case of a metal building, so both of these insulation layers are fiberglass. If you wanted to use a different material you would have to use U-factor

substitution, which is simple to do, and I think Pam will probably cover that a little bit in the COMcheck section of the presentation. How am I doing for time, Pam? Looks like –

Pam Cole: You're good. Yeah, you're okay.

Dan Walker: Okay. So on the wall section we have some different nomenclature. The ci stands for continuous insulation. Continuous insulation is material that's continuous across all structural members without thermal bridges other than fasteners and service openings. Okay. So this is considered continuous insulation. It's shown here as a board product –

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in this case. It could be fiberglass boards. It could be, even spray foam insulation can be continuous insulation if it has uniform thickness. But this material can't be compressed because it has a density to it. Now this fastener does not disrupt that because it's allowed in the definition of continuous insulation. Now this fiberglass next to it here, that is not continuous insulation. That is compressed and so it does not meet the requirement for continuous insulation. The two used in conjunction could be called R-13 plus R-13ci with the board product being 13ci and the R-13 here. And so there are different ways that that could be installed prescriptively, or if someone wanted to they could use U-factor substitution and do a completely different type of insulation. As I mentioned before, not all metal buildings have metal panel walls. Some designers may choose to use metal panel walls, and so what they really want, maybe what they really want here is stucco or they want a block wall. In that case –

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they would not be using a metal panel. They would not use this insulation system. And so the code is sort of describing a very basic building, and if you have variations from that in your design you're going to have to understand U-factor substitution or COMcheck. It's very easy to do. But you have to understand that the prescriptive sections of the code have to describe some basic building, and so that's what they're describing in the case of metal buildings as the most basic structure. But we can do just about anything if we use COMcheck or use U-factor substitution. And so if you want to see more insulation systems, ASHRAE 90.1 has a complete appendix full of insulation systems for walls, various different types in section A3.2.2, depending on the version of 90.1

you have. This is for 2013. That section could be different in earlier versions of 90.1. And so now we're looking at the U-factor method, and this looks a little scarier because we have very small numbers with U's in front of them.

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But we should not be afraid of the U. The U is a good thing. And so this gives us the flexibility to choose any type of insulation. Doesn't matter if it's fiberglass or spray foam. It could be spray applied cellulose material. It could be any type of insulation for any type of construction, and it really puts everything on an equal playing field, and you see that the requirements between the different types of construction are not really that different when you look at them in terms of U-factors, but when you look at the R-values they're wildly different because it takes different types of insulation to achieve the same performance in different types of construction. And so the U-factor for metal building roofs in all other or the commercial kind of stays the same for the most part at 0.035, which is a pretty good performance level. It's right up there with the performance level of the insulation entirely above deck, which is typically a continuous insulation system. But don't be afraid of the U-factors, though. U-factors are your friends and we can definitely deal with those.

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It does not require any specific type of insulation. It gives designers the option to use whatever type of insulation system that they would like to use. And so Note b here says you're allowed to use U-factors by suppliers if they're validated by testing means, and I think we highlight that in one of these slides. But so we're using U-factors, C-factors, or F-factors from 90.1 appendix A are permitted to be used. If you're going to use something that's not listed in ASHRAE 90.1 then it needs to be tested by the hot box test method, ASTM C1363. There are also calculation procedures in 90.1 that are specific to metal buildings for certain cases. If you're interested in looking at those, you can give me a call and I can walk you through how to do that. But for the most part everything you would need to do a metal building system project is in the appendix spelled out in nice neat tables. For walls the same thing. You have U-factors here. Of course they're not quite as stringent as the roof because walls have a lot more penetrations than roofs.

[0:38:00]

But looking at these, U-factor of 0.079 or a U-factor of 0.052 for the different climate zones, so not a whole lot of variation. There are quite a few systems that can meet that, and again same provisions apply. So you can use the 90.1 appendix. It's a different appendix table. Roofs are in A 2.3. Walls are in A 3.2. So that's where you find those, and again you can use hot box testing, and many of these U-factors have been hot box tested rigorously. So 90.1 has various different methods here. Space conditioning, you have R-value, you have U-factor method again, and these tables are basically the same information organized in a slightly different way. And so we have U-factors and R-values together in the same table. You'll notice that instead of having one table with all the performance values listed, in 90.1 they do it for the climate zone.

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And so if you live in climate zone six you can just tear climate zone six out of your 90.1 and stick it in your pocket, and you've got everything you need. But I don't advise you to do that because then you'll be missing pages in your standard. But so we have everything here we need, whether it's roofs or walls. All the different materials are listed here, insulation above deck, metal building, thankfully all the same as the IECC. So we don't have different definitions. The definitions for the construction types are contained in 90.1. IECC and 90.1 both use those same definitions, and so that's very helpful. The big change here, though, is we have this semi-heated table, and this chart here is for semi-heated spaces, as I said before. These are not air conditioned spaces. They can be mixed in with other spaces in a building, like a warehouse behind an office or in a manufacturing setting. And of course there's less stringency there. You see that in the metal building side here we have a U-factor of 0.031 required –

[0:40:00]

for the commercial case, which is an R-25 plus R-11 liner system. In the case of the semi-heated space, two layers of R-19 compressed together would be adequate. Now you're gonna ask me next, "I don't see an LS next to that second 19," and that's on purpose. That's a different insulation system and the LS is used to denote liner system. If there's not an LS there, that's a different type of system, and I've got a picture of one of those here. This is the liner system again where it has the fully uncompressed insulation in the first layer and then the compressed insulation in the second layer, and then we have the second system, the R-19

plus R-19. Very different looking system. This is for speed and efficiency, but there is no banding underneath. There is still a vapor barrier here. This vapor barrier is not supported by any metal mesh or anything. It's just held up by tension. And both layers of insulation are compressed at the purlin. So as you can see –

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this is not the same level of performance as a liner system, but it is efficient, it is cost effective, and so the code recognizes that for buildings that don't have as high of an energy use. Okay, and so there are the tables in 90.1 for the metal building requirements. Pretty simple there. And then just for fun we threw in a picture that shows an alternative compliance path because we can use U-factor substitution here. Let's do it. And so we've got a rigid board on the inside, a rigid board on the outside. Either one of these would comply with 90.1. We didn't have to use fiberglass. We could use rigid board. We like all kinds of insulation, so let's mix it up and try some different things. And so that's another way to do it, and it's not the same as using the fiberglass system. We can use board systems. We can also use insulated metal panels when they qualify as continuous insulation. And so the different methods are the same in both of these documents. So I mentioned before that 90.1 has a handy compilation of all the insulation systems for metal buildings, and I'm showing it here.

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This is table A2.3.3, and that's found in the appendix. That's what the A stands for. And it's got just about everything you could have for metal buildings listed, from systems that would primarily be used in a semi-heated application here, single layer. This is draped over the purlin and compressed. And then these are the double layer systems I showed you where both layers were compressed. And then down here lower we have the liner systems that are not compressed on that first layer and has a slightly compressed second layer. And you can see the variety of performance. An R-11 plus R-19 liner system has a 0.037 U-factor, very good U-factor. If we look at the R-11 plus R-19 double layer system, it's 0.072. So there's a big difference in the performance because there's less compression at the purlin. So I've highlighted here for you some options. If you had a requirement in a climate zone, let's just say we're building a project –

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in climate zone six. A conditioned building has a U-factor requirement for the roof in a metal building of 0.031. if it was a semi-heated building we'd have a 0.06 requirement for that same climate zone recognizing the lower energy use of that building. So what could we do to meet that? First we'll look at the semi-heated case. We can use no fiberglass. This is the first rated value of insulation, which is just for fiberglass. Everything in this column, these columns to the right are continuous insulation, so if you put no fiberglass and use R-15.8 of continuous insulation, the corresponding U-factor is 0.06. That would meet the intent of the code. You could – now in the conditioned case you could use R-32, which is continuous insulation. This would be for a roof. And R-32 would comply with the 0.031, so you could use a system that was not fiberglass. Looking at the fiberglass systems that comply, if you used R-10 or R-11 –

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you can add continuous insulation to those to get below that 0.031. So you can see how this table works. This insulation here, this continuous insulation in the right side of the table, is additive insulation to the fiberglass. Every case has a none case, which means no fiberglass. That's rigid board only. So it's a very flexible table. Lets you use it in many different ways. For the semi-heated case you could use a system of R-19 plus R-19, both layers draped over the purlin. That's also 0.06. So many different ways to use U-factor substitution in 90.1 or the IECC to get the same performance value. All of these methods would meet the code requirements, so we don't have to do this prescriptively. We can use R-value method or we can use the U-factor method. And so let's take a look again here at the liner systems for the conditioned case, and we'll go into the R-25 plus R-11, and that's 0.031. So number of different ways to get to that, and we have the same performance.

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So, Pam, I think that's the end of the formal presentation on the code part. Do you want to get going on the COMcheck part?

Pam Cole: Sure. Sure do. All right, Dan, great. A lot of detailed information that he provided, and we will have the materials out there available. So we're gonna go ahead and get started on the demo, and we're just gonna be really relaxed about this. I think Dan's gonna tag team with me on this one. He likes playing around with the software. So do I. Again, I'm Pam Cole with the Pacific Northwest National Lab. I've been on the Building Energy Codes

Program for over 18 years, and I manage the help desk, so when you submit a question you most likely will get me. So I know a lot about COMcheck and REScheck, and do some training on it as well. So with that, today just to give you some – this is we're gonna talk about very high level metal buildings, not really go into much detail, and I'm gonna put a case study out there later on just for metal buildings, and that'll be a resource for you that you can go grab and play around with.

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So Dan talked a little bit about the 2015, and now all codes can be different and there is something different about 2015 and 90.1 2013 as we moved into these newer codes. 2015 for the first time changed the way we calculated tradeoffs in COMcheck, meaning it's based upon a component performance basis alternative, where it made it much easier for us really because it really truly became a UA tradeoff, and that calculation and that section is in 2015. So that is kind of new to 2015 and how we recalculated. So if you were to take a project and you had an older project that you were complying with the 2009 and you wanted to compare it to 2015, I don't advise you to do that because you really can't compare the two because they're two different calculations in how COMcheck does it. And you could go back to 2009 and look at how that was done, but that was really based off of ASHRAE Appendix C methodology. This one is not. For 2015 only we are using that –

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that section in this calculation. And other codes, no, we use Appendix C as the baseline for the older codes. And then 90.1 2013 is its own animal because it uses full simulation and energy plus in the background. But we won't get into 2013 too much today. That is like a full day class if not a full week class to talk about 90.1 2013. But again you kind of have to tie the two together because with metal buildings you might be – you have that option to use either IECC in full or 90.1 in full, and again that means if you choose one or the other that includes everything, envelope, lighting, mechanical. All of it comes into play. You can't mix and match. So here we – I'm not gonna go too much more in detail on this one. This is just section C402.1.5, which is new, and this gives you the proposed U-factor, C-factors, and F-factors. Again, I always suggest go to those lookup tables in 90.1. That really for COMcheck is what we use, but this is the calculation that is the baseline for 2015. So, again, for the presentation today –

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I'm gonna cover some high level input screens. I'm gonna go into COMcheck, show you envelope only. I'm gonna look at the checklist. Definitely that's an important part of this, and the requirements tab that's in there, and that's somewhat new. It's been in there for over a year, almost two years now. But it really needs to be done by the designer and the designer really needs to go through and fill those checklists out before they submit their compliance report, and we'll get into that. The case studies, I'm gonna get those for you. The case studies, there was a comparison but that's not really gonna be helpful, so I'm gonna put a nice one together and we'll put it out there. I would say go back within a month, you know, and go out to the training page where you registered and look for that case study and we'll have it out there for you and make a really nice metal building. So let's go dive into this. Another resource right before I do – forgot about this page – is there are two videos, recorded videos that are out there that should be helpful. If you're not familiar with COMcheck, I always send people –

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to the COMcheck Basics webinar. It's kind of long and it really gives you the high level information about how COMcheck works. There's also REScheck for residential. And then I also did one for alterations, additions and that sort of thing that's a separate video, and I would take a look at that. So if you're doing alterations to metal buildings – and it doesn't get in detail about metal buildings, but it gives you the idea of how to show compliance to alterations within the tool. I would go take a look at those two recordings. And they're out there, again, under the training page. And here is a screenshot of the actual COMcheck page. So you have two options. You can either use the download the desktop or you can use the web tool. Here maybe in the near – not near future, but we might be transitioning to fully web-based tool. Not right now. Not anytime soon, but just keep that in mind. That might happen. REScheck we did. REScheck we're trying to transition to fully web-based. So those two tools are out there, but we're looking to hopefully –

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bring it all into the web-based because there's just more flexibility with that, and as you all know if you're dealing with many different contractors, especially on a commercial building, being able for

other designers or contractors to be able to jump into one project and having it out there web-based can make it nice and more flexibility to do so, instead of having to email a data file back and forth to different others that are responsibles. Example, lighting or mechanical. Okay. So I'm gonna go ahead and open up COMcheck and we'll get started and start playing around. And I was playing around with a building in here, so I'm, as I talk I'm just gonna show you things I'm doing. So if I was to open up a COMcheck and I had something in there, you always want to double check, make sure you're starting with a clean page, and that's what I'm going to do now is that I just went up to File and said no, I don't want to save this. So I'm gonna hit No. And now I'm working on a clean page, and this is the desktop version. This is the most recent one out there. That's another thing that I'll suggest is –

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look at the build version if you do have COMcheck. I would go out, uninstall, completely uninstall the version you have, and go get the most recent build version. We have these build versions for a reason. It's either we have a major release of the, a new code, but that only happens, we'll have that once, you know, happens once or twice a year that we might have a code version that comes in there, into play, which we call it our major release. But we do have some minor build versions that have to go in there such as maybe a minor bug fix or really enhanced features. And that's the big one. You want to grab those enhanced features because we do those because we get feedback from users telling us, hey, this would work better. We analyze it, we look at it, and if we can do it at a low cost we'll do it. So there is a lot of nice new stuff that's happened through the last couple years that our software developer is pretty busy putting these in. All right, so high level real quick, and then we'll start pulling in metal buildings, and Dan is gonna chime in anytime he wants. So if you're new to COMcheck, like I said, go to the Basics. But let's just go through real quick. At the very top is where you have –

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where you'd have your title of your project. It says Untitled because I don't have one open. And then the build version, which is this is the most recent one. And then the code. There are several codes in the software. DOE supports the last, the most recent version of the code and two versions back. So you'll always see three code versions within the tool, and then you'll see some specific codes that are in there. And again those are by the state

energy officer providing a state technical assistance request. If that's something you're familiar with, and we have a page on that, I would go out there and take a look at that information. But that's how those are in there. Those are gone through and approved, and those are ones where they have amendments, special amendments, and we have the ability to maybe model and put them in the tool. Doesn't mean we can put all of them in because some states have significant amendments that maybe it doesn't work, but those are why those are there. And then they have a free tool to use, so that makes it really nice to get the compliance going. All right, so the next down below that is the menu field, so you have File, Edit, View. Those are kind of Windows based options. They follow Windows applications.

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And under File, again, you see the options to save. You can save a report. You can email a report within the tool. You can export it. And when I say save, it's very important that there's two ways you can save a file in COMcheck. You can save a data file, so that's with a CCK extension, and you can save a report. The report is PDF. Make sure you're aware of that. It's really important that you don't skip and save a report and then you didn't save your data file. So pay attention to that if you're new to it. and then there's the edit feature, which has some preferences. Again, go look at the preferences if you haven't been familiar. That's where you can customize your stuff. I want to customize my signature line, I want to customize where I save my projects, and that sort of thing. That's under Preferences. View is the toolbar, status bar, but really important here is glazing requirements. And as the codes become a little bit more, I would say, strict to save energy and cost, then you really need to pay attention to glazing. And –

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while putting your project in, you might want to come up there and click on that, and it'll provide you a popup box, and it's calculating as you're moving along, as you're putting your fenestration in, it's gonna start calculating for you. And this is its own little application, meaning this is doing it outside of you running your project, because there are mandatory code requirements just on fenestration alone. There's the max window to wall ratio things that you could come up against, there's area weighted averages and they're based on the actual assembly now in 2015. Not all of the assembly is for fenestration. And so there are a couple things you want to pay attention to. And then the solar heat gain if that's

applicable as well, because there are limits on solar heat gain. And I get a lot of questions on this, and it's just because they need to go out there and take a look at, well, let's take a look at what those requirements are. But we made this other feature in here to make it easier for you so that you have it available, and it's doing the calculations for you so you know what you're up against as you're moving along with your project.

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Let's move along some more here. I'm gonna hit X to exit out of that. And then you come over, and I did use options. Now, those are all grayed out and they're grayed out for a reason, because I'm not within the tab that they would be applicable. And not all those options down below are applicable. It's based, it's code driven. And some are flexible, meaning even though it's code driven, let's say 2015 IECC, do I have to do orientation or is it required by code to do orientation? There are some things in there that will throw you where you wouldn't even have to check it because, for example, 90.1 2013 you have to do orientation or it can't calculate your building. So you wouldn't even have to click it. But you might want to show orientation doing 2015, is what I'm saying, so once you get started on it, before you put in a whole project in there, come up and take a look at what the options are available and the ones that aren't grayed out and see if that's something that you want to add to your project. There's also a comments and description field. For metal buildings this would be an important one, is when you get into having to choose other –

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as your assembly type, the more information you can provide on your compliance report the better because that's gonna help that plan reviewer, and I would start putting that information under the comments section, and I'll show you that in a minute. Then the last one here is your codes, and I explained that to you, how there's code versions in here, and right now we have four of them: 90.1 and three of IECC, because we just added 90.1 2016. We will be adding 2018 IECC. That's gonna be much later this year, and that will then take the basis of what the most recent versions of the code that are in there, and then we will start the process of removing the last one in there, which is the '07 and 2009. Again, states get informed of that. This isn't something we just do and not inform anyone. We provide as much information as possible and we're very proactive with people so they realize what's going on with these tools. All right, and then there's the help section, which

is the entire software users guide, so if you do have questions, before you submit it to the help desk go out there. A lot of good information under the help topics, and there's even some Q and A's. It gives you the definitions of the different assembly types that are in there and how you enter what values as far as insulation –

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and how you should be entering those software inputs. So take a look at that. All right. Down below project, you're putting your location in. We already have our code that we set and that's what we're gonna use right now. And then I can come down project type. If I have enough time I'll show you a little bit about alterations, and I'm gonna show you how you can maybe cheat a little – not cheat on a project, but let's say you didn't have the code book in front of you and you don't know what the threshold is for a certain assembly. When you go to alterations, alterations is very prescriptive meaning every assembly has to show compliance on its own. So with that, we put those thresholds in there as far as what that U-factor is that you must meet. So if you don't see it over here on this side, which you won't if you're just doing a new construction project – and don't tab back and forth, by the way, but you could go look at alterations, pull up that assembly, and see what that threshold is, that U-factor that you need to meet. But then again don't switch in between alterations and new construction in a project because they are two different calculations. That's just something that you might want to do if you don't have the code book in front of you that you would do off of –

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doing a project, if that makes sense. And I'll show you a little bit later. All right, so from there we have efficiency options, and this is where you would be entering – and there are several from 2015 that you would choose from. This is mandatory. You have to choose an efficiency option before you can get a compliance result. And, again, with these make sure that what you're choosing is something that you're gonna show compliance to. So if you're just doing the envelope and you have a mechanical contractor, you want to make sure you're in good communication that he is going by a different table if he was doing high performance HVACs, so to speak. Edit project details, not much there. That's pretty common. You're just putting in the information for your project in there that shows up on your compliance report. Then over here, and we're still on the project tab, we have three other tabs, interior tabs. So you have building envelope area types. That needs to be

filled in for new construction or an addition, and that takes precedent as the table that's in IECC. You can have more than one building area type if you need to. There's also space types but that's specifically for lighting. Need to have this filled in –

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so it knows what the baseline is for the building that you have. So if we were to go and put in – we'll just put in fire station. Then you're gonna put the square footage. Square footage that needs to be here is total conditioned floor area. That's the only time you'll put total conditioned floor area is in the project tab. Then when you get in the envelope, then you're doing the exterior of the building thermal envelope. Not interior walls, not interior floors. But right here you gotta make sure it's the total conditioned floor area. Again, space conditioning, Dan talked about that. So IECC does not have semi-heated. If you do, you want to look through everything that you have before you decide to go that route with 90.1 because you have, it's one or all and it's not now you can pick and choose. You move to 90.1, everything is 90.1, similar to IECC. The same way applies. But with metal buildings there are a lot of them that are semi-heated, and then you have metal buildings that have an unconditioned warehouse with an office space, and maybe that warehouse is semi-heated. So those are things that maybe with metal buildings you're paying more attention to –

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than another type of commercial building where it's just hands down it's a fully conditioned building. All right. Over here is where interior – this is lighting methods and then exterior lighting methods. Don't get caught up that this is, has anything to do with the building envelope. What this is, is you can do area category space by space. There are two tables in the code, or you can do building area method. And if you do building area method, if I click on that, it would take you back over to this tab, but all that's saying to you is for your lighting you are now showing compliance to the table that's for the building, whole building envelope area tables. And you have to define all of them that are in your project or in your building and put the square footage of each one, or all of it, and then it'll give you watts per square foot. If you don't choose that, then you – and you're doing lighting, you need to choose area category, the space-by-space, and as you enter that information here all this affects is your lighting and your space-by-space method that you had put in here.

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And then this actually transposes all the spaces that you put in here over to the lighting tab. It'll move all those area categories over with the description and the allowed wattage over to the interior lighting tab. Similar to the exterior lighting, same thing. Whatever you put in here is gonna bring it over to the exterior lighting as you start entering your fixtures. And it starts calculating for you, you know, your proposed watts against the allowed wattage. But we won't go any further that today, and nor are we gonna go into mechanical. We really want to touch on envelope. Okay. So with that said, we looked at the project and now we're gonna jump into the Envelope tab. But as I do so, there's another tab that sits up here. We see the Print, Cut features and those items that are kind of Windows based things, and now I'm going through the tabs, Project, Envelope, Interior Lighting, Exterior Lighting. But then on to the last one right here that I mentioned earlier was this Requirements tab. I'm not gonna click on it now because it's kind of dynamic, meaning it will start adding –

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more checklist provisions as you start defining your building, and when you're done doing your building, this is how I suggest it, you could go out there and look at it, but wait until you're done with your project and then don't forget to go over to the Requirements tab and finish going through and looking at every one of the provisions in there. As you'll see under Project I only have one checklist item. It's because I don't have anything entered for my building yet. More provisions will come down here as I start entering things into this project. Envelope, same thing. Now this gets a little more trickier. Well, I don't have anything for envelope. That's why it's showing nothing. But if you're only doing envelope and someone else is doing lighting, try to be in communication with each other that if there's a separate report that's going on that's outside of not doing a whole building, all of it together, lighting, envelope, mechanical, that they also go to the Requirements tab and they check off those provisions. What you're saying when you do that is that you're confirming that those other code provisions – and they are. They're other code provisions that come from the code that are not –

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items that you are putting into the software that's running a calculation, such as I have a continuous air barrier. That's not

something that you enter. It's that you're choosing it as an option item and then it'll add it to the checklist item. That's not a calculation. That's just saying that you're going to do it and it's a mandatory requirement. There's other ones like that as well. But you want to go out there and confirm you're doing these things, and then there are some things that you won't be applicable to do, and you want to make sure that you cite that as well. Very good resource to keep all these, all the compliance papers and the checklist, requirements checklist with you as something that you would hand over to your client. So let's get back over to envelope, and then I'll come back over here when we start adding some more things. So with envelope – and I need to go a little bit faster so we have time for questions – as I mentioned, under Roof here's the blue and white buttons that give you the assembly features to start choosing from for your building thermal envelope. Under Roof you have a dropdown list of assembly types, and you will see there are ones that are familiar with metal buildings, so you can do insulation entirely above the roof deck –

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which would allow you to put in a continuous insulation layer, and then codependent with this would pop up as far as if you need to do solar activity on that roof. And from the location that I'm in, this climate it's only required that you show it. I'm gonna hit cancel out and I'm gonna go back over here and I'm gonna come to metal building standing seam. Now with metal building standing seam – I keep getting that. That's okay. We come over and the construction details then brings down a little bit further. So now you have single layer, double layer, cavity, and that liner system that was mentioned, and the thermal blocks. So how do you go about this? I'm gonna show you a couple things as I move along, and this is how COMcheck works for any assembly that you choose. Right now it shows zero as the U-factor. As I start deciding on what I have for my insulation, it's gonna start putting a U-factor in there. You're not adding the U-factor at this point. You will never put a U-factor in here if you choose one of the assemblies from the dropdown list.

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But there is an option to choose other where you would enter your U-factor of your component or your building assembly that you've calculated. And I'll show you that in here. So I'm deciding what I have with my project. Do I have a single layer? Do I have a double layer? A lot of questions that come in is on double layer insulation

with a thermal block, so let's choose this. We have a little note that comes up because we knew we were getting a lot of questions on this to explain what that means. And don't run across these. If you see a popup please read them, because we put those there on the needs of that we were receiving a lot of questions and we needed to put more clarity in there for people to understand what that double layer meant. And so with the double layer it's insulation that's two different installations of insulation, as Dan mentioned. So you have the first rated R-value is the single layer, and then you have your double layer as the second rated R-value. And those are installed differently. One's perpendicular, which is the first one, installed perpendicular, and then you have the second layer. Now how do you put that – well, where is the R-value?

[1:06:00]

You're gonna add up those two R-values. Those two R, rated R-values from those two layers get added up and they are placed under the cavity insulation column, not the continuous R-value. Continuous is what it is. It's insulation that is installed out the thermal – or outside the studs. It has no thermal breaks. Typically rigid foam board is what that is. No thermal breaks, no thermal bridging, that is continuous. So I'm gonna click Okay here. I would put the square footage of my roof assembly. Now with the square footage of your roof assembly, questions that come up, it's where the insulation is placed. This one's easy. You get into where insulation is down at the ceiling level. It's not at the roof deck. Calculation can be different for your total square footage. But with this you know where you're calculating because you're typically – or at insulation of the roof deck you're calculating square footage at the roof deck. So another thing to pay attention to is where the insulation is being placed is how you would calculate the square footage of that assembly, and it's the entire gross opaque area.

[1:07:00]

And then I'm going to total up my two layers. Right here is where I would put my two layers. Now, as I put in a value and I added up two values, I'm putting an R of 29. The other thing that is important where the lookup tables come into play is the lookup tables have a limit of R-values. If you go past that limit that's in the tables, such as what if I – you wouldn't have this, but what if I had – and look at the U-factor over here that says 0.074. What if I had some – and this is just throwing it out there – a really nice two single layers of some insulation I've never heard of, and now I'm looking at R 50. And the U-factor changes to 0.060, but go to those

lookup tables because some of the assemblies that have a limit on what the insulation value is, such as a single layer cavity, that would go up to – this is just an example in the appendix. You're only going up to R 30. If you had more than R 30 –

[1:08:00]

you'll give the calculator a U-factor but you're not getting tradeoff credit for it. It'll only go up to that limitation that's in the table. So if you're thinking, "Why am I not getting more credit? I have such high R-values in there," it limits that out to where there's no tradeoffs available because it's not in that table. And that might happen, not all the time, but that has come about and questions have came in on that. So let's put it back to R 29. Okay. So I'm not gonna enter each one of these, but as you go through you can see that we have the screw down, and what screw down means – so go to the definition if you're not sure that that's the type that you have for your metal building roof. And then standing seam. Difference here is that you have some compressed insulation. Correct? With a screw down. The other thing to keep in mind is that the thermal – the spacer block that you're putting in, you don't add that R-value for that spacer block. That becomes a mandatory requirement depending on what assembly you choose here. That's already calculated into the assembly. It's not something that you would add.

[1:09:00]

All right, so let's go from roofs after I show you the other option. If one of those don't work for your assembly as such as maybe it's the type of insulation that I was talking about, and Dan discussed, is I would go to Other. With that, there always has to be a baseline in the software. It has to show something against a baseline because it's looking at a budget building against your proposed building. And on the report it'll show that. You have proposed U-factors and you have the budget U-factor. So with other, we have to tie it to something, and what we are doing is bringing it over to say, all right, if it's other, is it insulation above deck? Is this a metal building roof? Is it attic roof, which is typically wood, or is it other? And we need to make sure that if you're doing metal, then you choose metal building or insulation above deck. So when I choose this here, again, this is code driven. We'll click off that. It gives you a little note about U-factors. Again, if you're new to the software please read this. And then you are only putting in the calculated U-factor here and your gross square footage. These are grayed out.

[1:10:00]

The cavity and the continuous insulation columns are grayed out. Reason being is because you've chosen other, and it'll show up on the report that way. It helps the code official understand that you have not used the table. This is your own calculation. And then I highly advise that you provide how you calculated that assembly and back that up and provide that specs on how you did it to the code official so he can look through that and all of the information on the – all the components that are within that assembly. And, you know, they want to double check it just as much as probably as you are looking at it as you're adding it in. This is where it's nice, where I'd come up to Options and I would want that comments and description. Now that I'm in the envelope tab and I click on Options, all those are not grayed out except you go into lighting, because I'm not in the lighting tab, and I can choose those features if I want to. I can choose orientation, the visible transmittance, daylighting allowances, which is in the code for 2015, and glazing allowances. Those things might be applicable to you, and so you might be looking at your – starting to move around and adding more of those columns that would come over. And then you'd scroll over to the right as those items get added. And here –

[1:11:00]

over to the right, the very far right, is I have that description field where I could actually put in what I'm doing with that roof that is now other, so I have as much detail as possible when he goes to look at it. And then there's no stopping. There's no time delay that he is gonna throw that report back to you and say, "Here's all these highlighted items that I don't know what they are." And the more detail you provide, probably the faster it's gonna get through plan review. All right, so let's go over to exterior walls. We have wood-framed, steel-framed. We talked about what the difference with steel-framed versus metal building, and what is that? That's that exterior component. Is the exterior component gyp board stucco or is it metal? So if it's metal, then it's metal building. Steel-framed is just the studs itself and the material on the exterior could be a different type of material other than metal. That's how I always look at it in layman terms. So I'll go to metal building wall, and then you have concrete if you had concrete. And then you have other again, and here's that metal building wall that you can choose. So let's go over there to add it, and now we have two other dropdowns. Not as many as the roof.

[1:12:00]

But you have that single layer and double layer, and the liner system, since – and I'll show you that as well – the reason why it's not there is 'cause it's the project or location that I'm in right now. So I'm gonna click on double layer, but let's go back over to project real quick. Let's get out of climate zone three. That's gonna help us considerably. And let's just go to, we'll go to Pennsylvania, so we're looking at climate zone five. Now let's go back over to envelope, and then let's double check on over here we'll do double layer and the – I'm gonna put in – now I can have continuous if I want to, but what you'll see is when I clicked on this double layer, look at my U-factor. What is that U-factor? That U-factor entails everything about that assembly except the insulation. You don't add air films, you don't add the siding, and you don't add what the U-factor would be for the framing members. That's included in that U-factor. We use the same U-factors that are from 90.1.

[1:13:00]

These things are not made up. The only thing you need to be familiar with that you need to know what to enter, if you choose one of the assemblies in COMcheck, is that insulation. It's an important thing to keep in mind, especially if you're new, is this is probably one of the biggest questions we get is they want to add in other layers of the assembly, their components of that assembly into that assembly they're choosing, and they shouldn't. And it'll give them a lot more credit, or even could be, go against them in a building, actually, but it's just the insulation. But if you choose other, then that's where you're adding in your air films percentage of framing members, the U-factor R-value of those framing members, and so forth. Your air barrier. And then your exterior, whether it's stucco or whatever it might be, you're adding in all those layers to get your overall U-factor, and not with the ones that are in there. So let's move ahead and move on to – let's get to the –

[1:14:00]

floor real quick, and then I'm gonna move back and we're gonna play around, and Dan probably has stuff he wants to add in. Okay, so with floor you have steel joist, you have slab-on-grade, and another thing that has come up a bit is if you have a concrete floor, that's – total concrete floor, total square footage, is how you would look at that. The only assembly in COMcheck that requires a different area takeoff is slab-on-grade. Unheated, heated. Heated means you have a hydronic type system within the slab. Unheated,

you don't. So more the construction details, you are choosing how you're insulating that slab edge. Vertical, horizontal, vertical, and then the depth of the insulation. What I'm trying to get at here, which really isn't metal building but it's very important for you to know, is the area is in linear feet. As you get into 90.1 2013 it will automatically throw you out and not show compliance if you enter the area in total square footage. Something to really pay attention to on that one if you have slab-on-grade.

[1:15:00]

All right. So let's go back over to the assemblies up here, and let's start with – I'm gonna, Dan, I'm gonna ask you if you have anything you want to – and we've got about five minutes to talk about any specific assembly that you want to highlight before we go into question and answers.

Dan Walker: Sure. And so you're in the perfect place, Pam, so I'm glad you're where you are right now. So under roof, for instance, if you had a situation where you wanted to use – let's just say the next edition of ASHRAE 90.1 comes out, so in the next edition of 90.1 that's not even referenced by the 2015 IECC, and there's some new insulation system in there. For instance, in the 2015 IECC it's referencing 90.1 2013. We've had five years to develop that standard, and it's developed quite well. There are some new wall insulation systems in there that are not recognized in 2013 because it was developed five years ago. And so there are new liner system walls that I think everybody on the call should know about.

[1:16:00]

And the way to use those in this version of COMcheck is to use the other U-factor option. So under walls, you're on roof right now, but if you click the next one down, Pam, you'll go to walls. Under metal building wall – sure, right there. Yeah, so you can go other metal building wall, and then you can type in the square footage of that wall, and then you can type in the U-factor. And where I would get that U-factor from is I would get it from the version of 90.1 that you're using. And I would always go forward. You know, if you're going to use another version of 90.1, use something that's newer than the one that's specified in the code. I think for the most part building officials will recognizes that ASHRAE is an authority, that it is – that these U-factors are developed using engineering principles, which is really the intent of the energy codes, is that you can't just make up these U-factors. You get them from testing or you get them through other approved engineering

methods, and ASHRAE uses engineering methods. And so even though it's not recognized by COMcheck or it's not in this version of the code –

[1:17:00]

your insulation supplier may have a brand new system that the code doesn't know about, and you're allowed to use those. You do that through the U-factor substitution method, which is what Pam just did. She typed in the U-factor for a system that might be one of the – some proprietary system you're using on your project, then you would type in the notes "see attachment," and your attachment would be either a hot box test or it would be a reference to where it came from, like 90.1 2016 appendix A2. And then I, if I were you and you were submitting one of these, I would staple it right to your compliance report, or what I tell people who run COMcheck is make a binder for yourself. If you do a lot of metal building projects or a lot of other types of projects, the person in your company who's running COMcheck, print out the user manual, first of all, and put it in the binder for them so they can reference it and make notes on it. Second, I would get copies of any hot box tests you're going to be referencing and I would put them in an organized way in your binder. Because that way the building official, if they ask you for evidence of –

[1:18:00]

how you got that U-factor, you've got it right at the fingertips. You can fax it over. You can attach it to your permit application. It makes things a lot cleaner and it's a lot more transparent that way. But this really, very good software. I mean you have an opportunity here to be flexible in any way that you need to in order to show compliance, and it does all those calculations for you.

Pam Cole: Okay, great. Here's another note to mention is when I – with a liner system, I didn't show you where that liner system would come into play, but if you have screw down, that's where when he showed you the lookup tables and he showed you the prescriptive tables and he was talking about liner system, another note comes up because we received a lot of questions on liner systems, and it's providing a little more detail for you about the liner system, and read those. Again, up here I'm choosing that as part of it, so liner system with thermal blocks. What the value of insulation I'm adding here is not the thermal blocks. Don't add in that R-value. You're adding in the installed insulation. So let's go back over –

[1:19:00]

real quick to requirements, 'cause I said I would go there, and then we're gonna address some questions 'cause we're almost out of our time for this webinar. There's just so much to show, so much to do, and we have fun with this 'cause I could talk all day about COMcheck, believe me. Over here I said project and you only saw one checklist item. As you start entering the information in, more comes up. Go through these. Confirm that they're gonna be met or that they don't apply. You get to envelope. If that's all you're, that you are required to do, then go through all those provisions. As you go through them, you see these little red X's. They'll turn to green, so current requirements will be met. As I go through them again, air leakage, that's not an entry that you put into the software, but it's still a code requirement. We've made this a nice feature that it's a full round compliance tool that has took in that code and all the provisions from 2015 IECC or 90.1. All of them are there. There's nothing missing, and so you have a full code compliant building with all of the requirements specifications that it was not an entry point, but in this checklist area.

[1:20:00]

So pay attention to the other, these other details. Again, go through them. Click Does Not Apply, Does Apply, and if it doesn't put some note to it for why it would not apply. And you can also add on the page of the plans that it's at, and just another helpful feature to that code official. So I'm gonna stop there and, Dan, anything else that you want to throw in?

Dan Walker: No. I just want to thank you, Pam, for going through that overview of COMcheck and, you know, for inviting me to come and participate in this presentation. I'd like to see some of the questions, too, so why don't we get to that.

Pam Cole: Perfect. Do you see those questions up on my screen, by chance?

Dan Walker: I do not. I see them on my screen though.

Pam Cole: Okay. Okay, good. Okay, so I'm fine if you want to grab a few and start addressing them, by addressing a question first and then answering it. Do you want to do that, Dan, and then I'll address some as well.

Dan Walker: Sure.

Pam Cole: So we'll tag team it and just go through as many questions as we can.

Dan Walker: Yes, and one –

Pam Cole: And we're gonna extend the webinar. We know that this is a large one.

[1:21:00]

Dan Walker: Right. One question that I saw, and I don't know who asked it, but they're going by very quickly, was whether or not rigid board insulation can only be – I'm sorry, that continuous insulation can only be rigid board insulation, and the answer to that is no. Any kind of –

Pam Cole: No.

Dan Walker: – insulation can be considered continuous insulation, but it has to meet the definition. It can't be compressed. Now that doesn't mean it can't be compressible. It's okay because fiberglass is a compressible material, and so is certain types of foams are somewhat compressible, but if they rebound and if they're not compressed in their installation, then they're still continuous because they're holding the R-value consistent across the whole profile. And so you can use fiberglass boards, which is a compressed fiberglass product, but it's rated at its compressed thickness. And so as long as it's got the rating throughout its entire thickness and it's not interrupted, like cut and put in between studs or something like that, then that insulation product is continuous.

[1:22:00]

It's not exclusive to foam products. It's not exclusive to rigid board.

Pam Cole: Great for clarifying that. And, again, 'cause I said rigid foam board, but I didn't mean that that was the only thing that's continuous insulation. So thank you for clarifying that.

Dan Walker: Sure. It can be _____ –

[Crosstalk]

Pam Cole: You have another question? You want me –

Dan Walker: – cellulose. Doesn't really matter as long as it's continuous and its thickness is the same. So other questions.

Pam Cole: Okay.

Dan Walker: Boy, there's so many of them it's hard to pick one.

Pam Cole: I know. How about the vapor retarder? It's asking are there two vapor retarders in that liner system?

Dan Walker: No, there aren't. And so the liner systems themselves are made from unfaced fiberglass insulation. Okay? And so the vapor barrier liner itself is installed as a separate element, and then the insulation, which is unfaced, is installed on it. We typically try to avoid having two vapor retarders in any metal building insulation assembly. Just like any other assembly, you don't really want to have two vapor retarders unless you've done that by design.

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And so most of the assemblies in 90.1 have just one vapor retarder. So even the double layer insulations that we show where you have two layers compressed over the purlin, the first layer that goes over the purlins and then the second layer goes perpendicular and it lays sort of in that space, that's an unfaced layer, too. So we don't, we do not combine usually those vapor retarders unless the second one is vapor permeable by design.

Pam Cole: Yeah, because you don't want to encapsulate on your assembly where you don't have a breathable, and there might be some condensation and/or mold that grows. And so that's a no-no.

Dan Walker: That's right, yeah.

Pam Cole: The other thing is with vapor retarders, you might as well add in what about the air barrier. Mandatory requirement, continuous air barrier, that building thermal envelope. Get on your building plans. Take a highlighter, and you should never be able to pick that highlighter up. And go through that entire building thermal envelope assembly, and you should never have a disconnect to show that continuous air barrier. If you do, go back and reassess your designs. You don't want to have any breaks in that air barrier.

[1:24:00]

That's a mandatory requirement.

Dan Walker: Right.

Pam Cole: Depends on the vapor retarder. All right.

Dan Walker: So someone had a question here. It was actually Mike Smith asked the question can U-values generated using finite element analysis software based on ASHRAE calculations and standards be used in COMcheck? And I would say by definition you can. In fact I think the standard calls it finite difference modeling or fluid dynamics, but either way you can do that. It's just you have to find a qualified person to do that type of analysis. It's very complicated. If you're even asking the question, you know more about it than most people do, and so you can do it. The standard in section A9 specifically allows it, but you have to just make sure you've captured all of the different elements in that finite element model. It's a little more advanced than this webinar, but the answer is yes, you can do that. In fact, it has been done extensively to validate some of the hot box testing in the standard.

[1:25:00]

Pam Cole: Okay, another question came in is what is the R-value of the thermal spacer block?

Dan Walker: That's a great question.

Pam Cole: Yeah.

Dan Walker: That's changed over the years.

Pam Cole: Do you want to take it or you want me to? Yeah, it has.

Dan Walker: In terms of its requirement it has changed, and in 90.1 I believe that R-value is R 3.5, and that's, it's really, the thermal spacer block is sort of a misnomer. It does certainly provide space. Really the purpose of that piece of foam that's in the roof is really to hold the roof module. That is the, that the roof is installed in a very good appearance and that it doesn't start walking from the sagging of the roof panels, and so that's a tool that's been used for many years. Of course it does provide some thermal performance, but because it's such a narrow block the R-value of the block itself, in terms of physics, does not provide that much insulating performance because it's a very narrow band in a very large space. However, the space does matter –

[1:26:00]

and that space provides some insulating value. So the energy codes do have minimum requirements for that, and in ASHRAE 90.1 it's 3.5. In the IECC if you go back a few editions it was R-5 in some places, R-3.5. So what I would really ask your insulation supplier to do is to provide a drawing that shows you what's in the assembly, and then the 90.1 tables specify in A 2.3 what was used to obtain that U-factor, and I believe they're all 3.5 minimum. You could use an R-5. It doesn't hurt to go more, but you really can't go less. And from a practical standpoint you wouldn't have one that's less than 3.5. It would be too thin to be useful.

Pam Cole: And I think now it's R-5 is the spacer block with the –

Dan Walker: In the IECC I think you're correct. I'm not sure if 90.1 kept it at R-5. But it's one of those things where most of the suppliers today have hot box test reports or they have some other analysis where they can show you what the U-factor of their system is –

[1:27:00]

so if you're doing it prescriptively it does matter. If you're doing it by U-factor method it does not matter. It all depends on what was tested and the test report can stand on its own.

Pam Cole: Right. I'm just skimming through them, so if you have one and you want to say something, go ahead and bring it up. Do you have any details showing the roof to wall vapor barrier? That's another vapor barrier transition. We don't have pictures of that on energycodes.gov. Go ahead and send that question in to the help desk. I'll get you some resources, whoever asked that, more specific to that. For the linear footage of the floor – this might be a good one here – would we be using the perimeter, width, length, or thickness, or other? How do we calculate that floor? Now this – and when I mean floor, and Dan can chime in, not the slab-on-grade floor 'cause that's linear feet. You're going around the exposed edge of that slab –

[1:28:00]

and just adding it up, linear feet. But what if you have a concrete floor? How are you adding it? Where do you start adding it and what are the takeoffs gonna be? So perimeter? Width? Length? Thickness? Want me to chime in on that? Do you take it from the interior of the wall?

[Crosstalk]

Dan Walker: Yeah that's three questions. Why don't you go ahead and chime in?

Pam Cole: So you are taking it, so you have the wall assemblies and then you have the floor, so where do you start that conditioned floor area as your calculation? Take it from that interior wall and move in. So you've got total conditioned floor area and then you have the – so and I don't want to be confusing, so am I looking on the exterior of the building and then adding up my square footage, or I'm on the inside of the building on my building plans and I'm truly taking conditioned floor area. That's what you should be taking, because that comes into play as far as other things that happen, which is testing, air leakage testing. You get to the blower door testing, they have to put in some numbers to do that. They want to make sure they're consistent with the values that you're putting into the software. So when you do your takeoffs here –

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you're doing it from the interior conditioned floor area for that floor. Walls, it's the height times the length, and it's opaque meaning include your windows and doors if you're using COMcheck. COMcheck subtracts them out automatically.

Dan Walker: That's right. Yeah, you have to remember that. Don't take them out yourself. It does it for you.

Pam Cole: Yeah. So let's just answer about two more.

Dan Walker: I've got a great question here from Mike Reed, Pam. This is a really good one.

Pam Cole: Okay.

Dan Walker: It's near and dear to my heart. He says here COMcheck and the IECC appear to only allow performance for standing seam roofs. Can you comply with a through-fastened metal roof? And the answer is absolutely yes, and that is one of the reasons that you should use COMcheck because there is no prescriptive through-fastened roof table in the IECC or in 90.1, and so if you want to use a through-fastened roof you have to use COMcheck to show compliance. It is very easy to do with U-factor substitution. In fact, you can just put in the – now that they recognize the R-value of

through-fastened roofs in COMcheck, you can just put that one in directly and then just put a better performing wall in.

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That's one of the points we didn't really cover here is how does that calculation take place. It's behind the scenes. You don't really need to know how it works, but COMcheck is doing an average of the performance across the building. It's doing that with very complex algorithms. But if you put in a more, higher efficiency wall, that higher efficiency wall can make up for some deficiency somewhere else in the building. For instance, if you want to use a certain type of window that doesn't by itself meet the code requirements, you can just put more wall insulation in and it will average the performance of those two elements together and still allow you to perform and to comply with the code. And so that's how you do it with through-fastened roofs. You would just put a better performing wall in, a better performing slab, better performing windows or garage doors, and you'll see that it's not that hard to make a through-fastened roof comply with using COMcheck.

Pam Cole: And as a – I'm gonna do this last question. It's really more of this is informational. I didn't touch on it, but this is – when you have a metal building you always have to bring in other features. Windows is a big one. Right?

[1:31:00]

Dan Walker: That's right.

Pam Cole: So, if you didn't have a window, a fenestration that met the code, meaning in the code NFRC 100, 200, it has to be tested, rated, and labeled. If it's not, you have to use the defaults. So I brought up this little popup that comes up when you enter any window into COMcheck. You have to get past this window. And that means you have site built. If you have site built, you can get that rating right from NFRC, and we have that as far as a lookup. If you don't, forget that one and you can go to product performance, only if it's NFRC rated. And if you don't, you have to use defaults. Defaults are not favorable. They don't meet most of the prescriptive values. In fact, they don't meet them. And this is where the confusion comes in. You could not probably have a building that has all default, code default windows, and meet code. Because you have thresholds for area weighted U-factor and that solar heat gain that I

mentioned before. It's climate zone dependent. But that's why I would come up here and look at the, under view option –

[1:32:00]

look at that glazing requirements as it'll start calculating, and you could be failing. A building could have great insulation, could be a great metal building, but you can just be failing just the fenestration requirements. So if I didn't have those NFRC rated, again, you've got to use those defaults. Those come directly from the code. If you don't, come up here and add in your ratings, and the product ID can be your ID. It doesn't have to be NFRC's ID. It's one that's gonna help you say what you're doing when they go through plan review that's on your specs. So you can put your values in here and they'll automatically populate over.

Dan Walker: Another thing I would –

Pam Cole: So another good point to make.

Dan Walker: Another thing I would add, Pam, to that is –

Pam Cole: Go ahead.

Dan Walker: – that our industry has a great number of suppliers that provide really good performance window products, and so there's really nothing that's impossible to do. These windows perform great and you can find windows that comply with the prescriptive requirements for metal buildings all day long. But if you wanted to use one that didn't for some reason, again, that's where the –

[1:33:00]

U-factor substitution and the tradeoff happens with COMcheck, and it's not that hard to trade off window performance for insulation or for slab insulation. So get tons of flexibility with COMcheck. I would encourage everybody to use it. It's great software. You should watch the other PNNL webinars where COMcheck is outlined in more detail, because it's a very powerful tool and we're glad to have it.

Pam Cole: And hopefully if you have topics of interest, submit. Maybe you want to see an advanced webinar on COMcheck, which we would have to extend the timeframe because there's just so much to show in this tool. I didn't get to alterations, but if that's something that you want to see, please provide that information as a topic of

interest and maybe advanced COMcheck training and we maybe can have that happen later this year to do another webinar, or any other one if you have a topic that you see that would be of great interest related around the energy codes and buildings. And okay, so I really appreciate that everyone has attended today. We tried to touch on everything we could. I'm sure there's things that you might have had a question on. And if you did, we do have a help desk.

[1:34:00]

You submit those questions in to us through that help desk. And I'm gonna bring over what you, really is important, is that you are able to get your continuing education credits. So let's get there. Hold on one second. Now it wants me to go to this very end of this presentation where there's a URL for you to write down, and I should have brought that up when we were doing questions. I just go so involved in the COMcheck I completely just went right to the tool. Okay, so there are resources available. Look at the handout for the presentation. Didn't go through this too much as far as what's available out on the codes program, but you have the software but you also have tech support, you have code notes, publications, and there's resource guides. And there's full training sets of the codes. So full decks, slide decks, of 2015 are already out there if you want to grab those, free. Go get them. Play with them. And you can modify them to your needs if you're a trainer. And there is that training page that I mentioned several times within this presentation today. So here it is. I'm gonna leave this up for a little bit.

[1:35:00]

There is the codes website and there is the help desk URL. We will be, have this recording out in a couple weeks, and the presentation is out there, and as I mentioned before a nice case study will be here in the near future that will show a metal building that you can kind of go through and play around with. And, Dan, I really appreciate the time that you took with us today. It made it such a great webinar. And, DOE, I can't thank you enough for allowing us to provide this information out to the attendees that took the time to meet with us today and go over what we had to tell them about metal buildings and the energy codes. And I appreciate your time. Thank you, everyone.

Dan Walker: Thanks, Pam.

Pam Cole: Thank you.

[End of Audio]